MICHIGAN CONCRETE ASSOCIATION

Understanding Concrete Mix Design and the JMF Approval Process

presented by Steve Waalkes and Dave Cook

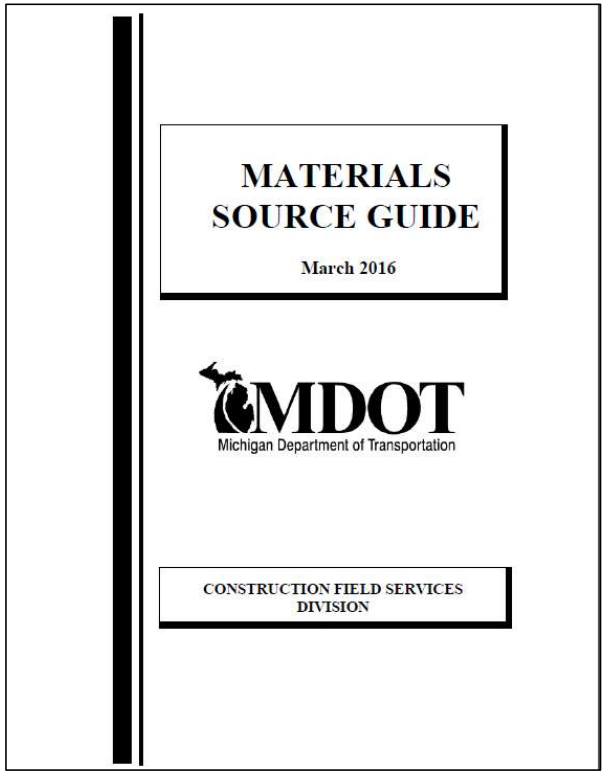
Thursday, October 1, 2020 10:00 to 11:15 am Eastern

PDF handouts: https://info.miconcrete.org/virtual-learning

Topics Covered Today

- MDOT Specs / Concrete Grades
- Basics on Concrete Mix Design
- MDOT Form 1976 – JMF
- JMF Submittal / Required Documents

Approved Materials



- Material Source Guide
  - A contract document
  - Current revision in place at the time of contractor's bid is binding for the project
  - Quarterly updates
  - Available on MDOT website at: http://www.michigan.gov/mdot
    - Select:
      - Reports, Publications & Specs
      - Publications
      - Manuals & Guides

Approved Materials – Cement

- Approved manufacturers of portland cement – Type I or Type I/II (MDOT 901)
- Prior to consideration onto approved list,
  - MDOT reviews historical mill reports for C150 compliance
  - Verifies physical properties of lab samples
- Ongoing,
  - Biannual mill report submitted and reviewed
  - Random samples are taken in the field for QA verification
- Type III cement is not permitted on MDOT projects

Approved Materials – SCM's

- Required amount: 25%-40% replacement of portland in P1M, DM, and S2M
- Approved Manufacturers of supplemental cementitious materials (MDOT 901)
- Prior to consideration onto list,
  - MDOT reviews historical mill reports for compliance
    - Fly ash – C618, Class C and F
    - Slag cement – C989, Grade 100, minimum
  - Verifies physical properties of lab samples
- Ongoing,
  - Monthly mill report submitted and reviewed
  - Random samples are taken in the field for QA verification

Approved Materials – Agg.

- Prequalified aggregate sources – approved manufacturers (MDOT Section 902)
  - Yearly inspection of labs
  - History of a well controlled process
  - History of specification compliance
  - Reduced MDOT QA acceptance of source
    - 1 test per 10,000 tons of material produced
- Non- Prequalified aggregate sources
  - No history of specification or process control
  - Normal MDOT QA acceptance of source
    - 1 test per 1000 tons of material produced

ASR Testing (Fine Aggregate only)

- ASTM C 1260
  - Expansion < 0.10% at 14 days
- ASTM C 1293
  - Expansion < 0.040% at 1 year
- ASTM C 1567
  - Must use replacement of portland cement with slag cement or fly ash
  - Expansion < 0.10% at 14 days

Back in the spec temporarily for now; May be removed as an option in future versions

Approved Materials – Admix.

- Admixtures (MDOT 903) – Qualified Products List (QPL)
  - Accepted for use on MDOT projects based on the trade name, model number, etc., as listed.
  - Manufacturer secures independent lab testing using three locally available cements
    - Air entraining C260
    - Water reducers, retarders, accelerators C494
    - Yearly affidavit from manufacturer
- Try to avoid the "witches brew"

Where do Mixes Originate?

- Contractor provided mixes:
  - Based on standard MDOT production mixtures
  - The contractor is responsible for submitting the mix documentation to the MDOT project engineer

- Department (MDOT) provided mixes:
  - Non-standard production mixes
  - Structural patching, mortar, and grout
  - Project-specific mixes
  - Pre-stressed concrete
  - Bridge deck overlays
  - Small quantities

Developing the Mix

- Contractor provided mix designs and mixture proportions
  - Supporting documentation
  - Methods of verification
    - Method 1 – Trial batches: same materials used on project
    - Method 2 – Same mix: recent experience with same ingredients
    - Method 3 – Similar mix: similar aggregates, same cement/additives
    - Method 4 – Annual verification: concrete plant verification, same materials

- All materials must be from MDOT approved sources

Mix Requirements- Cement & Strength

Table 601-2
Concrete Pavement Mixtures

Concrete Grade (b, c, g)	Section Number Reference (i)	Cement Content (d,h)		Minimum Class Design Strength (a)							
				Flexural Strength (psi)				Compressive Strength (psi)			
		lb/cyd	sacks	3days	7days	14days	28days	3days	7days	14days	28days
P-NC	603, 801	658	7.0	550	600	—	650	2,600	3,000	—	3,500
P1M (f)	602, 603	470 – 564	5.0 – 6.0	—	550	600	650	—	2,600	3,000	3,500
P1	602, 603, 801, 802, 803, 810	564	6.0	—	550	600	650	—	2,600	3,000	3,500
		526 (e)	5.6								
P2	602, 803, 804, 806, 808, 810, 813, 814, 819	517	5.5	—	500	550	600	—	2,200	2,600	3,000
		489 (e)	5.2								
M	Commercial grade concrete containing 517 lb/cyd (5½ sacks/cyd) of cement. If substituting 1.0 lb of fly ash for each pound of cement removed, the Contractor may reduce portland cement up to 20%, by weight.										
X	Unless otherwise specified, Grade X concrete contains at least 282 lb/cyd (3.0 sacks/cyd) of cement. If substituting 1.0 lb of fly ash for each pound of cement removed, the Contractor may reduce portland cement up to 20% by weight.										

Mix Requirements- Admix Slump Adjustments

Table 701-1A
Concrete Structure Mixtures by Slump

Concrete Grade (e, h)	Section Number Reference (i)	Cement content per cubic yard (b, c)		Slump (in)			
				Type A, D or no Admixture	Type MR, F, or G Admixtures (g)		
		lb	sack		Before Admixture	After Admixture (Type MR)	After Admixture (Type F or G)
D (a)	706, 711, 712	658 (d)	7.0	0 – 3	0 – 3	0 – 6	0 – 7
S1	705	611	6.5	3 – 5	0 – 3	3 – 6	3 – 7
T	705, 706	611	6.5	3 – 7	0 – 4	3 – 7	3 – 8
S2 (a)	401, 705, 706, 712, 713, 801, 802, 803, 810	564	6.0	0 – 3	0 – 3	0 – 6	0 – 7
		526 (d)	5.6				
S3	402, 403, 803, 804, 806	517	5.5	0 – 3	0 – 3	0 – 6	0 – 7
		489 (d)	5.2				

Note: See Table 701-1B below for table notes.

Table 701-1B
Concrete Structure Mixtures by Strength of Concrete

Concrete Grade (e, h)	Section Number Reference (i)	Cement content per cubic yard (b, c)		Minimum Strength of Concrete (f)					
				Flexural, (psi)			Compressive, (psi)		
		lb	sack	7 day	14 day	28 day	7 day	14 day	28 day
D (a)	706, 711, 712	658 (d)	7.0	625	700	725	3,200	4,000	4,500
S1	705	611	6.5	600	650	700	3,000	3,500	4,000
T	705, 706	611	6.5	550	600	650	2,600	3,000	3,500
S2 (a)	401, 705, 706, 712, 713, 801, 802, 803, 810	564	6.0	550	600	650	2,600	3,000	3,500
		526 (d)	5.6						
S3	402, 403, 803, 804, 806	517	5.5	500	550	600	2,200	2,600	3,000
		489 (d)	5.2						

12SP604(A)

Table 1: Minimum Mix Design Requirements for Concrete

Mix Design Parameter	Grade of Concrete						
	P1M (a,b,e)	P1 (a,b)	D,DM (a,b,e)	T	S1 (a)	S2,S2M (a,b,e)	S3/P2 (a)
Lower Specification Limit (LSL) (28-day compressive, psi)	3500	3500	4500	3500	4000	3500	3000
Rejection Limit for an Individual Strength Sample Test Result	3000	3000	4000	3000	3500	3000	2500
Maximum Water/Cementitious Ratio (lb/lb) (c)	0.45						
Cementitious Material Content (lb/yd3) (d)	470-564	517-611	517-658	517-611	517-611	517-611	489-517
Air Content (percent) (f)	5.5-8.5						
Slump (inch) (max.)	(g)						
Section Number Reference (h)	602, 603	602, 603, 801, 802, 803, 810	706, 711, 712	706, 718	705	401, 706, 712, 713, 718, 801, 802, 803, 810, 819	402, 403, 602, 803, 804, 806, 808, 810, 813, 814

12SP604(B)

Table 1: Minimum Mix Design Requirements for Concrete

Mix Design Parameter	Grade of Concrete						
	P1M (a,b,e)	P1 (a,b)	D,DM (a,b,e)	T	S1 (a)	S2,S2M (a,b,e)	S3/P2 (a)
PWL Applications							
Lower Specification Limit (LSL) (28-day compressive, psi)	3500	3500	—	—	—	—	—
Rejection Limit for an Individual Strength Sample Test Result	2500	2500					
Non-PWL Applications							
Lower Specification Limit (LSL) (28-day compressive, psi)	3500	3500	4500	3500	4000	3500	3000
Rejection Limit for an Individual Strength Sample Test Result	3000	3000	4000	3000	3500	3000	2500
All Concrete Applications							
Maximum Water/Cementitious Ratio (lb/lb) (c)	0.45						
Cementitious Material Content (lb/yd3) (d)	470-564	517-611	517-658	517-611	517-611	517-611	489-517
Air Content (percent) (f)	5.5-8.5						
Slump (inch) (max.)	(g)						
Section Number Reference (h)	602, 603	602, 603, 801, 802, 803, 810	706, 711, 712	706, 718	705	401, 706, 712, 713, 718, 801, 802, 803, 810, 819	402, 403, 602, 803, 804, 806, 808, 810, 813, 814

MDOT Grades of Concrete

P1M High Performance Concrete Pavement

All MDOT trunkline highways that are paved with concrete

- will be called 3500 HP in new spec book

P1 Concrete pavement

Old standard still used for low traffic roadways, small projects, local agency work

- will be called 3500 in new spec book

P2 Concrete shoulders

Used for concrete shoulders but can also use P1 or P1M

- will be called 3000 in new spec book

MDOT Grades of Concrete

P-NC Concrete pavement Repair

Joint and full-depth repairs of concrete pavements

NC requires non-chloride accelerator, 7 sack is standard

- will be called 3500 in new spec book

M Commercial Concrete

Typically used for non-MDOT concrete outside the right-of-way

MDOT Grades of Concrete

S1 Foundations and Piles

- will be called 4000 in new spec book

S2 Bridge Structure, Curb/Gutter and Driveways

- will be called 3500 in new spec book

S2M High Performance Bridge Structure

High traffic, high profile/long life bridges, bridge approach slabs

- will be called 3500 HP in new spec book

S3 Sidewalks

- will be called 3000 in new spec book

MDOT Grades of Concrete

D Bridge Deck/Railing

- will be called 4500 in new spec book

DM High Performance Bridge Deck and Railings

High traffic, high profile bridge decks and railings or where longer life is required

- will be called 4500 HP in new spec book

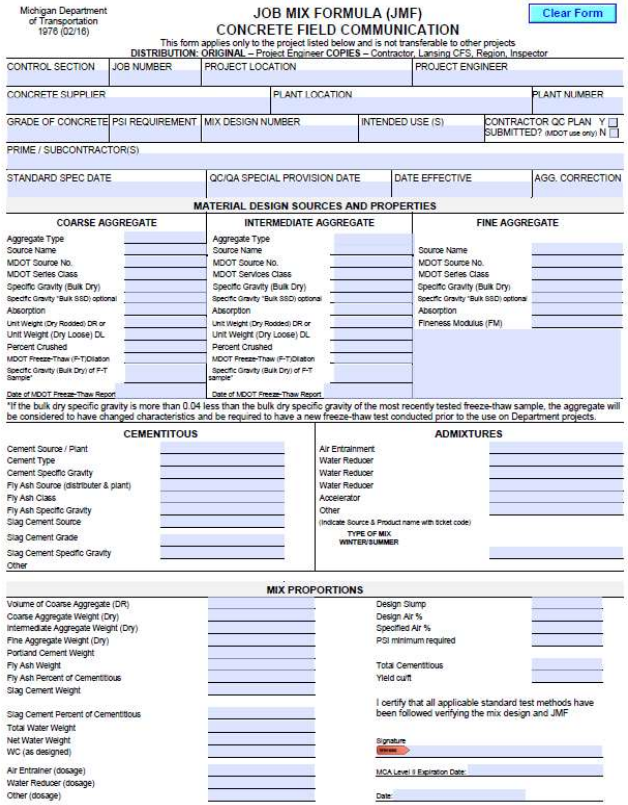
T Tremie Concrete

Underwater placements, usually for bridge foundation work

- will be called 3500 in new spec book

MDOT Form 1976 (JMF Form)

- Develop JMF (mix proportions) according to ACI 211
- Aggregate bulk density
  - Option for dry rodded, and shoveling (loose pour or dry loose)
  - Density values up to 10% greater with dry rodded



Michigan Department of Transportation 1976 (02/16)

JOB MIX FORMULA (JMF)
CONCRETE FIELD COMMUNICATION

Clear Form

This form applies only to the project listed below and is not transferable to other projects
DISTRIBUTION: ORIGINAL – Project Engineer COPIES – Contractor, Lansing CFS, Region, Inspector

CONTROL SECTION	JOB NUMBER	PROJECT LOCATION	PROJECT ENGINEER
CONCRETE SUPPLIER		PLANT LOCATION	PLANT NUMBER
GRADE OF CONCRETE	PSI REQUIREMENT	MIX DESIGN NUMBER	INTENDED USE (S)
PRIME / SUBCONTRACTOR(S)			
STANDARD SPEC DATE		QC/QA SPECIAL PROVISION DATE	DATE EFFECTIVE

CONTRACTOR QC PLAN SUBMITTED? (MDOT use only) Y N

AGG. CORRECTION

MATERIAL DESIGN SOURCES AND PROPERTIES

COARSE AGGREGATE
Aggregate Type
Source Name
MDOT Source No.
MDOT Series Class
Specific Gravity (Bulk Dry)
Specific Gravity "Bulk SSD) optional
Absorption
Unit Weight (Dry Rodded) DR or Unit Weight (Dry Loose) DL
Percent Crushed
MDOT Freeze-Thaw (F-T)Dilation
Specific Gravity (Bulk Dry) of F-T Sample*
Date of MDOT Freeze-Thaw Report

INTERMEDIATE AGGREGATE
Aggregate Type
Source Name
MDOT Source No.
MDOT Services Class
Specific Gravity (Bulk Dry)
Specific Gravity "Bulk SSD) optional
Absorption
Unit Weight (Dry Rodded) DR or Unit Weight (Dry Loose) DL
Percent Crushed
MDOT Freeze-Thaw (F-T)Dilation
Specific Gravity (Bulk Dry) of F-T sample*
Date of MDOT Freeze-Thaw Report

FINE AGGREGATE
Source Name
MDOT Source No.
MDOT Series Class
Specific Gravity (Bulk Dry)
Specific Gravity "Bulk SSD) optional
Absorption
Fineness Modulus (FM)

*If the bulk dry specific gravity is more than 0.04 less than the bulk dry specific gravity of the most recently tested freeze-thaw sample, the aggregate will be considered to have changed characteristics and be required to have a new freeze-thaw test conducted prior to the use on Department projects.

CEMENTITOUS
Cement Source / Plant
Cement Type
Cement Specific Gravity
Fly Ash Source (distributer & plant)
Fly Ash Class
Fly Ash Specific Gravity
Slag Cement Source
Slag Cement Grade
Slag Cement Specific Gravity
Other

ADMIXTURES
Air Entrainment
Water Reducer
Water Reducer
Water Reducer
Accelerator
Other
(Indicate Source & Product name with ticket code)
TYPE OF MIX WINTER/SUMMER

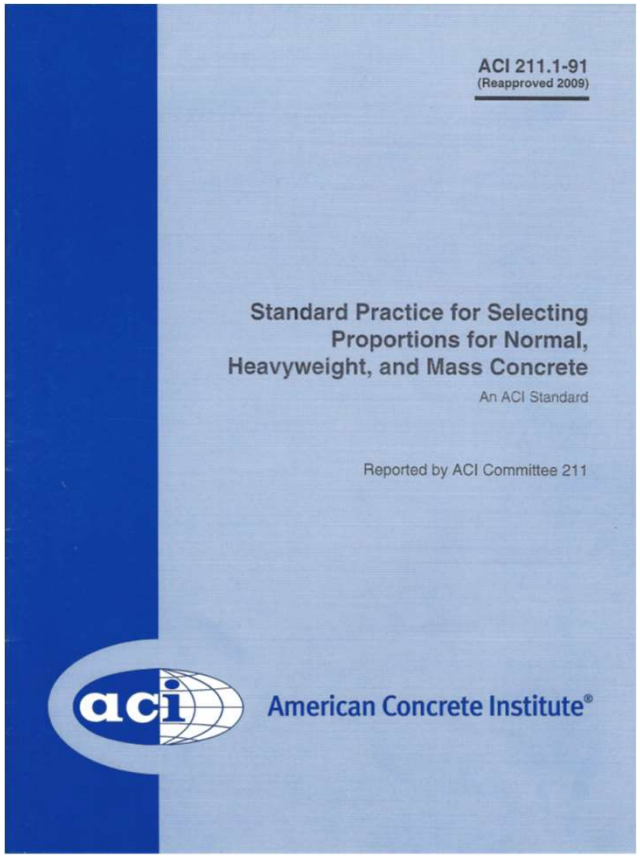
MIX PROPORTIONS
Volume of Coarse Aggregate (DR)
Coarse Aggregate Weight (Dry)
Intermediate Aggregate Weight (Dry)
Fine Aggregate Weight (Dry)
Portland Cement Weight
Fly Ash Weight
Fly Ash Percent of Cementitious
Slag Cement Weight
Slag Cement Percent of Cementitious
Total Water Weight
Net Water Weight
WC (as designed)
Air Entrainer (dosage)
Water Reducer (dosage)
Other (dosage)

Design Slump
Design Air %
Specified Air %
PSI minimum required
Total Cementitious
Yield cu/ft

I certify that all applicable standard test methods have been followed verifying the mix design and JMF

Signature
Name
MCA Level I Expiration Date
Date

Fundamentals of Mix Proportioning



Fundamentals of Mix Proportioning

Absolute Volume Method

The mix is proportioned to yield 27 ft^3 or 1 yd^3. Each of the component materials occupies a portion of the overall volume that is determined by dividing the mass (weight) of each material in the mix by the relative density (specific gravity) multiplied by 62.4 lb/ft^3, the density of water.

Example: What is the absolute volume (AV) of 564 lbs of Portland cement?

$$AV = 564\ lb/(3.15 \times 62.4\ lb/ft^3) = 2.87\ ft^3$$

Fundamentals of Mix Proportioning

What information do you need to get started?

- specified compressive strength, f'_c
- w/c or w/cm ratio (possibly)
- what is being constructed
- where in the country is it being constructed
- contractor requirements
- aggregate properties - stone size, fineness modulus - sand, relative density - sand/stone, aggregate absorption, aggregate total moisture, bulk density - stone
- cementitious properties – relative density of fly ash, slag cement, silica fume

Fundamentals of Mix Proportioning

TABLE 4.2.1 — EXPOSURE CATEGORIES AND CLASSES

Category	Severity	Class	Condition	
F Freezing and thawing	Not applicable	F0	Concrete not exposed to freezing-and-thawing cycles	
	Moderate	F1	Concrete exposed to freezing-and-thawing cycles and occasional exposure to moisture	
	Severe	F2	Concrete exposed to freezing-and-thawing cycles and in continuous contact with moisture	
	Very severe	F3	Concrete exposed to freezing-and-thawing and in continuous contact with moisture and exposed to deicing chemicals	
S Sulfate			**Water-soluble sulfate (SO_4) in soil, percent by mass***	**Dissolved sulfate (SO_4) in water, ppm†**
	Not applicable	S0	$SO_4 < 0.10$	$SO_4 < 150$
	Moderate	S1	$0.10 \le SO_4 < 0.20$	$150 \le SO_4 < 1500$ Seawater
	Severe	S2	$0.20 \le SO_4 \le 2.00$	$1500 \le SO_4 \le 10{,}000$
	Very severe	S3	$SO_4 > 2.00$	$SO_4 > 10{,}000$
P Requiring low permeability	Not applicable	P0	In contact with water where low permeability is not required	
	Required	P1	In contact with water where low permeability is required.	
C Corrosion protection of reinforcement	Not applicable	C0	Concrete dry or protected from moisture	
	Moderate	C1	Concrete exposed to moisture but not to external sources of chlorides	
	Severe	C2	Concrete exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources	

Fundamentals of Mix Proportioning

TABLE 4.3.1 — REQUIREMENTS FOR CONCRETE BY EXPOSURE CLASS

Exposure Class	Max. w/cm*	Min. f'_c, psi	Additional minimum requirements			
			Air content			Limits on cementitious materials
F0	N/A	2500	N/A			N/A
F1	0.45	4500	Table 4.4.1			N/A
F2	0.45	4500	Table 4.4.1			N/A
F3	0.45	4500	Table 4.4.1			Table 4.4.2
			Cementitious materials†—types			Calcium chloride admixture
			ASTM C150	ASTM C595	ASTM C1157	
S0	N/A	2500	No Type restriction	No Type restriction	No Type restriction	No restriction
S1	0.50	4000	II‡	IP(MS), IS (<70) (MS)	MS	No restriction
S2	0.45	4500	V§	IP (HS) IS (<70) (HS)	HS	Not permitted
S3	0.45	4500	V + pozzolan or slag‖	IP (HS) + pozzolan or slag‖ or IS (<70) (HS) + pozzolan or slag‖	HS + pozzolan or slag‖	Not permitted
P0	N/A	2500	None			
P1	0.50	4000	None			
			Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by weight of cement#			
			Reinforced concrete	Prestressed concrete	Related provisions	
C0	N/A	2500	1.00	0.06	None	
C1	N/A	2500	0.30	0.06		
C2	0.40	5000	0.15	0.06	7.7.6, 18.16**	

Fundamentals of Mix Proportioning

What if two exposure categories are specified?

Example: Concrete needs to meet both exposure class F3 and C2?

F3 requires a maximum w/cm of 0.45 and minimum f'_c of 4500 psi while C2 requires a maximum w/cm of 0.40 and minimum f'_c of 5000 psi.

ALWAYS select the most restrictive for developing the mix i.e. C2.

Fundamentals of Mix Proportioning

Step 1 Determine the required average compressive strength, f'_{cr}.

Once the licensed design professional has determined the specified compressive strength, f'_c, the next step is to determine the required average compressive strength, f'_{cr}. The required average compressive strength is the overdesign that is necessary to MINIMIZE the possibility of the cylinder strength falling below the specified compressive strength.

Fundamentals of Mix Proportioning

When field strength test records are not available or you lack sufficient data, the required average compressive strength, f'_{cr}, is determined from Table 4.2.3.1 of ACI 301.

f'_c, psi	f'_{cr}, psi
Less than 3000	$f'_c + 1000$
3000 to 5000	$f'_c + 1200$
Over 5000	$1.1f'_c + 700$

Fundamentals of Mix Proportioning

When field strength test records are available and are not older than 24 months and span no less than 45 calendar days for a class of concrete within 1000 psi of that required for the project, calculate the sample standard deviation, s_s, and determine the required average compressive strength, f'_{cr}, using Table 4.2.3.3(a)1 from ACI 301.

f_c', psi	f_{cr}', psi
	Use the larger of:
5000 or less	$f_{cr}' = f_c' + 1.34ks_s$
	$f_{cr}' = f_c' + 2.33ks_s - 500$
Over 5000	$f_{cr}' = f_c' + 1.34ks_s$
	$f_{cr}' = 0.90f_c' + 2.33ks_s$

Fundamentals of Mix Proportioning

If the number of field tests used in calculating the sample standard deviation, s_s, is not 30 or more (but 15 or greater), use Table 4.2.3.3(a)2 to increase the value of the sample standard deviation, s_s.

Total number of tests considered	*k*-factor for increasing sample standard deviation
15	1.16
20	1.08
25	1.03
30 or more	1.00

Note: Linear interpolation for intermediate number of tests is acceptable.

Fundamentals of Mix Proportioning

ACI 211.1-91

1.2 The methods provide a first approximation of proportions intended to be checked by trial batches in the laboratory or field and adjusted, as necessary, to produce the desired characteristics of the concrete.

2.2 The selection of concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density and appearance. The required characteristics are governed by the use to which the concrete will be put and by conditions expected to be encountered at the time of placement. These characteristics should be listed in the job specifications.

Fundamentals of Mix Proportioning

Let's get started....

Type of structure: Warehouse floor, 5 inches thick, unreinforced

Specified strength, f'_c 3500 psi

Sample std deviation, s_s 644 psi, based on 30 tests

Fundamentals of Mix Proportioning

Coarse aggregate properties

Nominal maximum size	1 inch
Relative density (dry)	2.58
Total moisture	3.5%
Absorption	3.1%
Free moisture	0.4%
Bulk density	97 lb/ft^3

Fine aggregate properties

Fineness modulus	2.80
Relative density (dry)	2.64
Total moisture	2.5%
Absorption	1.3%
Free Moisture	1.2%

Maximum vs Nominal Maximum Size

Maximum size: the smallest sieve opening through which the entire amount of aggregate is **required** to pass.

Nominal maximum size: the smallest sieve opening through which the entire amount of aggregate is **permitted** but not required to pass.

Fundamentals of Mix Proportioning

Verify choice of nominal maximum aggregate size per ACI 211.1-91.

6.3.2 In no event should the nominal maximum aggregate size exceed:

a. 1/5 the narrowest dimension between sides of forms

b. 1/3 the depth of the slab

c. 3/4 the minimum clear spacing between individual reinforcing bars, bundles of bars or pretensioning strands

1/3 of 5 inches = 1.67 inches maximum > therefore, 1 inch proposed for use is OK

Fundamentals of Mix Proportioning

Next, determine required overdesign, f'_{cr} for f'_c equal to 3500 psi:

$f'_{cr} = f'_c + 1.34\ ks_s$

$= 3500\ psi + 1.34\ (1.0)\ 644\ psi = 4363\ psi$ (k=1.0 for 30 tests)

$f'_{cr} = f'c + 2.33ks_s - 500$

$= 3500\ psi + 2.33\ (1.0)644\ psi - 500 = 4501\ psi$

ALWAYS select the larger of the two for proportioning the mix and round to the nearest 500 psi.

Fundamentals of Mix Proportioning

To determine mix proportions for first approximation:

1. Complete ACI table information
2. Calculate dry batch weights
3. Calculate dry batch volumes
4. Calculate saturated-surface-dry (SSD) weights
5. Adjust batch for actual moisture conditions

Fundamentals of Mix Proportioning

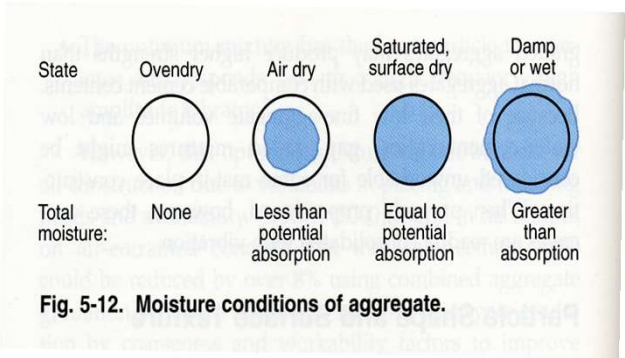
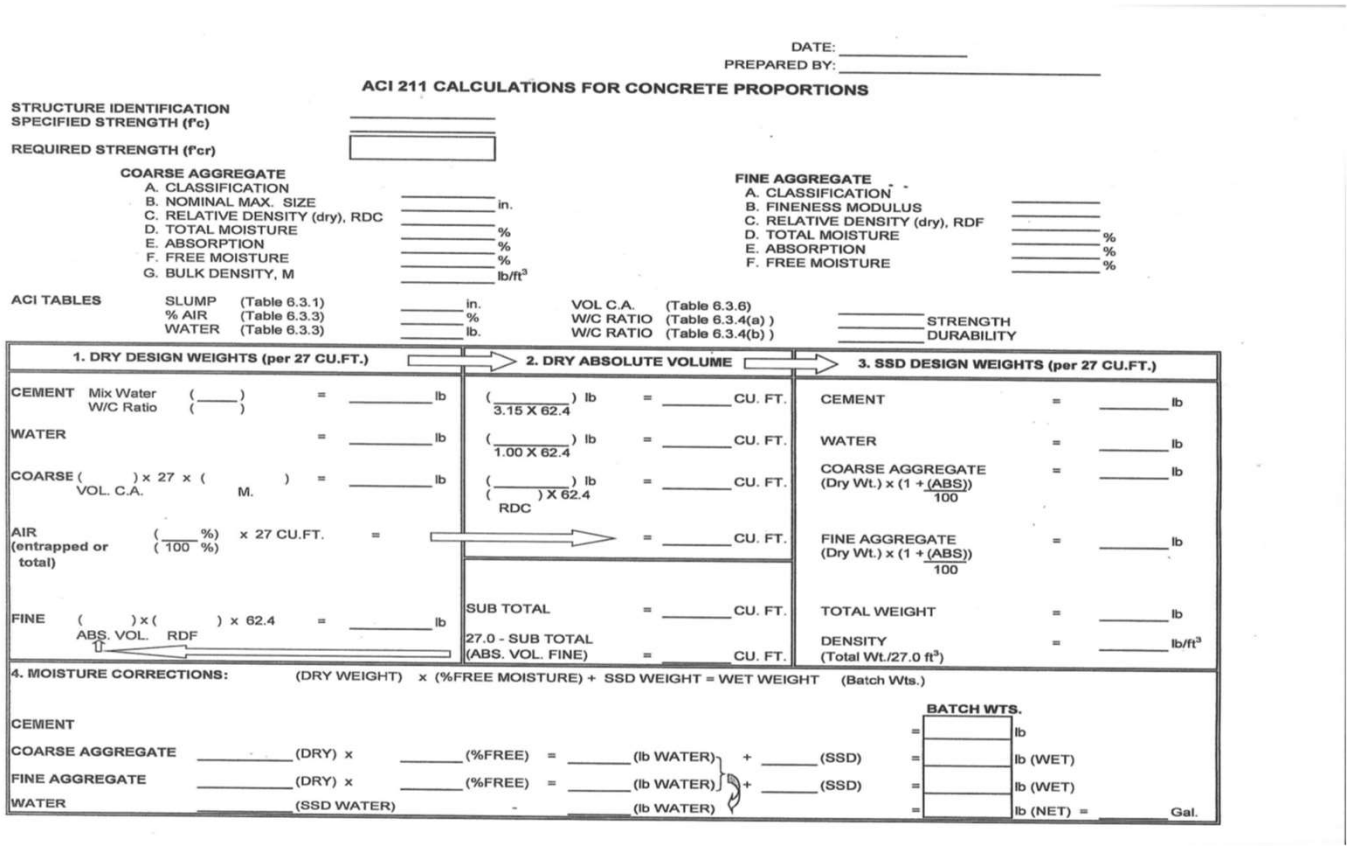


Fig. 5-12. Moisture conditions of aggregate.

Aggregates have an internal void or pore structure that at any time may or may not contain water (absorbed water). Depending on the moisture content, the four possible conditions for aggregates are as follows:

1. oven dry - no moisture present (only attainable in lab)
2. air dry - dry at surface, capable of absorbing additional water
3. saturated-surface dry (SSD) - fully saturated, neither absorbs nor contributes water to the mix
4. wet - contains an excess amount of surface moisture

Fundamentals of Mix Proportioning



DATE: _____

PREPARED BY: _____

ACI 211 CALCULATIONS FOR CONCRETE PROPORTIONS

STRUCTURE IDENTIFICATION _____

SPECIFIED STRENGTH (f'c) _____

REQUIRED STRENGTH (f'cr) _____

COARSE AGGREGATE

A. CLASSIFICATION _____
B. NOMINAL MAX. SIZE _____ in.
C. RELATIVE DENSITY (dry), RDC _____
D. TOTAL MOISTURE _____ %
E. ABSORPTION _____ %
F. FREE MOISTURE _____ %
G. BULK DENSITY, M _____ lb/ft³

FINE AGGREGATE

A. CLASSIFICATION _____
B. FINENESS MODULUS _____
C. RELATIVE DENSITY (dry), RDF _____
D. TOTAL MOISTURE _____ %
E. ABSORPTION _____ %
F. FREE MOISTURE _____ %

ACI TABLES

SLUMP (Table 6.3.1) _____ in.
% AIR (Table 6.3.3) _____ %
WATER (Table 6.3.3) _____ lb.

VOL C.A. (Table 6.3.6) _____
W/C RATIO (Table 6.3.4(a)) _____ STRENGTH
W/C RATIO (Table 6.3.4(b)) _____ DURABILITY

1. DRY DESIGN WEIGHTS (per 27 CU.FT.)	2. DRY ABSOLUTE VOLUME	3. SSD DESIGN WEIGHTS (per 27 CU.FT.)
CEMENT Mix Water ( ) W/C Ratio ( ) = _____ lb	( ) lb / 3.15 X 62.4 = _____ CU. FT.	CEMENT = _____ lb
WATER = _____ lb	( ) lb / 1.00 X 62.4 = _____ CU. FT.	WATER = _____ lb
COARSE ( ) x 27 x ( ) / VOL. C.A. M. = _____ lb	( ) lb / ( ) X 62.4 RDC = _____ CU. FT.	COARSE AGGREGATE (Dry Wt.) x (1 + (ABS))/100 = _____ lb
AIR (entrapped or total) (%) / (100 %) x 27 CU.FT. =	= _____ CU. FT.	FINE AGGREGATE (Dry Wt.) x (1 + (ABS))/100 = _____ lb
FINE ( ) x ( ) x 62.4 = _____ lb (ABS. VOL. RDF)	SUB TOTAL = _____ CU. FT.	TOTAL WEIGHT = _____ lb
	27.0 - SUB TOTAL (ABS. VOL. FINE) = _____ CU. FT.	DENSITY (Total Wt./27.0 ft³) = _____ lb/ft³

4. MOISTURE CORRECTIONS: (DRY WEIGHT) x (%FREE MOISTURE) + SSD WEIGHT = WET WEIGHT (Batch Wts.)

							BATCH WTS.
CEMENT						=	lb
COARSE AGGREGATE	_____ (DRY) x	_____ (%FREE)	= _____ (lb WATER)	+	_____ (SSD)	=	lb (WET)
FINE AGGREGATE	_____ (DRY) x	_____ (%FREE)	= _____ (lb WATER)	+	_____ (SSD)	=	lb (WET)
WATER	_____ (SSD WATER)		- _____ (lb WATER)			=	lb (NET) = _____ Gal.

Fundamentals of Mix Proportioning

DATE: _____

PREPARED BY: _____

ACI 211 CALCULATIONS FOR CONCRETE PROPORTIONS

STRUCTURE IDENTIFICATION: warehouse floor, 5" thick

SPECIFIED STRENGTH (f'c): 3500 psi S_s = 644 psi, n = 30 tests

REQUIRED STRENGTH (f'cr): 4500 psi

COARSE AGGREGATE

A. CLASSIFICATION	6AA	
B. NOMINAL MAX. SIZE	1	in.
C. RELATIVE DENSITY (dry), RDC	2.58	
D. TOTAL MOISTURE	3.5	%
E. ABSORPTION	3.1	%
F. FREE MOISTURE	0.4	%
G. BULK DENSITY, M	97	lb/ft^3

FINE AGGREGATE

A. CLASSIFICATION	2NS	
B. FINENESS MODULUS	2.80	
C. RELATIVE DENSITY (dry), RDF	2.64	
D. TOTAL MOISTURE	2.5	%
E. ABSORPTION	1.3	%
F. FREE MOISTURE	1.2	%

ACI TABLES

SLUMP	(Table 6.3.1)	3(4) in.	VOL C.A.	(Table 6.3.6)	0.67
% AIR	(Table 6.3.3)	1.5 %	W/C RATIO	(Table 6.3.4(a))	0.52 STRENGTH
WATER	(Table 6.3.3)	325 lb.	W/C RATIO	(Table 6.3.4(b))	N/A DURABILITY

4000 0.57

5000 0.48

∴ 4500 0.52

Fundamentals of Mix Proportioning

Table 6.3.1 — Recommended slumps for various types of construction*

Types of construction	Slump, in.	
	Maximum[1]	Minimum
Reinforced foundation walls and footings	3	1
Plain footings, caissons, and substructure walls	3	1
Beams and reinforced walls	4	1
Building columns	4	1
Pavements and slabs	3	1
Mass concrete	2	1

*Slump may be increased when chemical admixtures are used, provided that the admixture-treated concrete has the same or lower water-cement or water-cementitious material ratio and does not exhibit segregation potential or excessive bleeding.

[1]May be increased 1 in. for methods of consolidation other than vibration.

Fundamentals of Mix Proportioning

Table 6.3.3 — Approximate mixing water and air content requirements for different slumps and nominal maximum sizes of aggregates

Slump, in.	Water, lb/yd³ of concrete for indicated nominal maximum sizes of aggregate							
	⅜ in.*	½ in.*	¾ in.*	1 in.*	1-½ in.*	2 in.*†	3 in.†‡	6 in.†‡
Non-air-entrained concrete								
1 to 2	350	335	315	300	275	260	220	190
3 to 4	385	365	340	325	300	285	245	210
6 to 7	410	385	360	340	315	300	270	—
More than 7*	—	—	—	—	—	—	—	—
Approximate amount of entrapped air in non-air-entrained concrete, percent	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-entrained concrete								
1 to 2	305	295	280	270	250	240	205	180
3 to 4	340	325	305	295	275	265	225	200
6 to 7	365	345	325	310	290	280	260	—
More than 7*	—	—	—	—	—	—	—	—
Recommended averages' total air content, percent for level of exposure:								
Mild exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5**,††	1.0**,††
Moderate exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5**,††	3.0**,††
Severe exposure‡‡	7.5	7.0	6.0	6.0	5.5	5.0	4.5**,††	4.0**,††

Fundamentals of Mix Proportioning

Table 6.3.6 — Volume of coarse aggregate per unit of volume of concrete

Nominal maximum size of aggregate, in.	Volume of oven-dry-rodded coarse aggregate* per unit volume of concrete for different fineness moduli of fine aggregate'			
	2.40	2.60	2.80	3.00
⅜	0.50	0.48	0.46	0.44
½	0.59	0.57	0.55	0.53
¾	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1½	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76
6	0.87	0.85	0.83	0.81

*Volumes are based on aggregates in oven-dry-rodded condition as described in ASTM C 29.

These volumes are selected from empirical relationships to produce concrete with a degree of workability suitable for usual reinforced construction. For less workable concrete, such as required for concrete pavement construction, they may be increased about 10 percent. For more workable concrete see Section 6.3.6.1.

'See ASTM C 136 for calculation of fineness modulus.

Fundamentals of Mix Proportioning

Table 6.3.4(a) — Relationship between water-cement or water-cementitious materials ratio and compressive strength of concrete

Compressive strength at 28 days, psi*	Water-cement ratio, by weight	
	Non-air-entrained concrete	Air-entrained concrete
6000	0.41	—
5000	0.48	0.40
4000	0.57	0.48
3000	0.68	0.59
2000	0.82	0.74

Fundamentals of Mix Proportioning

Table 6.3.4(b) — Maximum permissible water-cement or water-cementitious materials ratios for concrete in severe exposures*

Type of structure	Structure wet continuously or frequently and exposed to freezing and thawing†	Structure exposed to sea water or sulfates
Thin sections (railings, curbs, sills, ledges, ornamental work) and sections with less than 1 in. cover over steel	0.45	0.40‡
All other structures	0.50	0.45‡

*Based on report of ACI Committee 201. Cementitious materials other than cement should conform to ASTM C 618 and C 989.

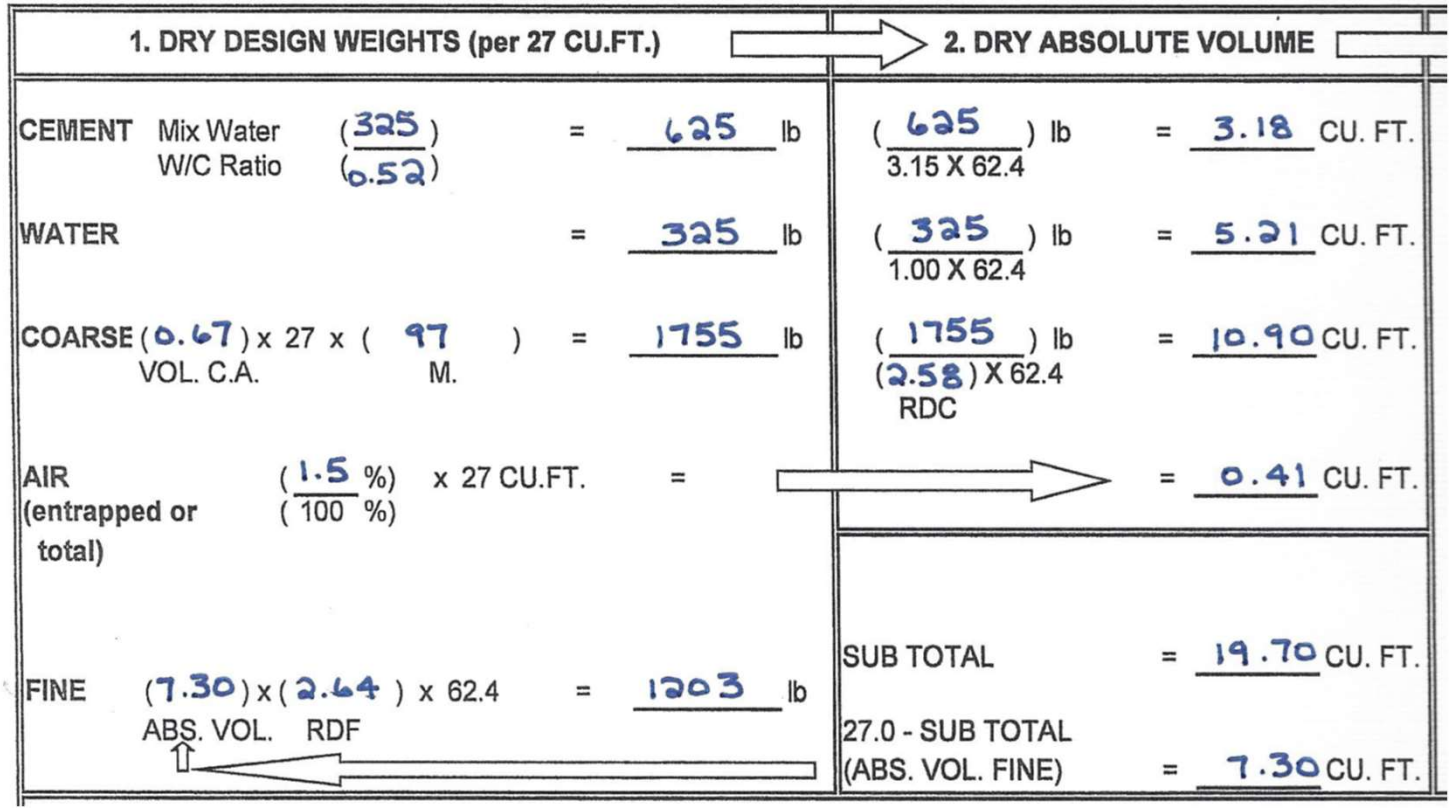
†Concrete should also be air-entrained.

‡If sulfate resisting cement (Type II or Type V of ASTM C 150) is used, permissible water-cement or water-cementitious materials ratio may be increased by 0.05.

Fundamentals of Mix Proportioning

Note: When looking at the w/c (w/cm) ratio for both strength (Table 6.3.4 (a)) AND durability (Table 6.3.4 (b)) – for example an exterior slab in a cold weather environment - the w/c (w/cm) that is selected for mix proportioning will always be the one that is most restrictive.

Fundamentals of Mix Proportioning



Fundamentals of Mix Proportioning

3. SSD DESIGN WEIGHTS (per 27 CU.FT.)

CEMENT	=	625 lb
WATER	=	325 lb
COARSE AGGREGATE (Dry Wt.) x (1 + (ABS)/100) 1755 x (1 + 3.1/100)	=	1809 lb
FINE AGGREGATE (Dry Wt.) x (1 + (ABS)/100) 1203 x (1 + 1.3/100)	=	1219 lb
TOTAL WEIGHT	=	3978 lb
DENSITY (Total Wt./27.0 ft^3)	=	147.3 lb/ft^3

Fundamentals of Mix Proportioning

4. MOISTURE CORRECTIONS: (DRY WEIGHT) x (%FREE MOISTURE) + SSD WEIGHT = WET WEIGHT (Batch Wts.)

										BATCH WTS.	
CEMENT									=	625	lb
COARSE AGGREGATE	1755 (DRY) x	(.4/100)	(%FREE) =	7	(lb WATER)	+	1809	(SSD)	=	1816	lb (WET)
FINE AGGREGATE	1203 (DRY) x	(1.2/100)	(%FREE) =	14	(lb WATER)	+	1219	(SSD)	=	1233	lb (WET) ÷ 8.33
WATER	325 (SSD WATER)			- 21	(lb WATER)				=	304	lb (NET) = 36 Gal.

Fundamentals of Mix Proportioning

DATE: _____

PREPARED BY: _____

ACI 211 CALCULATIONS FOR CONCRETE PROPORTIONS

STRUCTURE IDENTIFICATION: warehouse floor, 5" thick

SPECIFIED STRENGTH (f'c): 3500 psi

REQUIRED STRENGTH (f'cr): 4500 psi — S_o = 644 psi, n = 30 tests

COARSE AGGREGATE		FINE AGGREGATE	
A. CLASSIFICATION	6AA	A. CLASSIFICATION	2NS
B. NOMINAL MAX. SIZE	1 in.	B. FINENESS MODULUS	2.80
C. RELATIVE DENSITY (dry), RDC	2.58	C. RELATIVE DENSITY (dry), RDF	2.64
D. TOTAL MOISTURE	3.5 %	D. TOTAL MOISTURE	2.5 %
E. ABSORPTION	3.1 %	E. ABSORPTION	1.3 %
F. FREE MOISTURE	0.4 %	F. FREE MOISTURE	1.2 %
G. BULK DENSITY, M	97 lb/ft³		

ACI TABLES

SLUMP (Table 6.3.1)	3(4) in.	VOL C.A. (Table 6.3.6)	0.67		4000	0.57
% AIR (Table 6.3.3)	1.5 %	W/C RATIO (Table 6.3.4(a))	0.52	STRENGTH	5000	0.48
WATER (Table 6.3.3)	325 lb.	W/C RATIO (Table 6.3.4(b))	N/A	DURABILITY	∴ 4500	0.53

1. DRY DESIGN WEIGHTS (per 27 CU.FT.)		2. DRY ABSOLUTE VOLUME		3. SSD DESIGN WEIGHTS (per 27 CU.FT.)	
CEMENT Mix Water / W/C Ratio (325 / 0.52)	= 625 lb	(625 / 3.15 X 62.4) lb	= 3.18 CU. FT.	CEMENT	= 625 lb
WATER	= 325 lb	(325 / 1.00 X 62.4) lb	= 5.21 CU. FT.	WATER	= 325 lb
COARSE (0.67) x 27 x (97 M.) VOL. C.A.	= 1755 lb	(1755 / (2.58) X 62.4) lb RDC	= 10.90 CU. FT.	COARSE AGGREGATE (Dry Wt.) x (1 + (ABS)/100) 1755 x (1 + 3.1/100)	= 1809 lb
AIR (entrapped or total) (1.5 % / 100 %) x 27 CU.FT.	=		= 0.41 CU. FT.	FINE AGGREGATE (Dry Wt.) x (1 + (ABS)/100) 1203 x (1 + 1.3/100)	= 1219 lb
FINE (7.30) x (2.64) x 62.4 ABS. VOL. RDF	= 1203 lb	SUB TOTAL	= 19.70 CU. FT.	TOTAL WEIGHT	= 3978 lb
		27.0 - SUB TOTAL (ABS. VOL. FINE)	= 7.30 CU. FT.	DENSITY (Total Wt./27.0 ft³)	= 147.3 lb/ft³

4. MOISTURE CORRECTIONS: (DRY WEIGHT) x (%FREE MOISTURE) + SSD WEIGHT = WET WEIGHT (Batch Wts.)

								BATCH WTS.	
CEMENT								= 625	lb
COARSE AGGREGATE	1755 (DRY) x	(0.4/100) (%FREE)	= 7 (lb WATER)	+	1809 (SSD)	=		= 1816	lb (WET)
FINE AGGREGATE	1203 (DRY) x	(1.2/100) (%FREE)	= 14 (lb WATER)	+	1219 (SSD)	=		= 1233	lb (WET) ÷ 8.33
WATER	325 (SSD WATER)	-	21 (lb WATER)			=		= 304	lb (NET) = 36 Gal.

MICHIGAN CONCRETE ASSOCIATION

Fundamentals of Mix Proportioning

	Design Weights, lbs	Batch Weights, lbs
Cement	625	625
Water	325	304
Sand	1219	1233
Stone	1809	1816

Slump	3-4 inches
Air	1.5%
Density	147.3 lb/ft^3

Fundamentals of Mix Proportioning

Are we finished? Not quite.

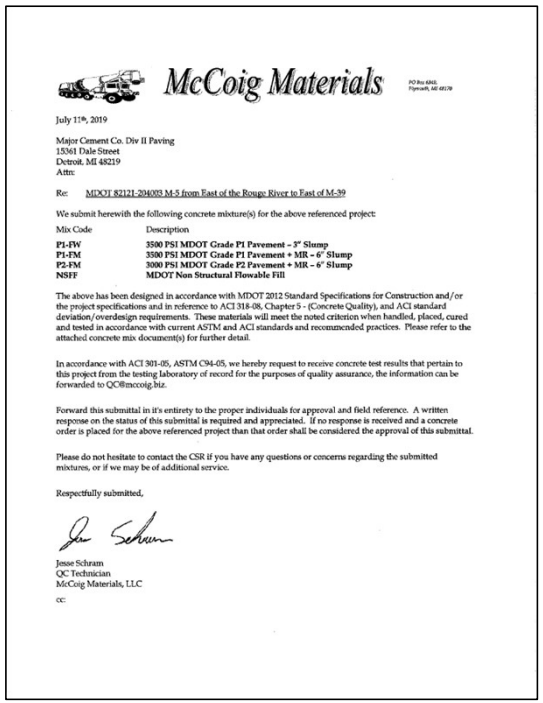
The mix must ALWAYS be checked by trial batches in the laboratory or field and adjusted, as necessary, to produce the desired characteristics. Specifically, we will be evaluating slump (3-4 inches), air (1.5%), density (147.3 lb/ft^3), strength (4500 psi), placeability and appearance (how does the mix look),

Reviewing the Mix

- Contractor submits mix documentation (Form 1976)
  - 10 days prior to anticipated date of placement
- Problems with submitted mix
  - Incomplete packages will be returned without review
- Annual verification – (ref. Method 4)
  - Most common with ready-mixed concrete
  - Historically
    - 2500 mixes generated by MDOT lab
    - Many were project specific
  - Future
    - MDOT wants to get out of the mix design business

Mix Design Submittal Info – Example

Summary page



McCoig Materials

July 11th, 2019

Major Cement Co. Div II Paving
15361 Dale Street
Detroit, MI 48219
Attn:

Re: MDOT 82121-204003 M-5 from East of the Rouge River to East of M-39

We submit herewith the following concrete mixture(s) for the above referenced project:

Mix Code	Description
P1-FW	**3500 PSI MDOT Grade P1 Pavement – 3" Slump**
P1-FM	**3500 PSI MDOT Grade P1 Pavement + MR – 6" Slump**
P2-FM	**3000 PSI MDOT Grade P2 Pavement + MR – 6" Slump**
NSFF	**MDOT Non Structural Flowable Fill**

The above has been designed in accordance with MDOT 2012 Standard Specifications for Construction and/or the project specifications and in reference to ACI 318-08, Chapter 5 - (Concrete Quality), and ACI standard deviation/overdesign requirements. These materials will meet the noted criterion when handled, placed, cured and tested in accordance with current ASTM and ACI standards and recommended practices. Please refer to the attached concrete mix document(s) for further detail.

In accordance with ACI 301-05, ASTM C94-05, we hereby request to receive concrete test results that pertain to this project from the testing laboratory of record for the purposes of quality assurance, the information can be forwarded to QC@mccoig.biz.

Forward this submittal in it's entirety to the proper individuals for approval and field reference. A written response on the status of this submittal is required and appreciated. If no response is received and a concrete order is placed for the above referenced project than that order shall be considered the approval of this submittal.

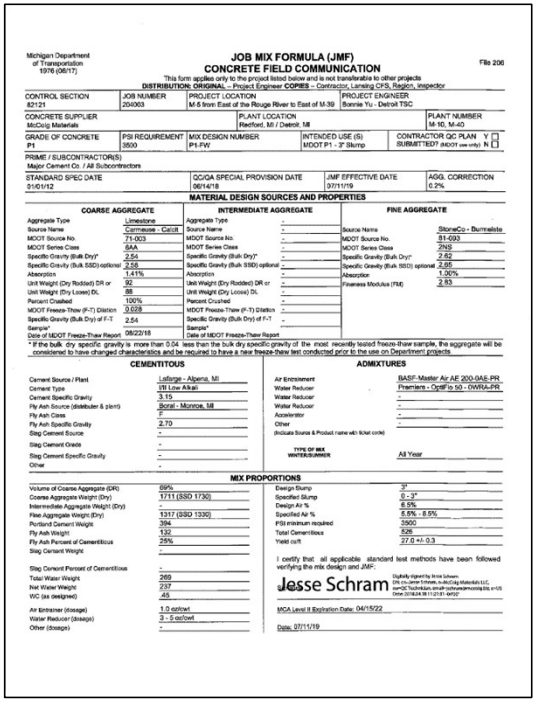
Please do not hesitate to contact the CSR if you have any questions or concerns regarding the submitted mixtures, or if we may be of additional service.

Respectfully submitted,

Jesse Schram
QC Technician
McCoig Materials, LLC

cc:

JMF Form 1976



Michigan Department of Transportation 1976 (08/17)

JOB MIX FORMULA (JMF)
CONCRETE FIELD COMMUNICATION

File 206

This form applies only to the project listed below and is not transferable to other projects
DISTRIBUTION: ORIGINAL – Project Engineer **COPIES** – Contractor, Lansing CPS, Region, Inspector

CONTROL SECTION	JOB NUMBER	PROJECT LOCATION	PROJECT ENGINEER
82121	204003	M-5 from East of the Rouge River to East of M-39	Bonnie Yu - Detroit TSC

CONCRETE SUPPLIER	PLANT LOCATION	PLANT NUMBER
McCoig Materials	Redford, MI / Detroit, MI	M-10, M-40

GRADE OF CONCRETE	PSI REQUIREMENT	MIX DESIGN NUMBER	INTENDED USE (S)	CONTRACTOR QC PLAN SUBMITTED? (MDOT use only)
P1	3500	P1-FW	MDOT P1 - 3" Slump	Y ☐ N ☐

PRIME / SUBCONTRACTOR(S)
Major Cement Co. / All Subcontractors

STANDARD SPEC DATE	QC/QA SPECIAL PROVISION DATE	JMF EFFECTIVE DATE	AGG. CORRECTION
01/01/12	08/14/18	07/11/19	0.2%

MATERIAL DESIGN SOURCES AND PROPERTIES

COARSE AGGREGATE		INTERMEDIATE AGGREGATE		FINE AGGREGATE	
Aggregate Type	Limestone	Aggregate Type	-		
Source Name	Carmeuse - Calcit	Source Name	-	Source Name	StoneCo - Burmeiste
MDOT Source No.	71-003	MDOT Source No.	-	MDOT Source No.	81-003
MDOT Series Class	6AA	MDOT Series Class	-	MDOT Series Class	2NS
Specific Gravity (Bulk Dry)*	2.54	Specific Gravity (Bulk Dry)*	-	Specific Gravity (Bulk Dry)*	2.62
Specific Gravity (Bulk SSD) optional	2.58	Specific Gravity (Bulk SSD) optional	-	Specific Gravity (Bulk SSD) optional	2.65
Absorption	1.41%	Absorption	-	Absorption	1.06%
Unit Weight (Dry Rodded) DR or	92	Unit Weight (Dry Rodded) DR or	-	Fineness Modulus (FM)	2.83
Unit Weight (Dry Loose) DL	88	Unit Weight (Dry Loose) DL	-		
Percent Crushed	100%	Percent Crushed	-		
MDOT Freeze-Thaw (F-T) Dilation	0.028	MDOT Freeze-Thaw (F-T) Dilation	-		
Specific Gravity (Bulk Dry) of F-T Sample*	2.54	Specific Gravity (Bulk Dry) of F-T Sample*	-		
Date of MDOT Freeze-Thaw Report	08/22/18	Date of MDOT Freeze-Thaw Report			

* If the bulk dry specific gravity is more than 0.04 less than the bulk dry specific gravity of the most recently tested freeze-thaw sample, the aggregate will be considered to have changed characteristics and be required to have a new freeze-thaw test conducted prior to the use on Department projects.

CEMENTITOUS		ADMIXTURES	
Cement Source / Plant	Lafarge - Alpena, MI	Air Entrainment	BASF-Master Air AE 200-0AE-PR
Cement Type	I/II Low Alkali	Water Reducer	Premiere - OptiFlo 50 - 0WRA-PR
Cement Specific Gravity	3.15	Water Reducer	-
Fly Ash Source (distributer & plant)	Boral - Monroe, MI	Water Reducer	-
Fly Ash Class	F	Accelerator	-
Fly Ash Specific Gravity	2.70	Other (Indicate Source & Product, name with ticket code)	-
Slag Cement Source	-	TYPE OF MIX WINTER/SUMMER	All Year
Slag Cement Grade	-		
Slag Cement Specific Gravity	-		
Other	-		

MIX PROPORTIONS

Volume of Coarse Aggregate (CR)	69%	Design Slump	3"
Coarse Aggregate Weight (Dry)	1711 (SSD 1730)	Specified Slump	0 - 3"
Intermediate Aggregate (Weight (Dry)	-	Design Air %	6.5%
Fine Aggregate Weight (Dry)	1317 (SSD 1330)	Specified Air %	6.5% - 8.5%
Portland Cement Weight	394	PSI minimum required	3500
Fly Ash Weight	132	Total Cementitious	526
Fly Ash Percent of Cementitious	25%	Yield cu/ft	27.0 +/- 0.3
Slag Cement Weight	-		
Slag Cement Percent of Cementitious	-		
Total Water Weight	269		
Net Water Weight	237		
WC (as designed)	.45		
Air Entrainer (dosage)	1.0 oz/cwt		
Water Reducer (dosage)	3 - 5 oz/cwt		
Other (dosage)	-		

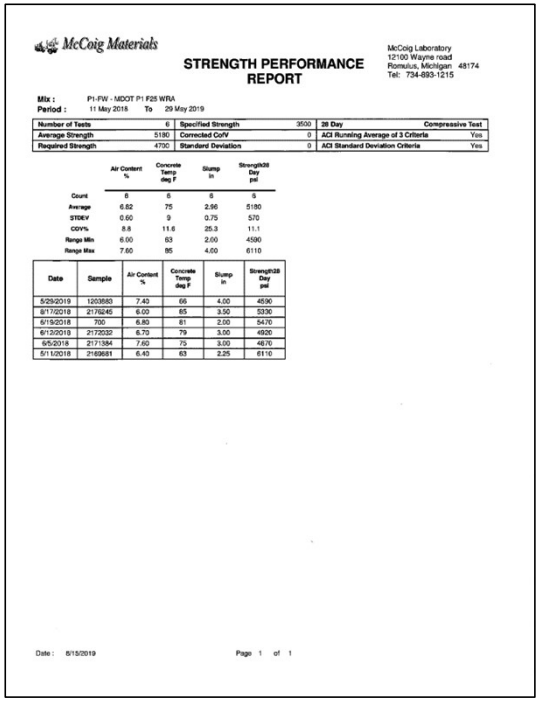
I certify that all applicable standard test methods have been followed verifying the mix design and JMF:

Jesse Schram

MCA Level II Expiration Date: 04/15/22

Date: 07/11/19

Strength Report



McCoig Materials

STRENGTH PERFORMANCE REPORT

McCoig Laboratory
12100 Wayne road
Romulus, Michigan 48174
Tel: 734-893-1215

Mix : P1-FW - MDOT P1 F25 WRA
Period : 11 May 2018 To 29 May 2019

Number of Tests	6	**Specified Strength**	3500	**28 Day**	**Compressive Test**
Average Strength	5180	**Corrected CoV**	0	**ACI Running Average of 3 Criteria**	Yes
Required Strength	4730	**Standard Deviation**	0	**ACI Standard Deviation Criteria**	Yes

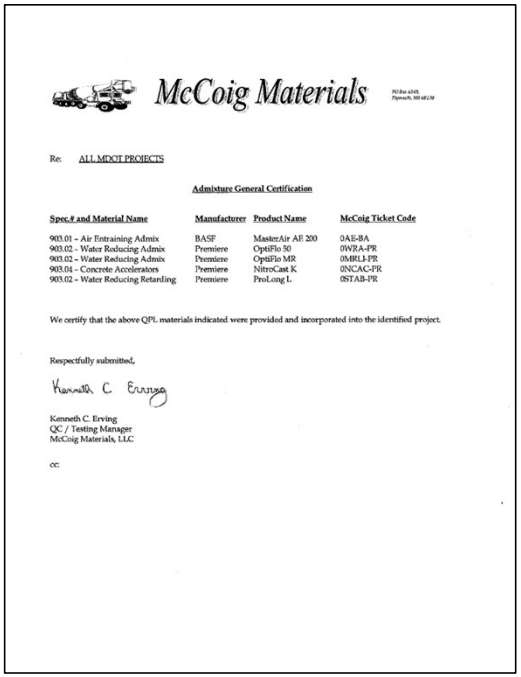
	Air Content %	Concrete Temp deg F	Slump in	Strength28 Day psi
Count	6	6	6	6
Average	6.82	75	2.96	5180
STDEV	0.60	9	0.75	570
COV%	8.8	11.6	25.3	11.1
Range Min	6.00	63	2.00	4590
Range Max	7.60	85	4.00	6110

Date	Sample	Air Content %	Concrete Temp deg F	Slump in	Strength28 Day psi
5/29/2019	1203883	7.40	66	4.00	4590
8/17/2018	2176245	6.00	85	3.50	5330
6/15/2018	700	6.80	81	2.00	5470
6/13/2018	2172032	6.70	79	3.00	4920
6/5/2018	2171384	7.60	75	3.00	4670
5/11/2018	2169681	6.40	63	2.25	6110

Date : 5/15/2019 Page 1 of 1

Mix Design Submittal Info – Example

Admixture Certs



McCoig Materials

Re: ALL MDOT PROJECTS

Admixture General Certification

Spec.# and Material Name	Manufacturer	Product Name	McCoig Ticket Code
903.01 – Air Entraining Admix	BASF	MasterAir AE 200	0AE-BA
903.02 – Water Reducing Admix	Premiere	OptiFlo 50	0WRA-PR
903.02 – Water Reducing Admix	Premiere	OptiFlo MR	0MRLI-PR
903.04 – Concrete Accelerators	Premiere	NitroCast K	0NCAC-PR
903.02 – Water Reducing Retarding	Premiere	ProLong L	0STAB-PR

We certify that the above QPL materials indicated were provided and incorporated into the identified project.

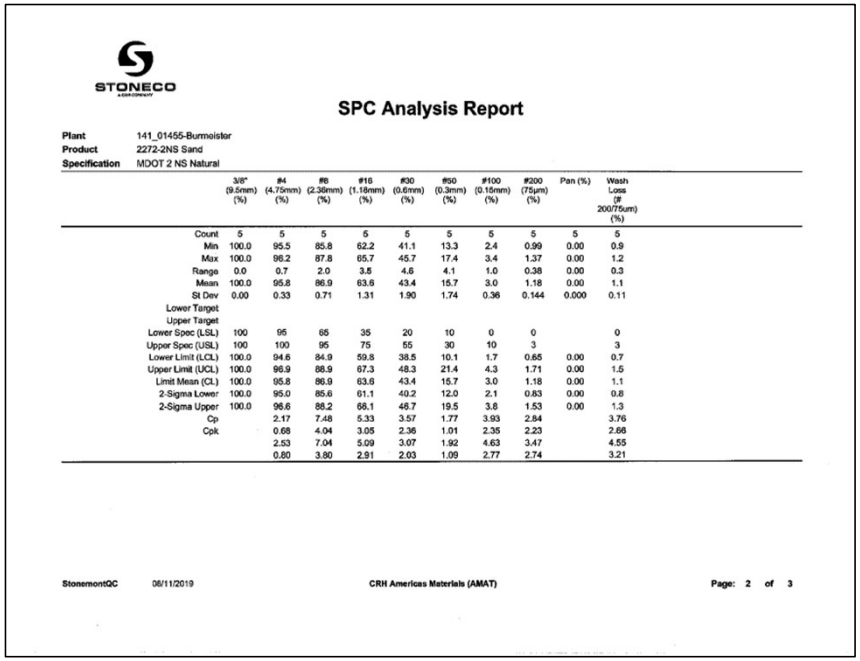
Respectfully submitted,

Kenneth C. Erving

Kenneth C. Erving
QC / Testing Manager
McCoig Materials, LLC

cc:

Sand Gradation



STONECO

SPC Analysis Report

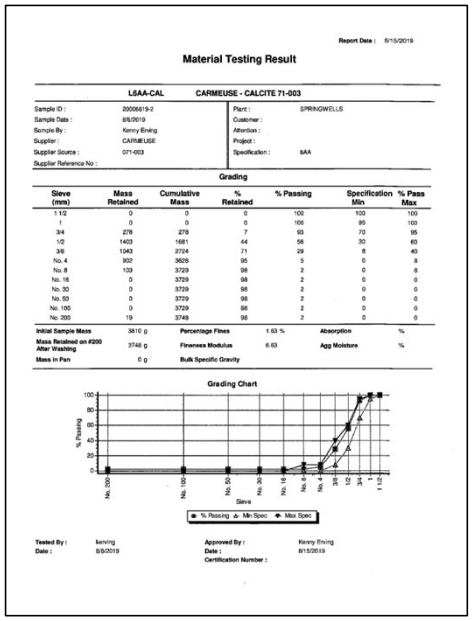
Plant 141_01455-Burmeister
Product 2272-2NS Sand
Specification MDOT 2 NS Natural

	3/8" (9.5mm) (%)	#4 (4.75mm) (%)	#8 (2.36mm) (%)	#16 (1.18mm) (%)	#30 (0.6mm) (%)	#50 (0.3mm) (%)	#100 (0.15mm) (%)	#200 (75µm) (%)	Pan (%)	Wash Loss (# 200/75um) (%)
Count	5	5	5	5	5	5	5	5	5	5
Min	100.0	95.5	85.8	62.2	41.1	13.3	2.4	0.99	0.00	0.9
Max	100.0	96.2	87.8	65.7	45.7	17.4	3.4	1.37	0.00	1.2
Range	0.0	0.7	2.0	3.5	4.6	4.1	1.0	0.38	0.00	0.3
Mean	100.0	95.8	86.9	63.6	43.4	15.7	3.0	1.18	0.00	1.1
St Dev	0.00	0.33	0.71	1.31	1.90	1.74	0.36	0.144	0.000	0.11
Lower Target										
Upper Target										
Lower Spec (LSL)	100	95	85	35	20	10	0	0		0
Upper Spec (USL)	100	100	95	75	55	30	10	3		3
Lower Limit (LCL)	100.0	94.6	84.9	59.8	38.5	10.1	1.7	0.65	0.00	0.7
Upper Limit (UCL)	100.0	96.9	88.9	67.3	48.3	21.4	4.3	1.71	0.00	1.5
Limit Mean (CL)	100.0	95.8	86.9	63.6	43.4	15.7	3.0	1.18	0.00	1.1
2-Sigma Lower	100.0	95.0	85.6	61.1	40.2	12.0	2.1	0.83	0.00	0.8
2-Sigma Upper	100.0	96.6	88.2	66.1	46.7	19.5	3.8	1.53	0.00	1.3
Cp		2.17	7.48	5.33	3.57	1.77	3.93	2.84		3.76
Cpk		0.68	4.04	3.05	2.36	1.01	2.35	2.23		2.66
		2.53	7.04	5.09	3.07	1.92	4.63	3.47		4.55
		0.80	3.80	2.91	2.03	1.09	2.77	2.74		3.21

StonermontQC 06/11/2019 CRH Americas Materials (AMAT) Page: 2 of 3

Mix Design Submittal Info – Example

Coarse Gradation



Report Date : 5/15/2019

Material Testing Result

	LSAA-CAL	CARMEUSE - CALCITE 71-003	
Sample ID :	20006819-2	Plant :	SPRINGWELLS
Sample Date :	8/6/2019	Customer :	
Sample By :	Kenny Erving	Attention :	
Supplier :	CARMEUSE	Project :	
Supplier Source :	071-003	Specification :	6AA
Supplier Reference No :			

Grading

Sieve (mm)	Mass Retained	Cumulative Mass	% Retained	% Passing	Specification Min	% Pass Max
1 1/2	0	0	0	100	100	100
1	0	0	0	100	95	100
3/4	278	278	7	93	70	95
1/2	1403	1681	44	56	30	60
3/8	1043	2724	71	29	8	40
No. 4	902	3626	95	5	0	8
No. 8	103	3729	98	2	0	8
No. 16	0	3729	98	2	0	0
No. 30	0	3729	98	2	0	0
No. 50	0	3729	98	2	0	0
No. 100	0	3729	98	2	0	0
No. 200	19	3748	98	2	0	0

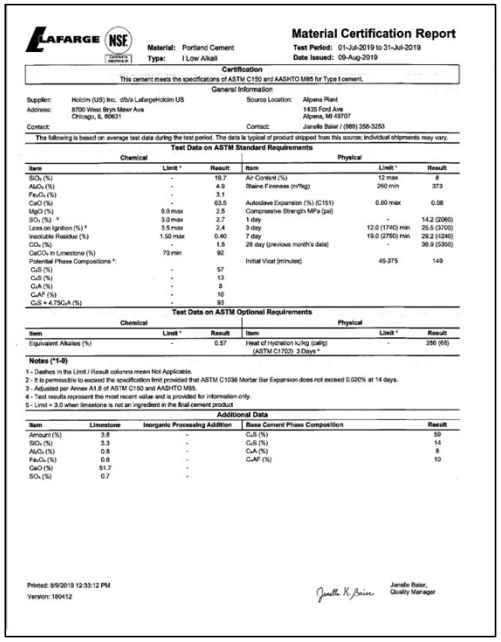
Initial Sample Mass	3810 g	Percentage Fines	1.63 %	Absorption	%
Mass Retained on #200 After Washing	3748 g	Fineness Modulus	6.63	Agg Moisture	%
Mass in Pan	0 g	Bulk Specific Gravity			

Grading Chart

Tested By : kerving
Date : 8/9/2019

Approved By : Kenny Erving
Date : 8/13/2019
Certification Number :

Cement Mill Report



LAFARGE NSF

Material Certification Report

Material: Portland Cement
Type: I Low Alkali
Test Period: 01-Jul-2019 to 31-Jul-2019
Date Issued: 09-Aug-2019

Certification

This cement meets the specifications of ASTM C150 and AASHTO M85 for Type I cement.

General Information

Supplier: Holcim (US) Inc. d/b/a LafargeHolcim US
Address: 6700 West Bryn Mawr Ave, Chicago, IL 60631
Contact:

Source Location: Alpena Plant
1435 Ford Ave, Alpena, MI 49707
Contact: Janelle Baier / (989) 358-3253

The following is based on average test data during the test period. The data is typical of product shipped from this source; individual shipments may vary.

Test Data on ASTM Standard Requirements

Chemical Item	Limit *	Result	Physical Item	Limit *	Result
SO_3 (%)	-	19.7	Air Content (%)	12 max	8
Al_2O_3 (%)	-	4.9	Blaine Fineness (m²/kg)	260 min	373
Fe_2O_3 (%)	-	3.1			
CaO (%)	-	63.5	Autoclave Expansion (%) (C151)	0.80 max	0.08
MgO (%)	6.0 max	2.5	Compressive Strength MPa (psi)		
SO_3 (%) *	3.0 max	2.7	1 day	-	14.2 (2060)
Loss on Ignition (%) *	3.5 max	2.4	3 day	12.0 (1740) min	25.5 (3700)
Insoluble Residue (%)	1.50 max	0.40	7 day	19.0 (2760) min	29.2 (4240)
CO_2 (%)	-	1.5	28 day (previous month's data)	-	36.9 (5350)
$CaCO_3$ in Limestone (%)	70 min	92			
Potential Phase Composition ^5			Initial Vicat (minutes)	45-375	149
C3S (%)	-	57			
C2S (%)	-	13			
C3A (%)	-	8			
C4AF (%)	-	10			
C3S + 4.75C3A (%)	-	93			

Test Data on ASTM Optional Requirements

Chemical Item	Limit *	Result	Physical Item	Limit *	Result
Equivalent Alkalies (%)	-	0.57	Heat of Hydration kJ/kg (cal/g) (ASTM C1702) 3 Days *	-	286 (68)

Notes (*1-9)

1 - Dashes in the Limit / Result columns mean Not Applicable.
2 - It is permissible to exceed the specification limit provided that ASTM C1038 Mortar Bar Expansion does not exceed 0.020% at 14 days.
3 - Adjusted per Annex A1.8 of ASTM C150 and AASHTO M85.
4 - Test results represent the most recent value and is provided for information only.
5 - Limit = 3.0 when limestone is not an ingredient in the final cement product.

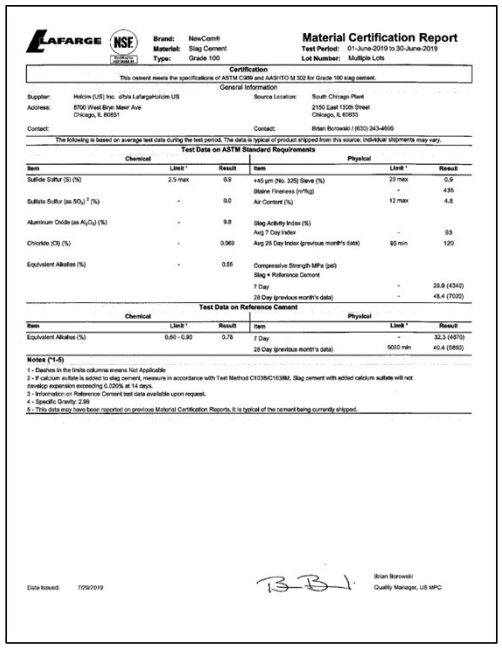
Additional Data

Item	Limestone	Inorganic Processing Addition	Base Cement Phase Composition	Result
Amount (%)	3.8	-	C3S (%)	59
SiO_2 (%)	3.3	-	C2S (%)	14
Al_2O_3 (%)	0.8	-	C3A (%)	8
Fe_2O_3 (%)	0.6	-	C4AF (%)	10
CaO (%)	51.7	-		
SO_3 (%)	0.7	-		

Printed: 8/9/2019 12:33:12 PM
Version: 180412

Janelle Baier, Quality Manager

Slag Cement Mill Report



LAFARGE NSF

Material Certification Report

Brand: NewCem®
Material: Slag Cement
Type: Grade 100
Test Period: 01-June-2019 to 30-June-2019
Lot Number: Multiple Lots

Certification

This cement meets the specifications of ASTM C989 and AASHTO M 302 for Grade 100 slag cement.

General Information

Supplier: Holcim (US) Inc. d/b/a LafargeHolcim US
Address: 6700 West Bryn Mawr Ave, Chicago, IL 60631
Contact:

Source Location: South Chicago Plant
2150 East 130th Street, Chicago, IL 60633
Contact: Brian Borowski / (630) 243-4699

The following is based on average test data during the test period. The data is typical of product shipped from this source; individual shipments may vary.

Test Data on ASTM Standard Requirements

Chemical Item	Limit *	Result	Physical Item	Limit *	Result
Sulfide Sulfur (S) (%)	2.5 max	0.9	+45 µm (No. 325) Sieve (%)	20 max	0.9
			Blaine Fineness (m²/kg)	-	435
Sulfate Sulfur (as SO_3) ^2 (%)	-	0.0	Air Content (%)	12 max	4.8
Aluminum Oxide (as Al_2O_3) (%)	-	9.8	Slag Activity Index (%)		
			Avg 7 Day Index	-	93
Chloride (Cl) (%)	-	0.003	Avg 28 Day Index (previous month's data)	95 min	120
Equivalent Alkalies (%)	-	0.55	Compressive Strength MPa (psi) Slag + Reference Cement		
			7 Day	-	29.9 (4340)
			28 Day (previous month's data)	-	48.4 (7020)

Test Data on Reference Cement

Chemical Item	Limit *	Result	Physical Item	Limit *	Result
Equivalent Alkalies (%)	0.60 - 0.90	0.76	7 Day	-	32.3 (4670)
			28 Day (previous month's data)	5000 min	40.4 (5860)

Notes (*1-5)

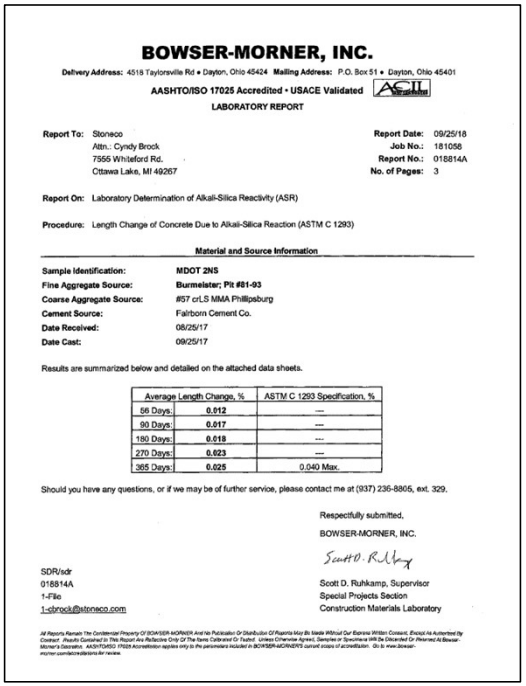
1 - Dashes in the limits columns means Not Applicable
2 - If calcium sulfate is added to slag cement, measure in accordance with Test Method C1038/C1038M. Slag cement with added calcium sulfate will not develop expansion exceeding 0.020% at 14 days.
3 - Information on Reference Cement test data available upon request.
4 - Specific Gravity: 2.89
5 - This data may have been reported on previous Material Certification Reports. It is typical of the cement being currently shipped.

Date Issued: 7/29/2019

Brian Borowski, Quality Manager, US MPC

Mix Design Submittal Info – Example

ASR (ASTM C1293) Data



BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 Mailing Address: P.O. Box 51 • Dayton, Ohio 45401

AASHTO/ISO 17025 Accredited • USACE Validated

LABORATORY REPORT

Report To: Stoneco
Attn.: Cyndy Brock
7555 Whiteford Rd.
Ottawa Lake, MI 49267

Report Date: 09/25/18
Job No.: 181058
Report No.: 018814A
No. of Pages: 3

Report On: Laboratory Determination of Alkali-Silica Reactivity (ASR)

Procedure: Length Change of Concrete Due to Alkali-Silica Reaction (ASTM C 1293)

Material and Source Information

Sample Identification:	MDOT 2NS
Fine Aggregate Source:	Burmeister; Pit #81-93
Coarse Aggregate Source:	#57 crLS MMA Phillipsburg
Cement Source:	Fairborn Cement Co.
Date Received:	08/25/17
Date Cast:	09/25/17

Results are summarized below and detailed on the attached data sheets.

Average Length Change, %		ASTM C 1293 Specification, %
56 Days:	0.012	---
90 Days:	0.017	---
180 Days:	0.018	---
270 Days:	0.023	---
365 Days:	0.025	0.040 Max.

Should you have any questions, or if we may be of further service, please contact me at (937) 236-8805, ext. 329.

Respectfully submitted,

BOWSER-MORNER, INC.

Scott D. Ruhkamp

Scott D. Ruhkamp, Supervisor
Special Projects Section
Construction Materials Laboratory

SDR/sdr
018814A
1-File
1-cbrock@stoneco.com

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NRMCA Plant Cert.

National Ready Mixed Concrete Association

NRMCA

Certificate of Conformance For Concrete Production Facilities

THIS IS TO CERTIFY THAT

Azteca Concrete Plant #3, Redford, MI

McCoig Materials, LLC

MDOT Plant No. M-10
McCoig Plant No. 3

has been inspected by the undersigned licensed professional engineer for conformance with the requirements of the *Check List for Ready Mixed Concrete Production Facilities*. As of the inspection date, the facilities met the requirements for production by

Truck Mixing with Automatic Batching and Recordings of Cementitious Materials, Aggregate, Water, and Chemical Admixtures

STATE OF MICHIGAN RUBEN E. RAMOS ENGINEER No. 30680 REGISTERED PROFESSIONAL ENGINEER

(Seal)

Signature of Licensed Professional Engineer

March 21, 2018 Inspection Date

May 06, 2020 Certification Expiration Date

This company will maintain these facilities in compliance with the *Check List* requirements and will correct promptly any deficiencies which develop.

Frank Manguso
Signature of Company Official

Plant Manager
Title of Company Official

NOTICE: The Check List indicates only that plant facilities are satisfactory for the production of concrete when properly operated. Conformance of the concrete itself with specification requirements must be verified by usual inspection methods in accordance with sales agreements.

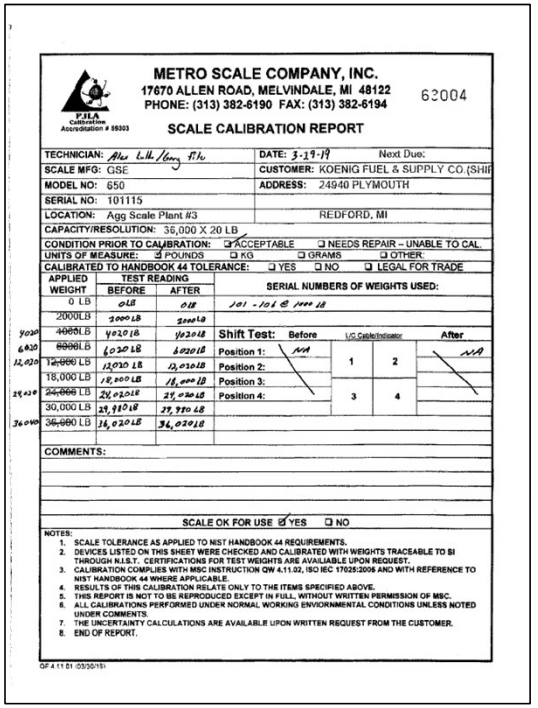
This certificate is issued by the National Ready Mixed Concrete Association on verification that the production facility conforms to the requirements of the NRMCA Certification of Ready Mixed Concrete Production Facilities, QC3. Unauthorized reproduction or misuse of this certificate may result in legal action.

Plant ID #: 800716

Certification ID #: 22680

National Ready Mixed Concrete Association 900 Spring Street • Silver Spring • Maryland 20910

Scale Calibration



METRO SCALE COMPANY, INC.
17670 ALLEN ROAD, MELVINDALE, MI 48122
PHONE: (313) 382-6190 FAX: (313) 382-6194

62004

A2LA Calibration Accreditation # 59303

SCALE CALIBRATION REPORT

TECHNICIAN: Alex Lilli/Jerry Fitz		DATE: 3-29-19	Next Due:
SCALE MFG: GSE		CUSTOMER: KOENIG FUEL & SUPPLY CO.(SHIP	
MODEL NO: 650		ADDRESS: 24940 PLYMOUTH	
SERIAL NO: 101115			
LOCATION: Agg Scale Plant #3		REDFORD, MI	
CAPACITY/RESOLUTION: 36,000 X 20 LB			
CONDITION PRIOR TO CALIBRATION: ☑ ACCEPTABLE ☐ NEEDS REPAIR – UNABLE TO CAL			
UNITS OF MEASURE: ☑ POUNDS ☐ KG ☐ GRAMS ☐ OTHER:			
CALIBRATED TO HANDBOOK 44 TOLERANCE: ☐ YES ☐ NO ☐ LEGAL FOR TRADE			

APPLIED WEIGHT	TEST READING BEFORE	TEST READING AFTER	SERIAL NUMBERS OF WEIGHTS USED:
0 LB	018	018	101 - 104 @ 1000 LB
2000LB	3000 LB	2000 LB	
~~4000~~ LB	4020 LB	4020 LB	Shift Test: Before / After
~~8000~~ LB	6020 LB	6020 LB	Position 1: NA
~~12,000~~ LB	12020 LB	12,020 LB	Position 2:
18,000 LB	18,000 LB	18,000 LB	Position 3:
~~24,000~~ LB	24,020 LB	24,020 LB	Position 4:
30,000 LB	29,980 LB	29,980 LB	
~~36,000~~ LB	36,020 LB	36,020 LB	

I/C Cable Indicator: 1 | 2 | 3 | 4 — After: NA

COMMENTS:

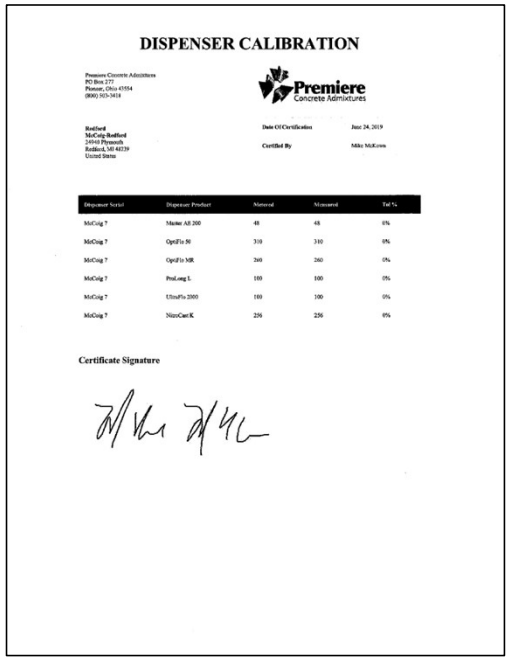
SCALE OK FOR USE ☑ YES ☐ NO

NOTES:
1. SCALE TOLERANCE AS APPLIED TO NIST HANDBOOK 44 REQUIREMENTS.
2. DEVICES LISTED ON THIS SHEET WERE CHECKED AND CALIBRATED WITH WEIGHTS TRACEABLE TO SI THROUGH N.I.S.T. CERTIFICATIONS FOR TEST WEIGHTS ARE AVAILIABLE UPON REQUEST.
3. CALIBRATION COMPLIES WITH MSC INSTRUCTION QW 4.11.02, ISO IEC 17025:2005 AND WITH REFERENCE TO NIST HANDBOOK 44 WHERE APPLICABLE.
4. RESULTS OF THIS CALIBRATION RELATE ONLY TO THE ITEMS SPECIFIED ABOVE.
5. THIS REPORT IS NOT TO BE REPRODUCED EXCEPT IN FULL, WITHOUT WRITTEN PERMISSION OF MSC.
6. ALL CALIBRATIONS PERFORMED UNDER NORMAL WORKING ENVIRONMENTAL CONDITIONS UNLESS NOTED UNDER COMMENTS.
7. THE UNCERTAINTY CALCULATIONS ARE AVAILABLE UPON WRITTEN REQUEST FROM THE CUSTOMER.
8. END OF REPORT.

QF 4.11.01 (03/30/15)

Mix Design Submittal Info – Example

Admixture Calibration



DISPENSER CALIBRATION

Premiere Concrete Admixtures

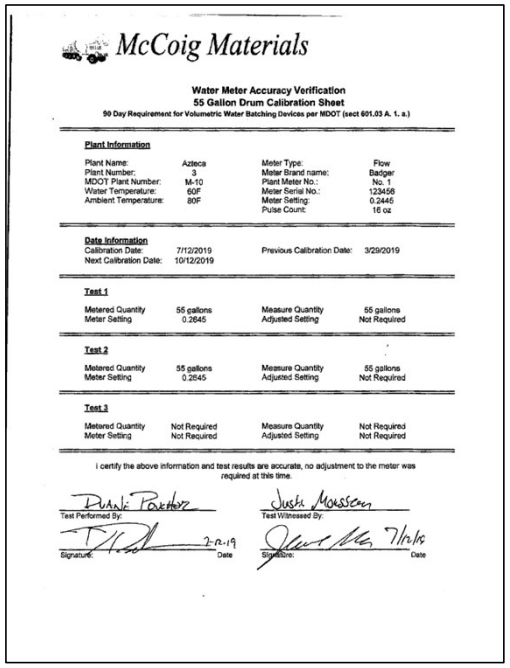
Date Of Certification: June 24, 2019

Certified By: Mike McKeon

Dispenser Serial	Dispenser Product	Metered	Measured	Tol %
McCoig 7	Master Air 200	48	48	0%
McCoig 7	OptiFlo 50	310	310	0%
McCoig 7	OptiFlo MR	260	260	0%
McCoig 7	ProLong L	100	100	0%
McCoig 7	UltraFlo 2000	100	100	0%
McCoig 7	NitroCure K	256	256	0%

Certificate Signature

Water Meter Calibration



McCoig Materials

Water Meter Accuracy Verification
55 Gallon Drum Calibration Sheet
90 Day Requirement for Volumetric Water Batching Devices per MDOT (sect 601.03 A. 1. a.)

Plant Information

Plant Name:	Azteca	Meter Type:	Flow
Plant Number:	3	Meter Brand name:	Badger
MDOT Plant Number:	M-10	Plant Meter No.:	No. 1
Water Temperature:	60F	Meter Serial No.:	123456
Ambient Temperature:	80F	Meter Setting:	0.2445
		Pulse Count:	16 oz

Date Information

Calibration Date: 7/12/2019
Next Calibration Date: 10/12/2019
Previous Calibration Date: 3/29/2019

Test 1

Metered Quantity	55 gallons	Measure Quantity	55 gallons
Meter Setting	0.2645	Adjusted Setting	Not Required

Test 2

Metered Quantity	55 gallons	Measure Quantity	55 gallons
Meter Setting	0.2645	Adjusted Setting	Not Required

Test 3

Metered Quantity	Not Required	Measure Quantity	Not Required
Meter Setting	Not Required	Adjusted Setting	Not Required

I certify the above information and test results are accurate, no adjustment to the meter was required at this time.

Test Performed By: Signature: Date 7-12-19

Test Witnessed By: Signature: Date 7/12/19

Stockpile Mgmt. Plan

McCoig Materials, LLC

CONTRACTOR / PRODUCER AGGREGATE STOCKPILE MANAGEMENT PLAN

Submitted By:

McCoig Materials, LLC
12100 Wayne Road,
Romulus, MI 48174

Summary

- Mix design is all about concrete strength, but also needs to balance:
  - Slump
  - Air content
  - Density
  - Durability
  - and sometimes, optimized aggregate gradation
- MDOT JMF Form 1976 requires backup documentation
  - Approved sources
  - i's dotted, t's crossed

Questions?

swaalkes@miconcrete.net
616-633-9629

dcook@miconcrete.net
517-230-2856

Thank you!!