



RC 2018 xvii Reunión del **CONCRETO**

El evento del Cemento, el Concreto y los Prefabricados

ENTENDIENDO LAS ESPECIFICACIONES. UN REQUISITO PARA ENTENDER LOS CÓDIGOS

Bill Rushing
ACI International
Estados Unidos

ACI 318

WHAT'S IN YOUR SPEC?



ACI 318 is....

- The Building Code.....
- A Key Document in concrete design and construction



ACI 318 is ...

- The concrete building code
- Satisfies minimum health and human safety requirements for structural concrete buildings
- Written through a consensus process
- **Written to the licensed design professional**

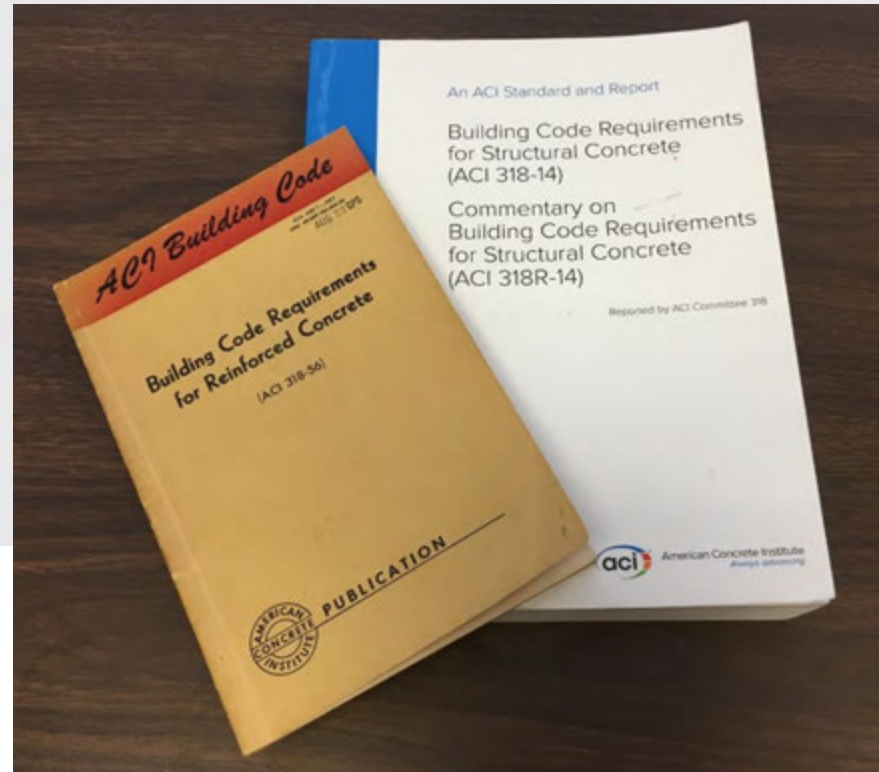
ACI 318-14

- What is in the Code that you should know?



ACI 318-14

What is in the Code that you should know? Increasing volume of info...



ACI 318

- Contains many requirements regarding the **MATERIALS**
- Do we actually meet these?
- Do we know what they are?



Many of us write specs that are
NOT code compliant!



So how can we create a code
compliant project construction
specification?



318-14 Chapters for Discussion

- **Chapter 4—Structural System Requirements**
- **Chapter 19—Concrete: Design and Durability Requirements**
- **Chapter 26—Construction Documents and Inspection**

Chapter 4

- Structural Systems
- Load Paths
- Analysis
- Serviceability/Durability/Sustainability

Chapter 4

Section 4.8.1 – Concrete mixtures **shall** be designed in accordance with requirements of 19.3.2 and 26.4, considering applicable environmental exposure to provide required durability.

Chapter 19 Concrete: Design and Durability Requirements

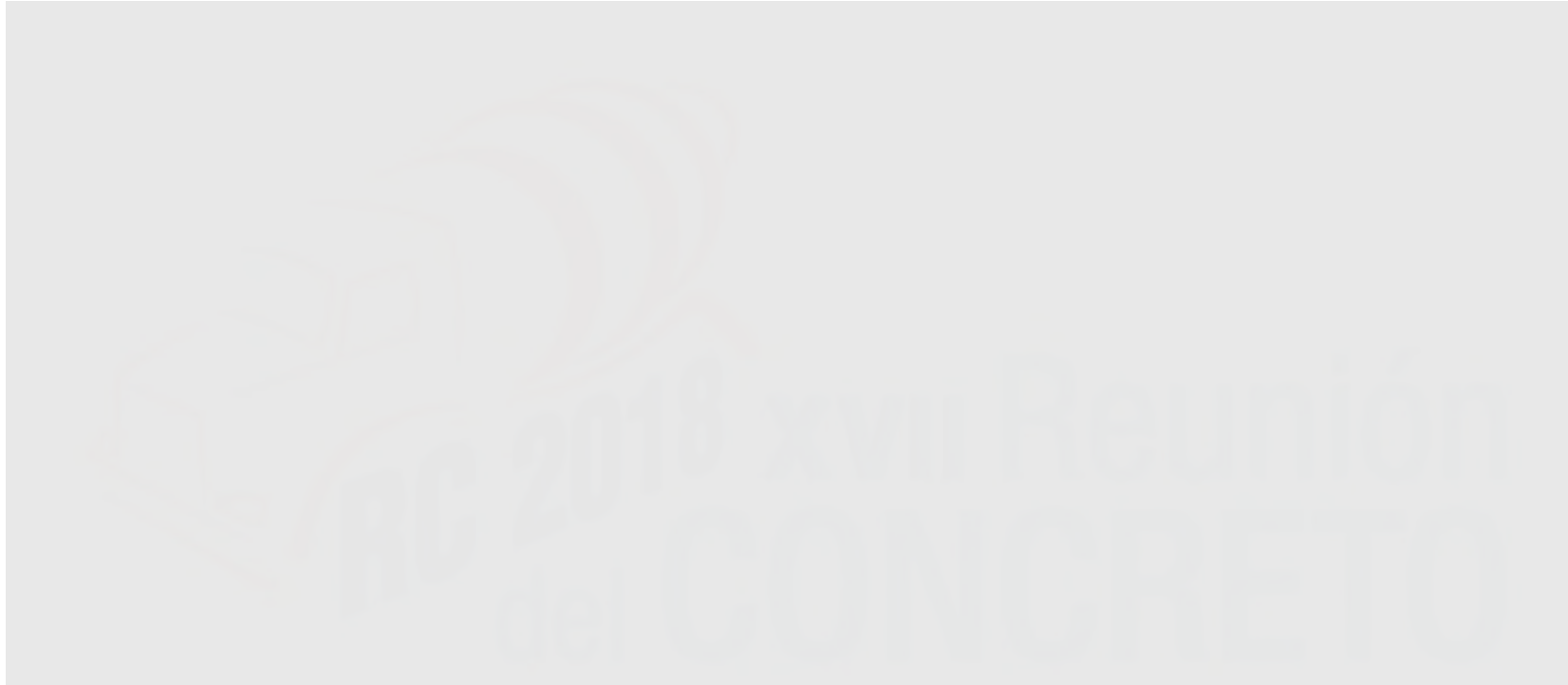
Scope:

- a) Properties to be used for design
- b) Durability Requirements

Most of the Chapter discusses Durability Requirements

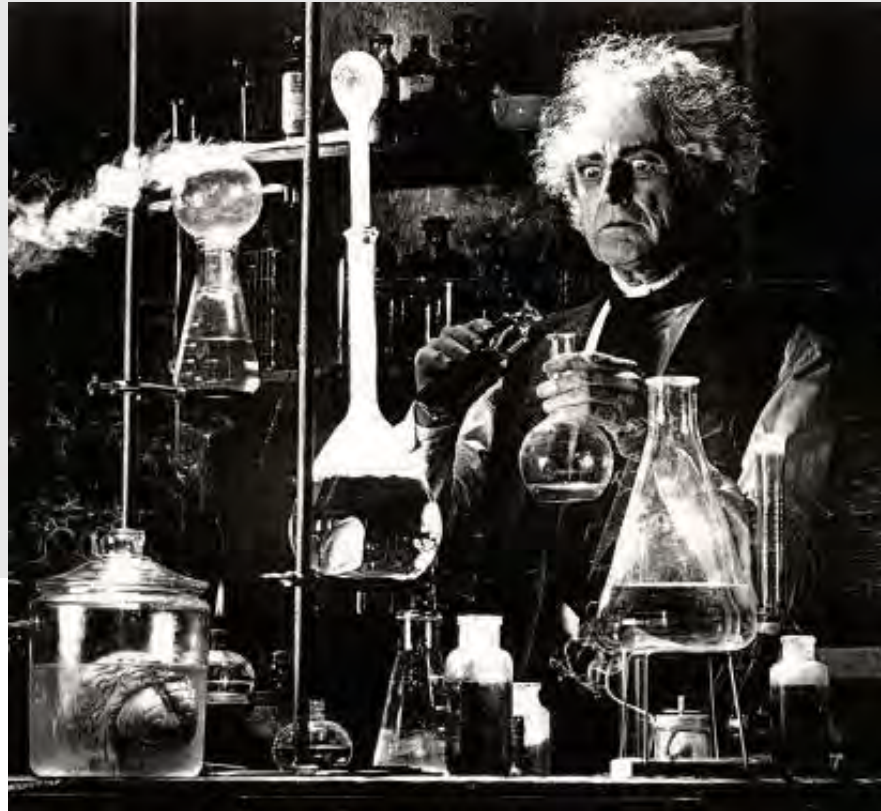
ACI 318-14

Section 19.3 Durability



Section 19.3 Durability

- Mix Design is now Chemistry



Section 19.3 Durability

- Use of SCM's
- Use of Admixtures
- Prescriptive vs Performance Specifications

ACI 318-14

Section 19.3 .1

The Licensed Design Professional **SHALL** assign exposure classes in accordance with the severity of the anticipated exposure of members for each exposure category listed in Table 19.3.1.1

Table 19.3.1.1

Category	Class	Condition	
Freezing and thawing (F)	F0	Concrete not exposed to freezing-and-thawing cycles	
	F1	Concrete exposed to freezing-and-thawing cycles with limited exposure to water	
	F2	Concrete exposed to freezing-and-thawing cycles with frequent exposure to water	
	F3	Concrete exposed to freezing-and-thawing cycles with frequent exposure to water and exposure to deicing chemicals	
Sulfate (S)		Water-soluble sulfate (SO_4^{2-}) in soil, percent by mass ^[1]	Dissolved sulfate (SO_4^{2-}) in water, ppm ^[2]
	S0	$\text{SO}_4^{2-} < 0.10$	$\text{SO}_4^{2-} < 150$
	S1	$0.10 \leq \text{SO}_4^{2-} < 0.20$	$150 \leq \text{SO}_4^{2-} < 1500$ or seawater
	S2	$0.20 \leq \text{SO}_4^{2-} \leq 2.00$	$1500 \leq \text{SO}_4^{2-} \leq 10,000$
	S3	$\text{SO}_4^{2-} > 2.00$	$\text{SO}_4^{2-} > 10,000$
In contact with water (W)	W0	Concrete dry in service Concrete in contact with water and low permeability is not required	
	W1	Concrete in contact with water and low permeability is required	
Corrosion protection of reinforcement (C)	C0	Concrete dry or protected from moisture	
	C1	Concrete exposed to moisture but not to an external source of chlorides	
	C2	Concrete exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources	

Exposure Requirements

4 Exposure Categories (Classes)

– F – Freezing and Thawing (4)

Category	Class	Condition
Freezing and thawing (F)	F0	Concrete not exposed to freezing-and-thawing cycles
	F1	Concrete exposed to freezing-and-thawing cycles with limited exposure to water
	F2	Concrete exposed to freezing-and-thawing cycles with frequent exposure to water
	F3	Concrete exposed to freezing-and-thawing cycles with frequent exposure to water and exposure to deicing chemicals

Exposure Requirements

4 Exposure Categories (Classes)

– S – Sulfate (4)

Category	Class	Condition	
Sulfate (S)		Water-soluble sulfate (SO_4^{2-}) in soil, percent by mass ^[1]	Dissolved sulfate (SO_4^{2-}) in water, ppm ^[2]
	S0	$\text{SO}_4^{2-} < 0.10$	$\text{SO}_4^{2-} < 150$
	S1	$0.10 \leq \text{SO}_4^{2-} < 0.20$	$150 \leq \text{SO}_4^{2-} < 1500$ or seawater
	S2	$0.20 \leq \text{SO}_4^{2-} \leq 2.00$	$1500 \leq \text{SO}_4^{2-} \leq 10,000$
	S3	$\text{SO}_4^{2-} > 2.00$	$\text{SO}_4^{2-} > 10,000$

Exposure Requirements

4 Exposure Categories (Classes)

– W – In contact with Water (Permeability) (2)

Category	Class	Condition
In contact with water (W)	W0	Concrete dry in service Concrete in contact with water and low permeability is not required
	W1	Concrete in contact with water and low permeability is required

Exposure Requirements

4 Exposure Categories (Classes)

– C – Corrosion Protection of Reinforcement (3)

Category	Class	Condition
Corrosion protection of reinforcement (C)	C0	Concrete dry or protected from moisture
	C1	Concrete exposed to moisture but not to an external source of chlorides
	C2	Concrete exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources

ACI 318-14

Section 19.3.2.1

Based on the exposure classes assigned from Table 19.3.1.1, concrete mixtures shall conform to the most restrictive requirements in Table 19.3.2.1

Exposure class	Maximum w/cm ^[1]	Minimum f _c ['] , psi	Additional requirements			Limits on cementitious materials
			Air content			
F0	N/A	2500	N/A			N/A
F1	0.55	3500	Table 19.3.3.1			N/A
F2	0.45	4500	Table 19.3.3.1			N/A
F3	0.40 ^[2]	5000 ^[2]	Table 19.3.3.1			26.4.2.2(b)
			Cementitious materials ^[3] — 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 ^{[4][5]}	Types IP, IS, or IT with (MS) designation	MS	No restriction
S2	0.45	4500	V ^[5]	Types IP, IS, or IT with (HS) designation	HS	Not permitted
S3	0.45	4500	V plus pozzolan or slag cement ^[6]	Types IP, IS, or IT with (HS) designation plus pozzolan or slag cement ^[6]	HS plus pozzolan or slag cement ^[6]	Not permitted

Table 26.4.2.2(b)—Limits on cementitious materials for concrete assigned to Exposure Class F3

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

Exposure class	Maximum w/cm ^[1]	Minimum f _c ['] , psi	Additional requirements			Limits on cementitious materials
			Air content			
F0	N/A	2500	N/A			N/A
F1	0.55	3500	Table 19.3.3.1			N/A
F2	0.45	4500	Table 19.3.3.1			N/A
F3	0.40 ^[2]	5000 ^[2]	Table 19.3.3.1			26.4.2.2(b)
			Cementitious materials ^[3] — 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 ^{[4][5]}	Types IP, IS, or IT with (MS) designation	MS	No restriction
S2	0.45	4500	V ^[5]	Types IP, IS, or IT with (HS) designation	HS	Not permitted
S3	0.45	4500	V plus pozzolan or slag cement ^[6]	Types IP, IS, or IT with (HS) designation plus pozzolan or slag cement ^[6]	HS plus pozzolan or slag cement ^[6]	Not permitted

Table 19.3.3.1—Total air content for concrete exposed to cycles of freezing and thawing

Nominal maximum aggregate size, in.	Target air content, percent	
	F1	F2 and F3
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

Exposure class	Maximum w/cm ^[1]	Minimum f'_c , psi	Additional requirements			Limits on cementitious materials
			Air content			
F0	N/A	2500	N/A			N/A
F1	0.55	3500	Table 19.3.3.1			N/A
F2	0.45	4500	Table 19.3.3.1			N/A
F3	0.40 ^[2]	5000 ^[2]	Table 19.3.3.1			26.4.2.2(b)
			Cementitious materials ^[3] — 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 ^{[4][5]}	Types IP, IS, or IT with (MS) designation	MS	No restriction
S2	0.45	4500	V ^[5]	Types IP, IS, or IT with (HS) designation	HS	Not permitted
S3	0.45	4500	V plus pozzolan or slag cement ^[6]	Types IP, IS, or IT with (HS) designation plus pozzolan or slag cement ^[6]	HS plus pozzolan or slag cement ^[6]	Not permitted



Exposure class	Maximum w/cm ^[1]	Minimum f _c ['] , psi	Additional requirements		Limits on cementitious materials
			Air content		
W0	N/A	2500	None		
W1	0.50	4000	None		
			Maximum water-soluble chloride ion (Cl ⁻) content in concrete, percent by weight of cement		
			Nonprestressed concrete	Prestressed concrete	
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	Concrete cover

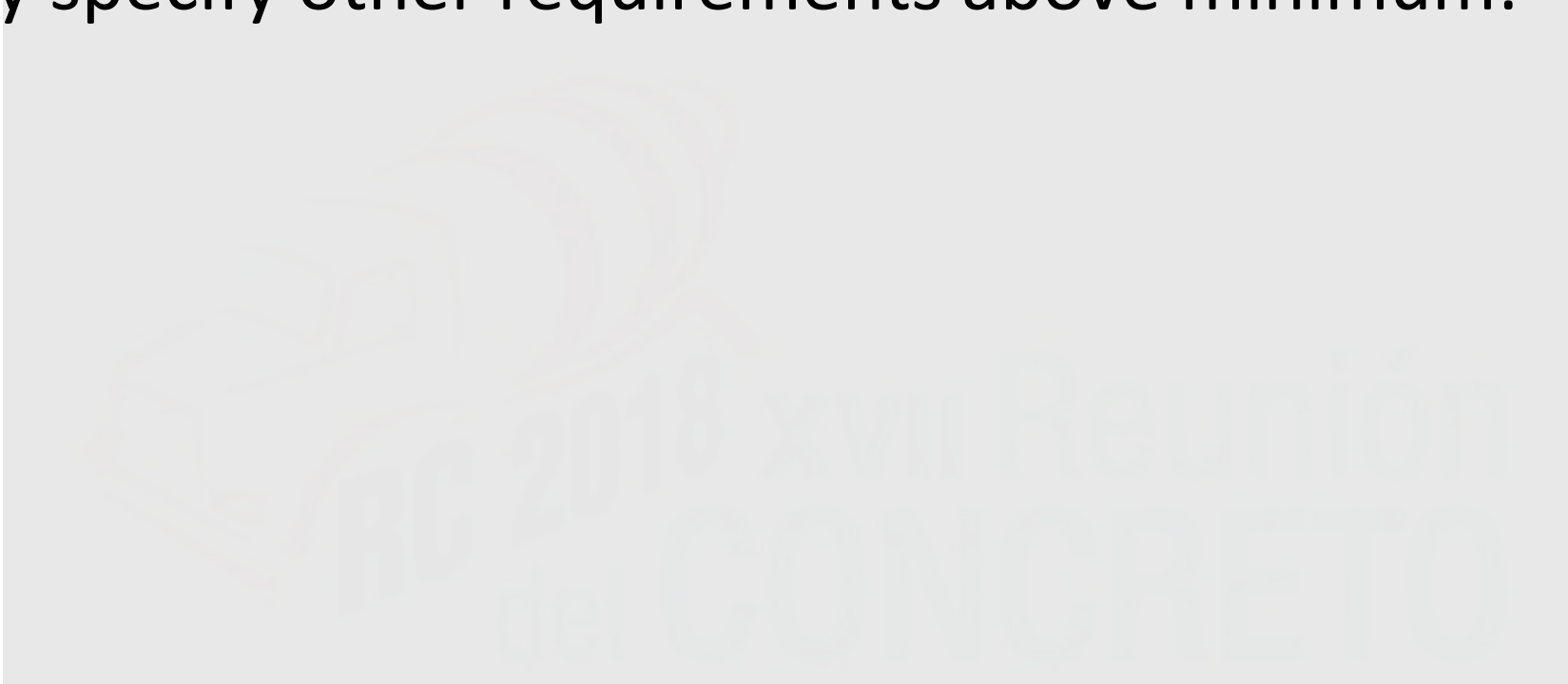
Requirements by Exposure Class

For every class, requirements listed for

1. Max w/c
2. Minimum $f'c$
3. Air
4. Limits on cementitious materials and types
5. Calcium Chloride admixtures
6. Aggregate Size

Requirements by Exposure Class

LDP may specify other requirements above minimum:



Requirements by Exposure Class

LDP may specify other requirements above minimum:

Minimum f'_c

w/c requirements

Permeability requirements (ASTM C1202)

An Overview of the requirements only!
The LDP needs to be familiar with these requirements

Chapter 26 – Construction Documents and Inspection

Can we tell the Contractor to comply with 318?



Is this a cop out? Are we just creating a fight?

Chapter 26 – Construction Documents

- Information that is required in documents
- Guidance for the LDP to direct the Contractor
- Do Not reference 318 to the Contractor!

Chapter 26 – Construction Documents

- 26.1 Scope (Commentary)
- This chapter establishes the minimum requirements that must be included in the construction documents...

Chapter 26 – Construction Documents

- 26.1 Scope (Commentary)
- This chapter is directed to the LDP responsible for incorporating project requirements into the construction documents.

Chapter 26 – Construction Documents

- 26.1 Scope (Commentary)
- The documents should contain all the necessary design and construction requirements for the Contractor to achieve compliance with the code

Chapter 26 – Construction Documents

- 26.1 Scope (Commentary)
- It is not intended that the Contractor will need to read and interpret the code

Chapter 26 – Construction Documents

- 26.1 Scope (Commentary)
- Understood that some design elements may go to the Contractor....

Chapter 26 – Construction Documents

26.1.1 This chapter addresses (a) through (c):

- (a) Design information that the licensed design professional shall specify in the construction documents, if applicable.
- (b) Compliance requirements that the licensed design professional shall specify in the construction documents, if applicable.
- (c) Inspection requirements that the licensed design professional shall specify in the construction documents, if applicable.

Chapter 26 – Construction Documents

26.1.1

Summarizing.....

Essentially, everything in Chapter 26 applicable to your project has to be in your specifications

Compliance Requirements

States the specific references that are required for concrete mix design requirements for:

Water

Aggregates

Admixtures

Steel Fibers

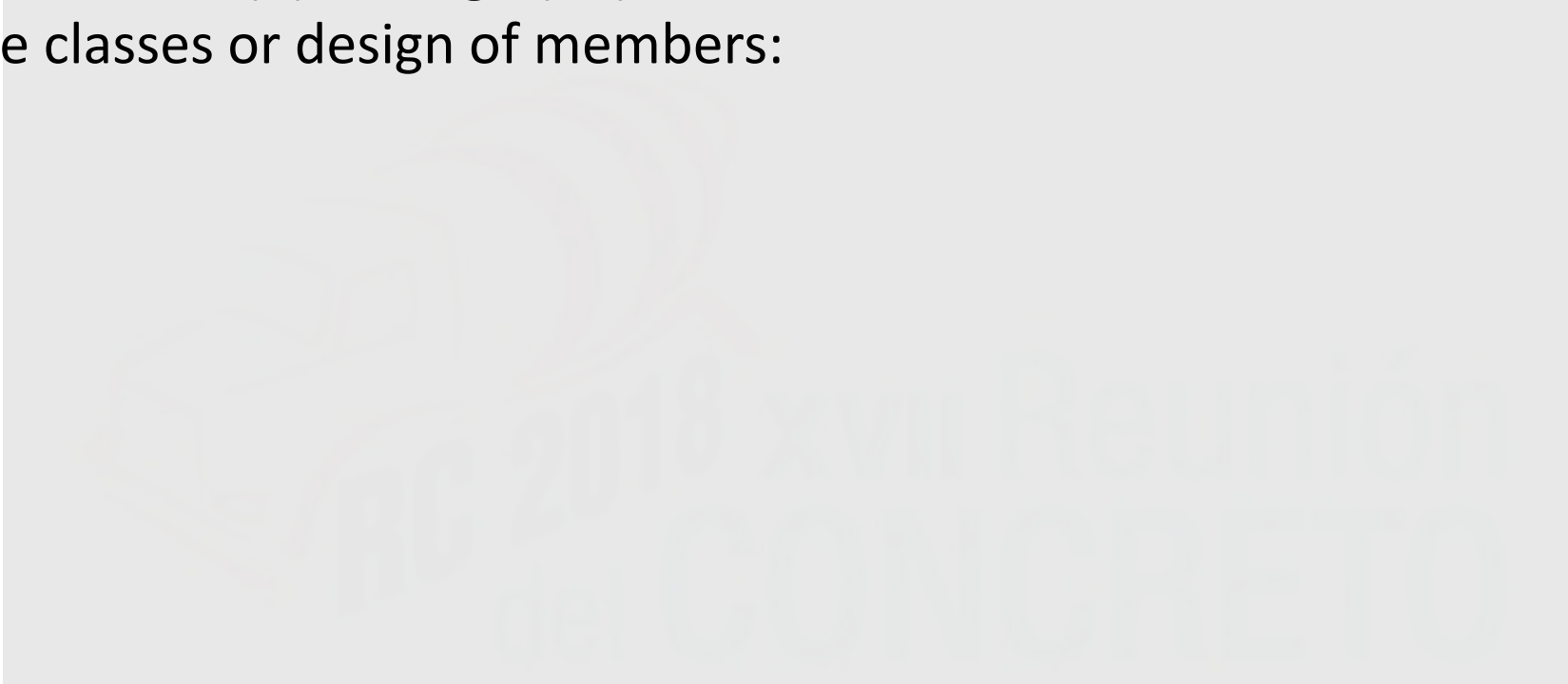
Example: 26.4.1.3.1

Mixing water shall conform to ASTM C1602

Concrete Mixture Requirements

26.4.2 Design Information

(a) Requirements (1) through (11) for each concrete mixture, based on assigned exposure classes or design of members:



Concrete Mixture Requirements

26.4.2 Design Information

- (a) Requirements (1) through (11) for each concrete mixture, based on assigned exposure classes or design of members:
 - (1) Minimum specified compressive strength of concrete, f_c' .
 - (2) Test age for demonstrating compliance with f_c' if different from 28 days.
 - (3) Maximum w/cm applicable to most restrictive assigned durability exposure class from 19.3.2.1.
 - (4) Nominal maximum size of coarse aggregate not to exceed the.....

Concrete Mixture Requirements

26.4.2 Design Information

- (5) For members assigned to Exposure Category F, air content from 19.3.3.1.
- (6) For members assigned to Exposure Class C, applicable chloride ion limits for assigned Exposure Class from 19.3.2.1.
- (7) For members assigned to Exposure Category S, type of cementitious materials for assigned Exposure Class from 19.3.2.1.
- (8) For members assigned to Exposure Class S2 or S3, admixtures containing calcium chloride are prohibited.

Concrete Mixture Requirements

26.4.2 Design Information

- (9) Equilibrium density of lightweight concrete.
- (10) Requirement for submittal of the volumetric fractions of aggregate in lightweight concrete mixtures for the verification of λ value if used in design.
- (11) If used for shear resistance in accordance with 9.6.3.1, requirements for steel fiber-reinforced concrete.

Chapter 26

- 26.7 Anchorage Requirements
- 26.8 Embedments
- 26.9 Precast
 - Tolerances
- 26.10 Prestressed

ACI 318-14

- Section 26.11 requires the design engineer to specify formwork information (ACI 347 and SP4)
 - Compressive strength at removal of formwork and shores
 - Requirements for the contractor to design, fabricate, install, and remove formwork
 - Requirements for how the formwork is designed and how it performs
 - Requirements for the removal of formwork

ACI 318-14 : Evaluation and Acceptance

- Section 26.12 covers
 - Concrete evaluation and acceptance
 - Testing
 - Low Strength

ACI 318-14 : Inspector and Building Official

- Section 26.13 covers
 - General rules regarding inspection
 - Role of the LDP
 - Inspection reports
 - Items requiring inspection

ACI 301-Specifications

Our fallback?



ACI 301 Specifications

Written to the Contractor



ACI 301-Specifications

Often, we reference in entirety...

Not 100% appropriate



ACI 301

- A Reference Specification



ACI 301

G1. ACI Specification 301-16 is to be used by reference or incorporation in its entirety in the Project Specification. Do not copy individual Sections, Parts, Articles, or Paragraphs into the Project Specification, because taking them out of context may change their meaning.

ACI 301

G2. If Sections or Parts of ACI Specification 301-16 are copied into the Project Specification or any other document, do not refer to them as an ACI specification, because the specification has been altered.

ACI 301

G3. A statement such as the following will serve to make ACI Specification 301-16 a part of the Project Specification:

“Work on (Project Title) shall conform to all requirements of ACI 301-10 Specifications for Structural Concrete published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents.”

ACI 301

G5. ACI Specification 301-16 is written to the Contractor. When a provision of this Specification requires action by the Contractor, the verb “shall” is used. If the Contractor is allowed to exercise an option when limited alternatives are available, the phrasing “either...or...” is used. Statements provided in the specification as information to the Contractor use the verbs “may” or “will.” Informational statements typically identify activities or options that “will be taken” or “may be taken” by the Owner or Architect/Engineer.

ACI 301

- Review mandatory and optional requirement checklists in ACI 301



ACI 301

- Review mandatory and optional requirement checklists in ACI 301

Supplied to the Engineer to assist in writing and preparing Project Specifications

Specification is incomplete until Mandatory Options are selected

ACI 301

- Review mandatory and optional requirement checklists in ACI 301

The Mandatory Requirements Checklist indicates Work requirements regarding specific qualities, procedures, materials, and performance criteria that are not defined in ACI Specification 301-16. The Specifier must include these requirements in the Project Specification.

ACI 301

- Review mandatory and optional requirement checklists in ACI 301

The Optional Requirements Checklist identifies Specifier choices and alternatives. The Checklist identifies the Sections, Parts, and Articles of the ACI Reference Specification 301-16 and the action required or available to the Specifier. The Specifier should review each of the items in the Checklist and make adjustments to the needs of a particular project by including those selected alternatives as mandatory requirements in the Project Specification.

ACI 301

- Review mandatory and optional requirement checklists in ACI 301
- Examples - Mandatory:
 - Minimum f'_c
 - Reinforcing grades, sizes
 - Show splices on contract drawings

ACI 301

- Review mandatory and optional requirement checklists in ACI 301
- Examples - Mandatory:
 - “Specify project specific definition of surface defects. Such definition may include dimensions, frequency of occurrence and prescribed conditions”

ACI 301

- Review mandatory and optional requirement checklists in ACI 301
- Examples – Optional:
 - When to submit Quality Plan
 - Acceptable certification programs
 - When cores may be required
- What non-destructive testing methods are permitted

ACI 318 and 301

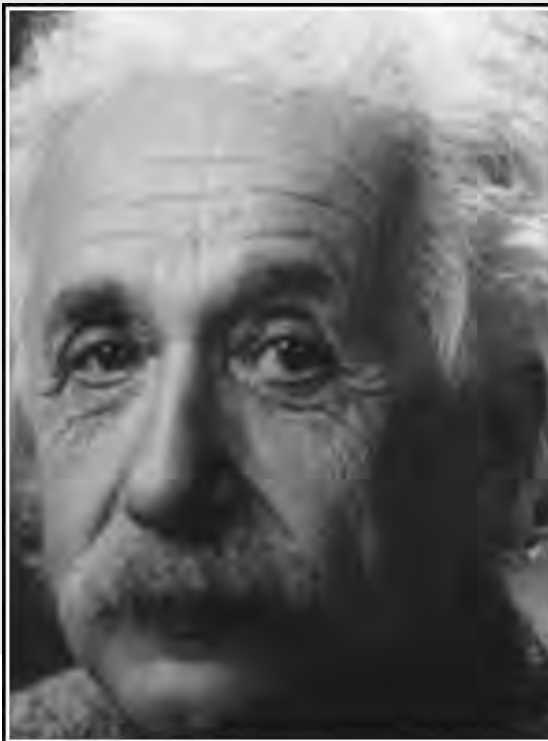
Companion documents

LDP should review and understand both

ACI 301 will remove some of the specification burden

ACI 318

WHAT'S IN YOUR SPEC?



The definition of genius is taking the
complex and making it simple.

— *Albert Einstein* —

AZ QUOTES

thelearningclinic.com.au

Questions?

