MICHIGAN CONCRETE ASSOCIATION

Codes, Standards and Specifications for Concrete

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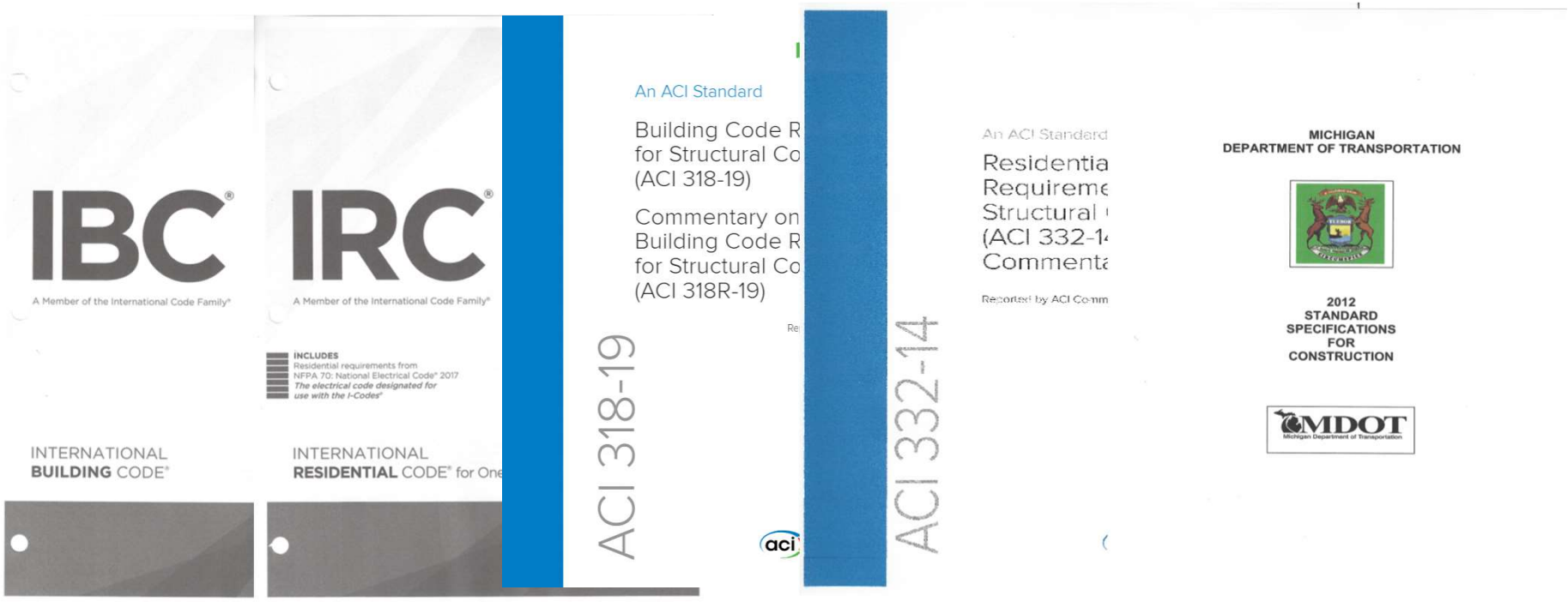
PDF handouts of slides: https://info.miconcrete.org/virtual-learning

Codes, Standards and Specifications for Concrete



Codes, Standards and Specifications for Concrete

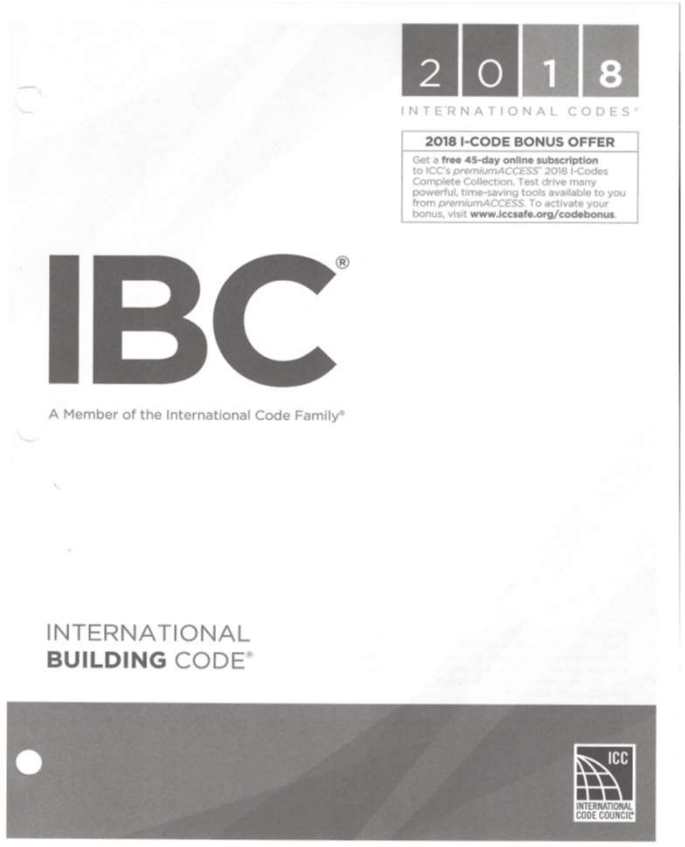
There are a number of codes, standards and specifications that are either required or can be used for reference when developing project specific concrete requirements. The list includes, but is not limited to, the following:

- International Building Code
- International Residential Code
- American Concrete Institute
  - 301 – Specifications for Structural Concrete
  - 318 – Building Code Requirements for Structural Concrete
  - 332 – Residential Code Requirements for Structural Concrete
- MDOT Standard Specifications
- County Specifications – Wayne County, Oakland County
- Local requirements

Definitions

Mix Design	Mixture characteristics are selected based on the intended use of the concrete, the exposure conditions, the size and shape of members and the physical properties of the concrete (such as strength) required for the structure. In short, what do you need?
Mix Proportioning	The selection of material proportions to produce a concrete that will satisfy the mix design requirements. A properly proportioned mix should possess acceptable workability; durability, strength and uniform appearance of hardened concrete; economy. In short, how do we make it? This subject will be addressed in a future webinar.

2018 International Building Code



2018 International Building Code

SECTION 1904
DURABILITY REQUIREMENTS

1904.1 Structural concrete. Structural concrete shall conform to the durability requirements of ACI 318.

Exception: *For Group R-2 and R-3 occupancies not more than three stories above grade plane, the specified compressive strength, f'_c for concrete in basement walls, foundation walls, exterior walls and other vertical surfaces exposed to the weather shall be not less than 3,000 psi (20.7 MPa).*

1904.2 Nonstructural concrete. *The registered design professional shall assign nonstructural concrete a freeze-thaw exposure class, as defined in ACI 318, based on the anticipated exposure of nonstructural concrete. Nonstructural concrete shall have a minimum specified compressive strength, f'_c, of 2,500 psi (17.2 MPa) for Class F0; 3,000 psi (20.7 MPa) for Class F1; and 3,500 psi (24.1 MPa) for Classes F2 and F3. Nonstructural concrete shall be air entrained in accordance with ACI 318.*

2018 International Building Code

310.3 Residential Group R-2. Residential Group R-2 occupancies containing *sleeping units* or more than two *dwelling units* where the occupants are primarily permanent in nature, including:

- Apartment houses
- *Congregate living facilities* (nontransient) with more than 16 occupants
  - *Boarding houses (nontransient)*
  - Convents
  - *Dormitories*
  - Fraternities and sororities
  - Monasteries
- Hotels (nontransient)
- *Live/work units*
- Motels (nontransient)
- Vacation timeshare properties

310.4 Residential Group R-3. Residential Group R-3 occupancies where the occupants are primarily permanent in nature and not classified as Group R-1, R-2, R-4 or I, including:

- Buildings that do not contain more than two *dwelling units*
- Care facilities that provide accommodations for five or fewer persons receiving care
- *Congregate living facilities* (nontransient) with 16 or fewer occupants
  - *Boarding houses (nontransient)*
  - Convents
  - Dormitories
  - Fraternities and sororities
  - Monasteries
- *Congregate living facilities* (*transient*) with 10 or fewer occupants
  - *Boarding houses (transient)*
- *Lodging houses* (*transient*) with five or fewer *guest rooms* and 10 or fewer occupants

2018 International Building Code

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

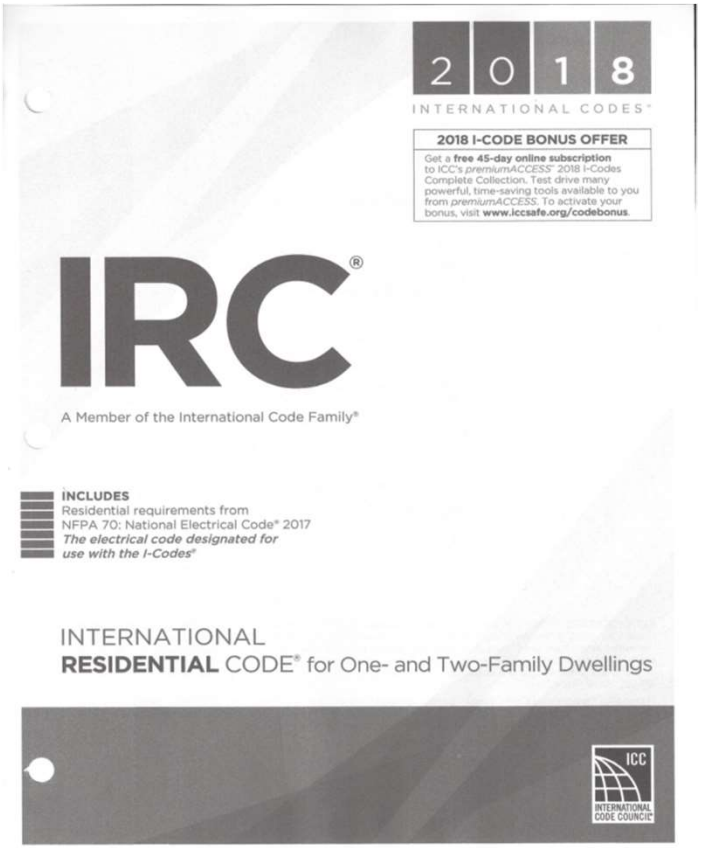
2018 International Building Code

CODE

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

2018 International Residential Code



2018 International Residential Code

R402.2 Concrete. Concrete shall have a minimum specified compressive strength of f'_c, as shown in Table R402.2. Concrete subject to moderate or severe weathering as indicated in Table R301.2(1) shall be air entrained as specified in Table R402.2. The maximum weight of fly ash, other pozzolans, silica fume, slag or blended cements that is included in concrete mixtures for garage floor slabs and for exterior porches, carport slabs and steps that will be exposed to deicing chemicals shall not exceed the percentages of the total weight of cementitious materials specified in Section 19.3.3.4 of ACI 318. Materials used to produce concrete and testing thereof shall comply with the applicable standards listed in Chapters 19 and 20 of ACI 318 or ACI 332.

2018 Residential Building Code

TABLE R402.2
MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF CONCRETE

TYPE OR LOCATION OF CONCRETE CONSTRUCTION	MINIMUM SPECIFIED COMPRESSIVE STRENGTH[a] (f'_c)		
	Weathering Potential[b]		
	Negligible	Moderate	Severe
Basement walls, foundations and other concrete not exposed to the weather	2,500	2,500	2,500[c]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500	2,500[c]
Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather	2,500	3,000[d]	3,000[d]
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	2,500	3,000[d, e, f]	3,500[d, e, f]

For SI: 1 pound per square inch = 6.895 kPa.

a. Strength at 28 days psi.

b. See Table R301.2(1) for weathering potential.

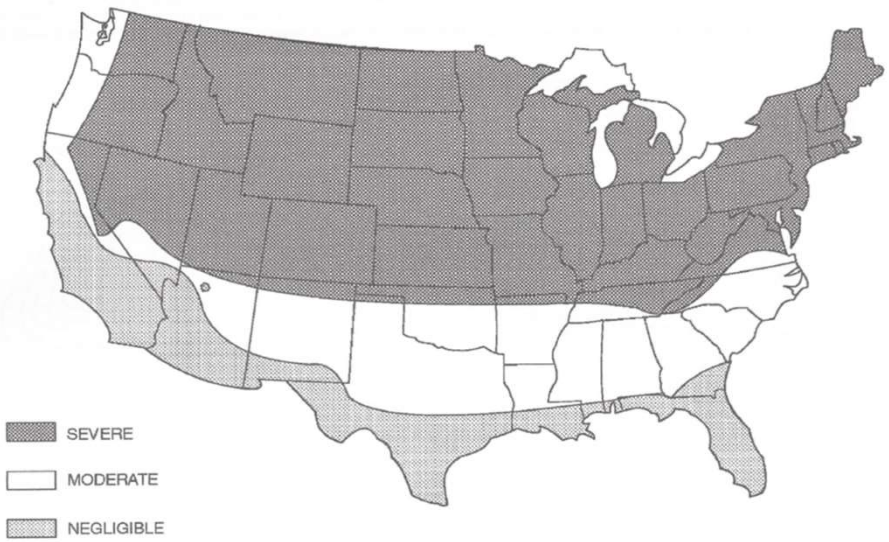
c. Concrete in these locations that is subject to freezing and thawing during construction shall be air-entrained concrete in accordance with Footnote d.

d. Concrete shall be air-entrained. Total air content (percent by volume of concrete) shall be not less than 5 percent or more than 7 percent.

e. See Section R402.2 for maximum cementitious materials content.

f. For garage floors with a steel-troweled finish, reduction of the total air content (percent by volume of concrete) to not less than 3 percent is permitted if the specified compressive strength of the concrete is increased to not less than 4,000 psi.

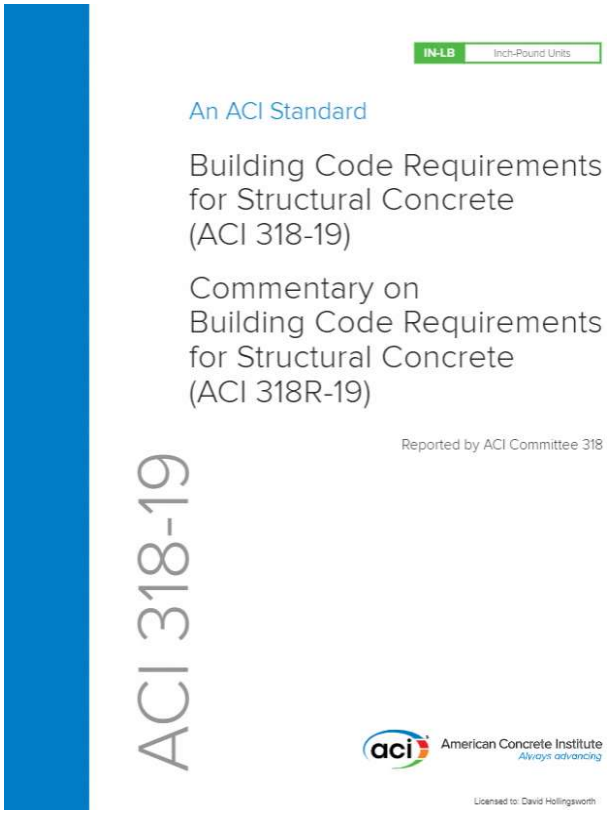
2018 International Residential Code



a. Alaska and Hawaii are classified as severe and negligible, respectively.
b. Lines defining areas are approximate only. Local conditions may be more or less severe than indicated by region classification. A severe classification is where weather conditions result in significant snowfall combined with extended periods during which there is little or no natural thawing causing deicing salts to be used extensively.

FIGURE R301.2(4)
WEATHERING PROBABILITY MAP FOR CONCRETE[a, b]

ACI 318-19 Building Code for Structural Concrete

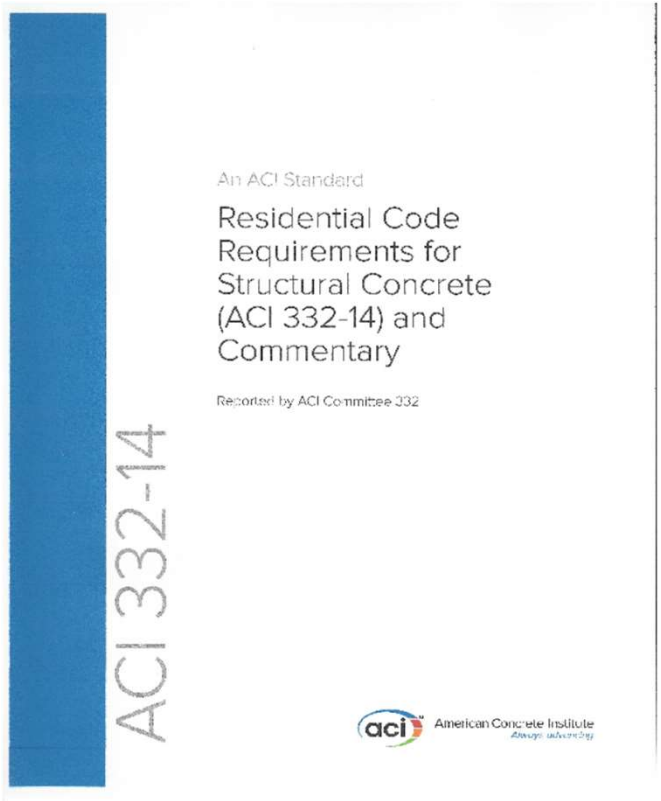


ACI 318 Building Code for Structural Concrete

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	

ACI Residential Code - 332



ACI Residential Code - 332

Table 5.2.1—Exposure categories and classes

Category	Severity	Class	Condition	
RF freezing and thawing	Not applicable	RF0	Concrete not exposed to freezing-and-thawing cycles	
	Moderate	RF1	Concrete exposed to moisture but not likely to be in a saturated condition when exposed to freezing-and-thawing cycles	
	Severe	RF2	Concrete exposed to moisture and with the potential of being in a saturated condition when exposed to freezing-and-thawing cycles	
	Very severe	RF3	Concrete exposed to moisture and application of deicing chemicals with the potential of being saturated when exposed to freezing-and-thawing cycles	
RS sulfate			Water-soluble sulfate (SO_4) in soil, percent by mass*	Dissolved sulfate (SO_4) in water, ppm†
	Not applicable	RS0	$SO_4 < 0.10$	$SO_4 < 150$
	Moderate	RS1	$0.10 \le SO_4 < 0.20$	$150 \le SO_4 < 1500$ Seawater
	Severe	RS2	$0.20 \le SO_4 \le 2.00$	$1500 \le SO_4 \le 10{,}000$
	very severe	RS3	$SO_4 > 2.00$	$SO_4 > 10{,}000$
RC‡ corrosion protection of reinforcement	Not applicable	RC0	Concrete dry or protected from moisture	
	Moderate	RC1	Concrete containing structural steel reinforcement and exposed to moisture but not to external sources of chlorides	
	Severe	RC2	Concrete containing structural steel reinforcement and exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources	

ACI Residential Code - 332

Table 5.3.2—Exposure categories and classes

Exposure class	Maximum slump*	Minimum f'_c, psi	Additional minimum requirements			
			Air content			Limits on cementitious materials
RF0	6	2500	N/A			N/A
RF1	5	3000	Table 5.4.1			N/A
RF2	5	3500	Table 5.4.1			N/A
RF3	4	4000	Table 5.4.1			Table 5.4.2
			Cementitious materials†—types			Calcium chloride admixture
			ASTM C150/C150M	ASTM C595/C595M	ASTM C1157/C1157M	
RS0	6	2500	No type restriction	No type restriction	No type restriction	No restriction
RS1	6	2500	II	IP(MS), IS (<70) (MS)	MS	No restriction
RS2	5	3000	V‡	IP (HS) IS (<70) (HS)	HS	Not permitted
RS3	5	3000	V + pozzolan or slag§	IP (HS) + pozzolan or slag§ or IS (<70) (HS) + pozzolan or slag cement§	HS + pozzolan or slag cement§	Not permitted
			Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by weight of cement‖ in reinforced concrete			
RC0	6	2500	1.00			
RC1	6	2500	0.30			
RC2	4	4000	0.15			

ACI Residential Code - 332

Table 5.4.1—Total air content for concrete assigned to exposure category RF

Nominal maximum aggregate size, in.*	Total air content, percent	
	Exposure Class RF1	Exposure Classes RF2 and FR3
3/8	6	7.5
1/2	5.5	7
3/4	5	6
1	4.5	6
1-1/2	4.5	5.5
2†	4	5
3†	3.5	4.5

ACI Residential Code - 332

Table 5.4.2—Requirements for concrete subject to exposure class RF3

Cementitious materials	Maximum percent of total cementitious materials by weight*
Fly ash or other pozzolans conforming to ASTM C618	25
Slag conforming to ASTM C989/C989M	50
Silica fume conforming to ASTM C1240	10
Total of fly ash, silica fume, slag, and other pozzolans	50†
Total of fly ash, silica fume, slag, and other pozzolans	35†

2012 Standard Specifications for Construction


MICHIGAN
DEPARTMENT OF TRANSPORTATION

2012
STANDARD
SPECIFICATIONS
FOR
CONSTRUCTION

MDOT
Michigan Department of Transportation

2012 Standard Specifications for Construction

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.										

2012 Standard Specifications for Construction

So what do the concrete grades mean?

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 and 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

2012 Standard Specifications for Construction

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

2012 Standard Specifications for Construction

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						

12SP-604A – QC/QA PCC for Local Agency Projects

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

12SP-604B – QA/QC for PCC

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

2012 Standard Specifications for Construction

So what do the concrete grades mean?

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

2012 Standard Specifications for Construction

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

12SP-604B ASR

A. Alkali-Silica Reactivity. Provide documentation to the Engineer that the concrete mixture does not present the potential for deleterious expansion caused by alkali-silica reactivity (ASR). Provide current ASR test results (valid for 2 years from completion of testing), for the fine aggregate that is proposed to be used in the concrete, from an independent testing laboratory proficient in ASR testing. The independent testing laboratory must certify in writing, including a signed statement that all testing was conducted in accordance with the designated standard test procedures, described herein. Test results must conform to the specified criterion for one of the following standard test methods. ASR testing is not required for concrete pavement repairs and temporary concrete pavements. Use the Rounding Method described in *ASTM E 29* when determining significant digits for reporting expansion test results.

12SP-604B ASR

(1) Method 1. *ASTM C 1293*. Concrete Prism Test. If the expansion of concrete prisms is not greater than 0.040 percent (rounded to the nearest 0.001 percent) after 1 year, the fine aggregate is considered non-deleterious to ASR and may be used in the JMF.

(2) Method 2. *ASTM C 1567*. Mortar Bar Test. If no previous test data are available for the fine aggregate that shows it is resistant to ASR using Method 1, above, replace 25 to 40 percent of the Portland cement in the concrete mixture with a supplementary cementitious material. A blended cement meeting the requirements of *ASTM C 595* containing the above Portland cement and supplementary cementitious material proportions may also be used.

12SP-604B ASR

(3) Method 3. *ASTM C 1260*. Mortar Bar Test. If the expansion of the mortar bars is less than 0.10 percent (rounded to the nearest 0.01 percent) at 14 days of immersion, the fine aggregate is considered non-deleterious to ASR and may be used in the concrete without the need for ASR mitigation.

County and Local Requirements

Wayne County Department of Public Services

WCDPS
(03-28-2012)

SPECIAL PROVISION
FOR
CONCRETE MIXTURE REQUIREMENTS

FHWA:APPR:04-06-2012

General

The concrete mixtures for this project shall be in accordance with Sections 601 and 701 of the MDOT Standard Specifications for Construction, and in accordance with Wayne County Standard Plan, P series, except as modified herein.

County and Local Requirements

Table 1 Minimum Mix Design Requirements for Concrete

Mix Design Parameter	Grade of Contents					
	D (a)	S1	T	S2/P1	S3/P2	P-NC
Class Design Strength (28 days, psi)	4500	4000	3500	3500	3000	3500
Water/Cement Ratio (max)	0.44	0.45	0.45	0.45	0.45	0.45
Cementitious Material Content (lb/yd^3)	658	564-612(b)	526-612(b)	526-612(b)	517-564(b)	658(c)

a. Water reducing or water reducing retarding admixtures is required.
b. The maximum cementitious material content may be reduced by 7 percent if a water reducing or water reducing retarding admixture is used.
c. Mid range water reducer: required for structure adjustments and concrete pavement patches.

County and Local Requirements

All concrete mixtures shall utilize one of the requirements listed below to mitigate any potential Alkali Silica Reactivity (ASR):

1. Between April 15th and October 15th, substitution of 25% of the total cementitious material by weight with Class F Fly Ash (ASTM C 618). The percent calcium oxide (CaO) for the fly ash shall be less than 15% and the available alkalis shall not exceed a maximum of 1.5%. Mill test reports for the fly ash must be submitted to the Testing Office. **Fly ash is not allowed for prestressed concrete beams.**

County and Local Requirements

2. A substitution of 35% of the total cementitious material by weight with Ground Granulated Blast Furnace Slag (GGBFS) Grade 100 or 120 (ASTM C 989).

   (a) Between November 1st and March 31st, unless otherwise directed by the Engineer, a non chloride accelerator will be added to the concrete mixture. The accelerator shall be from the approved materials list prescribed in the MDOT Material Sampling Guide.

3. Use of a cement with an alkali level of less than 0.60% (ASTM C150) expressed as equivalent Sodium Oxide (% Na_2O + 0.658 × % K_2O). The total alkali content from the Portland Cement shall not exceed 3.0 lbs./cyd. (Na_2O eq). Mill Test Reports verifying the total alkali content of the Portland Cement must be submitted to the Testing Office.

Questions?

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734.216.1221

ALSO, PLEASE SEND SUGGESTIONS
FOR ADDITIONAL CONCRETE WEBINAR TOPICS!

For the current webinar schedule:
https://info.miconcrete.org/virtual-learning