

# Masonry

- TMS 402
- Rational Approach
- Empirical Approach



Chilehaus, Hamburg  
Arch: Fritz Höger, 1924

# Mortar Types

Types M, S, N, O

The following mortar designations took effect in the mid-1950's:

**M** a **S** o **N** w **O** r **K**  
strongest weakest



**Table 2-3. Guide to the Selection of Mortar Type\***

Location	Building segment	Mortar type	
		Recommended	Alternative
Exterior, above grade	Load-bearing walls	N	S or M
	Non-load-bearing walls	O**	N or S
	Parapet walls	N	S
Exterior, at or below grade	Foundation walls, retaining walls, manholes, sewers, pavements, walks, and patios	S†	M or N†
Interior	Load-bearing walls	N	S or M
	Non-load-bearing partitions	O	N

\*Adapted from ASTM C270. This table does not provide for specialized mortar uses, such as chimney, reinforced masonry, and acid-resistant mortars.

\*\*Type O mortar is recommended for use where the masonry is unlikely to be frozen when saturated or unlikely to be subjected to high winds or other significant lateral loads. Type N or S mortar should be used in other cases.

†Masonry exposed to weather in a nominally horizontal surface is extremely vulnerable to weathering. Mortar for such masonry should be selected with due caution.

Note: For tuckpointing mortar, see "Tuckpointing," Chapter 9.

*Relative Parts by Volume*

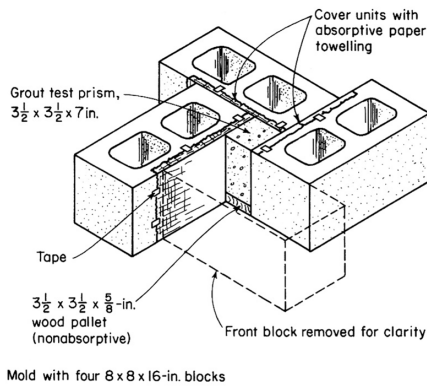
mortar type	Portland cement	lime	sand
M	1	$\frac{1}{4}$	$3\frac{1}{2}$
S	1	$\frac{1}{2}$	$4\frac{1}{2}$
N	1	1	6
O	1	2	9

sum should equal  $\frac{1}{3}$  of sand volume  
(assuming that sand has void ratio of 1 in 3)

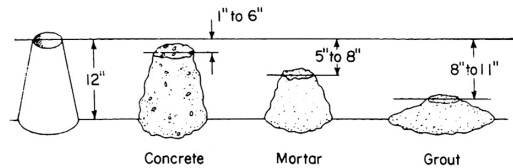
# Mortar Types

Type M, S, N, O

Slump is higher than cast concrete and based on workability



**Fig. 2-29.** ASTM C1019 method of using masonry units to form a prism for compression-testing of masonry grout.



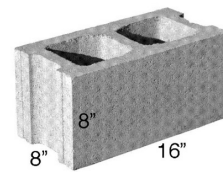
**Fig. 2-27.** Slump test comparison of concrete, mortar, and masonry grout.

# Masonry Strength

Masonry strength,  $f'_m$ , based on unit strength,  $f_u$ , and mortar type



Clay Masonry



Concrete Masonry

Required Net Area Compressive Strength of Clay Masonry Units (psi) $f_u$		$f'_m$ 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) $f_u$		$f'_m$ For Net Area Compressive Strength of Masonry (psi)
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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 <i>psi</i>	2000 <i>psi</i>
Type N mortar	$f'_m$	2440 <i>psi</i>	1750 <i>psi</i>
	$E_m$	$1.70 \times 10^6$ <i>psi</i>	$1.58 \times 10^6$ <i>psi</i>
Type M or S mortar	$f'_m$	2920 <i>psi</i>	2000 <i>psi</i>
	$E_m$	$2.05 \times 10^6$ <i>psi</i>	$1.80 \times 10^6$ <i>psi</i>

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	$\frac{0.7 \times 10^{-7}}{\text{psi}}$	$\frac{2.5 \times 10^{-7}}{\text{psi}}$

## 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



# Rational Masonry Analysis

Procedure

Strength Design (LRFD) – **non-reinforced**

# Rational Approach

for axial compression

using TMS 402 (2016)

Given: geometry, material

Find: axial compressive load capacity,  $P_n$

1. Determine the masonry strength,  $f'_m$ , based on unit strength,  $f_u$ , and mortar type (table)
2. Find the net area,  $A_n$ , and Moment of Inertia,  $I_n$  (see NCMA TEK 14-1B with HW problem pdf.)
3. Calculate radius of gyration,  $r = \sqrt{I/A}$
4. Calculate  $h/r$
5. Choose the axial strength equation,  $P_n$ :  
If  $h/r < 99$  use TMS 402 eq.9-11  
If  $h/r > 99$  use TMS 402 eq.9-12
6. Calculate  $\phi P_n$  where  $\phi$  for axial force = 0.90
7. Check that  $\phi P_n$  is greater than  $P_u$ .

(Equation 9-11) for  $h/r < 99$

$$P_n = 0.80 \left\{ 0.80 A_n f'_m \left[ 1 - \left( \frac{h}{140r} \right)^2 \right] \right\}$$

(Equation 9-12) for  $h/r > 99$

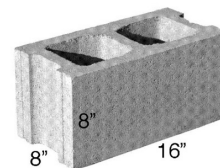
$$P_n = 0.80 \left[ 0.80 A_n f'_m \left( \frac{70r}{h} \right)^2 \right]$$

## Masonry Strength

Masonry strength,  $f'_m$ , based on unit strength,  $f_u$ , and mortar type



Clay Masonry



Concrete Masonry

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# Rational Masonry Analysis

Procedure

Strength Design – **non-reinforced**

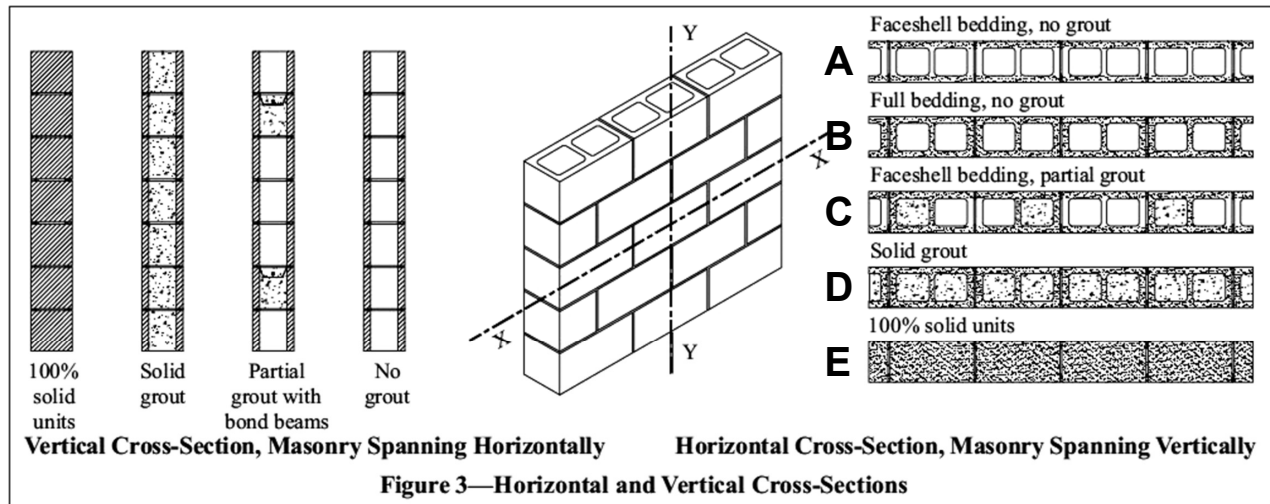
# Rational Approach

for axial compression

using TMS 402 (2016)

Section Properties of Concrete Masonry Walls NCMA TEK 14 – 1B

(attached to problem description, and also on Canvas, and on NCMA website)



# Rational Masonry Analysis

Procedure

Strength Design – **non-reinforced**

# Rational Approach

for axial compression

using TMS 402 (2016)

Section Properties of Concrete Masonry Walls NCMA TEK 14 – 1B

(attached to problem description and also on Canvas and on NCMA website)

**Table 3—8-inch (203-mm) Single Wythe Walls, 1¼ in. (32 mm) Face Shells (standard)**

<b>3a: Horizontal Section Properties (Masonry Spanning Vertically)</b>						
	Unit	Grout spacing (in.)	Mortar bedding	Net cross-sectional properties <sup>A</sup>		
				$A_n$ (in. <sup>2</sup> /ft)	$I_n$ (in. <sup>4</sup> /ft)	$S_n$ (in. <sup>3</sup> /ft)
<b>A</b>	Hollow	No grout	Face shell	30.0	308.7	81.0
<b>B</b>	Hollow	No grout	Full	41.5	334.0	87.6
<b>D/E</b>	100% solid/solidly grouted		Full	91.5	443.3	116.3
<b>C</b>	Hollow	16	Face shell	62.0	378.6	99.3
	Hollow	24	Face shell	51.3	355.3	93.2
	Hollow	32	Face shell	46.0	343.7	90.1
	Hollow	40	Face shell	42.8	336.7	88.3
	Hollow	48	Face shell	40.7	332.0	87.1
	Hollow	72	Face shell	37.1	324.3	85.0
	Hollow	96	Face shell	35.3	320.4	84.0
	Hollow	120	Face shell	34.3	318.0	83.4

# Rational Masonry Analysis

Example

Strength Design – **non-reinforced**

# Rational Approach

for axial compression

using TMS 402 (2016)

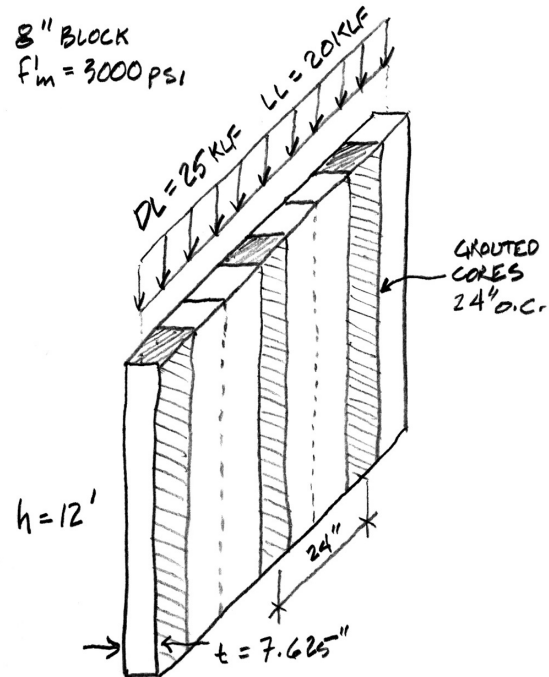
## Example Problem

Given: geometry: 8" block, grouted 24" o.c.  
material:  $f'_m = 3000$  psi

Find: check pass/fail for the given loading

1. Determine the masonry strength,  $f'_m$ , based on unit strength,  $f_u$ , and mortar type. (given  $f'_m = 3000$  psi)

Faceshell bedding, partial grout



# Rational Masonry Analysis

Example

Strength Design – **non-reinforced**

# Rational Approach

for axial compression

using TMS 402 (2016)

2. Find the net area,  $A_n$ , and Moment of Inertia,  $I_n$  (see NCMA TEK 14-1B)

Table 3—8-inch (203-mm) Single Wythe Walls, 1 $\frac{1}{4}$  in. (32 mm) Face Shells (standard)

3a: Horizontal Section Properties (Masonry Spanning Vertically)					
Unit	Grout spacing (in.)	Mortar bedding	Net cross-sectional properties <sup>A</sup>		
			$A_n$ (in. <sup>2</sup> /ft)	$I_n$ (in. <sup>4</sup> /ft)	$S_n$ (in. <sup>3</sup> /ft)
Hollow	No grout	Face shell	30.0	308.7	81.0
Hollow	No grout	Full	41.5	334.0	87.6
100% solid/solidly grouted		Full	91.5	443.3	116.3
Hollow	16	Face shell	62.0	378.6	99.3
Hollow	24	Face shell	51.3	355.3	93.2
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Hollow	48	Face shell	40.7	332.0	87.1
Hollow	72	Face shell	37.1	324.3	85.0
Hollow	96	Face shell	35.3	320.4	84.0
Hollow	120	Face shell	34.3	318.0	83.4

# Rational Masonry Analysis

Example

Strength Design – **non-reinforced**

3. Calculate  $r = \sqrt{I/A}$

TEK 14-1B 8" SINGLE WYTHE  
HOLLOW BLOCK - GROUTED 24" o.c. - FACE SHELL MORTAR  
 $A_n = 51.3 \text{ in}^2$   $I_n = 355.3 \text{ in}^4$  (NET)

4. Calculate  $h/r$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{355.3}{51.3}} = 1.952 \text{ in}$$

$$\frac{h}{r} = \frac{12'(12)}{1.952} = 73.75 < 99 \therefore \text{EQ 9-11}$$

5. Choose the axial strength equation,  $P_n$ :

If  $h/r < 99$  use TMS 402 eq.9-11

If  $h/r > 99$  use TMS 402 eq.9-12

(Equation 9-11) for  $h/r < 99$

$$P_n = 0.80 \left\{ 0.80 A_n f'_m \left[ 1 - \left( \frac{h}{140r} \right)^2 \right] \right\}$$

# Rational Masonry Analysis

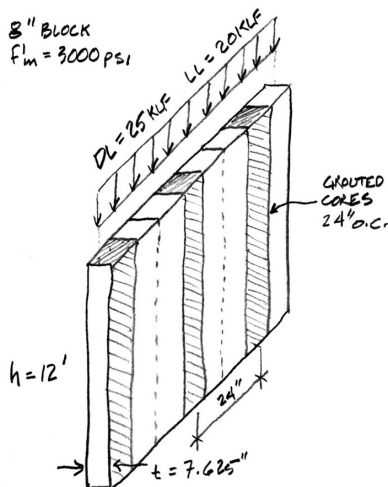
Strength Design – **non-reinforced**

Given: geometry: 8" block, grouted 24" o.c.

material:  $f'_m = 3000 \text{ psi}$

Area  $A_n = 51.3 \text{ in}^2/\text{ft}$

$r = 1.952 \text{ in}$



# Rational Approach

for axial compression

using TMS 402 (2016)

(Equation 9-11) for  $h/r < 99$

$$P_n = 0.80 \left\{ 0.80 A_n f'_m \left[ 1 - \left( \frac{h}{140r} \right)^2 \right] \right\}$$

$$P_n = 0.8 \left[ 0.8 A_n f'_m \left( 1 - \left( \frac{h}{140r} \right)^2 \right) \right]$$

$$P_n = 0.8 \left[ 0.8 (51.3) (3) \left( 1 - \left( \frac{144}{140(1.952)} \right)^2 \right) \right]$$

$$P_n = 0.8 [123.12 - 0.7223] = 71.4 \text{ K/FT}$$

$$\phi P_n = 0.9 (71.4) = 64 \text{ K/FT}$$

6. Calculate  $\phi P_n$

where  $\phi$  for axial force = 0.90

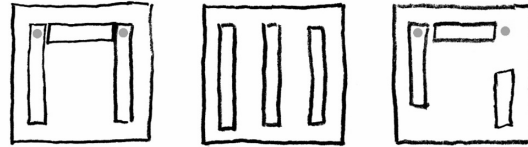
7. Check that  $\phi P_n$  is greater than  $P_u$ .

$$P_u = 1.2(25) + 1.6(20) = 62 \text{ K/FT}$$

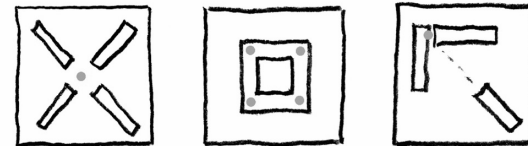
$$P_u = 62 \text{ K/FT} < 64 \text{ K/FT} = \phi P_n \therefore \text{OK} \checkmark$$

# Lateral Force Resistance

Stability requires at least 2 points of intersection.



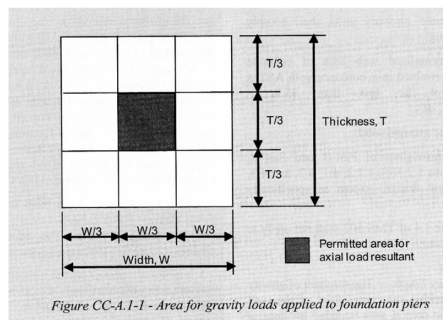
Force is more evenly resisted with centroid of walls in the kern of slab



## Empirical Approach

TMS 402-16 Tab. CC A.1.1  
Checklist for use of empirical design

foundation:



### COMMENTARY

Table CC-A.1.1 — Checklist for use of Appendix A – Empirical Design of Masonry

1.	Risk Category IV structures, or portions thereof, are not permitted to be designed using Appendix A.		
2.	Partitions are not permitted to be designed using Appendix A.		
3.	Use of empirical design is limited based on Seismic Design Category, as described in the following table.		
	Seismic Design Category	Participating Walls	Non-Participating Walls, except partition walls
	A	Allowed by Appendix A	Allowed by Appendix A
	B	Not Allowed	Allowed by Appendix A
	C	Not Allowed	With prescriptive reinforcement per 7.4.3.1 <sup>1</sup>
	D, E, and F	Not Allowed	Not Allowed
	<sup>1</sup> Lap splices are required to be designed and detailed in accordance with the requirements of Chapters 8 or 9.		
4.	Use of empirical design is limited based on wind speed at the project site, as described in Code A.1.2.3 and Code Table A.1.1.		
5.	If wind uplift on roofs result in net tension, empirical design is not permitted (A.8.3.1).		
6.	Loads used in the design of masonry must be listed on the design drawings (1.2.1b).		
7.	Details of anchorage to structural frames must be included in the design drawings (1.2.1e).		
8.	The design is required to include provisions for volume change (1.2.1h). The design drawings are required to include the locations and sizing of expansion, control, and isolation joints.		
9.	If walls are connected to structural frames, the connections and walls are required to be designed to resist the interconnecting forces and to accommodate deflections (4.4).  This provision requires a lateral load and uplift analysis for exterior walls that receive wind load and are supported by or are supporting a frame or roofing system.		
10.	Masonry not laid in running bond (for example, stack bond masonry) is required to have horizontal reinforcement (4.5).		
11.	A project quality assurance plan is required (3.1) with minimum requirements given in TMS 602 Tables 3 and 4 for Quality Assurance Level 1.		
12.	The resultant of gravity loads must be determined and assured to be located within certain limitations for walls and piers (A.1.2.1).		
13.	Ensure compliance of the design with prescriptive floor, roof, and wall-to-structural framing anchorage requirements, as well as other anchorage requirements (A.8.3 and A.8.4).		
14.	Type N mortar is not permitted for foundation walls (A.6.3.1(g)).		
15.	Design shear wall lengths, spacings, and orientations to meet the requirements of Code A.3.1.		

# Empirical Approach

## Risk Categories:

ASCE – 7

category IV is “not permitted”  
with empirical approach

**Table 1.5-1 Risk Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads**

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent low risk to human life in the event of failure	I
All buildings and other structures except those listed in Risk Categories I, III, and IV	II
Buildings and other structures, the failure of which could pose a substantial risk to human life	III
Buildings and other structures, not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure	IV
Buildings and other structures not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released <sup>a</sup>	
Buildings and other structures designated as essential facilities	IV
Buildings and other structures, the failure of which could pose a substantial hazard to the community	
Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released <sup>a</sup>	
Buildings and other structures required to maintain the functionality of other Risk Category IV structures	IV

# Empirical Approach

## Wind limitations:

Basic wind speed  $\leq 115$  mph  
(see TMS 402-16 Tab. A.1.1)

## Seismic limitations:

Can generally be used for Seismic Design Category (SDC) A, B, or C, or only A if part of the seismic lateral force resisting system.

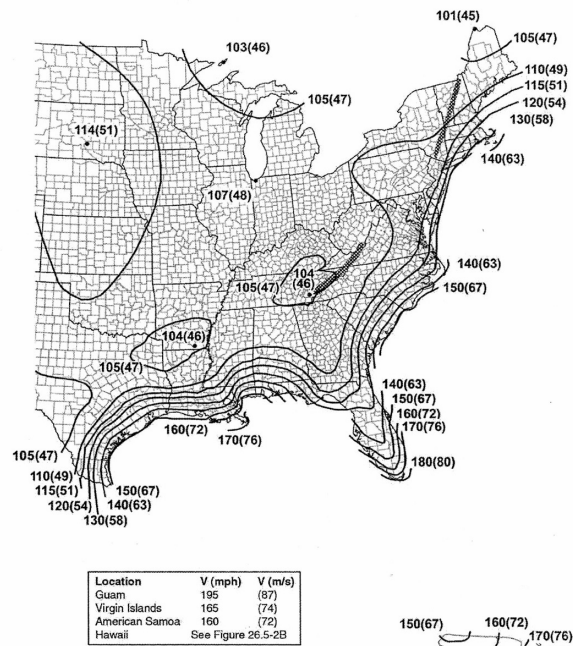
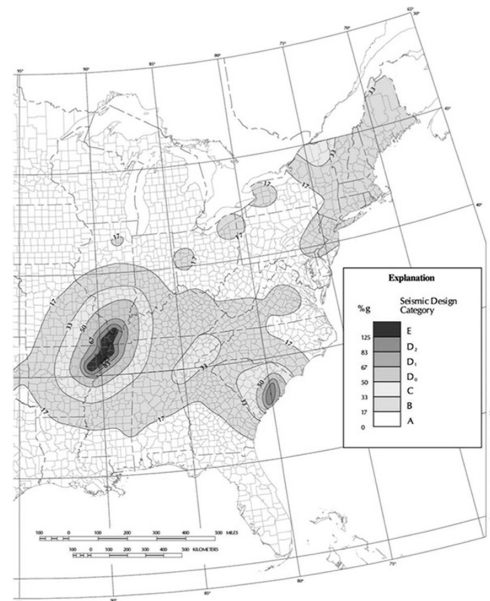


FIGURE 26.5-1B (Continued). Basic Wind Speeds for Risk Category II Buildings and Other Structures



Seismic zones A - E

# Empirical Design of Masonry

TMS 402-16

## Height limits by wind speed and application

**Table A.1.1 Limitations based on building height and basic wind speed**

Element Description	Building Height, ft (m)	Basic Wind Speed, mph (mps) <sup>1</sup>			
		Less than or equal to 115 (51)	Over 115 (51) and less than or equal to-120 (54)	Over 120 (54) and less than or equal to 125 (56)	Over 125 (56)
Masonry elements that are part of the lateral-force-resisting system	35 (11) and less	Permitted			Not Permitted
Interior masonry loadbearing elements that are not part of the lateral-force-resisting system in buildings other than enclosed as defined by ASCE 7	Over 180 (55)	Not Permitted			
	Over 60 (18) and less than or equal to 180 (55)	Permitted	Not Permitted		
	Over 35 (11) and less than or equal to 60 (18)	Permitted		Not Permitted	
	35 (11) and less	Permitted			Not Permitted
Exterior masonry elements that are not part of the lateral-force-resisting system	Over 180 (55)	Not Permitted			
	Over 60 (18) and less than or equal to 180 (55)	Permitted	Not Permitted		
	Over 35 (11) and less than or equal to 60 (18)	Permitted		Not Permitted	
Exterior masonry elements	35 (11) and less	Permitted			Not Permitted

<sup>1</sup>Basic wind speed as given in ASCE 7

## Empirical Design of Masonry TEK 14-8B (also TMS 402 – Tab. A.5.1) International Building Code (IBC) Limitations:

1. Lateral support requirements
2. Location of gravity load (in middle 1/3 of wall)
3. Maximum unreinforced spans

Table 2—Wall Lateral Support Requirements (ref. 1)		Table 3—Maximum Unreinforced Wall Spans, ft (m) <sup>A</sup>				
Construction (unreinforced)	Maximum wall length-to-thickness or height-to-thickness ratio <sup>A</sup>	Wall thickness, in. (mm)	6 (152)	8 (203)	10 (254)	12 (305)
Bearing walls		Bearing walls				
Solid units or solid grouted	20	Solid or solid grouted	10 (3.0) <sup>B</sup>	13.3 (4.1)	16.6 (5.1)	20 (6.1)
All others	18	All other	9 (2.7) <sup>B</sup>	12 (3.7)	15 (4.5)	18 (5.5)
Nonbearing walls		Nonbearing walls				
Exterior	18	Exterior	9 (2.7)	12 (3.7)	15 (4.5)	18 (5.5)
Interior	36	Interior	18 (5.5)	24 (7.3)	30 (9.1)	36 (11)
Cantilever walls <sup>B</sup>		Cantilever Walls <sup>C</sup>				
Solid	6	Solid	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Hollow	4	Hollow	2 (0.6)	2.6 (0.8)	3.3 (1.0)	4 (1.2)
Parapets (8-in. (203-mm) thick min.) <sup>B</sup>	3	Parapets <sup>C</sup>	1.5 (0.5)	2 (0.6)	2.5 (0.8)	3 (0.9)

<sup>A</sup> Ratios are determined using nominal dimensions. For multiwythe 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.

<sup>B</sup> The ratios are maximum height-to-thickness ratios and do not limit wall length.

<sup>A</sup> Note that Ref. 6 includes modified requirements for walls with openings.

<sup>B</sup> Unreinforced 6-in. (152-mm) thick bearing walls are limited to one story in height.

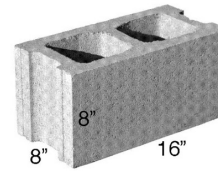
<sup>C</sup> For these cases, spans are maximum wall heights.

# Masonry Strength

Masonry strength,  $f'_m$ , based on unit strength,  $f_u$ , and mortar type



Clay Masonry



Concrete Masonry

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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)

## Empirical Design of Masonry TEK 14-8B (also TMS 402 – Tab. A.4.2)

Allowable compressive stress of concrete masonry:

### Solid or solidly grouted walls

Gross area compressive strength of unit, psi (MPa)	Allowable compressive stresses based on gross cross-sectional area, psi (MPa) <sup>A</sup>	
	Type M or S mortar	Type N mortar
<b>Solid and Solidly Grouted Masonry (refs. 1, 6):</b>		
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 <sup>B</sup> ):		
Solid units:		
2,500 (17) or greater	160 (1.10)	140 (0.97)
1,500 (10)	115 (0.79)	100 (0.69)

### Hollow unit walls

Gross area compressive strength of unit, psi (MPa)	Allowable compressive stresses based on gross cross-sectional area, psi (MPa) <sup>A</sup>	
	Type M or S mortar	Type N mortar
<b>Hollow Unit Masonry (Units Complying With ASTM C 90-06 or Later) (ref. 6)<sup>C</sup>:</b>		
Hollow loadbearing CMU, $t \leq 8$ in. (203 mm) <sup>D</sup> :		
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) <sup>D</sup> :		
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) <sup>D</sup> :		
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 <sup>B</sup> ):		
$t \leq 8$ in. (203 mm) <sup>D</sup>		
	75 (0.52)	70 (0.48)
$8 < t < 12$ in. (203 to 305 mm) <sup>D</sup>		
	70 (0.48)	65 (0.45)
$t \geq 12$ in. (305 mm) <sup>D</sup>		
	60 (0.41)	55 (0.38)

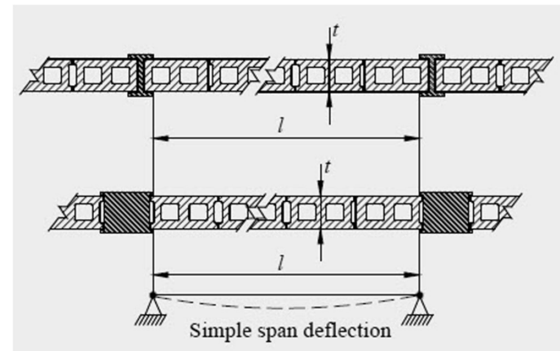
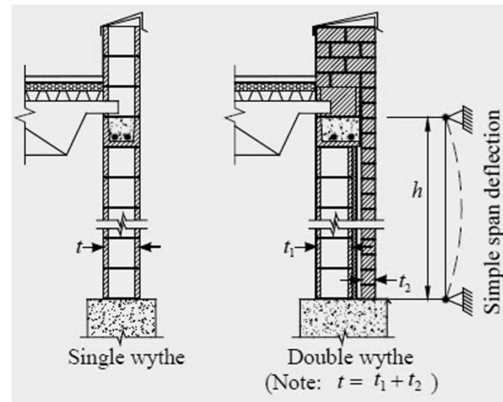
# Empirical Concrete Masonry

Procedure using TMS 402 - 2016

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 2016) compare with Tab. A.1.1
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 or TMS 402 – Tab. A.5.1
6. Determine allowable compressive stress from table 4 TEK 14-8B or TMS 402 – Tab. A.4.2
7. Allowable load = (stress) (gross area)  
(not LRFD so no  $\gamma$  factors)



$$P = F \times A_g$$

## Empirical Analysis Example

Given:

8" hollow non-reinforced CMU wall  
interior wall, Ann Arbor, Mich.

DL = 150 psf

Find:

LL capacity

Checks:

Axially loaded :

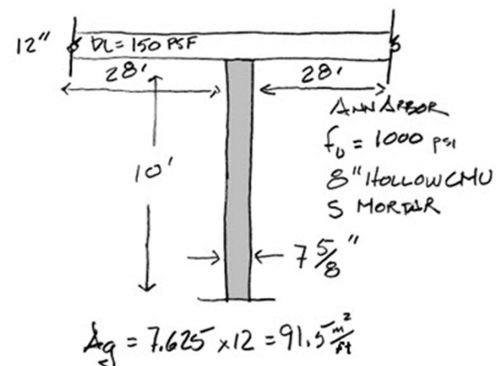
loaded within middle 1/3 (kern)

Seismic Category:

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

Wind:

less that 115 mph (ASCE 7 - 2016)



AXIAL LOADING ✓

FOR ANN ARBOR :

SDC → A ✓

WIND LOAD 107 mph < 115 ✓

# Wind and Seismic Limits

Wind for Ann Arbor – 107 mph  
SCD for Ann Arbor - Zones A

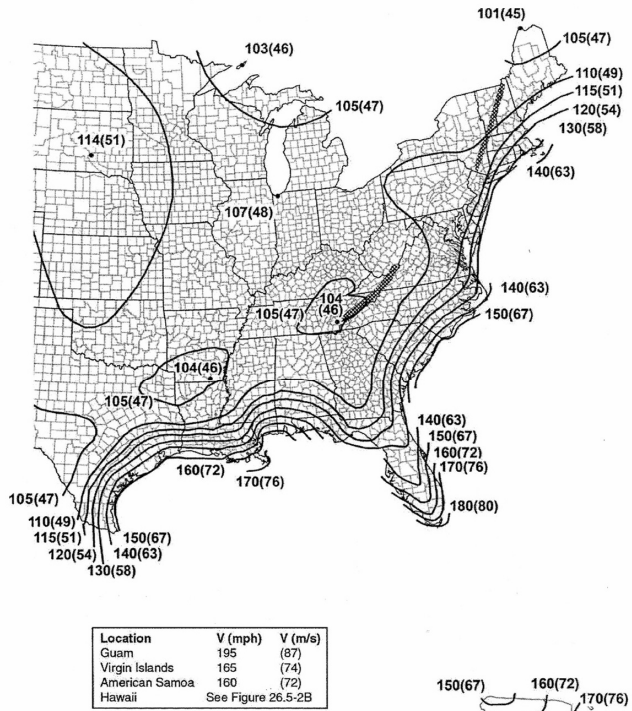
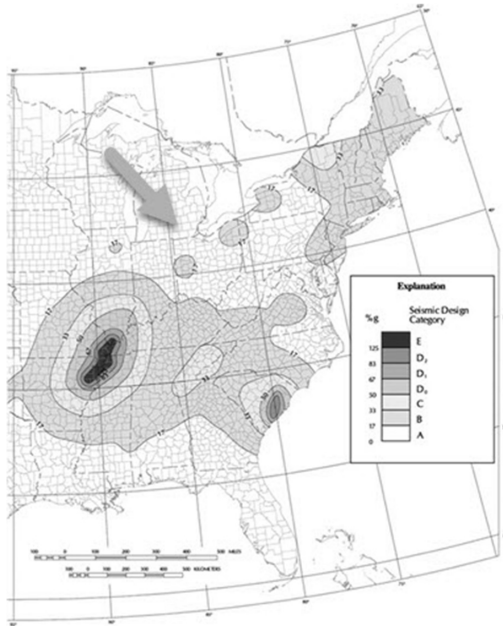


FIGURE 26.5-1B (Continued), Basic Wind Speeds for Risk Category II Buildings and Other Structures

## Empirical Analysis Example

Checks:

Maximum height – Table A.1.1

- wind speed = 107 mph
- interior, loadbearing
- $h < 35$  ft

MAX HEIGHT  
TABLE 1 10' ✓

H/e (TABLE 2)  
 $\frac{120''}{8} = 15 < 18$  ✓

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

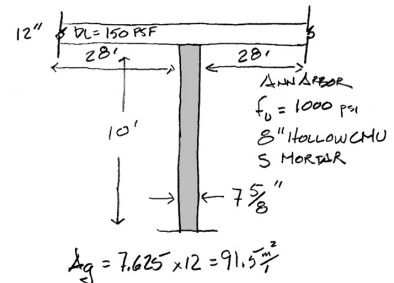


Table A.1.1 Limitations based on building height and basic wind speed

Element Description	Building Height, ft (m)	Basic Wind Speed, mph (mps) <sup>1</sup>			
		Less than or equal to 115 (51)	Over 115 (51) and less than or equal to 120 (54)	Over 120 (54) and less than or equal to 125 (56)	Over 125 (56)
Masonry elements that are part of the lateral-force-resisting system	35 (11) and less	Permitted			Not Permitted
Interior masonry loadbearing elements that are not part of the lateral-force-resisting system in buildings other than enclosed as defined by ASCE 7	Over 180 (55)	Not Permitted			
	Over 60 (18) and less than or equal to 180 (55)	Permitted	Not Permitted		
	Over 35 (11) and less than or equal to 60 (18)	Permitted		Not Permitted	
Exterior masonry elements that are not part of the lateral-force-resisting system	35 (11) and less	Permitted	Permitted		Not Permitted
	Over 180 (55)	Not Permitted			
	Over 60 (18) and less than or equal to 180 (55)	Permitted	Not Permitted		
Exterior masonry elements	Over 35 (11) and less than or equal to 60 (18)	Permitted		Not Permitted	
	35 (11) and less	Permitted			Not Permitted

<sup>1</sup>Basic wind speed as given in ASCE 7

# Empirical Analysis Example

Checks:

Minimum bracing – table 2

Maximum unreinforced height - table 3

MAX HEIGHT  
TABLE 1 10' ✓  
H/E (TABLE 2)  
 $\frac{120''}{8} = 15 < 18$  ✓  
MAX. UNREINF. HEIGHT  
TABLE 3 → 10' < 12' ✓

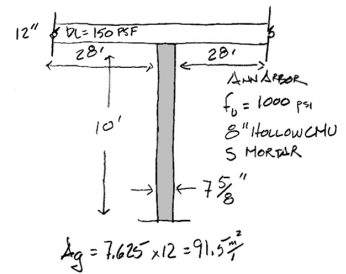


Table 2—Wall Lateral Support Requirements (ref. 1)		Table 3—Maximum Unreinforced Wall Spans, ft (m) <sup>A</sup>				
Construction (unreinforced)	Maximum wall length-to-thickness or height-to-thickness ratio <sup>A</sup>	Wall thickness, in. (mm)	6 (152)	8 (203)	10 (254)	12 (305)
<b>Bearing walls</b>		<b>Bearing walls</b>				
Solid units or solid grouted	20	Solid or solid grouted	10 (3.0) <sup>B</sup>	13.3 (4.1)	16.6 (5.1)	20 (6.1)
All others	18	All other	9 (2.7) <sup>B</sup>	12 (3.7)	15 (4.5)	18 (5.5)
<b>Nonbearing walls</b>		<b>Nonbearing walls</b>				
Exterior	18	Exterior	9 (2.7)	12 (3.7)	15 (4.5)	18 (5.5)
Interior	36	Interior	18 (5.5)	24 (7.3)	30 (9.1)	36 (11)
<b>Cantilever walls<sup>B</sup></b>		<b>Cantilever Walls<sup>C</sup></b>				
Solid	6	Solid	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Hollow	4	Hollow	2 (0.6)	2.6 (0.8)	3.3 (1.0)	4 (1.2)
Parapets (8-in. (203-mm) thick min.) <sup>B</sup>	3	Parapets <sup>C</sup>	1.5 (0.5)	2 (0.6)	2.5 (0.8)	3 (0.9)

<sup>A</sup> Note that Ref. 6 includes modified requirements for walls with openings.

# Empirical Analysis Example

Find allowable stress – table 4

Find load  
 $P = F A_g$

Calculate per foot using gross Area

psi (Mpa)	psi (Mpa)	psi (Mpa)
<b>Hollow Unit Masonry (Units Complying With ASTM C 90-06 or Later) (ref. 6)<sup>C</sup>:</b>		
Hollow loadbearing CMU, $t \leq 8$ in mortar		
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) <sup>D</sup> :		
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) <sup>D</sup> :		
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) <sup>B</sup> :		
$t \leq 8$ in. (203 mm) <sup>D</sup>	75 (0.52)	70 (0.48)
$8 < t < 12$ in (203 to 305 mm) <sup>D</sup>	70 (0.48)	65 (0.45)
$t \geq 12$ in (305 m.m) <sup>D</sup>	60 (0.41)	55 (0.38)

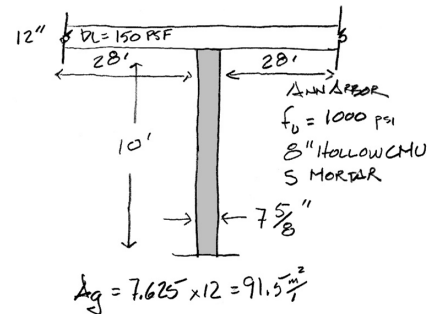


TABLE 4 Hollow 8"  $f'_m = 1000$   
TYPE S → 75 PSI

$$P = F A_g = 75 (7.625 \times 12) = 6862 \text{ #/ft}$$

TRIBUTARY STRIP = 28'

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

$$= 150(28) + LL(28)$$

$$LL = 95 \text{ PSF CAPACITY}$$