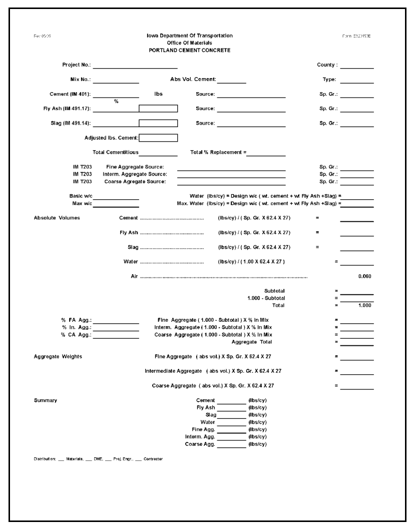
IOWA DOT
SMARTER | SIMPLER | CUSTOMER DRIVEN

PORTLAND CEMENT CONCRETE



Iowa Department Of Transportation
Office Of Materials
PORTLAND CEMENT CONCRETE

Project No.: ______ County : ______

Mix No.: ______ Abs Vol. Cement: ______ Type: ______

Cement (IM 401): ______ lbs Source: ______ Sp. Gr.: ______

%

Fly Ash (IM 491.17): ______ Source: ______ Sp. Gr.: ______

Slag (IM 491.14): ______ Source: ______ Sp. Gr.: ______

Adjusted lbs. Cement: ______

Total Cementitious ______ Total % Replacement = ______

IM T203 Fine Aggregate Source: ______ Sp. Gr.: ______
IM T203 Interm. Aggregate Source: ______ Sp. Gr.: ______
IM T203 Coarse Agregate Source: ______ Sp. Gr.: ______

Basic w/c ______ Water (lbs/cy) = Design w/c (wt. cement + wt Fly Ash +Slag) = ______
Max w/c ______ Max. Water (lbs/cy) = Design w/c (wt. cement + wt Fly Ash +Slag) = ______

Absolute Volumes
Cement .... (lbs/cy) / (Sp. Gr. X 62.4 X 27) = ______
Fly Ash .... (lbs/cy) / (Sp. Gr. X 62.4 X 27) = ______
Slag .... (lbs/cy) / (Sp. Gr. X 62.4 X 27) = ______
Water .... (lbs/cy) / (1.00 X 62.4 X 27) = ______
Air 0.060

Subtotal = ______
1.000 - Subtotal = ______
Total = 1.000

% FA Agg.: ______ Fine Aggregate (1.000 - Subtotal) X % In Mix = ______
% In. Agg.: ______ Interm. Aggregate (1.000 - Subtotal) X % In Mix = ______
% CA Agg.: ______ Coarse Aggregate (1.000 - Subtotal) X % In Mix = ______
Aggregate Total = ______

Aggregate Weights
Fine Aggregate (abs vol.) X Sp. Gr. X 62.4 X 27 = ______
Intermediate Aggregate (abs vol.) X Sp. Gr. X 62.4 X 27 = ______
Coarse Aggregate (abs vol.) X Sp. Gr. X 62.4 X 27 = ______

Summary
Cement ______ (lbs/cy)
Fly Ash ______ (lbs/cy)
Slag ______ (lbs/cy)
Water ______ (lbs/cy)
Fine Agg. ______ (lbs/cy)
Interm. Agg. ______ (lbs/cy)
Coarse Agg. ______ (lbs/cy)

Distribution: ___ Materials, ___ DME, ___ Proj. Engr., ___ Contractor

REFERENCE MANUAL
2015

TECHNICAL TRAINING AND CERTIFICATION PROGRAM

TABLE OF CONTENTS

Specifications

Construction Manual

CONSULTATION PROVIDED BY MATERIALS PERSONNEL ON CONSTRUCTION PROJECTS

INTRODUCTION

In addition to the routine duties associated with the inspection of materials, assurance sampling and testing, and certain laboratory operations, the District Materials Engineer (DME) is required to monitor Quality Control and acceptance procedures, and provide consultation when difficulties are encountered.

CONSULTATION

Plant inspectors are by instruction required to consult the DME through the Resident Construction or County Engineer when the contractor encounters difficulty with regard to specification compliance and satisfactory plant operations. Consultations are also required when technical problems become evident to personnel performing sampling and testing and other specialized functions. The DME should provide the necessary assistance and guidance when conditions indicate action is required.

GUIDELINES FOR CONSULTATION

In many cases plant equipment operation and maintenance practices are directly related to problems associated with the work. Materials handling and storage procedures also cause difficulty at times. Sampling, testing and related inspection functions require re-evaluation when difficulties are encountered on a project. The following guidelines should be observed when Materials personnel are consulted for guidance:

1. Determine who is responsible for the problem and advise the appropriate party.

2. If the difficulty is associated with sampling, testing or related inspection functions provide the necessary guidance or instruction if practical and advise the engineer in charge of action taken.

3. If the difficulty is associated with the contractor's equipment or procedures, reaffirm the responsibility and requirements assigned to the contractor by the contract documents. The DME should then assist the contractor in identifying the problem by performing additional tests, calibrations, or other measurements as provided for in the specifications and appropriate instructions.

4. In the event that the standard procedures do not properly identify the factors causing the difficulties encountered, the DME may provide additional guidance, if requested, with the clear understanding that such further consultation will not relieve or reduce the contractor's responsibility for solving problems associated with the work. Assistance so provided shall not include management services associated with the operation and maintenance of the contractor plant equipment and the direction of the contractor personnel.

INSPECTION OF CONSTRUCTION PROJECT SAMPLING & TESTING

INTRODUCTION

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

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

ACCEPTANCE PROGRAM FOR MATERIALS

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

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

In many cases more than one method may be required for acceptance in the 204 Appendices and tables in the back of this guide. For some new or special materials, the Materials Engineer may need to determine the most appropriate acceptance requirements.
In order to provide the Contractor the opportunity to construct a project with minimal sampling and testing delays, inspection is performed at the source for many materials. Source inspection may consist of inspecting process control, sampling for laboratory testing or a combination of these procedures. All source-inspected or certified materials are subject to inspection at the project site prior to being incorporated into the work. Project site inspections are for identification of materials with test reports and for any unusual alterations of the characteristics of the material due to handling or other causes. Verification samples secured by project Agency personnel of source-inspected, certified, or project processed materials are also required for some materials in order to secure satisfactory validation for acceptance.

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

A. SAMPLING & TESTING (TEST REPORT)

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

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

B. CERTIFICATION OF COMPLIANCE

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

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

The inspector will verify that the certification has been received by documenting it in the project materials book.

C. APPROVED SOURCE

(May also be referred to as "Approved Producer, Approved Supplier, Approved Fabricator, or Approved Brand") The source, producer, and the material must be evaluated and approved by the Office of Construction and Materials according to the appropriate Materials IM in order to be used on a project. Once a letter of approval is issued, the source or producer is approved for use on projects (with the exception of steel fabricators). Approved lists are issued biannually for general information only. Approval for a source or producer may be rescinded at any time if it no longer meets the requirements of the IM.

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

Most approved sources also require a certification.

D. APPROVED WAREHOUSE STOCK

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

E. APPROVED SHOP DRAWING & APPROVED CATALOG CUT

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

F. FABRICATION REPORT

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

G. VISUAL APPROVAL BY PROJECT ENGINEER

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

INDEPENDENT ASSURANCE PROGRAM

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

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

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

SMALL QUANTITIES

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

IM 204 Appendixes

Appendix A	Roadway & Borrow Excavation & Embankments
Appendix B	Soil Aggregate Subbase
Appendix C	Modified Subbase
Appendix D	Granular Subbase
Appendix E	Portland Cement Concrete Pavement, Pavement Widening, Base Widening, Curb & Gutter & Paved Shoulders
Appendix F	Hot Mix Asphalt (QMA)

Appendix H	Structural Concrete, Reinforcement, Foundations & Substructures, Concrete Structures, Concrete Floors, & Concrete Box, Arch & Circular Culverts
Appendix I	Concrete Drilled Shaft Foundations
Appendix K	Cold-In-Place Recycled Asphalt Pavement
Appendix L	Granular Surfacing/Driveway Surfacing
Appendix M	Concrete Bridge Floor Repair & Overlay & Surfacing
Appendix P	Surface Treatment (Seal Coat, Slurry, Joint Repair, Crack Filling & Fog Seal)
Appendix T	Base Repair, Pavement Repair
Appendix U	Granular Shoulders
Appendix V	Subdrains
Appendix W	Water Pollution Control, Erosion Control
Appendix X	Acceptance of Small Quantities of Materials
Appendix Z	Supplemental Guide, Basis of Acceptance

ROADWAY & BORROW EXCAVATION & EMBANKMENTS

Section 2102 & 2107

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Special Backfill, Crushed Stone (4132.02), Gravel (4132.03)		AS 209												
Crushed Concrete (4132.02), RAP (2303.02)		209,210												
Granular Backfill (4133, 4134)	Quality	AS 209												
Engr. Fabric (4196)	Quality	AS 496.01												
Contractor Furnished Borrow		545	CONTR	IM 545	IM 545	CONTR	IM 545 & Cert	V	RCE/ CONTR	1/10 QC tests	35 lb.	CTRL	Test Report	Note 4
GRADE INSPECTION														
Moisture Control, (QC by Contractor) Note 1	Proctor	309	CONTR	1/ soil class	25 lb	CONTR	Field Book & Test Report	V (7) IA (4)	CONTR/ RCE CONTR/ DME	1/ 10 req'd QC tests (min. 1)(5) 1/proj.	25 lb. 25 lb.	RCE/ DME CTRL	Field Book Test Report	
	Moisture	335, 334	CONTR	1/lift/1500 ft (for max of 1300 cy) (6)	3 lb	CONTR	Field Book & Test Report	V (7) IA (4)	RCE (2) DME	1/ 10 req'd QC tests (min. 1)(5) Witness 1/proj.	3 lb.	RCE	Field Book	
Moisture & Density Control, including Special Compaction of Subgrade (2109.03C), (QC by Contractor) Note 1	Proctor	309	CONTR	1/ soil class	25 lb	CONTR	Field Book & Test Report	V (7) IA (4)	CONTR/ RCE CONTR/ DME	1/ 10 req'd QC tests (min. 1)(5) 1/proj.	25 lb. 25 lb.	RCE/ DME CTRL	Field Book Test Report	
	Moisture	335, 334	CONTR	1/lift/1500 ft.(for max of 1300 cy) (6)	3 lb	CONTR	Field Book & Test Report	V (7) IA (4)	RCE (2) DME	1/ 10 req'd QC tests (min. 1)(5) Witness 1/proj.	3 lb.	RCE	Field Book	
	In-place Density	326 & 334, ASTM D2937, D2167, D1556, & AASHTO T191 & T233	CONTR	1/lift/1500 ft (for max of 1300 cy) (6)	As req'd by test	CONTR	Field Book & Test Report	V (7) IA (4)	RCE/ DME DME	1/10 req'd QC tests (min. 1)(5) Witness 1/proj.		RCE/ DME	Field Book	Note 3

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

Note 1: When Contractor QC testing is not required in the contact documents. The RCE will perform verification testing at the frequency listed for QC.
Note 2: RCE will direct the Contractor to take a moisture sample beside the RCE verification sample location.
Note 3: If testing is done with a portable moisture-density gauge, the gauge calibration will be verified on the ValiDator block.
Note 4: For earthwork quantities of less than 50,000 Yd^3, no IA will be required.
Note 5: If no QC tests are required, then no verification or independent assurance tests are required.
Note 6: If source of excavation and moisture have been consistent and within moisture control limits and density has been greater than or equal to minimum density (if required), testing of each lift will be waived. Minimum frequency will be 1 per 1300 Yd^3.
Note 7: For earthwork quantities of less than 1300 Yd^3, no verification tests will be required.

SOIL AGGREGATE SUBBASE
Section 2110

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Granular Surfacing Material (4120)		AS 209												
GRADE INSPECTION														
Mixed Materials (2110)	Density (Proctor)	309						V	RCE	2/mile (min. 2/proj.)	5000 gm	RCE	Field Book	Change of Soil type requires additional Proctors
Uncompacted Mixture	Pulverization Moisture	2" Sieve Visual						V	RCE	2/mile		RCE	Field Book	
Compacted Mixture (2110)	Density Thickness Width	311, 312, 334 337						V	RCE	2/mile		RCE	Field Book	
Finished Subbase	Cross Section	Stringline						V	RCE	10/mile		RCE	Field Book	Template for secondary park & institutional roads

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

MODIFIED SUBBASE
Section 2115

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Natural Aggregate	Quality Gradation	AS 209												
Recycled Products														
Composite	Gradation	*As Per Spec.												
PCC Pavement	Gradation	*As Per Spec.												
Rap		*As Per Spec.												
GRADE INSPECTION														
Compacted Subbase	Density	*As Per Spec.						V	RCE			RCE	Field Book	
Dimensions	Thickness Width	337						V	RCE	3/2 lane mi.		RCE	Field Book	
	Cross Section (Primary)	Stringline						V	RCE	10/mi.		RCE	Field Book	
	Cross Section (Other)	Template						V	RCE	3/mi.		RCE	Field Book	

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

* Use Current Specification for Modified Subbase

GRANULAR SUBBASE
Section 2111

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Natural Aggregate (4121)	Quality Gradation	AS 209												
PCC Pavement	Gradation	209												
GRADE INSPECTION														
Compacted Subbase (2111)	Density	By Specification						V	RCE			RCE	Field Book	
Dimensions	Thickness Width	337						V	RCE	3/2 lane mi.		RCE	Field Book	
	Cross Section (Primary)	Stringline						V	RCE	10/ mi.		RCE	Field Book	
	Cross Section (Others)	Template						V	RCE	3/mi		RCE	Field Book	

AS-Approved Source
ASD-Approved Shop Drawing
S&T-Sampling & Testing
Cert- Certification Statement
RCE-Resident Construction Engineer/Project Engineer
DME-District Materials Engineer
CTRL-Central Materials Office
CONTR-Contractor
IA-Independent Assurance
V-Verification

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

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

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S&T-Sampling & Testing
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CTRL-Central Materials Office
CONTR-Contractor
IA-Independent Assurance
V-Verification
QMC-Quality Management Concrete

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

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

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

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

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CONTR-Contractor
IA-Independent Assurance
V-Verification
QMC-Quality Management Concrete

NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 100,000 sy of concrete) at the discretion of the DME.
NOTE: When Certified Plant Inspection is not provided, the engineer is responsible for performing quality control sampling and testing.
NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.

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

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

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ASD-Approved Shop Drawing
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Cert- Certification Statement
RCE-Resident Construction Engineer/Project Engineer
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CONTR-Contractor
IA-Independent Assurance
V-Verification
QMC-Quality Management Concrete

NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 100,000 sy of concrete) at the discretion of the DME.
NOTE: When Certified Plant Inspection is not provided, the engineer is responsible for performing quality control sampling and testing.
NOTE: Quality samples not required when mix quantity is less than 2000 sq. yds., except for curing compound.
NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.

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

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

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	S&T TYPE	SAMP. BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	
GRADE INSPECTION														
Chloride Solution	Concentration	373	RCE	1/day										
Steel Reinforcement:														
Dowels	Quality	AS 451.03B						V	DME	1/District/Yr	2 ft	CTRL		
Dowel Basket Assembly	Quality	AS 451 Cert 451.03B												
Tie Bars	Quality	AS 451						V	DME	1/District/Yr	2 ft	CTRL		
General Use	Quality	AS 451						V	DME	1/District/Yr	48 in	CTRL		
Curing Compound (4105)	Quality	Tested 405						V	DME	1/batch	1/qt	CTRL		Sample batches not previously reported or as required by DME
Plastic Concrete	Air QMC	318 327	CONTR	1/350 cy, 1/100 cy ready mix		CONTR	E115	V IA	RCE	1/700 cy,1/350 cy ready mix 1/100,000 sy		RCE DME		Min. 1 test/pour
	Air Non-QMC	318 327					E115	V IA	RCE	1/700 cy,1/100 cy ready mix 1/100,000 sy		RCE DME		Min. 1 test/pour
	Slump	317						V	RCE	1/700 cy,1/100 cy ready mix		RCE		For hand finish or fixed form only. Min. 1/pour
	Grade Yield		RCE	1/1000 cy		RCE								
	Beams**	316, 327, 328	RCE	2/day		RCE	E115							
Hardened Concrete	Thickness*	346, 347						V IA	RCE/ CONTR	1/2000 sy 10%		RCE DME		
	Smoothness	341	CONTR		100%	CONTR		V	DME		10%	DME		

AS-Approved Source
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V-Verification
QMC-Quality Management Concrete

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

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

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

NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer. **NOTE:** Form #E115 available from the Office of Construction.

HOT MIX ASPHALT
Section 2303 & 2213

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE, & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Aggregates-Coarse (4127)		AS 209												
Aggregates-Fine (4127)		AS 209												
Hydrated Lime (4127)		AS 491.04												
Asphalt Binder		AS 437												
Emulsions & Cutbacks		AS 437												
Release Agent		AS 491.15												
Recycled Asphalt Shingles		AS 506												
PLANT INSPECTION														
Aggregates (2303)	Quality							V	DME	1/20,000 Ton	50 lb.	CTRL		
Combined Aggregate (4127)	Gradation		RCE/ CONTR	1/lot	IM 301	CONTR		V IA	RCE/ CONTR	Sample 1/day, Test 1st day + 20% Systems Approach*	IM 301	DME/ RCE	IM 216 IM 216	
	Moisture		CONTR	1 / half day	1000 gm	CONTR								Dryer Drum Plants Only

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

*A project approach may be applied at the discretion of the DME at the frequency 1/project.

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

HOT MIX ASPHALT
Section 2303 & 2213

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE, & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
PLANT INSPECTION														
Mineral Filler								V	DME	1/project	11 lb	DME	821278	
Asphalt Binder	DSR Quality	AS Cert						V V IA	RCE/ CONTR DME	Sample 1/day Test 1st 1/week 1/20,000 T of Mix Systems Approach	4 oz tin 1 qt	DME CTRL		Log all shipments
Cutback		AS Cert												Log all shipments
Emulsion	Residue	AS 360						V	RCE	1/project	1 qt	DME		Plastic bottle required
GRADE INSPECTION														
Uncompacted Mixture:	Lab Density & Lab Voids	321, 350 325G	RCE/ CONTR	As per 2303	40 lb	CONTR		V IA	RCE/ CONTR	As per 2303 Test 1/day Systems Approach	40 lb	DME		
	Moisture Sensitivity	AS 319 Article 2303.02, E,2						V	RCE/ CONTR	Test 1st Sample at 500 tons then sample 1/10,000 tons per 2303 until 1st sample accepted (test as needed)	70 lb	CTRL		
Compacted Mixture	Mat Density, Thickness & Voids	320, 321 337						V IA	RCE/ CONTR DME	Lot 1 lot/project*	Min 8/lot	RCE DME		
	Joint Density	Article 2303.03, D, 4, b						V	RCE/ CONTR	Each Joint = 1 Lot	4/lot	RCE		6-inch core per IM 511
	Smoothness	341	CONTR	100%	100%	CONTR		V	DME	10%		DME		

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S&T-Sampling & Testing
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* A system approach may be applied at the discretion of the DME.
NOTE: A Verification sample for asphalt binder quality and aggregate quality not required under 2000 tons of mix.
NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.

Sampling & Testing Guide-Minimum Frequency

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

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

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

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S&T-Sampling & Testing

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V-Verification

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

Sampling & Testing Guide-Minimum Frequency

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

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

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

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S&T-Sampling & Testing

Cert – Certification Statement

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V-Verification

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

Sampling & Testing Guide-Minimum Frequency

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

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

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

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Sampling & Testing Guide-Minimum Frequency

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

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

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

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

Cert – Certification Statement

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CONTR-Contractor

IA-Independent Assurance
V-Verification

(1) These verification samples for concrete materials not required when mix quantity is less than 50 cu. yd.

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

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

Sampling & Testing Guide-Minimum Frequency

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

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

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

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

Cert – Certification Statement

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V-Verification

(1) These verification samples for concrete materials not required when mix quantity is less than 50 cu. yd.
NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 1000 cy of concrete) at the discretion of the DME according to IM 207.
NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.
NOTE: Cylinders for strength on primary project bridge decks only and where specifically called for in the plans or specifications.

*Available from the Office of Construction.

October 21, 2014
Supersedes April 15, 2014

Sampling & Testing Guide-Minimum Frequency

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

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

Matls. IM 204
Appendix H (US) Units

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

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

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V-Verification

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

Sampling & Testing Guide-Minimum Frequency

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

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

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

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

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V-Verification

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

Sampling & Testing Guide-Minimum Frequency

CONCRETE DRILLED SHAFT FOUNDATIONS
Section 2433

April 15, 2014
Supersedes October 18, 2011

Matls. IM 204
Appendix I

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs		QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
				SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION															
Aggregate-Fine (4110)		AS	209												
Aggregate-Coarse (4115)		AS	209												
Portland Cement (4101)	Quality	AS	401												
Fly Ash (4108)	Quality	AS	491.17												
Mixing Water (4102)	Quality									DME	1/project	1 quart	CTRL	731	Not required for potable water from Municipal Supply
Air Entraining Admixture	Quality	AS	403												
Retarding Admixture	Quality	AS	403												
Reinforcing Steel Bars (4151)	Quality	AS	451												
Permanent Casing	Quality		Cert												According to plans or other instructions
Drilling Slurry		Visual	2433												

AS-Approved Source
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S&T-Sampling & Testing

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RCE-Resident Construction Engineer/Project Engineer
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CONTR-Contractor

IA-Independent Assurance
V-Verification

Quality samples not required when mix quantity is less than 50 cu. yd.

CONCRETE DRILLED SHAFT FOUNDATIONS
Section 2433

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
PLANT INSPECTION														
Aggregate- Fine (4110)	Gradation	302, 306 336	CONTR	IM 528	IM 301	CONTR		V IA	RCE/ CONTR DME	Sample 1/wk Test 1st day +20% 1/project	IM 301 IM 301	DME RCE		System Approach Applicable
	Moisture	308, 528	CONTR	IM 528	1000 gm	CONTR								See IM 528 if Moisture Probe is used
	Sp. Gr.	307	CONTR	IM 528	1000 gm	CONTR								
	Quality	AS 209												
Aggregate- Coarse (4115)	Gradation	302, 306 336	CONTR	IM 528	IM 301	CONTR		V IA	RCE/ CONTR DME	Sample 1/wk Test 1st day +20% 1/project	IM 301 IM 301	DME RCE		System Approach Applicable
	Moisture	308, 528	CONTR	IM 528	2000gm	CONTR								
	Sp. Gr.	307	CONTR	IM 528	2000gm	CONTR								
	Quality	AS 209						V	DME	1/1000 cy	50 lb	CTRL		
Portland Cement	w/c ratio	528	CONTR	1/pour		CONTR								
	Quality	AS Cert						V	DME	1/1000 cy	15 lb	CTRL		
Fly Ash	Quality	AS Cert		Each Load			800240							
Air-Entraining Admixture (4103)		AS 403						V	DME	1/batch	1 pint	CTRL		Sample lots not previously reported or as required by DME
Retarding Admixture		AS 403						V	DME	1/batch	1 pint	CTRL		Sample lots not previously reported or as required by DME

AS-Approved Source
ASD-Approved Shop Drawing
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V-Verification

Quality samples not required when mix quantity is less than 50 cu. yd.

CONCRETE DRILLED SHAFT FOUNDATIONS
Section 2433

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
GRADE INSPECTION														
Plastic Concrete	Air Content	316, 327						V IA	RCE	1/30 cy		RCE DME		DME may adjust
	Slump	317, 327						V IA	RCE	1/30 cy		RCE DME		DME may adjust
	Cylinders								DME	3/project		DME		Primary Projects Only (Information only)
Reinforcing Steel (4151)	Quality	AS Cert		Each Shipment			Field Book							
Metal Access Pipe		Visual												
Drilling Slurry	Density, Viscosity, pH, Sand Content	387	CONTR	1/ 2 hours		CONTR								1/ 4 hours if consistent
Crosshole Sonic Log Test		2433	CONTR	1/shaft		CONTR	Report, Analysis, Inter-pretation							

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S&T-Sampling & Testing

Cert- Certification Statement

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CONTR-Contractor

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V-Verification

Quality samples not required when mix quantity is less than 50 cu. yd.

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

COLD-IN-PLACE RECYCLED ASPHALT PAVEMENT

Section 2318, DS-01076

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Asphalt Stabilizing Agent	Quality	AS 437												
GRADE INSPECTION														
RAP (2318.02)	Max Size							V	RCE	1st day + 1/week	10 lb	RCE		
Stabilizing Agent (Engr. Emulsion)	Quality Residue	Cert 360						V	RCE/CONTR RCE/CONTR	1/project 1/day (2)	1 qt 1 qt	CTRL DME		Must use plastic bottle for emulsion
Stabilizing Agent (Foamed Asphalt)	Quality DSR	Cert						V	RCE/CONTR RCE/CONTR	1/project 1/day (2)	1 qt 1 qt	CTRL DME		
Stabilizing Agent (Std. Emulsion)	Quality Residue	Cert 360						V	RCE	1/day(2)	1 qt	DME		Must use plastic bottle for emulsion
Uncompacted Mixture	Moisture Density	504 504						V	RCE	1/lot	40 lb	DME		Sealed Container
Compacted Mixture	Moisture(1) Density	504 504	CONTR CONTR	10/lot 10/lot		CONTR CONTR								Witnessed by RCE
Completed CIR Layer	Moisture	504	CONTR	2/lot (3)		CONTR								
Smoothness		DS-01076 only												

AS-Approved Source ASD-Approved Shop Drawing S&T-Sampling & Testing	Cert- Certification Statement	RCE-Resident Construction Engineer/Project Engineer DME-District Materials Engineer CTRL-Central Materials Office CONTR-Contractor	IA-Independent Assurance V-Verification

(1) See IM 504 for Day 1 moisture correction factor.
(2) The sample from the first day and 1/week shall be forwarded to the District Laboratory for testing. The other samples shall be retained for submission in the event of a failing test result.
(3) No more than 3 calendar days between consecutive tests. Adjustments may be approved by the Engineer for inclement weather or conditions.

GRANULAR SURFACING/DRIVEWAY SURFACING

Sections 2312 & 2315

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Class C Gravel (4120.03)	Gradation Quality	AS 209												
Class A Crushed Stone (4120.04)	Gradation Quality	AS 209												
Class B Crushed Stone (4120.05)	Gradation Quality	AS 209												
Class D Crushed Stone (4120.06)	Gradation Quality	AS 209												
Aggregate for Type B, AC or cold laid Bituminous Concrete (for driveways only)	Gradation Quality	AS 209												
Crushed Stone Base (For driveways only) (4122)	Gradation Quality	AS 209												
GRADE INSPECTION														
Dimensions	Thickness Width Cross Slope		RCE	3/mi.			Field Book							

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

Cert- Certification statement

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

IA-Independent Assurance
V-Verification

CONCRETE BRIDGE FLOOR REPAIR & OVERLAY & SURFACING

Section 2413

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

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CONCRETE BRIDGE FLOOR REPAIR & OVERLAY & SURFACING

Section 2413

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

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CONCRETE BRIDGE FLOOR REPAIR & OVERLAY & SURFACING

Section 2413

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

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S&T-Sampling & Testing

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

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

April 16, 2013
Supersedes April 15, 2008

SURFACE TREATMENT (Seal Coat, Microsurfacing, Slurry, Joint Repair, Crack Filling, Fog Seal)

Section 2307, 2319, 2540, 2544, 2306, 2308

Matls. IM 204
Appendix P (US) Units

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Aggregates (4125)	Quality Gradation	AS 209												
Emulsions/ Cutbacks	Quality	AS 437												
Emulsion & Aggregate	Compatibility	349							DME	1/ source	1 qt & 10lb	DME/ CTRL		Seal Coat
Emulsion & Aggregate	Mix Design													Slurry& Microsurfacing
GRADE INSPECTION														
Aggregate	Quality Gradation	301 Cert D						V	DME	1/proj.	50 lb	CTRL		Seal Coat
Emulsion	Quality Residue Compatibility	Cert D 323, 360 349						 V V	 RCE RCE	 1/20,000 gal 1st day+ 1/week	 1 qt 1 qt & 10 lb	 DME DME	(2)	(1) Seal Coat
Cutback	Quality Viscosity Anti-Strip	Cert D 323 AS 323, 374												

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

Cert A-Type A Certification
Cert C-Type C Certification
Cert D-Type D Certification

RCE-Resident Construction Engineer/Project Engineer
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Emulsion samples in plastic bottles only.
No samples required for joint repair, crack filling, and fog seal. Acceptance based on certification only.
(1) Sample emulsion for full width placement seal coat, slurry, and microsurfacing only .
(2) Log all shipments

BASE REPAIR (2212), PAVEMENT REPAIR (PATCHES)

Sections 2529 & 2530

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Aggregates Fine (4110)		AS 209												
Aggregates Coarse (4115)		AS 209												
Portland Cement (4101)	Quality	AS 401												
Fly Ash (4108)	Quality	AS 491.17												
GGBFS (Ground Granulated Blast Furnace Slag)	Quality	AS 491.14												
Curing Compound (4105)	Lab Tested	405												
Air Entraining Admixture (4103)	Quality	AS 403												
Granular Backfill	Gradation Quality	AS Cert AS Cert												
Drain Tubing	Quality	AS 443												
Epoxy Grout		AS 491.11												
Joint Seal (4136.02)	Lab Tested	436.01 AS 436.02												
Backer Rod (4136.02)		AS 436.04												
Steel Reinforcing	Quality	AS 451												

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

BASE REPAIR (2212), PAVEMENT REPAIR (PATCHES)

Sections 2529 & 2530

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
PLANT INSPECTION														
Aggregates-Coarse (4115)	Grad	302 306 336	CONTR	IM 528	IM 301	CONTR		V	RCE/ CONTR	IM 528	IM 301	RCE		
	Moist	308	CONTR	IM 528	1000 gm	CONTR								
	Sp. Gr.	307	CONTR	IM 528	1000 gm	CONTR								
	Quality	AS 209												
Aggregate- Fine (4110)	Gradation	302, 306 336	CONTR	IM 528	IM 301	CONTR	830211	V	RCE/ CONTR	IM 528	IM 301 IM 301	RCE		
	Moisture	308, 528	CONTR	IM 528	IM 301	CONTR	830211							See IM 528 if Moisture Probe is used
	Sp. Gr.	307	CONTR	IM 528	IM 301	CONTR	830211							
	Quality	AS 209												
Portland Cement (4101)	Quality	AS Cert		Each Load										
Fly Ash	Quality	AS Cert		Each Load										
Air Entraining Admixture		AS 403						V	DME	1/batch	1 pt	CTRL		Sample lots not previously reported or as directed by DME
Water Reducing Admixture		AS 403						V	DME	1/batch	1 pt	CTRL		
Retarding Admixture		AS 403						V	DME	1/batch	1 pt	CTRL		

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

Cert- Certification Statement

RCE-Resident Construction Engineer/Project Engineer
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V-Verification

BASE REPAIR (2212), PAVEMENT REPAIR (PATCHES)

Sections 2529 & 2530

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE, & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
GRADE INSPECTION														
Uncompacted HMA Mixture		Scale ticket with JMF number												Job Mix Formula (JMF) approved by DME
Plastic Concrete	Air Slump	318 327 317 327						V V	RCE RCE	1/30 cy 1/30 cy		RCE RCE		Minimum 1 per pour
Reinforcing Steel Epoxy-Coated Steel	Quality Quality	AS 451 AS 451		Each Shipment										
Calcium Chloride	Concentr.	373	RCE	1/lot		RCE								
Smoothness for Compacted HMA or Hardened Conc. (2529.03, I)		341	CONTR			CONTR								Approval by DME See Plans/Specs for exclusions

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

Cert- Certification Statement

RCE-Resident Construction Engineer/Project Engineer
DME-District Materials Engineer
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V-Verification

GRANULAR SHOULDERS

Section 2121

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Aggregate (4120.02)	Gradation Quality	AS 209												
Aggregate (Paved Shoulder Fillets) (4120.07)	Gradation Quality	AS 209												
GRADE INSPECTION														
Dimensions	Thickness Width Cross Section	Template	RCE	3/mile 3/mile 3/mile		RCE	Field Book							
Aggregate (Paved Shoulder Fillets)	Gradation	Certification												

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

SUBDRAINS

Section 2502

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Drain Tubing (4143)	Quality	AS 443												
Rodent Guard (4143.01)		AS 443.01												
Subdrain Outlet (4143)		AS												
Porous Backfill (4131)	Quality Gradation	AS 209												
Granular Backfill (4133)	Quality Gradation	AS 209												
Class A (Outlets) (4120.04)	Quality Gradation	AS 209												
GRADE INSPECTION														
Drain Tubing (4143)	Quality	AS												
Engineering Fabric (4196)		AS 496.01												
Subdrain Outlet	Quality	AS Cert												
Porous Backfill (4131)	Gradation	AS Cert		Each Shipment										
Granular Backfill (4133)	Gradation	AS Cert		Each Shipment										
Class A (Outlets) (4120.04)	Gradation	AS Cert		Each Shipment										
Metal Posts (4154.09)		Visual	RCE											

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

Cert- Certification Statement

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

IA-Independent Assurance
V-Verification

WATER POLLUTION CONTROL
EROSION CONTROL
Section 2525, 2601

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
GRADE INSPECTION														
Seeds 4169		Seed Ticket (rural stabilizing) AS, mix report and cert (seed mixes except rural stabilizing) 469.02												
Fertilizer 4169		AS 469.03												
Inoculants 4169		Seed Manufacturer Recommendation												
Sticking Agent		Manufacturer Recommendation												
Sod 4169		Visual				RCE	Field Book							
Compost 4169		AS IM 469.10												
Straw Mulch 4169		Cert												
Hydraulic Mulch 4169		AS IM 469.10												
Stakes for Sod 4169		Visual				RCE	Field Book							
Wire Staples 4169		Visual				RCE	Field Book							
Wood Excelsior Mat 4169		AS IM 469.10												
Engineering Fabrics		AS IM 496.01					Field Book							
Silt Fence Wire and Posts (Std. Rd. Plan EC-201)		Visual				RCE	Field Book							

AS-Approved Source
ASD-Approved Shop Drawing
S&T-Sampling & Testing
Cert- Certification Statement
RCE-Resident Construction Engineer/Project Engineer
DME-District Materials Engineer
CTRL-Central Materials Office
CONTR-Contractor
IA-Independent Assurance
V-Verification

ACCEPTANCE OF SMALL QUANTITIES OF MATERIALS

Material		Maximum Quantity	Specifications	Alternate Acceptance Method
Aggregate, non-proportioned, non-critical		200 tons	IM 209	Approved Source and Visual
Asphalt, HMA	Mix	mixture bid item of 1000 tons	2303	Approved JMF, Contractor QC, and Contractor Certification
	Binder	mixture bid item of 1000 tons	4137	Approved Source and Supplier Certification
	Aggregate	mixture bid item of 1000 tons	4127	Approved Source, Producer Certification for gradation and quality, and Contractor QC.
Concrete, PCC Paving	Aggregate	Less than 2000 Square Yards of Concrete	4110, 4111, 4115	Approved Source, Producer Certification for gradation and quality, Agency gradation verification, and Contractor QC.
		Less than 10 Cubic Yards of Concrete or Non- structural items Defined in IM 528	4110, 4111, 4115	Approved Source, Producer Certification for gradation and quality, and Contractor QC.
	Portland Cement	Less than 2000 Square Yards of Concrete	4101	Approved Source and Producer Certification
	Fly Ash	Less than 2000 Square Yards of Concrete	4108	Approved Source and Producer Certification
	GGBFS	Less than 2000 Square Yards of Concrete	4108	Approved Source and Producer Certification
	Admixtures	Less than 2000 Square Yards of Concrete Yards		Approved Source

ACCEPTANCE OF SMALL QUANTITIES OF MATERIALS

Concrete, PCC Structural	Aggregate	Less than 50 Cubic Yards of Concrete		Approved Source, Producer Certification for gradation and quality, Agency gradation verification, and Contractor QC.
		Less than 10 Cubic Yards of Concrete or Non- structural items Defined in IM 528		Approved Source, Producer Certification for gradation and quality, and Contractor QC.
	Portland Cement	Less than 50 Cubic Yards of Concrete		Approved Source and Producer Certification
	Admixtures	Less than 50 Cubic Yards of Concrete		Approved Source
Dowel Baskets, Epoxy-coated		25		Visual & Field Check
Hardware for Timber		100 lbs.	4153.07	Visual
Joint Filler, Preformed		50 ft.	4136.03	Visual & Dimension
Lighting Material-Conduit & Fittings		100 ft	4185.10	Visual & Brand Name
Paint, Bridge		5 gal.	4182	Visual & Brand Name
Pipe, Welded Steel for Bridge Railing		100 ft.	4153.05	Letter of Compliance
Signing, Delineator posts		10	4186.10,C	Visual
Steel Reinforcement, Epoxy Coated **(other than bridge decks)**		Less than 5 tons	4151.03,B	Approved Source, Producer Certification
Steel Reinforcement, Uncoated		Less than 45 tons	4151	Approved Source, Producer Certification
Steel Reinforcement, Stainless		Less than 1 ton	4151	Approved Source, Producer Certification

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Admixture-Air Entraining	403	C. Ouyang	4103	1 pt.	DME or RCE	Approved Source Batch (Lot)	Project	Contact District Matls.
Admixture-Corrosion Inhibitor	402		4103	1 pt.	DME or RCE	Approved Source Batch (Lot)	Project	Contact District Matls.
Admixture-Retarder	403		4103	1 pt.	DME or RCE	Approved Source Batch (Lot)	Project	Contact District Matls.
Admixture-Water Reducer	403		4103	1 pt.	DME or RCE	Approved Source Batch (Lot)	Project	Contact District Matls.
Aggregates-Non-proportioned	209	B. Gossman	4110-4133	IM 301	DME/PROD.	Approved Source/Certified Truck Tickets, (Form #821278)	Source	Certified Ticket for pay items by weight
Aggregates-Proportioned	209 & 204		4110-4133	IM 301	CONTR/RCE/ DME	Approved Source/Certified Truck Tickets, (Form #821278)	Source Project	
Aluminum, Structural		Vacant	4190.01			Approved Shop Drawing & Fabrication Report		
Anchor Bolts	453.08	Vacant	2522.03, E,4 4185.02, A 4187.01, C	1 bolt, nut & washer per size, per project	DME	Approved Source/Test Report/Steel Mill Certifications		
Anchors, Concrete	453.09	C. Ouyang				Approved Source		
Anti-Strip Agent	491.16	S. Schram				Approved Source		
Arrow Panels, Solar-Assisted	486.12	J. Putherikcal	2528.03, G			Approved Source		
Asphalt Binder	437	S.Schram	4137	1 4-oz. tin	CONTR/DME	Approved Source/Certification Statement /Test Rpt.	Source Project	
Asphalt, Cutback	437		4138	1 qt. tin	RCE	Approved Source/Certification Statement /Test Rpt.	Source	
Asphalt, Emulsified	437	S.Schram	4140	1 qt. bottle	RCE	Approved Source/ Certification Statement /Test Rpt.	Source	Project verification for seal coat
Attenuators -see crash cushion								
Attenuators, Guardrail		Vacant				As per plan		
Backer Rod for Cold Pour Joint Seal	436.04	J. Puthericka	4136.02, B			Approved Source		

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Backer Rod for Hot Pour Joint Seal	436.04		4136.02, B			Approved Source		
Barrier Rail, Precast Concrete	571	M. Khoda	2513			Approved Source/DOT Stamp/Fabrication Report	Source	
Beads, Glass	484	J. Putherickal	4184	1 qt.	DME	Approved Source	Subcontr.	
Bearing, Bronze		Vacant	4190.03	1/project	DME	Test Report		
Bearing, Lead		Vacant	4195.01			Certification Statement		
Bearing, Neoprene	495.03	Vacant	4195.02	1/pad	DME	Fabrication Report/Approved Source	Fabricator	
Bentonite Clay						Visual Approval by RCE		
Bolts, Nuts & Washers, Structural	453.06B	Vacant	4153.06	Per IM 453.06B	DME	Mill Certification/Rotational Capacity Test/Test Report		
Calcium Chloride Solution	373		4194.01	4 lbs. or 1 qt.	RCE	Test by RCE		
Caulking Compound			4192			Visual Approval by RCE		
Concrete, Special Sections	445.01	M. Khoda	4145 4149.02, B			Approved Source, Fabricator's trade mark, Date of Manufacture, Certified stamp, Certification Statement	Source	
Concrete, Modular & Segmental Block	445.04	M. Khoda				Approved Source/Certification Statement		
Concrete, Precast Box Culvert	445.02		2415			Approved source, Approved Shop Drawing, Fabricator's trade mark, Date of Manufacture, Certified stamp, Certification Statement	Source	
Concrete, Prestressed, Precast Units	570		2407			Approved Source, Fabricator's trade mark, Date of Manufacture, DOT Inspection stamp, Fabrication Report	Source	
Concrete Sealer	491.12	C. Ouyang	4139			Approved Source		
Conduit – See Lighting Matl.								
Curing Matls., Burlap			4104			Visual Approval by RCE		

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Curing Matls., Clear	405.07	J. Putherickal	4105.07			Approved Source		
Curing Matls., Dark-colored	437	S.Schram	4105.06			Approved Source	Source	
Curing Matls., Plastic Film			4106.01			Visual Approval by RCE		
Curing Matls., White Pigmented	405	J. Putherickal	4105.05	1 qt.		Batch (Lot) Accept	Source	
Crash Cushion	455	J. Putherickal	2551			Approved Source, Certification Statement if source not clearly marked		
Delineators–See Signing Matls.								
Detectable Warning Panels	411	Vacant	2511.02, D			Approved Source		
Dowel-See Steel Reinforcement								
Drainage Trough, Elastomeric Bridge Joints	494	J. Putherickal				Approved Source		
Drains, Floor		Vacant	2406.03, D			Approved Shop Drawing & Fabrication Report		
Drums, Channelizing	488.02	J. Putherickal	4188.02			Approved Source		
Epoxy-coated Steel-See Steel Reinforcement								
Epoxy Injection Resin	491.19	C. Ouyang				Approved Source		
Erosion Control, Fertilizer	469.03	J. Putherickal	4169.03			Approved Source http://idalsdata.org/IowaData/fertilizer.cfm		If material is suspect, DME will sample
Erosion Control, Inoculant			4169.04			Seed Manufacturing Recommendation		
Erosion Control, Mulch			4169.07			Visual Approval by RCE		
Erosion Control, Mulch, Hydraulic	469.10	J. Putherickal	4169.07			Approved Source		
Erosion Control, Mulch, Weed Free			4169.07			Weed Free Certification Statement		

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Erosion Control, Perimeter & Slope Sediment Control Devices	469.10	J. Putherickal	4169.07			Approved Source		
Erosion Control, Seed	469.02		4169.02			Seed Ticket Printed with Test Data (rural stabilizing) Approved Source, seed mixture report and certification (seed mixes except rural stabilizing)		
Erosion Control, Silt Fence Fabric	496.01		4196.01			Approved Source		
Erosion Control, Silt Fence Wire & Posts						Visual Approval by RCE		
Erosion Control, Sod			4169.06			Visual Approval by RCE		
Erosion Control, Sod Stakes			4169.09			Visual Approval by RCE		
Erosion Control, Sticking Agent			4169.05			Seed Manufacturing Recommendation		
Erosion Control, Wire Staples			4169.10, A			Visual Approval by RCE		
Erosion Control, Wood Excelsior Mat	469.10	J. Putherickal				Approved Source		
Expansion Device, Steel		Vacant	4152.02			Approved Shop Drawing & Fabrication Report		
Expansion Tube			4191.01, B			Visual Approval by RCE		
Fabric Engineering	496.01	J. Putherickal	4196.01			Approved Source		
Fasteners, Aluminum Structural	486	Vacant	4190.02			Fabrication Report		
Fence, Barbed Wire			4154.04			Visual Approval by RCE		
Fence, Brace for Field Fence			4154.08			Visual Approval by RCE		

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Fence, Tie & Tension Wire			4154.05			Visual Approval by RCE		
Fence, Chain Link Fabric	454.10	Vacant	4154.03	1/source/yr		Approved Source/ Certification Statement	Project	
Fence, Chain Link Fittings			4154.11			Visual Approval by RCE		
Fence, Chain Link Posts, Braces, & Rails	454.10		4154.10	1/source/yr		Approved Source/ Certification Statement	Project	
Fence, Field Fence Fabric			4154.02			Visual Approval by RCE		
Fence, Gate			4154.12			Visual Approval by RCE		
Fence, Orange Mesh Safety	488.03	J. Putherickal	4188.03			Approved Source		
Fence, Silt-See Erosion Control								
Fence, Staples			4154.06			Visual Approval by RCE		
Fence, Steel Line Posts			4154.09			Visual Approval by RCE		
Fence, Wood Fence Post	462	C. Ouyang	4154.07			Approved Source/Certification of Grade/Certified Treatment Test Report		
Fertilizer-See Erosion Control								
Fly Ash	491.17	C. Ouyang	4108	15 lbs.	DME	Approved Source/ Certification Statement	Project Source	Verification on paving only
Galvanized Items		Vacant	4100.07		DME	Test Report by District Materials		
GGBFS	491.14	C. Ouyang	4108.02			Approved Source/ Certification Statement	Source Project	
Grating (Aluminum)		Vacant	4187.01, A			Approved Shop Drawing & Fabrication Report		
Grout, Hydraulic Cement	491.13	C. Ouyang				Approved Source		
Grout, Polymer	491.11	C. Ouyang				Approved Source		
Guardrail, Cable		Vacant	4155.03	6 ft.	DME	Test Report by Central Lab		

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Guardrail, High Tension Cable	455.01	Vacant	2505.03, B			Approved Source/ Certification Statement		
Guardrail, Formed Steel Beam	455.02		4155.02			Approved Source		
Guardrail, Steel Posts		Vacant	4155.05			Mill Test Report		
Guardrail, Wood Posts	462	C. Ouyang	4155.04			Approved Source/Certification of Grade/Certified Treatment Test Report		
Iron Castings, Utility Access Covers, etc.	453.04	Vacant	4153.04			Certification Statement & Proper Identification Imprint		
Iron Castings, Utility Access Adjustment Rings	449.05					Approved Source/Certification Statement		
Iron Bridge Rockers		Vacant	4153.04			Approved Shop Drawing & Fabrication Report		
Joint Filler, Flexible Foam-Type CF & EF Joints	436.05	J. Puthericka l	4136.03, B 4136.03, D			Approved Source		
Joint Filler, Type E Joint	436.03		4136.03, A			Approved Source		
Joint Filler, Bituminous	436.03		4136.03, A			Approved Source		
Joint Sealer for Concrete Sewer Pipes	491.09		4149.04,D,2			Approved Source		
Joint Sealer, Elastomeric (Neoprene)	436.02		4136.03			Approved Source		
Joint Sealer, Poured	436.01		4136.02, A			Approved Source		
Keyway			4191.01, A			Visual Approval by RCE		
Lighting Material, Aluminum Poles	557	Vacant	4185.02, F			Approved Shop Drawing/Approved Source/Certification Statement		
Lighting Material, Circuit Test			2523.03, U		Contractor	Test Report (Contractor) Form #820928		
Lighting Material, Connectors			4185.11			Approved Catalog Cut		
Lighting Material, Contactors			4185.05			Approved Catalog Cut		

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Lighting Material, Control Cabinet			4185.07			Approved Shop Drawing & Catalog Cut		
Lighting Material, Conduit & Fittings, Plastic			4185.10, D	4'-Plastic	DME	Test Report		
Lighting Material, Conduit & Fittings, Steel	485.10	J. Puthenickal	4185.10, B			Approved Source		
Lighting Material, Ground Rods & Clamps			4185.04			Visual		
Lighting Material, Handholes	445.01	M. Khoda	4185.08			Approved Source, Fabricator's trade mark, Date of Manufacture, Certified stamp, Certification Statement	Source	
Lighting Material, Junction Boxes			4185.09			Approved Catalog Cut		
Lighting Material, Lighting Tower	557	Vacant	2522.03, E			Approved Shop Drawing/Approved Source/Certification Statement		
Lighting Material, Lowering Device			2522.03, G			Approved Shop Drawing & Fabrication Report		
Lighting Material, Luminaries			4185.03			Approved Catalog Cut		
Lighting Material, Photoelectric Control			4185.06			Approved Catalog Cut		
Lighting Material, Sealant for Traffic Loop Detectors	491.18	J. Puthenickal				Approved Source		
Lighting Material, Steel Poles	557	Vacant	4185.02, E			Approved Shop Drawing/Approved Source/Certification Statement		
Lighting Material, Underground Warning Tape			2523.03, E			Visual Approval by RCE		
Lighting Material, Wire & Cable			4185.12			Approved Catalog Cut & Certification Statement		DME may obtain verification samples
Lighting Material, Wood Poles	462	C. Ouyang	4185.02, G			Approved Source/Certification Statement		

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Lighting Material, Fasteners for Poles	453.09	C. Ouyang	4185.02, B	1 each type	DME	Test Report & Approved Shop Drawing		
Lighting Material, Mastarms	557	Vacant	4185.02, C			Approved Shop Drawing/Approved Source/Certification Statement		
Lighting Material, Slip Base	557		4185.02, B			Approved Shop Drawing/Approved Source/Certification Statement		
Lighting Material, Transformer Base	557		4185.02, D			Approved Shop Drawing/Approved Source/Certification Statement		
Markers (reflective) for Guardrail & Concrete Barrier Rail	486.08	J. Putherickal	4186.12			Approved Source		
Markers, Raised Pavement	483.07		2527.02, D,5			Approved Source		
Mastarms-See Lighting Materials								
Paint, Epoxy Aluminum	482.04					Approved Source		
Paint, Traffic-VOC-Compliant Solvent-borne	483.03		4183.02			Approved Source		
Paint, Traffic Waterborne	483.03		4183.03			Approved Source	Subcontr.	
Paint, Waterborne Acrylic Finish (Bridge Paint)	482.05	J. Putherickal	4182.03			Approved Source/Certification Statement		
Paint, Zinc-rich Epoxy	482.02		4182.02			Approved Source/Certification Statement		
Paint, Zinc-silicate Solvent-borne	482.05		4182.02			Approved Source/Certification Statement		
Patch Material, Rapid-set Concrete	491.20	C. Ouyang				Approved Source		
Pedestrian Bridge, Pre-engineered	557	Vacant				Approved Source/Approved Shop Drawing		
Piling, Concrete	570	M. Khoda	4166			Approved Source, Fabricator's trade mark, Date of Manufacture, DOT Inspection stamp, Fabrication Report	Source	

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Pilling, Timber	462	C. Ouyang	4165			Approved Source/Certification of Grade/Certified Treatment Test Report		Charge number on butt ends
Piling, Steel	467	Vacant	4167			Approved Source/Mill Certification	Project	
Pipe, PVC Sewer	443, 446	J. Putherickal	4149.02			Approved Source/Certification Statement	Source	
Pipe, Concrete	445	M. Khoda	4145			Approved Fabricator, Fabricator's trade mark, Date of Manufacture, Certified stamp, Certification Statement	Source	
Pipe, Corrugated Aluminized	441	Vacant	4141			Approved Source/Certification Statement		
Pipe, Corrugated Polyethylene 3-10 in.	443	J. Putherickal	4146.02 4143.01			Approved Source	Source	
Pipe, Corrugated Polyethylene 12-36 in.	446	J. Putherickal	4146.02			Approved Source/Certification Statement	Source	
Pipe, Corrugated Steel	441	Vacant	4141			Approved Source/Certification Statement	Fabricator	
Pipe, Ductile Iron Sewer			4149.02			Certification Statement		
Pipe, Polyethylene Sewer	443, 446	J. Putherickal	4146.03			Approved Source/Certification Statement	Source	
Pipe, Rodent Guard for PE Pipe	443.01	Vacant	4143.01, B			Approved Source		
Pipe, Rodent Guard for CMP Pipe	443.01	Vacant	4143.01, B			Approved Source		
Pipe, Concrete Subdrain Tile	448	J. Putherickal	4148			Approved Source/Certification Statement	Source	
Pipe, Corrugated Metal Subdrain Outlet	441	Vacant	4143.01, B			Approved Source/Certification Statement	Fabricator	
Pipe, Corrugated Polyethylene Subdrain	443	J. Putherickal	4143.01, B			Approved Source	Source	
Pipe, Welded Steel for Bridge Rail (See Railing, Bridge)		Vacant						
Pipe, Horizontal Subdrain	443	J. Putherickal	4143.01, A			Approved Source	Source	

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Plant Material, Fertilizer	469.03	J. Puthérickal	4170.09, B			Approved Source		
Plant Material, Mulch	470	J. Puthérickal	4170.09, D		RCE	Field Review Report		
Plant Materials, Plants	470	C. Ouyang	4170.01-4170.08		Roadside Development	Field Review Report		Rpt. Issued-Roadside Development
Portland Cement Concrete Premix Pack	447					Approved Source/Certification Statement	Source	
Portland Cement, All Types	401	C. Ouyang	4101	10 lbs.	DME	Approved Source/Certification Statement	Project Source	
Railing, Bridge			4153.05			Approved Source/Approved Shop Drawing/Fabrication Report		
Reflective Sheeting-See Signing Material								
Release Agent			491.15	C. Ouyang				Approved Source
Sealant, Traffic Loop-See Lighting Material								
Seed-See Erosion Control								
Signing Material, Delineator Posts					4186.10, C	1 each supplier	DME	Test Report
Signing Material, Delineators	486.07	J. Puthérickal	4186.11			Approved Source	Project	
Signing Material, Finished Sign	486	J. Puthérickal	4186			Shipping Report/Approved Source/Certification Statement	Source	
Signing Material, Fasteners			4186.09			Fabrication Report		
Signing Material, Reflective	486.03	J. Puthérickal	4186.03			Approved Source	Source	
Signing Material, Sign Panels			4186.02			Approved Shop Drawing & Shipping Report		
Signing Material, Sign Support Structures	557	Vacant	4187			Approved Source/Approved Shop Drawing/Fabrication Report		
Signing Material, Stainless Steel Fasteners	453.07	Vacant		1 per size per proj.	DME	Approved Source/Mill Certification	Project	

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Signing Material, Steel Posts			4186.10			Approved Shop Drawing & Shipping Report		
Signing Material, Wood Posts	462	C. Ouyang	4186.10			Approved Source/Certification of Grade/Certified Treatment Test Report		
Signing Material, Galvanized Items			4100.07			Test Report by District Materials		
Sod-See Erosion Control								
Steel Castings			4153.03			Approved Source/Catalog Cut		
Steel Masonry Plates			4152.02			Mill Certification		
Steel Pipe, Welded			4153.05			Approved Shop Drawing & Fabrication Report		
Steel, Pins/Rollers, Cold Finished			4153.02			Approved Source/Catalog Cut		
Steel, Pins/Rollers, Forged			4153.01			Approved Source/Catalog Cut		
Steel Reinforcement, Basket Assemblies	451.03B	Vacant	4151.02			Approved Source/Certification Statement		
Steel Reinforcement, Epoxy-coated	451.03B	Vacant Vacant	4151.03, C	6 ft.	DME	Approved Source/Mill Certifications & Epoxy Certification Statement /Test Report	Project	Test sample should be 3 ft. away from end of the bar.
Steel Reinforcement, Epoxy-coated Tie Bars	451.03B		4151.02, A	1 per project per year		Approved Source/Certification Statement	Project	
Steel Reinforcement, Epoxy-coated Dowels	451.03B		4151.02, B	1 per project per year		Approved Source/Certification Statement	Project	
Steel Reinforcement, Galvanized	451		4151.03, B	3 ft.	DME	Mill Certifications & Test Report for Galvanizing	Project	

Sampling & Testing Guide-Minimum Frequency

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Steel Reinforcement, Stainless	452	Vacant	4151	6 ft.	DME	Approved Source/Certification Statement	Project	Sample when project quantity >=1ton.
Steel Reinforcement, Uncoated	451	Vacant	4151	*6 ft. of most common	DME	Approved Source/Mill Certification	Project	Sample when project quantity >=45ton.
Steel Reinforcement, Wire Mesh	451		4151.04	2 ft. x 2 ft.	DME	Approved Supplier or Distributor. Steel Reinforcement/ Mill Certification	Supplier	1 sample per source per year
Steel Mechanical Splicers for Reinforcement	451	Vacant				Approved Source/Mill Certification/Epoxy Certification	Project	Need: Certification Statement, Project #, Quantity, Heat #
Steel Structural	557, 561 to 565		2408 4152			Approved Source/Approved Shop Drawing/Fabrication Report/Mill Certifications		
Step Irons for Utility Access			4149.04, L			Fabrication Report		
Structural Items, Other						Approved Shop Drawing & Fabrication Report		
Structural Plate (Arches)	444	Vacant	4144	Visual	RCE	Approved Source/Certification Statement		
Studs, Shear	453.10	Vacant				Approved Source/ Mill Certification		
Tape, Pavement Marking	483.06	J. Putherickal	2527.02, D			Approved Source		
Torque Calibration Machine (skidmore)		Vacant	2408.03, S	Calibrate every 12 mo.	CTRL	Test Report		
Torque Wrench		Vacant	2408.03, S	Calibrate every 12 mo.	CTRL	Test Report		
Traffic Signalization, Electrical Tests			2525.03, E 2525.03, H		Contractor	Test Report (Contractor) Form #820928		
Water			4102	1 qt. per source	DME	Test Report or City Water Supply		
Wire & Cable-See Lighting Material								

SUPPLEMENTAL GUIDE – BASIS OF ACCEPTANCE

Material	IM	Contact	Spec.	Sample Size	Sampled By	Basis of Acceptance	Verification	Other Details
Watermain, Appurtenances				4150.05			Catalog Cut/ Mill Certification	
Watermain, Ductile Iron Pipe			4150.02			Mill Certification		
Watermain, Ductile Iron Pipe Fittings			4150.02			Catalog Cut/ Mill Certification		
Watermain, Fire Hydrant Assembly			4150.04			Catalog Cut/ Mill Certification		
Watermain, PVC Pipe	446	J. Putherickal	4150.02			Approved Source/Catalog Cut/ Certification Statement		
Watermain, PVC Pipe Fittings	446	J. Putherickal	4150.02			Approved Source/Catalog Cut/ Certification Statement		
Watermain, Valves			4150.03			Catalog Cut/ Mill Certification		
Wood, Hardware for Timber Structure	462	J. Putherickal	4153.07	1 ea. type		Test Report		
Wood, Treated Posts	462	J. Putherickal	4164			Approved Source/Certification of Grade/Certified Treatment Test Report		
Wood, Treated Timber & Lumber	462		4162			Approved Source/Certification of Grade/Certified Treatment Test Report		
Wood, Untreated Timber & Lumber	462	C. Ouyang	4162	Visual	RCE	Quality grad mark or certification of grade on items requiring grade		

IM 208
LAB QUALIFICATION

MATERIALS LABORATORY QUALIFICATION PROGRAM

GENERAL

The FHWA has outlined a Laboratory Qualification Program in the Federal-Aid Policy Guide update published as 23 CFR 637 on June 29, 1995. The updated guide has requirements for laboratories performing testing on Federal-Aid highway projects.

In order to avoid an appearance of a conflict of interest, any qualified non-DOT laboratory shall perform only one of the following types of testing on the same project: Verification testing, quality control testing, IA testing, or dispute resolution testing.

LABORATORIES TO BE QUALIFIED

The following laboratories are included in the qualification program for all Federal-Aid projects:

Central Materials Laboratory
6 District Laboratories
District Area Laboratories
Resident Construction Laboratories*
Aggregate Producer Laboratories
Soils Field Laboratories*
Ready Mix Laboratories
PCC Contractor Laboratories
HMA Contractor Laboratories
Consultant and Commercial Laboratories *
City and County Laboratories *

* May be qualified at the time of a project.

LABORATORY QUALIFICATION PROCESS

A two-level qualification system is required by the FHWA. Laboratories are either accredited or qualified. The accreditation process is more rigorous than the qualification process.

Accredited Laboratory Process

The Central Materials Laboratory and the six District Laboratories will be accredited as outlined in the 23 CFR 637 guide. The Central Materials Laboratory is accredited through the AASHTO Materials Reference Laboratory Program. The District Materials Laboratories will be accredited by using the Central Materials Staff and equipment to check testing and testing procedures and by using the same calibration and training documentation process. Laboratories will be accredited for a two-year period. In addition, an annual review will be made by the Central Office Staff. Appendix A contains the procedures for accrediting the District Materials Laboratories.

Qualified Laboratory Process

The remaining laboratories will be qualified as outlined below:

The District Materials Offices will qualify laboratories. Laboratories will be qualified for a two-year period. In addition, an annual review will be made by District Staff. Appendix B contains the procedures for qualifying materials laboratories.

Four laboratory types will be qualified, aggregate laboratories, PC Concrete laboratories, soils field laboratories, and Hot Mix Asphalt laboratories.

Qualified laboratories will have the following:

1. Current manuals and test methods to perform the qualified testing available

2. A technician certified by the Iowa DOT to perform the qualified testing

3. Proper equipment to perform the qualified testing (calibrated or checked annually according to Appendix B)

4. Satisfactory project and proficiency test results

5. Documentation of equipment calibrations, equipment checks, and proficiency results

The District may elect to accept qualifications, accreditations, or inspections from other government agencies or Laboratory inspection agencies. The AASHTO Materials Reference Laboratory (AMRL) and Cement and Concrete Reference Laboratory are 2 common Laboratory inspection programs. The links are:

http://www.amrl.net/amrlsitefinity/default/aap/r18labs.aspx

http://www.ccrl.us/Lip/LabListReport.pdf

ADMINISTRATION OF THE PROCESS

The Central Materials Laboratory will be responsible for implementation and operation of the Laboratory Qualification Program. The Central Materials Laboratory will accredit the District Laboratories. The District Materials Offices will qualify laboratories.

NON-COMPLIANCE/DISPUTE RESOLUTION

A laboratory that does not meet the requirements of the IM is subject to elimination from the qualification program.

Disputes concerning calibration and correlation of equipment will be resolved by the office responsible for the qualification. For disputes that cannot be resolved at the District, the Central Materials Laboratory will be the final authority.

DISTRICT LABORATORY ACCREDITATION PROGRAM

The Central Materials Laboratory (CML) will accredit the District Materials Laboratories and maintain records of the accreditation for five years. The CML Staff will check the following prior to accrediting a laboratory:

1. Check for current manuals and test procedures covering the accredited testing.
2. Check the certification and training records of the testing personnel.
3. Document that proper equipment is available to perform qualified testing.
4. Check documentation system.

Scheduling of the annual accreditation review will be discussed with the laboratories needing accreditation.

Table 1 is the list of items to be reviewed.

An oral close out on any deficiencies will be held with the testing personnel. Written notice will be sent within two months of the inspection. CML personnel will re-inspect if necessary after correction of any deficiencies.

A report showing the laboratory, the date accredited, and the expiration date will be issued by the Materials Testing Engineer.

NON-COMPLIANCE/DISPUTE RESOLUTION

A laboratory that does not meet the requirements of the IM is subject to elimination from the qualification program.

The CML and the District Materials Engineer will resolve disputes concerning calibration and correlation of equipment.

TABLE 1 - Laboratory Accreditation Checklist

	√	Minimum Calib./Verif. Interval	Calib./Verif. Procedure
Tester Qualifications-Proper Iowa DOT certifications			
Current Test Procedures			
Current Calibration Procedures & Records			
Documentation of correlation results and corrective actions taken for previous construction season			
Balances		12 months	Iowa 917-B
Ovens		12 months	Iowa 1501-A
Mechanical Shakers		12 months	Iowa 1502-A
Marshall Compactor T-245		12 months	Iowa 1504-A
Gyratory Compactor T-312		6 months	Iowa 1522-A
Marshall Molds T-245		12 months	Iowa 1523-A
Comp. Test Machine T-245		12 months	Iowa 1505-A
Sieves		6 months	Iowa 1506-A
Thermometers - Test		6 months	Iowa 1607-A
Thermometers - Ref.		12 months	Iowa 1607-A
Timers T-201, T-202		6 months	Iowa 1508-A
Sand Equivalent T-176		12 months	Iowa 1509-A
Gyratory Compactor Molds T-312		12 months	Iowa 1524-A
Vacuum Systems T-209		12 months	Iowa 1510-A
Pycnometers T-228, T209		12 months	Iowa 1618-A
Fine Aggregate Anularity T-304		12 months	Iowa 1525-A
Dynamic Shear Rheometer T-315		6 months	Iowa 1612-A
Balance Weights M-231		12 months	
Sample Splitters T-248		12 months	(visual condition)

LABORATORY QUALIFICATION PROGRAM

The District Materials Office will qualify the other laboratories and maintain records of the qualification for three years. The District Staff will check the following prior to qualifying a laboratory:

1. Establish the type of laboratory (Aggregate, Hot Mix Asphalt, Soils Field, PC Concrete).
2. Check for current manuals and test procedures covering the qualified testing.
3. Check the certification of the testing personnel.
4. Document that proper equipment is available to perform qualified testing.
5. Check documentation system.

Scheduling of the qualification review will be discussed with the laboratories seeking qualification. The District staff performing the qualification review should have the appropriate certification (IM 213) for the type of laboratory and tests being reviewed. The District Materials Engineer should be contacted for laboratories that have been qualified in other states. The District Materials Office may qualify a laboratory based on an acceptable qualification report and qualification program from another state transportation agency.

Table 1 and the pages following cover the list of items to be reviewed.

An oral close out on any deficiencies will be held with the testing personnel. Written notice will be sent within two weeks of the inspection. District personnel will re-inspect after correction of any deficiencies.

A form showing the laboratory type, the date qualified, and the expiration date will be issued by the District Materials Engineer.

The list of Qualified Laboratories will be maintained on a database accessible by authorized Materials Personnel.

NON-COMPLIANCE/DISPUTE RESOLUTION

A laboratory that does not meet the requirements of the IM is subject to elimination from the qualification program.

The office responsible for the qualification will resolve disputes concerning calibration and correlation of equipment. For disputes that cannot be resolved at the District level, the Central Materials Laboratory will be the final authority.

Table 1 - Laboratory Qualification Checklist

	√	Calib./Verif. Interval	Calib./Verif. Procedure
Tester Qualifications-Proper Iowa DOT certifications			
Current Test Procedures			
Current Calibration Procedures & Records			

Documentation of correlation results and corrective actions taken for previous construction season.			
Soils Field Laboratory			
Balances		12 months	Iowa 917
Sieves- wear, tear, size		12 months	
Mold, Base, and rammer condition		(a)	IM 309
Aggregate Laboratory			
Balances		12 months	Iowa 917
Sieves- wear, tear, size, and opening size		12 months	Iowa 1506
Splitter- condition		12 months	(Visual)
Mechanical Shakers- condition (if used)		12 months	Iowa 1502
HMA Laboratory			
Balances- and water bath		12 months	Iowa 917
Sieves- wear, tear, size, and opening size		12 months	Iowa 1506
Splitter- condition		12 months	(Visual)
Mechanical Shakers- condition (if used)		12 months	Iowa 1502
Rice equipment- vacuum and flask		12 months	IM 350
Thermometers		12 months	Iowa 1607
Ovens- temperatures		12 months	Iowa 1501
Gyratory Compactor and molds		12 months	Iowa 1522
PCC Laboratory			
Balances		12 months	Iowa 917
Sieves- wear, tear, size, and opening size		12 months	Iowa 1506
Splitter- condition		12 months	(Visual)
Mechanical Shakers- condition (if used)		12 months	Iowa 1502
Air Meter		12 months	IM 318
Slump Cone and equipment-condition		12 months	
Flexural Strength Apparatus		12 months	Central Lab
(a) The mold, base or rammer should be checked if the condition warrants.			

<u>LABORATORY ITEMS</u>

PCC Portable Paving Plant

The following list contains, as a minimum, what is required for a qualified PCC paving plant laboratory. The test equipment to perform each of the required tests is contained in the respective IM.

- Field Lab of suitable size for workspace, space to perform tests, and sample storage. Locate the Field Lab so it is convenient to the plant, but outside the influence of plant vibration.

  Air-conditioned
  Personal computer

Phone
All in one printer
Sample storage
Work table
Electrical outlets
Running water available to perform necessary testing
Desk and chair
Incidental spoon, pans, pails

- The personal computer shall be capable of running Iowa DOT programs. It is recommended to have at least Windows 2000 or newer software on the computer. Iowa DOT programs have been checked and are capable of running on Windows 2000 and newer software.

HMA Plant

The following list contains, as a minimum, what is required for a qualified asphalt laboratory. The test equipment to perform each of the required tests is contained in the respective IM.

- Field Lab and Office [Suggested size 8 ft. x 44 ft. (2.4 m x 13.41 m)]. Locate the Field Lab so it is convenient to the plant, but outside the influence of plant vibration.

Air-conditioned
Personal computer
Phone
Fax machine
Copy Machine
Sample storage
Work table
Bulletin board
Water available to perform necessary testing
Desk and chair
Incidental spoon, trowels, pans, pails

- The personal computer shall be capable of running Iowa DOT programs. It is recommended to have at least Windows 2000 or newer software on the computer. Iowa DOT programs have been checked and are capable of running on Windows 2000 and newer software.

Removable storage device
Color monitor, VGA or better
Printer

- Diamond saw for cutting core lifts.

- Diamond core drill (minimum 4” diameter core).

Iowa Department of Transportation

MATERIALS LABORATORY QUALIFICATION PROGRAM
Laboratory Inspection - per Materials Instructional Memorandum 208

Company Name: ______________________________

Laboratory name: ______________________________

Laboratory type: Aggregate HMA PCC Soils (Circle one)

Laboratory location: ______________________________

Laboratory contact person: ______________________________

Laboratory technician:	Certification number:	Expires:
____________	____________	____________
____________	____________	____________
____________	____________	____________

Current manuals and written test procedures available? ______________________________

Current calibration procedures and records? ______________________________

____

Documentation of correlation results and corrective actions taken for previous construction season? ____________

____

____

Proper equipment available to perform qualified testing? ______________________________

____

Other remarks: ______________________________

____

Date of inspection: ____________ Qualification expiration date: ____________

Inspection performed by: ______________________________
Print name

____
Sign name

Inspection received by: ______________________________
Print name

____
Sign name

District Number ____________

cc: Materials Engineer, Contractor/Producer, Ames, File

Iowa Department of Transportation

AGGREGATE LABORATORY INSPECTION QUALITY CONTROL CHECKLIST

Contractor/Producer: ____________________ Location: ____________________
Certified Technician: ____________________ Certification No: ____________________

		Yes	No
Balances	(Iowa Test Method 917)		
	Updated balance calibration records available?	______	______
	Check balance using 500 gm & 1000 gm calibrated weights?	______	______
	Is balance accurate to 0.1%?	______	______
Sieves	(Iowa Test Method 1506)		
	Is there adequate correlation history to qualify?	______	______
	Were go/no-go gauges used to check accuracy?	______	______
	Are the sieves in good condition (no loose frames, holes, or tears)?	______	______
Splitter			
	Is the splitter in good condition? (i.e., missing shuts, cracked welds, or leaking seams)	______	______
Shaker	(Iowa Test Method 1502)		
	Is shaker apparatus secure and level?	______	______
Scale			
	Are the laboratory weights used for routine calibrations accurate? (Use 0.1% difference from our calibrated weights as standard.)	______	______

Comments ____
____
____
____

cc:Materials Engineer
Contractor/Producer
Ames
File

Inspected By: ____________________

Date Inspected: ____________________

.

Iowa Department of Transportation

HMA LABORATORY INSPECTION
QUALITY CONTROL CHECKLIST

Contractor/Producer: ____________________ Location: ____________________

Certified Technician: ____________________ Certification No.: ____________________

		Yes	No
Thermometers	(IM 321, IM 325, IM 325G, IM 350)		
Thermometer Calibration and Documentation available?		____	____

Temperature of check: ____________ (25 deg C or 135 deg C)
State reference thermometer ____________
Contractor reference thermometer ____________
Difference ____________

		Yes	No
Rice Pycnometer	(IM 350)		
Calibration chart and/or documentation available?		____	____
Equipment achieves between 25.5 and 30mm of mercury vacuum?		____	____
Mercury is free of bubbles?		____	____
Gyratory/Marshall Compactor	(IM 325/IM 325G)		
Calibration documentation available?		____	____
Is equipment generally clean?		____	____
Documentation of annual mold measurements?		____	____
Ovens	(IM 325/IM 325G)		
Documentation of temperature checks?		____	____
General condition satisfactory?		____	____
Do all parts work as intended?		____	____

Water Bath (IM 321)
Temperature? ____________

Correlation

	Yes	No
Correlation results available for previous year?	____	____

Comments: ____

NOTE: HMA labs must also qualify as an aggregate lab.

cc: Materials Engineer
Contractor/Producer
Ames
File

Inspected By: ____________________

Date Inspected: ____________________

Iowa Department of Transportation

READY MIX/PCC PAVING LABS
QUALITY CONTROL CHECKLIST

Contractor/Producer: ____________________ Location: ____________

Certified Technician: ____________________ Certification No: ________

Inspection Checklist Items:

	Yes	No
Air Meter (IM 318)		
Check meter using approved 5% pugs.	____	____
Is air meter clean?	____	____
Proper rod and mallet.	____	____
Slump Cone (IM 317)		
Interior of cone free of dents or projections.	____	____
5/8" by 24" tamping rod.	____	____
Rigid, nonabsorbent base.	____	____
Equipment clean and free of hardened concrete.	____	____
Beam Breaker (IM 316)		
Current annual calibration sheet	____	____
Equipment clean.	____	____
Beam Molds (IM 328)		
Molds clean and free of dents	____	____
General condition of molds good.	____	____

Comments ____

NOTE: PCC labs must also qualify as an aggregate lab.

cc: Materials Engineer
Contractor/Producer
Ames
File

Inspected By: ____________________

Date Inspected: ____________________

Iowa Department of Transportation

SOILS FIELD LABORATORY INSPECTION
QUALITY CONTROL CHECKLIST

Contractor/Producer: ____________________ Location: ____________________

Certified Technician: ____________________ Certification No: ____________________

	Yes	No
Balances (Iowa Test Method 917)		
Updated balance calibration records available?	______	______
Check balance using 500 gm & 1000 gm calibrated weights?	______	______
Is balance accurate to 0.1%?	______	______
Sieves		
Are the sieves in good condition (no loose frames, holes, or tears)?	______	______
Mold, Base, and Rammer (IM 309)		
Are they in good condition. Mold round and the base flat? If not, check the dimensions for out-of-tolerance.	______	______
Rigid Foundation		
Do they have a concrete pad or floor or other rigid foundation to compact the specimen on?	______	______

Comments ____

____

____

____

cc:Materials Engineer
Contractor/Producer
Ames
File

Inspected By: ____________________

Date Inspected: ____________________

INDEPENDENT ASSURANCE PROFICIENCY & TESTING FOR HMA

GENERAL

The HMA Proficiency Program is part of the Independent Assurance Program described in IM 205. The HMA Proficiency Program provides participating laboratories with a means to:

- Check both the instrument and the operator under actual testing conditions.
- Compare individual test results with the average of a large body of results so that corrective action may be taken where wide discrepancies occur.
- Evaluate the quality of test results, thereby reducing the risk of dispute due to testing errors.

Each accredited and qualified Laboratory and certified staff shall establish and maintain their proficiency by following program described herein.

A project approach for independent assurance may be used for RCE, county, city, and consultant laboratories.

WITNESSING FOR IAP

The District Materials Offices are responsible for witnessing the HMA mix sampling, splitting, and testing; the binder sampling; and the cold feed aggregate sampling and quartering (if used as the acceptance method for gradation). When using either the project approach or the system approach, document with a written report (Figure 1 is a good example):

- Who was checked
- When
- Where including project number
- What activity was checked
- Comments on observations
- The name of the person doing the IA

PROFICIENCY SAMPLE

The Central Materials Laboratory will prepare and send out proficiency samples during the construction season (April through September). The samples and tests for laboratories will be as follows:

A. District Laboratories

1. Asphalt Binder

   a. G*/Sin Delta

2. HMA Mix

   a. G_{mb} Laboratory Density

   b. G_{mm} Maximum Specific Gravity
   c. % Binder, Ignition Oven
   d. Gradation, Ignition Oven
3. Combined Aggregate
   a. Gradation
   b. G_{sa} Apparent Specific Gravity (every other sample)
   c. G_{sb} Bulk Specific Gravity (every other sample)
   d. Percent Absorption (every other sample)
   e. Fine Aggregate Angularity (every other sample)
   f. Sand Equivalency (every other sample)

B. HMA Laboratories
1. HMA Mix
   a. G_{mb} Laboratory Density
   b. G_{mm} Maximum Specific Gravity
2. Combined aggregate
   a. Gradation

C. Aggregate Laboratories
1. Gradation

PROFICIENCY SAMPLE FREQUENCY

A. District Laboratories
Each District Laboratory will receive a set of proficiency samples monthly April through September. The samples will be tested and the results reported within 14 calendar days of receipt

B. Contractor HMA laboratories

Each active certified HMA technician performing quality control testing for state or local federal aid projects will pick-up proficiency samples in April from the closest District Laboratory. The samples will be tested and the results reported to the Central Materials Laboratory by May 15.

For active certified technicians that do not obtain a proficiency sample in April, they must contact the District Laboratory in the District where they will be working and obtain and test a proficiency sample prior to the start of paving. Results will be compared to the District Laboratory results for that month.

TEST RESULT ANALYSIS

Test results from the proficiency samples will be analyzed using the current AASHTO Material Reference Laboratory (AMRL) procedure. The analysis compares the results from each participant and each District and Central Laboratory to the overall mean. Test results will also be compared to the Central Materials Laboratory results.

Any test result that is 3.0 standard deviations or greater from the mean will be considered failing. Two consecutive proficiency sample results that are 2.0 standard deviations or greater from the mean will be considered failing.

In the event of a small data set or large or small variation within a data set, the individual results will be compared with the Central Laboratory results. IM 216 will be used to compare the results. Proficiency test results beyond the tolerance will be considered failing.

INVESTIGATION OF FAILING TEST RESULTS

The technician with failing test results shall review the calculation, test procedures, and perform a calibration if warranted. When there are two or more consecutive failing results, the Central Materials Laboratory or the District Material Engineer will contact the technician and arrange to conduct an evaluation of the procedures and equipment to correct any deficiencies. Three consecutive failing results by a technician will constitute unsatisfactory performance as defined in IM 213 and become a part of their permanent file.

If an active certified HMA technician fails to obtain and test a proficiency sample, the District Materials Engineer will conduct an investigation and if warranted issue an unsatisfactory performance notice.

If an active DOT certified HMA technician fails to test and report a proficiency sample by deadline, the District Materials Engineer will be notified to conduct an investigation and if warranted issue an unsatisfactory performance notice.

IM 211
RM PRODUCER PROG.

APPROVED READY MIX CONCRETE PRODUCER PROGRAM

APPROVED PRODUCER PROGRAM

In order to furnish ready mix concrete to projects, a ready mix producer must be on the approved producer listing (Appendix D). The specific requirements, including the details of the required quality control program are in Appendix A. Appendix B is the ready mix approval application form.

Non-compliance to the approved Ready Mix Concrete Producer Quality Control Program shall constitute grounds for the specific ready mix plant or the producer to be placed on conditional status by the District Materials Engineer. Continued non-compliance will be considered sufficient ground to remove the facility or company from the Approved Producers List.

Appendix C contains the “Notification of Violations of the Approved Producer’s Quality Control Program”. This is a written notice from the District Materials Engineer to a Producer identifying violation(s) of the Producer’s Quality Control Program or requirements of the Approved Producer program. A written response is required from the Producer describing how the violation occurred, how the violation will be rectified, and what will be done so the violation will not occur or continue to occur in the future.

A Ready Mix Concrete Review Board will meet, as needed, for disciplinary actions and appeals involving Approved Producers.

The Ready Mix Concrete Review Board shall consist of:
- The State Construction and Materials Engineer
- The Concrete Materials Engineer
- A District Materials Engineer from a District which does not monitor ready mix plants for the Producer in question
- Other independent consultant

CERTIFIED READY MIX CONCRETE – SAMPLING AND TESTING

The Ready Mix Concrete Producer shall be responsible for source (ready mix plant) product quality control. Verification (acceptance) testing of ready mix concrete is performed by the Engineer. The Ready Mix Concrete Producer has the sole responsibility for the quality of the concrete and individual constituent materials in the concrete.

Aggregates, cementitious materials, water, and admixtures to be used in concrete for highway construction projects shall be subject to sampling and testing, including Ready Mix Concrete Producer Quality Control (QC) sampling and testing. Sampling and testing shall be performed during production in accordance with the minimum frequencies specified in the contract documents.

A. Ready Mix Concrete Producer Quality Control Sampling and Testing

Ready Mix Concrete Producer QC sampling and testing personnel, laboratories, and equipment shall be qualified in accordance with the Iowa DOT Technical Training and

Certification Program (IM 213) and the Materials Laboratory Qualification Program (IM 208).

B. Iowa DOT Verification Sampling and Testing

The District Materials Office, in conjunction with the Project/Agency Engineer, will be responsible for monitoring the Producer's Quality Control Program. Verification of quality is through independent sampling and testing. Verification sampling and testing is performed by Agency personnel in accordance with IM 205 and IM 528. District Materials Office and Agency sampling and testing personnel, laboratories, and equipment shall be qualified in accordance with the Iowa DOT Technical Training and Certification Program (IM 213) and the Materials Laboratory Qualification Program (IM 208).

When requested by the Agency, Producer personnel may assist with the sampling as directed and witnessed by the certified Agency personnel. The sample time will be randomly selected by the Agency (except when noted elsewhere) and will only be given to the Producer immediately prior to sampling. To maintain the integrity of the sample, it will be transported by Agency personnel. The Agency will split the verification sample and give a portion to the Producer.

At no time will the District Materials Office or the Agency representative issue directions to the Producer. However, the representative will have the authority and responsibility to question and where necessary reject an operation or production, which is not in accordance with the Specifications, Special Provisions, and Materials Instructional Memorandums.

CERTIFIED READY MIX CONCRETE – DOCUMENTATION

A. Documentation

Report shall be reported weekly or as designated to the District Materials Engineer on the plant report Form #800240.

B. Plant Book

Document material quantities in plant book.

C. Batch Tickets

Each truckload of concrete must be identified by Form #830212 or acceptable computer generated plant ticket.

GUIDELINES FOR READY MIX CONCRETE PRODUCER QUALITY CONTROL PROGRAM

GENERAL

The following contains the minimum requirements for the Producer Quality Control Program in order to become an approved ready mix concrete producer, and to supply certified ready mix concrete to a project.

Producers must submit a written application to the District Materials Engineer (DME) for review and approval. The DME will forward to the Construction and Materials Engineer for signature. The ready mix approval application form is found in Appendix B.

Individual ready mix concrete plants must be calibrated at least once per year. At the time of calibration, the Producer shall provide a written update of contact information, and responsible persons.

NOTE: Producers with operations in more than one District shall apply to the District Materials Engineer where the certified ready mix corporate office exists. The application form is included in this Materials IM.

DEFINITIONS

The following definitions apply to the Quality Control Program guidelines:

Producer – the ready mix concrete company and its employees.

Source/Concrete Plant – any ready mix concrete plant where certified ready mix concrete is produced.

Conditional Status – This is a written notice for the District Materials Engineer to a producer that ready mix concrete will no longer be accepted from a particular source/plant. Application of Conditional Status may vary depending upon situation or specific circumstances. The Conditional Status may apply only to a source/plant. In other situations, when the deficiency is more widespread, the Conditional Status may apply to an entire company or division within a company until the problem is resolved.

GUIDELINES FOR READY MIX CONCRETE PRODUCER QUALITY CONTROL PROGRAM

1. Ready Mix Concrete Certification

   The producer has the overall responsibility of assuring the certified ready mix concrete being batched and delivered to highway and bridge construction projects conforms to all applicable specifications, and the producer Quality Control (QC) Program. The Iowa DOT and Contracting Agency, through their monitoring activities (sampling/testing, visual observations, report checking, etc.), will verify the continued compliance to the program.

2. Knowledge of Current Specifications

   The producer Quality Control representative(s) must maintain up-to-date knowledge of the specifications that apply to the ready mix concrete being produced at the source/plant. The producer representative shall have available, at the testing lab, a copy of the current Standard Specifications, all applicable Supplemental Specifications and all applicable Materials Instructional Memorandums for Portland cement concrete production. The producer will be aware of any Special Provisions, or plan notes, which change current Portland cement concrete specifications. This applies to quality, gradation, and operational requirements. The producer shall be responsible for providing these up-to-date publications to their QC representative(s).

3. Certified Plant Inspection

The producer shall perform all required duties of Certified Plant Inspection as defined in the applicable Standard Specifications, Materials IM's, and other contract documents. Certified Plant Inspectors (CPI's) shall possess all necessary Iowa DOT Technical Training Certification Program (TTCP) certifications to perform the necessary sampling, testing and inspection duties as required.

4. Quality Requirements

All materials incorporated in the Portland cement concrete must meet the designated quality before incorporation. The producer is responsible for supplying concrete materials meeting all quality requirements. Intentional shipment of out of specification material will constitute grounds for immediate rejection of material and placement of the source/plant and/or the producer on Conditional Status.

Producer QC staff will perform all required testing and CPI inspections in accordance with all applicable Iowa DOT Specifications, Materials IM's, and other contract documents. Failure to perform all required CPI duties will constitute grounds for placement of either the Producer or individual Ready Mix Plant on Conditional Status and possible suspension of production from the affected ready mix plant(s).

5. Production Notification

Prior to batching operations, the Producer will notify the Engineer (or his/her representative) of anticipated production as soon as practical after schedule is received from the Contractor. Notification shall include project number, concrete mix used, ready mix location, quantity, and any other pertinent information.

The Producer will be responsible for maintaining continuous, prompt contact with the Engineer (or his/her representative) during all batching and testing operations during the project. The Engineer (or his/her representative) will be immediately informed of any changes to mix designs or operations.

6. Production and delivery

The producer is responsible for quality control inspection (certified plant inspection) the plant operations at the source/plant on a continual basis. Quality control certified plant inspection can be defined as observing, among other things:

- Concrete plant calibrations and scale checks.
- Stockpiling operations, including deliveries of aggregates and cementitious materials.

- Batching operations, including weighing and mixing operations (including required mixing times, moistures (including probes)).
- Condition of the plant and transport vehicles (including required mixing times/revolutions).
- Project documentation and file management.

7. Documentation

Producer will provide and maintain all required documentation as specified in the contract documents.

BR, HPC, and QM-C Portland cement concrete mix designs will be provided to the Engineer by the Producer prior to batching, as well as flowable mortar designs for critical flow. Standard mix designs will be provided as requested by the Engineer.

Daily/weekly concrete plant reports will be submitted to the Project Engineer and District Materials Engineer by the Producer. The reports will be sent electronically within the required timeframe as defined in the contract documents.

Project diaries will be maintained by the Producer and shall be kept current and made available to the Engineer upon request, for up to three years.

8. Quality Control Structure

In order to ensure quality as a priority, the producer Quality Control personnel will have a line of communication directly to their management, as well as their production operation staff.

READY MIX CONCRETE PRODUCER APPROVAL APPLICATION

Company Name ____

Address ____
(IF MORE THAN ONE; i.e., Regional Offices, etc., PLEASE ATTACH LIST AND AREA COVERED.)

1. Are copies of current applicable specifications, aggregate testing IMs and source information data available at the respective sources or testing facilities? (Y ☐ or N ☐) If No, explain.

   ____

2. Are the project diaries maintained on a daily basis and available for inspection? (Y ☐ or No ☐) If No, explain.

   ____

3. Who (position) is responsible for production notification to the Plant Monitor?

   ____

4. Which company representative (position) is normally responsible for daily overall Quality Control processes at the plant? ______________________________

5. Describe the stockpile identification system in place at each plant.

   ____

6. Attach a detailed summary of your Quality Control Program. (**NOTE:** Refer to Guidelines for Required Ready Mix Producer Quality Control Program.)

7. Attach a flow chart of your current Quality Control structure (Include names, addresses, phone numbers of appropriate management personnel, chain of command, etc., for problem resolution).

Indicate the Iowa DOT District(s) for which you have operations to produce State of Iowa Certified material.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐

AUTHORIZED SIGNATURE ______________________ DATE ______________

DME RECOMMENDATIONS ____
____

DME SIGNATURE ______________________ DATE ______________
APPROVAL (YES or NO) REMARKS ____
____

CENTRAL CONSTR. & MAT'LS SIGNATURE______________________ DATE______________

****THIS IS A NEW APPENDIX. – PLEASE READ CAREFULLY.****

NOTIFICATION OF IM 211 VIOLATION

This appendix contains the Notification of Violations of the Approved Ready Mix Producer's Quality Control Program.

This is a written notice from the District Materials Coordinator or District Materials Engineer to a producer identifying violation(s) of the Producer's Quality Control Program or requirements of the Approved Ready Mix Concrete Producer Program (Office of Materials IM 211).

A written response is required from the Producer describing how the violation occurred, how the violation will be rectified, and what will be done so the violation will not occur or continue to occur in the future. After the written response is received, grounds for Conditional Status will be determined. Conditional Status requires that certified ready mix concrete will no longer be accepted from a particular source. The Conditional Status may apply only to a production operation and concrete produced by that operation. In other situations, when the deficiency is more widespread, the Conditional Status may apply to an entire company or division within a company until the problem is resolved. See Office of Materials IM 211, Appendix A for details. If the Notification of Violation is found to be in error, the Notification will be rescinded. Written responses should be sent to the District Materials Office and the Concrete Materials Engineer of the Construction and Materials Office.

Producer Name____

Date(s) of violation____

Nature of Violation (Circle all that apply)

1. Knowledge of Current Specifications
2. Plant Calibration/Quality Control Lab Qualification
3. Materials Certification
4. Stockpile Management and Other Visual Inspection
5. Production Notification
6. Quality Control (CPI) Testing
7. Plant Reporting – Correctness and/or Timely Distribution
8. Project Diary
9. Delivery (Non-Complying Concrete)
10. Quality Control Structure/Performing Non-CPI Duties During Batching
11. Other

Additional details (attach a separate document if more space is needed):

IOWA DOT SIGNATURE________________________________DATE________________

Copies to: District Materials Office
Concrete Materials Engineer, Construction and Materials Office

APPROVED READY MIX CONCRETE PRODUCERS

PRODUCER	Location
Allied Ready Mix	Charles City, IA 50616
American Concrete	Ankeny, IA 50021
Audubon-Exira Ready Mix	Audubon, IA 50025
Bard Materials	Dyersville, IA 52040
Bellevue Sand & Gravel	Bellevue, IA 52031
Benton's Ready Mix	Cedar Falls, IA 50613
Builders Sand and Cement (Block & Hahn RM)	Davenport, IA 52802
Cemstone Concrete Materials	Mendota Heights, MN 55120
Central Iowa Ready Mix (CSI & Iowa State)	Des Moines, IA 50316
Cohron Ready Mix	Council Bluffs, IA 51503
Concrete, Inc.	Marshalltown, IA 50158
Concrete Materials	Sioux Falls, SD 57107
Croell Ready Mix	New Hampton, IA 50659
CTI Ready Mix	Urbandale, IA 50322
Echo Concrete	Corning, IA 50748
Gerhold Ready Mix	Blair, NE 68008
Great River Ready Mix	Hamilton, IL 62341
GCC Ready Mix	Sioux Center, IA 51250
Hamilton Redi- Mix	Jefferson, IA 50129
Hawkeye Ready Mix (King's RM)	Coralville, IA 52241
Horsfield Materials, Inc.	Peosta, IA 52068

Ideal Ready Mix	West Burlington, IA 52655
Iowa City Ready Mix	Iowa City, IA 52244
Liberty Ready Mix	Urbandale, IA 50323
Mad Dog Concrete, LLC	Milan, IL 61264
Manatts, Inc.	Brooklyn, IA 52211
Manatts Metro	Johnston, IA 50131
Metro Ready Mix, LC	Cedar Rapids, IA 52404
Moorehouse Ready Mix, Inc.	Carroll, IA 51401
Norwalk Ready Mix	Norwalk, IA 50211
Pleasant Valley Redi-Mix	Bettendorf, IA 52722
Preston Ready Mix	Preston, IA 52069
Quality Concrete Co.	Clinton, IA 52732
Ready Mixed Concrete	Omaha, NE 68131
Shipley Ready Mix	Burlington, IA 52601
Siouxland Concrete	S. Sioux City, NE 68776
Skyline Ready Mix	Pella, IA 50219
Standard Ready Mix	Sioux City, IA 51105
Streb Construction Co, Inc.	Iowa City, IA 52244
Stowe Red E Mix	Harlan, IA 51537
Wendling Ready Mix	Preston, IA 52069
Witte Ready Mix	De Witt, IA 52742
Yohn Ready Mix	Clear Lake, IA 50248

IM 213
TRAINING & CERT.

TECHNICAL TRAINING & CERTIFICATION PROGRAM

GENERAL

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

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

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

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

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

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

** Appointed by Program Director

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

TRAINING

The Iowa DOT will provide the training necessary to become certified or an agency approved by the Program Director. Producers/Contractors are encouraged to conduct their own pretraining program. A complete listing of training opportunities is available in the Technical Training & Certification Program's Information and Registration Booklet or at the Technical Training & Certification Program website, www.iowadot.gov/training/ttcp.html. The book is available at any of the Iowa DOT Materials Offices.

CERTIFICATION REQUIREMENTS

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

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

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

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

4. Registered Professional Engineers, engineering graduates, and geology graduates from accredited institutions will be exempt from the training requirement in the areas they have had instruction. In order to obtain certification for any technical level, these persons must pass all applicable tests for the level of certification they wish to obtain. All certificates issued in accordance with these requirements will be subject to the same regulations concerning expiration, recertification, etc., as applies to certificates obtained via training and examinations.

Out-of-state technicians will be issued certifications when the following criteria are met:

1. The applicant must be certified in another state or shall have received equivalent training, if the state does not have a certification program, in each level of certification they are requesting.

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

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

Out-of-state applications should be submitted to the District Materials Office closest to the home location of the applicant. Copies of all the applicant's certifications must accompany the application.

CERTIFICATION

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

CERTIFICATION IDENTIFICATION

The certificate will contain letters that identify the District of record, the certificate holder, certification number, the level of certification, and the expiration date of each level.

The assigned certification number may change if the certificate holder changes their residence.

RENEWAL OF CERTIFICATION

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

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

The certificate holder shall be responsible for applying for certification renewal and for maintaining a current address on file with the appropriate District Materials Office.

Technicians certified as Level I HMA and/or Level II PCC shall attend a minimum of two update classes each in the five-year period between certification and each recertification. The Iowa DOT or an agency or organization approved by the TTCP will hold these classes. These update classes will be listed in the Technical Training & Certification Program Booklet and on the program website, or the certified technician may contact the Iowa DOT for information. If an individual does not attend the two update classes required before their certification expires, they must take the entire schooling and pass the examination for the certification required.

The certified technician will not receive credit for the following:

1. More than one update per training season in each level of certification.
2. An update taken during the same training season in which the individual recertified.

UNSATISFACTORY PERFORMANCE NOTICE

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

SUSPENSION & DECERTIFICATION

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

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

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

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

The certificate will become invalid for the following reasons:

1. Failure of the certificate holder to renew the certificate prior to regular expiration as described above.

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

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

4. Not performing tests and technician duties properly and in accordance to specifications.

Action will be effective on the date the Program Director issues the suspension or decertification notice.

Technicians that are decertified shall not perform any duties requiring certification. Technicians may request reinstatement after one year.

Appeals and reinstatement requests shall be submitted in writing to the Program Director. Appeals and reinstatement requests will be considered by the Certification Board.

If reinstatement is authorized, the applicant must attend and successfully complete the applicable certification courses.

FUNCTIONS & RESPONSIBILITES

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

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

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

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

QUALITY CONTROL, TESTING, & DOCUMENTATION

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

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

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

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

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

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

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

ACCEPTANCE

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

CERTIFICATION LEVELS

CERTIFICATION LEVEL	TITLE	PRE-REQUISITES
	AGGREGATE	
Level I Aggregate	Certified Sampling Technician	None
Level II Aggregate	Certified Aggregate Technician	Level I Aggregate
	PORTLAND CEMENT CONCRETE	
Level I PCC**	PCC Testing Technician	None
Level II PCC	PCC Plant Technician	Level II Aggregate & Level I PCC
Level III PCC	PCC Mix Design Technician	Level II PCC

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

CERTIFICATION LEVEL	TITLE	PRE-REQUISITES
	HOT MIX ASPHALT	
HMA Sampler	HMA Sampler	None
Level I HMA	HMA Technician	Level II Aggregate
Level II HMA	HMA Mix Design Technician	Level I HMA
	PROFILOGRAPH	
Profilograph	Profilograph Technician	None
	PRESTRESS	
Prestress	Prestress Technician	Level I PCC or ACI Grade I *If the technician will be performing gradations, they will need to be Aggregate Level II- certified.*
	SOILS	
Soils	Soils Technician	None
	EROSION CONTROL	
Erosion Control	Erosion Control Technician	None

UNSATISFACTORY PERFORMANCE NOTICE

Issued To: ____________________________ Date: ____________________

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

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

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

Unsatisfactory Performance:

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District Materials Engineer

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

CERTIFIED TECHNICIANS QUALIFICATIONS

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

LEVEL I AGGREGATE

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

LEVEL II AGGREGATE

- IM 210 – Production of Certified Aggregate From Reclaimed Roadways
- IM 216 - Guidelines for Verifying Certified Testing Results
- IM 302 - Sieve Analysis of Aggregates
- IM 306 - Determining the Amount of Material Finer Than #200 (75µm) Sieve in Aggregate
- IM 307 - Determining Specific Gravity of Aggregate
- IM 308 - Determining Free Moisture & Absorption of Aggregate
- IM 336 - Methods of Reducing Aggregate Field Samples to Test Samples
- IM 344 - Determining the Amount of Shale in Fine Aggregate
- IM 345 - Determining the Amount of Shale in Coarse Aggregate
- IM 368 – Determining the Amount of Clay Lumps & Friable Particles in Coarse Aggregate
- IM 409 – Source Approvals for Aggregate

LEVEL I PCC

- IM 204 - Inspection of Construction Project Sampling & Testing
- IM 208 - Materials Laboratory Qualification Program
- IM 216 - Guidelines for Verifying Certified Testing Results
- IM 315 - Method of Protecting, Curing, Making & Testing Concrete Cylinders
- IM 316 - Flexural Strength of Concrete
- IM 317 - Slump of Hydraulic Cement Concrete
- IM 318 - Air Content of Freshly-Mixed Concrete by Pressure
- IM 327 - Sampling Freshly-Mixed Concrete
- IM 328 - Making, Protecting, and Curing Concrete Flexural Specimens
- IM 340 - Weight Per Cubic Foot, Yield, & Air Content (Gravimetric) of Concrete
- IM 383 - Testing the Strength of PCC Using the Maturity Method
- IM 385 - Temperature of Freshly-Mixed Concrete
- IM 525 - Designing Flowable Mortar
- Iowa 410-B - Method of Test for Flow of Grout Mixtures
- AASHTO T97 - Third Point Loading

LEVEL II PCC

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

LEVEL III PCC

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

HMA SAMPLER

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

LEVEL I HMA

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

LEVEL II HMA

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

PROFILOGRAPH

- IM 341 - Determining Pavement & Bridge Ride Quality

PRESTRESS

- IM 570 - Precast & Prestressed Concrete Bridge Units

SOILS

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

AGGREGATE TECHNICIAN DUTIES

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

A. Sampling

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

   2. Sample at required frequencies.

   3. Identify samples with pertinent information such as:

      a. Type of material

      b. Intended use

      c. Production beds working depth

      d. Sampling method

   4. Reduce samples by approved method(s).

B. Gradation Testing

   1. Follow appropriate gradation testing methods.

   2. Maintain current applicable specifications.

   3. Post test results within 24 hours of sampling.

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

   1. Follow appropriate testing methods.

   2. Maintain current applicable specifications.

   3. Complete required reports.

D. Sampling & Testing Equipment

   1. Clean and check testing sieves for defects.

   2. Assure scale accuracy.

   3. Maintain sampling and testing equipment.

E. Communication

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

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

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

F. General

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

2. Assure proper identification of stockpiles.

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

4. Assure sampling locations are safe.

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

G. Documentation

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

2. Assure "plant production log" is maintained.

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

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

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

A. Stockpiles

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

B. Plant Facilities

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

C. Calibration

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

D. Cement (Fly Ash) & Aggregate Delivery

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

E. Plant Sampling

1. Check aggregate gradations by obtaining, splitting, and testing samples.
2. Check aggregate moistures and specific gravity.

F. Proportion Control

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

G. Concrete Tests

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

H. Test Equipment

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

I. Documentation

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

HOT MIX ASPHALT (HMA) TECHNICIAN INSPECTION DUTIES

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

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

A. Aggregate Stockpiles.

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

2. Document certified aggregate deliveries. (each delivery) (plant book, IM 508)
    a. Obtain truck tickets.
    b. Check for proper certification.
    c. Check for proper approved source.
    d. Enter deliveries in Plant Book Program, Aggregate Certification page.

3. Observe loader operation. (daily) (daily check list, IM 508)
    a. Check for proper stockpile to bin match-up.
    b. Check that loader does not get stockpile base material in load.
    c. Check that loader does not intermingle aggr. by overloading bins.

B. Asphalt Binder Delivery. (each delivery) (plant report & plant book, IM 508 & 509)

1. Check that material is pumped into correct tank.

2. Document Deliveries.
    a. Obtain truck tickets.
    b. Check for proper approved source.
    c. Check for proper certification.
    d. Check for proper grade.
    e. Check for addition of liquid anti-strip if required.
    f. Check if weight per gallon or specific gravity has changed.
    g. Enter deliveries into Plant Book Program, Asphalt Binder Shipment Log page.

C. Plant Operations. (daily)

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

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

2. Aggregate Delivery System. (daily check list, IM 508)

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

3. Mixing System. (daily check list, spec 2303.03, IM 508)

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

4. Loading System. (daily check list, spec 2303.03 & 2001.01, IM 508)

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

5. Asphalt Binder Quantity Determination. (plant report, IM 508 & 509)

    a. Perform start-up tank stick measurement before mix production begins (if applicable).
    b. Perform final tank stick measurement after mix production is done (if applicable).
    c. Perform intermediate tank stick measurements as needed.
    d. If using meter for quantity, obtain totalizer printout readings and periodically check against tank stick readings.
    e. If using batch count for quantity, obtain printouts of each batch and add up the asphalt binder used for total quantity.

D. Plant Operations. (2 hour intervals) (plant report, IM 508)

1. Temperatures.

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

2. Observe plant operation for any irregularities.

E. Weighing Equipment.

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

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

3. Weigh Belts. (daily) (daily check list)

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

4. Enter scale checks in Plant Book Program, Daily Check List or Plant Scale Checks page. (daily) (plant book)

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

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

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

3. Enter sample data into Plant Book Program, Sample Log page.

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

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

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

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

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

1. Field cores.

   a. Provide properly calibrated equipment for Contracting Authority technician's use.
   b. Obtain and record core location station and offset information.
   c. Obtain copy of core thickness measurements from Contracting Authority Technician.
   d. Obtain copy of core weights from Contracting Authority technician.
   e. Record weights and thickness in Plant Report Program.
   f. Enter sample data into Plant Book Program Sample Log page.

2. Uncompacted mix.

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

3. Aggregate.

   a. Split one sample each day as directed by Contracting Authority personnel and provide half for testing by Contracting Authority.
   b. Perform gradation analysis as per IM 302 and enter weights into Plant Report Program.
   c. Perform moisture tests and enter weights into Plant Book Program, Plant Moistures page (drum mix plants).

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

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

I. Documentation. (daily) (spec 2303.04, plant report, plant book, IM 204, 511 & 508)

1. Prepare computerized Daily Plant Report (form 241).

    a. Check that all data is correct.
    b. Check that all data is complete.
    c. Compute moving averages for gradation and lab voids.
    d. Compute tons of mix used to date.
    e. Enter mix adjustment data on report.
    f. Check for spec compliance.
    g. Immediately report non-complying results.
    h. Obtain and record mat temperatures and stationing.
    i. Provide daily Plant Report printout to DME.

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

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

3. Copy and export daily data and paste into control charts program.

4. Enter all asphalt binder or aggregate proportion changes in Plant Book Program, Mix Adjustments page.

5. Enter tack shipment quantities in Plant Book Program, Tack Shipment Log page.

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

J. Miscellaneous. (daily) (daily check list, IM 208 & 511)

1. Fill out Plant Book Program, Daily Check List page.

2. Clean lab.

3. Back-up computer files.

4. Dispose of samples as directed by District Lab.

5. Clean and maintain lab equipment.

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

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

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

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

4. Report test results on proficiency samples to Central Materials Office per IM 205.

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

1. Be in possession of appropriate mix design.

2. Be present during plant calibration.

3. Observe scale calibrations.

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

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

6. Check that release agents used in truck boxes are on the approved list in IM 491.15

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

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

PRESTRESS TECHNICIAN DUTIES

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

A. Pre-pour

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

B. Concrete Placement

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

C. Post-pour

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

PROFILOGRAPH TECHNICIAN DUTIES

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

A. Test pavement and bridge surfaces for ride quality.

B. Evaluate the test data.

   1. Indentify bumps and dips.

   2. Summarize the roughness into segments and sections.

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

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

C. Documentation

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

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

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

SOILS TECHNICIAN DUTIES

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

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

B. Proctor Testing

C. Other Testing as Required

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

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

D. Sampling & Testing Equipment

 1. Clean and check testing sieves for defects.

 2. Assure scale accuracy.

 3. Check and maintain other testing equipment.

E. Evaluate the test data.

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

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

F. Documentation and Communication

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

 2. Relay test results to appropriate supervisory personnel.

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

EROSION CONTROL TECHNICIAN DUTIES

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

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

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

C. Review copies of storm water inspection reports.

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

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

FEDERAL CODE 1020 and IOWA CODE 714.8

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

FEDERAL AID PROJECTS

IX. FALSE STATEMENTS CONCERNING HIGHWAY PROJECTS

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

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

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

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

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

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

NON-FEDERAL AID PROJECTS

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

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

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

April 15, 2014 Matls. IM 216
Supersedes April 16, 2013

GUIDELINES FOR DETERMINING THE ACCEPTABILITY OF TEST RESULTS

GENERAL

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

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

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

TOLERANCES

TEST NAME	TEST METHOD	TOLERANCE
Slump of PC Concrete		
1" or less on IA or Verification	IM 317	1/4 in. (6 mm)
More than 1" on IA or Verification		3/4 in. (18 mm)
Air Content of PC Concrete	IM 318	0.4%
Length of Concrete Cores	IM 347	0.10 in. (2 mm)
Free Moisture in Aggregate, by Pycnometer	IM 308	0.2%
Specific Gravity of Aggregate, by Pycnometer	IM 307	0.02
Moisture in Aggregate, by Hot Plate		0.3%
Moisture in Soil	IM 335, IM 334	1.5%
Proctor Optimum Moisture Content	IM 309	2.0%
Proctor Maximum Dry Density	IM 309	5.0 lb./ft^3 (80 kg/m^3)
In-Place Wet Density, Soils & Bases	IM 334, 326,	2.0 lb./ft^3 (32 kg/m^3)

	other approved	
G_{mm} Maximum Specific Gravity	IM 350	0.010
G_{mb} Density of HMA Concrete, by Displacement	IM 321	0.020
G*/Sin Delta	T315	10% of mean
% Binder, Ignition Oven	IM 338	0.3%
G_{sa} Apparent Specific Gravity	IM 380	0.010
G_{sb} Bulk Specific Gravity	IM 380	0.028
Percent Absorption	IM 380	0.37%
Fine Aggregate Angularity	T304	2.0%
Sand Equivalency	T176	10 % of mean
Pavement Profile Index (0.2” blanking band)	IM 341	
Verification Profile Index Test Result		
Inches/mile (mm/km)		
6.0 (95) or less		1.0 in./mi. (16 mm/km)
6.1 to 20.0 (96 to 315)		2.0 in./mi. (32 mm/km)
20.1 to 40.0 (316 to 630)		3.0 in./mi. (47 mm/km)
More than 40.0 (630)		5.0 in./mi. (79 mm/km)
Pavement Profile Index (0.0” blanking band)	IM 341	
Verification Profile Index Test Result		
Inches/mile (mm/km)		
25.0 (395) or less		3.0 in./mi. (47 mm/km)
25.1 to 40.0 (396 to 630)		4.0 in./mi. (63 mm/km)
More than 40.0 (630)		5.0 in./mi. (79 mm/km)
Bridge Profile Index (0.2” blanking band)	IM 341	
Verification Profile Index Test Result		
Inches/mile (mm/km)		
6.0 (95) or less		2.0 in./mi. (32 mm/km)
6.1 to 20.0 (96 to 315)		3.0 in./mi. (47 mm/km)
20.1 to 40.0 (316 to 630)		4.0 in./mi. (63 mm/km)
More than 40.0 (630)		6.0 in./mi. (95 mm/km)
Pavement International Roughness Index (IRI)	IM 341	
Verification IRI Test Result		
Inches/mile		
50.0 or less		10.0% of mean
50.1 to 150.0		8.0% of mean

More than 150.0	7.0% of mean

TOLERANCES FOR AGGREGATE GRADATIONS

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

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

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

Table 1 Tolerances for All Aggregates Except HMA-Combined Aggregate

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

Table 2 Tolerances for All HMA-Combined Aggregate

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

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

COMPARISON OF AGGREGATE GRADATIONS

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

Example 1 - PC Concrete Coarse Aggregate

Sieve Size	DOT Coarse Aggr Percent Passing	Prod./CPI Coarse Aggr Percent Passing	DOT Coarse Aggr Percent Retained	Prod./CPI Coarse Aggr Percent Retained	Fraction Difference	Applicable Tolerance	Complies
1.5"/37.5mm	100.0	100.0	0.0	0.0	0.0	2	Yes
1"/25.0mm	97.1	99.1	2.9	0.9	2.0	2	Yes
3/4"/19.0mm	72.2	65.1	24.9	34.0	9.1	6	No
1/2"/12.5mm	38.1	34.9	34.1	30.2	3.9	7	Yes
3/8"/9.5mm	12.0	8.8	26.1	26.1	0.0	6	Yes
#4/4.75mm	0.6	0.2	11.4	8.6	2.8	5	Yes
#8/2.36mm	0.5	0.2	0.1	0.0	0.1	1	Yes
Minus #200	0.3	0.2	0.3	0.2	0.1	1	Yes

The size fraction between consecutive sieves is found by calculating the difference between the percent passing reported for the two sieves. For example, the fraction between the 1.5 in. (37.5 mm) and 1 in. (25 mm) sieves for the above verification test is 100.0 - 97.1 = 2.9%. Between the 1/2 in. (12.5 mm) and 3/8 in. (9.5mm) sieves it is 38.1 – 12.0 = 26.1%. Since nothing passes the pan, the size fraction between the #200 sieve and the pan is equal to the percent passing the #200.

The example shows the fraction between each pair of consecutive sieve sizes for both tests and the difference between these fractions for both tests. The difference is compared with the applicable tolerance to determine a disposition. In this example, a suspect result is found in the fraction between the 1 in. (25 mm) and 3/4 in. (19 mm) sieves. Since the suspect difference is due primarily to the percent passing results on the 3/4 in. (19 mm) sieves, it is these results that should at least be investigated first. Only further investigation can determine which 3/4 in. (19 mm) sieve, if any is faulty.

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

Example 2 - PC Concrete Fine Aggregate

Sieve Size	DOT Fine Aggregate Percent Passing	Prod./CPI Fine Aggregate Percent Passing	DOT Fine Aggregate Percent Retained	Prod./CPI Fine Aggregate Percent Retained	Fraction Difference	Applicable Tolerance	Complies
3/8"/9.5mm	100.0	100.0	0.0	0.0	0.0	2	Yes
#4/4.75mm	95.0	95.0	5.0	5.0	0.0	3	Yes
#8/2.36mm	87.8	86.3	7.2	8.7	1.5	2	Yes
#16/1.18mm	72.0	71.5	15.8	14.8	1.0	3	Yes
#30/600um	44.0	43.8	28.0	27.7	0.3	4	Yes
#50/300um	12.2	13.0	31.8	30.8	1.0	4	Yes
#100/150um	1.5	1.3	10.7	11.7	1.0	3	Yes
Minus #200	0.4	0.4	0.4	0.4	0.0	1	Yes

Example 3 - HMA Combined Aggregate

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

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

D.O.T. FBR: ________

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

NOTE: The applicable tolerance for this combined aggregate sample is from Table 2. In this example, the suspect fractions would indicate a possible problem for two pairs of consecutive sieve sizes involving the #4 (4.75 mm) sieves. This evidence and the difference in the test values found for the #4 (4.75 mm) sieves, strongly point to an error in one of the #4 (4.75 mm) sieve results.

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

Example 4 HMA Cold-Feed to Ignition Oven Comparison

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

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

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

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

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

PC CONCRETE GRADATION COMPARISON REPORT

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

Rev 05/03

Iowa Department Of Transportation

Form 200

Reported Gradation & IM 216 Comparison Report

Project No.:______________________

Contract ID:______________________

County:______________________

Contractor/Producer:______________________

Design No.:____________

Coarse Agg. T203 A No.: ________

Fine Agg. T203 A No.: ________

Proper Equipment:________

Applicable Specs.:________

Intended Use: ______________________
(Paving, Structure, Patching, Incidental

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

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

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

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

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

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

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

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

Remarks:____

Distribution_______ Central Materials_______ Dist. Materials_______ Contr./Producer_______ Proj. Engineer_______ Technician_______

HMA GRADATION COMPARISON REPORT
(Computer Spreadsheet Available on Iowa DOT Office of Materials Web Site)

Rev 05/03

Iowa Department Of Transportation

Form 201

Reported Gradation & IM 216 Comparison Report

Project No.: ____________________

Contract ID: ____________________ Intended Use: ____________________

County: ____________________

Contractor/Producer: ____________________

Mix Design No.: ____________________

Mix Change (Y/N): ________

Date of Change: ________

Total, % Asphalt (Pb): ________

Effective % Asphalt (Pbe): ________

Proper Equipment: ________

Applicable Specs.: ________

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

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

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

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

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

DOT Gyratory Filler/Bitumen Ratio
0.00

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

Remarks: ____

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

Rev 05/08

Form 201 Modified

Iowa Department Of Transportation

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

Project No.: ______

Contract ID: ______ Intended Use: ______

County: ______

Contractor/Producer: ______

Mix Design No.: ______

Mix Change (Y/N): ______

Date of Change: ______

Total, % Asphalt (Pb): ______

Effective % Asphalt (Pbe): ______

Proper Equipment: ______

Applicable Specs.: ______

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

Ignition Oven Tested By: ______ Cert. No.: ______ Date: ______

Cold-Feed Tested By: ______ Cert. No.: ______ Date: ______

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

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

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

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

Remarks: ______

Distribution_______ Central Materials_______ Dist Materials_______ Contr./Producer_______ Proj. Engineer_______ Technician_______

QMC GRADATION COMPARISON REPORT

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

QMC Gradation Correlation I.M. 216

Project No.: ______________________

Contract ID: ____________ Date Sampled: ____________

Plant Name: ______________________ County: ____________ Gradation Date: ____________

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

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

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

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

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

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

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

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

Comments: ______________________

cc: ______________________

IM 301
AGG. SAMPLING

AGGREGATE SAMPLING & MINIMUM SIZE OF SAMPLES FOR SIEVE ANALYSIS

SCOPE

This IM sets forth approved sampling methods and the minimum amount of dry materials necessary for the determination of particle size distribution.

LOCATION FOR SAMPLING

Safety must be foremost when determining sample locations. The Contractor/Producer shall make adequate provisions, satisfactory to the Engineer, for the safety of personnel responsible to obtain representative samples of the aggregate.

Provisions shall include guards for moving belts, pulleys, and wheels near the sampling point, and a stable platform with adequate safety rails when sampling is to be done from an elevated location.

Stopped belt sampling locations must be equipped with an on-off switch near, and in plain view of the sampling location. This switch, when in the off position, must have full control of the belt.

1. Conveyor Belt/Template Method

A minimum of three locations is required when obtaining a sample using this method. Normally, the belt should be recharged for each location to help assure a representative sample. (Review section titled 'Sampling Stockpiles For Gradation Confirmation').

The ends of the template should be spaced to yield approximately one third of the total minimum required sample weight. More increments may be needed to achieve the required minimum weight.

Stop the belt and insert the template as illustrated. Remove all material from the belt contained within the template. A brush or whisk broom will be useful in capturing the finer particles.

The increments are combined together to make one field sample.

2. Stream Flow Method

   When obtaining a sample by interception of the aggregate stream flow, care must be exercised, so the sampling device (See picture below.) passes quickly through the entire stream flow and does not overflow. At least three separate passes shall be made with the sampling device when obtaining a sample. Each pass is an increment of the sample. This is normally considered to be the best method to obtain a representative sample of coarse aggregate.

3. Stockpile Method (for fine aggregate only, or as directed by the District Materials Engineer)

   Stockpile sampling of fine aggregate may be accomplished by either using a shovel or a sand probe. When obtaining a field sample by the stockpile method, a minimum of three increments shall be taken at different locations around the stockpile. Avoid sampling in areas prone to segregation, such as along the bottom of cone stockpiles.

   NOTE: Stockpile sampling of coarse ***or combined*** aggregate should be avoided. If it becomes absolutely necessary to obtain a sample from a ***production*** stockpile, consult the District Materials Engineer to help devise an adequate and proper sampling plan.

SAMPLING STOCKPILES FOR GRADATION CONFIRMATION

Stockpile sampling of coarse or mixed coarse and fine aggregate is difficult due to segregation. When sampling to determine gradation compliance of these materials, the Contractor, Producer or Supplier will supply equipment such as a sampling bin or flow-boy to provide a streamflow or stopped conveyor belt sampling location.

An end-loader will open the pile to be sampled in at least three locations. One end-loader bucket from each opened area is then placed into the sampling bin and sampled in a manner to assure representation of the entire quantity.

Alternately, material from each of the opened areas may be combined in a small stockpile, carefully blended to minimize degradation of the aggregate, and placed into the sampling bin.

Avoid obtaining sample increments at the beginning or end of bin discharge due to the natural tendency of segregation through the bin.

SHIPPING SAMPLES

Transport aggregate samples in bags or other containers constructed to preclude loss or contamination of the sample, or damage to the contents from mishandling during shipment.

Shipping containers for aggregate samples shall each have suitable identification attached and enclosed so that field reporting, laboratory logging and testing may be facilitated.

SAMPLE SIZES

Minimum sample sizes for sieve analysis of aggregates are based on the smallest sieve through which at least 95% of the sample will pass. The following table lists the required minimum field sample and test sample sizes:

SIEVE SIZE	FIELD SAMPLE (lbs/kg)	TEST SAMPLE (gms/kg)
1½ in.	50/23.0	5,000/5.0 ‹1›
1 in.	30/13.5	3,500/3.5
¾ in.	20/9.0	2,000/2.0
½ in.	20/9.0	1,500/1.5
⅜ in.	10/4.5	1,000/1.0 ‹2›
No. 4 sieve	10/4.5	500/0.5
No. 8 sieve	10/4.5	200/0.2

(Products with maximum sizes over 1½ in. (37.5 mm) are normally visually inspected. Contact the appropriate District Materials Engineer.)

(1) When testing 1½” aggregate for Special Backfill, Granular Subbase, or Modified Subbase the minimum test sample is 2500 grams.

(2) When testing fine aggregate with no more than 10% retained on the No. 4 sieve the minimum test sample is 500 grams.

IM 302
SIEVE ANALYSIS

SIEVE ANALYSIS OF AGGREGATES

SCOPE

This method of test covers the procedure for determination of the particle size distribution of aggregates.

PROCEDURE

A. Apparatus

1. Balance accurate to within 0.1 percent of the weight (mass) of the sample to be tested. **NOTE:** The balance shall be reset to zero before each weighing.

2. Sieves with square openings mounted on substantial frames, constructed in such a manner to prevent loss of material during sieving. Use suitable sieve sizes to furnish the information required by the specifications covering the material to be tested. The woven wire cloth shall conform to AASHTO M-92. This will normally consist of a set of **Box Sieves** for testing coarse aggregates consisting of the following sizes:

   1 ½ in., 1 in., ¾ in., ½ in., ⅜ in., No. 4, and No. 8.

   A set of **8 in. Diameter Sieves** for testing fine aggregates consisting of the following sizes:

   No. 4, No. 8, No. 16, No. 30, No. 50, No.100, No. 200, and Pan.

   A set of **12 in. Diameter Sieves** may be used for testing fine aggregate or aggregate containing both coarse and fine material.

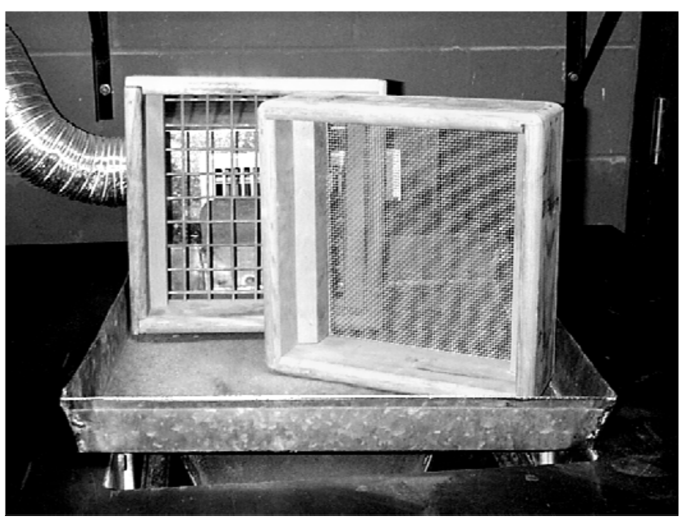


Figure 1. Box Sieves for testing coarse aggregates.

Figure 2. 12 and 8 in. sieves.

3. Mechanical and hand-powered sieve shakers

4. Drying oven or stove

5. Fiber bristle sieve cleaning brush (similar to stencil brush or cropped paintbrush)

B. Test Sample

1. Test samples for sieve analysis shall conform to the sample size for the applicable material as indicated by Materials IM 301.

2. Obtain the sample for sieve analysis (test sample) from the material to be tested (field sample) by the appropriate method as outlined in Materials IM 336. The test sample shall be approximately of the weight (mass) desired when dry and must be the end result of the reduction. Reduction to an exact predetermined weight (mass) shall not be permitted.

C. Preparation of Sample

1. When a determination of the amount of material passing the No. 200 sieve is required, test the sample according to Materials IM 306, *"Determining the Amount of Material Finer Than the No. 200 Sieve",* before completing the sieve analysis. For coarse aggregates with a nominal maximum size greater than ½ in., a single test sample may be used to determine both sieve analysis and the amount passing the No. 200, or separate test samples may be used for Materials IMs 306 and 302.

2. When the absorbed moisture stays essentially the same for different particle sizes the sample may be sieved at a surface-dry condition (no free water present).

3. Samples with a significant amount of material finer than the No. 4 sieve, or highly absorptive coarse aggregates (i.e. lightweight aggregates) which have changes in moisture for different particle sizes, must be dried to a constant weight (mass) before performing sieve analysis.

4. Coated particles may also be a problem. When this condition exists, the dried material must be washed over the smallest sieve for which there is a specification requirement (usually the No. 8 sieve), and dried again.

5. Recycled Materials: Material from crushed composite (HMA/PC) pavements must be sieved at a surface-dry condition using no artificial heat. No gradation determination will be made for material finer than the No. 8 sieve. In some instances, larger particles may be coated to the extent that dry sieving will not accurately reflect the true gradation of the material. In these instances, the air-dried sample must be washed over the No. 8 sieve and allowed to come to a surface-dry condition by air-drying.

   Note: For material made from crushed PC pavement, determination of the percent passing the No. 200 sieve may be required.

D. Test Procedure

1. Weigh and record the weight (mass) of the test sample as the Original Dry Mass. (This is the 'Dry Mass Washed Weight" if tested by Materials IM 306.)

2. Sieve the sample over the required sieves. The sieving operation must be accomplished by using a lateral and vertical motion of the sieve(s), accompanied by a jarring action, which keeps the sample moving continuously over the surface of the sieve. Do not attempt to turn or manipulate the aggregate particle through the sieve openings by hand.

When using a mechanical sieve shaker, excessive sieving times may result in degradation of the sample.

Method A

When testing a sample with a mixture of coarse and fine aggregate (combined aggregate), and sieve overload of the fine aggregate sieves is anticipated, the material finer than the No. 4 may distributed among two or more sets of sieves and each increment recombined for weighing:

Method B

Alternately, weigh and record the total minus No. 4 material (W1). Reduce the minus No. 4 material through the 1 in. or smaller mechanical splitter to a minimum 500 g. sample size. Weigh and record the selected reduced portion (W2) and place this material into the nest of fine aggregate sieves and continue step 2 (above).

The conversion factor is calculated by dividing W_1 by W_2, and recorded to the nearest 0.0001.

NOTE: Method B is recommended when using 8 in. sieves to test the fine aggregate portion of a sample, when overload is anticipated. If using 12 in. sieves and the original test sample is reasonably close to the required weight (mass), overload should not occur. When sieve overload is anticipated on the No. 8 sieve only, sieve the original sample through the No. 8 box sieve before placing the fine portion in the nest of 8 in. round sieves.

3. The sieving operation may be considered complete when not more than 0.5 percent by weight (mass) of the original sample passes any sieve during an additional one minute of hand-sieving.

   On the No. 4 and larger sieves, limit the amount of material carried on the sieve to a single layer when determining sieving to completion.

   When using 8 in. and 12 in. diameter sieves, the weights retained should not exceed the following:

8 in. diameter sieves	12 in. diameter sieves
No more than 200 grams	No. 4 no more than 850 grams No. 8 and smaller no more than 450 grams

   If sieving to completion (as described above) is not readily accomplished, reduce the amount of material carried on the sieve.

6. Clean the retained material from each sieve for weighing. Remove as much material as practical without damaging the wire cloth. Particles may be removed most readily from a sieve by inverting the sieve over a pan and tapping the sieve by hand and/or pushing

(without force) the particles out of the mesh into the pan. Care must be taken while cleaning the sieves, so no damage occurs to the wire mesh by bending or breaking the wires. A fiber-bristle brush should be used for cleaning the No. 16, No. 30 and No. 50 sieves. When cleaning the No. 100 or No. 200 sieves, a *soft* fiber bristle brush and gentle tapping may be employed. Avoid excessive force on the wire cloth. If clogging of the mesh occurs on these finer sieves, they should be sent to the District Materials Laboratory for cleaning.

5. Weight the fraction of material retained on each sieve and in the pan, to at least the nearest 0.5 gram and record.

6. Total the weight (mass) of the material retained on the sieves and in the pan. An accuracy check must be made comparing the weight (mass) of the material before sieving to the total of the weights (mass) after sieving. The total of the weights retained on the sieves and in the pan must be within 0.5 percent of the weight of the sample before sieving.

   When the percent finer than the No. 200 sieve is <u>not</u> determined:

$$\frac{\text{Total}}{\text{Original Dry Mass}} \times 100 = \text{Tolerance (99.5 to 100.5)}$$

   When the percent finer than the No. 200 sieve is determined by washing (IM 306):

$$\frac{\text{Total - Washing Loss}}{\text{Dry Mass Washed}} \times 100 = \text{Tolerance (99.5 to 100.5)}$$

   If the difference exceeds the 0.5 percent tolerance, check all the calculations, the sieves for retained material and the balance for proper care. If needed, weigh each increment of material retained again. If the error cannot be found, the test is void and a new sample shall be tested.

E. Calculations

1. When alternate step (D,2 b) has been used and a conversion factor determined, multiply each of the retained weights (B) from the sieved, reduced sample by the conversion factor and record to the nearest 0.1 as the *calculated weight* (A). Add this column and determine accuracy (Step D, 6).

2. Calculate the percent retained on each sieve by dividing the total *or calculated* weight (mass) of the material retained on each sieve, and in the pan, by the Original Dry Weight (mass) of the sample. Record to the nearest 0.1 percent when determining percent retained and the consequent percent passing. When computing the percent retained of a

washed sample, divide the **sum** of the washing loss and pan weight (mass) by the Original Dry Weight (mass).

3. Total the percent retained column. The percent-retained column should equal 100 percent. Because the weight (mass) of material retained on the sieves may not equal the Original Dry Weight (mass), the total of the percentages retained may not equal 100 percent. If this occurs, the percentages retained should be altered by prorating on the larger quantities, so they do equal 100 percent.

4. The percent passing is then determined by subsequent subtraction starting with the sieve with no material retained (100 percent passing).

5. Sieve analysis results are to be reported as percent passing and recorded to two significant figures, i.e., to the nearest whole percent for percentages above 10.0 and to the nearest tenth of a percent for lower results.

Examples:	Test Result	Report
	10.5	11
	11.5	12
	11.4	11
	9.8	9.8
	0.5	0.5

6. The Fineness Modulus, when required, may now be calculated by cumulative addition of the percent retained on each of the following sieves coarser than the No. 200 sieve and dividing that sum by 100: No.100; No. 50; No. 30; No. 16; No. 8; No. 4. The Fineness Modulus is typically calculated on the fine aggregate but the 3/8 in.; 3/4 in.; 1 ½ in., and larger, may be used in the calculation (i.e. doubling the previous sieve size).

Form 820180ex 11-01

EXAMPLE #1, COARSE AGGREGATE

Lab. No.:		
Material:		Grad. No.:
Co. & Proj.#:		
Producer:		
Contractor:		
Sampled By:	Date:	
Sample Loc.:		

Original Dry Weight:	5793.0	Total Minus No. 4 (W1):	
Dry Weight Washed:		Reduced Minus No. 4 (W2)	
Washing Loss:		Conversion Factor: W1/W2	
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus No. 4	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
1½”		0.0	0.0	100.0	
1”		657.0	11.3	88.7	
¾”		1068.0	18.4	70.3	
½”		1448.0	25.0 (25.1)	45.2	
⅜”		1383.0	23.9 (24.0)	21.2	
No.4		1082.0	18.7 (18.8)	2.4	
No. 8	(B)	141.0 (A)	2.4	0	
No.16	(B)	(A)			
No. 30	(B)	(A)			
No. 50	(B)	(A)			
No. 100	(B)	(A)			
No. 200	(B)	(A)			
Washing Loss					
Pan	(B)	1.5 (A)	0		
Total		5780.5	99.7 (100.0)		
Accuracy Check		99.8			

Wash Sample	Original Dry Weight:		2571.0	
	Dry Weight Washed:		2555.0	
	Washing Loss:		16.0	
Sieve Size	Weight Retd.	% Retd.	% Passing	Specs.
No. 200			0.8	
Washing Loss	16.0			
Pan	4.0	0.8		

Date Reported:	Cert No.:
Tested By:	

NOTE: No more than 200 grams should be retained on the 8” sieves. No more than 850 grams should be retained on the 12” No. 4 sieve, and a maximum of 450 grams on the No. 8 and smaller sieves.

Comments: ______________________

Form 820180ex 11-01

EXAMPLE # 2, FINE AGGREGATE

Lab. No.:			
Material:		Grad. No.:	
Co. & Proj.#:			
Producer:			
Contractor:			
Sampled By:	Date:		
Sample Loc.:			

Original Dry Weight:	594.0	Total Minus No. 4 (W1):	
Dry Weight Washed:	591.5	Reduced Minus No. 4 (W2)	
Washing Loss:	2.5	Conversion Factor: W1/W2	
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus No. 4	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
1½”					
1”					
¾”					
½”					
⅜”		0.0	0.0	100.0	
No.4		29.0	4.9	95.1	
No. 8	(B)	64.5 (A)	10.9	84.2	
No.16	(B)	102.0 (A)	17.2	67.0	
No. 30	(B)	181.5 (A)	30.6**(30.7)**	36.3	
No. 50	(B)	154.5 (A)	26.0**(26.1)**	10.2	
No. 100	(B)	51.0 (A)	8.6	1.6	
No. 200	(B)	6.0 (A)	1.0	0.6	
Washing Loss		2.5			
Pan	(B)	1.0 (A)	0.6		
Total		592.0	99.8**(100.0)**		
Accuracy Check		99.7			

Wash Sample

Original Dry Weight:	
Dry Weight Washed:	
Washing Loss:	

Sieve Size	Weight Retd.	% Retd.	% Passing	Specs.
No. 200				
Washing Loss				
Pan				

Date Reported: Cert No.:	
Tested By:	

NOTE: No more than 200 grams should be retained on the 8” sieves. No more than 850 grams should be retained on the 12” No. 4 sieve, and a maximum of 450 grams on the No. 8 and smaller sieves.

Comments: ____________________

Form 820180ex 11-01
EXAMPLE #3, COMBINED AGGREGATE,
8" AND BOX SIEVES

Lab. No.:			
Material:		Grad. No.:	
Co. & Proj.#:			
Producer:			
Contractor:			
Sampled By:	Date:		
Sample Loc.:			

Original Dry Weight:	2457.2	Total Minus No. 4 (W1):	2115.7
Dry Weight Washed:	2410.5	Reduced Minus No. 4 (W2)	537.2
Washing Loss:	46.7	Conversion Factor: W1/W2	3.9384
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus No. 4	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
1½"					
1"		0.0	0.0	100.0	
¾"		14.6	0.6	99.4	
½"		45.9	1.9	97.5	
⅜"		81.0	3.3	94.2	
No.4		154.0	6.3	87.9	
No. 8	57.6 (B)	226.9 (A)	9.2	78.7	
No.16	93.0 (B)	366.3 (A)	14.9	63.8	
No. 30	178.3 (B)	702.2 (A)	28.6 **(28.5)**	35.3	
No. 50	172.5 (B)	679.4 (A)	27.6 **(27.5)**	7.8	
No. 100	32.7 (B)	128.8 (A)	5.2	2.6	
No. 200	3.9 (B)	15.4 (A)	0.6	2.0	
Washing Loss		46.7			
Pan	0.8 (B)	3.2 (A)	2.0		
Total	538.8	2464.4	**100.2 (100.0)**		
Accuracy Check	100.3	100.2			

Wash Sample				
	Original Dry Weight:			
	Dry Weight Washed:			
	Washing Loss:			
Sieve Size	Weight Retd.	% Retd.	% Passing	Specs.
No. 200				
Washing Loss				
Pan				

Date Reported: Cert No.:	
Tested By:	

NOTE: No more than 200 grams should be retained on the 8" sieves. No more than 850 grams should be retained on the 12" No. 4 sieve, and a maximum of 450 grams on the No. 8 and smaller sieves.

Comments: ______________________________

Form 820180ex 11-01

EXAMPLE #4, COMBINED AGGREGATE, 12" SIEVES

Lab. No.:			
Material:		Grad. No.:	
Co. & Proj.#:			
Producer:			
Contractor:			
Sampled By:	Date:		
Sample Loc.:			

Original Dry Weight:	2051.2	Total Minus No. 4 (W1):	
Dry Weight Washed:	2011.4	Reduced Minus No. 4 (W2)	
Washing Loss:	39.8	Conversion Factor: W1/W2	
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus No. 4	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
1½"					
1"		0.0	0.0	100.0	
¾"		26.8	1.3	98.7	
½"		80.7	3.9	94.8	
⅜"		55.1	2.7	92.1	
No.4		182.7	8.9	83.2	
No. 8	(B)	229.7 (A)	11.2	72.0	
No.16	(B)	362.8 (A)	17.7	54.3	
No. 30	(B)	**610.5*** (A)	29.8	24.5	
No. 50	(B)	377.1 (A)	18.4	6.1	
No. 100	(B)	72.2 (A)	3.5	2.6	
No. 200	(B)	10.2 (A)	0.5	2.1	
Washing Loss		39.8			
Pan	(B)	3.4 (A)	2.1		
Total		2051.0	100.0		
Accuracy Check		100.0			

Wash Sample				
	Original Dry Weight:			
	Dry Weight Washed:			
	Washing Loss:			
Sieve Size	Weight Retd.	% Retd.	% Passing	Specs.
No. 200				
Washing Loss				
Pan				

Date Reported:	Cert No.:
Tested By:	

NOTE: No more than 200 grams should be retained on the 8" sieves. No more than 850 grams should be retained on the 12" No. 4 sieve, and a maximum of 450 grams on the No. 8 and smaller sieves.

Comments: **<u>*The No. 30 sieve was overloaded. Sieving to completion was verified by hand sieving.</u>**

Fineness Modulus Calculation
For Concrete Sand (Grad. #1 – Spec. 4110)
AASHTO T27

The Fineness Modulus is simply a calculation based on the 'cumulative' percent retained from the sieve analysis sample.

Starting with the largest sieve retaining any material, add the cumulative percents retained on each sieve through the No. 100 sieve and divide this total by 100. The result is reported to the nearest 0.01%.

Note: The percent retained on the No. 200 sieve is not calculated in determining the Fineness Modulus.

Example:

Sieve	Percent Retained	Cumulative Percent Retained
3/8"	0	0
No. 4	3.6	3.6
No. 8	16.9	20.5
No. 16	19.6	40.1
No. 30	23.4	63.5
No. 50	26.1	89.6
No. 100	9.5	99.1

Total Cumulative Percent Retained = 316.4

316.4 ÷ 100 = 3.16 Fineness Modulus

IM 306
FINER THAN #200

DETERMINING THE AMOUNT OF MATERIAL FINER THAN THE No. 200 (SIEVE IN AGGREGATE

SCOPE

This test method outlines the procedure for determining the quantity of material finer than a No. 200 sieve by washing and dry sieving.

PROCEDURE

A. Apparatus

1. A No. 200 sieve (wash sieve)

2. A wash pan large enough to prevent loss of water and material

3. Oven or drying stove

4. Balance accurate to 0.1 percent of the sample weight (mass)

5. A set of 8-in. or 12-in. diameter sieves for dry sieving

B. Test Sample

1. Select the test sample from the material to be tested by an appropriate method as outlined in Materials IM 336.

2. When determination of specification compliance is needed on each or any of the following sieves: No. 16, No. 30, No. 50, or No. 100, subject the entire sample to this test procedure.

3. When determination of specification compliance is needed for only the amount of material finer than the No. 200 sieve, reduce the remaining portion of the field sample from which the original test sample was selected, by the appropriate method as outlined in IM 336. A representative sample, sufficient to yield not less than the appropriate mass of dried material, as shown in the following table shall be selected:

Sieve Analysis Sample Weight (Mass) kg (See Materials IM 301)	Appropriate Minimum Weight (Mass) kg of Sample
5.0 kg	2.5 kg
3.5 kg	2.5 kg
2.0 kg	1.0 kg
1.5 kg	*
1.0 kg	*
0.5 kg	*
0.2 kg	*

*Use entire sample.

C. Test Procedure

1. Place the sample in the oven at 230˚F (110˚C) or on the stove and dry to a constant weight (mass). Care must be taken in drying the sample to avoid overheating causing the sample to “pop” or “sputter.”

2. Allow the sample to cool, weigh and record as the Original Dry weight (mass).

3. Place the sample in the wash pan and add a sufficient amount of water to cover it. A detergent, dispersing agent, or other wetting solution may be added to the water to ensure a thorough separation of fine material from the coarser particles.

4. Agitate the sample vigorously using a rotary motion of the pan for five to ten seconds.

5. Pour off the water through the No. 200 wash sieve. When washing samples with a high silt content, it may be necessary to vibrate or lightly tap the wash sieve in order to keep the mesh open so the water and the minus No. 200 sieve material may pass through freely. Repeat this operation until the wash water appears almost clear.

6. Rinse any material retained on the No. 200 sieve back into the sample and decant as much water as possible by carefully pouring the water through the No. 200 sieve.

7. Dry the washed sample, allow to cool, weigh and record as the Dry weight (mass) of the washed sample.

8. When determining only the amount passing the No. 200 sieve, screen the sample over the No. 8 sieve and discard the retained material. Place the portion of material passing the No. 8 sieve on a nest of sieves including the No. 50, No. 100 and No. 200 sieves and the pan. The sieves larger than the No. 200 sieve are included for protection of the No. 200 sieve. Place the nest of sieves in the mechanical sieve shaker and sieve to completion (normally five minutes or less). Weigh and record only the material retained in the pan.

9. When a complete sieve analysis is required, test the entire sample using the appropriate method as outlined in IM 302.

D. Calculations

$$\text{\% Passing No. 200 sieve} = \frac{\text{Washing Loss} + \text{Pan}}{\text{Original Dry Mass (Weight)}} \times 100$$

IM 307
SPECIFIC GRAVITY

DETERMINING SPECIFIC GRAVITY OF AGGREGATES

SCOPE

This method describes two procedures used for determining the bulk specific gravity of aggregates proposed for use in Portland Cement Concrete. This method is also described in Laboratory Test Method 201.

PROCEDURE A – SPECIFIC GRAVITY OF AGGREGATES USING A PYNCNOMETER

A. Apparatus

1. Balance having a capacity of at least 5,000 grams, accurate to 0.5 grams

2. Pycnometer – a fruit jar supplied with a gasket and conical pycnometer top. A two-quart pycnometer is used for coarse aggregates, and a one-quart pycnometer is used for fine aggregate. If a two-quart pycnometer cannot be obtained, a one-quart jar may be substituted (The engineer may require 2 samples be obtained and tested in separate 1-quart pycometers for some aggregates). The quantity of aggregate would be approximated 1100 grams for the one-quart pycnomter.

3. Thermometer – a thermometer with a range of at least 50°F (10°C) to 100°F (38°C)

4. Sieve – a No. 4 (4.75 mm) sieve

B. Field Sample

1. Obtain a field sample as prescribed in IM 301.

C. Preparation of Test Sample

1. Fine Aggregate

   a. Obtain a test sample of approximately 1100 grams from the material to be tested by one of the following methods:

      (1) Use of a sample splitter

      (2) Method of quartering after being thoroughly mixed and in a damp condition

      (3) By taking small scoops of material from various places over the field sample, after it has been dampened and thoroughly mixed. In order to avoid segregation, the material must be damp enough to stand in a vertical face when cut with a trowel. This method of sample reduction is applicable to sands only.

b. If the material has been continuously wet before being received on the job, it may be assumed to be saturated. Otherwise, the sample must be saturated by immersing it in water for period of not less than 15 hours.

c. After soaking, pour off the free water, spread the wet sample on a flat, non-absorbent surface, and allow it to come to a surface-dry condition by natural evaporation of free moisture. Circulation of air by means of a fan may also be used to attain the surface-dry condition. The sample should be stirred frequently to secure uniform drying.

2. Coarse Aggregate

a. Obtain the test sample as prescribed in IM 336, Methods of Reducing Aggregate Field Samples To Test Samples (See Sections on Quartering or Splitting).

b. Sieve the test sample over the No. 4 (4.75 mm) sieve. The sample should be of sufficient size to produce approximately 2100 grams of material retained on the No. 4 sieve. Discard the material that passes this sieve.

c. Immerse the sample (plus No. 4 sieve size) in water for a period of not less than 15 hours.

d. After soaking, pour off the free water and allow the sample to come to a saturated-surface-dry condition by spreading the sample on a flat, non-absorbent surface. The forced circulation of air by means of a fan, if available, may hasten this process. The sample should be stirred frequently to secure uniform drying. The predominance of free moisture may be removed initially by rolling the sample back and forth in a clean, dry, absorbent cloth.

e. The sample may be considered to be saturated-surface-dry when the particles look comparatively dull as the free moisture is removed from their surfaces. For highly absorptive aggregates, the saturated-surface-dry condition is reached when there is an absence of free moisture.

D. Calibration of Pycnometers

1. Fill the pycnometer jar nearly full of water at the temperature to be used in the actual test, plus or minus 3°F (1.7°C). This may be done either before or after the actual test.

2. Screw the pycnometer top down tightly on the jar and mark the position of the top on the jar by a scratch or mark on the threaded rim and a scratch in a corresponding position on the jar, which will establish a constant volume.

3. Fill the pycnometer completely by pouring water into the hole of the pycnometer top until a bead forms above the opening. Immediately wipe the bead of water level with the pycnometer opening. Wipe all other excess moisture from the outside surfaces of the pycnometer. If a bead of water forms at the opening during the final wiping, it should remain for weighing. Weigh the pycnometer to the nearest 0.5-gram.

E. Test Procedure

1. Weigh the saturated-surface-dry sample to the nearest 0.5-gram. For ease in calculations, the fine aggregate sample may be brought to exactly 1000 grams weight, and the coarse aggregate sample may be brought to exactly 2000 grams weight.

2. Place the sample in the appropriate pycnometer containing approximately two inches of water.

3. Nearly fill the pycnometer jar with water at the same temperature plus or minus 3°F (1.7°C) as used in the calibration.

4. Screw the cap down into the proper position by lining up the mark on the pycnometer top and the jar.

5. Entirely fill the pycnometer by adding additional water through the hole in the pycnometer top.

6. Hold one finger over the hole in the top and gently roll and shake the pycnometer to remove any trapped air in the sample.

7. When further rolling and shaking brings no more air bubbles to the top, fill, dry and weigh as in step C3.

F. Calculations

1. Calculate the saturated-surface-dry (SSD) specific gravity to the nearest 0.01 by the following formula:

$$\text{Bulk Specific Gravity (SSD)} = \frac{S}{P + S - W}$$

Where:

S = Weight in grams of aggregate in a saturated-surface-dry condition.

P = Weight in grams of the pycnometer filled with water.

W = Weight in grams of the pycnometer containing the sample and sufficient water to fill the remaining space in the pycnometer.

Pycnometers for Coarse and Fine Aggregates

PROCEDURE B – SPECIFIC GRAVITY OF COARSE AGGREGATE (AASHTO T 85)

A. Apparatus

1. Balance having a capacity of at least 5,000 grams, accurate to 0.5 grams

2. Sample Container – A wire basket of No. 6 (3.35 mm) or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4 to 7 L. The container shall be constructed so as to prevent trapping air when the container is submerged.

3. Water Tank – A watertight tank, into which the sample and container are placed for complete immersion while suspended below the balance, equipped with an overflow outlet for maintaining a constant water level.

4. Suspended Apparatus – Wire suspending the container shall be of the smallest practical size to minimize any possible effects of a variable immersed length.

5. Sieve - A No. 4 (4.75 mm) sieve

6. Thermometer – a thermometer with a range of 50°F (10°C) to 100°F (38°C)

B. Field Sample

1. Obtain a field sample as prescribed in IM 301.

C. Preparation of Test Sample

1. Prepare the test sample identical to that described in Procedure A.

D. Test Procedure

1. Weigh the saturated-surface-dry sample to the nearest 0.5-gram. For ease in calculations, the fine aggregate sample may be brought to exactly 1000 grams weight, and the coarse aggregate sample may be brought to exactly 2000 grams weight.

2. After weighing, immediately place the saturated-surface-dry sample in the sample container, remove all entrapped air by shaking the immersed container, and determine its mass in water at 73.4°F ± 3°F (23.0°C ± 1.7°C). Make sure the water is at a depth sufficient enough to cover the container and sample.

E. Calculations

1. Calculate the saturated-surface-dry (SSD) specific gravity to the nearest 0.01 by the following formula:

$$\text{Bulk Specific Gravity (SSD)} = \frac{S}{S - W}$$

Where:

S = Weight in grams of aggregate in a saturated-surface-dry condition.
W = Weight in grams of the saturated-surface-dry sample in water

IM 308
FREE MOISTURE

DETERMINING FREE MOISTURE & ABSORPTION OF AGGREGATES

SCOPE

This method describes several procedures for determining free moisture and absorption of aggregates.

PROCEDURE A - FREE MOISTURE IN AGGREGATES USING A PYCNOMETER

A. Apparatus

1. Balance having a capacity of at least 5,000 grams accurate to 0.5 grams
2. Pycnometer - A fruit jar supplied with a gasket and conical pycnometer top. A two-quart pycnometer is used for coarse aggregates. If a two-quart pycnomter cannot be obtained, a one-quart jar may be substituted (The engineer may require 2 samples be obtained and tested in separate 1-quart pycnometers for some aggregates). The quantity of aggregate would be approximately 1000 grams for the one-quart pycnomter. A one-quart pycnometer is used for fine aggregates.
3. Thermometer - -35°C (-30°F) to 50°C (120°F) thermometer
4. Scoop

B. Field Sample

1. Obtain a field sample as prescribed in IM 301.

C. Preparation of Test Sample

1. Obtain a test sample of about 1000 grams of fine aggregate or about 2000 grams of coarse aggregate by the following method:

   Place the field sample on a clean, hard non-absorbent surface. Mix the sample thoroughly, form a miniature stockpile and obtain small increments of materials from random locations from the stockpile until the desired sample size is obtained. **NOTE:** The moisture test should be completed as soon as possible after obtaining the field sample to avoid moisture loss due to evaporation.

2. Weigh to the nearest 0.5-gram, a 1000-gram sample of fine aggregate, or 2000-gram sample of coarse aggregate. To avoid moisture loss due to evaporation the weighing should be done immediately after obtaining the test sample. Also avoid any excessive manipulation of the aggregate, prior to weighing, which could cause a loss of moisture.

D. Calibration of Pycnometer

1. Calibrate the pycnometer by the procedure in IM 307.

E. Test Procedure

1. The test procedure is identical to IM 307 with the exception that the test sample is wet, as received, and not in a saturated surface dry condition. This procedure is intended for determining the moisture content of aggregates for Portland Cement Concrete.

F. Calculation

1. Calculate the moisture content, based on wet sample mass (weight), to the nearest 0.1 percent as follows:

$$\text{Percent Moisture as received} = \frac{(W - W_1)Gs \times 100}{(Gs - 1)s}$$

Where:

W = Mass (Weight) in grams of the pycnometer containing a saturated-surface-dry sample of the same mass (weight) as "s" and sufficient water to fill the remaining volume of the pycnometer as determined in IM 307.

W_1 = Mass (Weight) in grams of the pycnometer containing the wet sample and sufficient amount of water to fill the remaining volume of the pycnometer.

Gs = Specific gravity of material in a saturated-surface-dry condition. (This is obtained from Method IM 307.

s = Mass (Weight) in grams of wet sample

2. The percent of moisture, based on the saturated-surface-dry mass (weight), is calculated as follows:

$$\text{Percent Moisture (SSD)} = \frac{\%\text{Moisture as received}}{100 - \%\text{Moisture as received}} \times 100$$

<u>PROCEDURE B – FREE MOISTURE IN AGGREGATE BY MASS (WEIGHT) DIFFERENCE</u>

This procedure is an alternate to using a pycnometer and is also intended for determining the moisture content of aggregates for Portland Cement Concrete.

A. Apparatus

1. Balance having a capacity of at least 5,000 grams and accurate to 0.5 gram

B. Preparation of Sample

1. Prepare the test sample identical to that described in Procedure A.

C. Test Procedure

1. Bring the weighed wet sample to a saturated-surface-dry condition in the manner described in Materials IM 307 and weigh to the nearest 0.5 gram.

D. Calculation

1. Calculate the moisture content, based on wet mass (weight), to the nearest 0.1 percent as follows:

$$\text{Percent Moisture} = \frac{\text{Wt. as received - Wt. SSD}}{\text{Wt. as received}} \times 100$$

A negative result is due to absorption of the aggregate rather than free moisture.

2. The percent of moisture, based on saturated-surface-dry mass (weight), is calculated to the nearest 0.1 percent as follows:

$$\text{Percent Moisture SSD} = \frac{\text{\% Moisture as received}}{\text{100 - \% Moisture by wet mass (weight) as received}} \times 100$$

or

$$\text{Percent Moisture (SSD)} = \frac{\text{wet mass (weight) - saturated - surface - dry mass (weight)}}{\text{saturated - surface - dry mass (weight)}} \times 100$$

<u>PROCEDURE C - WATER ABSORPTION IN AGGREGATE</u>

This procedure is used for determining absorption of aggregates for use in asphaltic concrete as well as determining specification compliance for absorption.

A. Apparatus

1. Balance having the capacity of at least 5000 grams and accurate to 0.5 gram

2. Oven or hot plate

B. Preparation of Sample

1. Obtain a test sample of at least 1000 grams of fine aggregate and 2000 grams of coarse aggregate by following the appropriate procedure outlined in IM 307.

2. When the sample is not in a saturated condition it must be immersed in water at room temperature for a minimum of 15 hours before continuing with the test.

3. Allow the saturated sample to attain a surface-dry condition by following the procedure in IM 307.

C. Test Procedure

1. Weigh the saturated, surface-dry sample to the nearest 0.5 gram.

2. Dry the sample in the oven or on the hot plate or stove to a constant weight (mass).

3. Allow the sample to cool and weigh to the nearest 0.5 gram.

D. Calculation

1. The percent absorption, based on the oven dry mass (weight) is calculated to the nearest 0.01 percent as follows:

   Percent Absorption =

$$\frac{\text{Saturated - surface - dry mass (weight) - oven dry mass (weight)}}{\text{oven dry mass (weight)}} \times 100$$

IM 315
CONCRETE CYLINDERS

METHOD OF MAKING, PROTECTING, CURING & TESTING CONCRETE CYLINDERS

SCOPE

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

I. MAKING, PROTECTING & CURING SPECIMENS

A. Apparatus for Making Specimens

1. 6 in. x 12 in. (152.4 mm x 304.8 mm) or 4 in. x 8 in. (101.6 mm x 203.2 mm) steel, brass, or single-use plastic vertical molds meeting the requirements of AASHTO M205.

2. Molds shall be the vertical type.

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

Mold Size	Tamping Rod Diameter
4 in. x 8 in (101.6 mm x 203.2 mm)	3/8 in. (9.5mm)
6 in. x 12 in. (152.4 mm x 304.8 mm)	5/8 in. (16mm)

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

5. Rubber hammer

6. Wood float or equivalent

B. Making Test Specimens

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

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

3. Consolidation may be rodding with a tamping rod, or by vibration, either internal or external. Concrete with slump greater than 3 inches (75 mm) shall be consolidated

by rodding. Concrete with slump of 1 inch to 3 inches (25 mm to 75 mm) shall be consolidated by rodding or vibration. Concrete with slump of less than1 inch (25 mm) shall be consolidated by vibration.

a. Rodding. Specimens shall receive the proper number of roddings evenly distributed per layer as indicated in the table. The bottom layer shall be rodded throughout its depth. For each upper layer, the rod shall penetrate 1 inch (25 mm) into the underlying layer. After rodding each layer, the sides and ends of the mold shall be tapped with a rubber hammer until the surface of the concrete is relatively smooth. Use an open hand to tap the single-use molds. After consolidation, strike off the horizontal surface and finish with a float or trowel.

Mold Size	No. of Equal Depth Layers	No. of Roddings per Layer
4 in. x 8 in (101.6 mm x 203.2 mm)	2	25
6 in. x 12 in. (152.4 mm x 304.8 mm)	3	25

b. Internal Vibration. Specimens shall receive the required number of insertions of a vibrator layer as indicated in the table. If more than one insertion is required, distribute the insertion uniformly in each layer. Each layer shall be vibrated only long enough to make the surface relatively smooth. The time required will vary with the consistency of the concrete. Over vibration may cause segregation. In compacting the concrete, the vibrator shall not rest on or touch the sides of the mold. When vibrating the top layer, the element shall penetrate about 1/2 inch (13 mm) into the bottom layer. After vibrating, tap the sides of the mold with a rubber hammer to ensure removal of entrapped air bubbles at the surface of the mold. Use an open hand to tap the single-use molds. When consolidation is complete, strike off and finish with a wood float or trowel.

Mold Size	Vibrator Diameter	No. of Equal Depth Layers	No. of Insertions per Layer
4 in. x 8 in (101.6 mm x 203.2 mm)	¾ to I inch 19 to 25 mm	2	1
6 in. x 12 in. (152.4 mm x 304.8 mm)	¾ to I 1/2 inch 19 to 38 mm	2	2

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

C. Protecting & Curing

1. Initial Curing. During the first 24 hours after molding, specimens shall be stored under conditions that maintain the temperature immediately adjacent to the specimens in the range of 50°F to 80°F (10°C to 27°C) and prevent loss of moisture from the specimens. This may be done by covering specimens with wet burlap and placing a plastic sheet over the burlap, or use other suitable methods to ensure that the foregoing requirements are met.

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

3. Curing To Check the Adequacy of Laboratory Mix Proportions for Strength or As a Basis For Acceptance or For Quality Control. For this purpose, specimens are to be removed from the molds at the end of 16 to 24 hours and stored in a moist condition at 68°F to 81.5°F (20°C to 27.5°C) until the time of test. This condition can be met by immersion in saturated limewater. **NOTE:** Lime-saturated water is prepared by mixing 1 teaspoon (12 g) of hydrated lime, with 1 gallon (3.8 liters) of water. Hydrated lime should be a minimum of 90 percent calcium hydroxide (CaOH).

4. Steam Curing. When artificial heat is used to accelerate curing, concrete specimens shall be placed with the unit being cured and shall receive the same curing as the concrete they represent. Prior to testing the specimens, the temperature of the concrete shall be lowered to the temperature of the surrounding air at a rate not to exceed 40°F (22°C) per hour.

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

II. TESTING CONCRETE SPECIMENS FOR COMPRESSION

A. Apparatus

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

B. Time of Testing

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

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

C. Test Specimens

1. Neither end of compressive test specimens when tested shall depart from the perpendicularity to the axis by more than 0.5 degrees [approximately 1/8 in. in 12 in. (3 mm in 300 mm)]

2. The ends of the specimens that are not plane within 0.002 in. (0.05 mm) shall be capped. The planeness of the ends of every tenth specimen should be checked by means of a straightedge and feeler gauge, making a minimum of three measurements on different diameters, to insure that the end surfaces do not depart from a plane by more than 0.002 in. (0.05 mm).

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

D. Capping

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

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

E. Test Procedure

1. Placing Specimen

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

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

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

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

2. Rate of Loading

   a. Apply the load continuously and without shock. Apply the load at a constant rate within the range of 20 to 50 psi (138 kPa to 345 kPa) per second. During the application of the first half of the estimated maximum load, a higher rate of loading may be permitted.

   b. Do not make any adjustment in the controls of the testing machine while the specimen is yielding, especially in the period just before failure.

c. Increase the load until the specimen yields or fails, and record the maximum load carried by the specimen during test.

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

F. Calculations

1. Calculate the compressive strength of the specimen by dividing the maximum load carried by the specimen during the test by the cross sectional area, and express the result to the nearest 10 psi (0.1 MPa). The attached tables may be used to facilitate these computations.

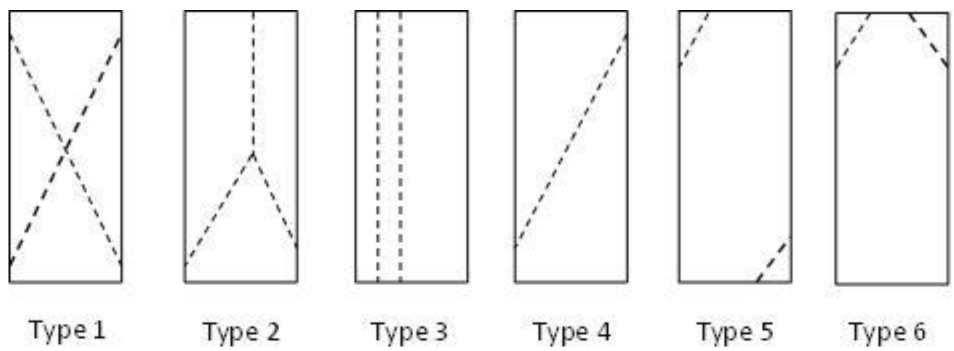


Figure 1. Compressive Fracture Types

Figure 2. Compression Testing Machine

Table for Computing MPa/1000 kPa on 6 in. x 12 in. (154.mm x 304.8 mm) Cylinders
Area = 0.01824m²

Load (kN)	MPa	Load (kN)	MPa	Load (kN)	MPa	Load (kN)	MPa	Load (kN)	MPa
175	9.59	425	23.30	675	37.01	925	50.71	1175	64.42
180	9.87	430	23.57	680	37.28	930	50.99	1180	64.69
185	10.14	435	23.85	685	37.55	935	51.26	1185	64.97
190	10.42	440	24.12	690	37.83	940	51.54	1190	65.24
195	10.69	445	24.40	695	38.10	945	51.81	1195	65.52
200	10.96	450	24.67	700	38.38	950	52.08	1200	65.79
205	11.24	455	24.95	705	38.65	955	52.36		
210	11.51	460	25.22	710	38.93	960	52.63		
215	11.79	465	25.49	715	39.20	965	52.91		
220	12.06	470	25.77	720	39.47	970	53.18		
225	12.34	475	26.04	725	39.75	975	53.45		
230	12.61	480	26.32	730	40.02	980	53.73		
235	12.88	485	26.59	735	40.30	985	54.00		
240	13.16	490	26.86	740	40.57	990	54.28		
245	13.43	495	27.14	745	40.84	995	54.55		
250	13.71	500	27.41	750	41.12	1000	54.82		
255	13.98	505	27.69	755	41.39	1005	55.10		
260	14.25	510	27.96	760	41.67	1010	55.37		
265	14.53	515	28.23	765	41.94	1015	55.65		
270	14.80	520	28.51	770	42.21	1020	55.92		
275	15.06	525	28.78	775	42.49	1025	56.20		
280	15.35	530	29.06	780	42.76	1030	56.47		
285	15.63	535	29.33	785	43.04	1035	56.74		
290	15.90	540	29.61	790	43.31	1040	57.02		
295	16.17	545	29.88	795	43.59	1045	57.29		
300	16.45	550	30.15	800	43.86	1050	57.57		
305	16.72	555	30.43	805	44.13	1055	57.84		
310	17.00	560	30.70	810	44.41	1060	58.11		
315	17.27	565	30.98	815	44.68	1065	58.39		
320	17.54	570	31.25	820	44.96	1070	58.66		
325	17.82	575	31.52	825	45.23	1075	58.94		
330	18.09	580	31.80	830	45.50	1080	59.21		
335	18.37	585	32.07	835	45.78	1085	59.48		
340	18.64	590	32.35	840	46.05	1090	59.76		
345	18.91	595	32.62	845	46.33	1095	60.03		
350	19.19	600	32.89	850	46.60	1100	60.31		
355	19.46	605	33.17	855	46.88	1105	60.58		
360	19.74	610	33.44	860	47.15	1110	60.86		
365	20.01	615	33.72	865	47.42	1115	61.13		
370	20.29	620	33.99	870	47.70	1120	61.40		
375	20.56	625	34.27	875	47.97	1125	61.68		
380	20.83	630	34.54	880	48.25	1130	61.95		
385	21.11	635	34.81	885	48.52	1135	62.23		
390	21.38	640	35.09	890	48.79	1140	62.50		
395	21.66	645	35.36	895	49.07	1145	62.77		
400	21.93	650	35.64	900	49.34	1150	63.05		
405	22.20	655	35.91	905	49.62	1155	63.32		
410	22.48	660	36.18	910	49.89	1160	63.60		
415	22.75	665	36.46	915	50.16	1165	63.87		
420	23.03	670	36.73	920	50.44	1170	64.14		

(Load in Thousands)

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

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

(Load in Thousands)

Table for Computing lb./in.² on 4 in. x 8 in. Cylinders
Area = 12.5666 in.²

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

Table for Computing MPa on 4 in. x 8 in. (101.6 mm x 203.3 mm) Cylinders
Area = 0.008107 m²

Load (kN)	MPa	Load (kN)	MPa	Load (kN)	MPa	Load (kN)	MPa
45	5.55	245	30.22	445	54.89	645	79.56
50	6.17	250	30.84	450	55.51	650	80.18
55	6.78	255	31.45	455	56.12	655	80.79
60	7.40	260	32.07	460	56.74	660	81.41
65	8.02	265	32.69	465	57.36	665	82.03
70	8.63	270	33.30	470	57.97	670	82.64
75	9.25	275	33.92	475	58.59	675	83.26
80	9.87	280	34.54	480	59.21	680	83.88
85	10.48	285	35.15	485	59.82	685	84.49
90	11.10	290	35.77	490	60.44	690	85.11
95	11.72	295	36.39	495	61.06	695	85.73
100	12.34	300	37.01	500	61.68	700	86.35
105	12.95	305	37.62	505	62.29	705	86.96
110	13.57	310	38.24	510	62.91	710	87.58
115	14.19	315	38.86	515	63.53	715	88.20
120	14.80	320	39.47	520	64.14	720	88.81
125	15.42	325	40.09	525	64.76	725	89.43
130	16.04	330	40.71	530	65.38	730	90.05
135	16.65	335	41.32	535	65.99	735	90.66
140	17.27	340	41.94	540	66.61	740	91.28
145	17.89	345	42.56	545	67.23	745	91.90
150	18.50	350	43.17	550	67.84	750	92.51
155	19.12	355	43.79	555	68.46	755	93.13
160	19.74	360	44.41	560	69.08	760	93.75
165	20.35	365	45.02	565	69.69		
170	20.97	370	45.64	570	70.31		
175	21.59	375	46.26	575	70.93		
180	22.20	380	46.87	580	71.54		
185	22.82	385	47.49	585	72.16		
190	23.44	390	48.11	590	72.78		
195	24.05	395	48.72	595	73.39		
200	24.67	400	49.34	600	74.01		
205	25.29	405	49.96	605	74.63		
210	25.90	410	50.57	610	75.24		
215	26.52	415	51.19	615	75.86		
220	27.14	420	51.81	620	76.48		
225	27.75	425	52.42	625	77.09		
230	28.37	430	53.04	630	77.71		
235	28.99	435	53.66	635	78.33		
240	29.60	440	54.27	640	78.94		

IM 316
BEAM BREAKING

FLEXURAL STRENGTH OF CONCRETE

SCOPE

This test method is used for determining the flexural strength of concrete by the use of a simple beam with center-point loading.

PROCEDURE

A. Apparatus

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

B. Test Specimen

1. The test specimen shall have approximate dimensions of 6 in. x 6 in. x 20 in. (152 mm x 152 mm x 508 mm). The test specimen shall be kept wet until the time of the test.

C. Test Procedure

1. Either before or after the beam is placed in the testing machine, draw a reference line on the top and bottom of the beam, as cast, about 10 in. (250 mm), or centered, from the end of the specimen. The two reference lines should be exactly opposite each other. A line drawn across the bottom of the beam, as placed in the machine, will meet these two lines, and will be perpendicular to them. The bottom of the beam as placed in the machine will be the side of the beam as cast.

2. Insert the stirrup pins in the slots at the bottom of the stirrups to prevent the stirrups from swinging while the beam is being placed in the machine. This also assures that the support bearings are in the correct position.

3. Place the beam in the testing machine so that the two reference lines on the side of the beam are directly under the centerline of the center bearing. The maximum fiber stress during application of the load will occur in the outer fiber in the line drawn across the bottom of the beam, this line being directly under the load.

4. Rotate the micro pump handle counter-clockwise to expose the maximum number of threads, and close the loading valve on the pump.

5. Apply a small initial load, and remove the stirrup pins.

6. The load may be applied rapidly up to approximately 50 percent of the estimated breaking load with the pump handle. The final half of the loading is accomplished by turning the crank of the micro pump, at a rate that the extreme fiber stress does not exceed 150 psi (1.0 MPa) per minute. This is approximately 1200 pounds (500 kg) per minute on the test gauge.

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

8. Measure the distance from the line drawn at the center of the span to the location of the break on the bottom side of the beam as tested. If this distance exceeds 1 1/2 in. (40 mm), the test results will not be used in determining when a pavement can be opened to traffic, when forms may be removed from a structure, or when a concrete structure can be subjected to exterior loads, which produce flexure.

D. Calculations

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

2. Calculate the modulus of rupture as follows:

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

<u>Where:</u>

R = Modulus of rupture, MPa or psi.
P = Corrected load indicated, N or lb.
l = Span length, mm or in., between supports (or 18 in. or 457 mm)
b = Width of beam at point of fracture, mm or in.
d = Depth of beam at point of fracture, mm or in.

3. The typical range of modulus of rupture should be from 300 psi to 700 psi (2 MPa to 5 MPa). Report the modulus of rupture to the nearest 5 psi (0.05 MPa).

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

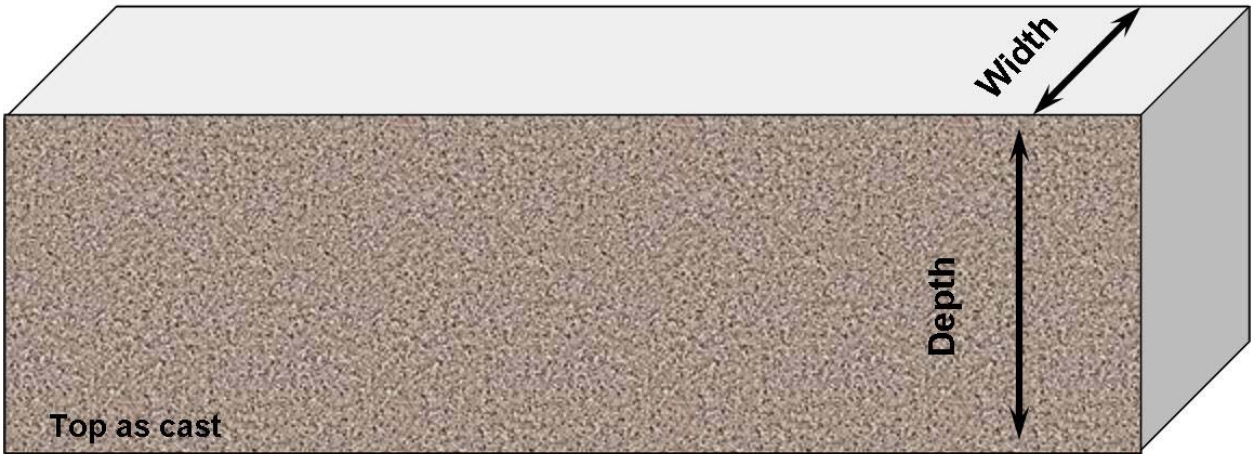


Figure 1

Figure 2. Concrete Specimen in Hydraulic Testing Machine

F. Precautions

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

Concrete Beam Coefficients - US Units

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

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

Concrete Beam Coefficients - Metic Units

	Width (mm)									
Depth (mm)	147	148	149	150	151	152	153	154	155	156
147	0.000216	0.000214	0.000213	0.000211	0.000210	0.000209	0.000207	0.000206	0.000205	0.000203
148	0.000213	0.000211	0.000210	0.000209	0.000207	0.000206	0.000205	0.000203	0.000202	0.000201
149	0.000210	0.000209	0.000207	0.000206	0.000204	0.000203	0.000202	0.000200	0.000199	0.000198
150	0.000207	0.000206	0.000204	0.000203	0.000202	0.000200	0.000199	0.000198	0.000197	0.000195
151	0.000205	0.000203	0.000202	0.000200	0.000199	0.000198	0.000196	0.000195	0.000194	0.000193
152	0.000202	0.000200	0.000199	0.000198	0.000196	0.000195	0.000194	0.000193	0.000191	0.000190
153	0.000199	0.000198	0.000197	0.000195	0.000194	0.000193	0.000191	0.000190	0.000189	0.000188
154	0.000197	0.000195	0.000194	0.000193	0.000191	0.000190	0.000189	0.000188	0.000186	0.000185
155	0.000194	0.000193	0.000191	0.000190	0.000189	0.000188	0.000186	0.000185	0.000184	0.000183
156	0.000192	0.000190	0.000189	0.000188	0.000187	0.000185	0.000184	0.000183	0.000182	0.000181
157	0.000189	0.000188	0.000187	0.000185	0.000184	0.000183	0.000182	0.000181	0.000179	0.000178

Modulus of Rupture = Total Load X Coefficient
R (MPa) = P (N) X Coefficient (mm-2)

SLUMP OF HYDRAULIC CEMENT CONCRETE

SCOPE

This procedure provides instructions for determining the slump of hydraulic cement concrete. It is not applicable to non-plastic or non-cohesive concrete, nor when the maximum size of the coarse aggregate is over 2 in. (50 mm).

SIGNIFICANCE

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

PROCEDURE

A. Apparatus

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

2. Tamping Rod. The tamping rod shall be 5/8 in. (16 mm) in diameter and approximately 24 in. (600 mm) in length, having a hemispherical tip.

3. Scoop.

4. Tape Measure or Ruler. These should have at least 1/8 in. (5 mm) gradations.

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

B. Test Procedure

1. Obtain the sample in accordance with IM 327.

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

3. Stand on both foot pieces in order to hold the mold firmly in place.

4. Fill the cone 1/3-full in volume, to a depth of 2 5/8 in. (67 mm) in depth.

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

6. Fill the cone 2/3-full in volume, to a depth of 6 1/8 in. (155 mm) in depth.

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

8. Fill the cone to overflowing.

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

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

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

12. Remove the mold from the concrete by raising it carefully in a vertical direction. Raise the mold 12 in. (300 mm) in 5 ± 2 seconds by a steady upward lift with no lateral or torsional motion being imparted to the concrete.

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

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

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

15. Measure the distance between the bottom of the rod and the displaced original center of the top of the specimen to the nearest 1/4 in. (6 mm).

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

AIR CONTENT OF FRESHLY MIXED CONCRETE BY PRESSURE

SCOPE

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

PROCEDURE

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

A. Apparatus

1. Measure bowl and cover assembly: All apparatus used shall incorporate the requirements of AASHTO Designation T-152 Section 4, for a Type B Washington-type meter.
2. Tamping Rod: 5/8 in. (16 mm) diameter, having a hemispherical tip.
3. Scoop
4. Strike-off bar
5. Rubber mallet
6. Rubber syringe or polyethylene unitary wash bottle

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

NOTE: It is recommended that a calibration be performed prior to any new pour.

1. Calibration of Apparatus
   Calibration Canisters (Plug method)
   The volume of the calibration canister should be 0.0125 ft^3 (354 ml). The effective air volume of the canister depends on the volume of the air meter being calibrated.

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

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

2. Calibration Plug Procedure

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

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

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

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

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

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

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

g. If the dial reading variation is +/- 0.2% or less from the effective air volume, repeat the test using 2 calibration canisters in the pot. If the dial reading variation is +/- 0.2% (+/-

0.25% for dials with 0.5 % graduations) or less from the effective air volume, the air meter is in proper calibration.

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

See Iowa Test Method 405 for Water Method Calibration

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

a. Fill the base with a sample of fresh concrete placing the concrete in the base in three equal layers. Rod each layer twenty-five times with the tamping rod provided with the meter. For slumps less than 1 in. (25mm), the sample may need to be consolidated by internal vibration.

b. Do not allow the rod to forcibly strike the bottom of the base while rodding the bottom layer. For each upper layer, the rod shall penetrate 1 inch (25 mm) into the underlying layer. Care should also be taken to avoid hitting the top edge of the base with the tamping rod.

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

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

e. Clamp cover on with petcocks open.

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

g. Using a rubber syringe, inject water through one petcock until all the air is expelled through the opposite petcock. Jar the base to insure removal of all air. Leave petcocks open. **<u>NOTE</u>:** Use care if injecting water through opposite petcock to not add air bubbles. When jarring the base to remove the air, the base shall not be tilted more than 2 inches (50 mm) from horizontal.

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

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

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

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

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

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

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

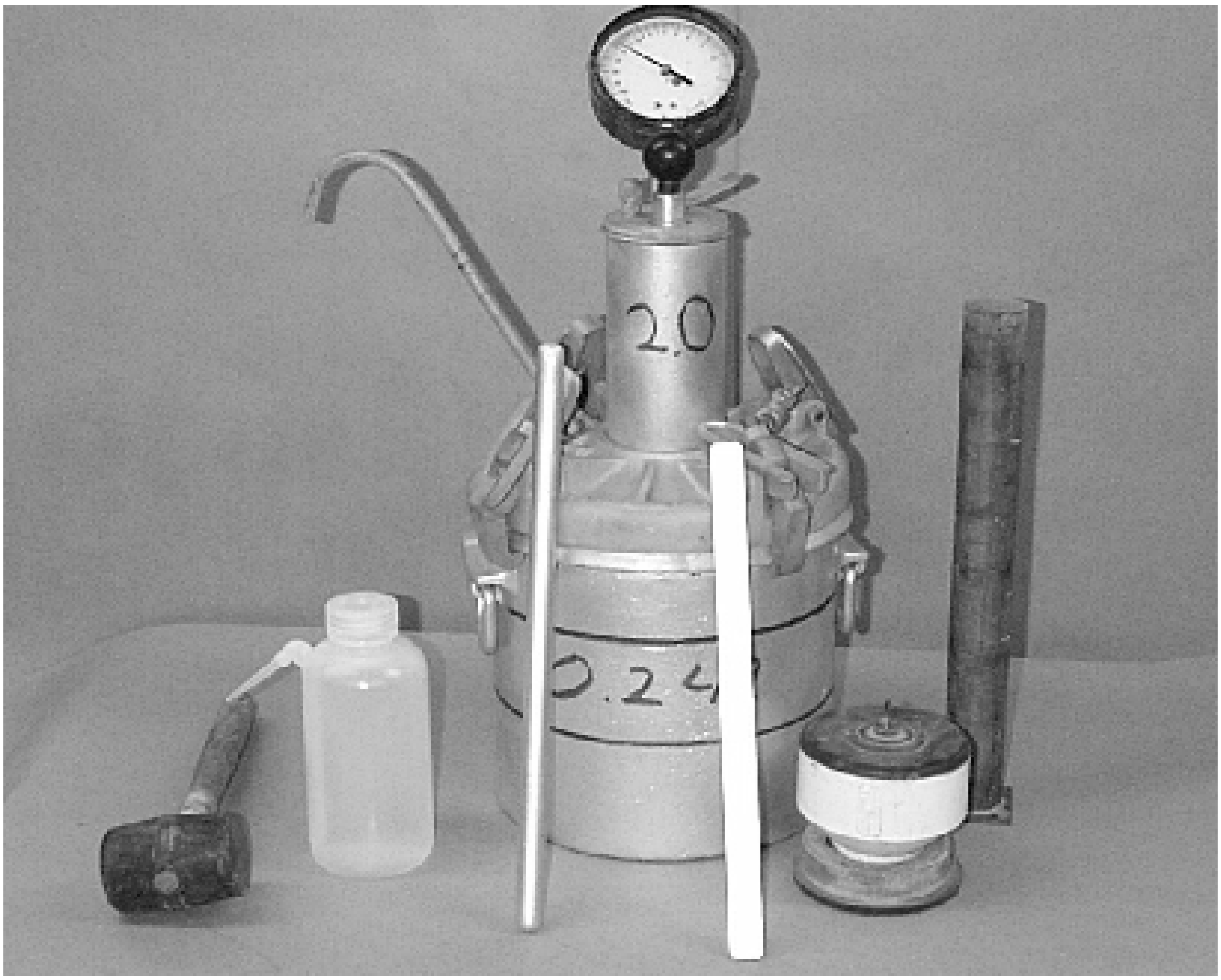
   Where:
   F_s = weight of fine aggregate in concrete test sample, lb (kg)
   S = volume of measuring bowl, ft^3 (m^3)
   B = volume of concrete produced per batch, ft^3 (m^3)
   F_b = weight of fine aggregate in the moisture condition used in batch, lb (kg)
   C_s = weight of coarse aggregate in concrete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

   <u>Example of C-3WR Mix</u>

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

   c. Mix representative samples of the coarse and fine aggregate, and place in a measuring bowl one-third full of water. Add the mixed aggregate to the bowl, introducing each scoopful in a manner which minimizes entrapped air. If necessary, add additional water to inundate the aggregate. Stir, rod and tap the sides of the bowl to eliminate entrapped air.
   d. Soak the aggregate for a time period approximately equal to the amount of time between the introduction of the water into the mixer and the time of performing the test for air content.
   e. Follow steps e, f, g, h, and i in paragraph 3. Operation of Apparatus
   f. The air content reading is the aggregate correction factor. For ease of determining plastic concrete air in the field, the aggregate correction factor will be rounded down to the nearest 0.5%.
   g. Actual concrete air content = Air meter reading - Aggregate correction factor

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



Air Meter and Calibrating Accessories

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

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

IM 327
CONCRETE SAMPLING

October 18, 2011 Matls. IM 327
Supersedes October 17, 2006

SAMPLING FRESHLY MIXED CONCRETE

SCOPE

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

SIGNIFICANCE

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

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

PROCEDURE

A. Apparatus

1. Wheelbarrow or other nonabsorbent container
2. Cover for wheelbarrow or container (plastic, canvas, or burlap)
3. Shovel
4. 5-gal. (19 L) bucket for water

B. Testing Procedure

For acceptance testing, obtain representative samples from the last practical point before incorporation, but before consolidation.

1. Sampling from Grade

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

2. Sampling from Ready Mix Truck

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

3. Sampling from Mobile Mixer

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

4. Sampling from Pump or Conveyor Placement Systems

   Sample after a minimum of 1/2 $yd.^3$ (1/2 m^3) of concrete has been discharged. Do not obtain samples until after all of the pump slurry has been eliminated. Sample by repeatedly passing a receptacle through the entire discharge system or by completely diverting the discharge into a sample container. Do not lower the pump arm from the placement position to ground level for ease of sampling, as it may modify the air content of the concrete being sampled. Do not obtain samples from the very first or last portions of the batch discharge.

5. Sampling from Concrete Slab as Placed

   Mark the approximate location of concrete placed on grade and sampled for air content. After the paver has passed the marked location, remove the sample from the slab, approximately in line with a vibrator and within an 18 in. x 18 in. (500 mm x 500 mm) square area to a depth approximately two-thirds of the pavement thickness. The sample should be obtained a minimum of 12 in. (300 mm) from the edge of slab to prevent extra handwork in maintaining the pavement edge.

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

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

MAKING, PROTECTING & CURING
CONCRETE FLEXURAL STRENGTH FIELD SPECIMENS

SCOPE

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

PROCEDURE

A. Apparatus

1. 6 in. x 6 in. x 20 in. (152 mm x 152 mm x 508 mm) beam mold. The molds provided will comply with the requirements of AASHTO T-23 for dimensions, construction, materials, smoothness and straightness.

2. Shovel (square point).

3. Rubber hammer or equivalent

4. Wood float or equivalent.

B. Test Procedure

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

1. Secure the concrete sample in accordance with IM 327, Method of Sampling Concrete for Slump, Air Content and Strength Testing. Specimens shall be molded on a level, rigid, horizontal surface as near as practicable to the place where they will be stored during the first 20 ± 4 hours. All jarring, striking, tilting or scarring (however, preliminary markings with a nail or other sharp object within 4 in. (100 mm) of the beam end will be permitted) of the specimen surface shall be avoided if moving immediately after striking off is necessary. Place the concrete in the mold in two equal layers and thoroughly spade each layer with the shovel. Use special care consolidating the sides and after spading each layer strike the sides of the form with a rubber hammer or equivalent until the spading marks are closed. Strike off the excess concrete and smooth the surface with as little manipulation of the concrete as possible. Excessive spading and smoothing must be avoided.

   When consolidating by vibration, fill concrete in one layer. Insert the vibrator at intervals not exceeding 6 in. (150 mm) along the centerline of the long dimension of the specimen, avoiding the exact center of the beam. Sufficient vibration is achieved as soon as the surface has become relatively smooth. Avoid overvibration which may cause segregation. After vibrating, strike the sides of the form with a rubber hammer 10 to 15 times to release any air bubbles that may have been trapped.

When consolidating by rodding, specimens shall receive the proper number of roddings evenly distributed per layer as indicated in the table. The bottom layer shall be rodded throughout its depth. For the upper layer, the rod shall penetrate 1 in. (25 mm) into the underlying layer. After rodding each layer, strike the sides of the form with a rubber hammer 10 to 15 times to release any air bubbles that may have been trapped.

Rod Size	No. of Layers	No. of Roddings per Layer
5/8 in. (16 mm)	2	60

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

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

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

5. Assign a chronological number, which corresponds with the day the beam was made to each beam. Begin with number 1. When more than one beam is made on a given day use capital letters A, B, C, etc., following the number which identifies the day to identify the daily making sequence. When two or more mixers are operated on separate sections of a project use a separate letter identification preceding the number assigned to the beams made from each respective mixer. Clean the beam and mark the numbers on the smooth bottom of the beam as cast. The numbers should be neatly made, and should be 4 to 8 inches (100 to 200 mm) from the end of the beam. When freshly marked specimens are being placed in storage, cover the marked section with a small board to keep the sand out of the marking.

6. Store the specimens in a wetted sand filled pit of adequate size to accommodate all specimens made on the project or in lime saturated water. A pit 4' x 6' x 18" (1.2 m x 1.8 m x 0.5 m) is normally adequate. Place the specimens on a reasonable smooth bed of sand and cover them completely with additional sand. If the temperature in the sand-filled pit drops below 40°F (4°C) remove the specimens and place them under wetted burlap in a heated enclosure or in lime saturated water. Maintain the specimens in a <u>continually wet</u> condition, and above 40°F (4°C) until they are tested. **<u>NOTE:</u>** Lime-saturated water is prepared by mixing 1 teaspoon (12 g) of hydrated lime with 1 gallon (3.8 liters) of water. Hydrated lime should be a minimum of 90 percent calcium hydroxide (CaOH).

Concrete Beam Mold

IM 340
WEIGHT, YIELD, AIR

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

SCOPE

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

SIGNIFICANCE

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

PROCEDURE

A. Apparatus

1. Measure: May be the base of the air meter used for determining air content from IM 318. Otherwise, it shall be a metal container meeting the requirements of AASHTO T-121. The capacity and dimensions of the measure shall conform to those specified in Table 1.
2. Balance or scale: Accurate to 0.3 percent of the test load at any point within the range of use.
3. Tamping Rod: 5/8 in. (16 mm) diameter, having a hemispherical tip.
4. Vibrator: 7000 vibrations per minute, 0.75 in. to 1.50 in. (19 mm to 38 mm) in diameter, at least 3 in. (75 mm) longer than the section being vibrated for use with low slump concrete.
5. Scoop
6. Strike off bar
7. A glass or acrylic strike off plate at least 1/2 in. (12 mm) thick, with a length and width at least 2 in. (50mm) greater than the diameter of the measure The edges of the plate shall be straight and smooth within tolerance of 1/16 in. (1.5mm).
8. Rubber Mallet

Table 1
Dimensions of Measures

Capacity M^3 (ft. ^{3})	Inside Diameter mm (in.)	Inside Height mm (in.)	Minimum Thickness mm (in.) Bottom	Minimum Thickness mm (in.) Wall	Nominal Maximum Size of Coarse Aggr. mm(in.)
0.0071	203 ± 2.54	213 ± 2.54	5.1	3.0	25
(1/4)	(8.0 ± 0.1)	(8.4 ± 0.1)	(0.20)	(0.12)	(1)

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

B. Calibration of Measuring Bowl

1. Determine the weight of the dry measure and strike-off plate.

2. Fill the measure with water at a temperature between 16ºC and 29ºC (60ºF and 85ºF) and cover with the strike-off plate in such a way as to eliminate bubbles and excess water.

3. Wipe dry the measure and cover plate, being careful not to lose any water from the measure.

4. Determine the weight of the measure, strike-off plate, and water in the measure.

5. Determine the weight of the water in the measure by subtracting the weight in Step 1 from the weight in Step 4.

6. Measure the temperature of the water and determine its density from Table 2, interpolating as necessary.

7. Calculate the volume of the measure, V_m, by dividing the weight of the water in the measure by the density of the water at the measured temperature, from Table 2.

Example: $V_m = \frac{15.57}{62.274}$ $\quad V_m = 0.250 \text{ ft.}^3$

Table 2
Unit Weight of Water
15ºC to 30ºC

ºC	**(ºF)**	**kg/m³**	**(lb./ft. ³)**	**ºC**	**(ºF)**	**kg/m³**	**(lb./ft. ³)**
15	(59.0)	999.10	(62.372)	23	(73.4)	997.54	(62.274)
15.6	(60.0)	999.01	(62.366)	23.9	(75.0)	997.32	(62.261)
16	(60.8)	998.94	(62.361)	24	(75.2)	997.29	(62.259)
17	(62.6)	998.77	(62.350)	25	(77.0)	997.03	(62.243)
18	(64.4)	998.60	(62.340)	26	(78.8)	996.77	(62.227)
18.3	(65.0)	998.54	(62.336)	26.7	(80.0)	996.59	(62.216)
19	(66.2)	998.40	(62.328)	27	(80.6)	996.50	(62.209)
20	(68.0)	998.20	(62.315)	28	(82.4)	996.23	(62.192)
21	(69.8)	997.99	(62.302)	29	(84.2)	995.95	(62.175)
21.1	(70.0)	997.97	(62.301)	29.4	(85.0)	995.83	(62.166)
22	(71.6)	997.77	(62.288)	30	(86.0)	998.65	(62.156)

C. Testing Procedure

NOTE: There are two methods of consolidating the concrete – rodding and vibration. If the slump is greater than 3 in. (75 mm), consolidation is by rodding. When the slump is 1 to 3 in. (25 to 75 mm), internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For slumps less than 1 in. (25 mm), the sample may be consolidated by internal vibration.

1. Determine the weight of the dry measure.
2. Obtain the sample in accordance with IM 327. Testing may be performed in conjunction with IM 318. When doing so, this test should be performed prior to IM 318. **NOTE:** If the two tests are being performed using the same sample, this test shall begin within five minutes of obtaining the sample.
3. Dampen the inside of the measure.
4. Fill the measure approximately 1/3-full with concrete.
5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.
6. Tap the sides of the measure smartly 10 to 15 times with the mallet to close voids and release trapped air.
7. Add the second layer, filling the measure about 2/3-full.
8. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 1 in. (25 mm) into the bottom layer.
9. Tap the sides of the measure smartly 10 to 15 times with the mallet.

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

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

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

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

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

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

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

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

D. Calculations

Unit Weight (density) – Calculate the net weight, W_3, of the concrete in the measure by subtracting the weight of the measure, W2, from the gross weight of the measure plus the concrete, W1. Calculate the density, ρ, by dividing the net weight, W_3, by the volume, V_m, of the measure as shown below.

$$W_1 - W_2 = W_3 \qquad \text{Example: } 42.8 - 7.6 = 35.2 \text{ lb.}$$

$$\rho = \frac{W_3}{V_m} \qquad \underline{\text{Example}}: \ \rho = \frac{35.2 \text{ lb.}}{0.249 \text{ cu. ft.}} = 141.37/\text{cu.ft.}$$

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

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

	Weight	SpGr	Abs. Vol.	Example Abs. Vol. Calc.
Cement	477	3.14	0.090	= 477/(3.14 x 62.4 x 27)
Fly Ash	84	2.68	0.019	
Total Water	220	1.00	0.131	(Plant, aggr., grade)

Fine	1246	2.65	0.279	Aggregate, SSD Dry Batch Weights
Intermediate	364	2.57	0.084	
Coarse	1451	2.57	0.335	
Total	3842		0.938	

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

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

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

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

$$A = \frac{T - \rho}{T} \times 100$$

Example: $$A = \frac{151.7 \text{ lbs./cu. ft.} - 141.37 \text{ lbs./cu. ft.}}{151.7 \text{ lbs./cu. ft.}} \times 100 = 6.8\%$$

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

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

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

$$Y = \frac{W_1 \div 27}{\rho}$$

Example: $$Y = \frac{3842 \text{ lbs. batched per cu. yd.} \div 27}{141.37 \text{ lb./cu. ft.}} = 1.007 \text{ cu. yd.}$$

MEASURING LENGTH OF DRILLED CONCRETE CORES

SCOPE

This method covers the procedure for determining the length of a core drilled from a PC Concrete structure, particularly from a PC Concrete pavement. The procedure is a modification of AASHTO T 148.

PROCEDURE

A. Apparatus

1. The apparatus consists of a calipering device that will measure the length of axial elements of the core.

2. The apparatus is designed so the specimen is held with its axis in a horizontal position by guide rods when making circumferential measurements, and a stand placed upon the guide rods for making a center measurement. The device is equipped with an auxiliary wheel that rests on the specimen and is calibrated such that one-half of a revolution of the wheel represents one-eighth the circumference of a 4 in. (100 mm) diameter core.

3. The device is constructed so the specimen is brought into contact with a single flat-faced probe 3/8 in. (10 mm) in diameter mounted on a fixed end of the device.

4. The measuring rod, which makes contact with the end surface of the specimen, is rounded to a radius of 1/8 in. (3 mm) and is mounted on a moveable plate, which in turn is mounted on guide rods. One guide rod is provided with a scale on which the length readings are made. The graduations of the scale are spaced at 0.10 in. (2.5 mm) intervals.

5. The apparatus provides for the accommodation of specimens of different nominal lengths over a range of 4 to 11 in. (100 mm to 275 mm).

6. The calipering apparatus is designed so it is possible to make a length measurement at the center of the specimen and at eight additional points spaced equally along the circumference of a circle whose center point coincides with the end area of the specimen and whose radius is not less than one-half, nor more than three-fourths, of the radius of the specimen.

7. The apparatus is stable and sufficiently rigid to maintain its shape and alignment without a distortion or deflection of more than 0.01 in. (0.25 mm) during all normal measuring operations.

B. Test Specimens

1. Cores used as specimens for length measurement must be in every way representative of the concrete in the structure from which they are removed. The specimen is to be drilled with the axis normal to the surface of the structure, and the ends must be free from all conditions not typical of the surfaces of the structure. A large screwdriver, hammer and wire brush may be used to force subbase material from the bottom of the core. Use enough force to remove the material, but not cause damage to the core. If the material is firmly cemented, or encased in mortar, it may not be possible to remove. (Figures 2 and 3) Cores that show abnormal defects or that have been damaged appreciably in the drilling operation should not be used.

C. Test Procedure

1. Before any measurements of the core length are made, calibrate the apparatus with suitable gauges so errors caused by mechanical imperfections are known. When these errors exceed 0.01 in. (0.25 mm), suitable corrections must be applied to the core length measurements.

2. Place the stand on the guide rods and place the specimen on the stand for the center point measurement. The smooth end of the core, that is, the end that represents the upper surface of a pavement slab or a formed surface in the case of other structures is to be positioned facing the fixed end of the measuring device. Bring the specimen into contact with the stud in the fixed end, slide the movable plate until it is in contact with the specimen and record the length.

3. Remove the stand, place the specimen directly on the guide rods and make another measurement as described in C2.

4. Place the small auxiliary wheel on the specimen so the scribed marks on the wheel are in alignment. Rotate the specimen until the marks are again in alignment (1/2 revolution of the wheel) and make another measurement. Continue in this manner until eight measurements in addition to the center measurements have been made.

5. Read each of the nine measurements directly to 0.10 in. (2.5 mm), and interpolate to the nearest 0.05 in. (1 mm) by estimation.

6. If, in the course of the measuring operation, it is discovered that at one or more of the eight circumferential measuring points the surface of the specimen is not representative of the general plane of the core end because of a small projection or depression, rotate the specimen slightly about its axis, and make another set of measurements with the specimen in the new position. If the center measurement is not representative of the general plane of the core end, it should not be used in computing the length of the core.

7. If some damage from drilling is apparent, no measurements are to be made in the damaged area. Reposition the core to avoid the areas when measuring the length. If these areas cannot be avoided, the length measurements made in these areas are not

to be used in computing the length of the core. In no case, are fewer than seven measurements to be used in determining the core length.

D. Report

1. The individual observations are to be recorded to the nearest 0.05 in. (1 mm) and the average of the nine measurements expressed to the nearest 0.05 in. (1 mm) and shall be reported as the length of the concrete core.

E. Precautions

1. Be careful to move the core away from the stud in the fixed end slightly when turned, so the stud will retain its proper length and shape.

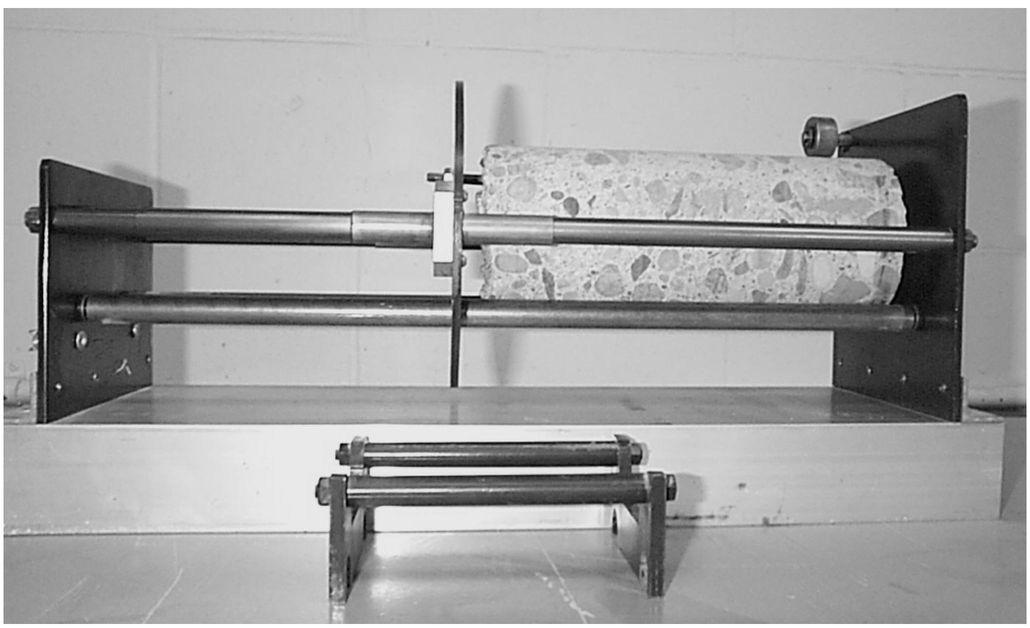


Figure 1. Concrete Core in Measuring Apparatus

Figure 2. Concrete core with granular subbase attached.

Figure 3. Concrete core with granular subbase removed.

DETERMINING FLOW OF GROUT MIXTURES
(FLOW CONE METHODS)

SCOPE

This method of test covers the procedure to be used both in the laboratory and in the field for determining the flow of grout mixtures by measuring the time of efflux of a specified volume of grout from a standardized flow cone.

The procedure is a modification of ASTM C939 and D6449.

APPARATUS

1. Flow cone as specified in ASTM C939 with a 1/2 inch (12.7 mm) orifice for flowable mortar (See Figure 1).
2. Flow cone as specified in ASTM D6449 with a 3/4 inch (19 mm) orifice for concrete grout for fabric formed concrete revetment.
3. Stopwatch accurate and readable to 0.2 seconds
4. Level
5. Calibration jug or container to hold a quantity of water equal to 2 qt. (1725 mL)

CALIBRATION OF CONE

1. The flow cone shall be firmly mounted in such a manner that the top will be level and the cone free from vibration (use level, rigid, horizontal surface).
2. Level the cone by adjusting the mounting forks.
3. Close the discharge tube of the cone by placing a finger over the lower end. (Be sure not to disturb the leveled cone.)
4. Introduce 1725 ± 1 mL of water into the cone.
5. Adjust the pointer so that the point just comes into contact with the water.
6. Start the stopwatch and remove the finger simultaneously. Stop the stopwatch when the flow stops. The elapsed time should be 8.0 +/- 0.5 seconds for the ½ inch orifice and 4.0 +/- 0.5 seconds for the 3/4 inch orifice.

SAMPLE

The test sample shall consist of 1725 ± 1 mL of grout.

PROCEDURE

1. Select the flow cone with the proper flow opening. A flow cone with a 1/2 inch (12.7 mm) orifice is for flowable mortar (ASTM C939). A flow cone with a 3/4 inch (19 mm) orifice is for concrete grout for fabric formed concrete revetment (ASTM D6449).

2. Moisten the inside surface of the flow cone.

3. Place a finger over the discharge opening.

4. Introduce grout into the cone until the grout surface rises into contact with the pointer.

5. Start the stopwatch and remove the finger simultaneously.

6. Stop the stopwatch at the first break in the continuous flow of grout from the discharge opening (when the cone is essentially empty).

7. Read time of efflux of the grout (which is the time indicated by the stopwatch).

   NOTE 1: If there is a break in the continuity of discharge prior to essential emptying of the cone, it is an indication that the grout is too thick to be properly tested for flow.

   NOTE 2: For the ½ inch orifice, if the sand used in the grout mixture is larger than No. 4 (4.75 mm) in size, then the sample should be sieved through a No. 4 (4.75 mm) sieve cloth prior to being introduced to the flow cone.

REPORT – (See Figure 2 for an Example.)

1. Average time of efflux to the nearest second.

2. Composition of the sample

3. Information and observation of the physical characteristics of the sample

FIGURE 1

Grout Flow Cone

FIGURE 2

IOWA DOT DISTRICT 1 LAB
FLOWABLE MORTAR

LAB NUMBER: 1AS4:008
PROJECT NUMBER: CONTRACT NUMBER:
COUNTY: POLK DESIGN:
CONTRACTOR:
MATERIAL: FINE SAND
SOURCE: HALLETT-JOHNSON
UNIT OF MATERIAL: CEMENT-LAFARGE, FLYASH-COUNCIL BLUFFS
QUANTITY: 50 LB BAG
PRODUCER: GNA CONCRETE
SAMPLED BY: SENDER'S NUMBER
DATE SAMPLED: 5/12/04 DATE RECEIVED: 5/12/04 DATE REPORTED: 5/14/04

SIEVE SIZE	PERCENT PASSING
3/8"	100
#4	99
#8	92
#16	78
#30	44
#50	8.2
#100	0.9
#200	0.5

DISPOSITION: COMPLIES WITH THE FOLLOWING PROPORTIONS: 400 LBS. FLYASH, 100 LBS. CEMENT, 2600 LBS. SAND. FLOWABILITY OF 16 SEC OBTAINED WITH 68 GAL/YD³ H20.

COPIES: DISTRICT 1
DISTRICT 1 MATERIALS LAB
OFFICE OF MATERIALS
S. TWOHEY
J. HART
OFFICE OF CONSTRUCTION
GNA CONCRETE

SIGNED: JOHN HART
MATERIALS ENGINEER

ESTIMATE OF PORTLAND CEMENT CONCRETE STRENGTH BY MATURITY METHOD

GENERAL

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

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

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

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

THE MATURITY CONCEPT

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

$$M\ (^{o}C \times hours) = \sum [(T - T_0)\ \Delta t]$$

Where M is the maturity in ^{o}C-hours [M is also termed the time-temperature factor (TTF)], Δt is the time interval in hours (or days), T is the average concrete temperature during the time interval Δt, and T_0 is the datum temperature at which concrete ceases to gain strength with time. The value of $T_0 = 14^{o}F\ (-10^{o}C)$ is most commonly used. As a result, Equation 1 becomes:

$$M\ (^{o}C \times hours) = \sum [(T + 10)\ \Delta t] \quad \text{Equation 2}$$

EQUIPMENT

- 12 - 6 in. x 6 in. x 20 in. (152 mm x 152 mm x 508 mm) beam molds
- 1 each shovel (square point), rubber hammer or equivalent, and wood float or equivalent
- Hydraulic testing machine – center point loading flexural
- Maturity meter – a device that automatically measures, records, and displays the maturity (TTF) value
- Hand-held thermometer - a temperature measuring device with a thermocouple wire or probes readable to the nearest 0.1°C and accurate to 1°C.
- Temperature data logger – a device that measures temperature and electronically stores the readings a minimum of once per hour

ESTABLISHMENT OF MATURITY-STRENGTH RELATIONSHIP - MATURITY CURVE

To establish a maturity-strength relationship for a concrete mix, a maturity meter and a hydraulic testing machine are needed. The following procedure shall be used: **(NOTE: Before using any maturity meter, check to be sure the datum temperature is set to -10°C.)**

1. Cast a minimum of twelve (12) 6 in. x 6 in. x 20 in. (152 mm x 152 mm x 508 mm) beams, as per IM 328. Test the entrained air content and slump of the concrete being used to cast the beams, as per IM 327. Record these values. The concrete shall meet specifications, with a minimum air content of 5.5%. Since there is a direct relationship between w/c ratio and strength, the concrete used to develop the maturity-strength relationship shall be at the maximum w/c ratio expected during production. The beams shall be cast from a batch of at least $3m^3$ (3 cu. yd.).

2. Embed a thermocouple wire near each end of a test beam (when flexural strength is to be determined) to monitor the temperature. This beam will be the last to be tested. A probe shall be inserted near each beam end to the approximate mid-depth and such that they are approximately 3 in. (75 mm) from each side and each end. Loop the wire around the beam box handles to prevent the wire from being inadvertently pulled out of the beam. The average of the two readings will be used in the development of the maturity-strength curve. A maturity meter shall be used to develop the curve. A temperature data logger may be used to develop the curve and the maturity (TTF) shall be calculated from hourly readings.

3. Cast, cure, and test the beams at the plant site. Test strength in accordance to IM 316. This will allow a maturity meter to be protected from the weather and theft. The meter can be stored in a lab trailer or vehicle with the probes run outside to the beam in the sandpit. The beams shall be covered with plastic immediately after casting and prior to form removal. If possible, wet burlap should be placed over the surface of the beams under the plastic. The forms shall be removed the following day. All beams shall be cured, buried in a pit of wet sand after form removal, until they are tested. Beams may be cured in a saturated lime tank, only if the water temperature is controlled at 60 to 80 °F (16 to 27°C).

   Precaution: When the concrete temperature is below 50°F (10°C), maturity strength development will cause over extended maturity (TTF) values. Development of strength maturity relationship should be performed on concrete with temperatures above 50°F (10°C).

When air temperatures are expected to fall below 40°F (4°C), place the beams on a piece of foam board or plywood to prevent the cold ground from lowering beam temperatures. Placing insulation over the beams to retain heat may also be warranted.

4. Determine maturity (TTF) and strength values at four different ages. Test three specimens for strength at each age and calculate the average strength at each age. The maturity (TTF) value shall be calculated from a temperature reading at the time the specimen is tested for strength. The tests shall be spaced such that they are performed at somewhat consistent intervals of time and span a range in strength that includes the opening strength desired. Ideally, there would be at least two sets of strength values below the opening strength. For Class C or QMC mixtures, the first set of beams will typically be tested at an age of approximately 12 to 16 hours, depending on concrete temperature. Test age may need to be increased when concrete temperature is below approximately 50 °F (10°C) or decreased at higher temperatures above approximately 85 °F (29°C). The average strength of the first set of beams must be less than 425 psi (2.93 MPa) for the curve to be valid.

   If the maturity curve is intended for use in determining the time to begin joint sawing, additional test specimens will need to be cast and strength testing must begin at lower maturity values.

   For pavements, a minimum flexural strength of 3.45 MPa (500 psi) is required for opening. (See Article 2301.03) For structural concrete, a minimum flexural strength of 3.95 MPa (575 psi) is required before forms may be removed and concrete may be subjected to flexural loading. Strength requirements vary for determining when forms for roofs of culverts may be removed (See Article 2403.0). Testing intervals may need to be increased over those for paving.

   For structural concrete where compressive strength of 4500 psi or greater is required, develop a maturity curve utilizing cylinders for compressive strength. Ensure the last set of cylinders is greater than the required design strength. Cast a minimum of 15 cylinders and place probes in two of the cylinders. Test a set of three cylinders at each age of 1, 3, 7, 14, and 28 days (or earlier if already above design strength). This maturity curve may be utilized for other units with lower compressive strength requirements

5. Plot the measured strength against the corresponding values of maturity at different ages, as determined by the maturity meter or by hand methods. Use the spreadsheet provided by the District Materials Concrete Technician to determine maturity-strength relationship. The maturity (TTF) value corresponding to the required opening strength shall be used to determine when the pavement or structure may be loaded. An example of the Maturity-Strength Development form, generated by the computer program, is included at the end of this IM. This form shall be reviewed by the DME. Copies will be provided to the Project Engineer, DME, Concrete Materials Engineer, and the contractor.

FIELD MATURITY (TTF) PROCEDURE – ESTIMATE IN PLACE CONCRETE STRENGTH

Placement of the Temperature Probes

Strip the coating from each end of the two wires and twist the ends together before inserting them into the fresh concrete.

Pavements

For pavements, insert the temperature probe into the concrete until the end is at approximately the pavement mid-depth and 1.6 feet (0.5 m) from the edge of the pavement. The wire ends are the points at which the temperature measurement is taken. Insertion may be accomplished by attaching the wire ends to a wooden dowel and embedding it into the slab. Check to ensure the concrete is consolidated around the dowel. The portion of the dowel that protrudes above the pavement should be cut or broken off after the testing is completed.

Probes may be placed at any point along the pavement slab. A minimum of two probes shall be placed in each day's placement with one at the end of the days run. On days when there is a large difference between daytime high temperatures and nighttime low temperatures, placing additional probes near the beginning of the day's run and at a point near the midday location provides useful information. The concrete placed during the middle of the day can gain strength faster than the concrete placed at the beginning of the day because of daytime heating. Place probes at side roads, or other locations, where opening to traffic is critical.

Structures

For structures, a minimum of two probes shall be attached to the reinforcing steel near the edge at the upper corner of the exposed surface. (See Figure 1 at the end of this IM.) The probe should be wrapped around the rebar and taped with approximately 1 to 2 inches (25 to 50 mm) extending below the rebar to prevent the probe from damage and removal during concrete placement. The rebar should also be taped 2 to 3 inches (50 to 75 mm) on both sides of the probe location to prevent contact with the reinforcing steel. (See Figure 2 at the end of this IM.)

Temperature Data Collection and Maturity (TTF) Calculation

Handheld thermometers (Pavements)

Typically, a handheld thermometer is used to collect temperature readings for pavements. The probe wire ends, extending out from the concrete, may be connected to a plug. A plug with thermocouple wires and clips attached to the handheld thermometer may also be used to connect to the wires extending from the concrete. Be careful to connect the copper wire to the copper plug prong (+).

Once the wires are placed, an initial temperature of the concrete shall be taken and recorded. Temperature readings should be taken in the morning and late afternoon as a minimum for standard A, B and C mixtures. For the fast-setting mixtures, readings should be taken every few hours, depending on weather conditions and mixture.

A Maturity Data Recording Sheet, provided at the end of this IM, may be used to record the temperature readings and calculate the maturity values.

A continuous temperature data logger is required for monitoring structures. The maturity value shall be calculated based on hourly readings obtained from the device. The device may also be used for monitoring pavements.

If a maturity meter is being used to monitor either pavements or structures, it should be connected to the probe as soon as possible to begin data collection. The maturity (TTF) value may be read directly from the maturity meter. Some maturity meters are not moisture proof and will be permanently damaged if not protected from water or moisture.

A Level I PCC technician shall place probes, perform all calculations, and submit forms to the Engineer. The Level I PCC technician may supervise other personnel to obtain temperature readings or read maturity values.

Implementation

For pavements, it is the intent of the procedure to use the maturity method to open the pavement to traffic from the very first day of paving, including the days of development of new curves.

Pavement placed on the first day during development of the strength-maturity curve may be opened when either of the following criteria has been met:

1. The TTF of the slab meets or exceed the opening TTF as determined by the strength-maturity curve being developed.

2. At a particular test age, the average strength of the three beams used for development of the strength-maturity curve meets or exceeds the required opening strength.

For structures, since maturity is to be used on units exposed to flexural loading, the maturity curve should be developed early in the project during placement of concrete exposed to compressive stress. If this is not possible, concrete placed on the same day as development of the strength-maturity curve may be loaded at a particular age using either of the first day placement criteria required for pavements.

Curve Validation

A curve validation is required once every 30 calendar days during normal plant production. If the plant has not supplied concrete to the project for a period of greater than 30 days, the curve must be validated prior to continued use The validation tests shall be conducted to determine if concrete strength is being represented by the current maturity curve. Cast and cure three (3) beams using the same procedure and manner as used to develop the current maturity curve. Test all three beams as close as possible to the maturity value determined to represent the opening strength of the pavement or the flexural loading strength or form removal strength of the structure.

Pavements

For pavements, if the average calculated strength value at the TTF the validation beams were tested is within the range of $\pm$50 psi (0.34 MPa) of the original curve, the original curve shall be considered validated.

Structures – compressive strength up to 4000 psi

For structures, if the average calculated strength is greater than the original curve at the TTF the validation beams were tested, the original curve shall be considered validated.

Structures – compressive strength 4500 psi or greater

A curve validation is required once every two weeks during placement of concrete with compressive strength requirement of 4500 psi or greater. If the average calculated compressive strength is greater than the original curve represented by the cylinders tested, the original curve shall be considered validated.

An example of the Validation of the Maturity Curve is included at the end of this IM. Copies shall be provided to the RCE, DME, and the contractor.

This validation procedure is a check to ensure the mix is basically the same as originally tested. If the test results indicate a new curve must be developed, this should be done in a timely manner. The curve currently being used shall be continued until new beams can be cast and at that point the implementation procedure described above shall be followed.

Factors Requiring a New Curve

Changes in material sources, proportions, and mixing equipment all affect the maturity value of a given concrete mixture. Development of a new maturity curve due to material source or proportion changes in a concrete mix may be waived by use of the validation procedure.

The following will require a new curve to be developed:

- The validation beams tested meet either of the following conditions:
    - For pavements, the average calculated strength at the TTF tested is below the minimum range (-50 psi (-0.34 MPa)) of the original maturity curve.
    - For structures, the average calculated strength at the TTF tested is lower than the original maturity curve.

- The w/c ratio of the production concrete exceeds the w/c ratio of the concrete used to develop the strength-maturity curve by more than 0.02.

Maturity Meter Calibration

Maturity meters shall be calibrated yearly to ensure proper temperature sensing. The calibration may be performed at the Central Laboratory, before the start of each construction season. To ensure accurate temperature measurement, the maturity meter should also be checked periodically against a certified thermometer or other calibrated meter. Some maturity meters may need to be sent to the manufacturer for calibration.

Maturity - Field Data

Project : FM-CO74(68)--55-74
County : Palo Alto
Contractor: Cedar Valley

Date Placed: 8/12/2009
Mix: C-3WR-C20
Certified Tech: John Smith ANE999

Maturity Curve #: CV-2

TTF Required for Opening or Loading : 1464

SITE 1 *Section of Pavement for Opening or Structural Unit for Loading by Maturity* 1 **Probe #** 2

Structual Unit or Probe Location From: 629+40 **Probe Location To:** 654+25

Date *Enter*	Time *Enter*	Age (hours) *Enter*	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
08/12/09	09:00 AM	0.00	22	0	0	
	01:00 PM	4.00	29	142	142	25
	05:30 PM	8.50	25	167	309	25
08/13/09	08:00 AM	23.00	19	464	773	19
	05:30 PM	32.50	22	290	1062	21
08/14/09	09:00 AM	48.00	21	488	1551	20

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: 1551 **Value in box should be greater than or equal to required TTF.**

SITE 2 *Section of Pavement for Opening or Structural Unit for Loading by Maturity* **Probe #**

Structual Unit or Probe Location - From: **To Probe Location:**

Date *Enter*	Time *Enter*	Age (hours) *Enter*	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
		0.00		0	0	

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: **Value in box should be greater than or equal to required TTF.**

cc: RCE

8/21/2010

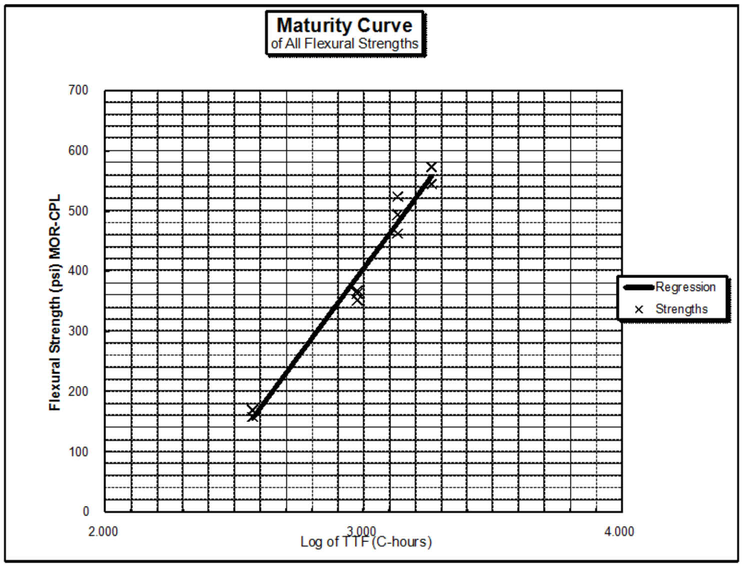
MATURITY - STRENGTH DEVELOPMENT MOR-CPL

COUNTY: Palo Alto
CURVE #: CV-2
PROJ. #: FM-CO74(68)--55-74
MONITOR: Berven
REP/CONTRACTOR: Cedar Valley Corp
PLANT LOCATION:
INSPECTOR: Busta NE720
DATE: 07/02/09

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH CPL (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	BEAM TEMP (AVG)
	Enter	*Enter*	*Enter*	*Enter*	*Enter*			*Enter*	*Enter*	*Enter*		*Enter*
1	1200	1270	0.25	6.05	6.00	0.123967	157	11.5	362	383	373	18
2	1300	1370	0.5	6.10	6.00	0.122951	168	11.5	362	383	373	18
3	1300	1370	0.25	6.05	6.00	0.123967	170	11.5	362	383	373	18
4	2900	2950	0.25	6.10	6.00	0.122951	363	35	940	955	948	18
5	2800	2840	1	6.05	6.00	0.123967	352	35	940	955	948	18
6	2950	2990	0	6.10	6.00	0.122951	368	35	940	955	948	18
7	3700	3760	0.75	6.10	6.00	0.122951	462	45	1355	1355	1355	25
8	4000	4050	0.75	6.15	6.00	0.121951	494	45	1355	1355	1355	25
9	4000	4050	0.75	6.10	5.85	0.129337	524	45	1355	1355	1355	25
10	4600	4630	0.5	6.05	6.00	0.123967	574	59	1843	1824	1834	20
11	4400	4430	0	6.10	6.00	0.122951	545	59	1843	1824	1834	20
12	4200	4240	0.25	6.05	5.75	0.134981	572	59	1843	1824	1834	20

MIX INFORMATION	*Enter*
AIR:	8.7
SLUMP:	3
w/c:	0.455
MIX:	C-3WR-C20
FLY ASH SOURCE:	C. Bluffs FA004C
GGBFS SOURCE:	
CEMENT SOURCE:	Holcim I PC301
COARSE AGGREGATE SOURCE:	Gilmore City A76004
INTERM. AGGREGATE SOURCE:	
FINE AGGREGATE SOURCE:	Emmetsburg A74502
WATER REDUCER BRAND:	WRDA82
Add. Rate:	3.5 CWT
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	6.0 oz/yd3
METHOD OF DEVELOPMENT:	Maturity Meter
Desired Flexural Strength (MOR-CPL):	500 psi

REQUIRED TTF: **1464**



Contractor Certified Technician- R. Busta ***Cert. #-*** NE520

Maturity Curve Reviewed - W. Dotzler
District Materials Engineer

Comments:

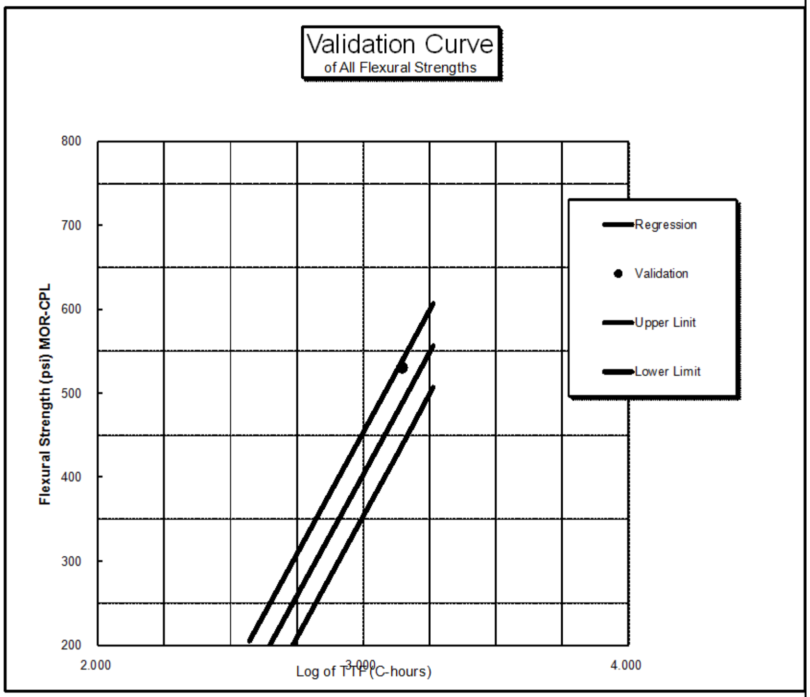
cc: RCE, DME, Contractor

VALIDATION OF MATURITY CURVE

CURVE #: CV-2
PROJ. #: FM-CO74(68)--55-74
MONITOR: Berven
CONTRACTOR: Cedar Valley Corp
INSPECTOR: Busta NE720
Validation DATE: 8/5/2009

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF
	Enter	*Enter*	*Enter*	*Enter*	*Enter*			*Enter*	*Enter*	*Enter*	
1	4200	4250	0.25	6.05	6.00	0.123967	527	38	1400	1390	1395
2	4250	4280	0	6.05	6.00	0.123967	531	38	1400	1390	1395
3	4300	4320	0.5	6.05	6.00	0.123967	536	38	1400	1390	1395

AIR: 8 *Enter*
SLUMP: 2.75 *Enter*
w/c: 0.45 *Enter*
MIX: C-3WR-C20
FLY ASH: C. Bluffs FA004C
GGBFS: 0
CEMENT: Holcim I PC301
COARSE AGGREGATE: Gilmore City A76004
INTERM. AGGREGATE: 0
FINE AGGREGATE: Emmetsburg A74502
WATER REDUCER: WRDA82
Add. Rate: 3.5 CWT
AIR ENTRAINER: Daravair 1400
Add. Rate: 6.0 oz/yd3
Method of Development: Maturity Meter
REQUIRED TTF: **1464**



CURVE VALIDATION

TTF @ Break	1395
Beam 1 MOR (psi)	527
Beam 2 MOR (psi)	531
Beam 3 MOR (psi)	536
Beam Avg. MOR (psi)	531

Calculated psi @ TTF	488	**Range**		
		Minimum	438	***Curve Validation***
				OK Within Range
		Maximum	538	

Comments:
Validation strength above the upper limit does not require a new curve.

Contractor Certified Technican - R. Busta NE520

Maturity Curve Validation Reviewed - W. Dotzler
District Materials Engineer

cc: RCE, Contractor

MATURITY.XLS
Aug-10

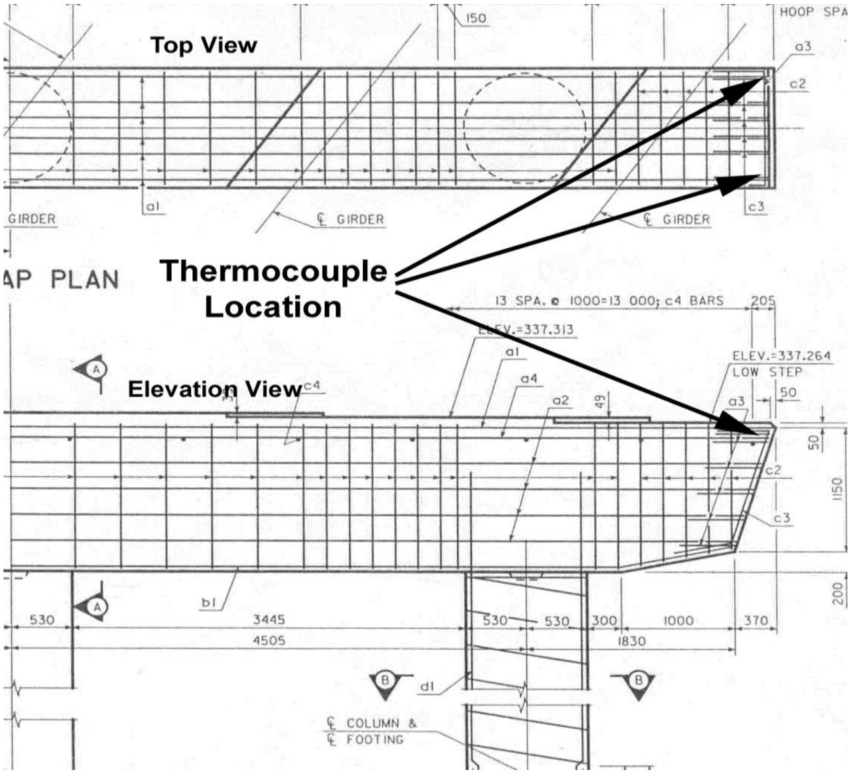


Figure 1. Typical thermocouple location placement in pier cap Use similar method for thermocouple placement in other structural elements.

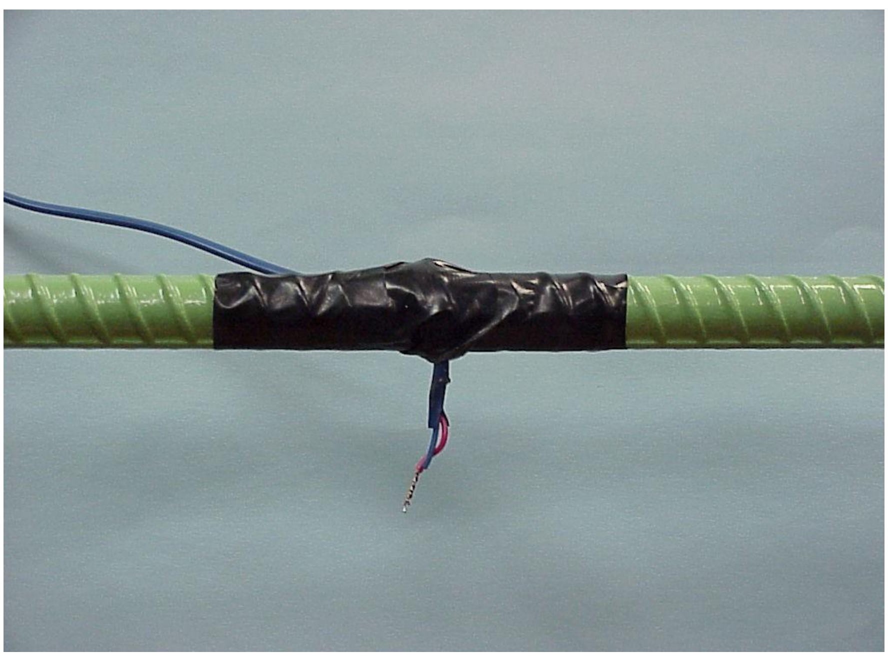


Figure 2. Typical attachment of thermocouple to reinforcing steel

IM 385
TEMPERATURE

TEMPERATURE OF FRESHLY MIXED CONCRETE

SCOPE

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

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

SIGNIFICANCE & USE

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

PROCEDURE

A. Apparatus

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

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

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

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

B. Calibration of Temperature-measuring Device

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

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

C. Sampling Concrete

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

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

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

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

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

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

D. Test Procedure

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

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

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

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

HYDRAULIC CEMENTS

GENERAL

Portland cement shall meet the requirements of ASTM C150 for the type specified. When blended cement is to be furnished, it shall meet the requirements of ASTM C595. Cement Type I, II, III, IP, IS and IL shall also meet the additional requirements outlined in Section 4101 of the Standard Specifications. Approval of any type of Portland and blended cements will be based on certification by an approved source or upon source sampling and testing before being incorporated into the work. Approved cement sources and distribution terminals are listed in the Materials Approved Products Listing Enterprise (MAPLE) as Appendixes A and B.

The available cement types are:

ASTM C150

Type I For general use.

Type II For moderate sulfate resistance. C_3A less than 8%.

Type III High early strength. Generally, a finer ground Type I cement.

White Cement White cement sources shall meet the requirements of ASTM C150, except the maximum Fe_2O_3 shall not exceed 0.5%. Approved sources of white cement are listed in the Appendix B.

ASTM C595

Type IS Type I Slag is a Portland cement blended, or clinker interground, up to 35% GGBSF.

Type IP Type I Pozzolan is a Portland cement blended or clinker interground, up to 25% pozzolan.

Type IL Type I Limestone is a Portland cement blended or clinker interground, between 5% and 15% limestone.

SOURCE APPROVAL

For consideration for approval, the manufacturer shall provide the following to the Materials Office:

1. A quality control program that meets the requirements of Section A.
2. A copy of the latest CCRL inspection report on quality control laboratory, including documentation of resolution of any discrepancies noted.
3. A 3-month strength uniformity report prepared in accordance with the requirements of ASTM C917, “Standard Test Method for Evaluation of Cement Strength Uniformity from a Single Source”.

4. A letter indicating the type of each processing addition, and the percent range that will be used in Type I cement.

The manufacturer shall also prepare a 24-hour composite sample of cement from current production according to ASTM C183. This sample will be tested by the Central Materials Laboratory for acceptance.

Iowa may approve a source based on another state source approval, provided that state will agree to the terms in Appendix C and the source meets Section 4101 of the Iowa DOT Standard Specifications.

Mixing of cement from different sources, different plants, or of different types in one storage bin or silo will not be allowed.

When less than 5% of limestone is used, the manufacturer shall inform the Office of Materials in writing on the amount of the addition. The manufacturer shall also supply comparative test data on chemical and physical properties of the cement with and without limestone. The amount of limestone used shall be included in the manufacturer's Mill Test Reports. Approval of Type IL cement which contains limestone in a range of 5% to 15%, is described in Section C of this IM.

A. Quality Control Program

The control of the production from each grinding mill type shall be considered separately. The following minimum testing frequencies are presented as a general guideline:

1. One sample representing 24 hours of production to be tested for air content, false set, and soundness. Determinations of free lime may be used to alter the frequency of testing soundness.

2. One sample representing 4 hours production to be tested for time of set and fineness.

3. One sample representing 48 hours production to be tested for chemical analysis.

4. One sample representing 4 day's production to be tested for 3- and 7-day compressive strength.

The sampling, tests and testing frequencies required may vary from the above guidelines depending of the particular production problems of the plant. In all cases, the quality control procedure used shall be submitted in writing to the District Materials Engineer for approval.

The plant sample test records shall be available for study by Highway Division personnel for at least seven years after the cement represented has been produced.

B. Quality Control Laboratory

The Portland cement plant is required to have a control laboratory compliant with ASTM C1222, Standard Practice for Evaluation of laboratories Testing Hydraulic Cement. The control laboratory shall be AASHTO accredited. This laboratory will perform testing on the applicable types of cement meeting ASTM C150 and C595. Any major difference on test results between the control laboratory and the Highway Division Ames Laboratory shall be resolved quickly. Continued unresolved differences in test results will be considered a basis for discontinuing control laboratory approval.

C. Approval of Type IL Cement

To apply for approval of a Type IL cement, manufacturer shall submit test results of two concrete mixtures, one with the Type IL cement and other with the control Type I/II cement of the same source, to the Office of Materials. These two concrete mixtures shall be cast per the Iowa DOT Concrete Mix Designation C-3WR-C20. The coarse aggregate used shall be an Iowa DOT approved limestone or dolomite. Fly ash, sand, air entraining agent and chemical admixtures used shall also be from Iowa DOT approval lists. The air content shall be in the range of 5.5% and 7.0%.

The tests and approval requirements are listed below:

- ASTM C39, Compressive Strength at 7, 28, and 56 Days: 90% or better of control.
- ASTM C78, Flexural Strength or ASTM C496, Splitting Tensile Strength at 28 and 56 Days: 95% or better of control or a 28-day 3rd point MR greater than 640 psi.
- ASTM C157, Concrete Shrinkage up to 56 Days: 95% or better of control or 56-day shrinkage less than 0.040%.
- ASTM C666, Freeze-Thaw Resistance up to 300 Cycles: 95% or better of control or a durability factor greater than 90%.
- ASTM C457, Air Void Analysis.
- ASTM C1202, Rapid Chloride Permeability.
- ASTM C1012, Sulfate Resistance up to 6 Months.

SOURCE APPROVED BY OTHER STATES

Iowa DOT will accept cements and cement blends approved or certified by other state transportation agencies, providing that state agrees to the following terms and that source meets Article 4101 of Standards Specifications.

1. The host state agency will require the cement plant within its boundaries to have a laboratory compliant with ASTM C1222, Standard Practice for Evaluation of Laboratories Testing Hydraulic Cement. This laboratory shall be AASHTO accredited and will perform testing on the applicable types of cement produced (ASTM C 150/AASHTO M 85, C595/AASHTO M 240, C 1157) and shipped for state agencies consumption. Agency laboratories used for verification testing must meet the same criteria.

2. The host state agency will require the cement plant within its boundaries to have a printed, agency acceptable quality control/quality assurance plan for the production of cements used by state agencies. The plan must include commitments to comply with ASTM C1222 and ASTM C183, Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement. The host state agency will verify compliance with the quality control plan.

3. The host state agency will require the cement producer to maintain and provide, for each lot (silo) of cement shipped, a compilation of Mill Test Reports in an electronic form (Excel spread

sheet). The applicable data will be provided to the host state agency at least semiannually.

4. The host state agency will require the cement producer to submit split samples of a regular Portland cement (ASTM C150/AASHTO M85) and a blended cement (ASTM C595/AASHTO M240) or performance specification cement (ASTM C1157) if produced, semiannually for verification testing.

5. The host state agency will require the cement producer to submit reports for ASTM C917, Standard Test Method for Evaluation of Cement Strength Uniformity From a Single Source, for both a regular Portland cement and a blended cement, if produced, at least semiannually.

6. The host state agency will require the cement producer to maintain production and quality control/quality assurance records for at least seven years and make those records available if requested.

7. The host state agency will review submittals from the cement producer along with agency test results. If deficiencies are discovered, the state agency will monitor corrective actions taken by the producer until the deficiencies are corrected. The reciprocal agreement state agency will be notified of the deficiencies and of each occurrence.

8. Any test results or submittals collected by the host state agency may be made available to the reciprocal agreement state agency upon request.

9. All cement plant information and data is confidential within the limits of a public agency and is for state agencies information and inspection only.

10. Quality assurance test results of field samples, performed by a reciprocal state, shall be reported to the host state agency when non-compliance occurs. The reciprocal state agency will deal directly with the cement producer. The host state agency will take action as described in Item 7. The host state agency shall notify all reciprocal agreement state agencies when non-compliance occurs.

11. Cement tests or requirements beyond the standards stated above may be provided to reciprocal state agencies by agreement between the host state and reciprocal state agencies.

CONTINUED SOURCE APPROVAL

A. DOT Sampling and Testing

After initial approval, random samples will be taken and tested at a minimum rate of one sample semiannually. The samples may be taken at the source or at the distribution terminal if the source is outside the district's normal area of travel.

A split-sample will be obtained from the plant of a Regular Supplier twice a year, preferably in January and July. The sample will be split and tested for complete chemical and physical properties by supplier's control laboratory and the Highway Division Ames Laboratory, respectively. The date of the split sampling and load out silo number will be identified on the sample identification report for later comparison.

Verification samples will be secured at the project site just before incorporation into the work. Test results, which do not comply with the specifications, may be considered sufficient cause to rescind approval to furnish cement. Construction that contains cement represented by verification samples showing deficient test results will be subject to the requirements of Article 1105.04 of the Standard Specifications.

B. Mill Test Reports

Mill Test Reports covering cement to be certified shall be submitted to the Cement and Concrete Engineer at the Central Laboratory at Ames, and if requested, to the District Materials Engineer who monitors the plant. An electronic form (Excel spreadsheet) is acceptable.

The plant of a regular supplier is required to submit reports for ASTM C917, Standard Test method for Evaluation of Cement Strength Uniformity at least annually.

PROJECT DOCUMENTATION

All approved cements shipped for intended use in Iowa shall be clearly identified. The producer of approved cement shall furnish for the project records, two invoices or bill of lading copies, which bear the following certification statement and the signature of an authorized representative of the producer:

CERTIFICATION STATEMENT

The material herein described has been sampled and tested as prescribed by the Highway Division of the Iowa Department of Transportation and complies with the applicable specification requirements for type ______________________________ cement.

Bin No.__________________________ Signed ______________________________
Date __________________________

The bills of lading or invoices shall include project number, if available, source name, source location, source code, type, and quantity in the shipments. For blended cements (Types IP and IS), the above type designation shall include the suffix (X), where (X) equals the targeted percentage of slag or pozzolan in the product.

In the case of truck shipments, these copies of the bill of lading or invoice shall accompany each load, and shall be retained at the project or ready mixed concrete plant for the project engineer records. In the case of rail shipments, these copies shall be mailed to the project or ready mix plant.

APPROVED SOURCES - PORTLAND & BLENDED CEMENTS

Data as of October 22, 2014
Refer to MAPLE for current data

SOURCE	PLANT	TYPE	SpG	CODE	APPROVED TERMINALS
Ash Grove Cement Company	Hannibal, MO	I/II	3.14	PC3502	Des Moines
Ash Grove Cement Company	Louisville, NE	I/II	3.14	PC0002	Louisville, NE; Des Moines, IA
Ash Grove Cement Company	Louisville, NE	IP(25)	2.95	PC0008	Louisville, NE; Des Moines, IA
Ash Grove Cement Company	Chanute, KS	I/II	3.14	PC0102	Chanute, KS; Des Moines, IA
Ash Grove Cement Company	Chanute, KS	IP(25)	2.97	PC0108	Chanute, KS; Des Moines, IA
Buzzi Unicem USA	Pryor, OK	I	3.14	PC1401	Bonner Springs, KS; Festus, MO
Buzzi Unicem USA	Cape Girardeau, MO	I/II	3.14	PC1502	Bonner Springs, KS; Festus, MO
Buzzi Unicem USA	Festus, MO	I/II	3.14	PC3002	Bonner Springs, KS; Festus, MO
Central Plains Cement Company	Sugar Creek, MO	I/II	3.14	PC0702	Sugar Creek, MO; Omaha, NE
Central Plains Cement Company	Omaha, NE	IS(20)	3.09	PC2807	Sugar Creek, MO; Omaha, NE
Central Plains Cement Company	Omaha, NE	IP(25)	2.95	PC2808	Sugar Creek, MO; Omaha, NE
Continental Cement Company, LLC	Hannibal, MO	I	3.14	PC0201	Bettendorf, IA; Hannibal, MO
Continental Cement Company, LLC	Hannibal, MO	I/II	3.14	PC0202	Bettendorf, IA; Hannibal, MO
GCC USA	Pueblo, CO	I/II	3.14	PC2902	Sioux Falls, SD; Hawarden, IA
GCC USA - Rapid City Terminal	Rapid City, SD	I/II	3.14	PC1002	Sioux Falls, SD; Hawarden, IA
GCC USA - Rapid City Terminal	Rapid City, SD	IP(25)	3.05	PC1008	Sioux Falls, SD; Hawarden, IA
Heracles General Cement/Holcim (US) Inc.	Milaki, Greece	I	3.14	PC1201	LaCrosse, WI
Holcim (US) Inc.	Three Forks, MT	I/II	3.14	PC1102	LaCrosse, WI; Fremont, NE; Des Moines, IA; Summit, IL; Lemont, IL; St. Paul, MN; Superior, NE; Sioux Falls, SD
Holcim (US) Inc.	Ada, OK	I	3.14	PC1901	LaCrosse, WI; Fremont, NE; Des Moines, IA; Summit, IL; Lemont, IL; St. Paul, MN; Superior, NE; Sioux Falls, SD
Holcim (US) Inc.	Portland/Florence, CO	I/II LA	3.14	PC2002	LaCrosse, WI; Fremont, NE; Des Moines, IA; Summit, IL; Lemont, IL; St. Paul, MN; Superior, NE; Sioux Falls, SD
Holcim (US) Inc.	Portland/Florence, CO	IP(25)	3.01	PC2008	LaCrosse, WI; Fremont, NE; Des Moines, IA; Summit, IL; Lemont, IL; St. Paul, MN; Superior, NE; Sioux Falls, SD
Holcim (US) Inc.	Ste. Genevieve, MO	I/II	3.14	PC3202	Mason City, IA; Des Moines, IA; Cedar Rapids, IA; LaCrosse, WI; Rock Island, IL; St. Paul, MN; Fremont, NE; Superior, NE; Sioux Falls, SD

APPROVED SOURCES - PORTLAND & BLENDED CEMENTS

Data as of October 22, 2014
Refer to MAPLE for current data

SOURCE	PLANT	TYPE	SpG	CODE	APPROVED TERMINALS
Holcim (US) Inc.	Ste. Genevieve, MO	IL(10)	3.14	PC3209	Mason City, IA; Des Moines, IA; Cedar Rapids, IA; LaCrosse, WI; Rock Island, IL; St. Paul, MN; Fremont, NE; Superior, NE; Sioux Falls, SD
Illinois Cement Company	LaSalle, IL	I/II LA	3.14	PC3302	LaSalle, IL
Lafarge North America	Buffalo, IA	I/II	3.14	PC0502	West Des Moines, IA; Buffalo, IA (Davenport); Winona, MN
Lafarge North America	Buffalo, IA	IS(20)	3.10	PC0507	West Des Moines, IA; Buffalo, IA (Davenport); Winona, MN
Lafarge North America	Exshaw, Alberta	I/II	3.14	PC1302	West Des Moines, IA
Lafarge North America	Alpena, MI	I	3.14	PC1801	West Des Moines, IA
Lafarge North America	Waukegan, IL	I	3.14	PC2301	West Des Moines, IA
Lafarge North America	Grand Chain, IL	IT(S20)(P5)	3.07	PC2508	West Des Moines, IA
Lehigh Cement Company	Mason City, IA	I	3.14	PC0401	Mason City, IA
Lehigh Cement Company	Mason City, IA	IL(10)	3.14	PC0409	Mason City, IA
Lehigh Cement Company	York, PA	I	3.15	(White cement)	Plainfield, IL
Lehigh Cement Company	Cimsa, Turkey	I	3.15	(White cement)	Plainfield, IL; Burnsville, MN
St Marys Cement Group	St. Mary's, Ontario	II	3.14	PC1702	
St Marys Cement Group	Charlevoix, MI	I/II LA	3.14	PC3402	
The Monarch Cement Company	Humboldt, KS	I/II	3.14	PC0802	West Des Moines, IA

CHEMICAL ADMIXTURES FOR CONCRETE

GENERAL

Air entraining admixtures shall meet the requirements of AASHTO M154. Water reducing and retarding, water-reducing, high range water reducing, and non-chloride accelerating admixtures shall meet the requirements of AASHTO M194. All chemical admixtures used for Portland Cement Concrete shall meet the requirements outlined in Section 4103 and other applicable Iowa Department of Transportation Standard Specifications. Approved brands of chemical admixtures for concrete are listed in the Materials Approved Products Listing Enterprise (MAPLE) as Appendixes A, B, C, D, E, F and G for different types of applications.

For all types of admixtures, the source, brand name, and lot/batch number must be identifiable by markings on the container and by description on the invoice. The manufacturer and supplier shall maintain a record of shipment, which identifies the brand, lot/batch number and certified test data for each shipment. This data shall be made available to the contracting authority when requested.

Material that (i) is suspected of being frozen, or (ii) exceeds its shelf life, or (iii) has been stored at plant site for more than 6 months shall be sampled and tested prior to use.

MANUFACTURER, BRAND NAME APPROVAL, USAGE GUIDELINES

To obtain approval for any admixture type, the manufacturer shall submit the following items to the Office of Materials in Ames:

1. Product identification including brand name and product number
2. Complete manufacturer's recommendation for usage
3. A copy of Level 1 product test report for the submitted admixture from the National Transportation Product Evaluation Program (NTPEP). The test result reported will be evaluated for compliance with appropriate AASHTO specification
4. A current Materials Safety Data Sheet (MSDS)
5. A one-quart (one-liter) representative sample may be required upon request

Specific requirements for each type of admixture are as follows:

A. Air Entraining Admixtures

   Air entraining admixtures shall meet the requirements of Iowa Department of Transportation Standard Specifications Section 4103 and AASHTO M154.

   Approved brands of air entraining admixtures are listed in Appendix A of this IM.

B. Retarding, and Water-Reducing & Retarding Admixtures for Bridge Deck and Drilled Shaft Concrete Required Extended Working Time

   Retarding, and water-reducing & retarding admixtures shall meet the requirements of AASHTO M194, Type B or Type D. These admixtures can be used for water reduction, retardation, or water reduction and retardation for bridge deck and drilled shaft concrete when extended working time is required.

Approved brands of retarding, and water-reducing & retarding admixtures for bridge deck and drilled shaft concrete required extended working time are listed in Appendix B of this IM. Appendix B also contains a guideline for dosage rates and working time limits based on an estimated maximum temperature of the concrete during placement at the point of discharge. Working time limits have been determined by AASHTO T197 using 200 psi (1.38 MPa) penetration resistance and shall be provided by manufacturer. In addition to the AASHTO M194 requirements, a minimum working time of 4.5 hours is required for the Type I/II cement mix used the maximum normal recommended dosage of an admixture and tested at the normal temperature (between 70^{o}F and 75^{o}F).

C. Water-Reducing Admixtures

Water-reducing admixtures shall meet the requirements of AASHTO M194, Type A.

Approved brands of water-reducing admixtures with their proper dosage rates are listed in Appendix C of this IM.

Mid-range water reducers used for bridge overlay concrete (Class HPC-O Mixture) are noted in Appendix C. In additional to the AASHTO M194 requirements, the use of these admixtures shall provide a maximum water content of 90% of the control at a normal dosage, and shall not result in a less initial set time as compared to the control The intent of these mid-range water reducers is to achieve a workable, dense, low water to cementitious material ratio concrete for bridge overlay as described in Article 2413.02 of Standard Specifications.

A combination of a water-reducing admixture and a retarding admixture may be used to aid in air entrainment and slump retention.

D. High Range Water-Reducing Admixtures

High Range water-reducing admixtures shall meet the requirements of AASHTO M194, Type F.

Approved brands of high range water-reducing admixtures with their recommended dosage rates are listed in Appendix D of this IM. As indicated, some of these high range water reducers listed can be used to cast self-consolidated concrete. If needed, a viscosity-modified admixture produced by the same manufacturer is allowed to cast self-consolidated concrete.

E. Non-Chloride Accelerating Admixtures

Non-Chloride Accelerating Admixtures shall meet the requirements of AASHTO M194, Type C or E. Total chloride content, which may come from some indirect sources, shall not exceed 0.1% in the admixtures.

Approved brands of non-Chloride accelerating admixtures with their recommended dosage rates are listed in Appendix E of this IM.

F. Admixtures for Prestressed & Precast Concrete

In addition to the admixtures listed in other Appendixes of this IM, the admixtures listed in Appendix F can also be used in prestressed and precast concrete. Benefits of those admixtures in Appendix F include increasing production rate, improvement of visual appeal, greater strength, more durable, better compactability, and extension of life of molds and machines parts for dry-cast concrete. In order to get an admixture approval, its producer shall prove that the use of the admixture will not reduce strength of concrete, and provide evidence of the above-mentioned benefits.

G. Retarding, Water-Reducing & Retarding Admixtures for Concrete with Normal Working Times

Retarding, water-reducing and retarding admixtures shall meet the requirements of AASHTO M194, Type B or Type D. These admixtures can be used for water reduction, retardation, or water reduction and retardation for concrete.

When use as a retarder is specified or authorized by the engineer, the contractor shall be responsible for its use and application of the proper dosage rate. It may also be necessary to adjust the quantity of air entraining agent. When fly ash is used in the concrete, the dosage rate shall be applied to both the cement and fly ash combined.

Approved brands of water-reducing and retarding admixtures with their recommended dosage rates are listed in Appendix G of this IM.

A hydration stabilizer/controller will be evaluated for approval as a retarder (Type B) or a water reducing & retarding admixture (Type D), and listed and identified in Appendix B or Appendix G after approved.

If alternative requirements specified in AASHTO M194 are met, an admixture may be provisionally approved based on six-month test results. Producer shall submit one-year test results for final approval as soon as they become available. The failure or delay in submitting one-year results may lead to revoking of provisional approval.

Approval of admixtures may be withdrawn because of deficient test results; product changes made after original approval, or unsatisfactory field performance.

AGITATION OF ADMIXTURES

Air entraining admixtures shall be stirred, agitated, or circulated at least weekly to ensure a uniform and homogeneous mixture of solids and solution. It is the admixture supplier's responsibility to the contractor to provide a quality product. Therefore the admixture suppliers shall be responsible for the system used to maintain the quality product described above.

Retarding, water-reducing, and high range water-reducing admixtures shall be stirred, circulated, or agitated thoroughly once a day prior to operation of the proportioning plant to maintain the solids in suspension. The agitating shall be done in such a way that the solution in the holding or storage tank is circulated for a minimum of five minutes each day per 100 gallons (380 liters) of solution or any fraction thereof. Use of a timer on the pump is recommended to prevent excessive heat from the pump. 5 minutes is adequate for smaller tanks to a maximum of 15 minutes for larger tanks.

A circulating pump with a 250-watt (1/3 hp) pump motor and a 1-inch (25 mm) inside diameter hose will be considered as a minimum requirement. The engineer shall approve the method of agitation. **NOTE:** Introducing air into a tank will not be acceptable.

CERTIFICATION

A. FOR MANUFACTURER

At the beginning of each calendar year, a certification form will be sent to each manufacturer. If the admixture to be supplied during that year is identical with the formulation previously tested and approved, then the manufacturer shall complete the quality control limits to be followed and return it to the Office of Materials in Ames, Iowa.

B. FOR DISTRIBUTOR

At the beginning of each calendar year, a certification form will be sent to each distributor. The distributor shall certify that admixtures to be supplied are not altered and will be distributed as received from the manufacturer.

MONITOR SAMPLING & TESTING, AND REJECTION OF MATERIAL

Monitor samples will be obtained and sent to Central Materials for testing. Sampling frequency shall be according to IM 204. The sample size shall be one 1 pint (0.5 liter).

For all admixtures, only one acceptance sample per lot/batch is necessary. No project assurance samples are needed.

Samples will be tested for variation from the manufacturer target for solids, specific gravity and chloride content if needed.

If the test result of a monitor sample is outside the quality control limits specified by AASHTO M154 or M194 and provided by the manufacturer, all material in the storage tank shall be rejected. The admixture company is not allowed to mix new replacement material with the non-compliance material. The admixture manufacturer is responsible for the condition of storage tanks and should determine if the tanks should be cleaned to prevent cross contamination and further product failures.

APPROVED SOURCES - AIR ENTRAINING ADMIXTURES

Data as of October 22, 2014
Refer to MAPLE for current data

Vinsol Resin

BRAND NAME	PRODUCER/DISTRIBUTER	LOCATION
Daravair - 1400	W.R. Grace & Company	Boston, MA
Darex II AEA	W.R. Grace & Company	Boston, MA
Eucon Air Mix	Euclid Chemical Company	Cleveland, OH; Des Moines, IA
MasterAir AE 200	BASF Corporation	Cleveland, OH
MasterAir AE 90	BASF Corporation	Cleveland, OH
MasterAir VR 10	BASF Corporation	Cleveland, OH
Polychem VR	General Resource Technology	Eagan, MN
Polychem VRC	General Resource Technology	Eagan, MN
RVR-15	RussTech, Inc.	Louisville, KY

Non-Vinsol Resin

BRAND NAME	PRODUCER/DISTRIBUTER	LOCATION
Air Plus	Fritz-Pak Corporation	Dallas, TX
Airalon 3000	W.R. Grace & Company	Boston, MA
Chryso Air 260	Chryso, Inc.	Rockwall, TX
ConAir	Premiere Concrete Admixtures™	Pioneer, OH
ConAir 260	Premiere Concrete Admixtures™	Pioneer, OH
Daravair 1000	W.R. Grace & Company	Boston, MA
Daravair AT 30	W.R. Grace & Company	Boston, MA
Daravair AT 60	W.R. Grace & Company	Boston, MA
Daravair M	W.R. Grace & Company	Boston, MA
Eucon AEA-92	Euclid Chemical Company	Cleveland, OH; Des Moines, IA
Eucon AEA-92S	Euclid Chemical Company	Cleveland, OH; Des Moines, IA
MasterAir AE 400	BASF Corporation	Cleveland, OH
Miracon 2315	Miracon™ Technologies	Richardson, TX
Polychem AE	General Resource Technology	Eagen, MN
Polychem SA	General Resource Technology	Eagen, MN
Polychem SA-50	General Resource Technology	Eagen, MN
RSA-10	RussTech, Inc.	Louisville, KY
Sika AEA-14	Sika Corporation	Marion, OH; Des Moines, IA
Sika AEA-15	Sika Corporation	Marion, OH; Des Moines, IA
Sika Air	Sika Corporation	Marion, OH; Des Moines, IA
Sika Air-260	Sika Corporation	Marion, OH; Des Moines, IA
Sika Air-360	Sika Corporation	Marion, OH; Des Moines, IA
Stable Air	Cellular Concrete Technologies LLC	Irvine, CA
Super Air Plus	Fritz-Pak Corporation	Dallas, TX
Terapave AEA	W.R. Grace & Company	Boston, MA

APPROVED SOURCES - WATER-REDUCING ADMIXTURES

Data as of October 22, 2014
Refer to MAPLE for current data

Normal Water Reducers

BRAND NAME	PRODUCER/DISTRIBUTOR	DOSAGE	RANGE
#1920 Auger Aid	Specco Industries, Inc.	8.0 fl. oz/100 lb	8.0 - 16.0 fl. oz/100 lb
EcoFlo Green	Premiere Concrete Admixtures™	1.5 fl. oz/100 lb	1.5 - 10.0 fl. oz/100 lb
Eucon MRX	Brett Admixtures	3.0 fl. oz/100	3.0 - 5.0 fl. oz/100
Eucon WR	Brett Admixtures	2.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
Eucon WR-75	Brett Admixtures	3.0 fl. oz/100 lb	2.0 - 3.0 fl. oz/100 lb
Eucon WR-91	Brett Admixtures	3.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
Fluid Optima 256	Chryso, Inc.	2.0 fl. oz/100 lb	2.0 - 7.0 fl. oz/100 lb
KB-1200	General Resource Technology	3.0 fl. oz/100 lb	3.0 - 8.0 fl. oz/100 lb
LC-400	RussTech, Inc.	4.0 fl. oz/100 lb	4.0 - 5.0 fl. oz/100 lb
LC-400P	RussTech, Inc.	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
MasterGlenium 3030	BASF Corporation	2.0 fl. oz/100 lb	1.0 - 3.0 fl. oz/100 lb
MasterPozzolith 200	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 4.0 fl. oz/100 lb
MasterPozzolith 322	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
MasterPozzolith 700	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
MasterPozzolith 80	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 6.0 fl. oz/100 lb
NCA	Fritz-Pak Corporation	1 - 3% by cement weight	
OptiFlo 50	Premiere Concrete Admixtures™	3.0 fl. oz/100 lb	3.0 - 8.0 fl. oz/100 lb
OptiFlo 500	Premiere Concrete Admixtures™	2.0 fl. oz/100 lb	2.0 - 4.0 fl. oz/100 lb
Plastocrete 100	Sika Corporation	2.0 fl. oz/100 lb	2.0 - 6.0 fl. oz/100 lb
Plastocrete 161	Sika Corporation	2.0 fl. oz./100 lb	2.0 - 4.0 fl. oz./100 lb
Plastocrete-10N	Sika Corporation	1.5 fl. oz/100 lb	1.5 - 3.5 fl. oz/100 lb
Polychem 3000	General Resource Technology	2.0 fl. oz/100 lb	2.0 - 3.0 fl. oz/100 lb
Polychem 400 NC	General Resource Technology	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
Polychem 775	General Resource Technology	2.0 fl. oz/100 lb	2.0 - 3.0 fl. oz/100 lb
Polychem Paver Plus	General Resource Technology	2.0 fl. oz/100 lb	2.0 - 8.0 fl. oz/100 lb
PS 1466	BASF Corporation	2.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
SDPA-12	Brett Admixtures	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
Sikament 686	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
UltraFlo 2000	Premiere Concrete Admixtures™	2.0 fl. oz/100 lb	2.0 - 3.0 fl. oz/100 lb
WRDA 82	W.R. Grace & Company	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
WRDA Pave 18	W.R. Grace & Company	3.0 fl. oz/100 lb	3.0 - 5.0 fl. oz/100 lb
WRDA with Hycol	W.R. Grace & Company	3.0 fl. oz./100 lb	3.0 - 5.0 fl. oz./100 lb
Zyla 620	W.R. Grace & Company	3.0 fl. oz/100 lb	2.0 - 7.0 fl. oz/100 lb

APPROVED SOURCES - WATER-REDUCING ADMIXTURES

Data as of October 22, 2014
Refer to MAPLE for current data

Mid-Range Water Reducers

BRAND NAME	PRODUCER/DISTRIBUTOR	DOSAGE	RANGE
Daracem 65	W.R. Grace & Company	3.0 fl. oz/100 lb	3.0 - 9.0 fl. oz/100 lb
Eucon MR	Brett Admixtures	7.0 fl. oz/100 lb	4.0 - 15.0 fl. oz/100 lb
Eucon MRX	Brett Admixtures	5.0 fl. oz/100 lbs	5.0 - 7.0 fl. oz/100 lbs
FinishEase-NC	RussTech, Inc.	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
Fluid Optima 256	Chryso, Inc.	3.0 fl. oz/100 lbs	3.0 - 7.0 fl. oz/100 lbs
KB-1200	General Resource Technology	3.0 fl. oz/100 lbs	3.0-12.0 fl. oz/100 lbs
MasterGlenium 3030	BASF Corporation	4 fl. oz/100 lbs	3.0 - 6.0 fl. oz/100 lbs
MasterPolyheed 1020	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
MasterPolyheed 1025	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
MasterPolyheed 1720	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
MasterPolyheed 1725	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
MasterPolyheed 900	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
MasterPolyheed 997	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
MIRA 62	W.R. Grace & Company	4.0 fl. oz/100 lb	2.5 - 9.0 fl. oz/100 lb
MIRA Pave 11	W.R. Grace & Company	6.0 fl. oz/100 lb	6.0 - 9.0 fl. oz/100 lb
OptiFlo MR	Premiere Concrete Admixtures™	4.0 fl. oz/100 lb	4.0 - 12.0 fl. oz/100 lb
OptiFlo Plus	Premiere Concrete Admixtures™	5.0 fl. oz/100 lb	5.0 - 10.0 fl. oz/100 lb
Polychem 3000	General Resource Technology	4.0 fl. oz/100 lb	3.0 - 6.0 fl. oz/100 lb
Polychem 775	General Resource Technology	3.0 fl. oz/100 lbs	3.0 - 6.0 fl. oz/100 lbs
Sikament AFM	Sika Corporation	5.0 fl. oz/100 lb	5.0 - 12.0 fl. oz/100 lb
Sikaplast 200	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
Sikaplast 300GP	Sika Corporation	2.0 fl. oz/100 lb	2.0 - 12.0 fl. oz/100 lb
Sikaplast 500	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb
UltraFlo 2000	Premiere Concrete Admixtures™	3.0 fl. oz/100 lbs	3.0 - 6.0 fl. oz/100 lbs
ViscoCrete 1000	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 6.0 fl. oz/100 lb

APPROVED SOURCES - HIGH RANGE WATER-REDUCING ADMIXTURES

Data as of October 22, 2014
Refer to MAPLE for current data

High Range Water Reducers

BRAND NAME	PRODUCER/DISTRIBUTOR	DOSAGE	RANGE
ADVA 140M	W.R. Grace & Company	9.0 fl. oz/100 lb	9.0 - 16.0 fl. oz/100 lb
ADVA 190	W.R. Grace & Company	3.0 fl. oz/100 lb.	3.0 - 15.0 fl. oz/100 lb.
ADVA 195	W.R. Grace & Company	3.0 fl. oz/100 lb.	3.0 - 15.0 fl. oz/100 lb.
ADVA 405	W.R. Grace & Company	12.0 fl. oz/100 lb	12.0 - 18.0 fl. oz/100 lb
ADVA 408	W.R. Grace & Company	12.0 fl. oz/100 lb	12.0 - 18.0 fl. oz/100 lb
ADVA Cast 530	W.R. Grace & Company	3.0 fl. oz/100 lb	3.0 - 10.0 fl. oz/100 lb
ADVA Cast 540	W.R. Grace & Company	5.0 fl. oz/100 lb	5.0 - 20.0 fl. oz/100 lb
ADVA Cast 555	W.R. Grace & Company	8.0 fl. oz/100 lb	8.0 - 20.0 fl. oz/100 lb
ADVA Cast 575	W.R. Grace & Company	3.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
ADVA Cast 600	W.R. Grace & Company	3.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
Daracem 100	W.R. Grace & Company	5.0 fl. oz/100 lb	5.0 - 20.0 fl. oz/100 lb
Daracem 19	W.R. Grace & Company	10.0 fl. oz/100 lb	6.0 - 20.0 fl. oz/100 lb
Eucon 1037	Euclid Chemical /Brett Admixtures	8.0 fl. oz/100 lb	8.0 - 25.0 fl. oz/100 lb
Eucon 37	Euclid Chemical/Brett Admixtures	10.0 fl. oz/100 lb	6.0 - 18.0 fl. oz/100 lb
Eucon MRX	Euclid Chemical/Brett Admixtures	7.0 fl. oz./100 lb	7.0 - 12.0 fl. oz./100 lb
EVO 2500	General Resource Technology	7.0 fl. oz./100 lb	5.0 - 9.0 fl. oz./100 lb
Fluid Optima 256	Chryso, Inc.	7.0 fl. oz./100 lb	7.0 - 16.0 fl. oz./100 lb
MasterGlenium 3030	BASF Corporation	6.0 fl. oz./100 lb	6.0 - 18.0 fl. oz./100 lb
MasterGlenium 3400	BASF Corporation	2.0 fl. oz/100 lb	2.0 - 12.0 fl. oz/100 lb
MasterGlenium 7500	BASF Corporation	3.0 fl. oz/100 lb	3.0 - 15.0 fl. oz/100 lb
MasterGlenium 7700	BASF Corporation	2.0 fl. oz/100 lb	2.0 - 15.0 fl. oz/100 lb
MasterRheobuild 1000	BASF Corporation	10.0 fl. oz/100 lb	10.0 - 25.0 fl. oz/100 lb
Melchem	General Resource Technology	8.0 fl. oz/100 lb	6.0 - 18.0 fl. oz/100 lb
MIRA 62	W.R. Grace & Company	9.0 fl. oz./100 lb	9.0 - 15.0 fl. oz./100 lb
Plastol 341	Euclid Chemical/Brett Admixtures	2.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
Plastol 341-S	Euclid Chemical/Brett Admixtures	2.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
Plastol 5000	Euclid Chemical/Brett Admixtures	3.0 fl. oz/100 lb	3.0 - 15.0 fl. oz/100 lb
Plastol 5500	Euclid Chemical/Brett Admixtures	2.0 fl. oz/100 lb	2.0 - 10.0 fl. oz/100 lb
Polychem 3000	General Resource Technology	8.0 fl. oz./100 lb	7.0 - 20.0 fl. oz./100 lb
Polychem 775	General Resource Technology	6.0 fl. oz./100 lb	6.0 - 20.0 fl. oz./100 lb
Polychem SPC	General Resource Technology	6.0 fl. oz/100 lb	6.0 - 20.0 fl. oz/100 lb
PS 1466	BASF Corporation	2.0 fl. oz./100 lb	2.0 - 10.0 fl. oz./100 lb
Sikament 686	Sika Corporation	3.0 fl. oz./100 lb	3.0 - 12.0 fl. oz./100 lb
Sikament AFM	Sika Corporation	7.0 fl. oz./100 lb	7.0 - 18.0 fl. oz./100 lb
Sikament SPMN	Sika Corporation	10.0 fl. oz/100 lb	1.0 - 40.0 fl. oz/100 lb
Sikaplast 500	Sika Corporation	3.0 fl. oz./100 lb	3.0 - 12.0 fl. oz./100 lb
Supercizer 1	Fritz-Pak Corporation	5.0 oz/100 lb	5.0 - 7.0 oz/100 lb
Supercizer 5	Fritz-Pak Corporation	5.0 oz/100 lb	5.0 - 7.0 oz/100 lb
Supercizer 6	Fritz-Pak Corporation	4.0 oz/100 lb	4.0 - 12.0 oz/100 lb
Supercizer 7	Fritz-Pak Corporation	4.0 oz/100 lb	4.0 - 12.0 oz/100 lb
Superflo 2000 SCC	RussTech, Inc.	3.0 fl. oz/100 lb	3.0 - 26.0 fl. oz/100 lb
Superflo 440	RussTech, Inc.	12.0 fl. oz/100 lb	12.0 - 20.0 fl. oz/100 lb
Superflo 443	RussTech, Inc.	10.0 fl. oz/100 lb	10.0 - 20.0 fl. oz/100 lb
UltraFlo 2000	Premiere Concrete Admixtures™	7.0 fl. oz./100 lb	7.0 - 16.0 fl. oz./100 lb
UltraFlo 4600	Premiere Concrete Admixtures™	7.0 fl. oz/100 lb	7.0 - 24.0 fl. oz/100 lb
UltraFlo DP	Premiere Concrete Admixtures™	4.0 fl. oz/100 lb	4.0 - 14.0 fl. oz/100 lb
ViscoCrete 1000	Sika Corporation	7.0 fl. oz./100 lb	7.0 - 18.0 fl. oz./100 lb
ViscoCrete 2100	Sika Corporation	2.0 fl. oz/100 lb	2.0 - 6.0 fl. oz/100 lb
ViscoCrete 2110	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 8.0 fl. oz/100 lb
ViscoCrete 4100	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 8.0 fl. oz/100 lb
ViscoCrete 6100	Sika Corporation	3.0 fl. oz/100 lb	3.0 - 8.0 fl. oz/100 lb

APPROVED SOURCES - NON-CHLORIDE ACCELERATING ADMIXTURES

Data as of October 22, 2014
Refer to MAPLE for current data

BRAND NAME	PRODUCER/DISTRIBUTOR	DOSAGE	RANGE
Accelguard NCA	Euclid Chemical Company	12.0 fl. oz/100 lb	12.0 - 75.0 fl. oz/100 lb
Daraset 400	W.R. Grace & Company	10.0 fl. oz/100 lb	10.0 - 60.0 fl. oz/100 lb
DCI	W.R. Grace & Company	2.0-6.0 gal./cubic yeard of concrete	
Lubricon NCA	W.R. Grace & Company	10.0 fl. oz/100 lb	10.0 - 32.0 fl. oz/100 lb
MasterLife Cl 30	BASF Corporation	1.0-6.0 gal./cubic yard of concrete	
MasterSet AC 534	BASF Corporation	10.0 fl. oz/100 lb	10.0 - 45.0 fl. oz/100 lb
MasterSet FP 20	BASF Corporation	5.0 fl. oz/100 lb	5.0 - 90.0 fl. oz/100 lb
NCA	Fritz-Pak Concrete Admixtures	1-3% by cement weight	
NitroCast K	Premiere Concrete Admixtures™	6.0 fl. oz/100 lb	6.0 - 90.0 fl. oz/100 lb
NitroCast NC	Premiere Concrete Admixtures™	10.0 fl. oz/100 lb	8.0 - 90.0 fl. oz/100 lb
Polarset	W.R. Grace & Company	8.0 fl. oz/100 lb	8.0 - 60.0 fl. oz/100 lb
Polychem Super Set	General Resource Technology	8.0 fl. oz/100 lb	8.0 - 32.0 fl. oz/100 lb
Sika Rapid-1	Sika Corporation	8.0 fl. oz/100 lb	8.0 - 48.0 fl. oz/100 lb
Sikamix NCA	Sika Corporation	6.0 fl. oz/100 lb	6.0 - 45.0 fl. oz/100 lb
SikaSet NC	Sika Corporation	10.0 fl. oz/100 lb	10.0 - 45.0 fl. oz/100 lb

APPROVED SOURCES - ADMIXTURES FOR PRESTRESSED & PRECAST CONCRETE

Data as of October 22, 2014

Refer to MAPLE for current data

BRAND NAME	USAGE	PRODUCER/DISTRIBUTOR	DOSAGE	RANGE
Daravair M	Air Entraining	W.R. Grace & Company	0.3 fl. oz/100 lb	0.3 - 6.0 fl. oz/100 lb
Eucon BK-S8	Plasticizer	Euclid Chemical Company	2.0 fl. oz/100 lb	2.0 - 4.0 fl. oz/100 lb
Eucon DC	Plasticizer	Euclid Chemical Company	2.0 fl. oz/100 lb	2.0 - 6.0 fl. oz/100 lb
MasterCast 730S	Plasticizer	BASF Corporation	2.0 fl. oz/100 lb	2.0 - 15.0 fl. oz/100 lb
MasterCast 750HS	Plasticizer	BASF Corporation	2.0 fl. oz/100 lb	2.0 - 5.0 fl. oz/100 lb
MasterCast 900	Plasticizer	BASF Corporation	2.0 fl. oz/100 lb	2.0 - 12.0 fl. oz/100 lb
MasterPel 240	Water-Repellent & Efflorescence Control	BASF Corporation	1.0 fl. oz/100 lb	1.0 - 5.0 fl. oz/100 lb
Quantec PL-490	Plasticizer	W.R. Grace & Company	2.0 fl. oz/100 lb	2.0 - 5.0 fl. oz/100 lb
Sikamix PL-90	Plasticizer	Sika Corporation	2.0 fl. oz/100 lb	2.0 - 6.0 fl. oz/100 lb
V-Mar F100	Rheology modifying	W.R. Grace & Company	5.0 fl. oz/100 lb	3.0 - 12.0 fl. oz/100 lb

APPROVED SOURCES - RETARDING, WATER REDUCING & RETARDING ADMIXTURES
PAVEMENT OR STRUCTURAL CONCRETE WITH NORMAL WORKING TIMES

Data as of October 22, 2014
Refer to MAPLE for current data

BRAND NAME	PRODUCER/DISTRIBUTOR	DOSAGE	RANGE
Daratard 17	W.R. Grace & Company	2.0 fl. oz./100 lb	2.0 - 8.0 fl. oz./100 lb
Daratard HC	W.R. Grace & Company	2.0 fl. oz./100 lb	2.0 - 4.0 fl. oz./100 lb
Delayed Set	Fritz-Pak Concrete Admixtures	1.0 oz./100 lbs	1.0 - 1.7 oz./100 lbs
Eucon Retarder 100	Euclid Chemical/Brett Admixtures	2.0 fl. oz./100 lb	2.0 - 6.0 fl. oz./100 lb
Eucon TR	Euclid Chemical/Brett Admixtures	3.0 fl. oz./100 lb	3.0 - 6.0 fl. oz./100 lb
Eucon WR-91	Euclid Chemical/Brett Admixtures	2.0 fl. oz./100 lb	2.0 - 10.0 fl. oz./100 lb
FR-1	Fritz-Pak Concrete Admixtures	1.5 oz./100 lb	1.5 - 3.0 oz./100 lb
LC-400R	RussTech, Inc	3.0 fl. oz./100 lb	3.0 - 6.0 fl. oz./100 lb
MasterPozzolith 322	BASF Corporation	5.0 fl. oz./100 lb	5.0 - 7.0 fl. oz./100 lb
MasterPozzolith 700	BASF Corporation	5.0 fl. oz./100 lb	5.0 - 7.0 fl. oz./100 lb
MasterPozzolith 80	BASF Corporation	6.0 fl. oz./100 lb	6.0 - 10.0 fl. oz./100 lb
MasterSet Delvo	BASF Corporation	3.0 fl. oz./100 lb	3.0 - 5.0 fl. oz./100 lb
MasterSet R 100	BASF Corporation	2.0 fl. oz./100 lb	2.0 - 4.0 fl. oz./100 lb
MasterSet R 300	BASF Corporation	3.0 fl. oz./100 lb	3.0 - 5.0 fl. oz./100 lb
OptiFlo 100R	Premiere Concrete Admixtures™	3.0 fl. oz./100 lb	2.0 - 8.0 fl. oz./100 lb
OptiFlo 500	Premiere Concrete Admixtures™	4.0 fl. oz./100 lb	4.0 - 8.0 fl. oz./100 lb
OptiFlo Renu	Premiere Concrete Admixtures™	3.0 fl. oz./100 lb	3.0 - 6.0 fl. oz./100 lb
Plastiment	Sika Corporation	2.0 fl. oz./100 lb	2.0 - 4.0 fl. oz./100 lb
Plastiment ES	Sika Corporation	2.0 fl. oz./100 lb	2.0 - 4.0 fl. oz./100 lb
Plastocrete 161	Sika Corporation	4.0 fl. oz./100 lb	4.0 - 6.0 fl. oz./100 lb
Plastocrete-10N	Sika Corporation	3.5 fl. oz./100 lb	3.5 - 5.0 fl. oz./100 lb
Polychem-R	General Resource Technology	2.0 fl. oz./100 lb	2.0 - 5.0 fl. oz./100 lb
Recover	W.R. Grace & Company	2.0 fl. oz./100 lb	2.0 - 6.0 fl. oz./100 lb
Sikatard 440	Sika Corporation	2.0 fl. oz./100 lb	2.0 - 8.0 fl. oz./100 lb
V-Mar VSC500	W.R. Grace & Company	7.0 fl. oz./100 lb	7.0 - 15.0 fl. oz./100 lb
WRDA with Hycol	W.R. Grace & Company	5.0 fl. oz./100 lb	5.0 - 6.0 fl. oz./100 lb

INSPECTION & ACCEPTANCE
GROUND GRANULATED BLAST FURNACE SLAG (GGBFS)

GENERAL

Acceptance of Ground Granulated Blast Furnace Slag (GGBFS), the glassy, granular material produced when molten blast furnace slag is rapidly chilled, will be on the basis of approved sources and upon satisfactory test results on samples obtained at the project site. Approved manufacturers and brands of GGBFS are listed in the Materials Approved Products Listing Enterprise (MAPLE).

Approval is based upon slag produced when the blast furnace is utilizing specific processes. Any change in the processes will void any source approval and require that a new approval be sought.

SOURCE APPROVAL

Approval of a GGBFS source is based on the requirement of ASTM C989.

A source may furnish Ground Granulated Blast Furnace Slag on the basis of certification provided:

A. The quality-monitoring program meets the minimum sampling and testing frequencies established in ASTM C-989. At least one sample for each 30 consecutive days shall be tested by the producer for conformance to Iowa Department of Transportation Specifications. The test reports for all monitor samples shall be submitted to the Iowa Department of Transportation, Office of Materials, within 45 days of the sampling date.

   The Quality Control Laboratory will be considered approved if it is properly equipped and staffed to perform the tests required for an accepted Quality Control Program. Continued approval of the control laboratory will depend on the comparison of its test results with the Iowa Department of Transportation Central Materials Laboratory. If major differences are found, an attempt to resolve them shall be made as quickly as possible. Continued unresolved differences in test results will be considered a basis for discontinuing control laboratory approval.

B. The Ground Granulated Blast Furnace Slag has shown conformance to the applicable specifications for a continuous period of at least six months.

C. Each shipment of Ground Granulated Blast Furnace Slag is properly certified.

   The supplier of certified Ground Granulated Blast Furnace Slag shall furnish, for the project records, two invoices or bill of lading copies, which bear the following certification statement and the signature of a responsible company representative:

Certification Statement

The material herein described has been sampled and tested as prescribed by the Highway Division of the Iowa Department of Transportation and complies with the applicable specification requirements for Ground Granulated Blast Furnace Slag.

Date ________________________ Signed______________________________

The bills of lading or invoices shall include project number, if available, source name, source location, source code, grade, and quantity of the shipments.

These copies of bill of lading or invoice shall accompany each load, and shall be retained at the project or ready mix plant for the Project Engineer record. The truck tanker shall have a copy of the invoice or bill of lading attached directly to the tanker portion of the truck. When the tanker unloads the contents at the project site, the unloading time and material final destination (storage "pig" number) shall be marked on this copy and left with the invoice or bill of lading copies.

In the case of more than one project being supplied by a ready mix plant, the plant shall furnish the Project Engineer, for each project, either a copy of each bill of lading or invoice, or a listing of the bills of lading or invoices representing the ground granulated blast furnace slag incorporated in the project. This listing shall bear the signature of a responsible supplier representative.

The source, car or truck number, ticket number, grade, and quantity of each shipment of ground granulated blast furnace slag used on a project shall be recorded on Form #830211, Form #830224, or other applicable form.

D. Monitor samples secured and tested by the Iowa Department of Transportation indicate compliance with current specifications. The District Materials Engineer will obtain annual samples.

APPROVED SOURCES - GROUND GRANULATED BLAST FURNACE SLAG (GGBFS)

Data as of October 22, 2014

Refer to MAPLE for current data

MARKETER	TRADE NAME	PRODUCER LOCATION	GRADE OF SLAG	SPECIFIC GRAVITY	SOURCE CODE	DISTRIBUTION TERMINALS
Central Plains Cement Company	NewCem	Chicago	Grade 100	2.93	SL04A	Omaha, NE; Sugar Creek, MO
Central Plains Cement Company	NewCem	Chicago	Grade 120	2.93	SL04B	Omaha, NE; Sugar Creek, MO
Holcim (US) Inc.	Grancem	Chicago (Skyway), IL	Grade 100	2.87	SL00A	Des Moines, Mason City, Cedar Rapids, Chicago, IL, Lemont, IL, Summit, IL, Rock Island, IL, Lacrosse, WI, St. Paul, MN
Holcim (US) Inc.	Obourg-Belgium Grancem	LaPorte, CO	Grade 100	2.91	SL01A	Des Moines, Mason City, Cedar Rapids, Chicago, IL, Lemont, IL, Summit, IL, Rock Island, IL, Lacrosse, WI, St. Paul, MN
Lafarge North America	NewCem	Chicago - New Orleans	Grade 100	2.93	SL03A	Davenport; West Des Moines; Omaha, NE
Lafarge North America	NewCem	Chicago	Grade 100	2.93	SL02A	Davenport; West Des Moines; Omaha, NE
Lafarge North America	NewCem	Chicago	Grade 120	2.93	SL02B	Davenport, West Des Moines, Omaha, NE

IM 491.17
INSP. & ACCEPT. – FLY ASH

FLY ASH

GENERAL

Acceptance of fly ash will be on the basis of approved sources and upon satisfactory test results on samples obtained at the project site. Test results of fly ash shall meet the requirements of AASHTO M 295 and the Specifications of the Iowa Department of Transportation. Approval will require identification of the specific sources of the coal from which the ash is derived.

Approval is based upon fly ash produced when the power plant is utilizing specific materials, equipment, and processes. Any change in materials, equipment, and processes will void any source approval and require that a new approval be sought. Approved fly ash sources are listed in the Materials Approved Products Listing Enterprise (MAPLE) as Appendixes A and B for two types of applications.

Fly ash produced immediately prior to shut down and after start up may be quite different from the fly ash normally obtained. The fly ash can be affected to the point that it does not meet specifications. Monitor samples or verification samples tested by the Iowa Department of Transportation not meeting specifications will void the source approval.

SOURCE APPROVAL

A. Certified Source

Approved certified sources of fly ash are listed in Appendix A of this IM. A source may furnish fly ash on the basis of certification provided:

1. The quality-monitoring program meets the minimum sampling and testing frequencies established in ASTM C 311. The tonnage units expressed therein are interpreted to refer to as-marketed material. The producer shall test at least one sample for each consecutive 30 days, for the months of March through October for conformance to Iowa Department of Transportation specifications. The test reports for all monitor samples shall be submitted to the Iowa Department of Transportation within 45 days of the sampling date.

   In addition to the test frequencies established in ASTM C 311, daily control tests shall be made to establish the uniformity of the fly ash being produced. Specific tests shall be agreed to by the engineer and may vary from source to source. As a minimum, the loss on ignition and percent retained on the No. 325 mesh sieve shall be determined.

   Sample test records and shipment reports shall be available for inspection by Iowa Department of Transportation personnel for at least three years after the fly ash has been tested.

   The Quality Control Laboratory will be considered approved if it is properly equipped and staffed to perform the tests required for an accepted Quality Control Program. Continued approval of the control laboratory will depend on the comparison of its test results with the Iowa Department of Transportation Central Laboratory. If major differences are found, an attempt to resolve them shall be made as quickly as possible. Continued unresolved differences in test results will be considered a basis for discontinuing control laboratory approval.

2. The fly ash has shown conformance to the applicable specifications for a continuous period of at least the last six months.

3. Available alkali in approval sources of fly ashes shall be less than 1.50%. The value of available alkali in fly ash can be either determined by the test method specified in ASTM C 311, or by the statistical formula developed by the Central Materials Laboratory based on the historical data. Fly ash sources that have available alkali between 1.50% and 2.50% will be approved based on satisfactory results of the following test. Mortar bars made per ASTM C 311 with 15% and 30% fly ash, Type I cement with 0.70% to 0.80% of alkali (Na_2O) equivalent (two cements may be mingled to achieve this alkali range), and Pyrex aggregate shall exhibit no more than 10% expansion over non-fly ash mortar bars at an age of 60 days. Testing shall be performed by a laboratory approved by the Iowa Department of Transportation.

4. Each shipment of fly ash is properly certified.

   The supplier of certified fly ash shall furnish for the project records two invoices or bill of lading copies that bear the following certification statement and the signature of a responsible company representative:

Certification Statement

> The material herein described has been sampled and tested as prescribed by the Highway Division of the Iowa Department of Transportation and complies with the applicable specification requirements for Class _____ fly ash.
>
> Date ____________________ Signed ____________________________

The bills of lading or invoices shall include project number, if available, source name, source location, source code, class, and quantity in the shipment.

These copies of the bill of lading or invoice shall accompany each load, and shall be retained at the project or ready mix plant for the Project Engineer records.

The truck tanker shall have a copy of the invoice or bill of lading attached directly to the tanker portion of the truck. When the tanker unloads the contents at the project site, the unloading time and material final destination (storage "pig" number) shall be marked on this copy and left with the invoice or bill of lading copies.

In the case of more than one project being supplied by a ready mix plant, the plant shall furnish the Project Engineer, for each project, either a copy of each bill of lading or invoice, or a listing of the bills of lading or invoices representing the fly ash incorporated in the project. This listing shall bear the signature of a responsible supplier representative.

The source, car or truck number, ticket number, ash type, and quantity of each shipment of fly ash used on a project shall be recorded on Form #830211, or Form #830224, whichever is applicable.

5. At least one monitor sample shall be secured annually from power plant sites, located in Iowa or within 50 miles from Iowa borders, and be tested by the Iowa Department of Transportation. The test results of monitor samples shall be in compliance with current specifications.

6. Co-Mingling of Fly Ash

   Mixing of fly ash from different sources, different generating plants/units, or different classes into one storage bin or silo will not be allowed, with the following exception.

   When the same coal stockpile, the same brand and model of generating equipment, the same process of operation, and the same brand and model of fly ash collection-equipment are used; fly ashes from different units at a generating plant may be considered for approval as a single blend and stored in a silo. To apply for the approval, the producer or marketer shall provide the composite sample test data (composite samples should represent 3200 ton increments of fly ash collection or the month whichever comes first) from the separate units for the previous 12 months. The Office of Materials will conduct a statistical t-test to compare major physical and chemical properties of the two fly ash sources. If the t-test results show the test data means to be equal at a significance level of 0.05, the blending process may be allowed. Annual analysis may be required for continued approval. Blending will only be allowed within the storage silo.

   At ready mixed concrete plants and paving batch plants, a fly ash storage bin shall be emptied, as far as practical, prior to refilling from a different source.

B. Sources for Pavement Subsealing and Jacking

1. Fly ash to be used for pavement subsealing and jacking may be accepted on an approved source basis as listed in Appendix B.

2. A mixture of 3 parts fly ash and 1 part Portland cement shall have an initial setting time between 30 minutes and 3.0 hours. Initial set is defined as 100-psi resistance when measured in accordance with ASTM C 403.

PROJECT ASSURANCE SAMPLING

Required verification samples will be secured at the project site just before incorporation into the work. Test results, which do not comply with the specifications, may be considered sufficient cause to rescind approval to furnish fly ash on certification basis. Construction, which contains fly ash represented by verification samples, which show deficient test results, will be subject to the requirements of Article 1105.04 of the Standard Specifications.

Depending upon certain chemical characteristics, fly ash is marketed as either Class F or Class C ash per AASHTO M 295. The identification submitted with the verification samples sent to the Central Laboratory should include the normal descriptive information as well as the source of the ash, the marketer and the class of the ash.

Precautionary measures shall be taken to prevent cement contamination of fly ash samples obtained at the proportioning plants. The samples shall be taken preferably as follows:

1. Directly from the delivery transport vehicles

2. Drop a sufficient amount of material in a clean container or a clean end loader bucket, and obtain a representative sample.

UNIFORMITY CHECK AND DENSITY UPDATE

For checking the AASHTO M 295 uniformity requirement, the average fly ash density for a source will be computed based on the values tested and reported by the Central Materials Laboratory. The value of average density will be updated if it is more than 0.10 gram/cm^3 different than the current value listed in the Appendix A. The density update will generally be done in the October IM revision unless a change in fly ash operation or coal source occurs.

APPROVED CERTIFIED SOURCES - FLY ASH

Data as of October 22, 2014
Refer to MAPLE for current data

Class C Fly Ash

SOURCE	CLASS ASH	PLANT LOCATION	MARKETER	SPECIFIC GRAVITY	CODE
Black Dog Generating Station	Class C	Burnsville, MN	Lafarge North America	2.66	FA039C
Burlington Generating Station	Class C	Burlington, IA	General Resource Technology	2.80	FA000C
Coal Creek Power Plant	Class C	Bismark, ND	Headwaters Resources, Inc.	2.48	FA003C
Columbia Generating Station #1	Class C	Portage, WI	Lafarge North America	2.75	FA001C
Columbia Generating Station #2	Class C	Portage, WI	Lafarge North America	2.75	FA002C
Council Bluffs Unit #3	Class C	Council Bluffs, IA	Headwaters Resources, Inc.	2.62	FA004C
Dynegy Power Plant	Class C	Havana, IL	Headwaters Resource, Inc	2.74	FA031C
Edgewater Unit #5 Generating Station	Class C	Sheboygan, WI	Lafarge North America	2.78	FA020C
Genoa Power Station #3, Dairyland	Class C	Genoa, WI	Headwaters Resources, Inc.	2.70	FA034C
Gerald Gentleman Station, Unit #1	Class C	Sutherland, NE	Nebraska Ash	2.62	FA028C
Iatan Generating Station	Class C	Weston, MO	Kansas City Fly Ash, LLC	2.78	FA007C
J.P. Madgett Station, Dairyland, Poz AC	Class C	Alma, WI	Enduracon Technologies, LLC	2.70	FA032C
La Cygne Station Power Plant, Unit #2	Class C	La Cygne, KS	Kansas City Fly Ash, LLC	2.64	FA035C
Labadie Power Plant Labadie	Class C	Labadie, MO	Mineral Resource Technologies, LLC	2.73	FA022C
Labadie Power Plant South Beloit	Class C	South Beloit, IL	Mineral Resource Technologies, LLC	2.73	FA024C
Lansing Generating Station	Class C	Lansing, IA	Headwaters Resources, Inc.	2.69	FA008C
Louisa Generating Station	Class C	Grandview, IA	Headwaters Resources, Inc.	2.75	FA009C
M.L. Kapp Generating Station	Class C	Clinton, IA	General Resource Technology	2.73	FA018C
Montrose Station Power Plant, Unit #3	Class C	Clinton, MO	Kansas City Fly Ash, LLC	2.67	FA036C
Muscatine Power & Water	Class C	Muscatine, IA	Lafarge North America	2.76	FA010C
Muskogee Generating Station	Class C	Muskogee, OK	Lafarge North America	2.69	FA042C
Nebraska City Station	Class C	Nebraska City, NE	Nebraska Ash	2.57	FA011C
North Omaha Generating Station	Class C	Omaha, NE	Nebraska Ash	2.68	FA012C
Northeastern Generating Station	Class C	Oolagah, OK	Lafarge North America	2.68	FA033C
Ottumwa Generating Station	Class C	Chillicothe, IA	General Resource Technology	2.75	FA013C
Platte Generating Station	Class C	Grand Island, NE	Ash Grove Resources, LLC	2.60	FA041C
Pleasant Prairie Generating Station	Class C	Kenosha, WI	Lafarge North America	2.55	FA014C

APPROVED CERTIFIED SOURCES - FLY ASH

Data as of October 22, 2014

Refer to MAPLE for current data

Class C Fly Ash

SOURCE	CLASS ASH	PLANT LOCATION	MARKETER	SPECIFIC GRAVITY	CODE
Port Neal Power Plant #2	Class C	Sioux City, IA	Headwaters Resources, Inc.	2.75	FA029C
Port Neal Power Plant #3	Class C	Sioux City, IA	Headwaters Resources, Inc	2.70	FA015C
Port Neal Power Plant #4	Class C	Sioux City, IA	Headwaters Resources, Inc.	2.65	FA016C
Riverside Generating Station, Unit #9	Class C	Bettendorf, IA	Headwaters Resources, Inc.	2.68	FA040C
Rush Island Power Plant	Class C	Festus, MO	Mineral Resource Technologies, LLC	2.69	FA027C
Thomas Hill Energy Center	Class C	Thomas Hill, MO	Headwaters Resources, Inc.	2.70	FA025C
Weston Generating Station	Class C	Rothschild, WI	Lafarge North America	2.64	FA026C

Class F Fly Ash

SOURCE	CLASS ASH	PLANT LOCATION	MARKETER	SPECIFIC GRAVITY	CODE
Durapoz F	Class F	Chanute, KS	Ash Grove Cement Co.	2.55	FA043F
Elm Road Generating Station #1 & #2	Class F	Oak Creek, WI	Lafarge North America	2.52	FA037F
Joliet Generating Station	Class F	Joliet, IL	Lafarge North America	2.54	FA017F
Monticello Plant	Class F	Mt. Pleasant, TX	Boral Material Technologies	2.50	FA021F
Petersburg Generating Station, Unit #3	Class F	Petersburg, IN	Charah, Inc	2.52	FA038F

IM 525
FLOWABLE MORTAR

DESIGNING FLOWABLE MORTAR

GENERAL

The laboratory design of flowable mortar involves determining the proper proportions to obtain the required flow characteristics. A mix design submitted for approval may also be assessed for flow with plant produced flowable mortar.

MATERIALS

Obtain representative samples of the following materials from the producing ready mix plant:

Sand	(75 lb.) 34 kg
Portland Cement	(15 lb.) 7 kg
Fly Ash	(15 lb.) 7 kg

PROCEDURE

A. Apparatus

1. Flow cone and equipment specified in IM 375

2. Mixer 4 qt. (4.5 L) or larger

3. 1,000 mL cylinder

4. Spatula

5. Equipment specified in IM 302

6. 1 mL pipette

B. Test Samples

1. Obtain samples for the sieve analysis and the trial mixes by one of the quartering methods listed in IM 302.

2. Two samples of at least 4,600 grams should be obtained for the trial mixes. Do not attempt to select a sample of an exact predetermined mass.

C. Preparation of Samples

1. Oven dry the samples to a constant mass and allow to cool. Screen the sample over a No. 4 (4.75 mm) sieve to remove over-sized material.

2. Weigh the dry sand samples to the nearest gram and calculate the cement and fly ash batch weight (mass) as follows:

$$\text{Cement Mass} = \text{Sand Mass x } \frac{(60\ \text{kg/m}^3)}{1550\ \text{kg/m}^3} \qquad \text{Cement Weight} = \text{Sand Weight x } \frac{(100\ \text{lb./yd.}^3)}{(2600\ \text{lb./yd.}^3)}$$

$$\text{Fly Ash Mass} = \text{Sand Mass x } \frac{(180\ \text{kg/m}^3)}{1550\ \text{kg/m}^3} \qquad \text{Fly Ash Weight} = \text{Sand Weight x } \frac{(300\ \text{lb./yd.}^3)}{(2600\ \text{lb./yd.}^3)}$$

Air entraining agent at 1 oz./cu. yd. (38.7 mL/m³)

$$\text{mL of Air Agent} = \text{Sand Mass x } \frac{38.7\ \text{mL/m}^3}{1550\ \text{kg/m}^3}$$

$$\text{mL of Air Agent} = \text{Sand Weight x } \frac{1\ \text{oz./cu. yd. x } 29.57\ \text{mL/oz.}}{2600\ \text{lb./cu. yd. x } 453.6\ \text{lb./gm}}$$

D. Mix Procedure

1. Add the air-entraining agent to the mixing water. Add the sand and part of the needed mixing water to the bowl. Start the mixer and add the cement, fly ash, and water. Add water until the mix appears fluid. Mix for three minutes after adding all materials.

   When too much water is added, the water and solids will separate after mixing. If too much water is added on the initial trial, the mix should be discarded. A good starting point for the water is 70 gallons per cubic yard (350 liters per cubic meter). The batch volume of water would be:

$$\text{mL of water} = \text{sand mass x } \frac{(350\ \text{L/m}^3)}{1550\ \text{kg/m}^3}$$

$$\text{mL of water} = \text{sand weight x } \frac{(70\ \text{gal./yd.}^3)(8.34\ \text{lb./gal.})}{2600\ \text{lb./yd.}^3}$$

2. Record the amount of water added. Run the flow test as per IM 375 to obtain the efflux time.

3. If the time of efflux is too long, increase the amount of water, air-entraining agent, or fly ash to improve the flow on the second trial. If additional water causes separation of the water and solids, fly ash should be added in 100-lb. (60-kg) increments up to a total of 400 pounds per cubic yard (240 kg per cubic meter). <u>Some sands will not produce satisfactory mix and will need to be rejected.</u>

E. Calculations and Reporting

1. Determine the final mix design weights as follows:

$$\text{Fly Ash Mass} = \frac{\text{(grams fly ash used)}}{\text{(grams sand)}} \text{ x } 1550 \text{ kg/m}^3$$

$$\text{Fly Ash Weight} = \frac{\text{(grams fly ash used)}}{\text{(grams sand)}} \text{ x } 2600 \text{ lb./yd.}^3$$

$$\text{Water (Liter)} = \frac{\text{(mL water used)}}{\text{(grams sand)}} \text{ x } \frac{1550 \text{ kg/m}^3}{1 \text{kg/L}}$$

$$\textit{Water} \text{ (Gallons)} = \frac{\text{(mL water used)}}{\text{(grams sand)}} \text{ x } \frac{(2600 \text{ lb./yd.}^3)}{(8.34 \text{ lb./gal.})}$$

Portland Cement = 100 lb. (60 kg)   Sand = 2600 lb. (1560 kg)

Air-Entraining Agent # oz./cu. yd. (#mL/m^3)

2. Report the time of efflux to the nearest 1 second. The test report should be issued like the report in the Appendix.

EXAMPLE:

IOWA DEPARTMENT OF TRANSPORTATION
NWITC - Materials Laboratory
Test Report - SAND
Sioux City, Iowa

MATERIAL: 1-4110 sand

INTENDED USE: Flowable Mortar

LAB NO.: 3FM6-3002

DATE REPORTED: 10/28/96

SOURCE: Higman's Sand & Gravel, Akron

QUANTITY: 30 cubic meters

UNIT OF MATERIAL: 75# sack
Use with LaFarge Portland Cement with Midwest Fly Ash Port Neal #4

COUNTY: Plymouth

PROJECT: STPN-12-2(13)--2J-75

DESIGN: —

CONTRACT: 73512

PRODUCER: Joe's Ready Mix

CONTRACTOR: Brower Construction.

SAMPLED BY: C. Fenceroy **SENDER'S NO.** CF10-24-96-5 **DATE SAMPLED:** 10/24/96 **DATE REC'D:** 10/24/96

Sieve Analysis	%
3/8	100
#4	99
#8	88
#16	65
#30	35
#50	11
#100	1.3
#20	0.7

CC: Materials - Ames, Geology, R. Kalsem, C. Narotam, Proj. Engineer, Contractor, Source, Producer, Lab, Proj. File

Disposition: Complies only with the following proportions: 100 lbs. cement, 300 lbs. fly ash, 2600 lbs. sand. Flowability obtained in 15.9 seconds with 66 yd3 H2O

SIGNED: C. E. Leonard
C. E. Leonard, NWITC Materials Engineer

IM 527
PAVING PLANT INSP.

PAVING PLANT INSPECTION

GENERAL

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

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

The plant inspector will normally be assigned the following duties:

1. Inspection or monitoring of proportioning and plant operation
2. Gradation determination of the aggregates used
3. Identification and tabulation of materials received and used
4. Protection, curing, and testing of the strength specimens, and care of the specimen forms
5. Maintenance of a daily diary and preparation of the Daily Plant and Strength Reports

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

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

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

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

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

If a test result on a project verification sample indicates specification noncompliance, appropriate action in accordance with the applicable specifications, instructional memorandums, and resident engineer instructions shall be taken. (See IM 204) Normally, the Contracting Authority will issue a Form #830246, Noncompliance Notice.

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

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

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

SAFETY

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

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

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

EQUIPMENT

1. BINS

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

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

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

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

2. PROPORTIONING EQUIPMENT

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

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

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

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

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

For ready mix plants, the District Materials Engineer may allow plant scales and water metering devices to be calibrated and sealed by a licensed commercial scale service. The District Materials Engineer will be given the opportunity to witness the annual calibration. A copy of the certification and calibration shall be provided to the engineer during laboratory inspection.

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

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

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

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

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

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

Suitable wind protection on all sides of the scales is required by the specification. This protection, if not provided by the plant design, can be fabricated from burlap, Masonite, plywood or other suitable material and should provide adequate room for the scale operator to work unobstructed. The District Materials Engineer may waive wind protection when non-suspended load cells are used and proven to be unaffected by wind.

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

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

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

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

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

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

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

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

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

Cement Yield Check

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

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

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

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

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

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

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

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

c. WATER MEASURING DEVICE. Scales or volume meters are permissible for measuring water. Scales may be operated manually or automatically. Regardless of the type of measuring equipment used, the amount of water delivered to the batch must be **accurate** to **2.2 lbs. (1 kg)** or within plus or minus **one percent** of the amount shown by the indicator whichever is greater. If water is measured with a scale, the **delivery**

tolerance must be determined at least **once for each day** of normal operation as described in 2b, Aggregate Scales. If a volume meter is used, the delivery tolerance need not be determined other than during the original calibration or at such time that a water-measuring problem is indicated. Testing a water meter is the duty of the District Materials Engineer or his/her representative.

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

3. MIXING EQUIPMENT

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

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

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

The following is the recommended method for determining mixing time:

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

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

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

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

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

b. READY MIX. The maximum size of the batch and the mixing speed recommended by the manufacturer for ready mix trucks shall be shown on a plate attached to the mixer. The Truck Mixer Manufacturer’s Bureau (TMMB) may issue the plate; if not, an independent, recognized laboratory, shall determine compliance as defined in Article 4103.01, and complete test results may be required. The batch size must not exceed that shown on the plate and the mixing speed must be in the range shown. Determine and record the mixing speed for each mixer at least once daily. The batch must be mixed from 70 to 90 revolutions at mixing speed unless otherwise directed by the engineer. All mixers must be equipped with a revolution counter. If the counter is one that counts revolutions only when the drum is turning at mixing speed, mixing may be permitted while the truck is in transit. If the counter is a simple re-settable counter, which counts all revolutions regardless of the drum speed, mixing must be accomplished at a location where it can be observed by the inspector. It is permissible for the mixing to be done either at the plant or the project site. A clear understanding must exist between the plant and grade inspectors as to where the mixing will be done.

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

4. TRANSPORTATION VEHICLES

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

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

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

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

<u>MATERIAL</u>

1. IDENTIFICATION

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

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

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

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

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

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

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

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

e. Approved brands of water reducing admixtures, retarding admixtures, and dosage rates are in IM 403. Any admixtures suspected of being frozen and materials older than 18 months shall not be used before being tested and approved. These admixtures shall be agitated in accordance with IM 403 to maintain the solids in suspension.

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

2. STORAGE & HANDLING OF MATERIALS

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

The storage and handling of all aggregates must comply with Article 2301. 02,C If alternate methods are used as permitted and the required sampling and testing indicates non-specification aggregate gradation, the District Materials Engineer must be informed immediately. The responsibility of and the authorization for proper changes, if necessary, lies with the District Materials Engineer. It is important that the moisture content of the aggregates be uniform. Fine aggregate must be drained at least 24 hours before it is placed in the batch. For both coarse and fine aggregate, moisture content of successive batches must not vary more than 0.5 percent or this will be considered non-compliant. In such a case, the engineer and the contractor must be immediately informed. The problem must be corrected within a reasonable amount of time, generally one day. The work must not be permitted to progress when such a problem is not corrected. Unless aggregates are stored on platforms or other smooth hard surfaces some material in the bottom of the pile will be unfit for use because of contamination by the underlying soil. (See Article 2301.02,C)

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

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

SAMPLING & TESTING

1. AGGREGATES

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

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

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

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

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

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

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

Quality Control Sampling, Testing, and Reporting

Production	Specific Gravity	Moisture	Gradation	Report
Continuous	1/day 1st 3 days, 1 per 3 days thereafter	1/half day	1/day >500 yd^3	1/day
Intermittent	1/ week	1/ week	1/ week	1/ week

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

Intermittent construction operation involving small quantities, less than 500 cubic yards per day, shall be grouped to establish a lot not to exceed one week. A minimum of one quality control sample shall be obtained and tested during the week. A minimum of one verification sample will be obtained and tested during the week. When intermittent production is longer than one week, sample once per week and test 20% of the samples obtained.

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

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

Verification Sampling and Testing

Production	Gradation Sampling	Gradation Testing
Continuous	1/day >500 yd^3	1st day, then 1/ week
Intermittent	1/ week	1st week, then 20%

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

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

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

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

d. MOISTURE. Tables T214A, showing the Moisture Reciprocals (multiplication factors) that can be used for adjusting the aggregate batch amounts for the moisture content are included. The method most preferred for adjusting batch amounts is located in the Proportions section of this instruction. The District Materials Engineer may approve the use of the Chapman flask (ASTM C70) for fine aggregate moisture provided accurate specific gravity of the source is known.

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

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

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

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

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

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

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

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

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

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

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

2. STRENGTH

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

PROPORTIONS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1. ADJUSTMENTS FOR MINERAL ADMIXTURE SUBSTITUTION & CEMENT MODIFICATION

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

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

2. PROPORTIONING A MIX FOR A MINERAL ADMIXTURE SUBSTITUTION

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

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

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

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

3. PROPORTIONING A MIX FOR ADDITIONAL CEMENT

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

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

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

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

The following example illustrates one of the methods used:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The plant inspector must keep a record in the plant field book of the total mixing water used, including the water in the aggregates, for at least each three (3) hours of normal operation to determine that the maximum permissible water content is not exceeded and to determine the batch volume. When ready mix trucks are used, water added on the grade must also be reported to the plant inspector.

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

If, after the District Materials Engineer investigation and evaluation, additional workability above that which is attainable with the maximum permissible water content is desired, the cement content may be increased in accordance with Article 2301. 02,B. This should be done only with the approval of the District Materials Engineer or his/her representative. The District Materials Engineer will provide the revised and adjusted mix proportions for these situations.

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

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

OTHER REPORTED TESTING

1. IN-PLACE AIR CONTENT

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

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

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

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

2. VIBRATION CHECKING

   In accordance with Article 2301.03,A, an electronic vibrator-monitoring device displaying the operating frequency of each individual internal vibrator is required for all Interstate and Primary paving over 50,000 square yards (40,000 m^2).

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

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

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

REPORTS & REPORTING

1. PLANT PAGE – FORM #240

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

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

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

2. PERSONAL COMPUTER

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

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

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

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

4. PORTLAND CEMENT SHIPMENT YIELD REPORT - FORM #820912

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

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

CONCRETE PLANT INSPECTION CHECKLIST

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Q. Other duties include:

- Close observation of stockpiling and handling of aggregates. There must be no intermingling of aggregates and no contamination.
- Frequent check on wet batch or dry batch truck cleanliness and degree of discharge.
- Document all the above data in diary.
- Make the following report daily: Plant Reports - Form #800240
- Make the following report as prescribed: Cement Yield Report - Form #820912E
- At the end of the project, make a copy of the plant book for the Engineer, within ten days.
- When required by Article 2301.03, make a copy of vibration-monitoring device records in electronic format.

IMs/SPECIFICATIONS USED IN PCC PLANT INSPECTION BY VOLUME

Volume II IMs:

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

Volume IV IMs:

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

Specifications:

2301	Portland Cement Concrete Pavement
2403	Structural Concrete
4100	General Provisions
2001	General Equipment Requirements

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

INSTRUCTIONS FOR COMPLETION OF PCC PAVING & STRUCTURAL REPORTS

The new reporting process does not include Mobile Mixer information. Use the following forms and reports when using a Mobile Mixer:

Form M or E 115	Air & Slump Record
Form M or E 120	Mobile Mixer Data Record
Report #820180	Gradation Test
Report #821297	Nuclear Density of Plastic PC Concrete
Report #820020	Mobile Mixer Calibration

Project No.
Enter the project number listed on the plans.

Plant Name
Enter the name of the ready mix plant and location for structural concrete. Enter the approximate location of a paving plant set up by a contractor.

Example: Croell - Waverly (Ready Mix)
2 miles NW of Waverly (Paving Plant)

Contractor/Sub
A group of people or a company must perform the work being done, either a prime or sub contractor. Enter the name of the contractor performing the work. If it is a subcontractor, list this after the contractor name.

Weather
Enter a brief description of the actual weather conditions at the paving plant. Weather conditions are not required for structural concrete (Ready Mix).

Contract ID
Enter the nine-digit contract number listed at the top of a contract. This is not the five-digit accounting ID number listed with the project number.

County
Enter the county listed on the project plans.

Temperatures, Min. & Max.
An air temperature shall be recorded early in the morning for the minimum and around mid-afternoon for the maximum. Take the temperatures in a shaded area, otherwise they are meaningless. Temperatures are not required for structural concrete (Ready Mix).

Report No.
Start with the number 1 at the beginning of work for each project. The ending report number shall coincide with the last day each item is completed for paving and the last week for structural. Do not restart the report sequence if the project carries over to the next year.

Example: (Paving) 16 days of 200-mm slip form paving - report 1 through 16.
(Ready Mix) 8 weeks of concrete on Des. 1290 - report 1 through 8.

Date This Report
Enter the date the concrete is placed for each day of paving. Enter the last day of the workweek for structures (normally the Saturday date).

Date of Last Report
Self-explanatory.

Design No.
Enter the design number of the structure where the concrete is being placed on each project. Leave this space blank on paving projects.

Check Mix (Central or Ready)
Place an "X" in the appropriate box provided indicating how the concrete is being produced.

Check Usage (Paving, Structural, Incidental, Patching)
Place an "X" in the appropriate box provided to indicate the type of work where the concrete is used.

Date (Mo./Day)
This column is only used for Ready Mix concrete applications. Enter the month and the date for each day of production during the week.

Example: 5/24, 7/01, 12/03, etc.

Mix Number
Enter the mix number being used that is listed in the proportion tables of IM 529.

Location- Station (Beg./End/Dir)
Enter the beginning and ending station for concrete placed daily by mix. Enter the direction (N, S, E, W) for divided sections or B for 2-lane sections. For structural concrete enter the unit placed (Example: pier, cap, footing, deck). Enter item placed for other work. (Example: sidewalk, drive) The grade inspector will provide the location or item placed to the plant inspector.

Batched
Enter the total cu. yds. (m^3) batched for each mix for a paving plant. Enter the total cu. yds. (m^3) batched for each unit poured for structures.

% Of Est. Used
Enter the percent of estimated concrete used. The grade inspector will provide the % of estimate used ((cubic yards used / cubic yards estimated) X100) to the plant inspector

Fine, Intermediate & Coarse Aggregate (Moisture)
Enter the percent moisture once in the morning and once in the afternoon for paving projects. Enter the percent moisture for each unit poured on structures.
Fine, Intermediate & Coarse Aggregate (T203 sp gr)

Enter the specific gravity for each aggregate listed in the T203 source tables.

Fine, Intermediate & Coarse Aggregate (Dry Mass or Wt.)
Enter the weight (mass) of each aggregate calculated by absolute volumes.

Actual Quantities Used Per cu. yds. (m^3) in Kilograms (Pounds)

Cement Enter the pounds (kilograms) of cement calculated by absolute volumes.
Fly Ash Enter the pounds (kilograms) of fly ash calculated by absolute volumes.
GGBFS Enter the pounds (kilograms) of ggbfs calculated by absolute volumes.
Fine Enter the actual pounds (kilograms) of fine aggregate adjusted by moisture content.
Inter. Enter the actual pounds (kilograms) of intermediate aggregate adjusted by moisture content.
Coarse Enter the actual pounds (kilograms) of coarse aggregate adjusted by moisture content.
In Agg. Enter the calculated difference between the actual weights (masses) and the dry weights (masses) of both fine and coarse aggregates.
Plant Enter the average pounds (kilograms) of water added at the plant for each cu. yd. (m^3).
Grade Enter the average pounds (kilograms) of water added on the grade (when permitted by specification).

Avg. W/C Ratio
Enter the ratio of total water, including water in the aggregates and water added on the grade, in one cu. yd. (m^3) divided by the total sum of cement, fly ash, and ggbfs in one cu. yd. (m^3), report to three decimal places.

CPI Gradations
This section of the report is for reporting the Certified Plant Inspector gradation test results for the coarse and fine aggregates being used in the mix. If one of the tests fail and backups are tested, record the average in the column provided, which is located just right of the specifications column.

Batched (Today or Week)
Place an “X” under the Today column if the report is being submitted daily (paving).
Place an “X” under the Week column if the report is being submitted weekly (structures).

Concrete Batched
Enter the total cu. yd. (m^3) of concrete batched under the appropriate column. Paving plant totals are normally under the Today column; structural concrete totals are normally under the Week column.

To Date Total
Enter the running total for both concrete and cement.

Air Entraining (Air Ent.)
Enter the brand name or source, average rate per cu. yd. (m^3), and lot number.

Water Reducer (Wat. Red.)
Enter the brand name or source, average dosage rate, and lot number.

Retarder
Enter the brand name or source, average dosage rate, and lot number.

Calcium Chloride (Cal. Chlor.)
Enter the brand name or source, average dosage rate, and lot number only when added at the plant site.

Superplasticizer (Superplas.)
Enter the brand name or source, average dosage rate, and lot number.

Concrete Treatment
Place an "X" directly behind Ice, Heated Water, or Heated Materials, if one or more are used. If ice is used to cool the mix, enter the pounds (kilograms) of ice per cu. yd. (m^3).

Cement
Enter the cement type, specific gravity, and source. See IM 401 for the actual source name.

Fly Ash
Enter the type and specific gravity and source. See IM 491.17 for the actual source name.

Example: Chillicothe and ISG Headwaters are not source names.
Ottumwa is the source name.

Rock
Enter the T203 A number, and gradation number.

GGBFS
Enter the grade, specific gravity, and source. See IM 491.14 for the actual source name.

Sand
Enter the T203 A number, and gradation number.

Intermediate
Enter the T203 A number.

Remarks
Enter delays, which may take place. Enter description of noncomplying test results.

CPI
Enter the Certified Plant Inspector name and certification number.

Monitor
Enter the plant monitor name and certification number.

If using the computer spreadsheet, most of this information will be entered on the Project Information and Mix Information sheets and automatically transferred to the Report. For QMC and BR mixes, the combined gradation will be calculated from aggregate percentages entered in the Mix Information Station From and To, Totals to Date Cement and Concrete, and Remarks will be entered directly on the Report.

The next page is an example of a completed Paving Plant Report.

800240E - 04/00 computer

Date of Placement	Location From	To
Mix 1 05/02/98	101+13	133+69
Mix 2 11/29/99		
Mix 3		
Mix 4		

Project No.: NHS-18-5(123)--19-17
Plant Name: CARLSON's HWY 65 & HWY 18
Contractor / Sub: FRED CARLSON
Weather: MOSTLY SUNNY

Contract ID: 17-0185-11
County: CERRO GORDO
Temp. (°F) Min: 48
Temp. (°F) Max: 70

Report No.: 2
Date This Report: 06/02/96
Date Of Last Report: 06/01/96

Check Mix(x)		Check One(x)		SEND
Central	X	Paving	X	(Daily)
Ready		Structure		(Weekly)
		Incidental		(Weekly)
		Patching		(Weekly) or end of Lot

	Mix	Batched (CY)	% Of Est. Used	Fine Aggregate Moist. (%)	Fine T-203 Sp. G.	Fine Wt. SSD (lbs)	Intermediate Aggregate Moist. (%)	Inter. T-203 Sp. G.	Inter. Wt. SSD (lbs)	Coarse Aggregate Moist. (%)	Coarse T-203 Sp. G.	Coarse Wt. SSD (lbs)	Actual Quantities Used Per cy (in pounds) Cement	Fly Ash	GGBFS	Fine	Inter.	Coarse	Water In Agg.	Water Plant	Grade	Avg w/c Ratio	Max w/c Ratio
1	C-3WR-C15	1,100.00	101.3	4.0	2.67	1,390				0.9	2.75	1,751	470	83		1,448		1,767	74	164.0		0.430	0.489
2																							
3																							
4																							

Coarse	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#200	Comply
	100	50-100	30-100	20-75	5-55	0-10	0-5	0-1.5	Y/N
	100	75	49	31	14	4.1	0.5	0.5	Y

Concrete Treatment (x)		lb / cy
Ice		
Heated Water		
Heated Materials		

Check One (X)	Batched Today	Week	Total To Date
	X		
Concrete (CY):	1,100.00		17,279.60
Cement (tons):	258.50		5,007.39

Inter.	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#200	Comply
									Y/N
									NA
									NA
									NA

	Brand / Source	Rate	Lot Number
Air Entraining:	SIKA AEA 15	7 0Z./CY	C80005M
Water Reducer:	SIKA PLASTOCRETE 161	3 OZ./CWT	D80002P
Retarder:			
Calcium Chloride:			
Superplasticizer:			

Fine	3/8"	#4	#8	#16	#30	#50	#100	#200	Comply
	100	90-100	70-100		10-60			0-1.5	Y/N
	100	88	69	44	25	11	4.7	0.3	Y

	Type	Sp. Gr.	Source
Cement:	IS	3.04	HOLNAM
Fly Ash:	C	2.56	PORTAGE 1
GGBFS:			

Adjusted % Passing Calculated Combined Gradation

	1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Within Target
Target													

	T-203 A - #	Grad No.
Coarse:	A17008	4
Intermediate:		
Fine:	A17514	1

Remarks
This is a test report

Distribution: ____ Central Materials ____ DME ____ Proj. Eng. ____ Plant

C.P.I.: JEFFREY BOLSINGER NE118
Monitor: JASON RUTER NE443

EXAMPLE A

Rev 05/09

Iowa Department Of Transportation
Office Of Materials
PORTLAND CEMENT CONCRETE

Form E820150E

Project No.:	STPN-005-3(52)--2J-63			County :	Marion
Mix No.:	C-3WR-C20-S20	Abs Vol. Cement:	0.108	Type:	I/II
Cement (IM 401):	571	lbs	Source: Lafarge I/II	Sp. Gr.:	3.14
	%				
Fly Ash (IM 491.17):	20	114	Source: HW Chillicothe	Sp. Gr.:	2.73
Slag (IM 491.14):	20	114	Source: Lafarge Newcem	Sp. Gr.:	2.93
Adjusted lbs. Cement:		343			
Total Cementitious		571	Total % Replacement = 40		

IM T203	Fine Aggregate Source:	A63512	Sp. Gr.:	2.67
IM T203	Interm. Aggregate Source:	A63002	Sp. Gr.:	2.51
IM T203	Coarse Agregate Source:	A63002	Sp. Gr.:	2.51

Basic w/c	0.430	Water (lbs/cy) = Design w/c (wt. cement + wt Fly Ash +Slag) =	246
Max w/c	0.489	Max. Water (lbs/cy) = Design w/c (wt. cement + wt Fly Ash +Slag) =	279

Absolute Volumes

Cement	(lbs/cy) / (Sp. Gr. X 62.4 X 27)	=	0.065
Fly Ash	(lbs/cy) / (Sp. Gr. X 62.4 X 27)	=	0.025
Slag	(lbs/cy) / (Sp. Gr. X 62.4 X 27)	=	0.023
Water	(lbs/cy) / (1.00 X 62.4 X 27)	=	0.146
Air			0.060
	Subtotal	=	0.319
	1.000 - Subtotal	=	0.681
	Total	=	1.000

% FA Agg.:	45	Fine Aggregate (1.000 - Subtotal) X % In Mix	=	0.306
% In. Agg.:		Interm. Aggregate (1.000 - Subtotal) X % In Mix	=	
% CA Agg.:	55	Coarse Aggregate (1.000 - Subtotal) X % In Mix	=	0.375
		Aggregate Total	=	0.681

Aggregate Weights

Fine Aggregate (abs vol.) X Sp. Gr. X 62.4 X 27	=	1377
Intermediate Aggregate (abs vol.) X Sp. Gr. X 62.4 X 27	=	
Coarse Aggregate (abs vol.) X Sp. Gr. X 62.4 X 27	=	1586

Summary

Cement	343	(lbs/cy)
Fly Ash	114	(lbs/cy)
Slag	114	(lbs/cy)
Water	246	(lbs/cy)
Fine Agg.	1377	(lbs/cy)
Interm. Agg.		(lbs/cy)
Coarse Agg.	1586	(lbs/cy)

Distribution: ___ Materials, ___ DME, ___ Proj. Engr., ___ Contractor

Form 830212
10-95

READY MIX CONCRETE

____________________ Plant

Truck No. __________ Ticket No. __________

Date __________ Des. No. __________

Proj. No. __________

Mix No. __________ Retarder/Water Reducer? ☐ Yes ☐ No

Conc. This Truck __________ C.Y./m^3

Air agent added this truck __________ oz./mL

Time Batched __________ Discharged __________

Rev. Mixed *(Plant)* __________ Grade __________

Water *(gal./L or lbs./kg This Truck)* 8.33lbs./gal.

In Aggregate	________	gal./L	________	lbs./kg
Added *(Plant)*	________	gal./L	________	lbs./kg
Subtotal	________	gal./L	________	lbs./kg
Added Grade	________	gal./L	________	lbs./kg
TOTAL WATER	________	gal./L	________	lbs./kg

Maximum Water Allowed ________ gal./L ______ lbs./cy or kg/m^3

Air __________ Slump __________

Plant Insp. __________

Receiving Insp. __________

Form 820912E - computer

Report No.: 1

Portland Cement Shipment Yield Report

Date Submitted: 01/02/04

Contract ID: 29999
Source: Ash Grove
Project No.: FM-85(25)--55-85
Contractor: Manatt's
County: Story
Plant Location: NW Corr E29

Date	Invoice Number	Billed Tons	Type	Date	Invoice Number	Billed Tons	Type	Date	Invoice Number	Billed Tons	Type
06/02/03	107312	28.19	I/II	06/04/03	107352	27.86	I/II	0	0	0.00	I/II
06/02/03	107313	28.14	I/II	06/04/03	107353	27.57	I/II	0	0	0.00	I/II
06/02/03	107314	27.85	I/II	06/04/03	107354	28.14	I/II	0	0	0.00	I/II
06/02/03	107315	27.81	I/II	06/04/03	107355	27.99	I/II	0	0	0.00	I/II
06/02/03	107316	27.92	I/II	06/04/03	107356	28.10	I/II	0	0	0.00	I/II
06/02/03	107317	28.21	I/II	06/04/03	107357	27.79	I/II	0	0	0.00	I/II
06/02/03	107318	25.49	I/II	06/04/03	107358	26.99	I/II	0	0	0.00	I/II
06/02/03	107319	26.57	I/II	06/04/03	107359	27.85	I/II	0	0	0.00	I/II
06/02/03	107320	28.06	I/II	06/04/03	107360	28.00	I/II	0	0	0.00	I/II
06/02/03	107321	28.02	I/II	06/04/03	107361	27.94	I/II	0	0	0.00	I/II
06/02/03	107322	28.15	I/II	06/04/03	107362	27.30	I/II	0	0	0.00	I/II
06/03/03	107323	28.36	I/II	06/04/03	107363	28.28	I/II	0	0	0.00	I/II
06/03/03	107324	28.08	I/II	06/04/03	107364	27.90	I/II	0	0	0.00	I/II
06/03/03	107325	27.73	I/II	06/04/03	107365	28.50	I/II	0	0	0.00	I/II
06/03/03	107326	28.26	I/II	06/04/03	107366	28.00	I/II	0	0	0.00	I/II
06/03/03	107327	25.55	I/II	06/04/03	107367	27.99	I/II	0	0	0.00	I/II
06/03/03	107328	28.19	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107329	27.61	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107330	28.18	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107331	28.37	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107332	28.24	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107333	28.20	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107334	28.03	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107335	28.18	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107336	28.03	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/03/03	107337	21.00	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107338	27.78	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107339	28.15	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107340	28.25	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107341	28.32	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107342	27.89	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107343	27.96	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107344	28.50	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107345	28.28	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107346	27.27	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107347	27.91	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107348	28.34	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107349	27.88	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107350	28.34	I/II	0	0	0.00	I/II	0	0	0.00	I/II
06/04/03	107351	28.35	I/II	0	0	0.00	I/II	0	0	0.00	I/II

Mix No.	Cement Per CY (lbs)	Batched (CY)		Cement Batched (Tons)
C-4WR-C15	503	5,782.00	....	1,454.17
M-4	825	168.00	....	69.30
C-4WR	593	147.00	....	43.59
0	0	0.00	....	0.00
0	0	0.00	....	0.00
Left In	This Check (+)			1.53
Scale (Tons)	Previous Yield Check (-)			1.68
	Total Weighed (Batch Scale)			1,566.91

Total Billed Weight (Tons) 1,555.84

Yield = 100.7 %

C.P.I.:

Signature

Distribution: _____ DME _____ RCE _____ Central Materials _____ Contractor _____ Inspector

Form 820917
11-94

Iowa Department of Transportation

Office of Materials

PLANT CALIBRATION REPORT

☐ Portland Cement Paving Plant
☐ Ready Mix Plant
☐ Initial Calibration ☐ Check Calibration ☐ Change in Material Source

Shaded area to be completed for paving plants and when applicable for ready mixed concrete plants.

Contractor/Producer	County
Plant Location	Project
Class of Concrete	Mix No.(s)
Design W/C Ratio(s)	Max W/C Ratio(s)

MATERIAL	SOURCE Producer Name & Location	SPECIFIC GRAVITY	DRY BATCH MASS
Aggregate (Coarse)			
Aggregate (Find)			
Cement			
Fly Ash			
Water			
Air Entraining Agent			
Curing Compound			
Water Reducing Agent			
Retarding Admixture			

Calibrated by: ______________ Title: ______________ Date: ________

Coarse Aggregate Sampling Point: ______________

Remarks: ______________

____

____

____

____

Note: Circulation of air entraining, water reducing, and retarding admixtures is required **prior to** use.

This above data is furnished by the Contractor/Producer as set forth in the Standard Specifications for plant operations. The Contracting Authority makes no representations as to accuracy, either express or implied, which are to be construed to relieve the contractor from the responsibility to comply with the specifications.

Witnessed ______________

Title ______________

Distribution: White Copy - Plant Inspector; Canary Copy - Contractor/Producer; Pink Copy - Transportation Center Materials Engineer; Goldenrod Copy - Resident Engineer
Send copy to Central Materials on city and county projects. (PCCP Only)

PORTLAND CEMENT & READY MIX PLANT CALIBRATION CHECKLIST

References: IM 527, 528 and noted Specifications

STORAGE & HANDLING OF MATERIALS

Aggregates: 2301.02

- Certified compliance
- Separation of materials
- Storage area floor shall be a minimum of 18” of similar material
- Fine aggregates shall drain a minimum of 24 hours on new bridge deck floors-2412.02

Cementitious Material: 2301.02

- Approved certified sources
- No intermingling of products or sources
- Stored in suitable weather proof enclosures

WATER

- Sample when required

ADMIXTURES

- Verify acceptance of lot
- Circulate 5 min. per 100 gal. of solution
- Proper storage to prevent freezing

PLANT REQUIREMENTS

Safety:

- Guards, ladders, railings and walkways
- Sampling location
- Proper template if belt sample
- Safety switches and belt lockouts in place
- Bins are structurally safe: 2001.06
- Settlement of footings is uniform
- Suitable wind protection for scale operation
- Automatic interlocks for projects over 6000 sq. yds: 2001.20 & 2301.13
- Weight indicator or digital readouts are in full view of the plant operator.

Scale Calibration: 2001.20

Calibration of batch plant scales as required by the specifications is performed by incrementally loading the scales with standard test weights and partial batches through the operating range of the scales. As each increment of load is applied, the actual observed weight and the required weight are compared. The differences plus or minus, are determined and converted to percentages of the required weight. If the percentage deviations are less than the tolerance allowed by the specifications and the scales are sensitive to the test loads, the scales will be considered in calibration. If the scales do not meet the various requirements, the contractor should be notified immediately and required to make the necessary repairs or adjustments. The engineer may order recalibration if the scale equipment malfunctions, material quantities do not agree with actual material quantities, or any repairs or replacement of equipment occurs.

- Calibrate scales to include the maximum weight for projected batches
- Commercially manufactured weights that have the weight stamped on the exterior and appear to be unaltered and in good condition may be assumed to meet the requirements of ASTM E617.
- Non-commercially manufactured test weights may be used in providing accumulating weight for loading the scales, if validated against commercially manufactured test weights, or a certified scale, a minimum of once every two years. Some manufactured weights may vary and require more frequent validation.
- Accumulate calibration error at each increment that material replaces known weight.

NOTE: Example uses 2000 lbs. of known weights applied at 1000 lb. increments. Accumulated error applies only when exchanging known weight with material.

Applied Wt.	Scale Reading	Error	Accum. Error	Wt. Replaced By Material
1000	995	-5		
2000	1995	-5	-5*	yes
3000	2990	-10	-15	<
4000	3995	-5	-10*	yes
5000	5000	0	-10	<
6000	6005	+5	-5*	yes
7000	7010	+10	+5	<

NOTE: *Accumulated error is from last known error prior to material replacement.

< Intermediate errors are measured to determine specification compliance, but are not part of the accumulated result.

As a guide, a working form to help record field calibration measurements is on page 4.

Water Calibration: 2001.20B

- Equipment shall be such that accuracy will not be affected by variations in pressure of the water supply.
- Weighing equipment to verify water calibration shall meet specification
- Repairs or adjustments will require equipment to be recalibrated.

Equipment for Dispensing Liquid Admixtures: 2001.20C

- Calibrate per Specification
- Measuring container of digital readout shall be on view of plant operator.

Truck Mixer & Agitator: 2001.21B

- Meet the requirements of specification
- Truck mixer certification (Form #820907) kept in truck and is up to date.

CONCRETE PLANT CALIBRATION WORKSHEET

DATE ________________________ ____ PAVING PLANT

LOCATION ____________________ ____ READY MIX PLANT

CEMENT SCALE – ACCURATE TO 0.5% OF BATCH WEIGHT

SENSITIVITY – EMPTY _________ FULL _________ LBS. @ _________ LBS.
TOLERANCE – 0.1% OF BATCH WEIGHT OR 2 LBS., WHICHEVER IS GREATER

applied weight	scale reading	error	accum. error	applied weight	scale reading	error	accum. error

AGGREGATE SCALE – ACCURATE TO 0.5% OF BATCH WEIGHT

SENSITIVITY – EMPTY _________ FULL _________ LBS. @ _________ LBS.
TOLERANCE – 0.1% OF BATCH WEIGHT OR 2 LBS., WHICHEVER IS GREATER

applied weight	scale reading	error	accum. error	applied weight	scale reading	error	accum. error

WATER-ACCURATE TO +/-1.0% OR 2 LBS., WHICHEVER IS GREATER

ADMIXTURES-ACCURATE TO +/-3.0% OF QUANTITY REQUIRED

metered		scale	error	area		water reducer		Retarder	
gal.	lbs.	reading		meter oz.	meas. oz.	meter oz.	meas. oz.	meter oz.	meas. oz.

READY MIX CONCRETE PLANT INSPECTION

GENERAL

Refer to IM 527 (General, Safety).

The following instruction is to be used when inspecting the operation of a ready mix concrete plant typically used for structural concrete, patching, and other concrete items. Refer to IM 527 for sampling and testing for paving.

EQUIPMENT

1. ELEVATED, LOW PROFILE, AND GROUND-LEVEL BINS

   Refer to IM 527 (Equipment Bins) and the following:

   Permanent ready mix concrete plants often have facilities for storing sizable quantities of a number of different aggregates. There is a tendency for the stockpiles to become too large for the available area and for the bins to be filled beyond their normal capacity. Aggregates thus tend to become intermingled. Aggregates may also become contaminated with foreign material from a number of sources, including the material, which underlies some stockpiles, if proper care is not taken. Materials, which have been intermingled or otherwise contaminated, must not be incorporated into the work.

2. PROPORTIONING EQUIPMENT

   Requirements for scales or meters for proportioning aggregates, cement, fly ash, water or air entraining agents or other admixtures are found in Article 2001.20 of the Standard Specifications, as modified by Supplemental Specifications. These requirements are in addition to Section 1 above for elevated bins.

   It is the duty of the District Materials Engineer to examine and evaluate all proportioning and plant equipment annually, and maintain a current list of approved ready mix concrete plants. The Calibration Report, Form #820917, with any appropriate restrictions, conditions, comments, etc., will be posted at the plant site. (See IM 527, Appendix C for a sample copy and Appendix D for calibration checklist.) Before concrete work begins on a project, the Project Engineer must communicate with the District Office and determine that the plant to be used has received annual approval.

   The PCC Level II certified technician must be familiar with all features of the plant operation before work begins. While the inspector must not personally make any of the manipulations or adjustments, an understanding of the basic machinery operation and the ability to recognize the significance of a malfunction is important.

   The proportioning equipment must be examined at regular intervals during a placement for correctness of the amount being delivered and for possible damage or malfunction. Special attention must be given to the empty balance and the position of the poise weights for beam and dial scales.

The normal plant operation causes vibration, which tends to change these adjustments. Accumulation of material clinging to the inside of the hoppers can also cause these adjustments to drift. Small amounts of material accumulation clinging to the inside of a hopper are not considered objectionable. If the amount exceeds one percent of the material batch, however, it must be removed and readjusted to indicate a zero load within 0.5% (Article 2001.20).

The scale sensitivity shall be checked at least at the beginning of a placement if operations are intermittent, and at the beginning of each day if the operations are continuous in the following manner:

> Place a mass equal to 1/10 percent of the batch on the fully-loaded scales while observing the movement of the indicator.

A properly sensitive scale will exhibit a visible indicator movement when tested in this manner. If no indicator movement is visible and immediate corrective action by the owner does not yield successful results, the District Materials Engineer must be informed.

Periodic observation of the measuring operation must be made to determine that the proper amounts of materials are being delivered to the concrete batch. The plant inspector must be able to recognize when the hopper is overloaded or underloaded by one percent of the batch. For a dial scale, these limits are readily recognizable on the graduated dial chart. For scales with a balance indicator, the location of the indicator hand when a one percent over and underload is applied and removed can be noted before work begins.

If an examination reveals that the scales are not properly sensitized or the proper amounts of material are not being furnished to the concrete batch, refer to IM 527, General, for the necessary action.

Document all routine scale sensitivity, delivery tolerance checks and any necessary corrective action taken, in the plant inspection diary.

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

- The plant superintendent or other authorized operator representative must make all necessary scale and equipment setting and/or adjustments. The PCC Level II certified technician is specifically directed not to participate in this activity.

- Before the plant operation begins or resumes, the PCC Level II certified technician will independently determine for himself/herself that the settings and/or adjustments are correct and that the amounts of material being delivered to the batch are correct. Errors must be corrected immediately. Strict adherence to the above procedure is necessary to maintain a proper division of authority and responsibility between the contractor and the contracting authority, and to minimize the possibility of operating with erroneous proportions.

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

An air-entraining admixture is required for all structural concrete, except Class X, and can be proportioned either manually or automatically. Mechanical dispensers must have a transparent measuring chamber so that each batch can be observed as it is measured and dispensed. Mechanical dispensers must be cleaned daily to minimize the possibility of deposits accumulating and causing a malfunction.

The amount of air entraining admixture required is determined by the results of the pressure meter air tests run on the plastic concrete, as described in IM 318. The contractor must decide the quantity to be used and the adjustments necessary, if any, after the pressure meter testing has been completed. Provision shall be made for agitation of the air-entraining agent. (See Article 4103.01A)

An admixture for set retardation may be required. The list of approved retarding admixtures, and recommended dosages, is found in IM 403. An admixture for water reduction may be used at the contractor's option in mixes so designated in IM 529. (See Article 2301.02,B.)

See IM 527 (Materials, Admixtures), regarding dosage, handling and storage of admixtures.

Most air entraining and retarding admixtures, when intermingled with each other tend to neutralize each other and negate the effects of each. Care must therefore, be taken to introduce each admixture into the mixer separately and allow the first to become intermingled into the batch before the second is introduced. A procedure, which has been used successfully, is to introduce the air-entraining agent first along with most of the mixing water and other ingredients, and after these have become intermingled then introduce the balance of the mixing water and the retardant admixture.

3. MIXING EQUIPMENT

Mixing equipment for structural projects will be one of the following types:

Truck-mounted transit mixers
Stationary central mixers with in-transit agitation
Stationary mixers located at the project site
Concrete-Mobiles

The truck-mounted transit mixers are the most popular with stationary, central mixers increasing in popularity. Stationary site mixers are seldom used.

Refer to IM 527 (Mixing Equipment) for inspection instructions relating to stationary central mixers and truck-mounted transit mixers, and IM 534 for Concrete-Mobiles.

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

MATERIAL

Refer to IM 527 (Material) for the necessary inspection instructions relating to material identification, handling and storage.

BATCHING

A PCC Level II certified technician may also act as a batch person for the following items only:

- Non-structural and miscellaneous items less than 50 cubic yards (40 cubic meters) per week
- Night work patching
- Two truckloads of structural concrete or less produced per day.

A PCC Level II certified technician shall perform required plant inspection duties prior to start up and a minimum of once per lot. A PCC Level II certified technician responsible for quality control shall be available by cell phone.

SAMPLING & TESTING

Quality Control

1. AGGREGATES

Refer to IM 527 (Sampling & Testing) for related inspection instructions.

Personnel performing aggregate testing shall be Aggregate Level II certified. The PCC Level II certified technician may direct this person performing the testing. The minimum frequencies for testing aggregates for structural concrete are as follows:

Specific Gravity - One sample for both coarse and fine aggregate as described in the table, unless the first two tests indicate variations greater than 0.02 from the tabular value T203, Aggregate Source Information, or from one test to the next. If the above variations are greater than 0.02, inform the Project Engineer and the District Materials Engineer immediately. The District Materials Engineer may adjust the specific gravity used to determine batch weights.

Moisture - One sample for each aggregate as described in the table. If a system with instantaneous moisture content measurement equipment is used to automatically adjust individual batch weights, see section titled Sampling & Testing/Moisture in IM 527 for instructions on approval, use, and monitoring of the system. Frequency shall be increased if stockpile changes occur. When specific gravity is not tested, moisture content may be determined by the mass (weight) difference method (IM 308 Method B).

Gradation - One sample for each aggregate per lot.

For structural concrete, a quality control lot shall consist of one week. If 50 cubic yards (40 m³) or less are produced in one calendar week, testing may be grouped with previous or subsequent lot, or 1 per two weeks. A bridge deck is considered a lot.

For non-structural concrete items as described below, a quality control lot shall be one per month. Testing and sampling for non-structural concrete is based on that being the only concrete being produced. If structural or paving concrete is being produced, no additional gradation sampling and testing is required for non-structural concrete produced from the same plant, since the sampling and testing frequency for structural and paving concrete is greater. If multiple projects are being supplied by the plant, one representative sample for the lot covers quality control sampling and testing for all of the projects.

Miscellaneous concrete and structural or non-structural concrete bid items supplied at 10 cubic yards (7.6 m³) or less for a project will be accepted without gradation testing. A gradation test for flowable mortar, revetment grout, or fabric formed revetment grout is required for the mix design only. The PCC Level II certified technician shall provide, for these bid items, materials certifications, batch tickets, and plant reports with the following statement on the PCC Plant report (Form 800240):

"The PCC mix contains certified materials, approved aggregates, and was produced in compliance with applicable specifications."

For projects requiring certified plant inspection, the certified inspector will obtain and test one gradation sample per lot, unless operations are prematurely shut down.

Quality Control Sampling, Testing, and Reporting

PRODUCTION	**Specific Gravity**	**Moisture**	**Gradation**	**Report**
Structural	1/ first week, monthly thereafter or 1/ two weeks thereafter for DWU sources	2/week or 1/deck	1/deck, or 1/week If <50 yd^3 produced in week 1/two weeks	1/lot or 1/deck
Non-Structural	1/month	1/two weeks	1/month	1/month
Miscellaneous	N/A	N/A	N/A	1/project

Verification

The engineer will perform verification sampling and testing at the minimum frequency described in the table for each aggregate. IM 205 describes the agency responsibility to randomly select sample location and time, and witness sampling with the contractor providing assistance in obtaining the samples. For production of less than 50 cubic yards (40 cubic meters) of structural concrete per week, verification sampling will be grouped with the previous or subsequent week, or 1 per two weeks. The engineer will split samples obtained with the plant inspector, or observe splitting by the plant inspector, and immediately take possession of the agency sample. Report test results to producer in a timely manner.

Testing and sampling for non-structural concrete is based on that being the only concrete being produced. If structural or paving concrete is being produced, no additional gradation sampling and testing is required for non-structural concrete produced from the same plant, since the sampling and testing frequency for structural and paving concrete is greater. If multiple projects are being supplied by the plant, one representative gradation sample for the lot covers sampling and testing for all of the projects.

Verification Sampling and Testing

PRODUCTION	**Gradation Sampling**	**Gradation Testing**
Structural Concrete	1/deck, or 1/week If <50 yd^3 produced in a week 1/two weeks	First week, then 20% of samples obtained or 1/deck
Non-Structural	1/project	1/project
Miscellaneous	N/A	N/A

Non-structural and Miscellaneous Concrete

The following Items of work are designated as non-structural and miscellaneous concrete. Other items may be designated by the Engineer as non-structural or miscellaneous concrete, for gradation sampling and testing, provided they are not structurally critical items that could directly affect the safety of the travelling public.

Non-structural Concrete

Article	**Work Type**
2201	PCC Base
2212	Base Repair
2213	Base Widening
2405	Seal course
2415	Curtain wall
2511	Sidewalks
2511	Trails
2512	Curb & Gutter

2515	Driveways
2517	Railroad Approach Sections
2529	Patching (Full Depth), Rumble Strips
2530	Patching (Partial Depth)

Miscellaneous Concrete

Article	**Work Type**
2304	Detour Pavement
2416	Pipe collars
2503	Catch basins, abandonment, collars
2506	Flowable Mortar
2507	Revetment Grout or Fabric Formed Revetment Grout
2519	Fence construction
2524	Type A and B signs
2554	Thrust Blocks

Test air and slump at the minimum rate for structural concrete or at least once daily for concrete exposed to freezing and thawing.

Non Complying Gradation

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

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

Acceptance of lots will be based on complying verification test results. The engineer will retain all samples representing the lots until the lots have been accepted. Since the contracting authority tests are verification, correlation with IM 216 is not required, but may be performed as a check of sampling and testing procedures.

2. WATER/CEMENT RATIO

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

If, after the District Materials Engineer investigation and evaluation, additional workability above that which is attainable within the maximum permissible water content is desired, the cement content may be increased in accordance with Article 2403.02,B. This should be done only with the approval of the District Materials Engineer or the engineer representative. The District Materials Engineer will provide the revised and adjusted mix proportions for these situations.

Also, in accordance with Article 2403.02,B, the engineer may authorize the use of a water-reducing admixture to improve workability. When authorized, only the water-reducing admixtures and dosage rates, as shown in IM 403 should be used.

When calcium chloride solution is added for patching M mix, water included in the calcium chloride solution should not be included in calculation of water-to-cement ratio.

3. STRENGTH TESTS

The test for Modulus of Rupture is the only strength test determined in the field. Test specimens are required for each day's placement of a structural unit in flexure.

Abutment backwalls, pier footings, bridge end posts, and culvert curtain walls are not considered structural units in flexure and therefore, test specimens are not required from these units, unless directed by the engineer.

Test the flexural specimens as prescribed in IM 316, Flexural Strength of Concrete. Testing will be done by contract authority personnel. IM 204 lists minimum testing requirements.

PROPORTIONS

Refer to IM 527 (Proportions)

REPORTS & REPORTING

1. PCC PLANT PAGE – FORM #240

The same form is to be used for PCC Paving and PCC Structures. Refer to IM 527 for instructions on completing the form and an example form.

Structural Reports are to be recorded in the computer program provided by the Iowa Department of Transportation. A separate, consecutively numbered, report is to be made for each project as required in the Quality Control Sampling, Testing, and Reporting table. A copy of the completed PCC Plant Page shall be faxed or delivered to the District Materials Engineer and Project Engineer within four hours on the next working day after the end of the lot. Use electronic mail as the method of delivery unless otherwise approved by the Engineer. When supplying multiple projects, one quality control gradation may be reported on all test reports.

The PCC Level II certified technician shall keep a copy of the PCC Plant Page and send the original to the Project Engineer. At the end of the project, make a copy of the plant book for the Engineer, within ten days.

Report non-structural and miscellaneous concrete as required in the Quality Control Sampling, Testing, and Reporting table.

2. READY MIXED CONCRETE, TRUCK TICKET FORM – FORM #830212

Each truckload of concrete must be identified by Form #830212 or an acceptable computer-generated plant ticket. If available, computer generated batch tickets shall be used. Computer generated batch tickets shall include wet and dry batch weights and information on Form #830212. Any information unable to be printed by the computer will be written on the computer generated batch ticket. See IM 527. The Engineer and District Materials Engineer will approve any variations to accepting the truck ticket form or computer generated form.

A PCC Level II certified batch person can fill out and sign the truck ticket forms so the plant inspector can perform their required duties. The District Materials Engineer may approve other personnel to fill out batch tickets. The PCC Level II inspector remains responsible for the batch tickets.

PORTLAND CEMENT (PC) CONCRETE PROPORTIONS

GENERAL

Materials for pavement concrete and structural concrete shall be mixed in any one of the following proportions for the class of concrete specified. Each mixture will have specific requirements for the coarse and fine aggregates and the type of cement. Concrete mix proportions include the unit volumes of all materials.

Mix numbers designate numerous aspects of the particular mix. The following is an explanation of the various aspects of the mix number:

- The first letter designates the class of concrete as designated in the contract documents.

- In certain mix designations, the letter V or L appears after the first hyphen. This indicates either Class V or Class L aggregate is to be used. If no letter is shown, aggregate other than Class V or Class L shall be used.

- The number indicates the relationship of coarse aggregate to fine aggregate. A mix with a 4 is a 50/50 mix. The following chart shows the number within the mix number and the proportions of the aggregates for each number:

2	is composed of 40% fine and 60% coarse
3	is composed of 45% fine and 55% coarse
4	is composed of 50% fine and 50% coarse
5	is composed of 55% fine and 45% coarse
6	is composed of 60% fine and 40% coarse
7	is composed of 65% fine and 35% coarse
8	is composed of 70% fine and 30% coarse
57	is composed of 50% fine and 50% coarse
57-6	is composed of 60% fine and 40% coarse

- The letters WR indicate water reducer is used in this mixture.

- When a C or an F is shown toward the end of the mix number, fly ash is a part of the mixture and C-fly ash or an F-fly ash, respectively, is used. The percentage of fly ash being used in the mixture shall be designated at the end of the mix number.

- When used as a mineral admixture, Ground Granulated Blast Furnace Slag (GGBFS) shall be designated through the letter “S,” followed by the percent substitution, and shown at the end of the mix number. This would be in the same convention used for fly ash substitution. When GGBFS is a portion of a blended cement, the cement type will be designated as IS, but special notation will not be made in the mix number.

- The following example illustrates a mix number showing a Class C concrete mixture, 50/50 aggregate proportions, using Class L aggregate, water reducer, and 35% GGBFS substitution.

<u>Example:</u> C - L 4 W R – S35

The following example illustrates a mix number showing a Class C concrete mixture, 50/50 aggregate proportions, using water reducer and a Class C fly ash substitution at a rate of 10%.

Example: C – 4 W R – C10

The following example illustrates a mix number showing a Class C concrete mixture, 50/50 aggregate proportions, using a water reducer, Class C fly ash substitution at 20%, and GGBFS substitution at 20%.

Example: C – 4 W R –C20-S20

The Class D mixtures and the Class V mixtures vary somewhat from the above pattern, but follow the general format.

MIX REQUIREMENTS

General requirements for the mixes are:

1. Fly Ash and GGBFS used in concrete mixtures shall meet the requirements of Section 4108. Fly Ashes for use in concrete mixtures shall be included on the list of approved sources (Materials IM 491.17). GGBFS for use in concrete mixtures shall be included on the list of approved sources (Materials IM 491.14).

2. A water-reducing admixture shall be used in concrete mixtures with the designation as follows: Those mixtures have mixture numbers which have the letters "WR" following a single digit number, all following the first hyphen in the mixture number. These mixtures have reduced cementitious contents to produce concrete of approximately equal strength compared with other mixtures in a particular class of concrete. A water-reducing admixture may be added to other concrete mixtures, without cement reduction, to aid in workability and air entrainment. Other admixture combinations may be approved based on manufactures recommendations.

   The water-reducing admixture shall meet the requirements of Section 4103 and shall be included on the list of Approved Sources of Water Reducing Admixtures (Materials IM 403, Appendix C). The dosage shall be as described in IM 403.

3. The total quantity of water in the concrete, including water in the aggregate, shall not exceed the maximum water to cement and fly ash ratio.

4. Type I, Type II, Type III, Type IP, and Type IS Cement shall be used as provided for in the specifications. All cement shall be from an approved source as per IM 401. The cement type shall be documented on all reports pertaining to a project.

5. The fine aggregates other than Class V (Section 4117) and Class L (Section 4111) shall meet the requirements of Section 4110 of the current specifications. The coarse aggregates for mixtures using aggregates, other than Class V aggregates, shall meet the requirements of Articles 4115.01 through 4115.04 of the current specifications. The coarse aggregates for Class O or Class HPC-O concrete mixtures shall meet the requirements of 4115.05 of the current specifications. Intermediate aggregates used for QMC, BR, or HPC-D mixes shall

meet 4112.

6. When approved by the Engineer, combined fine and coarse aggregate may be used in combination with screened coarse aggregate to produce proportions specified for Class D and Class X concrete mixtures according to the percentage of particles passing the No. 4 sieve in the combined aggregate at the time the material is used.

7. With Engineer approval, proportions designated for mixtures A-V, B-V or C-V with and without fly ash may be substituted for Class X concrete.

8. With Engineer approval, Class M concrete may be substituted for Class A, Class B or Class C concrete.

A-MIX

A-Mixes are specified primarily as paving mixes. They have a lower cement content and lower ultimate strength when compared to a Class C-Mix. A-Mix is commonly used on lower traffic roadways or detour pavement.

B-MIX

B-Mixes are specified primarily on sidewalks and trails. They have the least amount of cement of any paving mix. The strength is also lower than for other paving mixes.

C-MIX

C-Mixes are specified for use in both paving and structures. It is the normal paving mix used in primary paving. Typical structural uses would include box culverts, bridge piers, bridge abutments, and most bridge decks.

D-MIX

D-Mixes are specified for use primarily in structures. A typical use includes drilled shafts.

M-MIX

M-Mixes are designed for high early strength, suitable for many applications for which they are allowed. Calcium chloride should only be used when needed, for patching and other placements without steel reinforcement. Do not include water in calcium chloride solution when calculating water cement ratio.

O-MIX

O-Mixes are specified for low slump concrete, primarily for use in bridge deck overlays. The water-cement ratio is intended to be controlled by the slump specified elsewhere for concrete where these mixtures are used. A water-reducing agent is required for this mix, as described in IM 403. O-Mixes require coarse aggregate specifically intended for repair and overlay. See Article 4115.05. HPC-O is also used in bridge deck overlays. The HPC-O mix requires the use of blended cements, slag, and fly ash. The maximum water-cement ratio is 0.42 (basic of 0.40).

X-MIX

X-Mixes are specified to be used as seal course concrete, primarily in cofferdams. No air entraining is required. No maximum water-cementitious ratio is specified. See Article 2405.05 for limits on water usage.

QMC

Contractor-designed aggregate proportioning mixes for paving. Minimum absolute volume of cement is 0.106. For Type IP cement, use an absolute volume of 0.111. Basic water-cement ratio is 0.40. Maximum water-cement ratio is 0.45.

BR

BR mixes are used in slip form barrier rail in accordance with Section 2513. Determine aggregate proportions based on production gradations. Unless major changes occur to aggregate gradations, utilize aggregate proportions determined and assess gradation of individual aggregates during concrete production. The minimum absolute volume of cement is 0.114. For Type IP cement, use an absolute volume of 0.119. Maximum water-cement ratio is 0.45.

HPC

HPC mixes are used in bridge substructures and decks to achieve low permeability and higher compressive strength. The use of blended cements, slag, or Class F fly ash is required with these mixes. Class C fly ash may also be substituted. Maximum water-cement ratio is 0.42 (basic of 0.40) for decks and 0.45 (basic of 0.42) for substructures. Aggregate proportioning is required for HPC-D mixes with an absolute volume of cement of 0.118.

CLASS V

Class V is an aggregate classification, specified in Section 4117. The fine limestone aggregates in concrete mixes using Class V aggregate with/without fly ash shall meet the requirements of Article 4117.03 of the current specifications. Allowable cements and substitutions shall meet the requirements of Article 4117.05. This material may be used in various concrete mixes, including HPC mixes. The mixes utilizing this material will be designated with a Roman numeral V, in the Mix Number.

CLASS L

Class L is an aggregate classification, specified in Section 4111. This material may be used in various concrete mixes, so designated. The mixes utilizing this material will be designated with a Roman numeral L, in the Mix Number.

FLY ASH & GGBFS SUBSTITUTION

At Contractor option, fly ash or GGBFS may be substituted for a portion of the cement in concrete mixes, within the limitations set forth in the appropriate Article for each type of placement. IM 527 gives instructions on how to determine the proper batch proportions in a mix. When fly ash or GGBFS is substituted for the cement, the replacement shall be on a pound-for-pound (kilogram-for-kilogram) basis. Tables 1, 2, and 3 define concrete mixes with no substitution. These mixes shall be used as the basis for determining the final batch proportions and shall be adjusted accordingly. The change in volume resulting from the substitution shall be determined and an adjustment in both coarse and fine aggregate proportions shall be determined in order to ensure a unit volume. The change in aggregate proportions shall be in the same ratio as that of the specific mix. In those cases where the cement content is increased, relative to the standard design mix, the mix proportions shall be adjusted and a change in the aggregate content shall be determined, as described above.

When both fly ash and GGBFS are substituted for the cement in ready-mixed concrete, the replacement shall be on a pound-for-pound (kilogram-for-kilogram) basis and shall be substituted as shown in the following example.

<u>Example: C-3WR-C20-S20</u>

Absolute Volume Cement = 0.108

Cement = 0.108 X 62.4 X 27 X 3.14 = 571 lbs per cubic yard

Fly ash substitution 20% = 571 X 0.20 = 114 lbs per cubic yard

Slag substitution 20% = 571 X 0.20 = 114 lbs per cubic yard

Type IP and Type IS cements shall be considered cement with regard to substitution of fly ash. Refer to appropriate Article for limitations. A Type IS(25) cement with a 20% fly ash replacement is equivalent to a 40% weight replacement of Portland cement.

<u>Example: C-3WR-C20 using Type IS(20) cement</u>

Absolute Volume Cement = 0.108

Cement = 0.108 X 62.4 X 27 X 3.10 = 564 lbs per cubic yard

Fly ash substitution 20% = 564 X 0.20 = 113 lbs per cubic yard

Weight of cement = 564 – 113 = 451 lbs per cubic yard

Type IS(20) cement contains Portland cement and slag

451 x 0.80 = 361 lbs Portland cement
451 X 0.20 = 90 lbs slag

Total replacement of Portland cement
((113 + 90) / 564) X100 = 36%

Proportion Table 1
Concrete Mixes
Using Article 4110 and 4115 Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A MIXES	**Basic w/c = 0.474**	**Max w/c = 0.532**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
A-2	0.101	0.150	0.060	0.276	0.413
A-3	0.104	0.155	0.060	0.306	0.375
A-4	0.108	0.161	0.060	0.335	0.336
A-5	0.111	0.165	0.060	0.365	0.299
A-6	0.115	0.171	0.060	0.392	0.262
B MIXES	**Basic w/c = 0.536**	**Max w/c = 0.600**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
B-2	0.088	0.148	0.060	0.282	0.422
B-3	0.091	0.153	0.060	0.313	0.383
B-4	0.093	0.157	0.060	0.345	0.345
B-5	0.096	0.162	0.060	0.375	0.307
B-6	0.099	0.167	0.060	0.404	0.270
B-7	0.102	0.172	0.060	0.433	0.233
B-8	0.105	0.177	0.060	0.461	0.197
C MIXES	**Basic w/c = 0.430**	**Max w/c = 0.488**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
C-2	0.110	0.149	0.060	0.272	0.409
C-3	0.114	0.154	0.060	0.302	0.370
C-4	0.118	0.159	0.060	0.331	0.332
C-5	0.123	0.166	0.060	0.358	0.293
C-6	0.128	0.173	0.060	0.383	0.256
C-WR MIXES	**Basic w/c = 0.430**	**Max w/c = 0.489**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
C-3WR	0.108	0.146	0.060	0.309	0.377
C-4WR	0.112	0.151	0.060	0.338	0.339
C-5WR	0.117	0.158	0.060	0.366	0.299
C-6WR	0.121	0.163	0.060	0.394	0.262
D MIXES	**Basic w/c = 0.423**	**Max w/c = 0.450**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
D-57	0.134	0.178	0.060	0.314	0.314
D-57-6	0.134	0.178	0.060	0.377	0.251
M MIXES	**Basic w/c = 0.328**	**Max w/c = 0.400**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
M-3	0.149	0.153	0.060	0.287	0.351
M-4	0.156	0.161	0.060	0.311	0.312
M-5	0.160	0.165	0.060	0.338	0.277
O MIXES	**Basic w/c = 0.327**	**Max w/c = ------**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
O-4WR	0.156	0.160	0.060	0.312	0.312
	Basic w/c = 0.400	**Max w/c =0.420**			
HPC-O	0.134	0.168	0.060	0.316	0.317
HPC MIXES	**Basic w/c = 0.420**	**Max w/c =0.450**			
HPC-S	0.118	0.156	0.060	0.333	0.333
X MIXES	**Basic w/c = 0.423**	**Max w/c = ------**			
Mix No.	**Cement**	**Water**	**Air**	**Fine**	**Coarse**
X-2	0.124	0.165	0.000	0.284	0.427
X-3	0.129	0.171	0.000	0.315	0.385
X-4	0.134	0.178	0.000	0.344	0.344

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

Proportion Table 1
Concrete Mixes
Using Article 4110 and 4115 Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A MIXES Basic w/c = 0.474 Max w/c = 0.532

Mix No.	Cement	Water	Air	Fine	Coarse
A-2	0.101	0.150	0.060	0.276	0.413
A-3	0.104	0.155	0.060	0.306	0.375
A-4	0.108	0.161	0.060	0.335	0.336
A-5	0.111	0.165	0.060	0.365	0.299
A-6	0.115	0.171	0.060	0.392	0.262

B MIXES Basic w/c = 0.536 Max w/c = 0.600

Mix No.	Cement	Water	Air	Fine	Coarse
B-2	0.088	0.148	0.060	0.282	0.422
B-3	0.091	0.153	0.060	0.313	0.383
B-4	0.093	0.157	0.060	0.345	0.345
B-5	0.096	0.162	0.060	0.375	0.307
B-6	0.099	0.167	0.060	0.404	0.270
B-7	0.102	0.172	0.060	0.433	0.233
B-8	0.105	0.177	0.060	0.461	0.197

C MIXES Basic w/c = 0.430 Max w/c = 0.488

Mix No.	Cement	Water	Air	Fine	Coarse
C-2	0.110	0.149	0.060	0.272	0.409
C-3	0.114	0.154	0.060	0.302	0.370
C-4	0.118	0.159	0.060	0.331	0.332
C-5	0.123	0.166	0.060	0.358	0.293
C-6	0.128	0.173	0.060	0.383	0.256

C-WR MIXES Basic w/c = 0.430 Max w/c = 0.489

Mix No.	Cement	Water	Air	Fine	Coarse
C-3WR	0.108	0.146	0.060	0.309	0.377
C-4WR	0.112	0.151	0.060	0.338	0.339
C-5WR	0.117	0.158	0.060	0.366	0.299
C-6WR	0.121	0.163	0.060	0.394	0.262

D MIXES Basic w/c = 0.423 Max w/c = 0.450

Mix No.	Cement	Water	Air	Fine	Coarse
D-57	0.134	0.178	0.060	0.314	0.314
D-57-6	0.134	0.178	0.060	0.377	0.251

M MIXES Basic w/c = 0.328 Max w/c = 0.400

Mix No.	Cement	Water	Air	Fine	Coarse
M-3	0.149	0.153	0.060	0.287	0.351
M-4	0.156	0.161	0.060	0.311	0.312
M-5	0.160	0.165	0.060	0.338	0.277

O MIXES Basic w/c = 0.327 Max w/c = ------

Mix No.	Cement	Water	Air	Fine	Coarse
O-4WR	0.156	0.160	0.060	0.312	0.312

Basic w/c = 0.400 Max w/c =0.420

HPC-O	0.134	0.168	0.060	0.316	0.317

HPC MIXES Basic w/c = 0.420 Max w/c =0.450

HPC-S	0.118	0.156	0.060	0.333	0.333

X MIXES Basic w/c = 0.423 Max w/c = ------

Mix No.	Cement	Water	Air	Fine	Coarse
X-2	0.124	0.165	0.000	0.284	0.427
X-3	0.129	0.171	0.000	0.315	0.385
X-4	0.134	0.178	0.000	0.344	0.344

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

Standard Measurements

Weight of water per cubic foot 62.4 lbs./cu ft.

Weight of water per gallon 8.33 lbs. /gal

Cu ft. per Cu yd. = 27 cu ft.

To Figure Weight per Unit Volume

Absolute volume x Sp. Gr. X Unit Weight of water x Cu Ft. per Cu Yd.

To Figure Absolute Volumes

Batch weight/Sp. Gr. /Unit Weight of water/Cu Ft per Cu Yd.

Orange 2012 Specification Book:	2301	PCC Pavement
	2403	Structural Concrete

I.M.'s (Instructional Memorandums)

IM 401	appendix a	**approved cement sources**
IM 403		**chemical admixtures**
	appendix a	air admixtures
	appendix b	structural concrete retarding admixtures dosage rates And concrete pavement water reducers and retarding admixtures
	appendix c	approved brand water reducer admixture concrete paving And bridge deck overlay and repairs
	appendix d	approved brand high range water reducers
	appendix e	non chloride accelerating admixtures
	appendix f	approved brands admixtures for prestressed and precast concrete
IM 491.14		**Slags**
	appendix a	approved sources
IM 491.17		**Fly ash**
	appendix a	approved sources
IM 527		**Paving Plant Inspection**
IM 528		**Structural Concrete Plant Inspection**
IM 529		**PCC Concrete Proportions (Absolute Volumes)**
T-203		**Aggregate Section**

2	is composed of **40% fine** and **60% coarse**
3	is composed of **45% fine** and **55% coarse**
4	is composed of **50% fine** and **50% coarse**
5	is composed of **55% fine** and **45% coarse**
6	is composed of **60% fine** and **40% coarse**
7	is composed of **65% fine** and **35% coarse**
8	is composed of **70% fine** and **30% coarse**
57	is composed of **50% fine** and **50% coarse**
57-6	is composed of **60% fine** and **40% coarse**

Proportion Table 2
Concrete Mixes
Using Class V Aggregates Combined with Limestone
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

V47B MIXES

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
A-V47B	0.107	0.148	0.060	0.479	0.206	0.440	0.560
B-V47B	0.098	0.160	0.060	0.477	0.205	0.520	0.597
C-V47B[1]	0.107	0.148	0.060	0.479	0.206	0.440	0.560*
C-V47BF[2]	0.114	0.141	0.060	0.479	0.206	0.420	0.488*
M-V47B[3]	0.155	0.170	0.060	0.338	0.277	0.350	0.400

V MIXES

Mix No.	Cement	Water	Air	Class V.	Fine Limestone	Basic w/c	Max. w/c
A-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
B-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
C-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
M-V	0.160	0.196	0.060	0.555	0.029	0.390	0.420

CV-HPC MIXES

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
CV-HPC-D	0.126	0.158	0.060	0.361	0.295	0.400	0.420
CV-HPC-S	0.126	0.166	0.060	0.356	0.292	0.420	0.450

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

*The maximum w/c shall be 0.450 when used in concrete pavement.
[1]C-V47B mix shall be used when Type I/II cements are used with Class F fly ash or ggbfs.
[2]C-V47BF mix shall be used when Type IP or Type IS cements are used.
[3]M-V47B mix shall use Type I/II cements for patching projects.

Proportion Table 3
Concrete Mixes
Using Class L Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A-L MIXES Basic w/c = 0.474 Max w/c = 0.532

Mix No.	Cement	Water	Air	Fine	Coarse
A-L-2	0.107	0.159	0.060	0.270	0.404
A-L-3	0.111	0.165	0.060	0.299	0.365
A-L-4	0.115	0.171	0.060	0.327	0.327
A-L-5	0.118	0.176	0.060	0.355	0.291

B-L MIXES Basic w/c = 0.536 Max w/c = 0.600

Mix No.	Cement	Water	Air	Fine	Coarse
B-L-2	0.094	0.158	0.060	0.275	0.413
B-L-3	0.097	0.163	0.060	0.306	0.374
B-L-4	0.099	0.167	0.060	0.337	0.337
B-L-5	0.102	0.172	0.060	0.366	0.300

C-L MIXES Basic w/c = 0.430 Max w/c = 0.488

Mix No.	Cement	Water	Air	Fine	Coarse
C-L-2	0.117	0.158	0.060	0.266	0.399
C-L-3	0.121	0.163	0.060	0.295	0.361
C-L-4	0.125	0.169	0.060	0.323	0.323
C-L-5	0.131	0.177	0.060	0.348	0.284

C-LWR MIXES Basic w/c = 0.430 Max w/c = 0.489

Mix No.	Cement	Water	Air	Fine	Coarse
C-L3WR	0.115	0.155	0.000	0.301	0.369
C-L4WR	0.119	0.161	0.000	0.330	0.330
C-L5WR	0.124	0.167	0.000	0.357	0.292

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

Proportion Table 4
SUDAS Concrete Mixes
Using Article 4110 and 4115 Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

C-QMC MIXES Basic w/c = 0.400 Max w/c = 0.450

Mix No.	Cement	Water	Air	Fine	Coarse
C-QMC	0.106	0.133	0.060	0.315	0.386

Above mixture is based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

Using Class V Aggregates Combined with Limestone
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

CV-QMC MIXES Basic w/c = 0.400 Max w/c = 0.450

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
CV-QMC	0.114	0.135	0.060	0.380	0.311	0.400	0.450

Above mixture is based on Type IP cements (Sp. G. = 2.95).

IM 530
PAVEMENT QM & ACCEPT.

QUALITY MANAGEMENT & ACCEPTANCE
PC CONCRETE PAVEMENT

GENERAL

This Instructional Memorandum is based on the concept of mutual benefit partnership between the Contracting Agency and the Contractor during progress of the work. Technical partnering shall be a part of this work and a formal partnership agreement may or may not be in effect.

The Contractor shall submit and comply with a Quality Control Program. The Contractor shall be responsible for the design of a Portland Cement Concrete Design Mixture (CDM) for use in pavement and shall be approved by the District Materials Engineer. The Contractor shall perform process control sampling, testing, and inspection during all phases of the concrete work at the rate specified in the contract documents, with monitor inspection by the agency personnel. Inspection of all other aspects of the concrete paving operation remains the responsibility of the Engineer.

The Contractor shall have an Iowa DOT PCC Level II Certified Technician responsible for all process control sampling and testing and execution of the Quality Control Plan as specified in the specification and this Instructional Memorandum. An Iowa DOT PCC Level I Concrete Field Testing Technician may perform the sampling and testing duties for which he or she is certified.

MIX DESIGN PROCEDURE

An Iowa DOT PCC Level III Certified Technician shall perform the mix design. The Engineer shall concur with the Contractor designee.

The CDM shall be developed using the Excel spreadsheet developed by the Office of Construction and Materials. ACI 211 procedure, PCA procedure, or alternative methods may also be used. Aggregate proportions are contained on Form #955QMC (IM 532, Appendix A). When a CDM is developed, the absolute volume method shall be used.

The Contractor shall submit the CDM with test data, including a list of all ingredients, the source of all materials, target gradation, and the proportions, including absolute volumes.

A CDM with a satisfactory record of performance strength may be submitted in lieu of a new CDM. The concrete used for paving per this IM shall be produced with the same material sources and batched and mixed with the same equipment used to produce the concrete represented by the performance strength documentation.

QUALITY CONTROL PLAN

The Contractor shall submit a Quality Control Plan listing the type and frequency of inspection, sampling, and testing deemed necessary to measure and control the various properties of materials and construction governed by the specifications. As a minimum, the sampling and testing plan shall detail sampling location, sampling procedures, and the test frequency to be utilized. This Contractor Quality Control Plan shall be submitted to the Project Engineer prior to paving and will be retained for use on all QMC projects. A copy of the Quality Control Plan shall be available on the project at all times. Periodic updates may be required as necessary.

The Quality Control Plan shall include the Project Information Plan submitted for each project. The plan shall identify the personnel responsible for the contractor quality control. This should include the company official who will act as liaison with Iowa DOT personnel, as well as the certified technician who will direct the inspection program. The certified technician shall be responsible to an upper level company manager and not to those responsible for daily production. The Project Information Plan shall also include the mix design and mix design properties.

A. Elements of the Quality Control Plan

The plan shall address all elements that affect the quality of the concrete, including but not limited to, the following:

1. Stockpile management

2. Mixing time and transportation, including time from batching to completion of delivery and batch placement rate (batches per hour)

3. Placement and consolidation

4. The frequency of sampling and testing, coordination of activities, corrective actions to be taken, and documentation

5. How the duties and responsibilities are to be accomplished and documented, and whether more than one certified technician would be provided

6. The criteria used by the technician to correct or reject noncompliant materials, including notification procedures

B. Personnel Requirements

1. Perform and utilize process control tests and other quality control practices to ensure that delivered materials and proportioning meets the requirements of the mix design(s).

2. Periodically inspect all equipment utilized in transporting, proportioning, mixing, placing, consolidating, finishing, and curing to ensure proper operation. Monitor placement, consolidation, finishing, and curing to ensure conformance with the mix design and other contract requirements.

C. Elements of Project Information Plan

1. Mix design(s)

2. Mix design properties, as specified in the Specifications

3. The Contractor shall furnish name(s) and credentials of the quality control staff to the Engineer prior to the beginning of construction.

4. Project-related information

DOCUMENTATION

The Contractor shall maintain records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities represented by the test, and any corrective action taken. The contractor documentation procedures will be subject to the approval of the Iowa DOT prior to the start of the work and prior to regular monitoring during the progress of the work. Use standard Iowa DOT forms. Batch tickets and gradation data shall be documented in accordance with Iowa DOT requirements. Copies shall be submitted to the engineer as work progresses.

A control chart and running tabulation of individual test results shall be prepared for the following tests. An Excel spreadsheet is available from the Office of Construction and Materials to plot the test results. These shall be available to the Engineer at any time and submitted to the Engineer weekly:

1. Gradation (% passing) for each of the following sieves: 1 1/2 in. (37.5 mm), 1 in. (25 mm), 3/4 in. (19 mm), 1/2 in. (12.5 mm), 3/8 in. (9.5 mm), #4 (4.75 mm), #8 (2.36 mm), #16 (1.18 mm), #30 (600 µm), #50 (300 µm), #100 (150 µm), #200 (75 µm), and pan. Gradation test frequency is based on the running total of concrete production.

2. Moisture: Coarse Aggregate(s) & Sand

3. Unit Weight tested in front of the paver. Unit weight is used as a check on air content and batch changes. If the unit weight range exceeds the theoretical unit weight at the target air content, check batch proportions, scales, etc. for any problems.

4. Plastic Air Content

5. Coarseness & Workability Factors

6. Water/cementitious Ratio

Charting will be completed within 24 hours after testing. Working range limits shall be indicated on the control charts.

The Contractor shall notify the Engineer whenever the process approaches a specification limit and shall take action, which results in the test results moving toward the specification target, away from the limit.

All charts and records documenting the contractor quality control inspections and tests shall become property of the Iowa DOT upon completion of the work.

The PCC Level II Technician shall document the changes to the mix design, allowed by the specification, on the Iowa DOT QM-C Mix Adjustment form (IM 530, Appendix A). The PCC Level III Technician shall concur with the changes and shall periodically review mix changes affect on workability and placement in the field.

FIELD VERIFICATION TESTING

For continuous construction operation, a lot will be defined as a week of paving. Lots less than three days of paving will be grouped with the previous week. If less than 500 cu. yd. (500 m³) are produced in one day that day's production, group with the following day's production.

Intermittent construction operation involving quantities less than 500 cubic yards per day, shall be grouped to establish a lot, not to exceed one week.

The Engineer will perform verification testing at the following minimum test frequencies:

MINIMUM TEST FREQUENCIES

	Verification	
Unit Weight Plastic Concrete	None	IM 340
Gradation (Individual aggr., % passing)	Sample 1/day if production >500 yd3 Test 1st/day, then twice per week	IM 302
Flexural Strength, Third Point Loading - 28 days *	1/10,000 cu. yd. (1/10,000 m³) Maximum of five sets	IM 328
Air Content Unconsolidated Concrete	1/700 cu. yd. (1/550m³)	IM 318
Water/Cement Ratio	None	IM 527
Vibration Frequency	1/week	IM 384

*One set of two beams at the above rate shall be cast for pavement design purposes. The beams shall be delivered to the Central Laboratory in Ames for testing. Transported beams shall be stripped and wrapped in wet burlap and plastic to ensure adequate curing during delivery. Include information on project number, contractor, date cast and air content with delivery. Date of testing will be increased to 90 days when quartzite coarse aggregate is used.

CONTROL & ACCEPTANCE PROCESS OF PLASTIC AIR TESTING

On the first air test of each day, the Contractor and Agency shall run side by side tests to ensure both air meters are within the tolerance in IM 216. If the air tests are outside the tolerance, both air meters should be calibrated in accordance with IM 318 to resolve the difference.

Thereafter, the Engineer will randomly test the plastic air content at the minimum frequency in the table above. The Contractor may elect to run side by side comparison at the same time as the Engineer to ensure both meters are operating properly. When a verification test result is outside the tolerance for the target air content, the Contractor will be immediately notified.

The unconsolidated air content limits will be established according to Article 2301.04C using Contractor test results. The Contractor shall notify the Engineer whenever an individual quality control test result is outside the tolerance for the target air content. Lot acceptance shall be based on the agency verification test results on the unconsolidated mix on the grade.

DETERMINING COARSENESS & WORKABILITY INCENTIVE

On the first day of paving, the Engineer will direct and witness sampling and splitting of one sample of each aggregate. The split sample shall meet the requirements of IM 216. If correlation is not established, the District Materials Engineer will resolve the differences.

Thereafter, The Engineer will direct and witness sampling of one random independent sample per day. The agency will take immediate possession of the samples. The Engineer will randomly test a minimum of two samples per lot. The samples will be tested in a timely manner and the results will be given to the Contractor within a week after results are obtained. The Engineer will determine aggregate percentages based on the batch weights at the time the sample was obtained, compute the average coarseness and workability factors in accordance with IM 532 for the combined samples tested, and average the results. If the average results obtained by the Engineer fall within the same pay zone as the Contractor, appropriate incentive will be paid for the lot.

If the average results obtained by the agency are not in the same pay zone as the Contractor, the Engineer will test the remaining samples representing the lot and average all results for the lot. If the average results of all verification samples for the lot fall within the same pay zone as Contractor results for the lot, incentive will be paid for the lot. If the average results of all verification samples for the lot are in a different pay zone than Contractor, the agency results will govern for the basis of incentive for the lot.

CORRECTIVE ACTION

The Contractor shall take prompt action to correct conditions that have resulted, or could result, in the incorporation of noncompliant materials.

NONCOMPLIANT MATERIALS

The Contractor shall establish and maintain an effective and positive system for controlling noncompliant material, including procedures for its identification, isolation and disposition. Reclaiming or reworking of noncompliant materials shall be in accordance with procedures acceptable to the Iowa DOT.

All noncompliant materials and products shall be positively identified to prevent use, shipment, and intermingling with conforming materials and products.

AVOIDANCE OF DISPUTES

Every effort should be made by Contractor and Engineer personnel to avoid any potential conflicts in the Quality Assurance Program prior to and during the project by using partnering concepts. Potential conflicts should be resolved at the lowest possible levels between the Contractor and Engineer personnel. Correction of problems and performance of the final product should be the primary objective of this resolution process.

****THIS IS A NEW APPENDIX. – PLEASE READ CAREFULLY.****

IOWA DOT QM-C MIX ADJUSTMENT FORM

Project Number:

Contractor:

Date of Mix Adjustment (m/d/yy):

Station of Mix Adjustment:

Number of Mix Changes to Date:

Old Mix ID:

New Mix ID:

Mix Adjustment 1:
Reason:

Mix Adjustment 2:
Reason:

Mix Adjustment 3:
Reason:

	Old Mix Proportions		New Mix Proportions	
	Source	SSD Weight or Dosage	Source	SSD Weight or Dosage
Cement				
Fly Ash				
Water				
Coarse Aggregate				
Intermediate Aggregate				
Fine Aggregate				
Air Entraining Agent				
Water Reducer				
Retarder				

*PCC II Technician*_____________________________ *Cert No.* _______________

Copies To: District Materials Engineer
Resident Construction Engineer

Reissued April 16, 2013
Supersedes October 19, 2004

TEST METHOD FOR COMBINING AGGREGATE GRADATIONS

When the aggregate gradations for a PCC mixture are sampled and tested individually, the results must be mathematically combined to create a theoretical combined gradation. This combined gradation is based on their relative percent volume in the mixture.

Each individual aggregate gradation shall start with the largest appropriate sieve for that material and shall include all the consecutive smaller sieve sizes through the #200 (75-µm) sieve. They shall include: 1/2-in. (37.5-mm), 1-in. (25-mm.), 3/4-in. (19-mm), 1/2-in. (12.5-mm), 3/8-in. (9.5-mm), #4 (4.75-mm), #8 (2.3-mm), #16 (1.18-mm), #30 (600-µm), #50 (300-µm), #100 (150-µm), and #200 (75-µm) sieves. For coarse and intermediate aggregates, the #16 (1.18-mm) through #100 (150-µm) sieves may be determined mathematically.

The following methods outline the procedures to be used to determine the combined gradation. Method A is generally used for most aggregate combinations. Method B should be used when the specific gravity of the individual aggregates differ by more than 0.25.

METHOD A

Multiply relative percentage by the percent passing and sum all aggregates for each sieve size.

$$P = Aa + Bb + Cc$$

P = Combined percent passing of a given sieve
A,B,C = Percent passing given sieve for aggregate A, B, and C
a,b,c = Relative percent of total aggregates A, B, and C

Convert combined percent passing to combined percent retained by subtracting the combined percent passing on the top sieve from 100 and the combined percent passing from each subsequent sieve, thereafter.

Sieve	Coarse Aggregate	Intermediate Aggregate	Fine Aggregate	Theoretical Combined Gradation % Passing	Theoretical Combined Gradation % Retained
Relative Percent→	0.472	0.118	0.410		
1 1/2 inch	100	100	100	100	0.0
1 inch	83	100	100	92	8.0
3/4 inch	65	100	100	83.4	8.5
1/2 inch	35	100	100	69.3	14.2
3/8 inch	14	100	100	59.4	9.9
No. 4	2.1	33	96	44.2	15.2
No. 8	0.9	2.8	82	34.4	9.8
No. 16	0.8	2.3	63	26.5	7.9
No. 30	0.7	1.8	37	15.7	10.8
No. 50	0.5	1.2	9.4	4.3	11.4
No. 100	0.4	0.7	1	0.7	3.6
No. 200	0.3	0.1	0.4	0.3	0.4

METHOD B

STEP 1:

The percent volume of each of the aggregates is determined from the volume proportions of the mixture design. The relative proportion of each aggregate of the total aggregate is determined by dividing the individual aggregate portion in the mix by the total aggregate portion in the mix.

Example:

A mixture design has the following mix proportions by volume:

Cement	0.110
Water	0.150
Air Entraining	0.070
Fine Aggregate (PCC Sand)	0.270
½ inch Intermediate Aggregate (Limestone Chip)	0.100
1½ inch Coarse Aggregate (Limestone PCC Stone)	0.300
Total	1.000

The total aggregate portion is: 0.270 + 0.100 + 0.300 = 0.670

The relative percent retained portion for each aggregate by volume is determined as follows:

Fine Aggregate (0.270/0.670) = 0.403
Intermediate Aggregate (0.100/0.670) = 0.149
Coarse Aggregate (0.300/0.670) = 0.448

Check the total aggregate relative portions. They should equal 1.000.

0.403 + 0.149 + 0.448 = 1.000 (OK)

STEP 2:

These volume proportions are then adjusted by the specific gravity of the aggregates, since gradations are based on percent weight retained on each sieve. The proportion retained by weight is determined by multiplying each aggregate's volume proportion by its specific gravity. These weights are then summed to obtain a total weight. The proportion by weight is then determined by dividing each aggregate's weight by the total weight.

Example:

Aggregate	Proportion Volume	Specific Gravity	Weight	Proportion By Weight
Fine	0.403	2.67	1.07601	(1.07601/2.64912) = 0.406
Intermediate	0.149	2.59	0.38591	(0.38591/2.64912 = 0.146
Coarse	0.448	2.65	1.18720	(1.18720/2.64912) = 0.448
Total	1.000		2.64912	1.000

STEP 3:

Determine the theoretical combined gradation from the individual gradations. This is done by multiplying the percent retained on each sieve for the individual gradations by the relative portion of the aggregate volumes. Then total the percent retained of each product for each sieve size. This is the theoretical combined percent retained for each sieve. The total of these percents retained should equal 100.0. If the total is off due to rounding, prorate the rounding error.

Example:

Coarse Aggregate

Sieve	% Retained	Relative Volume	Adjusted % Retained
1 1/2 inch	0.0	0.448	0.0
1 inch	1.4	0.448	0.6
3/4 inch	23.7	0.448	10.6
1/2 inch	31.0	0.448	13.9
3/8 inch	24.5	0.448	11.0
No. 4	14.1	0.448	6.3
No. 16	0.7	0.448	0.3
No. 30	0.8	0.448	0.4
No. 100	0.4	0.448	0.2
No. 200	0.2	0.448	0.1
Minus 200	0.8	0.448	0.4

Similar calculations are done for the intermediate and fine aggregates.

STEP 4:

The individual adjusted gradations are summed to get the theoretical combined gradation, percent retained. The theoretical combined gradation, percent passing, may be calculated by subtracting subsequent sieves beginning with 100, as per IM 302. The following table shows the calculations:

Sieve	Coarse Aggregate	Intermediate Aggregate	Fine Aggregate	Theoretical Combined Gradation % Retained	Theoretical Combined Gradation % Passing
1 1/2 inch	0.0			0.0	100
1 inch	0.6			0.6	99.4
3/4 inch	10.6	0.0		10.6	88.8
1/2 inch	13.9	3.2		17.1	71.7
3/8 inch	11.0	5.4	0.0	16.4	55.3
No. 4	6.3	4.9	2.0	13.2	42.1
No. 8	0.9	0.4	4.1	5.4	36.7
No. 16	0.3	0.3	5.6	6.2	30.5
No. 30	0.4	0.1	12.9	13.4	17.1
No. 50	0.1	0.2	12.0	12.3	4.8
No. 100	0.2	0.1	3.1	3.4	1.4
No. 200	0.1	0.1	0.2	0.4	1.0
Minus 200	0.4	0.2	0.4	1.0	0.0

The theoretical combined gradations are used in graphically displaying aggregate blends of PCC mixture designs and for plotting control charts to compare target gradation with working ranges of the mixture design.

AGGREGATE PROPORTIONING GUIDE FOR PC CONCRETE PAVEMENT

GENERAL

This Instructional Memorandum covers procedures for developing a well-graded aggregate combination for use in Portland Cement Concrete paving. It is the responsibility of the mix designer to design a mix with appropriate properties for the intended application and placement method. The mixture should be economical, meet workability and finishing requirements, and allow for a proper air void system at a minimum water/cementitious ratio. Regardless of how the mix performs in controlled conditions, ultimately it must be evaluated on how well it performs during production and placement in the field.

Concrete mixtures produced with a well-graded aggregate combination tend to reduce the need for water, provide and maintain adequate workability, require minimal finishing, and consolidate without segregation. These characteristics tend to enhance placement properties as well as strength and long-term performance. Concrete mixtures produced with a gap graded aggregate combination tend to segregate easily, contain higher amounts of fines, require more water, and increase susceptibility to shrinkage. These characteristics tend to limit placement properties as well as strength and long term performance.

Achieving a uniform gradation may require the use of three or more different aggregate sizes. It is the responsibility of the mix designer to consider particle shape when designing a mix. When using the coarseness/workability chart it is assumed that particles are rounded or cubical shaped. Rounded or cubical shaped aggregates typically enhance workability and finishing characteristics. Flat and elongated aggregates typically limit workability and finishing characteristics.

COARSENESS/WORKABILITY CHART[1]

The mathematically combined gradation, expressed as percent retained, shall be calculated in accordance with IM 531. The coarseness and workability factors shall be calculated and then plotted in a coarseness/workability chart as shown in Figure 1.

$$\text{Coarseness Factor} = \frac{[\text{combined \% retained above 9.5 mm (3/8 in.) sieve}]}{[\text{combined \% retained above 2.36 mm (No. 8) seive}]} \times 100$$

Workability Factor = Combined % Passing No. 8 (2.36 mm) Sieve*
*The workability factor shall be increased by 2.5% for each increase of 94 pounds of cement over 564 pounds per cubic yard.

[1] ¹Shilstone, J. Sr., "Concrete Mixture Optimization", Concrete International, June 1990

Shilstone recommends a target of 60 Coarseness Factor and 35 Workability Factor. For a nominal maximum aggregate size of 1 in. to 1 1/2 in. (25 mm to 37.5 mm), Shilstone recommends a Workability Factor of 34 to 38 when the Coarseness Factor is 52 and a Workability Factor of 32 to 36 when the Coarseness Factor is 68.

Aggregate blends that plot close to the bottom boundary line may tend to have too much coarse aggregate. Aggregate blends with a point below the bottom boundary line (Zone V) will produce rocky mixtures with inadequate mortar and shall not be allowed.

Aggregate blends above the top boundary line (Zone IV) will produce sandy mixtures with high amounts of fines requiring higher water contents and potential for segregation.

Aggregate blends with coarseness factors higher than 75 (Zone I) will produce gap graded mixtures with inadequate workability and high potential for segregation.

Aggregate blends with a point in Zone III, respectively, corresponds with Zone II for aggregate sizes less than 1/2 in. (12.5 mm).

0.45 POWER CURVE

The 0.45 power curve is based on the mathematically combined percent passing gradation determined in accordance with IM 531. Historically, the 0.45 power curve has been used to develop uniform gradations for asphalt mix designs; however, it is increasingly being used to develop uniform gradations for Portland Cement Concrete mix designs.

To create a 0.45 power curve plot the mathematically combined percent passing for each sieve on a chart having percent passing on the y-axis and sieve sizes raised to the 0.45 power on the x-axis. Sieve sizes shall include the 1 1/2 in. (37.5 mm), 1 in. (25.0 mm), 3/4 in. (19.0 mm), 1/2 in. (12.5 mm), 3/8 in. (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No 16 (1.18 mm), No. 30 (600 µm), No 50 (300 µm), No. 100 (150 µm), and the No. 200 (75 µm). Connect the plotted points as shown in Figure 2. Plot the maximum density line from the origin of the chart to the sieve one size larger than the first sieve to have 90 percent or less passing.

A well-graded aggregate combination will follow the maximum density line to the No. 16 (1.18 mm) sieve. A slight deviation below the maximum density line at the No. 16 (1.18 mm) sieve will occur to account for the effect of the fines provided by the cementitious materials (Figure 2). A gap graded aggregate combination will produce an “S- shaped” curve deviating above and below the maximum density line (Figure 3).

PERCENT-RETAINED CHART

The percent-retained chart is based on the mathematically combined percent-retained gradation for each sieve in accordance with IM 531. The percent-retained chart has evolved from efforts to limit disproportionate amounts of material retained on any one sieve.

To create a percent-retained chart plot the mathematically combined percent retained for each sieve on a chart having percent retained on the y-axis and sieve sizes on the x-axis. Sieve sizes shall include the 1 1/2 in. (37.5 mm), 1 in. (25.0 mm), 3/4 in. (19.0 mm), 1/2 in. (12.5 mm), 3/8 in. (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300 µm), No. 100 (150 µm), and No. 200 (75 µm). Connect the plotted points and plot the boundary lines as shown in Figure 4.

A well-graded aggregate combination will have no significant peaks and/or dips (Figure 4). A gap graded aggregate combination will have significant peaks and dips (Figure 5). Shilstone recommends that the sum of percent retained on two consecutive sieves should be at least 13% to be an optimum gradation.

OPTIMUM AGGREGATE BLEND

Determining an optimum combined aggregate blend will require the use of all 3 graphical representations as well as sound practical experience. The coarseness/workability chart should be the primary method used to develop an aggregate combination that will produce a mixture with appropriate properties for the intended application and placement method. The 0.45 power curve and the percent-retained chart should be used as secondary means to verify the coarseness/workability chart results and to identify areas deviating from a well-graded aggregate combination. Aggregate blend for QMC mixes may be found on Form #955QMC (Appendix A).

For BR mixes, a well-graded aggregate mix design on the coarseness/workability chart will plot within Zones II-A and II-B.

AGGREGATE SHAPE EFFECT ON OPTIMUM GRADATION

The shape and texture of aggregate particles affect the volume of paste needed to coat particles and decrease interactions during placement. The ideal aggregate shape for workability is smooth and round. Smooth and round particles, such as gravels, have a low surface to volume ratio and require less paste to coat the surfaces of each particle. Crushed limestone aggregates, which usually tend to be more angular and rough than gravel aggregates, have a higher surface to volume ratio, and may require more paste to reduce particle interactions.

These rules are generalized and the mix designer must determine the actual optimum gradation, considering particle shape, with placing and finishing characteristics as the ultimate assessment of workability. Although other combinations can be used depending on aggregate top size, shape, and texture, typical optimum aggregate combinations tend to fall within the range of 44-48% coarse, 10-15% intermediate, and 38-42% fine aggregate.

FIGURE 1

[1] Workability Factor VS Coarseness Factor for Combined Aggregate

Assumptions: 564 lbs cement per cubic yard, 1 inch Aggregate, and Slipformed

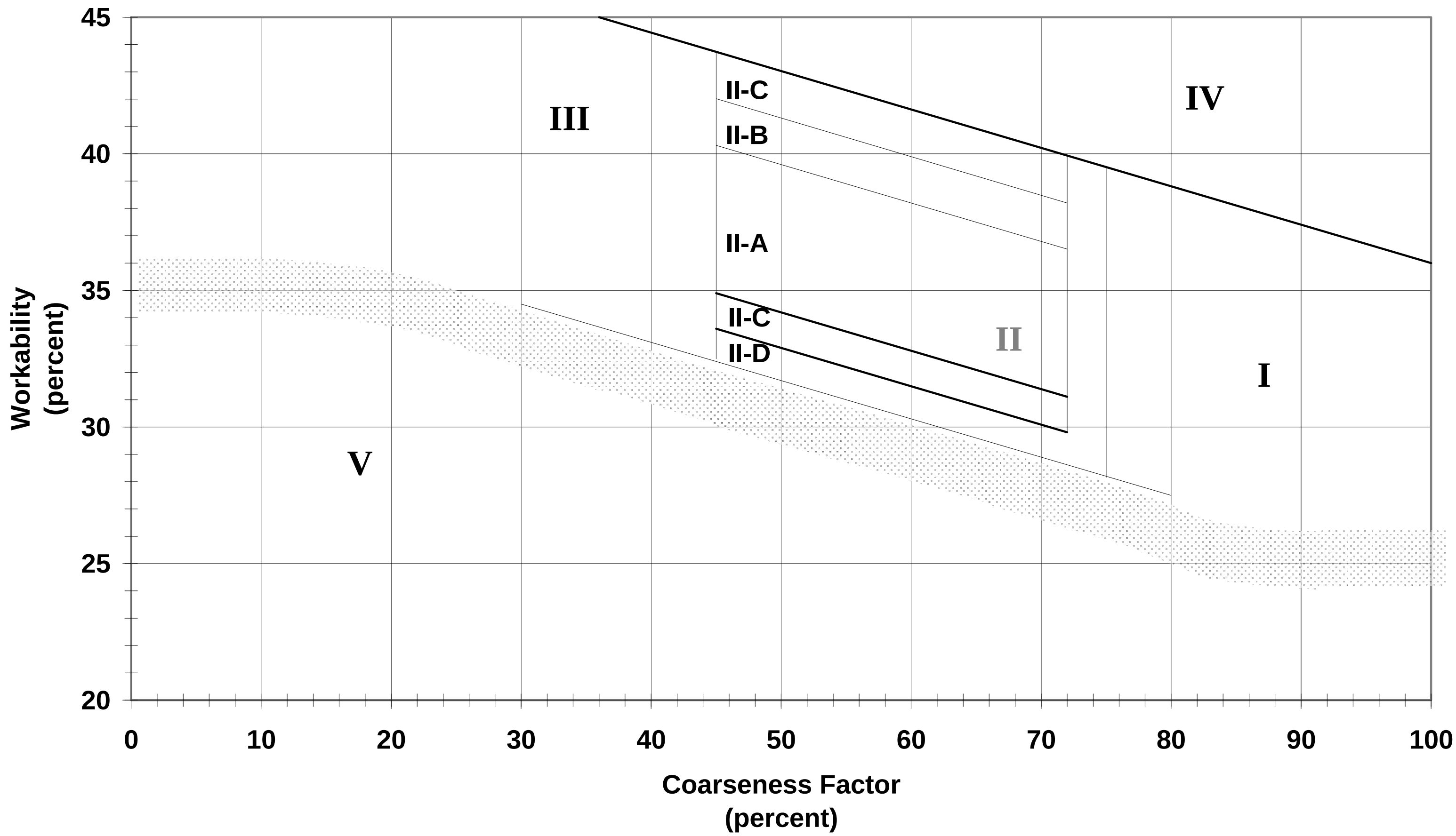


FIGURE #2

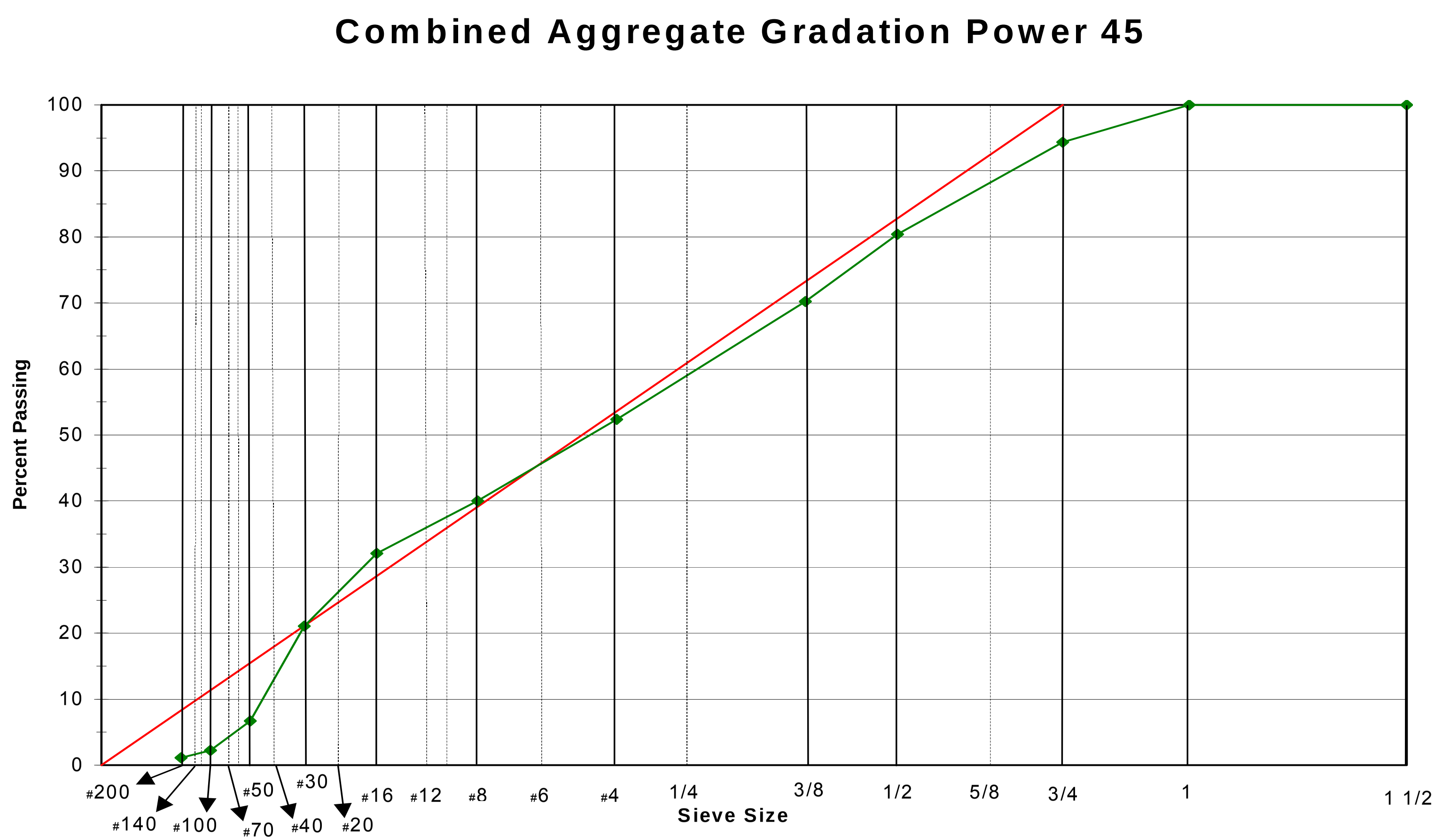

Combined Aggregate Gradation Power 45
Percent Passing
100
90
80
70
60
50
40
30
20
10
0
#200
#140
#100
#70
#50
#40
#30
#20
#16
#12
#8
#6
#4
1/4
3/8
1/2
5/8
3/4
1
1 1/2
Sieve Size

FIGURE 3

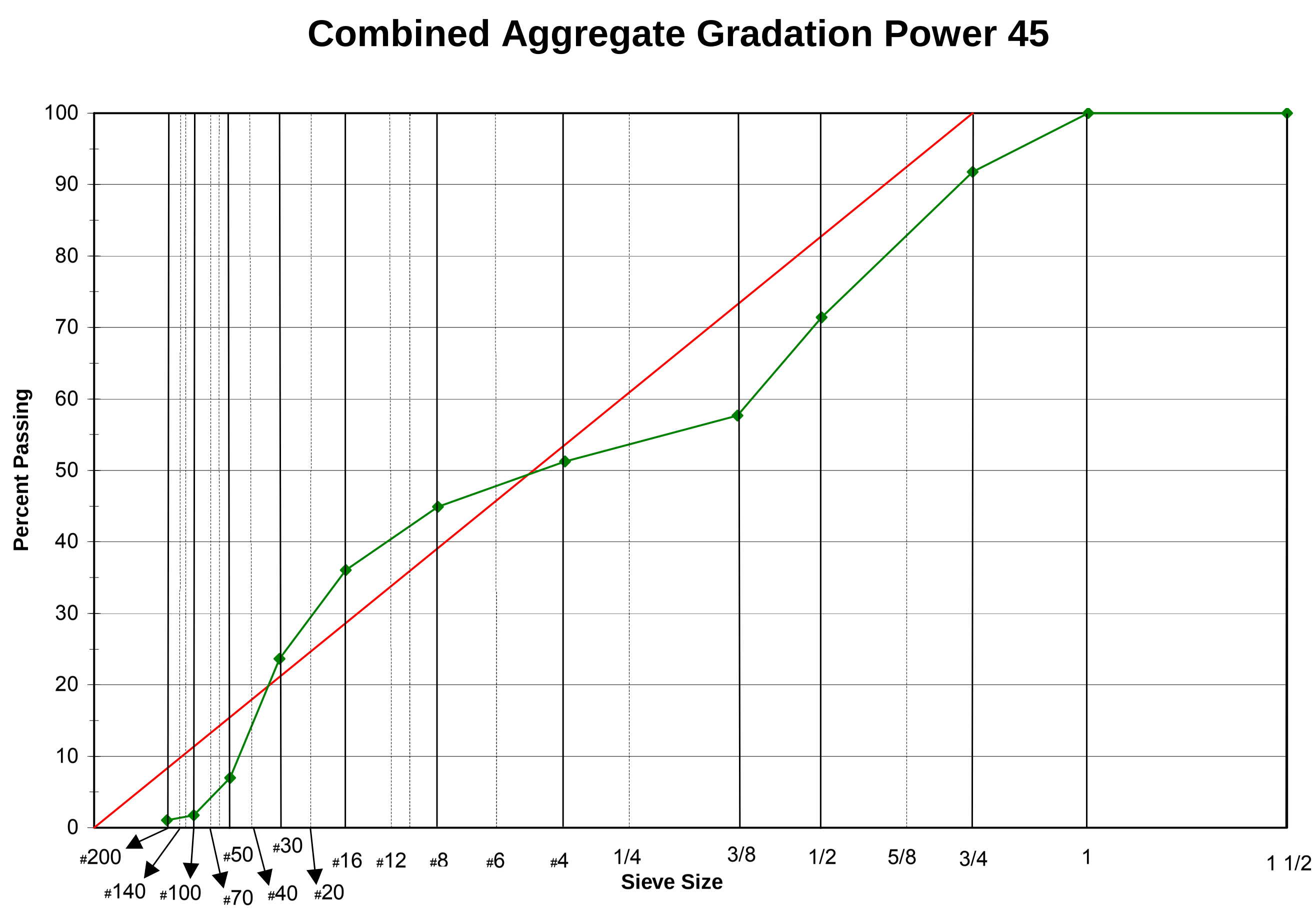

Combined Aggregate Gradation Power 45
Percent Passing
100
90
80
70
60
50
40
30
20
10
0
#200
#140
#100
#70
#50
#40
#30
#20
#16
#12
#8
#6
#4
1/4
3/8
1/2
5/8
3/4
1
1 1/2
Sieve Size

FIGURE 4

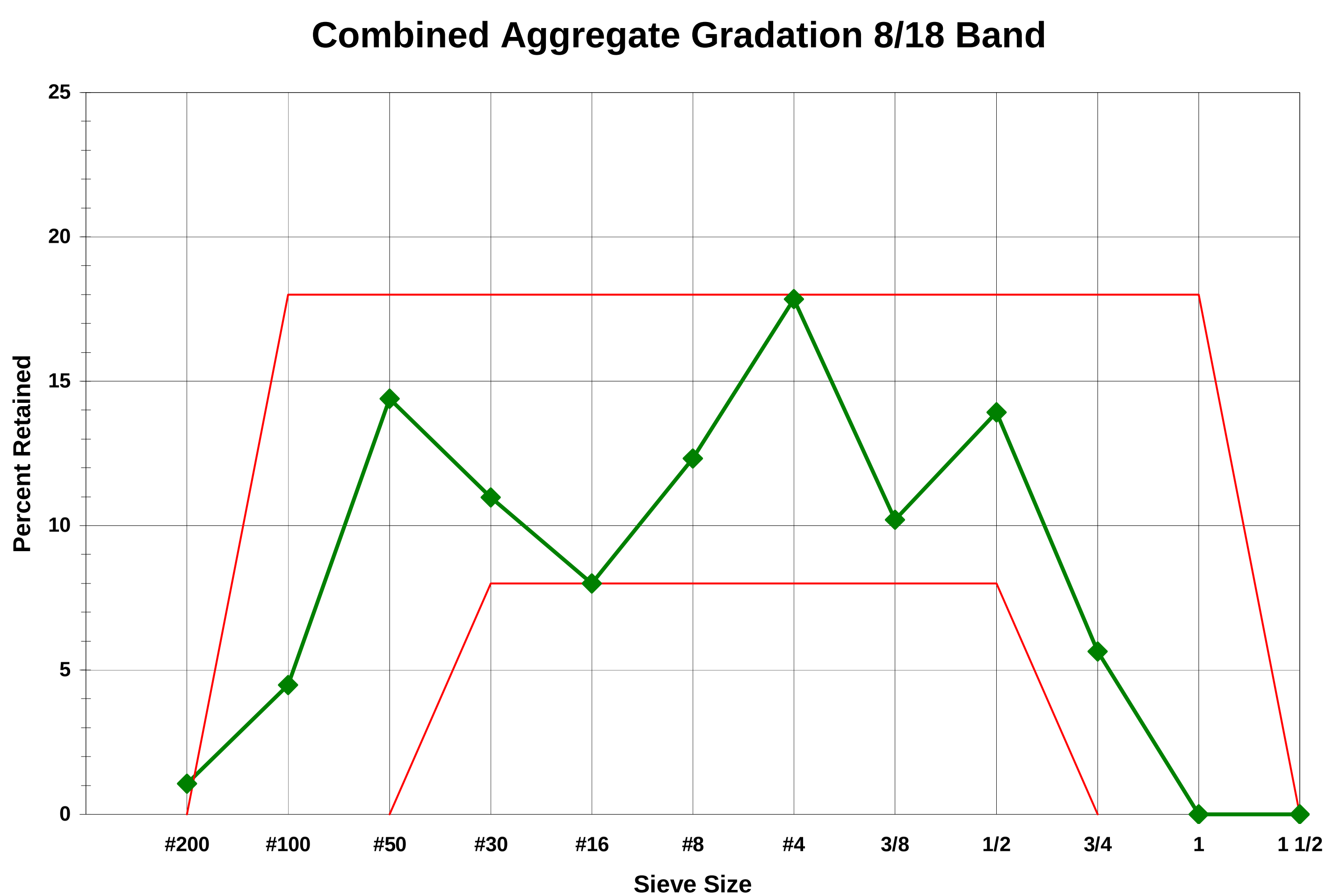
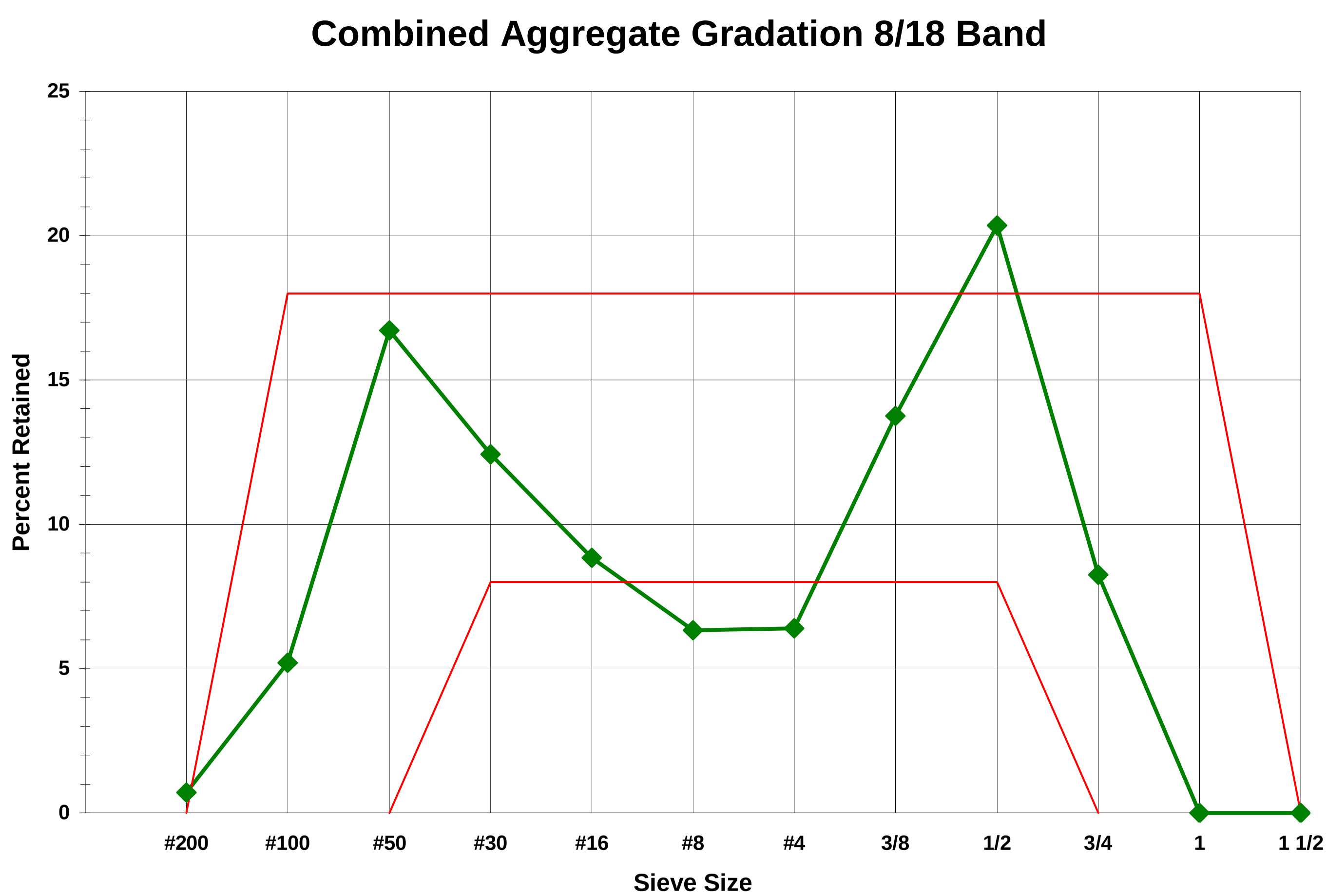

Combined Aggregate Gradation 8/18 Band
Percent Retained
25
20
15
10
5
0
#200
#100
#50
#30
#16
#8
#4
3/8
1/2
3/4
1
1 1/2
Sieve Size

FIGURE 5


Combined Aggregate Gradation 8/18 Band
Percent Retained
25
20
15
10
5
0
#200
#100
#50
#30
#16
#8
#4
3/8
1/2
3/4
1
1 1/2
Sieve Size

****THIS IS A NEW APPENDIX. – PLEASE READ CAREFULLY.****

Form 955QMC

Iowa Department of Transportation

Highway Division - Office of Materials

Proportion & Production Limits For Aggregates

County: Project No.: Date:

Project Location: Mix Design No.:

Contractor:

Material	Ident #	% in Mix	A #	Producer & Location
1 1/2 " Stone **Intermediate** **Conc. Sand**				

Individual Aggregates Sieve Analysis - % Passing (Target)

Material	1 1/2 "	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
1 1/2 " Stone Intermediate Conc. Sand												

Preliminary Target Gradation

* Upper Tolerance **Comb Grading** * Lower Tolerance												

Production Limits for Aggregates Approved by the Contractor & Producer.

	Coarse		Intermediate		
Sieve Size in.	1 1/2 " Stone 0.0%		Intermediate 0.0%		
	Max.	Min	Max.	Min.	
1 1/2					
1					
3/4					
1/2					
3/8					
#4					
#8					
#200	**1.5**	**0.0**			

	Fine Aggregate		
Sieve Size in.	Conc. Sand 0.0%		
	Max.	Min.	
3/8	**100.0**	**100.0**	
#4			
#8			
#16			
#30			
#50			
#100			
#200	**1.5**	**0.0**	

Comments:

The above target gradations and production limits have been discussed with and agreed to by an authorized representative of the aggregate producer.

Check (X)

Signed: ______________________ Coarse [ ] Signed: ______________________
Producer Interm. [ ] Contractor

Signed: ______________________ Fine [ ] Signed: ______________________
Producer Contractor

IM 535 & CM 3.07
PCC PLANT MONITOR

3.07 MATERIALS QUALITY ASSURANCE PROGRAM

It is important that a system be in place to assure that quality materials that meet the requirements of the contract documents are incorporated into all projects. *Materials IM 205* establishes a framework for the Quality Assurance Program describing how the quality of materials will be determined. The Quality Assurance Program consists of both an Acceptance program, including both quality control (QC) and verification sampling and testing, as well as an Independent Assurance (IA) program.

QC tests are typically run by a contractor or supplier, and they are the means by which the contractor/supplier control the quality of their work. Verification tests are typically run by the owner, and they either serve as the owner's acceptance test or provide a means to validate contractor's QC test results when used in the acceptance decision. Price adjustments may be assessed for deficient materials based on verification tests or QC tests when used in the acceptance decision.

IA tests are performed to insure that proper sampling and testing procedures, personnel, and equipment are being used for both QC and verification sampling and testing. IA test results are never to be used in the acceptance decision. They are intended solely to aid in identifying deficiencies in sampling and testing procedures, personnel, and/or equipment. IA test results may be used in the dispute resolution process when QC test results are used in the acceptance decision.

IM 204, including the appendices, further goes on to identify the required sampling and testing rates for the various types of work to comply with the Quality Assurance Program. It is very important to remember that all sampling and testing rates are minimums. Additional sampling and testing may be deemed necessary based upon project specific needs or circumstances.

On certified plant inspection projects, it is a requirement for the plant monitor to be a certified technician for the type of work involved. It is imperative that project engineers maintain an adequate staff of trained, experienced plant monitors. This can be accomplished by having employees participate in the appropriate technician training and certification programs and pass the examinations.

QM-A requirements can be considered an expansion of the certified plant program for HMA. In addition to normal certified plant inspection duties, under QM-A the contractor is also required to design and submit their own mix designs for agency approval. At the plant, the contractor is required to analyze and control mix production properties through frequent field testing, based on specified gyratory mix design criteria.

Certified plant inspection will apply to items of work as defined in *Specification 2521.03*. Any items of work excluded from certified plant inspection will be as noted in contract documents. Work excluded from certified plant inspection will also be excluded from QM-A requirements.

Quality Assurance for Portland Cement Concrete (PCC) Paving

IM 527 describes the plant inspection (Quality Control) requirements that a contractor must follow for a PCC Paving plant. *IM 535* describes the plant monitoring (Verification) responsibilities for a PCC Paving plant. *Appendix A* in *IM 535* lists the minimum monitoring requirements. A plant monitor will normally be assigned to each project with duties split between plant and grade inspection. Plant monitor should schedule work so the plant can be visited daily during production. The amount of time spent at the plant will depend on the overall quality control at the production plant. A list of all verification and IA responsibilities for PCC paving can be found in *Appendix 3-2*

Test beams for determining flexural strengths are to be transported from the grade to the plant site by contracting agency personnel.

Quality Assurance for Ready Mix Concrete
IM 528 describes the plant inspection (Quality Control) requirements that a contractor must follow for a PCC Ready Mix plant. *IM 535* describes the plant monitoring (Verification) responsibilities for a PCC Ready Mix plant. *Appendices B and C* in *IM 535* list the minimum monitoring requirements. A list of all verification and IA responsibilities for Ready Mix Concrete can be found in *Appendix 3-3.*

Test beams for determining flexural strengths are to be transported from the grade to the plant site by contracting agency personnel. The certified plant inspector is responsible for curing and storage of the beams. Contracting agency personnel are responsible for testing and reporting results.

Quality Assurance for Hot Mix Asphalt (HMA) Paving
IM 508 describes the plant inspection (Quality Control) requirements that a contractor must follow for an HMA Paving plant. *IM 511 and IM 511 - Appendix A* describe the plant monitoring (Verification) responsibilities and minimum monitoring requirements for an HMA Paving plant. A list of all verification and IA responsibilities for HMA paving can be found in *Appendix 3-4.*

A plant monitor will normally be assigned to each project with duties split between plant and grade inspection. For HMA projects, individual monitoring responsibilities may be shared between the plant monitor, grade inspector, and materials personnel. Materials engineers and project engineers may mutually coordinate and shift responsibilities between personnel on an individual project basis to achieve the most efficient use of their respective personnel. The plant monitor should schedule work so that the plant can be visited daily during production. The amount of time spent at the plant, beyond minimum requirements, will depend on the overall quality control at the production plant.

Core samples for determining HMA density (field voids) are transported from the grade to the plant site by contracting agency personnel (non-agency personnel may transport with tamper-proof identification/security measures in place). Agency personnel (plant monitor or project inspector) are responsible for performing the density testing and reporting results. The project inspector will also be providing production and placement information to be entered on the daily plant report.

Plant Reports
The project engineer should make arrangements with the certified technician for timely distribution of plant reports. On QM-A projects, the contractor shall deliver a copy of the daily plant report and QM-A Summary Sheet to the District Materials Engineer on a daily basis. The original and all copies of the plant report shall be kept at the plant until all documentation is completed. Normally, this will be the day following the end of the reporting period. Review and distribution of the reports will be made by the project engineer. This distribution will include a copy to be returned to the certified technician. Prompt consultation with the certified technician and monitor shall follow any significant error or omission.

Documentation
A separate field book should be set up on each project to document plant inspection. Some flexibility in the suggested format may be necessary depending on project size, type of plant, and if QM-A applies. It is important to document discrepancies and corrective action taken by the contractor.

A copy of this documentation must be furnished to the District Materials Engineer (DME) at the time of project acceptance. Also include the certified technician's name, certificate number, and statement from the monitor regarding the work performance of certified technician. A sample format for providing this documentation is contained in *Appendix 3-6*.

Specification Violations
Failing test results are to be recorded on the daily plant report by the plant inspector. Verbal notification of such failing results shall precede completion of paperwork to assure timely changes.

The plant monitor will convey to the responsible project inspector all specification violations, discrepancies in results with the plant inspector, and improper procedures and equipment used by the plant inspector. The project inspector will issue noncompliance notices for failing test results and inadequate testing procedures or equipment.

In order to use the contractor quality control test results for the acceptance decision, they must be validated by agency verification tests. It is important to notify the contractor and the DME when the results do not compare within the validation criteria in the Materials IM. The lot of material cannot be accepted until the validation issue is resolved by the DME.

All improper procedures, unresolved test discrepancies, or failure to perform inspection duties will be considered by the DME for possible decertification or other appropriate corrective action.

The role of the plant monitor is vital in assuring the DME is aware of any deficient or otherwise unsatisfactory work of the certified technician.

Testing Equipment & Supplies
Certain testing equipment is available for purchase from Department stock. Producers should refer to HMA and PCC Plant Inspection Manuals for specific information and Office of Materials Lab contacts. A list of equipment suppliers is included in the plant manuals.

Necessary plant inspection forms will be furnished to the producer at no cost. The producer can request these through the DME or project engineer. It is a good idea for the plant monitor to carry a supply of forms and make these available to the producers as needed.

The plant monitor can utilize contractor-furnished equipment for testing required at the plant site. HMA core density testing will most likely be done using the same balance, water bath, and thermometer as the contractor. Verification gradation testing should be done at a separate laboratory from the contractor’s if possible.

Samples
Verification samples are to be taken by agency personnel or by contractor personnel when directed and witnessed by agency personnel. *Materials IM 204* will indicate when contractor sampling assistance is required.

Verification samples that are not tested should be retained until the lot has been accepted.

If required by contract documents, transportation of secured verification samples to the District Materials Lab shall be performed by the contractor.

PCC PLANT MONITOR

GENERAL

The following instruction is to be used when monitoring the operation of a ready mix concrete plant or a central batch plant. The plant monitor is responsible for monitoring the plant operation, quality control procedures performed by the plant inspector, and ensure that proper concrete mix is being batched and delivered.

DUTIES

The following duties are performed by the plant monitor for structural and paving concrete. If non-structural concrete is being produced during the time that structural or paving concrete is produced, no additional plant site visits are required. When non-structural concrete is the only concrete being placed, perform monitor duties at least once per project.

Duty	Task	Minimum Frequency
1. Inspect stockpiles	•Observe stockpiling procedures. •Check for segregation. •Check for contamination. •Check for degradation. •Check for proper storage and handling of aggregates per Article 2301.02.C.1 and IM 527.	Observe during startup and during visits
2. Maturity Curve and Validation	•Witness curve development or beam break. •Verify that a valid maturity curve exists and has been signed by the DME. •Check for monthly validation in accordance with Materials IM 383.	When available Observe each occurrence
3. Test Equipment	•Inspect test equipment to ensure in good working order and lab has been qualified.	During startup and when problems arise
4. Material certifications	Check certifications for cement, fly ash, slag, aggregates, admixtures	During visits
5. Observe aggregate moisture and specific gravity testing	•Observe test performed in accordance with Materials IM 307 and IM 308.	Central Batch– once during first week Ready Mix 1/ project (structural or paving)

6. Plant proportion control	•Observe delivery tolerance. •Observe scale sensitivity. •Observe admixture dispenser operation. •Check for proper batch proportions on computer generated or hand written batch tickets	Central Batch– once during first week
7. Observe mix times for central batch plant	•Per Article 2001.21.	During visits
8. Audit Checks and Test results in Plant Book	•Check for proper completion of Daily Plant Checklist and Plant Site Inspection List. •Observe record of test results for moistures and specific gravities.	During visits
9. Audit Daily Diary	•Review for proper recording of events.	During visits
10. Plant Reports	•Check for proper project and mix identification. •Check for dates and report number. •Review batch weights and aggregate gradations. •Check materials brands and sources. •Check for correct concrete and cement totals (daily, weekly, and to date). •Check for appropriate Plant Inspector signature or initials. •Sign report after review. •Check for hard copy or electronic backup of files	Daily / Weekly
11. Inspect Transit Mixers	•Inspect for buildup in drum per Article 2001.21 B. •Inspect for fin wear or broken fins per Article 2001.21 B. •Check for current truck certification per Article 2001.21 B.	1/Month
12. Monitor agitors & dump trucks	•Check for properly cleaned dump box.	During visits
13. Inspect plant facility	•Observe plant calibration to assure compliance with Materials IM 527. •Check lab qualifications. •Inspect test equipment.	Central Batch - startup Ready Mix - Yearly

SAMPLING & TESTING

AGGREGATES

Verification Gradation - One sample for each aggregate per lot in accordance with IM 527 for paving or IM 528 for all other concrete.

The engineer will split samples obtained with the plant inspector, or observe splitting by the plant inspector, and immediately take possession of the agency sample. Report test results to producer in a timely manner.

Testing and sampling for non-structural concrete is based on that being the only concrete being produced. If structural or paving concrete is being produced, no additional gradation sampling and testing is required for non-structural concrete produced from the same plant, since the sampling and testing frequency for structural and paving concrete is greater. If multiple projects are being supplied by the plant, one representative gradation sample for the lot covers sampling and testing for all of the projects.

Example 1: If a sample was obtained for a footing and the ready mix produces concrete for a sidewalk project the next week, the gradation sample for the footing can be used for the sidewalk project.

Example 2: If a sample was obtained for a paving project and the ready mix produces concrete for a patching and a bridge pier, the gradation sample for the paving can be used for all projects.

Non Complying Gradation

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

Acceptance of lots will be based on complying verification test results. The engineer will retain all samples representing the lots until the lots have been accepted. Since the contracting authority tests are verification, correlation with IM 216 is not required, but may be performed as a check of sampling and testing procedures.

REPORTS & REPORTING

Enter monitor checks on plant monitor workbook for structural or paving. Report gradations on gradation verification form 821283.

PCC PAVING - FIELD AND PLANT SAMPLING AND TESTING GUIDE
(See Specifications for Complete Details.)

Article	Work Type	Field Acceptance	Plant Acceptance	
		Air & Slump (No slump for slipform paving)	**Gradation QC**	**Gradation Verification**
2122	PCC Shoulders	1/700 yd^3: 1/100 yd^3 RM	S/T 1st day, then 1/day>500 yd^3, If <500 yd^3/day 1/wk	S/T 1st/day, S 1/day >500 yd^3 & T 1/wk, If <500 yd^3/day S 1/wk & T 20% (4)
2301	PCC Pavement	1/700 yd^3: 1/100 yd^3 RM	S/T 1st day, then 1/day>500 yd^3, If <500 yd^3/day 1/wk	S/T 1st/day, S 1/day >500 yd^3 & T 1/wk, If <500 yd^3/day S 1/wk & T 20% (4)
2301	PCC Pavement - QMC	1/700 yd^3: 1/350 yd^3 RM	S/T 1/1500 yd^3, If <500 yd^3/day 1/wk	S/T 1st/day, S 1/day >500 yd^3, Test 2/week, If <500 yd^3/day, S/T 1 wk
2301	Bridge Approaches, Gores, tapers, radiuses	1/700 yd^3: 1/100 yd^3 RM	S/T 1st day, then 1/day>500 yd^3, If <500 yd^3/day 1/wk	n/a
2302	PCC Widening	1/700 yd^3: 1/100 yd^3 RM	S/T 1st day, then 1/day>500 yd^3, If <500 yd^3/day 1/wk	S/T 1st/day, S 1/day >500 yd^3 & T 1/wk, If <500 yd^3/day S 1/wk & T 20% (4)
2310	PCC Overlay	1/700 yd^3: 1/100 yd^3 RM	S/T 1st day, then 1/day>500 yd^3, If <500 yd^3/day 1/wk	S/T 1st/day, S 1/day >500 yd^3 & T 1/wk, If <500 yd^3/day S 1/wk & T 20% (4)
2310	PCC Overlay - QMC	1/700 yd^3: 1/100 yd^3 RM	S/T 1/1500 yd^3, If <500 yd^3/day 1/wk	S/T 1st/day, S 1/day >500 yd^3, Test 2/week, If <500 yd^3/day, S/T 1 wk

(1) If less than 20 yd^3/ day, the engineer may waive air testing if inspection is not available and producer has exhibited consistency in prior placements
(3) Sampling and testing rate if no other concrete supplied. Use structural or paving test results to cover non structural concrete items.
(4) If less than 500 yd^3 per day / intermittent construction continues for more than two weeks, obtain verification samples weekly and test 20% of the samples obtained.

PCC STRUCTURAL - FIELD AND PLANT SAMPLING AND TESTING GUIDE

(See Specifications for Complete Details.)

Article	Work Type	Field Acceptance	Plant Acceptance	
		Air & Slump	Gradation QC	Gradation Verification
2403	Structural Concrete	1/30 yd^3 (2)	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2405	Foundations	1/30 yd^3 (2)	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2406	Concrete Structures	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2412	Bridge Decks	1/30 yd^3 (2)	S/T 1/deck pour	S/T 1/deck pour
2413	Deck Repair	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2413	Deck Surfacing/Overlay HPC-O	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1/project
2413	Deck Surfacing/Overlay Class O	1/100 yd^2 (4)	n/a	n/a
2414	Railings	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2415	Box, Arch Circular Culverts	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2416	Rigid Pipe Culverts	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2423	Support Structures	1/30 yd3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2424	Shotcrete	1/30 yd^3	S/T for Mix Design only	n/a
2433	Drilled Shaft	1/30 yd^3 (2)	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2503	Storm Sewers	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2503	intakes, utility access	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	n/a
2501	Pile encasement	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2505	Guardail anchorage	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	n/a
2513	Concrete barrier	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%
2516	Walls and Steps	1/30 yd^3	S/T 1/week, if <50 yd^3/wk S/T 1/ 2 weeks	S/T 1st/wk; S 1/wk or S 1/2 wks if <50 yd^3/wk , T 20%

(1) If less than 20 yd^3/ day, the engineer may waive air testing if inspection is not available and producer has exhibited consistency in prior placements
(2) On large structural placements >350 yd^3, the DME may adjust air and slump testing to 1/50 yd^3 based on consistent results in the first 100 yd^3 placed
(3) Sampling and testing rate if no other concrete supplied. Use structural or paving test results to cover non structural concrete items.
(4) See 204 Appendix M for overlays >300 yd^2.

PCC NON-STRUCTURAL & MISCELLANEOUS - FIELD AND PLANT SAMPLING AND TESTING GUIDE

(See Specifications for Complete Details.)

Article	Work Type	Field Acceptance	Plant Acceptance	
		Air & Slump	Gradation QC	Gradation Verification
2212	Base Repair	1/30 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2201	PCC Base	1/700 yd^3: 1/100 yd^3 RM	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2213	Base Widening	1/700 yd^3: 1/100 yd^3 RM	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2304	Detour Pavement, 3 yrs or less	n/a	n/a	n/a
2405	seal course	n/a	n/a	n/a
2415	Curtain Wall	1/30 yd^3	n/a	n/a
2416	Pipe collars	n/a	n/a	n/a
2503	Catch basins, abandonment,collars	n/a	n/a	n/a
2506	Flowable Mortar	n/a	S/T for Mix Design only	n/a
2507	Revetment Grout	1/day	S/T for Mix Design only	n/a
	Fabric Formed Revetment	1/day	S/T for Mix Design only	n/a
2511	Sidewalks	1/100 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2511	Trails	1/100 yd^3	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2512	Curb & Gutter	1/100 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2515	Driveways	1/100 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2517	Railroad Approach Sections	1/100 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2519	Fence construction	n/a	n/a	n/a
2524	Type A and B	n/a	n/a	n/a
2529	Patching (Full depth), rumble strip	1/30 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2530	Patching (Partial depth)	1/30 yd^3 (1)	S/T 1st week, S/T 1 per month (3)	S/T 1/project (3)
2554	Thrust blocks	n/a	n/a	n/a

(1) If less than 20 yd^3/ day, the engineer may waive air testing if inspection is not available and producer has exhibited consistency in prior placements
(3) Sampling and testing rate if no other concrete supplied. Use structural or paving test results to cover non structural concrete items.

GENERAL AGGREGATE SOURCE INFORMATION

GENERAL

Only those sources which have been sampled or tested within the last ten years are listed. This listing additionally ranks sources in accordance with a frictional classification as defined herein for aggregates used in Hot Mix Asphalt (HMA) construction, durability class for coarse aggregates used in Portland Cement Concrete (PCC) construction, and Approved Fine Aggregate. Upon request, new sources or different combinations of beds within an existing source can be evaluated for classification. These rankings do not in any way waive the normal quality requirements for the particular types of aggregates indicated in contract documents.

Aggregate sources are continuously updated and the most current version of this IM can be found on the Materials Approved Product List Enterprise (MAPLE) website at https://maple.iowadot.gov/.

PORTLAND CEMENT CONCRETE AGGREGATES

Aggregates shall be produced from sources approved in accordance with the requirements of Office of Materials IM 409. The engineer may approve scalping of some portion of the coarser fraction.

All aggregates produced and inspected for intended use in contracts under Iowa Department of Transportation Specifications shall be stored in identifiable stockpiles unless they are being delivered as produced.

DURABILITY CLASSIFICATION

The coarse aggregates have been divided into three classes in accordance with their durability level as determined by performance or laboratory testing.

Class 2 durability aggregates will produce no deterioration of pavements of the non-interstate segments of the road system after 15 years and only minimal deterioration in pavements after 20 years.

Class 3 durability aggregates will produce no deterioration of pavements of non-interstate segments of the road system after 20 years of age and less than 5% deterioration of the joints after 25 years.

Class 3i durability aggregates will produce no deterioration of the interstate road system after 30 years of service and less than 5% deterioration of the joints after 35 years.

NOTE: Those sources with a “B” in their durability class designation are approved for 1/2 in. Bridge Deck Overlay/Repair material.

HOT MIX ASPHALT AGGREGATES

Aggregates for HMA construction have been classified into five main functional types in accordance with their frictional characteristics. Those aggregates with the potential to develop the greatest amount of friction under traffic conditions are classified as Type 1 with the potential for friction decreasing as the type number increases. One or more friction types may be specified for use in pavement surface courses. If a type is not specified in the contract documents, Type 5 or better will be acceptable. Tentative bed limitations are shown in this publication.

The frictional classification types are listed and defined in order of descending quality as follows.

Type 1: Aggregates, which are generally, a heterogeneous combination of minerals with coarse-grained microstructure of very hard particles (generally, a Mohs hardness range of 7 to 9) bonded together by a slightly softer matrix. These aggregates are typified by those developed for and used by the grinding-wheel industry such as calcined bauxite (synthetic) and emery (natural). They are not available from Iowa sources. Due to their high cost, these aggregates would be specified only for use in extremely critical situations.

Type 2: Natural aggregates in this class are crushed quartzite and both fine and coarse-grained crushed igneous rocks. The mineral grains in these materials generally have a Mohs hardness range of 5 to 7. Synthetic aggregates in this class are some air-cooled steel furnace slags and others with similar characteristics. For all L2 asphalt mixtures, pipestone and sandstone in quartzite may not exceed 1 percent. For all other asphalt mixtures, pipestone and sandstone in quartzite may not exceed 5 percent.

Type 3: Natural aggregates in this class are crushed gravels. The crushed gravels shall contain 40% or more igneous and metamorphic particles. Synthetic aggregates in this class are the expanded shales with a Los Angeles abrasion loss less than 35 percent.

Type 4: Aggregates crushed from dolomitic or limestone ledges in which 80 percent of the grains are 20 microns or larger. The mineral grains in the approved ledges for this classification generally have a Mohs hardness range of 3 to 4. For natural gravels, the Type 5 carbonate (see below) particles, as a fraction of the total material, shall not exceed the non-carbonate particles by more than 20 percent.

Type 5: Aggregates crushed from dolomitic or limestone ledges in which 20 percent or more of the grains are 30 microns or smaller.

SOURCE LISTINGS - Explanation

NOTE: - number indicates additional source restrictions (bottom of page)
L=limestone (<15% MgO) and D=dolomite (≥15% MgO), defines rock type for L2 surface mix designs.

Bed numbers shown for PCC aggregate are those on the formal source approval letter. Beds shown for HMA sources are those which have been used or have potential for use and are of the designated friction type.

Frictional Classification - as indicated on page 2
Hot Mix Asphalt - Type A and B

Durability Class for Portland Cement Concrete Coarse Aggregate
("B" indicates acceptability for Bridge Deck Overlay/Repair)
Fine Aggregate (X=PCC and HMA Approval, H=HMA use only)

Source Code Number - Used to identify sources on test requests and for data storage (A-number).

Specific Gravity
DWU-Determine When Used by Iowa DOT

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
29	**DES MOINES DIST 5**	**CRUSHED STONE**											
A29002	L&W QUARRIES INC	MEDIAPOLIS-LEONARD	SE	01	TO71	R04W	2.65	3		4	4	15	L, 1
										4	4	15 - 18	L
										5	5	20	L
A29008	CESSFORD CONST CO	NELSON	NE	26	TO72	R02W	2.62	3		4	4	21 - 24	
										4	4	7 - 20	L
											4	15 - 24	
										5	5	24 - 27	L
A29012	CESSFORD CONST CO	GEODE	NE	01	TO69	R05W				4	4	11 - 12	L
										5	5	9 - 13	L
										4	4	17	L
		SAND & GRAVEL											
A29502	CESSFORD CONST CO	SPRING GROVE	SW	36	TO69	R03W		3		4	4		
							2.66		X				

NOTE 1: AASHTO 57 GRADATION MAXIMUM

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
01	**ADAIR DIST 4**	**CRUSHED STONE**											
A01002	SCHILDBERG CONST CO INC	MENLO	NW	21	TO77	R31W				5	5	15A-15C	L
											4	14	
A01008	SCHILDBERG CONST CO INC	JEFFERSON	NE	17	TO77	R31W					5	20	
											5	25	
02	**ADAMS DIST 4**	**CRUSHED STONE**											
A02002	SCHILDBERG CONST CO INC	MT ETNA	SW	14	TO73	R34W					4	11 - 13	
A02004	SCHILDBERG CONST CO INC	CORNING	NE	09	TO71	R34W					4	3 - 5	
03	**ALLAMAKEE DIST 2**	**CRUSHED STONE**											
A03002	BRUENING ROCK PROD INC	WEXFORD	NE	36	TO98	R03W	2.70	3i		4	4	1C - 6	D
										4	4	1 - 8	D
A03008	BRUENING ROCK PROD INC	MCCABE	NE	06	TO97	R05W					4	1 - 6	
A03010	SKYLINE MATERIALS LTD	RUDE	SE	17	T100	R06W							
A03014	BRUENING ROCK PROD INC	HAMMELL-BOONIES	SW	02	TO99	R06W	DWU	3i		4	4	2 - 4C	D
A03022	SKYLINE MATERIALS LTD	LIVINGOOD	SW	07	TO96	R06W				4	4	4 - 7	L
											4	2 - 7	
A03026	BRUENING ROCK PROD INC	BYRNES	SE	25	TO99	R06W							
A03036	BRUENING ROCK PROD INC	SWENSON	SE	19	TO96	R05W							
A03038	RIEHM CONST CO INC	RIEHM	SE	07	T100	R04W	DWU	3i		4	4	1 - 4	D
A03040	BRUENING ROCK PROD INC	DEE	SE	21	TO99	R04W	DWU	3i		4	4	5A - 5D	D
A03042	NIEMANN CONST CO	CHURCHTOWN	SW	29	TO99	R04W					4	1 - 3	
										4	4	3	D
A03048	BRUENING ROCK PROD INC	POSTVILLE	SW	16	TO96	R06W	2.61	3		4	4	6 - 8	L
											4	2 - 5	
A03050	BRUENING ROCK PROD INC	GREEN	NW	16	TO96	R06W	2.63	3		4	4	2 - 3A	L
A03052	BRUENING ROCK PROD INC	ROSSVILLE	NE	35	TO97	R05W				4	4	1 - 5	L
A03054	BRUENING ROCK PROD INC	WEST RIDGE	NE	08	TO98	R06W							
A03058	BRUENING ROCK PROD INC	ELON	SW	33	TO98	R04W							
A03064	RAINBOW QUARRY LLC	RAINBOW	SE	26	TO97	R05W							
A03066	WILTGEN CONST CO	ELSBERND	NW	29	TO97	R06W	DWU	3		4	4	2	L
A03068	WILTGEN CONST CO	JEFFERSON	SW	30	TO97	R05W							
A03070	WILTGEN CONST CO	BULMAN	NW	31	T100	R05W							
A03072	STRONG ROCK & GRAVEL	STRONG	SE	24	TO99	R04W				4	4	1 - 8	D
A03074	RON WEYMILLER	WW	NE	12	T100	R05W							
		SAND & GRAVEL											
A03502	SKYLINE MATERIALS LTD	HARPERS FERRY	SW	07	TO97	R02W	2.67	3iB		3	3		
							2.67		X				
A03506	BRUENING ROCK PROD INC	HAMMELL-BOONIES	SW	02	TO99	R06W			H	4	4		
A03512	KNIFE RIVER MIDWEST LLC	ZEZULKA	NE	11	T100	R04W				3	3		
							2.66		X				
A03518	BRUENING ROCK PROD INC	IVERSON	NW	09	T099	R06W			H				
04	**APPANOOSE DIST 5**	**CRUSHED STONE**											
A04016	L&W QUARRIES INC	LEMLEY EAST #5	CT	35	TO70	R19W	2.70	2		5	5	1 - 3	L, 1
										5	5	6	L
A04018	L&W QUARRIES INC	CLARKDALE #8	SE	15	TO69	R18W					5	4	
A04020	CANTERA AGGREGATES	PLANO		05	TO69	R19W							
05	**AUDUBON DIST 4**	**SAND & GRAVEL**											
A05506	HALLETT MATERIALS CO	EXIRA	SW	08	TO78	R35W	2.68	3i		3	3		
							2.66		X				

NOTE: 1 – AASHTO 67, GRADATION #5, 40% MAXIMUM; RESTRICTION DOES NOT APPLY TO STRUCTURAL CONCRETE

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
06	**BENTON DIST 6**	**CRUSHED STONE**											
A06006	WENDLING QUARRIES INC	GARRISON B	NE	33	TO85	R11W	2.64	2		4	4	6 - 16	L
A06012	COOTS MATERIALS CO INC	JABENS	SW	07	TO85	R11W	DWU	2		5	5	6 - 11	L
							2.63	2		4	4	12	L
										4	4	10 - 12	L
										4	4	13 - 18	L
										4	4	20 - 23	L
A06014	WENDLING QUARRIES INC	VINTON-MILROY	S2	10	TO85	R10W					4		
A06016	COOTS MATERIALS CO INC	COOTS	SW	36	TO86	R11W							
		SAND & GRAVEL											
A06502	WENDLING QUARRIES INC	VINTON-MILROY	S2	10	TO85	R10W	2.65		X	4	4		
A06504	COOTS MATERIALS CO INC	COOTS SAND/VINTON	SW	31	TO86	R10W				3	3		
							2.65		X				
A06506	WENDLING QUARRIES INC	PORK CHOP	CT	11	TO85	R09W	DWU		X	4	4		
07	**BLACK HAWK DIST 2**	**CRUSHED STONE**											
A07004	BMC AGGREGATES LC	WATERLOO SOUTH	NW	18	TO87	R12W	DWU	3		5	5	25	L
										4	4	17 - 24	L
										4	4	32 - 36	L
										5	5	5 - 24	L
A07008	BMC AGGREGATES LC	MORGAN	NE	15	TO89	R12W	DWU	3i		4	4	5	L
											5	1 - 3	
											5	4A - 4B	
A07018	BMC AGGREGATES LC	RAYMOND-PESKE	SW	01	TO88	R12W	2.66	2		4	4	1B - 5	L
							DWU	2				2 - 5	L
							DWU	2				3 - 12	L
							DWU	2				3 - 13	L
							DWU	2		4	4	2 - 10	D
										4	4	6 - 10	L
										4	4	1B - 10	L
A07020	BMC AGGREGATES LC	STEINBRON	SE	01	TO88	R11W	DWU	3		4	4	1B	L
							DWU	2		4	4	1A - 1B	L
A07022	BMC AGGREGATES LC	MESSERLY	NE	08	TO90	R14W							
		SAND & GRAVEL											
A07504	BMC AGGREGATES LC	WATERLOO SAND	SW	09	TO89	R13W	2.65		X	3	3		
A07506	MANATT'S INC	ASPRO	NW	01	TO88	R13W	2.65		X	4	4		
A07508	BMC AGGREGATES LC	GILBERTVILLE		16	TO88	R12W	DWU	2		4	4		
							2.65		X				
A07512	BMC AGGREGATES LC	ZEIEN S&G	NW	23	TO87	R12W	2.65		X				
A07518	NIEMANN CONST CO	JANESVILLE	NE	14	TO90	R14W	2.66		X	3	3		
08	**BOONE DIST 1**	**SAND & GRAVEL**											
A08504	STRATFORD GRAVEL INC	JENSEN	SW	36	TO85	R25W			H				
A08526	STRATFORD GRAVEL INC	POWERS		29	TO84	R28W			H				
A08528	STRATFORD GRAVEL INC	LEININGER	SW	26	TO85	R25W			H				
09	**BREMER DIST 2**	**CRUSHED STONE**											
A09002	BMC AGGREGATES LC	FREDERIKA	NE	12	TO93	R13W					5	2 - 8	
A09006	NIEMANN CONST CO	TRIPOLI-PLATTE	SW	36	TO93	R13W	2.62	3i		4	4	1 - 5	D
							DWU	3iB		4	4	1 - 3	D
										4	4	4	D
A09008	NIEMANN CONST CO	DENVER #2	NE	20	TO91	R13W							
		SAND & GRAVEL											
A09504	NIEMANN CONST CO	NOLTE	SE	31	TO92	R11W	2.65		X	4	4		
A09508	NIEMANN CONST CO	TRIPOLI-PLATTE	SW	36	TO93	R13W			H				
A09510	CROELL REDI-MIX	PLAINFIELD-ADAMS	NE	32	TO93	R14W	2.66		X				
A09512	NIEMANN CONST CO	BOEVERS	NE	31	TO92	R11W	2.64		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
10	**BUCHANAN DIST 6**	**CRUSHED STONE**											
A10002	NIEMANN CONST CO	WESTON-LAMONT	NW	14	TO90	R07W	2.61	3iB		4	4	1 - 6	D
										4	4	1 - 7	D
A10004	NIEMANN CONST CO	BLOOM-JESUP	SW	32	TO89	R10W	2.63	3		4	4	2 - 5	L
										4	4	1 - 7	L
A10008	BRUENING ROCK PROD INC	OELWEIN	NW	02	TO90	R09W	2.65	3i		4	4	4 - 5	D
										4	4	4 - 6	D
A10010	NIEMANN CONST CO	HAZELTON	NW	11	TO90	R09W	2.60	3iB		4	4	4	D
A10012	NIEMANN CONST CO	INDEPENDENCE	NW	14	TO88	R09W					5		
A10014	NIEMANN CONST CO	OELWEIN #1	SW	02	TO90	R09W				5	5	1 - 12	L
A10016	NIEMANN CONST CO	OELWEIN #2	SE	03	TO90	R09W	DWU	3i		4	4	13 - 16	D
A10022	BRUENING ROCK PROD INC	BROOKS	NW	02	TO88	R09W	2.60	3i		4	4	7	L
											5	1 - 6	
A10024	NIEMANN CONST CO	RASMUSSEN #2	SE	21	TO88	R08W					5		
A10026	NIEMANN CONST CO	BRANDON	SE	27	TO87	R10W					5		
A10028	NIEMANN CONST CO	HERTZBERGER	NE	36	TO87	R10W					5		
A10030	NIEMANN CONST CO	SOUTH AURORA	NW	19	TO90	R07W	2.62	3iB		4	4	1 - 3	D
A10032	NIEMANN CONST CO	SELLS	NW	25	TO88	R09W					5		
A10040	ZUPKE SAND & GRAVEL	ZUPKE-OELWEIN	NE	04	TO90	R09W							
A10042	BRUENING ROCK PROD INC	BRANDON I-380	E2	23	TO87	R10W							
		SAND & GRAVEL											
A10504	NIEMANN CONST CO	WARD	NE	14	TO90	R07W	2.65		X	4	4		
A10506	MANATT'S INC	GREENLEY	SE	29	TO89	R09W				4	4		
							2.64		X				
A10510	NIEMANN CONST CO	HUFFMAN	SE	02	TO89	R08W				4	4		
							2.65		X				
A10514	NIEMANN CONST CO	HOLLERMAN	SE	26	TO90	R07W			H	4	4		
A10516	NIEMANN CONST CO	MILLER	NW	14	TO88	R09W	2.65		X				
A10518	MANATT'S INC	YEAROUS	SE	19	TO89	R09W	2.65		X				
A10520	BRUENING ROCK PROD INC	BROOKS	SW	02	TO88	R09W	DWU		X				
11	**BUENA VISTA DIST 3**	**SAND & GRAVEL**											
A11512	BUENA VISTA COUNTY	MARATHON	SE	19	TO93	R35W			H	4	4		
A11514	LUNDELL CONST	STORM LAKE	SW	18	TO90	R36W			H	4	4		
A11516	HALLETT MATERIALS CO	SIOUX RAPIDS	W2	12	TO93	R37W			H	3	3		
A11518	KNIFE RIVER MIDWEST LLC	MOLGAARD	NW	03	TO93	R38W			H				
A11520	WETHERELL SAND & GRAVEL	WETHERELL		02	TO93	R38W			H				
12	**BUTLER DIST 2**	**CRUSHED STONE**											
A12004	GREENE LS CO	LUBBEN	NW	25	TO93	R17W					5	1 - 21	
A12008	GREENE LS CO	FLORRY-STEERE	CT	08	TO93	R17W					5	1 - 11	
A12010	SKYLINE MATERIALS LTD	CLARKSVILLE-ENGLE	NE	16	TO92	R15W							
A12014	NIEMANN CONST CO	OLTMANN	SE	08	TO91	R16W							
A12016	GREENE LS CO	WIEGMANN-BRISTOW	SE	23	TO92	R18W						1 - 11	
A12018	GREENE LS CO	NEYMEYER	SW	28	TO90	R18W							
A12020	GREENE LS CO	BRUNS #2	NW	21	TO91	R18W							
		SAND & GRAVEL											
A12502	CROELL REDI-MIX	CLARKSVILLE	NW	01	TO92	R16W	2.67	2		4	4		
							2.67		X				
A12508	GREENE LS CO	AUSTINVILLE	NW	23	TO90	R18W	2.64		X	3	3		
A12514	GREENE LS CO	DE VRIES	SW	28	TO90	R18W				4	4		
							2.63		X				
A12516	GREENE LS CO	JENSEN	S2	18	TO93	R16W			H	4	4		
A12518	NIEMANN CONST CO	SHELL ROCK-ADAMS	NE	03	TO91	R15W				3	3		
							2.66		X				
A12520	CROELL REDI-MIX	PARKERSBURG	E2	19	TO90	R16W	DWU		X				
A12522	NIEMANN CONST CO	HOBSON		34	TO92	R15W			H				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION					BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
13	**CALHOUN DIST 3**	**SAND & GRAVEL**												
A13502	KNIFE RIVER MIDWEST LLC	LAKE CITY		NE	26	TO86	R34W			H	4	4		
A13504	TIEFENTHALER INC	JENSEN	N2	SW	07	TO86	R34W	DWU		X				
A13506	MOHR S&G CONST LLC	MOHR	E2	NW	23	TO86	R34W	DWU		X				
A13508	STRATFORD GRAVEL INC	PACKER		NE	26	TO86	R34W			H	3	3		
14	**CARROLL DIST 3**	**SAND & GRAVEL**												
A14510	TIEFENTHALER INC	LANESBORO		NW	17	TO85	R33W	2.72	2		4	4		
								2.68		X				
A14514	TIEFENTHALER INC	MACKE			06	TO85	R33W	2.69	2		4	4		
								2.66		X				
A14516	STRATFORD GRAVEL INC	RICHLAND		NE	23	TO83	R33W			H	4	4		
A14518	TIEFENTHALER INC	MILLER			21	TO85	R33W	DWU	2					
								DWU		X				
15	**CASS DIST 4**	**CRUSHED STONE**												
A15008	SCHILDBERG CONST CO INC	ATLANTIC MINE		SW	13	TO76	R37W					5	25	
16	**CEDAR DIST 6**	**CRUSHED STONE**												
A16004	WENDLING QUARRIES INC	LOWDEN-SCHNECKLOTH		NW	04	TO81	R01W	DWU	3i		4	4	1 - 4	D
A16006	WENDLING QUARRIES INC	STONEMILL		SE	14	TO80	R03W	DWU	3iB		4	4	4	D
A16010	WENDLING QUARRIES INC	PEDEN		NE	10	TO79	R03W				5	5		
A16012	WEBER STONE CO INC	ONION GROVE		NW	14	TO82	R02W	2.61	3i		4	4	1 - 7	D
A16014	WENDLING QUARRIES INC	TOWNSEND		NW	02	TO79	R02W							
A16022	WENDLING QUARRIES INC	TRICON		N2	09	TO82	R04W	DWU	3i		4	4	1	D
		SAND & GRAVEL												
A16502	WENDLING QUARRIES INC	SHARPLISS		NW	12	TO79	R03W				4	4		
								2.65		X				
A16506	WEBER STONE CO INC	ONION GROVE		NE	14	TO82	R02W	2.65		X				
A16508	WENDLING QUARRIES INC	MASSILLON		CT	11	TO82	R01W	2.65		X				
A16510	CROELL REDI-MIX	CEDAR BLUFF		SW	28	TO81	R04W	DWU		X				
17	**CERRO GORDO DIST 2**	**CRUSHED STONE**												
A17008	MARTIN MARIETTA	PORTLAND WEST		NE	19	TO96	R19W	2.75	3iB		4	4	1 - 8	L
A17012	MARTIN MARIETTA	UBBEN		SW	26	TO94	R20W	2.68	2		5	5	3	L
											5	5	1 - 3	L
A17020	MARTIN MARIETTA	MASON CITY		NE	29	TO97	R20W	DWU	3i		5	5	7	L
								2.73	3		5	5	7 - 9	L
											4	4	8 - 9	L
													1 - 6	
A17024	HEARTLAND ASPHALT	RIVERVIEW		NE	29	TO96	R19W				4	4	1 - 12	L
		SAND & GRAVEL												
A17506	KNIFE RIVER MIDWEST LLC	NELSON-FORBES		SW	27	TO96	R19W			H	4	4		
A17514	MARTIN MARIETTA	HOLCIM SAND		NE	19	TO97	R20W	DWU	3		3	3		
								2.65		X				
A17518	HEARTLAND ASPHALT	AIRPORT		NE	08	TO96	R21W			H	3	3		
A17520	NORTH IOWA S&G INC	TUTTLE		NE	13	TO97	R21W			H				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
18	**CHEROKEE DIST 3**	**SAND & GRAVEL**											
A18506	HALLETT MATERIALS CO	CHEROKEE SOUTH	NE	16	TO91	R40W	2.70	2		3	3		
							2.69		X				
A18514	HIGMAN SAND & GRAVEL	LARRABEE-MONTGOMERY	NE2	20	TO93	R39W	DWU	2		3	3		
							DWU		X				
A18526	HALLETT MATERIALS CO	CHEROKEE NORTH	SW	23	TO92	R40W	2.70	2		3	3		
							2.67		X				
A18528	HIGMAN SAND & GRAVEL	HSG WASHTA #1	SW	31	TO90	R41W	DWU	2		3	3		
							DWU		X				
A18530	HIGMAN SAND & GRAVEL	PATTERSON		32	TO91	R40W	2.69	2					
							DWU		X				
A18534	HALLETT MATERIALS CO	NELSON	CT	23	TO92	R40W	2.67	2		3	3		
							2.68		X				
A18536	HIGMAN SAND & GRAVEL	BECK	NE	30	TO93	R39W	DWU	2		3	3		
							DWU		X				
19	**CHICKASAW DIST 2**	**CRUSHED STONE**											
A19004	BRUENING ROCK PROD INC	DEERFIELD-MAHONEY	SE	33	TO97	R14W							
A19006	GREENE LS CO	HUNT	NE	29	TO94	R14W	2.57	2		4	4	9 - 10	L
A19008	GREENE LS CO	BOICE	NE	16	TO95	R14W					5		
		SAND & GRAVEL											
A19504	GREENE LS CO	HUNT	NW	29	TO94	R14W			H	4	4		
A19508	SKYLINE MATERIALS LTD	BUSTA	SE	23	TO96	R11W				4	4		
							2.65		X				
A19512	GREENE LS CO	PEARL ROCK	SE	31	TO94	R14W				4	4		
							2.65		X				
A19514	BRUENING ROCK PROD INC	NASHUA	SW	33	TO95	R14W				3	3		
							DWU		X				
A19516	NIEMANN CONST CO	REWOLDT	NE	25	TO94	R13W	2.64		X				
A19518	KNIFE RIVER MIDWEST LLC	AGGLAND		31	TO96	R12W	2.64		X				
A19520	WILTGEN CONST CO	ROFONKE	NE SE	16	TO95	R14W			H				
A19522	CROELL REDI MIX	BUCKY'S	NW	03	TO95	R11W	DWU	3iB		3	3		
							2.65		X				
A19524	NIEMANN CONST CO	REISNER	SE	23	TO96	R11W			H				
20	**CLARKE DIST 5**	**CRUSHED STONE**											
A20002	SCHILDBERG CONST CO INC	OSCEOLA	NW	12	TO72	R26W					5	25A -25E	
												20A-20C	1
21	**CLAY DIST 3**	**SAND & GRAVEL**											
A21506	DAVE'S S&G	EVERLY	SW	31	TO97	R38W	2.70	2		3	3		
							2.68		X				
A21516	SIEH S&G	SPENCER #1	SW	24	TO96	R36W	2.69	2		3	3		
							2.66		X				
A21518	HALLETT MATERIALS CO	SPENCER #2	SW	05	TO97	R37W			H	4	4		
A21522	KNIFE RIVER MIDWEST LLC	STAINS		30	TO97	R38W			H	4	4		
A21526	CLAY COUNTY	CLAY COUNTY	NW	20	TO96	R35W			H				
A21528	DAVE'S S&G	GOEKEN	NE	05	TO96	R38W	DWU	2	H				
A21530	HALLETT MATERIALS CO	BRAUNSCHWEIG		16	TO94	R36W			H	3	3		
A21532	CLAY COUNTY	ELSER	CT	03	TO94	R36W			H	3	3		
A21534	HALLETT MATERIALS CO	CLARK EVERLY	NW	06	TO96	R38W			H				
A21536	HALLETT MATERIALS CO	GILLETT GROVE	NE	03	TO94	R36W			H	3	3		

NOTE 1: FRICTION TYPE TO BE DETERMINED WHEN USED

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
22	**CLAYTON DIST 2**	**CRUSHED STONE**											
A22002	BARD-KUHLMAN	TWIN ROCK-SCHRADER	NW	14	TO94	R05W				4	4	1 - 11	D
										4	4	3 - 11	D
A22004	SKYLINE MATERIALS LTD	BENTE-ELKADER-WATSON	SW	12	TO93	R05W	2.66	2		4	4	6 - 9	L
										4	4	1 - 9	D
A22008	BARD-KUHLMAN	ANDEREGG	SE	32	TO92	R02W				4	4	2 - 8	D
A22010	BARD-KUHLMAN	OSTERDOCK	SE	02	TO91	R03W	2.67	2				2 - 5	
										4	4	1 - 8	
A22012	BARD-KUHLMAN	SCHMIDT	NE	33	TO91	R01W	2.66	3i		4	4	4B - 6	D
										4	4	2 - 6	D
A22014	SKYLINE MATERIALS LTD	BLUME	NE	09	TO93	R03W	2.64	2		4	4	1 - 7	D
										4	4	1 - 12	D
A22018	CJ MOYNA & SONS	ZURCHER	SE	01	TO94	R05W				4	4		
A22024	MIELKE'S QUARRY	MIELKE'S QUARRY	NE	21	TO95	R04W				4	4	1 - 2	D
A22032	BARD-KUHLMAN	WELLMAN	NW	25	TO92	R06W					4	1 - 6	
A22038	BARD-KUHLMAN	FASSBINDER	SW	09	TO92	R03W	2.67	3i		4	4	2B- 6	D
A22040	BARD-KUHLMAN	HARTMAN	NW	29	TO91	R06W	2.68	3i		4	4	1 - 4	D
A22042	SKYLINE MATERIALS LTD	MORAREND	CT	35	TO92	R03W						1 - 8	
										4	4	1 - 10	D
A22044	BARD-KUHLMAN	BOGE	SW	18	TO91	R02W							
A22058	SKYLINE MATERIALS LTD	ST OLAF	NW	25	TO94	R05W							
A22060	CROELL REDI MIX	JOHNSON	NW	26	TO93	R04W	2.64	3i		4	4	2 - 5	D
										4	4	1 - 5	D
A22062	CJ MOYNA & SONS	SNY MAGILL	SE	22	TO94	R03W	2.73	3i		4	4	6 - 10	D
A22068	RIVER CITY STONE	MILLVILLE	NW	10	TO91	R02W	DWU	3i		4	4	1 - 8	D
A22070	BRUENING ROCK PROD INC	BERNHARD/GIARD	NW	35	TO95	R04W	DWU	3i		4	4	1 - 3	D
A22072	PATTISON BROS	CLAYTON TERMINAL		07	TO93	R02W	DWU	3i		4	4	3 - 4	D
							DWU	3		4	4	1	D
A22074	RIVER CITY STONE	STRAWBERRY POINT	NE	19	TO91	R06W	DWU	3i		4	4	1 - 2	D
A22076	BRUENING ROCK PROD INC	LARSON	NW	08	TO93	R05W							
A22080	BARD-KUHLMAN	HILINE	NW	08	TO91	R03W							
A22084	CJ MOYNA & SONS	MOYNA		14	TO93	R05W	2.66	3i				6 - 8	L,1
										4	4	6 - 9	L
A22086	CJ MOYNA & SONS	WILLIE	SW	18	TO93	R02W							
A22088	WILTGEN CONST CO	KEPPLER	NW	29	TO94	R05W							
A22090	PATTISON BROS	FRENCHTOWN		7, 18	TO93	R02W	DWU	3i		4	4	S1C-S1D	D
							DWU	3		4	4	S1B	D
							DWU	3		4	4	S1B-S1D	D
							DWU	3i		4	4	G4	D
							DWU	3		4	4	G2- G3	D
A22092	CJ MOYNA & SONS	LARSON		07	TO94	R06W							
		SAND & GRAVEL											
A22510	SKYLINE MATERIALS LTD	BENTE	SE	15	TO93	R05W				4	4		
							2.66		X				
A22520	BARD-KUHLMAN	WELTERLEN	SE	32	TO91	R05W	2.65		X				
A22522	CJ MOYNA & SONS	MOYNA		13, 24	TO93	R05W				4	4		
							2.64		X				

NOTE 1: TOP 3' OF BED 8

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
23	**CLINTON DIST 6**	**CRUSHED STONE**											
A23002	PRESTON READY MIX	ELWOOD-YEAGER	NW	08	TO83	R02E	DWU	3i		4	4	1 - 2	D
A23004	WENDLING QUARRIES INC	BEHR	SW	02	TO81	R03E	2.61	3i		4	4	1 - 2	D
A23006	WENDLING QUARRIES INC	SHAFFTON	NE	11	TO80	R05E	DWU	3i		4	4	16 - 17	D
							DWU	3i		4	4	17 - 18	D
							DWU	3i		4	4	18 - 19	D
							DWU	3i		4	4	20 - 21	D
							DWU	3		4	4	3 - 14	D
										4	4	3 - 15	D
A23010	WENDLING QUARRIES INC	GOOSE LAKE	SW	22	TO83	R05E				4	4	1 - 10	D
A23012	WENDLING QUARRIES INC	TEEDS GROVE	SW	03	TO83	R06E					4		
A23016	WENDLING QUARRIES INC	LYONS	NW	18	TO82	R07E					4		
A23026	WENDLING QUARRIES INC	MILL CREEK	NE	22	TO82	R06E					4		
A23028	WENDLING QUARRIES INC	DELMAR	SE	06	TO83	R04E							
A23030	WENDLING QUARRIES INC	EDON VALLEY		04	TO83	R01E							
A23032	ANDERSON S&G	ANDERSON		23	TO81	R03E							
		SAND & GRAVEL											
A23502	WENDLING QUARRIES INC	DOYLE	NE	30	TO83	R07E				4	4		
							2.67		X				
A23504	WENDLING QUARRIES INC	BEHR	SW	02	TO81	R03E	2.68	2		4	4		
							2.68		X				
A23506	WENDLING QUARRIES INC	SCHNECKLOTH	S2	10	TO80	R05E				4	4		
							2.67		X				
A23508	WENDLING QUARRIES INC	GATEWAY	NE	27	TO81	R06E				4	4		
							2.66		X				
A23510	WENDLING QUARRIES INC	SHAFFTON	N2	11	TO80	R05E				4	4		
							2.66		X				
A23514	ANDERSON S&G	ANDERSON	NW	23	TO81	R03E	2.68		X				
A23516	WENDLING QUARRIES INC	OLSON	NW	23	TO81	R02E	DWU		X				
24	**CRAWFORD DIST 3**	**SAND & GRAVEL**											
A24512	HALLETT MATERIALS CO	DUNLAP	SE	27	TO82	R41W	2.70	2		3	3		
							2.66		X				
25	**DALLAS DIST 4**	**SAND & GRAVEL**											
A25510	HALLETT MATERIALS CO	PERRY	NW	01	TO81	R29W	2.70	2		4	4		
							2.67		X				
A25514	HALLETT MATERIALS CO	BOONEVILLE	S2	26	TO78	R26W	2.68	2		3	3		
							2.66		X				
A25516	HALLETT MATERIALS CO	VAN METER SOUTH	21	22	TO78	R27W	2.68	2		3	3		
							2.66		X				
A25518	MARTIN MARIETTA	RACCOON RIVER SAND	27	28	TO78	R26W	DWU	2					
							2.65		X				
26	**DAVIS DIST 5**	**CRUSHED STONE**											
A26004	DOUDS STONE LLC	LEWIS	W2	02	TO69	R12W	2.60	3		4	4	1	L
										5	5	3 - 7	L
											5	3 - 5	
										4	4	6 - 7	L
A26006	DOUDS STONE LLC	BROWN	SW NW	02	TO69	R12W	2.60	3		4	4	1	L
										5	5	3 - 7	L
											5	3 - 5	
										4	4	6 - 7	L
		SAND & GRAVEL											
A26502	DOUDS STONE LLC	ELDON-FRANKLIN	SW	01	TO70	R12W	2.67		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
27	**DECATUR DIST 5**	**CRUSHED STONE**											
A27002	SCHILDBERG CONST CO INC	GRAND RIVER	NW	22	TO70	R27W					5	25A - 25C	1
A27008	SCHILDBERG CONST CO INC	DECATUR		05	TO68	R26W						20C	2
											5	25A -25E	3
28	**DELAWARE DIST 6**	**CRUSHED STONE**											
A28008	BARD-KUHLMAN	EDGEWOOD WEST	CT	04	TO90	R05W	2.67	3i		4	4	2 - 7	D
										4	4	1 - 7	D
A28012	BARD-KUHLMAN	BAUL	SE	22	TO89	R06W	2.69	3i		4	4	1 - 4	L
A28014	BARD-KUHLMAN	LOGAN	SW	10	TO88	R05W	2.69	3		4	4	2 - 8	L
										4	4	1 - 8	L
A28016	BARD-KUHLMAN	WHITE	NW	02	TO88	R04W	2.72	3i		4	4	1 - 2	D
A28020	BARD CONCRETE CO	DEUTMEYER	SW	13	TO88	R03W	DWU	3i		4	4	2 - 6	D
A28030	BARD-KUHLMAN	GRIEF	NE	18	TO87	R03W					4		
A28032	RIVER CITY STONE	SCHNITTJER-DELHI	NE	35	TO88	R04W							
A28038	BARD-KUHLMAN	KUHLMAN	NW	06	TO90	R04W	2.70	3i		4	4	1B - 5	D
A28040	BARD CONCRETE CO	KRAPFL	SE	23	TO89	R03W	2.69	3iB		4	4	4	D
										4	4	1 - 4	D
A28042	BARD-KUHLMAN	WALSTON-MASONVILLE	SE	21	TO89	R06W	2.69	3i		4	4	1 - 4	L
										4	4	1 - 6	L
A28044	NIEMANN CONST CO	DUNDEE	NE	20	TO90	R06W	DWU	3i		4	4	2 - 7	D
											4		
A28046	BARD-KUHLMAN	PINS	NW	27	TO88	R03W							
A28050	BARD-KUHLMAN	BUCK CREEK	NW	20	TO87	R04W							
A28052	RIVER CITY STONE	MANCHESTER	SW	09	TO88	R05W	DWU	3		4	4	5 - 8	D
A28054	RIVER CITY STONE	WINCH	NW SW	02	TO87	R04W							
A28056	RIVER CITY STONE	THORPE	NW	33	TO90	R05W							
A28058	RIVER CITY STONE	ROSSOW/MANCHESTER	NE NW	16	TO88	R05W				4	4	1 - 8	L
		SAND & GRAVEL											
A28504	BARD CONCRETE CO	TEGLER	NE	36	TO89	R03W				4	4		
							2.65		X				
A28510	BARD-KUHLMAN	LOGAN	SW	10	TO88	R05W	2.65		X				
A28520	RIVER CITY STONE	MANCHESTER	SW	10	TO88	R05W	2.65		X				
A28524	BARD-KUHLMAN	LAKE DELHI	NW	14	TO88	R05W	2.64		X				
29	**DES MOINES DIST 5**	**CRUSHED STONE**											
A29002	L&W QUARRIES INC	MEDIAPOLIS-LEONARD	SE	01	TO71	R04W	2.65	3		4	4	15	L, 4
										4	4	15 - 18	L
										5	5	20	L
A29008	CESSFORD CONST CO	NELSON	NE	26	TO72	R02W	2.62	3i		4	4	21 - 24	L
							DWU	3		4	4	8 - 14	L
										4	4	7 - 19	L
										4	4	7 - 20	L
											4	15 - 24	
										5	5	24 - 27	L
A29012	CESSFORD CONST CO	GEODE	NE	01	TO69	R05W				4	4	11 - 12	L
										5	5	9 - 13	L
										4	4	17	L
											5	1 - 5	
		SAND & GRAVEL											
A29502	CESSFORD CONST CO	SPRING GROVE	SW	36	TO69	R03W	DWU	3		4	4		
							2.66		X				

NOTE 1: TOP 4' ONLY OF BED 25C.
NOTE 2: FRICTION TYPE TO BE DETERMINED WHEN USED.
NOTE 3: TOP 2.5' ONLY OF BED 25E.
NOTE 4: AASHTO 57 GRADATION MAXIMUM.

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION	BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
30	**DICKINSON DIST 3**	**SAND & GRAVEL**								
A30504	HALLETT MATERIALS CO	ROHLIN	NE 06 TO98 R36W			H	3	3		
A30508	HALLETT MATERIALS CO	FOSTORIA/LOST	32 TO98 R37W	2.71	2		3	3		
				2.67		X				
A30512	DICKINSON CO	WESTPORT	NE 17 TO98 R38W			H	4	4		
A30514	HALLETT MATERIALS CO	MILFORD/LEITH	NE 04 TO98 R37W	DWU	2	H	3	3		
A30516	COHRS CONSTRUCTION INC	CROSBY	NW 21 T100 R37W			H				
A30518	COHRS CONSTRUCTION INC	SMITH	SE 06 TO98 R36W			H				
A30520	HALLETT MATERIALS CO	MILFORD/DERNER	W2 13 E2 14 TO98 R37W	DWU	2					
				DWU		X				
A30522	HALLETT MATERIALS CO	FODNESS	CT 23 T100 R36W			H				
A30524	COHRS CONSTRUCTION INC	COHRS/DERNER	S2 NE 14 TO98 R37W			H				
A30526	NORTHWEST R/M CONC INC	MILL CREEK	SW 08 TO97 R36W			H				
31	**DUBUQUE DIST 6**	**CRUSHED STONE**								
A31002	RIVER CITY STONE	ROSE SPUR	27 TO90 R02E	2.66	3i		4	4	1 - 8	D
							4	4	1 - 15	D
A31006	BARD-KUHLMAN	DYERSVILLE-SUNDHEIM	SE 32 TO89 R02W	2.66	3i		4	4	5 - 12	D
							4	4	5 - 8	D
A31008	CJ MOYNA & SONS	KLEIN-RICHARDSVILLE	NW 33 TO90 R01E	DWU	3i		4	4	3A - 4B	D
							4	4	1 - 4	D
A31010	RIVER CITY STONE	BROWN	NW 33 TO89 R02E	2.65	3i		4	4	3 - 9A	D
							4	4	2 - 9	D
							4	4	9B	D
A31014	BARD CONCRETE CO	KURT	N2 35 TO87 R02W	2.70	3iB		4	4	1 - 2	D
A31018	RIVER CITY STONE	MELOY	NW 23 TO87 R01E	DWU	3i		4	4	1 - 3	D
A31020	RIVER CITY STONE	SCHLITCHE	SE 11 TO89 R02W	DWU	3i		4	4	1 - 4	D
A31024	BARD-KUHLMAN	JOHNS CREEK	SW 36 TO88 R02W	2.69	3i		4	4	3 - 4	D
							4	4	1 - 4	D
A31026	WENDLING QUARRIES INC	ARNSDORF	SE 25 TO87 R02E	DWU	3i		4	4	1 - 2	D
A31028	RIVER CITY STONE	THOLE	NW 21 TO87 R02E	DWU	3i		4	4	1 - 2	D, 1
A31030	RIVER CITY STONE	KEMP	NE 09 TO89 R01W					4		
A31032	BRUENING ROCK PROD INC	CASCADE-REITER	NW 28 TO87 R01W	DWU	3i		4	4	1B - 5	D
A31036	RIVER CITY STONE	BALLTOWN	SE 05 TO90 R01E							
A31040	RIVER CITY STONE	KENNEDY	NW 03 TO88 R01W					4		
A31042	RIVER CITY STONE	GANSEN	NW 09 TO87 R02E					4		
A31046	WENDLING QUARRIES INC	DECKER	SE 24 TO87 R02E	DWU	3i		4	4	1 - 5	D
A31048	RIVER CITY STONE	MCDERMOTT	NE 35 TO88 R01W	2.65	3i		4	4	2	D
A31050	RIVER CITY STONE	PLOESSEL-DYERSVILLE	N2 07 TO88 R02W	2.74	3i		4	4	3 - 5	D
A31052	HORSFIELD MATERIALS INC	EPWORTH-KIDDER	SW 02 TO88 R01W	DWU	3i		4	4	2	D
A31056	RIVER CITY STONE	RUBIE	SE 06 TO88 R03E	DWU	3iB		4	4	5 - 9	D, 2
A31058	RIVER CITY STONE	HOLY CROSS	SW 12 TO90 R02W							
A31060	BARD CONCRETE CO	EAST CASCADE	SE 22 TO87 R01W	2.71	3iB		4	4	2 - 5	D
A31064	RIVER CITY STONE	WEBER	NE 32 TO89 R02E	2.67	3i		4	4	3 - 9A	D
A31066	RIVER CITY STONE	FILLMORE	SW 26 TO87 R01W	2.70	3i		4	4	2 - 4	D
A31068	HORSFIELD MATERIALS INC	DYERSVILLE-MAIERS	SE 19 TO89 R02W	DWU	3i		4	4	2	D
		SAND & GRAVEL								
A31504	BARD CONCRETE CO	SAUSER PROPERTY	NW 36 TO87 R02W				4	4		
				2.66		X				
A31512	BARD CONCRETE CO	BURKLE	SW 19 TO89 R02W	2.66		X				
A31514	RIVER CITY STONE	FILLMORE	CT 26 TO87 R01W	2.66		X				
A31516	HORSFIELD MATERIALS INC	CASCADE-LOCHER	25 TO87 R02W	DWU		X				

NOTE 1: TOP 17.0' OF BED 2
NOTE 2: TOP 6.0' OF BED 9

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
32	**EMMET DIST 3**	**SAND & GRAVEL**											
A32502	HALLETT MATERIALS CO	ESTHERVILLE	N2	03	TO99	R34W	2.70	2		3	3		
							DWU		X				
A32506	EMMET COUNTY	FREY	NW	21	T100	R34W			H	4	4		
A32522	HALLETT MATERIALS CO	OLD ESTHERVILLE S&G		30	TO99	R33W			H				
A32524	EMMET COUNTY	PETERSON	SW	34	T100	R34W			H				
A32530	HALLETT MATERIALS CO	ESTHERVILLE/WHITE	SW	16	T100	R34W	DWU	2		4	4		
							DWU		X				
A32534	COHRS CONSTRUCTION INC	ENERSON		28	T100	R34W			H	4	4		
A32538	HALLETT MATERIALS CO	JENSEN	NW	03	T099	R34W	DWU	2					
							DWU		X				
A32540	HALLETT MATERIALS CO	FISHER	NE	33	TO98	R32W			H				
A32542	HALLETT MATERIALS CO	GRAETTINGER	SE	33	TO98	R33W			H	4	4		
A32544	DUININCK BROS INC	ANDERSON		7,8	T100	R34W				3	3		
							DWU		X				
A32546	DUININCK BROS INC	TROPHY RIDGE	SE	25	TO99	R34W			H				
33	**FAYETTE DIST 2**	**CRUSHED STONE**											
A33002	NIEMANN CONST CO	ELDORADO-JACOBSEN	SW	17	TO95	R08W	2.69	3iB		5	5	4 - 6B	L
A33010	WILTGEN CONST CO	VOSHELL	NW	21	TO93	R07W						1 - 4	
A33018	NIEMANN CONST CO	FAIRBANK	SW	28	TO91	R10W				4	4	5	D
											4	1 - 5	
A33020	NIEMANN CONST CO	YEAROUS	SW	19	TO93	R08W				4	4	1 - 10	L
A33024	NIEMANN CONST CO	WAUCOMA	NW	25	TO95	R10W	2.69	3iB		5	5	2 - 5	L
A33026	WILTGEN CONST CO	LYNCH	NW	05	TO95	R10W				4	4	1 - 5	D
A33032	BRUENING ROCK PROD INC	LANDIS	SE	12	TO93	R08W				4	4	1 - 5	D
A33034	NIEMANN CONST CO	MCDONOUGH	SE	36	TO94	R08W							
A33036	NIEMANN CONST CO	GRAHAM-HAWKEYE	SW	06	TO94	R09W				4	4	1 - 4	L
A33038	NIEMANN CONST CO	PAPE	NE	28	TO95	R08W	DWU	3iB		5	5	3 - 5	L
A33040	NIEMANN CONST CO	SINNOTT		25	TO93	R09W							
A33042	WILTGEN CONST CO	LEHMAN	SW	35	TO94	R07W							
A33044	BRUENING ROCK PROD INC	FAYETTE 93		30	TO93	R08W							
		SAND & GRAVEL											
A33506	NIEMANN CONST CO	ALPHA	NW	03	TO94	R10W				4	4		
							2.64		X				
A33508	SKYLINE MATERIALS LTD	DURSCHER	NW	03	TO94	R07W			H		4		
A33510	ZUPKE S&G	RANDALIA	NW	29	TO93	R09W				4	4		
							2.64		X				
A33512	NIEMANN CONST CO	WADENA	NE	25	TO93	R07W				4	4		
							2.66		X				
A33518	BARD-KUHLMAN	BASSETT	SE	11	TO91	R07W				4	4		
							2.65		X				
A33520	BRUENING ROCK PROD INC	OELWEIN SAND	NE	09	TO91	R09W	2.65		X				
A33522	BRUENING ROCK PROD INC	PAPE	SE	08	TO95	R08W	2.65		X				
A33524	CROELL REDI-MIX	ROGERS		04	TO94	R07W	2.66		X				
A33526	WILTGEN CONST CO	ELDORADO	NE	13	TO95	R09W			H	4	4		
A33528	NIEMANN CONST CO	KASEMEIER	SE	19	TO93	R10W	2.64		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
34	**FLOYD DIST 2**	**CRUSHED STONE**											
A34002	GREENE LS CO	CARVILLE-BUNN	SW	23	TO95	R15W	2.63	2		4	4	1 - 4	L
A34004	GREENE LS CO	MAXON	SE	07	TO94	R17W	2.68	2		5	5	4C - 19	L
										5	5	1 - 17	L
A34006	GREENE LS CO	JOHLAS	SW	07	TO94	R15W					5	6 - 7	
A34008	GREENE LS CO	WARNHOLTZ	SW	09	TO96	R16W	2.70	3i		5	5	1 - 4	L
							2.68	2		4	4	17 - 18	D
									H			1 - 18	
A34010	GREENE LS CO	LACOSTA	SE	25	TO97	R17W	2.67	3i		5	5	1 - 4	L
										5	5	1 - 8	L
										4	4	9 - 14	L
A34012	GREENE LS CO	WILLIAMS	NW	29	TO96	R18W							
A34014	BRUENING ROCK PROD INC	HANNMANN	NE	20	TO94	R15W							
A34018	CROELL REDI MIX	JONES	N	26	TO97	R17W	2.67	3iB		5	5	1 - 4	L
							DWU	3B				2 - 7	L
							DWU	3				5A - 7	L
A34020	CROELL REDI MIX	POWERS	SW	25	TO94	R16W							
		SAND & GRAVEL											
A34502	GREENE LS CO	ROCKFORD	SE	15	TO95	R18W	2.68	2		3	3		
							2.65		X				
A34506	GREENE LS CO	LENT	NE	08	TO96	R16W			H	4	4		
A34510	GREENE LS CO	BRACKEL	NE	17	TO94	R17W			H	4	4		
A34514	GREENE LS CO	LITTLE CEDAR	NW	01	TO95	R15W				3	3		
							2.65		X				
A34516	GREENE LS CO	CEDAR ACRE RESORTS	E2	17	TO95	R15W	2.65		X				
A34518	GREENE LS CO	ENABNIT	NW	21	TO94	R17W			H				
A34520	CROELL REDI MIX	FOOTHILL		26	TO95	R18W	DWU	2					
							2.66		X				
A34522	GREENE LS CO	ROTTINGHAUS	NE	35	TO96	R15W	2.66		X				
35	**FRANKLIN DIST 2**	**CRUSHED STONE**											
A35002	MARTIN MARIETTA	DOWS	NE	30	TO91	R22W				4	4	1 - 4	L
										4	4	1 - 12	L
										4	4	7 - 12	L
										5	5	5 - 6	L
A35006	MARTIN MARIETTA	HIBNESS	SE	22	TO91	R20W	2.58	3		5	5	1 - 4A	L
										4	4	1 - 12	L
A35010	GREENE LS CO	MILLER	NE	13	TO91	R19W					4	1 - 5	
A35016	GREENE LS CO	AYRES		01	TO92	R19W							
		SAND & GRAVEL											
A35502	SKLYINE MATERIALS LTD	GENEVA	SW	07	TO91	R19W	2.68	2		3	3		
							2.64		X				
A35516	KNIFE RIVER MIDWEST LLC	PETERS	SW	04	TO92	R20W				3	3		
							2.65		X				
A35518	KNIFE RIVER MIDWEST LLC	REINKE	SW	22	TO91	R20W			H	4	4		
A35520	STRATFORD GRAVEL INC	BRANDT	N2	34	TO90	R19W	2.68		X	4	4		
A35522	MARTIN MARIETTA	RASH	SE	27	TO90	R22W	DWU	2		4	4		
							2.61		X				
36	**FREMONT DIST 4**	**CRUSHED STONE**											
A36002	SCHILDBERG CONST CO INC	THURMAN	NW	23	TO70	R43W					4		
37	**GREENE DIST 1**	**SAND & GRAVEL**											
A37504	HALLETT MATERIALS CO	JEFFERSON	SW	04	TO83	R31W	2.66	2		4	4		
							2.64		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION	BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
37	**GREENE DIST 1**	**SAND & GRAVEL**								
A37514	ARCADIA LIMESTONE CO	WRIGHT	NW 05 TO84 R32W	2.66		X	4	4		
A37520	GREENE CO REDI MIX	HAMILTON	27 TO83 R30W	2.65		X				
A37522	STRATFORD GRAVEL INC	HAUPERT	20 TO84 R30W			H				
A37524	STRATFORD GRAVEL INC	DAVIS	30 TO82 R29W			H				
A37526	HALLETT MATERIALS CO	JEFFERSON-CLARKE	NE 23 TO84 R31W			H				
A37528	STRATFORD GRAVEL INC	MUIR	SW 10 TO83 R30W			H				
A37530	BEDROCK GRAVEL CO	BEDROCK #3	SW 02 TO83 R31W			H				
A37532	STRATFORD GRAVEL INC	MEARS	13 TO84 R30W							
38	**GRUNDY DIST 1**	**SAND & GRAVEL**								
A38504	SKYLINE MATERIALS LTD	HERONIMOUS	SE 35 TO88 R17W	2.63		X				
A38506	STRATFORD GRAVEL INC	MEESTER	NE NE 12 TO88 R17W	2.63		X				
39	**GUTHRIE DIST 4**	**SAND & GRAVEL**								
A39502	KNIFE RIVER MIDWEST LLC	HEILAND	SW 29 TO79 R30W			H	4	4		
A39508	MCALISTER AGGREGATES LLC	L & L	NE 33 TO78 R31W	2.64		X	4	4		
A39510	MCALISTER AGGREGATES LLC	GARNES	SE 22 TO81 R32W			H				
40	**HAMILTON DIST 1**	**CRUSHED STONE**								
A40006	MARTIN MARIETTA	GRANDGEORGE	SE 18 TO89 R25W	2.57	3iB		5	5	11B- 13	1
								5	3 - 5	
							4	4	7 - 11	L
							5	5	8 - 11	L
							5	5	12	L
		SAND & GRAVEL								
A40512	STRATFORD GRAVEL INC	ANDERSON	12 TO87 R26W	DWU		X				
41	**HANCOCK DIST 2**	**CRUSHED STONE**								
A41002	BMC AGGREGATES LC	GARNER NORTH	SE 11 TO95 R24W	2.77	3iB		4	4	1 - 4	D
				2.77	3iB		4	4	6	D
		SAND & GRAVEL								
A41504	HANCOCK COUNTY	HUTCHINS	E2 27 TO96 R26W			H		4		
A41506	HANCOCK COUNTY	KLEMME	26 TO95 R24W			H		4		
A41518	HANCOCK COUNTY	AUSTIN	NE 11 TO97 R25W			H				
42	**HARDIN DIST 1**	**CRUSHED STONE**								
A42002	MARTIN MARIETTA	ALDEN	NW 20 TO89 R21W	2.56	3iB		4	4	0 - 3	L, 2
				DWU	3iB		4	4	3	L
				DWU	3		5	5	0 - 1	L
A42004	GERHKE QUARRIES INC	GIFFORD	NW 04 TO86 R19W					5		
		SAND & GRAVEL								
A42512	CONCRETE INC	HARDIN AGGREGATES	SW 31 TO87 R19W	2.67		X	4	4		
A42524	STRATFORD GRAVEL INC	GRIFFEL	SE 31 TO89 R19W			H	3	3		
A42528	STRATFORD GRAVEL INC	LLOYD	04 TO86 R19W			H	4	4		
A42532	MARTIN MARIETTA	H & M FARMS	34 TO89 R20W	2.67		X				
43	**HARRISON DIST 4**	**CRUSHED STONE**								
A43002	SCHILDBERG CONST CO INC	LOGAN	19 TO79 R42W				5	5	25E	L
							5	5	25C- 25E	L
								4	26	
A43004	BEDROCK GRAVEL	LOGAN	17 TO79 R42W				5	5	25E	L
							5	5	25C- 25E	L
								4	26	

NOTE 1: TOP 13' OF BED 13
NOTE 2: WHEN BED 2 IS VISUALLY APPARENT, IT SHALL NOT EXCEED A THICKNESS OF ONE FOOT IN FULL-FACE OPERATION.

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
43	**HARRISON DIST 4**	**SAND & GRAVEL**											
A43512	HALLETT MATERIALS CO	WOODBINE-MCCANN	SW	29	TO81	R41W	2.68	3		3	3		
							2.64		X				
44	**HENRY DIST 5**	**CRUSHED STONE**											
A44002	COOTS MATERIALS CO INC	KINNEY & SONS	SE	17	TO71	R06W							
A44006	HENRY COUNTY	LEEPER	NE	18	TO71	R06W	DWU	2		4	4	8 - 11	D
A44008	DOUDS STONE LLC	MT PLEASANT	SW	36	TO71	R06W				4	4	13 - 14	L
										5	5	9 - 14	L
		SAND & GRAVEL											
A44502	CESSFORD CONST CO	NORTH ROME	SW	29	TO72	R07W	2.66		X	4	4		
A44504	IDEAL SAND CO	ENSMINGER-ROME	NW	32	TO72	R07W	2.67		X				
45	**HOWARD DIST 2**	**CRUSHED STONE**											
A45006	BRUENING ROCK PROD INC	NELSON	NE	33	TO99	R13W	2.54	2		4	4	1 - 3	L
							2.54	2		4	4	8 - 9	D
A45008	BRUENING ROCK PROD INC	DOTZLER	NE	23	TO99	R12W	2.50	3		4	4	7 - 10A	D
A45010	BRUENING ROCK PROD INC	DALEY	NE	11	TO98	R11W	2.59	3		4	4	9 - 11	D
A45014	FALK CONST CO	O'DONNEL	SE	08	TO97	R14W					5		
A45018	BRUENING ROCK PROD INC	LE ROY	NW	10	T100	R14W							
A45028	BRUENING ROCK PROD INC	ELMA	NW	06	TO97	R13W							
A45030	BRUENING ROCK PROD INC	DIEKEN-TANK	SE	24	T100	R13W							
A45032	SKYLINE MATERIALS LTD	KITCHEN		13	T100	R12W							
		SAND & GRAVEL											
A45502	BRUENING ROCK PROD INC	MAPLE LEAF-POTTER	SE	04	TO98	R13W			H	4	4		
A45504	SKYLINE MATERIALS LTD	ECKERMAN	NW	33	T100	R11W	DWU	3		4	4		
							2.65		X				
A45508	SKYLINE MATERIALS LTD	SOVEREIGN	SW	01	TO98	R12W	DWU	3		3	3		
							2.65		X				
A45516	BRUENING ROCK PROD INC	FREIDERICH	NE	15	TO98	R14W				3	3		
							2.67		X				
A45518	BRUENING ROCK PROD INC	ELMA	NW	06	TO97	R13W	2.67		X				
46	**HUMBOLDT DIST 2**	**CRUSHED STONE**											
A46004	STRATFORD GRAVEL INC	GRIFFITH	SW	24	TO91	R30W	DWU	3iB		4	4	1 - 4	L
										4	4	1 - 6	L
A46006	MARTIN MARIETTA	HODGES	NE	32	TO92	R28W	2.60	3i		4	4	10 - 18	L
							DWU	3i		5	5	4 - 8	L
A46014	MARTIN MARIETTA	PEDERSEN	SW	28	TO92	R28W	2.59	3i		5	5	4 - 13	L
							2.58	3i		5	5	4 - 20	L
							2.57	3i		5	5	14 - 20	L
A46016	KNIFE RIVER MIDWEST LLC	ERICKSON		30	TO91	R28W							
		SAND & GRAVEL											
A46512	NORTHWEST MATERIALS	WARREN	SW	08	TO92	R30W			H		4		
A46516	NORTHWEST MATERIALS	ERICKSON		30	TO91	R28W			H	3	3		
A46518	MARTIN MARIETTA	PEDERSEN	SW	28	TO92	R28W	2.66		X	4	4		
47	**IDA DIST 3**	**SAND & GRAVEL**											
A47502	HALLETT MATERIALS CO	BATTLE CREEK		05	TO86	R41W			H	3	3		
A47504	HIGMAN SAND & GRAVEL	CROCKER	NW	06	TO89	R41W	DWU	3	H				
48	**IOWA DIST 6**	**SAND & GRAVEL**											
A48502	MARENGO READY MIX	KIMMICH	SE	24	TO81	R11W	2.66		X	4	4		
A48506	WENDLING QUARRIES INC	MARENGO	NW	22	TO81	R11W	2.66		X				
A48508	MARENGO READY MIX	DISTERHOFT	SE	34	TO81	R10W	2.66		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
49	**JACKSON DIST 6**	**CRUSHED STONE**											
A49002	BELLEVUE S&G CO	BELLEVUE	SW	25	TO87	R04E	2.67	3i		4	4	1 - 3	D
A49004	BELLEVUE S&G CO	LAMOTT	NW	02	TO86	R03E				4	4		
A49008	WENDLING QUARRIES INC	IRON HILL	SW	16	TO85	R02E	DWU	3i		4	4	3 - 6	D
										4	4	1 - 6	D
A49010	WENDLING QUARRIES INC	ANDREW	NW	21	TO85	R03E	2.70	3iB		4	4	1B - 3	D
										4	4	1 - 7	D
A49012	WENDLING QUARRIES INC	FROST	SE	16	TO84	R03E	DWU	3iB		4	4	1A - 1D	D
										4	4	1 - 2	D
A49016	WENDLING QUARRIES INC	WEIS	SE	22	TO85	R04E					4		
A49018	WENDLING QUARRIES INC	PATASKA	NW	23	TO85	R05E					4		
A49020	WENDLING QUARRIES INC	PRESTON	SW	26	TO84	R05E	2.67	3i		4	4	7 - 10	D
							DWU	3		4	4	1 - 10	D
A49021	PRESTON READY MIX	PRESTON R/M	SW	26	TO84	R05E	2.67	3i		4	4	7 - 10	D
							DWU	3		4	4	1 - 10	D
A49022	WENDLING QUARRIES INC	BELLEVUE	SE	23	TO86	R04E				4	4		
A49024	WENDLING QUARRIES INC	MAQUOKETA EAST	SW	07	TO84	R03E	DWU	3i		4	4	1 - 8	D
							2.70	3i		4	4	7 - 8	D
A49030	BELLEVUE S&G CO	SPRINGBROOK		15	TO85	R04E				4	4		
A49040	WENDLING QUARRIES INC	JOINERVILLE-HAMANN	SE	20	TO84	R02E				4	4	1 - 3	D
A49044	WENDLING QUARRIES INC	FRANK	NW	14	TO87	R04E							
A49046	WENDLING QUARRIES INC	ROWAN	NE	25	TO86	R03E							
A49060	BELLEVUE S&G CO	ST DONATUS		18	TO87	R03E	DWU	3i		4	4	2 - 3	D
A49062	PRESTON READY MIX	JOHNSON		31	TO84	R04E							
A49064	BELLEVUE S&G CO	VEACH		01	TO85	R02E							
A49066	BELLEVUE S&G CO	MOREHEAD	NW	13	TO85	R01E							
		SAND & GRAVEL											
A49504	WENDLING QUARRIES INC	KNIPELMEYER	NE	36	TO87	R04E				4	4		
							2.64		X				
A49506	BELLEVUE S&G CO	BELLEVUE	E2	01	TO86	R04E	2.64	3iB		3	3		
							2.68		X				
A49510	WENDLING QUARRIES INC	MAQUOKETA	NE	13	TO84	R02E				4	4		
							2.65		X				
A49516	WENDLING QUARRIES INC	TURNER	NE	07	TO84	R07E	2.63	3iB		3	3		
							2.65		X				
A49520	WENDLING QUARRIES INC	BALDWIN	SW	28	TO84	R01E	2.66		X				
A49524	BELLEVUE S&G CO	GRIEBEL	SE	25	TO87	R04E	DWU	3B		4	4		
							2.67		X				
A49526	BELLEVUE S&G CO	BELLEVUE FARM	SE	25	TO87	R04E	DWU	3iB					
							DWU		X				
A49528	AGGREGATE MATERIALS CO	STEVENS	NW	02	TO84	R01E	2.65		X				
A49530	PRESTON READY MIX	PETERSON	SW	18	TO84	R07E	DWU	3iB		4	4		
							DWU		X				
A49532	WEBER STONE CO INC	IRON HILL	NE	16	TO85	R02E	2.65		X				
A49536	AGGREGATE MATLS-FLYNN	BELLEVUE SLOUGH	S2	30	TO87	R05E	DWU		X				
50	**JASPER DIST 1**	**CRUSHED STONE**											
A50002	MARTIN MARIETTA	SULLY MINE	SE	16	TO79	R17W	2.54	3i		4	4	36 - 41	D
		SAND & GRAVEL											
A50502	MARTIN MARIETTA	COLFAX	NE	01	TO79	R21W	2.66	2		3	3		
							2.67		X				
A50504	MARTIN MARIETTA	REASNOR	NE	10	TO78	R19W				4	4		
							2.66		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
51	**JEFFERSON DIST 5**	**CRUSHED STONE**											
A51006	WINN CORP	JEFFERSON	NE	09	TO71	R10W	DWU	3i					L, 1
										4	4	10 - 12	D
52	**JOHNSON DIST 6**	**CRUSHED STONE**											
A52002	WENDLING QUARRIES INC	FOUR CO	NW	04	TO81	R08W							
A52004	RIVER PRODUCTS CO	CONKLIN	NW	33	TO80	R06W	2.66	3iB		4	4	2 - 10	L
							DWU	3i		5	5	23 - 24	L, 2
										5	5	2 - 5	L
										4	4	6 - 10	L
										4	4	21	L
										5	5	21 - 22	L
A52006	RIVER PRODUCTS CO	KLEIN	NW	02	TO79	R07W	2.66	3iB		4	4	2 - 10	L
							DWU	3i		5	5	23 - 24	L, 2
										5	5	2 - 5	L
										4	4	6 - 10	L
										4	4	21	L
										5	5	21 - 22	L
A52008	RIVER PRODUCTS CO	ERNST	SW	20	TO80	R05W							
		SAND & GRAVEL											
A52502	S&G MATERIALS INC	SHOWERS	NE	27	TO79	R06W				4	4		
							2.65		X				
A52506	S&G MATERIALS INC	BUTLER	SW	33	TO79	R06W	DWU		X				
A52508	S&G MATERIALS INC	WILLIAMS	NW	34	TO79	R06W				3	3		
							DWU		X				
A52510	RIVER PRODUCTS CO	RIVERSIDE #2		34	TO78	R06W	DWU		X	4	4		
53	**JONES DIST 6**	**CRUSHED STONE**											
A53002	BARD CONCRETE CO	FARMERS-BEHRENDS	NE	14	TO86	R03W	2.64	3i		4	4	1 - 5	D
										4	4	5 - 7	D
A53004	WENDLING QUARRIES INC	MONTICELLO	NE	24	TO86	R04W	2.66	3i		4	4	1	D
A53006	WENDLING QUARRIES INC	ANAMOSA	SE	13	TO84	R04W	DWU	3i		4	4	1 - 5	D
										4	4	1 - 6	D
A53010	WENDLING QUARRIES INC	BALLOU-OLIN	NE	24	TO83	R03W	DWU	3iB		4	4	3	D
							DWU	3		4	4	2 - 3	D
										4	4	1 - 3	D
A53012	WENDLING QUARRIES INC	WYOMING		33	TO84	R01W	2.69	3iB		4	4	1 - 2C	D
A53014	WEBER STONE CO INC	JACOBS-SCOTCH GROVE	SW	07	TO85	R02W					5		
A53016	WEBER STONE CO INC	STONE CITY		5,6	TO84	R04W	2.45	3i		4	4	2B - 3	D
A53018	RIVER CITY STONE	FINN	NE	06	TO85	R01W	DWU	3i		4	4	2 - 5	D
A53024	RIVER CITY STONE	SULLIVAN	NW	14	TO86	R03W	DWU	3i		4	4	1 - 5	D
A53026	RIVER CITY STONE	ANAMOSA	SW	15	TO84	R04W							
		SAND & GRAVEL											
A53502	WENDLING QUARRIES INC	MONTICELLO	SE	07	TO86	R03W	2.66		X	4	4		
A53506	RIVER CITY STONE	FINN	N2	06	TO85	R01W	2.65		X	4	4		
A53508	WENDLING QUARRIES INC	ANAMOSA-VERNON	SW	13	TO84	R04W				4	4		
							2.66		X				
A53510	WENDLING QUARRIES INC	KNAPP	SE	27	TO84	R03W				4	4		
							2.65		X				
A53514	WENDLING QUARRIES INC	FLEMING	NE	12	TO83	R03W	2.66		X	4	4		
A53522	WEBER STONE CO INC	WEBER	SE,SW	05	TO84	R04W	2.66		X				
A53526	BARD CONCRETE CO	STEPHENS	NW	34	TO86	R03W	2.66		X	4	4		
A53528	WEBER STONE CO INC	ANAMOSA	NE	14	TO84	R04W	2.65		X				
A53530	RIVER CITY STONE	ANAMOSA-WOOD'S	CT	15	TO84	R04W	2.66		X	3	3		
A53532	BARD CONCRETE CO	LOES	NE	04	TO86	R01W	DWU		X				

NOTE 1: CEDAR FORK LEDGE
NOTE 2: 1.25 INCH MAXIMUM TOP SIZE

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
54	**KEOKUK DIST 5**	**CRUSHED STONE**											
A54002	DOUDS STONE LLC	KESWICK	NW	21	TO77	R12W	2.61	2		4	4	13 - 15	D, 1
										4	4	13 - 18	D
A54004	DOUDS STONE LLC	OLLIE	SW	01	TO74	R11W	2.66	3i		4	4	13 - 18	L
							2.57	3				27 - 29	1
										4	4	13 - 19	L
										4	4	27 - 30	L
										4	4	30 - 37	L
											5	31 - 33	
A54008	DOUDS STONE LLC	HARPER	SE	11	TO76	R11W				4	4	15 - 24	L
										4	4	32 - 37	L
										4	4	38 - 40	L
A54010	DOUDS STONE LLC	LYLE	NW	13	TO74	R13W	DWU	3		4	4	40	L
										4	4	36 - 38	L
										4	4	36 - 40	L
A54012	WINN CORP	KEOKUK COUNTY QUARRY	NW	21	TO74	R11W				5	5	1 - 5	L
		SAND & GRAVEL											
A54502	WINN S&G	WINN	SE	06	TO74	R10W	2.66		X				
55	**KOSSUTH DIST 2**	**SAND & GRAVEL**											
A55506	KOSSUTH COUNTY	WHITTEMORE	NW	16	TO95	R30W			H	4	4		
A55508	KOSSUTH COUNTY	IRVINGTON	NW	36	TO95	R29W			H		4		
A55518	REDING GRAVEL&EXCAVATING	REDING		02	TO94	R29W			H				
A55548	MARTIN MARIETTA	BORMANN SAND	NE	36	TO94	R29W			H				
56	**LEE DIST 5**	**CRUSHED STONE**											
A56002	CESSFORD CONST CO	HAWKEYE	NE	10	TO68	R06W					5	1 - 21	
										5	5	1 - 27	L
										4	4	22 - 27	L
A56006	CESSFORD CONST CO	ARGYLE	SE	18	TO66	R06W				4	4	1 - 17	L
											5	4 - 12	
										4	4	13 - 17	D
A56008	CESSFORD CONST CO	DONNELLSON	SE	05	TO67	R06W				4	4	10 - 15	L
A56012	CESSFORD CONST CO	VINCENNES	NW	19	TO66	R06W							
A56014	CESSFORD CONST CO	BEACH		24	TO69	R06W							
A56016	GREAT RIVER MATERIALS LLC	HERITAGE		26	TO69	R04W	DWU	2		4	4	9 - 11	L
										4	4	9 - 10	L
											4	6 - 8	2
A56018	CESSFORD CONST CO	OMG CESSFORD AUGUSTA	NW	25	TO69	R04W							
A56020	PNB PROCESSORS LLC	PNB PROCESSORS AUGUSTA	NW	25	TO69	R04W							
A56022	CESSFORD CONST CO	VINCENNES SAND PIT QUARRY	SE	32	TO66	R06W							
		SAND & GRAVEL											
A56504	CESSFORD CONST CO	VINCENNES	SE	32	TO66	R06W				4	4		
							2.67		X				
A56506	BROCKMAN SAND CO	FORT MADISON	SW	11	TO67	R05W				4	4		
							2.67		X				
A56508	SHIPLEY CONTRACTING CORP	LEE COUNTY S&G	SE	11	TO67	R05W	DWU		X				

NOTE 1: 1.25 INCH MAXIMUM TOP SIZE
NOTE 2: TOP 6' REMOVED

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
57	**LINN DIST 6**	**CRUSHED STONE**											
A57002	WENDLING QUARRIES INC	BETENBENDER-COGGON	SW	03	TO86	R06W	DWU	3i		4	4	8 - 9	D
							DWU	2		4	4	8 - 10	D
A57004	WENDLING QUARRIES INC	PLOWER	SE	36	TO86	R06W	2.62	3		4	4	9 - 11	D
										4	4	1 - 10	D
A57006	WENDLING QUARRIES INC	ROBINS	NE	21	TO84	R07W	2.57	3i		4	4	3	L, 1
A57008	WENDLING QUARRIES INC	BOWSER-SPRINGVILLE	SW	29	TO84	R05W	DWU	3i		4	4	6 - 7	D
							DWU	3i		4	4	8 - 9	D
										4	4	1 - 4	D
A57010	WENDLING QUARRIES INC	TROY MILLS	SE	09	TO86	R07W							
A57014	WENDLING QUARRIES INC	SWEETING	NW	18	TO85	R08W					4		
A57016	WENDLING QUARRIES INC	ALICE	NW	08	TO85	R07W					4		
A57018	MARTIN MARIETTA	CEDAR RAPIDS	NE	15	TO82	R06W	2.64	3i		4	4	2 - 9	D, 1
										4	4	2 - 14	D
A57022	CRAWFORD QUARRY CO	LEE CRAWFORD	NW	23	TO83	R08W	2.55	2		4	4	8	L
A57026	NIEMANN CONST CO	COOK	NW	10	TO86	R07W							
A57028	WENDLING QUARRIES INC	BEVERLY	NW	07	TO82	R07W	DWU	3i		4	4	6 - 7	D
A57030	CJ MOYNA & SONS	HENNESSEY	NE	01	TO82	R07W	DWU	3i		4	4	4 - 5	D
		SAND & GRAVEL											
A57502	WENDLING QUARRIES INC	SWEETING	NE	18	TO85	R08W				4	4		
							2.64		X				
A57506	WENDLING QUARRIES INC	CEDAR RAPIDS	NE	27	TO84	R08W				4	4		
							2.65		X				
A57508	WENDLING QUARRIES INC	EAST MARION	NE	36	TO84	R06W				3	3		
							2.65		X				
A57520	WENDLING QUARRIES INC	IVANHOE	NW	29	TO82	R05W				4	4		
							2.66		X				
A57522	WENDLING QUARRIES INC	CENTRAL CITY	NE	10	TO85	R06W				4	4		
							2.65		X				
A57524	WENDLING QUARRIES INC	COGGON	NW	11	TO86	R06W				4	4		
							2.65		X				
A57526	WENDLING QUARRIES INC	TROY MILLS	SE	09	TO86	R07W	2.65		X				
A57528	WENDLING QUARRIES INC	BLAIRSFERRY SAND	SW	26	TO84	R08W	DWU	2		3	3		
							2.65		X				
A57530	WENDLING QUARRIES INC	HESS	SW	04	TO82	R06W	DWU		X				
A57532	CROELL READY MIX	PALO	NE	21	TO84	R08W	DWU		X				
A57534	MARTIN MARIETTA	LINN COUNTY SAND	NE	05	TO82	R06W	DWU		X				
A57536	CROELL READY MIX	POWER PLANT PIT		16	TO84	R08W	DWU		X				
58	**LOUISA DIST 5**	**CRUSHED STONE**											
A58002	RIVER PRODUCTS CO	COLUMBUS JUNCTION	NW	03	TO74	R05W	2.55	3		4	4	16 - 19	D, 2
										4	4	15 - 19	D
										4	4	19 - 21	D
		SAND & GRAVEL											
A58504	RIVER PRODUCTS CO	FREDONIA A INLAND	SW	17	TO75	R04W				4	4		
		PUMPING					2.66		X				
		FREDONIA B RIVER	SW	17	TO75	R04W				4	4		
		PUMPING					2.66		X				

NOTE 1: 1.25 INCH MAXIMUM TOP SIZE
NOTE 2: AASHTO 57 GRADATION MAXIMUM

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
60	**LYON** DIST 3	**SAND & GRAVEL**											
A60502	PETTENGILL CONC & GRAVEL	ROCK RAPIDS #1	NW	33	T100	R45W	2.69	2		3	3		
							2.67		X				
A60504	PETTENGILL CONC & GRAVEL	ROCK RAPIDS #2	NE	09	TO99	R45W			H	3	3		
A60510	HALLETT MATERIALS CO	OLSON	NW	21	T099	R48W			H	3	3		
A60518	VALLEY SAND AND GRAVEL	OPEN	NW	17	TO99	R48W			H	4	4		
A60530	DUININCK BROS	KOOIKER		28	TO99	R45WH			H				
A60534	DUININCK BROS	EGEBO		16	TO99	R48W			H	3	3		
A60540	SOUTHERN MN CONST CO INC	KANANGEITER	SE	04	TO99	R43W			H				
A60542	KRUSE PAVING	EBEN	NW	17	TO99	R43W			H				
A60544	DAKOTA ROAD BUILDERS INC	ORVE	NE	24	T100	R49W			H				
A60546	HALLETT MATERIALS CO	VANDERBRINK	NW	07	TO98	R45W			H	3	3		
A60548	HALLETT MATERIALS CO	O'CONNER	NW	16	TO99	R48W			H	3	3		
A60550	HALLETT MATERIALS CO	DENGLER	SW	33	TO99	R45W			H				
61	**MADISON** DIST 4	**CRUSHED STONE**											
A61002	SCHILDBERG CONST CO INC	EARLY CHAPEL-DAGGETT	SW	03	TO76	R29W				5	5	15A-15C	L
											5	12	
											4	14B	
A61006	SCHILDBERG CONST CO INC	92 QUARRY	SW	05	TO75	R29W				5	5	15	
A61012	MARTIN MARIETTA	WINTERSET NORTH	SE	27	TO76	R27W					5	25	
A61013	SCHILDBERG CONST CO INC	WINTERSET WEST	SW	28	TO76	R27W					5	25E	
A61016	PERU QUARRY, INC	PERU	NE	27	TO75	R27W							
A61024	MARTIN MARIETTA	PENN-DIXIE	SW	32	TO76	R27W					5	25	
A61026	MARTIN MARIETTA	EARLHAM-MASON	SW	16	TO77	R28W					4	20	
											5	25	
A61032	MARTIN MARIETTA	EARLHAM-THRAILKILL	NE	08	TO77	R28W					4	20	
											5	25	
A61036	SCHILDBERG CONST CO INC	MONARCH CEMENT OF IOWA	NE	08	TO77	R28W					5	25B-25E	
62	**MAHASKA** DIST 5	**SAND & GRAVEL**											
A62502	SKYLINE CONST CO	G71	SW	15	TO74	R16W	2.67		X				
63	**MARION** DIST 5	**CRUSHED STONE**											
A63002	MARTIN MARIETTA	DURHAM MINE	NE	08	TO75	R18W	2.50	3i		4	4	101	L
							2.59	2		4	4	88 - 95	L
										4	4	95 - 96	L, 1
A63010	BRUENING ROCK PROD INC	S&S	SE	25	TO75	R20W	DWU	3		4	4	31A- 32D	L
											4		
		SAND & GRAVEL											
A63502	PELLA CONST CO LTD	BEAN PROPERTY	NE	02	TO75	R18W				4	4		
							2.67		X				
A63512	MARTIN MARIETTA	NEW HARVEY		11,12	TO75	R18W	DWU	3					
							2.67		X				

NOTE 1: BOTTOM 5.0' ONLY OF BED 95

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
64	**MARSHALL DIST 1**	**CRUSHED STONE**											
A64002	MARTIN MARIETTA	FERGUSON	SW	05	TO82	R17W	2.65	3i		4	4	10 - 21	L
							2.66	3		4	4	10 - 17	L
							DWU	2		4	4	8 - 17	L
							2.66	2		4	4	8 - 21	L
							DWU	2		4	4	2 - 17	L
										4	4	1 - 18	L
A64004	CESSFORD CONST CO	LE GRAND	SW	36	TO84	R17W	2.58	3i		5	5	1 - 7	L
							DWU	2		4	4	19B- 31	L
							DWU	2				8	L
										4	4	8 - 19A	L
										4	4	19B- 32	L
		SAND & GRAVEL											
A64502	MARTIN MARIETTA	MARSHALLTOWN	SW	29	TO84	R17W	2.65	2		4	4		
							2.65		X				
A64506	STRATFORD GRAVEL INC	BEACH	NW	09	TO85	R20W			H				
65	**MILLS DIST 4**	**CRUSHED STONE**											
A65006	SCHILDBERG CONST CO INC	MALVERN	NW SE	31	TO72	R41W							
66	**MITCHELL DIST 2**	**CRUSHED STONE**											
A66002	FALK CONST CO	DUENOW	SE	08	TO99	R17W	2.77	3iB		4	4	5	D
								3		5	5	13	L
										4	4	4	
										5	5	6 - 8	L
										4	4	9 - 10	D
A66016	FALK CONST CO	LESCH	SW	12	TO97	R17W	DWU	3i		5	5	6 - 7	L
										5	5	1 - 8	L
										4	4	9 - 14	L
A66020	FALK CONST CO	ASPEL	NE	03	TO99	R15W							
A66022	FALK CONST CO	WAGNER	NW	29	TO98	R16W				4	4	5B - 7	D
A66024	FALK CONST CO	GRUNDEL		07	TO98	R18W							
A66026	CROELL REDI-MIX	KOSTER	NE	35	TO99	R18W							
A66028	ULLAND BROS CONST	WINTERS	SW	23	TO99	R16W							
		SAND & GRAVEL											
A66502	FALK CONST CO	OSAGE-SCHMIDT	NW	01	TO97	R17W				4	4		
							2.63		X				
A66512	FALK CONST CO	KLAAHSEN	SW	36	TO99	R18W	2.66		X				
A66514	FALK CONST CO	LOVIK	SE SW	12	TO97	R17W	2.65		X				
A66516	CROELL REDI MIX	BOERJAN	W2	01	TO98	R18W	2.64		X				
A66518	FALK CONST CO	KITTLESON	NW	36	TO99	R18W			H				
A66520	FALK CONST CO	LESCH		12	TO97	R17W	DWU		X				
67	**MONONA DIST 3**	**SAND & GRAVEL**											
A67502	HALLETT MATERIALS CO	RODNEY		02	TO85	R44W	DWU	2		3	3		
							DWU		X				
68	**MONROE DIST 5**	**CRUSHED STONE**											
A68004	DOUDS STONE LLC	EDDYVILLE SOUTH	SW	02	TO73	R16W				4	4	6 - 7	L
69	**MONTGOMERY DIST 4**	**CRUSHED STONE**											
A69002	SCHILDBERG CONST CO INC	STENNETT	NE	27	TO73	R38W					4	16 - 17	
		SAND & GRAVEL											
A69504	WESTERN ENGINEERING	ELLIOT		13	TO73	R38W			H	4	4		

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
70	**MUSCATINE DIST 6**	**CRUSHED STONE**											
A70002	WENDLING QUARRIES INC	MOSCOW	NW	08	TO78	R02W	2.66	3i		5	5	11 - 17	L
							DWU	3iB		4	4	21A-21B	D
							2.67	3iB		4	4	21A- 24	D
							DWU	3iB		4	4	21C- 24	D
										5	5	8 - 17	L
											5	1 - 9	
A70006	TUBE CITY IMS CORP	WILTON	SE	02	TO78	R02W				2	2		
A70008	BLACKHEART SLAG	MONTPELIER	SE	11	TO77	R01E				2	2		
		SAND & GRAVEL											
A70504	WENDLING QUARRIES INC	ATALISSA-MCKILLIP	NW	20	TO78	R02W				4	4		
							2.66		X				
A70506	ACME FUEL AND MATERIALS	ACME	SE	22	TO76	R02W	2.65		X				
A70508	HAHN S&G	HAHN	SE	16	TO76	R02W			H				
71	**O'BRIEN DIST 3**	**SAND & GRAVEL**											
A71504	HALLETT MATERIALS CO	RABE PAULLINA	SW	15	TO94	R41W				4	4		
							DWU		X				
A71528	O'BRIEN COUNTY	COUNTY	NW	27	TO95	R39W			H	4	4		
A71530	HALLETT MATERIALS CO	ROHLIN		14	TO97	R42W			H	4	4		
A71532	KNIFE RIVER MIDWEST LLC	DOUMA	SE	05	TO96	R41W			H				
A71534	HALLETT MATERIALS CO	SHELDON / KLEINWALTERINK	CT	16	TO97	R42W			H				
A71536	DAVE'S S&G	PHLOW CREEK		25	TO97	R39W	DWU		X				
72	**OSCEOLA DIST 3**	**SAND & GRAVEL**											
A72504	NORTHWEST R/M CONC INC	OCHEYEDAN	SE 15 SW	14	TO99	R40W	2.71	2		3	3		
							2.68		X				
A72506	HALLETT MATERIALS CO	ASHTON	SW	28	TO98	R42W	2.69	2					
							2.69		X				
A72520	NORTHWEST R/M CONC INC	OCHEYEDAN NORTH	NE	23	TO99	R40W			H	4	4		
A72522	HIGMAN SAND & GRAVEL	KAPPES	NE	11	TO98	R42W	DWU	2					
							DWU		X				
A72524	STRATFORD GRAVEL INC	BOERHAVE	SE	21	TO98	R42W	DWU		X				
A72528	STRATFORD GRAVEL INC	DIRKS	SW	36	TO99	R40W			H				
A72530	NORTHWEST R/M CONC INC	BOYD	NW	36	TO99	R40W	2.65	2		3	3		
							2.66		X				
A72532	HALLETT MATERIALS CO	OCHEYEDAN/PEDLEY	NW	23	TO99	R40W	DWU		X				
A72534	HALLETT MATERIALS CO	ASHTON-SEIVERT		28	TO98	R42W	DWU	3		3	3		
							DWU		X				
A72536	NORTHWEST R/M CONC INC	HARTWIG	NE	16	TO99	R40W			H				
73	**PAGE DIST 4**	**CRUSHED STONE**											
A73004	SCHILDBERG CONST CO INC	SHAMBAUGH	SW	20	TO67	R36W				4	4	4 - 6	L
		SAND & GRAVEL											
A73508	HALLETT MATERIALS CO	SHENANDOAH-CONNELL II	NE	07	TO69	R39W	DWU	2					
							2.63		X				
74	**PALO ALTO DIST 3**	**SAND & GRAVEL**											
A74502	HALLETT MATERIALS CO	EMMETSBURG S&G		36	TO96	R33W	2.71	2		3	3		
							2.64		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION	BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
75	**PLYMOUTH DIST 3**	**SAND & GRAVEL**								
A75502	HIGMAN SAND & GRAVEL	AKRON	NW 01 TO92 R49W	2.70	2		3	3		
				2.65		X				
A75503	LG EVERIST INC	AKRON	NE 01 TO92 R49W	2.69	2		3	3		
				2.67		X				
A75514	WALKERS EXCAVATING CO	OYENS	05 TO92 R44W			H	3	3		
A75516	HALLETT MATERIALS CO	BRUNSVILLE	03 TO92 R46W			H	4	4		
A75518	HALLETT MATERIALS CO	HINTON	NW 16 TO90 R46W	DWU	3	H	3	3		
A75520	HALLETT MATERIALS CO	MERRILL	02 TO91 R46W			H	4	4		
A75524	L&M SAND & GRAVEL INC	G DIRKSEN #2	31 TO93 R44W	2.65		X				
A75526	L&M SAND & GRAVEL INC	FRITZ DIRKSEN	05 TO92 R44W	DWU		X				
A75528	HIGMAN SAND & GRAVEL	LEMARS	04 TO92 R45W	DWU		X				
76	**POCAHONTAS DIST 3**	**CRUSHED STONE**								
A76004	MARTIN MARIETTA	MOORE	NE 36 SW 25 TO92 R31W	2.65	3iB		5	5	1A - 3	L
							4	4	3	L
							5	5	1B - 3	L
							4	4	4 - 10	L, 1
							5	5	4 - 12	L
		SAND & GRAVEL								
A76512	MARTIN MARIETTA	LIZARD CREEK	13 TO90 R31W			H	4	4		
A76514	BLACKTOP SERVICES	MILLER	12 TO93 R31W				4	4		
				DWU		X				
77	**POLK DIST 1**	**SAND & GRAVEL**								
A77504	HALLETT MATERIALS CO	DENNY-JOHNSTON	08 TO79 R24W	2.71	2		3	3		
				2.67		X				
A77522	HALLETT MATERIALS CO	EDM #2-VANDALIA	NE 07 NW 08 TO78 R23W	2.69	2		3	3		
				2.65		X				
A77528	HALLETT MATERIALS	PLEASANT HILL	08 TO78 R23W	2.68	2		3	3		
				2.65		X				
A77530	HALLETT MATERIALS CO	NORTH DES MOINES	NE 16 TO79 R24W	2.65	2					
				2.66		X				
A77532	LOUNSBURY S&G	WEST DES MOINES	30 TO78 R25W			H				
A77534	MARTIN MARIETTA	SAYLORVILLE SAND	09 TO79 R24W	DWU	2		3	3		
				2.66		X				
78	**POTTAWATTAMIE DIST 4**	**CRUSHED STONE**								
A78002	SCHILDBERG CONST CO INC	CRESCENT	SW 26 TO76 R44W				4	4	25B-25C	L
							5	5	25B-25E	L
							5	5	25D-25E	L
								4	26A-26E	
A78006	SCHILDBERG CONST CO INC	MACEDONIA-K&S	NE 28 TO74 R40W					4		
		SAND & GRAVEL								
A78504	WESTERN ENGINEERING	OAKLAND	SW 23 TO75 R40W	2.65	3		4	4		
				2.65		X				
A78506	SCHILDBERG CONST CO INC	CRESCENT	NE 34 TO76 R44W			H	4	4		

NOTE 1: TYPE A HMA MUST BE THE END PRODUCT FROM CRUSHING +2“ MATERIAL FROM BEDS 4-10.

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
79	**POWESHIEK DIST 1**	**CRUSHED STONE**											
A79002	MARTIN MARIETTA	MALCOM MINE	SE	04	TO80	R15W	2.58	2		4	4	10C-13	L
										4	4	14 - 15	L
80	**RINGGOLD DIST 4**	**CRUSHED STONE**											
A80002	SCHILDBERG CONST CO INC	WATTERSON	SE	19	TO67	R29W					5	7	
81	**SAC DIST 3**	**SAND & GRAVEL**											
A81502	HALLETT MATERIALS CO	SACTON-LAKEVIEW	S2	08	TO86	R36W	2.72	3		3	3		
							2.67		X				
A81504	HALLETT MATERIALS CO	AUBURN	NW	02	TO86	R35W	2.68	2		3	3		
							2.64		X				
A81506	HALLETT MATERIALS CO	SAC CITY	NW	36	TO88	R36W				4	4		
							DWU		X				
A81508	LAKE VIEW CONCRETE PROD	LAKEVIEW	SE	05	TO86	R36W			H	4	4		
A81514	TIEFENTHALER INC	CARNARVON S&G	NE	16	TO86	R36W	2.68	2		3	3		
							2.66		X				
A81520	STRATFORD GRAVEL INC	UREN	SE	11	TO87	R36W				3	3		
							2.67		X				
A81522	HALLETT MATERIALS CO	ULMER	SW	28	TO87	R35W			H	4	4		
A81524	KNIFE RIVER MIDWEST LLC	NO NAME	SE	04	TO87	R37W			H	4	4		
A81528	HALLETT MATERIALS CO	WALL LAKE	NW	18	TO86	R36W	2.70	3					
							2.67		X				
A81530	HALLETT MATERIALS CO	LEITZ NORTH	SE	29	TO87	R35W	DWU		X				
A81532	HIGMAN SAND & GRAVEL	EARLY-THORPE		22	TO89	R37W	DWU	2		4	4		
							2.66		X				
A81534	HALLETT MATERIALS CO	EARLY	SE	22	TO89	R37W			H				
A81536	TIEFENTHALER INC	DAIKER	NE	12	TO86	R35W	DWU		X				
A81538	BEDROCK GRAVEL CO	HEIM	SE	12	TO86	R35W			H				
A81540	TIEFENTHALER INC	COLBURN		13	TO87	R35W			H				
A81542	HALLETT MATERIALS CO	WALL LAKE BOYER		13	TO86	R37W	DWU	2	X				
A81544	HALLETT MATERIALS CO	ULMER-MEISTER	SE SE	28	TO87	R35W	DWU	2	X				
A81546	HIGMAN SAND & GRAVEL	MEISTER	SE	07	TO86	R36W	DWU	3	X				
A81548	STRATFORD GRAVEL INC	PHILLIPS	NW	23	T87N	R36W			H				
82	**SCOTT DIST 6**	**CRUSHED STONE**											
A82002	RIVERSTONE GROUP INC	MCCAUSLAND (MC 39)	W2	17	TO80	R04E	DWU	3i		4	4	17 - 19	D, 1
							DWU	3		4	4	1 - 16	D, 1
A82004	RIVERSTONE GROUP INC	NEW LIBERTY (MC 41)	NE	33	TO80	R01E	DWU	3iB		4	4	1 - 2	D, 1
							DWU	3i		4	4	3 - 4	D
A82006	RIVERSTONE GROUP INC	LECLAIRE (MC 38)	NW	35	TO79	R05E	2.71	3i		4	4	14 - 29	D
							DWU	3i		4	4	28 - 29	D
							DWU	3i		4	4	30	D
							DWU	3		4	4	2 - 13	D
										4	4	1 - 28	D
A82008	LINWOOD MINING & MINERALS	LINWOOD MINE	SW	13	TO77	R02E	2.67	3i		5	5	20 - 25	L
							2.69	3i		5	5	27 - 30B	L
							DWU	3i		4	4	33 - 41	D
							DWU	3		5	5	19	L
										4	4	24 - 25	L
		SAND & GRAVEL											
A82502	RIVERSTONE GROUP INC	MCCAUSLAND (MC 43)	SW	17	TO80	R05E	2.66		X	4	4		
83	**SHELBY DIST 4**	**SAND & GRAVEL**											
A83506	HALLETT MATERIALS CO	HARLAN-REINIG	NW	30	TO79	R38W	2.65	3i					
							2.65		X				
A83508	BEDROCK GRAVEL CO	JACKSONVILLE		12	TO79	R37W			H				

NOTE 1: 1.25-INCH MAXIMUM TOP SIZE

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION					BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
84	**SIOUX DIST 3**	**SAND & GRAVEL**												
A84502	VALLEY SAND AND GRAVEL	VANZEE		NW	20	TO97	R46W	2.69	2		3	3		
								2.67		X				
A84506	HALLETT MATERIALS CO	HUDSON-OSTERCAMP		SE	07	TO96	R47W				3	3		
								2.69		X				
A84510	LG EVERIST INC	HAWARDEN-NORTH	S2	NW	22	TO95	R48W	2.67	3i		3	3		
								2.67		X				
A84518	STRATFORD GRAVEL INC	VON ARB		SE	15	TO94	R44W			H	4	4		
A84520	COUNTY PIT	CHATSWORTH		SW	28	TO94	R48W			H	4	4		
A84522	HALLETT MATERIALS CO	HYMAN		SW	31	TO96	R47W			H	3	3		
A84524	VALLEY SAND AND GRAVEL	GROTH		NW	36	TO97	R48W			H	3	3		
A84526	HIGMAN S&G	JONAS		NE	36	TO94	R44W				4	4		
								DWU		X				
A84528	HIGMAN S&G	HIGMAN-CHATSWORTH		W2	28	TO94	R48W	2.69	2		4	4		
								DWU		X				
A84530	VALLEY SAND AND GRAVEL	GROENWEG		NW	15	TO97	R46W	DWU	2		3	3		
								DWU		X				
A84532	STRATFORD GRAVEL INC	LASSON			32	TO94	R44W	DWU	2		3	3		
								DWU		X				
A84534	STRATFORD GRAVEL INC	CLEVERINGA		SE	25	TO95	R44W			H	3	3		
85	**STORY DIST 1**	**CRUSHED STONE**												
A85006	MARTIN MARIETTA	AMES MINE		SW	24	TO84	R24W				4	4	28 - 39	L
								2.68	3iB		5	5	47	L
								DWU	3iB		4	4	49 - 50	L
		SAND & GRAVEL												
A85510	HALLETT MATERIALS CO	AMES SOUTH			18	TO83	R23W	2.66	2		3	3		
								2.65		X				
86	**TAMA DIST 1**	**CRUSHED STONE**												
A86002	WENDLING QUARRIES INC	MONTOUR		NW	09	TO83	R16W	2.61	3i		5	5	1 - 7	L
								2.63	3i		4	4	13 - 20	L
											4	4	8 - 12	L
		SAND & GRAVEL												
A86502	MANATT'S INC	FLINT		NW	03	TO82	R15W				3	3		
								2.65		X				
88	**UNION DIST 4**	**CRUSHED STONE**												
A88002	SCHILDBERG CONST CO INC	THAYER		SE	35	TO72	R28W					5	25A-25E	
												5	25E	

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
89	**VAN BUREN DIST 5**	**CRUSHED STONE**											
A89002	DOUDS STONE LLC	DOUDS MINE	SE	25	TO70	R11W	2.46	2		4	4	6 - 13	D
A89006	CESSFORD CONST CO	FARMINGTON-COMANCHE	NE	05	TO67	R08W	2.69	3i		5	5	3	L
							2.52	2		4	4	16 - 17	L
											4	18 - 22	
										5	5	5 - 12	L
A89008	DOUDS STONE LLC	SELMA-GARDNER	NW	16	TO70	R11W	2.69	3		4	4	11	L
										5	5	7 - 10	L
										5	5	7 - 11	L
										4	4	14 - 21	L
										4	4	22 - 31	L
										4	4	14 - 31	L
90	**WAPELLO DIST 5**	**SAND & GRAVEL**											
A90506	WINN CORP	WAPELLO CO SAND & ROCK		5,6	TO71	R13W				3	3		
							2.66		X				
A90508	GEOTECH MATERIALS	STEVENSON	SE SE	30	TO71	R12W			H				
A90510	DOUDS STONE LLC	CHILLICOTHE		31	TO73	R14W	DWU		X				
92	**WASHINGTON DIST 5**	**CRUSHED STONE**											
A92002	DOUDS STONE LLC	WEST CHESTER	NE	19	TO76	R08W	2.64	3i		4	4	5 - 7	L
							DWU	3		4	4	14 - 16	L
A92006	DOUDS STONE LLC	COPPOCK	NE	30	TO74	R07W				5	5	3 - 4	L
A92008	RIVER PRODUCTS CO	PEPPER-KEOTA FIELD	SW	31	TO76	R09W							
A92014	DOUDS STONE LLC	COPPOCK NORTH	SE	19	TO74	R07W				4	4	6 - 8	L
		SAND & GRAVEL											
A92502	RIVER PRODUCTS CO	RIVERSIDE	NE	10	TO77	R06W				4	4		
							2.65		X				
94	**WEBSTER DIST 1**	**CRUSHED STONE**											
A94002	MARTIN MARIETTA	FT DODGE MINE	SW	24	TO89	R29W	2.62	3iB		4	4	36 - 42	L
A94008	STRATFORD GRAVEL INC	BUSKE	SE	36	TO90	R29W				5	5	1 - 11	L
		SAND & GRAVEL											
A94502	NORTHWEST MATERIALS	YATES	SW	01	TO89	R29W				4	4		
							2.63		X				
A94522	AUTOMATED S&G	CROFT	NW	14	TO89	R29W	2.65		X				
A94526	STRATFORD GRAVEL INC	BUSKE	SE	36	TO90	R29W				3	3		
							2.67		X				
A94528	STRATFORD GRAVEL INC	CONDON	NW	19	TO90	R30W			H				
A94530	AUTOMATED S&G	RASCH		10	TO89	R29W			H				
A94532	STRATFORD GRAVEL INC	REIGELSBERGER	NE	01	TO89	R29W	2.67		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
96	**WINNESHIEK DIST 2**	**CRUSHED STONE**											
A96002	SKYLINE MATERIALS LTD	KENDALLVILLE	NE	33	T100	R10W	2.68	3B		4	4	3 - 7	L
											4	1 - 7	
A96003	WILTGEN CONST CO	BROWN	NW	08	TO99	R10W							
A96004	SKYLINE MATERIALS LTD	HOVEY	SW	28	TO98	R08W	2.64	3B		4	4	1 - 4	L
										4	4	1 - 6	L
A96005	BRUENING ROCK PROD INC	MCGEE	NW	19	TO99	R10W							
A96007	WILTGEN CONST CO	JACKSON	NE	31	TO96	R10W							
A96011	BRUENING ROCK PROD INC	GJETLEY	NE	08	TO98	R07W	DWU	3iB		4	4	1 - 3	D
A96013	WILTGEN CONST CO	YOUNG	NE	05	TO98	R07W							
A96015	BRUENING ROCK PROD INC	MARTIN	SW	18	TO96	R09W							
A96017	BRUENING ROCK PROD INC	SKYLINE B	CT	10	TO98	R08W	2.63	3B		5	5	1 - 3	L
										4	4	4 - 8	L
										4	4	4 - 11	L
A96022	WILTGEN CONST CO	MADISON #2	NE	18	TO98	R08W					5		
A96040	SKYLINE MATERIALS LTD	LOCUST	NE	11	TO99	R08W							
A96046	BRUENING ROCK PROD INC	SERSLAND-SMORSTAD	SE	09	TO97	R07W							
A96048	NIEMANN CONST CO	LOVE #1	NW	30	TO96	R10W							
A96049	NIEMANN CONST CO	LOVE #2	SW	30	TO96	R10W				5	5	1 - 10	L
A96050	BRUENING ROCK PROD INC	BULLERMAN-FESTINA	SE	14	TO96	R09W					4	1 - 3	
A96052	SKYLINE MATERIALS LTD	ESTREM	SW	04	TO97	R07W	DWU	3i				2 - 4	L
										5	5	1 - 8	L
A96054	SKYLINE MATERIALS LTD	HORSESHOE BEND	SW	20	TO97	R09W							
A96060	SKYLINE MATERIALS LTD	BURR OAK	SE	23	T100	R09W				4	4		
A96064	RIVER CITY STONE	STIKA	NW	15	TO97	R10W	DWU	3i		4	4	1 - 4A	L
										4	4	1 - 8B	D
A96072	BRUENING ROCK PROD INC	MCKENNA NORTH	SW	34	T100	R09W							
A96074	WILTGEN CONST CO	OSSIAN	SW	21	TO96	R08W							
A96078	BRUENING ROCK PROD INC	BUSTA	NW	30	TO96	R10W							
A96082	WILTGEN CONST CO	CROW	SW	17	TO97	R10W							
A96084	WILTGEN CONST CO	YOUNG	SE	28	T100	R08W							
A96090	BRUENING ROCK PROD INC	MCKENNA SOUTH	SE	28	TO99	R09W	2.62	3iB		5	5	1 - 5	L
A96092	WILTGEN CONST CO	HANSON	SE	26	T100	R08W							
A96094	SKYLINE MATERIALS LTD	CAROLAN	SE	27	TO99	R09W							
		SAND & GRAVEL											
A96502	SKYLINE MATERIALS LTD	DECORAH	NE	22	TO98	R08W				4	4		
							2.63		X				
A96506	SKYLINE MATERIALS LTD	FREEPORT	NE	07	TO98	R07W	2.65		X				
A96520	SKYLINE MATERIALS LTD	SWEDES BOTTOM	NE	06	TO98	R08W				4	4		
							2.63		X				
A96522	BRUENING ROCK PROD INC	WOHLSEORS	NW	17	TO98	R10W			H				
A96526	RIVER CITY STONE	STIKA	NW	15	TO98	R08W			H				
A96528	BRUENING ROCK PROD INC	GJETLEY	NE	08	TO98	R07W	DWU		X	4	4		
A96530	SKYLINE MATERIALS LTD	CARLSON-FREEPORT	NE	13	TO98	R08W	2.63		X				
A96532	WILTGEN CONST CO	SCHMITT	NE	34	TO96	R09W				3	3		
							2.66		X				

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
97	**WOODBURY DIST 3**	**SAND & GRAVEL**											
A97502	HALLETT MATERIALS CO	CORRECTIONVILLE-BUCK	NW	13	TO89	R42W	DWU	3		3	3		
							DWU		X				
A97510	HALLETT MATERIALS CO	CORRECTIONVILLE-COCKBURN	SE	11	TO88	R43W				3	3		
A97514	HIGMAN S&G	SMITHLAND-PERSINGER	NW	25	TO86	R44W	DWU	2		3	3		
							DWU		X				
A97516	HALLETT MATERIALS CO	ANTHON		05	TO87	R43W	2.72	3		3	3		
							2.67		X				
A97518	HALLETT MATERIALS CO	SMITHLAND		35	TO86	R44W	2.69	3		3	3		
							2.67		X				
A97520	HALLETT MATERIALS CO	CORRECTIONVILLE-BREESIE		01	TO88	R43W			H	4	4		
A97526	FLEWELLING S&G	FLEWELLING	NW	10	TO89	R44W	2.67		X				
A97528	HALLETT MATERIALS CO	EDWARDS	SE	23	TO89	R42W	DWU		X				
A97530	NELSTAR	NELSTAR		14	TO88	R43W			H				
A97532	STRATFORD GRAVEL INC	CREASEY	SE	09	TO89	R44W	DWU		X				
A97534	HALLETT MATERIALS CO	ANTHON-TRUITT		05	TO87	R43W			H				
A97536	K & L CONSTRUCTION INC	ALEXSON	SE	28	TO88	R47W							1
98	**WORTH DIST 2**	**CRUSHED STONE**											
A98002	MARTIN MARIETTA	HARRIS	SW	29	T100	R20W	DWU	3i		4	4	10	L
							2.73	3B		4	4	6 - 7	L
							2.72	3		4	4	6 - 11	L
							2.72	2		4	4	2 - 11	L
										4	4	2 - 10	L
A98010	BMC AGGREGATES LC	FERTILE	SW	36	TO98	R22W	2.73	3B		4	4	15 - 20	D
							DWU	2		4	4	15 - 29	D
							DWU	2		4	4	22 - 29	D
											4	5 - 10	
										4	4	5 - 20	D
											4	5 - 14	
A98014	FALK CONST CO	STEVENS	NW	01	TO98	R20W	DWU	3		4	4	4 - 7	L
							2.77	3		4	4	8 - 11B	L
							2.73	3		4	4	4 - 11B	L
											5	1 - 3	
A98016	ULLAND BROS CONST	EMIL OLSON-BOLTON	SW	10	TO99	R20W	DWU	3i		5	5	1	L
							2.75	2		4	4	2 - 5A	L
										4	4	3 - 5B	D
										4	4	3 - 7	L
											5	1 - 7	
A98020	FALKSTONE	TRENHAILE	W2 NE	09	TO99	R20W	DWU	3		5	5	1	L
							DWU	2		4	4	2A - 2B	D
		SAND & GRAVEL											
A98502	FALKSTONE	RANDALL TRANSIT MIX	NW	31	T100	R20W	DWU	2		4	4		
							2.66		X				
A98504	BMC AGGREGATES LC	FERTILE	NW	36	TO98	R22W				3	3		
							2.63		X				
A98518	FALK CONST CO	COOPER	NE	12	TO98	R20W			H		4		
A98522	ULLAND BROS CONST	EMIL OLSON-BOLTON	SW	10	TO99	R20W			H				
A98524	FALKSTONE	TRENHAILE	W2 NE	09	TO99	R20W	2.64		X				
A98526	FALK CONST CO	MOUW	SE	31	T100	R20W			H				

NOTE 1: GRANULAR BACKFILL ONLY

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR		SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
99	**WRIGHT**	**DIST 2**	**CRUSHED STONE**											
A99002	MARTIN MARIETTA		VOSS		36	TO90	R26W	2.59	3i		4	4	8	L
												5	3 - 7	
			SAND & GRAVEL											
A99502	WRIGHT MATERIALS		WRIGHT	NW	12	TO93	R24W	2.65	3		3	3		
								2.63		X				
A99506	STRATFORD GRAVEL INC		LESHER	SE	26	TO90	R26W			H				
A99510	STRATFORD GRAVEL INC		MEINEKE	NE	14	TO90	R23W				4	4		
								2.65		X				
A99514	MARTIN MARIETTA		VOSS		36	TO90	R26W			H				
A99518	KNIFE RIVER MIDWEST LLC		REICHTER	SE	06	TO92	R26W			H				
A99520	KNIFE RIVER MIDWEST LLC		DENNIS PETERSON	NE	15	TO90	R23W			H				
A99522	STRATFORD GRAVEL INC		LOUX	SW	10	TO91	R23W			H				
A99524	WRIGHT MATERIALS		STECHER		13	TO93	R23W	2.63		X				
IL	**ILLINOIS**	**DIST 5**	**CRUSHED STONE**											
AIL002	CESSFORD CONST CO		BIGGSVILLE, HENDERSON CO		17	TO10	R04W				4	4		
AIL014	CESSFORD CONST CO		DALLAS CITY, HENDERSON CO	SW	36	TO08	R07W	DWU	3i		4	4	5A - 6	L, 1
											4	4	2 - 3	L
											5	5	8 - 10	L
AIL020	GRAY QUARRIES/W L MILLER		HAMILTON, HANCOCK CO	NE	31	TO05	R08W	2.65	3		4	4	2	L, 1
								DWU	3		4	4	4	L
								DWU	2		5	5	7	L
AIL040	COOTS MATERIALS CO INC		MONMOUTH, WARREN CO	NW	06	TO11	R02W							
AIL046	BLUFF CITY MINERALS LLC		BLUFF CITY MINERALS, MADISON CO		11	TO05	R10W	DWU	2				1 - 7	L
		DIST 5	**SAND & GRAVEL**											
AIL526	BLUFF CITY MINERALS LLC		BLUFF CITY SAND, MADISON CO		14	TO05	R10W	2.64		X				
		DIST 6	**CRUSHED STONE**											
AIL006	RIVERSTONE GROUP INC		MIDWAY (MC 45), ROCK ISLAND CO	SW	16	TO18	R02E	DWU	3iB		4	4	1 - 5	D
								DWU	3i				6	
AIL010	RIVERSTONE GROUP INC		ALLIED (MC 30), ROCK ISLAND CO		14	TO17	R02W	DWU	3i		4	4	18	D
								2.72	3i		4	4	16 - 18	D
								2.69	3		5	5	7 - 13	L
AIL012	MATERIAL SERVICES		OTTAWA-LIGHTWEIGHT								4	4		
AIL016	RIVERSTONE GROUP INC		CLEVELAND (MC 31), HENRY CO	SW	31	TO17	R02E	DWU	3i		4	4		D
AIL028	WENDLING QUARRIES INC		TURNBAUGH-MT CARROLL, IL	SW	10	TO24	R04E	DWU	3		4	4	3 - 7	D
AIL042	SAVANNA QUARRY INC		SAVANNA, CARROLL IL	SE	13	TO24	R03E							
AIL044	NW ILLINOIS CONST LLC		GAP GROVE, LEE IL		28	TO22	R08E							
		DIST 6	**SAND & GRAVEL**											
AIL502	RIVERSTONE GROUP INC		ALBANY (MC@511), ROCK IS CO	SW	34	TO20	R02E	2.65	3i		3	3		
								2.67		X				
AIL504	RIVERSTONE GROUP INC		BIG ISLAND (MC 51), ROCK IS CO		16	TO17	R02W	2.67	3		3	3		
								2.67		X				
AIL508	RIVERSTONE GROUP INC		BARSTOW (MC 52), ROCK IS CO	NE	34	TO18	R01E			H	4	4		
AIL510	NELSON S&G CO		WHITESIDE COUNTY-SAND	SW	29	TO21	R07E			H	4	4		
AIL514	MIDWEST S&G		HENRY PIT, MARSHALL CO	NW	03	TO13	R10E	DWU		X				
AIL516	BUILDERS SAND & CEMENT		CORDOVA, ROCK ISLAND CO	SE	33	TO21	R02E	DWU	3i		4	4		
								DWU		X				
AIL518	WENDLING QUARRIES INC		THOMPSON	SE	02	TO23	R03E	DWU		X				
AIL520	RIVERSTONE GROUP INC		CORDOVA (MC14@508), ROCK IS	S2	05	TO20	R02E	DWU	3iB					
								DWU		X				
AIL522	RIVERSTONE GROUP INC		CORDOVA INLAND (MC17), ROCK IS		7,8	TO20	R02E			H				
AIL524	CJ MATERIALS INC		LYNDON, WHITESIDE CO	SE	20	TO20	R05E			H				

NOTE 1: AASHTO 57 GRADATION MAXIMUM

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	FA	FRICT HMA A	B	BEDS	NOTE
MN	**MINNESOTA DIST 2**	**CRUSHED STONE**											
AMN004	MILESTONE MATERIALS	POOL HILL, HOUSTON CO	SW	33	T101	R04W	DWU	3i		4	4	1 - 8	D
AMN006	SKYLINE MATERIALS LTD	OTTERNESS, FILLMORE CO	E2	11	T101	R08W	2.75	3i		4	4	1 - 2	D
AMN008	NEW ULM QUARTZITE QUARRY	QUARTZITE, NICOLETT CO	SW	35	T110	R31W					5		1
AMN010	MARTIN MARIETTA	ST CLOUD, STEARNS CO		19	T124	R28W				2	2		
AMN014	SKYLINE MATERIALS LTD	BIG SPRINGS, FILLMORE CO	SW	09	T101	R10W					4	1 - 6	
AMN018	ULLAND BROS	GRAND MEADOW, MOWER CO	NE	09	T103	R14W							
AMN030	MILESTONE MATERIALS	GENGLER, HOUSTON CO	SW	16	T102	R05W	DWU	3B		4	4	1 - 2	D
AMN034	MILESTONE MATERIALS	ENGRAV, HOUSTON CO	NE	24	T101	R08W	DWU	3i		4	4	1A - 2B	D
AMN044	MILESTONE MATERIALS	BIESANZ, WINONA CO	SW	19	T107	R07W	DWU	3i		4	4	1 - 2	D
AMN046	MILESTONE MATERIALS	43 QUARRY, WINONA CO	NW	16	T106	R07W	DWU	3i		4	4	1 - 2	D
	DIST 2	**SAND & GRAVEL**											
AMN504	BRUENING ROCK PROD INC	NEW ALBIN, HOUSTON CO		09	T101	R04W			H	4	4		
AMN516	ULLAND BROS	OLSON, FREEBORN CO	NW	31	T102	R20W	DWU		X				
AMN518	SKYLINE MATERIALS LTD	LANESBORO, FILLMORE CO	SE	07	T104	R10W	DWU		X				
AMN522	AGGREGATE INDUSTRIES	PRAIRIE ISLAND #3, GOODHUE CO		23	T114	R15W	DWU	2	H				
AMN524	AGGREGATE INDUSTRIES	HASTING #2, DAKOTA CO		02	T114	R17W			H				
AMN526	NORTHWESTERN AGGR	LAKEVILLE, DAKOTA CO		01	T114	R20W			H				
AMN528	HANCOCK CONCRETE CO	POPE, POPE CO	NW	08	T125	R37W			H				
AMN532	ULLAND BROS	LARSON, FREEBORN CO		25	T102	R21W			H				
AMN536	AGGREGATE INDUSTRIES	ELK RIVER, SHERBURNE CO		9,10	TO33	R26W	DWU	2					
							DWU		X				
AMN538	ULLAND BROS	SHADE, MOWER CO	NW	04	T101	R18W	DWU		X				
AMN544	AGGREGATE INDUSTRIES	LAKEVILLE, DAKOTA CO		06	T114	R19W	DWU	2	H				
AMN546	M.R. PAVING & EXCAVATION	WALLNER, BROWN CO	NW	24	T110	R30W	DWU		H,L				2
AMN548	CEMSTONE	HENDERSON, SIBLEY CO		23	TO13	R26W	DWU	2	H				
AMN550	DAKOTA AGGREGATES	SACHS, DAKOTA CO	W2	24	T114	R19W	DWU	3i		3	3		
							DWU		X				
AMN552	EUREKA SAND & GRAVEL	WINDMILL, DAKOTA CO		12	T113	R20W	DWU		X				
AMN554	ANNENDALE ROCK PRODUCTS	ANNENDALE, WRIGHT CO		35	T121	R28W	DWU		X				
AMN558	AGGREGATE INDUSTRIES	ST CROIX, CHISAGO CO	SW	21	TO33	R19W	DWU	2					
							DWU		X				
	DIST 3	**CRUSHED STONE**											
AMN024	MARTIN MARIETTA	YELLOW MEDICINE, YLW MED CO	SW	28	T116	R39W	DWU	3i		2	2	1	
AMN026	LG EVERIST INC	BIG STONE, BIG STONE CO		26	T121	R46W	DWU	3i		2	2		
AMN032	SOUTHERN MN CONST CO INC	COTTONWOOD, COTTONWOOD CO	SE	08	T107	R35W	DWU	3i		2	2		
AMN042	DUININCK BROS INC	SCOTT, ROCK CO	NW	14	T104	R45W	DWU	3i		2	2		
AMN048	RED ROCK QUARRY	RED ROCK, COTTONWOOD CO		12	T107	R36W				2	2		
	DIST 3	**SAND & GRAVEL**											
AMN508	SOUTHERN MN CONST CO INC	HANSON, JACKSON CO	NE	34	T101	R34W			H	4	4		
AMN540	DUININCK BROS INC	SCOTT, ROCK CO		21	T104	R44W			H				

NOTE 1: AGGREGATE TOP SIZE IS LIMITED TO 3/8 INCH FOR USE AS: COVER AGGREGATE (GRADATION NO. 21), FINE AND COARSE SLURRY AGGREGATE (GRADATIONS NO. 22 AND 23), AND AGGREGATE FOR POLYMER-MODIFIED MICROSURFACING.
NOTE 2: APPROVED FOR CLASS L FINE AGGREGATE.

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION	BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
MO	**MISSOURI** **DIST 4**	**CRUSHED STONE**								
AMO032	SCHILDBERG CONST CO INC	GRAHAM, NODAWAY CO	NW 36 TO63 R37W				4	4	1 - 4	L
AMO040	S & A CONSTRUCTION	SO ALLENDALE, WORTH CO	NW SW 17 TO65 R30W							
AMO048	NORRIS QUARRIES LLC	BREIT, ANDREWS CO	28 TO59 R35W							
AMO052	NORRIS QUARRIES LLC	GOODEN, NODAWAY CO	31 TO65 R33W							
	DIST 4	**SAND AND GRAVEL**								
AMO520	PIERCE SAND	STANBERRY, GENTRY CO	15 TO63 R32W	2.65		X				
AMO522	PIERCE SAND	GUILFORD, NODAWAY CO	17 TO62 R34W			H				
	DIST 5	**CRUSHED STONE**								
AMO002	L&W QUARRIES INC	KAHOKA, CLARK CO	NE 17 TO65 R07W	DWU	2		4	4	2A - 3B	L
							4	4	14 - 16	L
AMO012	NORRIS QUARRIES LLC	DR JEFFERIES, HARRISON CO	NW 03 TO66 R26W				5	5	25C-25E	L
AMO018	NORRIS QUARRIES LLC	ROUTE C, DAVIESS CO	NE 30 TO61 R28W				5	5	2 - 5	L
AMO024	CENTRAL STONE CO	HUNTINGTON, RALLS CO	NE 17 TO56 R06W	2.68	3i		4	4	6 - 9	L
				2.68	3		4	4	6 - 11	L
AMO030	KNOX COUNTY STONE CO	EDINA, KNOX CO	NE 25 TO62 R12W				4	4	1 - 9	L
							4	4	10 - 17	L
AMO044	CENTRAL STONE CO	NEW LONDON, RALLS CO	NE 24 TO56 R05W							
AMO046	NORRIS QUARRIES LLC	BETHANY, HARRISON CO	SW 01 TO63 R28W				4	4	20A-20C	L
							5	5	25A-25E	L, 1
AMO050	NORRIS QUARRIES LLC	PRINCETON, MERCER CO	N2 03 TO64 R24W				4	4	20A-20C	L
							5	5	25A-25E	L
AMO054	CENTRAL STONE CO	BUTLER HILL, ST FRANCOIS CO	05 TO34 R06E				2	2		2
AMO056	NORRIS QUARRIES LLC	TRENTON, GRUNDY CO	24 TO61 R25W							
	DIST 5	**SAND AND GRAVEL**								
AMO502	IDEAL SAND CO	WAYLAND, CLARK CO	SW 21 TO65 R06W				3	3		
				2.66		X				
AMO516	STONER SAND CO	MT MORIAH, HARRISON CO	12 TO64 R26W	2.65		X				
AMO518	CENTRAL STONE CO	TAYLOR, MARION CO	NW 01 TO59 R06W			H				

NOTE 1: LESS THE TOP 4'.
NOTE 2: RHYOLITE (PIT #1) AND GRANITE (PIT #2) ARE BOTH FRICTION TYPE 2.

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION				BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
NE	**NEBRASKA DIST 4**	**CRUSHED STONE**											
ANE002	MARTIN MARIETTA	WEEPING WATER MINE, CASS CO		03	TO10	R11E	2.68	3iB		5	5	10A- 10B	L
							2.68	3iB		5	5	9-10A&B	L, 1
							2.68	3		5	5	9-10A&B	L, 2
							2.68	2		5	5	9-10A&B	L, 3
ANE004	KERFORD LIMESTONE CO	WEEPING WATER MINE, CASS CO		32	TO11	R11E	2.67	3iB		5	5	10A- 10B	L
							2.67	3iB		5	5	9-10A&B	L, 1
							2.67	3		5	5	9-10A&B	L, 2
							2.67	2		5	5	9-10A&B	L, 3
ANE010	MARTIN MARIETTA	FT CALHOUN, WASHINGTON CO	SE	01	TO17	R12E				4	4	25B- 25C	L
										5	5	25B- 25E	L
										5	5	25E	L
ANE012	MARTIN MARIETTA	SPRINGFIELD, SARPY CO		28	TO13	R12E							
ANE014	WESTERN CONTRACTING CORP	SPLITT, CASS CO	NE	06	TO10	R14E							
	DIST 4	**CLASS V AGGREGATE FOR CONCRETE**											
ANE502	LYMAN-RICHEY S&G	CULLOM #5, CASS CO	SW	31	TO13	R12E	2.62	3		4	4		
							2.62		X				
ANE504	LYMAN-RICHEY S&G	WATERLOO #40, DOUGLAS CO	SE	19	TO15	R10E	2.62	3		4	4		
							2.62		X				
ANE514	LYMAN-RICHEY S&G	OREAPOLIS #8, CASS CO	SE	36	TO13	R13E	2.62	3		4	4		
							2.62		X				
ANE534	MALLARD S&G	SPRINGFIELD #3, SARPY CO		32	TO13	R12E	2.62	3		4	4		
							2.62		X				
ANE542	LYMAN-RICHEY S&G	PLANT #47, DODGE CO	NW	07	TO17	R09E	2.62	3		4	4		
							2.62		X				
ANE544	MALLARD S&G	VALLEY, DOUGLAS CO	NE	06	TO15	R10E	2.62	3		4	4		
							2.62		X				
ANE546	LYMAN-RICHEY S&G	PLANT #77, HALL CO	NE SW	27	TO11	R09W	2.62		X				
ANE548	MALLARD S&G	PLANT #6, DOUGLAS CO		32	TO15	R10E	2.62	3		4	4		
							2.62		X				
ANE550	LYMAN RICHEY S&G	PLANT #50, SARPY CO	28	29	TO13	R10E	2.62	3		4	4		
							2.62		X				
ANE552	MALLARD S&G	PLANT #7, DOUGLAS CO	SW	08	TO15	R10E	2.62		X				
ANE554	LYMAN-RICHEY S&G	PLANT #7, DOUGLAS CO		36	TO16	R09E	2.62	3		4	4		
							2.62		X				
ANE556	LYMAN-RICHEY S&G	CULLOM #3, CASS CO	SW	35	TO13	R12E	2.62	3		4	4		
							2.62		X				
ANE560	LYMAN-RICHEY S&G	PLANT 47B, DODGE CO		06	TO17	R09E	2.62	3		4	4		
							2.62		X				
ANE562	LYMAN-RICHEY S&G	PLANT #51, SARPY CO		20	TO13	R10E	2.62	3		4	4		
							2.62		X				
ANE564	MALLARD S&G	KMG, DOUGLAS CO		15	TO16	R09E	2.62	3		4	4		
							2.62		X				
	DIST 3	**SAND & GRAVEL**											
ANE538	STALP S&G	WEST POINT, CUMING CO	SE	28	TO22	R06E	2.64		X				

NOTE 1: IF THE COARSE AGGREGATE DOES NOT EXCEED 45% OF THE TOTAL AGGREGATE IN THE CONCRETE MIX AND BED 9 IS LESS THAN 4' THICK AT THE TIME OF PRODUCTION, BED 9 CAN BE INCORPORATED WITH BEDS 10A&B, WITH A DURABILITY CLASS OF 3IB.
NOTE 2: IF THE COARSE AGGREGATE DOES NOT EXCEED 50% OF THE TOTAL AGGREGATE IN THE CONCRETE MIX AND BED 9 IS LESS THAN 4' THICK AT THE TIME OF PRODUCTION, BED 9 CAN BE INCORPORATED WITH BEDS 10A&B, WITH A DURABILITY CLASS OF 3.
NOTE 3: IF THE COARSE AGGREGATE EXCEEDS 50% OF THE TOTAL AGGREGATE IN THE CONCRETE MIX AND BED 9 IS LESS THAN 4' THICK AT THE TIME OF PRODUCTION, BED 9 CAN BE INCORPORATED WITH BEDS 10A&B, WITH A DURABILITY CLASS OF 2.

RECENTLY ACTIVE AGGREGATE SOURCES

CODE	OPERATOR	SOURCE NAME	LOCATION	BULK SSD SpGr	DUR PCC CA	DUR PCC FA	FRICT HMA A	FRICT HMA B	BEDS	NOTE
SD	**SOUTH DAKOTA DIST 3**	**CRUSHED STONE**								
ASD002	LG EVERIST INC	DELL RAPIDS E. MINNEHAHA CO	SW 10 T104 R49W	2.64	3iB		2	2		
ASD004	CONCRETE MATLS CO	SIOUX FALLS QUARTZITE	13 T101 R50W	2.64	3iB		2	2	1	
ASD006	MYRL & ROY'S PAVING INC	EAST SIOUX, MINNEHAHA CO	SE 27 T101 R48W	DWU	3i		2	2	1	
ASD008	SPENCER QUARRIES INC	SPENCER, HANSON CO	24 T103 R57W				2	2		
ASD010	LG EVERIST INC	DELL RAPIDS W. MINNEHAHA CO	NW 16 T104 R49W	2.64	3iB		2	2		
	DIST 3	**SAND & GRAVEL**								
ASD502	BOYER SAND AND GRAVEL	BOYER, UNION CO	10 TO95 R48W	DWU	2	H	4	4		
ASD508	CONCRETE MATERIALS CO	CANTON, LINCOLN CO	17 TO89 R48W				4	4		
				2.68		X				
ASD510	CONCRETE MATERIALS CO	MINNEHAHA CO	02 T101 R49W			H				
ASD514	HIGMAN S&G	HUDSON, UNION CO	02 TO95 R48W	DWU	2	H	4	4		
ASD516	HIGMAN S&G	VOLIN, CLAY CO	12 TO94 R54W			H				
ASD518	MYRL & ROY'S PAVING INC	MCVAY, LINCOLN CO	SE 17 TO98 R45W			H	3	3		
ASD520	BOYER SAND AND GRAVEL	BOYER NORTH, UNION CO	NE 01 TO95 R48W			H	3	3		
ASD522	LG EVERIST INC	BROOKINGS, BROOKINGS CO	S2 31 T110 R49W	DWU		X				
ASD524	HIGMAN S&G	SPINK, UNION CO	05 TO93 R50W			H				
ASD526	CONCRETE MATERIALS CO	CORSON, MINNEHAHA CO	23 24 T102 R48W	DWU	2					
				DWU		X				
WI	**WISCONSIN DIST 2**	**CRUSHED STONE**								
AWI022	MILESTONE MATERIALS	KINGS BLUFF, LA CROSSE CO	NE 25 TO18 R08W	DWU	3		4	4	1 - 4	D
				DWU	2		4	4	1 - 5	D, 1
AWI036	MILESTONE MATERIALS	TORK, WOOD CO.	NE SW 01 TO22 R05E							
AWI038	ROCKY MTN ENTERPRISES	ATHEN, MARATHON CO	SE 24 TO30 R04E	DWU	3i		2	2		
AWI040	MILESTONE MATERIALS	JACKSON COUNTY IRON MINE	22 TO21 R03W				2	2		
AWI042	BOON CONSTRUCTION CO	CROSBY	NW SW 13 TO23 R03W				2	2		
AWI044	MILESTONE MATERIALS	SLAMA, CRAWFORD CO	17,18 TO07 R06W	DWU	3i		4	4	3 - 8A	D
AWI046	COUNTY MATERIALS CORP	HAHN, VERNON CO	13 TO13 R06W	DWU	3		4	4	2 - 4	D
	DIST 2	**SAND & GRAVEL**								
AWI502	PRAIRIE S&G CO	PRAIRIE DU CHIEN, CRAWFORD CO	24 TO07 R07W	2.67	3i		4	4		
				2.67		X				
AWI506	PRAIRIE S&G CO	KRAMER, CRAWFORD CO	NE 12 TO07 R07W				3	3		
				2.68		X				
AWI508	PRAIRIE S&G CO	BARN	SE 12 TO07 R07W	2.69		X				
AWI512	MILESTONE MATERIALS	GIBBS	NE 25 TO25 R09W			H				
AWI514	HOLST EXCAVATION	HAGER CITY, PIERCE CO	NE 33 TO25 R18W	DWU	3i		3	3		
				DWU		X,L				2
AWI518	LYCON INC	BLAU, COLUMBIA CO	02 TO11 R08E			H				
AWI522	COUNTY MATERIALS CORP	RIB FALLS PLANT, MARATHON CO	NE 16 TO29 R05W	DWU		X				
AWI524	COUNTY MATERIALS CORP	HAEF, TREMPEALEAU CO	SW NE 19 TO18 R08W	DWU	3i		3	3		
				2.66		X,L				2
AWI526	HAAS & SONS	MILAS, CLARK CO	NW 03 TO29 R03W	DWU		X				
WI	**WISCONSIN DIST 6**	**CRUSHED STONE**								
AWI004	MILESTONE MATERIALS	ROCK SPRINGS, SAUK CO	SW 28 TO12 R05E				2	2		
AWI048	MILESTONE MATERIALS	HOGAN, GRANT CO	23,26 TO01 R02W							
	DIST 6	**SAND & GRAVEL**								
AWI504	HORSFIELD MATERIALS INC	VOGT FARM, GRANT CO	17 TO90 R03E	2.67	3i		3	3		
				2.67		X				
AWI510	RIVER CITY STONE	KRUG, GRANT CO	SW 17 TO01 R02W	DWU		X				

NOTE 1: BED 1- TOP 16' OF BED 5
NOTE 2: APPROVED FOR CLASS L FINE AGGREGATE

REVETMENT STONE
SOURCE APPROVAL

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
	DISTRICT 1							
A40006	MARTIN MARIETTA	GRAND GEORGE	SW	18	TO89	R25W	3-5	D
							7-9	D
							10-13	A, B, C, D, E
A42002	MARTIN MARIETTA	ALDEN	NW	20	TO89	R21W	3	A, B, C, D, E
A42004	GEHRKE QUARRIES INC	GIFFORD	NW	04	TO86	R19W	7-8, 10	A, B, C, D, E
A50002	MARTIN MARIETTA	SULLY	SE	16	TO79	R17W	36-41	A, B, C, D, E
							42-47	A, B, C, D, E
A64002	MARTIN MARIETTA	FERGUSON	SW	05	TO82	R17W	0-7	D
							1-7	A, B, C, D, E
							8-17	A, B, C, D, E
A79002	MARTIN MARIETTA	MALCOM MINE	SE	04	TO80	R15W	10C-13	A, B, C, D, E
A85006	MARTIN MARIETTA	AMES MINE	SW	24	TO84	R24W	26	E
							30-35	E
							47-49	A, B, C, D, E
A86002	WENDLING QUARRIES INC	MONTOUR	NW	09	TO83	R06W	8-12	A, B, C, D, E
							8-20	D
A94002	MARTIN MARIETTA	FORT DODGE MINE	SW	24	TO89	R29W	36-42	A, B, C, D, E
DISTRICT 2								
A03002	BRUENING ROCK PROD INC	WEXFORD	NE	36	TO98	R03W	1B-8	A, B, C, D, E
A03008	BRUENING ROCK PROD INC	MCCABE		06	TO97	R05W	1-6	D
A03014	BRUENING ROCK PROD INC	HAMMEL-BOONIES	SW	02	TO99	R06W	2-4C	A, B, C, D, E
A03038	RIEHM CONST CO INC	RIEHM	SE	07	T100	R04W	1-4	A, B, C, D, E
A03040	BRUENING ROCK PROD INC	DEE	SE	21	TO99	R04W	5A-5D	A, B, C, D, E
A03050	BRUENING ROCK PROD INC	GREEN	NW	16	TO96	R06W	1-3	A, B, C, D, E
A03064	RAINBOW QUARRY LLC	RAINBOW	SE	26	TO97	R05W	FULL FACE	D
A03066	WILTGEN CONST CO	ELSBERN	NW	29	TO97	R06W	2	A, B, C, D, E
A03072	STRONG ROCK AND GRAVEL	STRONG	SE	24	TO99	R04W	1-8	A, B, C, D, E
A07004	BMC AGGREGATES LC	WATERLOO SOUTH	NW	18	TO87	R12W	1-23	A, B, C, D, E
							17-23	A, B, C, D, E
A07008	BMC AGGREGATES LC	MORGAN	NE	15	TO89	R12W	5	A, B, C, D, E
A07018	BMC AGGREGATES LC	RAYMOND-PESKE	SW	01	TO88	R12W	1B-5	A, B, C, D, E
							1B-10	A, B, C, D, E
							6-10	A, B, C, D, E
							2-10	A, B, C, D, E
A09006	NIEMANN CONST CO	TRIPOLI-PLATTE	SW	36	TO93	R13W	1-4	A, B, C, D, E
A09008	NIEMANN CONST CO	DENVER #2	NE	29	TO91	R13W	2	A, B, C, D, E
A12004	GREENE LIMESTONE CO	LUBBEN	NW	25	TO93	R17W	1-20	D
A12014	NIEMANN CONST CO	OLTMANN	SE	08	TO91	R16W	1-TOP ½ BED 10	D
A12020	GREENE LIMESTONE CO	BRUNS #2	NW	21	TO91	R18W	1-5	D
A17008	MARTIN MARIETTA	PORTLAND WEST		19	TO96	R19W	1-8	A, B, C, D, E
A17020	MARTIN MARIETTA	MASON CITY	NE	29	TO97	R20W	1-6, 7-9	A, B, C, D, E
A19002	GREENE LIMESTONE CO	TRACY	SE	29	TO94	R11W	9-10	A, B, C, D, E
A19009	GREENE LIMESTONE CO	BOICE	NE	16	TO95	R14W	2-5	D
A22002	BARD-KUHLMAN	TWIN ROCK-SCHRADER	NW	14	TO94	R05W	3-11	A, B, C, D, E
A22004	SKYLINE MATERIALS LTD	BENTE/ELKADER/WATSON	SW	12	TO93	R05W	5-9	A, B, C, D, E
A22008	BARD-KUHLMAN	ANDEREGG	SE	32	TO92	R02W	2-8	A, B, C, D, E
A22010	BARD-KUHLMAN	OSTERDOCK	SE	02	TO91	R03W	3-8	A, B, C, D, E
A22012	BARD-KUHLMAN	SCHMIDT	NE	33	TO91	R01W	2-6	A, B, C, D, E
A22014	SKYLINE MATERIALS LTD	BLUME	NE	09	TO93	R03W	1-12	A, B, C, D, E
A22016	BARD-KUHLMAN	GISLESON	NW	06	TO95	R04W	1-15	A, B, C, D, E
A22020	BARD-KUHLMAN	MUELLER	NE	30	TO94	R03W	1-8	A, B, C, D, E
A22026	BARD-KUHLMAN	DOERRING-LUANA	SE	05	TO95	R05W	3-5	A, B, C, D, E
A22030	BARD-KUHLMAN	EBERHARDT	NW	27	TO93	R05W	1-6	A, B, C, D, E
A22034	BARD-KUHLMAN	KRUSE	NW	17	TO92	R04W	5-12	A, B, C, D, E

REVETMENT STONE
SOURCE APPROVAL

DISTRICT 2 (Continued)

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
A22038	BARD-KUHLMAN	FASSBINDER	SW	09	TO92	R03W	2-6	A, B, C, D, E
A22040	BARD-KUHLMAN	HARTMAN	NW	29	TO91	R06W	1-4	A, B, C, D, E
A22042	SKYLINE MATERIALS LTD	MORAREND	CT	35	TO92	R03W	1-9	A, B, C, D, E
A22046	BARD-KUHLMAN	JOY SPRINGS-BURRACK	NW	19	TO91	R06W	1-2	A, B, C, D, E
A22048	SKYLINE MATERIALS LTD	TUCKER	SW	18	TO91	R05W	1-3	D
A22060	CROELL REDI MIX	JOHNSON	NW	26	TO93	R04W	2-5	A, B, C, D, E
A22062	CJ MOYNA & SONS	SNY MAGILL	SE	22	TO94	R03W	6-10	A, B, C, D, E
A22070	BRUENING ROCK PROD INC	BERNHARD/GIARD	NW	35	TO95	R04W	1-3	A, B, C, D, E
A22074	RIVER CITY STONE	STRAWBERRY POINT	NE	19	TO91	R06W	1-2	A, B, C, D, E
A22084	CJ MOYNA & SONS	MOYNA		14	TO93	R05W	6-9	A, B, C, D, E
A33002	NIEMANN CONST CO	ELDORADO-JACOBSON	SW	17	TO95	R08W	4-6B	A, B, C, D, E
A33010	WILTGEN CONST CO	VOSHELL	NW	21	TO93	R07W	1-4	A, B, C, D, E
A33018	NIEMANN CONST CO	FAIRBANK	SW	28	TO91	R10W	1-5C	D
							5A-5C	A, B, C, D, E
A33020	NIEMANN CONST CO	YEAROUS	SW	19	TO93	R08W	1-10C	D
A33024	NIEMANN CONST CO	WAUCOMA	NW	25	TO95	R10W	1-TOP 4' BED 5	A, B, C, D, E
A33026	WILTGEN CONST CO	LYNCH	NW	05	TO95	R10W	6-8	A, B, C, D, E
A33032	BRUENING ROCK PROD INC	LANDIS	SE	12	TO93	R08W	1-5	A, B, C, D, E
A33034	NIEMANN CONST CO	MCDONOUGH	SE	36	TO94	R08W	1-3	D
A33036	NIEMANN CONST CO	GRAHAM-HAWKEYE	SW	06	TO94	R09W	1-4	A, B, C, D, E
A33038	NIEMANN CONST CO	PAPE	NE	28	TO95	R08W	1-3	A, B, C, D, E
							3-5	A, B, C, D, E
A33044	BRUENING ROCK PROD INC	FAYETTE 93		30	TO93	R08W	FULL FACE	D
A34004	GREENE LIMESTONE CO	MAXON	SE	07	TO94	R17W	4C-19	A, B, C, D, E
A34006	GREENE LIMESTONE CO	JOHLAS	SW	07	TO94	R15W	1-7	D
A34008	GREENE LIMESTONE CO	WARNHOLTZ	SW	09	TO96	R16W	5-16	D
							17-18	A, B, C, D, E
A35002	MARTIN MARIETTA	DOWS	NE	30	TO91	R22W	1-12	A, B, C, D, E
							1-13	D
A35006	MARTIN MARIETTA	HIBNESS	SE	22	TO91	R20W	1-12A	A, B, C, D, E
A41002	BMC AGGREGATES LC	GARNER NORTH	SE	11	TO95	R24W	6	A, B, C, D, E
A45006	BRUENING ROCK PROD INC	NELSON	NE	33	TO99	R13W	8-9	A, B, C, D, E
A45008	BRUENING ROCK PROD INC	DOTZLER	NE	23	TO99	R12W	7-10A	A, B, C, D, E
A45010	BRUENING ROCK PROD INC	DALEY	NE	11	TO98	R11W	9-10	A, B, C, D, E
A46006	MARTIN MARIETTA	HODGES	NE	32	TO92	R28W	4-18	D
A46014	MARTIN MARIETTA	PEDERSEN	SW	28	TO92	R28W	4-13, 4-20	D
A66002	FALK CONST CO	DUENOW	SE	08	TO99	R17W	6-8	A, B, C, D, E
A76002	MARTIN MARIETTA	GILMORE CITY	NE	36	TO92	R31W	1A-3	A, B, C, D, E
A76004	MARTIN MARIETTA	MOORE	SW	25	TO92	R31W	1A-3	A, B, C, D, E
A96002	SKYLINE MATERIALS LTD	KENDALLVILLE	NE	33	T100	R10W	2-9	A, B, C, D, E
A96004	SKYLINE MATERIALS LTD	HOVEY	SW	28	TO98	R08W	2-6	A, B, C, D, E
A96017	BRUENING ROCK PROD INC	SKYLINE B	CT	10	TO98	R08W	4-11	A, B, C, D, E
A96048	NIEMANN CONST CO	LOVE #1	NW	30	TO96	R10W	1-10	D
A96049	NIEMANN CONST CO	LOVE #2	NW	30	TO96	R10W	1-10	D
A96052	SKYLINE MATERIALS LTD	ESTREM	SW	04	TO97	R07W	2-8	A, B, C, D, E
A96060	SKYLINE MATERIALS LTD	BURR OAK	SE	23	T100	R09W	3-5	A, B, C, D, E
A96064	RIVER CITY STONE	STIKA	NW	15	TO97	R10W	5A-8B	A, B, C, D, E
A96090	BRUENING ROCK PROD INC	MCKENNA SOUTH	SE	28	TO99	R09W	6A-7	A, B, C, D, E
A98002	MARTIN MARIETTA	HARRIS	SW	29	T100	R20W	2-11	A, B, C, D, E
							6-11	A, B, C, D, E
A98010	BMC AGGREGATES LC	FERTILE	SW	36	TO98	R22W	15-20	A, B, C, D, E
A98016	ULLAND BROS	EMIL OLSON-BOLTON	SW	10	TO99	R20W	2-5B	A, B, C, D, E
A98020	FALK CONST CO	TRENHAILE	NE	09	TO99	R20W	2A-2B	A, B, C, D, E
A99002	MARTIN MARIETTA	VOSS		36	TO90	R26W	8	A, B, C, D, E

REVETMENT STONE
SOURCE APPROVAL

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
DISTRICT 2 (Continued)								
AMN004	MILESTONE MATERIALS	POOL HILL, HOUSTON CO	SW	33	T101	R04W	1-8	A, B, C, D, E
AMN030	MILESTONE MATERIALS	GENGLER, HOUSTON CO	SW	16	T102	R05W	1-4	A, B, C, D, E
AMN034	MILESTONE MATERIALS	ENGRAV, HOUSTON CO	NW	24	T101	R08W	1A-2B	A, B, C, D, E
DISTRICT 3								
AMN024	MARTIN MARIETTA	YELLOW MEDICINE, YELLOW MED	SW	28	T116	R39W	GRANITE	A, B, C, D, E
AMN032	SOUTHERN MN CONST CO INC	COTTONWOOD, COTTONWOOD CO	SE	08	T107	R35W	ENTIRE LEDGE*	A, B, C, D, E
AMN050	LG EVERIST INC	JASPER STONE, ROCK CO	NE	06	T104	R46W		A, B, C, D, E
ASD002	LG EVERIST INC	DELL RAPIDS, MINNEHAHA CO	SW	10	T104	R49W	ENTIRE LEDGE*	A, B, C, D, E
ASD004	CONCRETE MATERIALS CO	SIOUX FALLS QUARTZITE		13	T101	R50W	ENTIRE LEDGE*	A, B, C, D, E
ASD006	MYRL & ROY'S PAVING INC	EAST SIOUX, MINNEHAHA CO	SE	27	T101	R48W	ENTIRE LEDGE*	A, B, C, D, E
ASD008	SPENCER QUARRIES INC	SPENCER, HANSON CO		24	T103	R57W	ENTIRE LEDGE*	A, B, C, D, E

*ISOLATED POCKETS OF SANDSTONE MAY BE CAUSE TO REJECT ALL OR PORTIONS OF A SHOT; ALSO, THE PIPESTONE DEPOSITS WILL DEFINE THE LOWER LIMITS OF LEDGE. IN BOTH INSTANCES A VISUAL EXAMINATION WILL REVEAL THE PRESENCE OF EITHER UNCONSOLIDATED SANDSTONE OR PIPESTONE MATERIAL.

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
DISTRICT 4								
A01002	SCHILDBERG CONST CO INC	MENLO	SE	17	TO77	R31W	15A-15C	A, B, C, D, E
A01008	SCHILDBERG CONST CO INC	JEFFERSON	NE	17	TO77	R31W	25B-25E	D
A02002	SCHILDBERG CONST CO INC	MT ETNA	SW	14	TO73	R34W	11-13	D
A02004	SCHILDBERG CONST CO INC	CORNING		10	TO71	R34W	3-5	D
A15008	SCHILDBERG CONST CO INC	ATLANTIC MINE	NE	13	TO76	R37W	25B-25E	D
							20A-20C	D
A43002	SCHLDBERG CONST CO INC	LOGAN		19	TO79	R42W	25B-25E & 3' OF 26	A, B, C, D, E
A43004	BEDROCK SAND & GRAVEL	LOGAN		17	TO79	R42W	25B-25E & 3' OF 26	A, B, C, D, E
A61002	SCHILDBERG CONST CO INC	EARLY CHAPEL-DAGGETT	NW	10	TO76	R29W	14B	A, B, C, D, E
A61013	SCHILDBERG CONST CO INC	WINTERSET WEST	SW	28	TO76	R27W	25B-25C	E
A61024	MARTIN MARIETTA	PENN-DIXIE	SW	32	TO76	R27W	TOP 4' OF BED 20A	D, E
A61026	MARTIN MARIETTA	EARLHAM-MASON	SW	16	TO77	R28W	TOP 4' OF BED 20A	D, E
							25B-25C	D
A61032	MARTIN MARIETTA	EARLHAM-THRAILKILL	NE	08	TO77	R28W	TOP 4' OF BED 20A	D, E
							20A-20C	A, B, C, D, E
							25B-25E	A, B, C, D, E
							25B-25C	D
A61036	SCHILDBERG CONST CO INC	MONARCH CEMENT OF IOWA	NE	08	TO77	R28W	25B-25E	A, B, C, D, E
A65006	SCHILDBERG CONST CO INC	MALVERN	SE	31	TO72	R41W	ERVINE CREEK	D
A69002	SCHILDBERG CONST CO INC	STENNETT	NE	27	TO73	R38W	KERFORD	D
A73004	SCHILDBERG CONST CO INC	SHAMBAUGH	SW	20	TO67	R36W	4-6	D
A78002	SCHILDBERG CONST CO INC	CRESCENT	SW	26	TO76	R44W	25B-25E	A, B, C, D, E
							26A-26E	A, B, C, D, E
							20A-20C, 27A-27B	D
A78006	SCHILDBERG CONST CO INC	MACEDONIA	NE	28	TO74	R40W	16	D
A88002	SCHILDBERG CONST CO INC	THAYER	NE	35	TO72	R28W	20B	D
							25B-25E	A, B, C, D, E
AMO040	S&A CONSTRUCTION	SOUTH ALLENDALE, WORTH CO	SW	17	TO65	R30W	CAPTAIN CREEK	A, B, C, D, E
ANE002	MARTIN MARIETTA	WEEPING WATER, CASS CO		03	TO10	R11E	10A-10B	E
							9-10B	E
ANE010	MARTIN MARIETTA	FORT CALHOUN, WASHINGTON CO	SE	01	TO17	R12E	25B-25E	A, B, C, D, E
							25B-25C	D
							26A-26E	A, B, C, D, E

REVETMENT STONE
SOURCE APPROVAL

CODE	OPERATOR	SOURCE NAME	LOCATION					BEDS	REVETMENT CLASS
DISTRICT 5									
A04016	L&W QUARRIES	LEMLEY EAST #5		CT	35	TO70	R19W	1-3	D
								6	A, B, C, D, E
A04018	L&W QUARRIES	CLARKDALE #8		SE	15	TO69	R18W	1A	D, E
								1C	A, B, C, D, E
								4	D, E
A20002	SCHILDBERG CONST CO INC	OSCEOLA		NW	12	TO72	R26W	25A-25E	D
								20A	A, B, C, D, E
								25B-25C	A, B, C, D, E
A26004	DOUDS STONE LLC	LEWIS		W2	02	TO69	R12W	3-5	D
								6-7	D, E
								3-7	D, E
A26006	DOUDS STONE LLC	BROWN	SW	NW	02	TO69	R12W	1	D, E
								3-7	D, E
A27002	SCHILDBERG CONST CO INC	GRAND RIVER		NW	22	TO70	R27W	TOP 5.5" OF 25E	D
A27008	SCHILDBERG CONST CO INC	DECATUR		SE	32	TO69	R27W	20C	A, B, C, D, E
								25C	D
A29002	L&W QUARRIES	MEDIAPOLIS		SE	01	TO71	R04W	3-7	A, B, C, D, E
								15-18	A, B, C, D, E
A29008	CESSFORD CONST CO	NELSON		NE	26	TO72	R02W	7-14	A, B, C, D, E
								7-20	A, B, C, D, E
								15-20	D
								15-24	D
								21-24	A, B, C, D, E
								25-27	D
A29012	CESSFORD CONST CO	GEODE		NE	01	TO69	R05W	1-5	D, E
								9-13	D, E
								17	A, B, C, D, E
A44008	DOUDS STONE LLC	MT. PLEASANT		SE	36	TO71	R06W	9-14	D, E
								13-14	D, E
A51006	WINN CORP	JEFFERSON		NE	09	TO71	R10W	5-8	A, B, C, D, E
								LOWER 4' OF BED 8	A, B, C, D, E
								10-12	A, B, C, D, E
A54002	DOUDS STONE LLC	KESWICK		NW	21	TO77	R12W	13-15	A, B, C, D, E
								13-TOP 4' OF17	D
								BTM 21' OF BED 17	D
A54004	DOUDS STONE LLC	OLLIE		SW	01	TO74	R11W	9-12	A, B, C, D, E
								9-13	D
								9-18	A, B, C, D, E
								13-18	A, B, C, D, E
								19-26, 30-33	D
								27-29	A, B, C, D, E
								30-37	A, B, C, D, E
A54008	DOUDS STONE LLC	HARPER		SE	11	TO76	R11W	13-22	A, B, C, D, E
								32-37	A, B, C, D, E
								38-40	A, B, C, D, E
A54010	DOUDS STONE LLC	LYLE		NW	13	TO74	R13W	36-38	A, B, C, D, E
								40	A, B, C, D, E
A56002	CESSFORD CONST CO	HAWKEYE		NE	10	TO68	R06W	1-21	D
								22-27	A, B, C, D, E
A56008	CESSFORD CONST CO	DONNELLSON		SE	05	TO67	R06W	10-13	A, B, C, D, E
A56016	GREAT RIVER MATERIALS LLC	HERITAGE			26	TO69	R04W	3-5	A, B, C, D, E
								9-11	A, B, C, D, E
A56020	PNB PROCESSORS LLC	PNB PROCESSORS AUGUSTA		NW	25	TO69	R04W	0C	A, B, C, D, E
A63002	MARTIN MARIETTA	DURHAM MINE		NE	08	TO75	R18W	88-95	D, E
								95-96	D, E

REVETMENT STONE
SOURCE APPROVAL

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
DISTRICT 5 (Continued)								
A63010	BRUENING ROCK PROD INC	S&S	SE	25	TO75	R20W	25	A, B, C, D, E
							31A-32D	A, B, C, D, E
A89002	DOUDS STONE LLC	DOUDS MINE	SE	25	TO70	R11W	5-13	D, E
A89006	CESSFORD CONST CO	FARMINGTON-COMANCHE	NE	05	TO67	R08W	5-12	D
							14-15	D
							16-17	A, B, C, D, E
							18-23	D
A89008	DOUDS STONE LLC	SELMA-GARDNER	NW	16	TO70	R11W	11	A, B, C, D, E
							14-21	A, B, C, D, E
							14-31	A, B, C, D, E
							22-31	A, B, C, D, E
A92002	DOUDS STONE LLC	WESTCHESTER	NE	19	TO76	R08W	8-9	A, B, C, D, E
							14-16	A, B, C, D, E
A92008	RIVER PRODUCTS CO	PEPPER-KEOTA FIELD	SW	31	TO76	R09W	2-20	D
							22-28	D
							29-36	D
A92014	DOUDS STONE LLC	COPPOCK NORTH	SE	19	TO74	R07W	6-8	A, B, C, D, E
AIL002	CESSFORD CONST CO	BIGGSVILLE, HENDERSON CO		17	TO10	R04W	6-8	A, B, C, D, E
AIL014	CESSFORD CONST CO	DALLAS CITY, HENDERSON CO	SW	36	TO08	R07W	5-6	A, B, C, D, E
AIL020	GRAY QUARRY INC	GRAY, HANCOCK CO	NE	31	TO05	R08W	2	A, B, C, D, E
AMO002	L&W QUARRIES	KAHOKA, CLARK CO	NE	17	TO65	R07W	2A-3B	A, B, C, D, E
AMO012	NORRIS QUARRIES LLC	DR JEFFERIES, HARRISON CO	NW	03	TO66	R26W	25C-25D	D, E
AMO024	CENTRAL STONE	HUNTINGTON, RALLS CO	NE	17	TO56	R06W	6-11	A, B, C, D, E
AMO050	NORRIS QUARRIES LLC	PRINCETON	N2	03	TO64	R24W	20A	A, B, C, D, E
DISTRICT 6								
A06006	WENDLING QUARRIES INC	GARRISON B	NE	33	TO85	R11W	6-TOP 2' OF BED 27	A, B, C, D, E
							6-36	EROSION
A06012	COOTS MATERIALS CO INC	JABENS	SW	07	TO85	R11W	6-11, 12	A, B, C, D, E
							20-23	A, B, C, D, E
A06014	WENDLING QUARRIES INC	VINTON-MILROY	S2	10	TO85	R10W	1-7	D
A06016	COOTS MATERIALS CO INC	COOTS	SW	36	TO86	R11W	2A ON DOWN	D
A10002	NIEMANN CONST CO	LAMONT-WESTON	NW	14	TO90	R07W	1-6	A, B, C, D, E
A10004	NIEMANN CONST CO	JESUP-BLOOM	SW	32	TO89	R10W	2-5	A, B, C, D, E
							2-8	D
A10008	BRUENING ROCK PROD INC	OELWEIN-MISHLER	NW	02	TO90	R09W	4-5	A, B, C, D, E
A10010	NIEMANN CONST CO	HAZELTON	NW	11	TO90	R09W	4A-4D	A, B, C, D, E
A10016	NIEMANN CONST CO	OELWEIN #2	SE	03	TO90	R09W	13-17	A, B, C, D, E
A10022	BRUENING ROCK PROD INC	BROOKS	NW	02	TO88	R09W	4-5	EROSION
A10024	NIEMANN CONST CO	RASMUSSEN #2	SE	21	TO88	R08W	1-6 + QUARRY FLR	D
A10030	NIEMANN CONST CO	SOUTH AURORA	NW	19	TO90	R07W	1-3	A, B, C, D, E
A16004	WENDLING QUARRIES INC	LOWDEN-SCHNECKLOTH	NW	04	TO81	R01W	1-4	A, B, C, D, E
A16006	WENDLING QUARRIES INC	STONEMILL	SE	14	TO80	R03W	4A-4D	A, B, C, D, E
A16010	WENDLING QUARRIES INC	PEDEN	NE	10	TO79	R03W	1-3	D, EROSION
A16012	WEBER STONE CO	ONION GROVE	SE	14	TO82	R02W	1-7	A, B, C, D, E
A16014	WENDLING QUARRIES INC	TOWNSEND	NW	02	TO79	R02W	2-10	A, B, C, D, E
A16022	WENDLING QUARRIES INC	TRICON	N2	09	TO82	R04W	1	A, B, C, D, E
A23002	PRESTON READY MIX	ELWOOD-YEAGER	NW	08	TO83	R02E	1-2	A, B, C, D, E
A23004	WENDLING QUARRIES INC	BEHR	SW	02	TO81	R03E	1-2	A, B, C, D, E
A23006	WENDLING QUARRIES INC	SHAFFTON	NE	11	TO80	R05E	16-21	A, B, C, D, E
							3-14	D, EROSION
A23010	WENDLING QUARRIES INC	GOOSE LAKE	SW	22	TO83	R05E	2-4	E
A23012	WENDLING QUARRIES INC	TEEDS GROVE	SW	03	TO83	R06E	2-4	A, B, C, D, E
A23016	WENDLING QUARRIES INC	LYONS	NW	18	TO82	R07E	UPPER OR LOWER LEDGE	E

REVETMENT STONE
SOURCE APPROVAL

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
DISTRICT 6 (Continued)								
A28008	BARD-KUHLMAN	EDGEWOOD WEST	CT	04	TO90	R05W	2-7	A, B, C, D, E
A28014	BARD-KUHLMAN	LOGAN	SW	10	TO88	R05W	2-8	A, B, C, D, E
A28016	BARD-KUHLMAN	WHITE	NW	02	TO88	R04W	1-2	A, B, C, D, E
A28020	BARD CONCRETE	DEUTMEYER	SW	13	TO88	R03W	1-6	A, B, D
A28030	BARD-KUHLMAN	GRIEF	NE	18	TO87	R03W	1-2	A, B, C, D, E
A28038	BARD-KUHLMAN	KUHLMAN	NW	06	TO90	R04W	1B-5	A, B, C, D, E
							2-6	E
A28040	BARD CONCRETE	KRAPFL	SE	23	TO89	R03W	1-5	A, B, D
							4	E
A28052	RIVER CITY STONE	MANCHESTER	SW	09	TO88	R05W	6-8	A, B, E
							TOP LEDGES– NORTH	D
A28056	RIVER CITY STONE	THORPE	NW	33	TO90	R05W	FULL FACE	A, B, C, D, E
A28058	RIVER CITY STONE	ROSSOW/MANCHESTER	NW	16	TO88	R05W	2-8	A, B, C, D, E
A31002	RIVER CITY STONE	ROSE SPUR		27	TO90	R02E	1-8	A, B, C, D, E
A31006	BARD-KUHLMAN	DYERSVILLE-SUNDHEIM	SE	32	TO89	R02W	5-12	A, B, C, D, E
A31008	RIVER CITY STONE	KLEIN-RICHARDSVILLE	NW	33	TO90	R01E	2-4B	A, B, D
							3A-4B	E
A31010	RIVER CITY STONE	BROWN	NW	33	TO89	R02E	FULL FACE	D
							3-9	A, B, E
A31014	BARD CONCRETE	KURT	N2	35	TO87	R02W	1-2	A, B, C, D, E
A31018	RIVER CITY STONE	MELOY	NW	23	TO87	R01E	FULL FACE	A, B, D
							1-3	E
A31020	RIVER CITY STONE	SCHLITCHE	SE	11	TO89	R02W	1-4	A, B, C, D, E
A31026	WENDLING QUARRIES INC	ARNSDORF	SE	25	TO87	R02E	1-2	A, B, C, D, E
A31028	RIVER CITY STONE	THOLE	NW	21	TO87	R02E	2-3	A, B
							3	D, E
A31030	RIVER CITY STONE	KEMP	NE	09	TO89	R01W	FULL FACE	A, B, C, D, E
A31036	RIVER CITY STONE	BALLTOWN	SE	05	TO90	R01E	1-7	A, B, C, D, E
A31040	RIVER CITY STONE	KENNEDY	NW	03	TO88	R01W	FULL FACE	A, B, C, D, E
A31046	WENDLING QUARRIES INC	DECKER	SE	24	TO87	R02E	2-5	A, B, C, D, E
A31050	RIVER CITY STONE	PLOESSEL-DYERSVILLE	N2	07	TO88	R02W	2-5	A, B, D
							3-5	E
A31052	WEBER STONE CO	EPWORTH-KIDDER	SW	02	TO88	R01W	FULL FACE	A, B, C, D, E
A31056	RIVER CITY STONE	RUBIE	SE	06	TO88	R03E	5-9	A, B, E
							FULL FACE	D
A31058	RIVER CITY STONE	HOLY CROSS	SW	12	TO90	R02W	FULL FACE	A, B, C, D, E
A31060	BARD CONCRETE	CASCADE EAST	SE	22	TO87	R01W	1-5	A, B, D
							2-5	E
A31064	RIVER CITY STONE	WEBER	NE	32	TO89	R02E	3-9A	A, B, C, D, E
A31066	RIVER CITY STONE	FILLMORE	SW	26	TO87	R01W	FULL FACE	A, B, D
							2-4	E
A49002	BELLEVUE S & G CO	BELLEVUE	SW	25	TO87	R04E	1-3	A, B, C, D, E
A49004	BELLEVUE S & G CO	LAMOTT	NW	02	TO86	R03E	1-2	A, B, C, D, E
A49008	WENDLING QUARRIES INC	IRON HILL	SW	16	TO85	R02E	1-6	A, B, C, D, E
A49010	WENDLING QUARRIES INC	ANDREW	NW	21	TO85	R03E	1B-5B	A, B, C, D, E
A49012	WENDLING QUARRIES INC	FROST	SE	16	TO84	R03E	1A-1E	A, B, C, D, E
A49016	WENDLING QUARRIES INC	WEIS	SE	22	TO85	R04E	7	A, B, C, D, E
A49018	WENDLING QUARRIES INC	PATASKA	NW	23	TO85	R05E	1	A, B, C, D, E

REVETMENT STONE
SOURCE APPROVAL

CODE	OPERATOR	SOURCE NAME	LOCATION				BEDS	REVETMENT CLASS
DISTRICT 6 (Continued)								
A49020	WENDLING QUARRIES INC	PRESTON	SW	26	TO84	R05E	1-10	D, E
							7-10	A, B, C, D, E
A49021	PRESTON READY MIX	PRESTON R/M	SW	26	TO84	R05E	7-10	A, B, C, D, E
A49022	WENDLING QUARRIES INC	BELLEVUE	SE	23	TO86	R04E	1B-3	A, B, C, D, E
A49024	WENDLING QUARRIES INC	MAQUOKETA EAST	SW	07	TO84	R03E	1-8	A, B, C, D, E
A49040	WENDLING QUARRIES INC	JOINERVILLE	SE	20	TO84	R02E	1-3	A, B, C, D, E
A49060	BELLEVUE S & G CO	ST. DONATUS		18	TO87	R03E	2-3	A, B, C, D, E
A49064	BELLEVUE S & G CO	VEACH		01	TO85	R02E	1-3	A, B, C, D, E
A49066	BELLEVUE S & G CO	MOREHEAD	NW	13	TO85	R01E	1-2	A, B, C, D, E
A52002	WENDLING QUARRIES INC	FOUR COUNTY	NW	04	TO81	R08W	9-16	D
A52004	RIVER PRODUCTS CO	CONKLIN	NW	33	TO80	R06W	2-10	E
							23	E
A52006	RIVER PRODUCTS CO	KLEIN	NW	02	TO79	R07W	2-10	E
							23	E
A53002	BARD CONCRETE	FARMERS-BEHRENDS	NE	14	TO86	R03W	1-5	A, B, C, D, E
A53004	WENDLING QUARRIES INC	MONTICELLO	NE	24	TO86	R04W	FULL FACE	A, B, C, D, E
A53010	WENDLING QUARRIES INC	BALLOU-OLIN	NE	24	TO83	R03W	FULL FACE	A, B, C, D, E
A53012	WENDLING QUARRIES INC	WYOMING		33	TO84	R01W	1-2C	A, B, C, D, E
A53014	WEBER STONE CO	JACOBS-SCOTCH GROVE	SW	07	TO85	R02W	FULL FACE	A, B, C, D, E
A53016	WEBER STONE CO	STONE CITY	E2	06	TO84	R04W	1, 3	A, B, C, D, E
A53018	RIVER CITY STONE	FINN	NE	06	TO85	R01W	2-5	A, B, E
							FULL FACE	D
							4-5	E
A53024	RIVER CITY STONE	SULLIVAN	NW	14	TO86	R03W	FULL FACE	A, B, C, D, E
A53026	RIVER CITY STONE	ANAMOSA	SW	15	TO84	R04W	REEF MATERIAL	A, B, C, D, E
A57002	WENDLING QUARRIES INC	BETENBENDER-COGGON	SW	03	TO86	R06W	1-10	A, B, C, D, E
A57006	WENDLING QUARRIES INC	ROBINS	NE	21	TO84	R07W	1-3	D
A57008	WENDLING QUARRIES INC	BOWSER-SPRINGVILLE	SW	29	TO84	R05W	1-8	A, B, C, D, E
A57010	WENDLING QUARRIES INC	TROY MILLS	SE	09	TO86	R07W	FULL FACE	D
A57014	WENDLING QUARRIES INC	SWEETING	NW	18	TO85	R08W	1-4	D
A57018	MARTIN MARIETTA	CEDAR RAPIDS	NE	15	TO82	R06W	2-9	A, B, C, D, E
A57028	WENDLING QUARRIES INC	BEVERLY	NW	07	TO82	R07W	6-7	A, B, E
							1-7	D
A57030	BRUENING ROCK PROD INC	HENNESSEY	NE	01	TO82	R07W	9-14, 15-16	D
A70002	WENDLING QUARRIES INC	MOSCOW	NW	08	TO78	R02W	11-17	D, E
							21A-24	A, B, C, D, E
							1-9	EROSION
							8-17	EROSION
A82002	RIVERSTONE GROUP INC	MCCAUSLAND	W2	17	TO80	R04E	1-19*	A, B, C, D, E
A82004	RIVERSTONE GROUP INC	NEW LIBERTY	NE	33	TO80	R01E	1-2, 3-4	A, B, C, D, E
A82006	RIVERSTONE GROUP INC	LECLAIRE	NW	35	TO79	R05E	2-32	A, B, C, D, E
							2-13	A, B, C, D, E
							14-29	A, B, C, D, E
AIL006	RIVERSTONE GROUP INC	MIDWAY (MC 45), ROCK IS CO	SW	16	TO18	R02E	1-10	A, B, C, D, E
AIL010	RIVERSTONE GROUP INC	ALLIED (MC 30), ROCK ISLAND CO		14	TO17	R02W	7-13, 14, 16-18	A, B, C, D, E
AIL016	RIVERSTONE GROUP INC	CLEVELAND (MC 31), HENRY CO	SW	31	TO17	R02E	1-4, 5, 6, 7, 8	A, B, C, D, E

* A82002- BEDS 7-9 NOT TO EXCEED 25% OF LIFT WHEN PRODUCING REVETMENT STONE.

APPROVED PRODUCERS
WITH QC PROGRAMS

PRODUCER	STREET ADDRESS	CITY, STATE, ZIP	PHONE/FAX NUMBER
A			
A-LINE CRUSHING SERVICE	1025 CENTER STREET	CEDAR FALLS, IA 50613	319-277-3001
ACME FUEL & MATERIALS CO	2544 PETTIBONE AVENUE	MUSCATINE, IA 52761	563-263-1105
AGGREGATE INDUSTRIES	2915 WATERS ROAD STE 105	EAGAN, MN 55121	651-686-2302
AGGREGATE MATERIALS CO	1400 E 12TH STREET	DUBUQUE, IA 52001	563-583-6642
AGGREGATES INC	6101 BLAIRS FERRY ROAD NE	CEDAR RAPIDS, IA 52411	319-395-0050
ALLIANCE MATERIALS INC	1822 WOLVERINE RD	DIXON, IL 61021	815-284-2130
ANDERSON SAND & GRAVEL CO	2578 270TH AVENUE	DEWITT, IA 52742	563-659-5506
ARCADIA LIMESTONE CO	19011 CRYSTAL AVENUE	ARCADIA, IA 51430	712-689-2299
B			
BMC AGGREGATES LC	101 BMC DRIVE	ELK RUN HEIGHTS, IA 50707	319-235-6583 319-235-7065 **(FAX)**
BARD CONCRETE CO	2021 325TH AVENUE	DYERSVILLE, IA 52040	563-875-7145 563-875-7860 **(FAX)**
BARD-KUHLMAN	2021 325TH AVENUE	DYERSVILLE, IA 52040	563-875-7145 563-875-7860 **(FAX)**
BEDROCK GRAVEL CO	1002 HWY 59 SOUTH	SCHLESWIG, IA 51461	712-676-3752
BELLCO OF NEBRASKA INC	2826 SOUTH AVENUE	COUNCIL BLUFFS, IA 51503	712-322-8501 712-322-8526 **(FAX)**
BELLEVUE SAND & GRAVEL CO	29427 HWY 52	BELLEVUE, IA 52031	563-872-3886
BENTON'S SAND & GRAVEL	1410 CENTER STREET	CEDAR FALLS, IA 50613	319-266-2621 319-266-5926 **(FAX)**
BIG STONES QUARRY, INC	2487 290TH STREET	PERU, IA 50222	515-988-4106 515-440-0944 **(FAX)**
BOON CONSTRUCTION CO	N 5399 STATE HWY 73	NEILLSVILLE, WI 54456	
BOYER SAND & ROCK INC	4162 BIRCH AVENUE	HAWARDEN, IA 51023	712-552-2308
BRIDGEPORT MATERIALS	2241 PORT NEAL ROAD	SERGEANT BLUFF, IA 51054	712-253-8449
BROCKMAN SAND CO	2397 263RD AVENUE-POB 312	FORT MADISON, IA 52627	319-372-7138
BRUENING ROCK PRODUCTS INC /SKYLINE CONSTRUCTION	325 WASHINGTON STREET-POB 127	DECORAH, IA 52101	563-382-2933 563-382-8375 **(FAX)**
BUILDERS SAND & CEMENT CO	104 WESTERN AVENUE	DAVENPORT, IA 52801	563-322-1757
C			
C.A.P RECYLCING	3150 LEWISTON ST	SIOUX CITY, IA 51105	712-870-0243
C. J. MOYNA & SONS INC	24412 HWY 13	ELKADER, IA 52043	563-245-1442
CANTERA AGGREGATES	1847 100TH STREET	CORYDON, IA 50060	641-216-3526
CARNARVON SAND & GRAVEL	811 N 10TH ST	DENISON, IA 51442	712-664-2511
CEMSTONE PRODUCTS COMPANY	2025 CENTRE POINT BLVD- SUITE 300	MENDOTA SPRINGS, MN 55120-1221	651-688-9292
CENTRAL STONE CO #1	RR 1-POB 236	HANNIBAL, MO 63401-9622	573-735-4525
CESSFORD CONST CO	2320 ZELLER AVENUE	LE GRAND, IA 50142	641-479-2695 641-479-2003 **(FAX)**
CESSFORD CONST CO - SE DIV	3808 OLD HWY 61	BURLINGTON, IA 52601	319-753-2297 319-753-0926 **(FAX)**
COHRS CONSTRUCTION INC	15700 NORTH TRADEWIND DRIVE	SPIRIT LAKE, IA 51360	712-832-3714
CONCRETE INC	1710 EAST MAIN ST	MARSHALLTOWN, IA 50158	641-752-3696
CONCRETE MATERIALS CO	1201 WEST RUSSELL	SIOUX FALLS, SD 57104	605-357-6000
CONRECO INC	4901 G STREET	OMAHA, NE 68117	402-733-4100 402-733-5774 **(FAX)**
COOTS MATERIALS CO INC	1700 WEST D STREET	VINTON, IA 52349	319-472-3046 319-472-4485 **(FAX)**

**APPROVED PRODUCERS
WITH QC PROGRAMS**

PRODUCER	STREET ADDRESS	CITY, STATE, ZIP	PHONE/FAX NUMBER
C			
CORELL RECYCLING	200 SOUTH 13TH STREET	WEST DES MOINES, IA 50265	515-223-8010
COUNTY MATERIALS CORP	205 NORTH ST-POB 100	MARATHON, WI 54448	715-848-1365
CRAWFORD QUARRY CO	HWY 94 NW-POB 1027	CEDAR RAPIDS, IA 52406	319-396-5705
CROELL REDI MIX	POB 430	NEW HAMPTON, IA 50659	641-394-3770
CRUSHED AGGREGATE PRODUCTS	1720 E AVE	RED OAK, IA 51566	712-579-5062
D			
DAVE'S SAND & GRAVEL INC	RR 2-POB 58A	HARTLEY, IA 51346	712-834-2515
DELONG RECYCLING, INC	1320 N 8TH AVENUE, POB 488	WASHINGTON, IA 52353	319-653-3334
DES MOINES ASPHALT & PAVING	5109 NW BEAVER DRIVE	JOHNSTON, IA50131	515-262-8296
DOUDS STONE LLC	13133 ANGLE RD SUITE B-POB 187	OTTUMWA, IA 52501	641-683-1671 641-683-1673 **(FAX)**
DUININCK BROS INC	408 6TH ST-POB 208	PRINSBURG, MN 56281	320-978-6011
E			
ELDER CORPORATION	5088 EAST UNIVERSITY AVE	DES MOINES, IA 50327	515-266-3111
F			
FALK L R- CONSTRUCTION CO	227 W 4TH STREET-POB 189	ST ANSGAR, IA 50472-0189	641-713-4569
FALKSTONE LLC	227 W 4TH STREET-POB 189	ST ANSGAR, IA 50472-0189	641-713-4569
FLEWELLING SAND & GRAVEL	1157 HWY 140	MOVILLE, IA 51039	712-873-3174
FLOYD RIVER MATERIALS	32138 HICKORY AVE	SIOUX CITY, IA 51101	712-233-1111
FORT CALHOUN STONE CO	7001 US HWY 75-POB 284	BLAIR, NE 68008	402-426-4254 402-468-4380 402-468-4388 **(FAX)**
FORT DODGE ASPHALT CO	2516 7TH AVENUE SOUTH	FORT DODGE, IA 50501	515-573-3124
G			
GEHRKE QUARRIES INC	POB 521	ELDORA, IA 50627	641-858-3821 641-858-2564 **(FAX)**
GEO TECH MATERIALS	13091 EAGLE DRIVE	DOUDS, IA 52551	
GRAY QUARRIES INC	POB 386	HAMILTON, IL 62341	217-847-2712
GREAT RIVER MATERIALS, LLC	1444 320TH AVE	WEVER, IA 52658	319-528-4065 319-528-4063 **(FAX)**
GREENE LIMESTONE CO	1211 SOUTH MAIN ST-POB 687	CHARLES CITY, IA 50616	641-228-4255 641-228-4061 (Shop)
GRIMES ASPHALT AND PAVING	1001 SE 37TH ST-POB 139	GRIMES, IA 50111	515-986-3649
H			
HAHN READY MIX	POB 1107	MUSCATINE, IA 52761	563-263-6467
HALLETT MATERIALS CO	5550 NE 22ND STREET-POB3365	DES MOINES, IA 50316	515-266-9928 515-266-9857 **(FAX)** 800-838-2615 (WIA)
HANK STALP GRAVEL CO	1598 RIVER ROAD	WEST POINT, NE 68788	402-372-5491 800-372-5491 (T-F) 402-372-5477 **(FAX)**
HARSCO METALS	1770 BILL SHARP BLVD, GATE 4	MUSCATINE, IA 52761	563-506-0634
HAWKEYE PAVING CORPORATION	801 42ND STREET S	BETTENDORF, IA 52722	563-355-6299
HEARTLAND ASPHALT INC	2601 SOUTH FEDERAL AVENUE	MASON CITY, IA 50401	641-424-1733
HEIMES EXCAVATING & UTIL CO	9144 SOUTH 147TH STREET	OMAHA, NE 68138	402-894-1000
HIGMAN SAND & GRAVEL INC	POB 438	AKRON, IA 51001	712-568-2181
HORSFIELD MATERIALS, INC.	505 EAST MAIN ST-POB 305	EPWORTH, IA 52045	563-876-3335

APPROVED PRODUCERS
WITH QC PROGRAMS

PRODUCER	STREET ADDRESS	CITY, STATE, ZIP	PHONE/FAX NUMBER
I			
IDEAL SAND CO	3902 MT PLEASANT ST-POB 416	WEST BURLINGTON, IA 52655	319-754-4747
IOWA DRAINAGE INC	703 E. GILMAN ST- POB 7	SHEFFIELD, IA 50475	641-892-4330
K			
K&L CONSTRUCTION INC	501 S. RIDGE ROAD	SERGEANT BLUFF, IA 51054	712-943-2939
KERFORD LIMESTONE CO	36110 FLETCHER ST	WEEPING WATER, NE 68463	402-267-2415
KNIFE RIVER MIDWEST LLC	600 HIGHWAY 175-P.O. BOX 229	STRATFORD, IA 50249	515-838-2475
L			
L G EVERIST INC	POB 9	DELL RAPIDS, SD 57022	605-428-5419 605-428-3012 **(FAX)**
L&M SAND & GRAVEL INC	426 2ND AVENUE NE	LE MARS, IA 51031	712-546-5359
L&W QUARRIES INC	POB 335	CENTERVILLE, IA 52544	641-437-4830 641-437-4837 **(FAX)**
LA HARV CONST CO INC	POB 267	FOREST CITY, IA 50436	641-581-3643
LESSARD CONTRACTING INC	POB 705	SERGEANT BLUFF, IA 51054	712-252-4131
LINWOOD MINING & MINERALS CORP	5401 VICTORIA AVE, SUITE 110	DAVENPORT, IA 52807	563-359-8251 800-798-8251 (T-F) 563-344-3730 **(FAX)**
LOUNSBURY LANDSCAPING	6000 RACCOON RIVER DR	WEST DES MOINES, IA 50266	515-225-7100
LUNDELL CONSTRUCTION CO., INC	1420 EAST RICHLAND	STORM LAKE, IA 50588	712-732-4059
LYMAN-RICHEY SAND & GRAVEL	4315 CUMING STREET	OMAHA, NE 68131	402-558-2727
M			
MALLARD SAND & GRAVEL	POB 638	VALLEY, NE 68064	402-359-5287
MANATT'S INC	1755 OLD 6 ROAD-POB 535	BROOKLYN, IA 52211	641-522-9206 641-522-9407 **(FAX)** 641-522-5594 **(FAX)**
MANATT'S SAND & GRAVEL	1928 340TH STREET-POB 87	TAMA, IA 52339	641-484-4022
MARENGO READY MIX INC	POB 121	MARENGO, IA 52301-0121	319-642-3811
MARTIN COMMERCIAL ENTERPRISES		DAVENPORT, IA 52807	563-529-2223
MARTIN MARIETTA AGGREGATES	11252 AURORA AVENUE	DES MOINES, IA 50322	515-254-0030 800-332-5433 (T-F) 515-254-0035 **(FAX)**
MASS CUSTOM HAULING & CRUSHING	1207 W. 10TH ST.	MILAN, IL 61264	309-756-0217
MATX INC	110 CLUBRIDGE PLACE	COLORADO SPRINGS, CO 80906	
MCALISTER AGGREGATES LLC	1924 HWY 141- POB 157	BAYARD, IA 50029	800-642-6653 712-651-2018 **(FAX)**
MELLER EXCAVATING & ASPHALT	3321 190TH STREET	FORT MADISON, IA 52627	319-372-7410
MIELKE'S QUARRY	13303 SPOOK CAVE RD	MCGREGOR, IA 52157	563-539-4227
MILESTONE MATERIALS	920 10TH AVE NORTH-POB 189	ONALASKA, WI 54650	608-783-6411 608-783-4311 **(FAX)**
MOBILE CRUSHING & RECYCLING	2663 OSCEOLA AVENUE	OTHO, IA 50569	515-576-8080
MOHR SAND, GRAVEL & CONST. LLC	POB 232, 104 ASH STREET	LOHRVILLE, IA 51453	712-210-7078
M.R. PAVING AND EXCAVATION	2020 NORTH SPRING ST- POB 787	NEW ULM, MN 56073	507-354-4171
MURPHY HEAVY CONTRACTING CORP	101 ROOSEVELT ST	ANITA, IA 50020	712-762-3386
MYRL & ROY'S PAVING INC	1300 NORTH BAHNSON AVENUE	SIOUX FALLS, SD 57103	605-334-3204 605-334-0468 **(FAX)**

**APPROVED PRODUCERS
WITH QC PROGRAMS**

PRODUCER	STREET ADDRESS	CITY, STATE, ZIP	PHONE/FAX NUMBER
N			
NELSTAR	210 WALNUT	MERIDEN, IA 51037	712-443-8832
NEW ULM QUARTZITE QUARRY	ROUTE 5-POB 21	NEW ULM, MN 56073	507-354-2925
			507-359-7870 **(FAX)**
NORRIS QUARRIES LLC	219 3RD ST-POB 190	CAMERON, MO 64429	816-324-0310
NORTHERN CON-AGG, LLP	1450 131ST STREET	LUVERNE, MN 56156	507-283-2124
NORTH IA SAND & GRAVEL INC	18237 KILLDEER AVENUE	MASON CITY, IA 50401	641-424-5591
			641-423-1894 **(FAX)**
NORTHWEST ILLINOIS CONST LLC	1600 REGAN RD	ROCK FALLS, IL 61071	815-626-5192
NORTHWEST MATERIALS	16 NORTH TAFT-POB 632	FORT DODGE, IA 50501	515-573-8921
NORTHWEST R/M CONCRETE INC	6340 180TH STREET	OCHEYEDAN, IA 51354	712-758-3683
NU AGGREGATES	300 NORKA DRIVE	AKRON, IA 51001	712-568-2181
O			
ORTONVILLE STONE CO	POB 67	ORTONVILLE, MN 56278	320-839-6131
P			
PATRICK M. PINNEY CONTRACTORS	1915 FLOYD BLVD-POB 5107	SIOUX CITY, IA 51102	712-252-2774
PAUL NIEMANN CONST CO	24541 150TH STREET-POB 128	SUMNER, IA 50674-0128	563-578-3261
			563-578-3263 **(FAX)**
PBI CONST	4953 D AVE	MARCUS, IA 51035	712-376-4886
PELLA CONST CO LTD	POB 25	PELLA, IA 50219	641-628-3840
PERSINGER SAND & GRAVEL	3281 LUCAS AVENUE	SMITHLAND, IA 51056	712-889-2258
PERU QUARRY	2587 265TH ST	PERU, IA 50222	515-468-0315
PETERSON CONTRACTORS INC	104 BLACKHAWK-POB A	REINBECK, IA 50669	319-345-2713
PETTENGILL CONC & GRAVEL INC	800 NORTH BOONE	ROCK RAPIDS, IA 51246	712-472-2571
PNB PROCESSORS, LLC	POB 80	DENMARK, IA 52624	319-470-0050
PRAIRIE SAND & GRAVEL	POB 210	PRAIRIE DU CHIEN, WI 53821	608-326-6471
PRESTON READY MIX CORP	POB 399	PRESTON, IA 52069	563-689-3381
Q			
QUALITY CONCRETE CO	327 17TH AVENUE SOUTH	CLINTON, IA 52732	563-242-3524
R			
RAINBOW QUARRY LLC	800 VOLNEY RD	MONONA, IA 52159	563-535-7606
RECYCLED AGGREGATE PROD CO	2131 18TH STREET	SIOUX CITY, IA 51105	712-252-7732
REDINGS GRAVEL & EXCAVATING CO	2001 EAST OAK STREET	ALGONA, IA 50511	515-295-3661
RED ROCK QUARRY	12226 KNOX AVE.	SANBORN, MN 56083	507-648-3382
REILLY CONSTRUCTION CO	110 MAIN STREET-POB 99	OSSIAN, IA 52161	563-532-9211
			563-532-9759 **(FAX)**
RIEHM CONSTRUCTION CO INC	2340 9TH STREET SW	WAUKON, IA 52172	563-568-3314
RIVER CITY STONE	3747 CONSTRUCTORS COURT-POB 160	KEILER, WI 53812-0160	608-568-3433
RIVER PRODUCTS CO INC	3273 DUBUQUE ST NE- POB 2120	IOWA CITY, IA 52244-2120	319-354-1090
			319-353-6606 **(FAX)**
RIVERSTONE GROUP INC	1701 5TH AVENUE	MOLINE, IL 61265	309-757-8250
			309-757-8257 **(FAX)**
ROCK HARD CONCRETE RECYCLING	214 E. MAIN ST-POB 217	WEST BRANCH, IA 52358	319-631-3903
ROCKY MOUNTAIN ENTERPRISES	6515 COUNTY HIGHWAY H	ATHENS, WI 54411	715-257-1440
			715-257-1140 **(FAX)**

**APPROVED PRODUCERS
WITH QC PROGRAMS**

PRODUCER	STREET ADDRESS	CITY, STATE, ZIP	PHONE/FAX NUMBER
S			
S&A CONSTRUCTION LTD	POB 20	ALLENDALE, MO 64420	660-786-2233
S&G MATERIALS	4213 SAND ROAD SE	IOWA CITY, IA 52240	319-354-1667
SAVANNA QUARRY, INC	9859 SCENIC BLUFF ROAD	SAVANNA, IL 61074	815-273-4208
SCHILDBERG CONSTRUCTION CO	POB 358	GREENFIELD, IA 50849	641-743-2131
SCHMILLEN CONST INC	4772 C AVENUE	MARCUS, IA 51035-0488	712-376-2249
SHIPLEY CONTRACTING	2671 240TH STREET	FORT MADISON, IA 52625	319-372-1804
SIEH SAND & GRAVEL	101 WEST 18TH STREET-POB 1503	SPENCER, IA 51301	712-836-2244 712-262-4580
SOUTHERN MN CONST CO, INC.	1100 MARCUS ST-POB1100	FAIRMONT, MN 56031	507-235-3321
SPENCER QUARRIES	25341 430TH AVENUE	SPENCER, SD 57374	605-246-2344
STENSLAND GRAVEL CO	1741 ASHLEY AVE	LARCHWOOD, IA 51241	712-477-2280
STERZINGER CRUSHING INC	3273 290TH AVE	TAUNTON, MN 56291	
STONER SAND	33463 EAST 250TH	RIDGEWAY, MO 64481	660-824-4211
STRATFORD GRAVEL INC	3378 XAVIER AVE	DAYTON, IA 50530	515-571-3133
STRONG ROCK & GRAVEL	721 SOUTH FRONT ST	LANSING, IA 52151	563-538-4603
SWAIN CONSTRUCTION INC	6002 NORTH 89TH CIRCLE	OMAHA, NE 68134	402-571-1110
SWAN ROCK & SAND PRODUCTS, LLC	POB 111	CINCINNATI, IA 52549	641-658-2474 641-777-1233 (CELL)
T			
TIEFENTHALER AG-LIME INC	11975 HAWTHORNE AVENUE-POB 157	BREDA, IA 51436	712-673-2686
TRI CITY BLACKTOP	425 S. DEVILS GLEN RD	BETTENDORF, IA	563-359-3491
TRISTAR QUARRIES	11278 474TH ST	PLANO, IA 52581	
TUBE CITY IMS CORP	1500 WEST 3RD STREET	WILTON, IA 52778	563-732-4010
U			
ULLAND BROTHERS INC	2400 MYERS ROAD	ALBERT LEE, MN 56007	507-373-1960 507-433-1819
UNITED CONTRACTORS, INC	6678 NW 62ND AVE – P.O. BOX 347	JOHNSTON, IA 50131	515-276-6162
V			
VALLEY SAND & GRAVEL	POB 9	ROCK VALLEY, IA 51247	712-476-2063
W			
WEATHERTON CONTRACTING	307 N 16TH ST-POB151	BERESFORD, SD 57004	605-763-2078
WEBER STONE CO INC	12791 STONE CITY ROAD	ANAMOSA, IA 52205	319-462-3581 319-462-3585 **(FAX)**
WENDLING QUARRIES INC	POB 230	DEWITT, IA 52742	563-659-9181 563-659-3393 **(FAX)**
WEST DES MOINES SAND CO	3888 WALNUT WOODS DR	DES MOINES, IA 50265	515-287-2340
WESTERN ENGINEERING COMPANY	POB 350	HARLAN, IA 51537	712-755-5191
WETHERELL SAND & GRAVEL	POB 37	PETERSON, IA 51047	712-260-8556
WILTGEN CONSTRUCTION CO	113 EAST MAIN STREET-POB 817	CALMAR, IA 52132	563-562-3301 800-365-3301 (T-F)
WINN CORP SAND & GRAVEL	2334 JUNIPER AVENUE	FAIRFIELD, IA 52556	641-693-3333
WRIGHT MATERIALS CO	1127 HWY 69-POB 244	BELMOND, IA 50421	641-444-3920
Z			
ZUPKE SAND & GRAVEL	17963 150TH STREET	RANDALIA, IA 52164	563-428-4444

SPEC 2301
PCC PAVEMENT

Section 2301. Portland Cement Concrete Pavement

2301.01 DESCRIPTION.

A single course of PCC pavement of the type and class specified in the contract. If the class of concrete is not specified, Class C concrete shall be used.

A. Standard Concrete Pavement.
Standard concrete pavement may be reinforced or non-reinforced. Use the class of concrete specified in the contract documents. Reinforce as shown in the contract documents. Place within fixed forms, consolidate, and finish by equipment operating on forms.

B. Slip Form Pavement.
Slip form pavement may be reinforced or non-reinforced concrete of the class specified in the contract documents. Reinforce as shown in the contract documents. Place, consolidate, and finish without the use of fixed forms.

2301.02 MATERIALS.

A. General.

1. Meet the requirements for the respective items in Division 41. Unless specified otherwise, use coarse aggregate of the durability class required by Section 4115.

2. Ensure compatibility of all material combinations. If the concrete materials are not producing a workable concrete mixture, a change in the material may be required. Changes will be at no additional cost to the Contracting Authority.

B. Portland Cement Concrete Pavement.

1. General.

a. Proportion materials for pavement concrete in one of the mixtures identified in Materials I.M. 529 for the class of concrete specified in the contract documents. Any of the mixtures may be used, at the Contractor's option, provided the gradation of the separate aggregates complies with the gradation required for that mixture. Do not use C-5 and C-6 concrete mix proportions for pavements on Interstate or Primary highways.

b. After October 31, use Class A concrete to construct all items of concrete pavement specified to be constructed with Class B concrete. The Engineer will either require completion by continuing placement operations past October 31, or allow the Contractor the option of a winter shutdown. When completion is required, the Contracting Authority will pay the net increase in cost of materials resulting from the change in proportions for any pavement placed within the contract period or authorized extension of the contract period. Other increases shall be at no additional cost to the Contracting Authority.

2. **Combined Fine and Coarse Aggregate.**
   a. If using an approved fine and coarse aggregate combination, fix the proportions on the basis of the relative amount of fine and coarse aggregate contained so as to be equivalent to one of the appropriate mixes specified for screened aggregates. These proportions are based on a specific gravity of 2.62 for Class V aggregate and 2.65 for other aggregates.
   b. If the material furnished shows an average specific gravity other than the above values, adjust the proportions by the ratio of the actual average specific gravity to the above values.

3. **Water, Consistency, and Batch Yield.**
   a. Use an amount of mixing water that will produce workable concrete of uniform consistency. Unless specifically modified by the Engineer, ensure slump, measured according to Materials I.M. 317, is no less than 1/2 inch (15 mm) or no more than 4 inches (100 mm). Slump requirements will not apply to slip form paving.
   b. If it is not possible to produce concrete having the required consistency without exceeding the maximum allowable water cement ratio specified, the cement content may be increased or water reducing admixture may be added. Obtain the Engineer's approval. Do not exceed the maximum water cement ratio. Additional cement or water reducer will be considered incidental, with no additional cost to the Contracting Authority.
   c. The basic absolute volume of water per unit volume of concrete is based on average conditions. If material characteristics require that the total quantity of water used to secure the required consistency reduces the batch yield (computed on the basis of absolute volumes of the batch quantities used) by more than 2.0%, the Engineer may adjust the proportions to correct the yield. This adjustment will not be a basis for adjustment of the contract unit price.

4. **Entrained Air Content.**
   Use an approved air entraining agent. The target air content as determined by Materials I.M. 318 is 8.0%, with a tolerance of ± 2% when measured on the grade just prior to consolidation. Air content for non slip form paving is 7.0% ± 1.5%. The target air content may be adjusted by the Engineer based on random tests of the consolidated concrete behind the paving machine. These additional random tests will be used to consider the need for a target change, and will not be used in the acceptance decision.

5. **Admixtures.**
   Approved admixtures complying with Section 4103 may be used with the Engineer's authorization.

6. **Use of Supplementary Cementitious Materials.**
   The maximum allowable fly ash substitution rate is 20%. The GGBFS substitution rate shall not be more than 35% by weight (mass). The total mineral admixture substitution rate shall not exceed 40%. When Type IP or IS cement is used in the concrete mixture, only fly ash substitution

will be permitted. Between October 16 and March 15, substitution of Type I/II cement with fly ash and GGBFS, or Type IP or IS cement with fly ash will be allowed only when maturity method is used to determine time of opening.

C. Proportioning and Mixing of Concrete Materials.
Proportion and mix materials according to the following requirements:

1. Storage and Handling of Aggregates.

a. Store and handle aggregates to avoid contamination and frequent variations in specific gravity, gradation, or moisture content of the materials used.

b. Keep fine and coarse aggregate stored in piles or bins entirely separate of one another.

c. When aggregates are trucked to the proportioning plant, the trucks must dump off a ramp or into a walled pit. In either case, they must dump into a floored area. This floor shall consist of a substantial platform or a layer of similar aggregate at least 18 inches (0.5 m) thick placed entirely below the elevation of the surrounding ground.

d. Reduce, to a minimum the Engineer considers practical, the number of changes from one material to another having different frictional characteristics, class of durability, or average specific gravity.

e. At the time of proportioning or placing in proportioning bins, the moisture content of the aggregates shall be such that water will not drain or drip from a moisture sample. Handle aggregates in a manner that will prevent variations of more than 0.5% in moisture content of successive batches. Thoroughly wet coarse aggregates having an absorption greater than 0.5% and allow to drain for at least 1 hour before being used.

f. Drain fine aggregate at least 24 hours after washing and before batching.

g. Do not allow aggregates from two sources to commingle in stockpiles or in the finished pavement, except with the Engineer's approval.

2. Storage and Handling of Cement and Fly Ash.

a. Store cement in suitable weatherproof enclosures and handle to prevent loss.

b. Apply Section 4101 to cement which has developed lumps or which has been stored for extended periods.

c. Transport and store fly ash in suitable weatherproof enclosures in a manner to keep it dry.

d. Use proportioning equipment meeting the requirements of Article 2001.20, B.

3. Measurement of Materials.
Measurement of materials shall meet the requirements for the type of equipment used and the following additional requirements:

a. Operate cement scales within a delivery tolerance of 1.0% of the mass of cement per batch. When operated manually, balance scales to tare before each batch is weighed and after each batch is discharged.

b. Use cement and fly ash scales with automatic controls which meet the requirements of Article 2001.20, B, for all bid items involving more than 6000 square yards (5000 m^2) of pavement or base. Items made up of irregular areas, such as crossovers, turn lanes, and so forth, are excluded from this requirement.

c. Do not use manual controls for a period longer than 1 working day after a failure of the automatic controls, except with the Engineer's permission.

d. On work requiring automatic scales, the performance of the scale will be determined near the end of the first full day of production. Afterwards, performance of the scale will be determined at a frequency not to exceed 10,000 cubic yards (10,000 m^3) of concrete produced. Performance will be determined by comparing the accumulated mass of cement proportioned with the corresponding accumulated mass of cement shipped to the project. The Contractor shall cooperate. Cement scale performance determinations are not required when a permanent, commercial ready mix plant is used to furnish less than 10,000 cubic yards (10,000 m^3) of concrete for a contract.

e. Determine the performance of fly ash scale, if present, as in Paragraph d above.

f. Operate aggregate scales within a delivery tolerance of 1.0% for each aggregate.

g. Measure water within a delivery tolerance of 1.0% of intended quantity.

h. Measure admixtures with approved equipment and procedures that assure the quantity measured is within a delivery tolerance of 3.0% of batch quantity. Clean and flush out mechanical dispensing equipment daily, and more frequently if necessary to ensure proper operation.

4. Mixing of Materials.

a. General.

1) Mix concrete materials either at the site of placement or in a construction or stationary mixer to be used for work on the project only. Concrete may also be ready mixed or transit mixed. During any one individual placement, use the same cement, aggregates, and admixtures throughout the placement unless the Engineer approves otherwise. With the Engineer's approval, concrete mixtures may be furnished from multiple plants provided the same materials are used in each mixture and mix consistency can be maintained.

2) Mix concrete material as provided in Article 2001.21 for the type of equipment used.

3) Do not use concrete transported without continuous agitation if the elapsed period between the time the concrete is mixed and the time it is placed is greater than 30 minutes. With the Engineer's approval, an approved retarding admixture may be used at the rate prescribed in Materials I.M. 403. Also with the

Engineer's approval, the mixed-to-placed time period may be extended an additional 30 minutes.

4) Do not use concrete transported with agitation when the time between start of mixing and placement is more than 90 minutes.

5) Deliver and handle concrete in a manner that will:
- Prevent objectionable segregation or damage to the concrete, and
- Facilitate placing with a minimum of handling.

6) Thoroughly clean and flush the compartment in which the concrete is transported to the work at intervals necessary to ensure hardened concrete will not accumulate in the compartment. Discharge flushing water from the compartment before it is charged with the next batch.

7) Obtain Engineer's approval for plant equipment, operation, and procedures.

b. Concrete Mixed in a Construction or Stationary Mixer.

1) Use a method of handling batches and charging the mixer that ensures complete introduction of each batch separately without loss of materials.

2) Concrete discharged from the mixer is required to be uniform in composition and consistency. If this condition is not produced because of the size of the batch, the batch size may be reduced or the mixing time increased, or both, until this result is obtained.

c. Ready Mixed Concrete.

1) Ready mixed concrete is defined as concrete for which the required materials are as follows:

a) Proportioned in a central plant and mixed in a stationary mixer for transportation in trucks with or without agitation.

b) Proportioned and then mixed in a transit mixer prior to or during transit.

2) When additional mixing water is required at the site of placement, mix the batch for at least an additional 30 revolutions of the drum at mixing speed.

3) For main portions of the work designed to support public vehicular traffic:

a) Demonstrate to the Engineer before the work starts that each vehicle in which concrete will be delivered to the work is capable of discharging concrete having a slump not over 2 inches (50 mm) at an overall rate for its entire load of no less than 1.25 cubic yards (1 m^3) per minute.

b) Ensure concrete is delivered at a rate sufficient to maintain a sustained rate of progress no less than 100 feet (30 m) per hour for the width and depth of slab to be placed.

c) Ensure adequate and properly staffed dispatching system is utilized.

4) Ready mixed or transit mixed concrete may be used for other portions of the work under other restrictions specified for bid items involving 6000 square yards (5000 m^2) of pavement or less. Ready mixed or transit mixed concrete may also be used for irregular pavement areas such as crossovers and turn lanes.

2301.03 CONSTRUCTION.

When the contract allows for either standard or slip form pavement, the method used is the Contractor's option. When the contract allows only one type, use the type specified. When slip form is specified, small or irregular areas may be constructed with fixed forms. Irregularly shaped areas of either type of pavement may be formed and finished by hand methods.

A. Equipment.

1. General.
Provide sufficient equipment to perform all operations necessary to complete the work. Use equipment meeting the appropriate requirements of Section 2001 and the following provisions.

2. Proportioning and Mixing Equipment.
Use equipment that complies with the following:

a. Weighing and Proportioning Equipment.
Apply Article 2001.20.

b. Mixing Equipment.
Apply Article 2001.21.

c. Bins.
Apply Article 2001.06.

3. Construction Equipment for Portland Cement Concrete Pavement.
Use equipment that complies with the following requirements:

a. Equipment for Standard Concrete Pavement.

1) Side Forms.

a) General.

(1) Use side forms with a height (without horizontal joint) at least equal to the design thickness of the pavement at its edge. The additional height represented by integral curb may be secured by bolting extra forms on the top of the main form.

(2) Ensure the top face of a form does not vary from a true plane by more than 1/8 inch in 10 feet (3 mm in 3 m). Ensure the vertical face does not vary from a true plane by more than 1/4 inch in 10 feet (6 mm in 3 m).

(3) For curves having radii of 100 feet (30 m) or less, use flexible or curved forms.

b) Forms Required to Support Heavy Equipment.

(1) Use steel no thinner than U.S. standard 5 gauge (approximately 7/32 inch (5 mm)). Equip with a device that permits adjustment for horizontal and vertical curves for holding abutting sections firmly in alignment.

(2) If using forms having a height of 8 inches (200 mm) or more, ensure the base is no less than 8 inches (200 mm) wide. If using forms having a height less than 8 inches (200 mm), ensure their base width is no less than their height. Equip with no less than three staking points per each 10 feet (3 m) of length, with means for securely locking the form to each stake. Extend flange braces and staking pockets outward on the base no less than 65% of the height of the form.

c) Forms Not Required to Support Heavy Equipment.

(1) Forms not required to support heavy equipment may be made of wood or steel. Ensure forms have sufficient stiffness and are staked to remain vertical and true to line and grade during placing and finishing of concrete.

(2) Use nominal 2 inch (50 mm) stock straight wood forms.

(3) Use wood forms that are finished on the side supporting the concrete and on their upper edge.

2) Integral Curb Forms.

Meet the requirements of Section 2512.03, C.

3) Supplementary Rails.

a) Provide suitable metal rails capable of being securely attached to the top of the side forms to provide a track which will allow spreading, finishing, and curing equipment to back over the end of the previous day's run.

b) Ensure metal rail length is sufficient to accommodate all equipment which must be backed out of the way. Also ensure the rails are of such a height that all wheels and flanges of wheels will clear the previously placed concrete by at least 1/2 inch (15 mm).

4) Form Line Excavating Machine.

Excavate form lines for all forms supporting mechanical finishing equipment to line and grade by:

- A machine designed for this purpose and approved by the Engineer, or
- An approved machine which concurrently trims the subgrade or subbase to grade.

5) Subgrade Preparation.

Trim the subgrade or subbase to grade with a machine having electronic elevation controls. The Engineer's approval is required for other trimming methods.

6) Consolidating and Finishing Equipment.

For placing and finishing standard type pavement, the following equipment will be required:

a) Vibrators.

(1) Consolidate, with a single pass of an approved internal or surface vibrator, the full width and depth of concrete requiring a finishing machine. Operate internal vibrators within a frequency range of 4000 to 8000 vibrations per minute. The Engineer may authorize the minimum vibration frequency to be lowered to 3500 vibrations per minute for particular sections of paving, such as superelevations. Operate surface vibrators within a frequency range of 3500 to 6000 vibrations per minute.

(2) Avoid operating vibrators in a manner to cause a separation of mix ingredients, either a downward displacement of large aggregate particles or an accumulation of laitance on the surface of the concrete. When forward motion of the paver is reduced, vibrator frequency may need to be reduced to avoid separation of the mix.

(3) If a vibrator fails to operate within the specifications, repair or change the vibrator before paving begins:

- The following day, or
- The same day if the continuous paving that day is stopped at a header or the end of a session.

(4) If two adjacent vibrators fail to operate within specifications, stop paving operations and repair or replace the vibrators.

(5) Stop vibrators whenever forward motion of the paver is stopped.

(6) Use an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator for all Interstate and Primary contracts with PCC paving quantities of mainline paving over 50,000 square yards (40,000 m^2) and other projects when specified in the contract documents. When required on a contract, the vibrator monitoring device will only be required in areas where mainline pavement length exceeds 600 feet (175 m). When project staging necessitates small mainline sections be paved separately from the majority of mainline paving, the Engineer may waive this requirement for those small sections.

(7) Use a vibrator monitoring device that meets all of the following:

(a) Has a readout display near the operator's controls visible to the paver operator and the Engineer.

(b) Operates continuously while paving.

(c) Displays all vibrator frequencies with manual or automatic sequencing among all individual vibrators.

(d) Records, at a minimum, the clock time, station location, paver track speed, and operating frequency of individual vibrators. Make recordings after each 25 feet (8 m) of paving or after each 5 minutes of time.

(8) Provide the Engineer with an electronic record daily for the first 3 days of paving and weekly thereafter. The Engineer may determine that more frequent submission is necessary, particularly if equipment malfunctions occur.

(9) If the electronic monitoring device fails to operate properly, manually check vibrators immediately. If vibrators are functioning properly, paving may continue, but correct the problem as soon as possible. If recording device fails to operate, paving may continue, but correct the malfunction within 3 paving days. The Engineer may allow additional time if circumstances are beyond the Contractor’s control.

(10) Set the internal vibrator penetration depth into the concrete pavement slab to mid slab or as deep as possible while passing above reinforcing steel. Provide an operating position locking device so that no part of the vibrating unit can be lowered to the extent that it will come in contact with reinforcing steel or tie bars while paving.

(11) Do not exceed the manufacturer’s recommendations for vibrator horizontal spacing. Do not exceed 16 inches (410 mm) from center to center.

(12) Mount longitudinal axis of vibrator body approximately parallel to direction of paving. Tilt trailing end of each vibrator downward to an approximate slope of 15 degrees below horizontal.

(13) Use vibrators that meet or exceed the following specifications at the manufacturer's design frequency of 10,000 vpm:

- **(a)** Amplitude (peak to peak) 0.070 inches (1.75 mm).
- **(b)** Centrifugal force 1200 pounds (5500 N).

b) Finishing Machine.

(1) Where side clearance is provided, a finishing machine designed for concrete paving will be required on all uniform width slabs 8 1/2 feet (2.6 m) or wider upon which a continuous line of forms more than 600 feet (180 m) in length may be set. Obtain Engineer’s approval before using this machine. Utility accesses, intakes, and other small fixtures will not be considered as an obstruction to the continuity of the form line. Railroad tracks, bridges, and existing paved intersections will be considered as obstructions in the continuity of the form line.

(2) Use a finishing machine that leaves the top of the concrete slab smooth with the desired crown and at the proper elevation. When the contract documents require the pavement to be laid partly with crown and partly without crown, equip the screed so that it can be adjusted to the change in shape at the required rate of change.

(3) If during the operation of subgrade or finishing equipment it is necessary to operate one or both sets of wheels or tracks on previously placed concrete, adjust or alter the wheels or tracks so that the bearing on the concrete will not be closer than 3 inches (75 mm) from the pavement edge. When operating with one side of the machine on pavement and the other side on forms, the wheels operating on the forms may be double flanged. Use flangeless, rubber faced wheels on the pavement. When operating over the edge of concrete less than 2 months old, support the ends of the finishing machine screeds with an approved device to provide from 1/16 to 1/8 inch (2 mm to 3 mm) clearance between the screed and previously placed pavement.

(4) Suspension resulting in a pendulum effect will not be approved.

(5) Sections of pavement not required to be finished with a finishing machine may be finished by hand equipment as provided in Article 2301.03, A, 3, d.

b. Equipment for Slip Form Concrete Pavement.

1) Form Line Excavating Machine.

When it is necessary to excavate to line and grade the path over which the pavement laying machine travels, use either:

- A machine designed for this purpose and approved by the Engineer, or
- A machine which operates concurrently with the trimming of the subgrade or subbase.

2) Subgrade Preparation.

Use an electronically controlled machine to trim the subgrade or subbase to grade to the Engineer's satisfaction.

3) Placing, Consolidating, and Finishing Equipment.

a) Use a slip form paving machine that meets all of the following:

(1) Is designed for the specific purpose of placing, consolidating, and finishing concrete pavement slabs without the use of fixed side forms.

(2) Leaves the edges of the slab vertical.

(3) Is self propelled and equipped with a means for spreading the concrete to a uniform depth before it enters the throat.

(4) Vibrates the concrete to the full width and depth being placed in a single passage. Accomplish vibration with vibrating tubes or arms working in the concrete or a vibrating pan operating on the surface of the concrete. Apply Article 2301.03, A, 3, a, for the amplitude, rate of vibration, monitoring, and locking device for depth.

(5) Produces a surface reasonably free of voids and tears.

b) When slip form paver is operated with one or both tracks on previously placed concrete, use tracks that are rubber faced, or travel on cushions of wood or belting, to prevent damage to the pavement surface.

c) Use a paver equipped with automatic horizontal and vertical grade controls.

4) False Forms.

With Engineer's approval, false forms may be used on slip form pavement work in areas that:

- Are to be subsequently abutted with other lanes of pavement in the 20 feet to 30 feet (5 m to 10 m) preceding a day's work joint, or
- Require vertical edge support.

c. Curing Equipment.

1) To apply liquid curing compounds (if used) on surfaces of pavements of uniform width for a continuous length of over 5000 feet (1500 m), use approved mechanical spraying equipment operating on the forms or outside the pavement edges. Use equipment with a shield provided to prevent undue loss of curing compound by wind action.

2) Hand spraying equipment may be used on vertical edges, hand finished sections, and all other pavement surfaces.

d. Finishing Equipment, Hand Method.

Apply the following for placing and finishing concrete by hand methods:

1) Vibrators.

Use:

- Vibration rate between 3500 to 6000 vibrations per minute, and
- Amplitude sufficient to be perceptible on the surface of the concrete more than 12 inches (0.3 m) from the vibrating unit.

2) Screed.

Use a screed that is:

- True to crown (may be of wood or metal), and
- Adjustable for crown (or furnish a separate screed for each variation in crown).

e. Finishing Tools.

Provide all finishing tools necessary for proper finishing of the concrete, including straight edges for checking and correcting finished concrete surfaces.

f. Washing Water.

Maintain an adequate supply of water suitable for washing testing equipment. Place at a convenient location near the site of concreting operations, as directed by the Engineer and at no additional cost to the Contracting Authority.

B. Subgrade Construction.

1. Unless a subbase is specified, prepare the subgrade for standard pavement according to Section 2109.

2. Comply with the following for subgrade construction for slip form pavement:

a. When the contract documents include a bid item for Class 10 excavation, perform all the work necessary for proper preparation of the subgrade.

b. When the contract documents do not include a bid item for Class 10 excavation, it may be assumed that the subgrade has been or will be shaped and compacted by others. Acceptable tolerance for that work is described in Article 2102.03, L, except that at approaches to existing improvements or structures, corrections will be based on a practical minimum cut and fill for the project.

3. Shape and compact subgrade according to the applicable following method:
   a. **Subbase Not Specified.**
      If no subbase is specified, prepare the subgrade according to the requirements of Section 2109.
   b. **Subbase Specified.**
      If a subbase under pavement is specified, prepare the subgrade according to the requirements for that type of subbase.
   c. **Proof Rolling Requirements.**
      1) Proof roll subgrades (with or without subbase) no more than 1 week prior to trimming of the final grade. Perform proof rolling with a minimum of one pass using equipment meeting the requirements of Article 2001.05.
      2) Treat all areas not meeting the requirements of 2107.03, E, as specified in Section 2109.

C. Setting of Forms.

1. When side forms are used, set them accurately to the required grade and alignment. Found and secure them to maintain the required grade and alignment while concrete is being placed and finished and until it is time for the forms to be removed. Set forms on properly compacted materials.

2. Set forms with:
   - The base at the design elevation of the subgrade of the pavement at its edge, and
   - The top at the design elevation of the surface of the pavement at its edge.

3. With the Engineer's approval, forms having a height greater than design thickness of the edge of the pavement may be used when set as follows:
   a. **Side Forms.**
      Side forms may be set with their tops at the design elevation of the finished surface of the pavement and their bases at an elevation lower than the design base, subbase, or subgrade elevation. However, base, subbase, or subgrade material shall be excavated to meet the lower edge of the form with a straight, lateral slope no steeper than one vertical to four horizontal. Additional excavation and concrete required by this method will be at no additional cost to the Contracting Authority.
   b. **Integral Curb Forms.**
      Forms for integral curb shall be rigidly attached to supporting side forms using all fastenings provided by the manufacturer. Take special care to remove all water and laitance from the edge of the pavement before the curb is placed.

4. After setting and locking forms, tamp on both sides throughout their entire length using a suitable tool. Ensure tamping forces suitable material into contact with the base of the form for its entire length and width. Tamp the forms that are to support mechanical finishing machines. Tamping of forms set on bases or subbases may be waived if the excavation and bedding of the forms meet the Engineer's approval. If rain or standing water softens the earth or subbase so that the form is not adequately supported, reset the form on suitable material before concrete is placed.

5. Clean forms before resetting. Coat with form oil before concrete is placed against them. Use an oil that will produce a film to prevent concrete from adhering to form.

D. Fixtures in Pavement Surface.

1. Adjust manholes, intakes, valve boxes, or other fixtures encountered within the area to be paved to conform to the finished surface of the pavement to be built. Payment for adjustment of manholes and intakes will be per Section 2435. Payment for adjustment of valve boxes and other fixtures will be per Section 2554. Prior to placing the concrete, clean foreign material from the outside of the fixtures for the depth of the concrete.

2. Construct fixtures as shown in the contract documents. Fixtures that fall in a form line may be boxed out if a finishing machine is being used. Do not cut or divide boxed out concrete on the original form line.

E. Placing Reinforcement and Placing Dowel Bars.

1. **Placing Reinforcement.**
   a. Place reinforcement prior to vibration so it will be in its intended position in the completed concrete according to Article 2404.03, D. For slip form paving, tie bars may be installed after vibration, provided the concrete is consolidated around the bars. Reinforcing bars may be supported by approved chairs or be placed in position by a machine or method approved by the Engineer.
   b. Use approved continuous bolsters with runners to support reinforcement for bridge approach sections. Place supports transversely across the approach and space them longitudinally no greater than 4 feet (1.2 m). For double reinforced approach sections the top layer of reinforcing may be chaired off the bottom layer of reinforcing using approved continuous high chairs with runners, provided they are positioned directly above the continuous bolsters with runners supporting the bottom layer of reinforcing. Hold epoxy coated reinforcing steel in place with epoxy or plastic coated bar supports and epoxy or plastic coated tie wires. Use continuous bolsters with runners and continuous high chairs with runners, either plastic or steel, meeting the requirements of Materials I.M. 451.01.

c. When welded wire fabric reinforcement is used (alternate methods of placing welded wire fabric reinforcement will be considered for approval):
   1) Strike the concrete off at the elevation specified for fabric reinforcement.
   2) Place the sheets as indicated in the contract documents. Handle and place the fabric carefully to ensure its installation in the proper position. Ensure the fabric is flat.
   3) Deposit the balance of the concrete and vibrate in a manner that will not displace or distort the fabric. Sheets that have become bent or kinked may be rejected.

2. **Placing Load Transfer Devices.**
   a. Load transfer devices may be required in the contract documents. Accurately place these assemblies as shown. To prevent their movement during subsequent concrete paving operations, securely stake or fasten to the base to line and grade. Do not use mechanical dowel bar inserters.
   b. Do not use damaged assemblies. Ensure horizontal and vertical alignment of the load transfer bars does not exceed 1/4 inch (5 mm) from parallel to line and grade. Place each assembly so bars are in a horizontal plane at T/2 ± 1/2 inch (15 mm).
   c. Check placement of each assembly and the position of the bars within the assembly using a suitable template or other device approved by the Engineer. If assembly is found to be placed outside the above tolerances, correct the placement.
   d. A maximum of three tie wires may remain uncut on each load transfer assembly.

3. When dowels or tie bars or other articles are to be anchored in existing concrete, use a grout system listed in Materials I.M. 491.11 or 491.22 according to the manufacturer's instructions. Obtain Engineer’s approval.

4. For horizontal installation of dowels or tie bars, use either a pressure injection system with mechanical proportioning and mixing, or encapsulated chemical anchors. Install as follows:
   a. Ensure drilled or preformed holes to receive the grout match the dimensions and spacing shown in the contract documents. When not shown in the contract documents, the maximum nominal diameter of the hole must be 1/8 inch (3 mm) larger than the outside diameter of the dowel or bar, or as recommended by the manufacturer. Blow the hole clean with compressed air immediately prior to placing the grout.
   b. Pressure inject the grout into the rear of the hole. Use sufficient grout so that when the bar, insert, or other article to be grouted is placed in position, excess grout will be forced out the front of the hole. Rotate the article to be grouted during the insertion process to ensure complete coating with the grouting material. Hand proportioning and mixing will not be allowed.

5. If using grout with approved encapsulated anchors, install according to the manufacturer’s recommendations.

6. Use installation procedures for vertical or angled installations that are similar to those for horizontal installation. Pourable grouts may be used. Pourable grouts shall be mechanically mixed.

F. Placing Concrete.

1. The contract documents will show the width the pavement will be constructed. Unless otherwise shown, construct the pavement in a single pass.

2. Unless the Engineer permits otherwise, place pavement to be constructed using ready mix concrete in single lane widths only. Permission will be based on evaluation of type, quality, and quantity of equipment to be used and its anticipated rate of production.

3. At the Contractor's option, pavements may be placed in single traffic lane widths under the following conditions:
   - **a.** Submit a proposed plan of operation for approval of the Engineer.
   - **b.** Furnish (at no additional cost to the Contracting Authority) additional dowels, tie bars, or extra concrete required to conform to the approved, modified method of operation.
   - **c.** Deposit concrete upon the supporting surface in a manner which will minimize segregation and disturbance of reinforcement.
   - **d.** Except when welded wire fabric reinforcement is used, deposit concrete to the full depth of the pavement in a single operation. When welded wire fabric is used, apply Article 2301.03, E.

4. Operate vibrating units as recommended by the manufacturer and in a manner which complies with Article 2301.03, A, 3, a.

5. Concrete shall be placed and consolidated in a manner that prevents material retained in the grout box of the finishing machine from being incorporated into the pavement. At headers, concrete screeded over the header during finishing shall be removed.

6. Cure vertical edges of pavements and backs of curbs according to Article 2301.03, K.

7. Repair honeycombed areas on pavement edges immediately after removal of forms.

8. Place backfill material behind curbs, as directed by the Engineer, to prevent a flow of water in this area and subsequent undermining of pavement.

G. Multiple Lane Construction.

1. Construct all lanes and sections of pavement to the widths shown in the contract documents unless written approval has been secured for alternate methods described in Article 2301.03, F.

2. Construct expansion and contraction joints to be continuous across all lanes. Do not stagger expansion and contraction joints.

3. Edge the edge of the pavement adjacent to the steel form, or at any supplemental form or bulkhead that will be abutted by a subsequent slab, using a tool with a radius of 1/8 inch (3 mm) or less. Extend the cutting edge of the tool moving along the form downward beyond the rolled edge of the form to its vertical face. Tool the edge on abutting lanes in the same manner.

4. When keyed joints are required, fasten the keyway to the form by a method that will ensure construction of the keyed joint. Use fasteners that can remain in place until the concrete has been placed adjacent to and above the keyway.

H. Finishing and Texture.
Finish the concrete promptly after it has been placed and consolidated. Following the finishing operations, apply texture to the surface.

1. **Finishing.**
   - **a.** After the concrete has been consolidated, use the screed to strike off the surface to the true section. Finish the surface true to line and grade.
   - **b.** Ensure additional water is not added directly to the surface by spray wand, brush, or other methods. Burlap may be attached behind the screed and a small amount of water may be used to wet the burlap to facilitate finishing operations. Avoid wetting the surface to the extent a slurry is created.
   - **c.** Ensure the edge is true and uniform. Hand corrections may be needed if this is not accomplished by the paver.
   - **d.** When finishing by hand methods, consolidate concrete using vibrating units operating in the concrete. If the vibrating apparatus cannot consolidate the full width of the concrete in a single pass, use a definite system or pattern when operating the vibrator that ensures the full width of concrete in each linear foot (meter) of lane receives adequate and uniform consolidation. Obtain the Engineer’s approval for the vibrating system and methods. Do not use vibrating equipment as a tool for moving concrete laterally on the grade.
   - **e.** The Contractor may use a float on the pavement surface.

2. **Microtexture.**
   - **a.** Microtexture is constructed to produce a roughened surface on the driving areas of the pavement.

b. Drag artificial turf, coarse carpet, or burlap longitudinally over the finished surface to produce a tight, uniform, textured surface. Burlap may be dampened to prevent adhesion of PCC mixture.

c. When, for any reason, the desired texture normally obtained by the drag is not secured, the Engineer may require that the final finish be a broom finish in lieu of, or in addition to, the drag finish. To obtain a broom finish, drag a suitable broom transversely across the surface of the plastic concrete.

3. Macrotexture.

a. General.

Macrotexture (tining) is constructed by placing grooves in the surface of a pavement, normally while the concrete is plastic.

b. Application.

1) Where the speed limit is greater than 35 mph (60 km/h), place macrotexture as required in Table 2301.03-1.

2) When surface corrections are made in the hardened concrete, no macrotexture replacement is required.

Table 2301.03-1: Macrotexture Requirements

Pavement/Placement Type	Macrotexture Orientation		Macrotexture Not Required
	Longitudinal	Transverse	
Mainline - slip-form	X		
Mainline - handwork		X	
Turn lanes - slip-form	X	1	
Turn lanes - handwork		X	
Ramps - slip-form	X	1	
Ramps - handwork		X	
Gapped sections of mainline - slip-form	X	1	
Gapped sections of mainline - handwork		X	
Radii			X
Crossovers			X
Paved Medians			X
Shoulders			X
Irregular Areas			X
Bridge Approaches		2	

1. Transverse macrotexture permitted for placements less than 600 feet (180 m) in length.
2. Transverse tining required unless longitudinal grooving in concrete is specified in the contract documents.

c. Operation.

1) General.

For tining, use a mechanical device that:

- Has a single row of tines that are 1/8 inch ± 1/64 inch (3 mm ± 0.5 mm) wide, and
- Forms grooves in the plastic concrete that are1/8 inch (3 mm) deep as a target, with a ± 1/16 inch (± 1.5 mm) tolerance.

2) Transverse Tining.

a) For transverse tining, uniformly space tines at 1/2 inch (12 mm) intervals.

b) At transverse joints, leave a 4 inch to 6 inch (100 to 150 mm) wide strip of pavement surface (centered along the joint) that is not tined for the length of the joint.

c) Transverse tining may be placed by hand methods.

3) Longitudinal Tining.

a) For longitudinal tining, uniformly space the tines at 3/4 inch (20 mm) intervals.

b) Accomplish longitudinal tining using equipment with horizontal and vertical controls to ensure straight, uniform grooves.

c) At longitudinal joints, leave a 2 inch to 3 inch (50 to 75 mm) wide strip of pavement surface (centered along the joint) that is not tined for the length of the joint.

d) Do not place longitudinal tining by hand methods.

d. Limitations.

1) Place tining in a time and manner producing the desired surface texture while minimizing displacement of larger aggregate particles. Complete tining before pavement surface permanently sets.

2) Where abutting pavement is to be placed, extend tining as close as possible to the edge without damaging the edge. Where abutting pavement is not to be placed, do not tine the 6 inch (150 mm) area nearest the edge or 1 foot (300 mm) from the face of the curb.

3) Do not tine the outside 2 feet (0.6 meters) if placing structural rumble strips (rumble strips placed in the outside 2 feet (0.6 meters) of PCC pavements, as shown in the contract documents, to deter traffic).

4. Smoothness.

a. Construct the pavement to have a smooth riding surface within the following tolerances:

1) Periodically check the pavement longitudinally with a 10 foot (3 m) straightedge. The surface is not to deviate from a straight line by more than 1/8 inch in 10 feet (3 mm in 3 m).

2) If slip form methods are used, the 6 inches (150 mm) nearest the edge may exceed the 1/8 inch (3 mm) tolerance, but is not to exceed 1/2 inch deviation in 10 feet (13 mm deviation in 3 m).

3) Where abutting pavement is to be placed adjacent to the pavement being checked, the surface is not to deviate by more than 1/4 inch (6 mm) when checked 1 inch (25 mm) from the edge with:

- A 3 foot (1 m) straightedge used transversely, and

- A 10 foot (3 m) straightedge used longitudinally.

b. Apply Section 2317 to all PCC Pavement bid items of a Primary project if any individual PCC Pavement bid item for that project is 5000 square yards (4200 m^2) or greater. Apply Section 2316 to all other Primary projects or when specifically required for other projects.

I. Integral Curb.

1. Before placing curb concrete, remove all free water, laitance, dust, leaves, or other foreign matter which may have collected on the edge of the slab.

2. Construct integral curbs before the initial set, but following the main paving slab finishing, except as provided for in Article 2301.03, J.

3. Do not use concrete which has dried, partially hardened, or requires retempering.

4. Construct integral curb as rapidly as paving slab finishing operations will permit. Complete integral curb construction the same day the slab is placed, except for the length of section required at the end of the day's run to accommodate the mechanical placing and finishing equipment. In the section left for subsequent curb placement, depress the paving slab surface along the line of the inside curb slope so that the new concrete placed for curb is no less than 1 1/2 inches (40 mm) thick. Tie this section of curb to the slab by using No. 3 (Size 10) hooked steel bars spaced at 1 foot (300 mm) intervals. Roughen the surface of the slab back of the key notch. Create a depression around each dowel so it will project at least 2 inches (50 mm) into the curb concrete.

5. Consolidate curb concrete to secure adequate bond with the paving slab and eliminate honeycomb in the curb. Avoid disturbing the alignment of forms or gutter flow line.

6. After removing face forms or shaping with the curb slip form, complete the final finish on curbs using hand methods, including the use of a 6 foot (1.8 m) straightedge. Check the resulting surfaces of both curb and gutter using the 10 foot (3 m) straightedge. Correct if necessary. When removing forms, avoid creating slumps and disturbing partially set concrete.

7. When curb is built on slabs traversed by headers or contraction or expansion joints, extend the joints through the curb directly over the joint in the slab at the same thickness as in the main slab.

8. Edge, protect, and cure all curbs the same as other parts of the paving slab.

J. End of Run.

1. **General.**
   a. Install an approved header whenever 30 minutes or more have elapsed since the last concrete has been deposited on the subgrade, or if such a delay is anticipated.
   b. Do not construct a header joint:
      - Within 5 feet (1.5 m) of an intended or previously placed contraction joint.
      - Opposite a contraction joint in multiple lane construction.
   c. When a header joint is installed, wait a minimum of 6 hours to resume paving which abuts the header. When concrete delivery is resumed, place it adjacent to the exposed face of the header. Thoroughly consolidate the concrete and finish with an edging tool at the joint. Sawing and sealing of this joint is not required.
   d. When the end of the day's run occurs in curb section, omit sufficient curb to accommodate equipment which must be backed out of the way. Construct the portion of the curb omitted as shown in the contract documents and according to Article 2301.03, I.

2. **Headers Constructed in Plastic Concrete.**
   a. Construct the header true to line and grade with the face perpendicular to the surface and at right angles to the centerline of the pavement. Ensure tie bar reinforcement is level, true to line and grade, and normal to the header joint.
   b. Concrete collected by a finishing machine during its first pass must not be used adjacent to the header board. Promptly remove concrete screeded over the header during finishing.
   c. Consolidate concrete against the header and finish with an edging tool.
   d. Remove the header board and all supports before paving is resumed.

3. **Headers Constructed in Hardened Concrete.**
   The Contractor may pave past the location of the header. After the concrete has hardened, saw the pavement perpendicular to the centerline of the pavement, creating a vertical face. Drill holes for the tie bar reinforcement and grout the reinforcement into the holes according to Article 2301.03, E. Paving operations may begin adjacent to the header after a minimum of 1 hour following the placement of the reinforcement bars.

K. Curing and Protection of Pavement.

1. **General.**
   a. After finishing operations are complete, cure concrete pavement according to Article 2301.03, K, 2. Cure bridge approaches, medians, curbs, and ramps according to Article 2301.03, K, 2.
   b. Cure vertical edges of pavement and backs of curbs by the same method used for curing the surface.

2. **Curing with White Pigmented Liquid Curing Compound.**
   - **a.** Apply curing compound in a fine spray to form a continuous, uniform film on the surface and vertical edges of the pavement slab.
   - **b.** Apply curing compound as soon as the free water has appreciably disappeared, but no later than 30 minutes after finishing. With the Engineer's approval, cure application timing may be adjusted due to varying weather conditions and concrete mix properties to achieve acceptable macrotexturing.
   - **c.** Use an application rate of no less than 0.067 gallon per square yard covering 15 square yards per gallon (0.3 L/m^2 covering 3 m^2/L).
   - **d.** Ensure liquid curing materials are well agitated in the supply drum or tank immediately before transfer to the distributor. Keep curing materials well agitated during application.
   - **e.** Apply using power spraying equipment capable of producing a fine spray which will not damage the surface of the concrete. Hand operated sprayers may be used for spraying the sides and irregular areas.
   - **f.** If forms are used, coat vertical edges of the pavement within 30 minutes of form removal using curing material applied at the same rate as on the surface.
   - **g.** If, due to other operations, the coating is damaged within 72 hours after being applied, immediately re-coat the affected areas. Coating of the sawed surface with curing compound will not be permitted on joints that are to be sealed. When pavement is opened to traffic prior to 72 hours after application of the curing coating, a re-coating will not be required.
   - **h.** Apply a white pigmented curing compound meeting the requirements of Section 4105.

3. **Cold Weather Protection.**
   - **a.** Apply cure to all concrete pavement, including exposed edges of the slab, according to Article 2301.03, K, 2, prior to applying protection.
   - **b.** Protect concrete pavement less than 36 hours old as shown in Table 2301.03-1. Payment will be made as provided in Article 2301.05.

Table 2301.03-2: Concrete Pavement Protection Requirements

Night Temperature Forecast	Type of Protection[(a)]
35°F to 32°F (2°C to 0°C)	One layer of burlap for concrete.
31°F to 25°F (-1°C to -4°C)	Two layers of burlap or one layer of plastic on one layer of burlap.
Below 25°F (-4°C)	Four layers of burlap between layers of 4 mil (100 μm) plastic, insulation blankets meeting the requirements below, or equivalent commercial insulating material approved by the Engineer.

(a) Protection shall remain overnight the first night covering is required. After the first night of covering, protection may be removed when one of the following conditions is met:
1. The pavement is 5 calendar days old.
2. Opening strength is attained.
3. Forecasted low temperatures exceed 35°F (2°C) for the next 48 hours.
4. Forecasted high temperatures exceed 55°F (13°C) in the next 24 hours and subgrade temperatures are above 40°F (4°C).

c. When insulation blankets are used, use blankets consisting of a layer of closed cell polystyrene foam protected by at least one layer of plastic film, rated by the manufacturer with a minimum R-value of 1.0 (0.1761 for metric units).

d. Shut down paving operations in time to comply with protection requirements outlined above. The cover may be temporarily removed to perform sawing or sealing. The Engineer may modify temperature restrictions and protection requirements.

4. Rain Protection.

a. Protect the pavement from rain damage.

b. To protect against the effects of rain on paving, have materials available near the worksite for proper protection of the edges and surface of concrete. Protective material may consist of sheets of burlap, paper, or plastic film. Keep planks (or other material with suitable stakes) on hand that can be used as temporary forms.

c. Failure to properly protect concrete may constitute cause for removal and replacement of defective pavement.

d. When pavement is placed directly on natural subgrade (Section 2109) construct earth check dams immediately after removing forms or after the slip form passes. This will prevent water from flowing along the edge of the pavement and undermining the slab. Space earth check dams and construct them wide enough such that they do not provide an approach over which a vehicle may be driven onto the pavement.

L. Safety Fence for Pavement.

1. In addition to the requirements of Article 1107.09, install a safety fence for the full width of the slab near the end of each day's run.

2. Support the safety fence by setting posts near to the edge of the slab. Extend posts at least 2 feet (0.6 m) into the ground. Between the posts, stretch and secure a 48 inch (1.2 m) nominal height orange mesh safety fence meeting the requirements of Article 4188.03. Cut the twisted ends of the wire off flush with the twist so that a tool would be required to cut or otherwise release the fastening.

3. Support the fence span between the posts with no less than four equally spaced plastic drums weighted to make them stable and difficult to move. Use drums approved according to Materials I.M. 488.02.

4. On urban work where it is not feasible to set posts, steel drums or sand box supports may be substituted for the end posts.

5. Place a similar safety fence parallel to and within 50 feet (15 m) from the edge of the slab at public road and side street intersections. Construct these fences similar to the end of day's run safety fences.

6. To prevent traffic from entering on and damaging the pavement slab, install safety fences within 1 hour of the completion of finishing and curing operations at the fence location. Leave safety fences in place and maintain until the concrete has attained the strength and age requirements of Article 2301.03, U.
7. Intermediate safety fences may be required for the purpose of opening the slab for access to a side road, side street, or entrance.

M. Removal of Forms.

1. Leave side forms and curb forms in place for no less than 6 hours after the concrete is placed, unless earlier removal is required by Article 2301.03, N.

2. Exercise care when removing forms to prevent cracking, spalling, or over stressing the concrete.

3. Remove all stakes in any form before the form is raised.

4. If the method of form removal causes damage to the concrete, the Engineer may require forms to remain in place for more than 6 hours.

N. Sawing Joints.

1. Saw joints in a single cutting operation for a specific joint. Make saw cuts true to line and to the dimensions shown in the contract documents.

2. Begin joint sawing as soon as the concrete has hardened sufficiently to permit sawing without raveling or moving of aggregate. Saw joints before uncontrolled cracking takes place.

3. Control joints may be sawed by any saw designed for concrete sawing.

4. If necessary, use continuous sawing operations regardless of weather or daylight conditions.

5. Discontinue sawing a joint if a crack develops ahead of the saw.

6. A heavy span saw which is supported on the new pavement will not be allowed for sawing pavements and concrete overlays less than 7 inches (180 mm) deep.

7. If the pavement has been covered or protected due to cold weather, rain, or snow, saw joints by conventional saw equipment only.

8. Saw joints requiring compression sealant materials to be installed according to Article 2301.03, P, so that the compression sealant material can be installed and function correctly.

9. Repair uncontrolled cracking or random transverse cracking (at no additional cost to the Contracting Authority). Use repair methods approved by the Engineer.

10. When the normal pavement section is reduced by box-outs, such as for intakes, construct a contraction joint by sawing. Begin at one end of the box-out and extend to the pavement edge. Alternate types of transverse joints will be considered for approval. If box-out length exceeds 15 feet (4.5 m), construct a contraction joint at both ends.

O. Expansion Joints.

1. Install preformed joint material perpendicular to the pavement surface. Exercise care throughout pavement construction to ensure that the joint material remains in proper position.

2. Set reference stakes or markers showing exact joint location prior to placing concrete adjacent to the joint. After the mechanical finishing equipment has passed over the joint, check the joint for movement. If movement in excess of 1/2 inch (10 mm) has occurred, immediately correct the installation to its intended position.

3. After the surface finishing has been completed, edge the joint as shown in the contract documents with minimum disturbance to the adjacent concrete. Supplemental vibration equipment is required for proper consolidation of the concrete.

P. Sealing Joints.

1. Unless provided otherwise, seal joints as designated in the contract documents before any portion of the pavement is opened to the Contractor’s forces or to general traffic. Saw or prepare joint openings to the designated dimensions. Clean and seal joint openings with one of the appropriate materials described in Section 4136.

2. Use joint sealer described in Article 4136.02, A, to seal sawed joints in PCC pavement, shoulders, medians, crossovers, and side road pavements, unless specified otherwise in the contract documents.

3. Within 3 hours after a joint has been wet sawed to the finished dimension, flush the wet sawing residue away from the sawed faces using a high pressure water blast operating with a minimum pressure of 1000 pounds per square inch (7000 kPa). Within 3 hours after the joint has been dry sawed to the finished dimension, blow the dry sawing residue from the joint. Use air compressors that provide moisture and oil free compressed air.

4. Immediately prior to installation of sealant, clean joints with an air blast. Do not perform sealing until visual examination verifies the joint surfaces appear dry, in addition to being clear of dust and contamination. Prepare joint sealer and install in the joint and to the proper level as shown in the contract documents and as recommended by the manufacturer. Heat hot poured sealers in a thermostatically controlled heating kettle. Heat the material to the temperature required for use, but not above that recommended by the manufacturer. After sealing, remove excess sealer from the pavement surface.

5. Place joint sealer only when the pavement and ambient air temperatures are 40°F (4°C) or above. When near this minimum, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the joint faces. When this sealer cannot be properly placed due to late fall work, submit a joint construction plan and sealing details to the Engineer for approval before commencing paving. Delay the cleaning, sealing, and, if required, resawing of joints until the following spring. This delay requires the Engineer's approval.

6. When surface correction is required, repair seals damaged from the corrective work. Joint preparation, cleaning, and sealing may be delayed until after corrective work, provided the pavement is not opened to traffic before corrective work is performed.

7. The Engineer may limit the wheel loads and axle loads of equipment operating on the pavement during preparation, cleaning, and sealing operations, if prior to the age and strength specified in Article 2301.03, U. Additional tests to determine the modulus of rupture may be required.

8. If early pavement opening is specified, the cleaning, sealing, and, if required, resawing of joints shall be accomplished after the pavement is opened to traffic if hot pour sealing material is used.

Q. Concrete Median Strip.

Where the contract documents call for construction of concrete median strip between adjacent slabs, construct the median strip to conform to the dimensions shown and to the following provisions:

1. Construct the subgrade for the median strip to the elevation shown according to Article 2109.03, A.

2. Use the class of concrete specified for the pavement. Use placement and finishing methods that meet the requirements of this Section. Hand methods may be used and surface texturing will not be required.

3. Saw and seal joints as required for jointed pavement. When spacing is not designated, space joints as required for jointed pavement. Match median joints with joints in the abutting pavement.

4. Gore areas will be considered median strips. When constructed or reconstructed while the highway is open to public traffic, use Class M concrete.

R. Bridge Approach Sections, Reinforced Paved Shoulders, and Full-width Reinforcement for Pavements.

1. Construct bridge approach sections, reinforced paved shoulders, and full-width reinforcement for pavements as shown in the contract documents.

2. Use epoxy coated reinforcing according to Article 4151.03, except that cut or sheared ends need not be recoated.

3. Unless otherwise noted in the contract documents, use a clear distance of 2 inches (50 mm) between the face of concrete to near reinforcing steel.

4. Use Class C Concrete with coarse aggregate durability according to Section 4115.

S. Restriction of Operations Because of Weather.

1. Do not place concrete when stormy or inclement weather will prevent good quality work.

2. Do not use aggregates containing frozen lumps.

3. Do not place concrete on a frozen subgrade.

4. Concrete mixing and placement may be started, if weather conditions are favorable, when the air temperature is at least 34ºF (1ºC) and rising. At the time of placement, concrete shall have a temperature of at least 40ºF (4ºC).

5. Stop mixing and placing when the air temperature is 38ºF (3ºC) or less and falling.

6. During cold weather conditions, protect concrete less than 36 hours old in the manner specified in Article 2301.03, K, 3.

T. Night Operation.
Do not place concrete when darkness would prevent good quality work in placing and finishing operations. Unless shown in the contract documents or approved by the Engineer, placing and finishing operations under artificial light will not be permitted. Organize work accordingly.

U. Time for Opening Pavement for Use.

1. The time for opening pavement for use will be based on the restrictions listed in Table 2301.03-2, with flexural strength determined from beam specimens made during the progress of the work.

Table 2301.03-3: Minimum Flexural Strength

Strength Class of Concrete	Minimum Age	psi (MPa)
A	14 calendar days[(a)]	500 (3.45)
B	14 calendar days	400 (2.80)
C	7 calendar days[(b)]	500 (3.45)
M	48 hours[(c)]	500 (3.45)
(a) 10 calendar days for concrete 8 inches (200 mm) thick or more. (b) 5 calendar days for concrete 9 inches (230 mm) thick or more. (c) Pavement may be opened for use prior to 48 hours when minimum flexural strength requirements are met.		

2. At the Contractor's option (unless specified otherwise in the contract documents), the time for opening pavement may be determined through the use of the maturity method as described in Materials I.M. 383.

3. Apply the following when the maturity method is used:

a. The time for opening pavement will be based on strength requirements only, as specified in Table 2301.03-2. Furnish all labor, equipment, and materials necessary for the development of the maturity-strength relationship as described in Materials I.M. 383.

b. The Engineer will determine if sufficient strength has been achieved for opening a section of pavement. The Contractor's maturity testing may be used as the basis for this determination. Provide sufficient documentation of maturity testing before opening a section to traffic.

c. Should circumstances arise which are beyond the Contractor's or Engineer's control and strength cannot be determined by the maturity method, apply minimum age, minimum flexural strength, and fly ash restrictions.

d. Develop a new maturity curve for any change of a material source or proportion in the concrete mixture.

4. In cases where early opening of pavement is desirable, the Engineer may require the use of Class M concrete mixtures. Such sections of pavement may be opened to traffic in accordance with Table 2301.03-2.

5. At the Contractor's option, when Type I/II cements are used, Class C fly ash may be substituted for up to 10%, by weight (mass), of the cement in Class M concrete mixtures. Type IP and Type IS cements may be used in Class M concrete mixtures without fly ash substitution.

V. Shoulders.

Construct shoulders according to Section 2121, 2122, or 2123, as indicated in the contract documents.

W. Surfacing Approaches to Intersecting Roads, Driveways, and Turnouts.

Surface approaches to intersecting roads, driveways, and turnouts as provided in Section 2315.

2301.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Portland Cement Concrete Pavement.

1. Square yards (square meters), of the type specified, shown in the contract documents. The area of manholes, intakes, or other fixtures in the pavement will not be deducted from the measured pavement area.

2. The coring requirements for thickness do not apply to detour pavements, paved drives, and temporary pavements. The thickness of pavement constructed will be determined from core depths as follows:

- **a.** The division of sections, lots, and core locations will be according to Materials I.M. 346.
- **b.** At locations determined by the Engineer, cut samples from the pavement, as directed above, by drilling with a core drill that will provide samples with a 4 inch (101.6 mm) outside diameter. Restore the surface by tamping low-slump concrete into the hole, finishing, and texturing. The Engineer will witness the core drilling, and identify and measure the cores immediately. The Engineer will measure the cores and determine the thickness index according to Materials I.M. 346. After measurement on the grade, deliver the cores to the Engineer's office or field laboratory. When cores are not measured on the grade, the Engineer will take immediate possession of the cores.
- **c.** Coring of pavement and other work for thickness determination may be waived by mutual agreement for sections of the same design thickness less than 5,000 square yards (4200 m^2).
- **d.** Only sections which are cored will be included in the thickness index determination. Areas not cored will be paid for at the contract unit price.

B. Integral Curb.

Incidental to the other items of work. Not measured for payment.

C. Concrete Median.

Square yards (square meters) shown in the contract documents. This will be calculated to the nearest 0.1 foot (0.1 m) of the length along the surface and the overall width of median when no integral curb is involved, or the width from back to back of curb when integral curb is involved.

D. Bridge Approach Sections.

Square yards (square meters) shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and a price per cubic yard (cubic meter) for excavation, the excavation required for preparation of natural subgrade will be measured as provided in Article 2102.04. The volume measured for payment will include only the materials actually removed above the elevation of the pavement subgrade and between vertical planes 1 foot (0.3 m) outside the edge of the finished pavement.

2. Other work connected with preparation of natural subgrade will not be measured for payment.

3. When the contract provides a unit price for earth shoulder construction (whether or not a unit price per cubic yard (cubic meter) of excavation is provided in the contract), excavation required for preparation of natural subgrade will not be measured for payment. Unless otherwise provided in the contract documents, work connected with preparation of natural subgrade will not be measured for payment.

F. Driveway Surfacing Material.
Tons (megagrams) or cubic yards (cubic meters), as provided in the contract and in Section 2315, placed at intersecting roads, drives, and turnouts. Excavation required for placement of this material will not be measured for payment.

G. Portland Cement Concrete Pavement Samples.
Not individually counted for payment when furnished according to Article 2301.04, A, or when required in the contract documents.

H. Saw Cut and Joint Sealing.

1. Saw cut for constructing joints in new pavement will not be measured for payment.

2. Saw cut for cutting old existing pavement, which is to be abutted with new pavement, will not be measured for payment.

3. Joint sealing will not be measured for payment.

I. Safety Fence for Pavement.
Not measured for payment.

J. Rumble Strip Panel (PCC Surface)
By count for Rumble Strip Panels properly installed at locations designated in the contract documents.

2301.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Portland Cement Concrete Pavement.

1. Contract unit price for Standard or Slip-Form Portland Cement Concrete Pavement of the type specified per square yard (square meter).

2. Payment for the quantities of pavement in square yards (square meters) will be at a percentage of the contract unit price according to Table 2301.05-1.

Table 2301.05-1: Payment Schedule for Quantities of Pavement

Thickness Index Range	Percent Payment	Thickness Index Range	Percent Payment
English (Metric)		English (Metric)	
0.00 or more (0.00 or more)	103	-0.56 to -0.60 (-13.98 to -15.24)	91
-0.01 to -0.05 (-0.01 to -1.27)	102	-0.61 to -0.65 (-15.25 to -16.51)	90
-0.06 to -0.10 (-1.28 to -2.54)	101	-0.66 to -0.70 (-16.52 to -17.78)	89
-0.11 to -0.15 (-2.55 to -3.81)	100	-0.71 to -0.75 (-17.79 to -19.05)	88
-0.16 to -0.20 (-3.82 to -5.08)	99	-0.76 to -0.80 (-19.06 to -20.32)	87
-0.21 to -0.25 (-5.09 to -6.35)	98	-0.81 to -0.85 (-20.33 to -21.59)	86
-0.26 to -0.30 (-6.36 to - 7.62)	97	-0.86 to -0.90 (-21.69 to -22.86)	85
-0.31 to -0.35 (-7.63 to -8.89)	96	-0.91 to -0.95 (-22.87 to -24.13)	84
-0.36 to -0.40 (-8.90 to -10.16)	95	-0.96 to -1.00 (-24.14 to -25.40)	83
-0.41 to -0.45 (-10.17 to -11.43)	94	-1.01 to -1.05 (-25.41 to -26.67)	82
-0.46 to -0.50 (-11.44 to -12.70)	93	-1.06 to -1.10 (-26.68 to - 27.94)	81
-0.51 to -0.55 (-12.71 to -13.97)	92	-1.11 or less (-27.95 or less)	80

3. Use the following formula to determine the thickness index for the section of pavement thickness:

Where: $TI = (\overline{X} - S) - T$

TI = thickness index for the section.
$\overline{X}$ = mean core length for the section.
T = design thickness.
S = core length standard deviation (of the sample) for the section.

4. Replace pavement represented by cores deficient from design thickness by 1 inch (25 mm) or greater. The deficient areas and the replacement of the deficient cores will be determined according to Materials I.M. 346.

5. At the Contractor's option, cores that are three standard deviations or greater than design thickness may be removed from analysis for thickness index determination. Do not remove more than 10% of the total cores in a section. Do not replace cores removed from the analysis.

6. Gaps in the pavement less than 500 feet (150 m), required by staging, will be considered irregular areas for analysis of pavement thickness determinations.

7. The percent payment for projects which have all core lengths greater than design thickness will be at least 100%.

B. Integral Curb.
Not paid for separately.

C. Concrete Median.
Contract unit price per square yard (square meter).

D. Bridge Approach Sections.

1. Contract unit price for bridge approach pavement per square yard (square meter).

2. Payment is full compensation for:
    - Excavation for modified subbase and subdrain.
    - Furnishing and installing subdrain.
    - Furnishing and installing subdrain outlet.
    - Furnishing and installing polymer grid.
    - Furnishing and placing porous backfill material.
    - Furnishing and placing modified subbase backfill material.
    - Saw cutting.
    - Furnishing and installing reinforcing steel, tie bars, and dowel assemblies.
    - Placing, finishing, texturing, grooving, and curing.
    - All joint construction.
    - All other materials and labor to construct the Bridge Approach Section as shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and the contract also provides a price per cubic yard (cubic meter) for excavation, payment will be the contract unit price per cubic yard (cubic meter) for excavation in connection with subgrade preparation and building shoulders.

2. When the contract provides a unit price for earth shoulder construction, the excavation required for preparation of subgrade and construction of shoulders will not be paid for as a separate item. It is incidental to

pavement construction and earth shoulder construction and is to be included in those contract prices.

3. When no price per cubic yard (cubic meter) for excavation is provided in the contract and no unit price is provided for earth shoulder finishing or earth shoulder construction, excavation necessary for subgrade preparation is incidental to pavement construction and is to be included in that contract unit price.

F. Driveway Surfacing Material.
Contract unit price as provided in Section 2315 for the quantity of driveway surfacing placed.

G. Portland Cement Concrete Pavement Samples.

1. Lump sum contract price for furnishing samples of finished pavement or other course according to Article 2301.04, A, or when required in the contract documents.

2. Payment is full compensation for furnishing all such samples for all courses or items of work.

H. Saw Cut and Joint Sealing
Incidental to the price for pavement.

I. Safety Fence for Pavement.
Incidental to the price for pavement.

J. Rumble Strip Panel (PCC Surface)
Each. Payment is full compensation for construction of the panels as detailed in the contract documents.

K. General.

1. Deleted.

2. When any of the types of additional protection described in Article 2301.03, K, 3, is necessary, additional payment will be made as extra work at the rate of $1.00 per square yard ($1.20 per square meter) of surface protected. Payment will be limited to protection necessary within the contract period. Protection necessary after November 15 will be paid for only when the Engineer authorizes the work.

3. Furnish concrete for test specimens and transport the specimens and molds between the grade and plant as directed by the Engineer, at no additional cost to the Contracting Authority.

4. The above prices are full compensation for furnishing all tools, equipment, labor, and materials necessary for construction of the pavement in accordance with the contract documents.

5. The cost of furnishing, installing, and monitoring vibrators, as well as the vibrator monitoring device itself, is incidental to the contract unit price for PCC pavement.

SPEC 2403
STRUCTURAL CONCRETE

Section 2403. Structural Concrete

2403.01 DESCRIPTION.
Portland Cement Concrete used for constructing bridges and other structures. For PCC Pavement, refer to Section 2301.

2403.02 MATERIALS.

A. General.

1. Meet the requirements for the respective items in Division 41.

2. Unless otherwise specified, use Class 2 durability coarse aggregate, or better, as defined in Section 4115.

3. Unless otherwise specified, use the following:
- **a.** Class BR or Class C concrete for bridge barrier rails.
- **b.** Class X concrete for seal courses.
- **c.** Class C concrete for all other structural concrete, including concrete for bridge curbs, bridge medians, and bridge sidewalks. Refer to Article 2412.03 for concrete used for one course bridge floors and the first course of two course bridge floors.

B. Proportions.

1. General.
- **a.** Materials for structural concrete may be mixed in proportions for any of the mixes allowed for the class of concrete specified in the contract documents and the current Materials I.M. 529, provided the gradation of each aggregate conforms to the gradation required for that proportion.
- **b.** The contract documents will indicate where each class shall be used and the approximate quantities of each class.
- **c.** Class D or Class M mixtures may be substituted for Class C proportions, except in bridge floors.

2. Water and Consistency.
- **a.** Place with a slump between 1 and 3 inches (25 and 75 mm) as a target range, allowing a maximum of 4 inches (100 mm) as a tolerance.
- **b.** If the characteristics of the materials used are such that the total quantity of water used (including free water in aggregate) to secure the required consistency reduces, by more than 2%, the batch volume computed on the basis of absolute volumes of the batch quantities used, the proportions may be adjusted accordingly.
- **c.** If the characteristics of the materials used are so that the required consistency is not secured within the specified maximum water content, increase the proportions of cement to aggregate as necessary to secure the required consistency within the specified maximum water content. Additional cement will be considered as incidental, and no additional payment will be allowed. Free moisture

in the aggregate plus the total mixing water shall not exceed that shown in Table 2403.03-1.

Table 2403.03-1: Mixing Water and Free Moisture

Class of Concrete	Pounds (kg) of Water per Pound (kg) of Cementitious Material
C Separated Aggregate	0.488
X Separated Aggregate	0.444
C with Class V Aggregate	0.444
X with Class V Aggregate	0.422
D57	0.437

3. Entrained Air Content.

Use an approved air entraining agent complying with Section 4103 to accomplish air entrainment. Air content will be tested according to Materials I.M. 318. The intended air entrainment is 6%. To allow for loss during placement, use a target value of 6.5%, with a maximum variation of -1.0% and +2.0%, for the air content of fresh, unvibrated structural concrete.

4. Other Admixtures.

a. Other approved admixtures may be used with the Engineer's approval.

b. Approved retarding admixture complying with Section 4103 may be required by the contract documents or by the Engineer. Add the retarding admixture in amounts recommended by the manufacturer for conditions which prevail on the project and as approved by the Engineer. When used, introduce it into the mixer after all other ingredients are in the mixer. The Engineer may approve other procedures.

c. Ensure retarding admixtures are compatible with the air entraining agent used. Previous experience, satisfactory to the Engineer, will be required to indicate the approximate adjustments necessary by the addition of the admixture and compatibility with other materials to be used. Agitate the retarding admixture prior to and during its use.

d. Calcium chloride will not be allowed where reinforcing steel is used.

5. Use of Fly Ash and GGBFS.

The Contractor may use fly ash or GGBFS as a substitute for a portion of the Portland cement in structural concrete. Use fly ash and GGBFS meeting the requirements of Section 4108. The maximum allowable substitution rates are 20% for fly ash and 35% for GGBFS with a maximum total mineral admixture substitution rate of 50%.

C. Proportions for Lightweight Structural Concrete.

When lightweight concrete is specified, the aggregate quality, proportions, mixture characteristics, and controls will be included in the contract documents.

D. Proportioning and Mixing of Concrete.
Apply the respective paragraphs of Article 2301.02, C, to storage and handling of cement, fly ash, aggregates, measurement of materials, and ready mixed concrete, except for the truck dumping area required in Article 2301.02, C, 1, c.

1. Mixing of Materials.
Thoroughly mix materials in an approved mixer at the site of placement or by an approved ready mix plant. The Engineer may withhold approval for using ready mixed concrete from any plant with a previous record of unsatisfactory performance.

2. Concrete Mixed on the Site.

a. When using approved mixers at the site of placement, mix materials according to the specific requirements for the equipment used. Use a mixing capacity so that finishing operations can proceed at a steady pace with final finishing completed before concrete starts its initial set.

b. Ensure concrete discharged from the mixer is uniform in composition and consistency. Thoroughly discharge each batch of concrete from the mixer before the next batch is introduced. Thoroughly clean and flush the mixer upon cessation of mixing for any considerable length of time.

3. Heating Aggregates.
When aggregates are heated, heat and handle them to avoid damage by overheating and to ensure uniform moisture content of aggregate entering the mixer. Aggregates may be heated by steam pipes or coils through aggregate piles. Do not heat aggregates by direct, dry heat unless they are mechanically agitated during the heating process.

2403.03 CONSTRUCTION.

A. Equipment General.
Use equipment meeting the requirements of Section 2001 and the following:

1. Weighing and Proportioning Equipment.
Apply Article 2001.20.

2. Mixing Equipment.
Apply Article 2001.21.

3. Bins.
Apply Article 2001.06.

B. Placing and Finishing Equipment.
Use equipment complying with the following requirements:

1. Above Water or Dry Placement Equipment.

a. Tremies.
When required, use a tremie to deposit concrete in the dry. Use a tremie that:

- Is no more than 12 inches (300 mm) in diameter,
- Has no aluminum parts in contact with the concrete, and
- Is of sufficient length to extend to the bottom of the placement area.

b. Chutes.
Use chutes for depositing concrete that are constructed of metal or have a metal lining, and:

- Have no aluminum in contact with the concrete,
- Are of sufficient length for the delivery point to be as close as possible to the point of deposit, and
- Provide a slope to allow the concrete to flow slowly without segregation.

2. Underwater Placement Equipment.

a. Place concrete under water using a tremie, pump, or other equipment which meets the Engineer's approval.

b. Use a tremie that:

- Is constructed to be water tight and readily discharge concrete,
- Is no more than 12 inches (300 mm) in diameter,
- Has no aluminum parts in contact with concrete,
- Has the discharge end constructed to prevent water intrusion and permit free flow of concrete during placement operations, and
- Is of sufficient weight (mass) and length to rest on the bottom of the placement area prior to start of concrete placement.

c. Support the tremie so that it can be raised or lowered to increase or reduce the discharge of concrete.

3. Consolidation.

a. Use vibrating units to vibrate all concrete for box and arch culverts, bridge substructures, bridge decks, and bridge deck overlays. Operate all vibrators at speeds no less than 3500 vibrations per minute.

b. Furnish adequate vibration equipment to avoid delays due to breakdown.

c. Use a sufficient number of vibrating units to properly consolidate the concrete placed.

d. Use vibrator heads covered with rubber or other resilient material approved for consolidation when consolidating concrete reinforced with epoxy coated bars.

4. Heating and Protection Equipment.
Meet the following requirements whenever heating is done:

a. Equip the attendant with no less than one non-freezing fire extinguisher of adequate capacity.

b. To prevent movement or overturning, adequately support, anchor, and guy any heating equipment involving combustion in or near the space to be heated.

c. Use of a salamander or other type of open flame heating unit is prohibited.

d. Use heating equipment constructed with a shield so that metal in direct contact with the open flame is not exposed.

5. Forms.

a. Use forms that are:
- Metal, surfaced lumber, plywood, masonite, hard pressed composition board, or other approved material backed by suitable studding, walers, and so on, and
- Are free from knotholes, cracks, splits, warps, or other defects which would prevent it from producing the strength, accuracy, and appearance necessary in the finished concrete surface.

b. Construct forms with mortar tight joints. Use material sufficient in strength to hold concrete without bulging between supports.

c. Design forms for strength as specified in Article 2403.03, L. Use metal, plywood, fiberglass, or hard pressed water resistant composition board no less than 3/16 inch (5 mm) thick to line wood forms for all exposed surfaces, except:
- wingwalls parallel to the culvert barrel,
- headwalls, and
- such portions as may be completely covered by a single board.

d. Use forms in good condition. Make joints in the lining mortar tight. Smoothly cut and break joints with the form lumber. Small irregular areas may be formed with lumber against concrete to be rubbed, provided there is no joint in lumber used on any flat surface of concrete except at angles, ribs, bevels, molding, and so on where there is a juncture between two surfaces. Place blocks, ribs, bevels, moldings, and so on for ornamental effect on lined surfaces inside the lining.

e. Design and construct forms so that they may be removed without damage to the concrete. Remove blocks and bracing with the forms. In no case leave any portion of wood forms in the concrete.

f. Construct forms so that the finished concrete is of the form and dimensions shown in the contract documents, and true to line and grade. Fillet forms 3/4 inch (20 mm) at all sharp corners (90 degrees or sharper). Give a draft in the case of all projections, such as girders, copings, and so on, sufficient to insure their easy removal. Ties and bracing shall be sufficient to support the expected load.

g. When forms appear to be insufficiently braced or unsatisfactorily constructed either prior to or during placement of concrete, the Engineer will order the work stopped until defects have been corrected.

h. Coat forms with an approved form release agent prior to the placement of concrete. Thoroughly wet forms with water immediately prior to concrete placement. Thoroughly clean reused forms and ensure they are free of bulges, splits, warps, or bends.

i. Use stay-in-place forms only when specified in the contract documents.

C. Placing Concrete.

1. Place concrete mixed at the site of the work immediately after mixing. Place ready mixed concrete as soon as practical after delivery, but in all cases within the specified time limit for the equipment used for delivery.

2. Place concrete in a manner which will avoid segregation or separation of the ingredients. In placing concrete, observe all the following precautions:
   - **a.** In handling concrete from the mixer to the place of deposit, take care to avoid segregation.
   - **b.** When concrete is deposited through a chute, slope the chute to allow concrete to flow slowly without segregation. Place the delivery point of the chute as close as possible to the point of deposit. Keep chutes and spouts clean. Thoroughly flush them with water before and after each run. Discharge the water outside the forms. Do not pump concrete through aluminum conduit or tubing.
   - **c.** A tremie is not required when filling steel pipe piles or encasing steel H-piles. Use a tremie whenever the distance through which other concrete must be dropped vertically exceeds 6 feet (2 m). Do not exceed a drop of 3 foot (1 m) for bridge floors and culvert slabs. A tremie is not required for concrete placement of elements which have a maximum dimension no greater than 12 inches (300 mm) provided that Paragraph d below is adhered to and concrete is placed in lifts.
   - **d.** Do not deposit concrete in large quantities at a single point, causing it to flow along inside the forms.
   - **e.** In depositing concrete, take care to fill the form entirely without bulging the form or disturbing its alignment.
   - **f.** Manipulate and vibrate concrete in a manner to bring a thick layer of mortar into contact with forms and reinforcement and to prevent formation of pockets of coarse aggregate.
   - **g.** Do not place concrete in flowing water within the area of a footing. Control such flowing water in pipes or trenches outside the forms. In extreme cases, a seal course may be ordered to overcome this difficulty.
   - **h.** Protect concrete placed when the air temperature is at or below 40°F (4°C) as provided in Article 2403.03, F.

3. Maintain an adequate supply of water suitable for washing testing equipment at a convenient location, as directed by the Engineer, near the site of concrete placing operations.

4. When concrete is being placed during cold weather, provide an approved, conveniently located shelter (enclosed on at least three sides and covered), suitable for use in performing on the site tests of the concrete being placed. Place the shelter to provide maximum protection from the weather.

D. Vibration of Concrete.

1. Manipulate vibrators through all available space in the mass of concrete, with particular attention to corners and faces of concrete against forms and joints. Use caution to prevent the vibrator from penetrating any portion of previously set concrete.

2. Vibrate each batch of concrete as it is placed in the form to settle and thoroughly consolidate the concrete into close contact with the forms, reinforcement, and previously placed concrete. Discontinue vibration before segregation or localized areas of grout form. Ensure placement and consolidating operations result in concrete that, upon removal of forms, is smooth and dense and free from all honeycomb or pockets of segregated aggregate.

3. Design forms to withstand effects of vibration without appreciable distortion from the desired shape or position.

E. Protection and Curing of Concrete.

1. Protect concrete which has been placed from external stress between the time it ceases to be plastic and the time it may be stressed, as provided in Article 2403.03, N.

2. Ensure runways for transporting materials over concrete floors less than 7 calendar days old are supported directly over structural members, piers, or abutments so the floor concrete is subjected to compressive stress only.

3. Ensure runways built over portions of formed, but unpoured floors are supported on floor forms or beams.

4. Unless concrete is protected as specified in Article 2403.03, F, protect exposed surfaces, including surfaces from which forms have been removed less than 60 hours after the concrete has been placed, in the following manner for at least 4 calendar days after concrete is placed:
    a. Coat the surface immediately after required finishing operations are completed with white pigmented curing compound, meeting requirements of Article 4105.05, applied at a rate of no more than 135 square feet per gallon (3.3 m^2/L).
    b. As alternatives, the surfaces may be covered with paper or plastic film, meeting requirements of Section 4106, or the surface may be covered with burlap, straw, or sand kept continuously wet.

5. Do not use white pigmented curing compound on surfaces against which concrete is to be placed or which will receive a sealer. When the Contractor elects to use white pigmented curing compound on any part of an integral unit, the Engineer may require use of the curing compound on adjacent areas of the integral unit so that each pier, abutment, or other surface visible after construction presents a uniform and pleasing appearance.

6. Cure concrete floors as provided in Article 2412.03, E.

7. Cure barrier railing as provided in Article 2513.03, D.

F. Placing and Protection in Cold Weather.

1. Do not place concrete, without permission from the Engineer, when the air temperature is 40°F (4°C) or less.

2. Do not use frozen materials in the concrete.

3. Do not place concrete against frozen forms, earth, or rock or against other concrete having a temperature below 40°F (4°C).

4. In addition to protecting the concrete against chilling or freezing, heat the water or aggregates, or both, so that when placed the concrete will have a temperature appropriate for the mass and dimensions of the portion of the structure being placed, but from 45°F (7°C) or to 80°F (27°C).

5. Before concrete is placed at ambient air temperatures below 40°F (4°C) or when these temperatures might occur during the protection period, provide heating or protecting facilities, or both, meeting requirements of Article 2403.03, B, 4, adequate to protect the work as follows:
   - **a.** Maintain the concrete temperature at no less than 50°F (10°C) for the first 48 hours after placing. Then gradually reduce the concrete temperature at a rate not exceeding 25°F (15°C) in 24 hours. When heating and housing is used, locate temperature monitors in the concrete at the furthest and closest point from the heat source. Do not allow the maximum temperature of the monitor point closest to the heat source to exceed 150°F (65°C).
   - **b.** In lieu of protection involving housing and heating, the Contractor may protect concrete by the use of forms insulated with a commercial insulating material adequate to maintain the concrete temperature at no less than 50°F (10°C) for the first 48 hours after placing. Leave these insulated forms undisturbed for the next 48 hours, after which they may be removed. When forms are insulated, protect exposed horizontal surfaces with a similar layer of the insulating material or an adequate layer of hay or straw, properly secured.
   - **c.** Make suitable provision, including cast-in-wells for thermometers, to provide a means for determining the temperature of the concrete.
   - **d.** Whenever heating is done, firmly secure combustible material to prevent contact with any source of heat, and take adequate precautions to prevent fires.
   - **e.** If all the concrete is at least 1 foot (0.3 m) below ground water level, it may be placed at a temperature no less than 40°F (4°C) and flooded to a minimum depth of 1 foot (0.3 m) in lieu of other methods of protection and curing. Ensure that concrete cured in this manner is not subjected to freezing temperatures within 10 calendar days after it is placed. In lieu of flooding, culvert footings

may be protected from freezing by an adequate layer of straw or hay for at least 5 calendar days.

G. Placing Large Volumes of Concrete.
Whenever the volume is too great to be placed in one continuous operation, subdivide the work as shown in the contract documents or as directed by the Engineer.

H. Bonding Construction Joints.

1. When concrete placement in any section of a structure must be interrupted, locate the construction joint as specified in Article 2403.03, O. Leave the surface of the concrete in horizontal joints rough (except in the area near the form) to increase the bond with concrete that is to be placed later. Finish the top surface of the concrete adjacent to the forms to a horizontal 3/4 inch (20 mm) bevel strip.

2. Embed keyways no less than 1 1/2 inches by 3 inches (35 mm by 75 mm) into the surface of the concrete. Form tapered sections, which would otherwise result in a feather edge, by an insert so that the succeeding layer of concrete will end in a section no less than 6 inches (150 mm) thick. In addition to the key notches in concrete that is not reinforced, set steel dowels no smaller than 3/4 inch (20 mm) around the edge of the section at intervals no greater than 2 feet (0.6 m). Set the dowels to project at least 1 foot (0.3 m) on each side of the joint.

I. Bonding New and Old Work.

1. When new concrete is placed in contact with existing concrete, first thoroughly clean the existing concrete surface of laitance, loose particles of concrete, dirt, or other foreign materials by sandblasting followed by an air blast. Next, place forms against the existing concrete, using care to avoid contamination of the cleaned surface. Finally, place fresh concrete against the clean, dry surface and thoroughly consolidate it to ensure a tight joint and a good bond.

2. Bonding agent may be required as specified in the contract documents.

J. Displacing Water with Concrete.
Do not place concrete into or under flowing water. Concrete may be placed in still water only under the following conditions and under the Engineer's supervision.

1. The Contractor may place the concrete starting at a point most removed from the sumps and progressing toward the sumps, shoving and displacing water as the placement progresses if:
   - Water courses and sumps are provided outside the area over which concrete is placed, and
   - It is demonstrated that the water elevation can be controlled to an elevation at or near the elevation of the bottom of the concrete to

be placed to the extent that no appreciable or objectionable flow crosses said area.

2. Maintain the water elevation within the forms at the start of placing at substantially the same elevation through the pour by bailing or pumping. Direct pumping from inside the forms will not be permitted in excess of the pumping necessary to remove the quantity of water displaced by concrete.

3. The Contractor may slowly displace entrapped water with concrete during placement if:
- There are required excavations or trenches within the area, the bottoms of which are below the general elevation of the area, and
- It is impossible or impractical to provide gravity drainage to the sumps.

4. The Contractor may be required to bail or otherwise dewater the trench immediately prior to or during the placement. A prerequisite to placing concrete in excavations or trenches is that the depth of water shall not appreciably exceed 30% of the depth of concrete being placed.

5. Place seal courses in the following manner if other methods for placement are not provided in the contract documents:

a. When possible, place seal courses in one continuous operation. Place concrete to approximately the required depth. Progress from one end over the entire area in such a manner that the volume of concrete will be gradually expanded without dropping the concrete through water. Minimize agitation. Ensure the surface of the seal course is approximately level. Place sumps or depressions for pumping out the water outside the area of the footing.

b. Place concrete using equipment described in Article 2403.03, B, 2. In operating a tremie, keep the tremie filled at all times. Raise the discharge end only an amount sufficient to permit the concrete to be discharged.

c. When pile encasements are placed by use of a tremie and the bottom of the encasement is below the controlled water level, provide drain holes no less than 1 inch (25 mm) in diameter in the encasement form at intervals of 1 foot, 2 feet, and 3 feet (0.3 m, 0.6 m, and 0.9 m) above the controlled water elevation. Place the concrete in this area at a rate so no free water is entrapped inside the form above the top drain hole.

K. Laitance.

Remove laitance from the surface of seal courses before the footing is placed. Use care in placing other concrete to prevent formation of laitance on the surface of the concrete. Entirely remove laitance by means of shovels, stiff wire brooms, or by other suitable methods before the succeeding layer of concrete is placed.

L. Design and Construction of Forms and Falsework.

1. General.

a. Have a Professional Engineer licensed in the State of Iowa design and certify falsework plans.

b. Materials for forms and falsework may be either new or used. It is the Contractor's responsibility to ensure that materials are suitable for the use intended. Material which the Engineer determines to be damaged, defective, or otherwise unsuitable will be rejected.

c. Design values for lumber and timber vary considerably depending on size and or use, species, and grade. For each type of structural member, list on the falsework plans specifications for the following if known: size or use category, species group, and minimum grade.

2. Construction of Forms.

a. Use materials, and construct forms that will be in direct contact with concrete, as specified in Article 2403.03, B, 5.

b. For wall or column forms, use studs, wales, and ties designed to withstand the maximum fluid pressure discussed below.

c. Use prefabricated form systems certified for the expected pressures.

d. Guy, shore, and/or brace forms for walls and columns to withstand wind loads and to prevent alignment shift resulting from construction live load.

3. Construction of Falsework.

a. Build falsework used to support construction of reinforced concrete superstructures, reinforced beams, and substructure cantilevers, on sufficiently strong foundations to carry the loads safely and without significant deflection. Drive ample falsework piling to support falsework which cannot be founded on rock, shale, thick deposits of compact gravels, coarse sand, or the firm clays in natural beds. On the soils materials listed above, mudsills or other spread footings may be used. Determine their sizes considering the applied loads and the bearing value of the soil.

b. Determine bearing values of all piles used to support falsework as provided in Section 2501. Bearing values are to be at least equal to the applied loads.

c. To ensure stability for pile bents 10 feet (3 m) or less in height that are not sway braced, show pile type, size, and minimum embedment length on plans. Transversely sway brace pile bents exceeding 10 feet (3 m) in height to resist lateral loads. Longitudinally brace pile bents exceeding 10 feet (3 m) in height to resist construction live loads, unless the bents are secured to longitudinal members which are secured against longitudinal movement. Bracing and connections are to be shown on falsework plans. The Engineer will review adequacy of bracing and connections.

d. Secure pile caps to each pile. Ensure blocks, wedges, and jacks for height adjustment are secure and stable. The Engineer will review them before concrete placement. Hold transverse joists against individual collapse. Use a positive spreader system over each support of a longitudinal stringer.

e. Secure continuous members against uplift from unbalanced concrete placement. Place concrete in a manner which will minimize unequal loads on hanger legs.

4. Design Loads.

Design formwork and falsework for the following loads:

a. Vertical load of concrete with a density of 150 pounds per cubic foot (2400 kg/m^3).

b. Horizontal load of fresh concrete as a liquid with a density of 150 pounds per cubic foot (2400 kg/m^3) for the depth of plastic concrete, except when lesser pressures are permitted by AASHTO Guide Design Specifications for Temporary Works.

c. Vertical dead load of forms and falsework.

d. Vertical dead load of rail and walkway applied at edge of deck form equal to 75 pounds per linear foot (1.1 kN/m)

e. Construction live load equal to 50 pounds per square foot (2.4 kPa) of horizontal projection.

f . Live load equal to 6 kips (26.69 kN) of finishing machine located along the edge of the deck form to maximize the design condition.

g. Wind loads equal to 50 pounds per square foot (24 kPa) for elevations to 30 feet (10 m) above the ground, increased for elevations above 30 feet (10 m).

h. Other applicable loads such as horizontal loads due to equipment or construction sequence, additional live load, impact, stream flow, and snow loads specified in AASHTO Guide Design Specification for Bridge Temporary Works.

5. Design Stresses.

a. Design formwork and falsework using load groups specified in AASHTO Guide Design Specifications for Bridge Temporary Works and material working stresses. For structural steel and reinforced concrete use the allowable stress percentages given with load groups. For lumber and timber use appropriate load and duration factors instead of percentages. Calculate lumber strength on the basis of dressed size. Publications of the APA – The Engineered Wood Association, ACI, and the American Forest & Paper Association, American Wood Council will be considered standard references for design and analysis of plywood, lumber, and timber formwork and falsework.

b. Do not exceed 50 times the dimension of the least side for the unsupported length of wood columns and compression members.

c. Unless the Contractor certifies a higher stress grade or value as allowed by AASHTO Guide Design Specification for Temporary Works, adequacy of falsework material will be reviewed on the basis of the following values:

1) Structural steel stresses for 36,000 psi (248 MPa) yield strength and 22,000 psi (151 MPa) maximum working stress.

2) Plywood sheathing stresses per APA – The Engineered Wood Association for Plyform, Class I, wet use, 7 day duration of load, span-perpendicular-to-face grain. Orientation of plywood panels must be shown on drawings if advantage is taken of greater strength with span-parallel-to-face grain.

3) Design values for lumber in good condition and 4 inches (100 mm) or less in thickness, in psi (MPa) as follows:

f_b, bending	= 875 (6.03)
f_t, tension	= 450 (3.10)
f_v, shear	= 135 (0.93)
f_c, perpendicular to grain	= 425 (2.93)
f_c, parallel to grain	= 1150 (7.93)
E, modulus	= 1,400,000 (9650)

These design values are to be modified for seven-day duration of load (except for fc, perpendicular to grain and E, modulus) and other applicable adjustment factors when determining allowable stresses.

4) Design values for timber in good condition and 5 inches (125 mm) thick and thicker in psi (MPa) as follows:

f_b, bending	= 850 (5.86)
f_t, tension	= 450 (3.10)
f_v, shear	= 125 (0.86)
f_c, perpendicular to grain	= 425 (2.93)
f_c, parallel to grain	= 625 (4.31)
E, modulus	= 1,300,000 (8960)

These design values are to be modified for seven-day duration of load (except for fc, perpendicular to grain and E, modulus) and other applicable adjustment factors when determining allowable stresses.

5) Safe bearing value of coarse sand, gravel, very firm clay, and other similar confined soils in thick beds at 1500 pounds per square foot (72 kPa) unless recommended otherwise by a Professional Engineer licensed in the State of Iowa. Safe bearing value of compacted berms at 2000 pounds per square foot (96 kPa).

6. Deflection.

a. Ensure falsework for slab and girder bridges provides for slight settlements, deformations of members, crushing, and closing of joints. Sag in excess of 1 inch (25 mm) or 1/800 of the span length, whichever is greater, in the soffit of a girder or slab may be cause for rejection.

b. Limit deflection of sheathing and joists to 1/360 of the span length. Calculate deflection of falsework stringers. Adjust screed guides to compensate.

7. Falsework Plans.

a. Submit plans for falsework and centering on all concrete slab and cast-in-place concrete girder bridges according to Article 1105.03. Submittal of forming details for bridge decks on concrete beam and steel beam bridges is not required unless specified in the contract documents.

b. The Engineer may require calculations or evidence of adequacy. The Engineer may require revised plans later because of unforeseen site conditions, unusual construction procedures, or deviation from original falsework plans.

M. Removal of Forms and Falsework.

Remove forms and falsework, unless otherwise indicated in the contract documents. Normally, they may normally be removed according to the following provisions. However, in cool or unfavorable weather, the Engineer may require forms to remain in place for longer periods.

1. Forms Which May be Removed in Less than 5 Calendar Days.

a. Forms for ornamental work, railings, parapets, curbs, and any other vertical surfaces may be removed whenever the concrete will not be damaged by doing so, but no less than 12 hours after the concrete is placed.

b. Do not remove forms for concrete open railing less than 24 hours after concrete placement.

c. Forms for roofs of culverts may be removed when the concrete has attained an age of 3 calendar days and a flexural strength of:

- 350 psi (2.4 MPa) for spans of 4 feet (1.2 m) or less,
- 400 psi (2.8 MPa) for spans 4 to 6 feet (1.2 m to 1.8 m), and
- 450 psi (3.1 MPa) for spans exceeding 6 feet (1.8 m).

d. When Maturity Method (according to Materials I.M. 383) for strength determination is used, the above stated flexural strengths will be required. The days of age will depend on the Maturity Curve for the concrete mix used.

2. Forms Which Shall Remain in Place 5 Calendar Days or Longer.

a. Except when form removal is permitted in less than 5 calendar days, forms may be removed as soon after 5 calendar days as the concrete has attained the strength required in Article 2403.03, N, 2. When Maturity Method (according to Materials I.M. 383) for strength determination is used, the flexural strength of 575 psi (4.0 MPa) will be required. The days of age will depend on the Maturity Curve for the concrete mix used.

b. When strength is not determined, forms for box culverts 4 feet (1.2 m) or less in width may be removed after the concrete has attained an age of 7 calendar days. Forms for other concrete may be removed after the concrete has attained an age of 14 calendar days.

c. Remove forms and supporting falsework for continuous concrete slabs, concrete girders, and rigid frame structures in the following manner:

Ensure there is at least one span for which the concrete has attained the age (or age and strength) specified above between the span from which forms are about to be removed and any span for which the concrete has not attained the age (or age and strength) specified above.

3. Falsework and Falsework Piling.

Remove falsework and falsework piling in the berm slope fill, extended to the streambed, to at least 1 foot (0.3 m) below the finished berm line or berm line extended. For falsework and falsework piling in the channel area:

a. For structures spanning natural streams or overflow channels of natural streams, removal to at least 1 foot (0.3 m) below streambed elevation will be required.

b. For structures spanning drainage channels constructed under the drainage laws of Iowa, removal to at least 4 feet (1.2 m) below streambed elevation will be required unless complete removal is specified.

N. Subjecting Concrete to Exterior Loads.

Concrete may not be subjected to loads other than the load caused by the weight (mass) of the concrete itself except as follows:

1. Loads Producing Simple Compressive Stress Only.

Concrete may be subjected to simple compressive stress as soon as it sets sufficiently to prevent the surface being marred or the edges being chipped from the effect of such loads.

2. Loads Producing Flexural Stresses.

a. Unless otherwise indicated in the contract documents, concrete may be subjected to loads due to placing backfill material or to legal traffic when the concrete has reached the minimum age stipulated in Table 2403.03-2 and developed a flexural strength of at least 575 psi (4.0 MPa).

Table 2403.03-2: Minimum Age for Concrete

Portland cement (Type I and Type II with or without Class C fly ash)	7 calendar days
With Class F fly ash substitution	8 calendar days
Class M mix (with or without Class C or Class F fly ash)	3 calendar days
If strength is not determined (regardless of type of cement or class of fly ash)	14 calendar days

b. Determine flexural strength by testing (according to Materials I.M. 316) specimens of concrete used in the part of the structure in question, cured under conditions similar to those of the concrete in the structure.

c. Footings for piers supported by piling may be subjected to loads of subsequent pier stem concrete placement no less than 18 hours after footing placement is complete, with no minimum strength requirements.

d. Unless otherwise specified in the contract documents, the Contractor may request, the time for subjecting to loads to be determined through the use of the Maturity Method as described in Materials I.M. 383. When the Maturity Method is used, the time for loading will be based on strength requirements only, as specified above. Furnish labor, equipment, and materials necessary for the development of the maturity-strength relationship as described in Materials I.M. 383.

e. Determining sufficient strength has been achieved for loading a part of a structure remains the Engineer’s responsibility when the Maturity Method is used. The Contractor's maturity testing may be used as the basis for this determination. Provide sufficient documentation of maturity testing before loading a part of a structure or opening to traffic.

f. Apply the following when the Maturity Method is used:

1) Should circumstances arise beyond the Contractor's or Engineer's control and strength cannot be determined by the Maturity Method, the minimum age, minimum flexural strength, and fly ash restrictions apply. Cure flexural strength specimens under conditions similar to those of the concrete in the structure.

2) Any changes of a material source or proportion in the concrete mixture require a new maturity curve.

O. Joints.

Unless otherwise provided in the contract documents, construct joints in the following manner:

1. Construction Joints.

a. Place construction joints between successive layers of concrete as provided in Article 2403.03, H.

b. The location of required or optional construction joints in the structure will be shown in the contract documents. If the volume of concrete is too great to be placed without use of additional construction joints, locate and construct these joints in a manner not impairing the strength and appearance of the structure.

c. Locate construction joints in planes perpendicular to principal lines of stress and at points the Engineer designates.

2. Expansion Joints.

Construct expansion joints as shown in the contract documents.

P. Surface Finish.

Finish and seal concrete surfaces exposed, or will likely be exposed, after the structure is completed as follows:

1. Finish concrete floors and concrete sidewalks as provided in Sections 2412, 2413, and 2511.

2. Provide a Class 1, finish to horizontal surfaces not cast against a form and not subject to wear (for example, bridge seats, tops of backwalls, piers, abutments, wingwalls, retaining walls, spandrel walls, struts between pedestal piers, and horizontal surfaces of curbs and sidewalks of the bridge). For all other surfaces required to be finished, provide a Class 2, finish to low water line or 1 foot (0.3 m) below the finished ground line.

a. Class 1, Floated Surface Finish.

Overfill forms with concrete. Strike off concrete to the required elevation with a template and thoroughly work the surface with a wood float until the surface is uniformly smooth, dense, and true.

b. Class 2, Strip Down Surface Finish.

Immediately after removal of the forms, complete the following:

1) Remove rods and other devices used as form ties to the extent contemplated in their design.

2) Remove paper or fiber tubes used to facilitate removal of rod ties.

3) Except as designated below, cut off wires used as form ties flush with the surface of the concrete and drive them 1/4 inch (5 mm) below the surface.

4) Remove all fins and irregular projections from the concrete surfaces required to be finished.

5) On surfaces, thoroughly clean the cavities produced by form ties and all other holes, honeycomb spots, and broken corners and edges. After being saturated with water, carefully fill, point, and true with a mortar of cement and fine aggregate of the same kind as that which was used in the concrete being finished. Shallow voids, other than honeycomb, which appear on the formed surface after proper consolidation will not be considered as holes and need not be filled unless they appear in an abnormal concentration.

6) Clean the entire surface required to be finished of stains from form oil or other substances.

7) Ensure the resulting surfaces are true and uniform.

8) Clip off flush with the surface wire ties or reinforcing steel chairs protruding through culvert barrels or the bottom of bridge floors.

9) Leave construction and expansion joints in the completed work carefully tooled and free from mortar and concrete.

10) Leave expansion joint filler exposed for its full length and thickness and with clean true edges.

3. Concrete Sealer.

a. Use sealer material meeting the requirements of Article 4139.01, B, when designated in the contract documents.

b. The contract documents may designate a sealer for the bridge seat surface or tops of piers or both. This surface includes bridge seat steps and edge fillets. The contract documents or the Engineer may also designate other concrete surfaces to be sealed.

c. All surfaces to be sealed shall be sound, clean, and dry. For existing surfaces, the Engineer may require removal of unsound material by hand methods or sandblasting, or both. As a minimum, all designated surfaces, both existing and new, shall receive a light sandblast (brush blast), followed by air cleaning. Clean sufficiently to remove road film and contamination from existing concrete and form oil from new concrete.

d. Perform application procedures according to the manufacturer's recommendations. Unless otherwise required in the contract documents, apply sealer material at the coverage rates in Materials I.M. 491.12.

2403.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Structural Concrete:

1. Quantity shown in the contract documents.

2. The Engineer will compute in cubic yards (cubic meters) the total volume of the respective classes of structural concrete placed using dimensions shown in the contract documents, along with the changes that have been made according to a written order from the Engineer. From this volume, 0.8 cubic foot (0.075 m^3) will be deducted for each linear foot (meter) of concrete, steel shell, or wood piling projecting into the footings or caps. Deductions from the volume of concrete will not be made for the volume of concrete displaced by the steel reinforcement, floor drains, expansion joints, shear lugs, beam flanges, H-piles, or metal strips for sealing joints.

3. Additional concrete required to bring floors, curbs, and handrails to the required elevation will not be measured for payment if such addition is made necessary by inaccuracies in the shape or placement of steel or concrete beams or by distortion of falsework.

B. Reinforcing Steel and Structural Steel: according to Sections 2404 and 2408, respectively.

C. The surface area on which concrete sealer is applied to structural concrete: not measured separately for payment.

D. Subdrains, porous backfill material, and granular backfill material required and furnished for structural concrete placement at bridge abutments: not measured separately for payment.

2403.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Net volume of Structural Concrete as specified above:

1. Contract unit price per cubic yard (cubic meter).

2. For concrete placed within the contract period, additional payment will be made for heating or protecting or both.

3. Payment for heating will be made when materials which are proportioned and mixed at the site are heated to meet requirements of Article 2403.03, F, or when heating is charged by the supplier of ready mixed concrete. For concrete proportioned and mixed at the site, the additional payment for heating will be $5.00 per cubic yard ($6.60 per cubic meter). For ready mixed concrete, the additional payment for heating will be the customary amount charged for heating, and separately identified on the invoice, with a maximum of $5.00 per cubic yard ($6.60 per cubic meter).

4. Payment for protection will be made when heated housing or insulated forms are used to meet requirements of Article 2403.03, F. The additional payment for protection will be $7.00 per cubic yard ($9.25 per cubic meter). If a footing is protected by flooding with water, no payment will be made. If footings are protected with coverings of burlap, hay, straw, plastic, insulation, and/or other materials sufficient to meet the temperatures and time specified in Article 2403.03, F, payment for protection will be made.

B. Reinforcing Steel and Structural Steel: according to Sections 2404 and 2408, respectively.

C. Concrete sealer application to structural concrete: included in the contract unit price for structural concrete.

D. Subdrains, porous backfill material, and granular backfill material required and furnished for structural concrete placement at bridge abutments: included in the contract unit price for the structural concrete.

E. When an admixture is required to be added by the contract documents or the Engineer for the purpose of retarding the set, the cost of the retarding admixture is incidental to the contract unit price per cubic yard (cubic meter) of structural concrete

F. Payment is full compensation for:
- Furnishing all materials, including materials for filling and sealing joints, but not including structural steel or steel reinforcement.
- Furnishing, constructing, and removing all forms, ties, and falsework.
- Incidental work necessary for completion of the work in conformance with the contract documents.

G. Heating frozen soil or protecting soil from freezing, or both, prior to concrete placement is incidental regardless of winter work being specified on the contract documents.

CM 9.0
PCC PAVEMENT

CHAPTER 9
PORTLAND CEMENT CONCRETE (PCC) PAVEMENT

9.00 GENERAL

There are many different activities that take place in the construction of a Portland Cement Concrete (PCC) Pavement. There are also numerous inspection and documentation functions that are associated with those various activities. It is important that inspectors are knowledgeable of PCC paving and have the proper tools to adequately inspect the work and ensure that acceptable materials and proper construction practices are being provided in accordance with the contract documents. To aid in proper inspection of PCC paving activities, a PCC Paving Field Inspection Checklist was developed and is included in *Appendix 9-9*. This checklist, along with many other resources may also be found at the following locations:

DOTNET: http://dotnet/construct/construct_body_index2.asp
WEB: http://www.iowadot.gov/construction/pcc.html

9.01 PRE-CONCRETING CONFERENCE

On all projects involving PCC pavement, the Project Engineer and inspectors should meet with appropriate contractor and supplier personnel to discuss concrete production and pavement placement quality issues before any materials are placed. When ready mix concrete is used, the ready mix producer should also attend.

For the various types of work, the following items should be covered:

- Approvals and required quantities of aggregate and cement, class of mix, time and rate of delivery, haul routes, percent of air, slump, batch weights, volume per truck, total quantity required, preparation of delivery tickets, testing arrangements, procedures in case of load rejection, responsibility for setting batch weights and amount of admixtures, placing, finishing and curing arrangements, and personnel work assignments.
- Placement schedule, types of placement to be used (slip-form or fixed form), and method of determining opening strength.
- Settings and condition of paving equipment, dust control, subgrade treatment, procedure for checking steel placement, utility and street return box outs, heading-up equipment, joint sawing and cleaning, joint sealing, rain damage prevention, and cold weather protection.

Only one pre-concreting conference is considered necessary for thoroughly discussing the work, responsibilities, and duties of all involved in the project. On small projects it may be possible to include a pre-concreting conference with the preconstruction conference.

9.02 “PCC PLANT PAGE” (FORMS 800240E and 800240M)

The daily inspection report on paving work is a record of the construction progress, working conditions, weather, etc. during paving and plant operations which may affect pavement quality. This report keeps district and central offices advised on job status and serves as a detailed permanent record of the paving project. At the end of each day on which any pavement was placed, this report is to be completed by plant inspection staff for appropriate distribution. Copies of forms are included in *Appendix 9-5.* Refer to *Materials I.M. 527* for instructions on preparing and distributing this form.

9.03 USE OF COMMERCIAL READY MIX CONCRETE ON PAVING PROJECTS

When the concrete source for a paving project is a commercial ready mix plant, each truck load of concrete must be identified by Form 830212 or an acceptable alternate plant ticket. A current copy of the Form 830212 is included in *Appendix 9-1*.

Required Information:

- For continuous mainline paving, Form 830212 shall be filled out completely for the first truck. Tickets for subsequent trucks need only to have the Truck No., Ticket No., Conc. This Truck, Time Batched, Water Subtotal, and Maximum Water Allowed portion filled out. When any change in the moisture content, plant adjustments in mixing water, or any other changes to the batching or materials in the concrete are made, a complete ticket must be filled out for the first load that includes the changes.

- For intermittent production other than mainline paving, such as bridge approaches and street returns, all information on Form 830212 is required for each load because of the greater possibility of need for water adjustment on grade.

Moisture tests must be made frequently at the plant, and water added on grade must be documented to ensure uniformity in concrete consistency and accurate tracking of water to cementitious ratios. Discharge time must be entered on Form 830212 for each load to properly document the amount of time from batching to placement.

9.04 CONCRETE DELIVERY TIMES

To insure that quality concrete is incorporated into pavement, maximum delivery times have been included in Specification 2301.02, C, 4 for both continuous agitation (agitor and ready mix trucks) and non-agitated trucks (dump trucks).

These delivery times should be verified at least once during each day of normal paving. Per *Materials IM 527*, cement to water contact time should be recorded at least daily. These verifications should be recorded in project field books. During hot, dry, windy weather, maximum time limitations listed in specifications are critical limits to insure that quality concrete is being placed and incorporated into project.

CM 9.5
PROT., CURING, REP.

9.50 PROTECTION, CURING, AND REPAIR

9.51 PREVENTION OF RAIN DAMAGE TO PLASTIC CONCRETE

Specifications 1105.04 and 2301.3, K, 4 require contractors to produce a quality product and have materials for proper protection of edges and the surface of concrete available near the work site. The Contractor must protect the pavement from damage due to rain. Failure to properly protect concrete may constitute cause for removal and replacement of defective pavement.

At the preconstruction conference, it is important to emphasize that protective coverings and temporary forms must be available and that protection of fresh pavement from rain damage is the Contractor’s responsibility. The contractor should be advised to follow weather forecasts closely to prevent being caught unprepared in case of rain. Plastic film is preferred for surface and edge protection, since burlap alone in a heavy rain is insufficient to prevent access of water and subsequent pavement surface erosion.

When using concrete mixtures containing slag, the concrete often gains strength much slower than a mix without slag. This can be a problem when a rain event occurs. When slag is being used it is often necessary for the contractor to cover a significantly larger section of pavement to prevent rain damage on the surface.

The District should be notified when pavements are damaged by rain so an evaluation of damage can be made. Acceptance or rejection of damaged portions of the pavement will be based on extent of damage incurred as provided in *Specification 1105.04* and *Construction Manual 2.53*. Repair of damaged edges and surface may be considered, but extensively damaged pavement may require removal and replacement.

9.52 CURING OF KEYED AND DOWELED JOINTS

For curing vertical sides of the pavement in areas where KT and K joints are constructed, the use of liquid curing compound is an acceptable method of curing this portion of the slab. Generally, little or no bond is obtained or expected between vertical faces of adjacent concrete. Deformations on tie bars provide adequate lateral support.

9.53 REPAIR OF DEFICIENT PAVEMENT

Pavements damaged by rain, vehicles traveling on unhardened concrete, and deficiencies caused by poor workmanship may be repaired or restored to an acceptable condition without complete removal and replacement of damaged areas.

Rain damage varies considerably depending on rainfall intensity, duration, and protective measures taken by the Contractor. Covering and side forms placed by the Contractor afford sufficient protection to unhardened concrete in some cases. In other cases, surface and edges may erode to such a degree that removal and replacement of the slab is the only solution.

Guidelines follow for corrective measures that may be taken or used to restore damaged pavement to an acceptable condition. This instruction is not intended to cover the whole spectrum of deficiencies that may occur on a paving project during construction. Other proposed procedures or methods suggested by the contractor may be considered.

Recommended Repair Method

A. Rain Damage and Excessive Edge Slump

1. On plastic concrete:
   - Pavement surfaces which have slight surface damage due to placement of protective covering or sandy appearance may be retextured provided concrete is still plastic and in workable condition.
   - Eroded edges may be repaired by setting side forms and replacing eroded concrete with fresh mix.
   - Excessive edge slump may be corrected by setting side forms of proper height along slumped edge and refinishing to correct elevation.

   NOTE: *When fresh concrete mix is added to plastic pavement for the purposes of replacing eroded mix or repairing excessive edge slump, the mix shall be vibrated to ensure proper consolidation.*

2. After concrete has hardened:
   - Pavement surfaces that have lost the texture without affecting the surface profile shall have the necessary texture reestablished. This may include diamond grinding or grooving. Grooving shall be reestablished in the same direction as placed in the adjacent pavement.
   - Pavement surfaces which have been severely eroded require reprofiling by diamond grinding equipment.
   - Minor edge erosion and edge slump with a key and doweled joint where an adjacent slab needs to be butted to the existing pavement. Establish a new edge, not to exceed 75 mm (3 inches) in from previous edge, by sawing to the top of the tie bar, remove the concrete and replace it when the new adjacent pavement is poured. If necessary to go more than 75 mm (3 inches) from edge of pavement to correct eroded or slumped edge, the edge shall be repaired by using Class A bridge repair methods prior to pouring the adjacent slab.
   - Excessive edge slump may be repaired by using Class A bridge repair methods.
   - Edges or panels that have been severely eroded may require all or a section of lane to be removed or replaced. If determined that a section of lane more than 600 mm (2 feet) in width should be removed, then the entire lane or panel shall be removed and replaced with new concrete. Areas less than 600 mm (2 feet) in width shall require full depth repair with holes drilled and tie bars installed to anchor new concrete to remaining concrete.
   - For areas with an extreme severely eroded surface and edges, the contractor should be required to place an ACC or bonded PCC overlay.

B. Vehicle Traffic on Plastic Concrete

Remove and replace sections where rutting is severe.

Minor wheel track rutting may be repaired by using Class A bridge floor repair methods.

C. Random/Uncontrolled Cracking

Specification 2301.03, N requires the Contractor to repair random and uncontrolled cracks at no additional cost to the Contracting Authority. The intent of this specification is to hold the Contractor responsible for cracking resulting from the Contractor's operations. Methods of repair are to be submitted to the Engineer for approval. Recommended methods of repair for random or uncontrolled cracks are included in Appendix 9-6. Project specific circumstances may dictate that repair methods other than those listed in Appendix 9-6 be allowed with approval of the Project Engineer.

D. Shrinkage Cracks

Remove and replace affected areas with new pavement in severe cases.

Minor cracks may be filled with pressure injected epoxy or repaired using Class A bridge floor repair methods.

E. Rough Pavement Sections

Surface variations, which exceed the specification smoothness requirements, require correction by the Contractor. Surface correction shall be accomplished with approved diamond grinding equipment. Use of milling machines, Roto Mill, Galion Scarifier, or other impact devices shall not be permitted.

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F. Edge Damage

Throughout the various activities involved in construction of a PCC pavement, the edges of the pavement can become damaged. Whether it be damage from a maintainer while preparing subgrade and base material for shoulders, or a trencher excavating a subdrain trench, or a roller compacting granular or HMA shoulder material, the edges of a PCC pavement can be exposed to harsh treatment.

While edge damage typically is not a structural problem, it is unsightly and a result of substandard workmanship. Edge damage can affect the functional performance of the pavement by influencing drainage and reducing the effective width of pavement markings. In many cases typical repair methods such as partial depth patching may not be practical for minor edge damage. Construction Manual 2.53 includes recommended repairs and/or price adjustments for PCC pavement edge damage based on severity of the damage.

G. Limitations

Necessary corrective measures on hardened concrete shall only be made after concrete attains age and strength requirements in Specification 2301.03, U.

All required corrective measures shall be completed prior to coring for pavement thickness measurements.

Consultation with the Office of Construction is recommended before placing an HMA or bonded PCC overlay.

9.54 MUD BALL REPAIR

Occasionally mud balls appear in the surface on new concrete pavements. These usually are due to clay balls from a quarry, trucks dropping mud from their axles when dumping from a bridge over a dump pit, or end loader operators digging too deep when removing material from a stockpile.

Correction of any discovered mud balls in a pavement surface shall be as follows:

- Any thin concrete skin around the perimeter of the mud ball should be removed so that nearly vertical void walls remain.

- Each void shall be cleaned by a high pressure washer, followed by air blasting to dry the void.
- Voids shall be filled with material meeting *Materials I.M. 491.20*, *Appendix A*. This material shall be used according to manufacturer's recommendations.
- The surface of filled voids shall be given the same texture as the surrounding pavement.
- A void repair shall be given the proper cure time recommended by the manufacturer prior to opening the roadway to normal traffic.

If a severe problem with mud balls is suspected on a specific project, formal acceptance by the Project Engineer should be delayed until the following spring. This will allow the winter freeze-thaw cycles and snowplowing activities to expose additional mud balls located adjacent to pavement surface. These newly discovered mud ball areas will then also require corrective measures as stated above.

9.55 COLD WEATHER PAVING AND PLANT OPERATIONS

Cold Weather Pavement Protection

During cold weather, Specification 2301.03, K, 3 requires that newly placed paving, less than 36 hours old, be protected against freezing temperatures. This protection is necessary to allow the hydration process of the curing concrete to continue in cold weather. Adequate protection of concrete allows for paving to be placed later in the season.

The required cold weather protection needed during any given day should be mutually agreed upon between the Contractor and Project Engineer. A daily predetermined weather forecast should be used. For example, the low temperature forecast from the 4:00 pm local radio newscast could be the agreed upon temperature forecast. Once a decision is made as to the appropriate cold weather protection needed, any changes to the amount of protection needed must be agreed between the Contractor and Project Engineer to avoid potential claims.

Below -4^o C (25^o F), Specification 2301.03, K, 3 requires four layers of burlap between layers of 1.0 x 10^{-4} mm (4 mil) plastic or an equivalent commercial insulating material approved by the Project Engineer. Equivalent materials include:

- 3 layers of Burlene
- 1 layer of insulating blankets with a minimum R-value of 1.0
- 1 layer of 12 mm (1/2 inch) extruded polystyrene, must be weighted down
- 2 layers of 6 mm (1/4 inch) air celled polyethylene
- 1 layer of 12 mm (1/2 inch) air celled polyethylene

Specification 2301.03, K, 3 also includes provisions for removal of the cold weather protection. Often a night or two of low temperatures is followed by several days of warmer temperatures. The provisions in 2301.03, K, 3 provide a means for allowing the removal of cold weather protection when it will no longer be necessary. This is especially important in that it allows the Contractor to reuse covering materials more quickly rather than unnecessarily leaving them on pavement that no longer needs to be covered.

When cold weather protection is required, the Contractor will be reimbursed for extra work per Specification 2301.05, J. The reimbursement amount is the same value regardless of number of layers of protection required.

Cold Weather Plant Operation

Specification 2301.03, S states that concrete mixing and placement may be started when the air temperature is at least 1° C (34° F) and rising. In the late fall season before the subgrade begins to freeze and soil temperatures are still relatively warm, it is permissible to allow paving plant operations to begin below 1° C (34° F) providing a decent weather forecast is predicted. Paving plant operations basically self regulate during these conditions.

The intent is to maximize the remaining good paving weather still available in the fall. This provision is not intended to make a paving day out of one that is not, but to allow for as much concrete pavement placement as possible during a day forecast for good weather.

After the subgrade begins to freeze, the above provisions should be halted and specifications strictly enforced.

9.56 CURING

White pigmented liquid curing compound is required to be used to cure concrete pavements. The purpose of the curing compound is to provide a protective, semi-impermeable coating to aid in retaining moisture in the concrete. This helps to ensure that adequate moisture will be available for thorough hydration and strength gain.

Cure is typically delivered to a project site in reusable plastic totes. Each tote should be properly labeled to identify the brand and lot number of the cure within. Occasionally totes have been refilled on a project by a tanker directly from the supplier. This is an acceptable practice provided the totes are relabeled to identify the new material. If a different brand of cure or cure from a different lot is used to refill the tote, the tote should be relabeled to properly identify the material. In addition, any label that does not correctly identify the new material should be removed.

The cure shall be applied to the pavement as soon as practical after the finishing operation is complete. This is normally applied with a machine that both applies the curing compound and creates the texture. This is a stop and go operation since curing and texturing can be accomplished faster than the paving operation. Curing shall not be delayed simply because the tines are creating too deep of a texture groove. The goal is a shallow groove and the texture machine can be adjusted in order for the tines to apply less pressure on the surface of the fresh concrete. With a consistent concrete mixture, the downward pressure on the tines can be adjusted in order to allow the tining machine, and thereby the curing process, to be kept right behind the finishers.

The curing shall be applied no later than one half hour after placement. In very hot, dry, windy conditions this is not soon enough. A price adjustment schedule is provided as Table C5 in Appendix 2-34C for areas of pavement where cure is not applied in a timely manner.

9.60 CONCRETE MATERIALS ISSUES

9.61 CONCRETE SAMPLING LOCATIONS

Concrete samples shall be taken as described in *Materials I.M. 327*. The sample location point shall be after plastic concrete has been placed on the grade, either by direct depositing from a batch truck or by use of a placer/spreader machine. On slipform paving projects, the optimum sample location is between placer/spreader and slipform paver machines. For safety considerations, samples may be taken from concrete deposited on the grade in front of the belt placer. Care should be taken to avoid sampling concrete that has been vibrated manually or mechanically. Samples should be taken at locations within the batch that appear to be representative.

9.62 TESTING PROCEDURES

When making test specimens, a sample should consist of about 0.03 cubic meters (one cubic foot) and should be remixed a minimum amount by use of a shovel to ensure uniformity. For routine air and slump tests, smaller samples may be used.

For standard methods of tests, refer to *Materials I.M. 327* (Sampling Freshly Mixed Concrete), *Materials I.M. 316* (Flexure Strength Tests), *Materials I.M. 317* (Slump Test), *Materials I.M. 318* (Air Content Test), and *Materials I.M. 328* (Making, Protecting, and Curing Beams).

9.63 AIR ENTRAINMENT IN PLASTIC CONCRETE

Specification 2301.02, B, 4 discusses the required percent of entrained air needed for concrete paving mixes. These percentages have been developed to allow for loss of entrained air as the plastic concrete is placed and consolidated as it goes through the paving operation. The concrete paving mixes have been developed to provide for consolidated concrete containing a 6% air content. Because the entrained air content percentages account for air loss through the paver, it is important to check the actual air loss through the paver to ensure that the amount of air loss is reasonably close to the anticipated loss. Air content should be checked behind the paver once each day for the first three days of paving. After that, air should be checked once per week behind the paver to verify the amount of air loss through the paver is consistent. The target air content for slip form pavement as determined by Materials I.M. 318 shall be 8.0%, plus or minus 2.0%, when measured on the grade just prior to consolidation. The air content for non slip form paving shall be 7.0% plus or minus 1.5%. Even when within the allowable air content range, the contractor should be making a reasonable effort to work toward the target air content. For slip form paving, adjustments to the mix should be made when the air content is less than 7% or greater than 9%. For non-slip form paving adjustments should be made when the air content is less than 6.0% or greater than 8.0%.

Aggregate Correction Factor

Per *Materials I.M.* 318, an adjustment to the target air content called an aggregate correction factor may be required for some quarries that have highly absorptive aggregates. The aggregate correction factor may be obtained from the District Materials Office. The target air content for PCC mixes utilizing these aggregates would be the specified target for the application plus the aggregate correction factor (see example below). Applying the aggregate correction factor when using aggregates from these quarries helps ensure that proper air content is achieved in the hardened concrete and also reduces excessive bleeding.

Example: For slip form PCC paving utilizing ready mixed concrete, specified air is 7.0% plus or minus 1.5% for the first day of paving. For an aggregate correction factor of 1.0%, the target would be 8.0% (8.0% equals the specified target of 7.0% plus the aggregate correction factor of 1.0%) plus or minus 1.5% .

The aggregate correction factor is in addition to any correction added for air content lost through the paver.

The following process will be used in verifying entrained air content in PCC paving mixes:

Control of Air Content
On projects where the contractor is performing quality control testing, the contractor and agency shall run side by side tests on the first air test of each day to ensure air meters are within the tolerance in IM 216. If the air tests are outside the tolerance, the air meters should be calibrated in accordance with IM 318. The contractor shall notify the engineer whenever an individual quality control test result is outside the tolerance for the target air content.

Verification
Lot acceptance shall be based on the agency verification test results on the unconsolidated mix on the grade. A lot is defined as the amount of a concrete mix placed since the last complying verification air content test.

Air Content Outside Tolerance
When a verification test result is outside the tolerance for the target air content, the contractor will be notified immediately. The contractor shall make immediate adjustments to the mix production and placement process to bring the air content back within tolerance. An air test will be immediately run behind the paver to aid in identifying the limits of the non-complying air. A test result between 5% and 8% behind the paver will be considered complying. This test will represent all concrete from the back of the paver back to the last verification test (or witnessed and documented quality control test when applicable).

All loads placed after the non-complying load will be tested until air content is within tolerance for two consecutive loads. Loads below the lower target air content tolerance by more than 0.5 % shall not be used. A price adjustment will be applied to all incorporated, non-complying loads that are out of tolerance. Removal and replacement may be required.

Air Content More Than 0.5% Below Lower Target Content
When the lot verification test result is below the lower target air content by more than 0.5 percent and the test run behind the paver indicates air content below 5% or above 8%, the contractor may elect to take concrete core samples from the pavement to define the portion of the lot that is non-complying. The lot will be divided into equal 200 square yard (170 square meter) sublots, from the last complying verification test, or witnessed and documented quality control test. A randomly located core will be identified in each sublot. Coring will be at the contractor's expense. The agency will direct and witness the taking of cores. The contractor may either:

1. Provide the agency with the cores for testing by Materials Laboratory Test Procedure 407.

2. Provide an independent laboratory for testing and a test procedure acceptable to the agency. The agency will take possession and ship the cores at the contractor's expense. Results will be directly reported to the agency and the testing will be at the contractor's expense.

Price Adjustments

Price adjustment or removal and replacement will be required for the following:

1. The load of concrete represented by the non-complying verification test.
2. The concrete between the load of concrete represented by the non-complying verification test and the test location behind the paver when the test behind the paver is between 5% and 8%.
3. All concrete between the non-complying verification test and the last complying verification test (or witnessed and documented quality control test when applicable) when the test behind the paver is less than 5% or greater than 8%.
4. When coring, sublots represented by cores with an entrained air content below 5.0 percent or above 8.0 percent.

Appendix 2-34(C) is the price adjustment table that lists price adjustments to be applied to concrete in which verification test results fall outside the specified limits.

9.64 CONCRETE VIBRATION AND CONSOLIDATION

Specification 2301.03, A, 3, a, 6, a requires vibration frequency to be maintained between 4000 and 8000 vibrations per minute for concrete paving finishing machines. To ensure proper consolidation of the plastic concrete, the vibration system used in the finishing machine should provide continuous and full coverage.

The depth of penetration into the concrete of internal vibrators should be set to mid slab height or as deep as possible while passing above any reinforcing steel. An operating position locking device should be provided so that no part of the vibrating unit can be lowered to the extent that it will come in contact with reinforcing steel or tie bars while paving.

Horizontal spacing of vibrators should not exceed the manufacturer's recommendation or 16 inches (410 mm), whichever is less. The Engineer may allow exceptions to this spacing in situations where structural elements of the paver make it impractical to maintain exact spacing. Vibrator spacing should not be increased for tie steel insertion or lack of adequate number of vibrators. Centerline spacing may be increased up to 30 inches

The longitudinal axis of the vibrator body should be mounted approximately parallel to the direction of paving with the exception that the trailing end of each vibrator shall be tilted downward to an approximate slope of 15 degrees below horizontal.

On large projects, greater than 50,000 square yards (40,000 square meters), an electronic monitoring device, which monitors and records the frequency of each vibrator on the paver, is required. The inspector will periodically check the electronic monitor by use of a manual device. The inspector will periodically check the monitor during the paving day and review, on a spot basis, the daily record of the vibration frequencies. Specification 2301.03, A, 3, a, 6, a requires submittal of vibration monitoring data daily for the first three days of paving and weekly thereafter. It is important that these submittals occur because it gives the Engineer the opportunity to review the vibration data to ensure that vibrators are being operated within the allowable frequencies. Upon completion of the project, all vibration monitoring data should be submitted to the Office of Construction and Materials.

When a vibrator monitor is not required, vibrator readings should be taken and recorded at the start of concrete placement. Vibrators may be checked in the morning, before paving operation begins. This check can detect malfunctioning or dead vibrators. But, the frequencies will change as the hydraulic oil is heated once paving begins. A check of frequency levels needs to be made after the paver has been operating for some period of time, at least after the first 20 minutes or half hour. Readings should also be taken at least twice daily to check for mechanical failures or problems in the vibration system of the paver. When vibration monitoring is used, these checks are intended to verify that the vibration rate displayed by the monitor is the actual rate of vibration. When vibration monitoring is not used, vibration rate of each vibrator should be checked and recorded twice daily. Vibrator readings should be recorded on Form 830213 “Project Information/Paver Inspection.” A copy of this form is included in *Appendix 9-3*.

If vibrator frequencies are greater than allowed by the specification, the Contractor should be informed to adjust the paving operations so that future measurements are within required specifications. Excessive vibration frequencies have been known to produce lower entrained air and premature concrete pavement deterioration with shorter pavement life. A price adjustment schedule for out of tolerance vibration can be found in *Appendix 2-34(C)*.

It is also helpful to watch for the presence of vibrator trails in the plastic concrete surface behind the transverse texturing operation (but before the curing compound application). These trails show in the surface of the plastic concrete by a deeper groove in the textured surface. This deeper texture follows the path of the vibrator. Many existing Portland cement concrete pavements are showing these “vibrator trails.”

9.65 PAVEMENT THICKNESS CORES

Materials I.M. 346 describes procedures for coring PCC pavement for evaluating thickness requirements. The procedures are the basis for acceptance and payment of work. The Engineer will witness the coring and measure the cores immediately on the grade. If cores are not measured on the grade, the Engineer must take immediate possession of the core samples as they are drilled to ensure a proper chain of custody for acceptance. At no time should the contractor have possession of the cores prior to measurement by the Engineer.

9.66 PAVEMENT SMOOTHNESS

Pavement smoothness shall be evaluated in accordance with *Specification 2316, Specification 2317,* and *Materials I.M. 341.* See *Construction Manual 3.60* for additional information.

9.67 QUALITY MANAGEMENT CONCRETE (QM-C)

QM-C is the design, testing, placement, and monitoring of a Portland cement concrete mixture by a contractor in partnership with the owner for the purpose of making a superior product while promoting innovation and understanding.

The Iowa DOT requires QM-C on large paving projects typically greater than 50,000 square yards (42,000 square meters). It is mainly used on rural type paving projects, without a lot of staging and/or handwork. The mix design is based on an optimized gradation, usually requiring three aggregates of coarse, intermediate, and fine (sand) sizes. QM-C mixes are designed for use in slip-form paving operations only. The optimized gradation allows easier slip-form placement without edge slump, especially on pavements with thicker pavement section (i.e. 12 inch thick interstate pavements). The QM-C mix design is typically coarser than Class C mix design and is not intended for handwork placement. The QM-C Developmental Specification requires Class C concrete for handwork. However, in some cases the QM-C mix may be workable enough to be acceptable for handwork. With approval from the Project Engineer, a QM-C mix may be used for handwork.

Since three aggregates are typically required to produce the optimized gradation, QM-C mix designs are better suited on large rural paving projects where batches are proportioned in a central plant. Many ready mix producers do not have the capability to handle more than two aggregates, thus, it is usually not feasible to require QM-C on small projects that would typically use ready mixed concrete.

The biggest misconception of using the QM-C specification is that the contracting authority does not have to do verification testing since the contractor performs quality control testing. This is not true. The contracting authority is obligated to do the same testing whether a project is QM-C or not. IM 530 describes the testing required by the contracting agency. The contracting agency's test results must be used in the acceptance decision to comply with the requirement of the Materials Sampling and Testing Program. By not performing any verification testing, the owner may jeopardize federal aid on the project.

Since the contractor incurs additional costs for mix design, grade testing, and increased amount of coarse aggregate in QM-C mixes, Class C concrete may be more economical on smaller projects, urban projects, and projects with extensive staging. Class C concrete will perform equally as well as the QM-C mix design and is sometimes better suited for certain placements and field situations.

Measurement and Payment

Measurement and payment can be difficult when using QM-C mixes. An incentive payment is applied to QM-C pavement items based upon the aggregate gradation achieved in the CDM throughout the project. However, the incentive only applies to the area of pavement placed using the CDM, and it should never be paid on non-QM-C bid items, even when the CDM is used.

NOTE: *For overlays, the incentive payment for gradation is applied to both the QM-C Furnish item and the QM-C Placement item.*

The square yard (meter) items for QM-C are plan quantity and typically would not need to be measured. However, because the Coarseness/Workability incentive payment only applies to the slip formed portion of the square yard (meter) item, the area of all hand pours must be measured and subtracted from the plan quantity to determine the appropriate Coarseness/Workability incentive payment. This is further complicated by the contractor's option to use the QM-C mix for non-QM-C pavements on a project. See *Appendix 9-7* for guidance on payment for PCC pavements under the QM-C specification.

Materials I.M. 530 requires submittal of all QM-C quality control charts and records to the

Project Engineer. The Project Engineer should forward copies of these files to the Office of Construction and Materials upon completion of the project.

11.50 CONCRETE (STRUCTURAL, CLASS X, AND FLOWABLE MORTAR)

11.51 PCC PLANT PAGE (FORMS 800240E and 800240M)

The project engineer shall report weekly all concrete placed for each project on "PCC Plant Page" (Form 800240). This form will record concrete placements, all results of sieve analysis tests, and all data on test beams made and tested. The week covered by each report shall begin on Sunday morning and end on Saturday evening. A separate Form 800240 is required for each bridge design, including bridge deck surfacing and resurfacing, and each group of culverts. Refer to *Materials I.M. 527* for instructions on preparing this form.

11.52 USE OF READY MIXED STRUCTURAL CONCRETE

Prepour Meeting

It is very important to use the prepour meeting to discuss the specifics of placement, establish communication, and resolve potential "sticky" issues prior to placement. Generally it is recommended to discuss:

- Chain-of-command. Who is in charge for contractor? Who needs to be notified if material tests do not comply with specifications? Establish prior to placement how test results are reported (i.e., does the contractor want to be notified verbally, or in writing each time?).

- Material requirements and admixtures needed for the placement (Examples: Single cement source, concrete temperature and methods used to cool the mix, source and amount of any admixtures, specific mixes required for bridge decks, etc.).

  Procedures for introducing admixtures during mixing operations need to be discussed and formalized. For example: How and where will the air entraining agent be introduced? There is a growing concern that placement location of admixtures is causing significant variability in mixes. The plant monitor must watch and document how admixtures are introduced during mixing.

- Method and frequency of acceptance testing during placement. Inform the contractor what is expected if non-acceptable material is found during placement. Recommend to the contractor that they arrange to have a representative from the ready mix plant on site to coordinate concrete delivery, adjustments to concrete mix, and provide direct communication with the ready mix plant during concrete placements.

- Scheduling, truck availability, placement method, and required placement rates.

- Establish an acceptable source of pre-placement weather forecasting. Agree on weather parameters which will be used for "go" or "no-go" decisions both "prior to" and "during" the placement activity.

- Review & Discuss items under “Concrete Bridge Floors” in Section 11.62. **NOTE: On pretensioned prestressed concrete beam bridges the beams must be at least 28 days old before the floor is placed, to enable time for beam creep and camber to develop**.

Inspector's Checklist

A. Specifications regarding plant inspection, equipment approval, and batching operations should be reviewed for familiarity. In addition to proper plant calibration, the inspector should verify that each truck mixer used on the job has a current certification as required by Specification 2001.21, C and *Materials I.M. 528*. It is good practice to inspect a random sample of ready mix trucks that will be used on the job, verifying that the certification accurately reflects the truck's condition. Truck certification numbers should be recorded in the inspector's diary and will need to be reverified at least every 30 days. Required information to be recorded on ready mixed concrete truck batch tickets shall be according to Construction Manual Section 9.03.

B. Batching and mixing should be limited to the lead truck until slump and air content have been tested for conformance with specifications. Contractors may make preliminary tests at the plant, but project acceptance is based on job site tests. It is intended that the ready mix plant supply concrete to the construction site that conforms to all applicable specifications at the point where the acceptance sample is taken.

Specification 2403.02, B, 2, a states for Structural Concrete: "Concrete shall be placed with a slump between 25 mm and 75 mm (1 and 3 inches) as a target range, allowing a maximum of 100 mm (4 inches) ..."

Specification 2403.02, B, 3 states for Structural Concrete:
"... unvibrated structural concrete shall be 6.5 percent, as a target value, with a maximum variation of plus 1.5% or minus 1.0%." Note: As stated in I.M. 318, an adjustment to the target air content called an aggregate correction factor may be required for some aggregates obtained from quarries in Iowa that have highly absorptive aggregates (refer to related list of aggregate sources in Materials I.M. 318). The aggregate correction factor may be obtained from the District Materials Engineer. The target air content for structural concrete utilizing these aggregates would be the specified target for the application plus the aggregate correction factor (see example below). Applying the aggregate correction factor when using aggregates from these quarries helps ensure that proper air content is achieved in the hardened concrete and also reduces excessive bleeding.

Example: For structural concrete specified air content is 6.5% plus 1.5% or minus 1.0%. For an aggregate correction factor of 1.0%, the target would be 7.5% (7.5% equals a specified target of 6.5% plus aggregate correction factor of 1.0%) plus 1.5% or minus 1.0%.

If concrete is being delivered which deviates much from these target values, the contractor is responsible for taking corrective action to bring the mix to within target values even if the current mix is within specified limits. The intent of the tolerance is to provide latitude during placement for unforeseen changes in materials, mixes, and placement methods. Placing concrete "consistently" near a tolerance limit is not desirable and warrants additional sampling.

What is important is the contractor's response to test results approaching tolerance limits. Continually having to add water and/or air agent to each load at the site will not be permitted. If such practice is occurring, the inspector shall notify the contractor (or whoever was designated as "the" responsible individual in charge of the concrete at the site). Ultimately, it is the contractor's responsibility to initiate immediate corrective action.

Non-responsiveness on the contractor's part is reason to initiate sampling and testing of each truck or halt placement. The purpose for additional testing is to ensure that no noncomplying materials are incorporated into the project.

In some cases admixtures, such as water reducers, are required to be added in split doses or sometimes totally at the site.

C. All Structural Concrete

- At the start of each day's placement, no concrete is to be placed in the forms or on the deck until the first truck has been sampled, tested, and approved. Incorporation of materials from this truck will not be permitted unless desired slump and air content are within specified limits. Continuous placement shall not begin until after test results indicate the material meets specified requirements.

  If the first load is close to a limit value, it is recommended to sample and test the second load unless site experience indicates it is not necessary.

- Initial start up test results (if taken from the truck chute) must account for method of placement. For example, if placement will be through a pump, air values should be on the high side of target to account for loss during pumping. Again, site/project experience should be factored in this decision.

- Routine acceptance testing will be at a minimum frequency of one sample per 25 cubic meters (30 cubic yards). This frequency may be changed for large, continuous placement where placement rates warrant a lesser frequency. Minimum *quantity* placed between routine acceptance tests is 25 cubic meters (30 cubic yards). This rate of testing may be ***increased*** (made more frequent) if the inspector has a concern that target values are not being met.

  NOTE: Only the District Materials Engineer has authority to approve ***decreasing*** (less frequent) testing frequencies from those listed in *Materials I.M. 204*. PLAN AHEAD and obtain approval for those cases where a variance would be reasonable.

- For routine acceptance testing, obtain a representative sample *at the last practical point* before incorporation, but prior to consolidation. The intent here is to obtain a sample that will most accurately represent the values of slump and air content of the concrete placed. There have been some questions regarding what is considered the *last practical point* before incorporation. This is an area for good judgement relative to the particular placement. As a guideline, if an inspector has access to the point of discharge of the concrete and will be in this location for other inspection being performed it would seem reasonable that a sample could be obtained for testing. The testing of the sample should be able to be conducted in a reasonably close proximity to the point of sampling.

  NOTE:
  When concrete is placed by means other than directly from the back of the truck, the sample shall be taken, if possible, after the concrete has passed through the conveyance method being used. (This includes placement by bucket, belt, pumps, power buggies, etc.)

- Routine acceptance sampling and testing does not require holding a truck until results are available. However, if there are obvious deficiencies, the inspector has the authority to hold that truck until test results are available.

- Inspectors should be alert to obvious visual changes in consistency, with routine acceptance air and slump tests being made as noted above. Any load having questionable consistency should be checked for slump.

- If noncomplying test results are found during routine acceptance sampling, no more material (from that truck or others) shall be incorporated until complying test results are obtained. When test results indicate noncomplying material:
  1. The rest of that load shall be rejected and not incorporated, unless adjustments can be made to bring it back into compliance *(Specification 1106.04).* In an attempt to bring noncomplying concrete into compliance, the supplier may make field adjustments (i.e., add air entraining agent, add portland cement, or rotate the drum). Such "field" adjustments shall be an **EXCEPTION** and not the general rule and the 90 minute time restriction shall not be waived for any situation.

  2. For all noncomplying test results the inspector shall immediately notify the contractor or their representative in charge of the concrete. This notification shall also inform the Contractor if noncomplying materials have been incorporated into the structure.

  3. If test results indicated noncomplying materials have been incorporated, the inspector shall make a note in the diary indicating the test results, approximate volume incorporated, location the material was placed, and to whom the notification was given. The inspector should also note a noncomplying event on that particular truck's delivery ticket.

     At the end of each day or each placement event (whichever is sooner) the inspector shall prepare a Noncompliance Notice (Form 830245) for all noncomplying material incorporated and not removed/replaced during that day or placement event. This notice shall be given to the Contractor yet that day *(Materials I.M. 204).*

  4. When noncomplying materials are found, the inspector will a) hold each truck, and b) initiate sampling and testing of each truck until two consecutive loads meet specifications. At this point, sampling and testing may return to normal project acceptance frequency.

D. *Specifications* and *Materials I.M.s* spell out requirements that materials must meet to be acceptable. Further, *Materials I.M. 204* identifies a frequency for sampling/testing and whether the test is an acceptance or assurance test.

   Authority for initially rejecting noncomplying materials and poor quality work performance is given to the inspector in *Specification 1105.07*. This rejection authority is only superseded by the project engineer. There is an old saying to the effect, *"We shall not knowingly incorporate noncomplying material into a project."* This means exactly what it says and there is ample support in the specifications for this position.

E. During placements, the inspector should alternate sampling among the various trucks involved in the operation.

F. If there is a specific truck which is identified as causing a problem with consistency, that truck shall be rejected from further use. (Refer to Specification 2001.21,C, 6.)

G. Transit mixers shall be completely emptied of wash water before reloading. If the truck's top fill hopper is washed after loading, no wash water shall be allowed to enter the mixer.

H. When it is not practical to sample at the last point prior to incorporation, then a method of correlation between point of placement and the actual point of sampling must be developed. While such cases should be the **EXCEPTION and NOT THE GENERAL RULE**, one approved method is as outlined below:

When concrete reaches a stable consistency and is within target ranges, correlation tests can be run between the last practical sampling location and the place of deposition. If differences are consistent, then correlated tests can be taken at the last practical sampling location.

The following is a guideline if tests are not consistent:
Test a minimum of three loads of concrete sampled from the "last practical sampling location" and at the point of discharge. Average the difference between the test results. This average (correction factor) is used until another correlation is determined. Correlation tests should be determined, as a minimum, at the beginning, middle, and toward the end of a pour. The inspector needs to factor in situations such as size of pour, changing weather conditions, changes in conveyor length, changes in pumping configuration or pipe angles, and changes in batch proportions when determining frequency of correlation tests.

All subsequent "acceptance" tests are taken at the last practical sampling location and are adjusted using the correlation factor.

All correlation tests and correction factors are to be documented in the field books and noted on the "PCC Plant Page" (Forms 800240E and 800240M) or on a sheet attached to the form. Results reported using correction factors shall be identified with an asterisk (*) or written note.

I. The inspectors will need to satisfy themselves regarding compliance with the specifications for the number of drum revolutions at mixing speed.

J. If water, air entrainment, or other admixtures are added at the project site, acceptance testing will not be performed until all additions have been made AND 30 revolutions at mixing speed have been completed following the change.

11.53 ADMIXTURES

Admixtures are those ingredients in concrete other than portland cement, water, and aggregates, that are added to the mixture immediately before or during mixing. Admixtures typically encountered on our jobs can be classified by function as follows:

- Air entraining admixtures
- Water reducing admixtures
- Set retarding admixtures

- Set accelerating admixtures
- Corrosion inhibiting admixtures
- Finely divided and permeability mineral admixtures (Fly Ash, Ground Granulated Blast Furnace Slag & Silica Fume)
- Coloring agents (normally not used for Iowa DOT work)

The amount of any admixture used in a mix should be as recommended by the manufacturer and verified through laboratory testing or trial mixes. Effectiveness of an admixture depends upon such factors as type, brand, and amount of cement; water content; aggregate shape; gradation and proportions; mixing time; slump; and temperatures of concrete and air.

Air Entraining Admixtures
Air entraining admixtures are used to purposely entrain microscopic air bubbles in concrete. Air entrainment will dramatically improve the durability of concrete exposed to moisture during cycles of freezing and thawing. Entrained air greatly improves concrete's resistance to surface scaling caused by chemical deicers.

Rules-of-Thumb

- As cement content increases, air agent must increase to maintain equal entrained air.
- As cement fineness increases, the amount of air agent must increase to maintain equal entrained air.
- As coarse aggregate size decreases, the air content increases for a given amount of air agent.
- As fine aggregate volume increases, the air content increases for a given amount of air agent.
- As mixing water increases, the air content increases for a given amount of air agent.
- Air entraining admixtures should be introduced into mix at the plant, but additional may be added at the site to adjust mix for correct air content.
- Air entraining admixtures should (usually) be added to the front of the truck at the plant. If corrosion inhibiting admixture is used, air entraining agents should be added to the back of the truck.

Water Reducing Admixtures - Regular
Water reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump or reduce the water-cement ratio. Regular water reducers reduce water content by about 5% to 10%.

Adding a water reducing admixture to a mix without reducing water content can produce a mixture with a much higher slump.

Rules-of-Thumb

- Typically, water reducing admixtures do not reduce the rate of slump loss; in most cases, it is increased. Rapid slump loss results in reduced workability and less time to place concrete at the higher slump.
- Typically, water reducing admixtures have no effect on bleed water.
- Certain types of sulfate starved portland cements may cause false-set with certain brands of water reducers. Typically, water reducers contain lignosulfonates and these sulfates are easily attracted by sulfate starved cements. This action may cause early false-set.

- Despite reduction in water content, water reducing admixtures can cause a significant increase in drying shrinkage.

Water Reducing Admixtures - Super Plasticizers
Super plasticizers are simply "high-range water reducers." They are added to concrete with low-to-normal slump and water content to make high slump "flowable" concrete. Flowable concrete is a highly fluid, but workable concrete that can be placed with little or no vibration and can still be free of excessive bleeding or segregation. Flowable concrete has applications:

1. In areas of closely spaced and congested reinforcing steel
2. In tremied concrete where "self consolidation" is desirable
3. In pumped concrete to reduce pump pressure
4. To produce low water-cement ratio - high strength concrete. High-range “super plasticizers" can reduce water content by about 12% to 30%.

Rules-of-Thumb

- The effect of most super plasticizers in increasing workability or flowable concrete is short lived. Typically, maximum is 30 to 60 minutes followed by a very rapid loss in workability.
- Typically, super plasticizers are added as split treatments (part at the plant, part at the site). Sometimes the addition is totally at the site.
- Setting time may be affected depending on the brand used, dosage rate, and interaction with other admixtures.
- Excessively high slumps of 250 mm (10 inches) or more may cause segregation.
- High-slump, low water/cement super plasticized concrete has less dry-shrinkage than does high-slump high water/cement conventional concrete.
- Effectiveness of super plasticizer is increased with an increased amount of cement, and/or increased fineness of cement.
- Effectiveness of water reducers on concrete is a function of their chemical composition, cement composition and fineness, cement content, concrete temperature, and other admixtures being used.
- Some water reducing admixtures, such as lignosulfonates, may also entrain some air in the mix.

Retarding Admixtures
Retarding admixtures (retarders) are used to delay the initial set of concrete. High temperatures of fresh concrete 30^{o}C (85^{o}F) and up often cause an increased rate of hardening. Since retarders do not decrease the initial temperature of concrete, other methods of counteracting the effect of temperature must be used.

Rules-of-Thumb

- Retarders are sometimes used to delay initial set of concrete when difficult, long placement times, or unusual placement conditions exist.

  NOTE: Retarders are not to be used when the anticipated temperature of the mix is below 13^{o}C (55^{o}F); however, placement requirements must be met within the initial set time indicated for the non-retarded concrete.

  Retarding admixtures require a concrete temperature of 13^{o}C (55^{o}F) or greater in order to activate and effectively retard the set of concrete. If the proposed placement cannot be accomplished within the initial set time for non-retarded concrete, the concrete mix temperature will have to be increased through the use of heated materials. When heated materials are used, it is recommended that a concrete mix temperature of 18°C (65°F) be targeted for effective activation of retarding admixtures.

- Retarders offset the set acceleration effect of hot weather.
- Retarders can be added at the site.
- In general, some reduction in strength at early ages (one to two days) accompanies the use of retarders.
- Use of retarders must be closely monitored, because there is probably no single admixture which has caused more field problems.
- If too much retarder has been used in a mix:
  1. Time will usually counter the effects.
  2. "Be sure" to maintain the cure during the added time.

Accelerating Admixtures
Accelerating admixtures (accelerators) are used to accelerate the setting time and strength development of concrete at an early age. Strength development can also be accelerated by using:

- Type III "high-early" cement
- Lowering water/cement ratio
- Curing at controlled higher temperatures

Calcium Chloride ($CaCl_2$) is the material most commonly used in accelerating admixtures. Besides accelerating strength gain, calcium chloride also causes an increase in drying shrinkage, potential reinforcement corrosion, discoloration, and potential scaling.

Rules-of-Thumb

- Always add calcium chloride in solution form as part of the mixing water.
- Calcium chloride is not an antifreeze agent. When used in allowable amounts, it will only reduce the freezing point of concrete by a few degrees.

Corrosion Inhibiting Admixtures
Concrete protects embedded steel from corrosion through its highly alkaline nature (12.5 pH). This causes a passive and non-corroding protective oxide film to form on steel. However, carbonation or the presence of chloride ions from deicers, can destroy or penetrate the protective film. Once this happens, an electronic cell (very small battery) is formed and an electro-chemical process of corrosion begins. This process ultimately forms rust. Rust is expansive (up to 4 times original volume). This induces internal stress and eventually causes spalling to occur.

Corrosion inhibiting admixtures chemically inhibit the corrosion reaction. Calcium nitrite, the most commonly used inhibitor, blocks a corrosion reaction by chemically reinforcing the concrete's passive film.

Rules-of-Thumb

- Corrosion inhibitors should be added at the plant.
- Experience indicates corrosion inhibitors should be placed in the front of the truck (first-in) and air entrainment agent should be placed at the back (last-in).
- Corrosion inhibitors are accelerators and will affect set times. It is recommended to consider adding about a one-half dose of retarder to extend working times.
- Air content of mixes using corrosion inhibitors is often difficult to stabilize. Watch the target air closely.

- A certain amount of calcium nitrite can protect up to a certain threshold level of chloride. Therefore, the amount of corrosion inhibitor added to a mix must be developed for an assumed maximum level of chloride ingress expected.

Finely Divided Mineral Admixtures
These admixtures are powdered or pulverized materials added to concrete to improve or change the properties (plastic or hardened) of concrete. Based on the mineral's chemical or physical properties, they are classified as: (1) Cementitious, (2) Pozzolans, (3) Pozzolanic and Cementitious, and (4) Nominally inert. Typical PCC mix designs use #3 above.

Pozzolanic Materials
A pozzolan is a siliceous or aluminosiliceous material that in itself possesses little or no cementitious value but will, in finely divided form and in the presence of water, chemically react with the calcium hydroxide released by the hydration of portland cement to form compounds possessing cementitious properties. Pozzolans include fly ash and silica fume.

Fly Ash (Class C & F)
Fly ash is a finely divided residue that results from the combustion of pulverized coal in electric power plants.

Silica Fume
Silica fume, also referred to as micro-silica or condensed silica fume, is another material that is used as a pozzolanic admixture. This light to dark gray powdery product is a result of the reduction of high-purity quartz with coal in an electric arc furnace.

Fly ash and silica fume have a spherical shape. Silica fume has an extremely small particle size (about 100 times smaller than the average cement particle). Although silica fume is normally in powder form, because of its small size and increased ease of handling the product is commonly available in liquid form.

Cementitious Materials
Cementitious materials are substances that alone have hydraulic cementing properties (set and harden in the presence of water). Cementitious materials include ground granulated blast furnace slag.

Ground Granulated Blast Furnace Slag (GGBFS)
GGBFS made from iron blast-furnace slag is a non-metallic product consisting essentially of silicates and aluminosilicates of calcium and other bases developed in a molten condition simultaneously with iron in a blast furnace. The molten slag is rapidly chilled in water to form a glassy sandlike material which is ground to a particle size similar to fly ash. Unlike fly ash and silica fume which have a spherical shape, GGBFS is rough and angular-shaped.

Rules-of-Thumb
- Mixes containing fly ash or GGBFS will generally require less water (about 1% to 10%) for a given slump. Silica fume concrete requires more water for a given slump.
- The amount of air-entraining admixture required to obtain a specified air content is normally greater when fly ash or silica fume is used. Ground slags have variable effects on the required dosage rate of air-entraining admixtures. The amount of air-entraining admixture for a certain air content is a function of the fineness, carbon

content, and alkali content.

- Fly ash and ground slag will generally improve the workability of concretes of equal slump. However, fly ash in low slump concrete will tend to tear and have reduced workability. Silica fume tends to reduce workability, thus high-range water reducers are usually added to maintain workability.
- Concrete using fly ash or silica fume generally shows less segregation and bleeding than plain concrete. Concrete using some ground slags tend to have slightly higher bleeding than plain concretes, but have no adverse effect on segregation.
- Use of fly ash and ground slag will reduce the amount of heat build-up in concrete. Silica fume most likely will not reduce the heat of hydration, because typically high-range water reducers are used and they increase mass temperatures.
- Use of fly ash and ground slag will tend to generally retard the setting time of concrete. Silica fume alone will accelerate the setting time, however, high-range water reducers tend to offset this.
- Use of fly ash and ground slag generally aids the pumpability of concrete.
- With adequate and correct curing, fly ash and ground slag generally reduce~~s~~ the permeability. Silica fume is especially effective in this regard.

11.54 USE OF INSULATED FORMS FOR PROTECTION

Commercial insulation may be used for protecting concrete during cold weather, or when the contract documents require controlling the heat of hydration. This technique is the contractor's option and could be used in lieu of housing and heating. It will then be the contractor's responsibility to furnish insulation of sufficient quality and thickness to maintain concrete at a temperature of not less than 10^{o}C (50^{o}F) for the first 48 hours after placing, if air temperatures will be less than 5^{o}C (40^{o}F). (Refer to Specification 2403.03, F, 5, b.)

Concrete must be between 7^{o}C and 27^{o}C (45^{o}F and 80^{o}F) when placed. To ensure a concrete temperature of at least 10^{o}C (50^{o}F) for 48 hours after placement, the concrete for thin sections such as culvert walls, end posts, piling encasements, etc. should be 18^{o}C (65^{o}F) or higher, since the only additional heat source is the heat of hydration. Concrete for massive sections such as stub abutments, heavy piers, and footings should be in the 13^{o} to 18^{o}C (55^{o} to 65^{o}F) range.

Since only dry insulation is effective, any insulation that has a propensity to adsorb water or become saturated must be protected with a waterproof membrane. The insulation system must provide complete coverage and be secured to provide maximum protection during the full curing period.

For typical protection applications, insulated forms must be left undisturbed for 96 hours before being removed. (Refer to Specification 2403.03, F, 5, b.)

Checking Temperature of Concrete

For checking compliance with minimum temperature requirements during the 48-hour period after placement, thermometer wells should be cast in the concrete during the pour. The following procedure for checking temperature is suggested:

1. Drill an 8 mm (5/16 inch) hole through the form at one or more locations where temperature checks will be made.
2. Grease the thermometer probe and insert it through the hole about 100 mm (4 inches) into the plastic concrete.
3. Remove probe after the concrete is set and cover hole with insulating material.
4. Further checks can be made by inserting the thermometer through the insulation into

the well developed in step 2. Leave thermometer in place if desired, but protect from damage or theft.

NOTE: The thermometer stem should be inserted about 75 mm (3 inches) into the concrete because the sensitive portion of stem is about 70 mm (2 3/4 inches) below the groove.

Other acceptable methods for monitoring concrete temperature are the use of maturity meter with temperature probe wires embedded in the concrete or use of thermal 'iButtons' embedded in the concrete with exposed wires for data collection and recording.

Record temperature daily for 48 hours following the pour. Temperature readings below 10^{o}C (50^{o}F) during the first 48 hours should be reported to the Office of Construction and Materials for evaluation of possible damage or price adjustment.

11.55 DECK PLACEMENT AND HEAT OF HYDRATION FOR MASS CONCRETE PLACEMENTS

Cracking of concrete in bridge deck placements and large concrete elements (ie: bridge footings, columns, pier caps, etc.) can occur unless the placements are properly controlled. The following provides information on measures that are used in the effort to control cracking of concrete in bridge decks and large concrete element placements.

Deck Placement

Sometime ago the Office of Bridges and Structures, and Office of Construction and Materials began evaluating the phenomena of bridge deck cracking. Measures have been implemented to manage bridge deck placement and prevent cracking through the use of Evaporation Rate Controls.

Research continues in the management of quality bridge deck placements and deck cracking control. To provide needed site specific data for this research, Forms E122, E139, M122 and M139 were developed. These reporting forms were initiated during 1991. Since that time, the information provided from the field has been compiled into a database for evaluation. The evaluation of this data is ongoing and includes review of the effectiveness of Evaporation Rate Controls and possible trends which may lead to a better understanding of crack development.

Forms E122, E139, M122 and M139 are included in *Appendix 11-16*. Since they are not available in Office Supplies, please photocopy as needed. Submit completed forms to the Office of Construction and Materials.

Deck Concrete Temperature and Curing

Specification 2412 identifies requirements for placing and curing concrete bridge floors. Of importance for this section are:

- Plastic concrete, when placed, shall not exceed 32^{o}C (90^{o}F).
- Concrete floors will not be placed if the theoretical rate of evaporation exceeds 1 kg/m^2/hr (0.2 lbs./sq.ft./hr.).

NOTE: A theoretical evaporation chart is included in Specification 2412.03, C, 4. As an alternative, a computer program has been developed for calculation of theoretical rate of evaporation using Excel. This program incorporates the charts from the specifications in a formula table included on report Forms E122 and M122. The program simplifies the determination of the theoretical rate of evaporation and enables the user to perform trial evaluations for possible changes in air temperature, relative humidity, plastic concrete temperature, and wind velocity. A copy of the Excel program for theoretical rate of evaporation is available at

English -
http://www.iowa.dot.gov/construction/structures/theoretical_evaporation_rate.xls

Metric -
http://www.iowa.dot.gov/construction/structures/theoretical_evaporation_rate_metric.xls

- The curing method requires prewetted burlap to be placed within 10 minutes of final - finishing and followed by a “wet” burlap cure for four (4) days. A continuous sprinkling system is required to keep the burlap wet during this time.
- Plastic, in addition to wet burlap, may only be used between October 1 and April 1. The plastic provides a moisture proof barrier above the wet burlap and replaces the sprinkling system after 20 hours of the application of water during cold weather.

The placing of concrete will require close monitoring to comply with the specification. The contractor or ready mix plant should determine temperature of previously placed concrete to project a mix temperature prior to a deck pour. Further, they should obtain a weather report to determine predicted air temperature, wind velocity, and relative humidity for the pour day. Based on this information, you will be able to reasonably predict an evaporation rate.

The above information should be discussed by the inspector, contractor, and ready mix plant operator before a deck pour. The pour should not be attempted if concrete temperature is predicted at 29^{o}C (85^{o}F) or higher and predicted air temperature is above 32^{o}C (90^{o}F). Also, the pour should not be attempted if an evaporation rate would exceed 1 kg/m^2/hr. (0.2 lbs./sq.ft./hr.).

District Materials Office has sling psychrometers and wind gauges available for usage the day of the pour. A sling psychrometer is used to determine the relative humidity by finding "wet" and "dry" bulb temperatures. (Refer to Charts in *Appendix 11-17*.) With these values, compute temperature difference and locate the "Difference Between Readings..." column. Then locate the row labeled with appropriate dry bulb temperature. The value at the intersection of "Difference" column and "Dry" bulb temperature is the relative humidity.

> **EXAMPLE:** (English units only)
> If the dry bulb temperature is 71^{o}F and the wet bulb temperature is 64^{o}F, the difference is 7^{o}F. At the top of the chart, locate the column headed 7. Follow this column down to the dry bulb temperature row of 71^{o}F. The intersection indicates a relative humidity of 68%.

There are also electronic pocket weather meter/station devices (ie: Ketsrel) which is a hand-held instrument for air temperature, wind speed, and relative humidity determination which can be used for evaluation of the theoretical evaporation rate.

Placement Considerations

A. If there is any doubt about the concrete temperature exceeding 29^{o}C (85^{o}F), the contractor needs to identify measures which will be implemented to keep mix temperatures within specifications. If the contractor is not prepared to maintain a mix temperature below specifications, the pour should be postponed.

There are several ways concrete temperatures may be kept within specifications. They are:

- Scheduling placements during cooler times of the day
- Wetting the aggregate stockpiles
- Covering/shading the aggregate stockpiles
- Maintaining a supply of portland cement on hand to preclude getting hot material from the supplier
- Chilling the mixing water is one of the most effective ways to lower mix temperatures.
- Shaved ice can be used; however, the ready mix operator must submit a proposal for this to the project engineer for review by the Office of Construction and Materials.

NOTE:
1. No payment will be made for methods taken to keep concrete temperatures and evaporation rates within specifications.
2. If pour has to be delayed because of temperature, and pouring is the controlling operation, no working days will be charged.

B. Location of permissible headers should be discussed with the contractor. If during the pour, it appears:
   - The temperature may exceed 32^{o}C (90^{o}F)
   - And/or the theoretical evaporation rate would exceed 1 kg/m^{2}/hr. (0.2 lbs./sq.ft./hr.)

   and these deficiencies cannot be corrected by immediate action, the placement shall be halted at the first permissible joint. On slab bridges, any joint location listed on the plans can be used. For girder beam bridges (steel or concrete), placement may be stopped, in an emergency, at locations as follows:

Case A. (Continuous or noncontinuous beams, positive section)
If the positive section has not been completed:
Complete the positive section and stop at the header location shown on the plans.

Case B. (Noncontinuous beams, negative section)
If placement has not proceeded beyond the pier:
Do not place concrete in the pier diaphragm, and stop just short of the beam end.

Case C. (Noncontinuous beams, negative section)
If placement has progressed beyond centerline of the pier:
Placement must continue through that negative section and stop at the header shown on the plans.

Case D. (Continuous beams, negative section)
If problem occurs after starting the negative section:
Placement must continue through the negative section, and stop at the header shown on the plans.

See *Appendix 11-24* for case illustration.

In every case listed above, contact the Office of Construction and Materials for curing times and beam break strengths before allowing the contractor to resume deck placement.

Field Documentation
The temperature of concrete should be taken as soon as concrete is placed. It should be taken when the first load is placed and at intervals shown on Forms E122 and M122, Appendix 11-16. Additional checking is warranted if temperature is running at or near maximum. Air temperature should also be taken about the same time as the concrete temperature.

Heat of Hydration for Mass Concrete Placements
Occasionally, projects will require placement of large volumes of concrete for individual concrete elements (ie: bridge footings, columns, pier caps, etc.). A concrete element is considered as mass concrete when the least dimension is greater than 5 feet (1.5 m) for footings or greater than 4 feet (1.2 m) for other concrete placements. Controlling the temperature of this large volume is important to reduce cracks and potential premature deterioration from thermal cracking that can result from a large temperature difference between the center of the concrete element and its surface. In these cases the contract documents may require the specification for "Mass Concrete – Control of Heat of Hydration".

The cooling of large volumes of concrete can take considerable time, and during that time monitoring is required by using temperature sensors embedded in the concrete and temperatures electronically recorded automatically.

11.56 PLACEMENT METHODS (PUMPING, BELTING, AND CRANE BUCKET)

Much concern has been expressed about the method of concrete placement because of lost entrained air. Rough handling of plastic concrete during placement has, at times, reduced entrained air to less than 2% not to mention potential segregation problems. While testing at the point of placement "should" identify such problems, varying placement conditions during the pour can affect concrete conditions significantly.

General conditions which must be avoided, or at least severely minimized, are as follows. If one of the following cannot be avoided, *at least* be aware of the condition, and *be sure* to conduct additional testing should any of the conditions present themselves.

Crane and Bucket
In the past it was felt the crane and bucket placement method did not adversely affect concrete. This is now in question when viewed from loss of air and potential segregation. Therefore, this method will now also require testing at the placement location, if practical.

Points-to-Watch For

- Free fall of unrestrained concrete shall not exceed 2 m (6 feet) for vertical placement and 1 m (3 feet) for floors and slabs. (Refer to Specification 2403.03,C, 2,c. If the distance is exceeded: (1) reduce the pour depth, (2) remove a section of form work for intermediate placement, (3) or use a tremie.
- Discharge from the bucket must be controllable.
- Cross section of the drop-chute should permit inserting into the form work without

interfering with reinforcing steel.

Belt Placement

Belt equipment is typically used to convey concrete to a (1) lower, (2) horizontal, or (3) somewhat higher level.

Points-to-Watch For

- Keep the number and distance of drops between belts to an absolute minimum. Drops tend to encourage segregation and reduce entrained air.
- As belt conveyors are removed from the line (i.e., as on deck pours), recheck the "as placed" air content.
- Be sure all mortar is being removed at the discharge. (No mortar should be on the return belt.)
- Check discharge for potential segregation problems.
- In adverse weather (hot and/or windy conditions), long belt runs need to be covered.

Pump Placement

The modern mobile pump with hydraulic placing boom is economical to use in placing both large and small quantities of concrete. These units are used to convey concrete directly from a truck unloading point to the concrete placement area.

Points-to-Watch For

- Typically, pumps are initially flushed with a thin water/cement paste mixture to coat the lines. This slurry must be wasted and the lines charged with the project mix before beginning. Observe, and be sure initial pump charge is thoroughly removed from the pipelines.
- Always pump at a constant rate and keep pipelines full of concrete. High air loss can occur when concrete is allowed to free-fall inside pump lines.
- Avoid, if at all possible, having steep angles in the pump pipelines. Steep angles and slow placement rates are probably the worst conditions for minimizing air loss and segregation. If this condition occurs:
  1. Attempt to relocate the pumper, thereby minimizing lift angle.
  2. If discharge is not maintaining a constant flow with partial concrete head in the pipe, request pump operator to place a reducer and short section of hose at the discharge end. The purpose is to avoid free falling concrete from impacting the epoxy coated reinforcing steel, deck or forms at high velocity. High velocity impact of concrete aggregate on epoxy coated bars can potentially damage the epoxy coating.
  3. If above condition is unavoidable, watch and test the discharge frequently for loss in air and potential segregation.

Rules-of-Thumb for Pumping

- Pump concrete with pipelines as flat as possible (or at least with minimal down angle)
- Minimize (or eliminate) free falling concrete in the pipelines. To do this, maintain some amount of concrete head in the pipelines
- Pump concrete through as few elbows and restrictions as possible
- Pump concrete at "some" constant rate
- Watch for, and test frequently, when situations are not optimized

11.57 FORM REMOVAL

Setting Beams

The following should be used as a guide in conjunction with *Specification 2403.03, N:*

A. On diaphragm piers, beams may be set as soon as doing so will not mar or chip the concrete. It is recommended that 24 hours be considered a minimum cure time. (In cooler weather, ambient temperatures below 5°C (40°F), the minimum time indicated should be increased to 48 hours.)

B. No beams may be set on pedestal (T or P10A) piers until the cap concrete is 7 days old and modulus of rupture is at least 3,800 kPa (550 psi) or more. The contractor has the option under *Specification 2403.02,B,c* to substitute Class M concrete mix for Class C except in bridge floors. When Class M concrete mix is used, beams may be set when the cap concrete is 3 days old and the modulus of rupture is at least 3,800 kPa (550 psi) or more. (Refer to Specification 2403.03, N.)If no test beams are made, the time must be extended to 14 days. (Refer to Specification 2403.03, N, 2, a).

   There have been special situations where the contractor has been allowed to set beams on piers that have not attained the above strengths. In these cases, the bottom forms have remained in place for an extended period of time. Before approving any variance, contact the Office of Construction and Materials for approval.

C. On stub abutments or integral abutments, steel beams and girders may be set as under A above. Concrete beams on stub abutments or integral abutments, same as A above. (Stub abutments are abutments with battered piling, sliding bearings, and the abutment does not move. Integral abutments have vertical piling in prebored holes, beams are rigidly connected to the abutment, and the abutment moves.) On full abutments (solid and continuous from spread footing), same as A above.

11.58 CONCRETE SURFACE FINISH

Concrete Railings

Surfaces of concrete for barrier rails placed against fixed forms, either on site or in precasting, shall be given a surface finish described for exterior beams in Specification 2407.03, L, 1 before application of curing. This should be done as the forms are removed. The contractor may opt to broom (brush) finish the slipform barrier rail.

Surface Finish on Other Concrete Surfaces

In addition to Specification 2403.03, P the contract documents may address additional special requirements for the finish of specified concrete surfaces.

11.59 FLOWABLE MORTAR

Flowable mortar is being used for four separate purposes according to the current specification:

- **Backfilling culverts** with flowable mortar is specified for the purpose of capping and stabilizing granular backfill material that has been consolidated by flooding. Flowable mortar backfill of open trench culverts is typically used when the height from the top of the culvert to the future roadway pavement surface is less than or equal to 1.2 m (4 feet). In this case, flowable mortar fluidity, as discussed in the specifications, is considered non-critical.

- **Backfilling culverts constructed under bridges** with flowable mortar is specified when existing bridge structures are being converted into roadway embankment sections. This involves constructing a drainage structure under the bridge and converting the existing bridge superstructure into a fully supported roadway section. Flowable mortar backfill is used under the bridge superstructure to fill the embankment area under the bridge up to the bottom of the existing bridge deck. The flowable mortar method is specified since normal soil backfill and compaction methods are not practical and would not achieve the required embankment support for the converted bridge deck. In this case, flowable mortar fluidity is considered non-critical in the area placed below the bridge beams, but would be considered critical between the beams. Flowable mortar for this case is typically specified to be placed in two or more stages.

- **Filling void between culvert and culvert liner** with flowable mortar is specified to provide support between the culvert liner and existing culvert to prevent future culvert collapse. Flowable mortar is used since normal soil backfilling and compaction methods are not possible. In this case, flowable mortar fluidity is critical and flow distance is limited which may require incremental placement points.

- **Plugging culverts** with flowable mortar is specified when it is either not possible or practical to remove existing culverts, therefore these culverts are being abandoned in place. In this case, flowable mortar fluidity is critical and flow distance is limited which may require incremental placement points.

Depending on the application, samples of sand, cement, and fly ash may need to be submitted to the Office of Construction and Materials for a mix design. (Refer to *Specification 2506.02, E, 2* for information as to when material will meet the required flow time as measured with a flow cone.) Free water in the sand pile must be considered as mix water because a mix design uses oven dried sand.

Refer to *Appendix A of Materials I.M. 491.17* for approved fly ash sources and classes.

The success of all flowable mortar projects depends on establishing uniform under-drainage.

Where flowable mortar is to be placed against joints, the joints should be wrapped with a fabric as per *Specification 4196.01, B, 2.*

If the contractor uses crushed limestone for granular backfill, it shall meet the requirements for Granular Backfill. (Refer to *Specification 4133.01*.) If flooded backfill is specified the granular backfill shall meet the requirements of *Specification 4134.*

Remember flowable mortar is a liquid which has a density of about 2,136 kg/m^3 (3,600 lbs./cu yd.) until the water has dissipated. Bulkheads should be strong enough to withstand those pressures.

Under normal conditions, flowable mortar should be set-up sufficiently within 24 to 48 hours for placement of the final lift of either earthfill or special backfill. If "set-up" does not occur or if it seems slow, typically the problem relates directly to drainage of the granular backfill. Often contamination or "dirty" granular backfill is the culprit. Check to be sure it is draining. If not, additional time will help. If time is critical, you may have to physically cut trenches (drainage paths) into the flowable mortar.

Backfilling Culverts - Typical Grading

Use of flowable mortar in backfilling culverts is shown in Standard Road Plan RF-30A. For cover heights less than or equal to 1.2 m (4 feet), a 150 mm (6 inch) flowable mortar cap is required above the flooded backfill. For cover heights greater than 1.2 m (4 feet), no flowable mortar cap is required. Since the purpose of flowable mortar is to cap and stabilize flooded backfill, flowable mortar is not required when a culvert is installed by "fill installation" per RF-30A.

Quantity of flowable mortar for pipe culverts can be found in *Tabulation 104-3* Drainage Structure by Road Contractor in the contract drawings.

Tabulation 104-4 is the tabulation of Drainage Structure by Culvert Contractor. The Floodable Backfill columns on this tab will normally not contain values. Normally, culverts are let a year in advance of the paving and backfilled according to the Compaction Adjacent to Structures specification. Occasionally, the pavement above the culvert will be constructed in the same year as the culvert. In these cases, flooded backfill is often used to prevent pavement issues caused by settlement of this material. In these situations, a note will be added in the remarks column stating "Backfill in accordance with RF-30A", quantities will be added to the tab, the DS for flooded backfill will be included in the contract documents, and a bid item will be included for flooded backfill.

If the Contractor opts to excavate a larger area than assumed for plan quantity, additional excavation, backfill, and flowable mortar will not be considered for pay. We will however, require additional excavation to be backfilled in a manner as identified by the plans or typicals.

Plugging Culverts
For culverts 20 m (60 feet) or less in length, flowable mortar may be placed into the outlet first, then the inlet. For culverts more than 20 m (60 feet) long, the desirable spacing for placing flowable mortar should be 20 m (60 feet). The optimum travel of flowable mortar is 10 m (30 feet) with approximately 75 mm (3 inches) of fall in the surface. To avoid drilling through pavement, the spacing can be increased to 25 m (80 feet) if necessary.

Backfilling Culverts - Under Bridges
Flowable mortar backfill is used under the bridge superstructure according to the following cases: 1) For bridge replacements with restricted height, flowable mortar is used to fill the complete backfill area up to the bottom of the existing bridge deck in two stages. The first stage is to 150 mm (6 inches) below the bottom of the existing bridge beams or deck, whichever is lower, and the second stage is from the top of the first stage to the bottom of the bridge deck. 2) For bridge replacements that do not have restricted height, floodable backfill is placed to within 1.2 m (5 feet) of the bottom of the superstructure, and then flowable mortar is placed to the bottom of the bridge deck in two stages. The first stage is to 150 mm (6 inches) below the bottom of the existing bridge beams or deck, whichever is lower, and the second stage is from the top of the first stage to the bottom of the bridge deck.

Prior to placing flowable mortar, bridge beams should be fitted with Styrofoam filler to full width of the flanges. Refer to illustration in *Appendix 11-25*. This will prevent adding dead load to the beams with flowable mortar.

In the second stage, flowable mortar is placed through holes drilled in the deck at spacings identified in the plans or specifications. Typically, begin at one abutment and continue longitudinally down the bridge until the other abutment has been reached, filling all holes on one side of the centerline. Then begin on the other side of the bridge and work holes nearest the centerline and proceed to the outside.

After flowable mortar has been placed, the contractor is required to saw a minimum of 75 mm (3 inches) deep cut into the original deck before any sidewalk, curb, or handrail is removed. It is important that this 75 mm (3 inch) saw cut be done prior to any curb removal, thereby preventing damage to the deck.

Placing flowable mortar under a bridge can be accomplished during staged construction. The specification requires a 72-hour delay between stage 1 and stage 2 placement of flowable mortar to allow for settlement of the granular backfill.

Filling Voids Between Culverts

If there is room to place granular backfill between culverts, do so to one-half the new culvert height. In situations such as multiple barrels, or a new pipe inside a box, the granular backfill will adequately maintain pipe location during flowable mortar placement.

If granular backfill cannot be used, culvert(s) should be blocked at 3 m (10 foot) intervals or less and flowable mortar placed as usual. If a pipe inside a culvert has to be blocked in place, the blocking must be situated in a manner to prevent damming and causing voids in the mortar. All blocking placed on the top of the inside culvert must be saddle shaped to fit the culvert. This distributes the buoyant forces over a larger area and reduces chance of pipe buckling. To further reduce buoyant forces:

- Place about one-half of the total flowable mortar
- Delay about four hours before placing the remainder

In all cases, a drainage system must be established on each side of the culvert(s). The drainage system should be a 100 mm (4 inch) slotted drain with a minimum of 150 mm (6 inches) of granular backfill cover. The drainage system reduces buoyancy effects and allows for dewatering of the flowable mortar.