SE INSIGHTS FOR MASONRY DESIGN

Masonry Partition Walls

According to TMS 402 standards set forth by The Masonry Society, a partition wall (Figure 1) is defined as an interior, non-structural element that does not support loads from floors above, contribute to the lateral force-resisting system, or resist external wind or seismic pressures. Contrary to the assumption that such walls require minimal design considerations, they do necessitate certain engineering attention.Masonry materials offer significant benefits for partition walls, including enhanced durability, security, fire resistance, and acoustic control. Additionally, due to their thermal mass, masonry walls can improve energy efficiency, while offering a variety of aesthetic finishes, such as painting, burnishing, rock-facing, or unique bond patterns. These advantages contribute to the widespread use of masonry in partition wall applications. To optimize design outcomes, a detailed exploration of cost-effective detailing strategies is warranted.

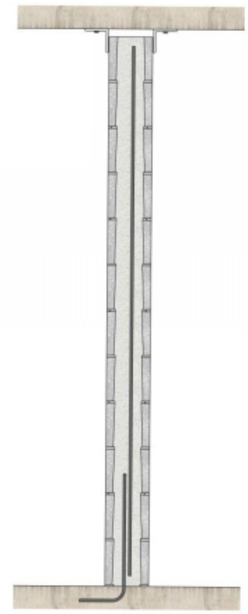


Figure 1: Partition Wall Section

What are the Reinforcement Requirements for Partition Walls?

The first design item we will explore is reinforcement requirements for partition walls. If detailed correctly, the only load that partition walls are to be designed for is an interior horizontal design pressure. IBC Code 2015, Section 1607.14 requires a minimum interior pressure of 5 psf service (8 psf ultimate) to be considered. Partition walls should not resist any gravity loading. Therefore, partition wall height, thickness, and reinforcement (if any) do not need to be checked to resist loads other than minimal interior horizontal pressure. What does the TMS 402 Code mandate in terms of minimum reinforcement for partition walls? To understand TMS Code requirements, we first define partition walls as 'nonparticipating elements', which are masonry elements that are not part of the seismic (or lateral) force-resisting structural system. Per TMS 402-13 Section 7.4.1, partition walls in low seismic areas located in Seismic Design Category (SDC) A or B do not have minimum reinforcement area or maximum spacing requirements. Therefore, partition walls can be unreinforced in low seismic areas if adequate to resist the service 5 psf pressure.

For example, consider an unreinforced 8" thick CMU partition wall with f'm = 2500 psi, Type S mortar, 18'-0 tall, simply supported, and located in Seismic Design Category (SDC) A or B. This wall can resist an interior pressure of 5 psf service without reinforcement. Refer to the calculation in Figure 2. A partition wall constructed of 12" block can span up to 28 feet high as an unreinforced masonry wall. As we increase wall height and/or reduce wall thickness, light reinforcement is needed to resist the interior pressure of 5 psf. See Table 1 for guidance on partition wall reinforcement for low seismic loading, SDC A or B. It is important to note that such reinforcement is possible only with correct detailing and isolation of the wall, which will be discussed further. A useful complimentary tool in calculating partition wall reinforcement was developed by the International Masonry Institute (IMI) called the Masonry Partition Wall Software. An example calculation from this tool is shown in Figure 2 and can be found at http://imiweb.org/masonry-software/masonry-partition-wall-software/.

Partition Wall Guide
f'm=2500psi, Type S Mortar
IBC Code Min Interior Pressure 5psf Service, 8psf Ultimate
SDC A, B

	10 ft	12 ft	14 ft	16 ft	18 ft	20 ft	24 ft	28 ft	30 ft
6 inch	none	none	none	#4 @ 120	#4 @ 96	#4 @ 72	#4 @ 48	#4 @ 32	#4 @ 24
8 inch	none	none	none	none	none	#4 @ 120	#5 @ 120	#5 @ 80	#5 @ 64
10 inch	none	none	none	none	none	none	none	#5 @ 96	#5 @ 96
12 inch	none	none	none	none	none	none	none	none	#4 @ 96
16 inch	none	none	none	none	none	none	none	none	none

Table 1: Partition Wall Reinforcement Guide
for Seismic Design Category A or B

Higher seismic design categories, however, do have minimum prescriptive reinforcing code requirements. Per TMS 402-13 Section 7.4.3.1, partition walls in SDC C require vertical reinforcement spaced at no more than 120 inches. Partition walls in SDC D require a maximum spacing of 48 inches per TMS 402-13 Section 7.4.4.1. SDC E or F requires a maximum spacing of 24 inches in fully grouted partition walls and additional reinforcement requirements per TMS 402-13 Section 7.4.4.2.3. Also, as seismic requirements increase, partition wall design will likely be controlled by seismic demands on nonstructural components rather than the minimum partition load. Table 2 provides guidance on partition wall reinforcement for SDC C. Overall, it is good to be aware of the prescriptive reinforcement requirements for partition walls. For projects in low seismic areas, we can avoid over-reinforcing, or even avoid providing any reinforcing at all, in our partition walls that are not intended to resist gravity or high lateral loads.

At times, structural design for masonry shear walls is applied to partition walls as well in structural documents, inadvertently or not. A set of design drawings may contain a 'General Note' stating that

Partition Wall Guide
f'm=2500psi, Type S Mortar
IBC Code Min Interior Pressure 5psf Service, 8psf Ultimate
SDC C

	10 ft	12 ft	14 ft	16 ft	18 ft	20 ft	24 ft	30 ft
6 inch	#4@120	#4@120	#5@120	#4 @ 72	#4 @ 56	#4 @ 40	#5 @ 40	#5 @ 24
8 inch	#4@120	#4@120	#4@120	#5@120	#5 @ 96	#5 @ 88	#5 @ 56	#5 @ 32
10 inch	#4@120	#4@120	#4@120	#4@120	#5@120	#5 @ 96	#5 @ 72	#5 @ 40
12 inch	#4@120	#4@120	#4@120	#4@120	#4@120	#5@120	#5 @ 88	#5 @ 48

Table 2: Partition Wall Reinforcement Guide
for Seismic Design Category C

masonry walls shall have #4 vertical bars spaced at 48" typical unless noted otherwise. Is it clear whether this note is applicable to or necessary for nonstructural partition walls? As discussed above, partition walls can span tall story heights as unreinforced walls when detailed correctly. Therefore, a General Note requiring reinforcement for all masonry walls - shear walls, load-bearing, and partition walls - may over-reinforce non-load bearing partition walls on the project. It is cost-effective to clearly communicate the reinforcement requirements for structural walls in wall schedules in lieu of utilizing catch-all statements in General Notes. There is the potential that a project will have more total volume of masonry partition walls than structural reinforced walls, and avoiding catch-all general notes can lead to significant cost savings on a project.

Up to this point, the focus has been on partition walls without openings. However, architectural plans often require the design to consider openings for doors, windows, or other miscellaneous items. Table 3 displays lintel reinforcement requirements to support the weight of masonry above the opening when the requirements for arching action are met.

3/20/2019

Masonry Partition Wall Design Results

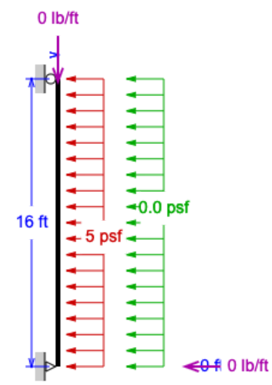
Masonry Partition Wall Design

Provided by:
team IMI INTERNATIONAL MASONRY INSTITUTE
EDUCATION PROVIDER

Unreinforced Concrete Masonry
Non-Loadbearing Partition Wall

No external applied gravity loads
Interior pressure = 5 psf
Wall height = 18'-0"
Wall thickness = 8"
f'm = 2500 psi
Unreinforced wall is acceptable

Project: Sample Partition Wall
Designer: FORSE Consulting, LLC
Notes:
Date: Wed Mar 20 2019 09:50:34 GMT-0500 (Central Daylight Time)
Masonry Type: ASTM C 90 CMU Medium weight
Mortar Type: ASTM C 270 Type S Portland Cement Lime or Mortar Cement
Bond Pattern: running
f'_m: 2500 psi
Wall Span: vertical
Wall Thickness (nominal): 8 inches
Wall Thickness (actual): 7.625 inches
Grout Spacing: none
Rebar Spacing: none
Wall Height: 18 ft
Wall Weight: 36 lb/ft^2
Net Wall area: 30 inches^2
Section Modulus: 81 ft^3
Horizontal Uniform Load: 5 lb/ft^2
Horizontal Concentrated Load: 0 lb/ft @ 0 ft
Vertical Load: 0 lb/ft, 0 inches eccentricity
Risk Category IV: No
Egress Stairway: No
S_{DS}: 0.33
S_{D1}: 0.133
Code Type: 2015 IBC/2013 TMS 402 ASD



Wall Side View
Concentrated Load
Uniform Load
Seismic Load

Design Status: **Good**

Load Combination	Status	x (ft)	Axial Force (lb)	Moment (ft-lb)	f_t/F_t (psi)	f_b/F_b (psi)	Unity	R_{top} lb/ft
A: $0.6D+w_L$	OK	9.0	194	203	23.5 / 33.0	30 / 833	0.049	45.0

Unreinforced Design Results

Load Combinations: All passed

R_{top}: 45.0 lb/ft

Seismic load: 0.00 psf

Seismic Design Category B:

Grouting and Reinforcing: All masonry and grouting and reinforcing work shall be performed by masonry craftworkers who have successfully completed the International Masonry Institute (1-800-IMI-0988) training course for Grouting and Reinforced Masonry Construction, or equal.

Print this page

1/2

Figure 2: Partition Wall Sample Calculation
International Masonry Institute Masonry Partition Wall Software
http://imiweb.org/masonry-software/masonry-partition-wall-software/

Partition Wall Opening - Lintel Reinforcement

	6” CMU		8” CMU		10” CMU		12” CMU	
Clear Opening Width	8” Deep	16” Deep	8” Deep	16” Deep	8” Deep	16” Deep	8” Deep	16” Deep
4’-0”	1 - #4	-	1 - #4	-	1 - #4	-	1 - #4	-
6’-0”	1 - #4	-	1 - #4	-	1 - #4	-	1 - #4	-
8’-0”	-	1 - #4	-	1 - #4	-	1 - #4	-	1 - #4
10’-0”	-	1 - #4	-	1 - #4	-	1 - #4	-	1 - #4
12’-0”	-	1 - #4	-	2 - #4	-	2 - #4	-	2 - #4

Schedule Assumptions:

1) f'm = 2,500psi
2) Arching action requirements have been fulfilled
3) Fully grouted 45^{O} triangular load placed on top of lintel self weight.
4) 8” bearing each end: effective span = clear opening + 8”
5) Deflection limit = L/600 or 0.3”
6) Clear distance from bottom of lintel to bottom of tension reinforcement = 2” to satisfy code minimum for interior partition wall, course grout, and bar placement tolerance.

Detailing Tips for Partition Walls

Table 3: Partition Wall Opening Lintel Reinforcement

Another way to minimize the cost of partition walls is to consider the top and bottom of partition wall connections. TMS 402-13 Section 7.3.1 mandates that nonparticipating elements, or partition walls in our case, shall be isolated from the lateral force resisting system. Isolating the partition wall from any adjacent structure will ensure that no gravity or lateral forces from the floors, beams, or columns are inadvertently transferred to the nonstructural wall. Failure to prevent force transfer could result in damage to the partition wall.
What are sound detailing tips for ensuring partition wall isolation? Since the intent of a partition wall is to avoid structural loading,

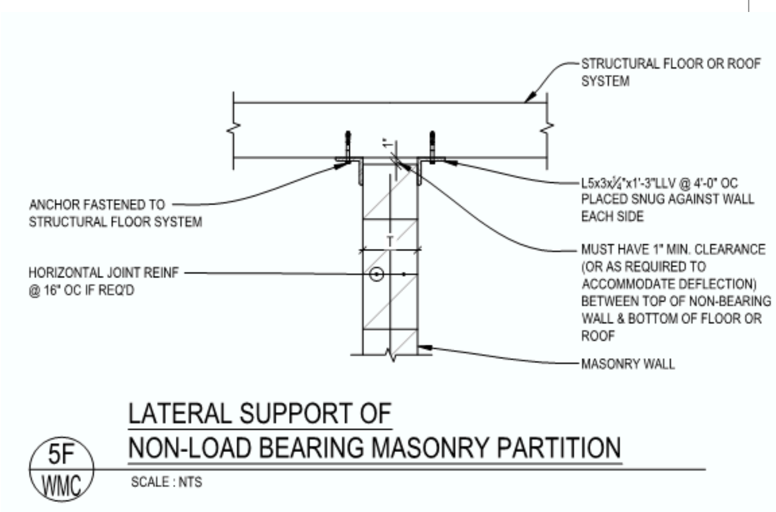
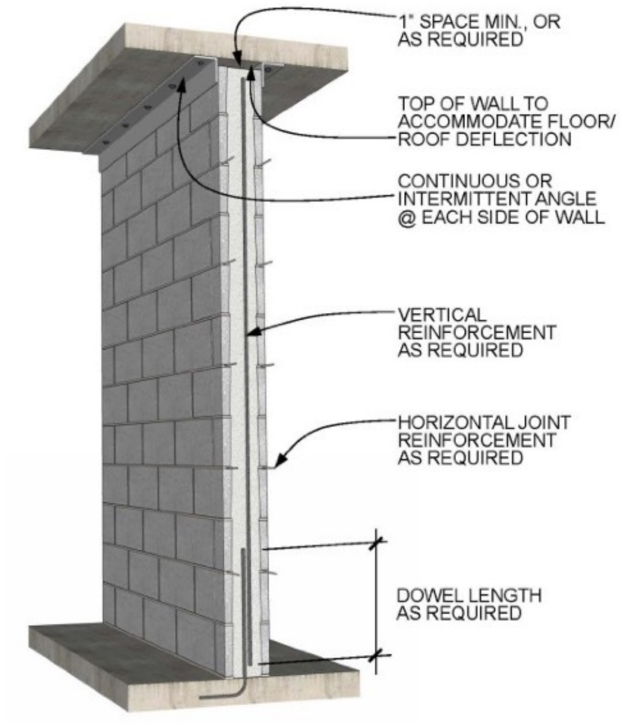


Figure 3: Top of Partition Wall Detail



designers must pay special attention to the detailing of the wall's connections to the overall structure. Common practice is to detail the top of a partition wall with a vertical slip connection and a gap between the top of the wall and the bottom of the structure above. The depth of this ver tical gap shal l accommodate the anticipated deflection of the framing structure above the wall. This detailing prevents the wall from being loaded due to differential movements between the level above the wall and the level on which the wall rests. Vertical gaps and compressible fillers should also be considered where partition walls abut structural walls or columns that are part of the lateral system to ensure drifting of the main structure does not impose lateral loads onto the partition walls.

Figure 4: Partition Wall Detail with Top of Wall Bracing

Base of Wall

One option to prevent the transfer of loads at the top of the wall is to not have any connection at all by using a cantilevered wall leaving a gap between the wall and the structure above. Unfortunately, the increase in the reinforcing that is required to fix the base of wall connection could potentially offset any cost savings.

Because of this, partition walls are typically designed as simply supported which requires a top connection but simplifies the base of wall connection. Generally, a dowel from the floor or foundation below will extend into the bottom of the wall as shown in Figures 4 & 5 (dowel is not required by code). This dowel does not need to be lapped or be in the same cell as the wall reinforcement (if wall reinforcement is required) giving contractors flexibility and the result is a more affordable design.

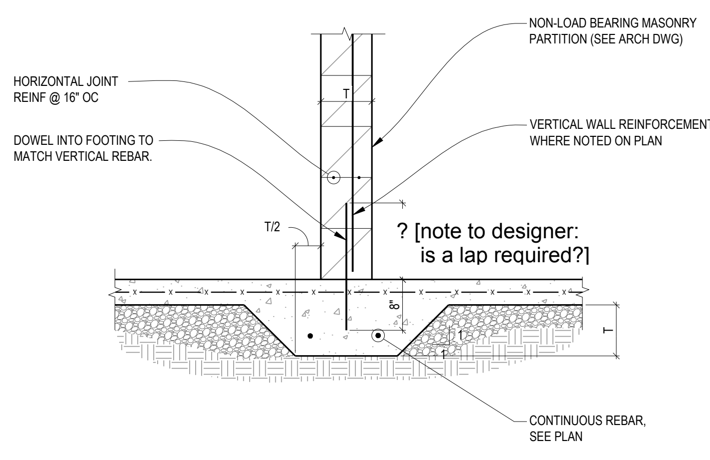


Figure 5: Simple Base Connection at the Base of Wall

Top of Wall

When used in the design, the connection at the top of the wall must be capable of resisting out-of-plane lateral loads to brace the wall while not transferring vertical or in-plane lateral loads. The

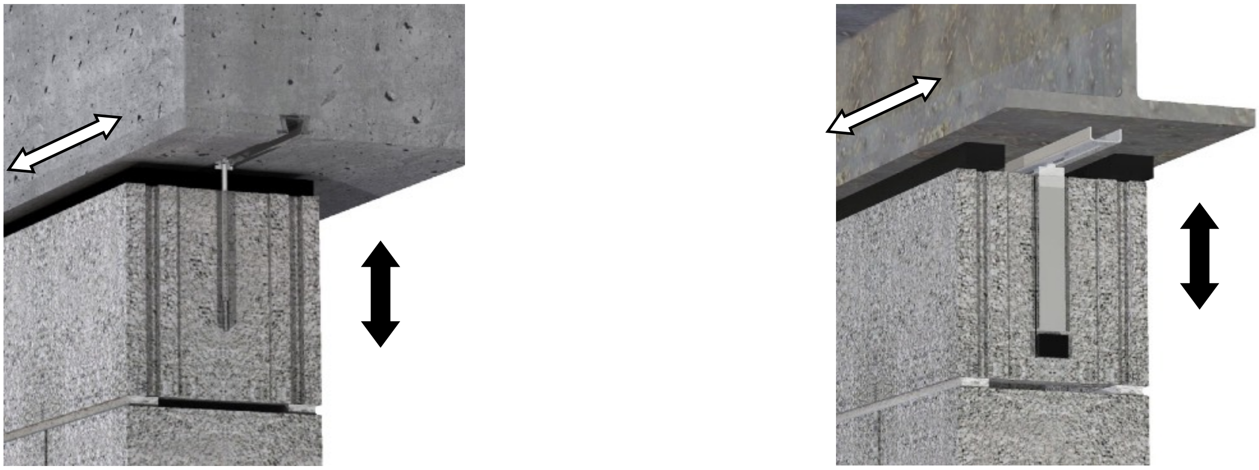


Figure 6: Partition Top Anchors (PTA) with Two-Way Flexibility
source: www.h-b.com

preferred way to connect the top of a partition wall to the floor above is by using a direct connection at the grouted cells. This connection may consist of intermittent angles bracing the wall (Figure 3) and attached to the floor structure above. The angles are to align with any vertically grouted cells in the partition wall to ensure a load path for out-of-plane forces in the wall. This can be the simplest and most cost-efficient option. The advantage of this detail is that it does not require a bond beam at the top of the wall since it attaches to cells that are already grouted for vertical reinforcement. The disadvantage to this connection is that the angle locations must be coordinated with the grouted cell locations. Another option is to provide a continuous angle at the top of the wall (Figure 4). Again, no bond beam is required since the wall does not have to span horizontally between connection points. This option will cost more than the first due to a continuous steel angle at each side of the top of the wall opposed to shorter, intermittent pieces. Lastly, one could detail a heavier intermittent angle that is not coordinated with the wall reinforcing — for instance, the angle could be specified at 6'-0 on center. The disadvantage is that now a continuous bond beam is required at the top of the wall for attachment of the angle and for the wall to span horizontally. The placement of this bond beam provides challenges for masons to install at the underside of the floor structure above since the top of the wall gap does not provide enough room to install grout.

As an alternative to the external top of wall connections noted above, there are proprietary commercial products available. Figure 6 demonstrates two different types of partition top anchors (PTA) that are placed into grouted cells. These anchors provide aesthetic benefits since they are installed internally. Additionally, there are external PTAs shown in Figure 7 that do not require direct connection to the masonry. Care must be taken to verify the products specified are indeed designed for use with partition walls as some PTAs are intended to transfer shear loads and thus must be reserved for shear walls only.

Figure 7: Partition Top Anchors (PTA)
source: www.h-b.com

Summary

While masonry is a popular material for partition walls, there is the potential they may be over-designed. Partition walls can expend a good portion of a project's budget due to the inclusion of unnecessary heavy reinforcement. In order to minimize cost overrun, it helps to consider good design and detailing practices. First, partition walls are not shear walls. The point of a shear wall is to participate in the main lateral force resisting system for the building, while a partition wall is not intended to resist any structural loads whatsoever. Partition walls, especially those in low seismic zones, do not have requirements for minimum reinforcing. Also, it is possible to make more economical connections at the top of partition walls by coordinating the connection locations with cells that are already grouted. When these design parameters and options are considered during the design phase, a project can benefit from all of the advantages masonry partitions provide while eliminating the drawbacks.

- Savings are realized when designers take into consideration:
    - Partition walls are not shear walls and therefore do not need to meet the minimum reinforcement requirements of shear walls.
    - No reinforcement is *required* in masonry partitions. Partitions can be unreinforced and ungrouted when not required by the loading and project geometry.
- Smarter and more cost-effective connections are possible at the top and bottom of the walls.
    - Connections must prevent unintended loads.
    - List of options for top of wall connections:
        1. Direct connection at reinforced/grouted cells (most preferred by contractors)
            - The simplest, most affordable option
        2. Continuous angle at the top of the wall
            - Requires only a small angle and small fastener to structure above
        3. Intermittent heavy angle, non-coordinated top of wall connection
            - Common, but not preferred
            - Requires heavy angle and heavy connector
            - Also requires a costly and hard-to-place top of wall masonry bond beam
    - The bottom of the wall only needs to be fixed when the partition wall is a cantilevered wall.
        - Most bottom of partition wall connections can be minimal.