QUALITY ASSURANCE AND SPECIAL INSPECTION REQUIREMENTS FOR MASONRY

August 13, 2021

Presented by:

MASONRY INSTITUTE OF AMERICA
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AIA CES Provider

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AIA Quality Assurance

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

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Learning Objectives

- Understand the History Behind Masonry Quality Assurance
- Know the Code Requirements for Minimum Quality Assurance
- Be Aware of the Critical Components of Structural Masonry
- Have the Ability to Develop an Effective Quality Assurance Program

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Outline

- Part 1-Code Requirements
  - History and Where We Are Today
- Part 2-Developing a Quality Assurance Program
  - What Are We Obligated To Do
- Part 3-What to Look For in the Field
  - Critical Components of Masonry
- BONUS-QA Simplified

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Outline

- History – UBC – Inspection requirements in 1943
- History – IBC
- Critical Components
  - Reinforcement
  - Grouting
  - Connections
- The Right Specification
- Conclusion – Moving Forward

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Part 1

CODE REQUIREMENTS

HISTORY AND WHERE WE ARE TODAY

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Code Requirements

- History-Uniform Building Code

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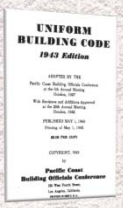
Where it All Began - 1943

Sec. 204 (b) Registered Inspector Required. In addition to the inspections to be made by the Building Inspector as specified in this Section, the owner or his agent shall employ a registered inspector for full-time inspection on the following types of work:

1. Reinforced Concrete. On reinforced concrete work when the design is based on an f'_c, in excess of 2,000 pounds.
2. Masonry. On masonry when the design is based on unit stresses in excess of 50 percent of those allowed in Chapter 24.
3. Welding. On all structural welding.



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Where it All Began - 1943

Sec. 204 (b) Registered Inspector Required.
The "registered inspector" shall be approved by, registered with, deputized by and assigned to a particular building or structure by the Building Inspector. Such "registered inspector" shall be thoroughly qualified by knowledge and experience in the design and construction of the structure to which he is assigned and he shall be thoroughly familiar with the requirements of this Code applying to that building or structure and with their practical application.

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Continuous or Periodic?

- The Great Mystery
  - What Does 'Periodic' Mean With Respect to Inspecting Masonry Work?
  - Building Officials Have Sidestepped the Question
  - Designers Want Industry to Quantify Periodic .....Since 1943

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Continuous or Periodic?

- The Great Mystery

(1997 Uniform Building Code)
1701.6 Continuous and Periodic Special Inspection.

1701.6.1 Continuous special inspection. Continuous special inspection means that the special inspector is on the site at all times observing the work requiring special inspection.

1701.6.2 Periodic special inspection. Some inspections may be made on a periodic basis and satisfy the requirements of continuous inspection, provided this periodic scheduled inspection is performed as outlined in the project plans and specifications and approved by the building official.

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Continuous or Periodic?

- The Great Mystery

(1997 Uniform Building Code)

2107.1.2 Masonry allowable stresses. When quality assurance provisions do not include requirements for special inspection as prescribed in Section 1701, the allowable stresses for masonry in Section 2107 shall be reduced by one half.

2108.1.2 Quality assurance provisions. Special Inspection during construction shall be provided as set forth in Section 1701.5, Item 7.

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Continuous or Periodic?

- The Great Mystery

(1997 Uniform Building Code)

1701.5, Item 7. Structural masonry.

7.1 For masonry, other than fully grouted open-end hollow unit masonry, during preparation and taking of any required prisms or test specimens, placing of all masonry units, placement of reinforcement, inspection of grout space, immediately prior to closing of cleanouts, and during all grouting operations.

EXCEPTION: For hollow-unit masonry where the f'_m is no more than 1,500 psi (10.34 MPa) for concrete units or 2,600 psi (17.93 MPa) for clay units, special inspection may be performed as required for fully grouted open-end hollow-unit masonry specified in Item 7.2.

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Continuous or Periodic?

- The Great Mystery

(1997 Uniform Building Code)

1701.5, Item 7. Structural masonry.

7.2 For fully grouted open-end hollow-unit masonry during preparation and taking of any required prisms or test specimens, at the start of laying units, after the placement of reinforcing steel, grout space prior to each grouting operation, and during all grouting operations.

EXCEPTION: Special inspection as required in Items 7.1 and 7.2 need not be provided when design stresses have been adjusted as specified in Chapter 21 to permit noncontinuous inspection.

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Code Requirements

- History-Uniform Building Code
- **History-International Building Code**

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Continuous or Periodic?

- The Great Mystery

(2000 IBC Chapter 17)

SPECIAL INSPECTION. Inspection as herein required of the materials, installation, fabrication, erection or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.

SPECIAL INSPECTION, CONTINUOUS. The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.

SPECIAL INSPECTION, PERIODIC. The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work has been or is being performed and at the completion of the work.

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Continuous or Periodic?

- The Great Mystery

(2021 IBC Chapter 2)

SPECIAL INSPECTION. Inspection of construction requiring the expertise of an *approved special inspector* in order to ensure compliance with this code and the *approved construction documents.*

Continuous special inspection. Special inspection by the *special inspector* who is present when and where the work to be inspected is being performed.

Periodic special inspection. Special inspection by the *special inspector* who is intermittently present where the work to be inspected has been or is being performed.

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The Dreaded Tables

- Prior to 2000 IBC
  - o No clear guidance on what to inspect
  - o Continuous meant 'All the time'
- Here come the tables
  - o Individual tasks listed
    - ▪ Many not well-defined
  - o 'Periodic' still ambiguous

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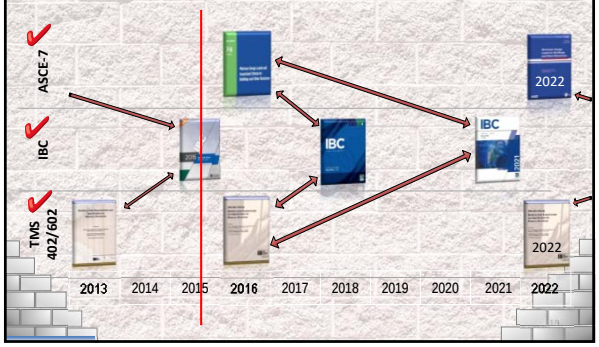
Code Timeline



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The Tables Mature

International Building Code	TMS 402, Masonry Standard
• 2000, Levels 1 & 2	• 1999, Levels 1, 2 & 3
• 2003, Levels 1 & 2	• 2002, Levels 1, 2 & 3
• 2006, Levels 1 & 2	• 2005, Levels A, B & C
• 2009, Levels 1 & 2	• 2008, Levels A, B & C
• 2012, Gone	• 2011, Levels A, B & C
• 2015, Gone	• 2013, Levels A, B & C
• 2018, Gone	• 2016, Levels 1, 2 & 3

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1997 – Beginning of the Table

- TMS 402/602-99 Quality Assurance Level 3

Table 5—Level 3 Quality Assurance	
MINIMUM TESTS AND SUBMITTALS	MINIMUM INSPECTION
Certificates for materials used in masonry construction indicating compliance with Contract Documents Verification of f'_m: • prior to construction • every 5,000 sq. ft (464.5 m²) during construction Verification of proportions of materials in mortar and grout as delivered to the site	From the beginning of masonry construction and continuously during construction od masonry, verify the following are in compliance: • proportions of site-mixed mortar and grout • placing of masonry units and construction of mortar joints • placement of reinforcement and connectors • grout space prior to grouting • placement of grout Observe preparation of grout specimens, mortar specimens, and/or prisms Verify compliance with the required inspection provisions of the contract documents and the approved submittals

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1997 – Beginning of the Table

- (2000) IBC Quality Assurance Level 2

TABLE 1704.5.3—LEVEL 2 SPECIAL INSPECTION

INSPECTION TASK	FREQUENCY OF INSPECTION		REFERENCE FOR CRITERIA		
	Continuous during task listed	Periodically during task listed	IBC Section	ACI 530/ ASCE 5/ TMS 4020	ACI 530.1/ ASCE 6/ TMS 602
1. From the beginning of masonry construction, the following shall be verified to ensure compliance: a. Preparation of site-mixed mortar and grout. b. Placement of masonry units and con of mortar joints c. Placement of reinforcement and connectors d. Grout space prior to grouting e. Placement of grout.	 X X	 X X 	--	Ch. 8	 Art. 2.6A Art. 3.3B Art 3.4 Art 3.2D Art. 3.5
2. The inspection program shall verify: a. Size and location of structural elements b. Type, size and location of anchors, including other details of anchorage of masonry to structural members frames or other construction c. Specify size, grade and type of reinforcement d. Welding of reinforcing bars e. Protection of masonry during cold/hot weather	 X X	 X X X 	 Sec. 2108.9.2.11, Item 2 Sec 2104.3, 2104.4	Sec 1.15A, 2.12 Sec. 1.12 Sec. 8.5.7 and Sec. 8.5.7.2	3.3G Art. 2.4, 3.4 Art. 1.8
3. Preparation of any required grout specimens, mortar specimens and/or prisms shall be observed.	X	--	2105.3, 2105.4, 2105.5	--	Art. 1.4
4. Compliance with required inspection provisions of the construction documents and the approved submittals	--	X	--	--	Art. 1.5

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The Tables Mature-TMS 402/602-08

Table 5 - Level C Quality Assurance
MINIMUM TESTS
Verification of f'_m and f'_{AAC} in accordance with Article 1.4 B prior to construction and for every 5,000 sq. ft (464.5 m²) during construction
Verification of proportions of materials in premixed or preblended mortar, prestressing grout, and grout other than self-consolidating grout as delivered to the site
Verification of Slump flow and VSI as delivered to the site in accordance with Article 1.5 B.1.b.3 for self-consolidating grout

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The Tables Mature-TMS 402/602-08

Table 5 - Level C Quality Assurance		
MINIMUM INSPECTION		
Inspection Task	Frequency	
	Continuous	Periodic
1. Verify compliance with the approved submittals		X
2. Verify that the following are in compliance:		
a. Proportions of site-prepared mortar		X
b. Grade, type, and size of reinforcement and anchor bolts, and prestressing tendons and anchorages		X
c. Placement of masonry units and construction of mortar joints		X
d. Placement of reinforcement, connectors, and prestressing tendons and anchorages	X	
e. Grout space prior to grouting	X	

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The Tables Mature-TMS 402/602-08

Table 5 – Level C Quality Assurance

MINIMUM INSPECTION		
Inspection Task	Frequency	
	Continuous	Periodic
f. Placement of grout and prestressing grout for bonded tendons	X	
g. Size and location of structural elements		X
h. Type, size, and location of anchors including other details of anchorage of masonry to structural members, frames, or other construction	X	
i. Welding of reinforcement	X	
j. Preparation, construction, and protection of masonry during cold weather (temperature below 40°F) or hot weather (temperature above 90°F)		X
k. Application and measurement of prestressing force	X	
3. Observe preparation of grout specimens, mortar specimens, and/or prisms	X	

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The Tables Mature-2009 IBC

Table 1704.5.3 – LEVEL 2 REQUIRED VERIFICATION AND INSPECTION OF MASONRY CONSTRUCTION

VERIFICATION AND INSPECTION	CONTINUOUS	PERIODIC	REFERENCE FOR CRITERIA		
			IBC SECTION	TMS 402/ACI 530/ASCE 5	TMS 602/ACI 530.1/ASCE 6
1. Compliance with required inspection provisions of the construction documents and the approved submittals.	---	X	---	---	Art. 1.5
2. Verification of f'_m and f'_{AAC} prior to construction and for every 5,000 square feet during construction.	---	X	---	---	Art. 1.4 B
3. Verification of proportions of materials in premixed or preblended mortar and grout as delivered to the site.	X	---	---	---	Art 1.5 B
4. Verification of slump flow and VSI as delivered to the site for self-consolidating grout.	X	---	---	---	Art 1.5 B.1.b.3
5. The following shall be verified to ensure compliance:					
a. Proportions of site-prepared mortar, grout and prestressing grout for bonded tendons.	---	X	---	---	Art. 3.4, 3.6 A

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Code Requirements

- History-Uniform Building Code
- History-International Building Code
- **TMS 402/602 Takes Charge**

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The Tables Mature-TMS 402/602-11

TMS 602 Table 5 – Level C Quality Assurance

MINIMUM TESTS				
Verification of f'_m and f'_{AAC} in accordance with Article 1.4 B prior to construction and for every 5,000 sq. ft (465 sq. m) during construction				
Verification of proportions of materials in premixed or preblended mortar, prestressing grout, and grout other than self-consolidating grout as delivered to the project site				
Verification of Slump flow and Visual Stability Index (VSI) as delivered to the project site in accordance with Article 1.5.B.1.b.3 for self-consolidating grout				
MINIMUM INSPECTION				
Inspection Task	Frequency		Reference for Criteria	
	Continuous	Periodic	TMS 402/ACI 530/ASCE 5	TMS 602/ACI 520.1/ASCE 6
1. Verify compliance with the approved submittals		X		Art 1.5
2. Verify that the following are in compliance:				
a. Proportions of site-mixed mortar, grout, and prestressing grout for bonded tendons		X		Art 2.1, 2.6 A
b. Grade, type, and size of reinforcement and anchor bolts, and prestressing tendons and anchorages		X		Art 2.4, 3.4

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The Tables Mature

TMS 402/602 Quality Assurance Levels (Based on TMS 402, Table 3.1)

Design Method	Risk Category I, II, III	Risk Category IV
• Veneer • Glass Masonry • Partition Walls • Empirical Masonry (App)	Level 1	Level 2
• Allowable Stress Design • Strength Design • Prestressed Masonry • AAC Masonry • Masonry Infill (App) • Limit States Design (App)	Level 2	Level 3

Small Commercial

Disaster Shelters

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The Tables Mature

2016 TMS 602 – Table 3, Minimum Verification Requirements

Minimum Verification	Required for Quality Assurance			Reference for Criteria
	Level 1	Level 2	Level 3	TMS 602
✓ Prior to construction, verification of compliance of submittals.	R	R	R	Art 1.5
✓ Prior to construction, verification of f'_m, and f'_{AAC}, except where specifically exempted by the Code.	NR	R	R	Art 1.4 B
✓ During construction, verification of Slump flow and Visual Stability Index (VSI) when self-consolidating grout is delivered to the project site.	NR	R	R	Art 1.5 & 1.6.3
✓ During construction, verification of f'_m, and f'_{AAC} for every 5,000 sq. ft.	NR	NR	R	Art 1.4 B
✓ During construction, verification of proportions of materials as delivered to the project site for premixed or preblended mortar, prestressing grout, and grout other than self- consolidating grout.	NR	NR	R	Art 1.4 B

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The Tables Mature

2016 TMS 602, Table 3 MINIMUM SPECIAL INSPECTION			
Inspection Task	Frequency		
	Level 1	Level 2	Level 3
1. As masonry construction begins, verify that the following are in compliance:			
a. Proportions of site-prepared mortar	NR	P	P
b. Grade and size of prestressing tendons and anchorages	NR	P	P
c. Grade, type and size of reinforcement, connectors, anchor bolts and prestressing tendons and anchorages	NR	P	P
d. Prestressing technique	NR	P	P
e. Properties of thin-bed mortar for AAC masonry	NR	C[b]/P[c]	C
f. Sample panel construction	NR	P	C

Note: Reference for Criteria included on table but not listed here

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The Tables Mature

2016 TMS 602, Table 3 MINIMUM SPECIAL INSPECTION			
Inspection Task	Frequency		
	Level 1	Level 2	Level 3
2. Prior to grouting, verify that the following are incompliance:			
a. Grout space	NR	P	C
b. Placement of prestressing tendons and anchorages	NR	P	P
c. Placement of reinforcement, connectors, and anchor bolts	NR	P	C
d. Proportions of site-prepared grout and prestressing grout for bonded tendons	NR	P	P

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The Tables Mature

2016 TMS 602, Table 3 MINIMUM SPECIAL INSPECTION			
Inspection Task	Frequency		
	Level 1	Level 2	Level 3
3. Verify compliance of the following during construction:			
a. Materials and procedures with the approved submittals	NR	P	P
b. Placement of masonry units and mortar joint construction	NR	P	P
c. Size and location of structural members	NR	P	P
d. Type, size, and location of anchors, including other details of anchorage of masonry to structural members, frames, or other construction	NR	P	C
e. Welding of reinforcement	NR	C	C

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The Tables Mature

2016 TMS 602, Table 3 MINIMUM SPECIAL INSPECTION			
Inspection Task	Frequency		
	Level 1	Level 2	Level 3
3. Verify compliance of the following during construction:			
f. Preparation, construction, and protection of masonry during cold weather (temperature below 40°F) or hot weather temperature above 90°F	NR	P	P
g. Application and measurement of prestressing force	NR	C	C
h. Placement of grout and prestressing grout for bonded tendons is in compliance	NR	C	C
i. Placement of AAC masonry units and construction of thin bed mortar joints	NR	C[b]/P[c]	C
4. Observe preparation of grout specimens, mortar specimens and/or prisms.	NR	P	C

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Part 2

DEVELOPING A QUALITY ASSURANCE PROGRAM

WHAT WE ARE OBLIGATED TO DO

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Developing a QA Program

- **Responsibility – Who Does What?**

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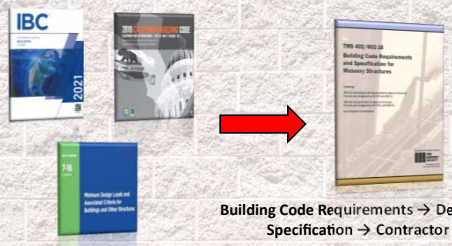
Start With the Rules



Building Code Requirements → Designer
Specification → Contractor

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List of Requirements

TMS 402, Building Code Requirements for Masonry Structures

1.2.1 Show all Code-required drawing items on the project drawings, including:

(a) Name and date of issue of Code…
(b) Loads used for the design of masonry structures.
(c) Specified compressive strength of masonry…
(d) Size and location of structural elements.
(e) Details of anchorage of masonry to structural members…
(f) Details of reinforcement…
(g) Reinforcing bars to be welded…
(h) Provision for dimensional changes resulting from elastic deformation, creep, shrinkage, temperature, and moisture.
(i) Size and permitted location of conduits, pipes, and sleeves.

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Quality Assurance

TMS 402, Building Code Requirements for Masonry Structures
3.1 — Quality Assurance program

The quality assurance program shall comply with the Level defined in Table 3.1, depending on how the masonry was designed and the Risk Category as defined in ASCE 7 or legally adopted building code. The quality assurance program shall itemize the requirements for verifying conformance of material composition, quality, storage, handling, preparation, and placement with the requirements of TMS 602….

Commentary

A quality assurance program must be defined in the contract documents, to answer questions such as "how to", "what method", "how often", and "who determines acceptance".

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Quality Assurance

TMS 602, Specification for Masonry Structures
1.6 A *Testing Agency's services and duties*
1.6 B *Inspection Agency's services and duties*

1.6 B.6 When there is reason to believe that any material furnished or work performed by the Contractor fails to fulfill the requirements of the Contract Documents, report such discrepancy to the Architect/Engineer and to the Contractor and, when requested, to the Owner and the Building Official.

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The Alternative

- Legal Resolution
  - How Much Time Will Be Spent in Depositions and Court?

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Developing a QA Program

- Responsibility – Who Does What?
- **Communication**

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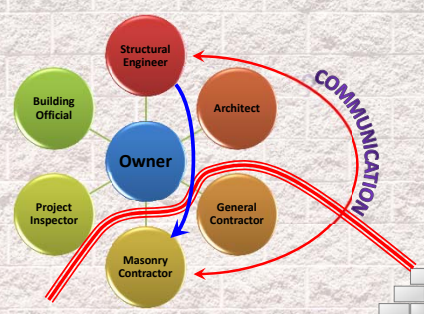
The Players



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Type of Arrangement

- Traditional Contract
- General Contractor = Project Manager
- Design-Build
- Building Information Modeling

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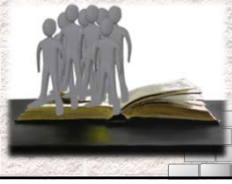
Proactive Communication

- Preconstruction Meeting
  - Architect
  - Engineer
  - General Contractor
  - Subcontractor
  - Testing Agency
  - Inspection Agency
  - Material Suppliers



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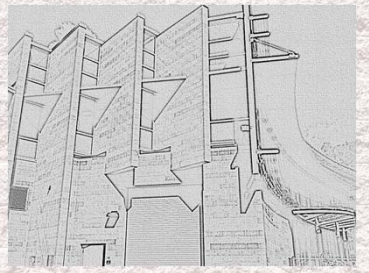
I Can Design It



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Can you Build It?

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I Can Design It

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Can You Build It?

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Developing a QA Program

- Responsibility – Who Does What?
- Communication
- **Qualification**

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Skilled Craft Workers

- This is Really a Difficult Area
  - When Things are Slow, Everybody is competing for the work and reputable contractors will not bid a job knowing they will lose money
  - When Things are Busy, it may be difficult to have a reputable contractor bid a job

Not Enough Work

Too Much Work

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Skilled Craft Workers

- To Make Matters Worse
  - There are Good and Bad Union Contractors
  - There are Good and Bad Non-Union Contractors

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Qualified Contractors

- Specify Minimum Experience

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: All primary products specified in this section will be supplied by a single manufacturer with a minimum of ten years experience.

B. Installer Qualifications: All products listed in this section are to be installed by a single installer with a minimum of five years demonstrated experience in installing products of the same type and scope as specified.

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Developing a QA Program

- Responsibility – Who Does What?
- Communication
- Qualification
- **Execution**

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Testing and Inspection

- Specify Minimum Tests and Inspections
  - Why? Because the Code Requires It.

TMS 402-16
3.1 — Quality Assurance program

The quality assurance program shall comply with the Level defined in Table 3.1, depending on the Risk Category, as defined in ASCE 7 or the legally adopted building code. The quality assurance program shall itemize the requirements for verifying conformance of material composition, quality, storage, handling, preparation, and placement with the requirements of TMS 602….

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Testing and Inspection

- What Does This All Mean?
  - Specify Minimum QA Level on Structural Notes ✓
    - Basic—Level 2
    - More Critical Facilities—Level 3
  - If Desired, Indicate Additional Requirements ✓
  - Periodic
    - Frequency
    - Randomness
  - Continuous
    - Old Method—Every Minute Contractor was on Job
    - Revised to Being Present During Critical Operations

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Developing a QA Program

- Responsibility – Who Does What?
- Communication
- Qualification
- Execution
- **Structural Notes**
  - **Clear Guidance Leads to Better Quality**

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Typical Structural Notes

One Designer Inserted just below 'Structural Notes' Title

THE STRUCTURAL NOTES DEFINE GENERAL DESIGN AND MATERIAL REQUIREMENTS AND ARE INTENDED TO SUPPLEMENT, BUT NOT REPLACE, THE PROJECT SPECIFICATIONS ✓

GENERAL

1. Reference to standards or specifications of technical societies, organizations, or associations, or to codes of local/state authorities, means the latest standard, specification, or code adopted by the date shown on the Drawings, unless specifically noted otherwise.
2. Material, workmanship, and design shall conform to the referenced Building Code. ✓

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Typical Structural Notes

CONCRETE MASONRY

1. CMU Minimum Compressive Strength unless noted otherwise, f'_m = 1,500 psi. Refer to the Drawings for locations where higher masonry compressive strengths are required.

What is f'_m and is it exactly equal to 1,500 psi in the field?

2. Mortar: Type M (All Walls)

Type 'M' mortar should be limited in use to very high compressive strength and resistance to soil or other exposure.

3. Coarse Grout: 2,500 psi min. compressive strength conforming to ASTM C476. Grout solid all bond beams, reinforced CMU cores, and all CMU cores below grade.

2,000 psi grout is more than adequate for a design of 1,500 psi.

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Typical Structural Notes

CONCRETE MASONRY (Cont'd)

4. Horizontal Joint Reinforcement: No. 9 gage longitudinal wires at 16" vertically, unless noted otherwise. Provide special accessories for corners, intersections, etc.
5. Contraction Joints: Maximum spacing of 3 times of wall height or 30 feet (whichever is less) in all concrete masonry walls.

Exceeds NCMA Tek Note industry recommendations.

6. Submit written construction procedures prior to the start of masonry construction.

This sounds great, but I am not sure of the goal. No doubt the contractor will object and provide something that is not even close to what the SE was expecting.

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Improved Typical Structural Notes

CONCRETE MASONRY

1. Furnish and install masonry materials in conformance with TMS 602, Specification for Masonry Structures.
2. CMU: ASTM C90 (Normal/Medium/Lightweight), (Designate Higher Strength if Required).
3. Mortar: ASTM C270, Type (M/S/N) by (Property or Proportion)
4. Coarse Grout: ASTM C476, minimum compressive strength of 2,000 psi or masonry design strength, f'_m, whichever is greater.
5. Horizontal Contraction Joints: As indicated on drawings with maximum spacing of 25 ft or 1.5 times masonry panel height.
6. Submit written procedures for grouting prior to the start of construction.

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Project Documents

- Specify Only What is Necessary
  - Rely more on Material Standards than listing perceived important 'bits-and-pieces'. Why?
  - Material Standards Change, usually to more stringent requirements
  - Specify enough to be clear about what materials and special conditions are required for the project, but avoid overspecifying

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Project Documents

- Specify Only What is Necessary
  - Catch 22-TMS 402, Section 1.2.1

1.2.1 Show all Code-required drawing items on the project drawings, including:

Code reference	Any reinforcement welding
Loads	Details of reinforcement
Details of anchorage	Provisions for movement
Size/location of structural members	Conduits, Pipes, Sleeves
Specified masonry compressive strength	

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Project Documents

- Concrete Masonry Units—ASTM C90

Furnish Masonry Units conforming to ASTM C90, Grade N, Type I, with f'_m = 1,900 psi.

  - Grades S, N have not been in the Standard since 1990 (in favor of the more stringent requirement)
  - Types I, II have not been in the Standard since 2000 (in favor of the more stringent requirement)
  - f'_m is a Design Strength, not a masonry unit strength and verification should always be expressed as a minimum value
  - In 2015, the average minimum compressive strength was raised to 2,000 psi for all concrete masonry units. Only specify unit strength if a higher strength is required

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Project Documents

- Mortar—ASTM C270, C780, C1586
  - ASTM C270 *Standard Specification for Mortar for Unit Masonry* ***(What we want)***
  - ASTM C780 *Standard Specification for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry* ***(How we test and verify we are getting what we want)***
  - ASTM C1586 *Standard Guide for Quality Assurance of Mortars* ***(How to properly use ASTM C270 and C780)***

65

Structural Notes

- Structural Notes as Listed

PROVIDE CONCRETE BLOCK OF MEDIUM WEIGHT CLASSIFICATION COMPLYING WITH ASTM C90, GRADE N-1 WITH MINIMUM AVERAGE COMPRESSIVE STRENGTH OF 1900 PSI (1500 PSI FOR INDIVIDUAL UNITS). ALL UNITS SHALL BE OPEN END AND BOND BEAM UNITS SHALL BE USED AT HORIZONTAL REINFORCING.

- Better

PROVIDE [Normal/Medium/Light] WEIGHT OPEN-END BOND BEAM CONCRETE MASONRY UNITS COMPLYING WITH ASTM C90 *[Only specify strength above 2,000 psi if required].*

66

Structural Notes

- Structural Notes as Listed

PROVIDE MORTAR COMPLYING WITH ASTM C270, TYPE S, ATTAINING A MINIMUM COMPRESSIVE STRENGTH OF 2000 PSI AT 28 DAYS. PROVIDE AGGREGATE COMPLYING WITH ASTM C144.

- Better

PROVIDE TYPE [M/S/N/O] MORTAR COMPLYING WITH ASTM C270 BY [Proportion/Property] REQUIREMENTS.

Mortar by PROPERTY			
Mortar Type	Compressive Strength, psi	Cement	Bond
M	2,500	More Cement	Less Bond
S	1,800	Sweet Spot	
N	750		
O	350	Less Cement	More Bond (Good)

67

Structural Note

- Structural Notes as Listed

PROVIDE GROUT COMPLYING WITH ASTM C476 ATTAINING A MINIMUM COMPRESSIVE STRENGTH OF 2000 PSI AT 28 DAYS. ADMIXTURE WILL BE SIKA GROUT AID. PROVIDE AGGREGATE COMPLYING WITH ASTM C204

ASTM C204 *Standard Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus* (Note: Typo, should be ASTM C404)

- Better

PROVIDE MASONRY GROUT COMPLYING WITH ASTM C476. *[TMS 602, Article 2.2 requires grout strength the greater of 2,000 psi or f'_m] [Only include additive or admixtures when specific properties are desired]*

68

Structural Notes

- Structural Notes as Listed

PROVIDE PORTLAND CEMENT AS INDICATED PER CAST-IN-PLACE CONCRETE NOTES.

- Better

(NOTHING)

ASTM C150 Cement Type	Cast in Place Concrete	C270 Mortar	C476 Grout
I-General Use	☑	☑	☑
II-General Use/Sulfate Res	☑	☑	☑
III-High Early Cure	☑	☑	☑
IV-Low Heat of Hydration	☑	N/A	N/A
V-High Sulfate Resistance	☑	N/A	N/A

69

Structural Notes

- Structural Notes as Listed

GROUT THICKNESS BETWEEN THE BLOCK UNIT AND REINFORCING STEEL SHALL NOT BE LESS THAN 1/2 INCH. SPACE BETWEEN ADJACENT BARS SHALL NOT BE LESS THAN 1" OR THE BAR DIAMETER, WHICHEVER IS GREATER.

- Better

(NOTHING)

TMS 602, Article 3.4 B.3 Maintain clear distance between reinforcing bars and the interior of masonry unit or formed surface of at least ¼ in. (6.4 mm) for fine grout and ½ in. (12.7 mm) for coarse grout, except where the cross webs of hollow units are used as supports for horizontal reinforcement

TMS 602, Article 3.4 B.5 Maintain minimum clear distance between parallel bars of the nominal bar size or 1 in. (25.4 mm), whichever is greater.

70

Structural Notes

- Structural Notes as Listed

IF WORK IS STOPPED FOR ONE HOUR OR LONGER, PROVIDE HORIZONTAL CONSTRUCTION JOINTS BY STOPPING GROUT 1-1/2 INCHES BELOW TOP OF BLOCK.

- Better

IF PLACEMENT OF GROUT IS STOPPED FOR ONE HOUR OR LONGER, PROVIDE HORIZONTAL CONSTRUCTION JOINTS BY STOPPING GROUT A MINIMUM 1-1/2 INCHES BELOW TOP OF BLOCK.

TMS 602, Article 3.4 F *Grout key* – When grouting, form grout keys between grout pours. Form grout keys between grout lifts when the first lift is permitted to set prior to placement of the subsequent lift.

71

Structural Notes Simplified

- Incorporate TMS 602
- Use Quality Assurance Tables
- Consider Necessary Requirements for Materials
  - Concrete Masonry Units
    - Strength/Weight
  - Mortar
    - Clarify Proportion or Property if needed (You only get one)
  - Grout
    - Limit Admixtures
- List Ancillary Material Requirements

72

Structural Notes Simplified

MASONRY

✓ 1. PROVIDE MATERIAL AND INSTALLATION CONFORMING TO THE REQUIREMENTS OF TMS 602 *(Designate Year?)*.

✓ 2. VERIFY COMPLIANCE OF MASONRY IN ACCORDANCE WITH QUALITY ASSURANCE LEVEL (1,2,3) AND THE APPLICABLE PROVISIONS OF THE FOLLOWING TABLE:

Minimum Verification	Required for Quality Assurance [a]		
	Level 1	Level 2	Level 3
Prior to construction, verification of compliance of submittals.	R	R	R
Prior to construction, verification of f'_m and f'_{AAC}, except where specifically exempted by the Code.	NR	R	R
During construction, verification of Slump flow and Visual Stability Index (VSI) when self-consolidating grout is delivered to the project site.	NR	R	R
During construction, verification for f'_m and f'_{AAC} for every 5,000 sq. ft. (465 m^2)	NR	NR	R
During construction, verification of proportions of material as delivered to the project site for premixed or preblended mortar, prestressing grout, and grout other than self-consolidating grout.	NR	NR	R

[a] R=Required, NR=Not Required

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Structural Notes Simplified

MASONRY

✓ 3. INSPECT MASONRY IN ACCORDANCE WITH THE APPLICABLE PROVISIONS OF THE FOLLOWING TABLE FOR QUALITY ASSURANCE LEVEL (1,2,3).

Inspection Task	Frequency [a]		
	Level 1	Level 2	Level 3
1. As masonry construction begins, verify that the following are in compliance:			
a. Proportions of site-prepared mortar	NR	P	P
b. Grade and size of prestressing tendons and anchorages	NR	P	P
c. Grade, type and size of reinforcement, connectors, anchor bolts, and prestressing tendons and anchorages	NR	P	P
2. Prior to grouting verify that the following are in compliance:			
a. Grout space	NR	P	C
b. Placement of prestressing tendons and anchorages	NR	P	P
c. Placement of reinforcement, connectors, and anchor bolts	NR	P	C
d. Proportions of site-prepared grout and prestressing grout for bonded tendons	NR	P	P

[a] C=Continuous, P=Periodic, NR=Not Required

List Entire Table from TMS 602

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Structural Notes Simplified

MASONRY

✓ 4. DESIGN STRENGTH, f'_m = 2,000PSI UNO

✓ 5. CMU: ASTM C90 (Normal/Medium/Lightweight), (Designate Higher Strength if Required).

✓ 6. MORTAR: ASTM C270, TYPE (M/S/N) BY (Property or Proportion)

✓ 7. COARSE GROUT: ASTM C476, MINIMUM COMPRESSIVE STRENGTH OF 2,000 PSI OR MASONRY DESIGN STRENGTH, f'_m, WHICHEVER IS GREATER.

……ADD OTHER NOTES AS NEEDED FOR CLARITY

75

Part 3

WHAT TO LOOK FOR IN THE FIELD

CRITICAL COMPONENTS OF MASONRY

76

Critical Components

- **Interpretation**

77

Can We Mess Up A Good Thing?

- Structural Notes
  - Consistency with Code and ASTM Standards?
  - Consistency with Project Specifications?
- Project Drawings

78

Can We Mess Up A Good Thing?

- What is f'_m?
  - Strength of Masonry?

TMS 402, Building Code Requirements for Masonry Structures
2.1 -- Notation
f'_m = specified compressive strength of clay masonry or concrete masonry, psi (MPa)

ACI 318, Building Code Requirements for Structural Concrete
2.2 -- Notation
f'_c = specified compressive strength of concrete, psi

79

Can We Mess Up A Good Thing?

- One Example

SECTION 5: MASONRY

5-1 BLOCK MASONY UNITS SHALL BE SINGLE OR DOUBLE OPEN-END BOND BEAM UNITS CONFORMING TO ASTM C90, LATEST REVISION, TYPE I.

5-2 MINIMUM f'_m UNO: 8" CMU = 1500 psi
12" CMU = 2000 psi

(2021 IBC) Code Definition
$f'm$ = Specified compressive strength of masonry at age of 28 days, psi (MPa).

80

Can We Mess Up A Good Thing?

- One Example

SECTION 5: MASONRY

5-3 f'_m SHALL BE DETERMINED PER THE IBC, SECTION 2105. PROVIDE SUBMITTALS, TESTING AND INSPECTIONS AS REQUIRED BY IBC SECTION 1704.5.2.

5-4 IN NO CASE SHALL COMPRESSIVE STRENGTH OF BLOCK UNITS BE LESS THAN 125% OF SPECIFIED f'_m. IN NO CASE SHALL GROUT FOR THE BLOCK UNITS HAVE A COMPRESSIVE STRENGTH LESS THAN 2000 psi AND 125% OF SPECIFIED f'_m AT 28 DAYS. MORTAR SHALL BE TYPE "S" OR "M".

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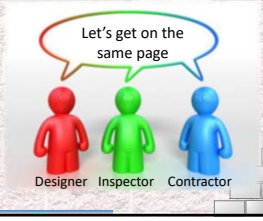
Critical Components

- Interpretation
- **Verification**

82

Who Does What?

- Three Levels of Verification (Inspection)
  - Building Official
  - Special Inspector
  - Structural Observation



83

Who Does What?

- Building Official

(2021) IBC Section 202 / (2016) CBC Section 202
BUILDING OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

(2021) IBC / (2019) CBC Section 104 DUTIES AND POWERS OF BUILDING OFFICIAL
104.4 Inspections. The building official shall make the required inspections, or the building official shall have the authority to accept reports of inspection by approved agencies or individuals.

84

Who Does What?

- Special Inspector

(2021) IBC Section 202 / (2016) CBC Section 202
SPECIAL INSPECTOR. A qualified person employed or retained by an approved agency and approved by the building official as having the competence necessary to inspect a particular type of construction requiring special inspection.

(2016) TMS 602, Article 1.6 B—*Inspection Agencies Services and Duties*
2. Utilize qualified Special Inspectors to inspect and evaluate construction in accordance with Tables 3 and 4, as specified for the project.
3. When required, inspect and evaluate items beyond the scope of the applicable QA Table.
4. Unless otherwise required, report inspection results to the Architect/Engineer, and Contractor promptly after they are performed. Include in inspection reports a summary of conditions under which the inspections were made and state what portion of the construction is represented by each inspection.

85

Who Does What?

- Structural Observation

(2021) IBC / (2019) CBC Section 202
STRUCTURAL OBSERVATION. The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents.

1704.6 Structural observations. (2021) IBC / (2019) CBC
Where required by the provisions of Section 1704.6.1, 1704.6.2 or 1704.6.3, the owner or the owner's authorized agent shall employ a registered design professional to perform structural observations. Structural observation does not include or waive the responsibility for the inspections in Section 110 or the special inspections in Section 1705 or other sections of this code.

Prior to the commencement of observations, the structural observer shall submit to the building official a written statement identifying the frequency and extent of structural observations.

86

Who Does What?

- One Final Note on Verification
  - The Inspector is NOT the Design Professional
  - Note that the Code uses 'Discrepancy', not 'Deficiency'

(2021) IBC / (2019) CBC
1704.2.4 Report requirement.
….Discrepancies shall be brought to the immediate attention of the contractor for correction. If they are not corrected, the discrepancies shall be brought to the attention of the building official and to the registered design professional in responsible charge prior to the completion of that phase of the work. A final report documenting required special inspections and tests, and correction of any discrepancies noted in the inspections or tests, shall be submitted at a point in time agreed upon prior to the start of work by the owner or the owner's authorized agent to the building official.

87

Critical Components

- Interpretation
- Verification
- **Delivery**

88

Significant Basics

- The Important Stuff
  - Reinforcement Placement
  - Grouting
  - Connections
  - Significance of Material Test Results
- The Obvious Stuff
  - Exposed Wall

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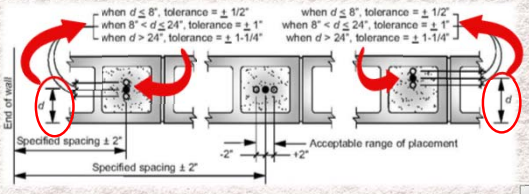
Significant Basics-Reinforcement

- Reinforcement Placement
  - Within Tolerances—Bars Do Not Need to be Tied



90

Significant Basics-Grout

- Grouting
  - Needs to be Wet, Wet, Wet
  - Unlike Concrete, Excess Water is Needed for:
    - Flow Into Confined Cell Areas
    - Absorption by the Masonry Units


91

Significant Basics-Connections

- Lessons Learned from 1971 San Fernando Earthquake

92

Significant Basics-Material Testing

- Concrete Masonry Units
  - 2,000 psi Required—Should Get 2,700 psi or more
- Grout
  - 2,000 psi minimum—To Pump, Need 6 Sack or Equivalent
  - Most of the Time, Tests at 3,000 psi or Greater
  - Needs Water, Not Plasticizers
- Mortar—The Misunderstood Component
  - NOT the Weak Link in the Chain
  - ASTM C270, C780, C1586—Mortar Test Only to Compare to Preconstruction Mortar Test
  - Compression Tests of Field Mortar NOT Expected to Equal Values in ASTM Property Table

93

Critical Components

- Interpretation
- Verification
- Delivery
- **Preparation**

94

Critical Components

- So what are we supposed to inspect?


Preparation of Foundation

First Course Layout

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Critical Components

- So what are we supposed to inspect?


Reinforcement Placement

Grouting

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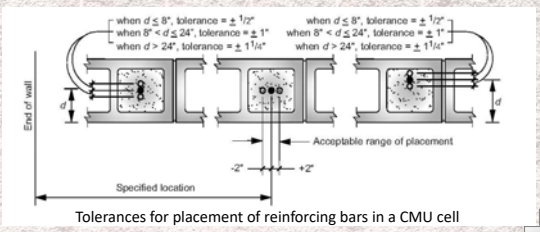
Critical Components

- Interpretation
- Verification
- Delivery
- Preparation
- **Reinforcement**

97

Reinforcement

- Location



Tolerances for placement of reinforcing bars in a CMU cell

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Reinforcement

- Congestion

99

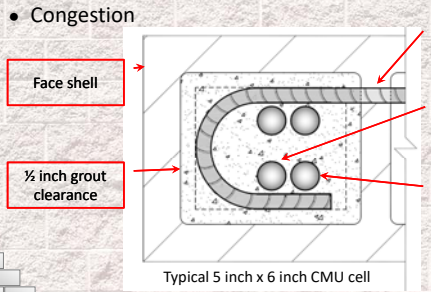
Reinforcement

- Congestion

100

Reinforcement

- Congestion



Typical 5 inch x 6 inch CMU cell

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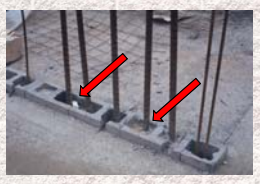
Critical Components

- Interpretation
- Verification
- Delivery
- Preparation
- Reinforcement
- **Grouting**

102

Grouting

- Cells should be reasonably clean



Unacceptable Cells

Ready for Grouting

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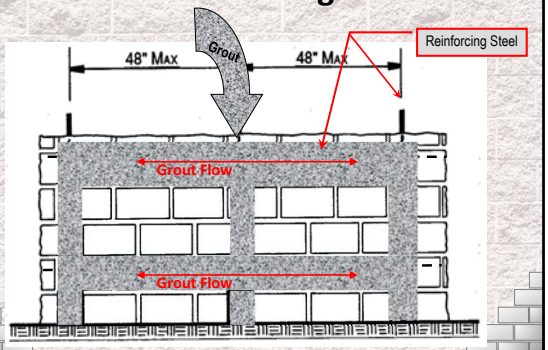
Grouting



104

Grouting

- Placement of Grout

105

Grouting

- Placement of Grout

106

Grouting

- Consolidation and Reconsolidation

107

Critical Components

- Interpretation
- Verification
- Delivery
- Preparation
- Reinforcement
- Grouting
- **Connections**

108

Connections

- ASCE 7-16 Section 1.4.4
  - Anchorage of Structural Walls

Walls that provide vertical load bearing or lateral shear resistance for a portion of the structure shall be attached to the roof and all floors and members that provide lateral support for the wall or that are supported by the wall.

109

Connections

- ASCE 7-16 Section 12.1.4
  - Seismic Design Requirements for Building Structures

A positive connection for resisting a horizontal force acting parallel to the member shall be provided for each beam, girder or truss either directly to its supporting elements, or to slabs designed to act as diaphragms.

- ASCE 7-16 Section 13.4
  - Nonstructural Component Anchorage

Component attachments shall be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.

110

Connections

- Masonry Wall Supporting Roof Beam

111

Critical Components

- Interpretation
- Verification
- Delivery
- Preparation
- Reinforcement
- Grouting
- Connections
- **Bits & Pieces**

112

Periodic Inspection—How Much?

- (2021 IBC) Code Definition

SPECIAL INSPECTION. Inspection of construction requiring the expertise of an *approved special inspector* in order to ensure compliance with this code and the *approved construction documents*.

Continuous special inspection. Special inspection by the *special inspector* who is present when and where the work to be inspected is being performed.

Periodic special inspection. Special inspection by the *special inspector* who is intermittently present where the work to be inspected has been or is being performed.

Not much help

113

Periodic Inspection—How Much?

- Need to Quantify 'Periodic' – TMS 602 Commentary

3.1 — Quality Assurance program

…The level of required quality assurance depends on whether the masonry was designed in accordance with Part 3, Appendix B, or Appendix C (engineered) or in accordance with Part 4 or Appendix A (empirical or prescriptive).

NEW-2016 TMS 602 Quality Assurance Table 4 require inspection tasks to be performed on a continuous or periodic basis. The Architect/Engineer should define the required timing of periodic inspections so that they are sufficient to verify a representative sample of the materials and workmanship. The frequency of periodic inspection varies depending on the size and complexity of the project.

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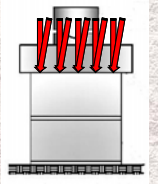
Bad Test Reports? – Don't Panic

- Case where prisms were capped out-of-tolerance



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Bad Test Reports? – Don't Panic

- Test specimen extraction done incorrectly

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Moving Forward

117

Field/Lab Testing Certification

- Ever Had Trouble with Test Results?

ASTM C1019, Section 6.2 Alternative Methods
Alternative methods of forming the specimens shall be used only with the approval of the specifier. Such approval shall be based on comparative testing of grout specimens constructed from molds as described in 6.1 and the alternative method.

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Field/Lab Testing Certification

TMS/ACI Joint Certification Program

- Lab Testing Technician
  - Knowledgeable with ASTM C90, C140, C270, C780, C1019, C1314, C1552
  - 1½ hour open book written test-70 questions
  - Closed Book Performance Examination
  - Must pass both sections 70% minimum overall
- Field Testing Technician
  - Knowledgeable with ASTM C67, C90, C140, C270, C780, C1019, C1314, C1552
  - 1 hour closed book written test-60 questions
  - Closed Book Performance Examination
  - Must pass both sections 70% minimum overall

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Field/Lab Testing Certification

- TMS/ACI Joint Certification Program
  - ICC considering certification as part of SMSI Credentials
  - Certification will require Lab and Field Techs to be know the correct ways to sample and test

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Moving Forward

- Today, Take Away Three Thoughts about Masonry QA and Inspection
  1. Masonry Special Inspection is a Way to Assure the Designer that the Contractor is Meeting AT LEAST the Minimum Code and Project Requirements
  2. A Concise QA Program Consistent with Masonry Code Requirements will be Most Effective-Structural Notes Should be for Clarity, Not Redundancy
  3. Know What Important Structural Components Matter

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In Conclusion

- Dumb Down When it Comes to How Project Documents Can Be (Mis)Interpreted
- Develop a Clear Quality Assurance Program to Assure Comfort That Construction Meets Design Intent
- Remember that Structural Notes should be for Clarity, not Redundancy

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