THE BEAUTY OF BLOCK
DESIGN COLLECTIVE

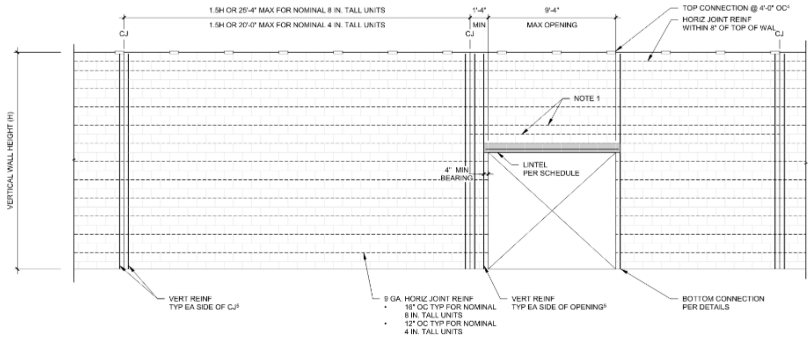
DESIGN AND DETAILING GUIDE FOR NONLOADBEARING CONCRETE MASONRY PARTITION WALLS

This guide provides a comprehensive resource for the design and detailing of interior nonloadbearing concrete masonry partition walls, outlining key considerations that influence performance, constructability, and efficiency. It brings together best practices related to fire resistance, sound control, structural behavior, crack control, and connection detailing, while also emphasizing strategies that improve cost-effectiveness and reduce material use. Through a combination of explanatory content and pre-engineered solutions, the guide is intended to support designers in making informed decisions and efficiently incorporating concrete masonry partitions into project documents.

SCHEDULES

The following series of pre-engineered schedules summarize the analyses and recommendations presented in this guide for nonloabearing concrete masonry partitions. Details include maximum design span options for both reinforced and unreinforced partition walls covering design wind speeds up to 180 mph as well as seismic design and detailing requirements for low to high seismic design categories. Where partition openings are present, lintel design schedules are also provided for clear spans up to 9 ft-4 in.

These schedules are available for free download in various formats through the Block Design Collective website:
https://beautyofblock.com/resource-type/details-specs/



NOTES:

1. INSTALL 9 GA. LADDER TYPE JOINT REINFORCEMENT IN FIRST TWO JOINTS ABOVE OPENING FROM CONTROL JOINT TO CONTROL JOINT.
2. INSTALL 9 GA. LADDER TYPE JOINT REINFORCEMENT IN FIRST OR SECOND MORTAR JOINT BELOW SILL FROM CONTROL JOINT TO CONTROL JOINT.
3. PLACE VERTICAL REINFORCEMENT AT ENDS AND CORNERS OF ALL WALLS.
4. MAXIMUM SPACING TO BE 4'-0" OR PER MANUFACTURER'S RECOMMENDATIONS.
5. FOR UNREINFORCED MASONRY PARTITIONS, VERTICAL REINFORCEMENT MAY BE EMBEDDED IN GROUT OR MORTAR.

1 UNREINFORCED 6 IN. (SDC A OR B)

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

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

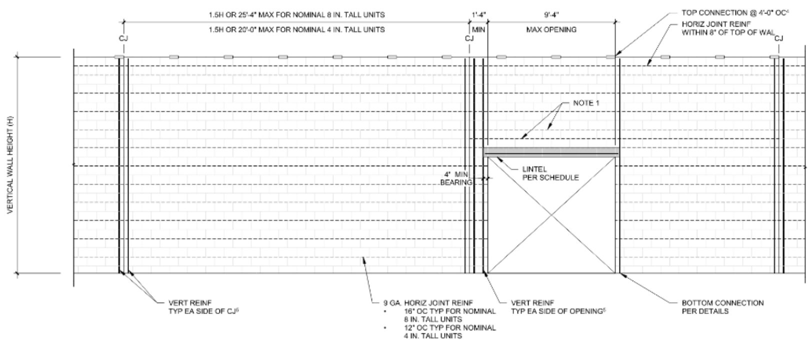
MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MAXIMUM VERTICAL OR HORIZONTAL SPAN OF NON-LOADBEARING, UNREINFORCED 6 IN. NOMINAL CMU PARTITIONS ASSIGNED TO SDC A OR B					
MORTAR TYPE	DESIGN WIND SPEED (MPH)				
	100	120	140	160	180
VERTICALLY SPANNING MASONRY					
TYPE N MASONRY CEMENT MORTAR	8.00	8.00	7.33	6.67	6.00
TYPE S MASONRY CEMENT MORTAR	10.67	10.00	9.33	8.67	8.00
TYPE N PORTLAND OR MORTAR CEMENT MORTAR	12.00	11.33	10.67	9.33	8.67
TYPE S PORTLAND OR MORTAR CEMENT MORTAR	13.33	12.67	12.00	11.33	10.00
HORIZONTALLY SPANNING MASONRY					
TYPE N MASONRY CEMENT MORTAR	12.00	11.33	10.67	9.33	8.67
TYPE S MASONRY CEMENT MORTAR	14.67	14.00	13.33	12.00	11.33
TYPE N PORTLAND OR MORTAR CEMENT MORTAR	16.67	16.00	14.67	14.00	12.67
TYPE S PORTLAND OR MORTAR CEMENT MORTAR	19.33	18.00	16.67	16.00	14.67



NOTES:

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3. PLACE VERTICAL REINFORCEMENT AT ENDS AND CORNERS OF ALL WALLS.
4. MAXIMUM SPACING TO BE 4'-0" OR PER MANUFACTURER'S RECOMMENDATIONS.
5. FOR UNREINFORCED MASONRY PARTITIONS, VERTICAL REINFORCEMENT MAY BE EMBEDDED IN GROUT OR MORTAR.

2 UNREINFORCED 8 IN. (SDC A OR B)

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

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MAXIMUM VERTICAL OR HORIZONTAL SPAN OF NON-LOADBEARING, UNREINFORCED 8 IN. NOMINAL CMU PARTITIONS ASSIGNED TO SDC A OR B					
MORTAR TYPE	DESIGN WIND SPEED (MPH)				
	100	120	140	160	180
VERTICALLY SPANNING MASONRY					
TYPE N MASONRY CEMENT MORTAR	11.33	10.67	10.00	9.33	8.67
TYPE S MASONRY CEMENT MORTAR	14.67	14.00	12.67	12.00	11.33
TYPE N PORTLAND OR MORTAR CEMENT MORTAR	16.67	15.33	14.67	13.33	12.67
TYPE S PORTLAND OR MORTAR CEMENT MORTAR	18.67	18.00	16.67	15.33	14.00
HORIZONTALLY SPANNING MASONRY					
TYPE N MASONRY CEMENT MORTAR	16.67	15.33	14.67	13.33	12.67
TYPE S MASONRY CEMENT MORTAR	20.67	19.33	18.00	16.67	15.33
TYPE N PORTLAND OR MORTAR CEMENT MORTAR	23.33	22.00	20.67	18.67	17.33
TYPE S PORTLAND OR MORTAR CEMENT MORTAR	26.67	25.33	23.33	22.00	20.00

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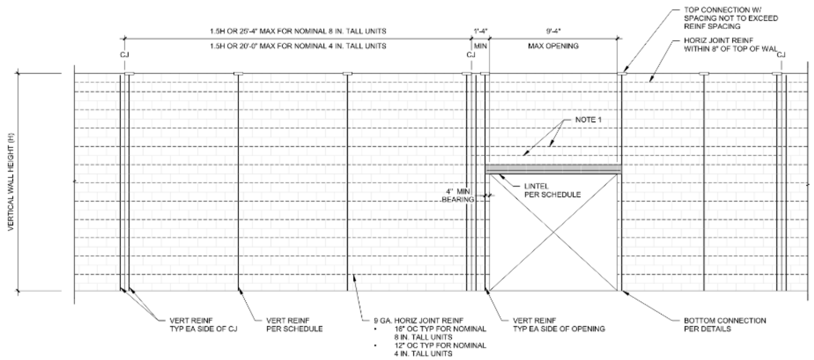
PARTITION WALL DETAILS (URM)



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3. PLACE VERTICAL REINFORCEMENT AT ENDS AND CORNERS OF ALL WALLS.
4. IF VERTICAL REINFORCEMENT IS INTERRUPTED BY OPENINGS, PLACE ONE ADDITIONAL JAMB REINFORCEMENT BAR FOR EVERY INTERRUPTED BAR.

1 REINFORCED 6 IN. (SDC A OR B)

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

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

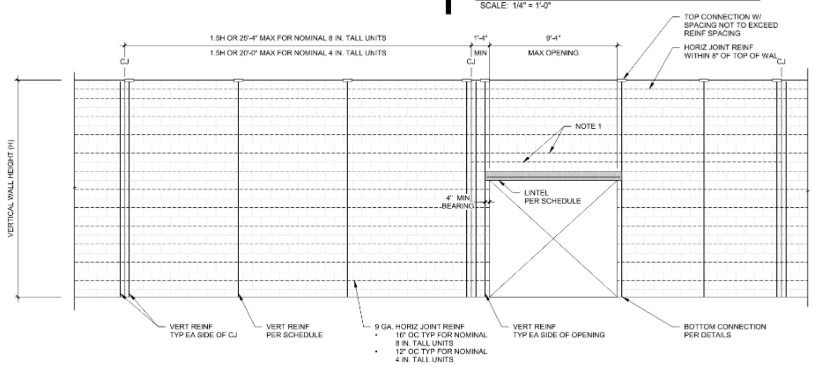
[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

6 IN. NOMINAL CMU PARTITIONS FOR BUILDINGS ASSIGNED TO SEISMIC DESIGN CATEGORY A OR B[1]					
SPECIFIED WALL HEIGHT, FT	MAXIMUM SPACING (FT) OF NO. 4 VERTICAL REINFORCING BARS FOR BASIC WIND SPEED (MPH) LESS THAN OR EQUAL TO:				
	100	120	140	160	180
12.00 AND LESS	10.00	10.00	10.00	10.00	10.00
12.67	10.00	10.00	10.00	10.00	9.33
13.33	10.00	10.00	10.00	10.00	8.00
14.00	10.00	10.00	10.00	8.67	6.00
14.67	10.00	10.00	9.33	6.00	5.33
15.33	10.00	10.00	8.67	5.33	4.67
16.00	10.00	9.33	5.33	5.33	4.67
16.67	9.33	8.67	5.33	4.67	4.00
17.33	8.67	5.33	4.67	4.00	3.33
18.00	8.00	4.67	4.00	4.00	3.33
18.67	4.67	4.00	4.00	3.33	3.33
19.33	4.00	4.00	3.33	3.33	2.67
20.00	4.00	3.33	3.33	2.67	2.67
20.67	3.33	3.33	3.33	2.67	2.67
21.33	3.33	2.67	2.67	2.67	2.00
22.00	2.67	2.67	2.67	2.67	2.00
22.67	2.67	2.67	2.67	2.00	2.00
23.33	2.67	2.00	2.00	2.00	2.00
24.00	2.00	2.00	2.00	2.00	2.00

[1] LINEAR INTERPOLATION NOT PERMITTED.



NOTES:

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3. PLACE VERTICAL REINFORCEMENT AT ENDS AND CORNERS OF ALL WALLS.
4. IF VERTICAL REINFORCEMENT IS INTERRUPTED BY OPENINGS, PLACE ONE ADDITIONAL JAMB REINFORCEMENT BAR FOR EVERY INTERRUPTED BAR.

2 REINFORCED 6 IN. (SDC C)

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

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

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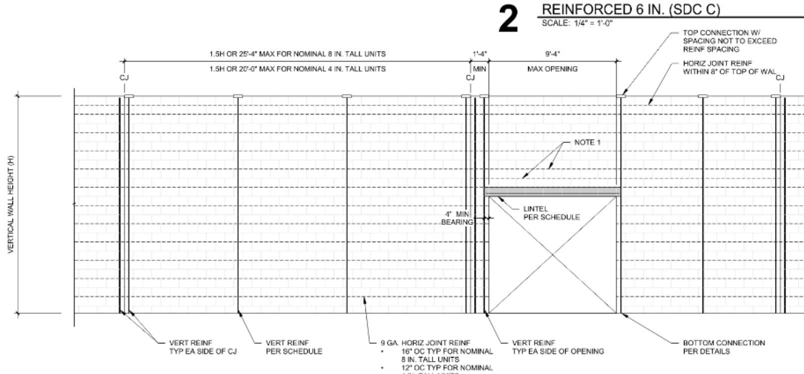
MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

6 IN. NOMINAL CMU PARTITIONS FOR BUILDINGS ASSIGNED TO SEISMIC DESIGN CATEGORY C[1]				
SPECIFIED WALL HEIGHT, FT	MAXIMUM SPACING (FT) OF NO. 4 VERTICAL REINFORCING BARS FOR BASIC WIND SPEEDS OF 180 MPH OR LESS FOR S_{NS} VALUES LESS THAN OR EQUAL TO:			
	0.33	0.40	0.45	0.50
9.33 AND LESS	10.00	10.00	10.00	10.00
10.00	10.00	10.00	9.33	8.67
10.67	10.00	9.33	8.67	6.67
11.33	9.33	8.00	6.67	6.00
12.00	8.67	6.00	6.00	5.33
12.67	6.00	5.33	5.33	4.67
13.33	5.33	4.67	4.67	4.00
14.00	4.67	4.67	4.00	4.00
14.67	4.67	4.00	3.33	3.33
15.33	4.00	3.33	3.33	3.33
16.00	4.00	3.33	2.67	2.67
16.67	3.33	2.67	2.67	2.67
17.33	3.33	2.67	2.67	2.67
18.00	2.67	2.67	2.67	2.00
18.67	2.67	2.67	2.00	2.00
19.33	2.67	2.00	2.00	2.00
20.00	2.00	2.00	2.00	1.33
20.67	2.00	2.00	2.00	1.33
21.33	2.00	2.00	1.33	1.33
22.00	2.00	1.33	1.33	1.33

[1] LINEAR INTERPOLATION NOT PERMITTED.



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3. PLACE VERTICAL REINFORCEMENT AT ENDS AND CORNERS OF ALL WALLS.
4. IF VERTICAL REINFORCEMENT IS INTERRUPTED BY OPENINGS, PLACE ONE ADDITIONAL JAMB REINFORCEMENT BAR FOR EVERY INTERRUPTED BAR.

3 REINFORCED 6 IN. (SDC D)

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

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

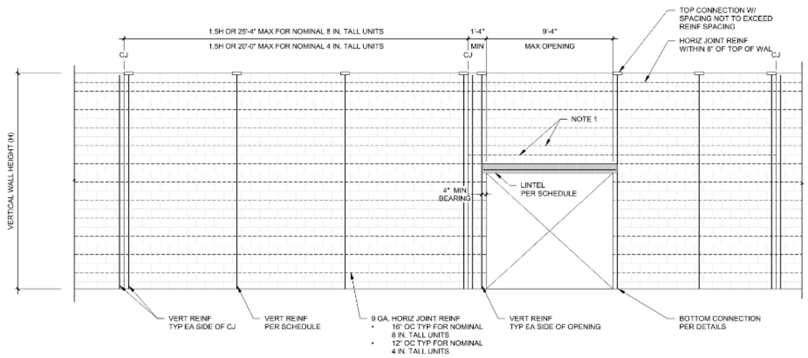
[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

6 IN. NOMINAL CMU PARTITIONS FOR BUILDINGS ASSIGNED TO SEISMIC DESIGN CATEGORY D[1]						
SPECIFIED WALL HEIGHT, FT	MAXIMUM SPACING (FT) OF NO. 4 VERTICAL REINFORCING BARS FOR BASIC WIND SPEEDS OF 180 MPH OR LESS FOR S_{NS} VALUES LESS THAN OR EQUAL TO:					
	0.50	0.60	0.70	0.80	0.90	1.00
10.67 OR LESS	4.00	4.00	4.00	4.00	4.00	4.00
11.33	4.00	4.00	4.00	4.00	3.33	3.33
12.00	4.00	4.00	4.00	3.33	3.33	3.33
12.67	4.00	4.00	3.33	3.33	2.67	2.67
13.33	4.00	3.33	3.33	2.67	2.67	2.67
14.00	4.00	3.33	2.67	2.67	2.00	2.00
14.67	3.33	3.33	2.67	2.00	2.00	2.00
15.33	3.33	2.67	2.67	2.00	2.00	2.00
16.00	2.67	2.67	2.00	2.00	2.00	1.33
16.67	2.67	2.00	2.00	2.00	1.33	1.33
17.33	2.67	2.00	2.00	1.33	1.33	1.33
18.00	2.00	2.00	1.33	1.33	1.33	DR[2]
18.67	2.00	2.00	1.33	1.33	DR[2]	DR[2]
19.33	2.00	1.33	1.33	DR[2]	DR[2]	DR[2]
20.00	1.33	1.33	DR[2]	DR[2]	DR[2]	DR[2]

[1] LINEAR INTERPOLATION NOT PERMITTED.
[2] DR - DESIGN REQUIRED IN ACCORDANCE WITH TMS 402.

THE BEAUTY OF BLOCK DESIGN COLLECTIVE

PARTITION WALL DETAILS (REINFORCED)



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4. IF VERTICAL REINFORCEMENT IS INTERRUPTED BY OPENINGS, PLACE ONE ADDITIONAL JAMB REINFORCEMENT BAR FOR EVERY INTERRUPTED BAR.

1 REINFORCED 8 IN. (SDC A OR B)

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

MINIMUM LAP SPLICE LENGTHS

	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]

CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]

CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

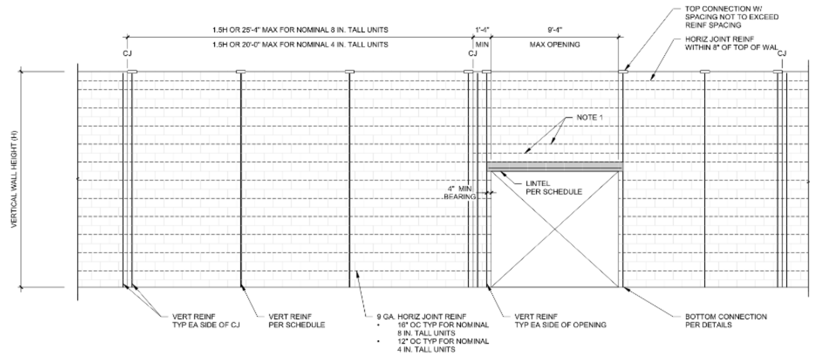
8 IN. NOMINAL CMU PARTITIONS FOR BUILDINGS ASSIGNED TO SEISMIC DESIGN CATEGORY A OR B[1]

SPECIFIED WALL HEIGHT, FT	MAXIMUM SPACING (FT) OF NO. 5 VERTICAL REINFORCING BARS FOR BASIC WIND SPEED (MPH) LESS THAN OR EQUAL TO:				
	100	120	140	160	180
18.00 AND LESS	10.00	10.00	10.00	10.00	10.00
18.67	10.00	10.00	10.00	10.00	7.33
19.33	10.00	10.00	10.00	10.00	6.67
20.00	10.00	10.00	10.00	6.67	6.00
20.67	10.00	10.00	10.00	6.00	5.33
21.33	10.00	10.00	6.00	6.00	5.33
22.00	10.00	10.00	6.00	5.33	4.67
22.67	10.00	6.00	5.33	5.33	4.67
23.33	10.00	5.33	4.67	4.67	4.00
24.00	5.33	4.67	4.67	4.00	4.00
24.67	4.67	4.67	4.67	4.00	3.33
25.33	4.00	4.00	4.00	4.00	3.33
26.00	4.00	4.00	4.00	3.33	3.33
26.67	3.33	3.33	3.33	3.33	3.33
27.33	3.33	3.33	3.33	2.67	2.67
28.00	3.33	3.33	2.67	2.67	2.67
28.67	2.67	2.67	2.67	2.67	2.67
29.33	2.67	2.67	2.67	2.67	2.67
30.00	2.67	2.67	2.67	2.67	2.67
30.67	2.00	2.00	2.00	2.00	2.00
31.33	2.00	2.00	2.00	2.00	2.00
32.00	2.00	2.00	2.00	2.00	2.00
32.67	2.00	2.00	2.00	2.00	2.00
33.33	2.00	2.00	2.00	2.00	2.00
34.00	1.33	1.33	1.33	1.33	1.33

[1] LINEAR INTERPOLATION NOT PERMITTED.

THE BEAUTY OF BLOCK DESIGN COLLECTIVE

PARTITION WALL DETAILS (REINFORCED)



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4. IF VERTICAL REINFORCEMENT IS INTERRUPTED BY OPENINGS, PLACE ONE ADDITIONAL JAMB REINFORCEMENT BAR FOR EVERY INTERRUPTED BAR.

1 REINFORCED 8 IN. (SDC C)
SCALE: 1/4" = 1'-0"

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

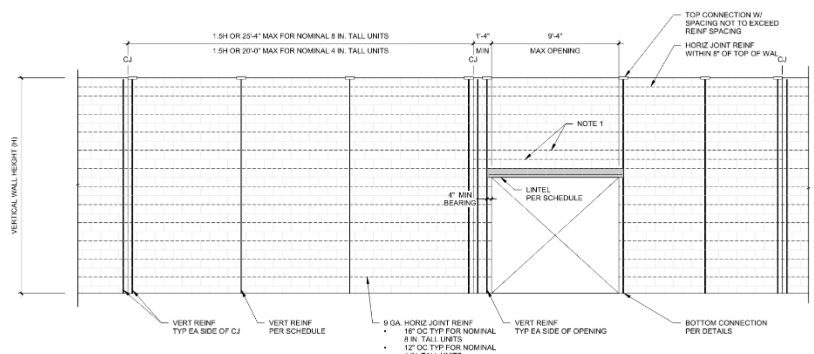
[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

8 IN. NOMINAL CMU PARTITIONS FOR BUILDINGS ASSIGNED TO SEISMIC DESIGN CATEGORY C[1]				
SPECIFIED WALL HEIGHT, FT	MAXIMUM SPACING (FT) OF NO. 5 VERTICAL REINFORCING BARS FOR BASIC WIND SPEEDS OF 180 MPH OR LESS FOR S_{MS} VALUES LESS THAN OR EQUAL TO:			
	0.33	**0.40**	**0.45**	**0.50**
12.00 AND LESS	10.00	10.00	10.00	10.00
12.67	10.00	10.00	10.00	8.67
13.33	10.00	10.00	8.67	8.00
14.00	10.00	8.00	7.33	6.67
14.67	10.00	7.33	6.67	6.00
15.33	8.00	6.67	6.00	6.00
16.00	7.33	6.00	5.33	5.33
16.67	6.67	5.33	5.33	4.67
17.33	6.00	5.33	4.67	4.00
18.00	5.33	4.67	4.00	4.00
18.67	4.67	4.67	4.00	4.00
19.33	4.67	4.00	4.00	3.33
20.00	4.00	4.00	3.33	3.33
20.67	4.00	3.33	3.33	2.67
21.33	4.00	3.33	2.67	2.67
22.00	3.33	2.67	2.67	2.67
22.67	3.33	2.67	2.67	2.67
23.33	3.33	2.67	2.67	2.00
24.00	2.67	2.67	2.00	2.00
24.67	2.67	2.00	2.00	2.00
25.33	2.67	2.00	2.00	2.00
26.00	2.00	2.00	2.00	2.00
26.67	2.00	2.00	2.00	1.33
27.33	2.00	2.00	1.33	1.33
28.00	2.00	1.33	1.33	1.33
28.67	2.00	1.33	1.33	DR[2]
29.33	1.33	1.33	1.33	DR[2]
30.00	1.33	1.33	DR[2]	DR[2]
30.67	1.33	DR[2]	DR[2]	DR[2]
31.33	1.33	DR[2]	DR[2]	DR[2]

[1] LINEAR INTERPOLATION NOT PERMITTED.
[2] DR - DESIGN REQUIRED IN ACCORDANCE WITH TMS 402.



NOTES:

1. INSTALL 9 GA. LADDER TYPE JOINT REINFORCEMENT IN FIRST TWO JOINTS ABOVE OPENING FROM CONTROL JOINT TO CONTROL JOINT.
2. INSTALL 9 GA. LADDER TYPE JOINT REINFORCEMENT IN FIRST OR SECOND MORTAR JOINT BELOW SILL FROM CONTROL JOINT TO CONTROL JOINT.
3. PLACE VERTICAL REINFORCEMENT AT ENDS AND CORNERS OF ALL WALLS.
4. IF VERTICAL REINFORCEMENT IS INTERRUPTED BY OPENINGS, PLACE ONE ADDITIONAL JAMB REINFORCEMENT BAR FOR EVERY INTERRUPTED BAR.

2 REINFORCED 8 IN. (SDC D)
SCALE: 1/4" = 1'-0"

MINIMUM LAP SPLICE LENGTHS		
	NO. 4 REINFORCING BARS	NO. 5 REINFORCING BARS
6 IN. CMU PARTITION	19 IN.	30 IN.
8 IN. CMU PARTITION	14 IN.	21 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING CLOSED-BOTTOM LINTEL UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
6.00 AND LESS	(1) NO. 4 - GRADE 60	8 IN.
UP TO 9.33	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

MINIMUM LINTEL REINFORCEMENT AND LINTEL DEPTH FOR 6 IN. AND 8 IN. CMU LINTELS CONSTRUCTED USING KNOCK-OUT AND REDUCED WEB BOND BEAM UNITS[1]		
CLEAR OPENING, FT	REINFORCEMENT	NOMINAL LINTEL DEPTH
9.33 AND LESS	(1) NO. 4 - GRADE 60	16 IN.

[1] BASED ON A MINIMUM BOTTOM COVER DISTANCE OF 2.0 IN.

8 IN. NOMINAL CMU PARTITIONS FOR BUILDINGS ASSIGNED TO SEISMIC DESIGN CATEGORY D[1]						
SPECIFIED WALL HEIGHT, FT	MAXIMUM SPACING (FT) OF NO. 5 VERTICAL REINFORCING BARS FOR BASIC WIND SPEEDS OF 180 MPH OR LESS FOR S_{MS} VALUES LESS THAN OR EQUAL TO:					
	0.50	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
14.00 OR LESS	4.00	4.00	4.00	4.00	4.00	4.00
14.67	4.00	4.00	4.00	4.00	4.00	3.33
15.33	4.00	4.00	4.00	4.00	3.33	3.33
16.00	4.00	4.00	4.00	3.33	3.33	2.67
16.67	4.00	4.00	3.33	3.33	2.67	2.67
17.33	4.00	4.00	3.33	2.67	2.67	2.00
18.00	4.00	3.33	3.33	2.67	2.67	2.00
18.67	4.00	3.33	2.67	2.67	2.00	2.00
19.33	3.33	2.67	2.67	2.00	2.00	2.00
20.00	3.33	2.67	2.67	2.00	2.00	1.33
20.67	2.67	2.67	2.00	2.00	2.00	1.33
21.33	2.67	2.67	2.00	2.00	1.33	1.33
22.00	2.67	2.00	2.00	1.33	1.33	1.33
22.67	2.67	2.00	2.00	1.33	1.33	1.33
23.33	2.00	2.00	1.33	1.33	1.33	DR[2]
24.00	2.00	2.00	1.33	1.33	DR[2]	DR[2]
24.67	2.00	1.33	1.33	DR[2]	DR[2]	DR[2]
25.33	2.00	1.33	1.33	DR[2]	DR[2]	DR[2]
26.00	2.00	1.33	DR[2]	DR[2]	DR[2]	DR[2]
26.67	1.33	1.33	DR[2]	DR[2]	DR[2]	DR[2]
27.33	1.33	DR[2]	DR[2]	DR[2]	DR[2]	DR[2]
28.00	1.33	DR[2]	DR[2]	DR[2]	DR[2]	DR[2]

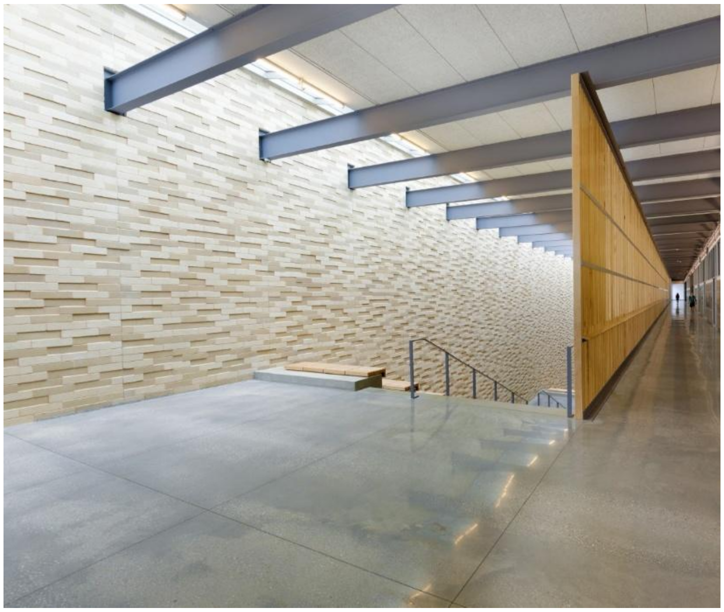
[1] LINEAR INTERPOLATION NOT PERMITTED.
[2] DR - DESIGN REQUIRED IN ACCORDANCE WITH TMS 402.

THE BEAUTY OF BLOCK DESIGN COLLECTIVE

PARTITION WALL DETAILS (REINFORCED)

1 ELEVATING INTERIOR DESIGN WITH CONCRETE MASONRY

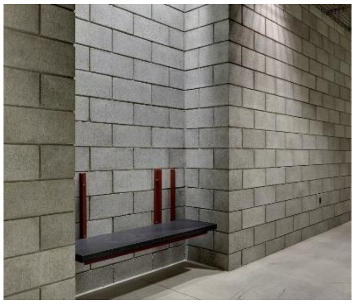
In modern architecture, the interior partition wall is far more than a simple spatial divider. It is a critical component of a building's visual appeal, safety, and occupant comfort. Concrete masonry partitions offer a superior solution to address an array of project and performance objectives from fire safety, sound abatement, durability, thermal mass, functional aesthetic, mold and moisture resistance, and carbon sink strategies – whether using standard gray concrete masonry units (CMU) or the unlimited colors and textures of architectural CMU.



— BEST BLOCK

Interior concrete masonry partitions can be either loadbearing – resisting gravity, lateral, or both types of loads within a building – or nonloadbearing. Nonloadbearing partitions are still required to be designed to resist occupant loads from routine use, internal pressures resulting from external wind loads, and where applicable, inertial seismic loads. This guide provides a comprehensive resource covering the design and detailing of interior nonloadbearing partition walls constructed using nominal 6 inch and 8 inch concrete masonry units.

— JANDRIS BLOCK



— MASONRY INSTITUTE OF MICHIGAN

While not all topics covered in this guide are applicable to every concrete masonry partition wall, the content covered here reviews the design and detailing considerations commonly encountered for all interior partition walls, including fire resistance, sound transmission, construction detailing, structural design, crack control strategies, and others. These strategies and recommendations are summarized at the beginning of this guide in a series of pre-engineered partition walls schedules that can be easily incorporated into project documents.

2 DESIGN AND INSTALLATION EFFICIENCY

One of the key objectives of this guide is to highlight design decisions and detailing practices that maximize efficiencies while still meeting building code requirements and occupant comfort objectives. When structural design efficiency is optimized, construction costs naturally decrease. Similarly, when material use is reduced, so is the embodied carbon of the construction.

One highly effective design efficiency strategy for nonloadbearing partitions given the relatively small design loads these assemblies are subjected to is spacing reinforcement at the maximum spacing permitted by TMS 402 [Ref. 1]. When not governed by design loading, TMS 402 does have prescriptive limits on the spacing of reinforcement as follows:

- For shear walls, when horizontal shear reinforcement is required to resist in-plane design loads, the maximum spacing of the vertical reinforcement is limited to 96 inches. As this guide addresses the design and detailing of nonloadbearing partition walls, this requirement does not apply.
- For nonloadbearing partition walls that are assigned to Seismic Design Category (SDC) A or B, TMS 402 defines no limit on the maximum spacing of the vertical reinforcement. For nonloadbearing partitions assigned to SDC C, however, the spacing of the vertical reinforcement of vertically spanning partition walls is limited to 120 inches. While this requirement does not apply to partitions assigned to SDC A or B, for reasons reviewed in more detail in the Structural Design section of this guide, this maximum spacing limit is adopted for reinforced partition walls. For SDC D and higher, the spacing of the vertical reinforcement in vertically spanning nonloadbearing partitions is limited to 48 inches. For partition walls designed as unreinforced masonry, there is no spacing limit on the reinforcement, if present.

A common misconception with masonry design is that the spacing of reinforcing steel cannot exceed 48 inches, regardless of whether the masonry is a bearing or nonloadbearing assembly. While TMS 402 does include limits on the effective compression width of masonry subject to flexural loading, this only applies when considering the contribution masonry has to an assembly's overall flexural strength. There are many scenarios, especially with nonloadbearing partitions, where the reinforcement can be spaced at distances far beyond 48 inches.

Consider a partition wall using 8-inch CMU with vertical steel spaced at 48 inches on center. A more efficient design could be spacing the vertical steel out to 120 inches on-center for most low load applications. An even more efficient design would use 6-inch CMU instead of 8-inch CMU as 6-inch CMU can also be designed for the majority of interior partition loads. Not only does this save on materials and labor, the embodied carbon of each of these scenarios is also significantly reduced.

2 DESIGN AND INSTALLATION EFFICIENCY

Table 1 – Embodied Carbon Design Efficiencies		
8 in. CMU Partition – Reinforcement at 48 in.	8 in. CMU Partition – Reinforcement at 120 in.	6 in. CMU Partition – Reinforcement at 120 in.
CO_2e = 5.2 lb/ft^2	CO_2e = 4.6 lb/ft^2 (11.5% CO_2e Reduction)	CO_2e = 3.7 lb/ft^2 (28.8% CO_2e Reduction)

There are several variables that directly impact masonry's installation productivity and thereby its cost to construct – not the least of which is the lay rate for installing masonry units. While it isn't the only factor that affects construction productivity, the weight of each masonry unit is a key driver behind installation productivity. Hollow 6-inch CMU weigh in the range of 20-25 pounds each, depending on the density of the unit, whereas hollow 8-inch CMU often typically fall in the 28-33 pound range, again, depending on their density. While a difference of 5-10 pounds per unit may not seem significant, over the course of a day, laying 6-inch CMU can translate to an increase in productivity of 15-20%, which significantly impacts the cost of construction [Ref. 2]. 6-inch CMU partitions are often an overlooked solution, saving cost and interior space while still providing the same durable, non-combustible solution of 8-inch concrete masonry assemblies [Ref. 3].

— KINGS MATERIALS

3 SOUND ABATEMENT

The Sound Transmission Class (STC) rating of CMU partitions is a function of the installed weight of the assembly. The base assembly weight (without finishes) of concrete masonry partitions is a function of the density of the CMU and the how much grout or other approved fill material is placed in the wall. Tables 2 and 3 summarize the STC ratings of 6-inch and 8-inch concrete masonry assemblies for a range of CMU densities and grout spacing.

Table 2 – Sound Transmission Class Rating for 6 in. Nominal CMU Assemblies

	CMU Density (lb/ft^3)			
Grout Spacing	100 lb/ft^3	110 lb/ft^3	120 lb/ft^3	130 lb/ft^3
Fully Grouted	52.8	53.2	53.6	54.1
16	48.6	49.2	49.7	50.2
24	46.8	47.4	48.0	48.6
32	45.8	46.5	47.1	48.0
40	45.4	46.1	46.8	47.4
48	44.7	45.8	46.5	47.1
56	44.7	45.4	46.1	46.8
64	44.3	45.0	45.8	46.5
72	43.9	45.0	45.8	46.5
80 or greater	43.5	44.3	45.0	45.8
Ungrouted	42.7	43.5	44.3	45.1

Table 3 – Sound Transmission Class Rating for 8 in. Nominal CMU Assemblies

	CMU Density (lb/ft^3)			
Grout Spacing	100 lb/ft^3	110 lb/ft^3	120 lb/ft^3	130 lb/ft^3
Fully Grouted	57.2	57.2	57.5	58.0
16	52.6	52.6	53.2	53.6
24	50.7	50.7	51.4	51.9
32	49.7	49.7	50.5	51.0
40	49.2	49.2	49.7	50.5
48	48.6	48.6	49.4	50.0
56	48.3	48.3	49.2	49.7
64	48.0	48.0	48.9	49.4
72	47.7	47.7	48.6	49.4
80 or greater	47.1	47.0	48.0	49.0
Ungrouted	46.1	46.1	47.1	47.7

When necessary, the STC can be further increased through the installation of various finishes that increase the weight of the concrete masonry assembly (such as through the installation of an anchored or adhered veneer or application of stucco) or by providing layers to isolate unwanted noise (such as the installation of resilient channels and gypsum wallboard).

3 SOUND ABATEMENT

The most common failure in acoustic design often isn't the wall itself, but the gaps, joints, and penetrations within and through the wall. Additional detailing recommendations to address these conditions are available in Ref. 4 and 5. Common areas of detailing concern include:

- Top-of-Wall and Control Joint Joints: As there is typically a gap between the top of the partition and the floor/roof above to accommodate floor/roof deflection without loading the partition wall, this joint should be detailed to keep sound from bypassing the partition. Control joints located in partition walls should be similarly detailed. If the assembly is fire rated, the use of a combined fire/acoustic seal would be necessary.
- Penetrations: When incorporating outlets or similar penetrations into partitions, they should be offset on opposite sides of the wall so they are not directly located opposite one another [Ref. 5]. When the partition is fire rated, the area around the penetration is required to be filled with mortar or grout to maintain the fire resistance rating [Ref. 6]. Filling the annular gap around through-penetrations would also be equally important to maintaining the sound abatement qualities of the assembly.

TMS 302, *Standard Method for Determining Sound Transmission Ratings for Masonry Assemblies* [Ref. 7], includes the following prescriptive detailing requirements for sealing penetrations and joints as illustrated in Figure 1. These details are also available for digital download in multiple formats [Ref. 8].

- Through-wall and membrane penetrations are to be sealed with joint sealant, mortar, or grout. Prior to sealing around penetrations, the perimeter space behind the surface sealant is required to be filled with foam, cellulose fiber, glass fiber, ceramic fiber, or mineral wool.
- Movement joints and joints between the top of masonry and roof/floor assemblies are required to be sealed with joint sealant. The space behind the sealant is required to be filled with mortar, grout, foam, cellulose fiber, glass fiber, or mineral wool.

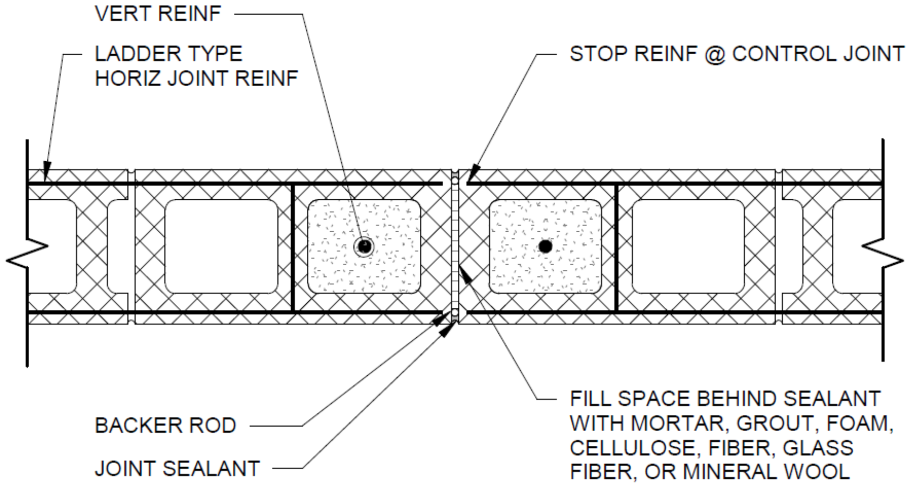


Figure 1 – Detailing Control Joints for Sound Abatement

4 FIRE RESISTANCE

Building codes take a multi-faceted approach to protecting life and property during a fire. These requirements address the combustibility, flame spread, smoke release, and structural stability of the systems that are used to mitigate the occurrence and spread of fire within or adjacent to buildings while allowing the safe evacuation of occupants when necessary.

Concrete masonry is inherently non-combustible. It provides a robust fire barrier that maintains structural stability under extreme heat, offering critical protection for egress paths and high-hazard separations without the need for additional fireproofing treatments. The fire resistance rating of a concrete masonry assembly is a function of the volume of the concrete masonry units (the equivalent thickness), the type of aggregate used in manufacturing the units [Ref. 3], and where all cells are filled with an approved material, such as grout. Because neither of these properties may be known to the designer during the early phases of design, it is best practice to simply specify the required fire resistance rating. Doing so ensures the lowest cost options for a given market are leveraged for each project. In specifying a partition wall thickness based on the required fire resistance rating, however, Table 4 can be used as guidance for targeting a desired fire resistance rating.

Table 4 – Available Fire Resistance Ratings Based on Nominal CMU Thickness (hour)

Nominal Unit Thickness (in.)	Typical Hollow Unit	Solid or Solid Grouted Unit
4 in. CMU	1 to 1.5 hours	1.5 to 2.5 hours
6 in. CMU	1.25 to 2 hours	3.25 to 4 hours
8 in. CMU	1.75 to 3 hours	4 hours
10 in. CMU	2.25 to 3.75 hours	4 hours
12 in. CMU	2.75 to 4 hours	4 hours

Joints and penetrations in fire rated assemblies are required to be detailed to maintain the fire resistance rating of the base assembly [Ref. 6]. ACI/TMS 216.1 [Ref. 9] provides several prescriptive means of detailing joints in concrete masonry assemblies for fire resistance, which are illustrated in Figures 2, 3, and 4.

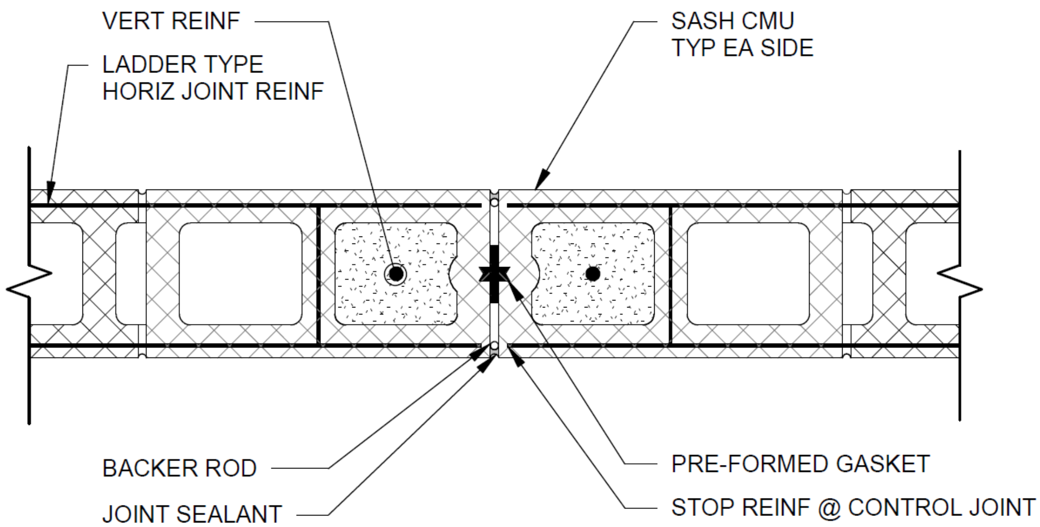


Figure 2 – One Hour Fire Rated Control Joint

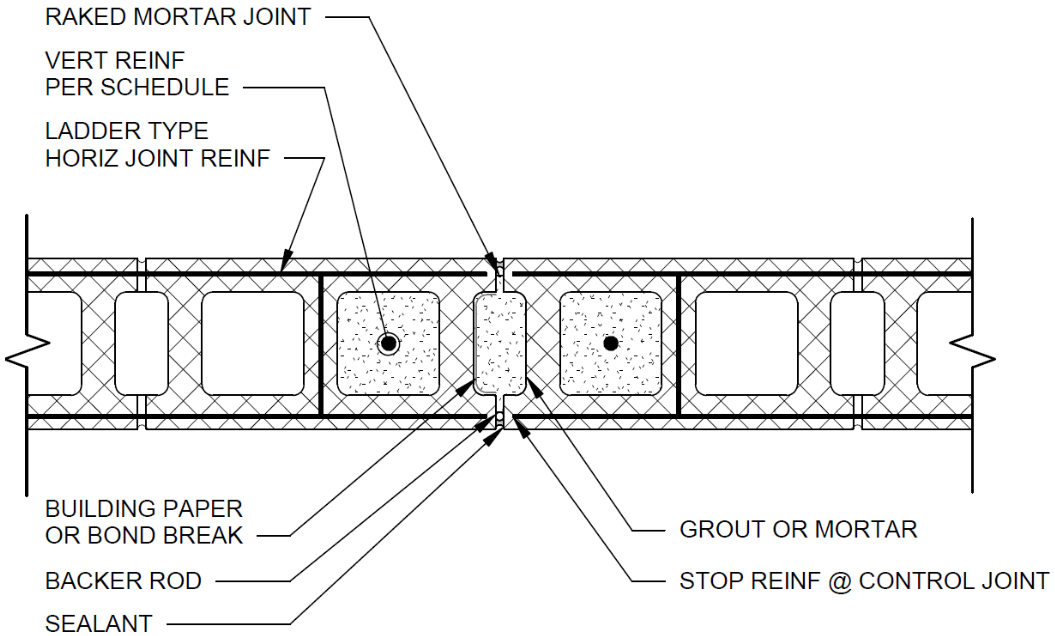


Figure 3 – Four Hour Fire Rated Control Joint

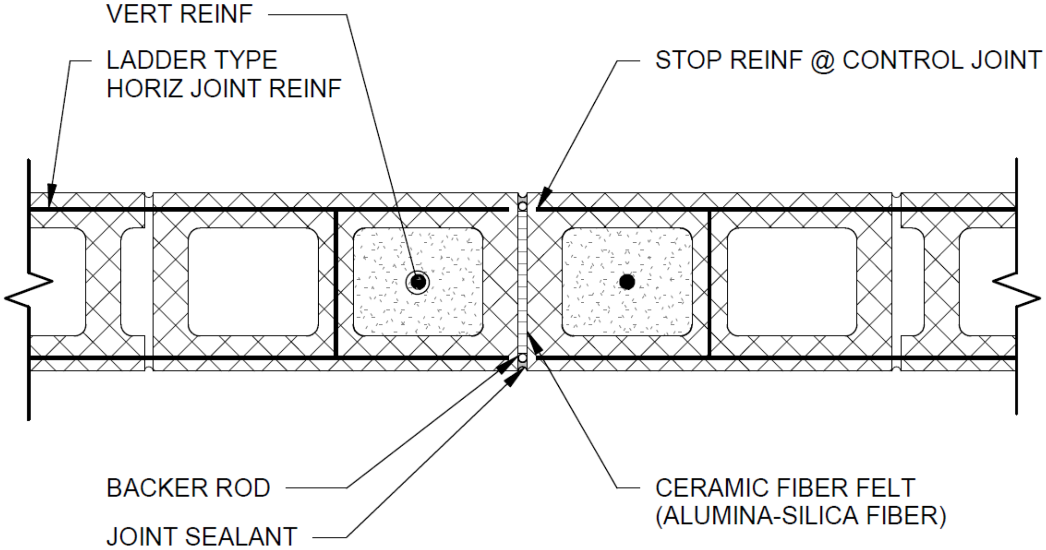


Figure 4 – Four Hour Fire Rated Control Joint

5 CRACK CONTROL STRATEGIES

Although interior partition walls are not exposed to the extreme temperature and moisture fluctuations exterior walls are, they do still move, and over the long-term, will experience net shrinkage due to a combination of carbon sequestration and drying. As such, for long interior partitions, incorporating control joints at regular intervals or known stress concentration (such as at changes in wall height) is recommended following industry practices [Ref. 10]. Table 5 summarizes the prescriptive approach to spacing control joints in concrete masonry construction.

Table 5 – Empirical Control Joint Spacing [Ref. 10]

	Maximum Length-to-Width Ratio of Concrete Masonry Panel	Maximum Control Joint Spacing	Spacing of 9 Guage Joint Reinforcement
Nominal Unit Height: 8 inches	1.5 to 1	25 ft – 4 in.	16 in.
Nominal Unit Height: 4 inches		20 ft	12 in.

The spacing between each control joint is governed by the targeted length-to-height ratio where the distance between control joints does not exceed 1.5 multiplied by the wall height, but not to exceed 25 ft-4 in. or 20 ft for CMU having nominal heights of 8 inches and 4 inches, respectively. In addition to these control joints, 9 gauge joint reinforcement is also placed in the mortar bed joints at 16 inches or 12 inches, again for CMU having nominal heights of 8 inches and 4 inches, respectively. Because walls constructed of CMU having nominal heights of 4 inches are constructed using more mortar compared to similar walls constructed using nominal 8-inch tall CMU, there is more potential for plastic shrinkage to occur with smaller height units.

When openings are located in partitions, it is recommended to locate control joints away from the opening. This allows for any trim reinforcement necessary around the opening for strength or crack control purposes to be properly placed while also providing sufficient bearing on both sides of the opening for the lintel above. For nonloadbearing partitions, a minimum nominal control joint offset of 16 inches is recommended along with a minimum nominal bearing length of 4 inches for the lintel on each side of the opening. These detailing practices are covered in more detail in the Structural Design Section of this guide.

6 DETAILING OF CONNECTIONS

As with all masonry assemblies, partitions can be designed to span horizontally, vertically, or simultaneously in both directions depending on which solution is optimum for a given project. When partitions intersect other internal partitions at regular, closely spaced intervals, a practical solution may be to consider the walls as horizontally spanning elements. For the horizontally spanning unreinforced partitions covered in this guide, each end of the partition must be laterally supported by other interior masonry partition walls, laid in running bond construction, with the units at the intersecting interface interlocking.

For most interior partitions, however, the relatively short floor-to-ceiling distance often makes distributing partition loads to these supports more feasible and economical. The challenge with vertically spanning masonry partitions, however, is that the top connection at the floor/roof above must be detailed so that they support the partition, but do not transfer loads into the partition the wall was not designed to resist. Figure 5 [Ref. 8] illustrates a practical means of providing the top of the partition with out-of-plane lateral support while preventing axial and in-plane loads from being transferred to the partition. Here, a gap is provided at the top of the partition to accommodate the deflection of the floor/roof above without imparting axial load to the partition. The size of this gap depends on the anticipated floor/roof deflection.

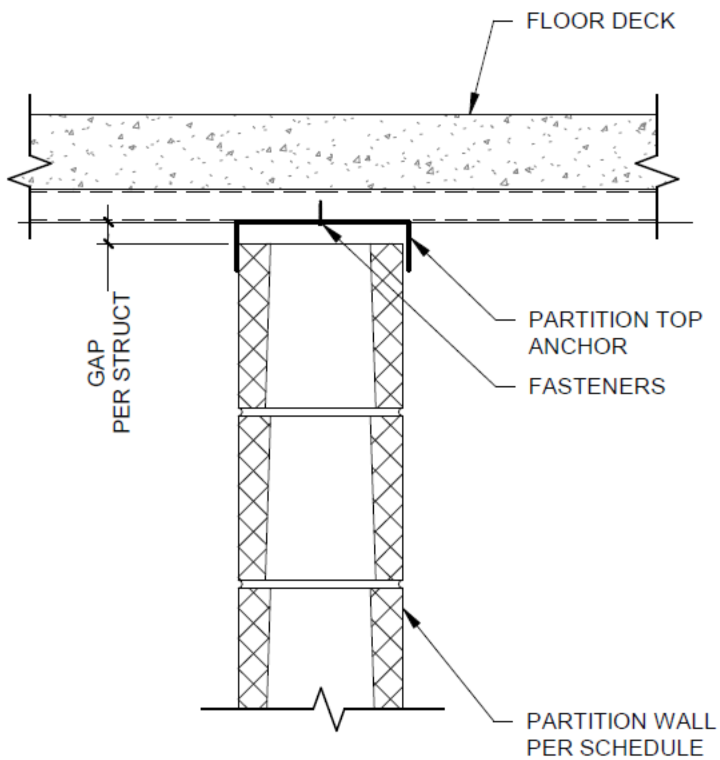


Figure 2 – Partition Top-of-Wall Connection

6 DETAILING OF CONNECTIONS

The out-of-plane base support for reinforced partitions can be accomplished using conventional dowels lapped with the vertical reinforcement in the partition as illustrated in Figure 3. When the reinforcement is required to be fully developed, the minimum lap splice lengths given in Table 6 would apply.

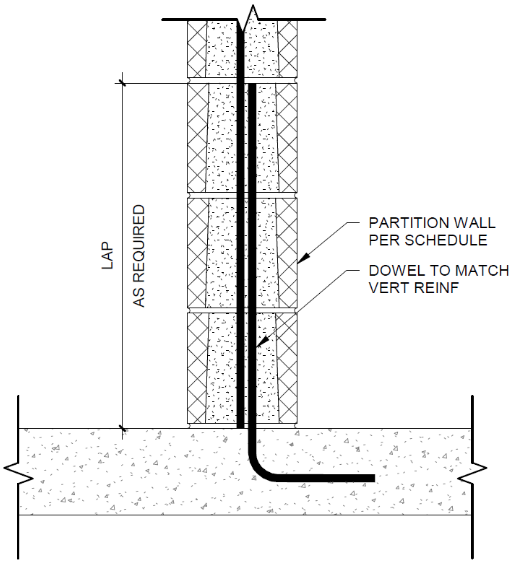


Figure 3 – Doweled and Lapped Base Connection

Table 6 – Minimum Lap Splice Lengths		
	No. 4 Reinforcing Bars	No. 5 Reinforcing Bars
6 in. CMU Partition	19 in.	30 in.
8 in. CMU Partition	14 in.	21 in.

Alternatively, when the partition is part of an enclosed or partially open structure, the partition is part of a building assigned to SDC A, B, or C, and the partition height does not exceed 15.33 ft, the base connection can be accomplished using a reinforcing bar epoxied into the supporting slab as shown in Figure 4.

6 DETAILING OF CONNECTIONS

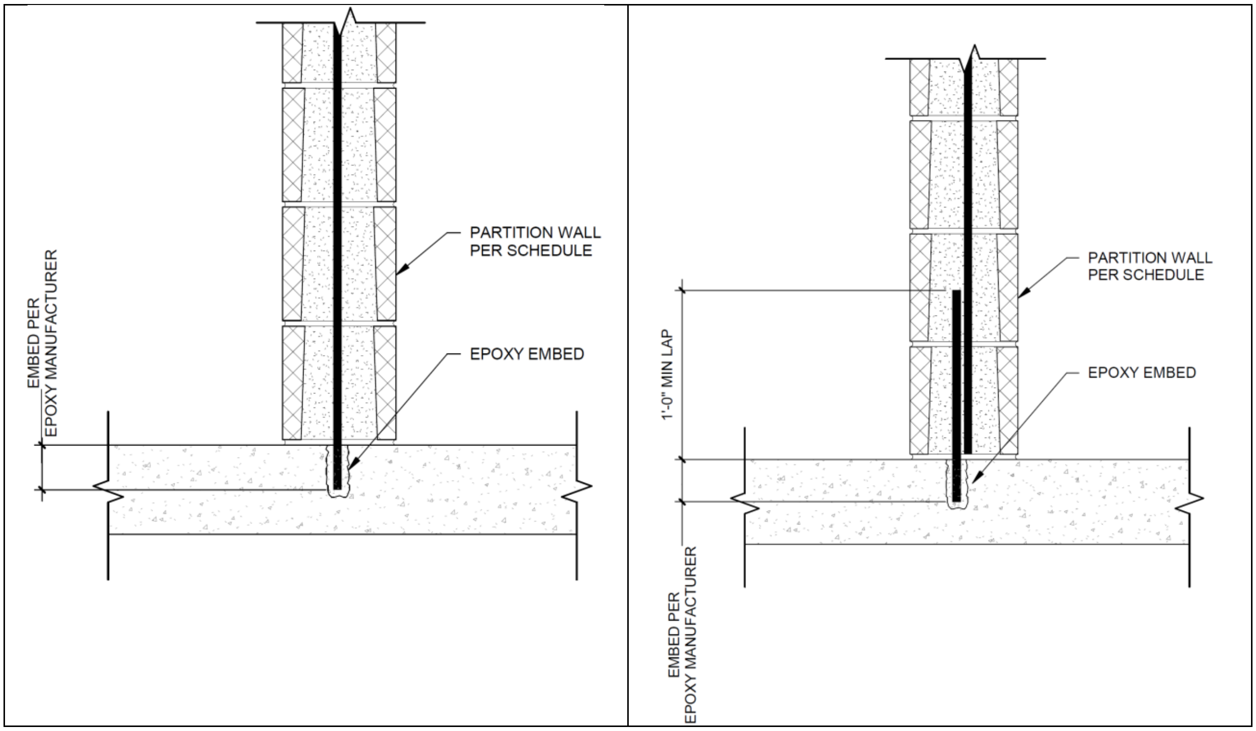


Figure 4 – Epoxied Base Connections

7 STRUCTURAL DESIGN

Although the scope of this guide applies to nonloadbearing CMU partitions, these partitions are still subject to out-of-plane design loads due to wind, seismic, and occupant live loads. Partition live loads are stipulated by Section 4.3.3 of ASCE/SEI 7 [Ref. 11] as follows:

> **4.3.4 Interior Walls and Partitions** Interior wall and partitions that exceed 6 ft (1.83 m) in height, including their finish materials, shall have adequate strength and stiffness to resist the loads to which they are subjected but not less than a horizontal load of 5 psf (0.240 kN/m^2).

Section 1607.16 of the International Building Code [Ref. 12] has similar requirements for partition live loads. In addition to live loads, interior walls are subject to internal wind pressures, typically 18% of the external design wind pressure for enclosed and partially open buildings or 55% of the external design wind pressure for partially enclosed buildings. Finally, interior partitions that are part of buildings assigned to Seismic Design Category (SDC) C or higher are subject to inertial seismic loading. Per ASCE/SEI 7 Table 13.3-1, partitions in buildings assigned to SDC A and B are exempt from seismic loading. When determining the basic design wind speed or seismic design category, ASCE has an online tool to quickly determine these design parameters for any location in the U.S.: https://ascehazardtool.org/ [Ref. 13].

Applying these loading criteria, Section 7.1 and 7.2 provide pre-engineered design solutions for unreinforced and reinforced concrete masonry partition walls, respectively. For more specialized partition design parameters, the Block Design Collective also maintains an online partition wall design calculator that can provide quick design solutions based on a wide array of design conditions: https://beautyofblock.com/resource-type/design-calculators/partition-wall-calculator/ [Ref. 14].

7.1 UNREINFORCED CONCRETE MASONRY PARTITIONS

In regions of low seismic risk (SDC A or B), unreinforced masonry partitions are often a viable option. While unreinforced masonry partitions may be designed and constructed in higher seismic risk regions, TMS 402 [Ref. 1] requires minimum prescriptive reinforcing be provided for partitions even when not part of the seismic force-resisting system. As such, designing partitions as unreinforced in SDC C or higher offers little benefit as they are prescriptively required to include reinforcing steel.

Unreinforced masonry relies on the bond strength between the mortar and unit to resist flexural tension stresses resulting from out-of-plane loading. Table 7 summarizes the modulus of rupture values for hollow, ungrouted CMU assemblies. For vertically spanning assemblies, the modulus of rupture values associated with flexural tensile stresses normal to the bed joints govern. For horizontally spanning assemblies, the modulus of rupture values associated with flexural tensile stresses parallel to the bed joints govern.

Table 7 – Modulus of Rupture: Hollow, Ungrouted CMU Assemblies [Ref. 1]

Direction of Flexural Tensile Stress	Portland Cement/Lime or Mortar Cement		Masonry Cement or Air Entrained Portland Cement/Lime	
	Type M or S	Type N	Type M or S	Type N
Normal to Bed Joints	84	64	51	31
Parallel to Bed Joints	167	127	100	64

The following example illustrates the design of an unreinforced concrete masonry partition wall using the strength design provisions of TMS 402. The partition is assumed to span in the vertical direction and subject to the following design parameters:

Material Properties	
Specified Compressive Strength of Masonry, f'_m	1,750 lb/in.^{2}
Mortar: Type N Portland Cement-Lime Modulus of Rupture, f_r (Ungrouted hollow units, normal to bed joints)	64 lb/in.^{2}
Assembly Properties	
Nominal Wall Thickness, t	8 in.
Specified Wall Thickness, t_{sp}	7.625 in.
Ungrouted Assembly Weight, W_w	35 lb/ft^2
Face Shell Bedded Net Cross-Sectional Area, A_n	30.0 in.^{2}/ft
Face Shell Bedded Net Moment of Inertia, I_n	308.7 in.^{4}/ft
Vertical Design Span, S	12 ft
Construction	Running Bond
Design Loads	
Out-of-Plane Live Load, L	5.0 lb/ft^2

Out-of-Plane Internal Wind Pressure, *W*	5.4 lb/ft^2
Seismic Design Category	B

The factored out-of-plane load combination is determined from Chapter 2 of ASCE/SEI 7. For partitions subjected to out-of-plane loading with negligible axial load, the two load combinations that typically control are:

$$(1.6)(L) \quad \text{or} \quad (1.0)(L) + (1.0)(W \text{ or } E)$$

The live load for partitions is given in Section 4.3.4 of ASCE/SEI 7 as a minimum of 5 lb/ft^2. The internal wind pressure on the partitions is based on the external Main Wind Force Resisting System (MWFRS) wind pressure adjusted based on the enclosure classification of the building. The external pressure (q_z) for this example is determined in accordance with Equation 26.10-1 of ASCE/SEI 7 as follows:

$$q_z = 0.00256(K_z)(K_{zt})(K_e)(V^2)$$

Applying the following design parameters:

- Basic Wind Speed: V = 140 mph
- Wind Exposure Category = B
- Ground Elevation = 0 ft
- Ground Elevation Factor: K_e = 1.0
- Mean Roof Height: z = 30 ft
- Pressure Exposure Coefficient: K_z = 0.70
- Topographic Factor: K_{zt} = 1.0

The resulting external pressure is then:

$$q_{30} = 0.00256(0.70)(1.0)(1.0)(140)^2 = 35.1 \ {}^{\text{lb}}/_{\text{ft}^2}$$

Considering this structure as an enclosed building, the internal pressure coefficient (GC_{pi}) per Section 26.13 of ASCE/SEI 7 is 0.18. Applying a directionally factor (K_d) of 0.85, the resulting internal partition wind pressure is:

$$p = (q_{30})(K_d)(GC_{pi}) = \left(35.1 \ {}^{\text{lb}}/_{\text{ft}^2}\right)(0.85)(0.18) = 5.4 \ {}^{\text{lb}}/_{\text{ft}^2}$$

Finally, because this structure is assigned to SDC B, ASCE/SEI 7 does not require out-of-plane seismic loading to be considered per Section 13.3.1. The critical out-of-plane design load for this example is then:

$$1.0L + 1.0W = (1.0)\left(5\ {}^{\text{lb}}/_{\text{ft}^2}\right) + (1.0)\left(5.4\ {}^{\text{lb}}/_{\text{ft}^2}\right) = 10.4\ {}^{\text{lb}}/_{\text{ft}^2}$$

Considering the wall as a simple span assembly, the resulting factored, out-of-plane moment at mid-span of the 12 ft partition height is then:

$$M_u = \frac{\left(10.4\ {}^{\text{lb}}/_{\text{ft}^2}\right)(12\ \text{ft})^2}{8}\left(12\ \frac{\text{in.}}{\text{ft}}\right) = 2{,}247\ \frac{\text{in.-lb}}{\text{ft}}$$

The assembly dead load is reduced by a load factor of 0.9. The resulting axial stress due to the self-weight of the assembly at mid-height is:

$$P_{DL} = (0.9)(W_w)\left({}^{L}/_{2}\right) = (0.9)\left(35\ {}^{\text{lb}}/_{\text{ft}^2}\right)\left({}^{12\ \text{ft}}/_{2}\right) = 189\ \text{lb}$$

The resulting compressive stress due to the assembly dead load is:

$$C = \frac{P_{DL}}{A_n} = \frac{189\ \text{lb}}{5.4\ {}^{\text{in.}^2}/_{\text{ft}}} = 6.3\ {}^{\text{lb}}/_{\text{in.}^2}$$

The corresponding net flexural tensile stress, reduced by the compressive stresses from the self-weight of the wall is then:

$$F_t = \frac{(M_u)\left({}^{t_{sp}}/_{2}\right)}{I_n} - C = \frac{\left(2{,}247\ \frac{\text{in.-lb}}{\text{ft}}\right)\left({}^{7.625\ \text{in.}}/_{2}\right)}{308.7\ {}^{\text{in.}^4}/_{\text{ft}}} - 6.3\ {}^{\text{lb}}/_{\text{in.}^2} = 21.5\ {}^{\text{lb}}/_{\text{in.}^2}$$

Per Table 7, the maximum modulus of rupture of a Type N portland cement/lime mortar is 64 lb/in.^{2}. Per TMS 402, the strength reduction factor for unreinforced masonry is 0.6 resulting in a design modulus of rupture of: (0.6)(64 lb/in.^{2}) = 38.4 lb/in.^{2}. As such, this assembly is only stressed to 56% of its design strength. Given that the resulting maximum net tensile stresses of this example are 21.5 lb/in.^{2}, any mortar type listed in Table 7 could be safely used.

For the design of the top and bottom partition connection, the resulting factored out-of-plane uniform loading along the top and bottom of the 12 ft tall partition is then:

$$P_{conn} = \frac{\left(10.4\ {}^{\text{lb}}/_{\text{ft}^2}\right)(12\ \text{ft})}{2} = 62.4\ {}^{\text{lb}}/_{\text{ft}}$$

The resulting anchorage would need to be sized and spaced to accommodate this out-of-plane support load. The maximum shear load in the partition equals the out-of-plane anchorage load at the top and bottom of the partition (e.g., $V_u = P_{conn}$). While out-of-plane shear strength rarely controls in these scenarios, it is checked here to illustrate the design check. Per TMS 402 Section 9.2.6, the controlling nominal shear strength for this assembly (V_n) is equal to $56A_{nv}$ neglecting any contribution from axial load, where A_{nv} is the net shear area taken equal to the net cross-sectional area of the partition (A_n) for unreinforced masonry. The resulting design shear strength of this assembly applying a strength reduction factor of 0.8 is then:

$$\phi V_n = (\phi)(56A_{nv}) = (0.8)\left(56\ ^{\text{lb}}/_{\text{in.}^2}\right)\left(30\ ^{\text{in.}^2}/_{\text{ft}}\right) = 1{,}344\ ^{\text{lb}}/_{\text{ft}}$$

Which exceeds the ultimate shear load of 62.4 lb/ft. TMS 402 limits the out-of-plane deflection to 0.7% of the design span, or: (0.007)(12 ft)(12 in./ft) = 1.0 in. Because unreinforced masonry assemblies are required to remain uncracked under design loading, by inspection this limit is met.

For ease of application, Tables 8 and 9 provide pre-engineered maximum vertical and horizontal design spans for 6-inch and 8-inch unreinforced CMU assemblies, respectively for each mortar type and mortar cement type from Table 7. These tables are based on the same analyses presented in the unreinforced design example solving for the maximum design span permitted for the input design parameters. Additional constraints on the use of Tables 8 and 9 include:

- The building is classified as enclosed or partially open in accordance with ASCE/SEI 7 Table 26.13-1.
- The minimum specified compressive strength of the masonry, f'_m, is 1,750 lb/in.^{2}.
- The assembly is constructed using concrete masonry units meeting the requirements of ASTM C90.
- The partition is located in a building assigned to Seismic Design Category A or B.
- Horizontal bed joint reinforcement is not required, but is recommended for crack control.
- The wind exposure category is Exposure B as determined in accordance with ASCE/SEI 7 Section 26.7.
- The wind topographic factor is 1.0 as determined in accordance with ASCE/SEI 7 Section 26.8.
- The partition is part of a building assigned to Risk Category I, II, or III as determined in accordance with ASCE/SEI 7 Section 1.5.
- The importance factor of the partition is 1.0 as determined in accordance with ASCE/SEI 7 Section 13.1.3.
- The maximum out-of-plane live load is 5 lb/ft^2.

7.1 UNREINFORCED CONCRETE MASONRY PARTITIONS

- For horizontally spanning unreinforced masonry partitions, no openings are permitted within the design span of the partition and the masonry is required to be laid in running bond construction.
- For vertically spanning unreinforced masonry partitions, the connections at the top and bottom of the assembly are to be sized and spaced to transfer a minimum out-of-plane factored strength level load of 100 lb/ft. Top-of-wall anchorage connections are to be provided within 8 inches of the end of the partition, within 8 inches of the end of all openings, and at a maximum spacing of 10 ft on center.

Table 8 – Maximum Vertical or Horizontal Span of Nonloadbearing, Unreinforced 6 in. Nominal CMU Partitions Assigned to SDC A or B

Mortar Type	Design Wind Speed (mph)				
	100	120	140	160	180
Vertically Spanning Masonry					
Type N Masonry Cement Mortar	8.00	8.00	7.33	6.67	6.00
Type S Masonry Cement Mortar	10.67	10.00	9.33	8.67	8.00
Type N Portland or Mortar Cement Mortar	12.00	11.33	10.67	9.33	8.67
Type S Portland or Mortar Cement Mortar	13.33	12.67	12.00	11.33	10.00
Horizontally Spanning Masonry					
Type N Masonry Cement Mortar	12.00	11.33	10.67	9.33	8.67
Type S Masonry Cement Mortar	14.67	14.00	13.33	12.00	11.33
Type N Portland or Mortar Cement Mortar	16.67	16.00	14.67	14.00	12.67
Type S Portland or Mortar Cement Mortar	19.33	18.00	16.67	16.00	14.67

Table 9 – Maximum Vertical or Horizontal Span of Nonloadbearing, Unreinforced 8 in. Nominal CMU Partitions Assigned to SDC A or B

Mortar Type	Design Wind Speed (mph)				
	100	120	140	160	180
Vertically Spanning Masonry					
Type N Masonry Cement Mortar	11.33	10.67	10.00	9.33	8.67

Type S Masonry Cement Mortar	14.67	14.00	12.67	12.00	11.33
Type N Portland or Mortar Cement Mortar	16.67	15.33	14.67	13.33	12.67
Type S Portland or Mortar Cement Mortar	18.67	18.00	16.67	15.33	14.00
Horizontally Spanning Masonry					
Type N Masonry Cement Mortar	16.67	15.33	14.67	13.33	12.67
Type S Masonry Cement Mortar	20.67	19.33	18.00	16.67	15.33
Type N Portland or Mortar Cement Mortar	23.33	22.00	20.67	18.67	17.33
Type S Portland or Mortar Cement Mortar	26.67	25.33	23.33	22.00	20.00

7.2 REINFORCED CONCRETE MASONRY PARTITIONS

For larger design loading scenarios, or when partitions are constructed in moderate to high seismic risk regions, reinforced concrete masonry partitions are often a more economical solution compared to unreinforced partitions. To maximize the design economy of a reinforced CMU partition, the horizontal joint reinforcement used for crack control or prescriptive seismic reinforcement should be used in conjunction with vertical reinforcing bars to resist out-of-plane design loads. Effectively, a partition with both horizontal and vertical reinforcement can carry and distribute the out-of-plane loads due to live loads, wind loads, or seismic loads much more efficiently compared to design models that assume the masonry spans in only a single direction.

To illustrate the design of bi-axial load distribution, consider a concrete masonry partition wall subject to the following design parameters:

Material Properties	
Specified Compressive Strength of Masonry, f'_m	1,750 lb/in.^{2}
Specified Yield Strength of Reinforcing Bars, f_y	60,000 lb/in.^{2}
Specified Yield Strength of Reinforcing Wire, f_y	70,000 lb/in.^{2}
Mortar: Type N Portland Cement-Lime Modulus of Rupture, f_r (Ungrouted hollow units, normal to bed joints)	64 lb/in.^{2}
Assembly Properties	
Diameter of Reinforcing Bars (No. 4), d_b	0.5 in.
Diameter of Reinforcing Wire (9 Guage), d_{jr}	0.148 in.
Nominal Wall Thickness, t	6 in.
Specified Wall Thickness, t_{sp}	5.625 in.
Ungrouted Assembly Weight, lb/ft^2	24 lb/ft^2
Vertical Design Span, S	10 ft
Construction	Running Bond
Design Loads	
Out-of-Plane Live Load, L	5.0 lb/ft^2
Out-of-Plane Internal Wind Pressure, W	4.7 lb/ft^2
Out-of-Plane Inertial Seismic Load, E	1.8 lb/ft^2
Seismic Design Category	C

The following example applies the TMS 402 strength design provisions in designing this partition.

The factored out-of-plane load combination is determined from Chapter 2 of ASCE/SEI 7. For partitions subjected to out-of-plane loading with negligible axial load, the two load combinations that typically control are:

$$(1.6)(L) \quad \text{or} \quad (1.0)(L) + (1.0)(W \text{ or } E)$$

7.2 REINFORCED CONCRETE MASONRY PARTITIONS

The live load for partitions is given in Section 4.3.4 of ASCE/SEI 7 as a minimum of 5 lb/ft^2. The internal wind pressure on the partitions is based on the external Main Wind Force Resisting System (MWFRS) wind pressure adjusted based on the enclosure classification of the building. The external pressure (q_z) for this example is determined in accordance with Equation 26.10-1 of ASCE/SEI 7 as follows:

$$q_z = 0.00256(K_z)(K_{zt})(K_e)(V^2)$$

Applying the following design parameters:

- Basic Wind Speed: V = 120 mph
- Wind Exposure Category = B
- Ground Elevation = 0 ft
- Ground Elevation Factor: K_e = 1.0
- Mean Roof Height: z = 30 ft
- Pressure Exposure Coefficient: K_z = 0.70
- Topographic Factor: K_{zt} = 1.2

The resulting external pressure is then:

$$q_{30} = 0.00256(0.70)(1.2)(1.0)(120)^2 = 31.0\ {}^{\text{lb}}/_{\text{ft}^2}$$

Considering this structure as an enclosed building, the internal pressure coefficient (GC_{pi}) per Section 26.13 of ASCE/SEI 7 is 0.18. Applying a directionally factor (K_d) of 0.85, the resulting internal partition wind pressure is:

$$p = (q_{30})(K_d)(GC_{pi}) = \left(31.0\ {}^{\text{lb}}/_{\text{ft}^2}\right)(0.85)(0.18) = 4.7\ {}^{\text{lb}}/_{\text{ft}^2}$$

Because this partition is part of a building assigned to Seismic Design Category C, the out-of-plane inertial seismic forces must also be considered. Per ASCE/SEI 7 Chapter 13, the out-of-plane seismic load (F_p) is a function of the following parameters:

$$F_p = 0.4 S_{DS} I_P W_P \left(\frac{H_f}{R_\mu}\right)\left(\frac{C_{AR}}{R_{po}}\right)$$

Applying the following design parameters from ASCE/SEI 7:

- Mapped Short Period Spectral Response Parameter: S_{MS} = 0.40
- Design Short Period Spectral Response Parameter: S_{DS} = (2/3)S_{MS} = 0.27
- Importance Factor: I_p = 1.0
- Wall Weight (assuming a lightly reinforced, medium weight CMU): W_p = 33 lb/ft^2
- Location of Partition Above Grade: $_z$ = 0 ft

- Seismic Force Amplification Factor: H_f = 1.0
- Ductility Reduction Factor: R_μ = 1.3
- Resonance Ductility Factor: C_{AR} = 1.0
- Partition Wall Strength Factor: R_{po} = 1.5

The resulting out-of-plane seismic loading is then:

$$F_p = 0.4(0.27)(1.0)\left(33\ \mathrm{lb}/_{\mathrm{ft}^2}\right)\left(\frac{1.0}{1.3}\right)\left(\frac{1.0}{1.5}\right) = 1.8\ \mathrm{lb}/_{\mathrm{ft}^2}$$

In this example, the out-of-plane wind load controls over the out-of-plane seismic load, hence:

$$1.0L + 1.0W = (1.0)\left(5\ \mathrm{lb}/_{\mathrm{ft}^2}\right) + (1.0)\left(4.7\ \mathrm{lb}/_{\mathrm{ft}^2}\right) = 9.7\ \mathrm{lb}/_{\mathrm{ft}^2}$$

Considering the wall as a simple span assembly in the vertical direction, the resulting factored, out-of-plane moment is then:

$$M_u = \frac{\left(9.7\ \mathrm{lb}/_{\mathrm{ft}^2}\right)(10\ \mathrm{ft})^2}{8}\left(12\ \frac{\mathrm{in.}}{\mathrm{ft}}\right) = 1{,}455\ \frac{\mathrm{in.\text{-}lb}}{\mathrm{ft}}$$

Assume No. 4 vertical reinforcement placed within the center of the assembly (e.g., the effective depth, d = 2.81 in. for a nominal 6-inch CMU). For SDC C structures, TMS 402 prescriptively limits the maximum spacing of reinforcement in nonparticipating members (e.g., nonloadbearing partitions) to 120 inches on center. For an initial check, apply this maximum spacing of the vertical reinforcement. The normalized area of vertical reinforcement provided is then calculated as:

$$A_s = \frac{0.2\ \mathrm{in.}^2}{10\ \mathrm{ft}} = 0.02\ \frac{\mathrm{in.}^2}{\mathrm{ft}}$$

Per Section 5.1.2 of TMS 402, the effective compression width is limited to the lesser of the center-to-center spacing of the reinforcement, six times the nominal wall thickness (here, 36 in. for a 6 in. nominal unit thickness), or 72 in. Because the spacing of the vertical reinforcement in this case exceeds these limits, the conventional approach of modeling the assembly on a unit strip (per foot) basis cannot be used. Instead, an equivalent section width, b, is determined by dividing the controlling effective compression width (36 in.) by the spacing of the reinforcement (10 ft) as follows:

$$b = \frac{36\text{ in.}}{10\text{ ft}} = 3.6\ \frac{\text{in.}}{\text{ft}}$$

Considering the self-weight of the wall taken equal to 24 lb/ft^2, which conservatively corresponds to an ungrouted, lightweight assembly, the mid-height axial with a 0.9 dead load load factor is:

$$P_u = (0.9)\left(\frac{10\text{ ft}}{2}\right)\left(24\ {}^{\text{lb}}/_{\text{ft}^2}\right) = 108\ {}^{\text{lb}}/_{\text{ft}}$$

TMS 402 includes a variable strength reduction factor (φ), depending on whether the section under consideration is tension-controlled, compression-controlled, or transitioning between these two boundaries. To be considered tension-controlled, the ratio of the depth of to the neutral axis (c) to the effective depth to the reinforcement (d) must be less than or equal to 0.333. The neutral axis depth is calculated per TMS 402 Equation 9-29 as:

$$c = \frac{A_s f_y + P_u}{0.64 f'_m b} = \frac{\left(0.02\ \frac{\text{in.}^2}{\text{ft}}\right)\left(60{,}000\ {}^{\text{lb}}/_{\text{in.}^2}\right) + 108\ {}^{\text{lb}}/_{\text{ft}}}{0.64\left(1{,}750\ {}^{\text{lb}}/_{\text{in.}^2}\right)\left(3.6\ \frac{\text{in.}}{\text{ft}}\right)} = 0.32\text{ in.}$$

The neutral axis depth divided by the effective depth of this assembly is:

$$\frac{c}{d} = \frac{0.32\text{ in.}}{2.81\text{ in.}} = 0.11$$

Which is less than 0.333 and therefore this wall assembly is tension-controlled and the strength reduction factor of 0.9 applies.

Although not significant, the presence of the axial compression due to the self-weight of the assembly will slightly increase the out-of-plane flexural strength. Increasing the factored axial load by tension-controlled strength reduction factor (0.9), the depth of the compression block is then calculated per TMS 402 Section 9.3.4 as:

$$a = \frac{(A_s)(f_y) + {}^{P_u}/_{\phi}}{(0.80)(f'_m)(b)} = \frac{\left(0.02\ \frac{\text{in.}^2}{\text{ft}}\right)\left(60{,}000\ {}^{\text{lb}}/_{\text{in.}^2}\right) + {}^{108\ {}^{\text{lb}}/_{\text{ft}}}/_{0.9}}{(0.80)\left(1{,}750\ {}^{\text{lb}}/_{\text{in.}^2}\right)\left(3.6\ {}^{\text{in.}}/_{\text{ft}}\right)} = 0.26\text{ in.}$$

Which is well within the face shell of the CMU. Therefore, the resulting nominal flexural strength of this assembly is determined as:

$$M_n = \left\{(A_s)(f_y) + {}^{P_u}/_{\phi}\right\}\left\{d - {}^{a}/_{2}\right\} =$$

$$\left\{\left(0.02\ \frac{\text{in.}^2}{\text{ft}}\right)\left(60{,}000\ {}^{\text{lb}}/_{\text{in.}^2}\right) + {}^{108\ {}^{\text{lb}}/_{\text{ft}}}/_{0.9}\right\}\left\{2.81\ \text{in.} - {}^{0.26\ \text{in.}}/_{2}\right\} = 3{,}537\ \frac{\text{in.-lb}}{\text{ft}}$$

Applying the tension-controlled strength reduction factor of 0.9, the resulting design moment strength is 3,183 in.-lb/ft, which more than satisfies the factored out-of-plane bending moment of 1,455 in.-lb/ft. Again, however, per Section 5.1.2 of TMS 402 the effective compression width is limited to the lesser of the center-to-center spacing of the reinforcement, six times the nominal wall thickness (here, 36 in.), and a maximum of 72 in., which is exceeded in this example. To address this requirement and provide a load path for out-of-plane loads applied to the field of the assembly far from the vertical reinforcement, consider the wall bending in both the vertical and horizontal directions (bi-axial bending). Because most concrete masonry walls will have horizontal reinforcement present in the form of joint reinforcement for crack control, check whether 9 gauge joint reinforcement spaced at 16 in. on center can span horizontally between the vertically reinforced section (e.g., a design span of 10 ft corresponding to the spacing of the vertical reinforcement previously assumed).

Although the horizontal spans could be considered continuous instead of simply supported, there will likely be openings and similar discontinuities in the partition assembly. As such, conservatively use the same factored out-of-plane bending moment for simply-supported conditions as before:

$$M_u = 1{,}455\ \frac{\text{in.-lb}}{\text{ft}}$$

Each course of the assembly where the joint reinforcement is located will contain two wires, however, only one wire will be in the tension zone. Therefore, the normalized area of reinforcement provided by the joint reinforcement spaced at 16 inches is calculated as:

$$A_s = \frac{0.017\ \text{in.}^2}{{}^{16\ \text{in.}}/_{12\ {}^{\text{in.}}/_{\text{ft}}}} = 0.0128\ \frac{\text{in.}^2}{\text{ft}}$$

For horizontally spanning assemblies, the self-weight is not contributing to the out-of-plane flexural resistance. Therefore, here consider P_u = 0. Further, because the spacing of the joint reinforcement is less than six times the nominal wall thickness, the horizonal out-of-plane bending can be analyzed using a conventional unit strip basis. The resulting compression block depth is then:

$$a = \frac{(A_s)(f_y)}{(0.80)(f'_m)(b)} = \frac{\left(0.0128\ \frac{\text{in.}^2}{\text{ft}}\right)\left(70{,}000\ ^{\text{lb}}/_{\text{in.}^2}\right)}{(0.80)\left(1{,}750\ ^{\text{lb}}/_{\text{in.}^2}\right)\left(12\ ^{\text{in.}}/_{\text{ft}}\right)} = 0.053\ \text{in.}$$

Given that the typical cover distance provided between the surface of the masonry and the surface of the joint reinforcement is $^5/_8$ inch, the resulting effective depth of the joint reinforcement is 4.93 inches (5.625 in. – 0.625 in. – 0.074 in. = 4.93 in.) and the resulting design moment strength is:

$$\phi M_n = \phi\{(A_s)(f_y)\}\{d - {^a}/_2\} =$$

$$(0.9)\left\{\left(0.0128\ \frac{\text{in.}^2}{\text{ft}}\right)\left(70{,}000\ ^{\text{lb}}/_{\text{in.}^2}\right)\right\}\left\{4.93\ \text{in.} - {^{0.053\ \text{in.}}}/_2\right\} = 3{,}954\,\frac{\text{in.-lb}}{\text{ft}}$$

Which again is considerably more than the factored out-of-plane moment of 1,455 in.-lb/ft. By considering the assembly as spanning horizontally using the joint reinforcement to the vertically reinforced sections, which in turn are supported at the base and top-of-wall, a very efficient design can be achieved while still complying with the requirements of TMS 402. Additionally, this reinforcement schedule would also meet the prescriptive seismic detailing requirements for nonparticipating elements assigned to SDC A, B, or C.

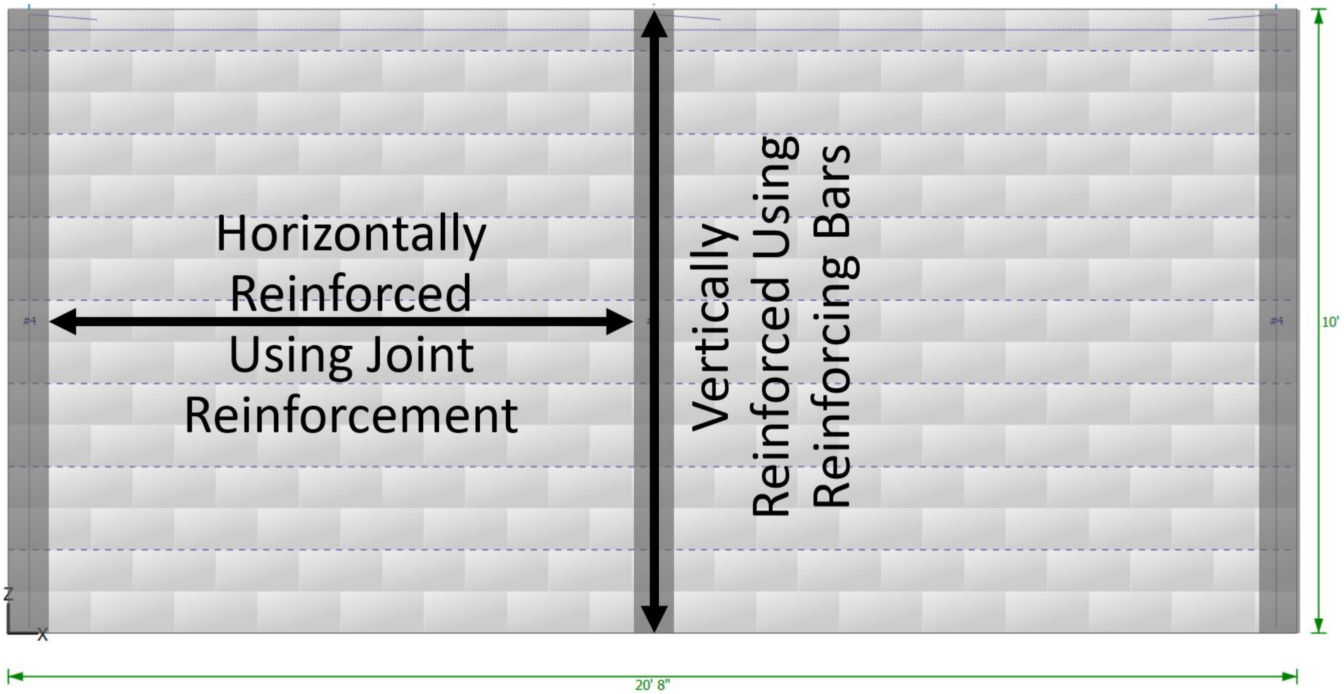


Figure 5 – Bi-Directional Resistance Design Model

Although it rarely controls for interior partitions, the out-of-plane shear is checked per TMS 402 Section 9.3.3.1.2. Given that no shear reinforcement is provided in the out-of-plane direction, the resulting shear strength provided by the masonry is determined by:

$$\phi V_{nm} = \phi \left\{ 4.0 - 1.75 \left(\frac{M_u}{V_u d_v} \right) \right\} A_{nv} \sqrt{f'_m} + 0.25 P_u$$

The critical shear plane will be at the top of the wall where the self-weight of the assembly is effectively zero (P_u = 0) and not contributing to the out-of-plane shear strength. Conservatively considering the ratio $M_u/V_u d_v$ is equal to 1.0 and incorporating a strength reduction factor of 0.80 for shear, the above equation reduces to:

$$\phi V_{nm} = (0.80)(2.25) A_{nv} \sqrt{f'_m} = (1.8) A_{nv} \sqrt{f'_m}$$

The net shear area determined in accordance with TMS 402 Section 4.4.5. For partially grouted construction, the area effective in resisting out-of-plane shear is the length of a grouted cell including the mortared webs on each side multiplied by the effective depth of the reinforcement. The full thickness of the wall assembly is not used as a portion of the wall is assumed to be in tension and therefore have reduced or negligible shear strength. For a CMU with a nominal length of 16 in., the length of the grouted cell plus cross-mortared webs on each side is approximately 8.3 in. Therefore, the net shear area, A_{nv}, is calculated as:

$$A_{nv} = (8.3\text{ in.})(2.81\text{ in.}) = 23.3\text{ in.}^2$$

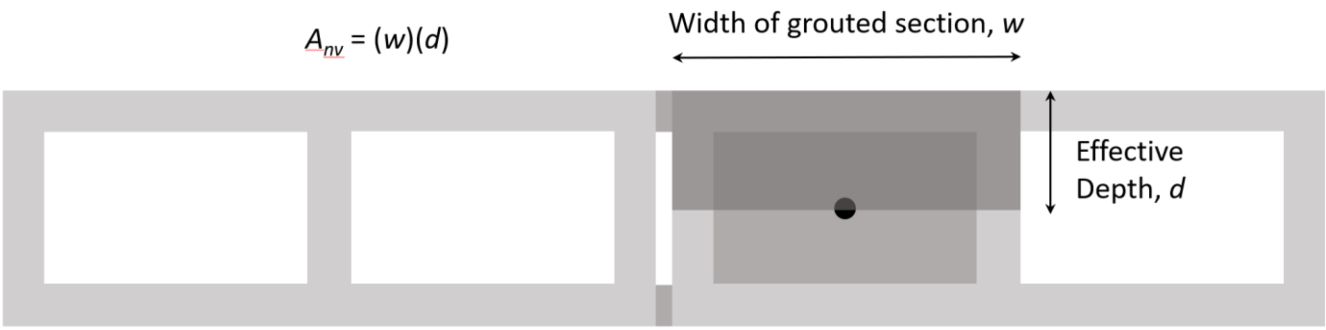


Figure 6 – Net Shear Area for Partially Grouted Masonry Loaded Out-of-Plane

The design shear strength for each vertically reinforced section is then calculated as:

$$\phi V_{nm} = (1.8)\left(23.3\text{ in.}^2\right)\sqrt{1{,}750\ {}^{\text{lb}}/_{\text{in.}^2}} = 1{,}754\text{ lb}$$

The factored out-of-plane shear load at each vertically reinforced section is the out-of-plane pressure multiplied by the spacing of the vertical reinforcement considered as a uniform line load over the vertically reinforced section as follows:

$$V_u = \frac{\left(9.7\ {}^{\text{lb}}/_{\text{ft}^2}\right)(10\text{ ft})(10\text{ ft})}{2} = 485\text{ lb}$$

Which is less than the design shear strength, thus satisfying this design check. In accordance with Section 9.3.4.5 of TMS 402, the out-of-plane deflection, δ_s, due to allowable stress level loads is limited to 0.7% of the design span (S), which results in a maximum permitted mid-height deflection of:

$$\delta_s \leq 0.007(S) = (0.007)(10\text{ ft})\left(120\ {}^{\text{in.}}/_{\text{ft}}\right) = 0.84\text{ in.}$$

Because the loads for deflection checks are allowable stress level loads, the critical load combination from ASCE/SEI 7 is often controlled by one of the following:

$$(1.0)(L) \quad \text{or} \quad (0.75)(L) + (0.75)(0.6)(W) \quad \text{or} \quad (0.75)(L) + (0.525)(E)$$

Again, because the out-of-plane seismic loads are less than the internal wind pressure, the controlling out-of-plane allowable stress level load is:

$$(0.75)\left(5 \ {}^{\text{lb}}/_{\text{ft}^2}\right) + (0.75)(0.6)\left(4.7 \ {}^{\text{lb}}/_{\text{ft}^2}\right) = 5.9 \ {}^{\text{lb}}/_{\text{ft}^2}$$

Because the wall is considered to distribute loads in both the horizontal and vertical direction, the deflection is checked in each of these directions similar to the strength analyses. Further, because the design span in both the horizontal and vertical direction for this assembly is 10 ft, the resulting normalized bending moment is the same in each direction. Considering the wall as a simple span assembly, the resulting allowable stress level, out-of-plane moment in both the vertical and horizontal direction is then:

$$M_s = \frac{\left(5.9 \ {}^{\text{lb}}/_{\text{ft}^2}\right)(10 \text{ ft})^2}{8}\left(12 \ \frac{\text{in.}}{\text{ft}}\right) = 885 \ \frac{\text{in.-lb}}{\text{ft}}$$

Vertical Deflection Analysis

The calculated out-of-plane deflection considering the partition spanning in the vertical direction will depend on whether the assembly has exceeded the modulus of rupture (cracked), thus requiring a cracked section analysis. For a 6-inch CMU assembly containing grout at 120 in. on center, the average section modulus is 50.1 in.^{3}/ft. Per Table 9.1.9.1 of TMS 402, the modulus of rupture for a Type N portland cement-lime mortar normal to the bed joints is 64 lb/in.^{2} for an ungrouted assembly and 158 lb/in.^{2} for a fully grouted assembly. Linearly interpolating based on the percentage of grout provided in this assembly results in a modulus of rupture of 70 lb/in.^{2} and a resulting cracking moment strength of:

$$M_{cr} = \left(70 \ {}^{\text{lb}}/_{\text{in.}^2}\right)\left(50.1 \ {}^{\text{in.}^3}/_{\text{ft}}\right) = 3{,}507 \ \frac{\text{in.-lb}}{\text{ft}}$$

Which exceeds the allowable stress level out-of-plane moment. Therefore, the assembly is uncracked and the deflection is calculated based on net section properties. The net moment of inertia, I_n, for a 6-inch CMU assembly grouted at 120 in. is 133.6 in.^{4}/ft. The modulus of elasticity, E_m, per Section 4.2.2 of TMS 402 is 1,575,000 lb/in.^{2}. The resulting out-of-plane deflection due to allowable stress level loads calculated in accordance with Section 9.3.4.4.2 of TMS 402 is:

$$\delta_s = \frac{(5)(M_s)(h^2)}{(48)(E_m)(I_n)} = \frac{(5)\left(885\ \frac{\text{in.-lb}}{\text{ft}}\right)(120\text{ in.})^2}{(48)\left(1{,}575{,}000\ {}^{\text{lb}}/_{\text{in.}^2}\right)\left(133.6\ {}^{\text{in.}^4}/_{\text{ft}}\right)} = 0.006\text{ in.}$$

Which is considerably less than the permitted out-of-plane deflection of 0.84 in.

Horizontal Deflection Analysis
The out-of-plane deflection analysis considering the partition spanning in the horizontal direction is performed the same way as in the vertical direction, except the section properties of the assembly change. For a 6-inch CMU assembly spanning horizontally, containing grout at 120 in. on center, the net section modulus is 49.5 in.^{3}/ft. Per Table 9.1.9.1 of TMS 402, the modulus of rupture for a Type N portland cement-lime mortar parallel to the bed joints is 127 lb/in.^{2} for an ungrouted assembly. This results in a cracking moment strength of:

$$M_{cr} = \left(127\ {}^{\text{lb}}/_{\text{in.}^2}\right)\left(49.5\ {}^{\text{in.}^3}/_{\text{ft}}\right) = 6{,}286\ \frac{\text{in.-lb}}{\text{ft}}$$

Which exceeds the allowable stress level out-of-plane moment, and by inspection with the vertical deflection analysis, satisfies the out-of-plane deflection check in the horizontal direction.

Given that there is no applied axial load to this partition and the wall height is relatively short, second-order effects are unlikely to control, but are checked here for completeness. For simplicity, the moment magnifier of Section 9.3.4.4.3 of TMS 402 is applied. The axial buckling strength of this assembly is calculated as follows taking the effective moment of inertia, I_{eff}, equal to 75% of the net moment of inertia, In, as stipulated by TMS 402 because the assembly is uncracked.

$$P_e = \frac{(\pi^2)(E_m)(I_{\text{eff}})}{h^2} = \frac{(3.14^2)\left(1{,}575{,}000\ {}^{\text{lb}}/_{\text{in.}^2}\right)(0.75)\left(133.6\ {}^{\text{in.}^4}/_{\text{ft}}\right)}{(120\text{ in.})^2} = 108{,}050\ {}^{\text{lb}}/_{\text{ft}}$$

The resulting magnified moment is then calculated as:

$$M_{u-m} = \left(\frac{1}{1-\frac{P_u}{P_e}}\right)(M_u) = \left(\frac{1}{1-\frac{108\ {}^{\text{lb}}/_{\text{ft}}}{108{,}050\ {}^{\text{lb}}/_{\text{ft}}}}\right)\left(1{,}455\ \frac{\text{in.-lb}}{\text{ft}}\right) = 1{,}455\ \frac{\text{in.-lb}}{\text{ft}}$$

For the design of the top and bottom partition connection, the resulting factored out-of-plane uniform loading along the top and bottom of the 10 ft tall partition is then:

$$P_{conn} = \frac{\left(9.7\ {}^{\text{lb}}\!/_{\text{ft}^2}\right)(10\ \text{ft})}{2} = 48.5\ {}^{\text{lb}}\!/_{\text{ft}}$$

The resulting anchorage would need to be sized and spaced to accommodate this out-of-plane support load.

For ease, Tables 10 through 15 offer pre-engineered design solutions for reinforced partitions constructed using nominal 6-inch and 8-inch CMU for both wind and seismic loading conditions. The following design constraints apply when using Tables 10 through 15. For more customized partition design, the Block Design Collective has a free online calculator for designing concrete masonry partitions here: https://beautyofblock.com/2026/02/03/partition-wall-calculator/

- The building is classified as enclosed or partially open in accordance with ASCE/SEI 7 Table 26.13-1.
- The minimum specified compressive strength of the masonry is 2,000 lb/in.^{2}.
- The assembly is constructed using concrete masonry units meeting the requirements of ASTM C90 and laid in Type S or Type N non-air entrained portland cement/lime mortar.
- Vertical reinforcement is as indicated in Table 10 through 15 with a minimum specified yield strength of 60,000 psi and specified to be located in the center of the assembly.
- Horizontal reinforcement consists of two wire W1.7 (9 gauge) ladder-type joint reinforcement spaced at not more than 16 in. (406 mm) on center.
- The wind exposure category is Exposure B as determined in accordance with ASCE/SEI 7 Section 26.7.
- The wind topographic factor is 1.0 as determined in accordance with ASCE/SEI 7 Section 26.8.
- The partition is part of a building assigned to Risk Category I, II, or III as determined in accordance with ASCE/SEI 7 Section 1.5.
- The importance factor of the partition is 1.0 as determined in accordance with ASCE/SEI 7 Section 13.1.3.
- The partition is supported at the top and bottom for out-of-plane loads and the spacing of the supporting connections is not to exceed the maximum permitted spacing of the vertical reinforcement indicated in the applicable Table 10 through 15.
- The maximum out-of-plane live load shall be 5 lb/ft^2.
- Linear interpolation between tabulated values is not permitted.

In addition to the reinforcement schedules shown here, place one vertical reinforcing bar in the first whole cell on each side of an opening in the partition. Unless verified by analysis, the length of openings in nonloadbearing partitions is limited to the spacing of the vertical reinforcement. Also, place one vertical reinforcing bar at each corner, within 8 inches of each side of control joints, and within 8 inches of the end of the partition as illustrated in Figure 7.

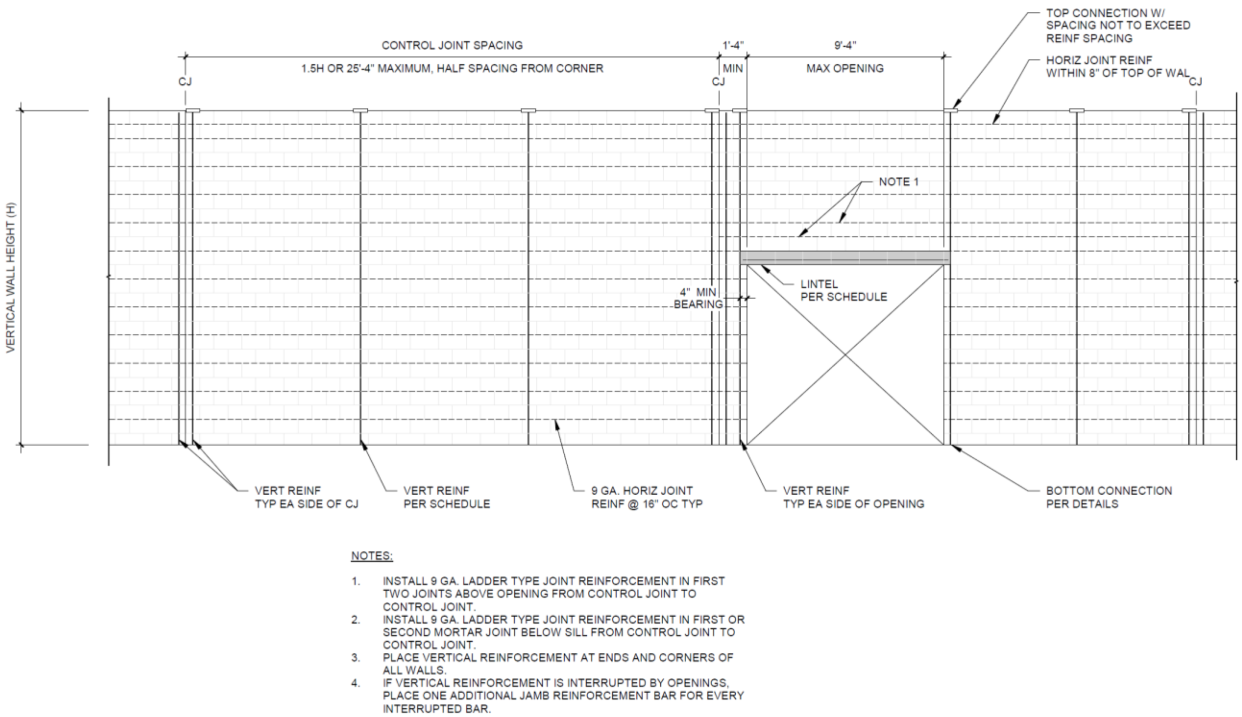


Figure 7 – Placement of Partition Wall Reinforcement

Table 10 – 6 in. Nominal CMU Partitions for Buildings Assigned to Seismic Design Category A or B[1]

Specified Wall Height, ft	Maximum Spacing (ft) of No. 4 Vertical Reinforcing Bars for Basic Wind Speed, mph Less Than or Equal to:				
	100	120	140	160	180
12.00 and less	10.00	10.00	10.00	10.00	10.00
12.67	10.00	10.00	10.00	10.00	9.33
13.33	10.00	10.00	10.00	10.00	8.00
14.00	10.00	10.00	10.00	8.67	6.00
14.67	10.00	10.00	9.33	6.00	5.33
15.33	10.00	10.00	8.67	5.33	4.67
16.00	10.00	9.33	5.33	5.33	4.67
16.67	9.33	8.67	5.33	4.67	4.00
17.33	8.67	5.33	4.67	4.00	3.33
18.00	8.00	4.67	4.00	4.00	3.33

18.67	4.67	4.00	4.00	3.33	3.33
19.33	4.00	4.00	3.33	3.33	2.67
20.00	4.00	3.33	3.33	2.67	2.67
20.67	3.33	3.33	3.33	2.67	2.67
21.33	3.33	2.67	2.67	2.67	2.00
22.00	2.67	2.67	2.67	2.67	2.00
22.67	2.67	2.67	2.67	2.00	2.00
23.33	2.67	2.00	2.00	2.00	2.00
24.00	2.00	2.00	2.00	2.00	2.00

[1] Linear interpolation not permitted.

Table 11 – 6 in. Nominal CMU Partitions for Buildings Assigned to Seismic Design Category C[1]				
Specified Wall Height, ft	**Maximum Spacing (ft) of No. 4 Vertical Reinforcing Bars for Basic Wind Speeds of 180 mph or less for S_{MS} Values Less Than or Equal to:**			
	0.33	**0.40**	**0.45**	**0.50**
9.33 and less	10.00	10.00	10.00	10.00
10.00	10.00	10.00	9.33	8.67
10.67	10.00	9.33	8.67	6.67
11.33	9.33	8.00	6.67	6.00
12.00	8.67	6.00	6.00	5.33
12.67	6.00	5.33	5.33	4.67
13.33	5.33	4.67	4.67	4.00
14.00	4.67	4.67	4.00	4.00
14.67	4.67	4.00	3.33	3.33
15.33	4.00	3.33	3.33	3.33
16.00	4.00	3.33	2.67	2.67
16.67	3.33	2.67	2.67	2.67
17.33	3.33	2.67	2.67	2.67
18.00	2.67	2.67	2.67	2.00
18.67	2.67	2.67	2.00	2.00
19.33	2.67	2.00	2.00	2.00
20.00	2.00	2.00	2.00	1.33
20.67	2.00	2.00	2.00	1.33
21.33	2.00	2.00	1.33	1.33
22.00	2.00	1.33	1.33	1.33

[1] Linear interpolation not permitted.

Table 12 – 6 in. Nominal CMU Partitions for Buildings Assigned to Seismic Design Category D[1]						
Specified Wall Height, ft	**Maximum Spacing (ft) of No. 4 Vertical Reinforcing Bars for Basic Wind Speeds of 180 mph or less for S_{MS} Values Less Than or Equal to:**					
	0.50	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
10.67 or less	4.00	4.00	4.00	4.00	4.00	4.00
11.33	4.00	4.00	4.00	4.00	3.33	3.33
12.00	4.00	4.00	4.00	3.33	3.33	3.33
12.67	4.00	4.00	3.33	3.33	2.67	2.67
13.33	4.00	3.33	3.33	2.67	2.67	2.67
14.00	4.00	3.33	2.67	2.67	2.00	2.00
14.67	3.33	3.33	2.67	2.00	2.00	2.00
15.33	3.33	2.67	2.67	2.00	2.00	2.00
16.00	2.67	2.67	2.00	2.00	2.00	1.33
16.67	2.67	2.00	2.00	2.00	1.33	1.33
17.33	2.67	2.00	2.00	1.33	1.33	1.33
18.00	2.00	2.00	1.33	1.33	1.33	DR[2]
18.67	2.00	2.00	1.33	1.33	DR[2]	DR[2]
19.33	2.00	1.33	1.33	DR[2]	DR[2]	DR[2]
20.00	1.33	1.33	DR[2]	DR[2]	DR[2]	DR[2]

[1] Linear interpolation not permitted.

[1] DR – Design required in accordance with TMS 402 [Ref. 1].

Table 13 – 8 in. Nominal Concrete Masonry Partitions for Buildings Assigned to Seismic Design Category A or B[1]					
Specified Wall Height, ft	**Maximum Spacing (ft) of No. 5 Vertical Reinforcing Bars for Basic Wind Speed, mph Less Than or Equal to:**				
	100	**120**	**140**	**160**	**180**
18.00 and less	10.00	10.00	10.00	10.00	10.00
18.67	10.00	10.00	10.00	10.00	7.33
19.33	10.00	10.00	10.00	10.00	6.67
20.00	10.00	10.00	10.00	6.67	6.00
20.67	10.00	10.00	10.00	6.00	5.33
21.33	10.00	10.00	6.00	6.00	5.33
22.00	10.00	10.00	6.00	5.33	4.67
22.67	10.00	6.00	5.33	5.33	4.67
23.33	10.00	5.33	4.67	4.67	4.00
24.00	5.33	4.67	4.67	4.00	4.00
24.67	4.67	4.67	4.67	4.00	3.33
25.33	4.00	4.00	4.00	4.00	3.33

26.00	4.00	4.00	4.00	3.33	3.33
26.67	3.33	3.33	3.33	3.33	3.33
27.33	3.33	3.33	3.33	2.67	2.67
28.00	3.33	3.33	2.67	2.67	2.67
28.67	2.67	2.67	2.67	2.67	2.67
29.33	2.67	2.67	2.67	2.67	2.67
30.00	2.67	2.67	2.67	2.67	2.67
30.67	2.00	2.00	2.00	2.00	2.00
31.33	2.00	2.00	2.00	2.00	2.00
32.00	2.00	2.00	2.00	2.00	2.00
32.67	2.00	2.00	2.00	2.00	2.00
33.33	2.00	2.00	2.00	2.00	2.00
34.00	1.33	1.33	1.33	1.33	1.33

[1] Linear interpolation not permitted.

Table 14 – 8 in. Nominal Concrete Masonry Partitions for Buildings Assigned to Seismic Design Category C[1]

Specified Wall Height, ft	Maximum Spacing (ft) of No. 5 Vertical Reinforcing Bars for Basic Wind Speeds of 180 mph or less for S_{MS} Values Less Than or Equal to:			
	0.33	**0.40**	**0.45**	**0.50**
12.00 and less	10.00	10.00	10.00	10.00
12.67	10.00	10.00	10.00	8.67
13.33	10.00	10.00	8.67	8.00
14.00	10.00	8.00	7.33	6.67
14.67	10.00	7.33	6.67	6.00
15.33	8.00	6.67	6.00	6.00
16.00	7.33	6.00	5.33	5.33
16.67	6.67	5.33	5.33	4.67
17.33	6.00	5.33	4.67	4.00
18.00	5.33	4.67	4.00	4.00
18.67	4.67	4.67	4.00	4.00
19.33	4.67	4.00	4.00	3.33
20.00	4.00	4.00	3.33	3.33
20.67	4.00	3.33	3.33	2.67
21.33	4.00	3.33	2.67	2.67
22.00	3.33	2.67	2.67	2.67
22.67	3.33	2.67	2.67	2.67
23.33	3.33	2.67	2.67	2.00
24.00	2.67	2.67	2.00	2.00

24.67	2.67	2.00	2.00	2.00
25.33	2.67	2.00	2.00	2.00
26.00	2.00	2.00	2.00	2.00
26.67	2.00	2.00	2.00	1.33
27.33	2.00	2.00	1.33	1.33
28.00	2.00	1.33	1.33	1.33
28.67	2.00	1.33	1.33	DR[2]
29.33	1.33	1.33	1.33	DR[2]
30.00	1.33	1.33	DR[2]	DR[2]
30.67	1.33	DR[2]	DR[2]	DR[2]
31.33	1.33	DR[2]	DR[2]	DR[2]

[1] Linear interpolation not permitted.
[2] DR – Design required in accordance with TMS 402 [Ref. 1].

Table 15 – 8 in. Nominal Concrete Masonry Partitions for Buildings Assigned to Seismic Design Category D[1,]

Specified Wall Height, ft	Maximum Spacing (ft) of No. 5 Vertical Reinforcing Bars for Basic Wind Speeds of 180 mph or less for S_{MS} Values Less Than or Equal to:					
	0.50	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
14.00 and less	4.00	4.00	4.00	4.00	4.00	4.00
14.67	4.00	4.00	4.00	4.00	4.00	3.33
15.33	4.00	4.00	4.00	4.00	3.33	3.33
16.00	4.00	4.00	4.00	3.33	3.33	2.67
16.67	4.00	4.00	3.33	3.33	2.67	2.67
17.33	4.00	4.00	3.33	2.67	2.67	2.00
18.00	4.00	3.33	3.33	2.67	2.67	2.00
18.67	4.00	3.33	2.67	2.67	2.00	2.00
19.33	3.33	2.67	2.67	2.00	2.00	2.00
20.00	3.33	2.67	2.67	2.00	2.00	1.33
20.67	2.67	2.67	2.00	2.00	2.00	1.33
21.33	2.67	2.67	2.00	2.00	1.33	1.33
22.00	2.67	2.00	2.00	1.33	1.33	1.33
22.67	2.67	2.00	2.00	1.33	1.33	1.33
23.33	2.00	2.00	1.33	1.33	1.33	DR[2]
24.00	2.00	2.00	1.33	1.33	DR[2]	DR[2]
24.67	2.00	1.33	1.33	DR[2]	DR[2]	DR[2]
25.33	2.00	1.33	1.33	DR[2]	DR[2]	DR[2]
26.00	2.00	1.33	DR[2]	DR[2]	DR[2]	DR[2]
26.67	1.33	1.33	DR[2]	DR[2]	DR[2]	DR[2]

27.33	1.33	DR[2]	DR[2]	DR[2]	DR[2]	DR[2]
28.00	1.33	DR[2]	DR[2]	DR[2]	DR[2]	DR[2]

[1] Linear interpolation not permitted.
[2] DR – Design required in accordance with TMS 402 [Ref. 1].

8 DESIGN OF LINTELS OVER OPENINGS

Lintels over openings in masonry construction can be designed to carry the full superimposed gravity design loads from above the opening, or when sufficient masonry is present above the opening, can be designed assuming a arching mechanism is formed above the opening that sheds the majority of the gravity loads around the opening reducing the design loading on the lintel. In order for an arching mechanism to form, the following conditions must be met:

- The masonry assembly is laid in running bond construction.
- Control joints or other discontinuities are located no closer than 16 inches from the edge of the opening.
- The height of masonry above the opening is sufficient for the arching mechanism to form as illustrated in Figure 8.

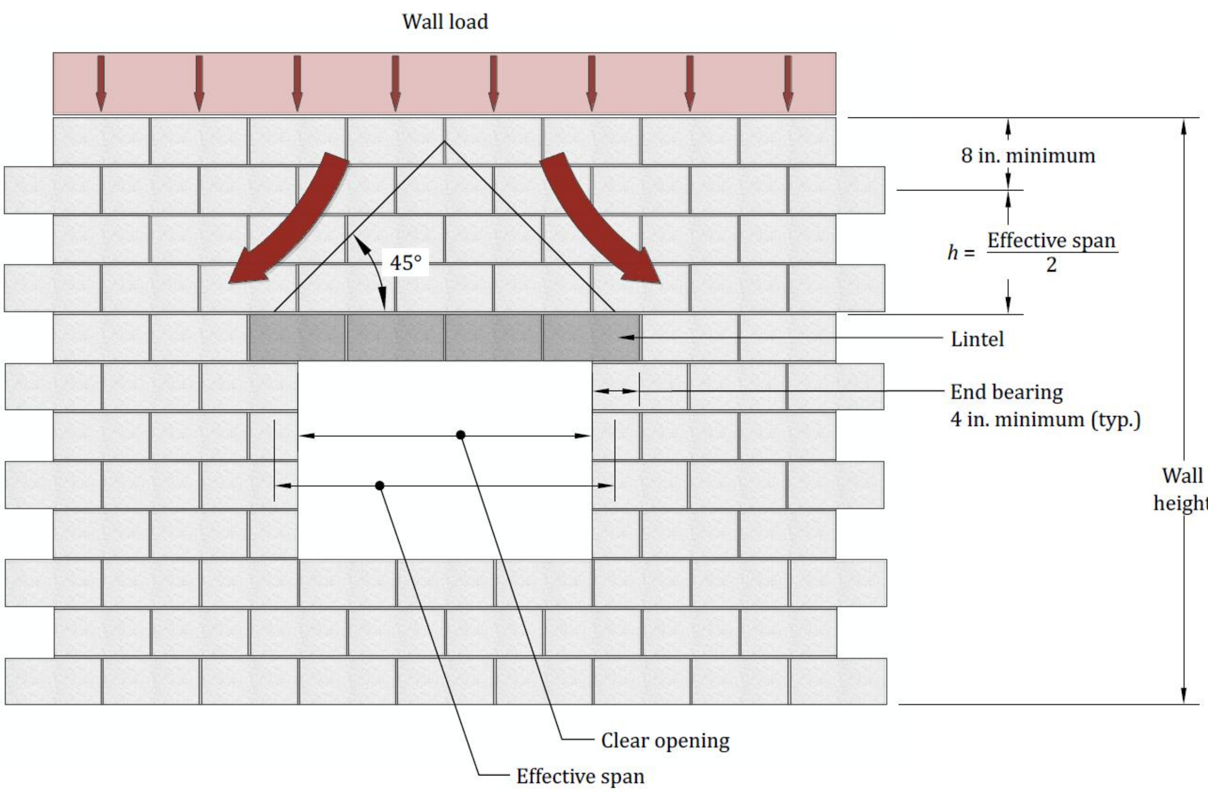


Figure 8 – Arching Action Over Openings in Masonry

For nonloadbearing partitions covered in this guide, there is no superimposed loads applied to the top of the wall. As such, lintels over openings are only required to carry the self-weight of the masonry above the opening. The maximum height of masonry above an opening that would need to be supported by the lintel would correspond to the smallest height necessary for arching to occur, after which an arching mechanism develops and the loading on the lintel reduces. The maximum wall self-weight a lintel would need to be designed to carry is illustrated by the shaded area in Figure 9.

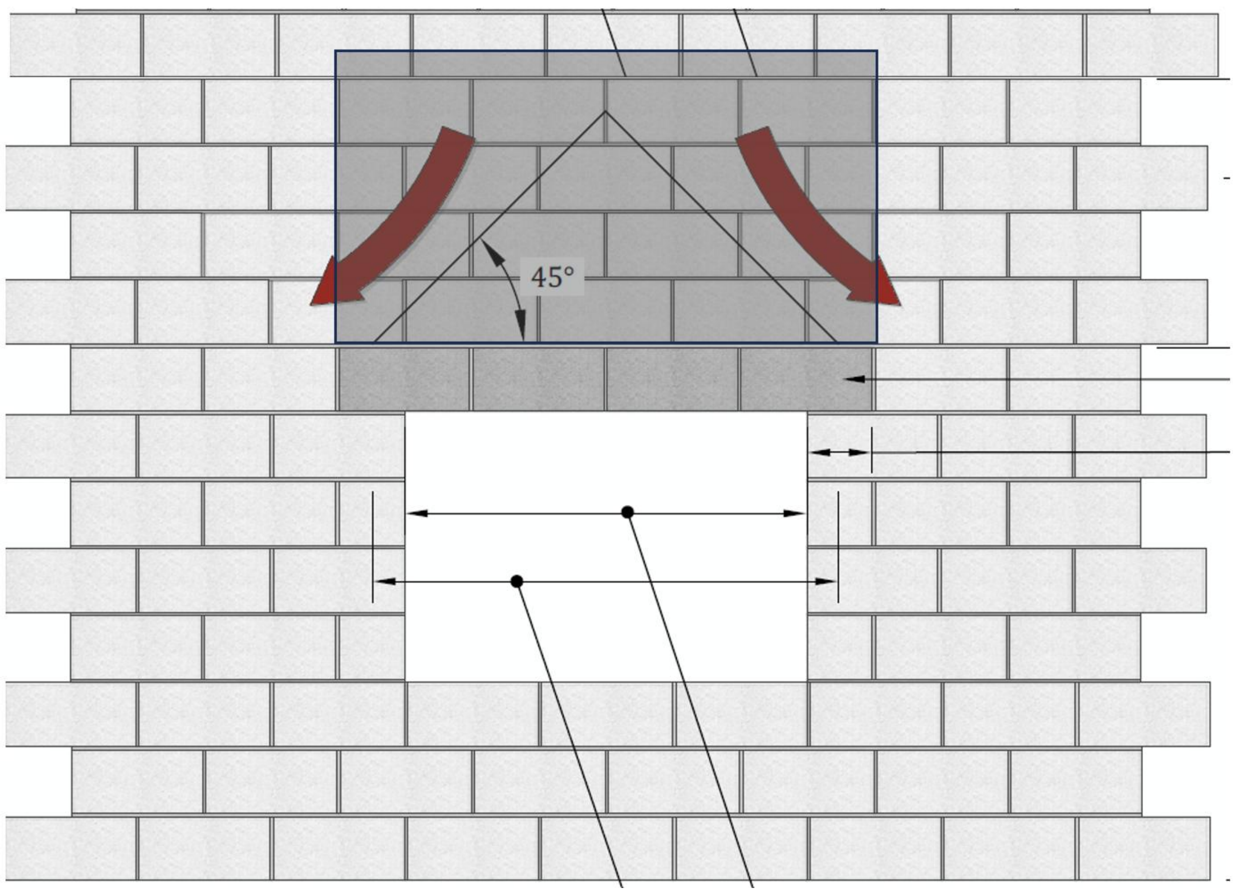


Figure 9 – Maximum Wall Self-Weight Design Loading

The following illustrates the design of a lintel over an opening located in a nonloadbearing concrete masonry partition applying the following design parameters:

Material Properties	
Specified Compressive Strength of Masonry, f'_m	1,750 lb/in.^{2}
Specified Yield Strength of Reinforcing Bars, f_y	60,000 lb/in.^{2}
Mortar: Type N Portland Cement-Lime Modulus of Rupture, f_r (Fully grouted hollow units, parallel to bed joints)	200 lb/in.^{2}

8 DESIGN OF LINTELS OVER OPENINGS

Assembly Properties	
Diameter of Reinforcing Bars (No. 4), d_b	0.5 in.
Nominal Wall Thickness, t	6 in.
Specified Wall Thickness, t_{sp}	5.625 in.
Fully Grouted Assembly Weight, lb/ft^2	63 lb/ft^2
Clear Span, S	8 ft
Design Span, S_d	8.67 ft
Bearing Length	8 in.
Construction	Running Bond
CMU Configuration	Knock-Out Bond Beam Unit

Masonry lintels over openings can be constructed using either solid bottom lintel units or open-bottom knock-out bond beam units as illustrated in Figure 10. While either unit configuration serves the same purpose of allowing horizontal reinforcing steel to be placed in the lintel, they differ in where that reinforcement can be placed. With solid bottom lintel units, the reinforcement can typically be placed near the bottom of the unit, whereas with knock-out bond beam units, the depth of the knock-out is typically around mid-height of the unit or higher. As a result, the effective depth of the reinforcement varies between these two unit configurations, which in turn impacts the resulting flexural strength of the lintel.

For simplicity in this guide, the bottom cover of lintels constructed using solid bottom lintel units is assumed to be 2.0 inches, which also satisfies the minimum cover distance at the lintel for corrosion protection for reinforcing bar sized covered in this guide. For lintels constructed using knock-out bond beam units, the bottom cover is assumed to be 4 inches, such that the horizontal reinforcement is located roughly mid-height of the bottom lintel unit. Because the reinforcement to placed close to the top of the unit, this guide prescriptively requires all lintels constructed using knock-out bond beam units to be at least two courses in depth. This guarantees that there will be sufficient masonry to resist resulting shear loads as well as sufficient effective depth to resist flexural bending.

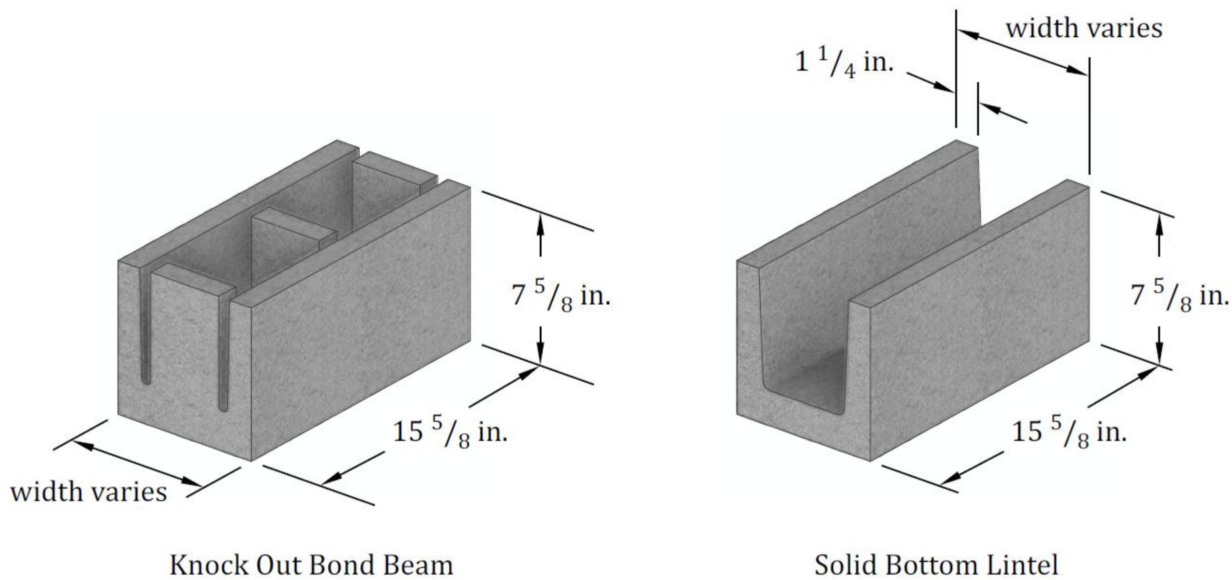


Figure 10 – Lintel Unit Configurations

In this example, a knock-out bond beam unit is being used resulting in a nominal lintel depth of at least 16 inches and a bottom clear cover of 4 inches. The resulting effective depth to the reinforcement is then calculated as the specified lintel depth minus the bottom clear cover minus one-half of the diameter of the horizontal reinforcement: d = 15.625 in. – 4.0 in. – (0.5/2 in.) = 11.375 in.

For simplicity, the pre-engineered lintel design options covered in this guide assume the masonry assembly is fully grouted and constructed using normal weight units as this maximizes the lintel design loading. While a conservative assumption, this does not result in overly conservative designs for openings in nonloadbearing partitions having relatively small span openings given the absence of axial gravity loads applied to the top of the partition. For a fully grouted 6-inch CMU partition constructed using normal weight units, the resulting wall self-weight can be assumed to be 63 lb/ft^2. Assuming simple support conditions and 8 inches of bearing on either side of the opening, the design span can be estimated to be the clear span plus one-half of the bearing length on each side of the opening: 8 ft + (8/12 ft)/2 + (8/12 ft)/2 = 8.67 ft.

The maximum height of masonry above the opening before an arching mechanism is developed is one-half of the design span plus 8 inches: (8.67 ft/2) + (8/12 ft) = 5.0 ft. Adding to this the depth of a two course lintel, the total height of masonry being supported by this lintel is: 5.0 ft + (16/12 ft) = 6.33 ft. Applying a 1.4 dead load factor, the resulting factored uniform loading along the length of the lintel is calculated as:

$$w = (1.4)\left(63\ {}^{\text{lb}}\!/_{\text{ft}^2}\right)(6.33\ \text{ft}) = 559\ {}^{\text{lb}}\!/_{\text{ft}}$$

TMS 402 Section 5.3.1.4 permits the maximum design shear to be calculated at a distance of $d/2$ from the face of the support, however, given the relatively low design loads considered here, the design shear at the face of the support can conservatively be used:

$$V_u = \frac{(w)(S)}{2} = \frac{\left(559\ {}^{\text{lb}}\!/_{\text{ft}}\right)(8.67\ \text{ft})}{2} = 2{,}423\ \text{lb}$$

Per TMS 402 Section 9.3.3.1.2, the design shear strength assuming no shear reinforcement is provided is determined by:

$$\phi V_{nm} = \phi\left\{4.0 - 1.75\left(\frac{M_u}{V_u d_v}\right)\right\} A_{nv}\sqrt{f'_m} + 0.25P_u$$

As there is no axial load applied the lintel (P_u = 0) and conservatively considering the ratio $M_u/V_u d_v$ is equal to 1.0 and incorporating a strength reduction factor of 0.80 for shear, the above equation reduces to:

$$\phi V_{nm} = (0.80)(2.25)A_{nv}\sqrt{f'_m} = (1.8)A_{nv}\sqrt{f'_m}$$

The net shear area (A_{nv}) is determined in accordance with TMS 402 Section 4.4.5. For masonry lintels, the area effective in resisting shear is the effective depth of the multiplied by the specified lintel thickness:

$$A_{nv} = (d)(t_{sp}) = (11.375\ \text{in.})(5.625\ \text{in.}) = 63.9\ \text{in.}^2$$

The resulting design shear strength is then:

$$\phi V_{nm} = (0.80)(2.25)(63.9\ \text{in.}^2)\sqrt{1{,}750\ {}^{\text{lb}}\!/_{\text{in.}^2}} = 4{,}811\ \text{lb}$$

Which exceeds the factored design shear force; thus, a two course masonry lintel can be used to resist the design shear loading without the use of shear reinforcement.

Section 5.3.2 of TMS 402 includes additional deep beam design checks and detailing requirements when the effective span-to-depth ratio (S/d) less than 2.0. Here, the effective span-to-depth ratio is: (8.67 ft)(12 in./ft)/11.375 in. = 9.1. Therefore, the deep beam design checks and prescriptive detailing requirements do not apply. The pre-engineered lintels covered in this guide are configured such that the deep beam requirements of TMS 402 would not be triggered.

The next design check is to provide sufficient horizontal reinforcement to resist the resulting flexural loading. The resulting factored bending moment for this lintel is:

$$M_u = \frac{\left(559\ {}^{\text{lb}}\!/_{\text{ft}}\right)(8.67\ \text{ft})^2}{8} = 5{,}253\ \text{ft-lb} = 63{,}030\ \text{in.-lb}$$

Assuming a single No. 4 reinforcing bar with an effective depth of 11.375 inches, the resulting depth of the compression block is:

$$a = \frac{A_s f_y}{0.80 f'_m b} = \frac{\left(0.2\ \text{in.}^2\right)\left(60{,}000\ {}^{\text{lb}}\!/_{\text{in.}^2}\right)}{(0.80)\left(1{,}750\ {}^{\text{lb}}\!/_{\text{in.}^2}\right)(5.625\ \text{in.})} = 1.52\ \text{in.}$$

The resulting nominal flexural strength is calculated per the following. Here, a strength reduction factor of 0.9 is used assuming the lintel if tension-controlled (as required by TMS 402). This will be verified in subsequent checks.

$$\phi M_n = \left(A_s f_y\right)\left(d - \frac{a}{2}\right) = \left(0.2\ \text{in.}^2\right)\left(60{,}000\ {}^{\text{lb}}\!/_{\text{in.}^2}\right)\left(11.375\ \text{in.} - \frac{1.52\ \text{in.}}{2}\right) = 127{,}380\ \text{in.-lb}$$

Which exceeds the factored bending moment of 63,030 in.-lb thus satisfying this design check.

To ensure masonry lintels are tension-controlled, TMS 402 limits the reinforcement ratio to the following where the maximum compression strain () for concrete masonry is taken equal to 0.0025:

$$\rho_{max} = \frac{0.64 f'_m}{f_y}\left(\frac{\varepsilon_{mu}}{\varepsilon_{mu} + 0.005}\right) = \frac{0.64\left(1{,}750\ {}^{\text{lb}}\!/_{\text{in.}^2}\right)}{\left(60{,}000\ {}^{\text{lb}}\!/_{\text{in.}^2}\right)}\left(\frac{0.0025}{0.0025 + 0.005}\right) = 0.006$$

The reinforcement ratio of this lintel is:

$$\rho = \frac{A_s}{bd} = \frac{0.2\ \text{in.}^2}{(5.625\ \text{in.})(11.375\ \text{in.})} = 0.003$$

Thus, the maximum reinforcement ratio is satisfied and the lintel is tension-controlled. TMS 402 Section 9.3.3.2.2 also requires that the nominal flexural strength of lintels not be less than 1.3 times the nominal cracking moment strength (M_{cr}) to mitigate brittle failures. Applying a modulus of rupture value of 200 lb/in.2 per Table 9.1.9.1 of TMS 402, the resulting factored cracking moment strength is:

$$1.3M_{cr} = \frac{1.3f_rI_n}{y} = \frac{(1.3)\left(200\ ^{\text{lb}}/_{\text{in.}^2}\right)\left\{\left(\frac{1}{12}\right)(5.625\text{ in.})(15.625\text{ in.})^3\right\}}{\frac{15.625\text{ in.}}{2}} = 59{,}509\text{ in.-lb}$$

Which is less than the design flexural strength, thus satisfying this design check.

TMS 402 Section 4.6 requires all beams of any material supporting unreinforced masonry be deflection limited to $S/600$ under allowable stress level dead and live loads. While the lintels of this guide can be used to support masonry that is either reinforced or unreinforced, the deflection limit for lintels supporting unreinforced masonry is applied for both conditions.

For a simply supported lintel, the vertical deflection under an allowable stress level uniform load is given by:

$$\delta_s = \frac{5w_aS^4}{384E_mI_{eff}}$$

Where the allowable stress level uniform load is calculated as:

$$w = (1.0)\left(63\ ^{\text{lb}}/_{\text{ft}^2}\right)(6.33\text{ ft}) = 399\ ^{\text{lb}}/_{\text{ft}}$$

Resulting in an allowable stress level bending moment of:

$$M_a = \frac{\left(399\ ^{\text{lb}}/_{\text{ft}}\right)(8.67\text{ ft})^2}{8} = 3{,}749\text{ ft-lb} = 44{,}989\text{ in.-lb}$$

The effective moment of inertia (I_{eff}) is determined from TMS 402 Equation 5-1:

$$I_{eff} = I_n\left(\frac{M_{cr}}{M_a}\right)^3 + I_{cr}\left(1 - \left(\frac{M_{cr}}{M_a}\right)^3\right) \leq I_n$$

And the cracked moment of inertia is calculated as:

$$I_{cr} = nA_s(d-c)^2 + \frac{bc^3}{3}$$

With the depth to the neutral axis is given by:

$$c = \frac{A_s f_y}{0.64 f'_m b} = \frac{\left(0.2\ \text{in.}^2\right)\left(60{,}000\ {}^{\text{lb}}\!/\!_{\text{in.}^2}\right)}{(0.64)\left(1{,}750\ {}^{\text{lb}}\!/\!_{\text{in.}^2}\right)(5.625\ \text{in.})} = 1.52\ \text{in.}$$

The resulting cracked moment of inertia is:

$$I_{cr} = \frac{29{,}000{,}000\ {}^{\text{lb}}\!/\!_{\text{in.}^2}}{(900)\left(1{,}750\ {}^{\text{lb}}\!/\!_{\text{in.}^2}\right)}\left(0.2\ \text{in.}^2\right)(11.375\ \text{in.} - 1.52\ \text{in.})^2 + \frac{(5.625\ \text{in.})(1.52\ \text{in.})^3}{3} = 364\ in.^4$$

The resulting effective moment of inertia is:

$$I_{eff} = 1{,}788\ \text{in.}^4\left(\frac{45{,}776\ \text{in.-lb}}{44{,}989\ \text{in.-lb}}\right)^3 + 364\ \text{in.}^4\left(1 - \left(\frac{45{,}776\ \text{in.-lb}}{44{,}989\ \text{in.-lb}}\right)^3\right) = 1{,}812\ \text{in.}^4$$

Which exceeds the net moment of inertia (I_n), and thus is limited to 1,788 in.^{4}. The resulting deflection is then:

$$\delta_s = \frac{5\left(399\ {}^{\text{lb}}\!/\!_{\text{ft}}\right)(8.67\ \text{ft})^4}{384\left((900)\left(1{,}750\ {}^{\text{lb}}\!/\!_{\text{in.}^2}\right)\right)\left(1{,}812\ \text{in.}^4\right)}\left(12\ {}^{\text{in.}}\!/\!_{\text{ft}}\right)^3 = 0.017\ \text{in.}$$

For a design span of 8.67 ft (104 in.) and a deflection limit of S/600, the maximum permitted deflection is: 104 in./600 = 0.17 in.

Tables 16 and 17 tabularize various reinforcement options for lintels above openings located in both reinforced and unreinforced masonry partitions. Table 16 applies to closed-bottom lintel units whereas Table 17 applies to open-bottom knock-out bond beam units.

8 DESIGN OF LINTELS OVER OPENINGS

Table 16 – Minimum Lintel Reinforcement and Lintel Depth for 6 in. and 8 in. CMU Lintels Constructed Using Closed-Bottom Lintel Units[1]		
Clear Opening, ft	Reinforcement	Nominal Lintel Depth
6.00 and less	1 No. 4 or 1 No. 5	8 in.
Up to 9.33	1 No. 4 or 1 No. 5	16 in.

[1] Based on a minimum bottom cover distance of 2.0 in.

Table 17 – Minimum Lintel Reinforcement and Lintel Depth for 6 in. and 8 in. CMU Lintels Constructed Using Knock-Out Bond Beam Units[1]		
Clear Opening, ft	Reinforcement	Nominal Lintel Depth
9.33 and less	1 No. 4 or 1 No. 5	16 in.

[1] Based on a minimum bottom cover distance of 4.0 in.

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