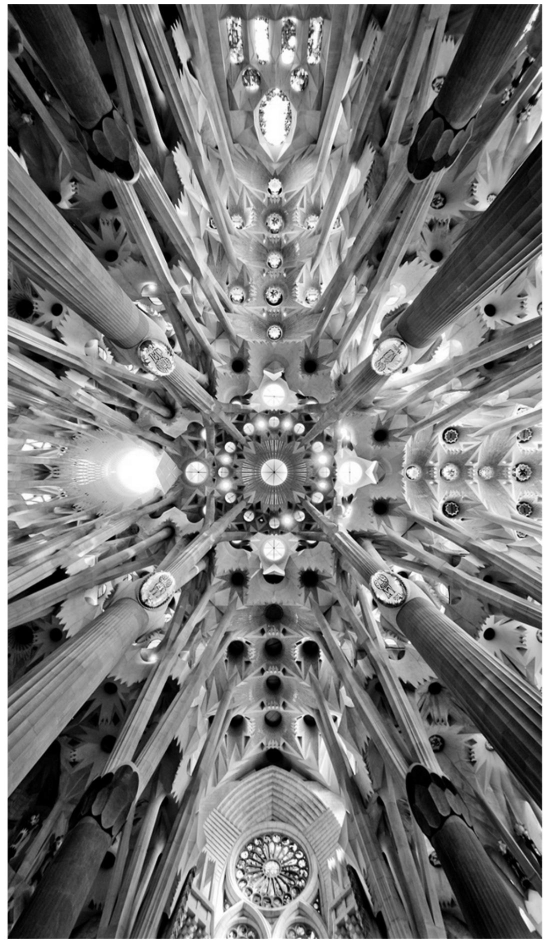
Architecture 504
Masonry Structures

Masonry Walls

- Non-reinforced axial compression
- Reinforced axial compression



Sagrada Familia
Barcelona, Spain
Arch: Antonio Gaudi

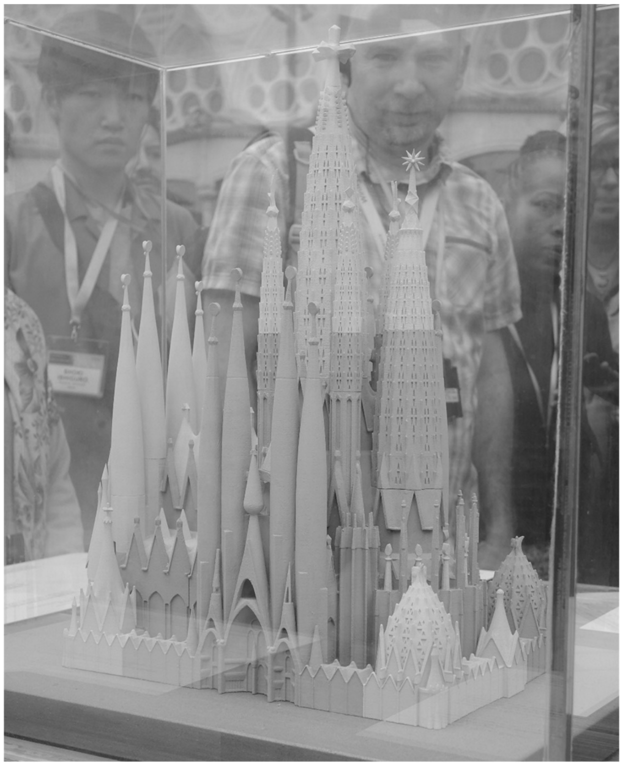
Sagrada Familia 1882 – 2026?

Antonio Gaudi 1852 – 1926
Barcelona, Spain

Sagrada Familia 1882 – 2026?

Antonio Gaudi 1852 – 1926

Barcelona, Spain



Sagrada Familia 1882 – 2026?

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Barcelona, Spain

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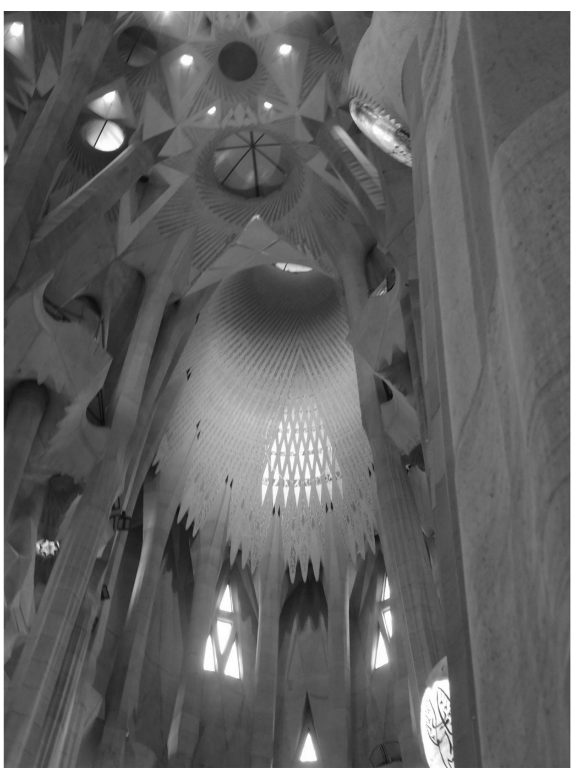

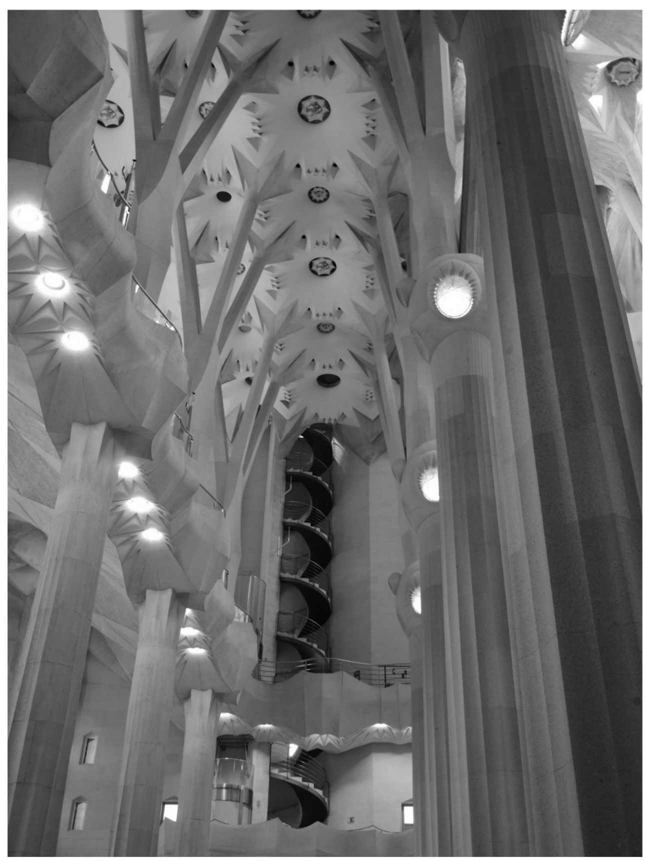

Sagrada Familia 1882 – 2026?
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Barcelona, Spain

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Barcelona, Spain

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Antonio Gaudi 1852 – 1926
Barcelona, Spain

Casa Milà 1906 – 1912
Antonio Gaudi 1852 – 1926
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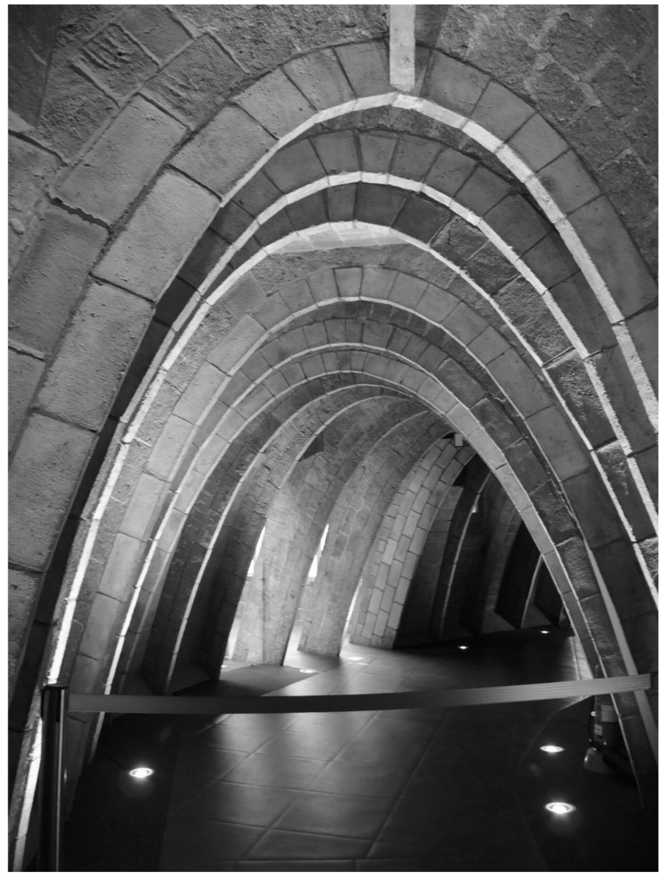
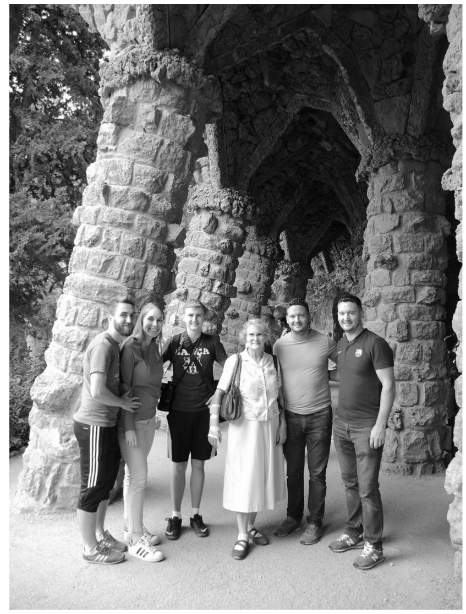
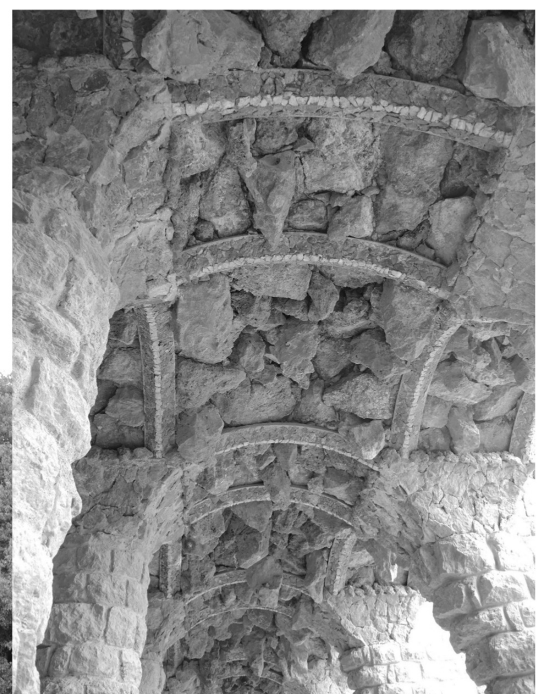


Casa Milà 1906 – 1912
Antonio Gaudi 1852 – 1926
Barcelona, Spain

Park Güell 1900 –
Antonio Gaudi 1852 – 1926
Barcelona, Spain



Park Güell 1900 –
Antonio Gaudi 1852 – 1926
Barcelona, Spain



Park Güell 1900 –
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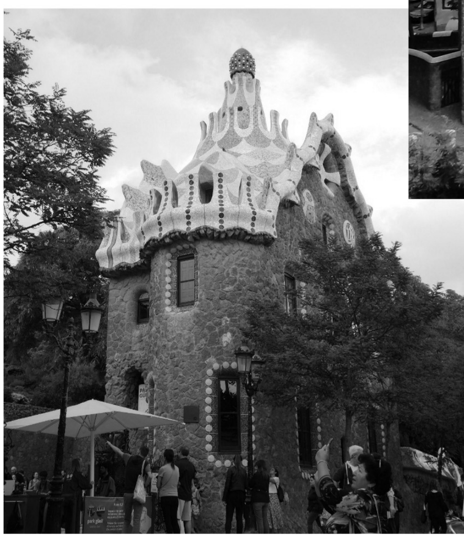
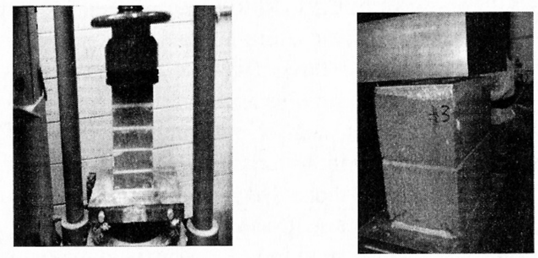


Park Güell 1900 –
Antonio Gaudi 1852 – 1926
Barcelona, Spain

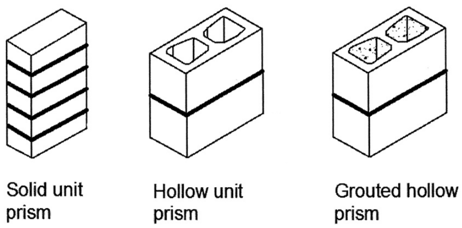
Masonry Strength

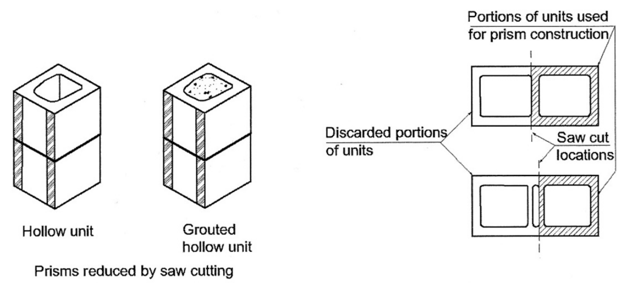
f'm – specified masonry strength
f'mt - tested masonry strength, based on prism test

- unit strength – fu
- mortar type – M, S, N, O
- grout strength – f'g
- quality (inspected, full joints)



Prisms with Full Size Units



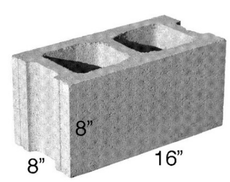


Prisms with Saw-Cut Half Units

Masonry Strength

Masonry strength, f'm, based on unit strength, fu, and mortar type

Clay Masonry



Concrete Masonry

TMS 602 1.4 table 1.

Required Net Area Compressive Strength of Clay Masonry Units (psi) fu		f'm For Net Area Compressive Strength of Masonry (psi)
When Used With Type M or S Mortar	When Used With Type N Mortar	
1,700	2,100	1,000
3,350	4,150	1,500
4,950	6,200	2,000
6,600	8,250	2,500
8,250	10,300	3,000
9,900	––	3,500
11,500	––	4,000

(*From Masonry Standards Joint Committee* Specifications for Masonry Structures, *ACI 530.1/ASCE 6/TMS 602-99*)

Required Net Area Compressive Strength of Concrete Masonry Units (psi) fu		f'm For Net Area Compressive Strength of Masonry (psi)
When Used With Type M or S Mortar	When Used With Type N Mortar	
1,250	1,300	1,000
1,900	2,150	1,500
2,800	3,050	2,000
3,750	4,050	2,500
4,800	5,250	3,000

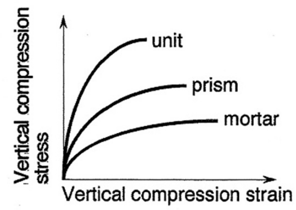
(*From* International Building Code 2000 *and Masonry Standards Joint Committee* Specifications for Masonry Structures, *ACI 530.1/ASCE 6/TMS 602-99*)

Constructive Properties

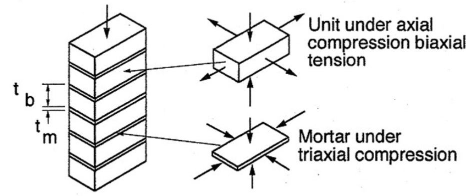
Typical Values

Property		Clay Masonry	Concrete Masonry
Unit strength		$8000\ psi$	$2000\ psi$
Type N mortar	f'_m	$2440\ psi$	$1750\ psi$
	E_m	$1.70x10^6\ psi$	$1.58x10^6\ psi$
Type M or S mortar	f'_m	$2920\ psi$	$2000\ psi$
	E_m	$2.05x10^6\ psi$	$1.80x10^6\ psi$

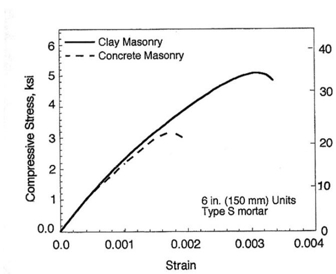
Property	Clay Masonry	Concrete Masonry
Modulus of Elasticity, E_m	$700f'_m$	$900f'_m$
Shear Modulus, G	$0.4E_m$	$0.4E_m$
Coefficient of Creep	$\frac{0.7\ x10^{-7}}{psi}$	$\frac{2.5x10^{-7}}{psi}$



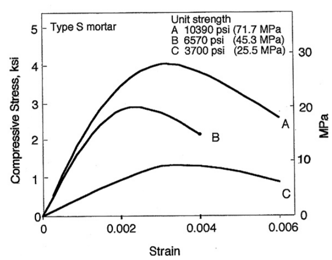
(a) Stress-Strain Relationships



(b) States of Stress of Units and Mortar



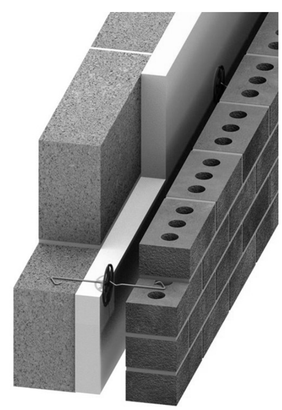
(a) Concrete and Clay Masonry



(b) Clay Brick Masonry

Analysis and Design

Empirical approach
- based on experience
- limits on lateral loading
- limits on height
- limits on eccentricity (basically no flexure)
- non-reinforced

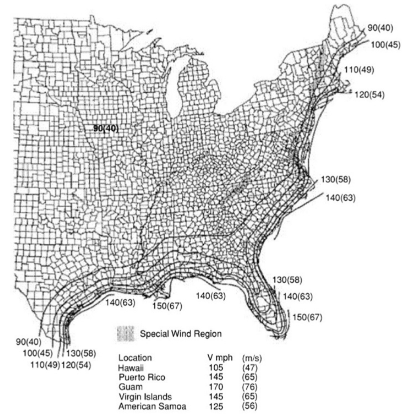


Rational approach
- based on Strength Design (LRFD)
- either reinforced or non-reinforced
- limited by strength

Empirical Design of Concrete Masonry Walls

Application
- non-reinforced
- low lateral loads – wind or seismic
- e.g. exterior curtain walls & interior partitions

Prescriptive Criteria
- wall height to thickness
- shear wall length & spacing
- minimum wall thickness
- maximum building height
- usually with running bond



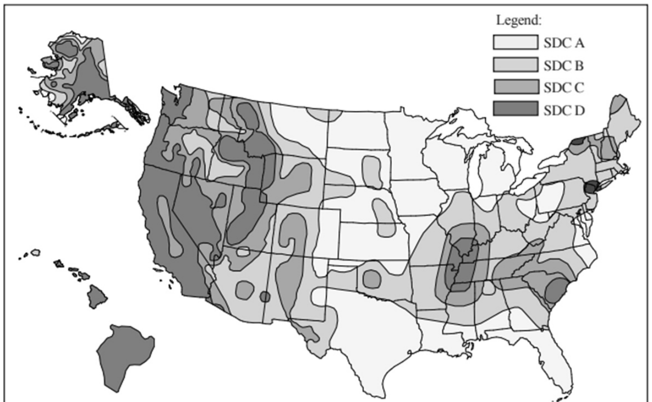


Figure 1—Seismic Design Categories for Site Class D, Seismic Use Group I and II, for a 0.2-Second Spectral Response Acceleration

Empirical Design of Concrete Masonry Walls

Three things to check by International Building Code (IBC 2006)
- Seismic Design Category
  - if not part of seismic resisting system – A, B or C
  - if part of the seismic lateral force resisting system – A only
- Basic wind speed vs building height (IBC table 1)
- gravity load resultant within the kern (middle 1/3)

Table 1—2006 IBC Empirical Design Limitations Based on Building Height and Basic Wind Speed[A]

Masonry wall type:	Building height, h, ft (m)	Basic wind speed, w, mph (m/s): $w \le 90$ ($w \le 40$)	$90 < w \le 100$ ($40 < w \le 45$)	$100 < w \le 110$ ($45 < w \le 49$)	$110 < w$ ($49 < w$)
Part of the lateral force-resisting system	$h \le 35$ (11)	Allowed			Not allowed
Interior, not part of the lateral force-resisting system, in buildings other than enclosed[A]	$h > 180$ (55)	Not allowed			
	60 (18) < $h \le 180$ (55)	Allowed	Not allowed		
	35 (11) < $h \le 60$ (18)	Allowed		Not allowed	
	$h \le 35$ (11)	Allowed			Not allowed
Exterior, not part of the lateral force-resisting system	$h > 180$ (55)	Not allowed			
	60 (18) < $h \le 180$ (55)	Allowed	Not allowed		
	35 (11) < $h \le 60$ (18)	Allowed 2005		Not allowed	
Exterior	$h \le 35$ (11)	Allowed			Not allowed

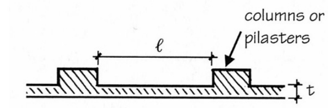
[A] Per *Minimum Design Loads for Buildings and Other Structures*, ASCE 7 (ref. 4).

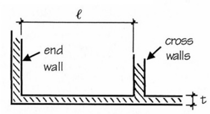
Minimum wall thickness
- for one story t ≥ 6” thick (also for shear walls)
- for more than one story t ≥ 8” thick
- t min for unreinforced foundation wall is 8”

Empirical Design of Concrete Masonry Walls

Lateral Support

- horizontal direction
  - cross walls
  - pilasters
  - buttresses
  - structural frame members
- vertical direction
  - floor diaphragms
  - roof diaphragms
  - structural frame members
- maximum interval of support
  - see tables 2 & 3





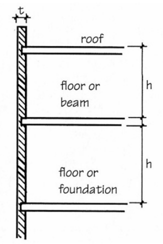
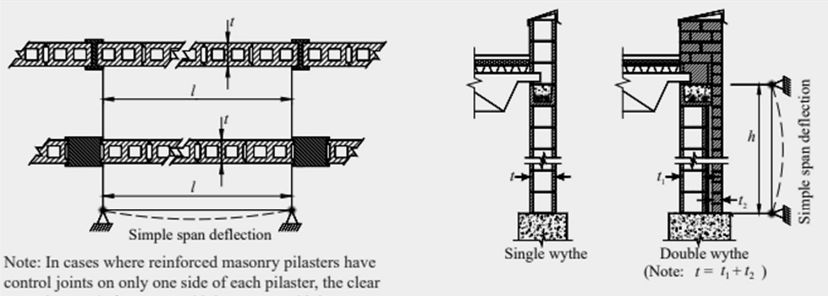


Table 2—Wall Lateral Support Requirements (ref. 1)

Construction (unreinforced)	Maximum wall length-to thickness or height-to thickness ratio[A]
Bearing walls	
Solid units or solid grouted	20
All others	18
Nonbearing walls	
Exterior	18
Interior	36
Cantilever walls[B]	
Solid	6
Hollow	4
Parapets (8-in. (203-mm) thick min.)[B]	3

[A] Ratios are determined using nominal dimensions. For multi-wythe walls where wythes are bonded by masonry headers, the thickness is the nominal wall thickness. When multiwythe walls are bonded by metal wall ties, the thickness is taken as the sum of the wythe thicknesses. Note that Reference 6 includes modified requirements for walls with openings.

[B] The ratios are maximum height-to-thickness ratios and do not limit wall length.



Note: In cases where reinforced masonry pilasters have control joints on only one side of each pilaster, the clear span, l, extends from control joint to control joint.

Where:
h = clear span between supports
l = horizontal span
t = nominal wall thickness
t_1, t_2 = nominal wythe thicknesses

Figure 1—Lateral Support of Empirically Designed (Unreinforced) Concrete Masonry Walls

Table 3—Maximum Unreinforced Wall Spans, ft (m)[A]

Wall thickness, in. (mm)	6 (152)	8 (203)	10 (254)	12 (305)
Bearing walls				
Solid or solid grouted	10 (3.0)[B]	13.3 (4.1)	16.6 (5.1)	20 (6.1)
All other	9 (2.7)[B]	12 (3.7)	15 (4.5)	18 (5.5)
Nonbearing walls				
Exterior	9 (2.7)	12 (3.7)	15 (4.5)	18 (5.5)
Interior	18 (5.5)	24 (7.3)	30 (9.1)	36 (11)
Cantilever Walls[C]				
Solid	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Hollow	2 (0.6)	2.6 (0.8)	3.3 (1.0)	4 (1.2)
Parapets[C]	1.5 (0.5)	2 (0.6)	2.5 (0.8)	3 (0.9)

[A] Note that Ref. 6 includes modified requirements for walls with openings.

[B] Unreinforced 6-in. (152-mm) thick bearing walls are limited to one story in height.

[C] For these cases, spans are maximum wall heights.

Empirical Design of Concrete Masonry Walls

Allowable Compressive Stress

- solid or fully grouted
  - based on full gross area
- hollow units
  - use correct area - voids
  - most new CMU will be ASTM C90 2006 or later
  - older units use "previous editions"

Table 4—Allowable Compressive Stress for Empirical Design of Masonry

Gross area compressive strength of unit, psi (MPa)	Allowable compressive stresses based on gross cross-sectional area, psi (MPa)[A] Type M or S mortar	Type N mortar
Solid and Solidly Grouted Masonry (refs. 1, 6):		
Solid concrete brick:		
8,000 (55) or greater	350 (2.41)	300 (2.07)
4,500 (31)	225 (1.55)	200 (1.38)
2,500 (17)	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)
Grouted concrete masonry:		
4,500 (31) or greater	225 (1.55)	200 (1.38)
2,500 (17)	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)
Solid concrete masonry units:		
3,000 (21) or greater	225 (1.55)	200 (1.38)
2,000 (14)	160 (1.10)	140 (0.97)
1,200 (8.3)	115 (0.79)	100 (0.69)
Hollow walls (noncomposite masonry bonded[B]):		
Solid units:		
2,500 (17) or greater	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)
Hollow Unit Masonry (Units Complying With ASTM C 90-06 or Later) (ref. 6)[C]:		
Hollow loadbearing CMU, $t \leq 8$ in. (203 mm)[D]:		
2,000 (14) or greater	140 (0.97)	120 (0.83)
1,500 (10)	115 (0.79)	100 (0.69)
1,000 (6.9)	75 (0.52)	70 (0.48)
700 (4.8)	60 (0.41)	55 (0.38)
Hollow loadbearing CMU, 8 in. $< t <$ 12 in. (203 to 305 mm)[D]:		
2,000 (14) or greater	125 (0.86)	110 (0.76)
1,500 (10)	105 (0.72)	90 (0.62)
1,000 (6.9)	65 (0.49)	60 (0.41)
700 (4.8)	55 (0.38)	50 (0.35)
Hollow loadbearing CMU, $t \geq 12$ in (305 mm)[D]:		
2,000 (14) or greater	115 (0.79)	100 (0.69)
1,500 (10)	95 (0.66)	85 (0.59)
1,000 (6.9)	60 (0.41)	55 (0.38)
700 (4.8)	50 (0.35)	45 (0.31)
Hollow walls (noncomposite masonry bonded[B]):		
$t \leq 8$ in. (203 mm)[D]	75 (0.52)	70 (0.48)
$8 < t < 12$ in (203 to 305 mm)[D]	70 (0.48)	65 (0.45)
$t \geq 12$ in (305 m.m)[D]	60 (0.41)	55 (0.38)
Hollow Unit Masonry (Units Complying With Previous Editions of ASTM C 90) (ref. 1)[C]:		
Hollow concrete masonry units:		
2,000 (14) or greater	140 (0.97)	120 (0.83)
1,500 (10)	115 (0.79)	100 (0.69)
1,000 (6.9)	75 (0.52)	70 (0.48)
700 (4.8)	60 (0.41)	55 (0.38)
Hollow walls (noncomposite masonry bonded[B]):		
Hollow units	75 (0.52)	70 (0.48)

[A] Linear interpolation for intermediate values of compressive strength is permitted.

[B] Where floor and roof loads are carried on one wythe, the gross cross-sectional area is that of the wythe under load; if both wythes are loaded, the gross cross-sectional area is that of the wall minus the area of the cavity between the wythes. Walls bonded with metal ties shall be considered as noncomposite walls unless collar joints are filled with mortar or grout.

[C] Minimum unit face shell thicknesses, for units 10 in. (254 mm) and greater in width, were reduced beginning with ASTM C 90-06. Hence, minimum allowable compressive stresses should be reduced accordingly when using these units. See text for further information.

[D] t = nominal unit thickness.

Empirical Design of Concrete Masonry Walls

Allowable Compressive Stress

- solid or fully grouted
  - based on full gross area
- hollow units
  - use correct area - voids
  - most new CMU will be ASTM C90 2006 or later
  - older units use "previous editions"

Table 4—Allowable Compressive Stress for Empirical Design of Masonry

Gross area compressive strength of unit, psi (MPa)	Allowable compressive stresses based on gross cross-sectional area, psi (MPa)[A] Type M or S mortar	Type N mortar
Solid and Solidly Grouted Masonry (refs. 1, 6):		
Solid concrete brick:		
8,000 (55) or greater	350 (2.41)	300 (2.07)
4,500 (31)	225 (1.55)	200 (1.38)
2,500 (17)	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)
Grouted concrete masonry:		
4,500 (31) or greater	225 (1.55)	200 (1.38)
2,500 (17)	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)
Solid concrete masonry units:		
3,000 (21) or greater	225 (1.55)	200 (1.38)
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Hollow walls (noncomposite masonry bonded[B]):		
Solid units:		
2,500 (17) or greater	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)
Hollow Unit Masonry (Units Complying With ASTM C 90-06 or Later) (ref. 6)[C]:		
Hollow loadbearing CMU, $t \le 8$ in. (203 mm)[D]:		
2,000 (14) or greater	140 (0.97)	120 (0.83)
1,500 (10)	115 (0.79)	100 (0.69)
1,000 (6.9)	75 (0.52)	70 (0.48)
700 (4.8)	60 (0.41)	55 (0.38)
Hollow loadbearing CMU, 8 in. $< t <$ 12 in. (203 to 305 mm)[D]:		
2,000 (14) or greater	125 (0.86)	110 (0.76)
1,500 (10)	105 (0.72)	90 (0.62)
1,000 (6.9)	65 (0.49)	60 (0.41)
700 (4.8)	55 (0.38)	50 (0.35)
Hollow loadbearing CMU, $t \ge$ 12 in (305 mm)[D]:		
2,000 (14) or greater	115 (0.79)	100 (0.69)
1,500 (10)	95 (0.66)	85 (0.59)
1,000 (6.9)	60 (0.41)	55 (0.38)
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Hollow walls (noncomposite masonry bonded[B]):		
$t \le 8$ in. (203 mm)[D]	75 (0.52)	70 (0.48)
$8 < t < 12$ in (203 to 305 mm)[D]	70 (0.48)	65 (0.45)
$t \ge 12$ in (305 m.m)[D]	60 (0.41)	55 (0.38)
Hollow Unit Masonry (Units Complying With Previous Editions of ASTM C 90) (ref. 1)[C]:		
Hollow concrete masonry units:		
2,000 (14) or greater	140 (0.97)	120 (0.83)
1,500 (10)	115 (0.79)	100 (0.69)
1,000 (6.9)	75 (0.52)	70 (0.48)
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Hollow walls (noncomposite masonry bonded[B]):		
Hollow units	75 (0.52)	70 (0.48)

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[D] t = nominal unit thickness.

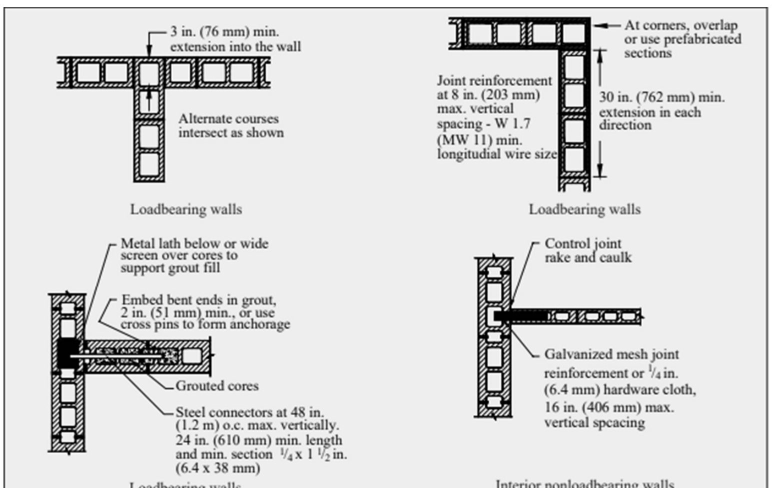
Empirical Design of Concrete Masonry Walls

Anchorage requirements for lateral support of bracing walls

- see figure 2

Anchorage to structural frames

- ½" bolts at max. 4 ft o.c.
- 4" embedment length in masonry



Note: Other metal ties, joint reinforcement or anchors may be used, provided they are spaced to provide an equivalent area of anchorage.

Figure 2—Empirical Anchorage Requirements for Lateral Support of Intersecting Masonry Walls

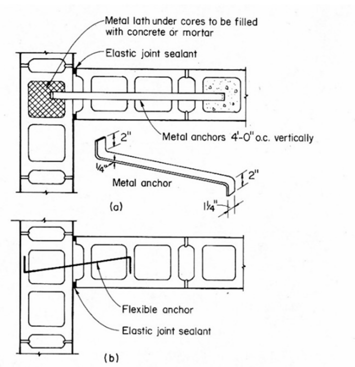


Fig. 4-46. Flexible connections for intersecting walls.

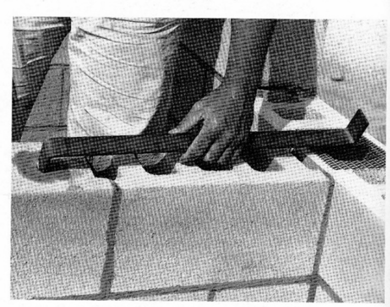
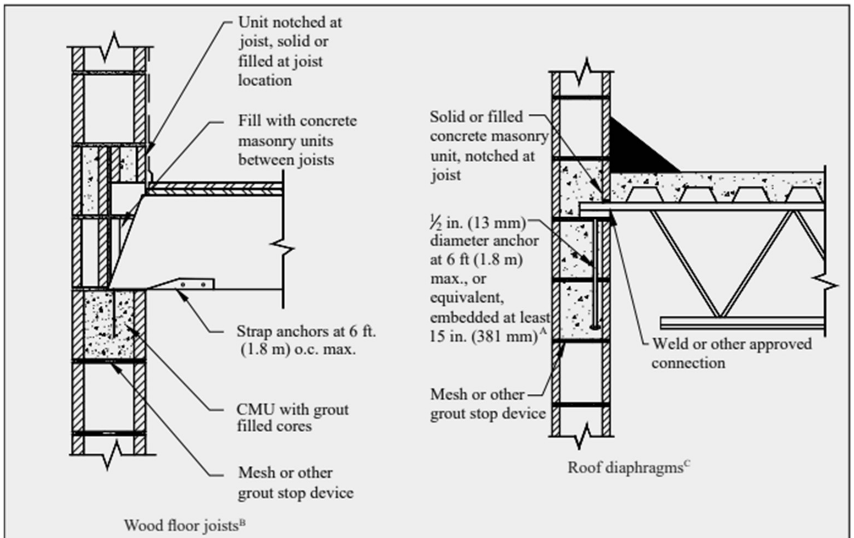


Fig. 4-47. Steel tiebar provides lateral support to wall at right.

Empirical Design of Concrete Masonry Walls

Anchorage requirements for floor and roof diaphragms

- see figure



Notes:

[A] As an alternative, the bolts can be hooked or welded to at least 0.2 in.^{2} (No. 4, M#13) of bond beam reinforcement placed at least 6 in. (152 mm) from the top of the wall.

[B] Wood joists anchored parallel to masonry walls require metal straps which extend over or under the joists and which are secured to at least three joists. Anchors must be spaced at a maximum of 6 ft (1.8 m). Blocking is required between joists at each strap anchor.

[C] Steel floor joists which bear on and are anchored to masonry walls require $^3/_8$ in. (9.5 mm) reinforcing bars spaced a maximum of 6 ft (1.8 m) on center, or equivalent anchorage. Where joists are parallel to the wall, anchors must be located at joist cross bridging.

[D] Refer to TEK 5-7A, *Floor and Roof Connections to Concrete Masonry Walls* (ref. 10) for other types of connections. Note that elements such as flashing, weeps, insulation, etc. are not shown for clarity.

Figure 3—Empirical Anchorage Requirements for Floor and Roof Diaphragms[D]

Empirical Design of Concrete Masonry Walls

Shear walls

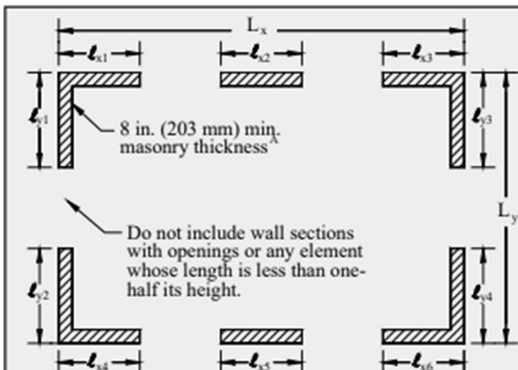
- Spacing
  - minimum cumulative length = 40% of building length (Figure 4)
  - shear wall must be longer than ½ its height

Maximum diaphragm ratios

- shear walls spaced so that the length-to-width ratio of each diaphragm transferring lateral forces to the shear wall does not exceed the values in Table 5

Table 5—Shear Wall Diaphragm Length-to-Width Ratios (ref. 1)

Floor or roof diaphragm construction	Maximum length-to-width ratio of diaphragm panel
Cast-in-place concrete	5:1
Precast concrete	4:1
Metal deck with concrete fill	3:1
Metal deck with no fill	2:1
Wood diaphragm	2:1



In x-direction,
cumulative shear wall length = $l_{x1} + l_{x2} + ... + l_{xn}$
In y-direction,
cumulative shear wall length = $l_{y1} + l_{y2} + ... + l_{yn}$
In each direction, cumulative shear wall length must exceed the larger of $0.4L_x$ and $0.4L_y$ [B]

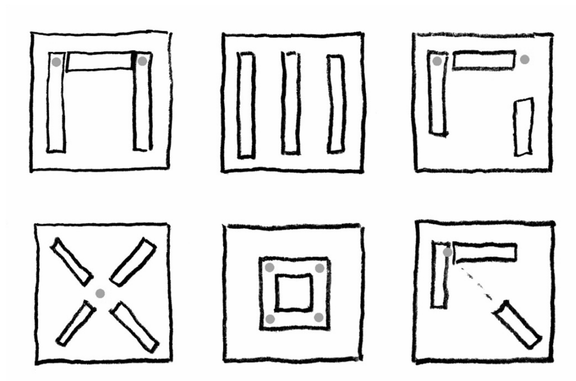
[A] Note that the 2003 IBC allows shear walls of one-story buildings to have a minimum thickness of 6 in. (152 mm).

[B] Note that in the 2008 *Building Code Requirements for Masonry Structures*, this criteria is: In each direction, cumulative shear wall length must exceed the larger of $0.2L_x$ and $0.2L_y$

Figure 4—Empirically Designed Shear Wall Requirements

Empirical Design of Concrete Masonry Walls

Lateral Force Resistance



Stability requires at least 2 points of intersection.

Force is more evenly resisted with centroid of walls in the kern of slab

Empirical Design of Concrete Masonry Walls

Bonding of Multiwythe Walls

- masonry headers – solid units
  - 4% of wall surface
  - extend 3” min. into backing wall
  - or overlap from both sides by 3”
  - max. distance between = 24”
- masonry headers – hollow units
  - vertical intervals of min. 34”
  - with 3” overlap
- metal wall ties
  - wire size W2.8
  - one tie for each 4.5 ft^2 wall surface
  - adjustable ties each 1.77 ft^2 surface
  - max. vertical spacing = 24”
  - max horizontal spacing = 36”
  - hollow walls use rectangular ties
  - min. 2” hook at ends
- prefabricated joint reinforcement
  - 1 crosswire for each 2.67 ft^2 wall surface
  - max. vertical spacing = 24”
  - min. wire size = W1.7

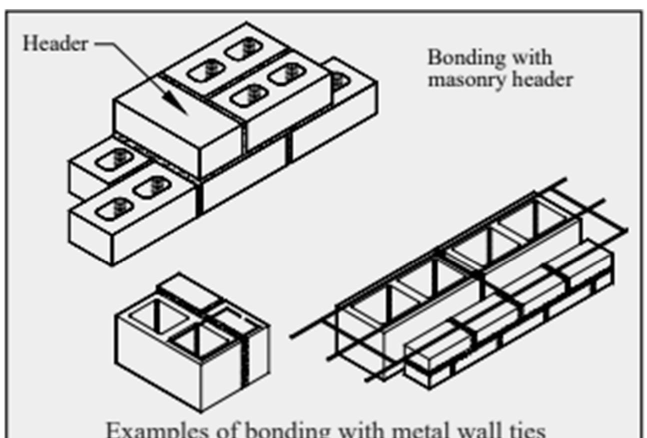


Figure 5—Types of Bonding

Empirical Design of Concrete Masonry Walls

Other details

- a change in wall thickness requires a grouted course in the thinner section to transfer load to the thicker section
- Chases and recesses in the wall > 12” require a lintel
- Lintel end bearing min. 4” (8” is typical)
- Do not support masonry walls on wood spanning members
- Corbelling – see Figure 6

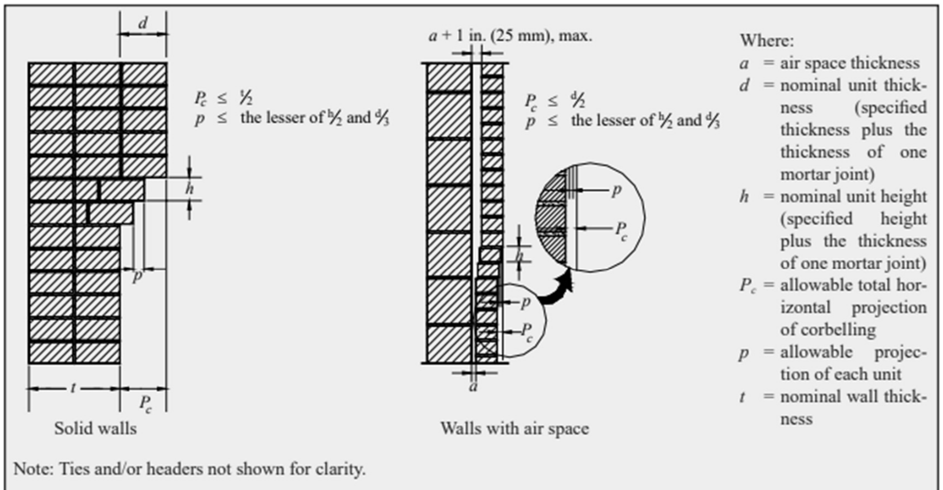


Figure 6—Prescriptive Requirements for Corbelling

Empirical Design of Concrete Masonry Walls

Interior Partition Walls

- must be isolated from load bearing structure
- gaps must be allowed (not filled with mortar) between partition wall and floor above to accommodate any deflection of the floor.

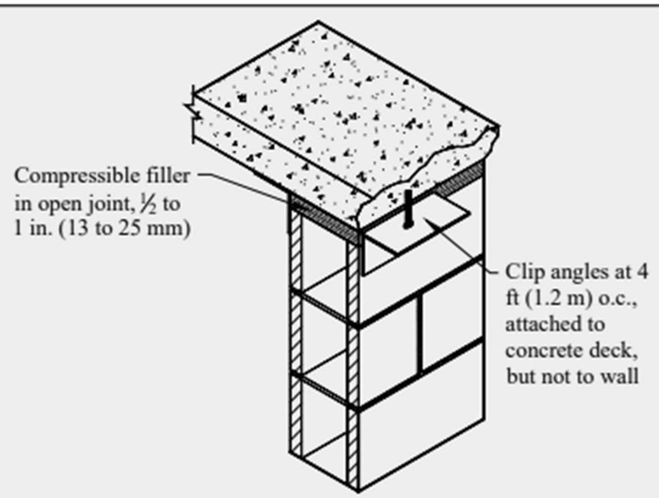
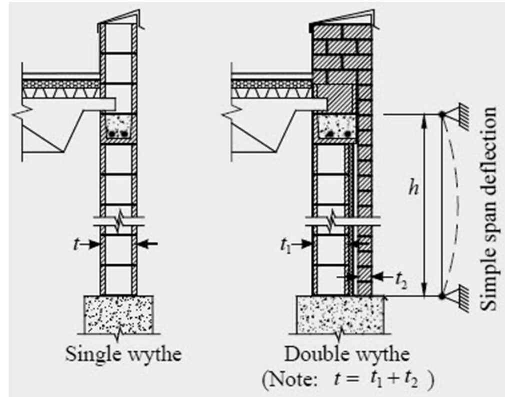


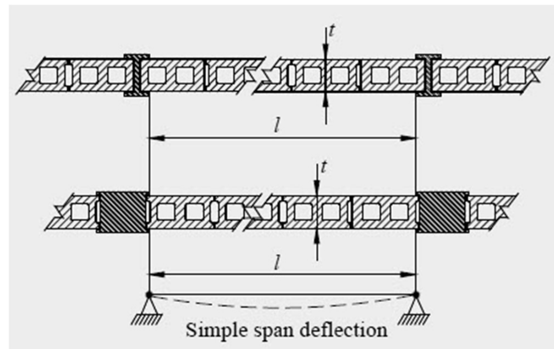
Figure 7—Example of Support for Empirically Designed Masonry Partition Wall

Empirical Concrete Masonry
Using TEK 14-8B (2006 IBC)

Given: location, geometry, material
Find: strength (load capacity)

1. Check axial loading – must be within middle 1/3
2. Check seismic category to be A, B, or C , or only A if part of the seismic lateral force resisting system.
3. Check wind speed (ASCE-7 2005) compare with table 1, TEK 14-8B
4. Check minimum thickness.
   1 story = 6” min.   2 story = 8” min.
5. Check lateral support (vertical or horizontal) tables 2 and 3 TEK 14-8B
6. Determine allowable compressive stress from table 4 TEK 14-8B
7. Allowable load = (stress) (gross area)





$$P = F \times A_g$$

Empirical Design Example

Given:
8” hollow non-reinforced CMU wall
Ann Arbor, Mich.
Interior
DL = 150 PSF

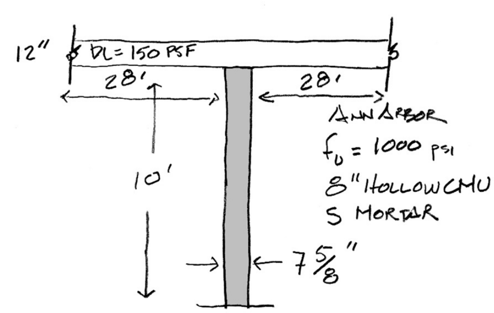
Find:
LL capacity

Checks:

Axially loaded :
loaded within middle 1/3 (kern)

Seismic Category:
A, B, or C , or only A if part of the seismic lateral force resisting system

Wind:
less that 90mph (by 2006 code)



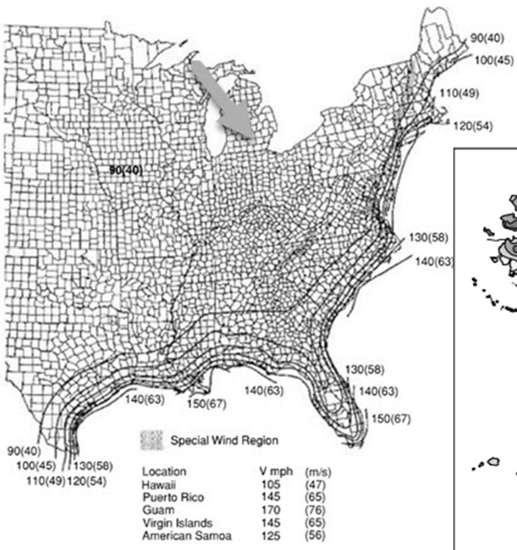
$A_g = 7.625 \times 12 = 91.5 \frac{in^2}{1}$

AXIAL LOADING ✓

FOR ANN ARBOR :
SDC → A ✓
WIND LOAD 90MPH < 110 ✓

Wind and Seismic Limits

Wind for Ann Arbor – 90 mph
SCD for Ann Arbor - Zones A



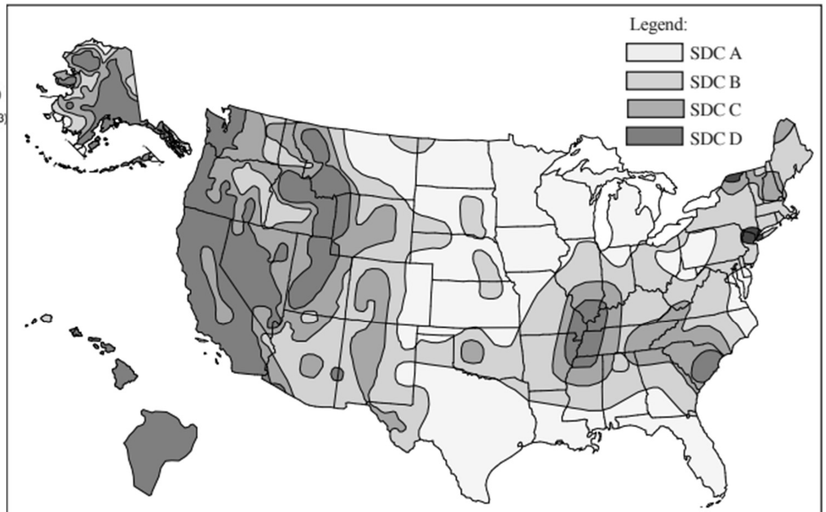


Figure 1—Seismic Design Categories for Site Class D, Seismic Use Group I and II, for a 0.2-Second Spectral Response Acceleration

Empirical Design Example

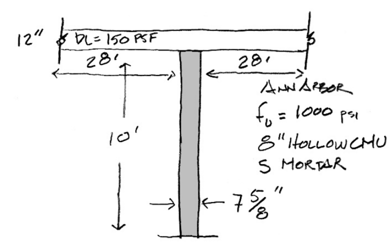
Checks:

Maximum height – table 1

MAX HEIGHT
TABLE 1 10' ✓

H/t (TABLE 2)
$\frac{120''}{8''} = 15 < 18$ ✓

MAX. UNREINF. HEIGHT
TABLE 3 → 10' < 12' ✓



$A_g = 7.625 \times 12 = 91.5 \frac{in^2}{'}$

Table 1—2006 IBC Empirical Design Limitations Based on Building Height and Basic Wind Speed[A]

Masonry wall type:	Building height, h, ft (m)	Basic wind speed, w, mph (m/s): $w \le 90$ ($w \le 40$)	$90 < w \le 100$ ($40 < w \le 45$)	$100 < w \le 110$ ($45 < w \le 49$)	$110 < w$ ($49 < w$)
Part of the lateral force-resisting system	$h \le 35$ (11)	Allowed			Not allowed
Interior, not part of the lateral force-resisting system, in buildings other than enclosed[A]	$h > 180$ (55)	Not allowed			
	$60\ (18) < h \le 180$ (55)	Allowed	Not allowed		
	$35\ (11) < h \le 60$ (18)	Allowed		Not allowed	
	$h \le 35$ (11)	Allowed			Not allowed
Exterior, not part of the lateral force-resisting system	$h > 180$ (55)	Not allowed			
	$60\ (18) < h \le 180$ (55)	Allowed	Not allowed		
	$35\ (11) < h \le 60$ (18)	Allowed		Not allowed	
Exterior	$h \le 35$ (11)	Allowed			Not allowed

[A] Per *Minimum Design Loads for Buildings and Other Structures*, ASCE 7 (ref. 4).

Empirical Design Example

Checks:

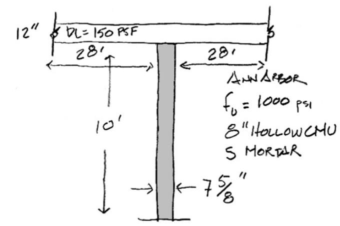
Minimum bracing – table 2

Maximum unreinforced height - table 3

MAX HEIGHT TABLE 1 10' ✓

H/t (TABLE 2) $\frac{120''}{8''} = 15 < 18$ ✓

MAX. UNREINF. HEIGHT TABLE 3 → 10' < 12' ✓



$A_g = 7.625 \times 12 = 91.5 \frac{in^2}{1}$

Table 2—Wall Lateral Support Requirements (ref. 1)

Construction (unreinforced)	Maximum wall length-to thickness or height-to thickness ratio[A]
Bearing walls	
Solid units or solid grouted	20
All others	18
Nonbearing walls	
Exterior	18
Interior	36
Cantilever walls[B]	
Solid	6
Hollow	4
Parapets (8-in. (203-mm) thick min.)[B]	3

Table 3—Maximum Unreinforced Wall Spans, ft (m)[A]

Wall thickness, in. (mm)	6 (152)	8 (203)	10 (254)	12 (305)
Bearing walls				
Solid or solid grouted	10 (3.0)[B]	13.3 (4.1)	16.6 (5.1)	20 (6.1)
All other	9 (2.7)[B]	12 (3.7)	15 (4.5)	18 (5.5)
Nonbearing walls				
Exterior	9 (2.7)	12 (3.7)	15 (4.5)	18 (5.5)
Interior	18 (5.5)	24 (7.3)	30 (9.1)	36 (11)
Cantilever Walls[C]				
Solid	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Hollow	2 (0.6)	2.6 (0.8)	3.3 (1.0)	4 (1.2)
Parapets [C]	1.5 (0.5)	2 (0.6)	2.5 (0.8)	3 (0.9)

[A] Note that Ref. 6 includes modified requirements for walls with openings.

Empirical Design Example

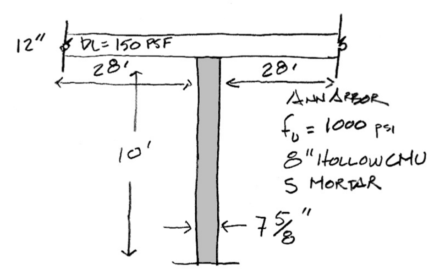
Find allowable stress – table 4

Find load
P = F Ag

Calculate per foot using gross Area

psi (Mpa) psi (Mpa)

Hollow Unit Masonry (Units Complying With ASTM C 90-06 or Later) (ref. 6)[C]:	Type M or S mortar	Type N mortar
Hollow loadbearing CMU, $t \leq 8$ in		
2,000 (14) or greater	140 (0.97)	120 (0.83)
1,500 (10)	115 (0.79)	100 (0.69)
1,000 (6.9)	75 (0.52)	70 (0.48)
700 (4.8)	60 (0.41)	55 (0.38)
Hollow loadbearing CMU, 8 in. < t < 12 in. (203 to 305 mm)[D]:		
2,000 (14) or greater	125 (0.86)	110 (0.76)
1,500 (10)	105 (0.72)	90 (0.62)
1,000 (6.9)	65 (0.49)	60 (0.41)
700 (4.8)	55 (0.38)	50 (0.35)
Hollow loadbearing CMU, $t \geq 12$ in (305 mm)[D]:		
2,000 (14) or greater	115 (0.79)	100 (0.69)
1,500 (10)	95 (0.66)	85 (0.59)
1,000 (6.9)	60 (0.41)	55 (0.38)
700 (4.8)	50 (0.35)	45 (0.31)
Hollow walls (noncomposite masonry bonded[B]):		
$t \leq 8$ in. (203 mm)[D]	75 (0.52)	70 (0.48)
8 < t < 12 in (203 to 305 mm)[D]	70 (0.48)	65 (0.45)
$t \geq 12$ in (305 m.m)[D]	60 (0.41)	55 (0.38)



$A_g = 7.625 \times 12 = 91.5 \frac{in^2}{1}$

TABLE 4 HOLLOW 8" f_u = 1000
TYPE S → 75 PSI

$P = F A_g = 75\,(7.625 \times 12)$
$= 6862 \,\#/1$

TRIBUTARY STRIP = 28'

$P = 6862 = DL(28') + LL(28')$
$= 150(28) + LL(28)$

LL = 95 PSF CAPACITY