



US Army Corps
of Engineers
Kansas City District

Infrastructure Conference 2005

United Facilities Criteria Masonry Design for Buildings

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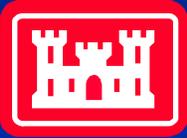




What Has Changed?

- Infrastructure Conference 2001
 - Strength Design for masonry introduced
- Infrastructure Conference 2003
 - New look at min / max reinforcement
 - Slight change in crack control (no moisture controlled units)
- Infrastructure Conference 2005
 - IBC (for the most part)
 - Crack control
 - QA / QC





Old Criteria

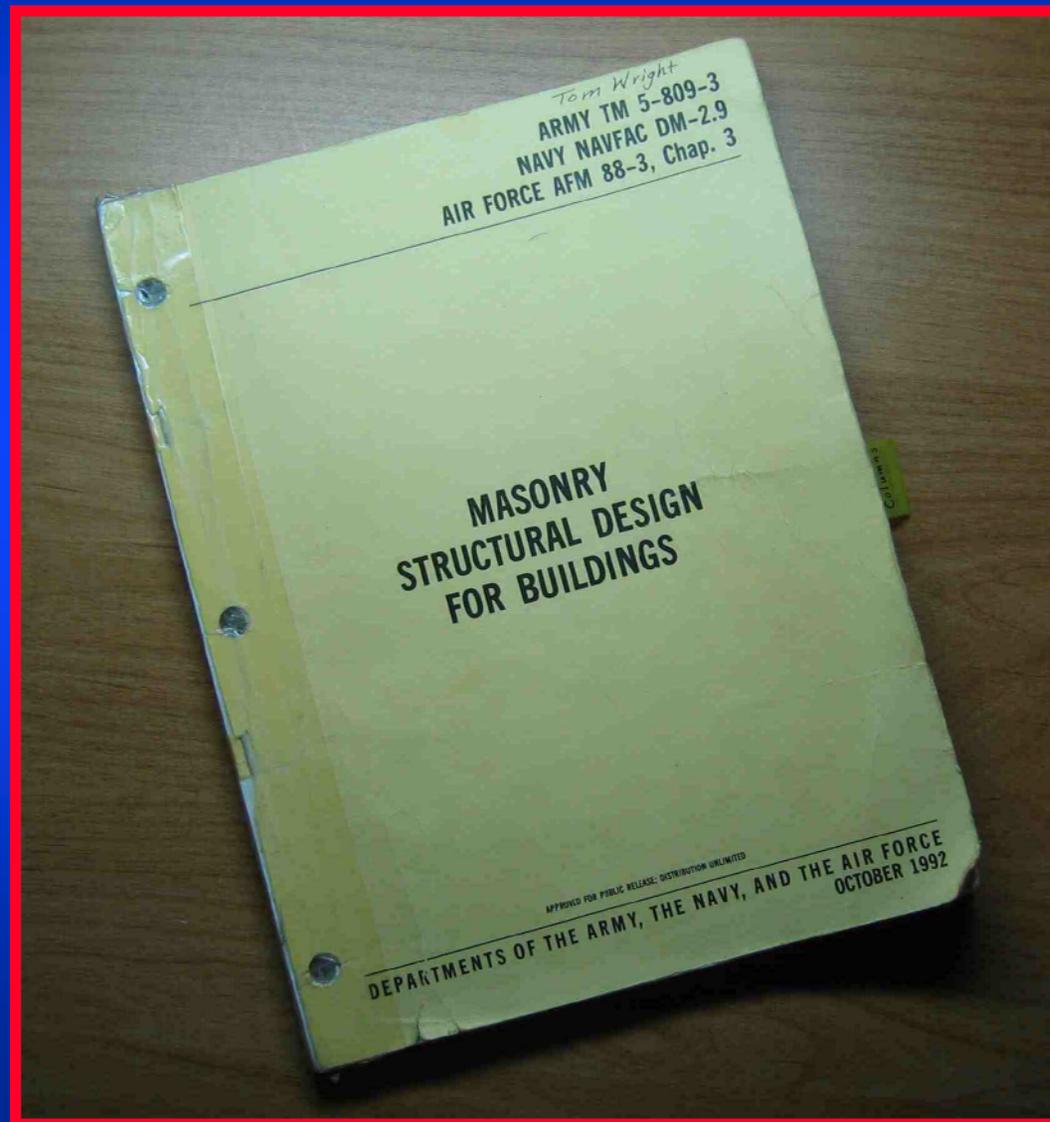
- TM 5-809-3 **Masonry Structural Design for Buildings**
 - Published in 1992
 - Allowable Stress (Working Stress) Design
 - Generally based on ACI 530 (MSJC)
- TI 809-04 **Seismic Design for Buildings**
 - Published in 1998
 - Uses Strength Design / performance based design
 - Applies to Life Safety Performance Objective (1A)
 - Applies to Enhanced Performance Objectives (2A, 2B, & 3B)
 - Seismic design is a good reason to use strength design





History of Masonry Criteria

- TM 5-809-3





TM 5-809-3

Chapters

1. Introduction
2. Quality Assurance In Masonry
3. Materials, Properties, Standards Tests
4. Design for Crack Control
5. General Criteria for Reinforced Masonry
6. Reinforced Masonry Walls
7. Reinforced Masonry Shear Walls
8. Lintels
9. Columns and Pilasters
10. Nondestructive Evaluation Techniques
11. Appendices A, B, and C (Design Aids for Walls and Lintels)





History of Masonry Criteria

Draft TI 809-06

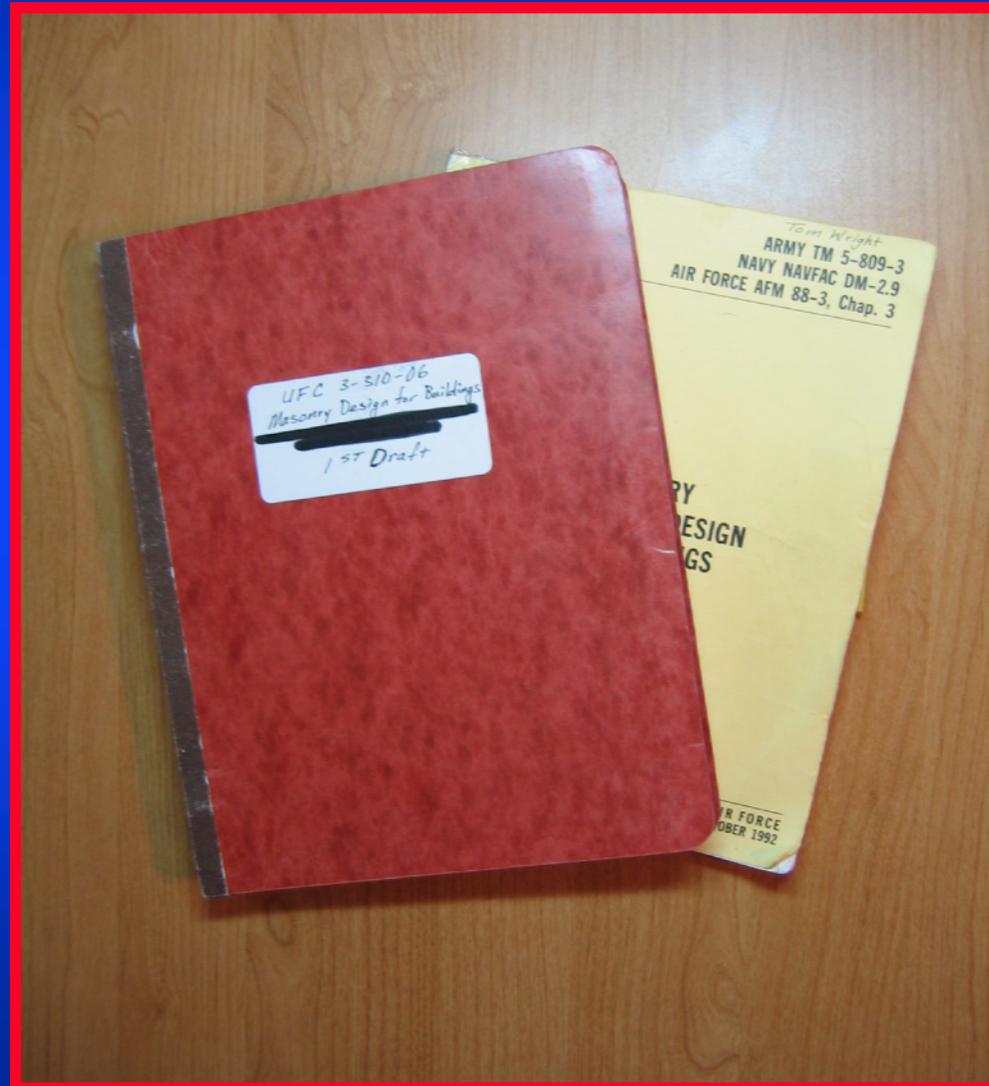
1. Introduction
2. Quality Control and Quality Assurance
3. Materials
4. Design for Crack Control
5. General Criteria for Reinforced Masonry
6. Reinforced Masonry Walls
7. Reinforced Shear Walls
8. Lintels
9. Columns and Pilasters
10. Evaluation of Existing Structures
11. Appendices A, B, C, and D (Design Aids for Walls, Lintels, Columns and Pilasters)

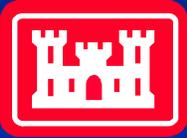




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First Draft UFC



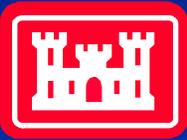


History of Masonry Criteria

Draft UFC 3-310-06

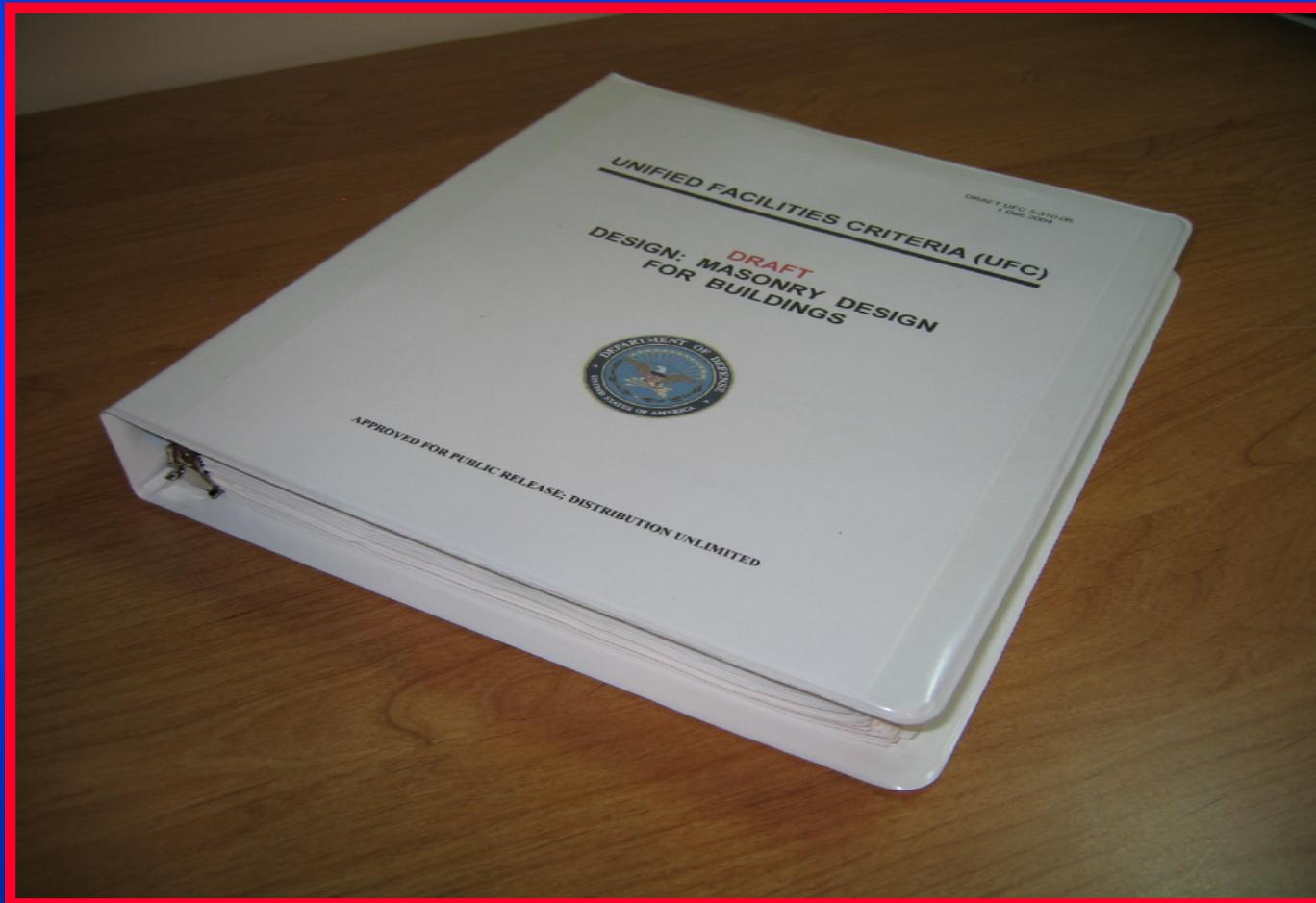
1. Introduction
2. Quality Control and Quality Assurance
3. Materials
4. Design for Crack Control
5. General Criteria for Reinforced Masonry
6. Reinforced Masonry Walls
7. Reinforced Shear Walls
8. Lintels
9. Columns and Pilasters
10. AT / FP for Masonry Buildings
11. Appendices A, B, C, and D (Design Aids for Walls, Lintels, Columns and Pilasters)

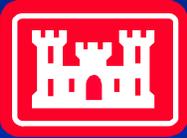




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2nd Draft UFC 3-310-06





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UFC 1-200-01

31 Jul 2002

UFC 1-200-01
31 JULY 2002

UNIFIED FACILITIES CRITERIA (UFC)

DESIGN: GENERAL BUILDING REQUIREMENTS



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UFC 1-200-01

31 Jul 2002

1-6.22 Chapter 21 – MASONRY.

- Use Chapter 21 and UFGS Division 4, Masonry. Chapter 21 supercedes Army TM 5-809-3, NAVFAC DM-2.9, AFM 88-3, Chapter 3, *Masonry Structural Design for Buildings*.
- Give special attention to control cracking in concrete masonry structures using the guidance contained in Tables 1-2 and Table 1-3. Because the Masonry Society has a waiver for use of metric products, brick and concrete masonry units (CMU) are normally not available in metric sizes.





UFC 1-200-01

31 Jul 2002

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Table 1-2 Recommended Joint Control Spacing^(a)

Vertical Spacing Of Joint Reinforcement With 2-#9 Wires ^(b) (in)	Maximum Ratio Of Panel Length To Wall Height (L/H) ^(c)	Maximum Spacing Of Control Joints ^(d) (ft)
None ^(e)	2	18
16	3	24
8	4	30

^(a) Based on moisture-controlled, type I, concrete masonry in intermediate humidity conditions (ASTM C 90). The designer should adjust the control joint spacing for local conditions. The recommended spacing may be increased 6 ft in humid climates and decreased 6 ft in arid climates.

^(b) Joint reinforcement will be cold-drawn deformed wire with a minimum 9-gauge longitudinal wire size.

^(c) L is the horizontal distance between control joints. H is generally the vertical distance between structural supports.

^(d) The spacing will be reduced approximately 50% near masonry-bonded corners or other similar conditions where one end of the masonry panel is restrained.

^(e) Not recommended for walls exposed to view where control of cracking is important.

**Table 1-3 Maximum Spacing of Vertical Expansion Joints in Brick Walls,
 $\Delta T=100^{\circ}F$**

EXP.JT Width (in)	W x in	Max. Spacing of BEJs ^(a)
3/8	3/16	22
1/2	1/4	30
3/4	3/8	44
1 (MAX)	1/2	60

^(a) Provide expansion joints at 6 to 10 ft from corners.

Recommended vertical BEJ locations.

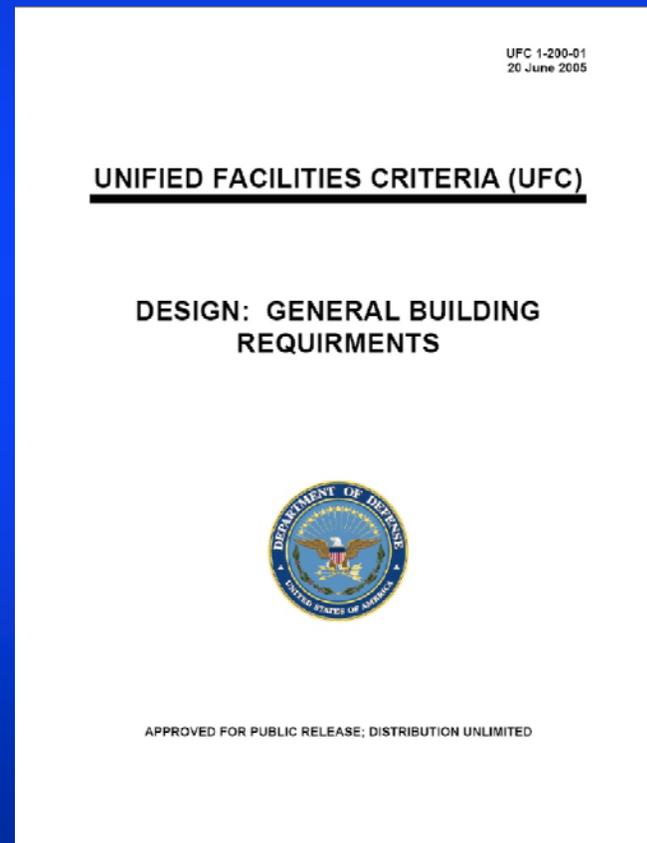
- a. At regular intervals as noted in table above.
- b. At changes in wall height or thickness
- c. Near wall intersections in "L", "T", and "U"-shaped buildings at approximately 6 to 10 ft) from corners.
- d. At other points of stress concentration.
- e. At edges of openings.





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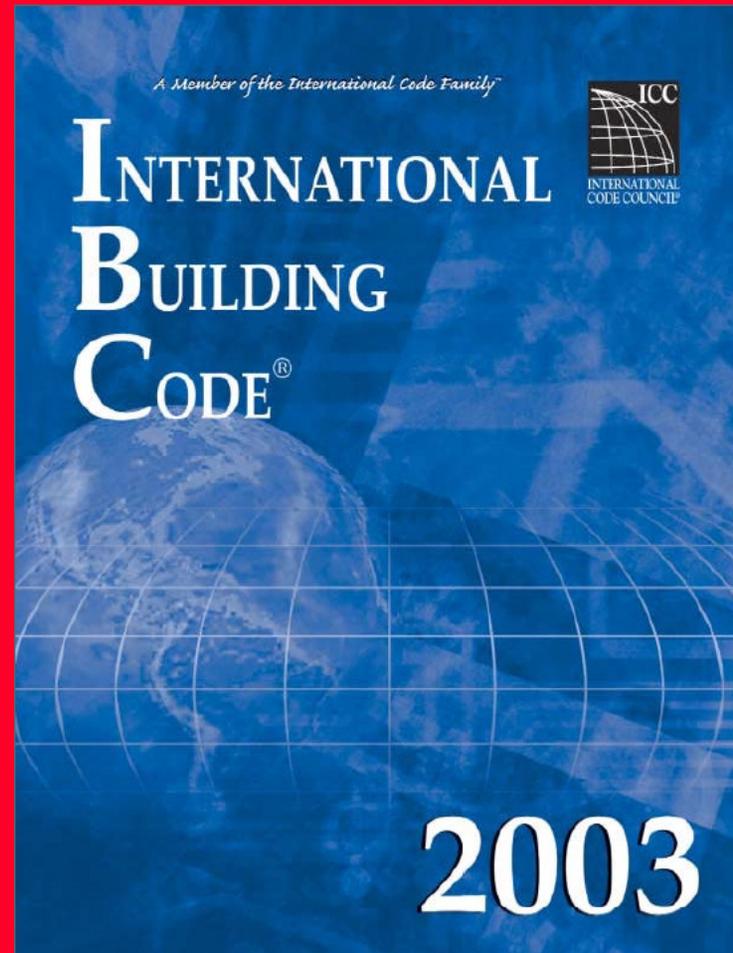
UFC 1-200-01 20 June 2005





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20 June 2005

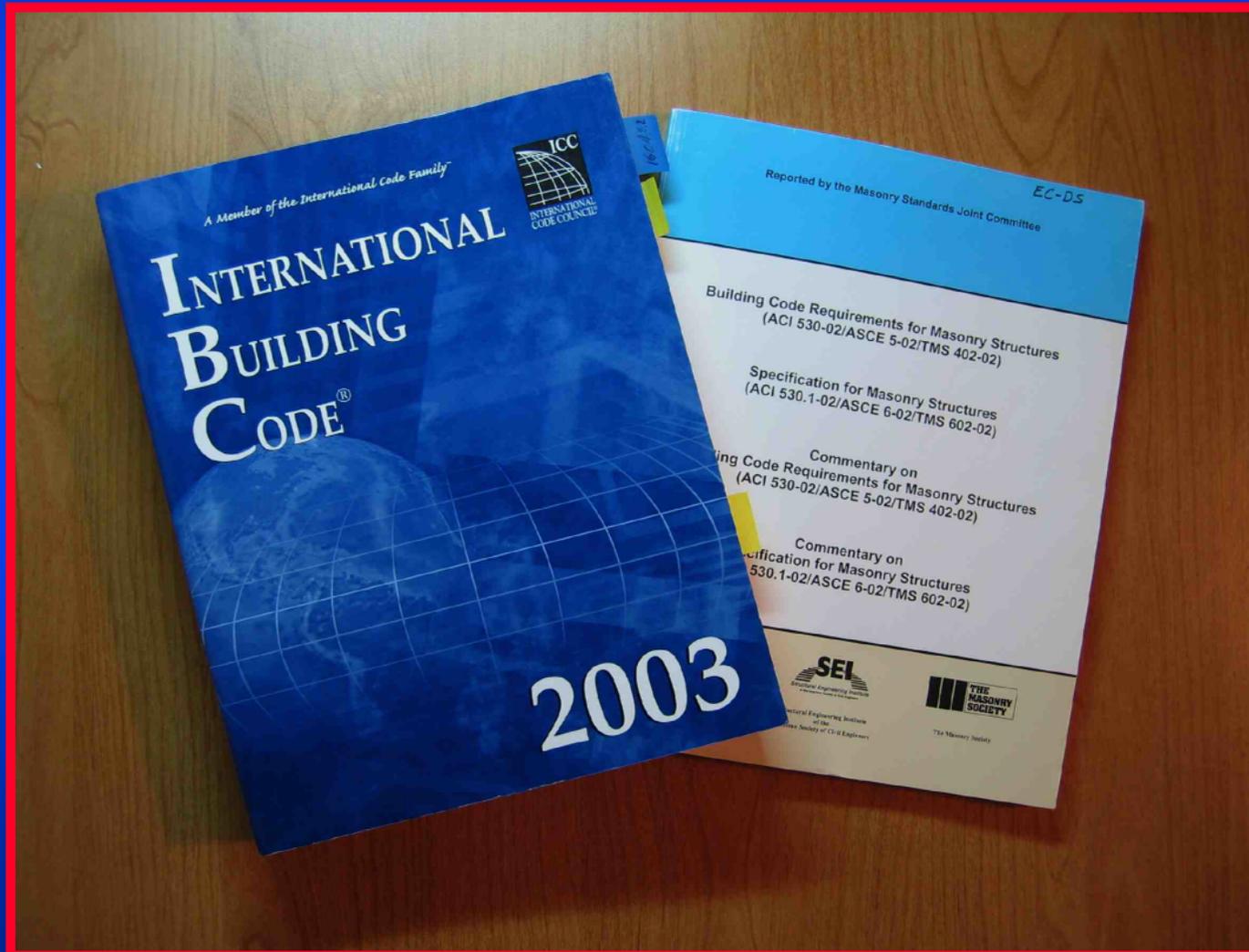
“2-21 CHAPTER 21 – MASONRY”





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UFC 1-200-01 Masonry: Use Chapter 21





Revised (Reduced) Draft UFC 3-310-06

IBC Exceptions

- Chapter 1 Introduction and General Discussion
- Chapter 2 Exceptions to the IBC
- 9 pages
 - Crack control – 4 pages
 - QC / QA – 2 pages

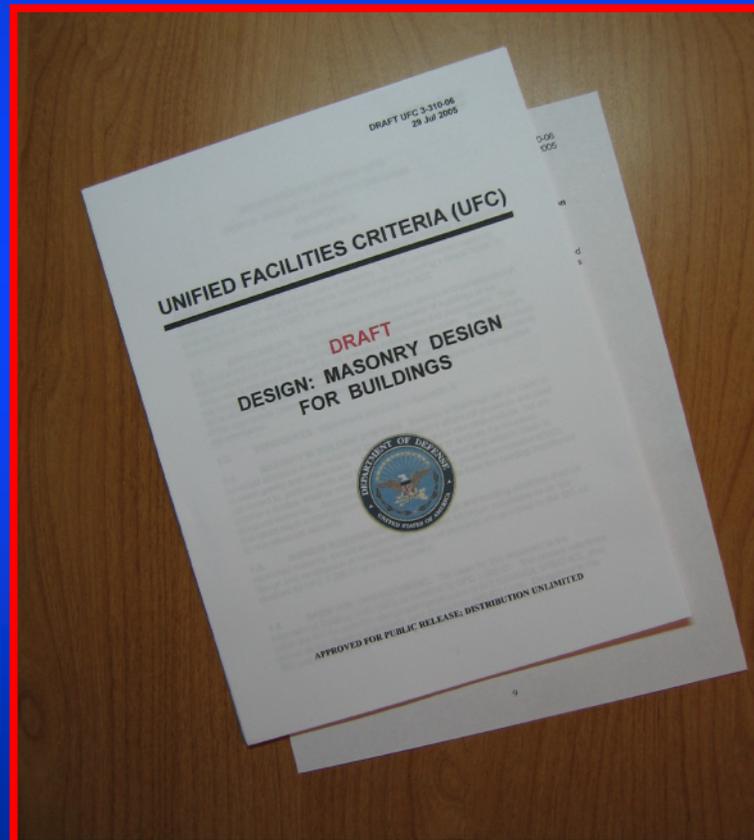




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Revised (Reduced) Draft UFC 3-310-06

- 9 Pages





IBC Exceptions (Proposed)

- Reinforced Masonry
- Design Method -- Strength Design for SDC C, D, E, and F
- Empirical Design not permitted
- Crack control criteria
- Quality Assurance





Reinforced Masonry

- All except non-structural masonry in SDC A
- Design Unreinforced Masonry per IBC (MSJC)
- Masonry veneer may be designed and detailed to meet the prescriptive requirements of ACI 530 Chapter 6 and design provision of IBC Chapters 14, 16 and 21.
- Maintain serviceability and crack control provisions
- Include reinforcement for AT/FP (UFC 4-010-01)

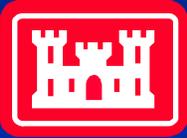




Design Method

- Use Strength Design method for all masonry structures in SDC C, D, E, and F.
- Working Stress (Allowable Stress) method permitted for SDC A and B only
- Empirical Design method is not permitted for DOD facilities
- Rational and prescriptive methods may be used for veneer and glass block.





Crack Control

CMU - Vertical Control Joints

- Not covered by IBC
- Use NCMA TEK 10-3, CONTROL JOINTS FOR CONCRETE MASONRY WALLS – ALTERNATIVE ENGINEERED for vertical control joint spacing
- Aspect Ratio not to exceed 1.5
- Maximum spacing of 25 feet
- Reduce to $\frac{1}{2}$ joint spacing at wall intersections, changes in wall height, and other stress concentration points





CMU Control Joints

Control Joint Spacing vs Aspect Ratio

Aspect Ratio (Maximum ratio of panel length to wall height)(1)	Vertical Spacing of Joint Reinforcement (inches)(2)	Maximum Control Joint Spacing (feet)(3,4)
1.25	None (5)	16
1.5	16	25

(1) Length is the horizontal distance between control joints. Height is generally the vertical distance between structural supports.

(2) 2 9-gage wires @ 16in o.c. = 0.0255 in² /ft.

(3) The designer should adjust the control joint spacing for local conditions. The recommended spacing may be increased 6 feet in humid climates and decreased 6

(4) The spacing will be reduced approximately 50% near masonry bonded corners or other similar conditions where one end of the masonry panel is restrained

(5) Not recommended for walls exposed to view where control of cracking is important.

Note: Recommendations are for any type of concrete units. Moisture controlled units have been eliminate from ASTM C90.





Crack Control Brick Expansion Joints

VERTICAL JOINTS SPACING and SIZE (horizontal expansion)

- Compute unrestrained expansion
– $W_x = [\varepsilon_A + \varepsilon_T(\Delta T)](L)$
- Joint width = $2 \times W_x$





CLAY BRICK VERTICAL EXPANSION JOINT SPACING

Expansion Joint Width (inches)	Total Brick Expansion W_x (inches)	Max. Spacing of Brick Expansion Jts (feet)
3/8	3/16	22
1/2	1/4	30
3/4	3/8	44
1 (max)	1/2	60





Horizontal Brick Expansion Joint (vertical expansion)

- Minimum of 3/8 inch wide
- Do not exceed height limits in ACI 530 Chapter 6
- Place horizontal BEJ
 - Under shelf angles
 - At each floor level of multi-story buildings
 - At points of vertical movement restraint



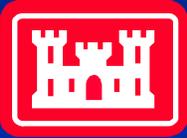


Quality Assurance

QA addressed in 3 areas:

- Quality Assurance Plans and Special Inspections
- Contractor Quality Control
- Structural Observations and Site Visits





Quality Assurance

- Quality Assurance Plans and Special Inspections
 - IBC:
 - ◆ QAP prepared by Design Professional working for the owner.
 - ◆ Design Professional or agent provides Special Inspections
 - Government:
 - ◆ QAP prepared by construction contractor
 - ◆ Construction contractor provides Special Inspections
 - ◆ Use UFGS (01452 and others)

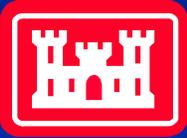




Quality Assurance

- Contractor Quality Control
 - IBC:
 - ◆ Acknowledgement of special requirements
 - ◆ Acknowledgement that control will be exercised
 - ◆ Procedures for exercising control
 - ◆ Identification and qualifications of persons exercising control
 - Government:
 - ◆ CQC plan prepared by construction contractor (UFGS 01451A)
 - ◆ DQC plan prepared by construction contractor for Design-Build contracts (UFGS 01451A)





Quality Assurance

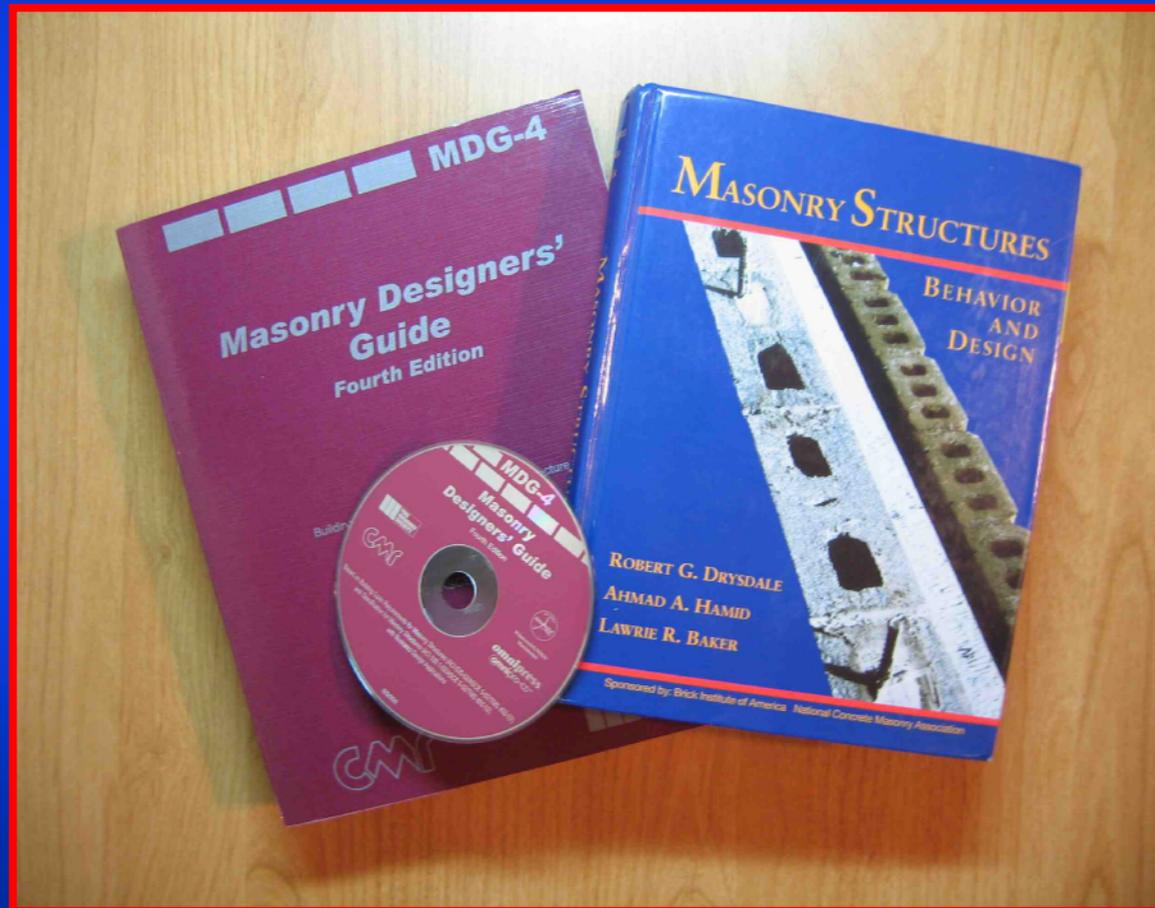
- Structural Observations
 - IBC:
 - ◆ Required for select structural systems
 - ◆ Required to be done by the Registered Design Professional
 - Government:
 - ◆ Required for select structural systems
 - ◆ Required to be done by the Registered Design Professional





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Where should you go for guidance?





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QUESTIONS

