

# Arch324

# **STRUCTURES II**

Winter 2026  
Recitation

FACULTY: Prof. Peter von Bülow  
Mohsen Vatandoost

# Arch324: STRUCTURES II

## Welcome to Recitation session 04/17

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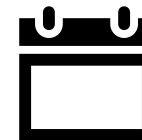
Office: Room 3128

hours:

Fri: 11:30 – 12:30

Mon, Wed: 11:00 - 12:00

walk-ins welcome!



[Click here to make an appointment](#)

Please feel free to ask questions.

# Arch324: STRUCTURES II

## Welcome to Recitation session 04/18

### Outline:

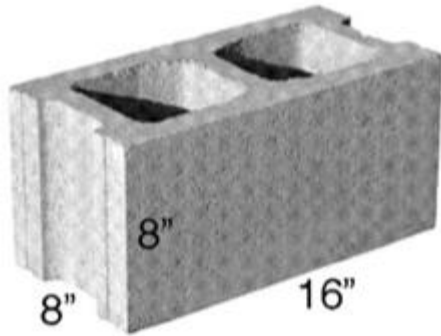
- Quick **Recap** of the week
- Provide the solution for the assignment (**Homework 11**)
- Answering student's questions
- Lab: **Lateral Stability**
- **Tower Project:** Final report due by **April 19**

Please feel free to ask questions.

# Recap of the week



Clay Masonry



Concrete 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

# Recap of the week

## Rational Masonry Analysis

Procedure

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

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  $h/r$  Slenderness ratio for the wall, (h: height of the wall, r: radius of gyration)
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  $P_u$ .

## Rational Approach

for axial compression  
using TMS 402 (2016)

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

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

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

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

# Provide the solution for the assignment – HW11

## 11. Masonry Walls

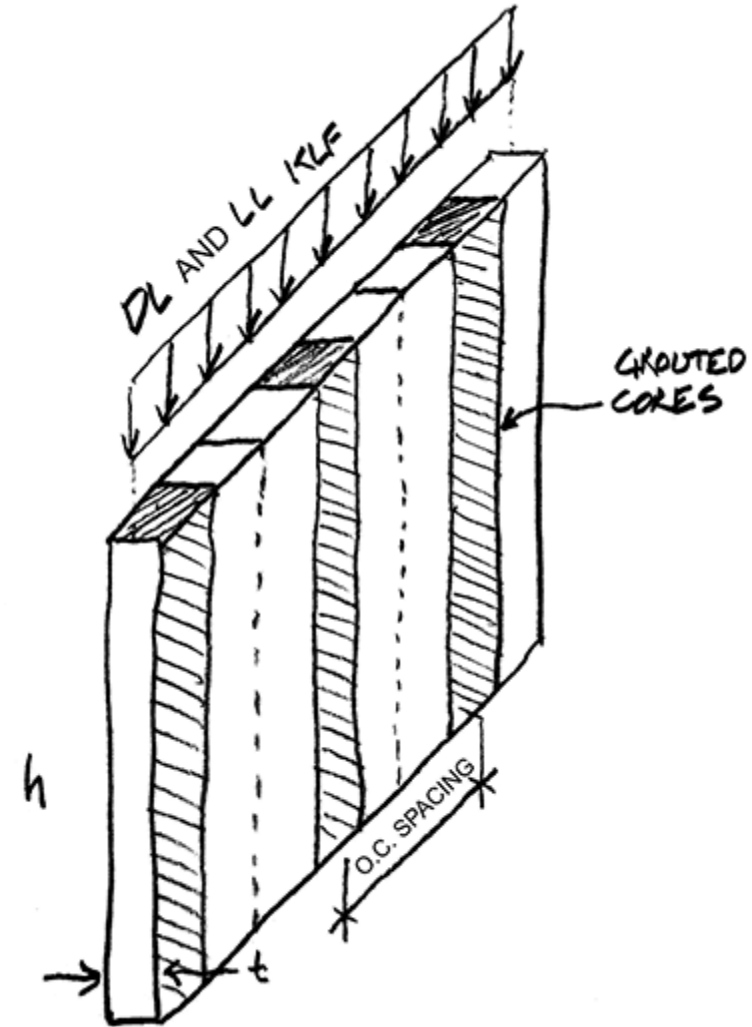
Using the strength method for axial compression (masonry spanning vertically) described in TMS 402, determine the safety of the given concrete masonry wall (pass or fail). Calculate the factored nominal axial strength,  $\phi P_n$  and compare it to the required strength,  $P_u$  for the given loads. (loads are given without factors)

DATASET: 1

-2-

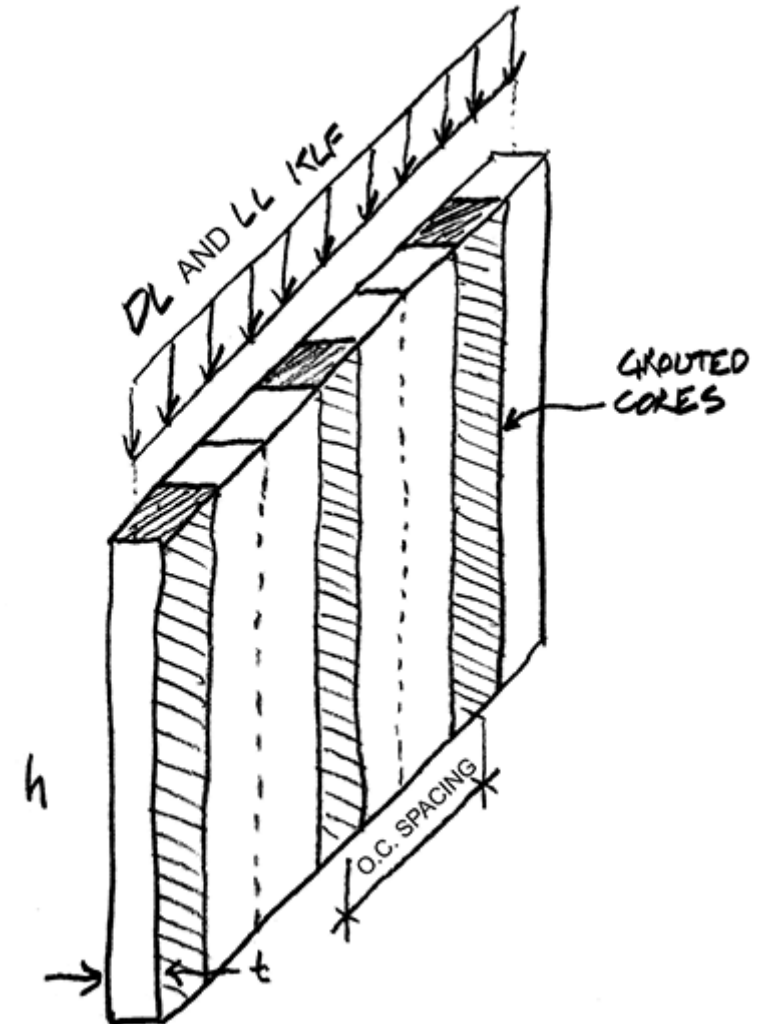
-3-

Height of wall, $h$	25 FT
Nominal thickness of wall	12 IN
grouted cells o.c. spacing	32 IN
Masonry compressive strength, $f_m$	1500 PSI
The wall DL	13 KLF
The wall LL	10 KLF



# Provide the solution for the assignment – HW11

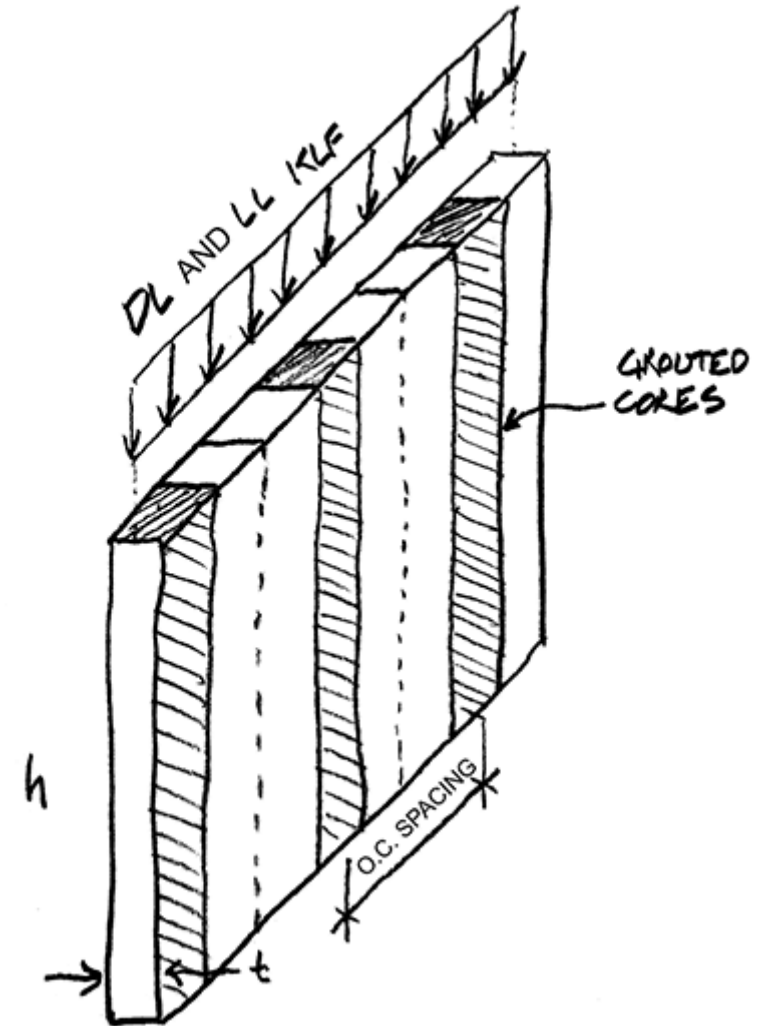
#	Question	Your Response
1	Actual wall thickness, $t$ (see TEK 14-1B)	<input type="text"/> IN
2	Net area per foot of wall, $A_n$	<input type="text"/> IN <sup>2</sup>
3	Net moment of inertia per foot of wall, $I_n$	<input type="text"/> IN <sup>4</sup>
4	Radius of gyration per foot of wall, $r$	<input type="text"/> IN
5	Ratio of $h/r$	<input type="text"/>
6	Which TMS equation used? (11 or 12)	<input type="text"/>
7	Nominal axial strength, $P_n$	<input type="text"/> KLF
8	Factored nominal axial strength, $\phi P_n$	<input type="text"/> KLF
9	Axial strength required by loads, $P_u$	<input type="text"/> KLF
10	Does the wall pass or fail? (1=pass 0=fail)	<input type="text"/>



# Provide the solution for the assignment – HW11

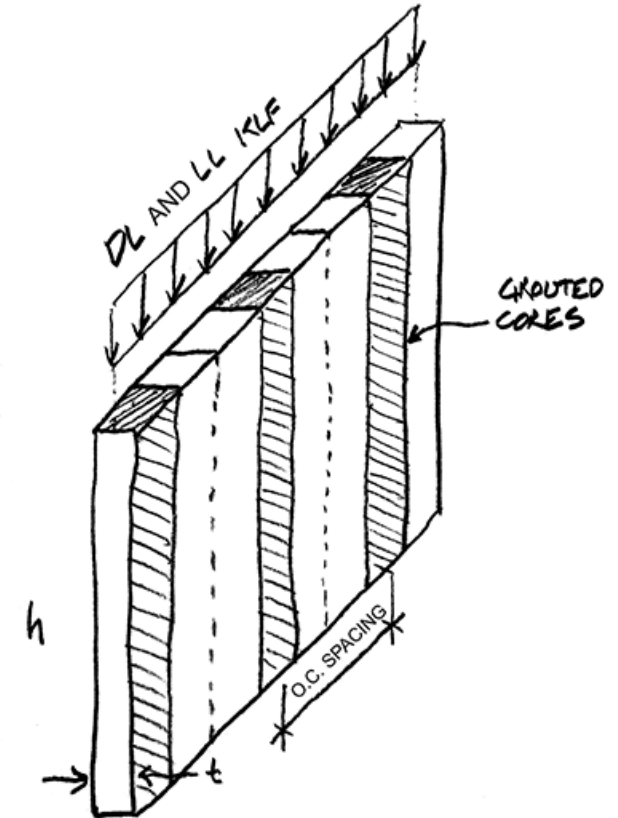
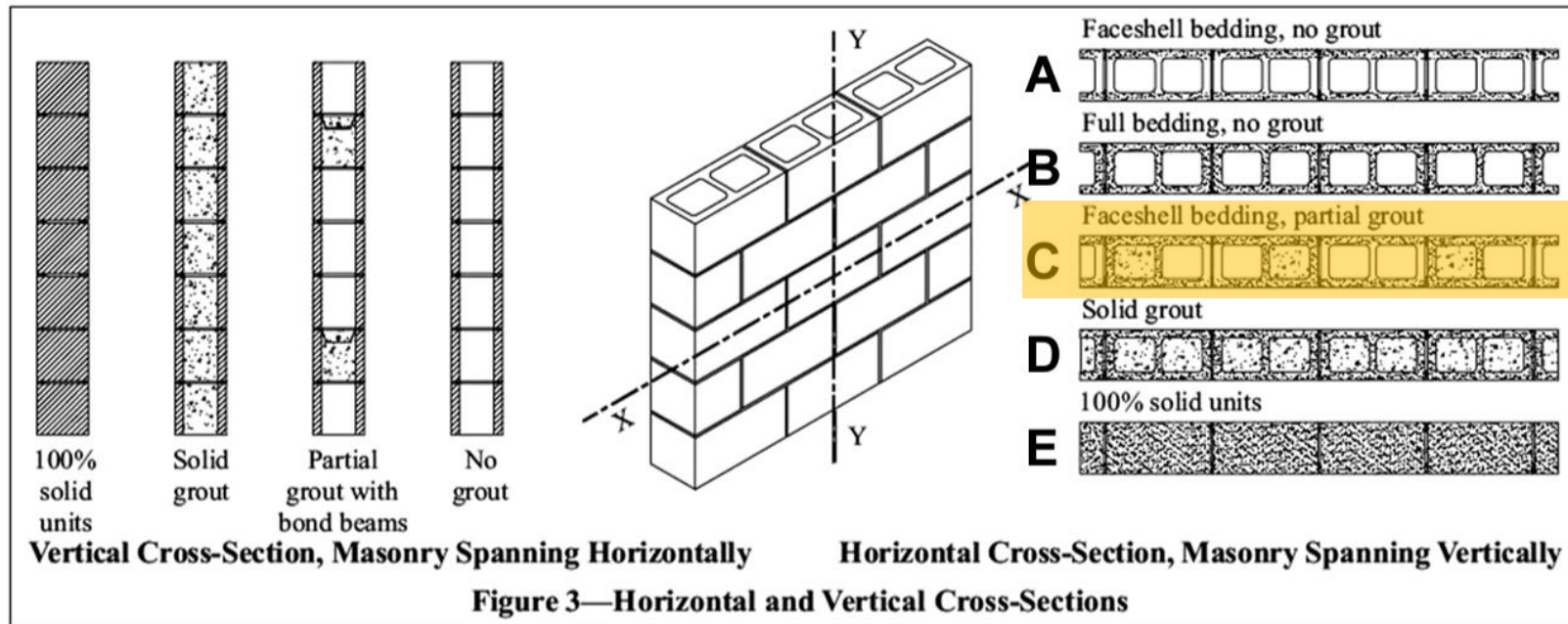
## Procedure

1. Determine the masonry strength,  $f'_m$
2. Find the net area,  $A_n$ , and Moment of Inertia,  $I_n$  (see TEK 14-1B)
3. Calculate  $r = \sqrt{I_n/A}$
4. Check  $h/r$  ratio to determine the correct TMS equation for  $P_n$
5. Calculate  $\phi P_n$  where  $\phi$  for axial force = 0.90



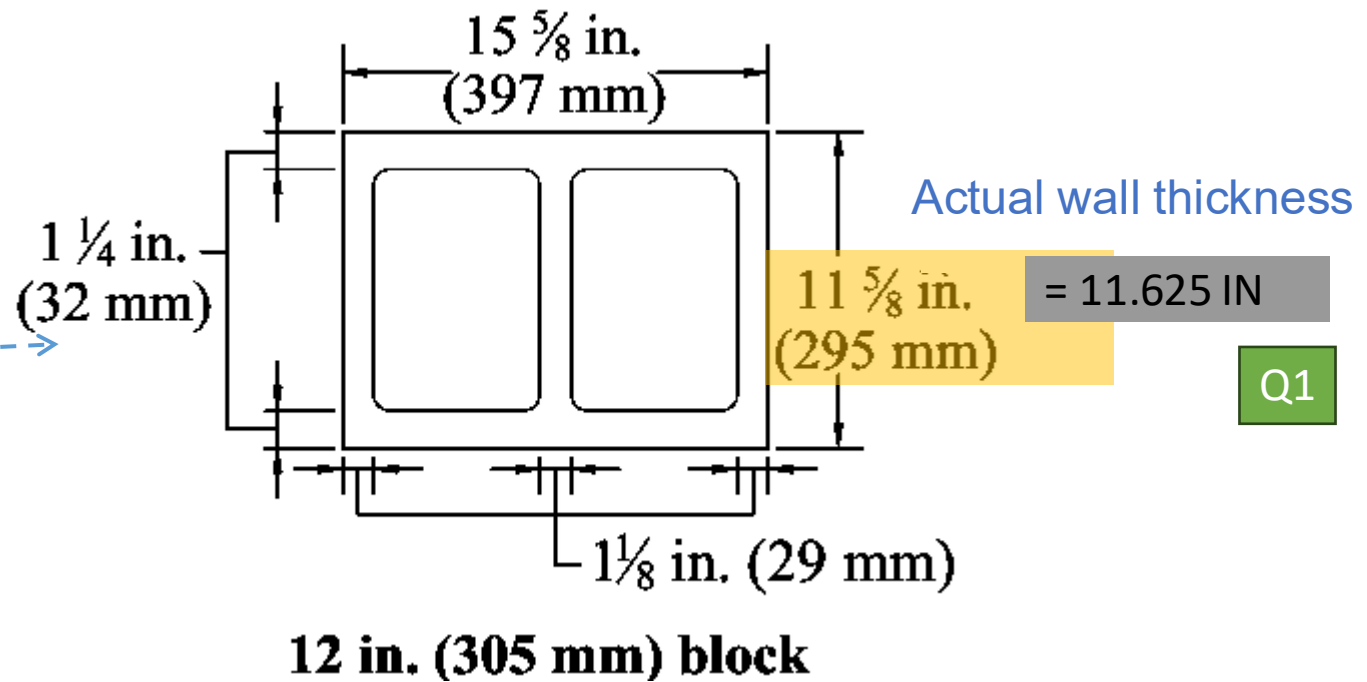
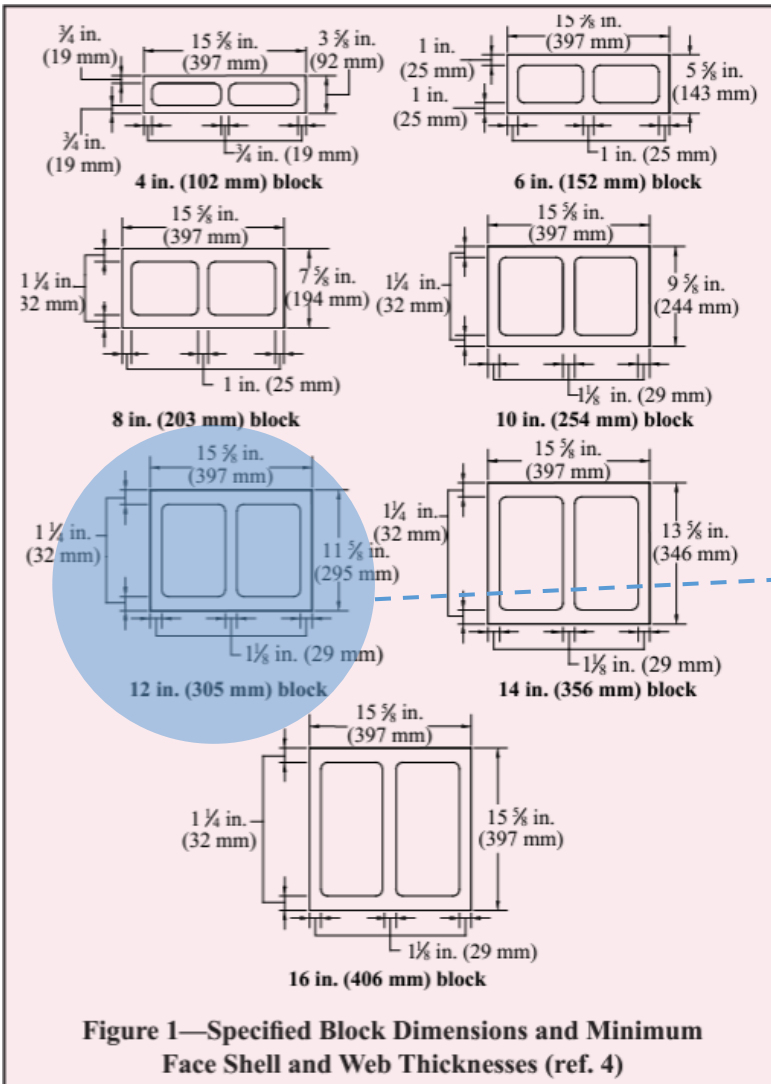
# Provide the solution for the assignment – HW11

Section Properties of Concrete Masonry Walls NCMA TEK 14 – 1B  
 (attached to problem description, and also on Canvas, and on NCMA website)



# Provide the solution for the assignment – HW11

**TEK 14-1B**  
Structural (2007)



Nominal thickness of wall in problem description: 12 inch

# Provide the solution for the assignment – HW11

Net area per foot of wall,  $A_n$

Net moment of inertia per foot of wall

**Table 5—12-inch (305-mm) Single Wythe Walls, 1 $\frac{1}{4}$  in. (32 mm) Face Shells (standard)**

**5a: Horizontal Section Properties (Masonry Spanning Vertically)**

Unit	Grout spacing (in.)	Mortar bedding	Net cross-sectional properties <sup>A</sup>			Average cross-sectional properties <sup>B</sup>			
			$A_n$ (in. <sup>2</sup> /ft)	$I_n$ (in. <sup>4</sup> /ft)	$S_n$ (in. <sup>3</sup> /ft)	$A_{avg}$ (in. <sup>2</sup> /ft)	$I_{avg}$ (in. <sup>4</sup> /ft)	$S_{avg}$ (in. <sup>3</sup> /ft)	$r_{avg}$ (in.)
Hollow	No grout	Face shell	30.0	811.2	139.6	53.1	971.5	167.1	4.28
Hollow	No grout	Full	53.1	971.5	167.1	53.1	971.5	167.1	4.28
100% solid/solidly grouted		Full	139.5	1,571.0	270.3	139.5	1,571.0	270.3	3.36
Hollow	16	Face shell	87.3	1,208.9	208.0	95.0	1,262.3	217.2	3.64
Hollow	24	Face shell	68.2	1,076.3	185.2	81.0	1,165.4	200.5	3.79
Hollow	32	Face shell	58.7	1,010.1	173.8	74.1	1,116.9	192.2	3.88
Hollow	40	Face shell	52.9	970.3	166.9	69.9	1,087.8	187.2	3.95
Hollow	48	Face shell	49.1	943.8	162.4	67.1	1,068.4	183.8	3.99
Hollow	72	Face shell	42.7	899.6	154.8	62.4	1,036.1	178.3	4.07
Hollow	96	Face shell	39.6	877.5	151.0	60.1	1,020.0	175.5	4.12
Hollow	120	Face shell	37.6	864.2	148.7	58.7	1,010.3	173.8	4.15

Q2

Q3

# Provide the solution for the assignment – HW11

④ Radius of gyration:

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{1010.1 \text{ in}^4}{58.7 \text{ in}^2}} = 4.1482 \text{ in}$$

Q4

⑤ Ratio of  $h/r$ :

$$\frac{25 \times 12}{4.1482} = 72.32 \text{ unit/less} < 99 \rightarrow (\text{Eq. 9-11})$$

Q5

⑦ Nominal axial strength,  $P_n$

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

$$P_n = 0.80 \left\{ 0.80 (58.7) \frac{(1500)}{\text{psi} \left( \frac{\text{lb}}{\text{in}^2} \right)} \left[ 1 - \left( \frac{25 \times 12}{140(4.1482)} \right)^2 \right] \right\}$$

$$P_n = 41314.47 \times \frac{1}{1000} = 41.31447 \text{ KLF}$$

Q7

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

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

Q6

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

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

# Provide the solution for the assignment – HW11

Factored nominal axial strength

$$\textcircled{8} \phi P_n = 0.9 \times 41.31447 = 37.1830 \text{ KLF}$$

Q8

Axial strength required by loads,  $P_u$

$$\textcircled{9} P_u = 1.2(OL) + 1.6(LL)$$

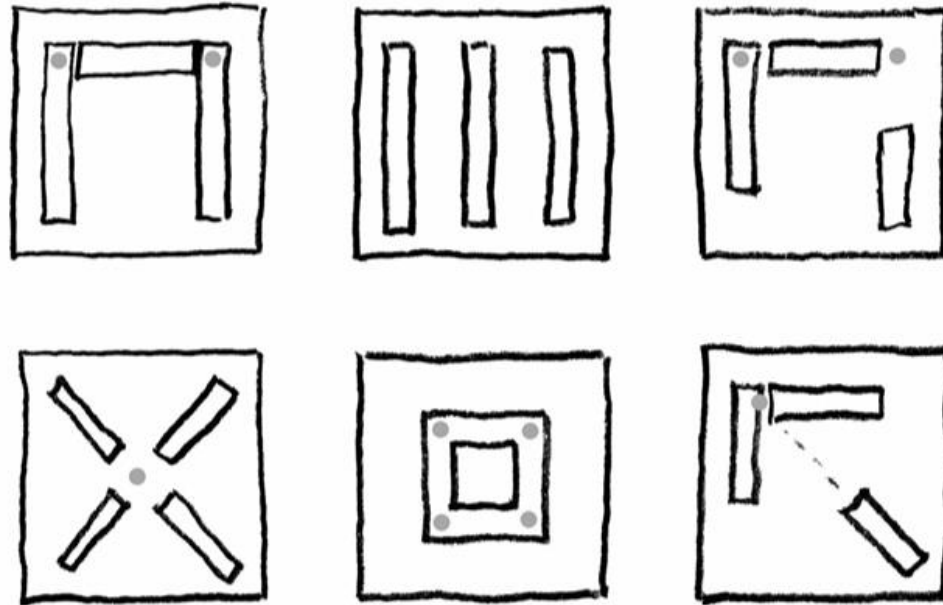
$$= 1.2(13) + 1.6(10) = 31.6 \text{ KLF} < \phi P_n = 37.18$$

Q9

KLF  
OK ✓

Q10

# Lab : Lateral Stability



## Description

This project investigates stable arrangements of structural walls against lateral loading.

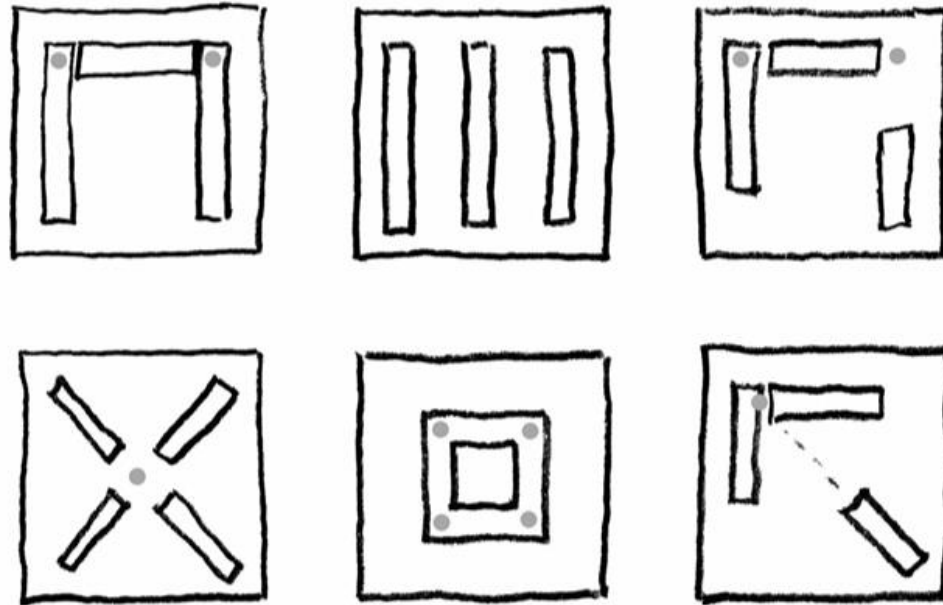
## Goals

To observe the effects of lateral loading

To investigate the criteria of stable wall patterns

To develop stable arrangements of shear walls based on the 2 point rule

# Lab : Lateral Stability



## Procedure

1. Arrange the small wood walls on the foam core base to support the MDF slab.
2. Make each of the six arrangements.
3. Apply lateral and torsional accelerations to the base and note the effects on the assembly. Mark on the diagrams below which fail and which remain stable.
4. Make your own stable and unstable arrangement.
5. Sketch the arrangements below and mark the intersection points.

[https://structures.tcaup.umich.edu/recitation/LAB9\\_LateralStability.mp4](https://structures.tcaup.umich.edu/recitation/LAB9_LateralStability.mp4)

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Thank you.

Any question?

Please feel free to ask questions.