



MASONRY INSIGHTS

written in conjunction with International Masonry Institute

Horizontal Reinforcement for Masonry Walls

Horizontal Reinforcement with regular Control Joints (CJ)

The masonry code, **TMS 402 Building Code Requirements for Masonry Structures** does not have a lot of information on the topic of horizontal reinforcement for masonry walls in low to moderate seismic areas. In high seismic situations for structural masonry walls, masonry shear walls, and masonry partition walls there are horizontal reinforcement requirements. There are three main reasons for horizontal reinforcement in masonry walls:

1. Crack Control - if the walls primarily span vertically, then there is little demand for reinforcement in the horizontal direction. Therefore only a minimal amount of reinforcement is needed. The amount and spacing of the reinforcement will depend on CJ location and crack control plan.
2. Horizontal bending - even when the walls primarily span in the vertical direction, it is likely that portions of the wall will have horizontal bending moment, such as masonry lintels directly above openings.
3. Prescriptive horizontal reinforcement - shear walls that are specified as intermediate or special reinforced walls have prescriptive horizontal reinforcement based on code requirements.

This guide focusses on #1, Crack Control. The National Concrete Masonry Association (NCMA) has two documents that provide guidance:

1. NCMA TEK 10-2D Control Joints for Concrete Masonry Walls - Empirical Method
2. NCMA TEK 10-3 Control Joints for Concrete Masonry Walls - Alternate Engineered Method

TEK 10-2D is based on historical performance of masonry walls. TEK 10-3 is based strictly on material properties of masonry and reinforcement. There are several options for the amount and location of horizontal reinforcement in masonry walls based on the frequency of Control Joint (CJ), partial or fully grouted walls, number of openings in the walls, and the type of horizontal reinforcement.

Horizontal reinforcement is either wire joint reinforcement that is placed within the mortar joints, or standard bar reinforcement within bond beams. TMS 402-16, section 6.1.2.3 requires minimum size to be W_{1.1} (MW₇), and a maximum wire size of one-half the joint thickness. Based on a standard joint size of 3/8", the maximum wire size would be 3/16" diameter.

The most common joint reinforcement used in masonry is W1.7 (9 gage). Contractors prefer to use this size of reinforcement as larger sizes can be hard to place when constructing the wall. Using the chart within TEK 10-2D, W1.7 (9 gage) should be placed at 16 inches on center. This is based on control joint placement of 1.5x wall height up to a 25ft spacing. See Table 2A below.

TABLE FROM NCMA TEK 10-2D

Reinforcement size	Maximum spacing, in. (mm)
W1.7 (9 gage) (MW11) ¹	16 (406)
W2.1 (8 gage) (MW13) ¹	16 (406)
W2.8 (3/16 in.) (MW18) ¹	24 (610)
No. 3 (M#10)	48 (129)
No. 4 (M#13)	96 (2,348)
No. 5 (M#16) or larger	144 (3,658)
¹ Minimum two wires per course.	

Table 2A—Maximum Spacing of Horizontal Reinforcement to Provide 0.025 Square Inches per Foot of Masonry Height (52.9 Square Millimeters per Meter)

Incorporating the criteria from TEK 10-3 requires a reinforcement ratio of 0.0007 for the area of steel (As) to the net area of concrete of concrete masonry. This ratio considers possible the total movement from drying shrinkage, carbonation shrinkage, and contraction due to temperature. The table from TEK 10-3 also considers the additional material with thicker walls and solid grouted masonry.

TABLE FROM NCMA TEK 10-3

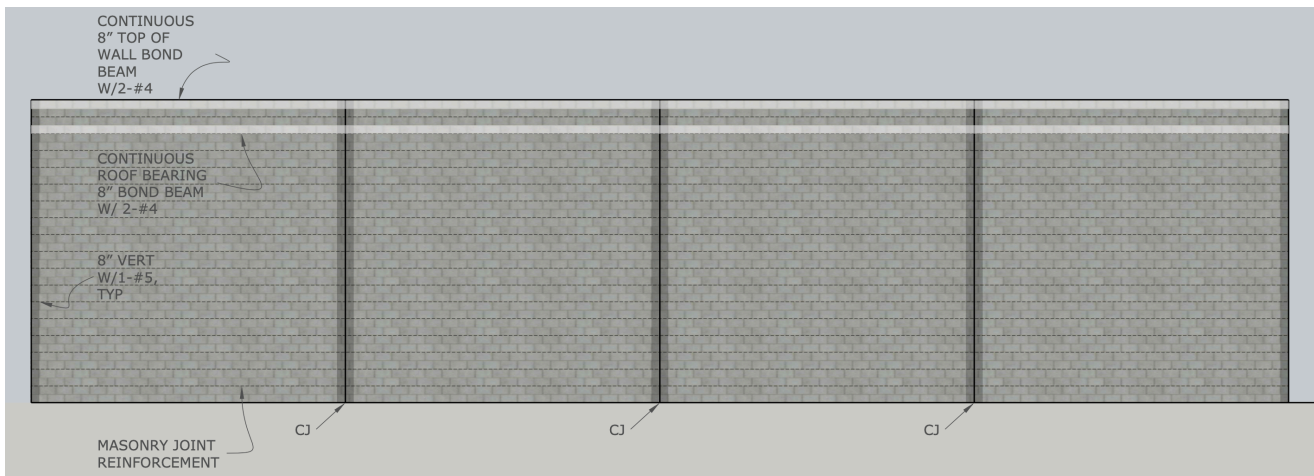
Wall thickness, in. (mm)	Maximum spacing of horizontal reinforcement, in. (mm)								
	Reinforcement size								
	No. 5 (M 16)	No. 4 (M 13)	No. 3 (M 10)	4 x3/16 in. (MW 18)	4 x 8 gage (MW 13)	4 x 9 gage (MW 11)	2 x3/16 in. (MW 18)	2 x 8 gage (MW 13)	2 x 9 gage (MW 11)
UngROUTED or partially grouted walls									
6 (152)	144 (3658)	128 (3251)	64 (1626)	72 (1829)	56 (1422)	48 (1219)	40 (1016)	24 (610)	24 (610)
8 (203)	144 (3658)	96 (2438)	40 (1016)	64 (1626)	48 (1219)	40 (1016)	32 (813)	24 (610)	16 (406)
10 (254)	136 (3458)	80 (2032)	32 (1219)	56 (1422)	40 (1016)	32 (813)	16 (406)	16 (406)	16 (406)
12 (305)	120 (3048)	72 (1829)	24 (610)	48 (1219)	40 (1016)	32 (813)	16 (406)	16 (406)	16 (406)
Fully grouted walls									
6 (152)	72 (1829)	48 (1219)	24 (610)	24 (610)	16 (406)	16 (406)	8 (203)	8 (203)	8 (203)
8 (203)	56 (1422)	32 (813)	16 (406)	16 (406)	8 (203)	8 (203)	8 (203)	8 (203)	—
10 (254)	40 (1016)	24 (610)	16 (406)	16 (406)	8 (203)	8 (203)	8 (203)	—	—
12 (305)	32 (813)	24 (610)	8 (203)	8 (203)	8 (203)	8 (203)	—	—	—
1. A_n includes cross-sectional area of grout in bond beams									

Table 2—Maximum Spacing of Horizontal Reinforcement to Meet the Criteria $A_s >$

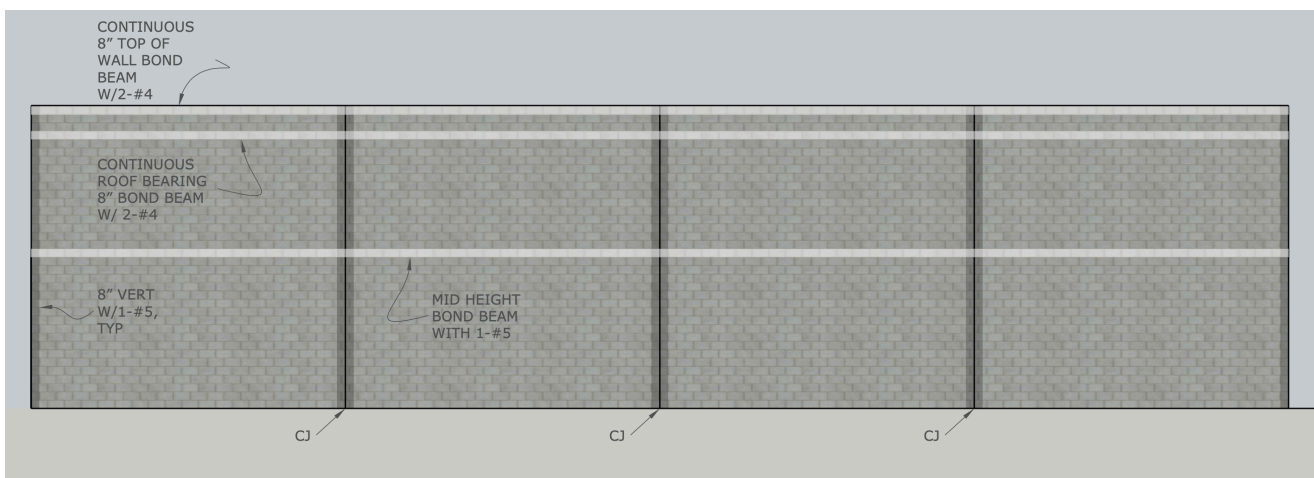
Therefore both guides indicate joint reinforcement of W1.7 (9 gage) at 16 inches on center.

Contractors can also consider placing standard reinforcement within bond beams and not using joint reinforcement as another effective and efficient means to reinforce the masonry walls. Using a #5 bar in a bond beam at 12 feet on center would be effective for 6 inch and 8 inch masonry walls. 10 inch and 12 inch walls would require slightly closer spacing. Below are examples of an option for joint reinforcement and an option with standard reinforcement in a bond beam.

EXAMPLE 1: WALL ELEVATION WITH JOINT REINFORCEMENT



EXAMPLE 2: WALL ELEVATION WITH STANDARD REINFORCEMENT/BOND BEAMS



These examples show the options for horizontal reinforcement with regular CJ locations. There are situations when regular CJ are either not possible or not desirable for a variety of reasons.

Horizontal Reinforcement without Control Joints (CJ)

The criteria from TEK 10-3, determines that a reinforcement ratio required if there are no Control Joints. The reinforcement ratio of 0.002 for the area of steel (As) to the net area of concrete of concrete masonry is necessary. This ratio considers possible the total movement from drying shrinkage, carbonation shrinkage, and contraction due to temperature.

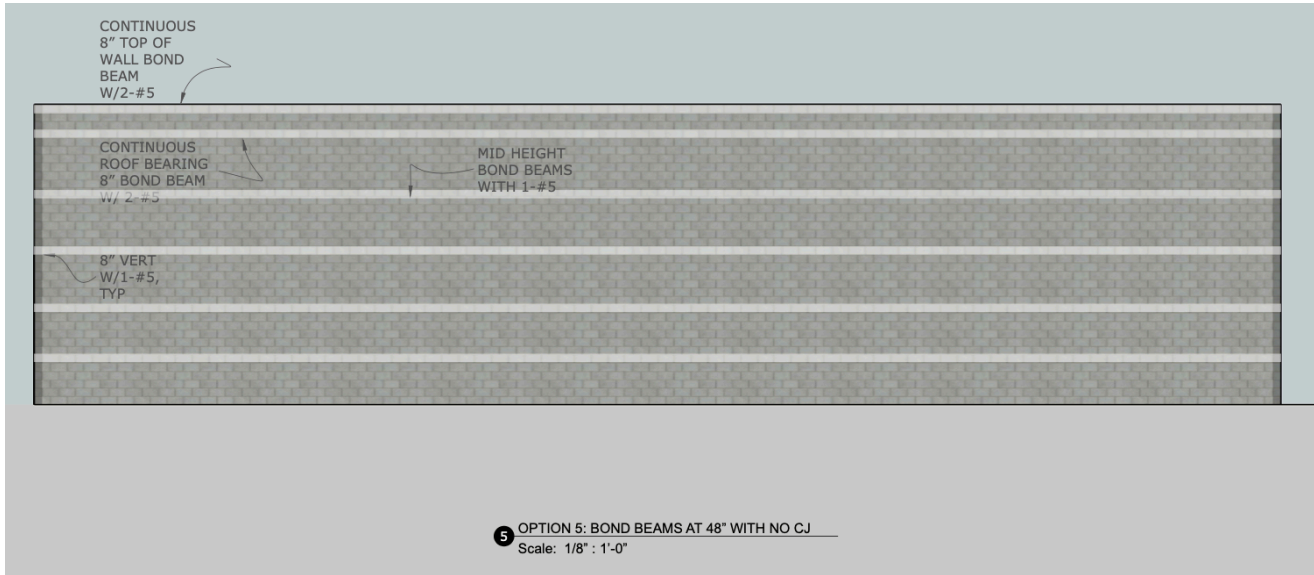
TABLE BASED ON NCMA TEK 10-3

CMU PROPERTIES & WEIGHT													
ASTM C-90 MINIMUM CONCRETE MASONRY UNIT DIMENSIONS													
PARTIAL GROUT			Masonry Joint Reinforcement based on NCMA TEK 10-3, based on criteria As > 0.002										
Nominal Width (in)	Actual Width (in)	Face-Shell Thickness (in)	Face Shell Area (in ² /8 inch)	Reinf	(2) #6	(2) #5	(2) #4	#6	#5	#4	2 x 3/16	2 x 9ga	
				Reinf Area	0.88	0.62	0.4	0.44	0.31	0.2	0.055	0.034	
6	5.625	1.00	16.0	Horiz Spacing of Reinf				48*	48*	32.000	8.000	8.000	
8	7.625	1.25	20.0			48*	48*	48*	40.000	16.000	8.000		
10	9.625	1.375	22.0		48*	48*	48.000	48*	32.000	16.000	8.000		
12	11.625	1.5	24.0		48*	48*	40.000	48.000	24.000	8.000	8.000		
14	13.625	1.5	24.0		48*	48*	32.000	40.000	16.000		8.000		
16	15.625	1.5	24.0		48*	48*	32.000	32.000	16.000		8.000		
SOLID GROUTED			Masonry Joint Reinforcement based on NCMA TEK 10-3, based on criteria As > 0.002										
Nominal Width (in)	Actual Width (in)	Masonry Area (in ² /8 inch)	Reinf	(2) #6	(2) #5	(2) #4	#6	#5	#4	2 x 3/16	2 x 9ga		
			Reinf Area	0.88	0.62	0.4	0.44	0.31	0.2	0.055	0.034		
6	5.625	45.0	Horiz Spacing of Reinf				32.000	24.000	16.000				
8	7.625	61.0			40.000	24.000	24.000	16.000	8.000				
10	9.625	77.0		40.000	32.000	16.000	16.000	16.000	8.000				
12	11.625	93.0		32.000	24.000	16.000	16.000	8.000	8.000				
14	13.625	109.0		32.000	16.000	8.000	16.000	8.000					
16	15.625	125.0		24.000	16.000	8.000	8.000	8.000					

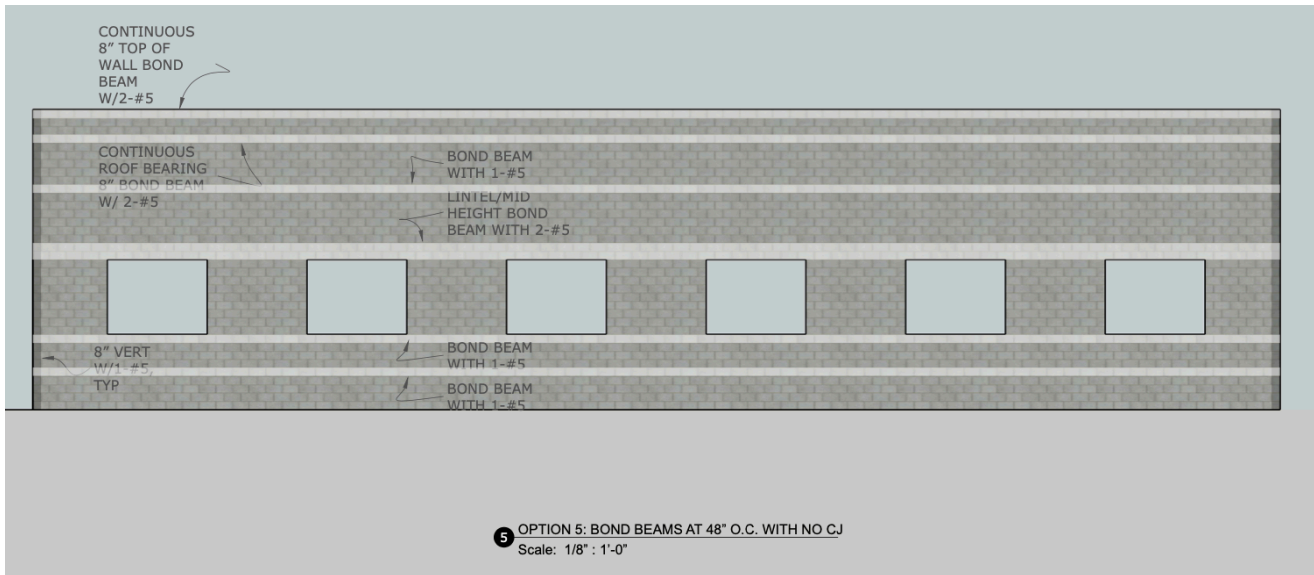
There is also a requirement for the reinforcement to be distributed throughout the wall and be at a maximum horizontal spacing of 48 inches on center - in the table above, 48* indicates reinforcement scenarios that could have been spaced further apart, but the spacing was capped at 48 inches. Also in the table above, the partially grouted wall requires much less reinforcement than the solid grouted wall.

Walls with openings, especially a series of openings, are good candidates for using more horizontal reinforcement without control joints because of the lintel and sill reinforcement that is already present in the wall. Walls with a lot of openings can also have potential issues spacing control joints in needed locations because of the size and or configuration of the openings.

EXAMPLE 3: WALL WITH BOND BEAMS AND NO JOINT REINFORCEMENT AND NO CJ



EXAMPLE 4: WALL WITH OPENINGS AND HORIZONTAL REINFORCEMENT AT BOND BEAMS AND NO JOINT REINFORCEMENT AND NO CJ



Finally, using the criteria we have defined above, we also have another option in masonry walls with both horizontal joint reinforcement and bond beams. One example of when this may occur is for masonry walls that are the back up wall and part of a cavity wall system. When the brick is anchored to the backup wall utilizing the joint reinforcement. In this scenario, the bond beams can be spaced further apart.

TABLE BASED ON NCMA TEK 10-3

CMU PROPERTIES & WEIGHT											
ASTM C-90 MINIMUM CONCRETE MASONRY UNIT DIMENSIONS											
PARTIAL GROUT			Masonry Joint Reinforcement based on NCMA TEK 10-3, based on criteria $A_s > 0.002$ - Using a combination of bar reinforcement and 2x9gage joint reinforcement at 16" o.c.								
Nominal Width (in)	Actual Width (in)	Face-Shell Thickness (in)	Face Shell Area (in ² /8 inch)	Reinf	(2) #6	(2) #5	(2) #4	#6	#5	#4	2 x 9ga
				Reinf Area	0.88	0.62	0.4	0.44	0.31	0.2	
6	5.625	1.00	16.0	Horiz Spacing of Reinf				144.000	128.000	72.000	16.000
8	7.625	1.25	20.0				104.000	120.000	72.000	40.000	16.000
10	9.625	1.375	22.0			144.000	80.000	96.000	56.000	24.000	16.000
12	11.625	1.5	24.0		144.000	120.000	64.000	72.000	40.000	8.000	16.000
14	13.625	1.5	24.0		144.000	112.000	48.000	56.000	24.000		16.000
16	15.625	1.5	24.0		144.000	104.000	40.000	48.000	16.000		16.000
SOLID GROUTED			Masonry Joint Reinforcement based on NCMA TEK 10-3, based on criteria $A_s > 0.002$ - Using a combination of bar reinforcement and 2x9gage joint reinforcement at 16" o.c.								
Nominal Width (in)	Actual Width (in)	Masonry Area (in ² /8 inch)	Reinf	(2) #6	(2) #5	(2) #4	#6	#5	#4	2 x 9ga	
			Reinf Area	0.88	0.62	0.4	0.44	0.31	0.2		0.034
6	5.625	45.0	Horiz Spacing of Reinf				48.000	32.000	16.000	16.000	
8	7.625	61.0		64.000	40.000	24.000	32.000	16.000	8.000	16.000	
10	9.625	77.0		48.000	32.000	16.000	24.000	16.000	8.000	16.000	
12	11.625	93.0		40.000	24.000	16.000	16.000	8.000	8.000	16.000	
14	13.625	109.0		32.000	24.000	8.000	16.000	8.000		16.000	
16	15.625	125.0		24.000	16.000	8.000	8.000	8.000		16.000	