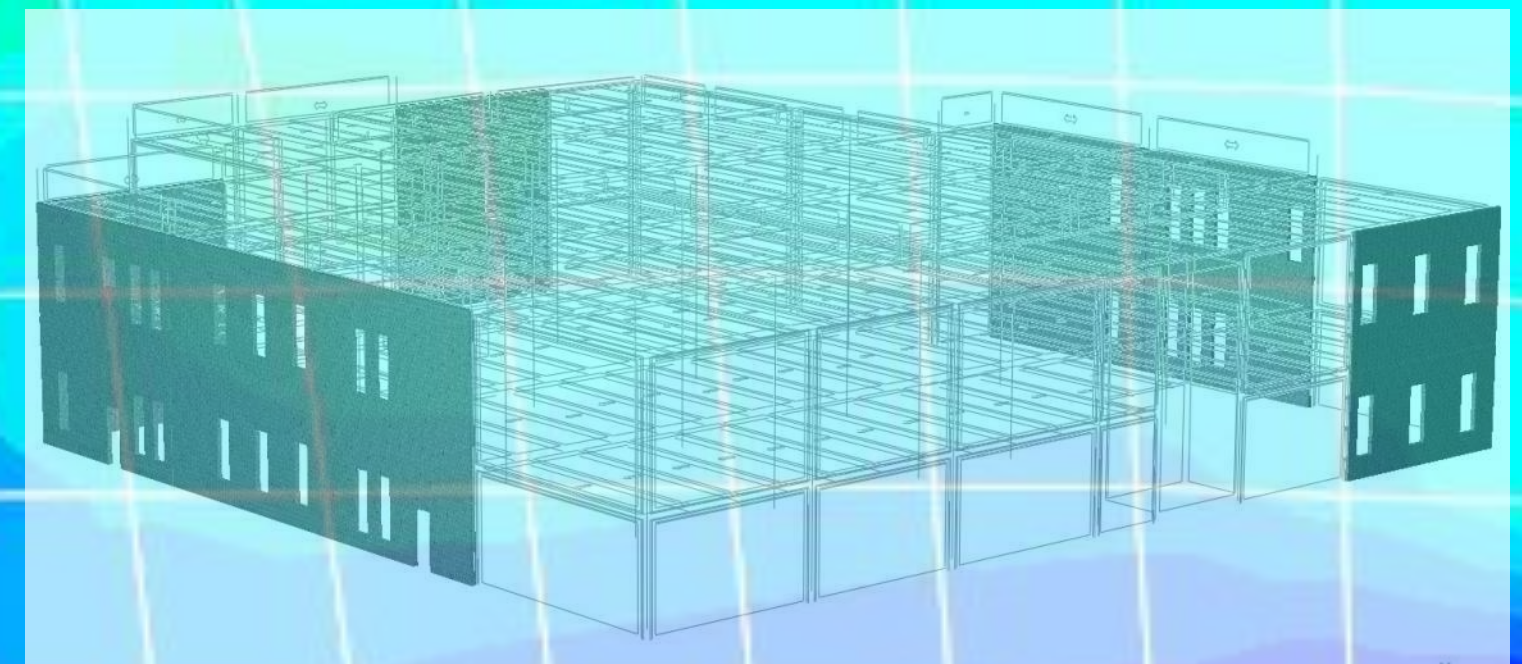
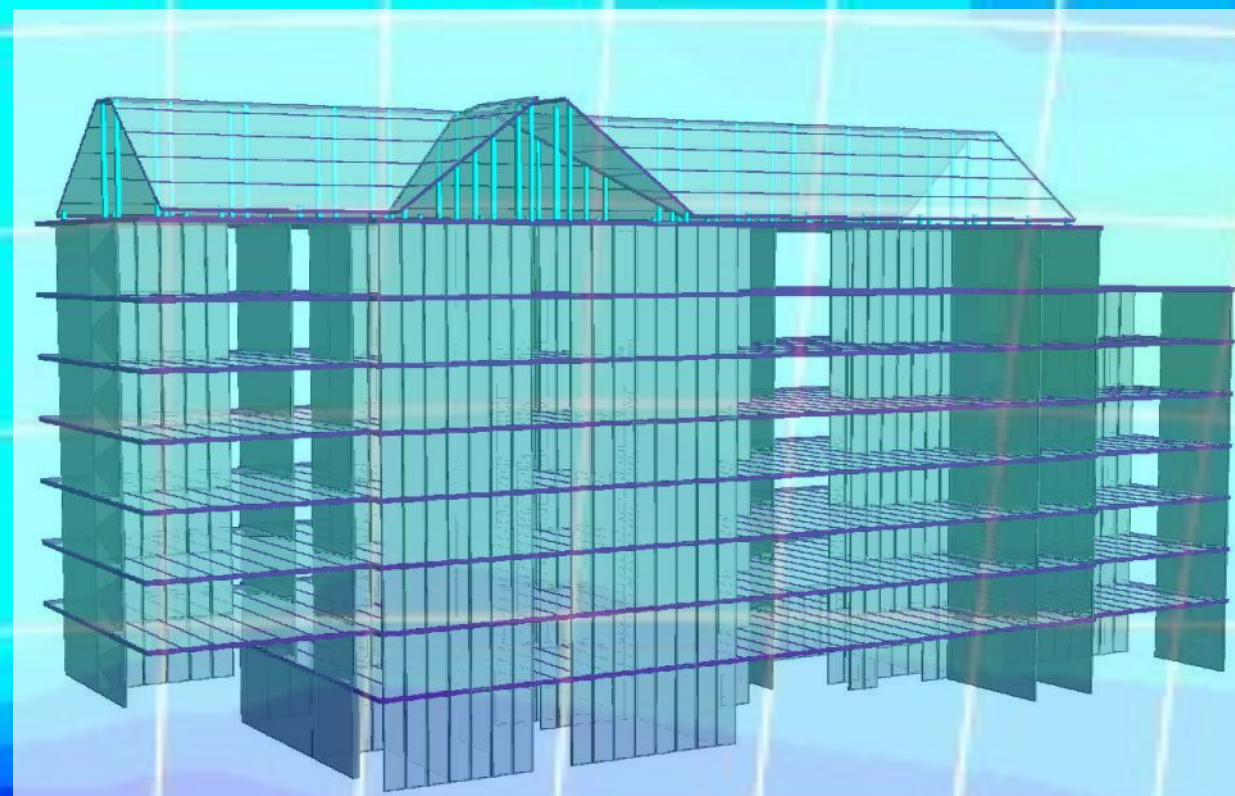
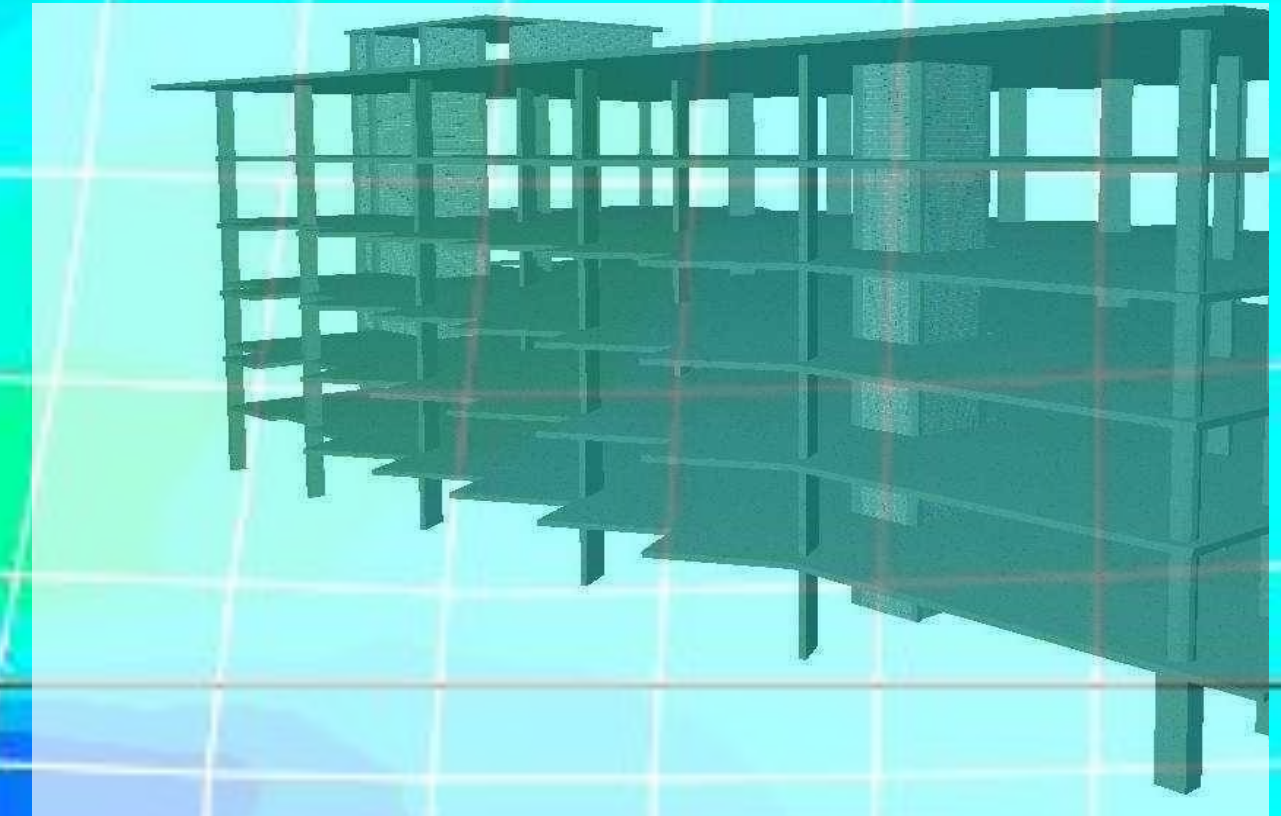
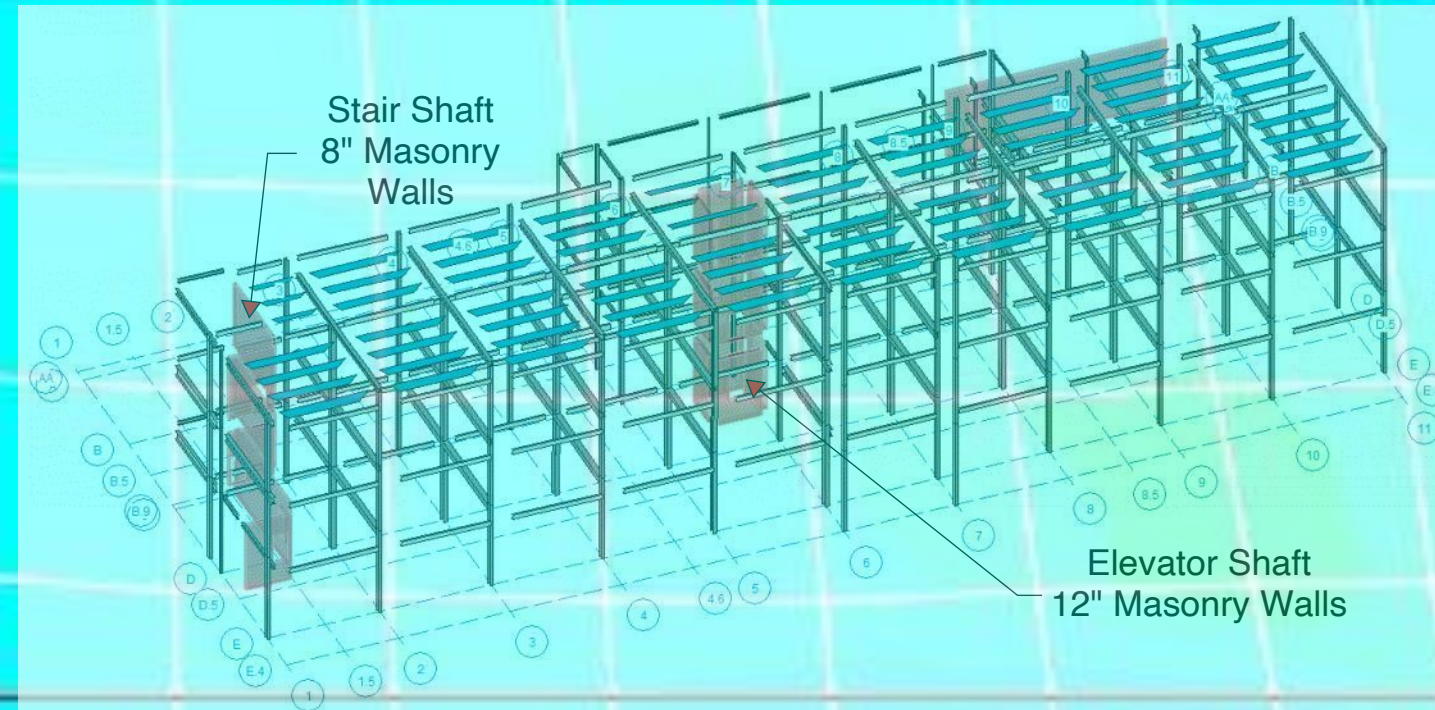


Connections to Masonry



about your instructor....

Sam Rubenzer, PE, SE, MBA

Founder of FORSE Consulting

email: sam@forseconsulting.com

phone: (715) 563-5390

Experience / Background

- Licensed Structural Engineer (SE) in the State of IL
- Structural Engineering: University of Minnesota
- MBA: Marquette University

FORSE Consulting

- team of engineers with extensive masonry design experience
- consultant for IMI since February 2010
- specialize in structural masonry design



Available Presentations

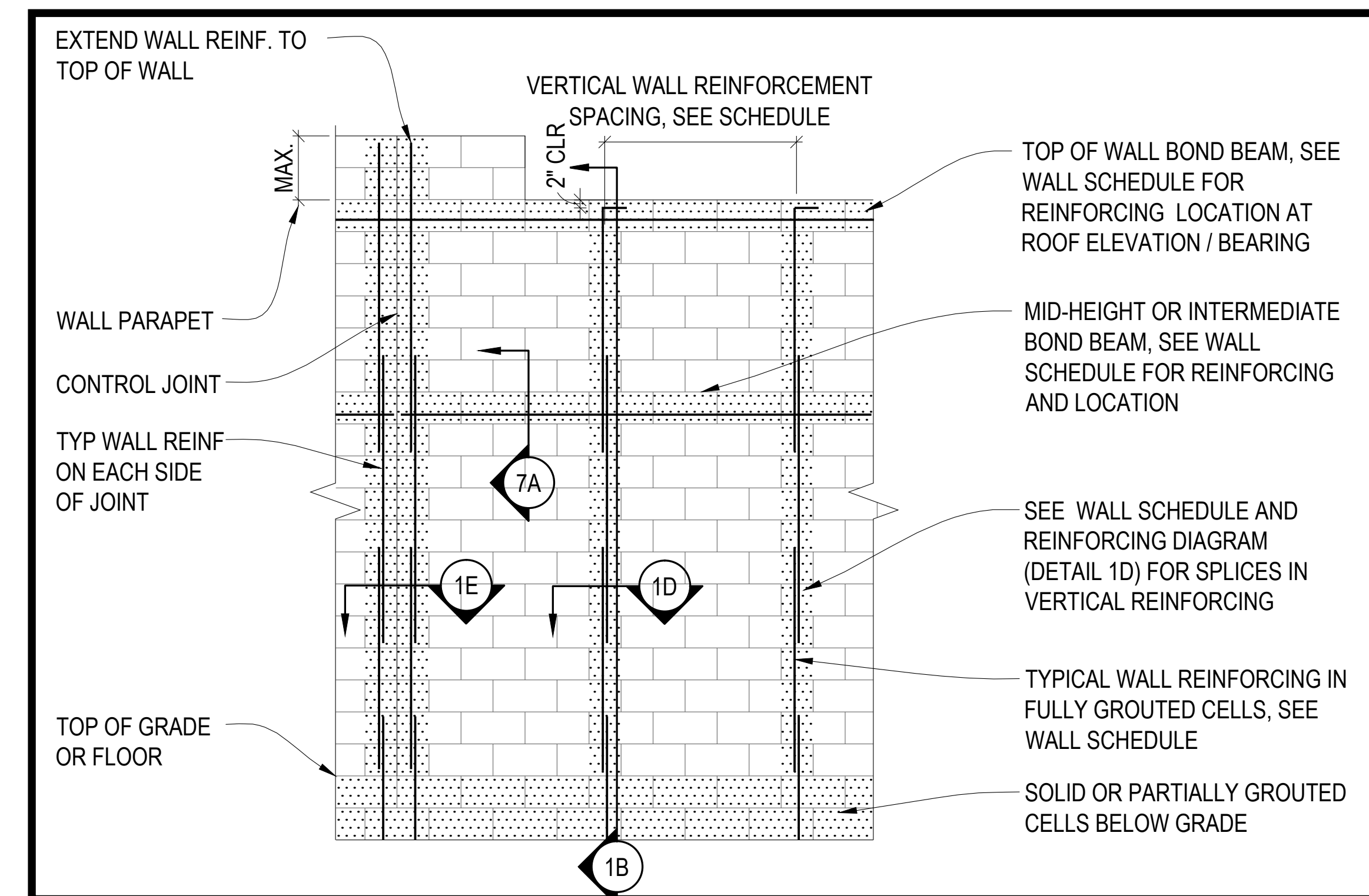
1. What Non-Engineers need to know about Structural Masonry
2. Intro to Structural Masonry Design
3. Structural Concrete Masonry Design
4. Structural Clay Masonry Design
5. Masonry Notes, Details, and Prototypes
6. Software Review for Structural Masonry Design
7. Masonry Analysis and Design with Finite Element Software
8. Movement Joints, Structural Edition
9. Masonry Shear Wall Design
10. Lintels for Masonry Walls
11. Connection to Masonry walls
12. Storm Shelter design with Masonry
13. Cutting Edge Masonry Codes & Standards
14. Masonry Case Studies
15. Building System Selection (featuring Masonry)
16. Hybrid Masonry with PT Concrete



Agenda



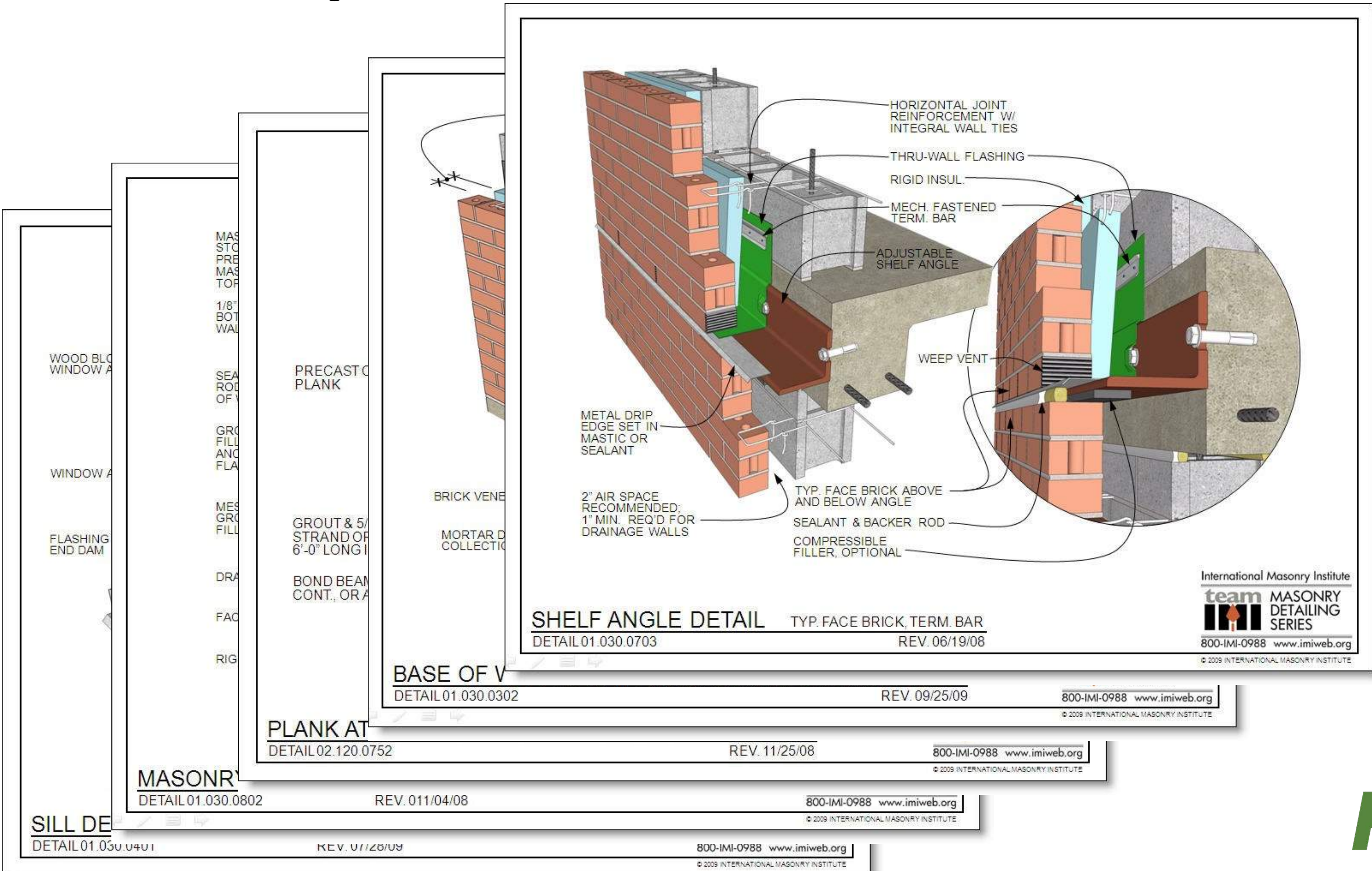
- General Notes Overview
 - Material notes
 - What to specify and what NOT to specify
- Connections to masonry walls
 - Dowels and laps in masonry walls
 - Bearing plates
 - Tension and shear connections to walls
 - Embedded fasteners into masonry
 - Connections from lintels
 - Connections for veneers
- Details of connections to masonry walls
 - Roof and Floor framing details
 - Foundation details
 - Partition Wall details
 - Storm Shelter details



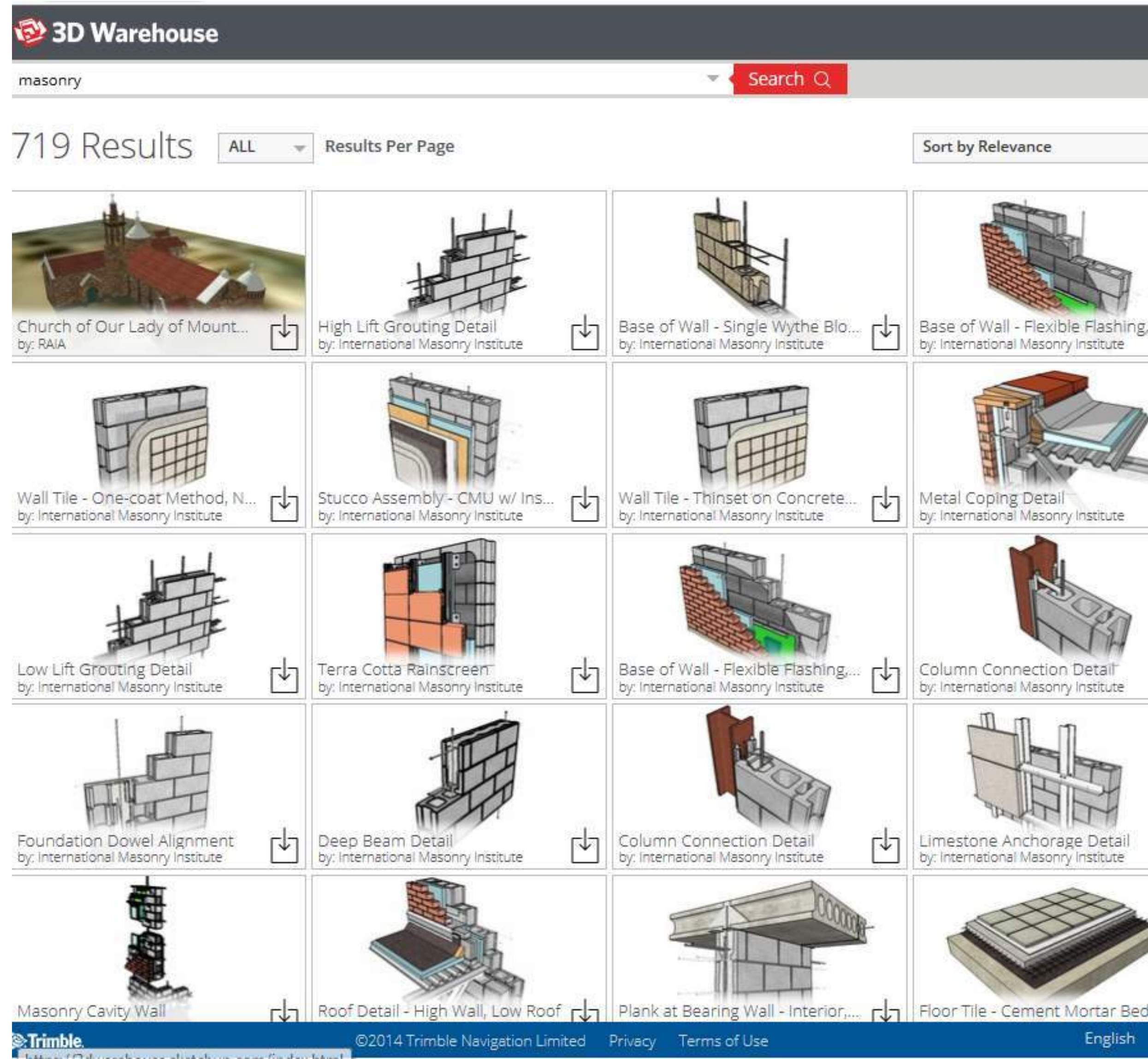
MASONRY DETAILING SERIES



www.imiweb.org



Sketchup 3D Warehouse loaded with free IMI Masonry detail



CONNECTIONS TO MASONRY GONE WRONG...







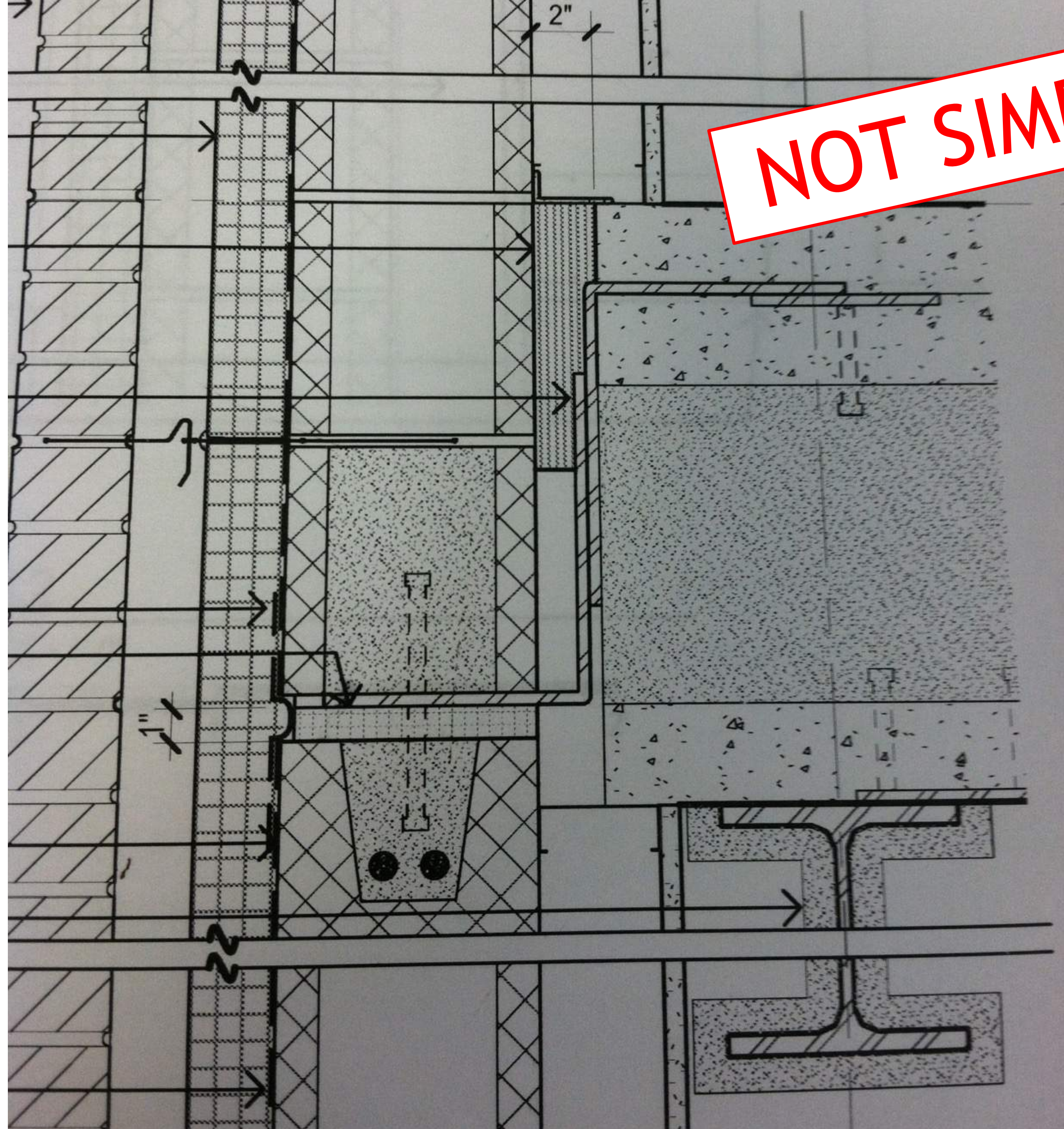






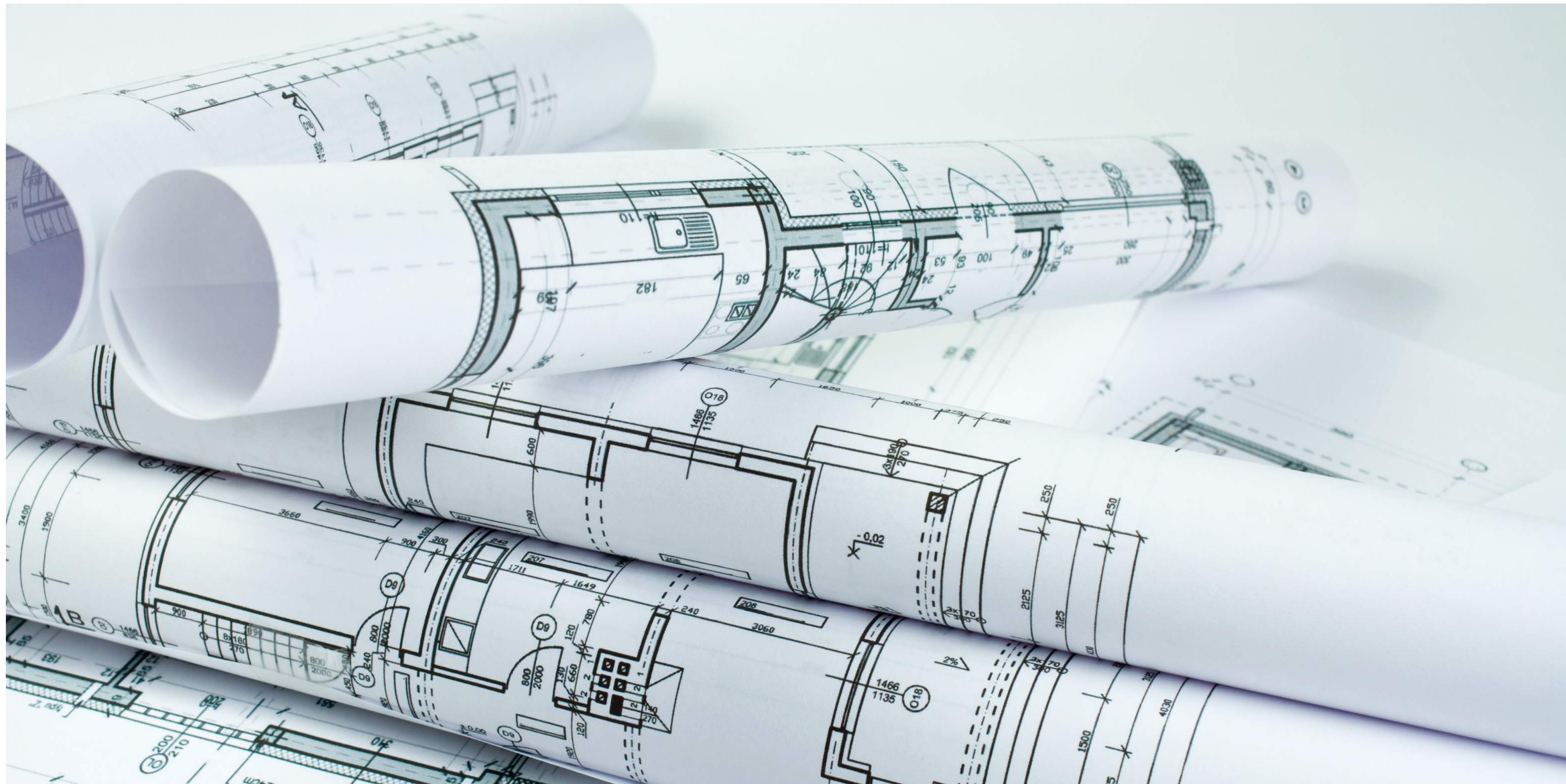


NOT SIMPLE





ORSE



MASONRY GENERAL NOTES



Specification Section 04200

STARTS WITH A GOOD SPEC SECTION - 04200

PART 1 GENERAL

~~DELETE~~

~~1.03 SYSTEM DESCRIPTION~~

~~A. Performance Requirements:~~

- ~~1. Provide unit masonry that develops the following installed compressive strengths (f'_m) at 28 days:
 - ~~a. For Concrete Unit Masonry: Based on net area: $f'_m = 1900$ PSI (13.1 MPa).~~
 - ~~b. For Brick Unit Masonry: Based on gross area: $f'_m = 2500$ PSI (17.3 MPa).~~~~

REPLACE WITH...

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Provide unit masonry that develops the following installed compressive strengths (f'_m) at 28 days:
 - a. For Concrete Unit Masonry: Based on net area: $f'_m = 2500$ PSI
 - i. f'_{CMU} , individual concrete masonry unit compression strength, shall be 3250 PSI or greater
 - ii. f'_G , grout compressive strength, shall be 2500 psi or greater
 - iii. Mortar shall be Type S
 - b. For Brick Unit Masonry: Based on gross area: $f'_m = 2500$ PSI
 - i. f'_{BRICK} , individual concrete masonry unit compression strength, shall be 8250 PSI or greater
 - ii. Mortar shall be Type N

masonry design notes

material notes

- don't *just* say “f'm = _____”
- call out each part of the assembly: CMU, grout, and mortar
- for example:

Masonry assembly strength shall be 2,500 psi

- f'_{CMU} shall be 3250 psi or greater
- f'_G shall be 3000 psi
- mortar shall be Type S
 - *don't need to call out strength of mortar*
- also, it is possible to use two different masonry strengths on the same project!

COMMENTS ON MASONRY NOTES

TYPE S MORTAR PER ASTM C270 1800 PSI
GROUT PER ASTM C476 2000 PSI

4. THE DESIGN COMPRESSIVE STRENGTH OF MASONRY (f_m) BASED ON THE COMPRESSIVE STRENGTH OF MASONRY UNITS AND MORTAR TO BE USED ARE AS FOLLOWS:

CONCRETE MASONRY	$f_m = 1500$ PSI
CLAY (BRICK) MASONRY	$f_m = 2000$ PSI

5. FOR ALL WALLS AS INDICATED ON THE STRUCTURAL DRAWINGS THE MORTAR SHALL BE TYPE S AND ONLY NORMAL WEIGHT UNITS SHALL BE USED IN BELOW GRADE APPLICATIONS.

6. MASONRY REINFORCEMENT SHALL BE AS FOLLOWS:

BOND BEAMS AND ALL VERTICAL REINFORCEMENT:
DEFORMED BARS - ASTM A615 GRADE 60

BED JOINT REINFORCEMENT:
PARALLEL WIRES - ASTM A82 WITH MINIMUM YIELD STRESS OF 70.0 KSI.

CONTINUOUS HORIZONTAL WIRE TIES SHALL BE PLACED SUCH THAT THE DISTANCE BETWEEN THE FACE OF THE MASONRY WALL AND THE PARALLEL WIRE IS NOT MORE THAN ONE INCH.

FOR SINGLE AND DOUBLE WYTHE BLOCK PROVIDE:
(2)#9 GAGE DEFORMED WIRES,(1) AT EACH FACE SHELL, TRUSS TIED.

FOR VENEER OTHER THAN RUNNING BOND PROVIDE:
(1) WIRE OF SIZE W1.7 @ 18" OC MAX

these values
are too low

when specifying
mortar, you are
not required to
indicate strength

these values
are too low

horizontal reinf.
should be ladder
type

GETTING THE NOTES RIGHT!

MS.01 ALL MASONRY CONSTRUCTION SHALL CONFORM TO THE LATEST EDITION OF THE "BUILDING CODE REQUIREMENTS FOR MASONRY STRUCTURES," ACI 530/ASCE 5/TMS 402.

MS.02 THE OWNER'S MASONRY TESTING LABORATORY SHALL PERFORM ALL TESTING OF UNIT MASONRY COMPONENTS IN ACCORDANCE WITH ACI 530/ASCE 5/TMS 402 AND SECTION XXX OF THE XXXX BUILDING CODE. WRITTEN REPORTS, SIGNED AND SEALED BY THE INSPECTING PROFESSIONAL AND INCLUDING THE LICENSE EXPIRATION DATE, SHALL BE SUBMITTED TO THE ARCHITECT FOR REVIEW. SEE ALSO THE PROJECT SPECIFICATIONS.

MS.03 ALL CONCRETE MASONRY UNITS SHALL BE NORMAL WEIGHT WITH TWO (2) CELLS AND CONFORM TO ASTM C 90.

MS.04 ALL BRICK MASONRY UNITS SHALL CONFORM TO ASTM C 216. REFER TO THE ARCHITECTURAL DRAWINGS FOR SIZE AND COLOR.

MS.05 ALL MORTAR SHALL CONFORM TO ASTM C 270.

MS.06 ALL GROUT SHALL CONFORM TO ASTM C 476.

MS.07 THE MINIMUM SPECIFIED NET AREA COMPRESSIVE STRENGTH OF MASONRY (f'_m) SHALL BE 2500 PSI AND SHALL CONSIST OF THE FOLLOWING COMPONENTS:

CONCRETE MASONRY UNITS:
3750 PSI MINIMUM NET AREA COMPRESSIVE STRENGTH

BRICK MASONRY UNITS:
4400 PSI MINIMUM NET AREA COMPRESSIVE STRENGTH

PORTLAND CEMENT MORTAR: TYPE S

GROUT: 2500 PSI MINIMUM COMPRESSIVE STRENGTH

MS.08 ALL BAR REINFORCEMENT STEEL USED IN MASONRY SHALL BE HIGH STRENGTH NEW BILLET STEEL CONFORMING TO THE LATEST EDITION OF ASTM A 615, GRADE 60. REFER TO REINFORCEMENT STEEL NOTES THIS SHEET FOR ADDITIONAL INFORMATION.

MS.09 THE MINIMUM CLEAR DISTANCE BETWEEN PARALLEL REINFORCEMENT BARS, EXCEPT IN COLUMNS, SHALL BE EQUAL TO THE NOMINAL DIAMETER OF THE BAR OR 1", WHICHEVER IS GREATER.

EXCELLENT!!

design strength of masonry

$$\begin{array}{l} \text{individual CMU} \\ \text{NET AREA psi} \end{array} + \begin{array}{l} \text{mortar type} \\ \text{(Type S, N)} \end{array} = f'm$$

$$\text{1,900 psi} + \text{Type S} = \text{1,500 psi}$$

OLD CODE
MINIMUM...
NOT STANDARD

$$3,250 \text{ psi} + \text{Type S} = 2,500 \text{ psi}$$

COMMON - AVAILABLE
ALMOST EVERYWHERE

$$4,500 \text{ psi} + \text{Type S} = 3,000 \text{ psi}$$

ALSO AVAILABLE
(not as common)

ACHIEVED WITH PRISM TESTING 4,000 psi +



CMU BLOCK STRENGTH RESULTS

42

MINIMUM STRENGTH

3020

AVERAGE STRENGTH

4292

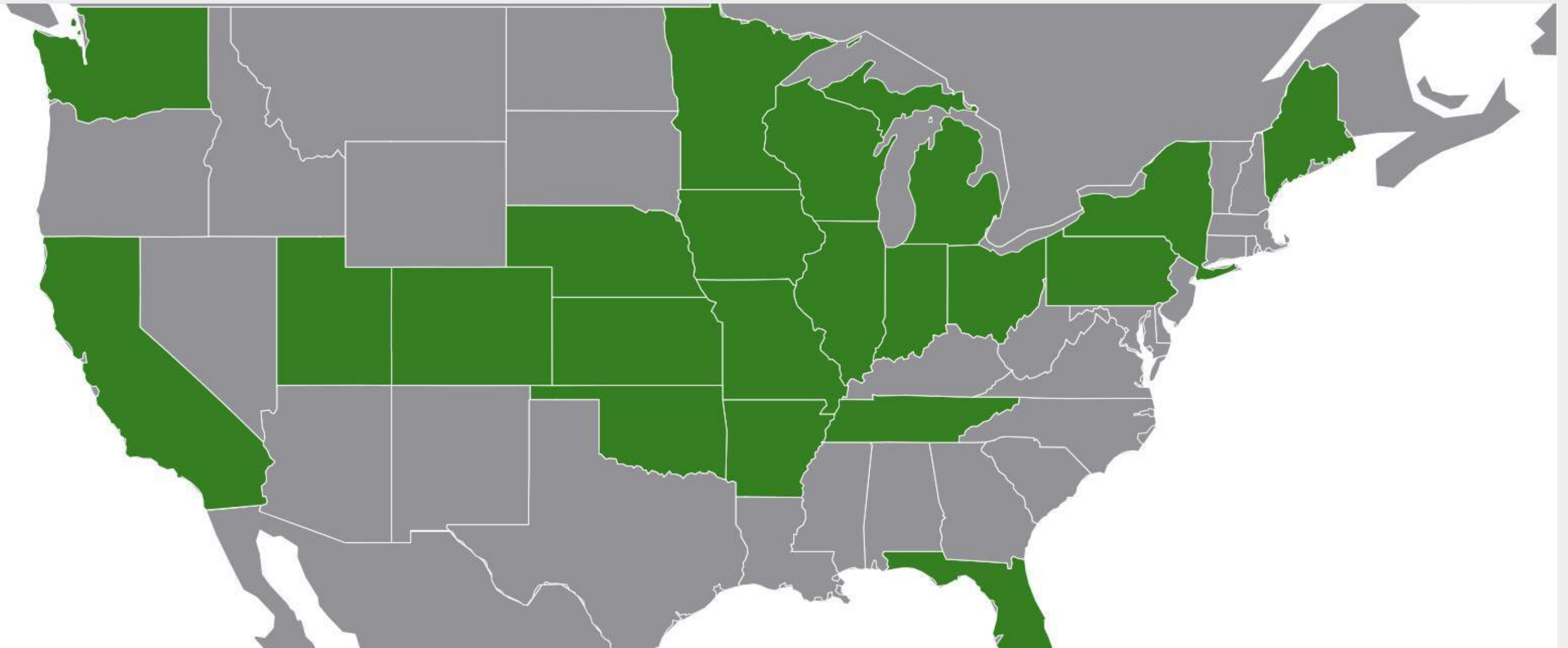
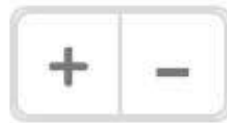
MAXIMUM STRENGTH

7870

CHANGE STATES, BLOCK TYPE, AND YEAR RANGE TO UPDATE CMU STATISTICS

States

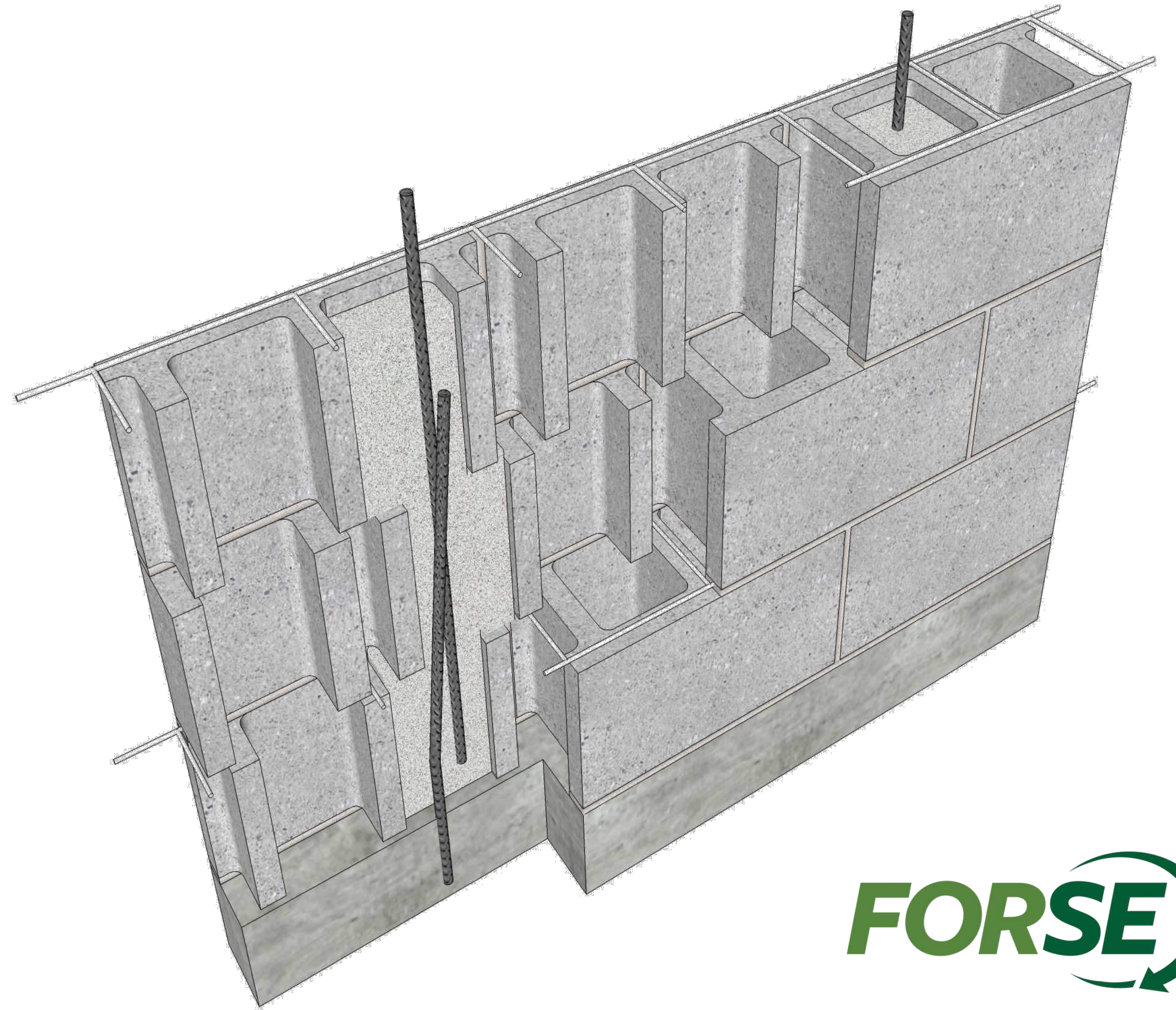
AR x	CA x	CO x
FL x	IA x	IL x
IN x	KS x	ME x
MI x	MN x	MO x
NE x	NY x	OH x
OK x	PA x	TN x
UT x	WA x	WI x



why is f'_m so important?

more efficient design w/ higher f'_m

- **wall**
 - bearing wall
 - non-bearing wall
 - shear wall
- **lintel**
- **column/pilaster**
- **lap lengths**
 - much shorter
- **connections to masonry**
 - will be much more efficient
 - embed plates
 - anchors

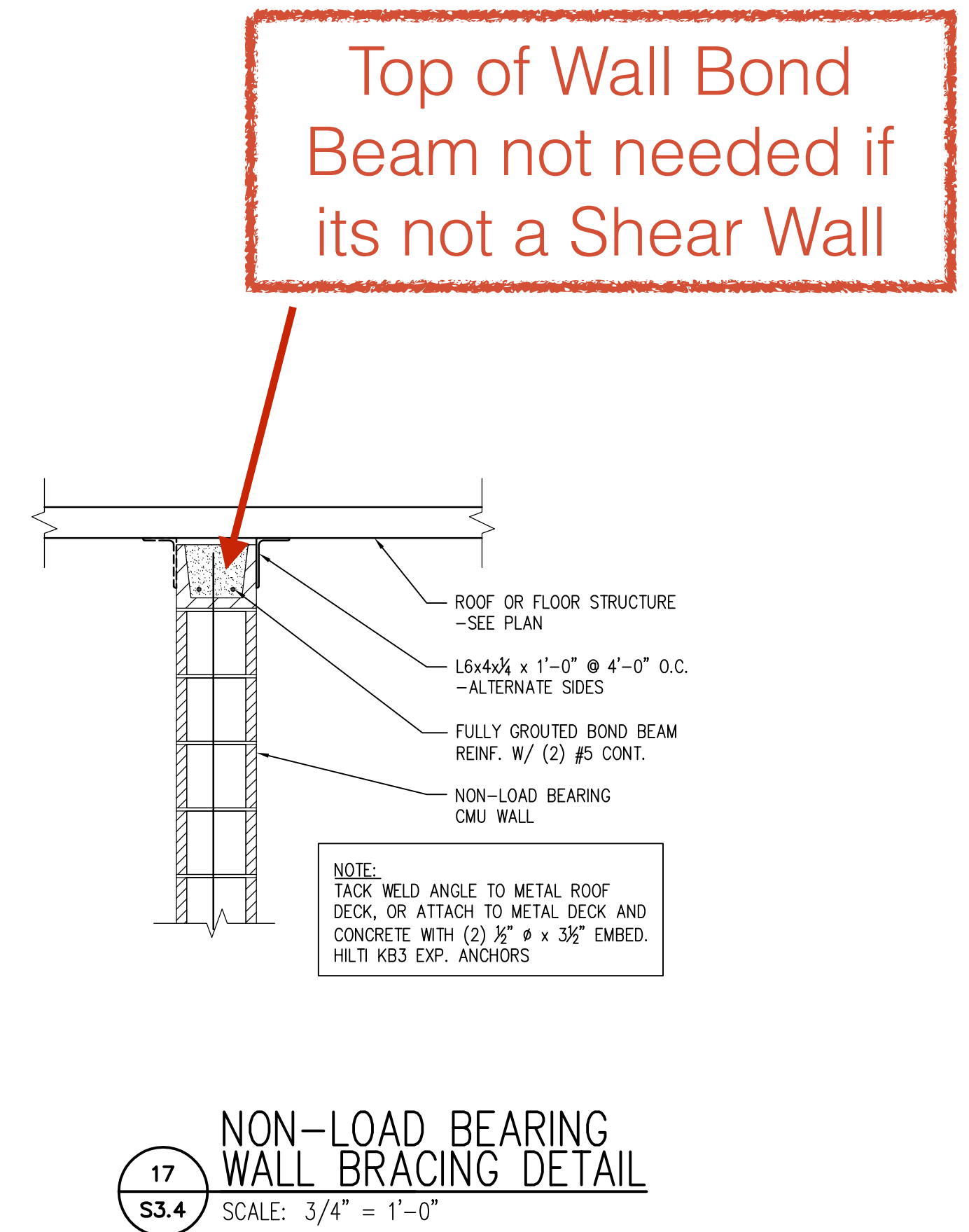


masonry design notes

general notes

don't make general catch all statements

- don't define "maximum reinforcing spacing" ...
- eliminates unreinforced walls which are still very reasonable options
- too often when engineers define "maximum reinf spacing", it is far less than code defined maximum (120 inches on center)
- don't add a top of wall bond beam to all walls
- arbitrarily adds unnecessary element that adds a lot of costs, difficult



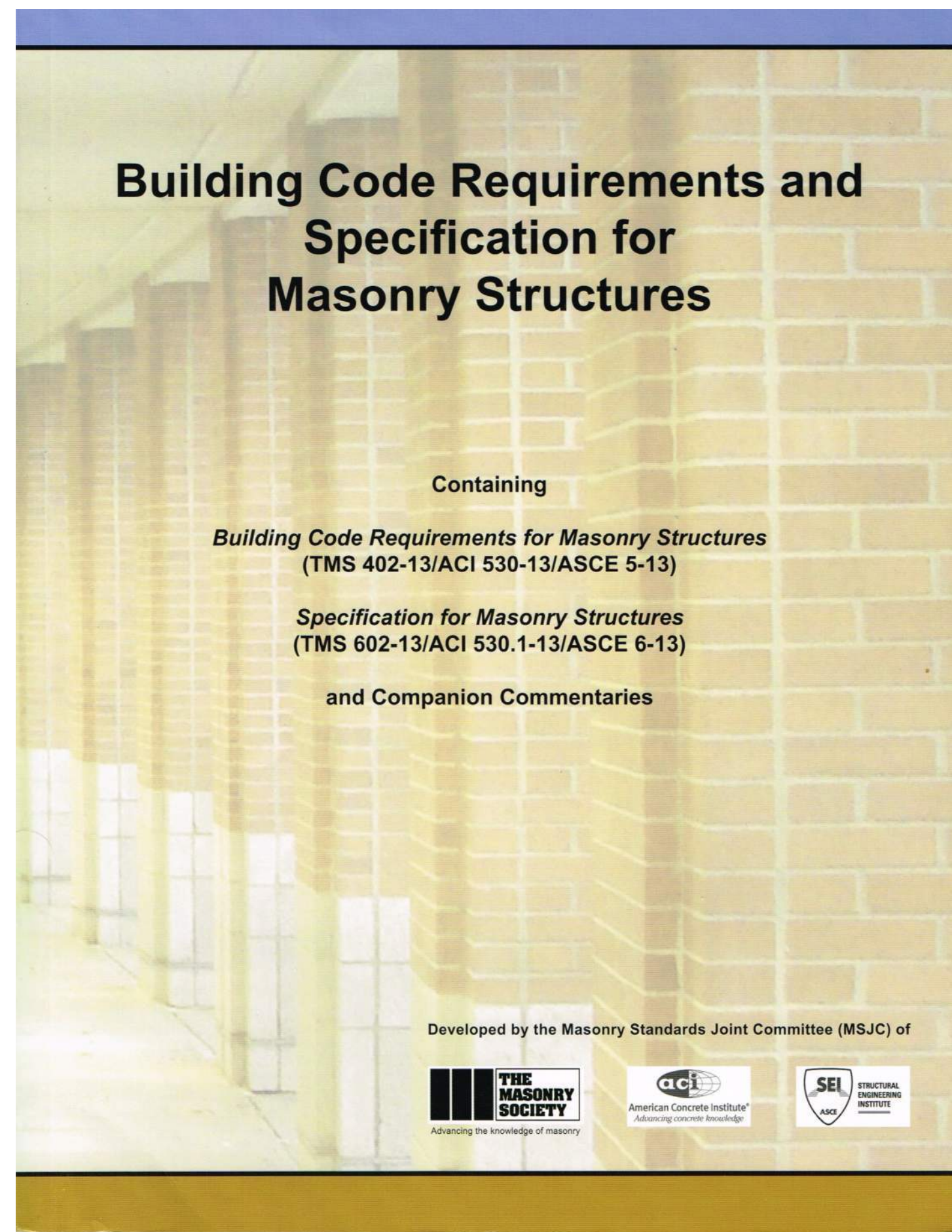
masonry design notes

general notes

don't define control joint spacing via notes

- brick veneer and concrete masonry have different movement requirements
 - one expands, one contracts
 - one does not have reinf, one does have reinforcement
- designers are required by code to locate movement joints
 - make specific locations on plans and elevations
 - don't try to define with words

Who is responsible for locating movement joints?



MSJC 2013, Section 12.1.6.3

“Design and detail the veneer to accommodate differential movement.”

MSJC 2013 - Mandatory Requirements Checklist – “Notes to Architect / Engineer”, Part 3, 3.3 D.6, page S-81

“Indicate type and location of movement joints on the project drawings.”



CAN **NOT** LOCATE CJ VIA NOTES

5. FOR ALL WALLS AS INDICATED ON THE STRUCTURAL DRAWINGS THE MORTAR SHALL BE TYPE S AND ONLY NORMAL WEIGHT UNITS SHALL BE USED IN BELOW GRADE APPLICATIONS.

6. MASONRY REINFORCEMENT SHALL BE AS FOLLOWS:

BOND BEAMS AND ALL VERTICAL REINFORCEMENT:

DEFORMED BARS - ASTM A615 GRADE 60

BED JOINT REINFORCEMENT:

PARALLEL WIRES - ASTM A82 WITH MINIMUM YIELD STRESS OF 70.0 KSI.

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FOR SINGLE AND DOUBLE WYTHE BLOCK PROVIDE:

(2)#9 GAGE DEFORMED WIRES,(1) AT EACH FACE SHELL, TRUSS TIED.

FOR VENEER OTHER THAN RUNNING BOND PROVIDE:

(1) WIRE OF SIZE W1.7 @ 18" OC MAX

7. UNLESS OTHERWISE SHOWN OR NOTED, REINFORCING STEEL FOR MASONRY SHALL BE 1 ADDEN

this note is
dangerous -
it might result in
CJ locations that
adversely affect
structural
capacity

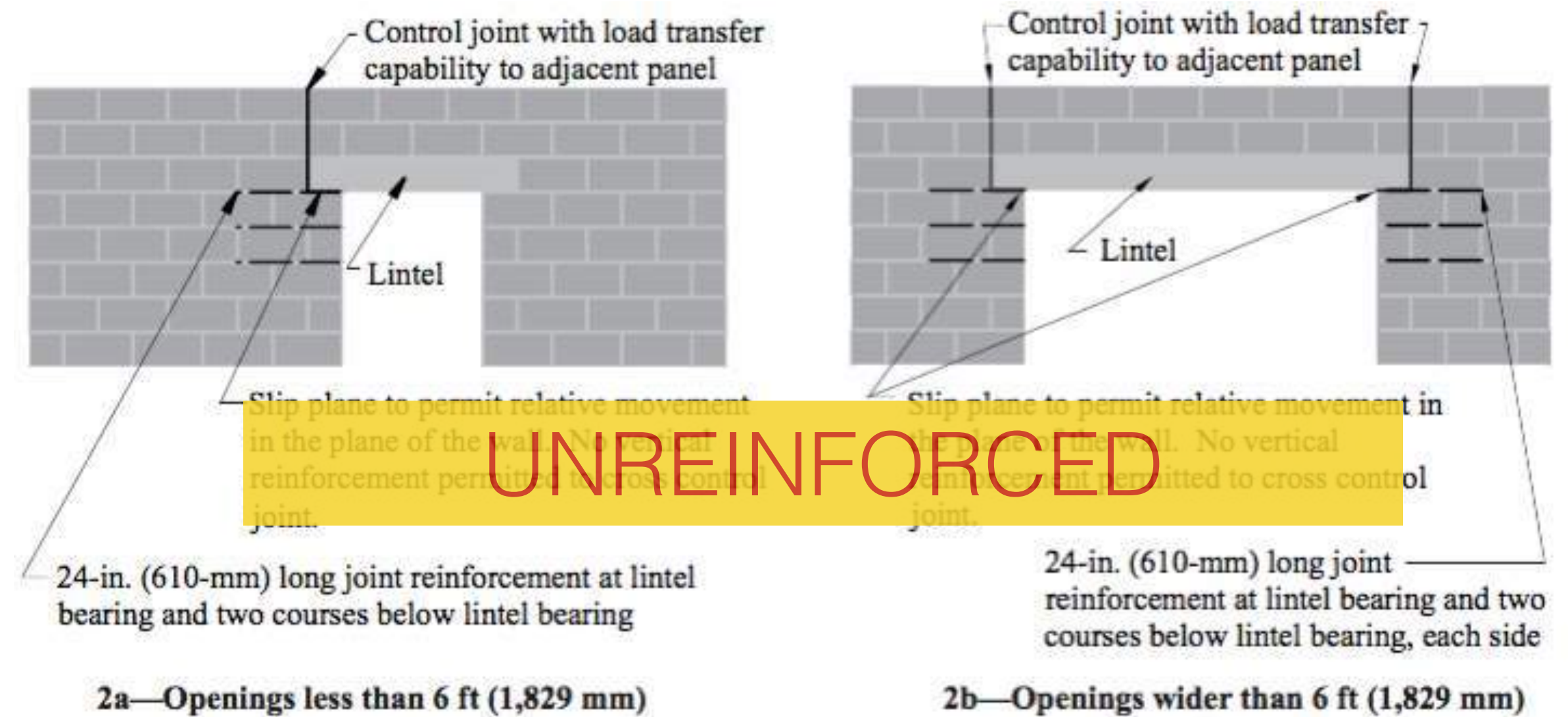
masonry - control joints

- two options for controlling cracking
 1. min. horiz. reinf. and control joints for masonry (unreinforced and reinforced)
 - does NOT need bar reinforcement like concrete
 - needs gauge reinforcement
 - CJ based on max 25 ft or 1.5 x wall height, or at:

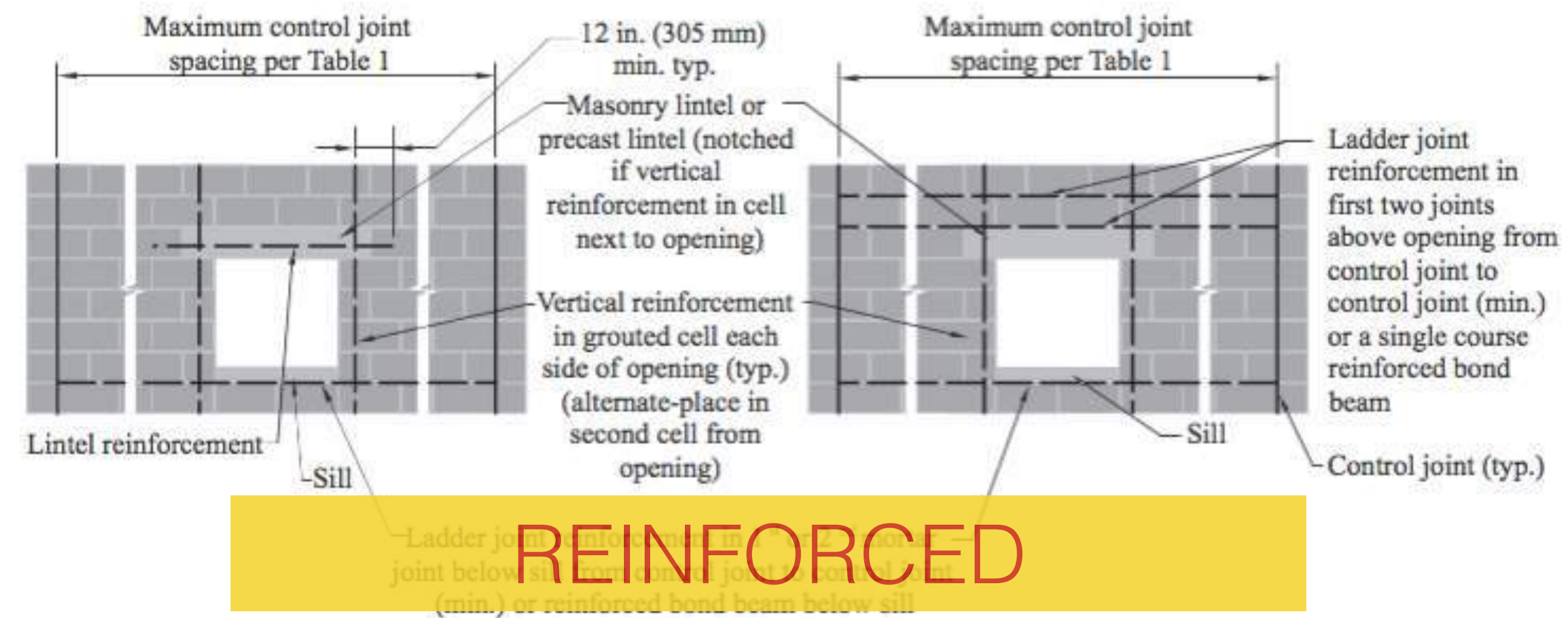
masonry - control joints

- two options for controlling cracking
 1. min. horiz. reinf. and control joints for masonry
 - CJ in unreinforced wall
 - CJ in reinforced wall
 - (AWAY FROM OPENINGS!!)

Figures from NCMA TEK 10-2C



Control Joints at Openings in Walls With No Reinforcement in Adjacent Cells



Control Joints at Openings Wrapped with Reinforcement

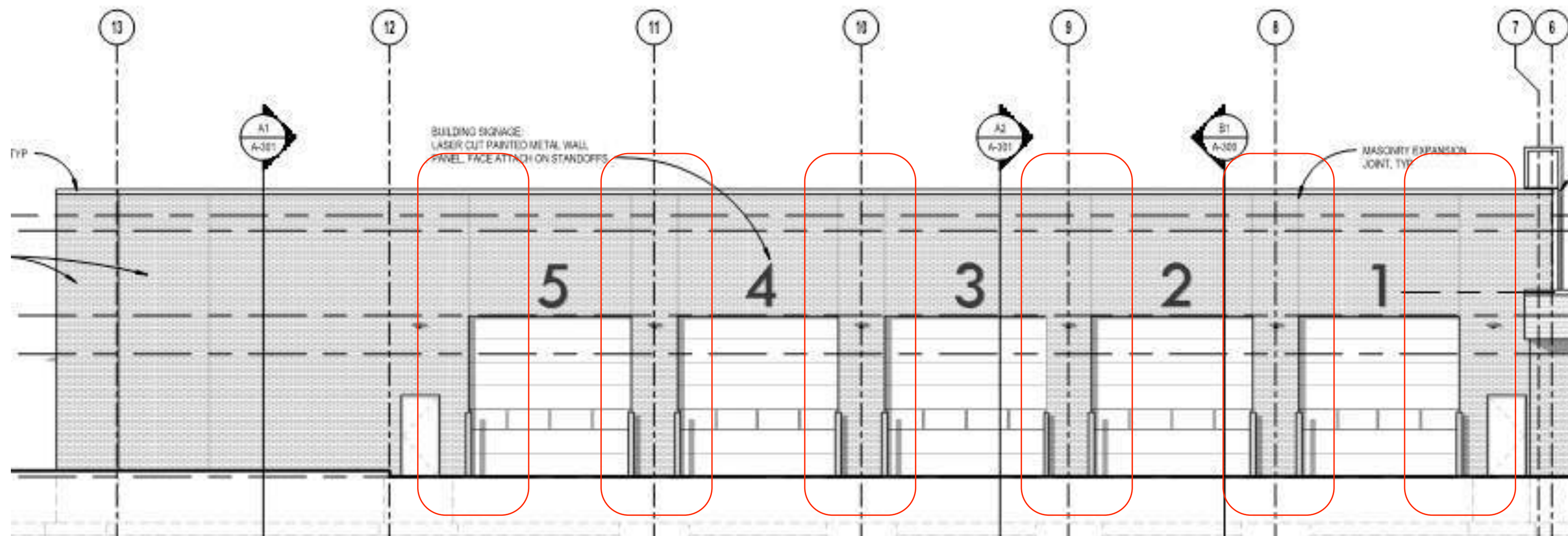
masonry - no control joints

- two options for controlling cracking
 1. additional vert. reinf. and NO control joints
 2. additional horiz. reinf. and NO control joints
 - use horiz. reinf. of $0.002 A$
 - similar to concrete, but less area

Table 3—Maximum Spacing of Horizontal Reinforcement to Meet the Criteria $A_s > 0.002A_n$ ¹			
Wall thickness, in. (mm)	Maximum spacing of horizontal reinforcement, in. (mm)		
	Reinforcement size		
	No. 6 (M19)	No. 5 (M16)	No.4 (M13)
UngROUTED or partially grouted walls			
6 (152)	48 (1219)	48 (1219)	32 (813)
8 (203)	48 (1219)	40 (1016)	24 (610)
10 (254)	48 (1219)	32 (813)	16 (406)
12 (305)	48 (1219)	24 (610)	8 (203)
Fully grouted walls			
6 (152)	32 (813)	24 (610)	16 (406)
8 (203)	24 (610)	16 (406)	8 (203)
10 (254)	16 (406)	16 (406)	8 (203)
12 (305)	16 (406)	8 (203)	8 (203)
1. A_n includes cross-sectional area of grout in bond beams			

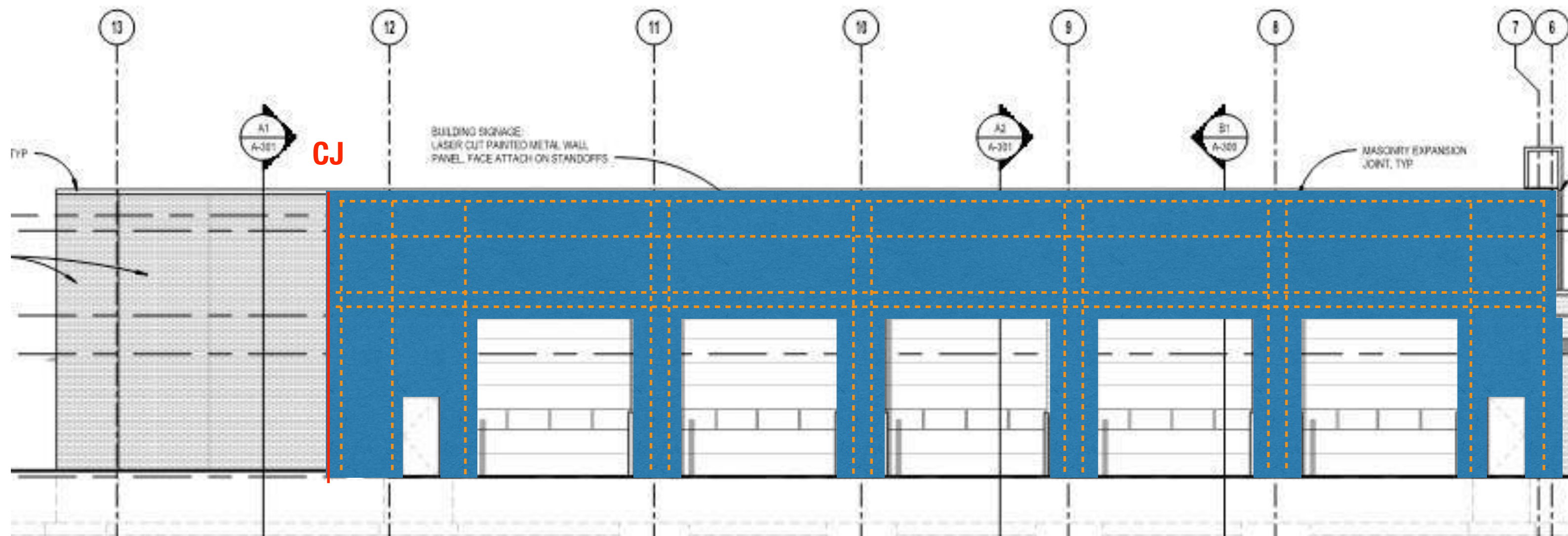
Figure from NCMA TEK 10-3

tips for control joints



MINIMAL AREA AT PIER TO PLACE CONTROL JOINTS

tips for control joints

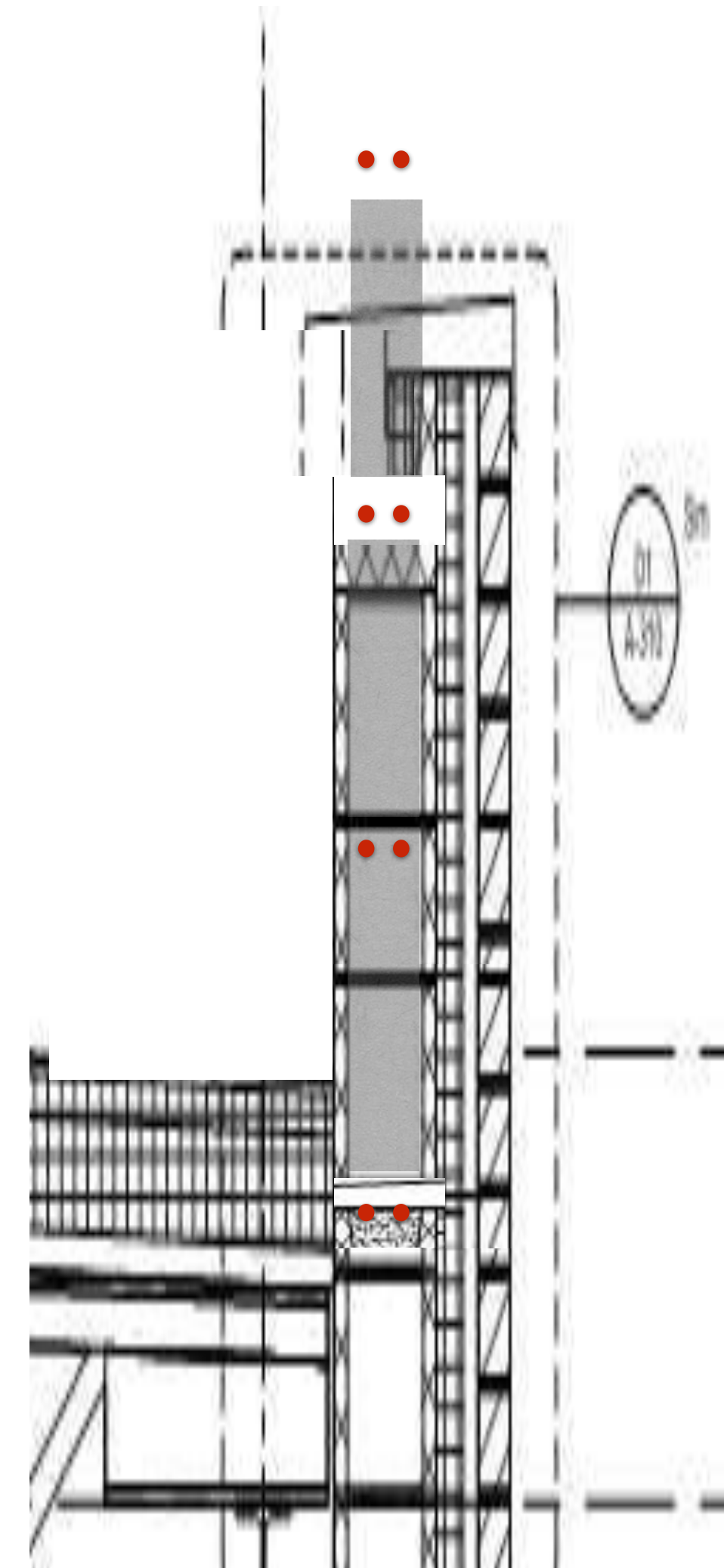


tips for control joints

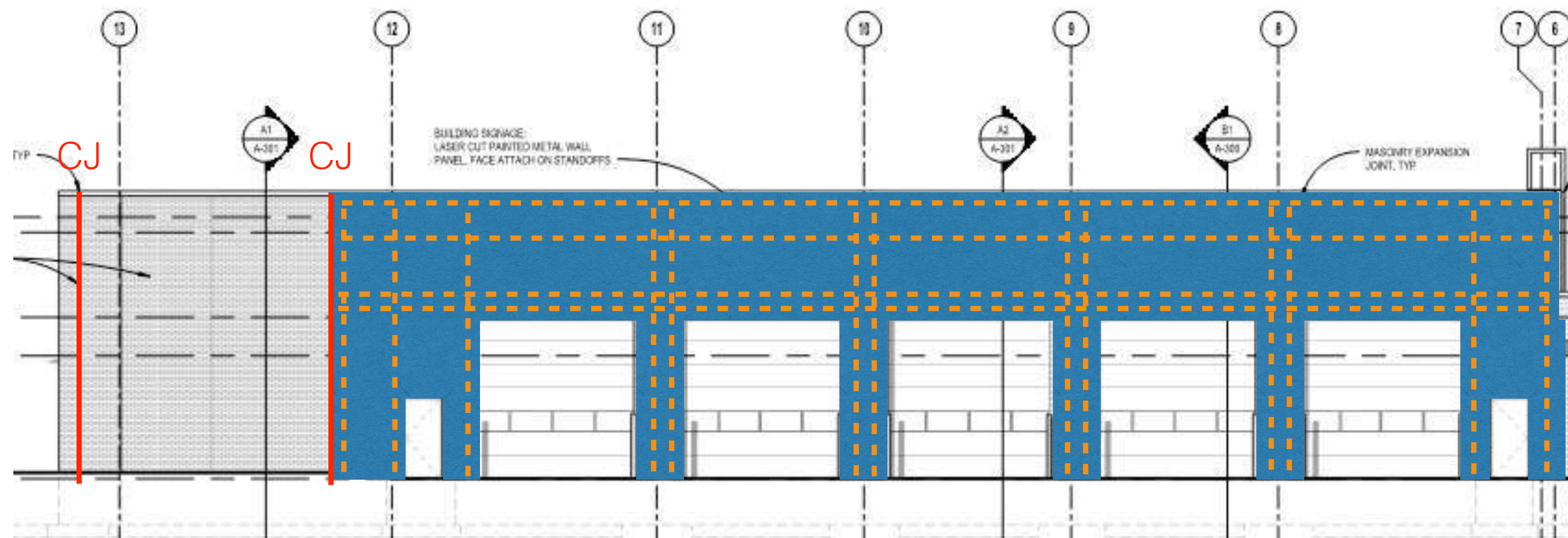
CONTINUOUS:

- LINTELS
 - TOP AND BOTTOM REINF
- JOIST BEARING
- TOP OF WALL

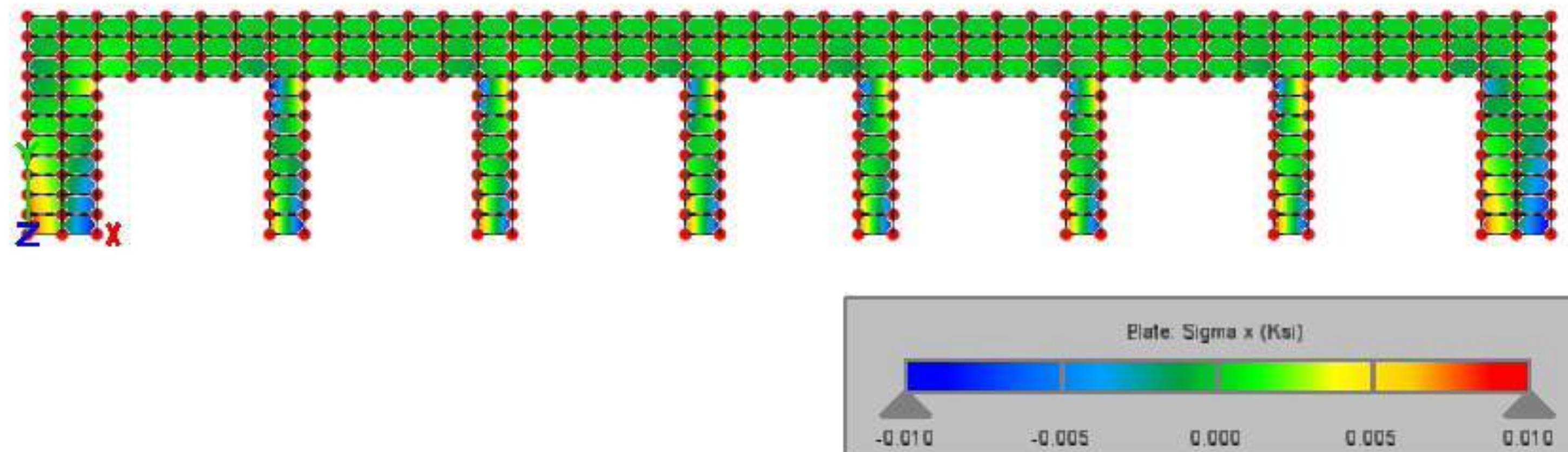
Final design likely grouted solid in this case



control joints affect structural performance

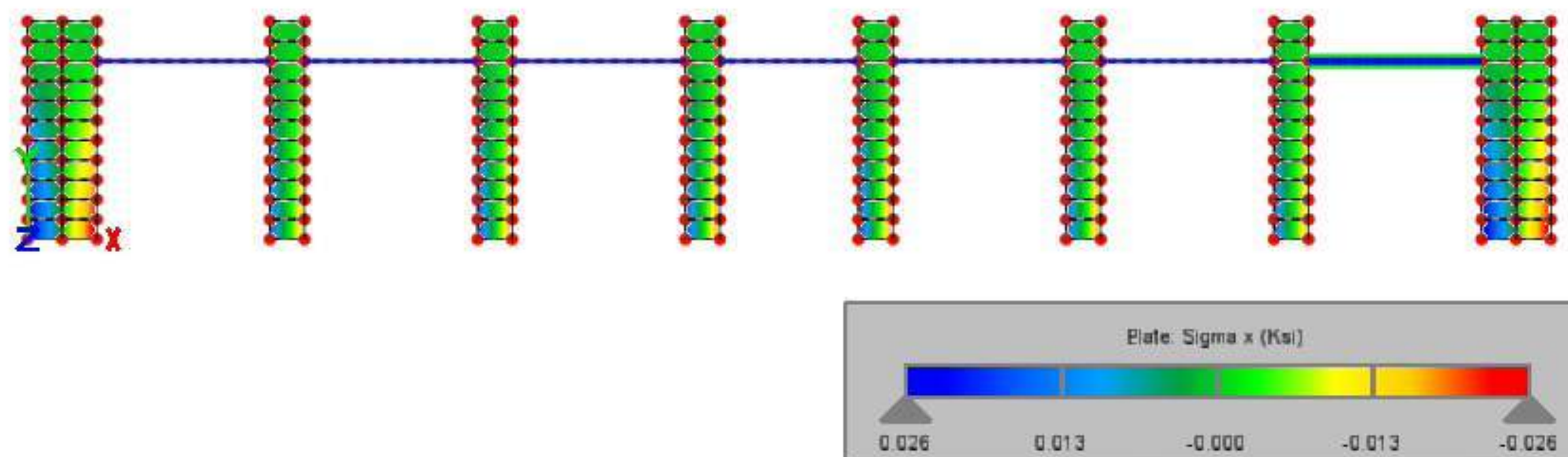


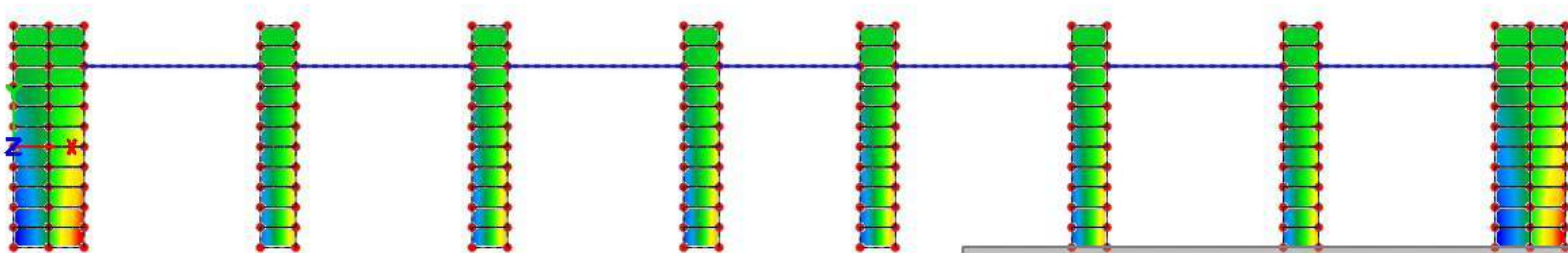
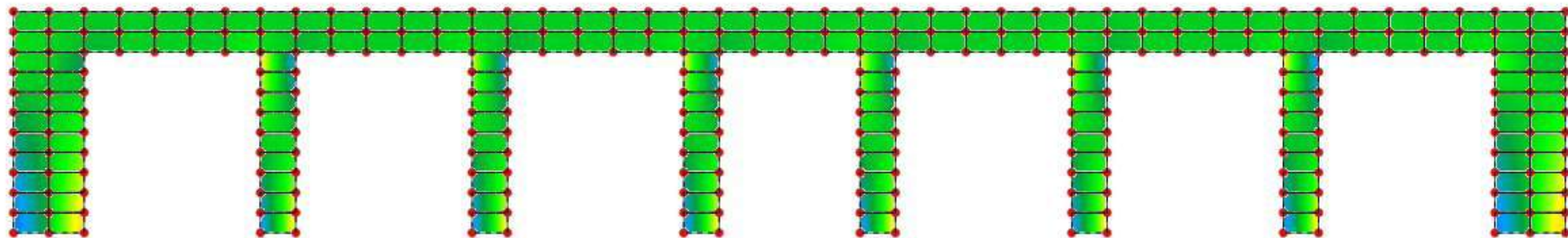
control joints affect structural performance



Front

control joints affect structural performance





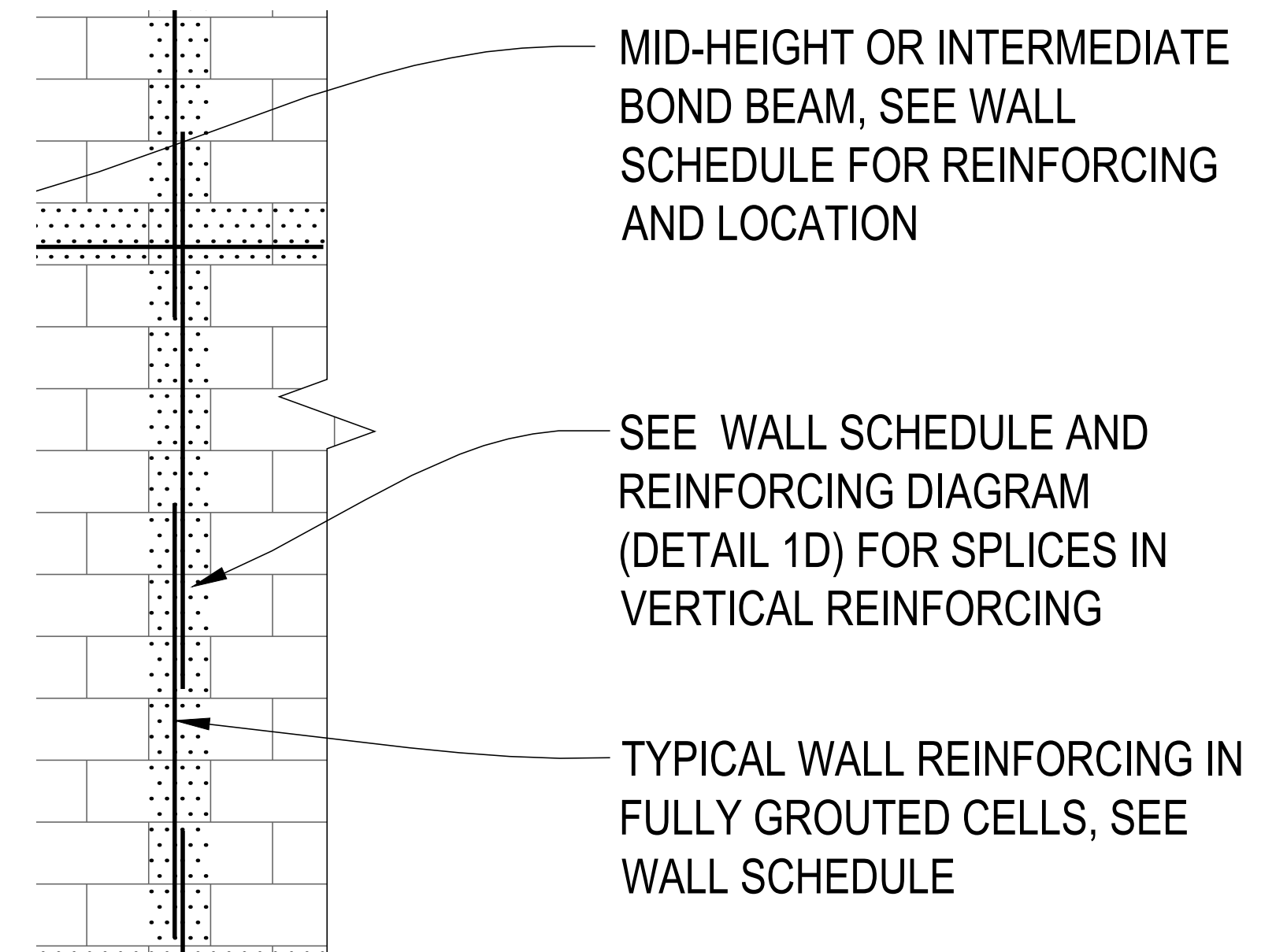
Front



masonry design notes

lap splices

- lap splices are different for a variety of reasons
- all of the following change lap lengths
 - bar sizes
 - reinforcement in center, or at each face
 - spacing
 - masonry wall strength
- include in masonry wall schedules



masonry design notes

masonry wall schedules

- material notes
- lap splice notes
- masonry wall schedules

MASONRY WALL SCHEDULE				
MARK	THICKNES S	VERTICAL REINFORCEMENT		NOTES
		BAR(S)@SPACING	LAP DISTANCE	
W1	8"	1-#4 @ 64" O.C.	12 inches	
W2	8"	1-#6 @ 32" O.C.	33 inches	
W3	8"	2-#4 @ 24" O.C.	20 inches	
W4	8"	1-#7 @ 8" O.C.	46 inches	
W5	12"	1-#6 @ 32" O.C.	21 inches	

$f'_m = 2500 \text{ psi}$

EXTEND WALL REINF. TO
TOP OF WALL

VERTICAL WALL REINFORCEMENT
SPACING, SEE SCHEDULE

MAX.

2" CLR

TOP OF WALL BOND BEAM, SEE
WALL SCHEDULE FOR
REINFORCING LOCATION AT
ROOF ELEVATION / BEARING

WALL PARAPET

CONTROL JOINT

TYP WALL REINF
ON EACH SIDE
OF JOINT

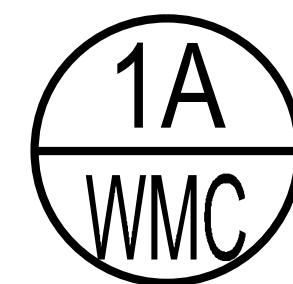
MID-HEIGHT OR INTERMEDIATE
BOND BEAM, SEE WALL
SCHEDULE FOR REINFORCING
AND LOCATION

SEE WALL SCHEDULE AND
REINFORCING DIAGRAM
(DETAIL 1D) FOR SPLICES IN
VERTICAL REINFORCING

TOP OF GRADE
OR FLOOR

TYPICAL WALL REINFORCING IN
FULLY GROUTED CELLS, SEE
WALL SCHEDULE

SOLID OR PARTIALLY GROUTED
CELLS BELOW GRADE



TYPICAL MASONRY WALL REINFORCING ELEVATION

SCALE : 1/4" = 1'-0"

SEE ARCH. FOR OTHER MASONRY DETAILS,
DIMENSIONS AND FINISHES

SEE MASONRY WALL CONSTRUCTION
SPECIFICATIONS FOR MORE INFORMATION

PLACE GROUT TO 4" BELOW TOP

ALL MASONRY WALLS MUST BE ADEQUATELY
BRACED DURING CONSTRUCTION. BRACING
SHALL REMAIN IN PLACE UNTIL STRUCTURAL
ROOF DECK IS COMPLETED.

* —> NOTE:
LAY WALL TO THIS HEIGHT; PLACE NEXT
REINF. BAR OR BARS TO SPECIFIED
TOLERANCES; PLACE GROUT TO 4"
BELOW TOP. SPACES TO BE GROUTED
SHALL BE FREE OF MORTAR DROPPINGS,
DEBRIS LOOSE AGGREGATES AND ANY
MATERIAL DELETERIOUS TO MASONRY
GROUT.
CONSOLIDATE GROUT AT TIME OF
PLACEMENT USING MECHANICAL
VIBRATION. AFTER INITIAL SETTLEMENT
AND WATER LOSS HAS OCCURRED.

TOP OF WALL BOND BEAM (MIN.
(1) #4 REBAR)

BUILD WALL IN 4'-8" (MAX.) LIFTS
UNLESS CLEANOUTS ARE PROVIDED,
THEN 12'-8" LIFTS CAN BE USED.

REPEAT REINF. PATTERN TO
TOP OF WALL

VERTICAL REBAR MUST RUN
CONTINUOUSLY THROUGH ALL
BOND BEAMS

REBAR SIZE PER PLAN OR
MASONRY WALL REINFORCING
SCHEDULE

LAP BARS
MIN. (TYP.) SEE
WALL SCHEDULE

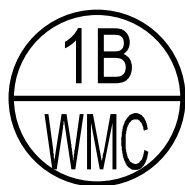
ALL CELLS WITH REINF. SHALL
BE FULLY GROUTED.

CMU (CONCRETE MASONRY UNIT),
SEE PLAN AND SCHEDULE FOR
THICKNESS (SEE ARCH. SHEETS
FOR COLOR AND TEXTURE)

SEE ARCH. PLANS FOR GRADE
AND FLOOR REQUIREMENTS

FULL MORTAR BEDDING AT
FIRST COURSE

PROVIDE MATCHING DOWELS WITH
STANDARD 90° HOOK INTO
FOUNDATION FOR ALL REINFORCED
WALLS LAP AS INDICATED IN SCHD



TYPICAL MASONRY WALL REINFORCING SECTION

SCALE : 1/2" = 1'-0"

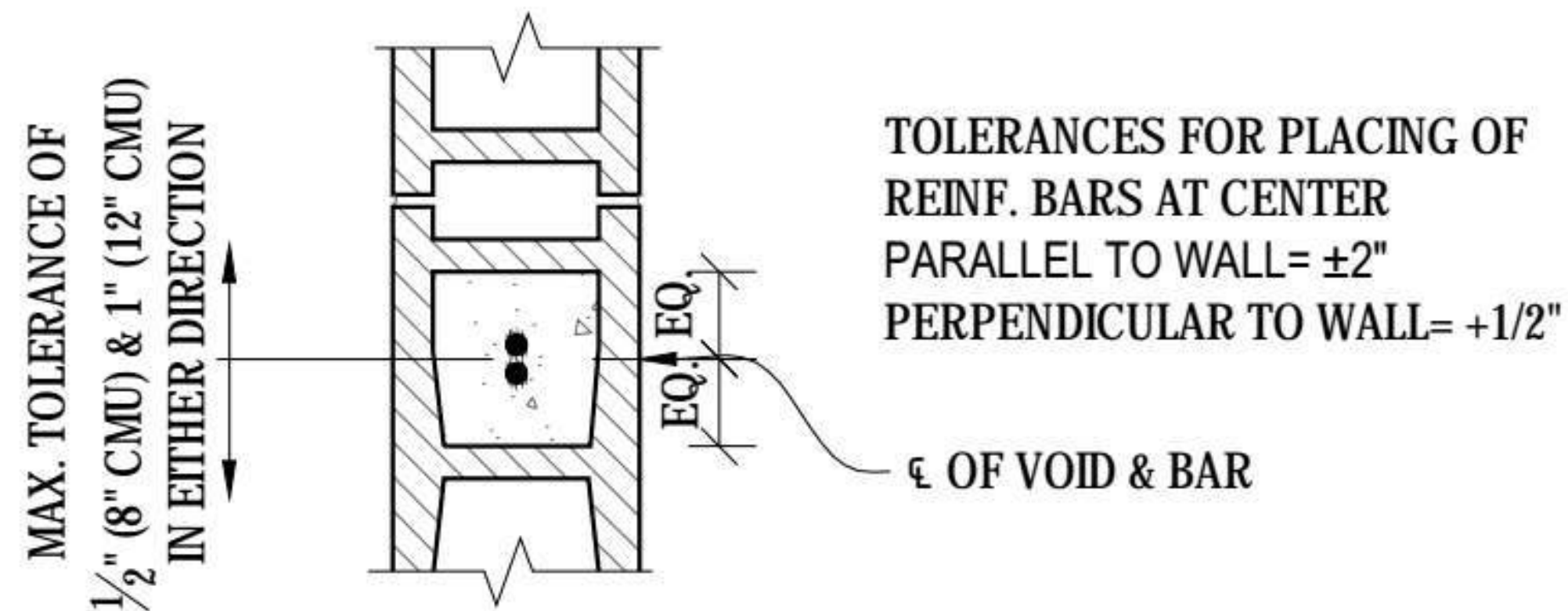
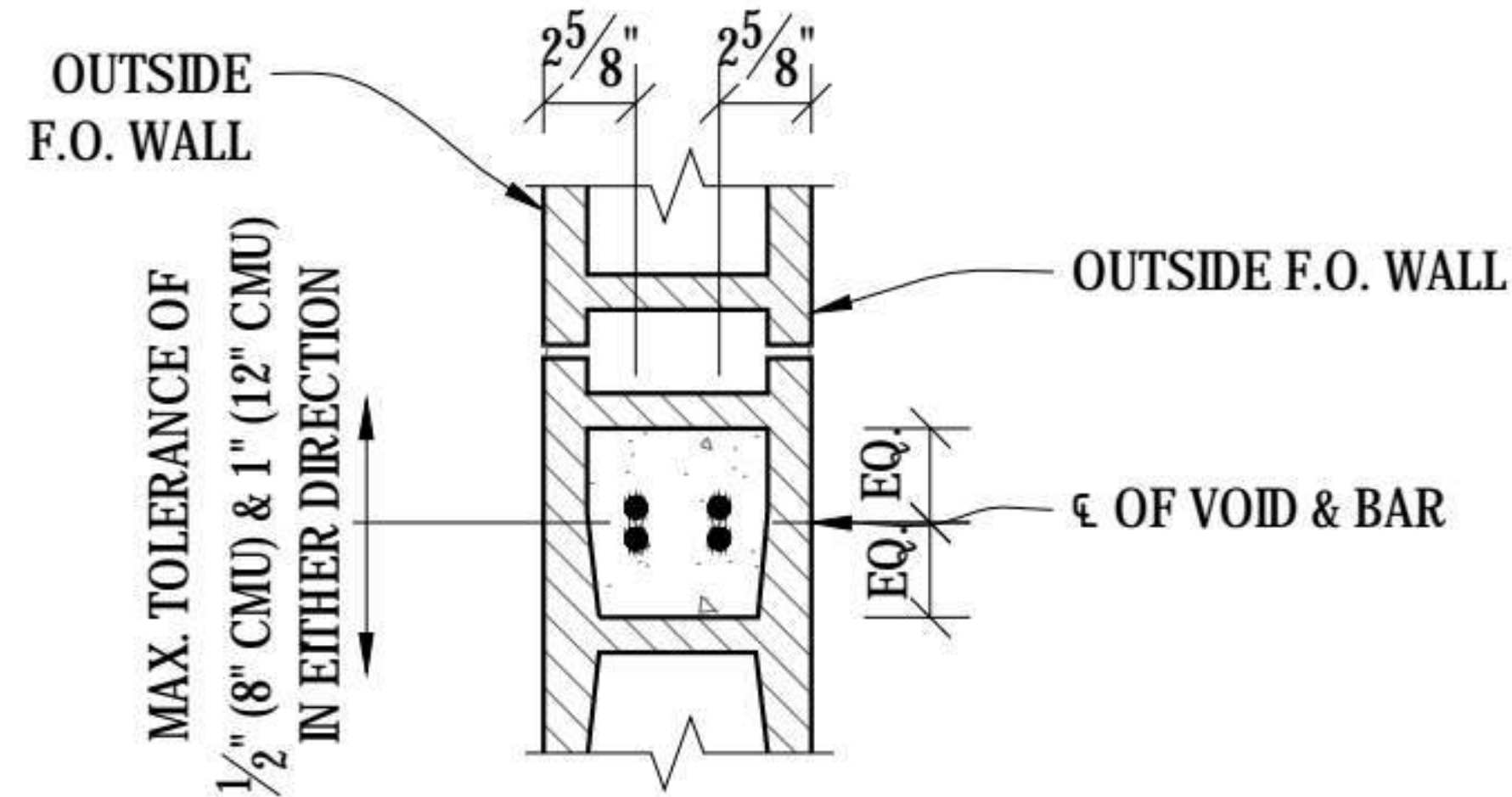


VERTICAL REINFORCEMENT LAP SCHEDULE

REBAR SIZE / NUMBER	LAP DISTANCE	
	8" CMU	12" CMU
#3	12	12
#4	12	12
#5	17	12
#6	33	22
#7	46	29
#8	71	44
#9	91	n/a
(2) #3	12	12
(2) #4	16	16
(2) #5	24	n/a
(2) #6	46	n/a

IT IS IMPORTANT REINF. BARS SHALL BE PLACED IN CONTINUOUS UNOBSTRUCTED CELL OF NOT LESS THAN 3" x 4" AND WITHIN MAX. TOLERANCE AS SHOWN

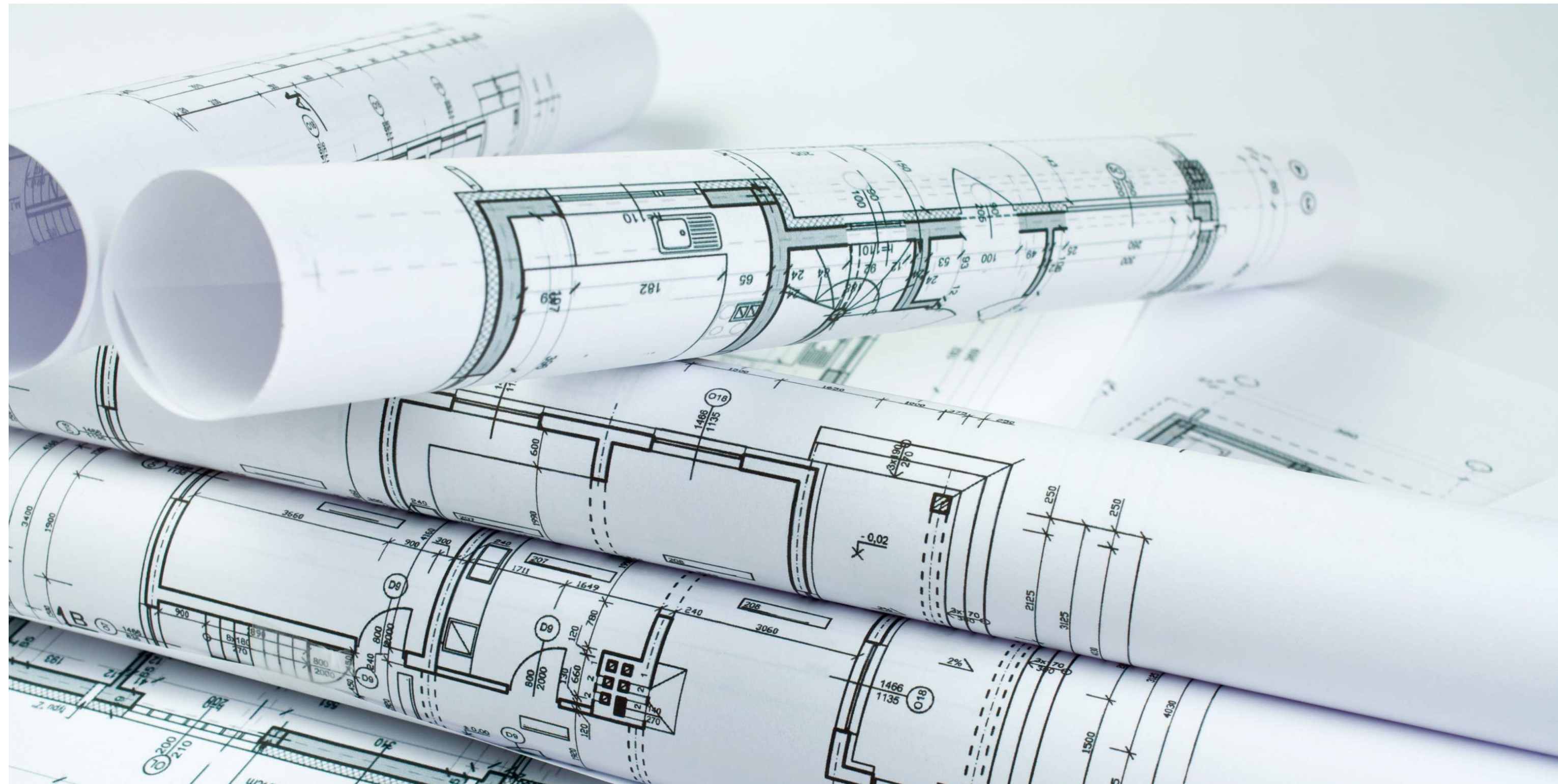
TOLERANCES FOR PLACING OF REINF. BARS AT EACH FACE
 PARALLEL TO WALL= $\pm 2"$
 PERPENDICULAR TO WALL= $+1/2"$ (TOWARD INSIDE)
 PERPENDICULAR TO WALL= $-1/4"$ (TOWARD OUTSIDE)



REBAR LAP AND PLACEMENT DETAIL

SCALE : 1" = 1'-0"





masonry partition walls

And their connections

IMI MASONRY PARTITION SOFTWARE – V2

imiweb.org/structural-solutions/masonry-partition-wall-software/

Code: ☐ 2012 IBC (2011 TMS 402/602) ☒ 2009 IBC (2008 TMS 402/602)

Masonry Specifications

☐ CMU (Light weight, 105 pcf) ☐ CMU (Medium weight, 125 pcf) ☒ CMU (Normal weight, 135 pcf) ☐ Clay

Masonry Type: ☐ Solid

Nominal Thickness: ☐ 4" ☐ 6" ☒ 8" ☐ 10" ☐ 12"

Specified Masonry Compressive Strength (f'_m): 2500 psi

☐ Automatic Uncheck Automatic for manual input

Mortar Type: ☐ Type N Masonry Cement ☒ Type S Masonry Cement ☐ Type N Portland Cement Lime or Mortar Cement ☐ Type S Portland Cement Lime or Mortar Cement

Wall Specifications

Wall Side View
Concentrated Load
Uniform Load
Seismic Load

Design Status: Good

Calculate/Report

Set all parameters to default values

Information

- [Background](#)
- [Reinforced Example](#)
- [Unreinforced Example](#)

Nominal Thickness:
☐ 4" ☐ 6" ☒ 8" ☐ 10" ☐ 12"

Specified Masonry Compressive Strength (f'_m): 2500 psi

☐ Automatic Uncheck Automatic for manual input

☐ Type N Masonry Cement
☒ Type S Masonry Cement
☐ Type N Portland Cement Lime or Mortar Cement
☐ Type S Portland Cement Lime or Mortar Cement

Bond Pattern: ☒ Running Bond ☐ Not Running Bond

Grout Spacing: none inches

Rebar Spacing: 120 inches

Actual Thickness: 112 inches ☒ Automatic

Net Area: 96 ft² ☒ Automatic

Section Modulus: 88 ft³ ☒ Automatic

Weight: 80 psf ☒ Automatic

Uncheck Automatic box for manual input

Specifications

Masonry **shear walls** for seismic loads

IBC – seismic wall characteristics

- Ordinary Reinforced Section - 1.17.3.2.4 (summary)
 - at least #4 vertical reinforcement within:
 - 16" of edge of opening and within last 8" of wall ends
 - 2-W1.7 horizontal joint reinforcement at 16" o.c.
 - reinforcement top and bottom of openings $\geq 16"$
 - extend 24" past opening, nor less than $40d_b$
 - reinforcement within 16" of top of walls
 - based on ASD or SD
- Intermediate Reinforced - Section 1.17.3.2.4 (summary)
 - all requirements of Ordinary Reinforced
 - and vertical reinforcement no further apart than 48" o.c.
- Special Reinforced - Section 1.17.3.2.4 (summary)
 - all requirements of Ordinary Reinforced
 - and reinforcement no further than 48" o.c. vertically and horizontally **and much, much more**

partition wall

MSJC 2013

an interior wall without
structural function
based on MSJC 2013, new
chapter 7, need to ensure no
in-plane forces enter wall
which are not accounted for



f'm=2500psi, mortar cement

IBC min load - 5 psf service, 8 psf factored/ultimate loading

SDC A, B

	10 ft	12 ft	14 ft	16 ft	18 ft	20 ft	24 ft	30 ft
6 inch	none	none	none	#4 @ 96	#4 @ 96	#4 @ 72	#4 @ 40	#5 @ 24
8 inch	none	none	none	none	none	#4 @ 96	#5 @ 96	#5 @ 48
10 inch	none	none	none	none	none	none	none	#4 @ 96
12 inch	none	none	none	none	none	none	none	#4 @ 96
16 inch	none	none	none	none	none	none	none	none

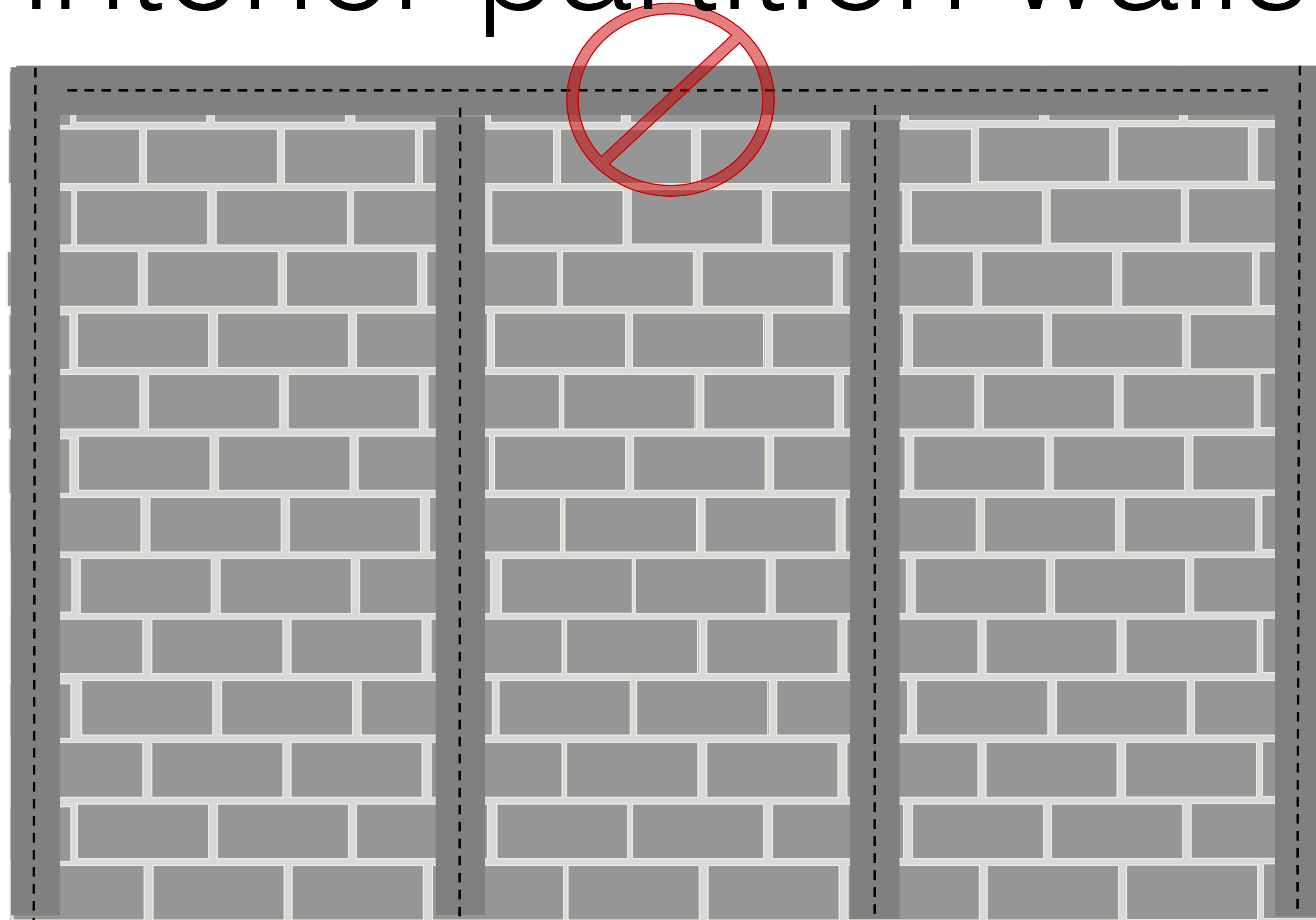


f'm=2500psi, mortar cement
IBC min load - 5 psf service, 8 psf factored/ultimate loading
SDC C

	10 ft	12 ft	14 ft	16 ft	18 ft	20 ft	24 ft	30 ft
6 inch	#4@120	#4@120	#4@120	#4 @ 96	#4 @ 96	#4 @ 72	#4 @ 40	#5 @ 24
8 inch	#4@120	#4@120	#4@120	#4@120	#4@120	#4 @ 96	#5 @ 96	#5 @ 48
10 inch	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120	#4 @ 96
12 inch	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120	#4 @ 96
16 inch	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120	#4@120

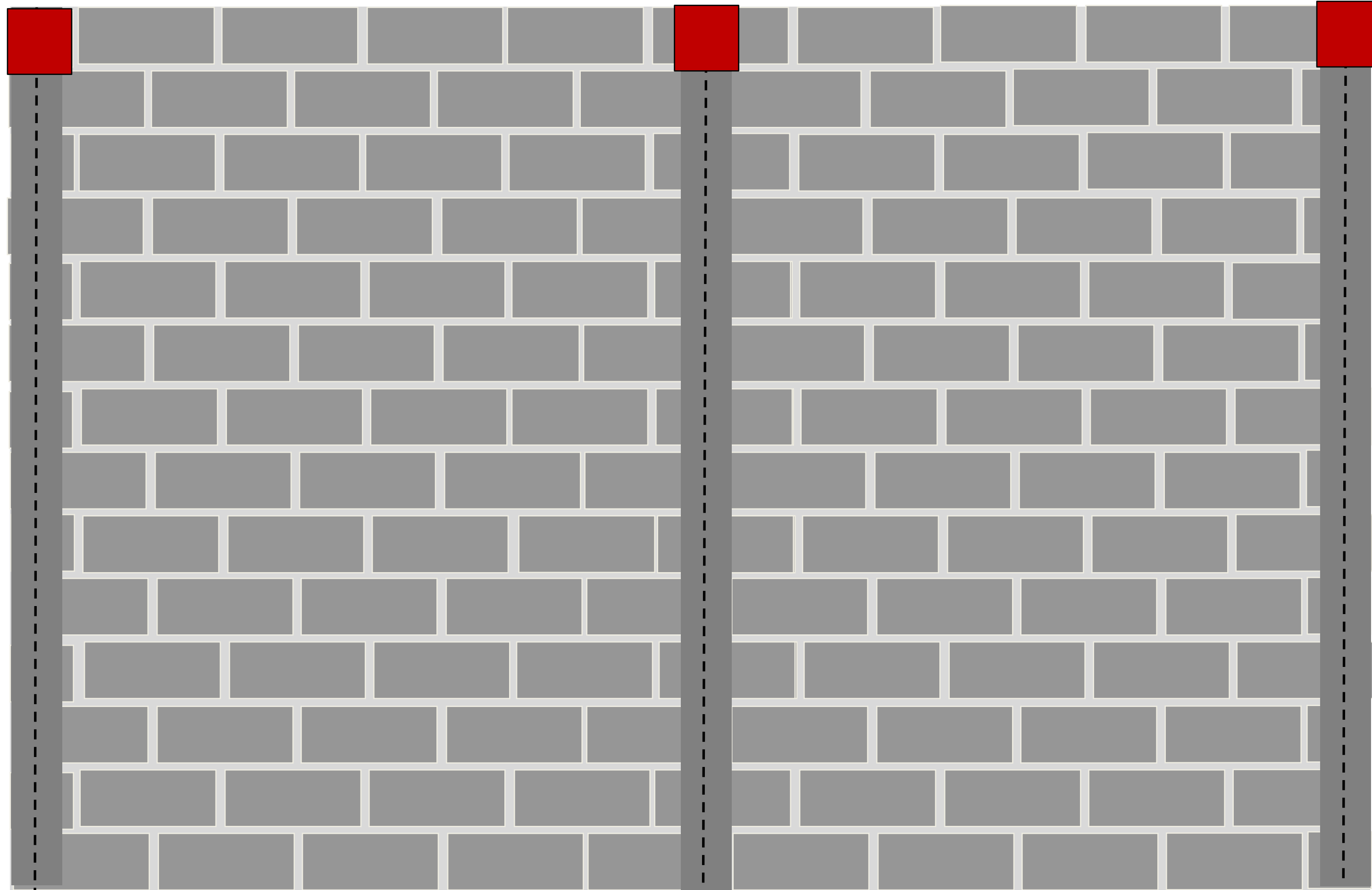


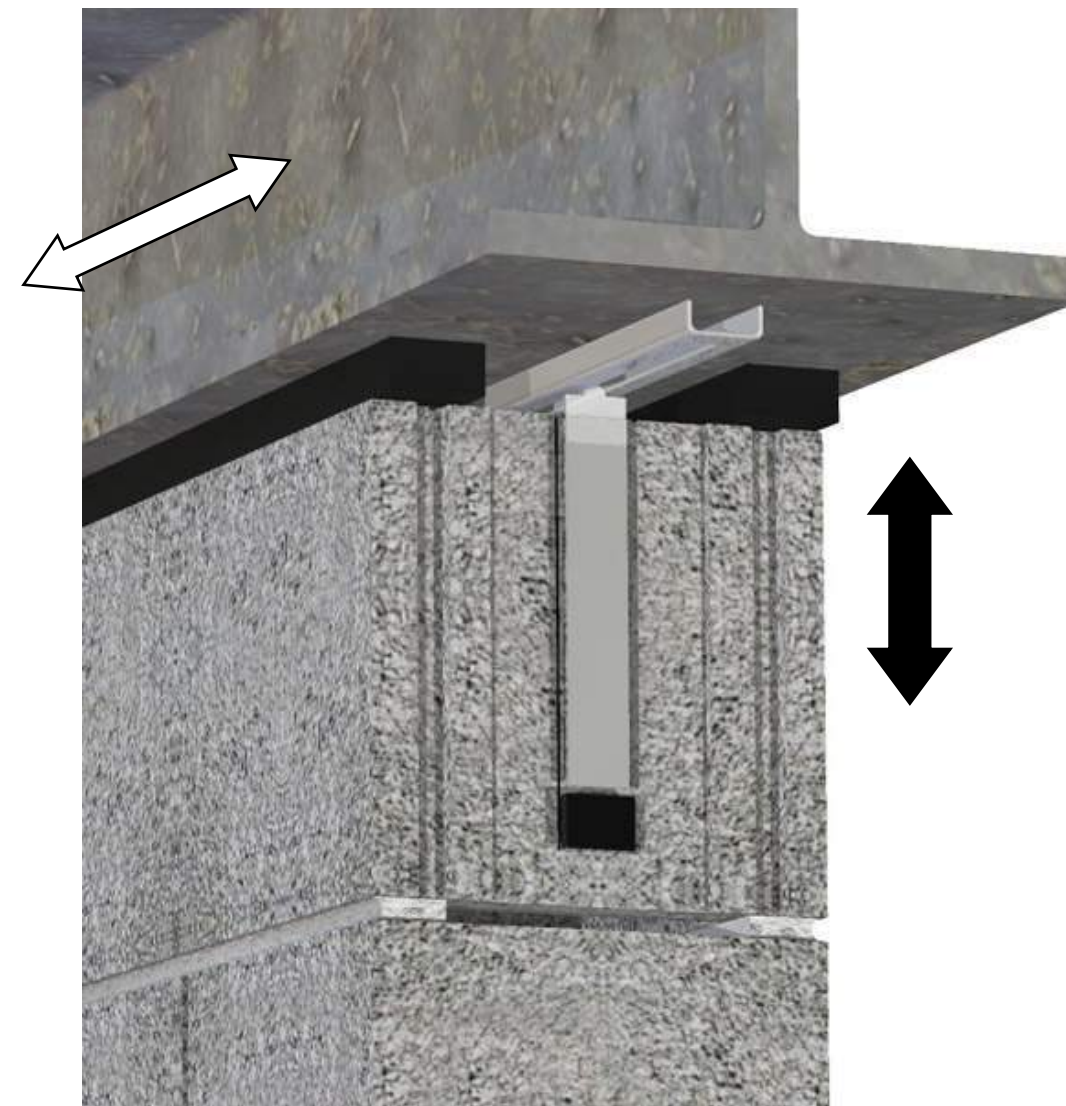
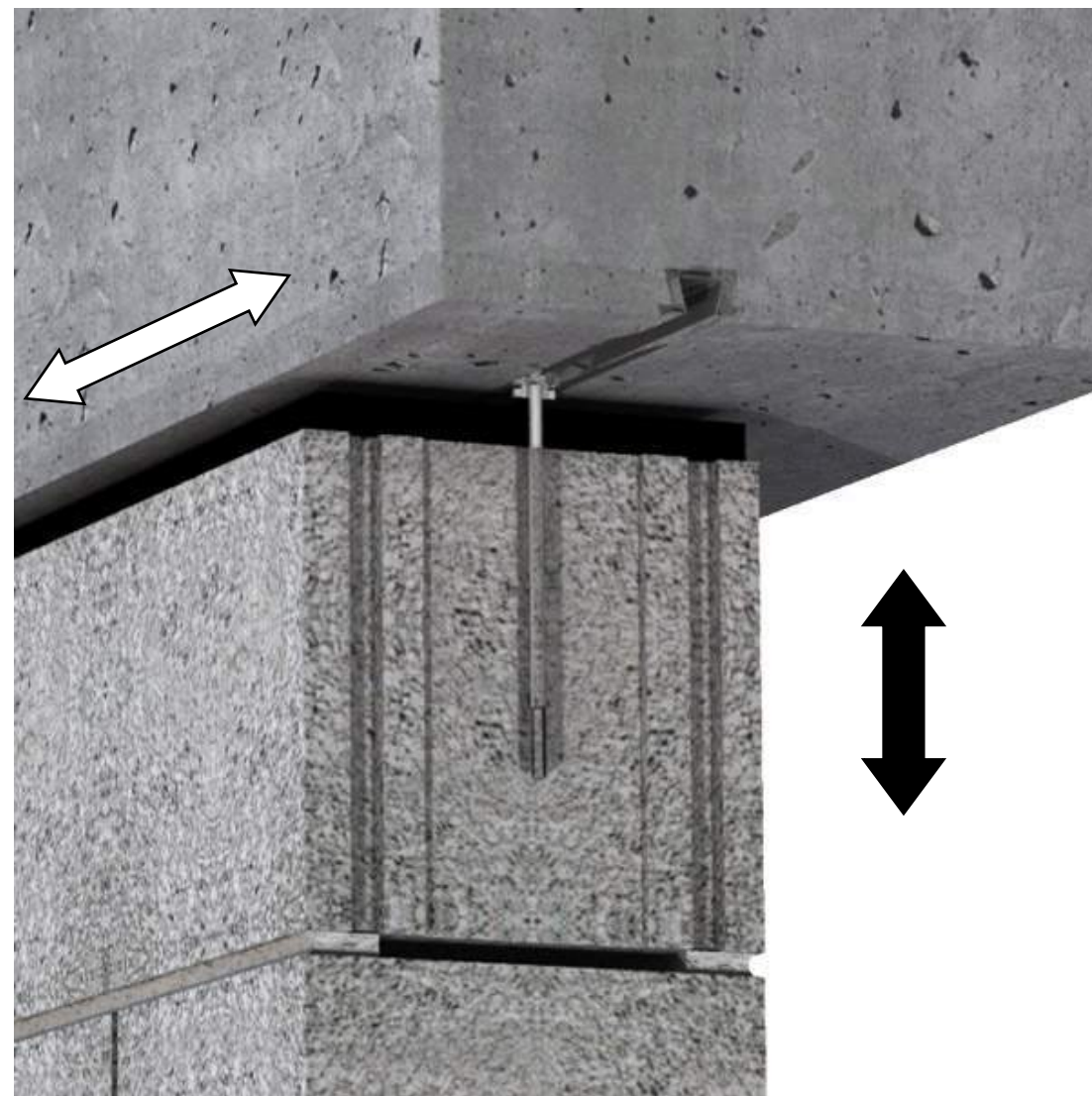
interior partition walls



interior partition walls

option: connect @ reinforced cells



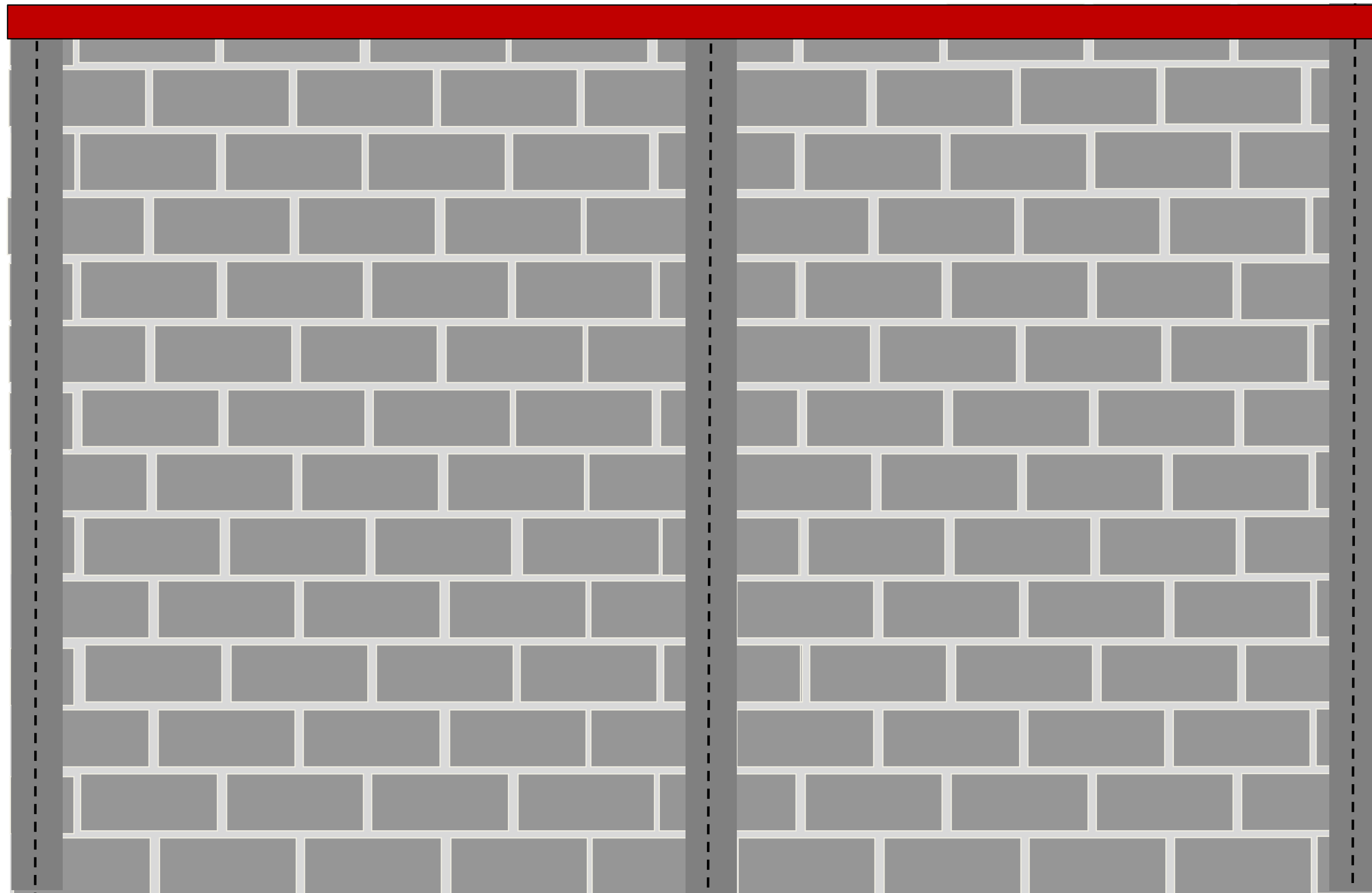


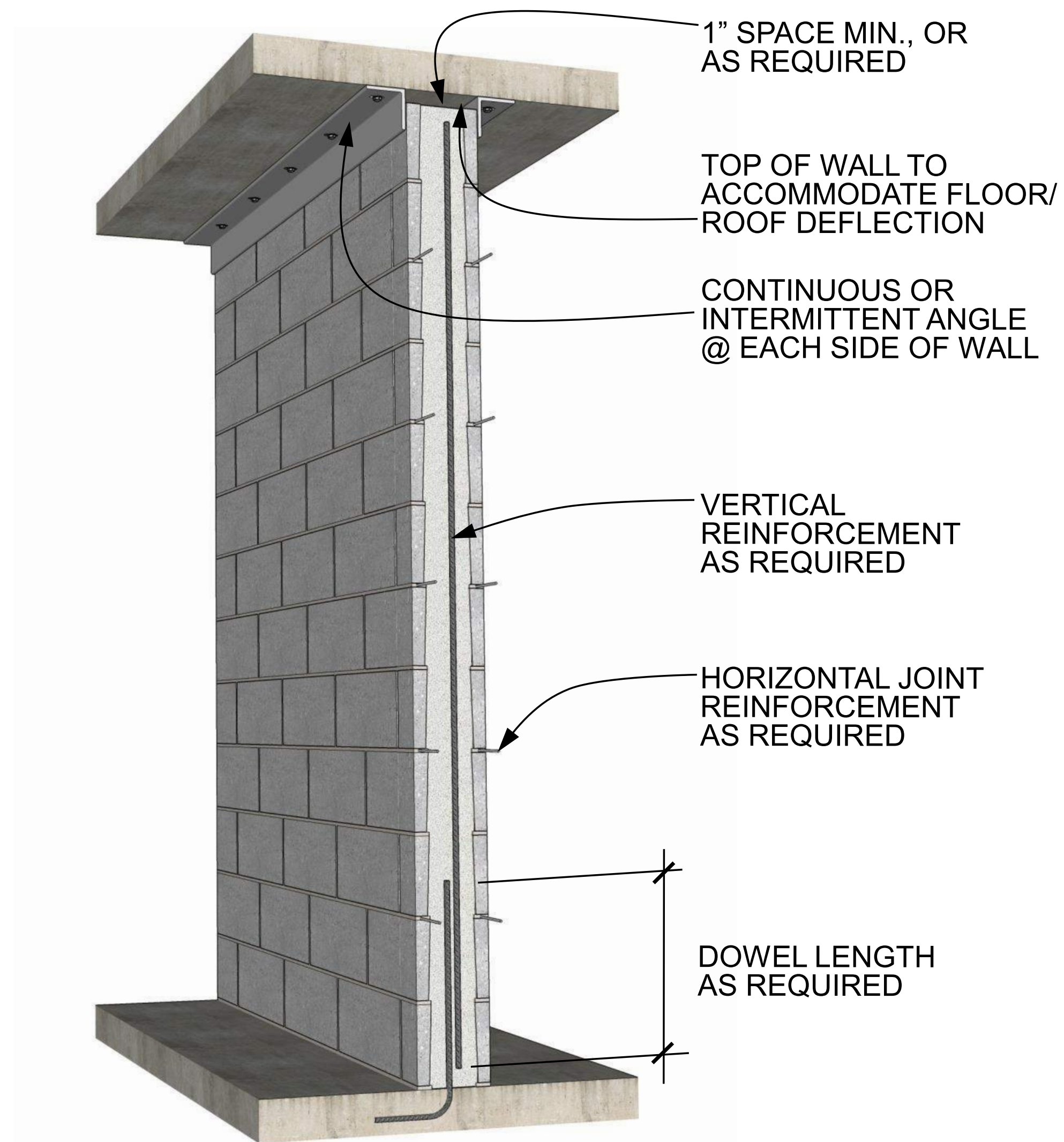
Partition Top Anchors (PTA)

source: www.h-b.com

interior partition walls

another option: light-gauge continuous angle





2D VIEW

NOTES:

REINFORCED WALL SHOWN;
UNREINFORCED WALL SIMILAR.

TOP & BOTTOM DETAILING MAY VARY.

VERTICAL SPAN

CMU PARTITION

DETAIL 02.020.0202

REV. 06/12/13

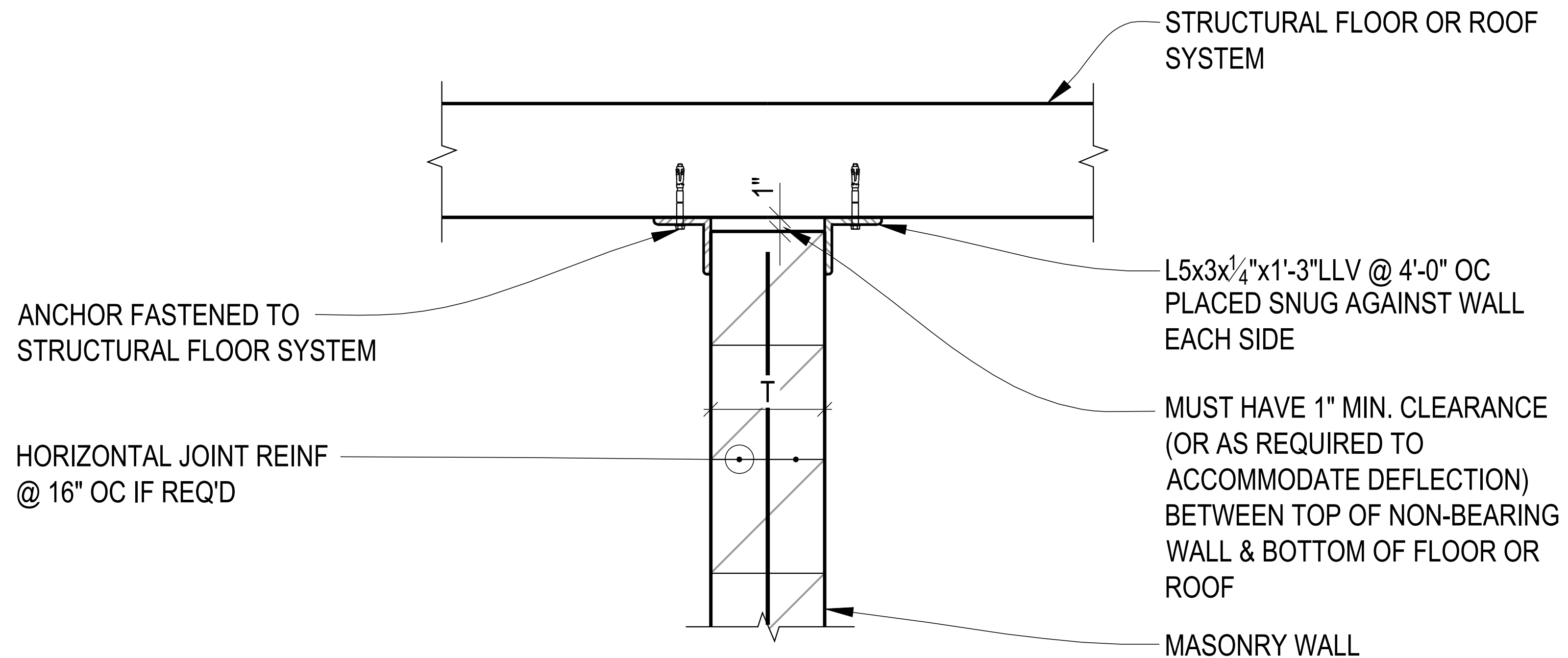
International Masonry Institute



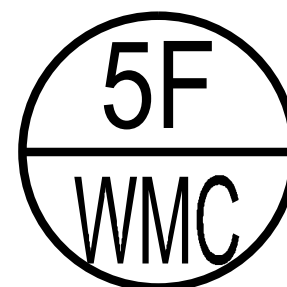
MASONRY
DETAILING
SERIES

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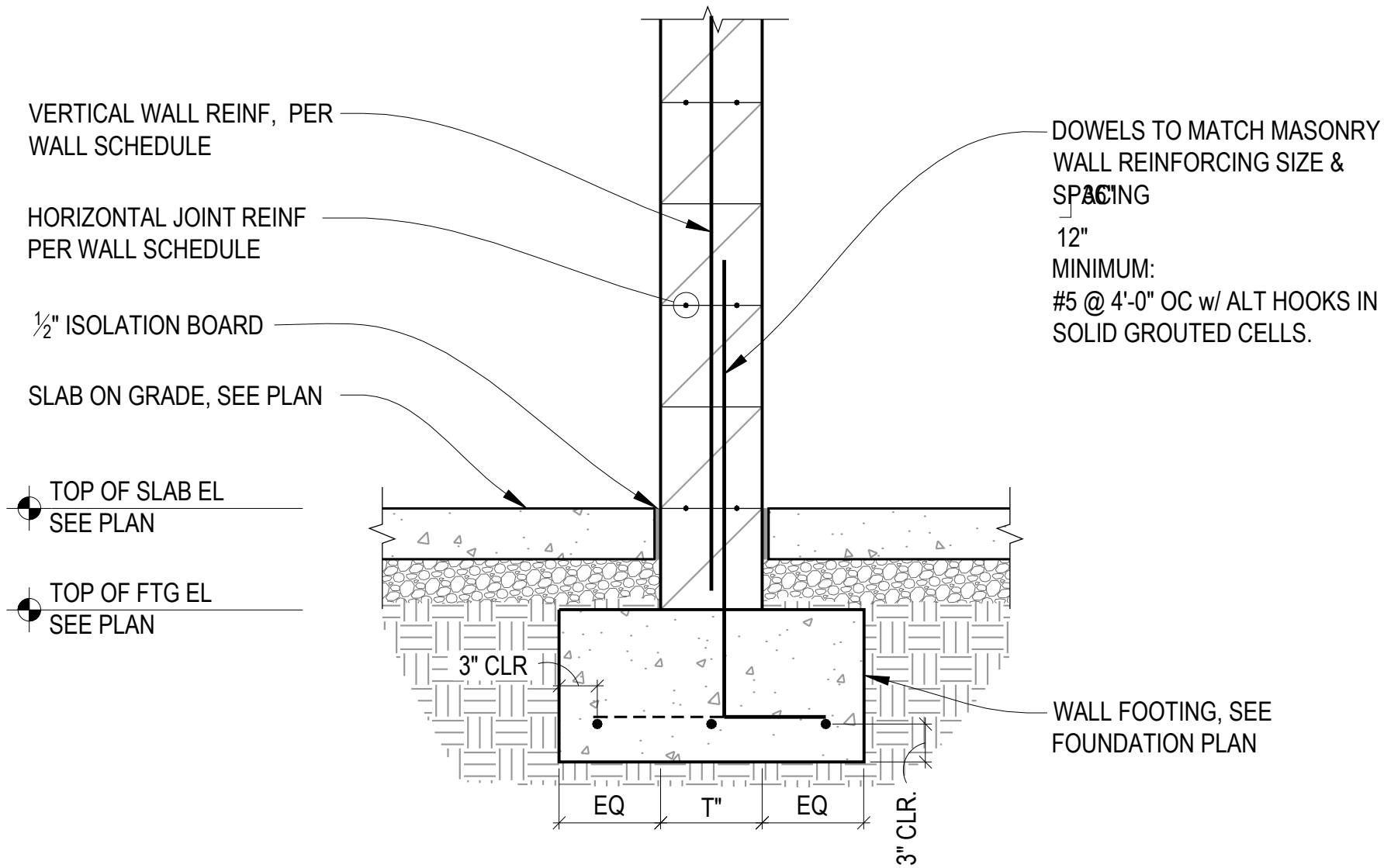




LATERAL SUPPORT OF NON-LOAD BEARING MASONRY PARTITION



SCALE : NTS

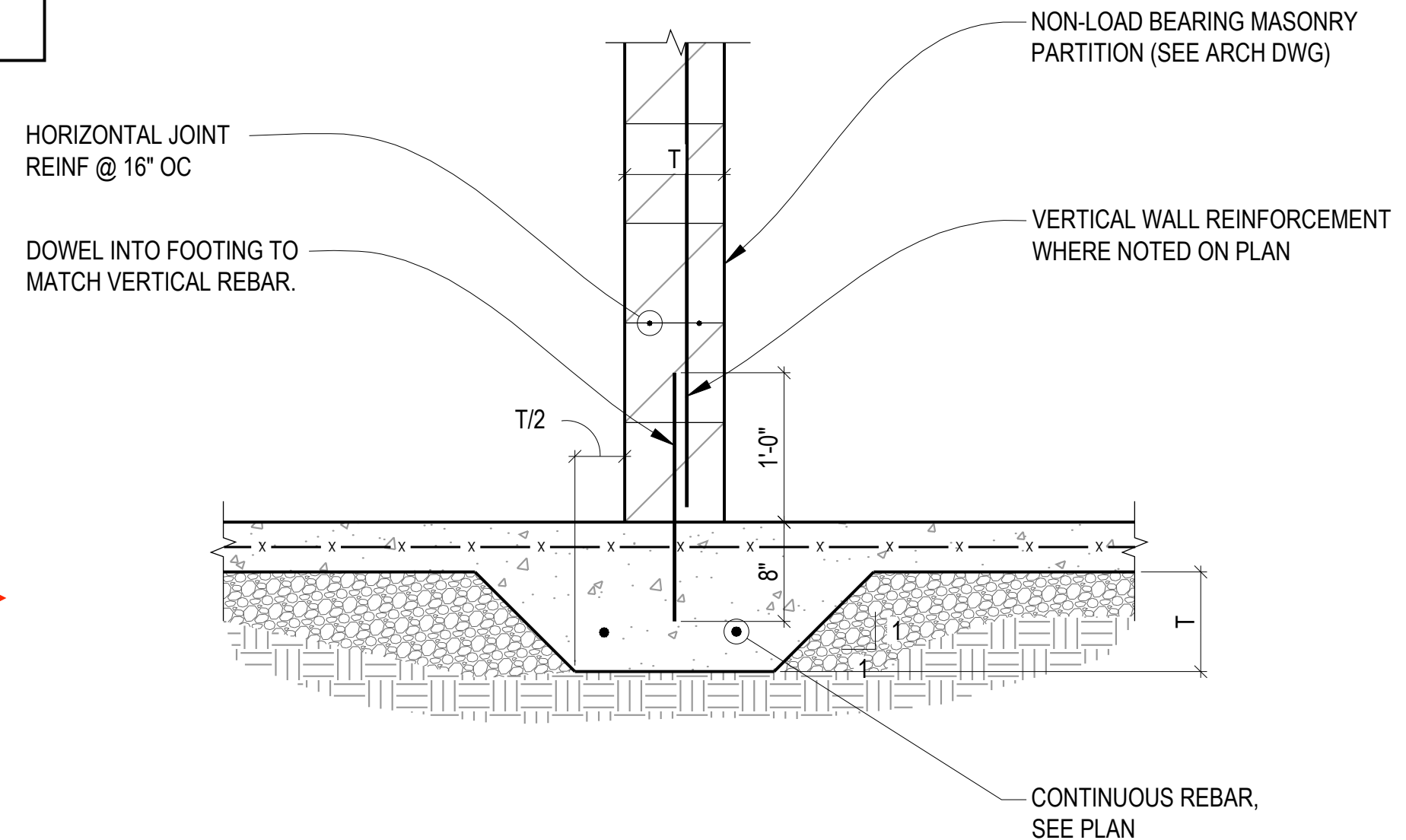


5C
WMC

INTERIOR MASONRY WALL

SCALE : NTS

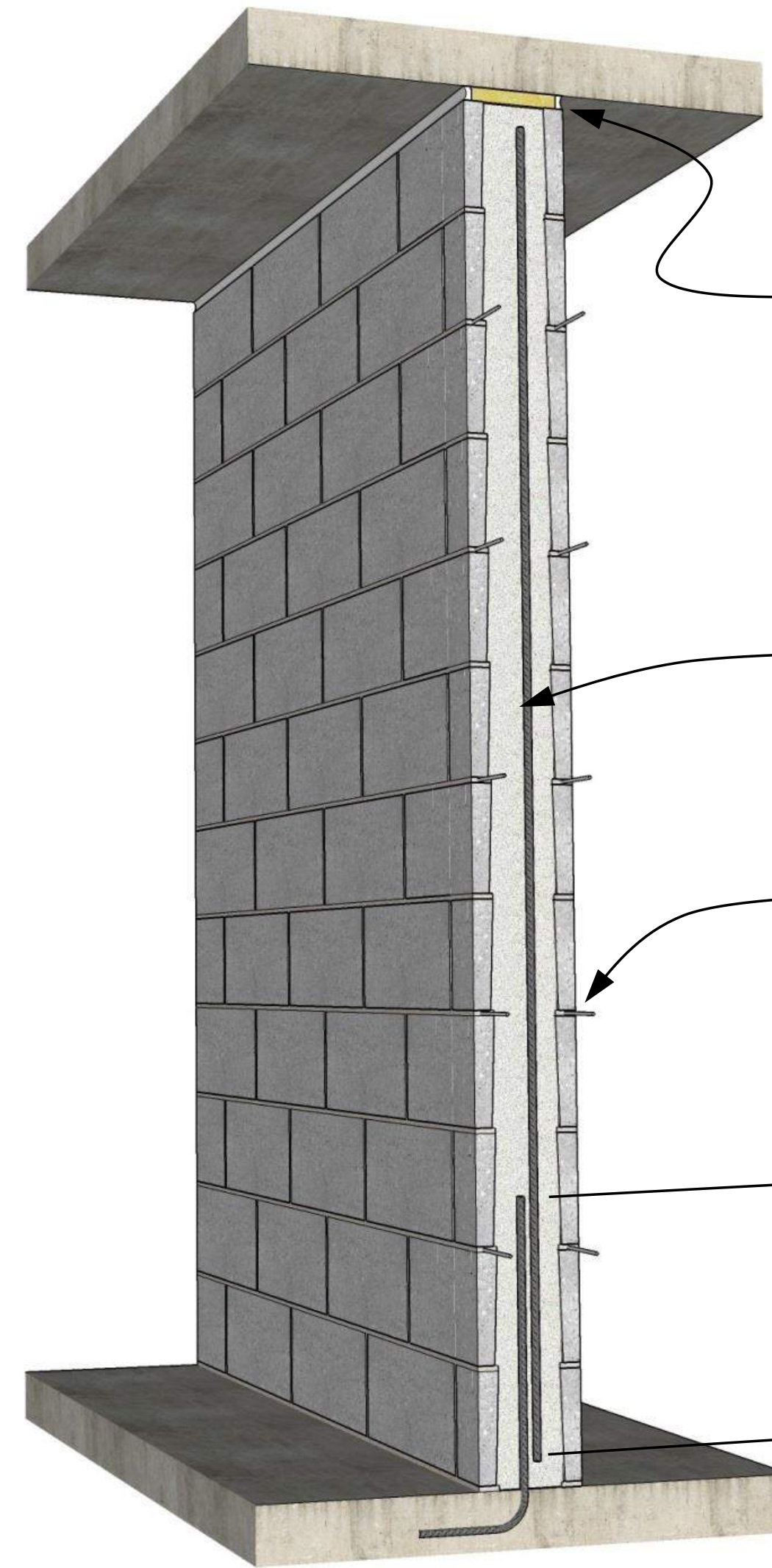
Preferred, unless the wall is cantilevered



5E
WMC

INTERIOR MASONRY WALL THICKENED SLAB SECTION

SCALE : NTS

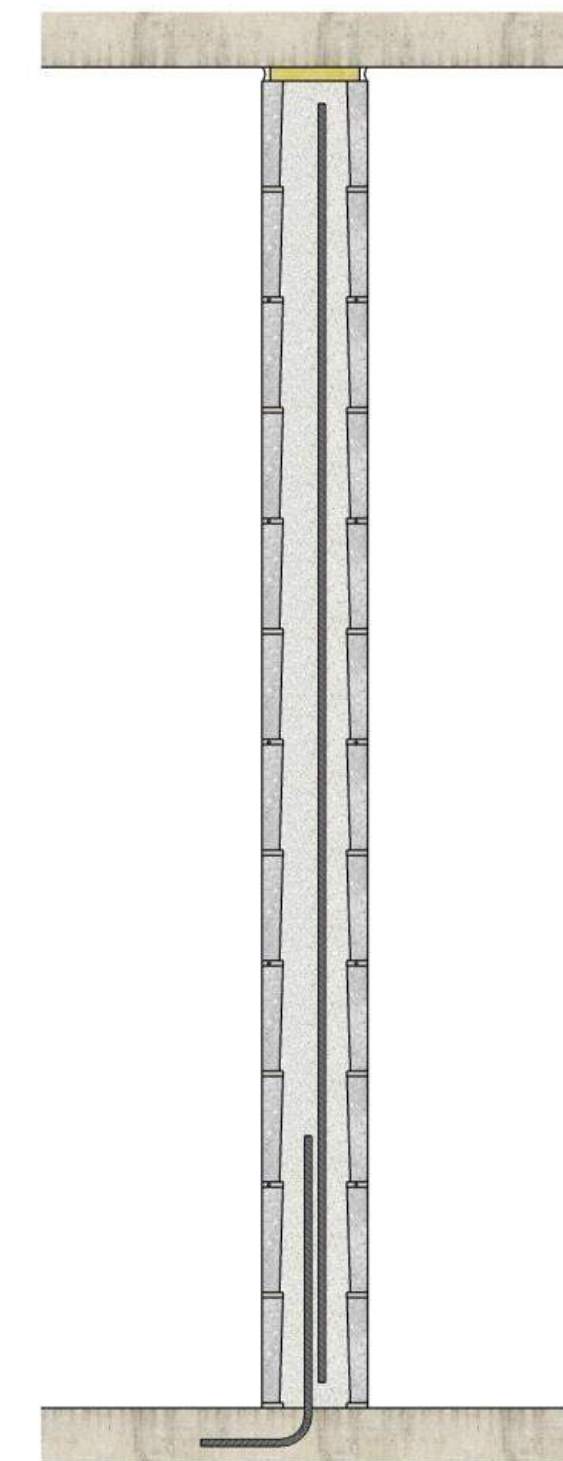


TOP OF WALL TO
ACCOMMODATE FLOOR/
ROOF DEFLECTION

VERTICAL
REINFORCEMENT
AS REQUIRED

HORIZONTAL JOINT
REINFORCEMENT
AS REQUIRED

DOWEL LENGTH
AS REQUIRED



2D VIEW

NOTES:

REINFORCED WALL SHOWN;
UNREINFORCED WALL SIMILAR.

TOP & BOTTOM DETAILING MAY VARY.

VERTICAL CANTILEVER WALL

DETAIL 02.020.0201

CMU PARTITION

REV. 06/10/13

International Masonry Institute

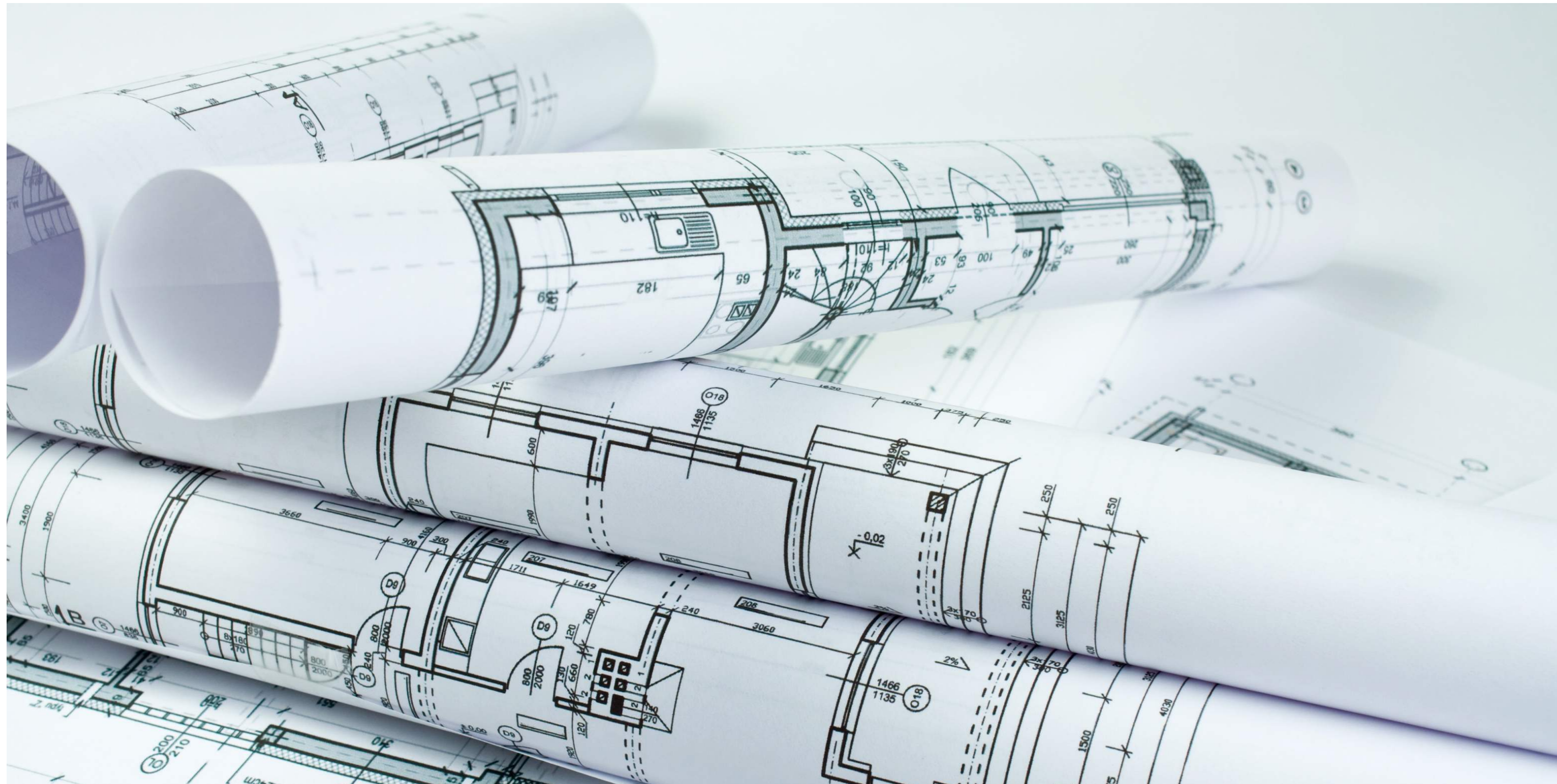


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Masons prefer to connect top of partition walls by...

1. Direct connection at reinforced/grouted cells
 - preferred
 - simplest, cheapest option, no top of wall bond beam required
2. Continuous angle at top of wall
 - small angle size, small connector, no bond beam
3. intermittent heavy angle, non-coordinated top of wall connection
 - not preferred
 - heavy angle, heavy connector, hard to place bond beam



CONNECTIONS TO MASONRY AND WITHIN MASONRY

MSJC and IBC bar
development, lap length

$$l_d = \frac{0.13 d_b^2 f_y \gamma}{K \sqrt{f'_m}} \leq 72 d_b$$

SPLICE LENGTHS

MSJC Equations & IBC SD requirements

Lap length **INCREASES** as:

- Bar size increases,
- Cover or distance between bars decreases

Lap length **DECREASES** as:

- Bar size decreases,
- Cover or distance between bars increases,
- Masonry compressive strength increases

- options to avoid long lap lengths:
 - Use smaller diameter bars at closer spacing.
 - Cover distance is key – maximize cover for minimum lap lengths.
 - Minimize laps by permitting higher grout lifts
 - Use specified f'_m , not just minimum value...

reduce splice length when appropriate

- use specified f'_m , not just minimum value...

Example:

8" CMU, single bar centered, grade 60 steel

IBC 2009 Strength Design provisions

	$f'_m = 1500\text{psi}$	$f'_m = 2000\text{ psi}$	$f'_m = 2500\text{ psi}$	$f'_m = 3000\text{ psi}$
#4	12"	12"	12"	12"
#5	22"	19"	17"	16"
#6	43"	37"	33"	30"

ASTM C90 minimum unit
compressive strength,
Type S mortar

Using actual f'_m for project



reduce splice length when appropriate

- use specified f'_m , not just minimum value...

Example:

8" CMU, single bar centered, grade 60 steel

IBC 2009 Strength Design provisions

	$f'_m = 1500\text{psi}$	$f'_m = 2000\text{ psi}$	$f'_m = 2500\text{ psi}$	$f'_m = 3000\text{ psi}$
#4	2 courses	2 courses	2 courses	2 courses
#5	3 courses	3 courses	3 courses	2 courses
#6	6 courses	5 courses	5 courses	4 courses

spreadsheet for determining lap lengths

thickness:	8 inches				reinf spacing:	16 inches	
f'm:	2250 psi				position:	centered	
Bar	db	l_d	f_y	γ	K	f'_m	
#3	0.375	12 inches	60000 psi	1	3.375	2250 psi	
#4	0.5	12 inches	60000 psi	1	3.5625	2250 psi	
#5	0.625	18 inches	60000 psi	1	3.5	2250 psi	
#6	0.75	35 inches	60000 psi	1.3	3.4375	2250 psi	
#7	0.875	48 inches	60000 psi	1.3	3.375	2250 psi	
#8	1	74 inches	60000 psi	1.5	3.3125	2250 psi	
#9	1.125	96 inches	60000 psi	1.5	3.25	2250 psi	

REMEMBER THE SCHEDULE

MASONRY WALL SCHEDULE				
MARK	THICKNES S	VERTICAL REINFORCEMENT		NOTES
		BAR(S)@SPACING	LAP DISTANCE	
W1	8"	1-#4 @ 64" O.C.	12 inches	
W2	8"	1-#6 @ 32" O.C.	33 inches	
W3	8"	2-#4 @ 24" O.C.	20 inches	
W4	8"	1-#7 @ 8" O.C.	46 inches	
W5	12"	1-#6 @ 32" O.C.	21 inches	

$f'_m = 2500 \text{ psi}$

WHEN TO CONSIDER SPLICES INSTEAD?



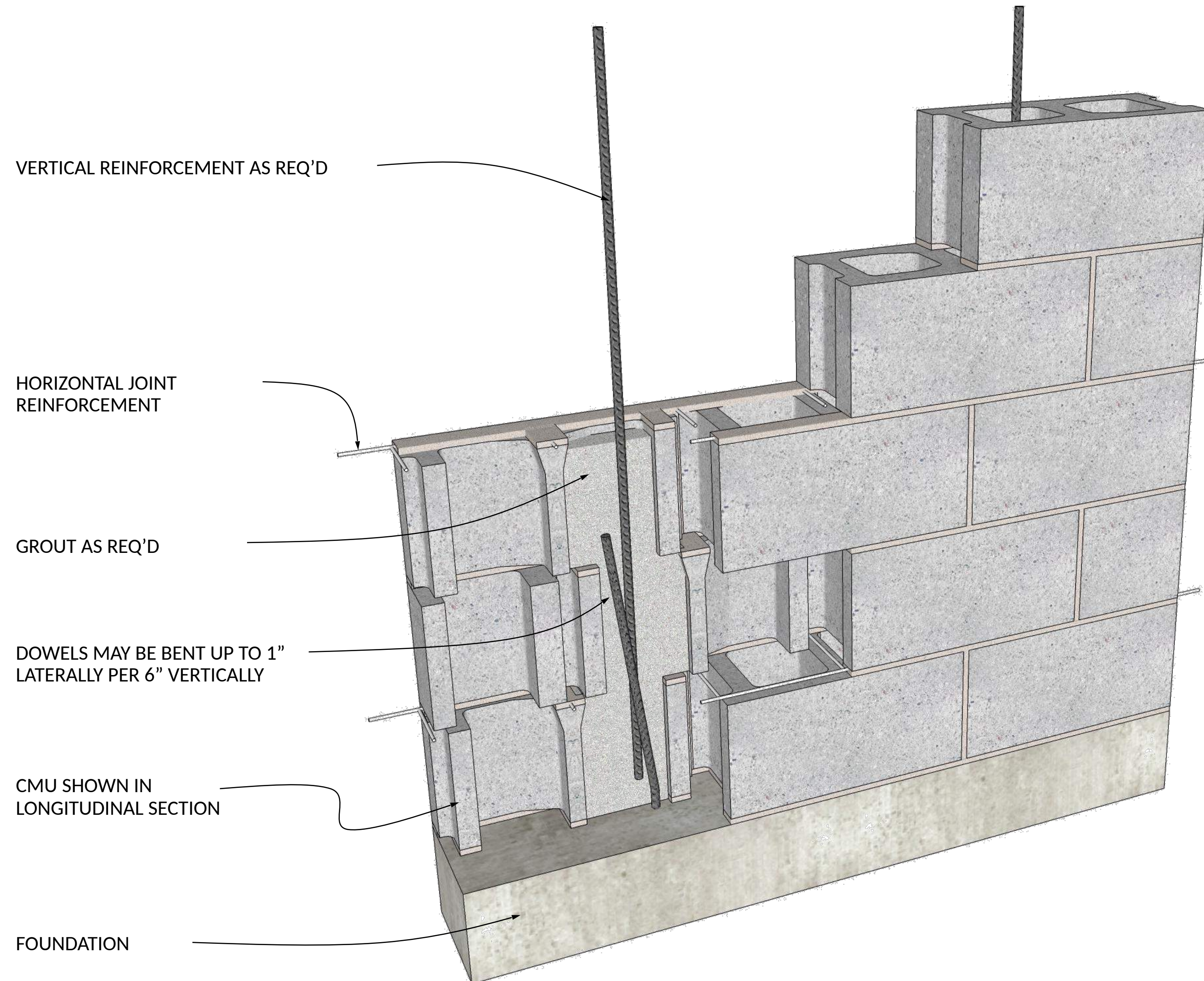
MSJC/IBC additional requirements for splices

- ASTM A706 steel is required for welded lap splices
- if used, mechanical splices must comply with ACI 318 Type 1 or 2 mechanical splices
- couplers (threaded) or welded splices must develop develop $1.25 f_y$



couplers w/ threaded 5'-0" rebar

FOUNDATION LAPS AND ALIGNMENT



include splice lengths in project documents

Question: Why should the splice lengths and locations be included on the project drawings?

Answer: The design professional has the information necessary to calculate lap lengths, the contractor does not. Contractors cannot be expected to know which lap length equation is applicable nor the variables that are included in some lap splice equations.

Consider that laps may vary based on:

- Bar diameter

- Design method (ASD or SD)

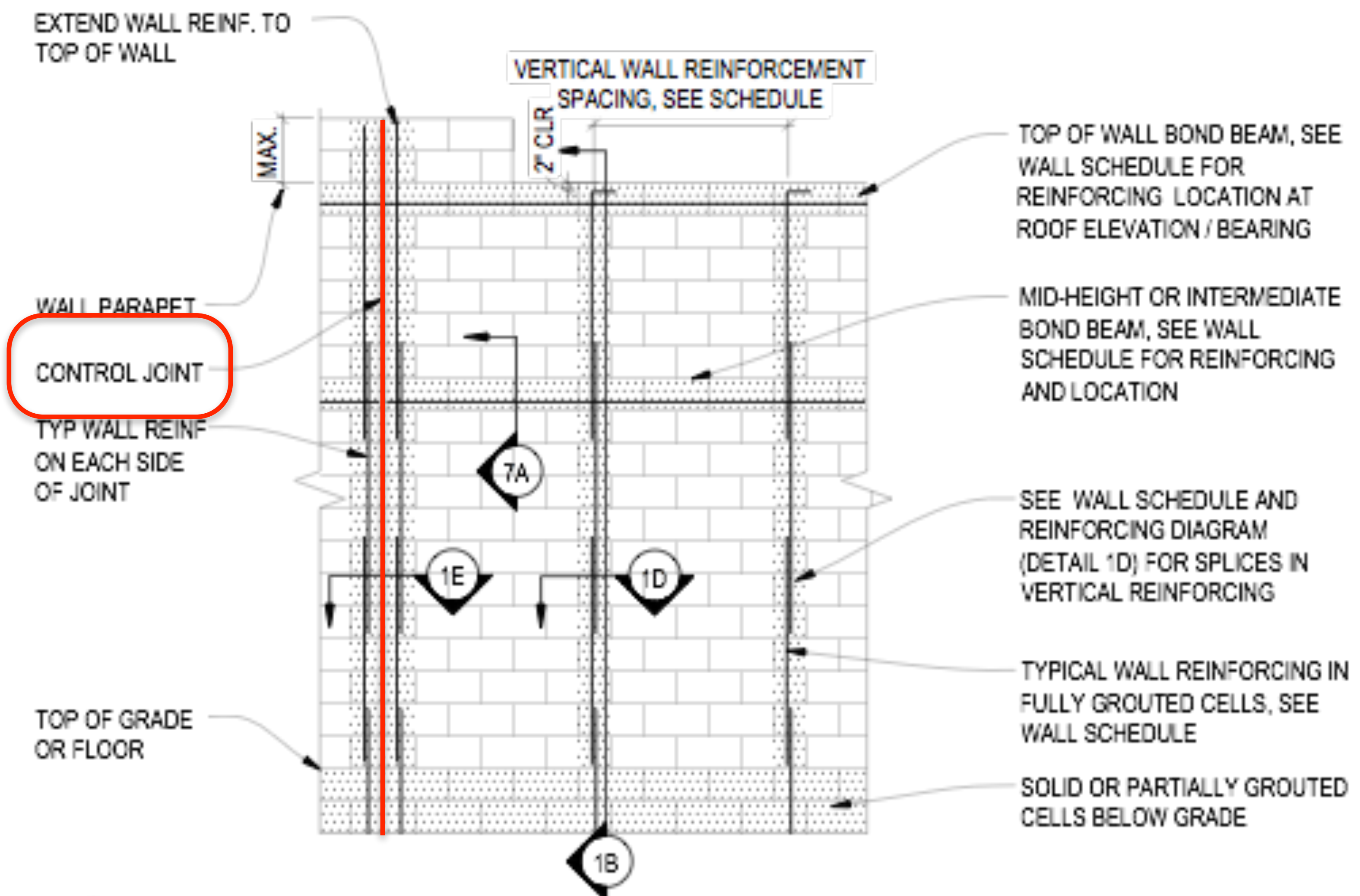
- Locally adopted building code

- Specified cover

- Specified f'_m

- and more...





1A
WMC

TYPICAL MASONRY WALL REINFORCING ELEVATION

SCALE : 1/4" = 1'-0"

PROVIDE VERTICAL REINF. IN FIRST
CELL EACH SIDE OF CONTROL JOINT
MATCH TYPICAL WALL REINF. BAR SIZE
AND NUMBER WITH IN CELL

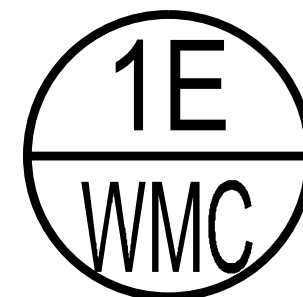
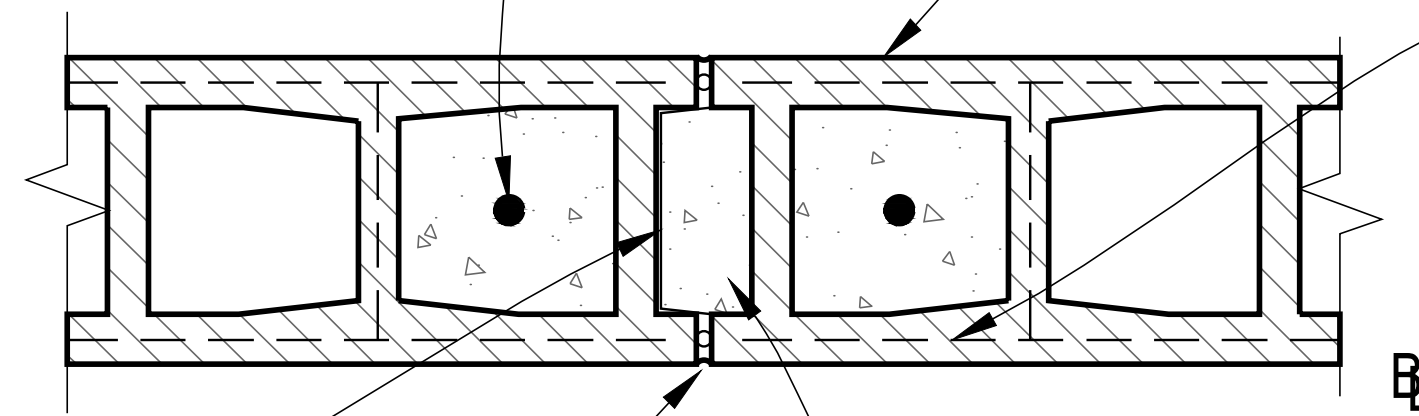
VERT. GROUT, AND REINF. BARS SHALL BE
CONTINUOUS AT CONTROL JOINTS, FROM BOND
BEAM AT ROOF, DOWN TO TOP OF FOOTING.

TERMINATE ALL HORIZONTAL
REINFORCEMENT AT CONTROL
JOINT, EXCEPT AT ROOF
ELEVATION AND TOP OF WALL.

BUILDING PAPER

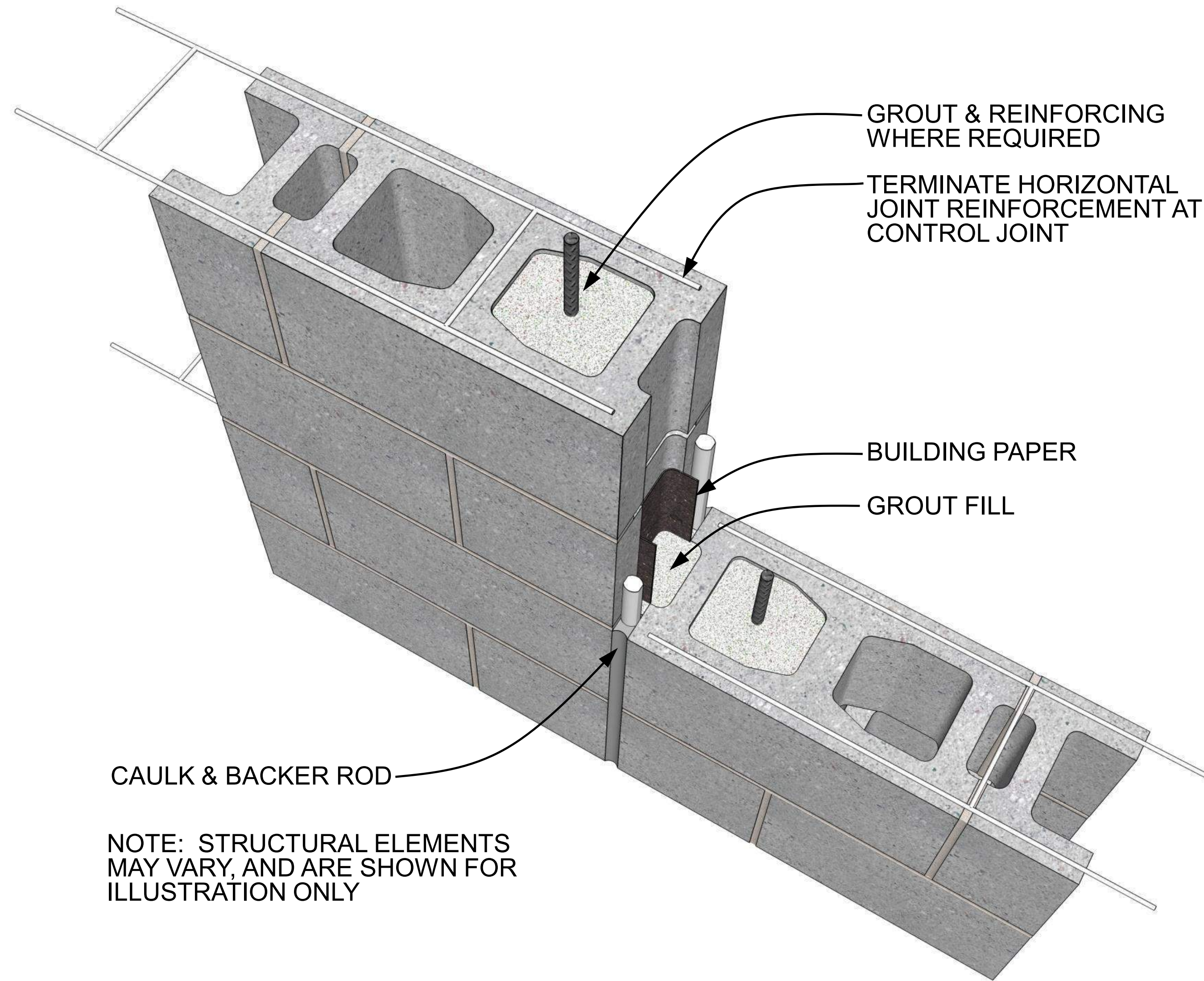
CONTROL JOINT PER ARCH. SHEETS

GROUT FILL



TYPICAL CONTROL JOINT

SCALE : 1" = 1'-0"



CONTROL JOINT

DETAIL 02.010.1302

GROUT FILL

REV. 03/14/11

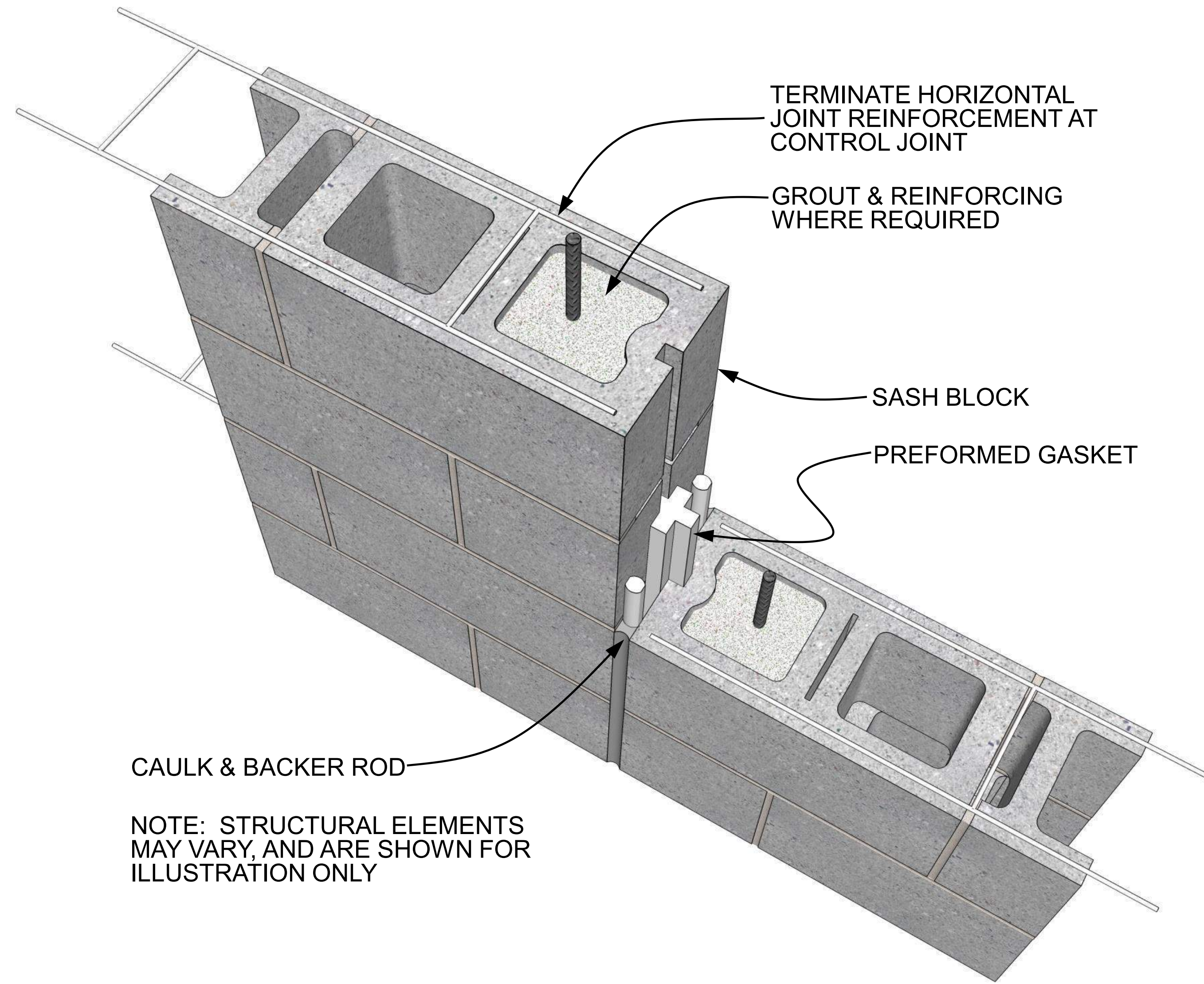
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NOTE: STRUCTURAL ELEMENTS
MAY VARY, AND ARE SHOWN FOR
ILLUSTRATION ONLY

CONTROL JOINT PREFORMED GASKET
DETAIL 02.010.1301 REV. 03/14/11

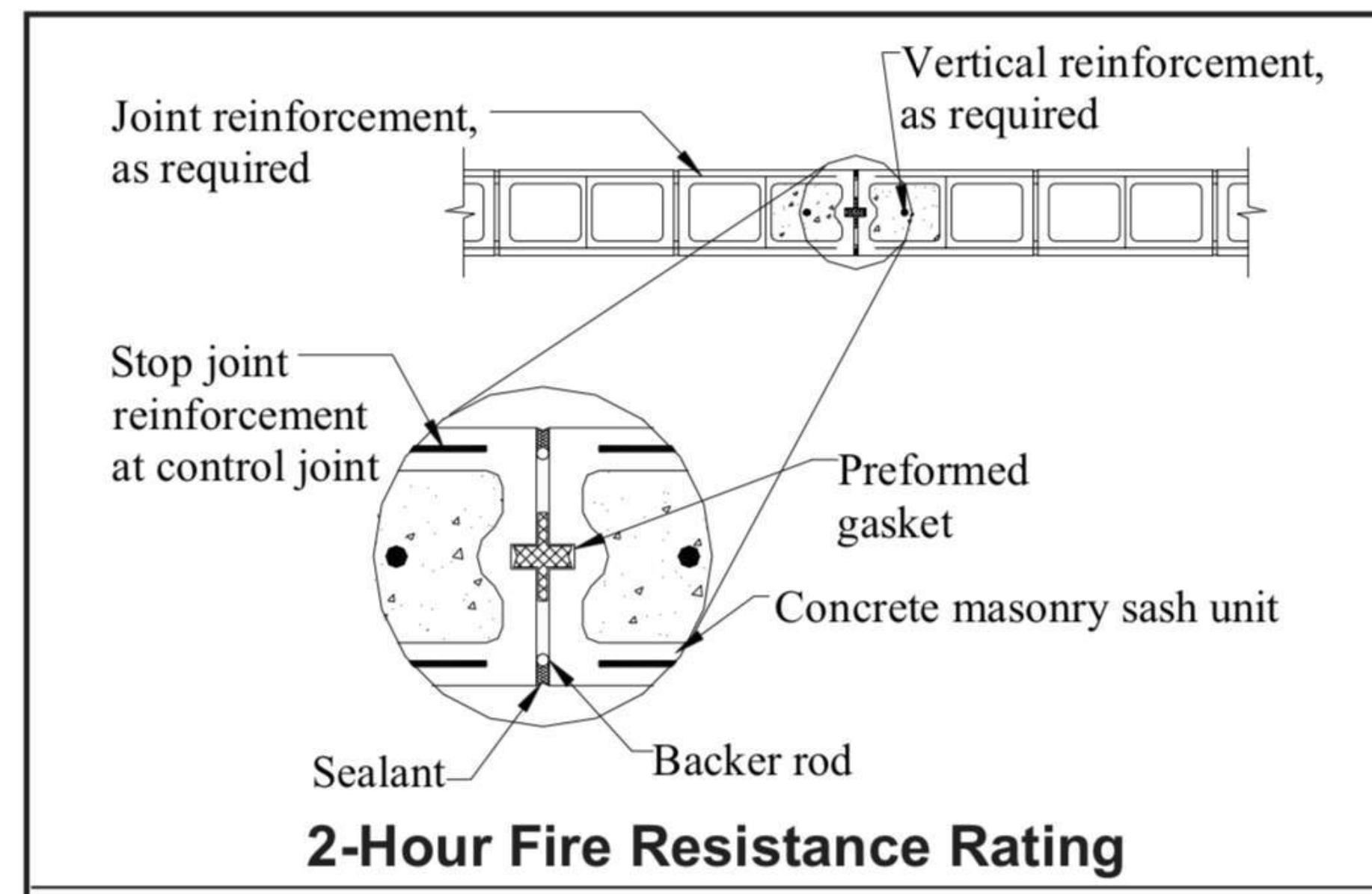
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FIRE RATING AT CJ

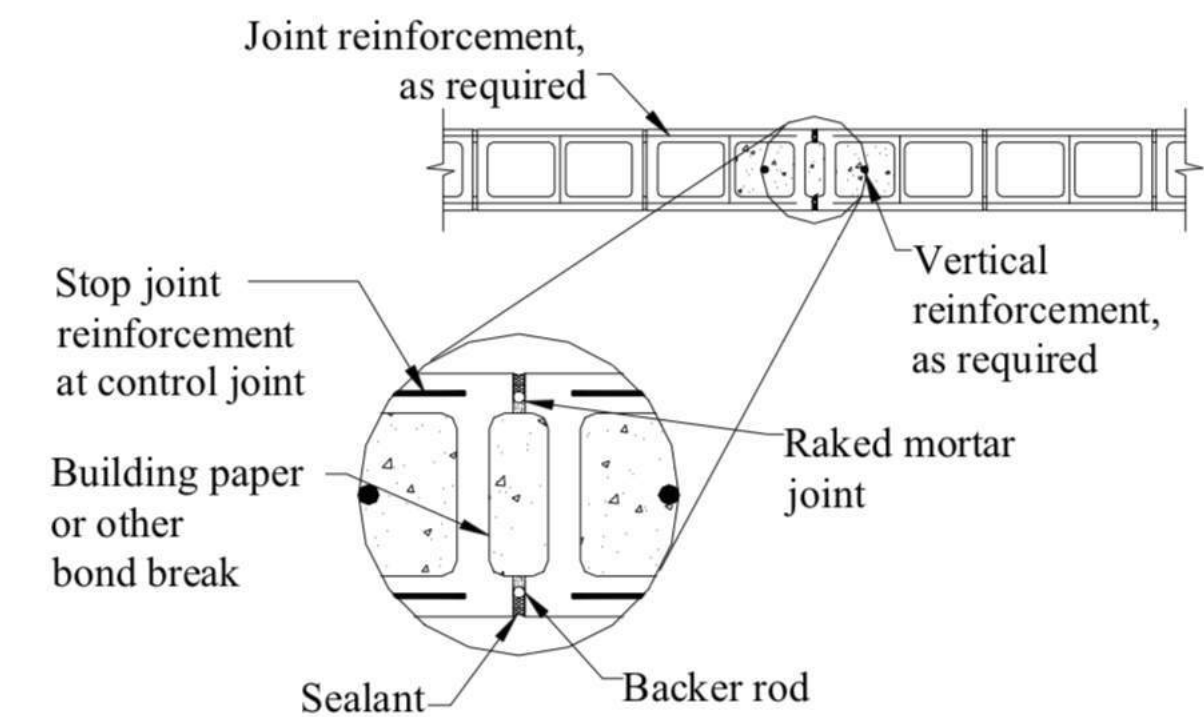
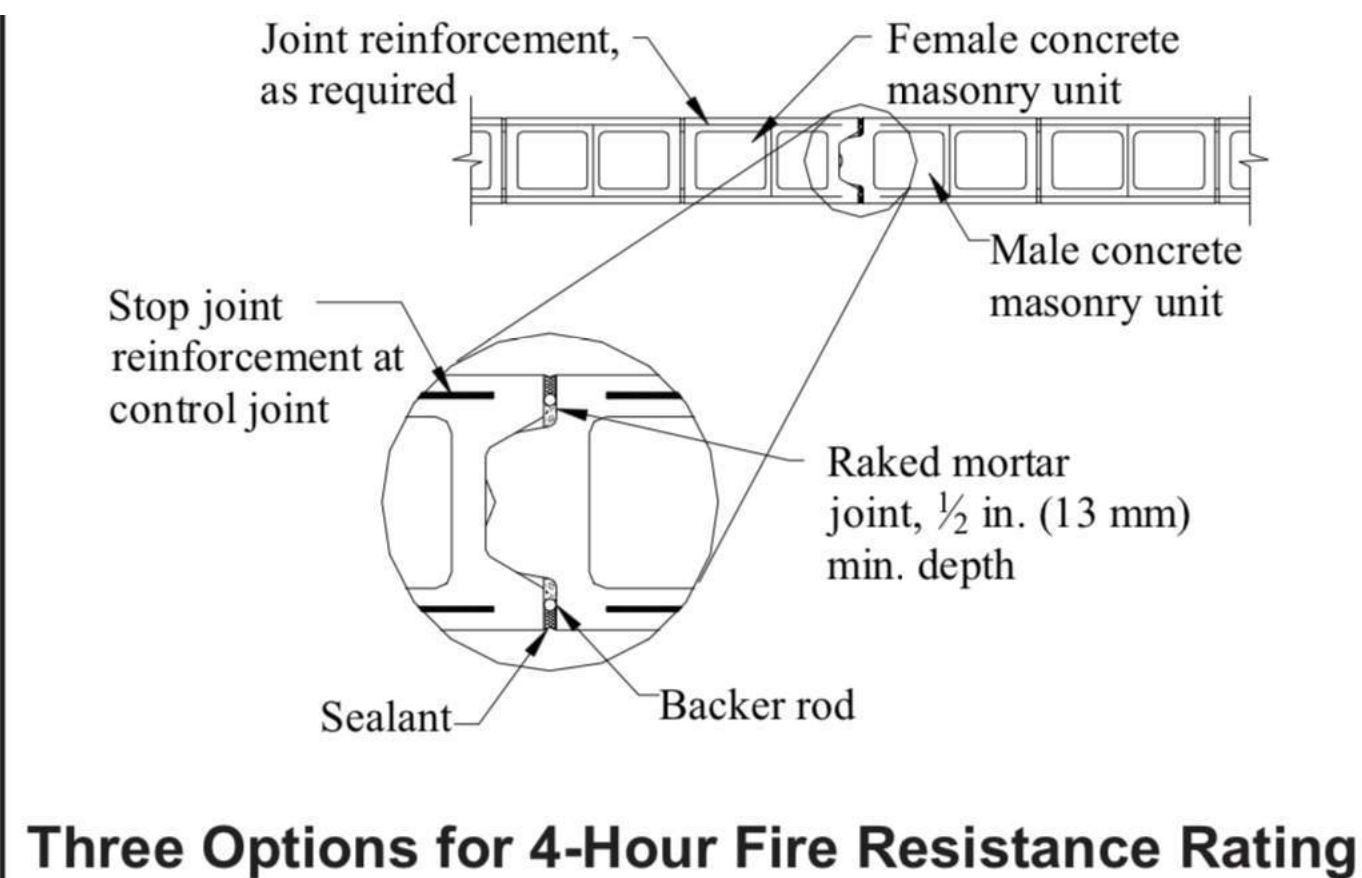
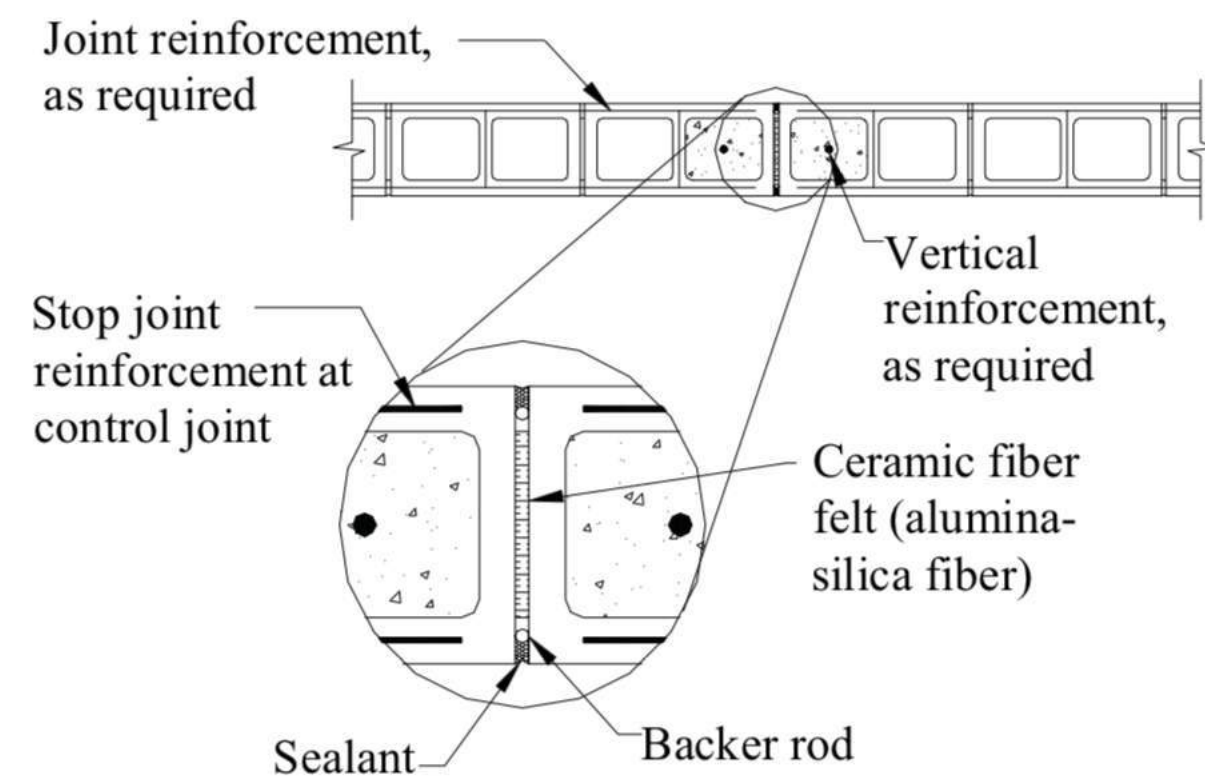
- Masonry Control Joints



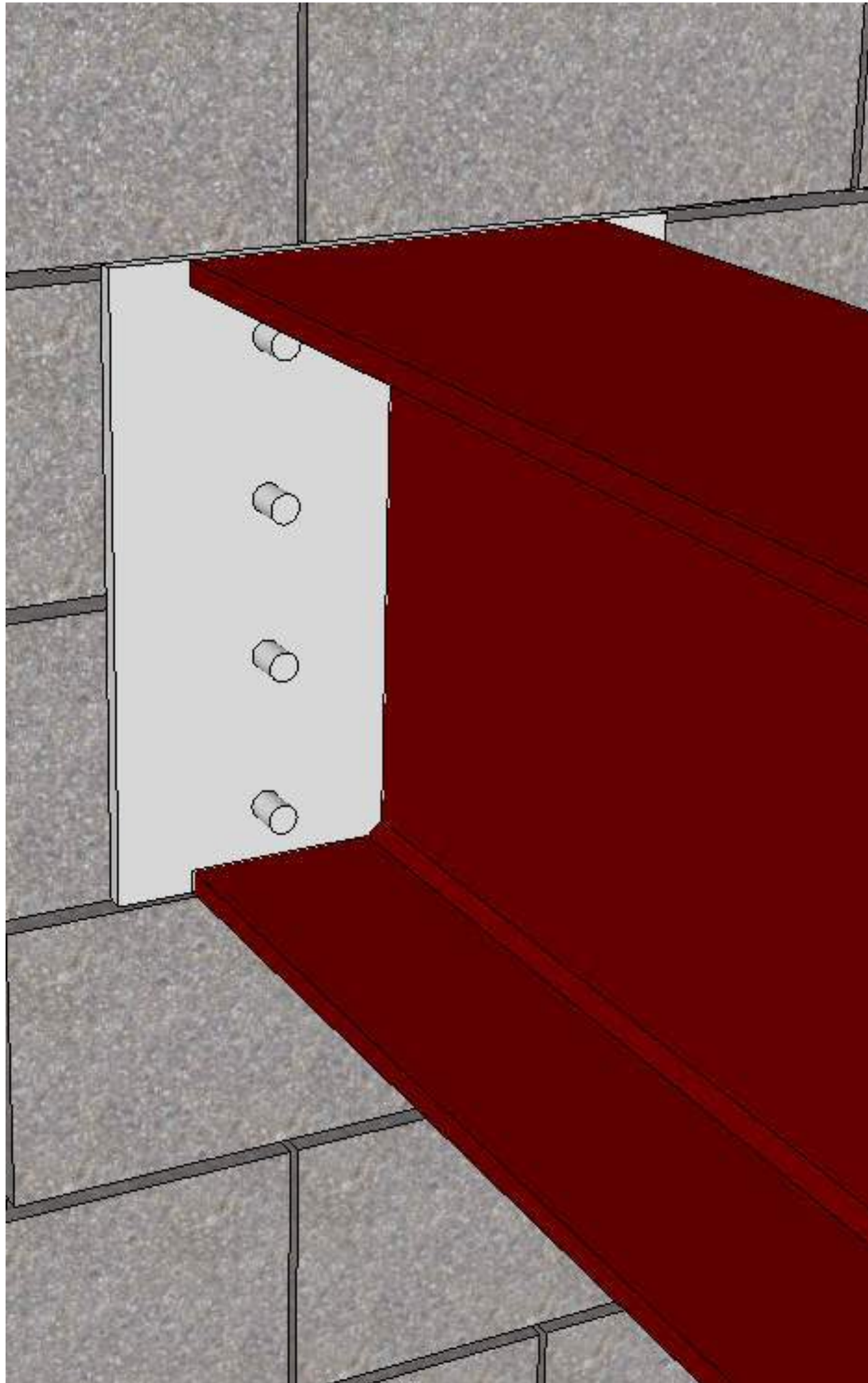
NCMA TEK 7-1C

FIRE RATING AT CJ

- Masonry Control Joints

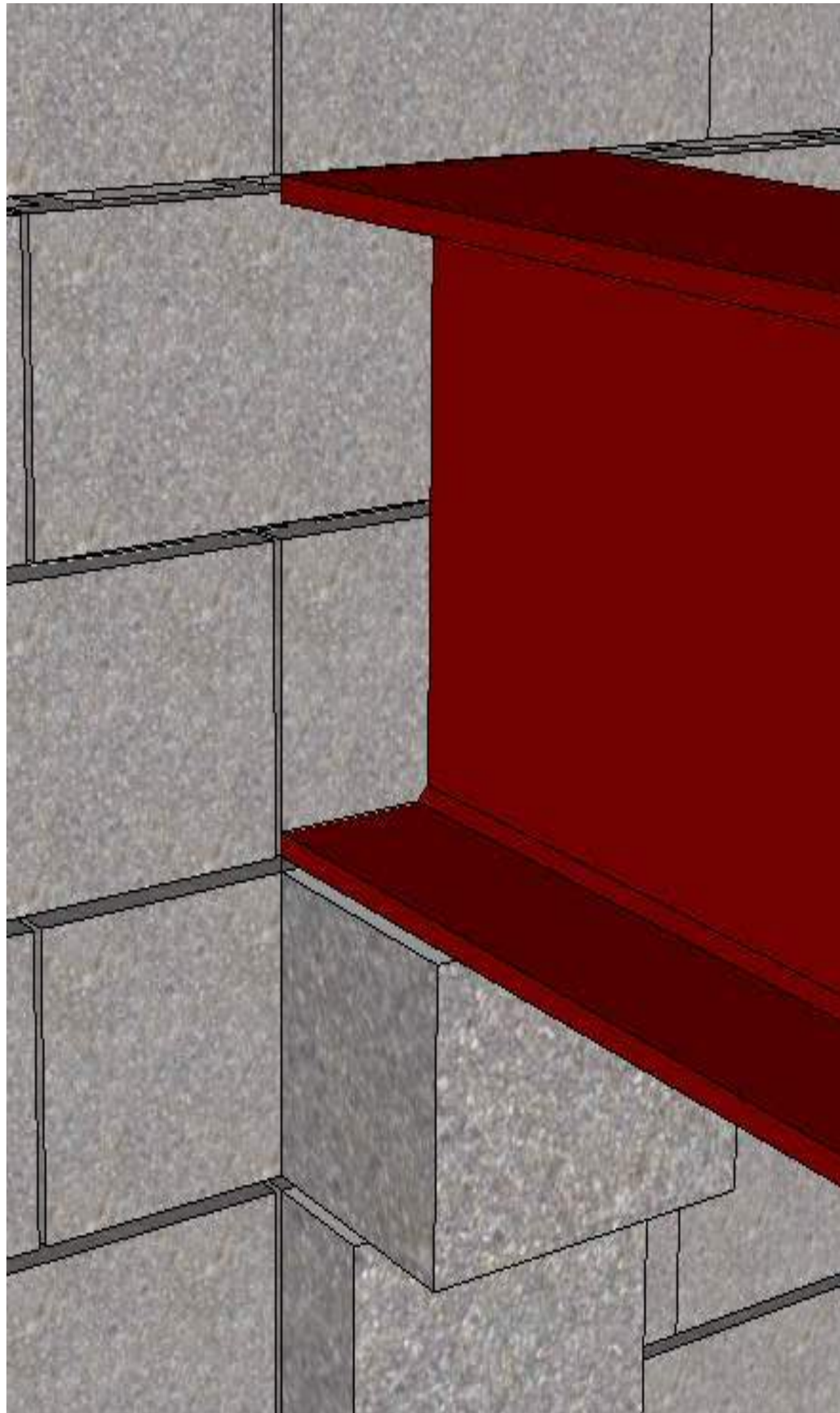


embed plates



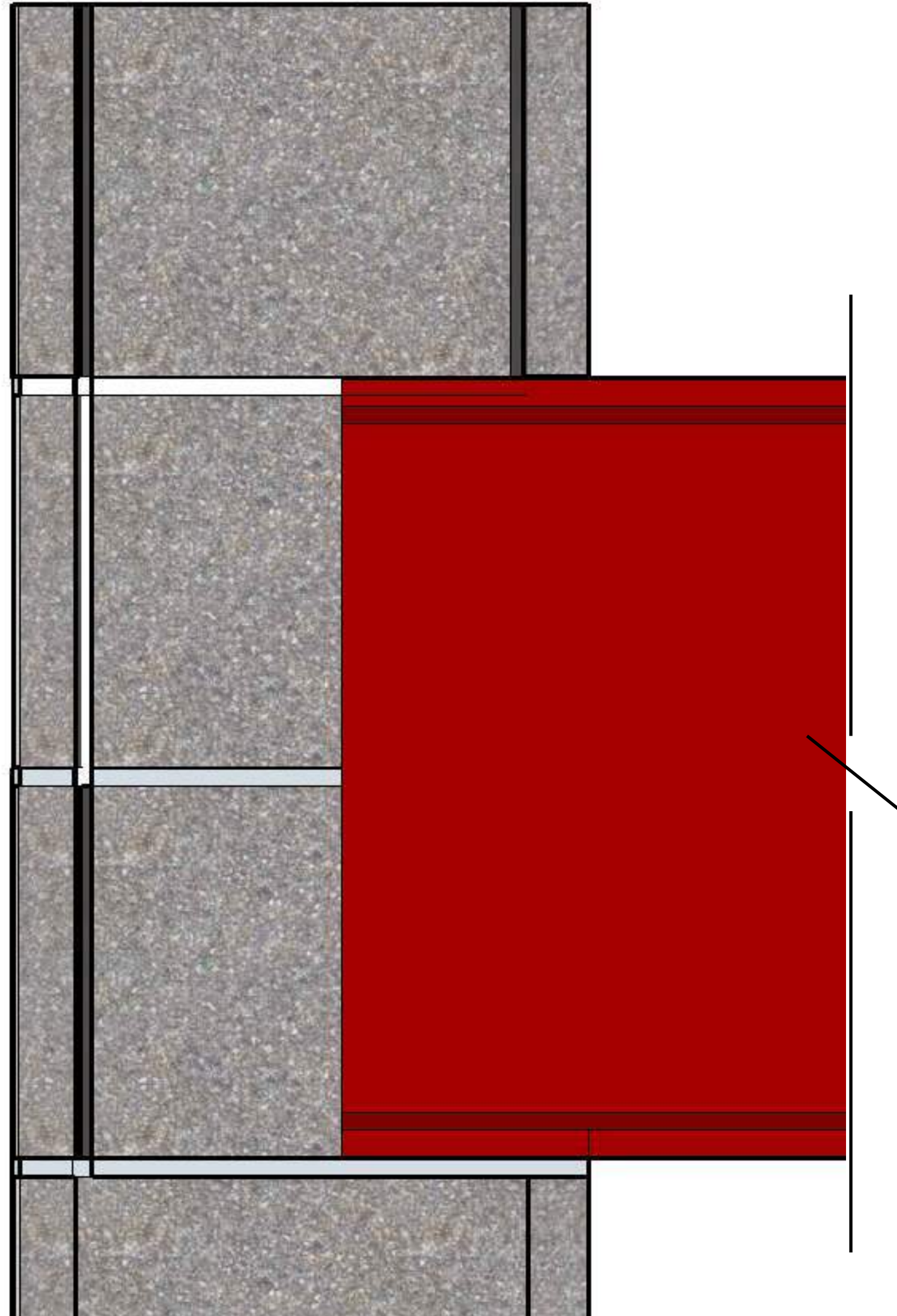
- simple solution
- does not require masonry wall to be grouted, but it usually needs to be
- fastener can be:
 - headed stud
 - mechanical anchor
- good solution for retrofit / adding a beam to existing building

masonry corbel



- Not common
- slightly more complicated
- requires reinforcement for corbel
- bearing plate usually needed, but not required

beam pocket



- very simple
- bearing plate usually needed, but not required
- more complicated when wall has a required fire rating
 - fire stopping material may be required
 - requires approx 2in for 2-hour fire rating (face shell is 1 ¼")

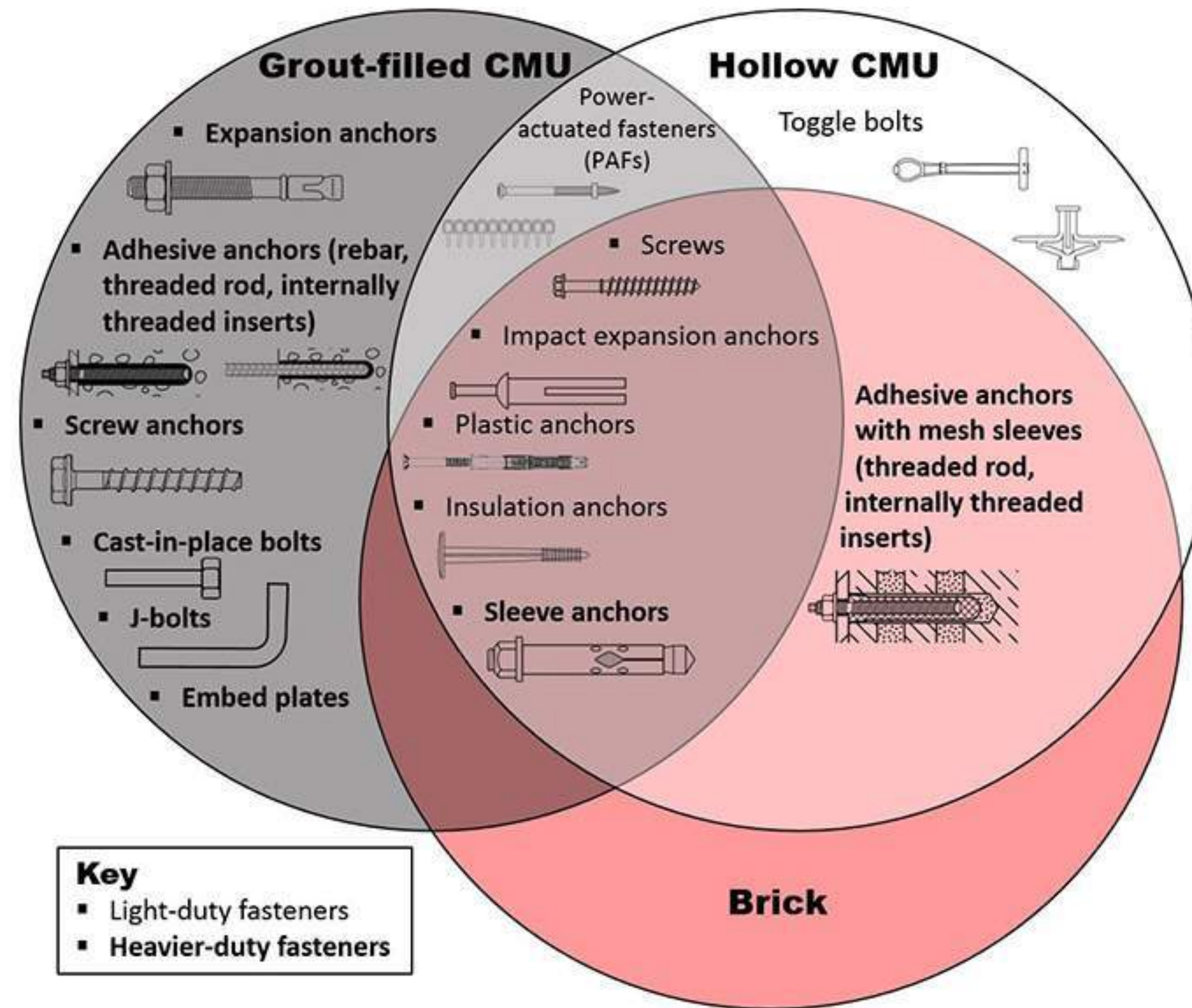
connecting to masonry wall

- embed plate or bearing plate?
 - depends on the situation
- embed plate
 - may be better tension connection
 - adequate for light loads
- bearing plate
 - much more capacity for vertical shear loads

anchor bolts

- tensile capacity governed by
 - yield of anchor in tension
 - tensile breakout
 - tensile pullout (bent – bar anchor bolts only)
- shear capacity governed by
 - yield of anchor in shear
 - shear breakout
- for combined tension and shear, use linear interaction

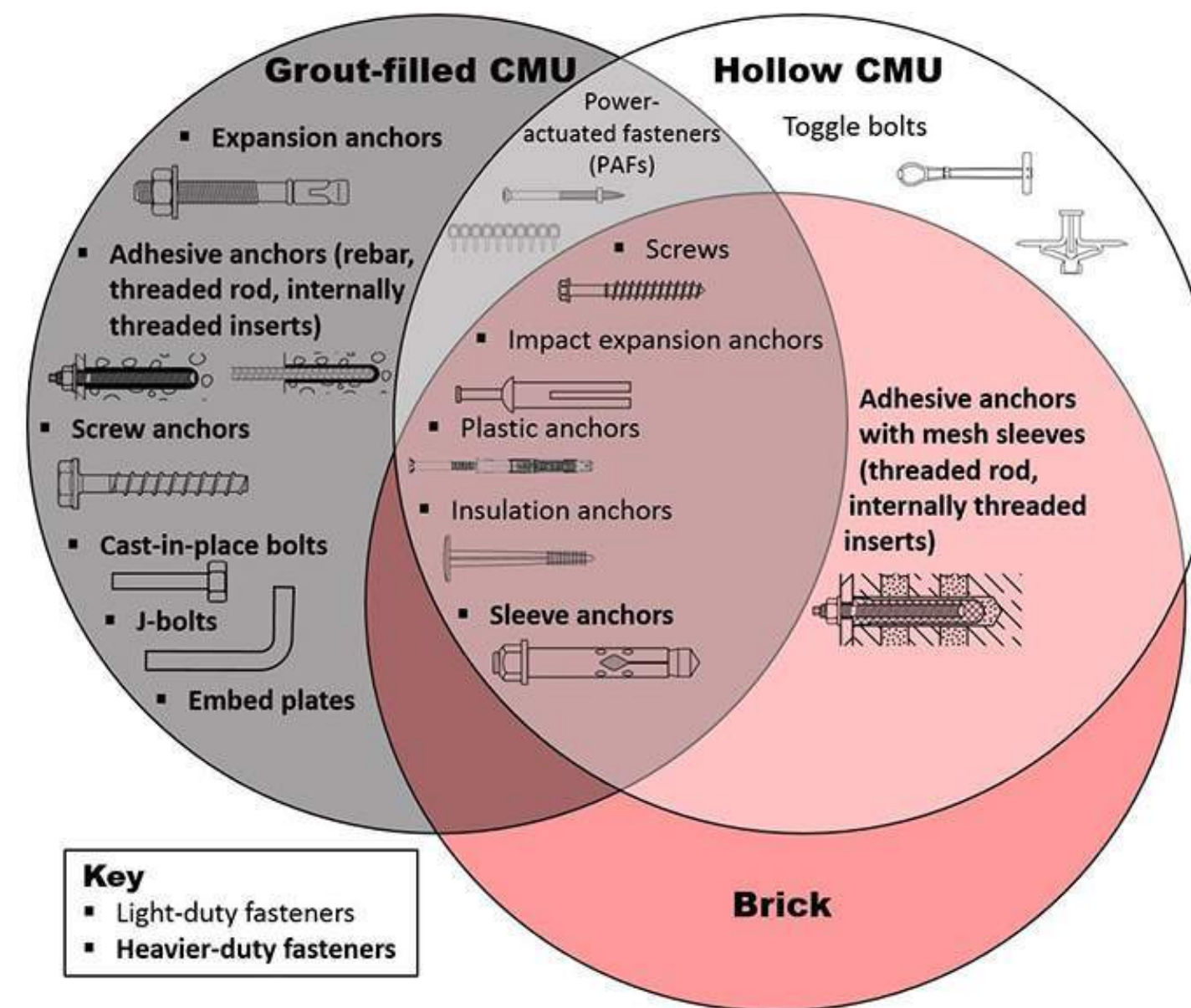
Embedded Fasteners to masonry



Source: Masonry Contractors article

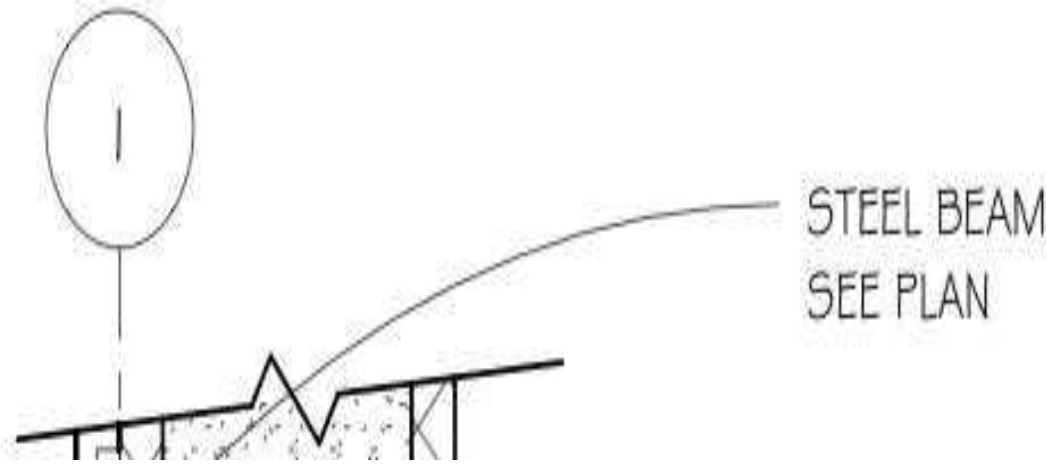
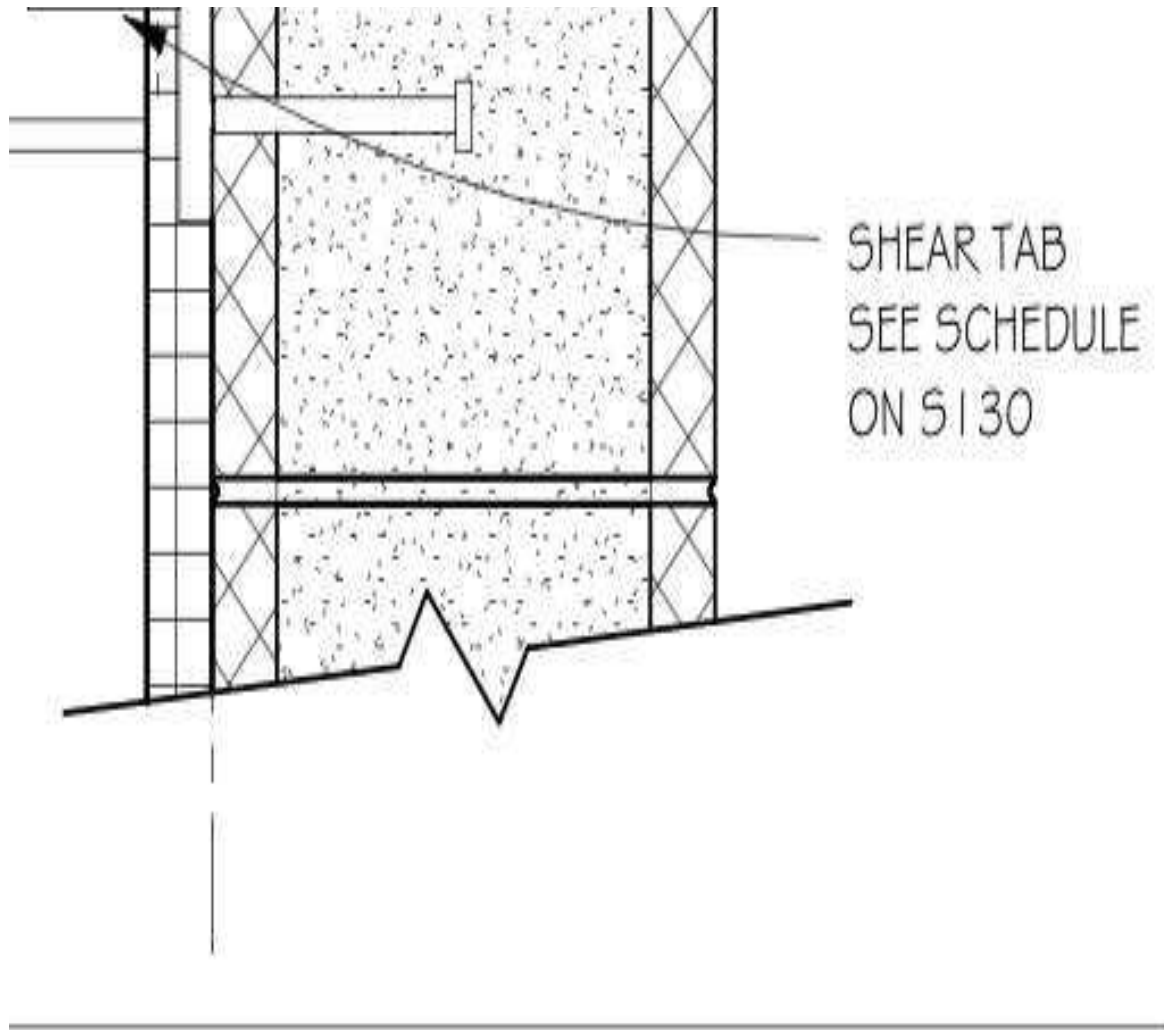
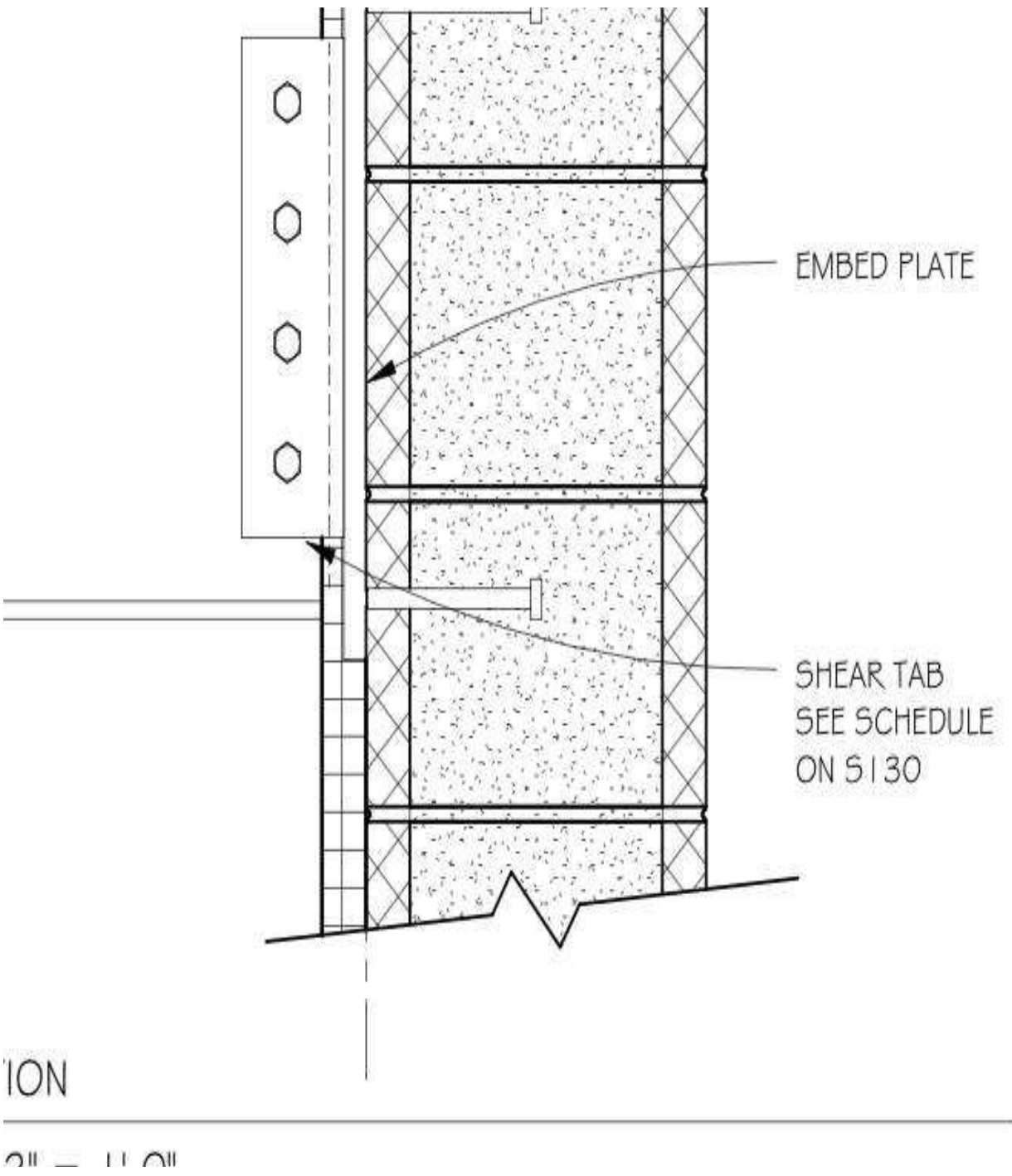
AN INTRODUCTION TO EMBEDDED FASTENERS IN MASONRY

<https://www.masoncontractors.org/2016/08/15/an-introduction-to-embedded-fasteners-in-masonry/#newsletter>



Cast-in anchors TO MASONRY

EMBED PLATE SCHEDULE			
MARK	DESCRIPTION		REMARKS
	SIZE	HEADED STUDS (QUANTITY) - DIAMETER x LENGTH	
EP-1	3/4" x 10" x 38"	(12) - 3/4" Ø x 6"	-
EP-2	3/4" x 10" x 28"	(10) - 3/4" Ø x 6"	-
EP-3	3/4" x 22" x 28"	(18) - 3/4" Ø x 6"	-
EP-4	3/4" x 16" x 34"	(18) - 3/4" Ø x 6"	-
EP-5	3/4" x 16" x 16"	(9) - 3/4" Ø x 6"	-
EP-6	3/4" x 11" x 16"	(4) - 3/4" Ø x 6"	-
EMBED PLATE DIAGRAMS			



NCMA TEK 12-3C: DESIGN OF ANCHOR BOLTS EMBEDDED IN CONCRETE MASONRY

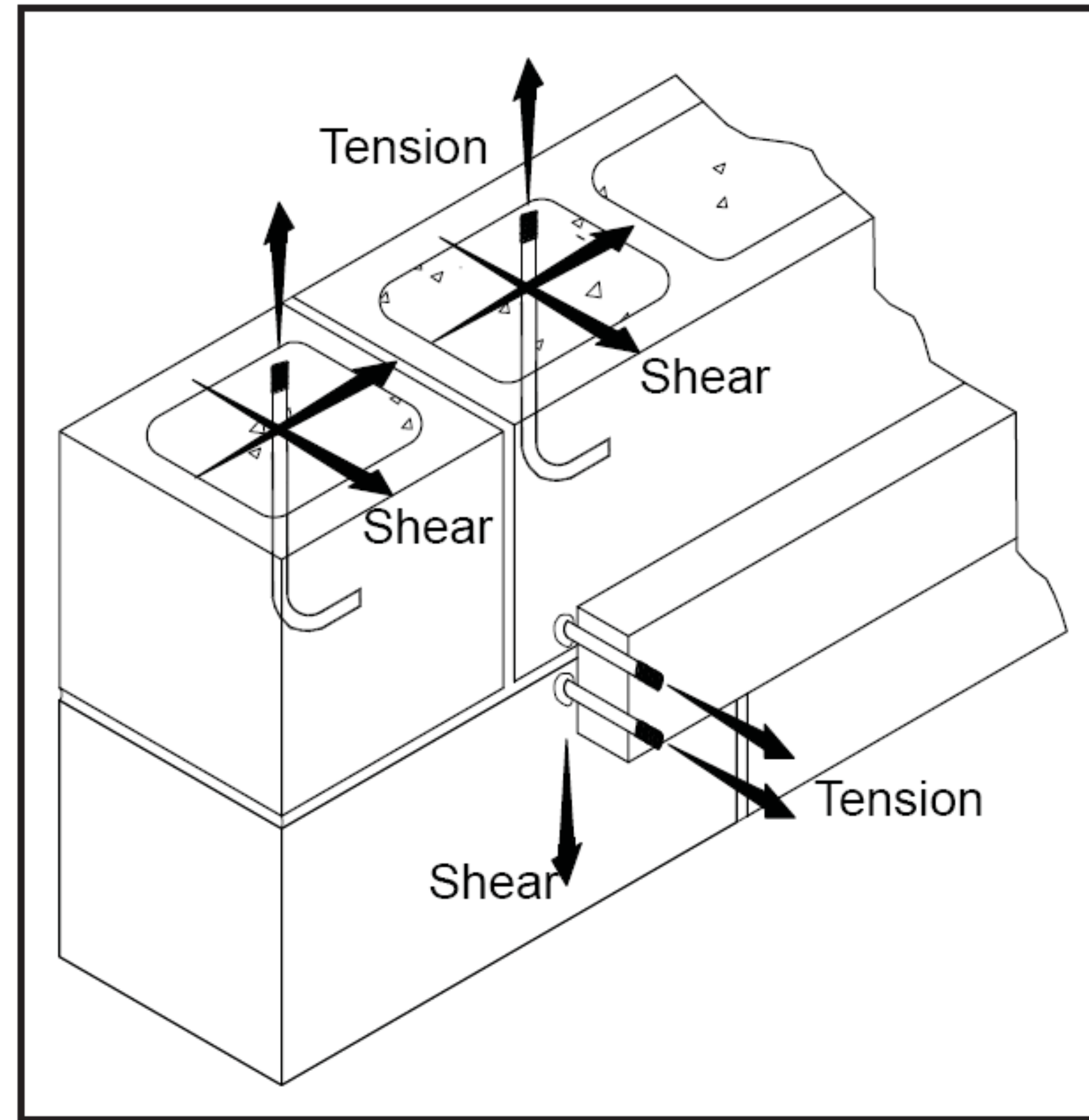


Figure 1—Anchorage Design Loads

anchoring to masonry

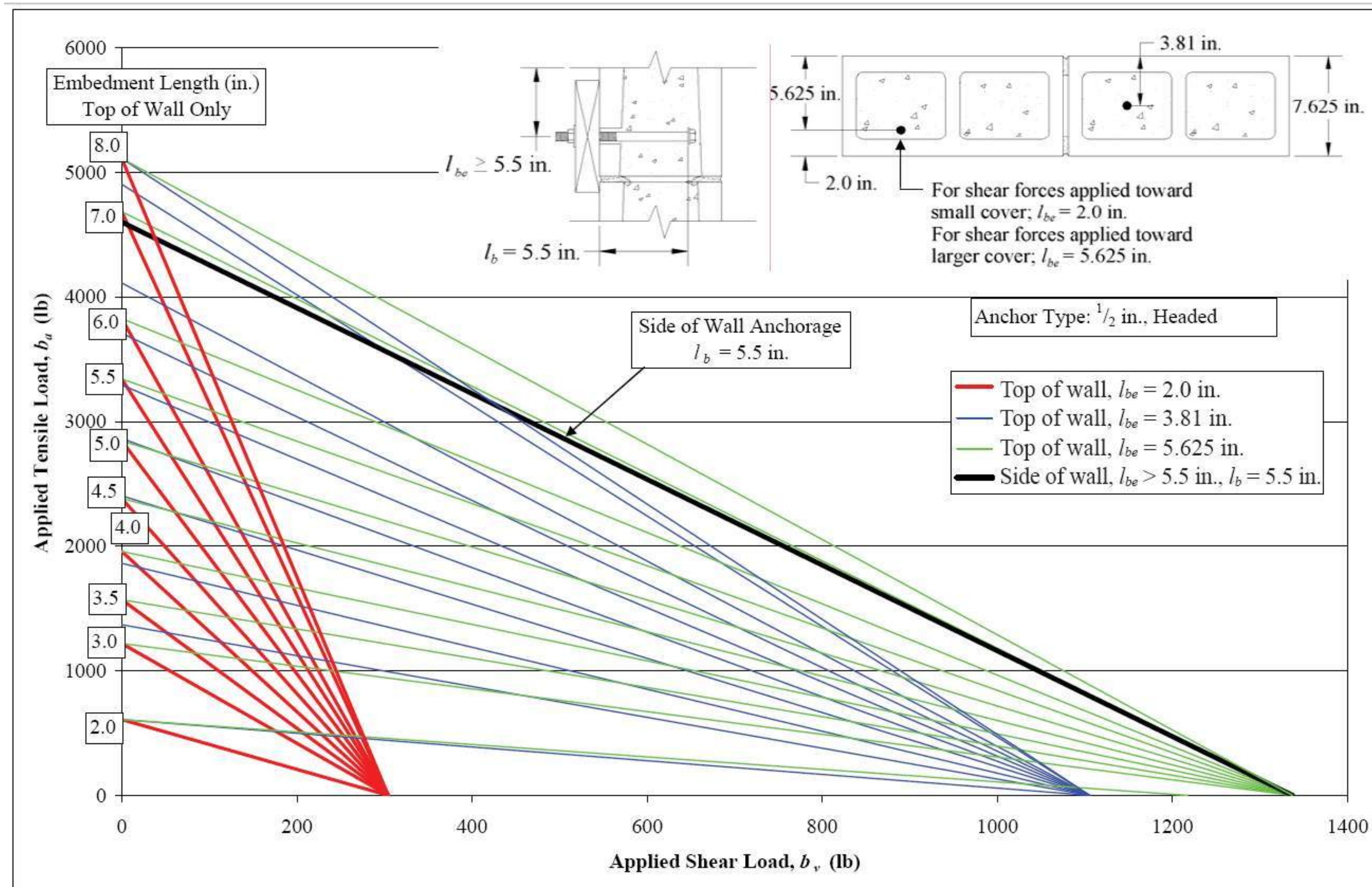


Figure 6—Allowable Stress Design: Allowable Design Axial Tension and Shear For a 1/2-in. (13-mm) Headed Anchor Bolt in an 8-in. (203-mm) Concrete Masonry Wall

anchoring to masonry

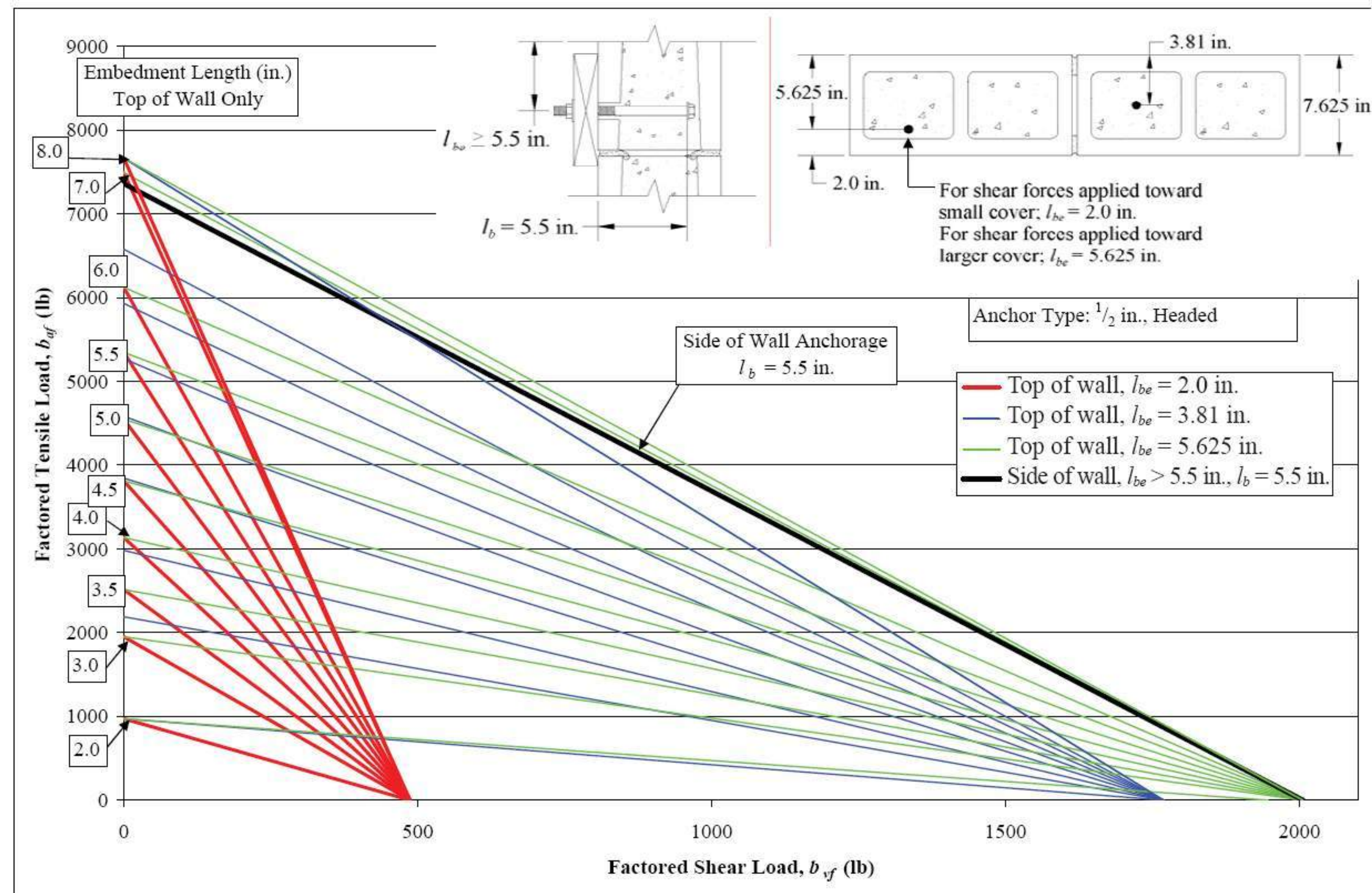


Figure 7—Strength Design: Nominal Design Axial Tension and Shear For a 1/2-in. (13-mm) Headed Anchor Bolt in an 8-in. (203-mm) Concrete Masonry Wall

code 3.1.6.3.1 - nominal tensile capacities for anchor bolts

- tensile yield of anchor

$$B_{ans} = A_b f_y$$

- tensile breakout of anchor

$$B_{anb} = 4 A_{pt} \sqrt{f'_m}$$

- tensile pullout of anchor

$$B_{an} = 1.5 f'_m e_b d_b + \left[300 \pi (l_b + e_b + d_b) d_b \right]$$

code 3.1.6.3.2 - nominal shear capacities for anchor bolts

- shear breakout of anchor

$$B_{vn} = 4 A_{pv} \sqrt{f'_m}$$

- shear crushing of masonry

$$B_{vnc} = 1050 \sqrt[4]{f'_m A_b}$$

- shear pryout of anchor

$$B_{vnpry} = 2.0 B_{anb} = 8 A_{pt} \sqrt{f'_m}$$

- shear yield of anchor

$$B_{vn} = 0.6 A_b f_y$$

combined tension and shear
on anchor bolts

$$\frac{b_{af}}{\phi B_{an}} + \frac{b_{vf}}{\phi B_{vn}} \leq 1$$

2013 MSJC Anchor Bolt Design
Strength Design

***user input indicated by blue cells

DATA INPUT AND SUMMARY OF DESIGN

Properties and Geometry

Weather or Soil Exposure

YES

Top or Face Mounted

Top

**Assumed adequate spacing from adjacent anchors to allow no overlap of breakout cones

Anchor Type =

headed

Anchor Yield Strength, f_y =

60000 psi

Anchor Diameter, d_b =

1/2 in

Anchor Hook Length, e_h =

0 in

**For headed anchor set hook length equal to 0

f_m =

2000 psi

Wall thickness, t =

7.625 in

Edge Distance, l_{be} =

3.25 in

Net Anchor Area, A_b =

0.142 in²

Effective Embed. Length, l_e =

8.00 in

Loading (factored)

Shear Force, V_u =

500 lbs

Offset distance, e =

2.00 in

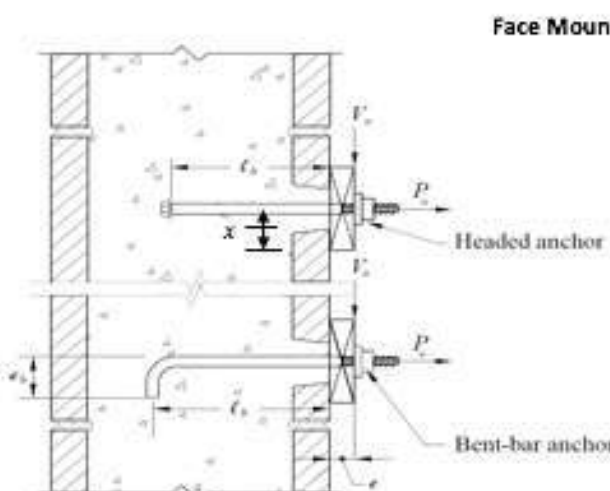
Dist. From C.L. of Bolt To Edge of

Ledger, x =

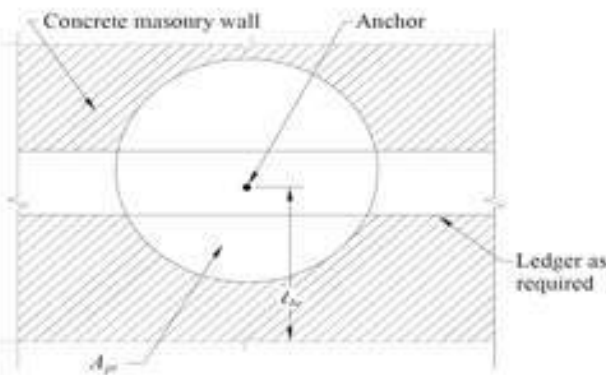
4.00 in

Direct Tension Force, P_u =

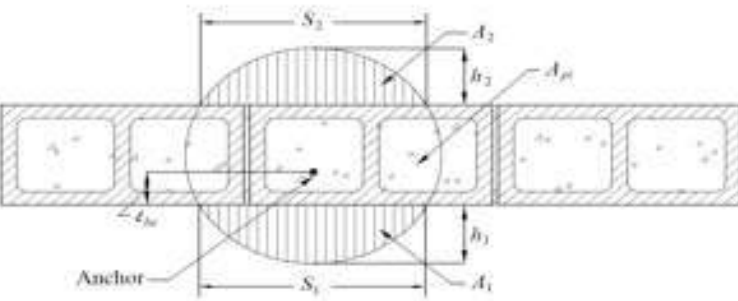
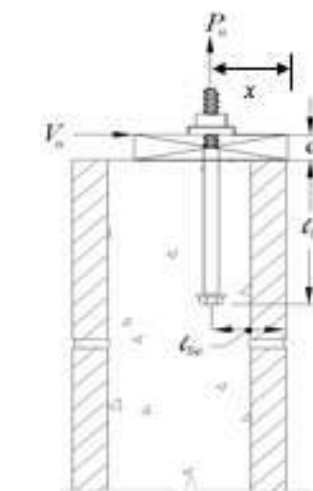
1000 lbs



Face Mounted Anchor



Top Mounted Anchor



<<Anchor design is satisfactory. See detailed analysis>>

Detailed Analysis

Check minimum embed.

[TMS 402-13 §1.17.6] l_e = 8.00 in > $l_{e,min} = \min(4d_b, 2 \text{ in}) = 2.00 \text{ in}$ <Satisfactory>

Check minimum cover

[TMS 402-13 §1.16.4.1] $cover_{reqd}$ = 1.50 in

$cover_{actual}$ = (for top mounted) $t - l_{be} = 3.25 \text{ in}$ <Satisfactory>

(for face mounted) $t - l_e =$

Total Tension Force Considering Ecc., b_{af}

$b_{af} = P_u + \frac{V_u e}{(\frac{5}{8})d} = 1300 \text{ lbs}$ ***assuming that moment arm is (5/8) of 'd'

Determine Tensile Capacity

$h_1 = 4.75 \text{ in}$ $s_1 = 14.62 \text{ in}$ $A_1 = 49.96 \text{ in}^2$

$h_2 = 3.63 \text{ in}$ $s_2 = 13.40 \text{ in}$ $A_2 = 34.76 \text{ in}^2$

$A_{pet} = \pi l_b^2 = 116.95 \text{ in}^2$

[TMS 402-13 Eqn. 9-1] Masonry Tensile Breakout ($\phi = 0.5$) $B_{anb} = 4A_{pet}\sqrt{f'_m} = 20920 \text{ lbs}$

[TMS 402-13 Eqn. 9-2] Steel Tensile Yield ($\phi = 0.9$) $B_{ans} = A_b f_y = 8520 \text{ lbs}$

[TMS 402-13 Eqn. 9-4] Anchor Pullout ($\phi = 0.65$) $B_{anp} = (1.5f'_m e_h d_b + 300\pi(l_b + e_h + d_b)d_b) = \text{N/A lbs}$

Design Axial Strength $\phi B_{an} = 7668 \text{ lbs}$ > b_{af} <Satisfactory>

Governing Failure Mode: Anchor Yielding

Determine Shear Capacity

$A_{pv} = \frac{\pi l_{be}^2}{2} = 16.59 \text{ in}^2$

[TMS 402-13 Eqn. 9-6] Masonry Shear Breakout ($\phi = 0.5$) $B_{vnb} = 4A_{pv}\sqrt{f'_m} = 2968 \text{ lbs}$

[TMS 402-13 Eqn. 9-7] Masonry Crushing ($\phi = 0.5$) $B_{vnc} = 1050\sqrt{f'_m A_b} = 4310 \text{ lbs}$

[TMS 402-13 Eqn. 9-8] Anchor Shear Pryout ($\phi = 0.5$) $B_{vnp} = 2.0B_{anb} = 8A_{pet}\sqrt{f'_m} = 41841 \text{ lbs}$

[TMS 402-13 Eqn. 9-9] Steel Shear Yielding ($\phi = 0.9$) $B_{vns} = 0.6A_b f_y = 5112 \text{ lbs}$

Design Shear Strength $\phi B_{vn} = 1484 \text{ lbs}$ > b_{vf} <Satisfactory>

Governing Failure Mode: Breakout

Check Combined Tension and Shear Interaction

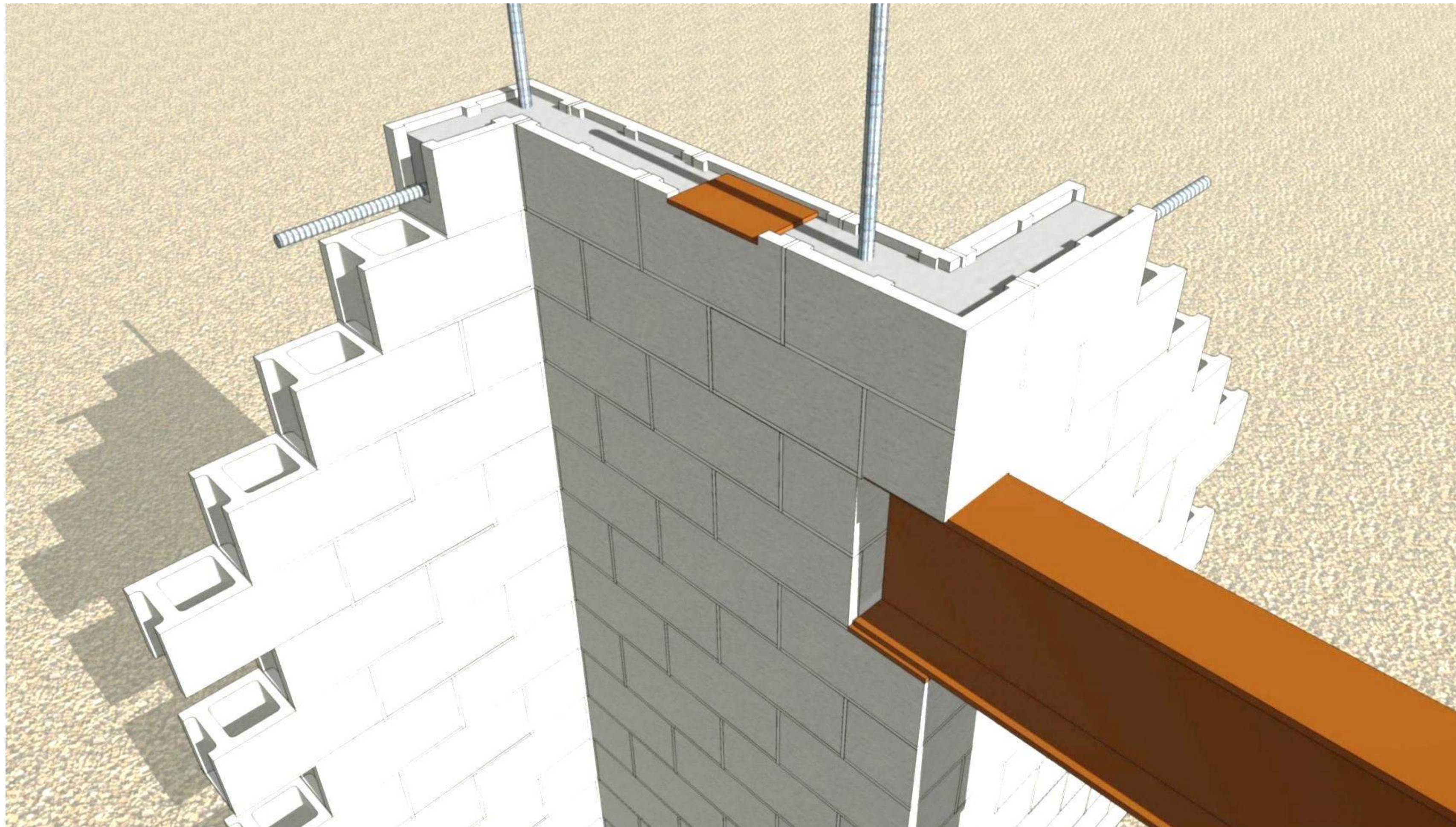
[TMS 402-13 Eqn. 9-10] $\frac{b_{af}}{\phi B_{an}} + \frac{b_{vf}}{\phi B_{vn}} = 0.506 < 1.000$ <Satisfactory>

anchoring to masonry
spreadsheet
from NCMA

anchoring to masonry
spreadsheet
from FORSE

Embedded Plate Design (NCMA TEK 12-3B)				Shear Design			
Bolt Group: 4 bolts Embedment: 4.0 in # of spaces = 1 y, spacing = 6.0 in edge dis = 48.0 in				Loading: shear: 2.0 k axial: 1.5 k moment: 2.0 ft-k			
# of spaces = 1 x, spacing = 8.0 in				Resultant loads on anchors shear: 2.0 k (b_{vf}) axial: 5.5 k (b_{af})			
Masonry $f_M = 2250$ psi		Headed Studs Stud $d_b = 3/4$ $F_Y = 60000$ psi $l_b = 4.0$ in $l_{be} = 48.0$ in eff. $A_b = 0.334$ in					
Tensile Design nominal axial tensile strength governed by anchor yielding $\Phi B_{ans} = \Phi * A_b * F_Y$ (Eqn 12) $\Phi = 0.90$ $\Phi B_{ans} = 18.0$ k # of bolts in tension = 2 $\Phi B_{ans} = (2 \text{ bolts}) = 36.1$ k				nominal shear strength governed by anchor yielding $\Phi B_{vns} = \Phi * 0.6 * A_b * F_Y$ (Eqn 17) $\Phi = 0.90$ $\Phi B_{vns} = 10.8$ k # of bolts in shear = 4 $\Phi B_{vns} = (4 \text{ bolts}) = 43.3$ k			
nominal axial tensile strength governed by masonry breakout $\Phi B_{anb} = \Phi * 4 * \pi * l_b^2 * \text{sqrt}(f_M)$ (Eqn 11) $\Phi = 0.5$ $\Phi B_{anb} = 4.8$ k # of bolts in tension = 2 $\Phi B_{anb} = (2 \text{ bolts}) = 9.5$ k				nominal shear strength governed by masonry breakout $\Phi B_{vnb} = \Phi * 4 * \pi * l_{be}^2 / 2 * \text{sqrt}(f_M)$ (Eqn 14) $\Phi = 0.5$ $\Phi B_{vnb} = 686.7$ k # of bolts in shear = 2 $\Phi B_{vnb} = (2 \text{ bolts}) = 1373.4$ k			
				nominal shear strength governed by crushing of masonry $\Phi B_{vnpry} = \Phi * 1050 * \text{sqrt}^4(A_b * f_M)$ (Eqn 15) $\Phi = 0.50$ $\Phi B_{vnpry} = 1.2$ k # of bolts in shear = 4 $\Phi B_{vnpry} = (4 \text{ bolts}) = 4.8$ k			
				nominal shear strength governed by masonry pryout $\Phi B_{vns} = \Phi * 8 * \pi * l_b^2 * \text{sqrt}(f_M)$ (Eqn 16) $\Phi = 0.5$ $\Phi B_{vns} = 9.5$ k # of bolts in shear = 4			
Combined Shear and Tension $b_{af} =$ + $b_{vf} =$ = 0.993 $\Phi B_{an} =$ $\Phi B_{vn} =$							

bearing plates – what to know



Graphic Only

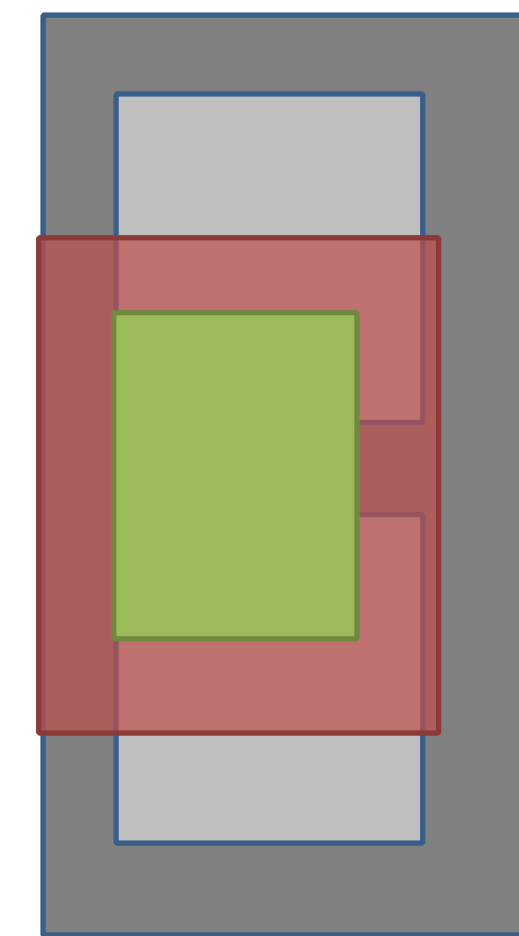
bearing plates – what to know

- bearing capacity
 - un-restrained
 - restrained
 - calculation for determining bearing capacity
 - helps to move bearing plates away from face of masonry
- bearing plates vs beam flanges
 - are bearing plates required?
 - not in every situation

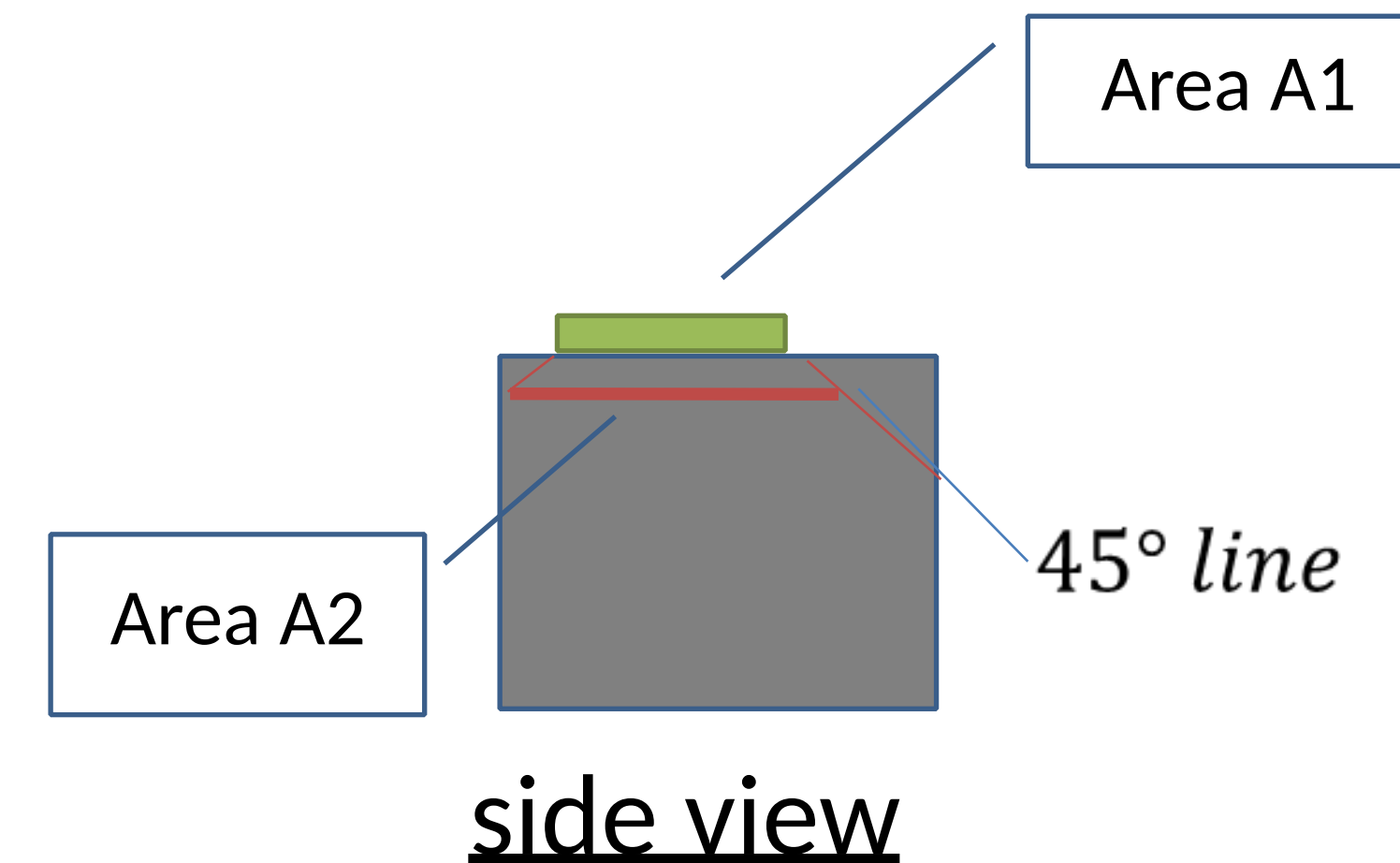
code 3.1.7 - nominal bearing strength

- nominal capacity is product of effective bearing area and $0.80 f'_m$
- notice that design bearing capacity has two factors:
 - $\phi=0.60$ for the nominal capacity
 - the other for the capacity reduction factor.

- Bearing area is the lower of
$$\begin{cases} A_1 \sqrt{A_2/A_1} \\ 2A_1 \end{cases}$$



top view

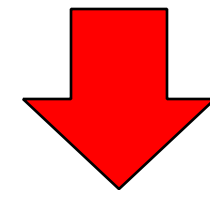


tale of the unhappy mason

mason (not happy)

over 600 lintels

(that's over 1,200 bearing plates!)



block
(7 5/8" thick)



bearing plate, both ends of all lintels
(actual 7" x 7" sq.)

the rest of the story

- 7x7 bearing plate at edge

- $A_1 = 49 \text{ in}^2$
- $A_2 = 49 \text{ in}^2$
- $A_{br} = 49 \text{ in}^2$

- **5x7 bearing plate, inset $1\frac{1}{4}$ "**

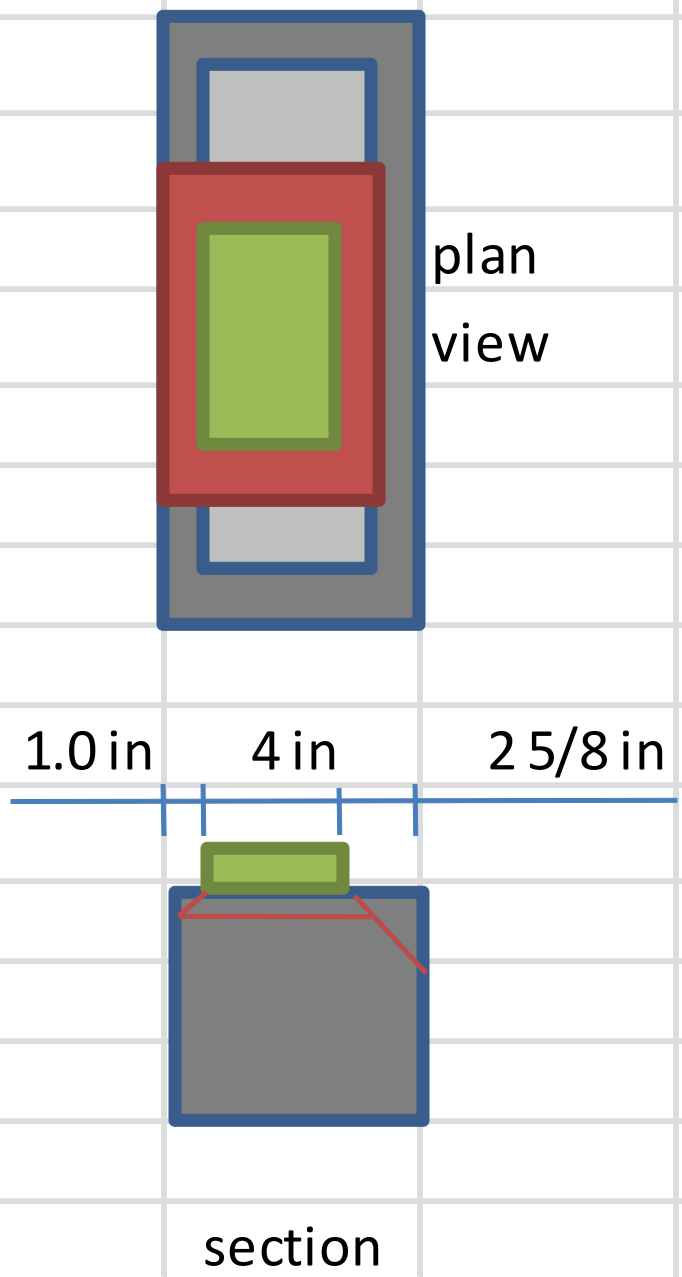
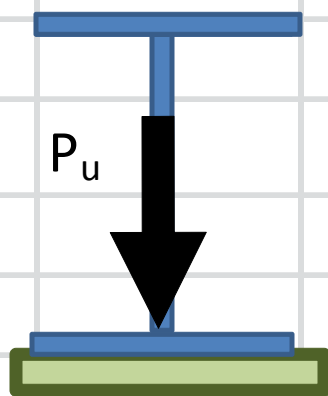
- $A_1 = 35.0 \text{ in}^2$
- $A_2 = 71.3 \text{ in}^2$
- $A_{br} = 49.9 \text{ in}^2$



Who wants to tell the mason??

Bearing plate calculations

$F_y = 36.0 \text{ ksi}$		DL factor	1.2	$f'_m = 2250 \text{ psi}$
		LL factor	1.6	$0.8 * f'_m = 1800 \text{ psi}$
Location	P1			
plate, $t_{req} =$	0.625 in	Capacity	78.9 k	
DL =	5.0 k		OK > 17.2	
LL =	7.0 k	$A_{br} \text{ (in}^2\text{)}$	43.8	
$P_u =$	17.2 k	$A_1 \text{ (in}^2\text{)}$	32.0	
beam, $t_w =$	0.40 in	$A_2 \text{ (in}^2\text{)}$	60.0	
beam, $t_f =$	0.50 in	block width	8 in	
beam, $b_f =$	7.00 in	actual width	7 5/8 in	
Z-plate = in ³	0.391	plate width	8 in	
$\phi_b M_n \text{ (plate)} =$	12.7 in-k	plate length	4 in	
Z-beam fl in ³	0.250	plate set-back	1.0 in	
$\phi_b M_n \text{ (flange)} =$	8.1 in-k			
$\phi_b M_n \text{ (total)} =$	20.8 in-k			
$M_u =$	17.2 in-k			
	OK < 20.8			
$M_u \text{ (overhang)} =$	0.3 in-k			
	OK < 12.7			



bearing
plate
spreadsheet



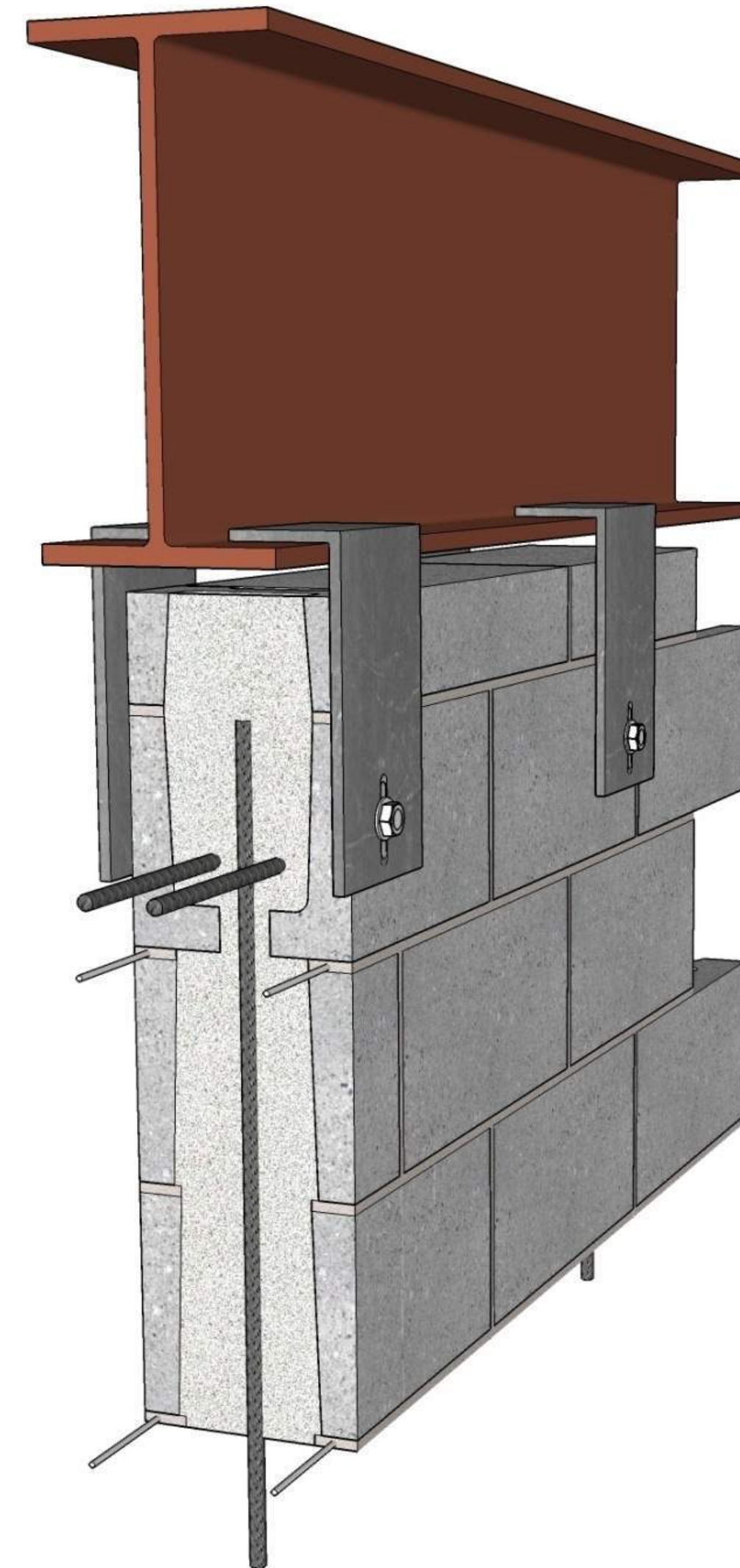
SUMMARY - EMBED OR BEARING?

- embed plate or bearing plate?
 - depends on the situation
- embed plate
 - may be better tension connection
 - adequate for light loads
- bearing plate
 - much more capacity for vertical shear loads

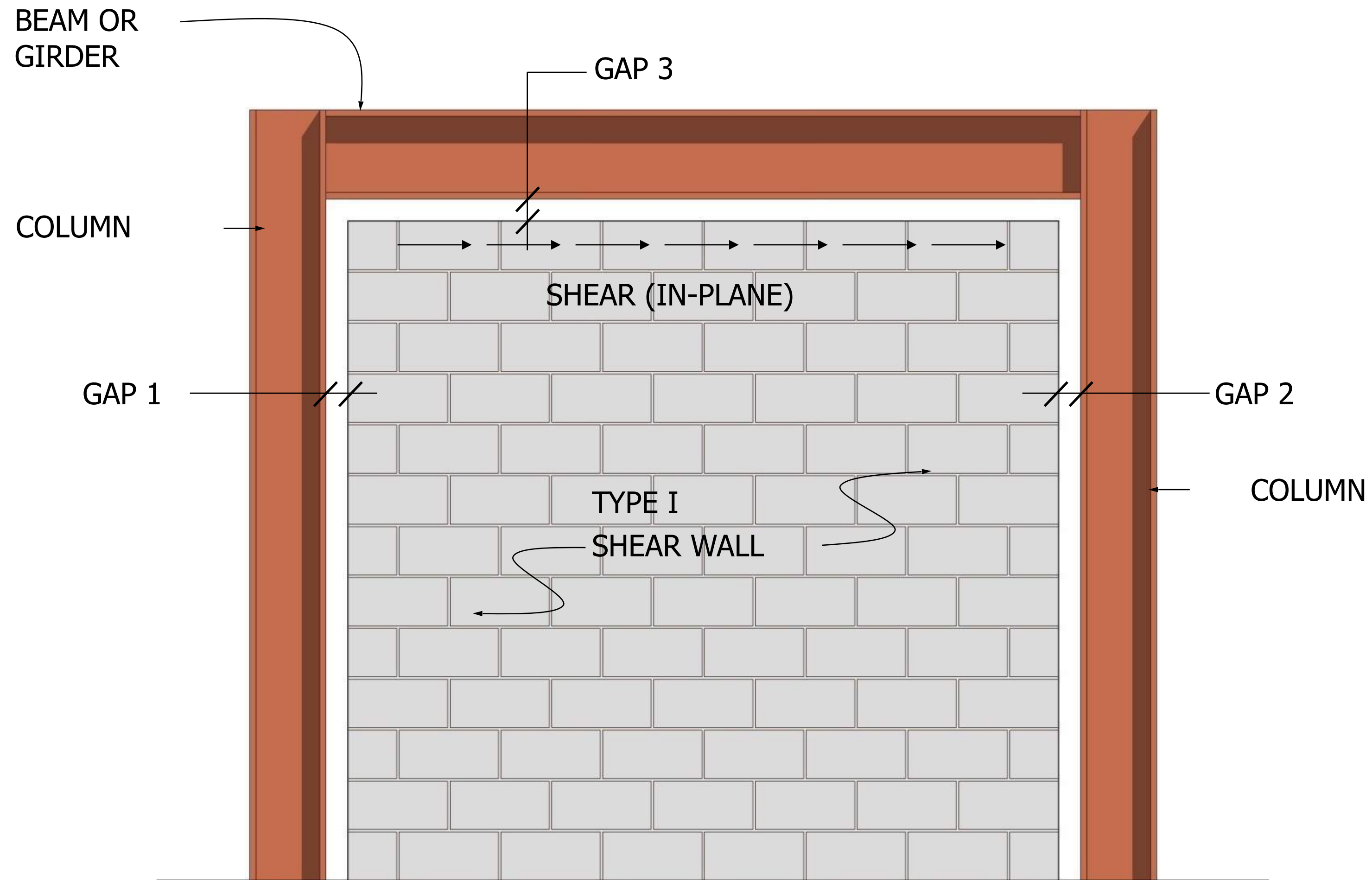


hybrid frame connection tools?

- main benefits:
 - reduces time and effort for masonry structural design.
 - combines the unique structural properties of masonry and combines them with other materials such as steel and concrete to produce a total force resistant building system.
 - reduces overall cost of building construction by reducing tonnage of structural steel.



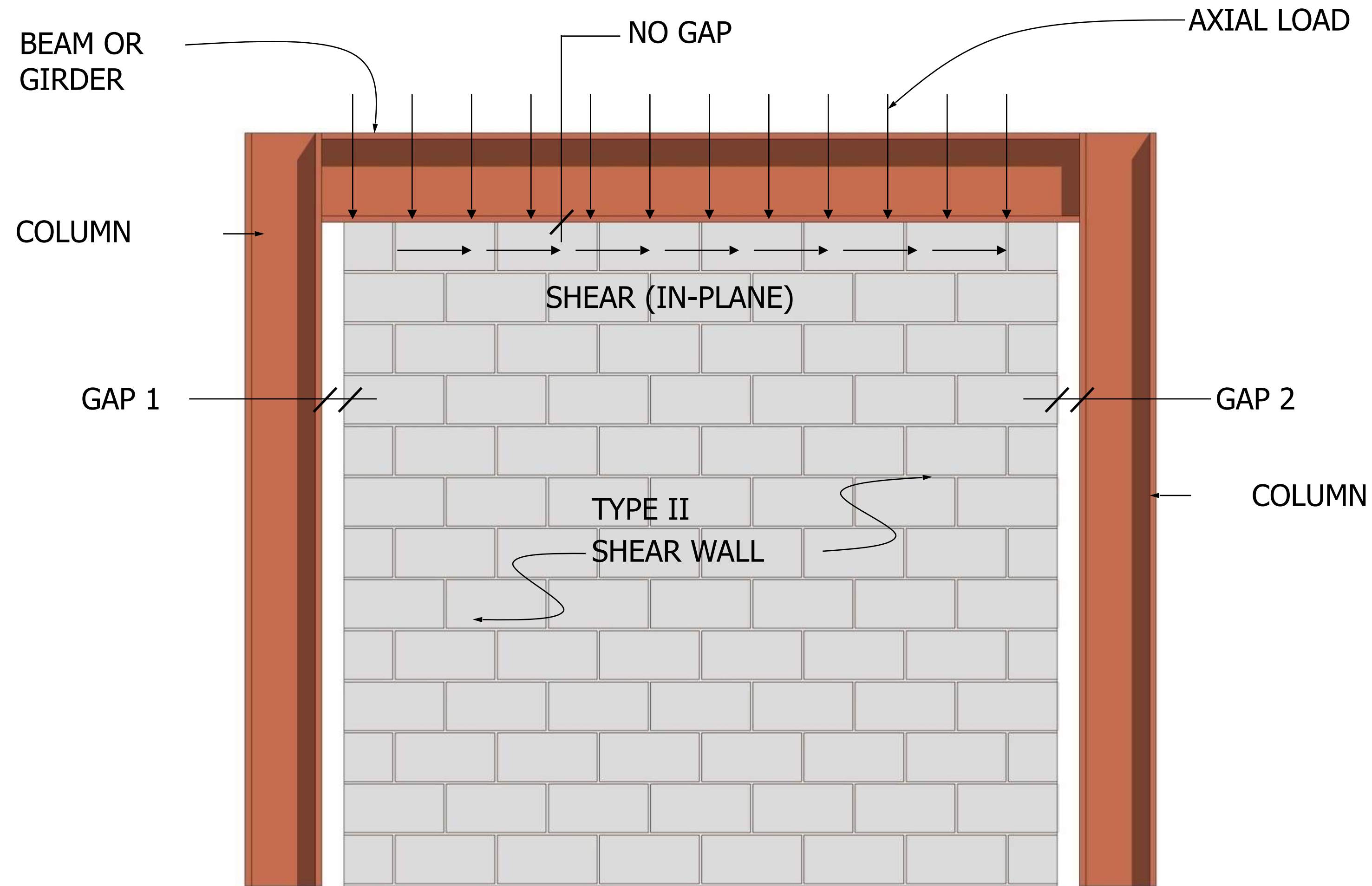
type I hybrid wall



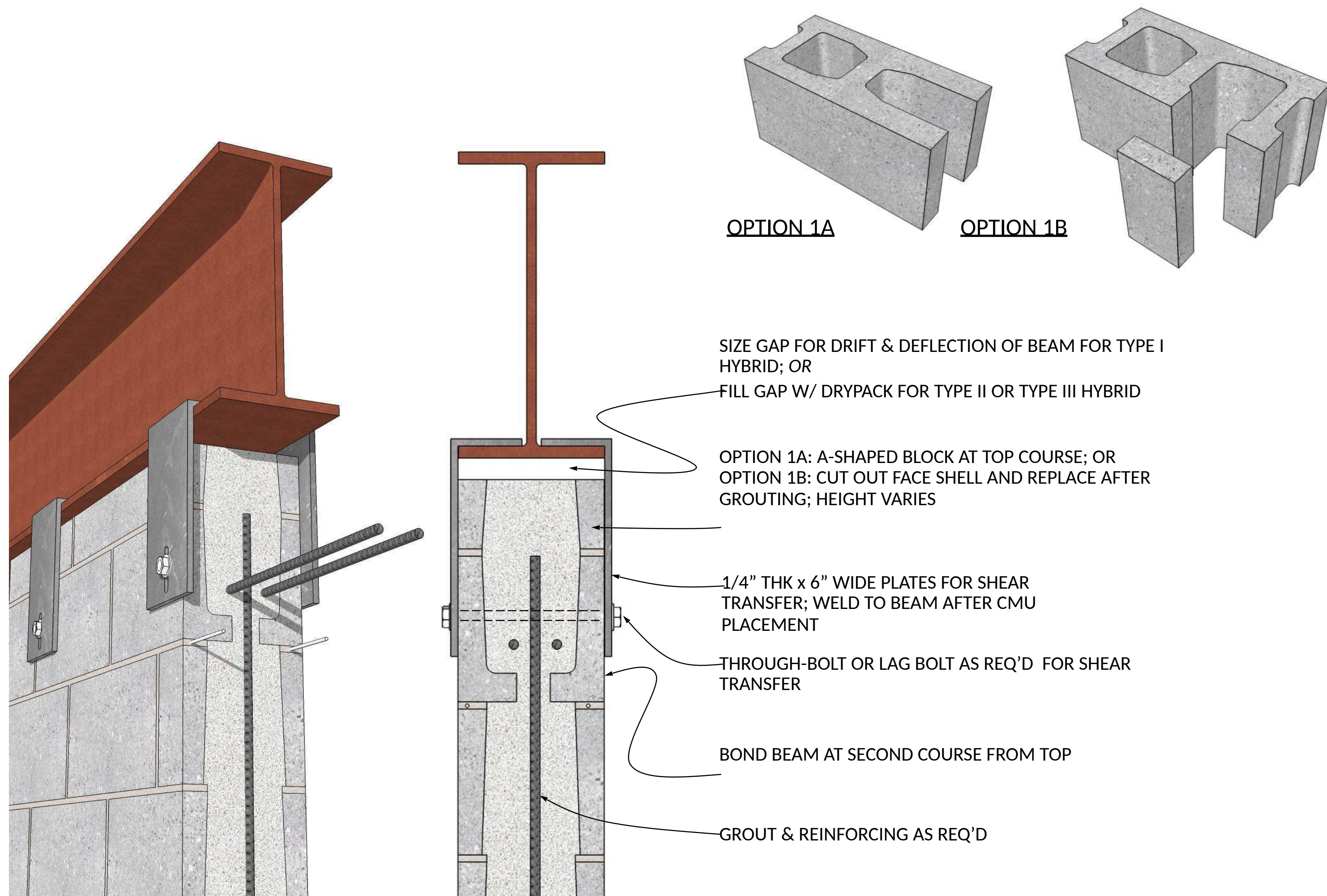
GAPS 1, 2: NO IN-PLANE LOAD TRANSFER

GAP 3: TRANSFERS IN-PLANE SHEAR LOAD; NO AXIAL LOAD

type II hybrid wall



GAPS 1, 2: NO IN-PLANE LOAD TRANSFER (SOFT JOINTS)
BEAM/GIRDER TRANSFERS IN-PLANE SHEAR LOAD



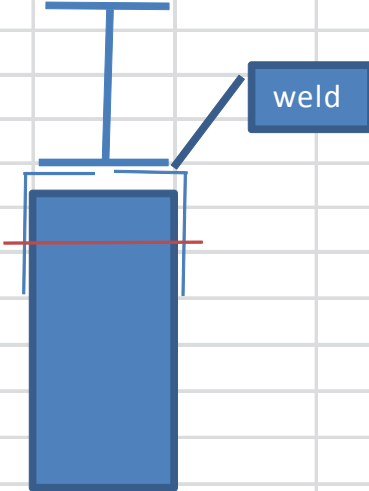
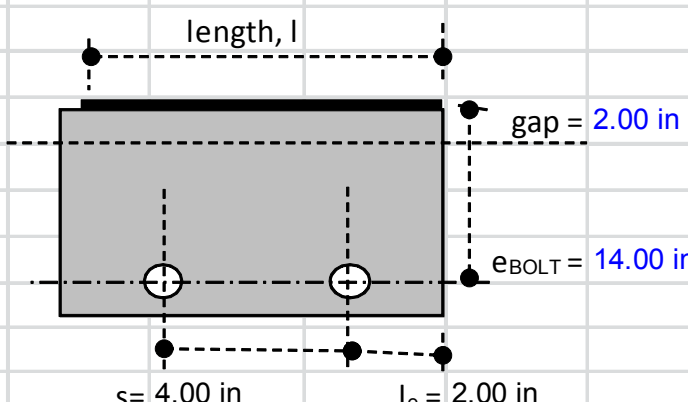
UNDERSIDE OF BEAM

DETAIL 02.120.1201

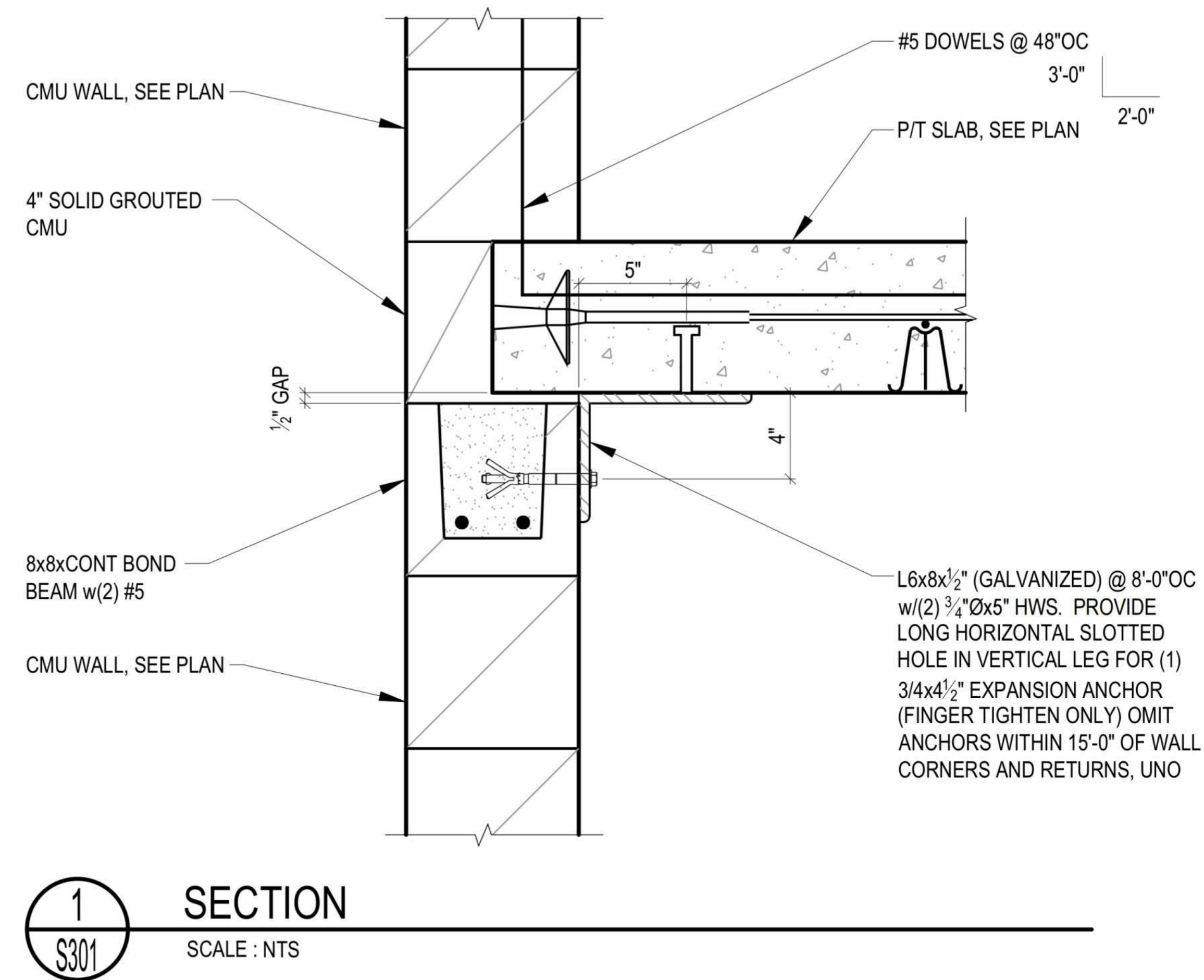
OPTION 1

REV. 03/02/09

hybrid frame
connection
spreadsheet

HYBRID CONNECTION									
	ASD reaction				out-of-plane bending				
	factored uniform load =		2.2 k/ft		C&C wind pressure				
	plate spacing =		4.0 ft o.c.		42.0 psf				
	connection req capacity =		8.9 k		story height		17.0 ft		
Concrete									
f _M =		2250	psi						
F _Y =		60000	psi						
Stud d _b =		1/2	in						
eff. A _b =		0.142	in						
anchor spacing =		4.00 in							
wall =		8.00 in							
Connection Materials									
Members		F _Y =	50.0 ksi	F _U =	65.0 ksi				
Connection Plates		F _Y =	36.0 ksi	F _U =	58.0 ksi				
Members and plates		E =	29000 ksi						
Weld Electrodes		E70XX	F _{EXX} =	70.0 ksi					
Shear Connection									
nominal shear strength governed by anchor yielding									
$\Phi B_{VNS} = \Phi * 0.6 * A_b * F_Y$									
$\Phi = 0.90$									
$\Phi B_{VNS} = 4.6$ k									
# of bolts in shear = 2									
$\Phi B_{VNS} = (2 \text{ bolts}) = 9.2$ k									
nominal shear strength governed by bearing of masonry									
$\Phi B_{BEARING} = \Phi * 2 * d_b * t_{wall} f_M$									
$\Phi = 0.33$									
$\Phi B_{BEARING} = 5.9$ k									
# of bolts in shear = 2									
$\Phi B_{BEARING} (2 \text{ bolts}) = 11.9$ k									
nominal shear strength governed by masonry pryout									
$\Phi B_{VNS} = \Phi * 2.5 * A_{BPEAK} * \text{sqrt} (f_M)$									
$\Phi = 0.5$									
$\Phi B_{VNS} = 18.0$ k									
Shear capacity of the plate									
$\Phi R_N = \phi * A_P * F_Y = 0.6 * 0.375 * 8 * 36 = 64.8$ k									
$\phi = 0.6$									
thickness, t = 3/8 in									
length, l = 8.0 in									
Design angle or bent plate welded to the beam bottom flange									
Angle to beam									
Welds [Capacity per AISC-ASD 13th Ed, Section J2.4 & Table J2.5]									
$R_N/\Omega = \min$									
2 welds weld $\Omega = 2$									
base $\Omega = 2$									
weld thickness, t = 1/8									
length, l = 2.0 in									
$R_N/\Omega = \min$									
$\left[\begin{array}{l} 2 * (0.6 * F_{EXX} * t / \sqrt{(2) * l}) / \Omega = 29.7 \text{ k} \\ \Omega = 2 \\ 2 * (F_Y * t * l) / \Omega = 36.0 \text{ k} \\ \Omega = 2 \end{array} \right] = 29.7 \text{ k}$									
$>8.9 \text{ k} - \text{OK}$									
weld thickness, t = 1/8 in									

masonry - concrete hybrid design



PT Concrete & masonry “**hybrid**” structure

(masonry in plane with concrete frame)

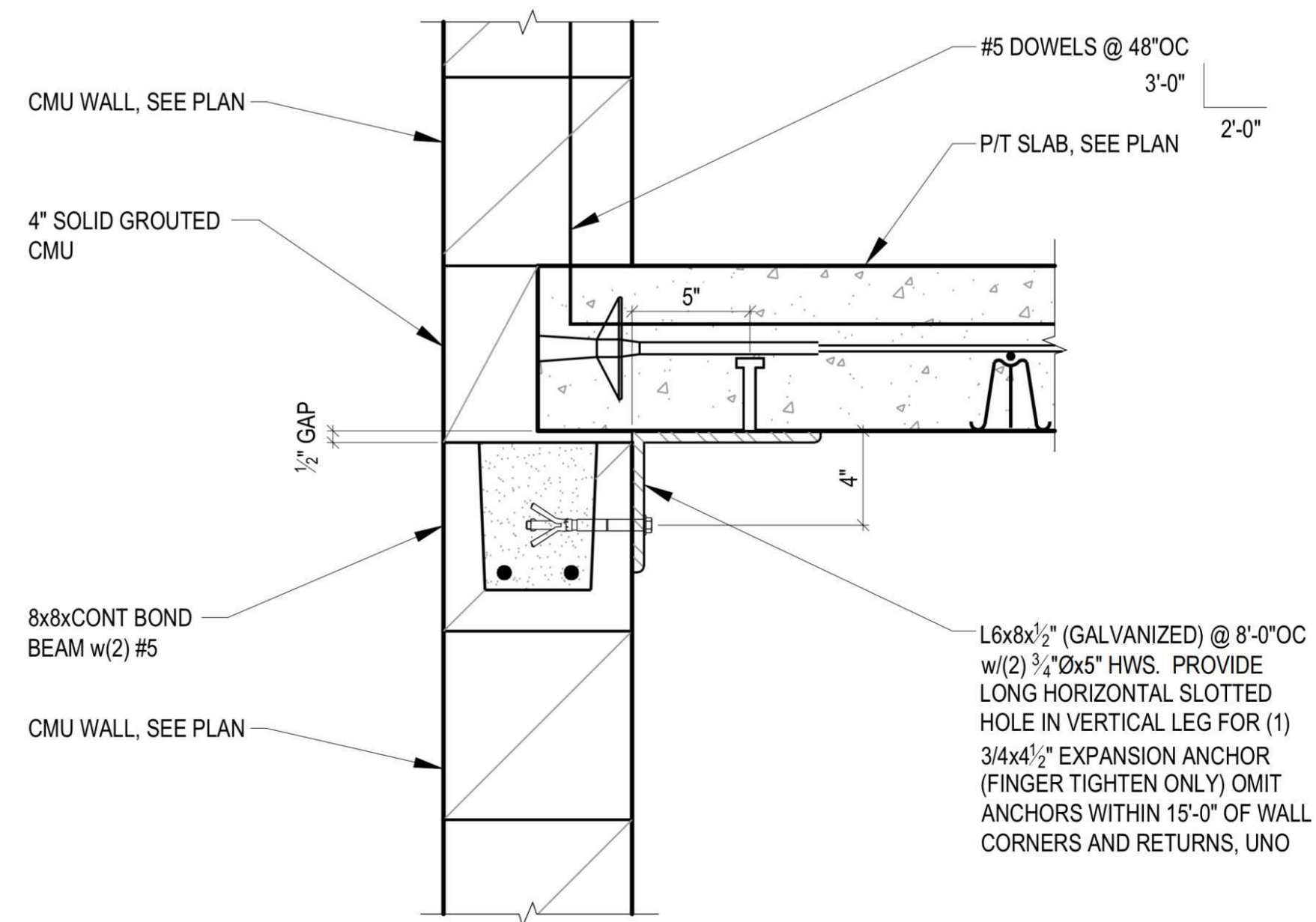


masonry walls between
concrete columns

Discuss how masonry - concrete hybrid design works

main benefits:

- reduces time and effort for masonry structural design.
- combines the unique structural properties of masonry and combines them with other materials such as steel and concrete to produce a total force resistant building system.
- reduces overall cost of building construction by reducing tonnage of structural steel.



Review examples of a PT slab with a hybrid concrete frames and masonry infill

- Concrete walls and PT slabs either lead to over restrained slab (and less effective PT) or complicated detail to “release” the wall restraint
- Masonry - concrete hybrid design allows for conventional construction of concrete, PT slab, and masonry
- Normal sequencing of construction allows for slab to move prior to masonry wall construction





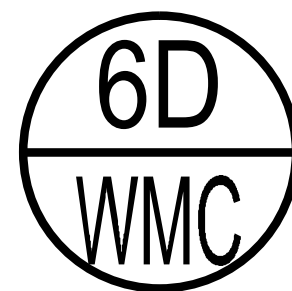
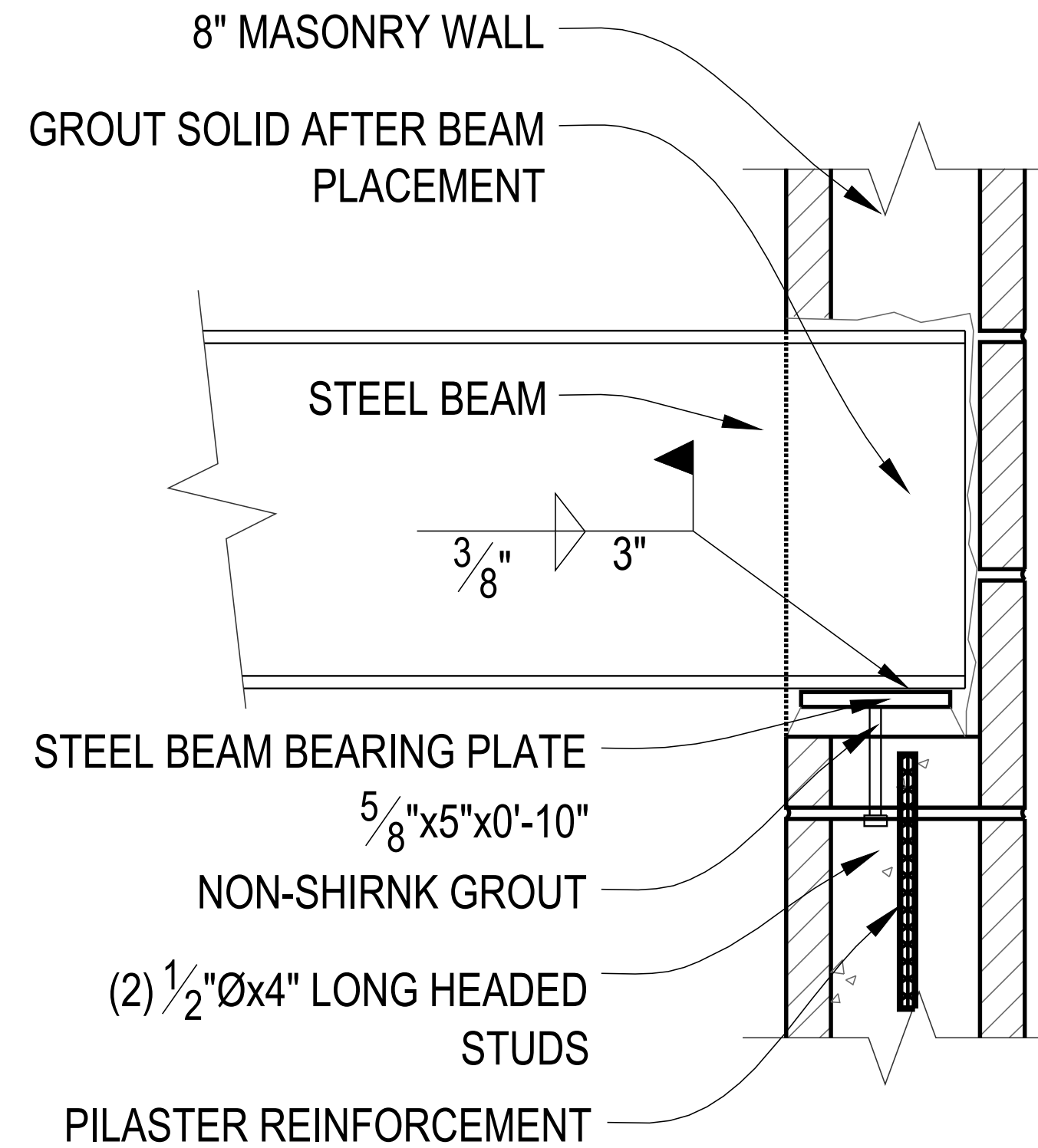
connection details

completing the design process



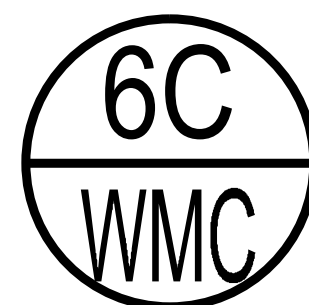
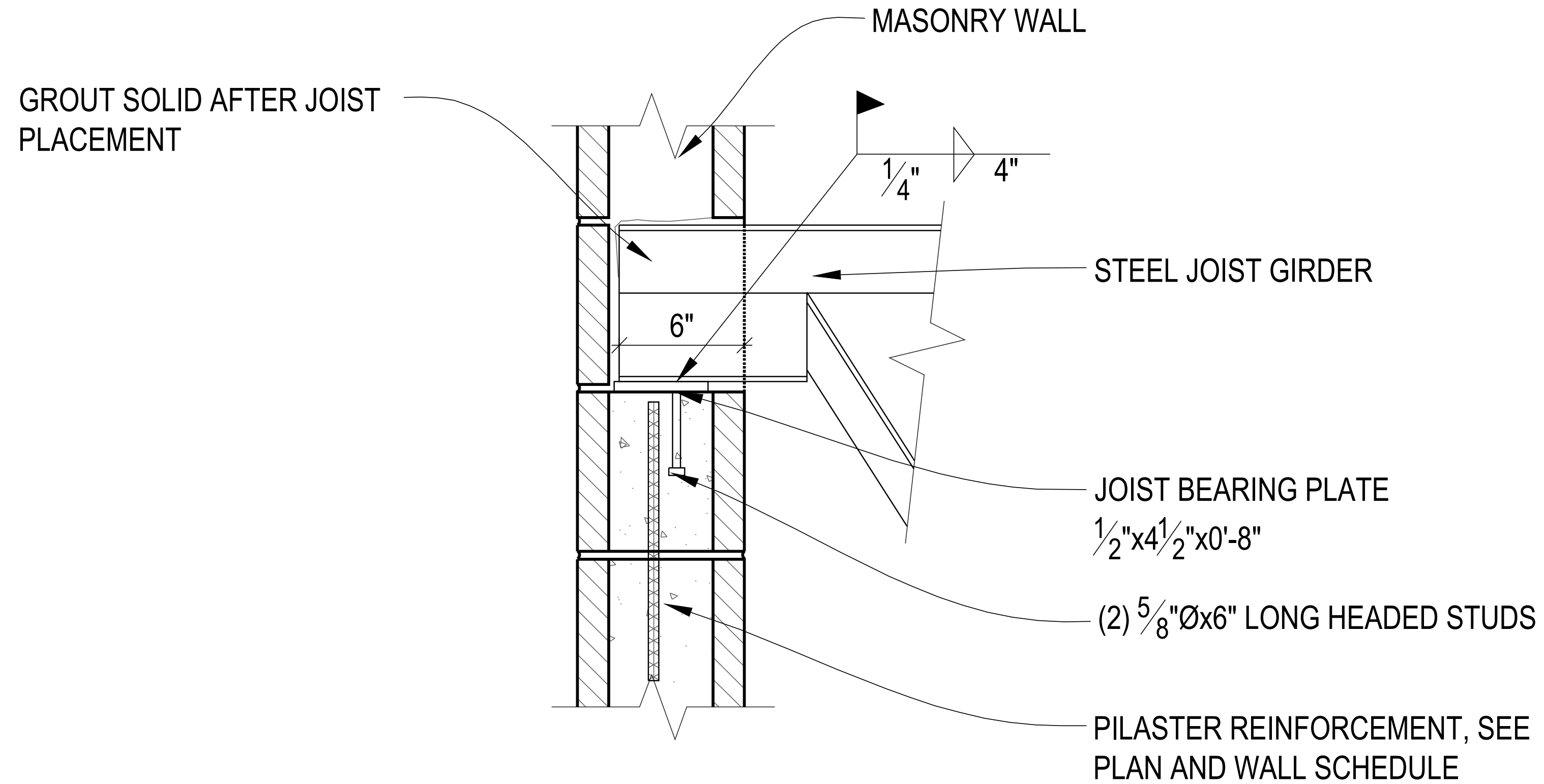
connection details at masonry piers for point loads

- how to detail?
 - where is load applied, concentric or eccentric?
- control joints and masonry piers



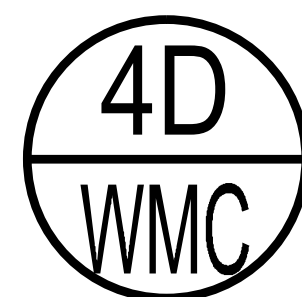
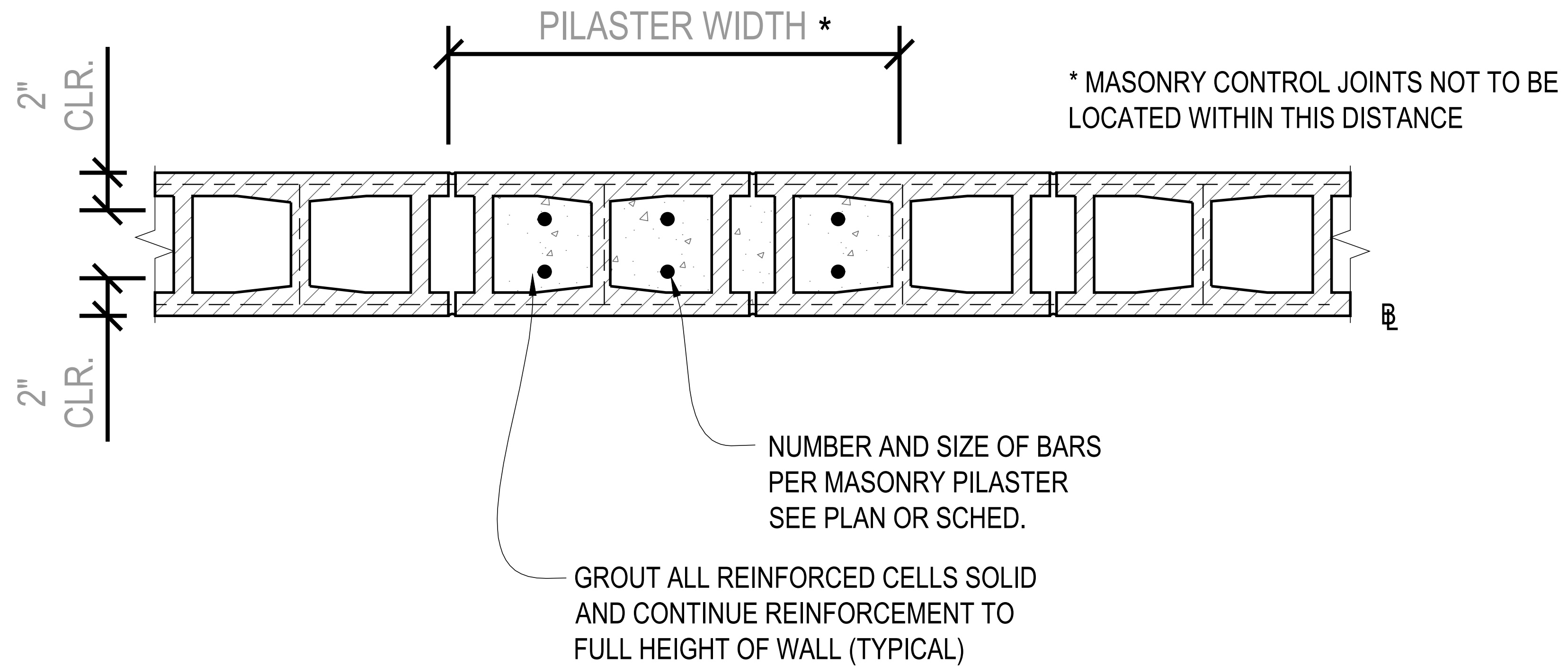
STEEL BEAM BEARING

SCALE : 1" = 1'-0"



JOIST GIRDER BEARING

SCALE : 1" = 1'-0"



TYPICAL MASONRY PILASTER

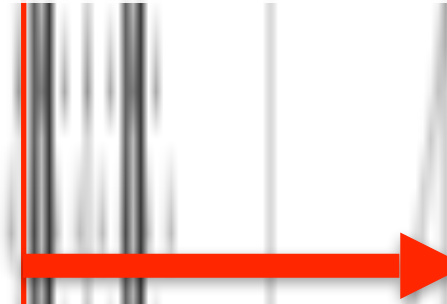
SCALE : 1" = 1'-0"



connections & lintels

- how to detail?
 - wide flange steel with bottom plate
 - HSS with bottom plate
 - double angle with bottom plate
- architectural considerations for adding steel

CJ HERE
OR TO
THE
RIGHT

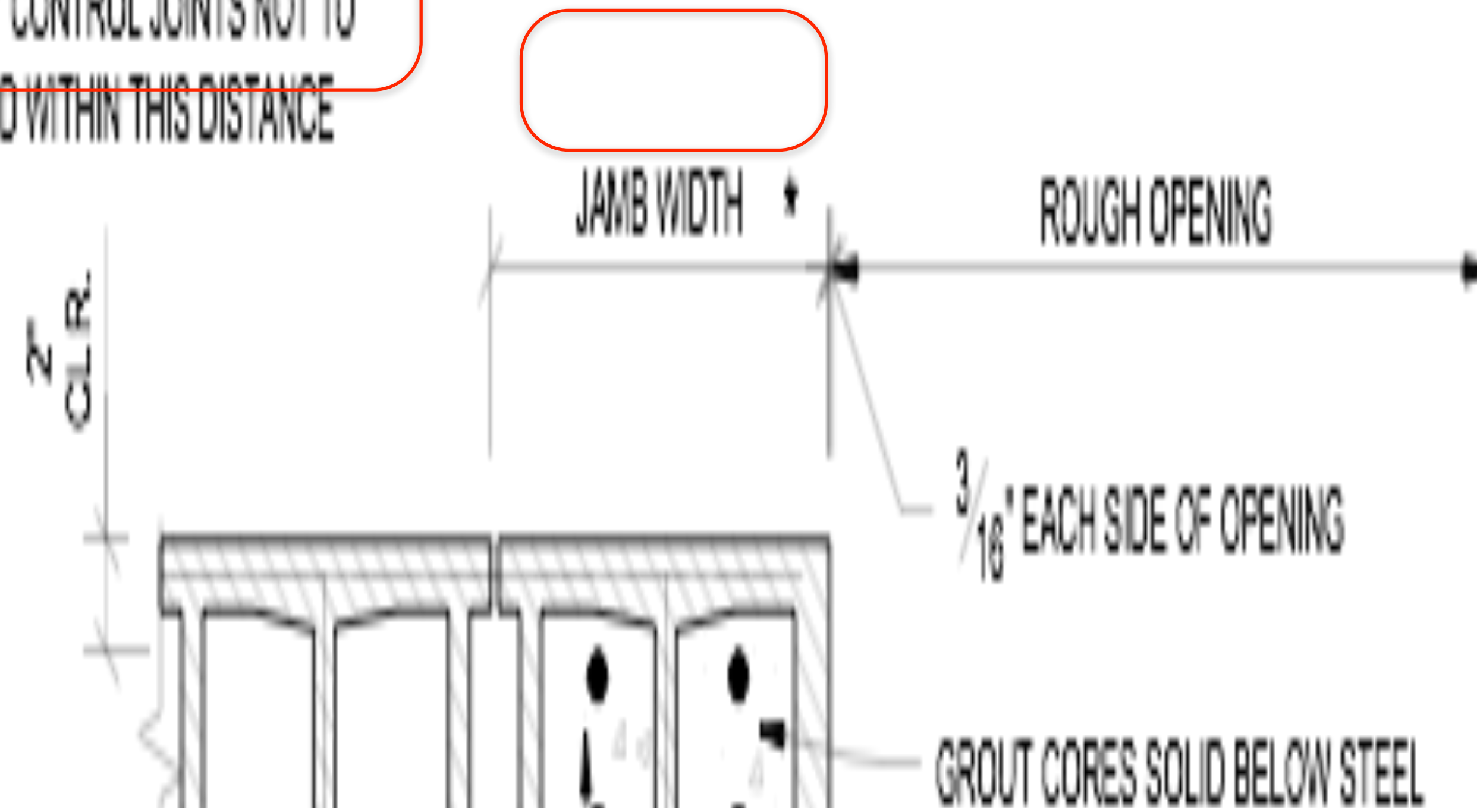


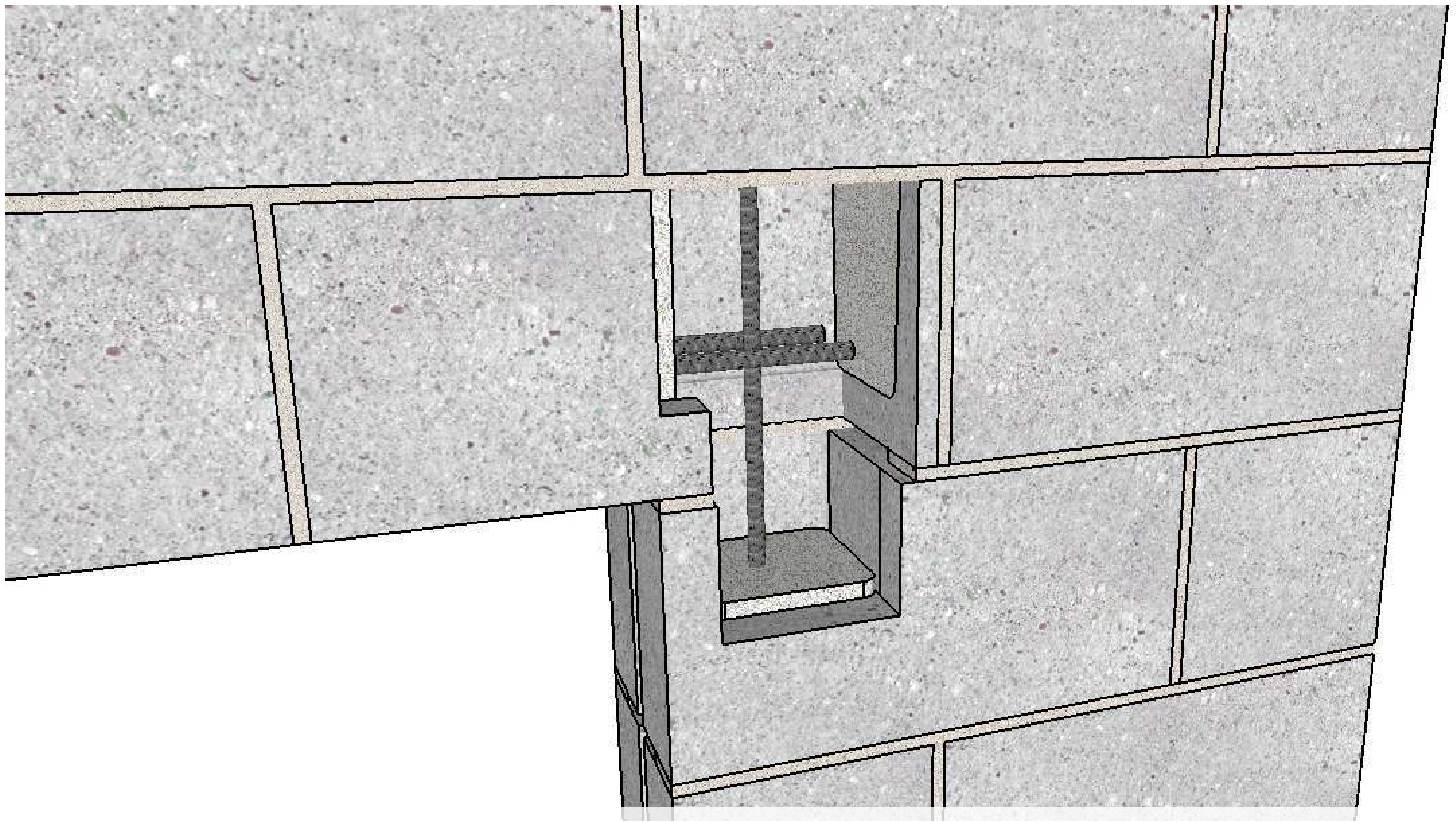
MINIMUM OF 2" V OF
OF OPENING EACH
STRAIGHT LITEL
REINFORCEMENT A
HOOKED LITEL

HOOKED LITEL

REINFORCEMENT IN **FORSE**

* MASONRY CONTROL JOINTS NOT TO
BE LOCATED WITHIN THIS DISTANCE





masonry lintels are integral with masonry wall, creates a robust efficient design



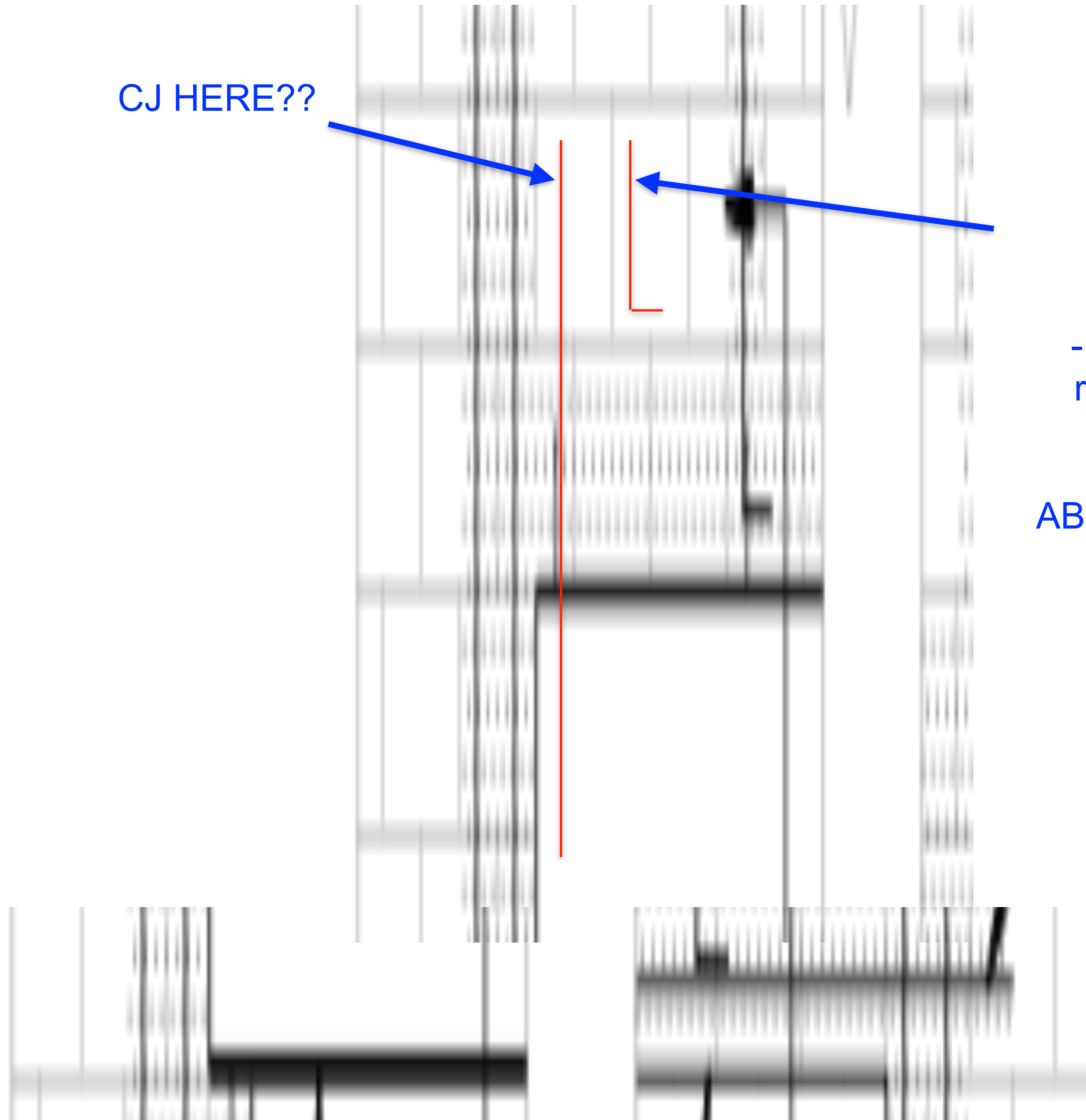
Complicated to do it right

CJ HERE??

OR CJ HERE??
+ better for thermal
performance

- but worse, because it
requires slip under the
bearing of steel

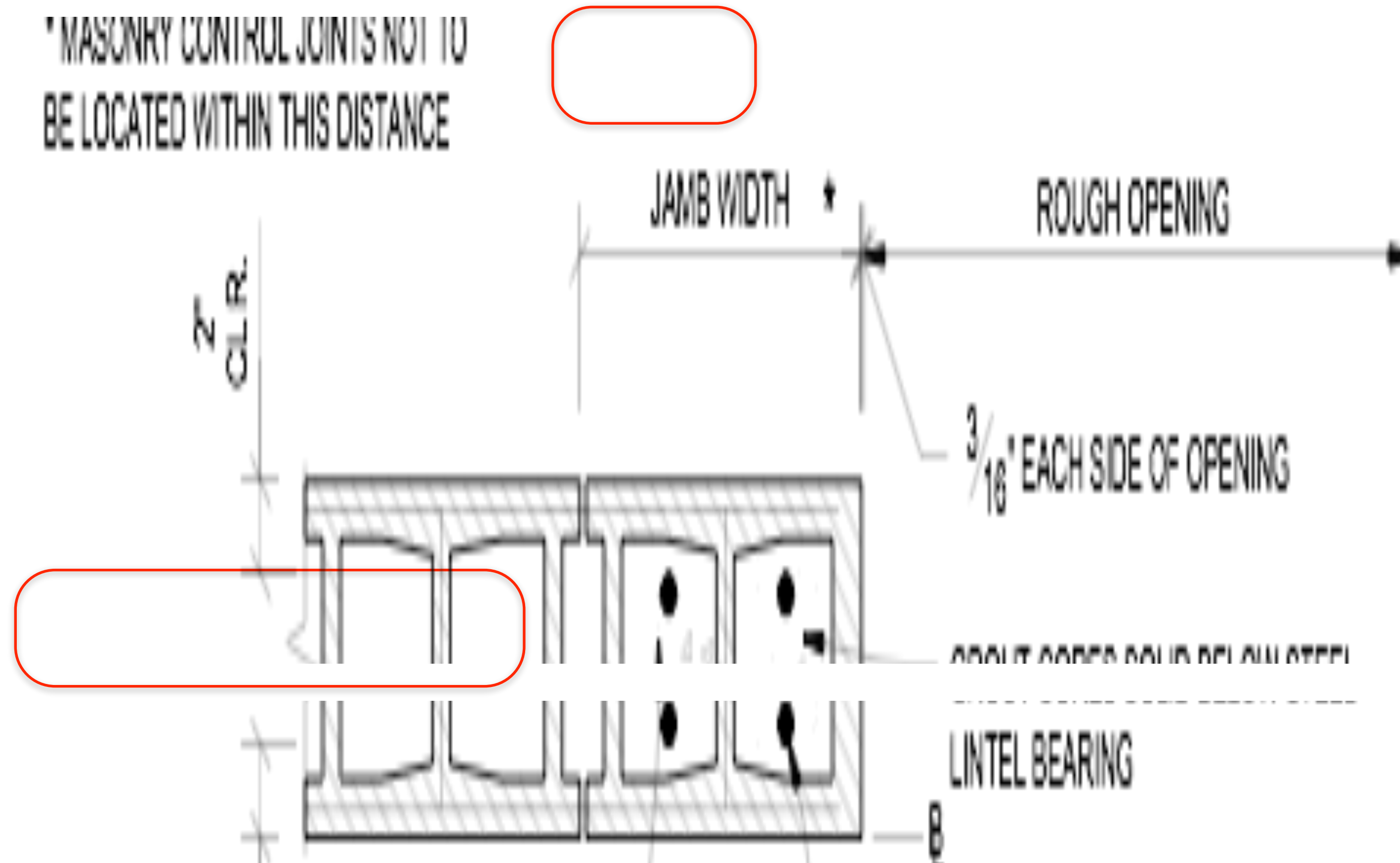
ABSOLUTELY REQUIRES
HORIZONTAL
REINFORCING AT
BEARING!



FORSE

FORSE

??



KEEPER BAR
3/8" # x 4" LG.
(1) EA. SIDE
OF FLANGE

WHAT PREVENTS TORSION?
W-FLANGE WILL FOLD

LINTEL SEE PLAN

1/2"
TYP.

3/16"

3"

THIS
END
ONLY

BEAM BOTT. PL

WILL NOT SLIDE LONG TERM
CEMENTICIOUS MATERIAL CREATES FRICTION
H2O+DAMP + STEEL = RUST!!

BEARING PLATE
TOO BIG!

FIXED CONN.

CONTROL JT. @
SLIDING END
SEE ARCH

BRG.

BRG. PL: 7 1/2" x 1/2" x 0'-7 1/2"
W/2- 1/2" # x 4" H. STUDS
PROVIDE SLIDING CONN. ONE
END & FIXED CONN. @ OPP. END

LINTEL SEE PLAN

MASONRY WALL PROVIDE
JAMB REINF. & GROUT SOLID

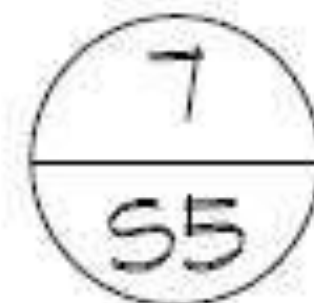
EXPECT A
CRACK HERE

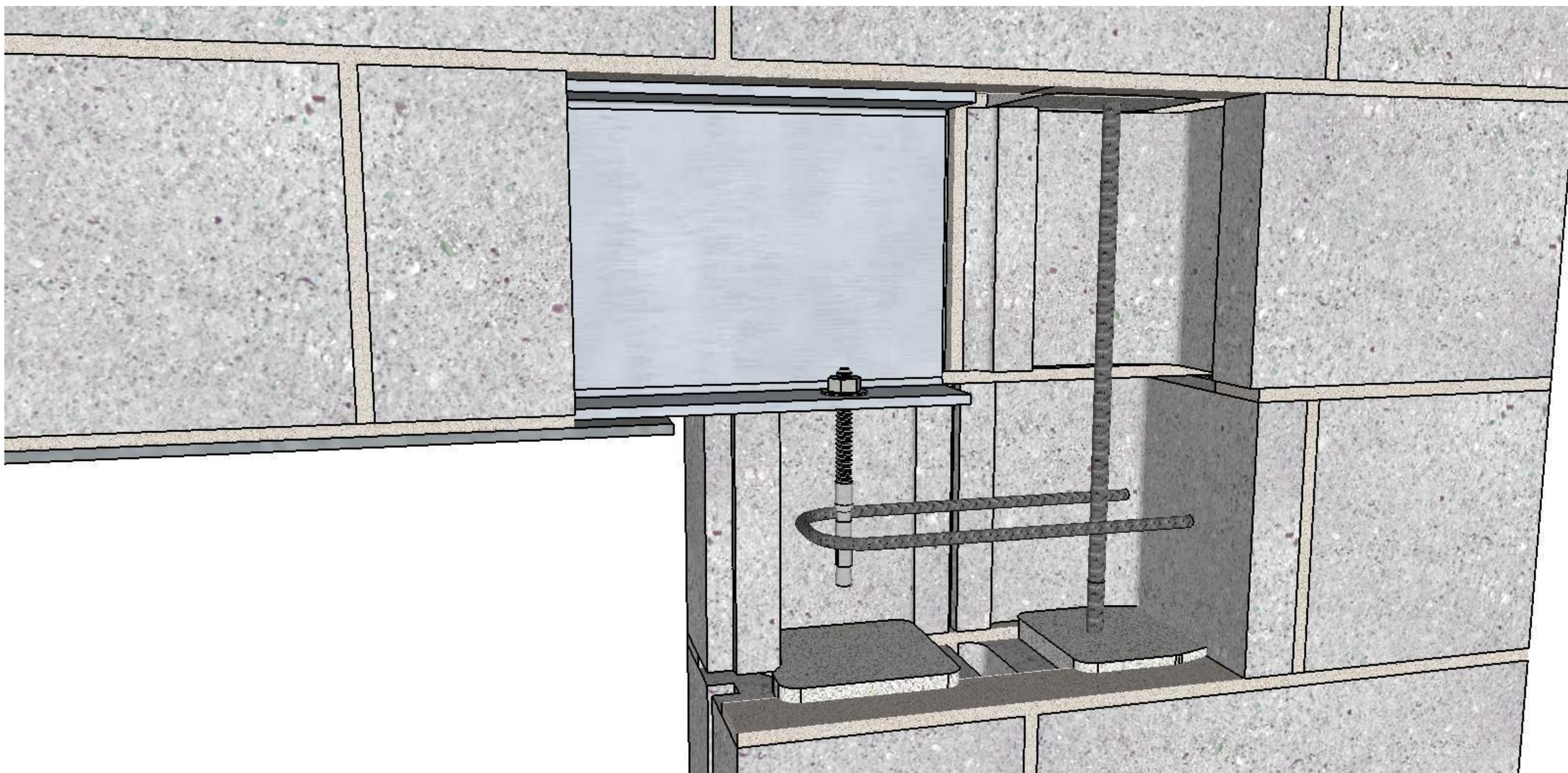
TYP. STL. LINTEL

BRG. ON MASONRY

JAMB REINF SHOULD GO FULL
HEIGHT, OTHERWISE WALL HINGE

SCALE: NOT TO SCALE





thats a lot of steel at the bearing







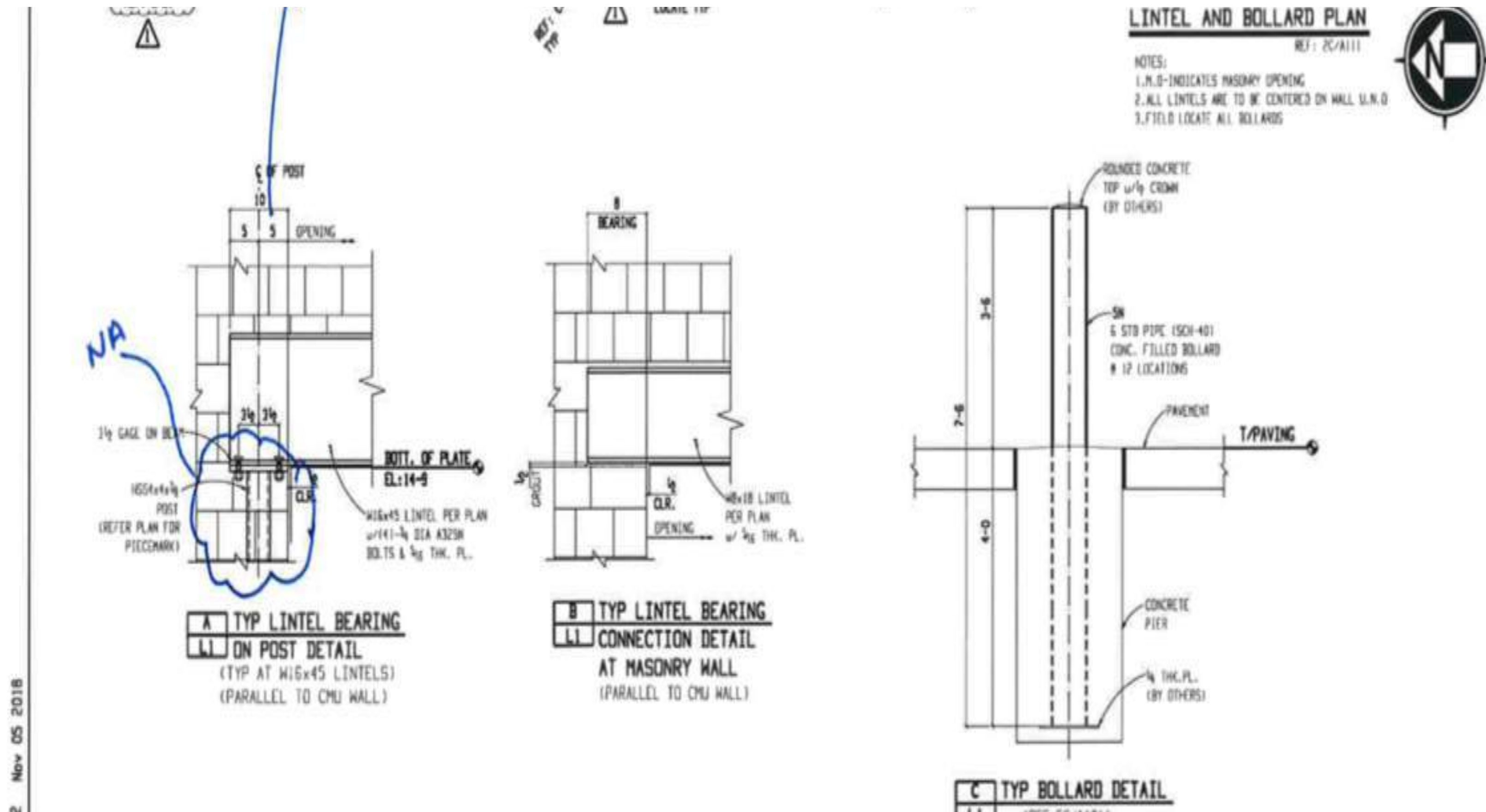




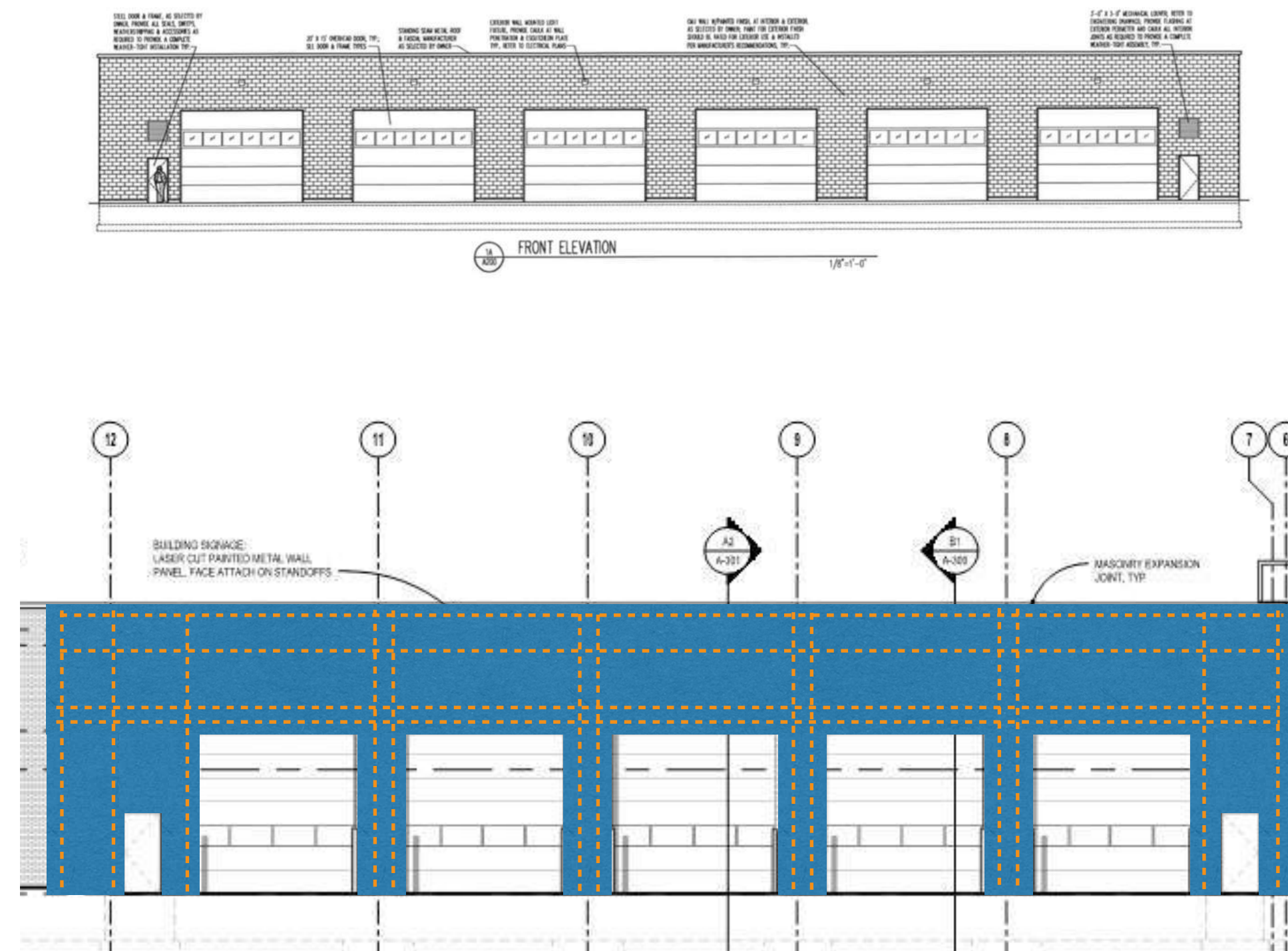
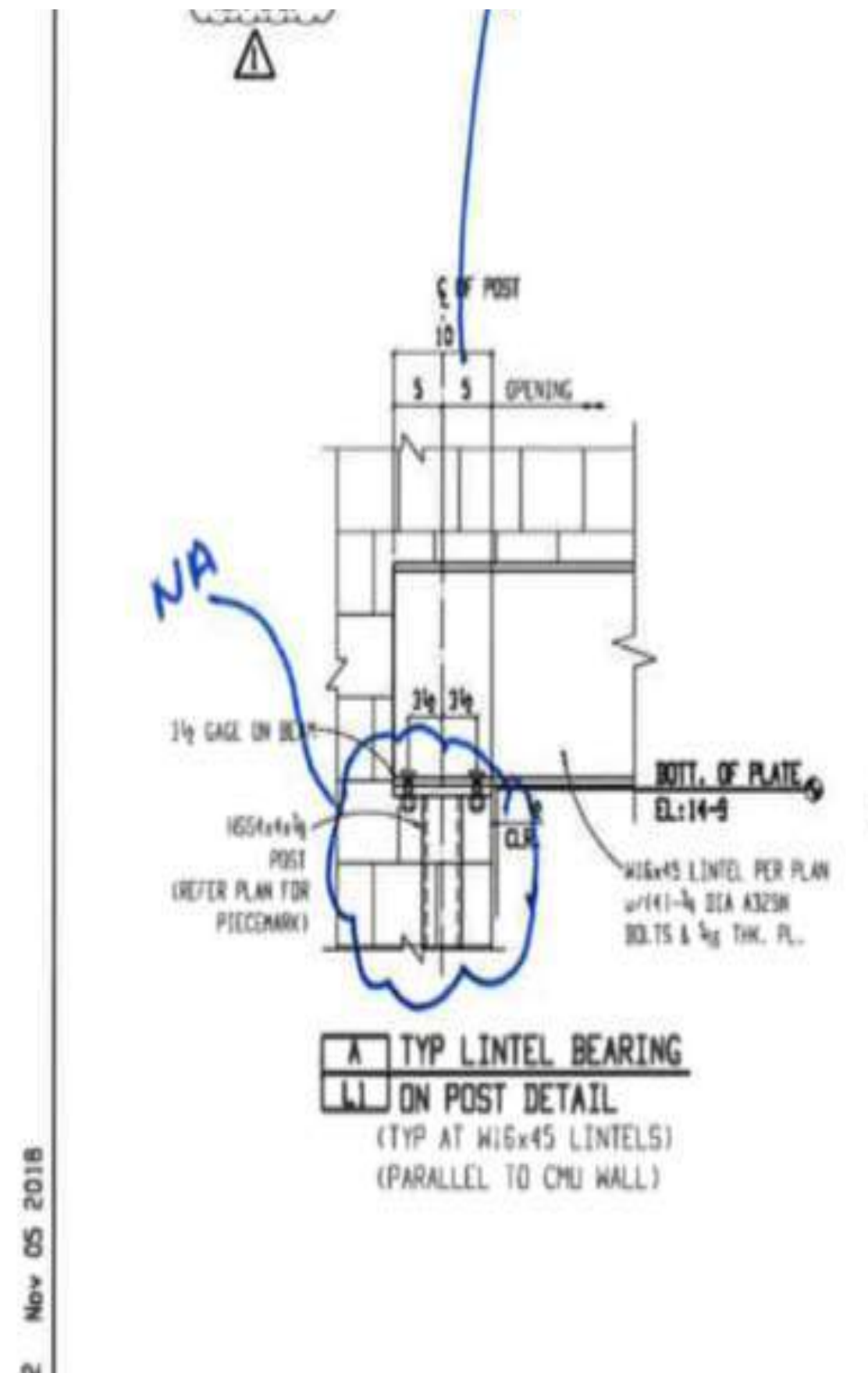


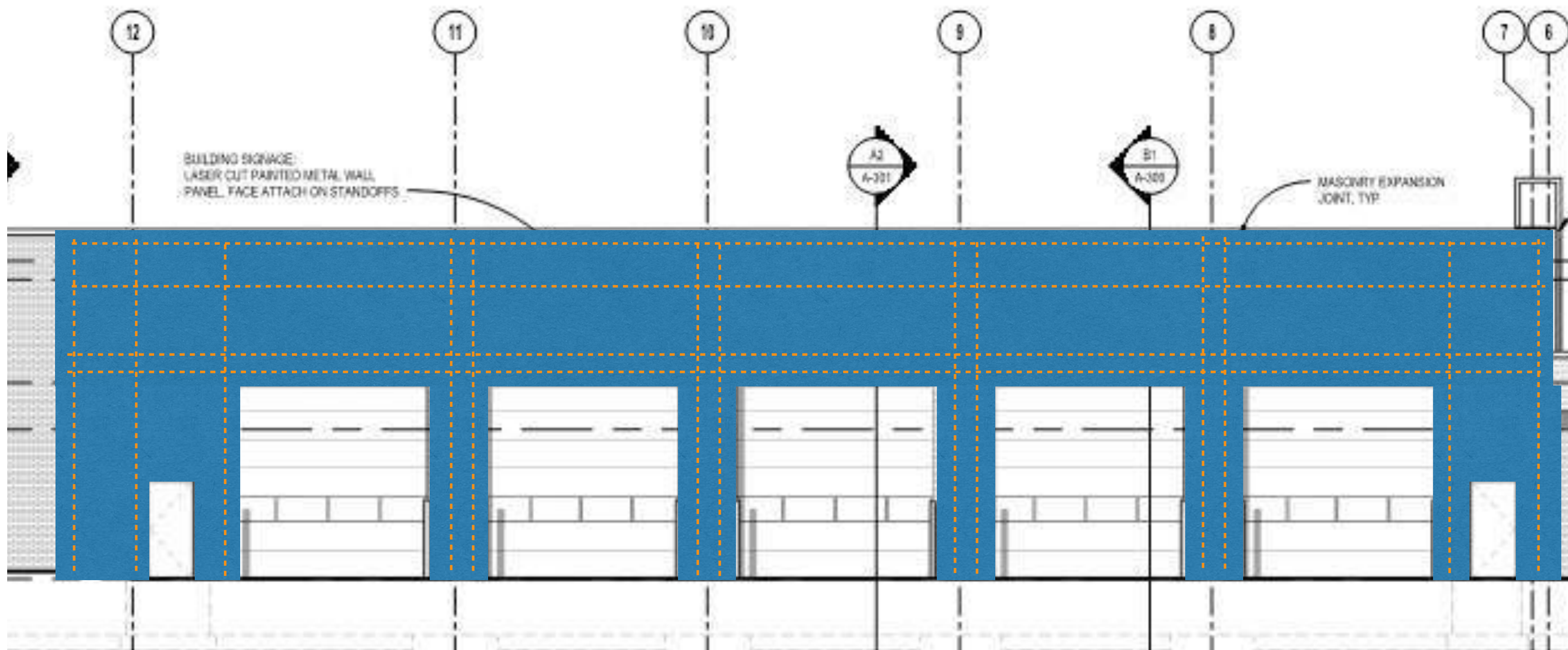


Steel Lintels leading to more steel???



ALL Steel or ALL Masonry???

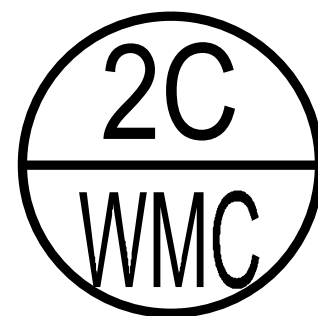
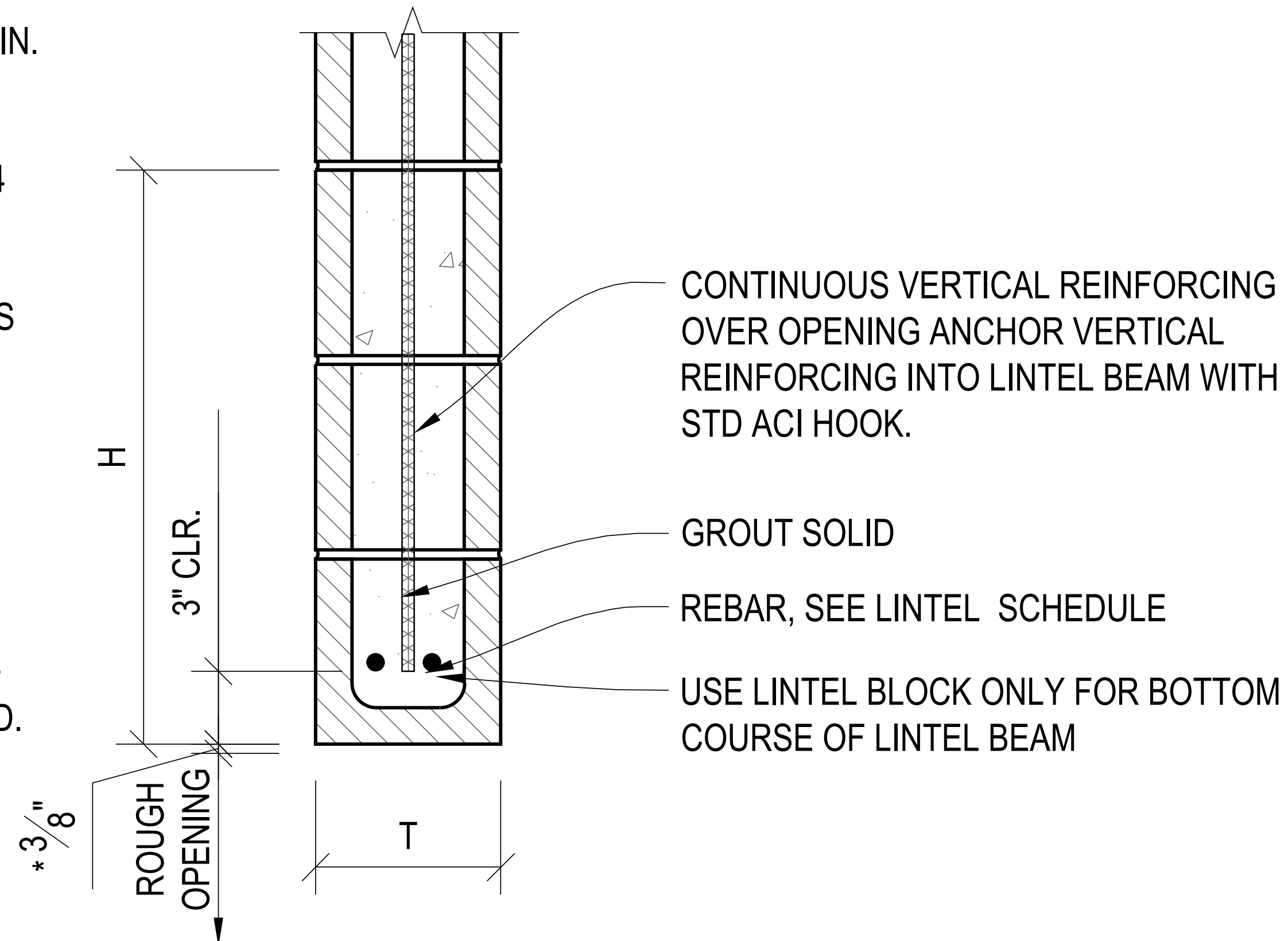




LINTEL NOTES:

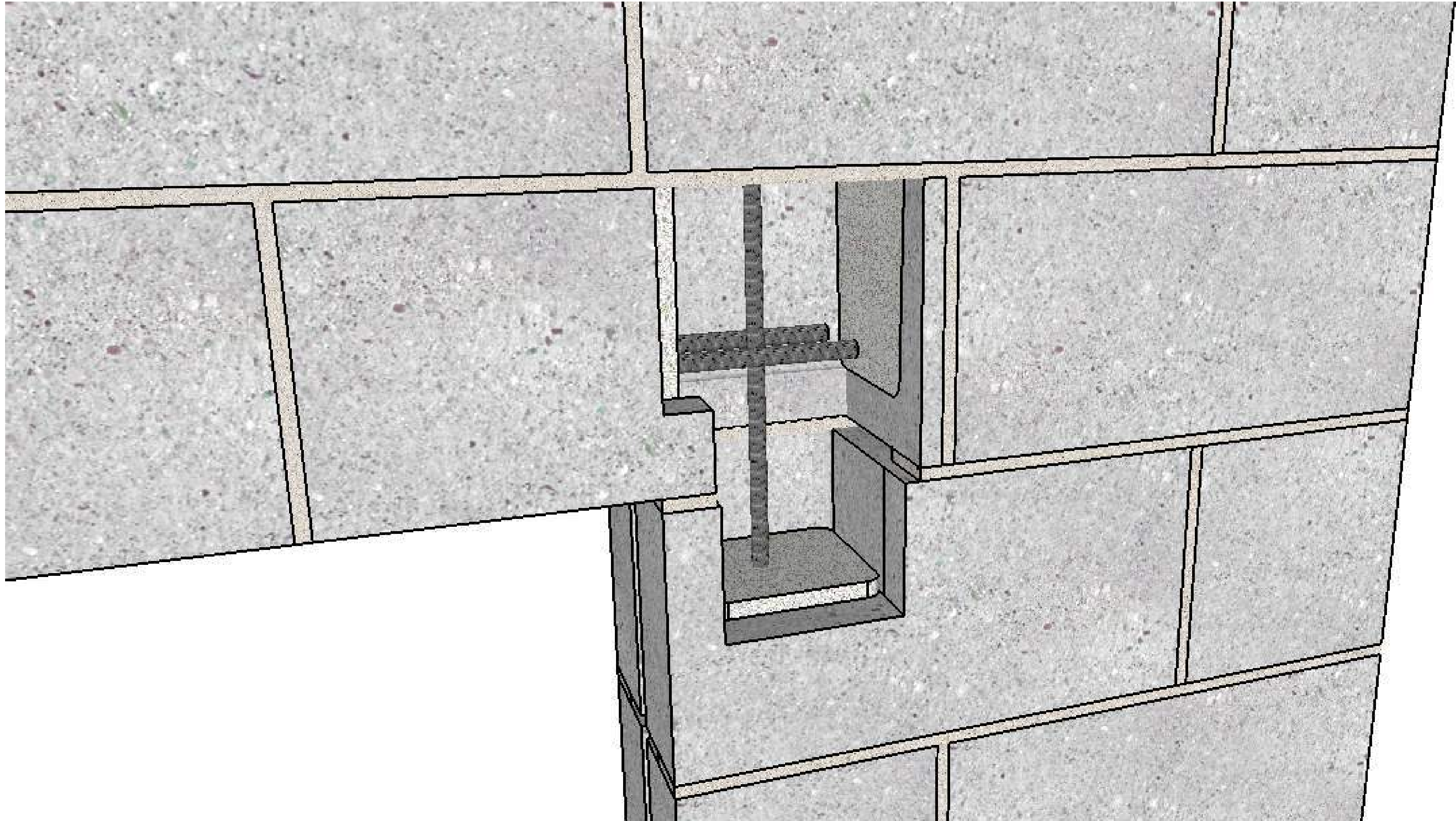
1. MASONRY LINTEL END BEARING, MIN. OF 8". SEE LINTEL SCHEDULE
2. MIN. LINTELS JAMB (SUPPORT), SOLID GROUTED CELL WITH (1) #4 REBAR. SEE LINTEL SCHEDULE (THIS IS IN ADDITION TO ANY TYP. WALL REINFORCEMENT.) (UNLESS OTHERWISE NOTED)

* THE ACTUAL ROUGH OPENING WILL TYPICAL BE $\frac{3}{8}$ " LARGER THEN LISTED.



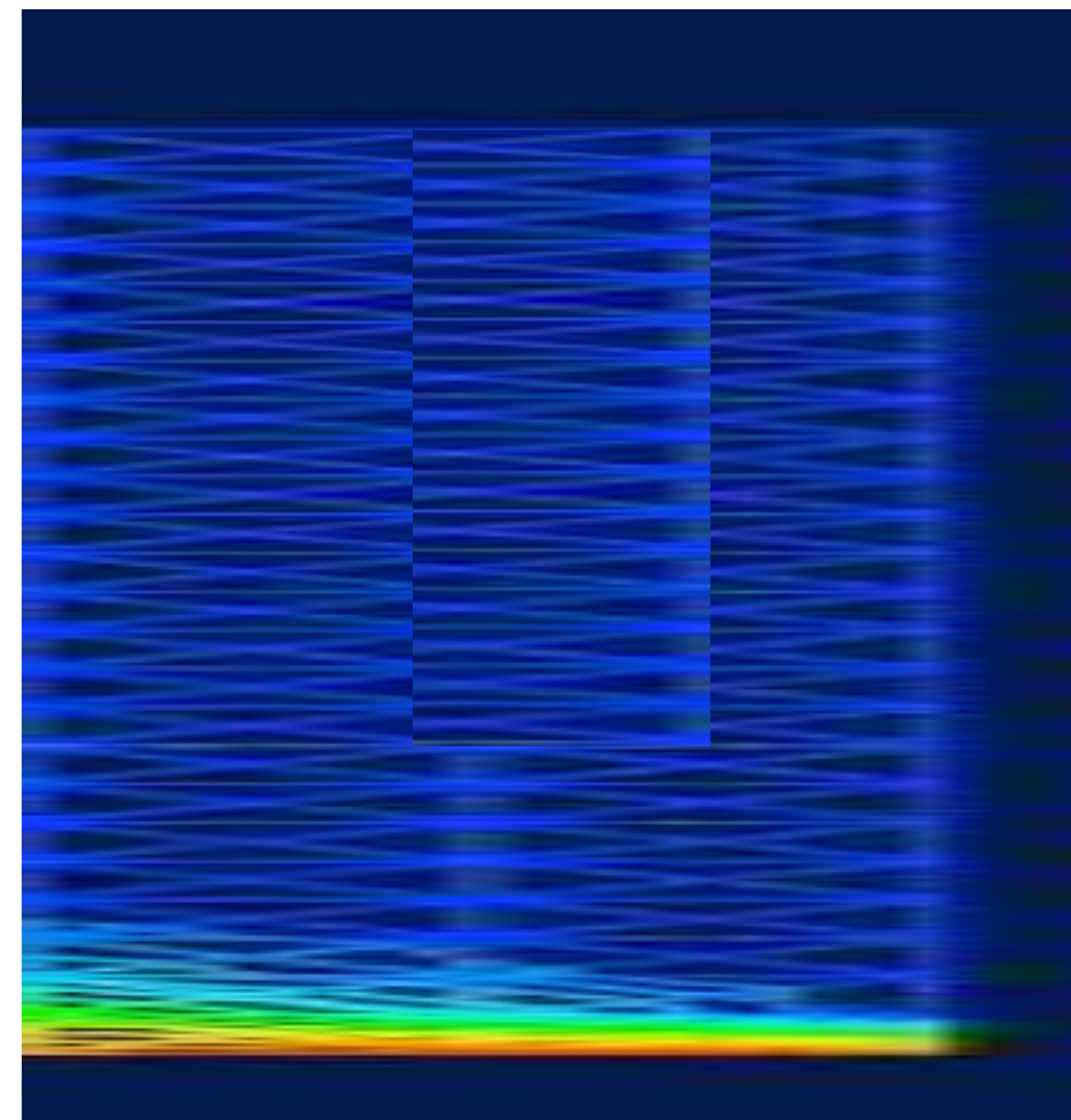
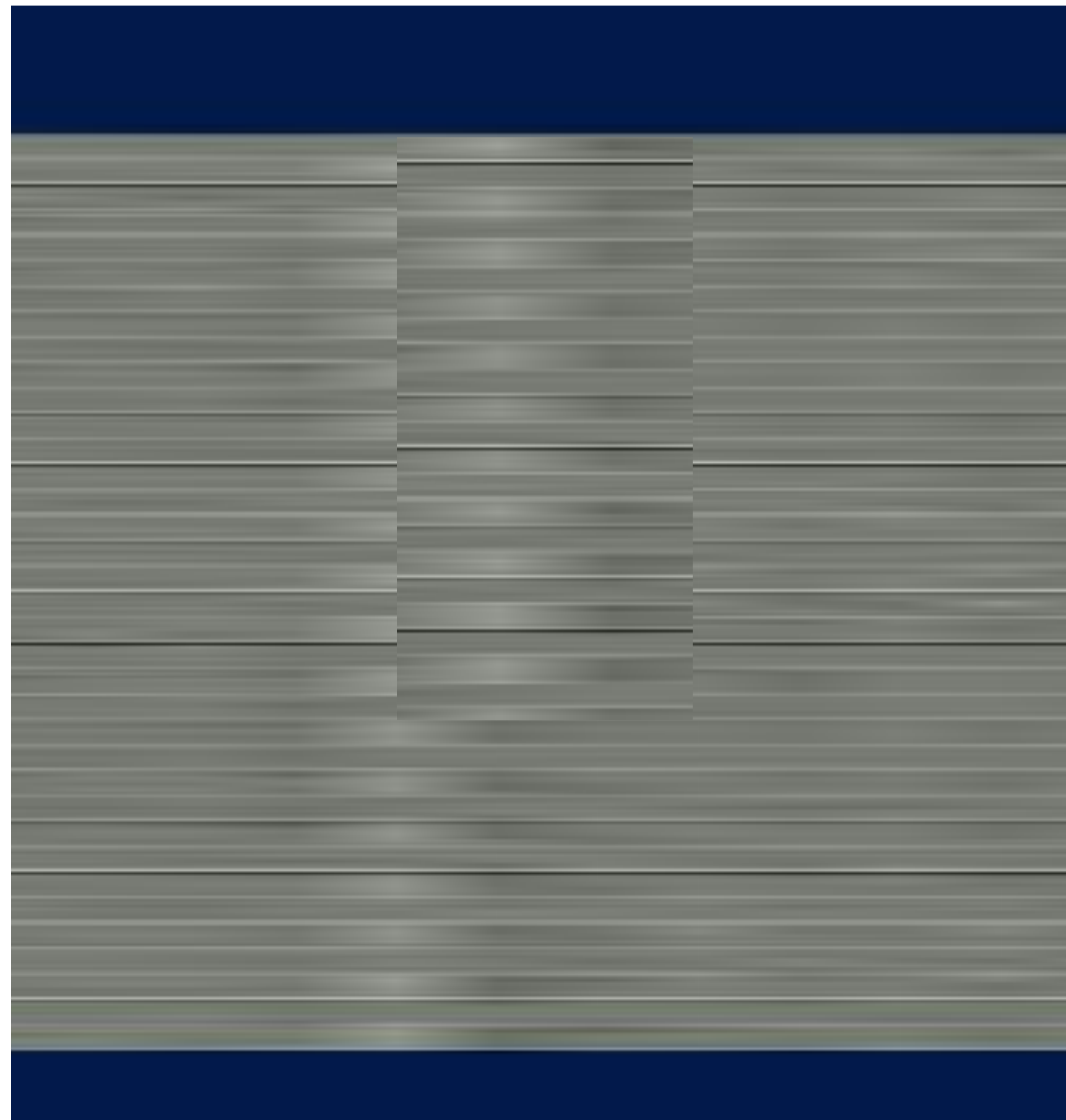
MASONRY LINTEL DETAIL

SCALE : 1" = 1'-0"



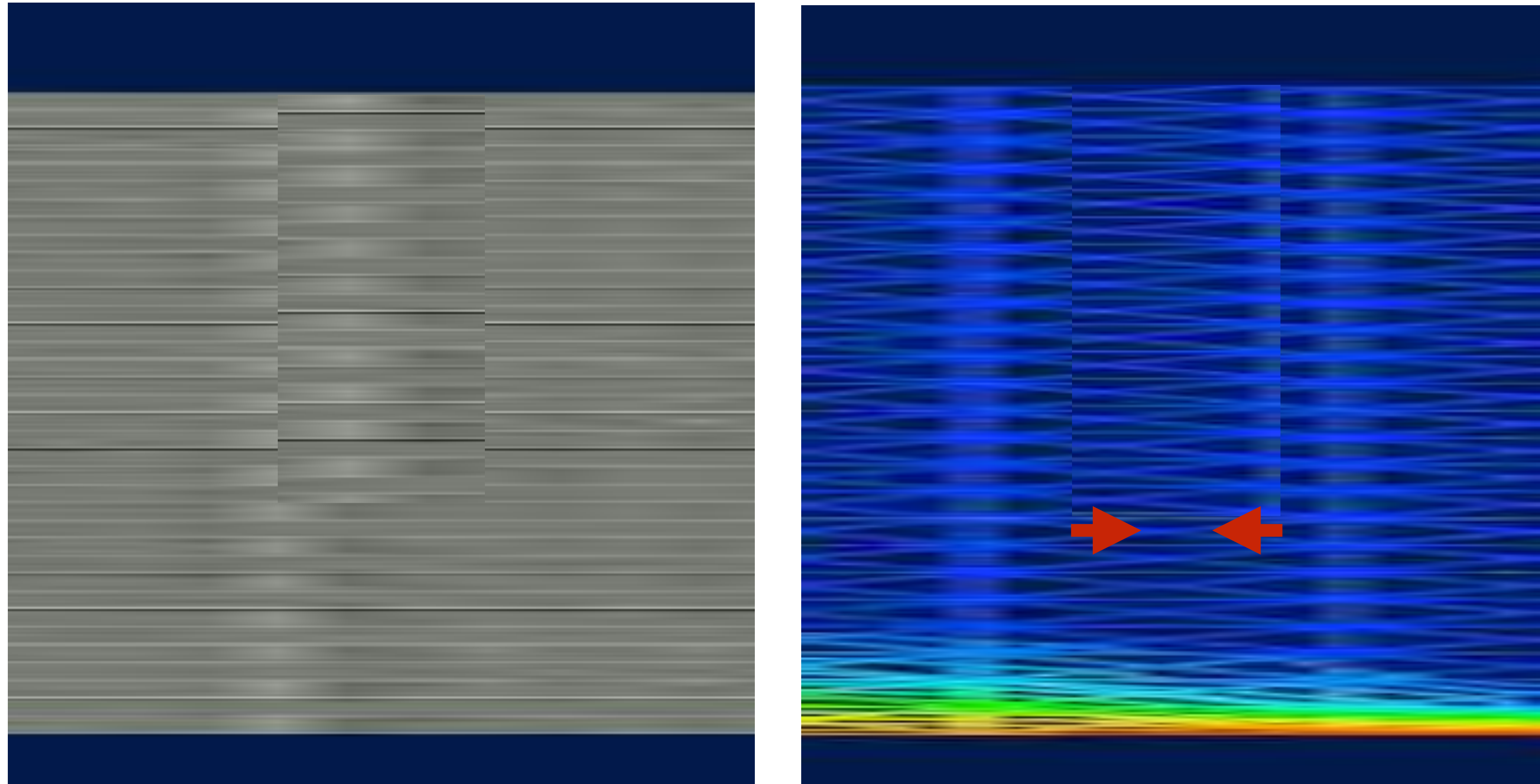


What does FEA tell us about steel lintels?



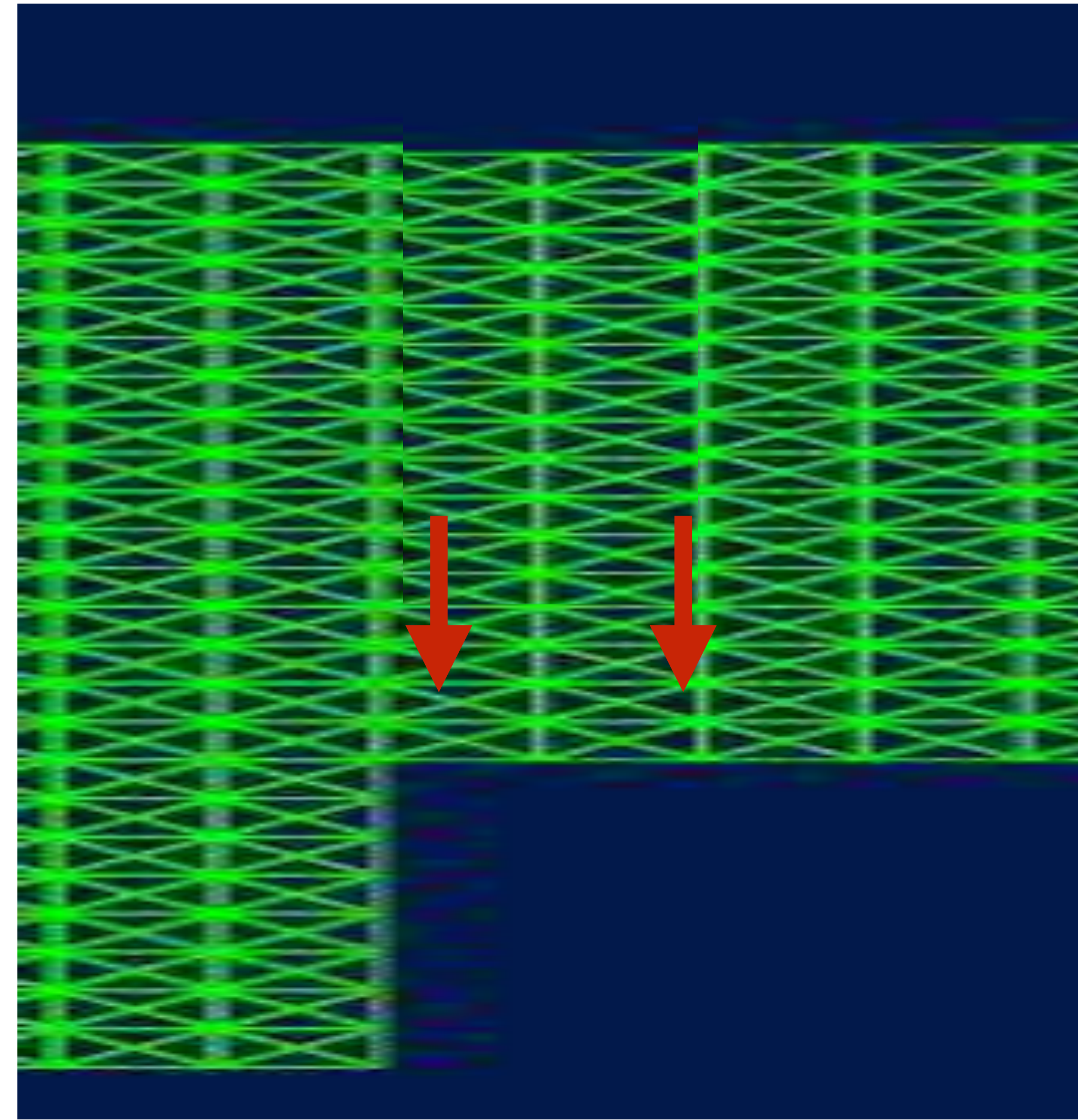
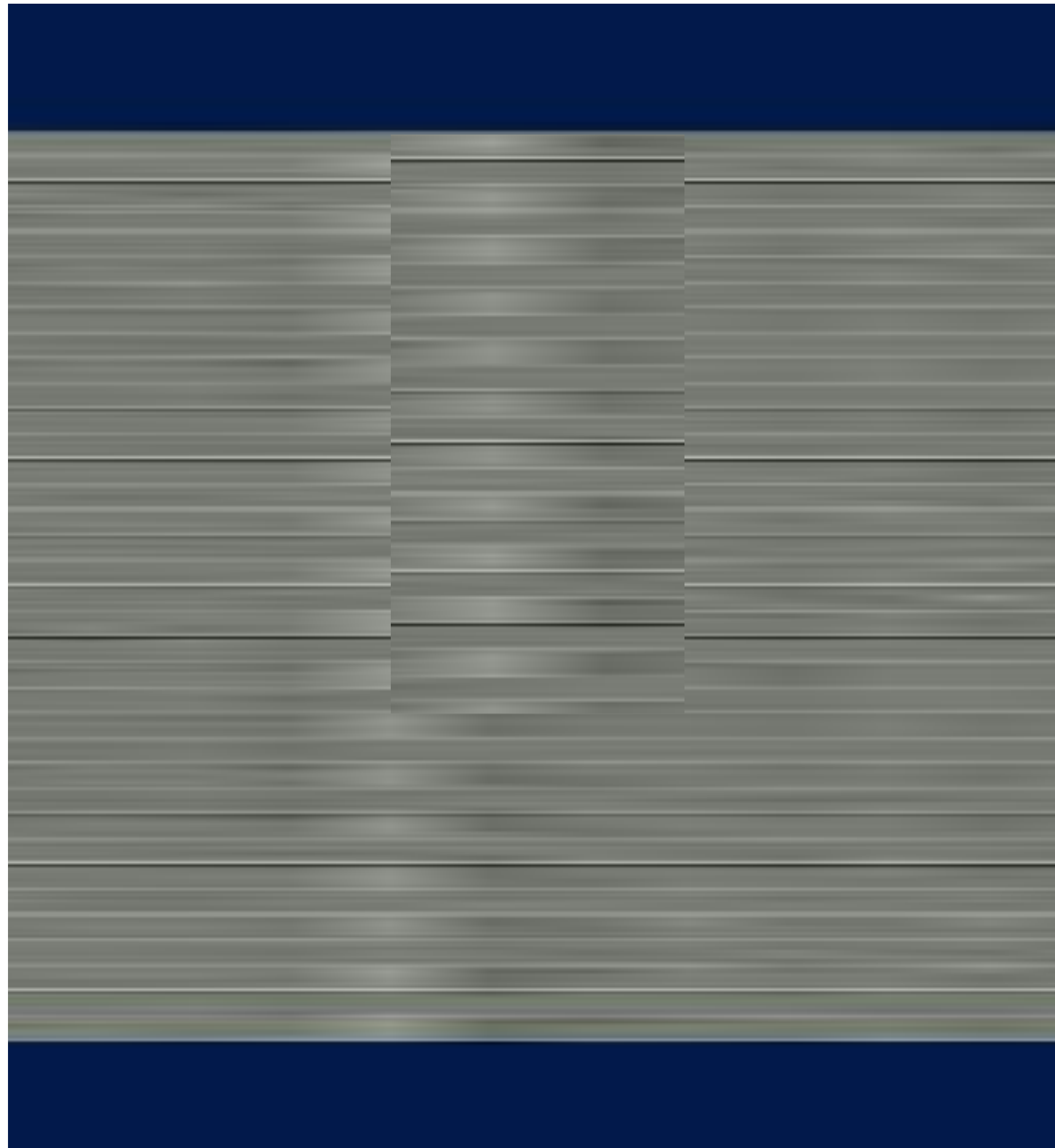
temperature load, slip occurs

What does FEA tell us about steel lintels? - if lintel bearing doesn't slip



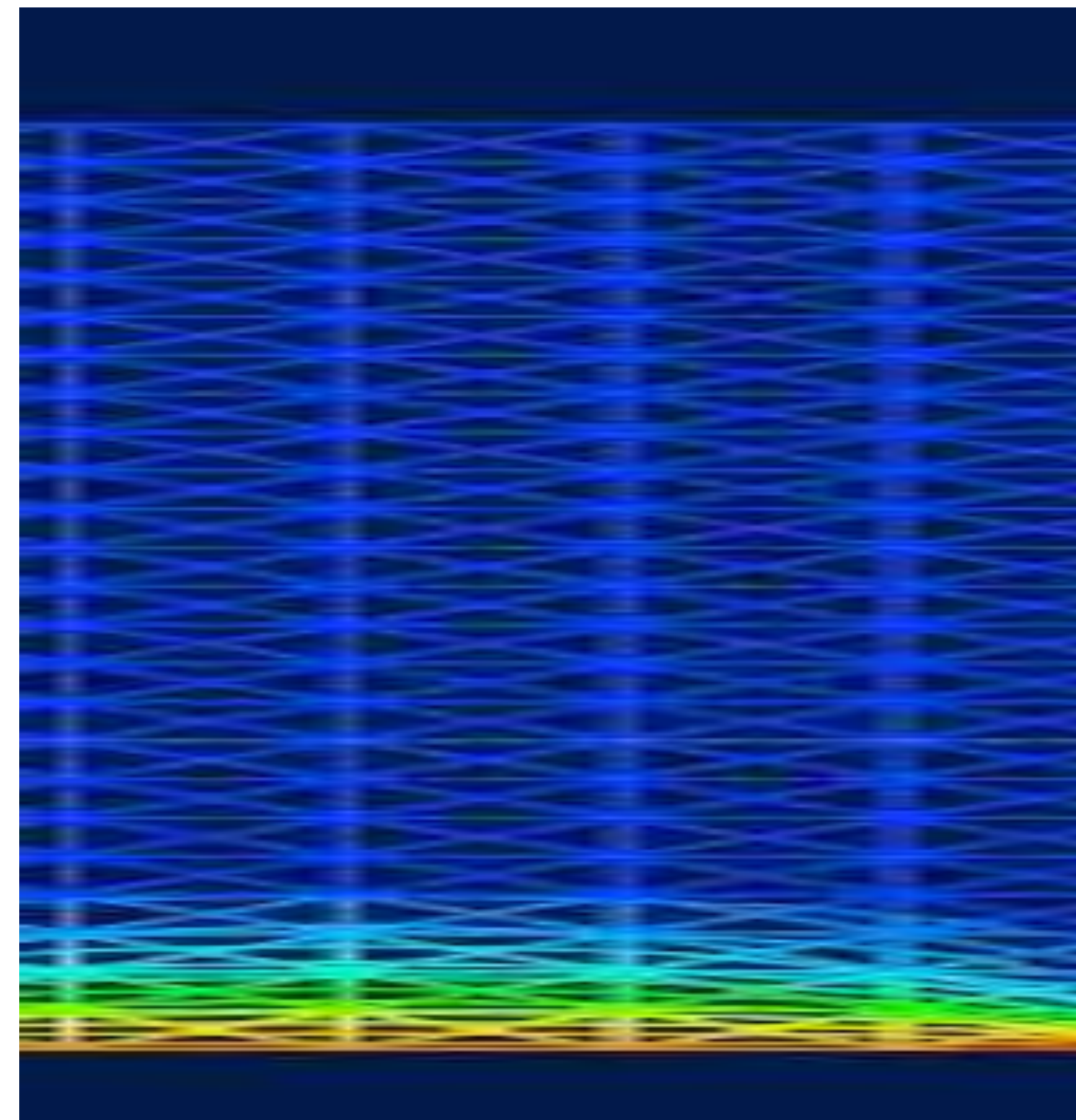
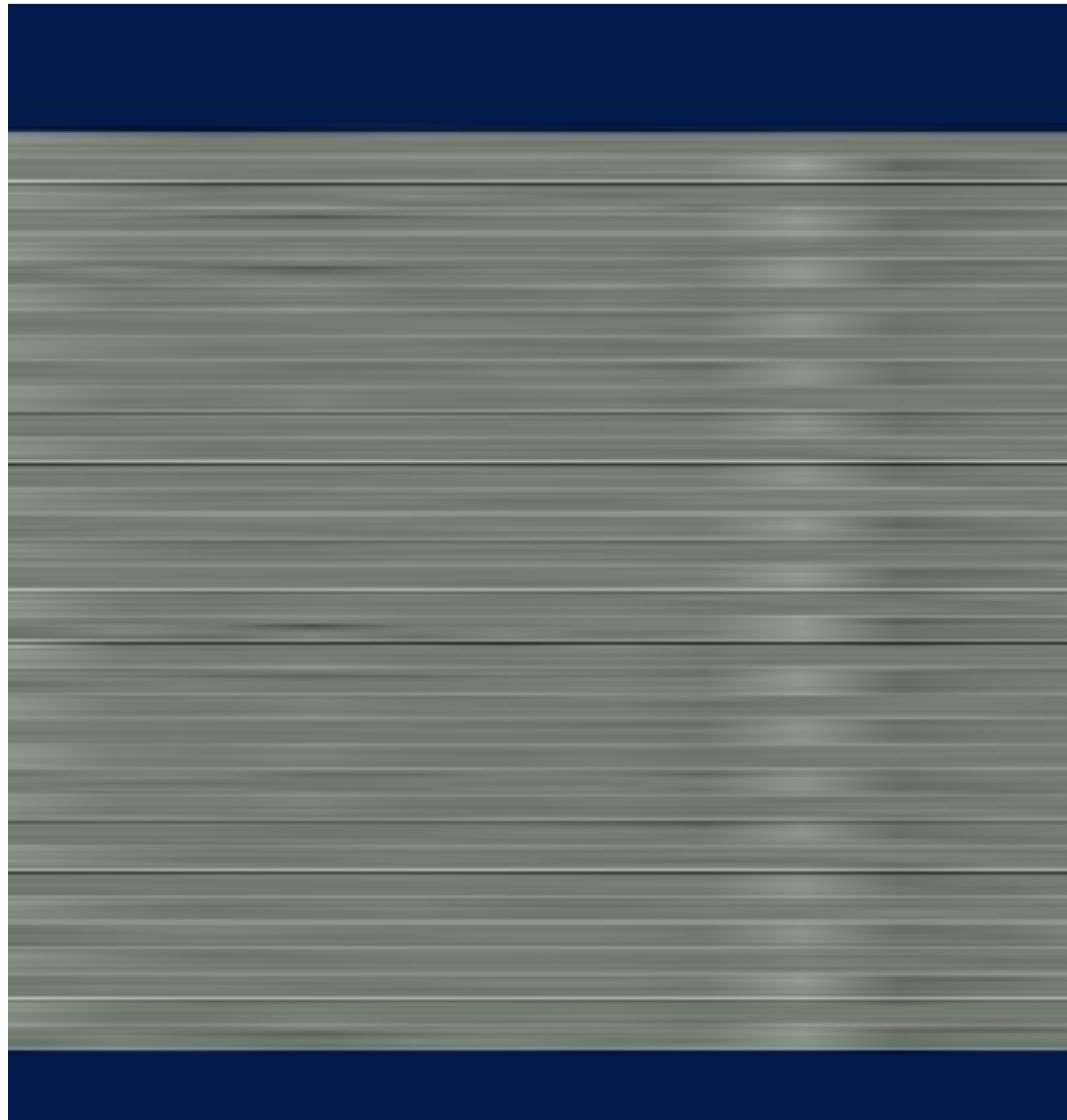
massive force, 30k, 40 degree temp change

What does FEA tell us about steel
lintels? - dead load stressful...



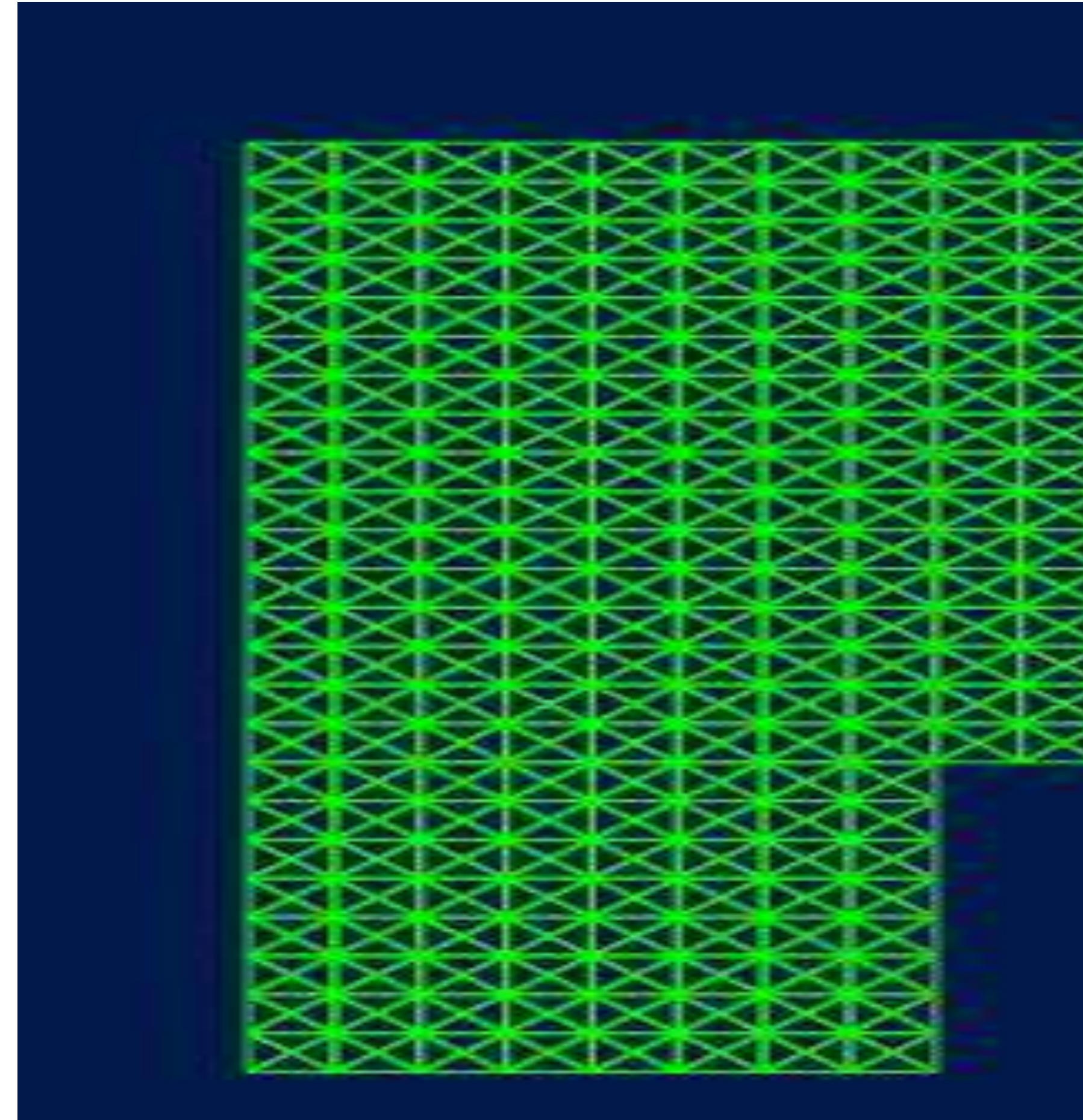
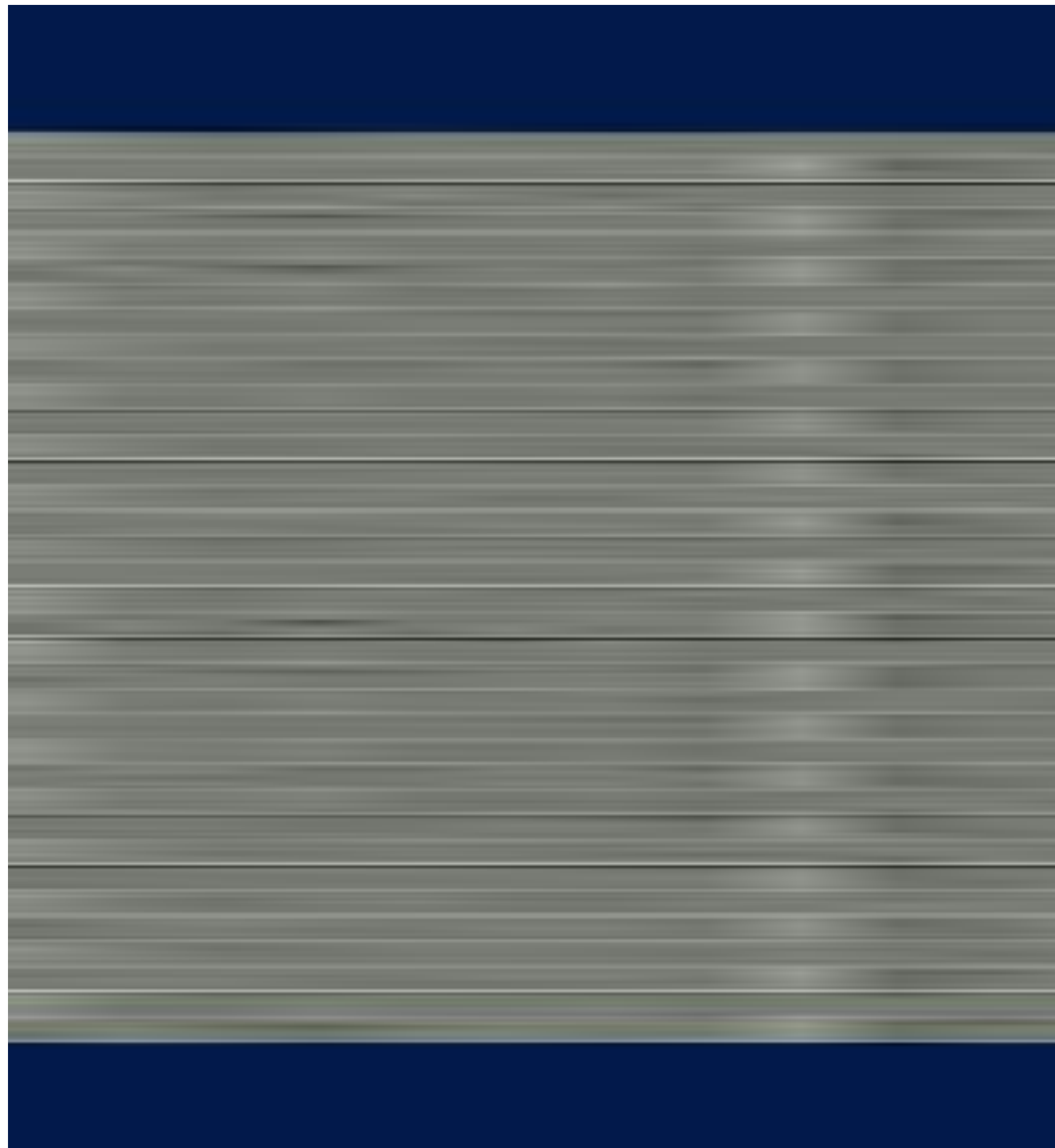
dead load causes stress concentration too

What does FEA tell us about
masonry/integrated lintels?



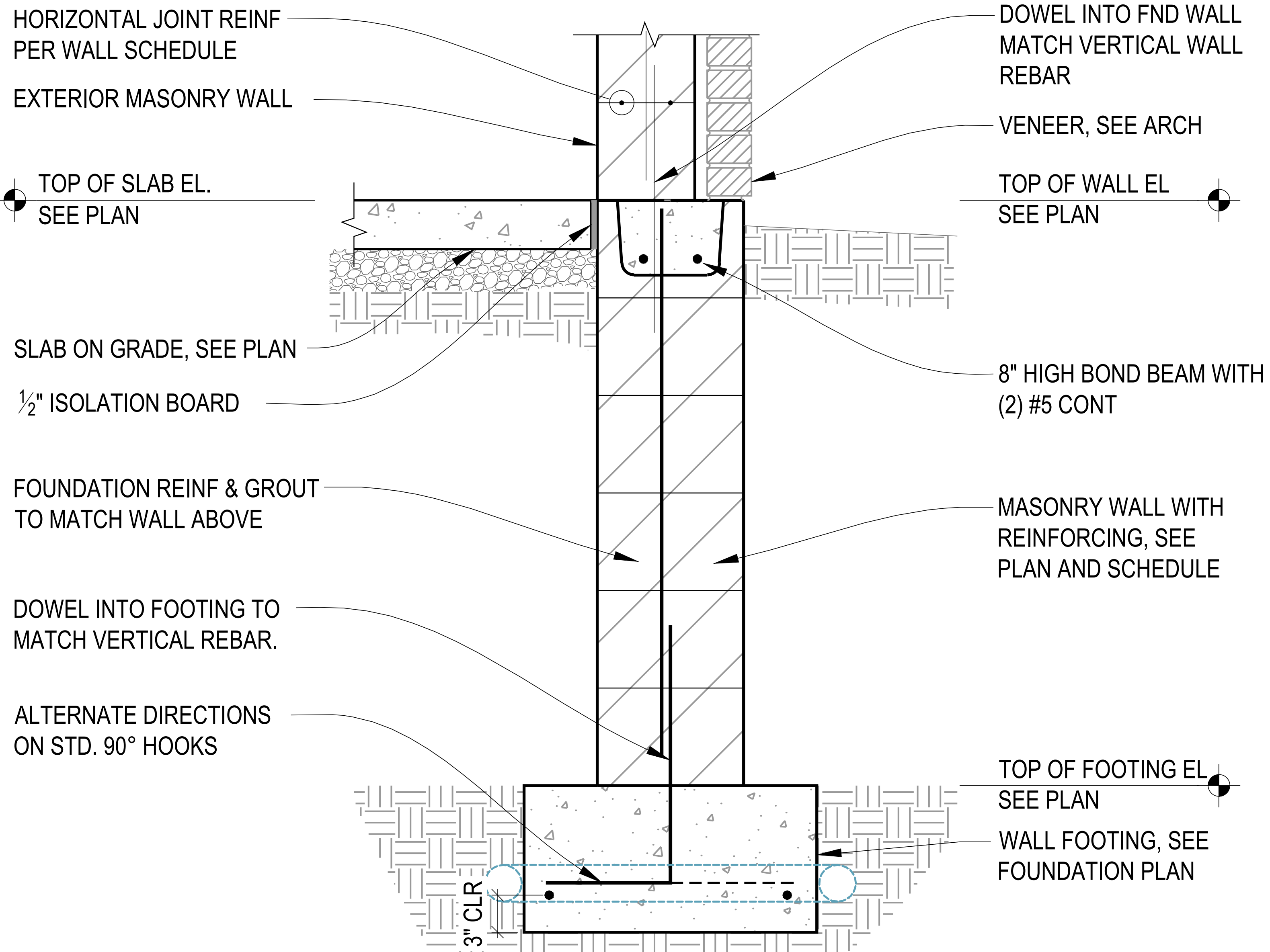
temperature load

What does FEA tell us about steel
lintels? - dead load stressful...



dead load force flows around opening

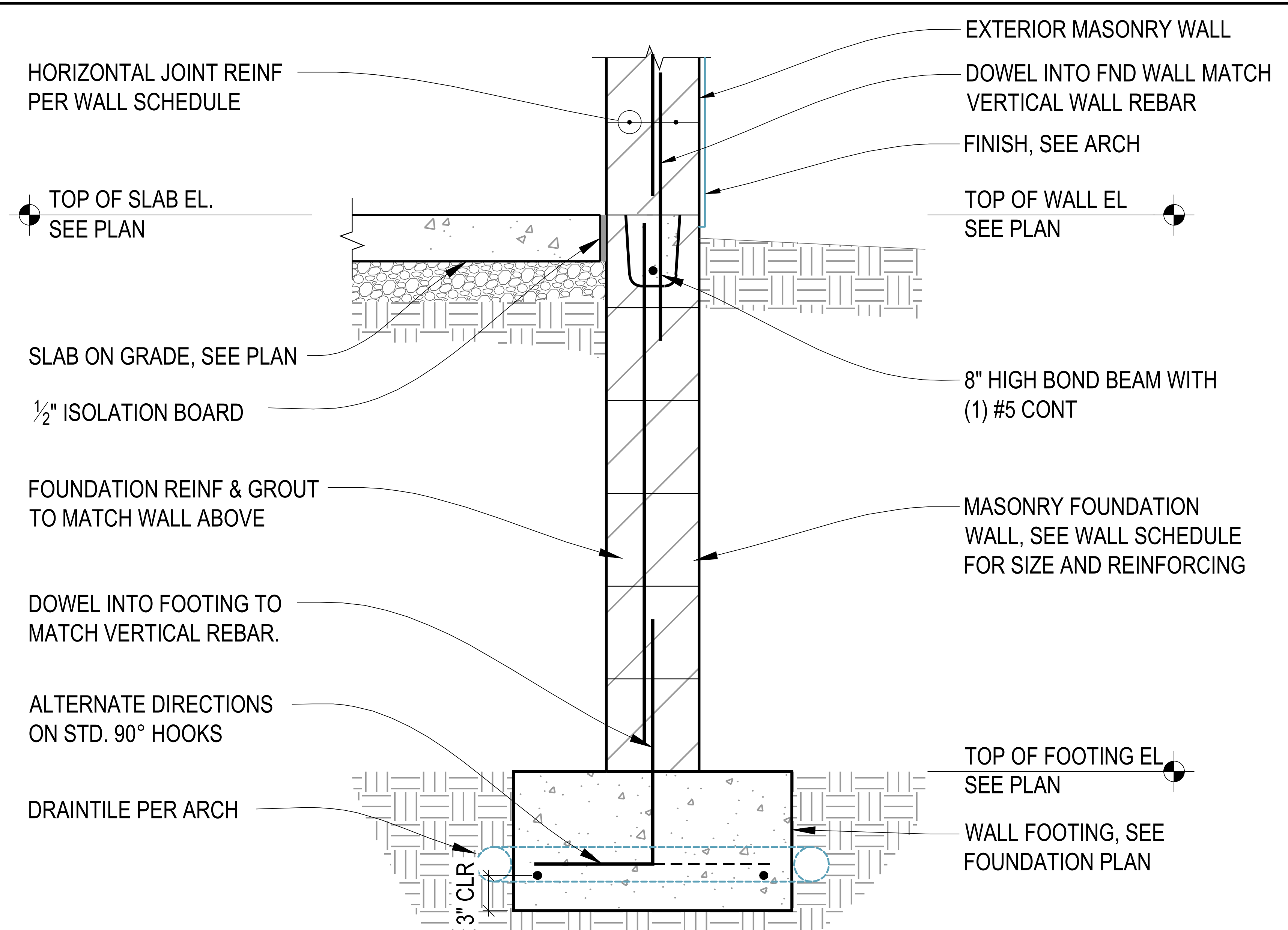
Foundations



5A
WMC

EXTERIOR FOUNDATION WALL SECTION

SCALE : 3/4" = 1'-0"

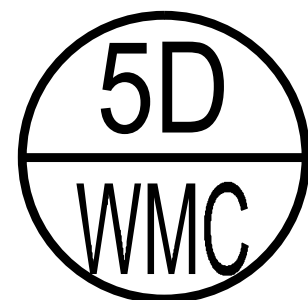
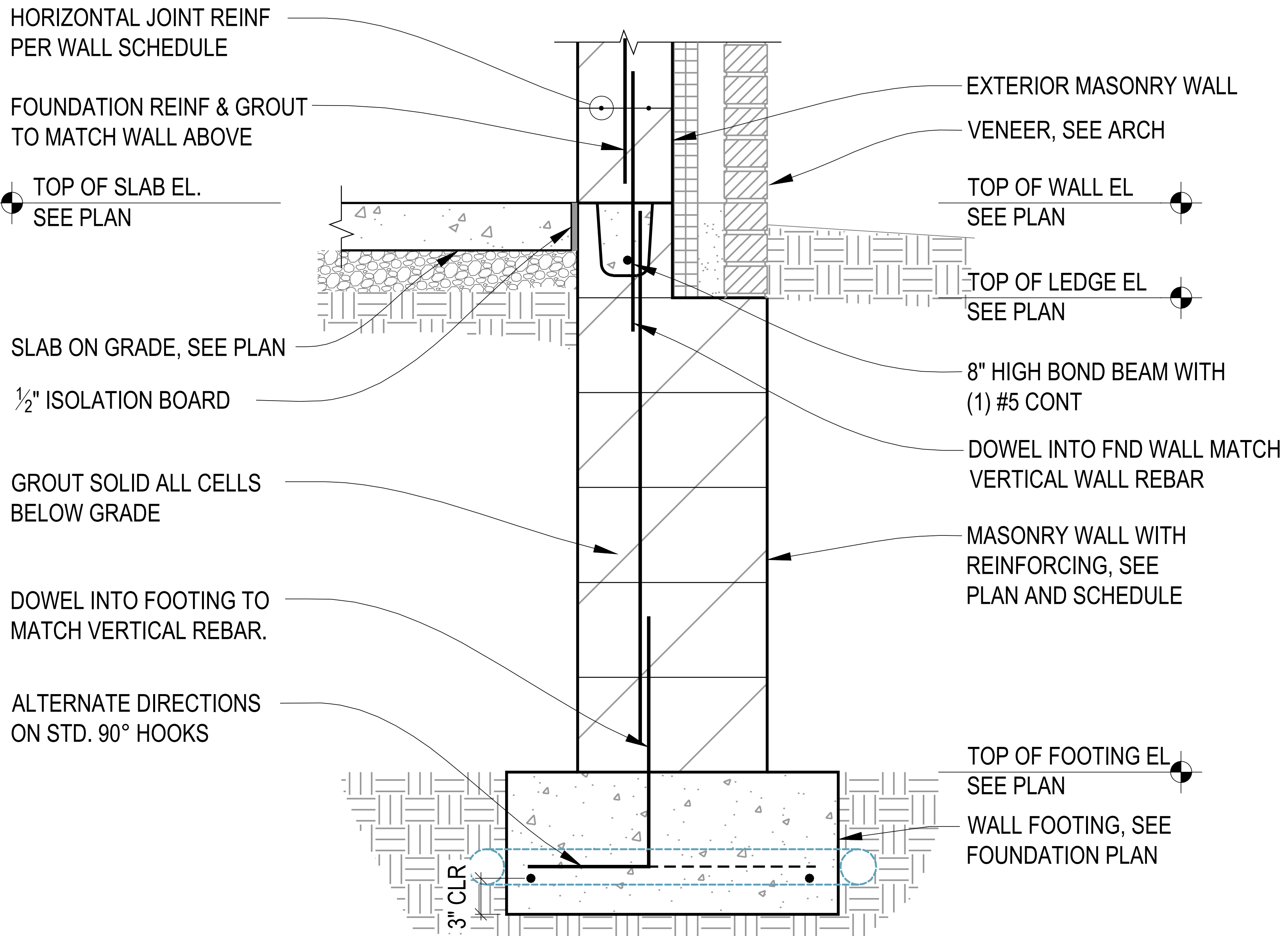


5B
WMC

EXTERIOR FOUNDATION WALL SECTION

SCALE : 3/4" = 1'-0"



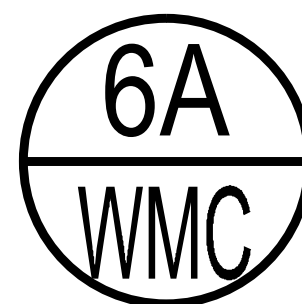
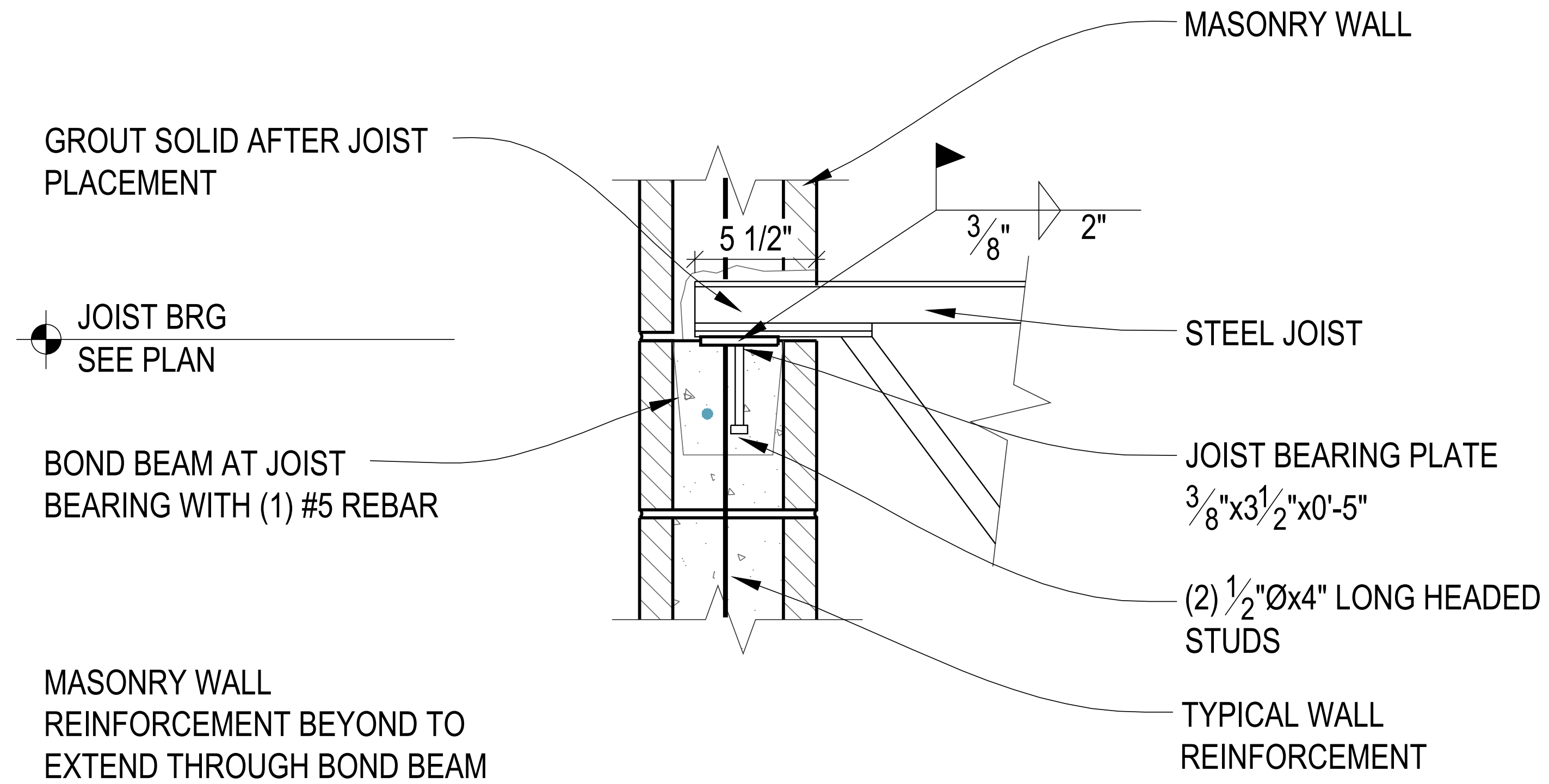


EXTERIOR FOUNDATION WALL SECTION

SCALE : $\frac{3}{4}$ " = 1'-0"

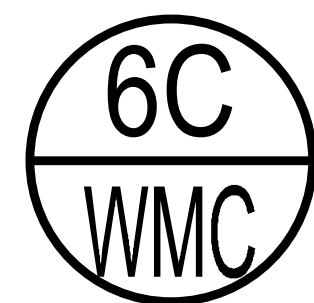
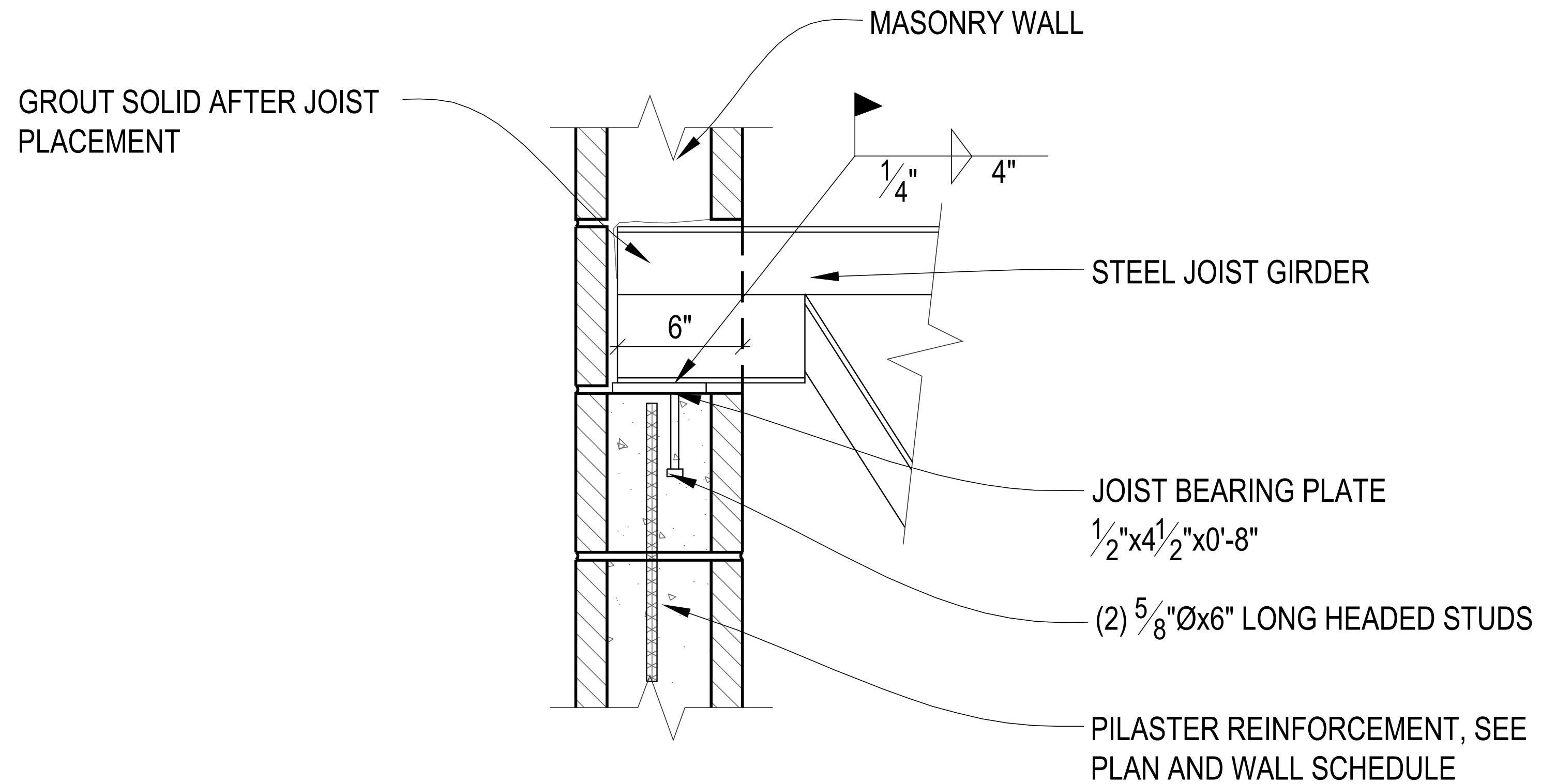


Roof Details



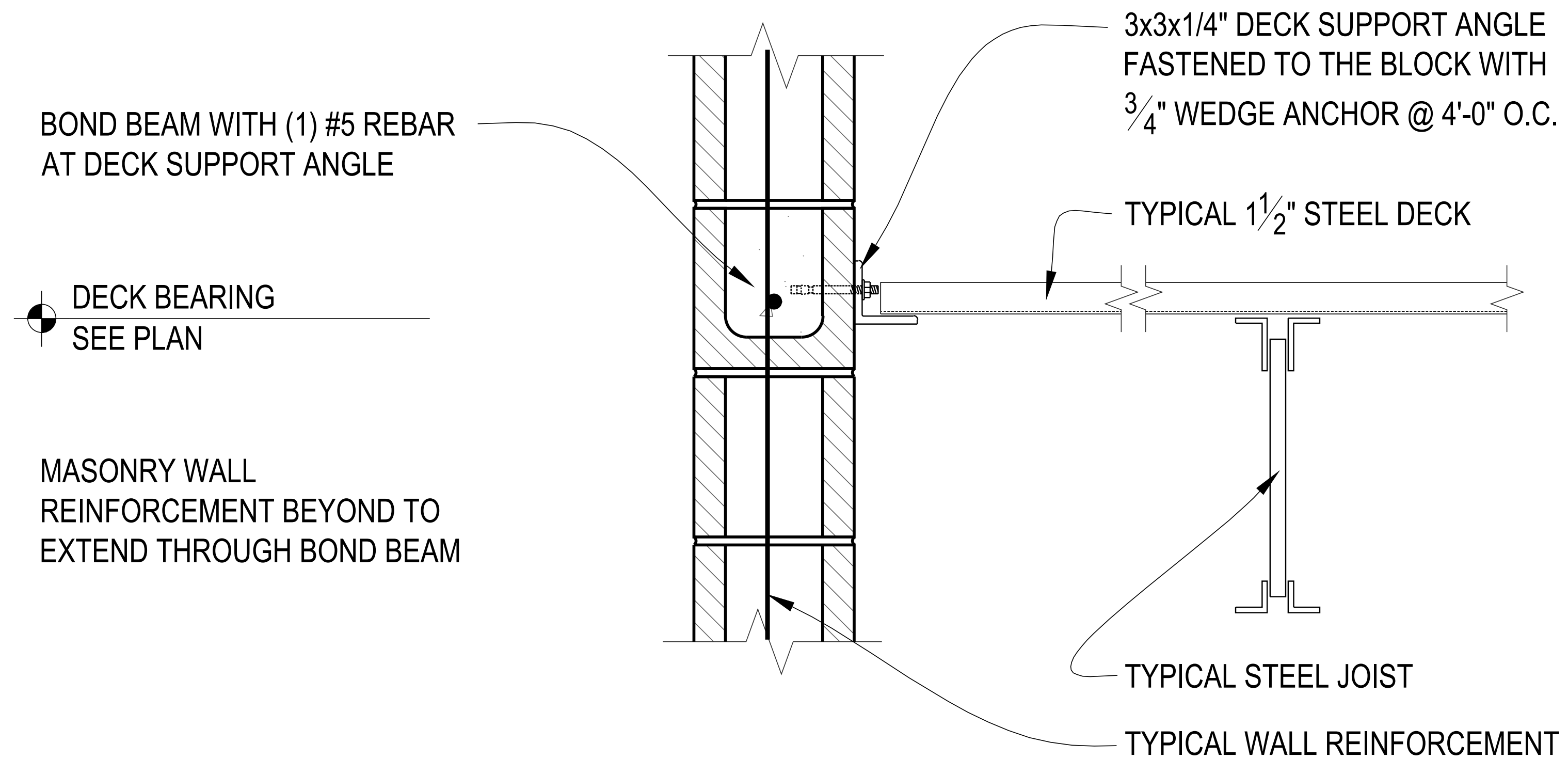
JOIST BEARING

SCALE : 1" = 1'-0"



JOIST GIRDER BEARING

SCALE : 1" = 1'-0"



6B
WMC

STEEL DECK CONNECTION TO MASONRY

SCALE : 1" = 1'-0"

Veneer Connections when
there are no shelf angles...

options for **forgoing** a shelf angle

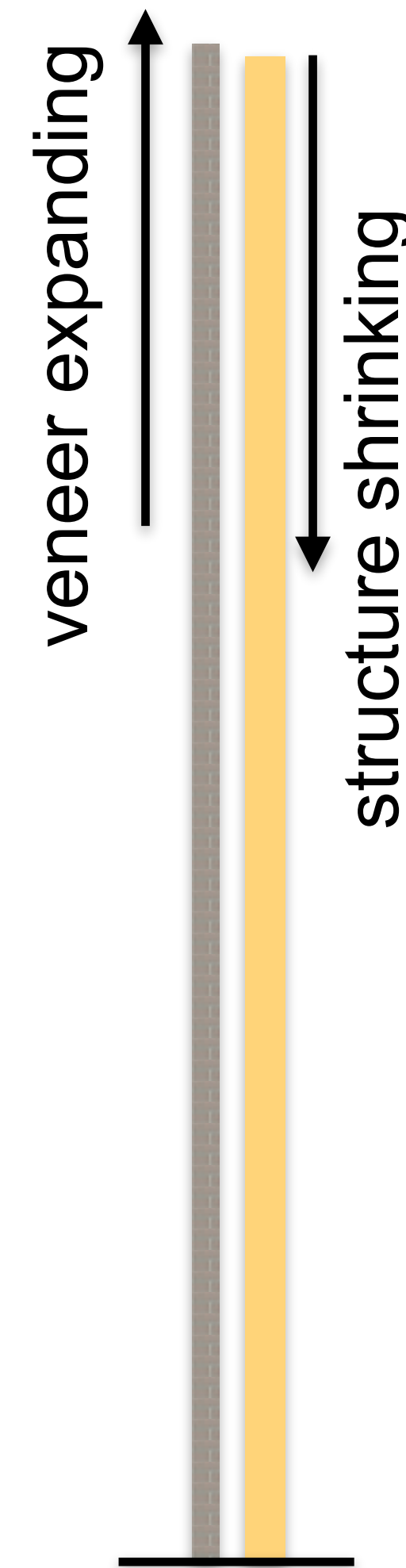
- run an analysis of structure
 - wood structure shrinks (shortening)
 - steel substructure shrinks (flexible)
 - concrete and masonry substructures are much more rigid (very little vertical movement)
- analyze the brick movement
 - will generally expand vertically/horizontally
 - expand vertically, doesn't obey gravity!!
- account for the differential movement



to eliminate horizontal joint:
calculate differential movement

To estimate the differential deflections, compare:

- brick movement
 - add Δ brick moisture
 - add Δ brick temperature
 - minus Δ brick compression
- structure
 - Δ structure shortening
- brick vs structure $\longrightarrow \Delta$ differential
 - anchor needs to accommodate movement



Flexible Anchors from H-B

- Examples of flexible anchors:
 - http://www.h-b.com/index.php?main_page=index&cPath=93_76_9

DW-10®

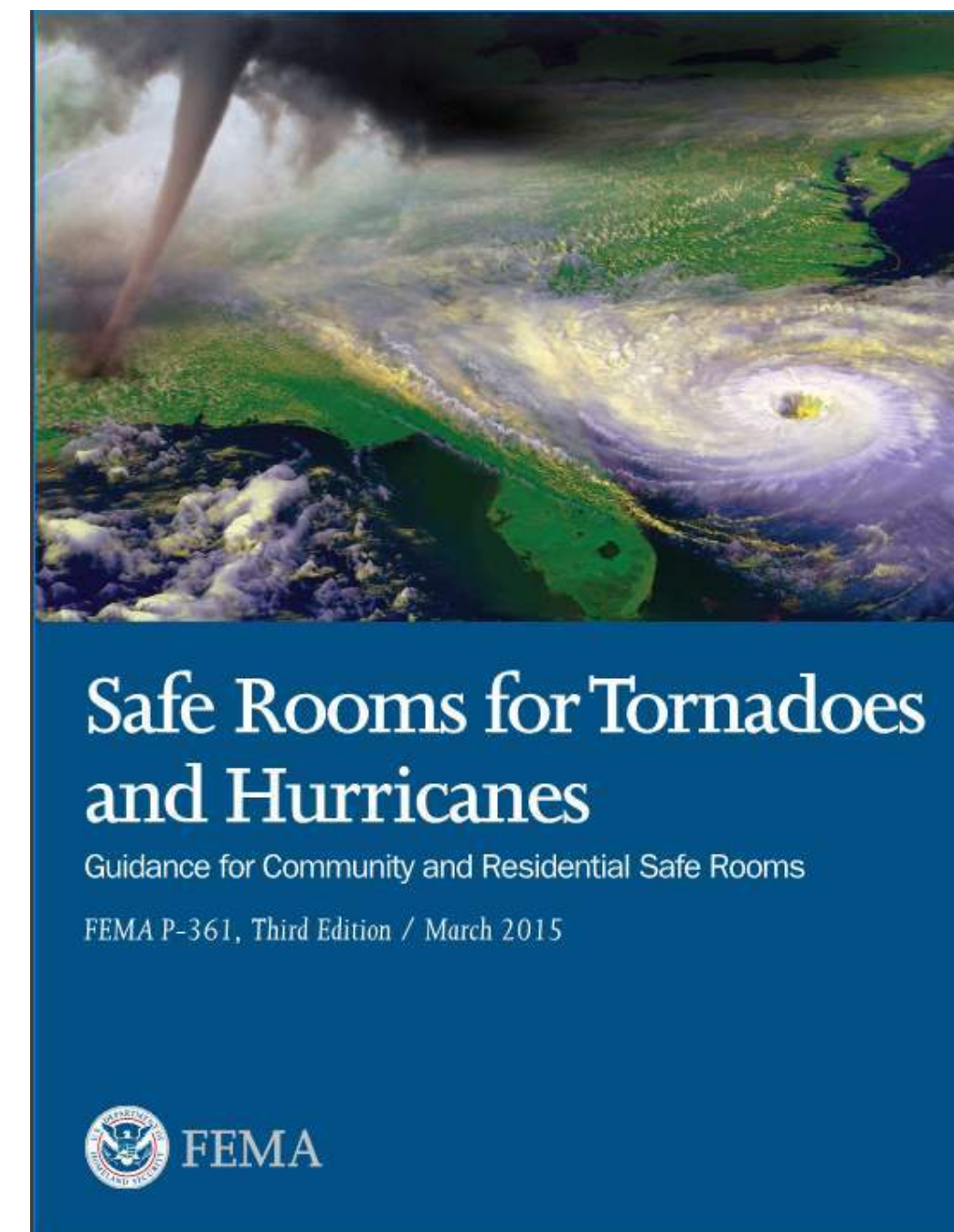
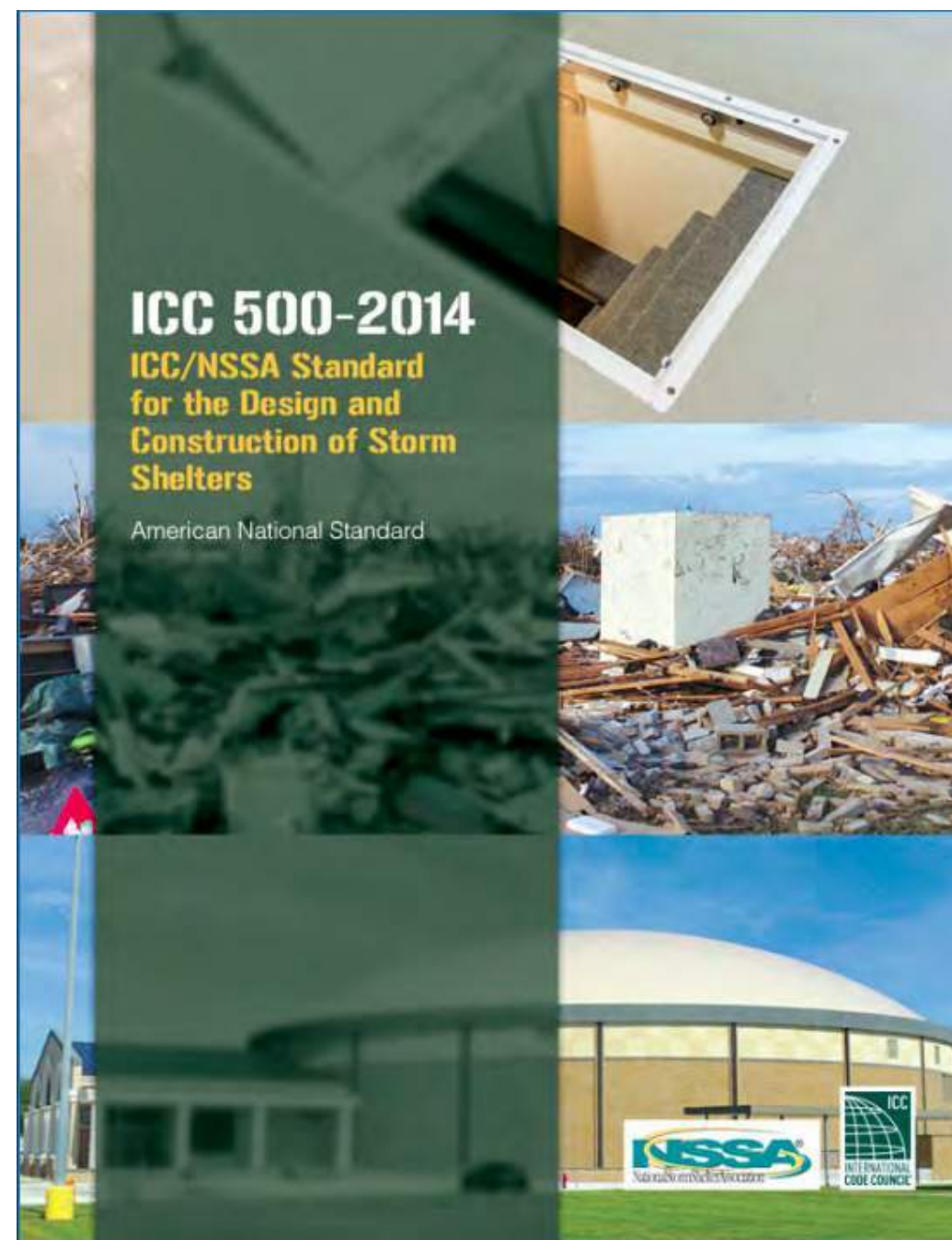


361 - Gripstay™ Channel Slot

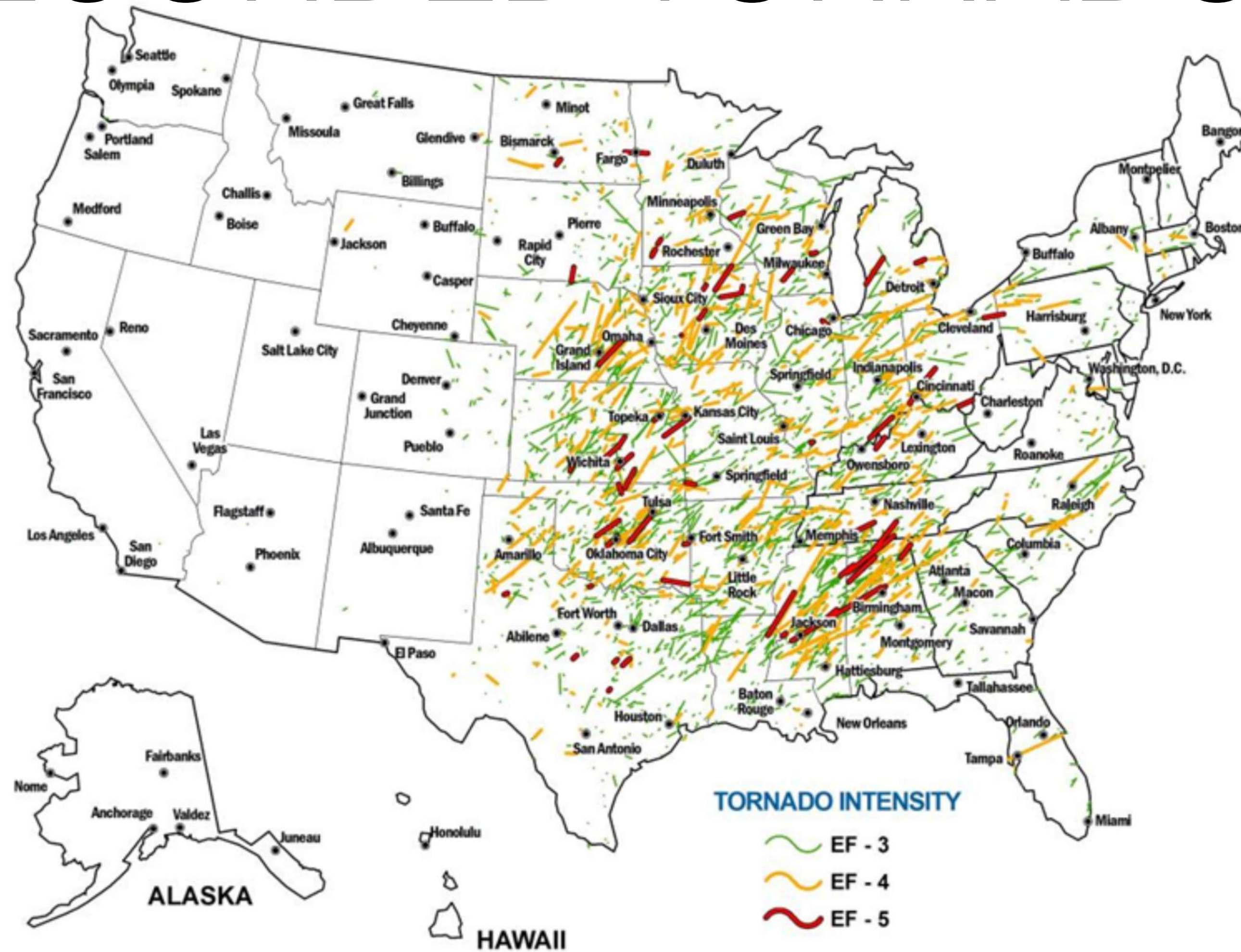


masonry design

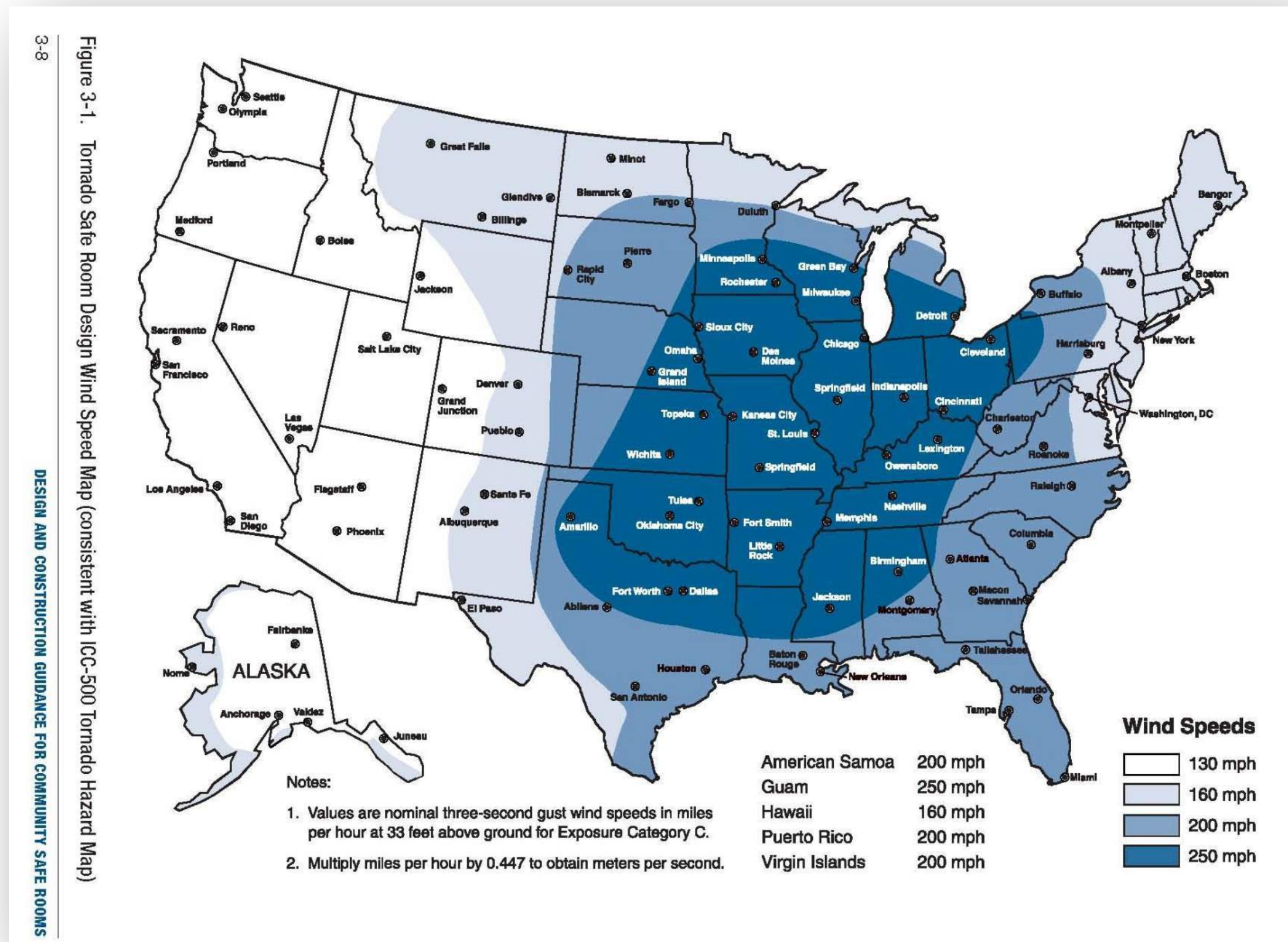
storm shelter connections



RECORDED TORNADOES



ICC 500 & IBC 2015



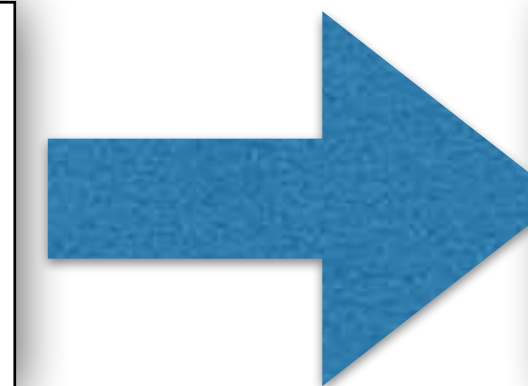
$$q_z = 0.00256 K_z K_{zt} K_d V^2 (\text{lb/ft}^2)$$

q_z = Design wind pressure

V = basic wind speed

Doubling V results in Design Wind Pressure * 4

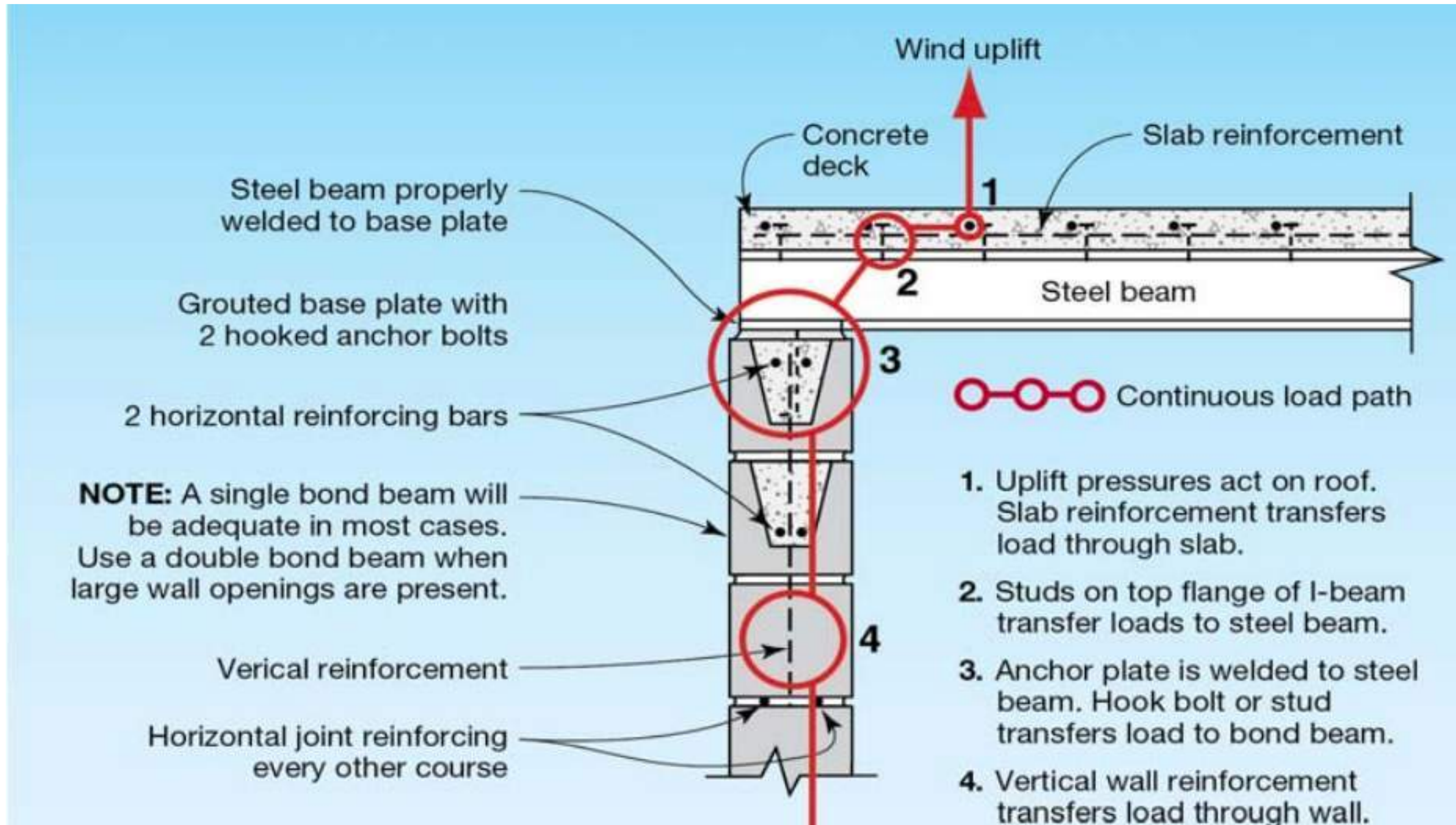
$V = 115 \text{ mph}$



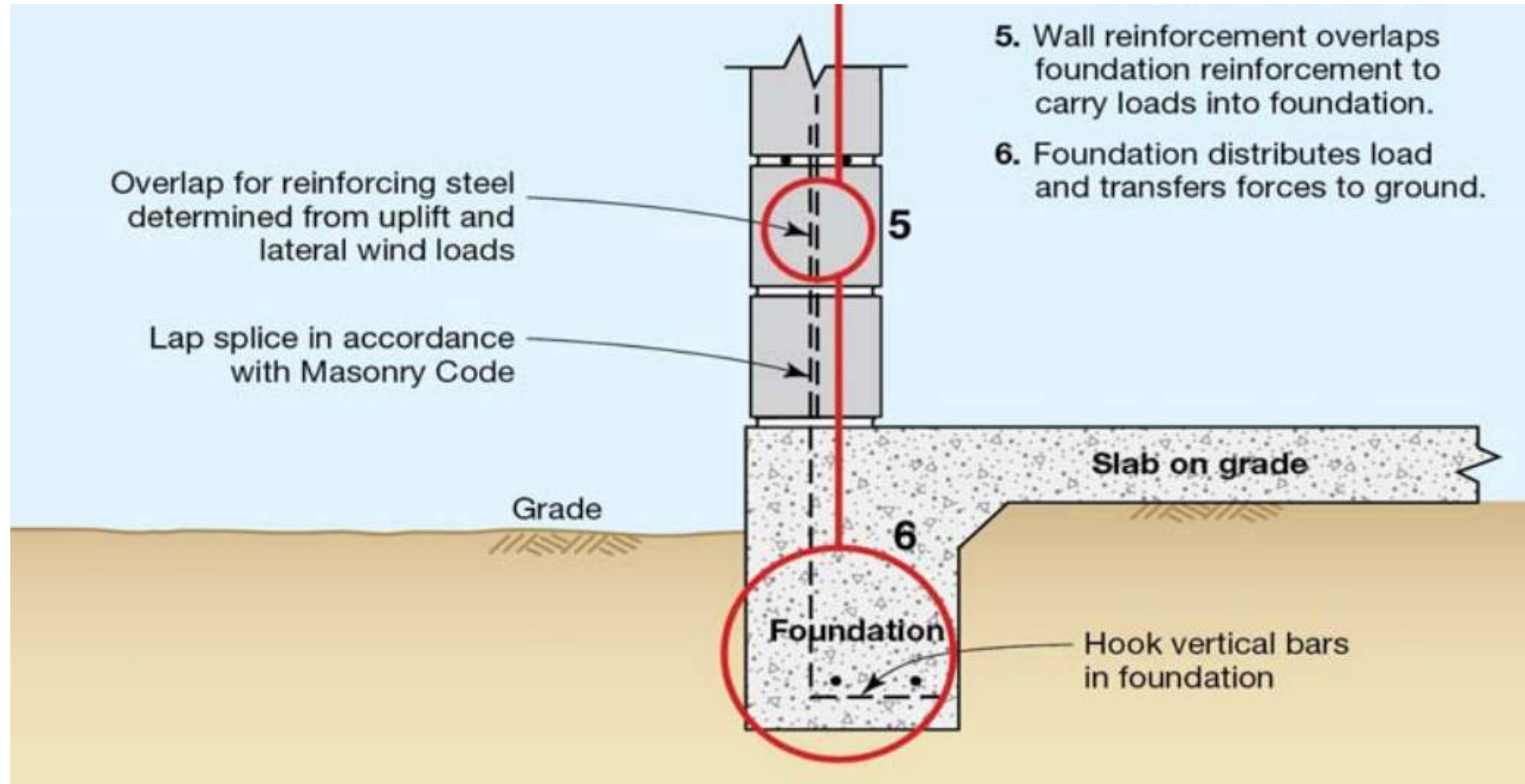
$V = 250 \text{ mph!}$

Dark Blue = Areas required to comply with ICC 500 storm shelter requirements

CONTINUOUS LOAD PATH

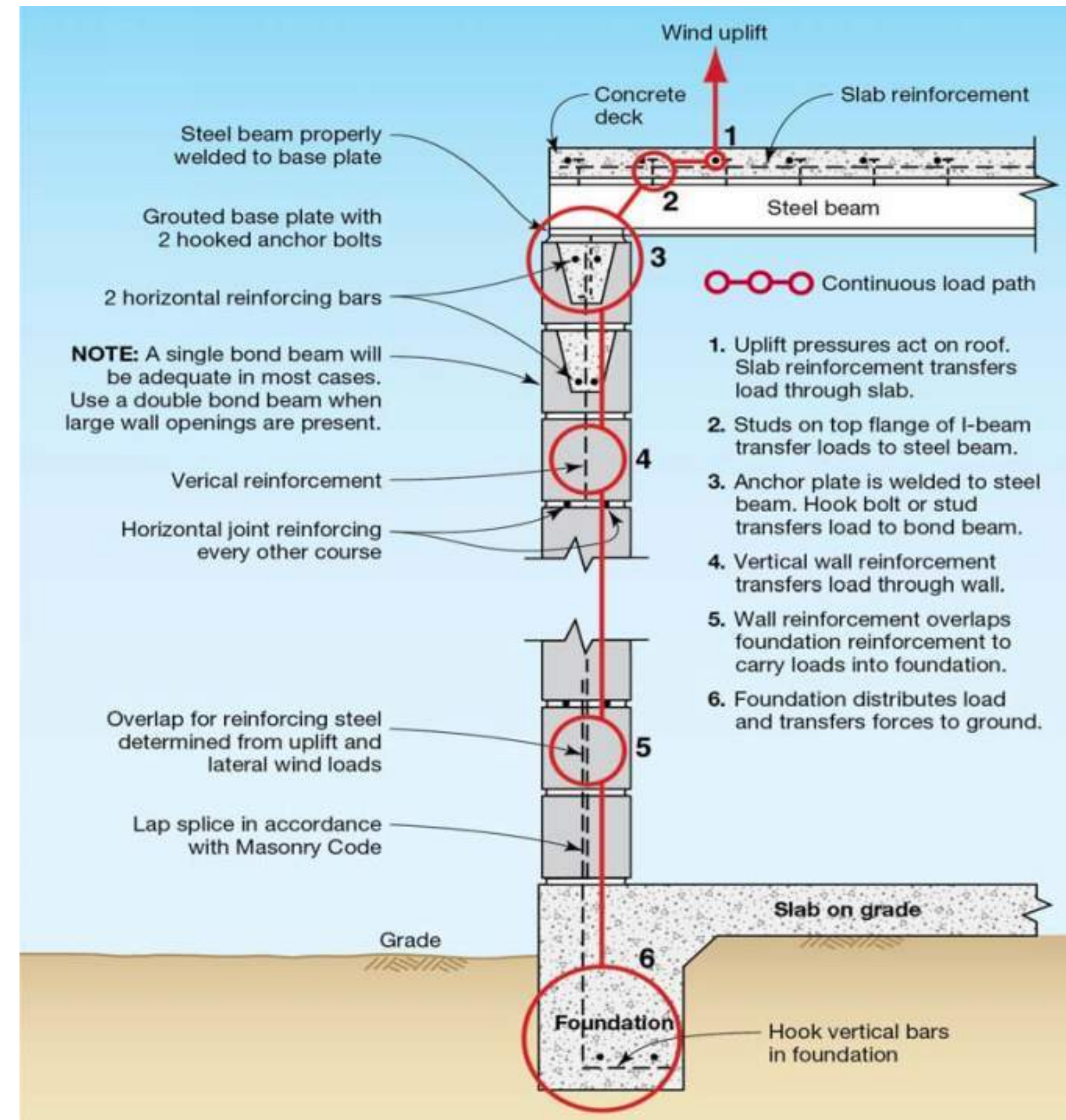


CONTINUOUS LOAD PATH



CONTINUOUS LOAD PATH

- Roof weight helps:
 - reduces net uplift
 - if heavy enough, compression on wall
- Wall weight helps
- Connections key:
 - roof connections to wall system
 - wall system to foundation
 - full bar lap lengths used
 - bars hooked into foundation



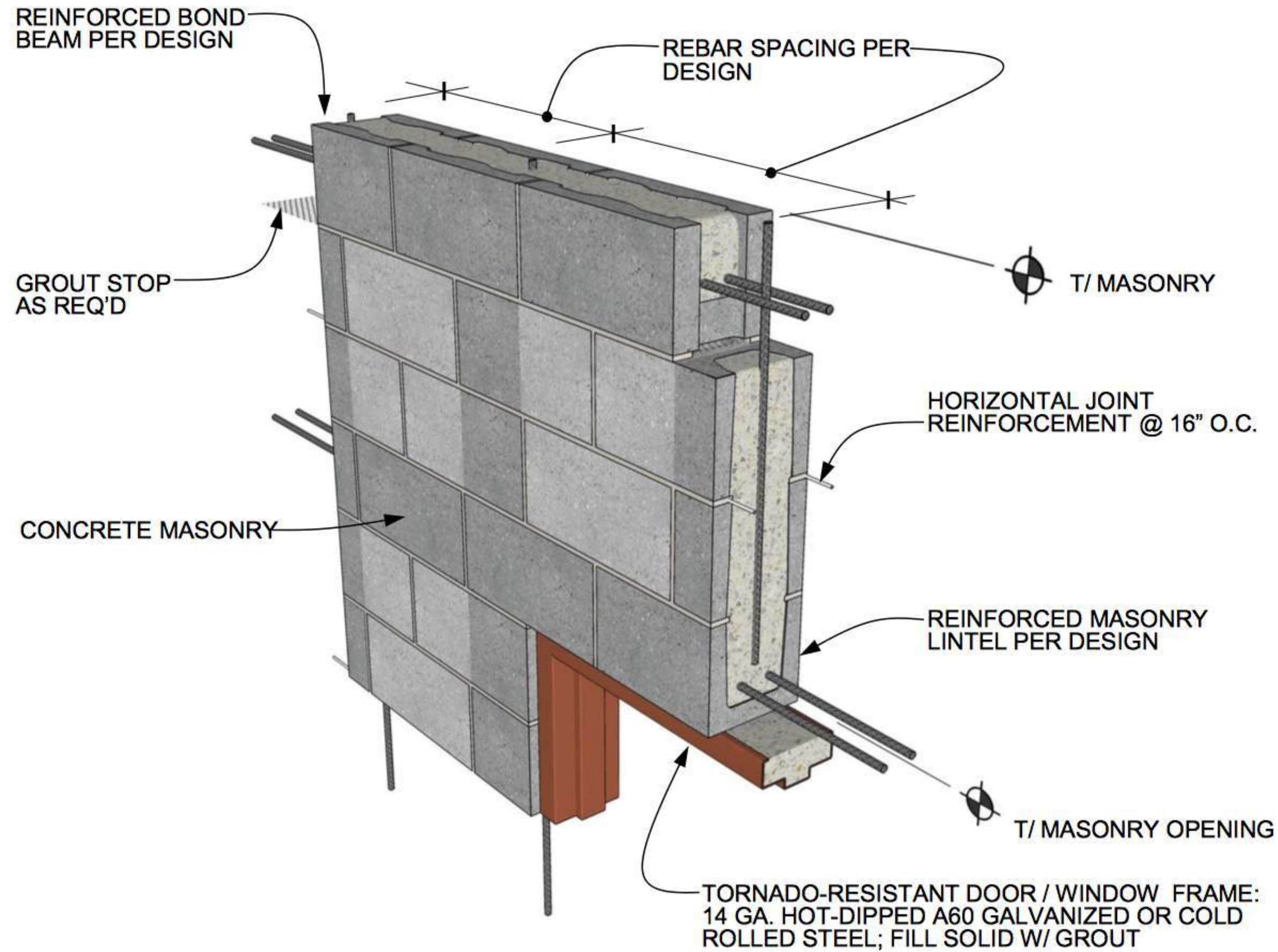


Masonry Wall/ Roof Deck Connection



Continuous Load Path - Connections

- It's all about Load Path & Connections
- Foundation to wall
 - Full development not just dowels
 - Masonry foundation walls – continuity and better connection options over concrete stem walls.
- Wall to roof
 - Bond beams and anchorage
- Doors and windows to walls
 - Critical so no breach of the envelope
- Veneer to structural wythe
 - If both used for impact resistance



HEAD DETAIL STORM SHELTER WINDOW / DOOR HEAD

DETAIL 02.120.0601

REV. 02/12/14

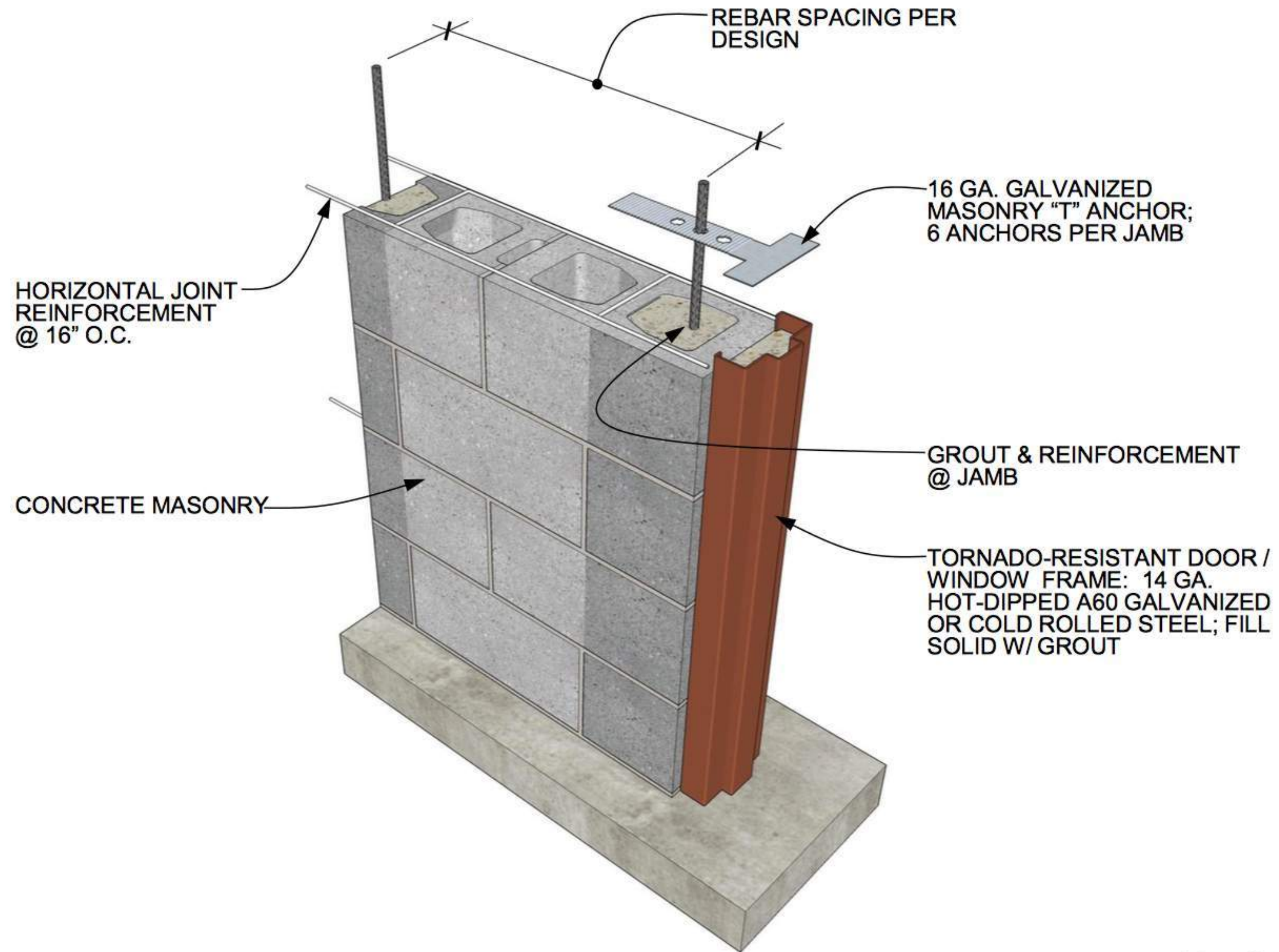
International Masonry Institute



800-IMI-0988 www.imiweb.org

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JAMB DETAIL STORM SHELTER WINDOW / DOOR JAMB

DETAIL 02.120.0501

REV. 02/12/14

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New masonry ideas (prefab)
lead to more special connections



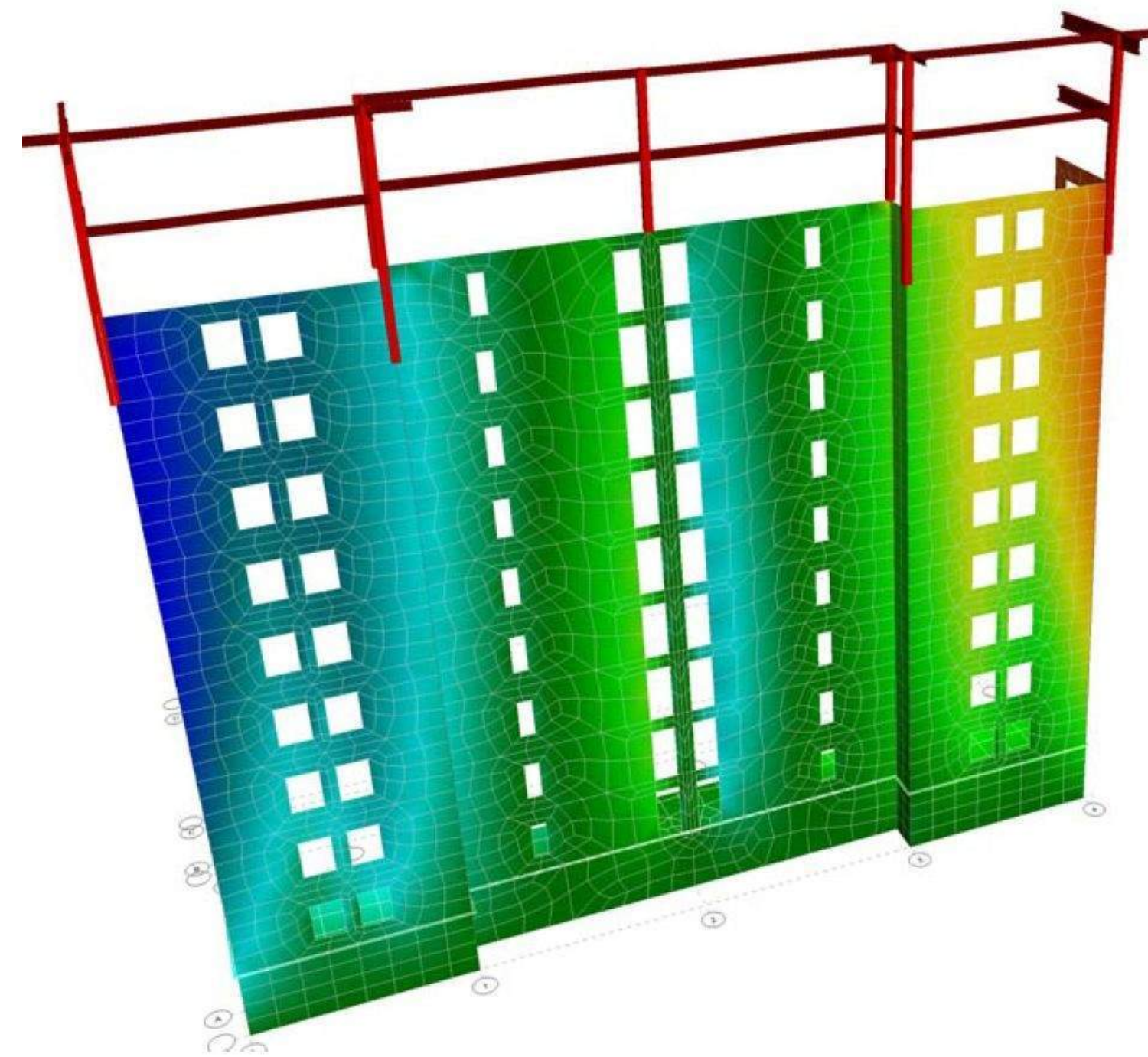
Conclusions

Masonry Connections

- know block strength
- determine laps and document on drawings
- embed plates and bearing plates

Consider details and how to connect to masonry:

- point loads and piers
- lintels with steel are complex
- masonry lintels require internal connections
- connecting to masonry foundations
- roof connections and internal connections at bond beams



?

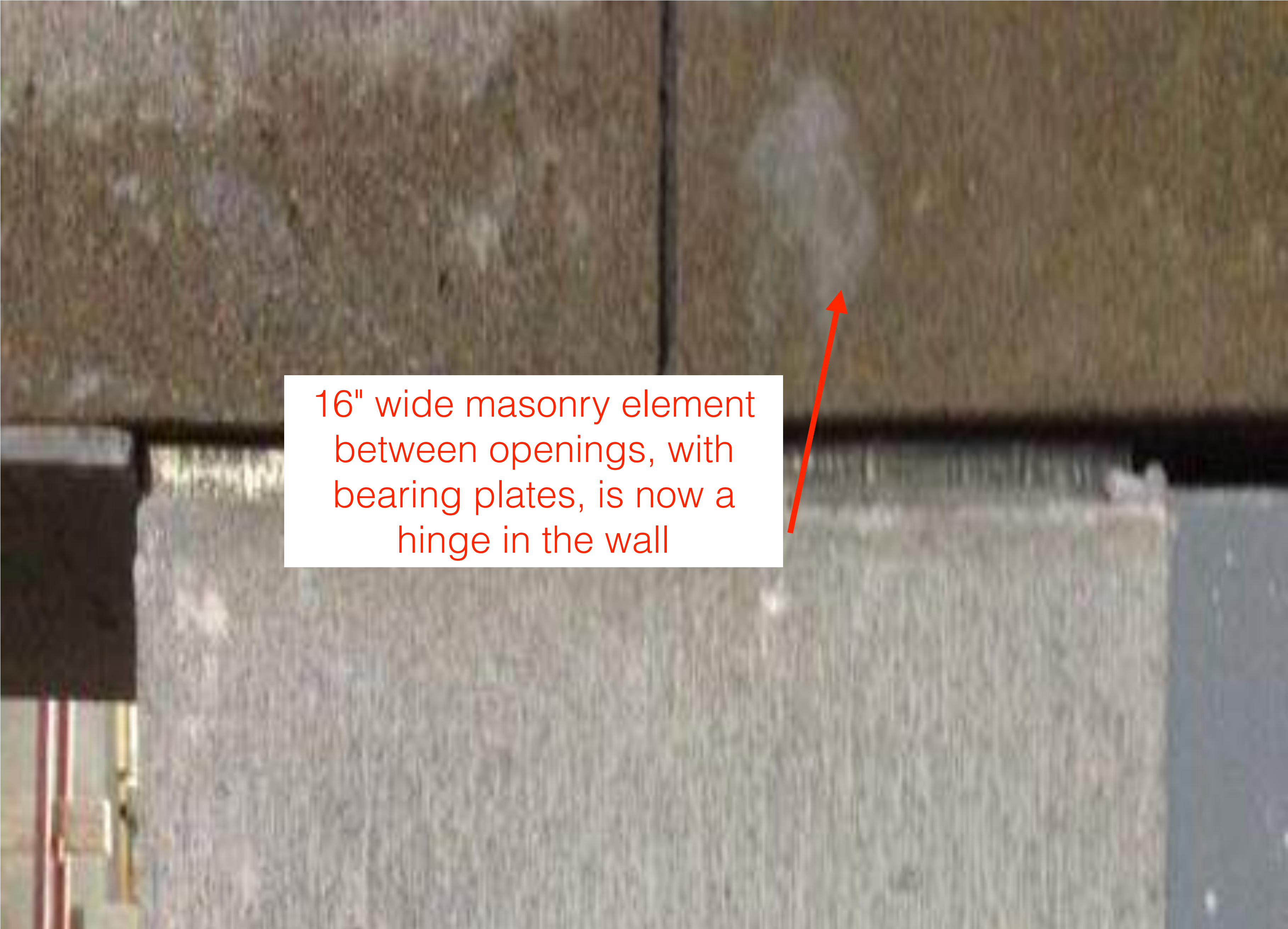
Questions

Sam Rubenzer, PE, SE
sam@forseconsulting.com





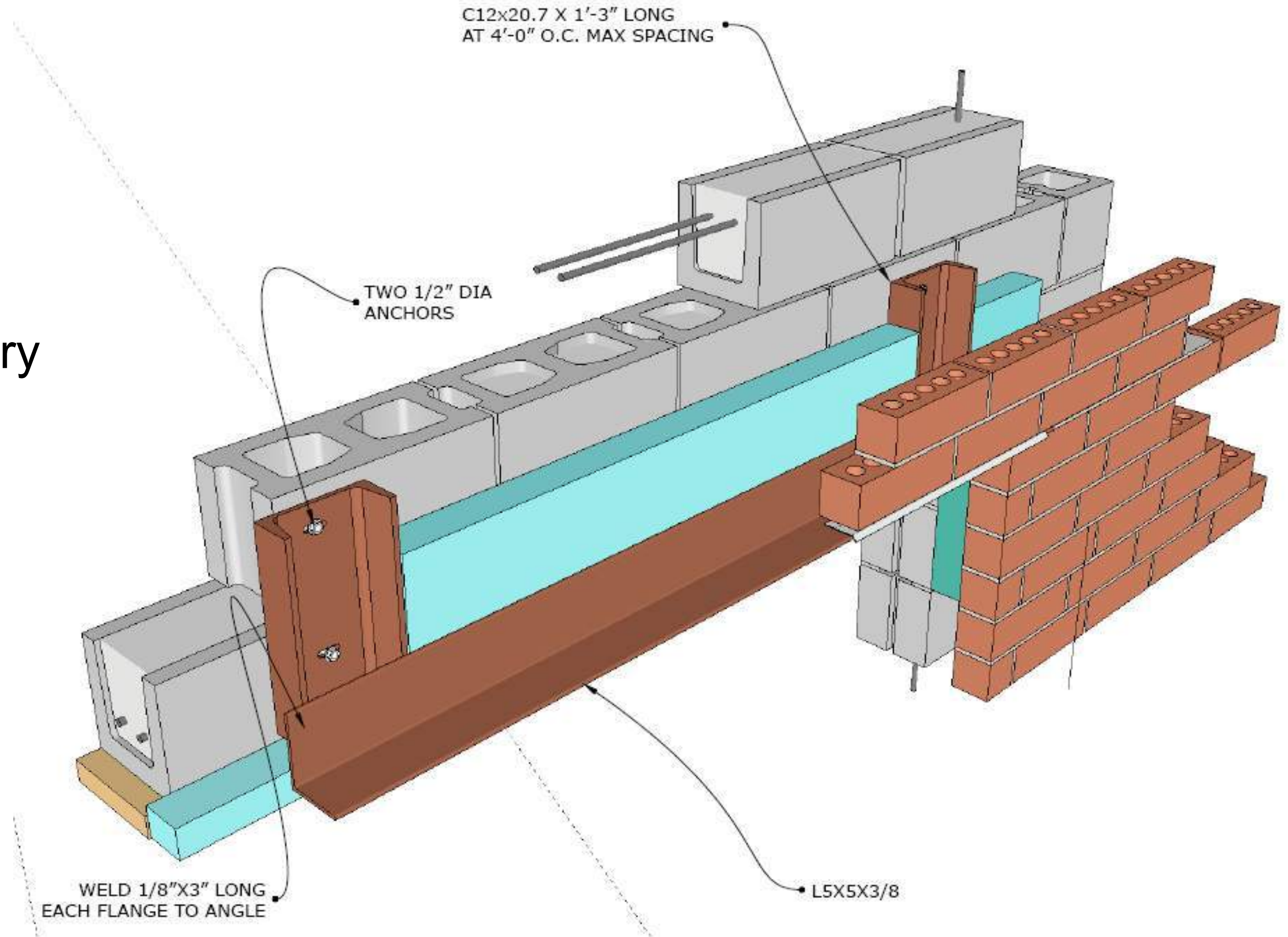




16" wide masonry element
between openings, with
bearing plates, is now a
hinge in the wall

Long lintel with thermal break

With torsional capacity, masonry lintels allow us to use thermal "friendly" lintels



Storm shelter connections