TAUBMAN COLLEGE
ARCHITECTURE & URBAN PLANNING
UNIVERSITY OF MICHIGAN

Arch324
STRUCTURES II

Winter 2025
Recitation

FACULTY: Prof. Peter von Bülow
Mohsen Vatandoost

Welcome to Recitation session 04/18

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Office: Room 3122

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.

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 18~~ **(extended to Tuesday 22)**

Please feel free to ask questions.

Contact: Mohsenv@umich.edu

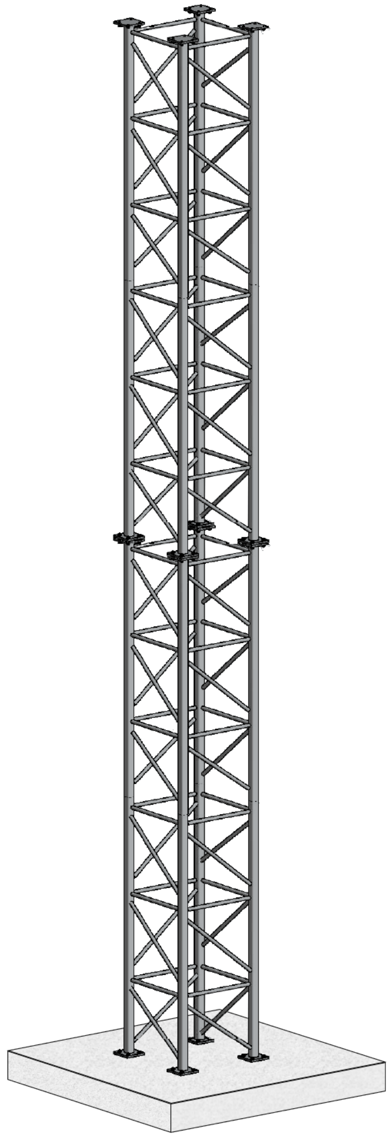
Tower Project:

Tower Project final report:

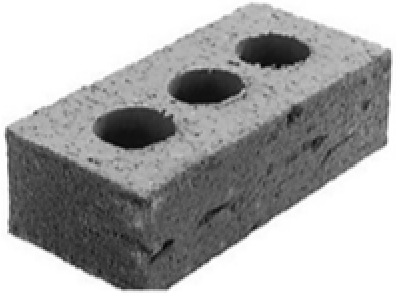
~~April, 18~~

~~Today~~

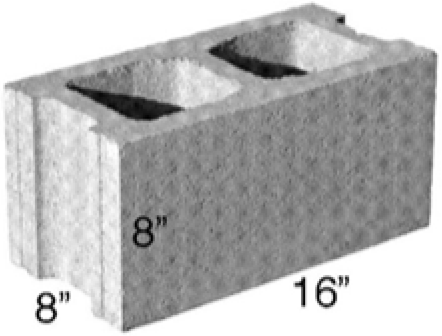
Extended to Tuesday 22,



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**

Rational Approach
for axial compression
using TMS 402 (2016)

Given: geometry, material
Find: axial compressive load capacity, Pn

1. Determine the masonry strength, f'm, based on unit strength, fu, 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, Pn:
   If $h/r < 99$ use TMS 402 eq.9-11
   If $h/r > 99$ use TMS 402 eq.9-12
6. Calculate øPn where ø for axial force = 0.90
7. Check that øPn is greater than Pu.

(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

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

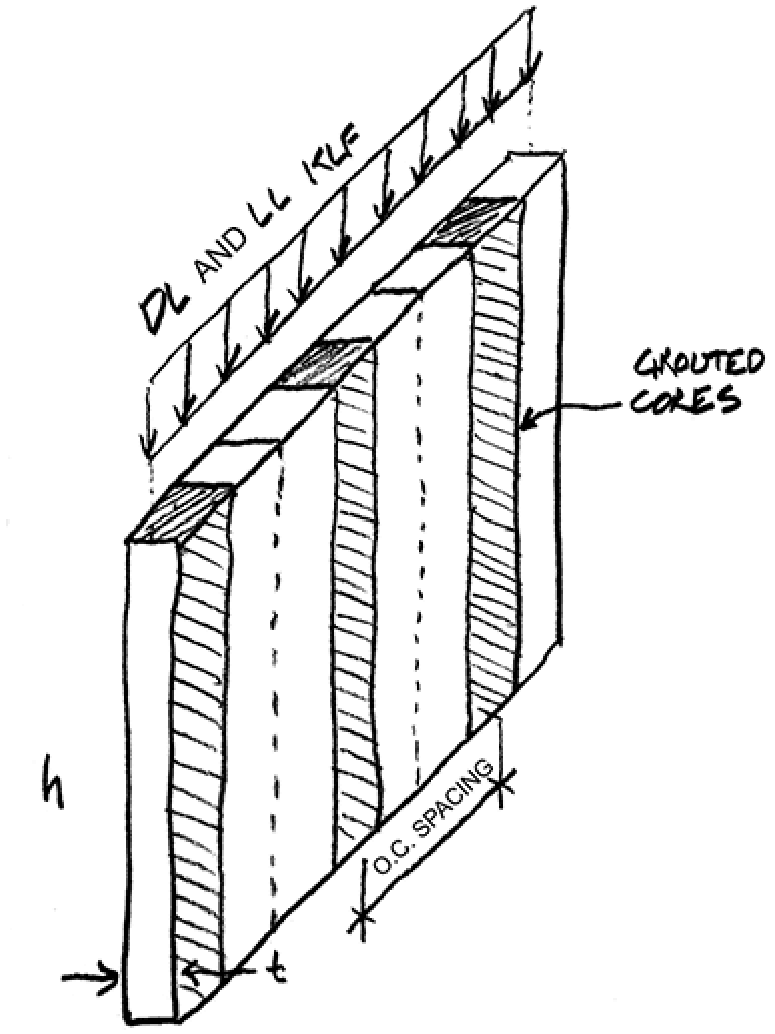
Provide the solution for the assignment – **HW11**

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_Pn and compare it to the required strength, Pu for the given loads. (loads are given without factors)

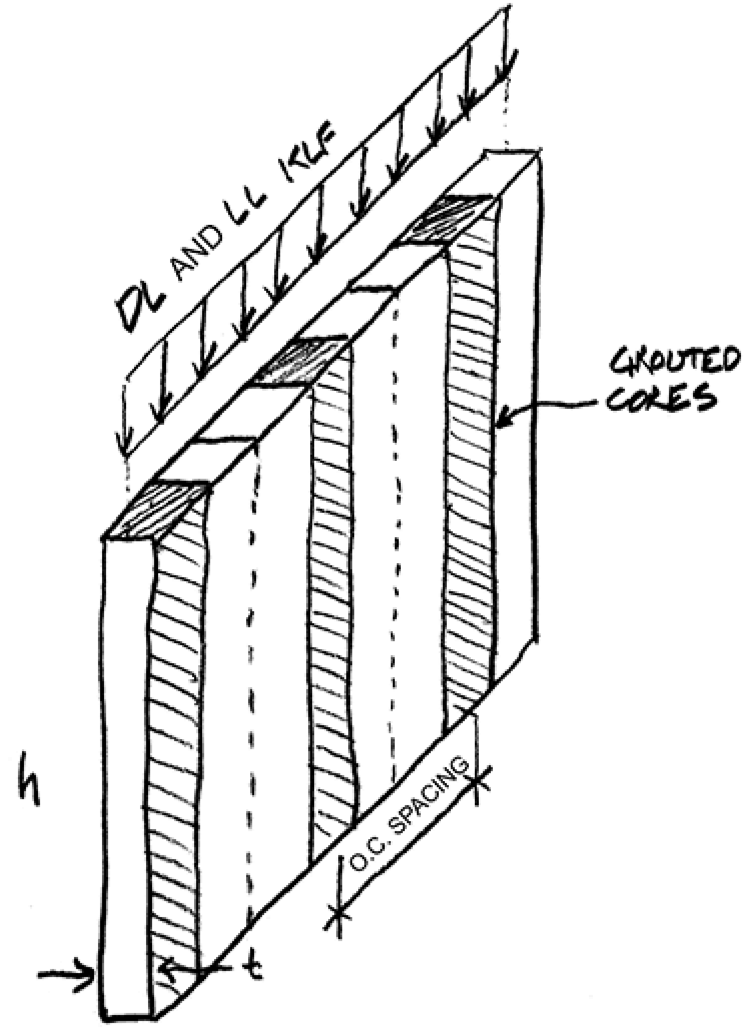
DATASET: 1 -2- -3-

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**

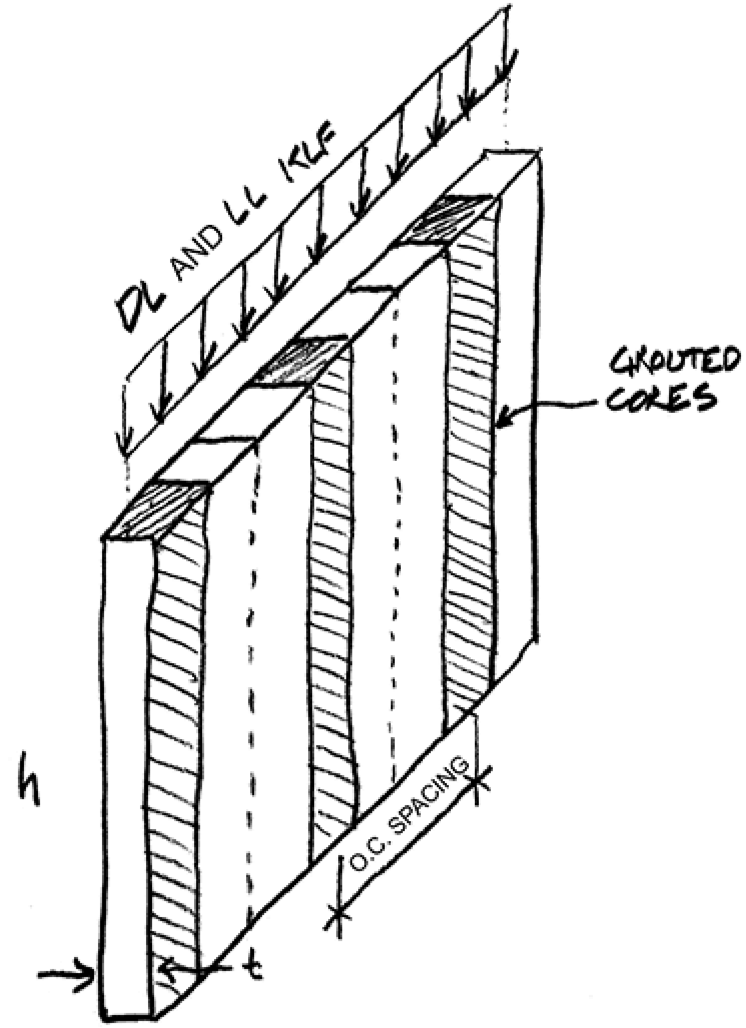
#	Question	Your Response	
1	Actual wall thickness, t (see TEK 14-1B)		IN
2	Net area per foot of wall, An		IN2
3	Net moment of inertia per foot of wall, In		IN^4
4	Radius of gyration per foot of wall, r		IN
5	Ratio of h/r		
6	Which TMS equation used? (11 or 12)		
7	Nominal axial strength, Pn		KLF
8	Factored nominal axial strength, phi_Pn		KLF
9	Axial strength required by loads, Pu		KLF
10	Does the wall pass or fail? (1=pass 0=fail)		



Provide the solution for the assignment – **HW11**

Procedure

1. Determine the masonry strength, f'm
2. Find the net area, An, and Moment of Inertia, In (see TEK 14-1B)
3. Calculate $r = \sqrt{I/A}$
4. Check h/r ratio to determine the correct TMS equation for Pn
5. Calculate øPn where ø 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)

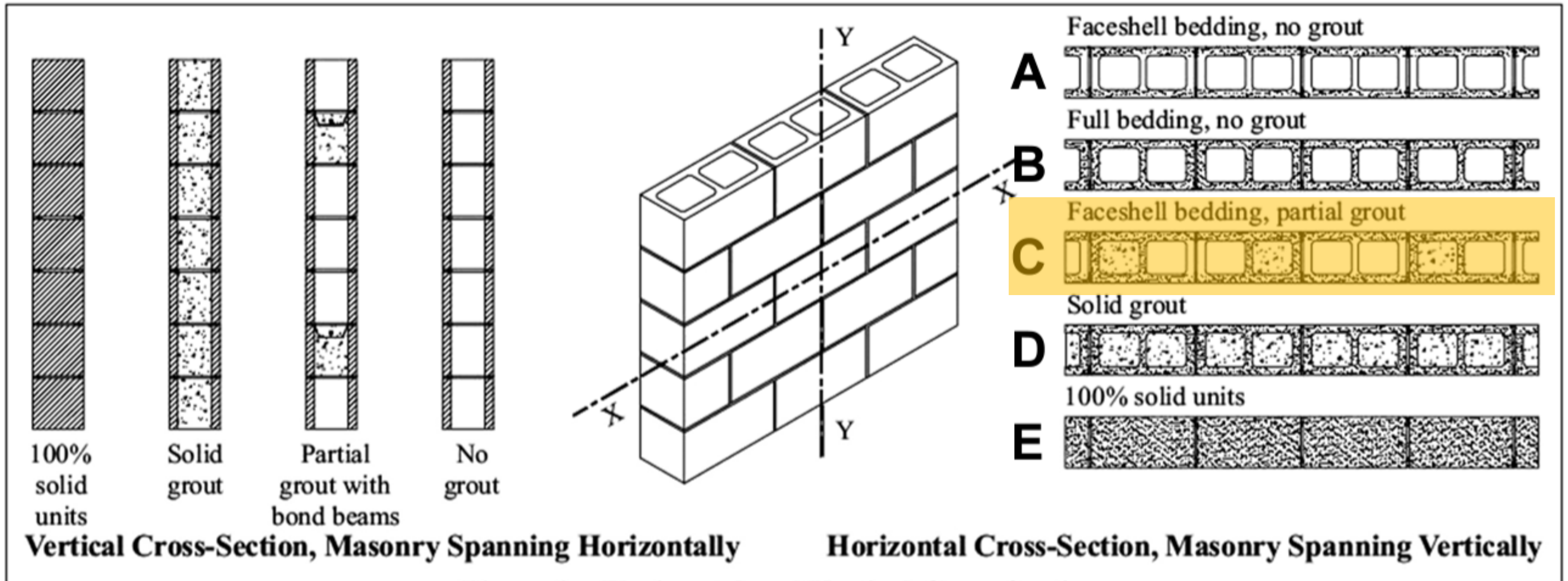
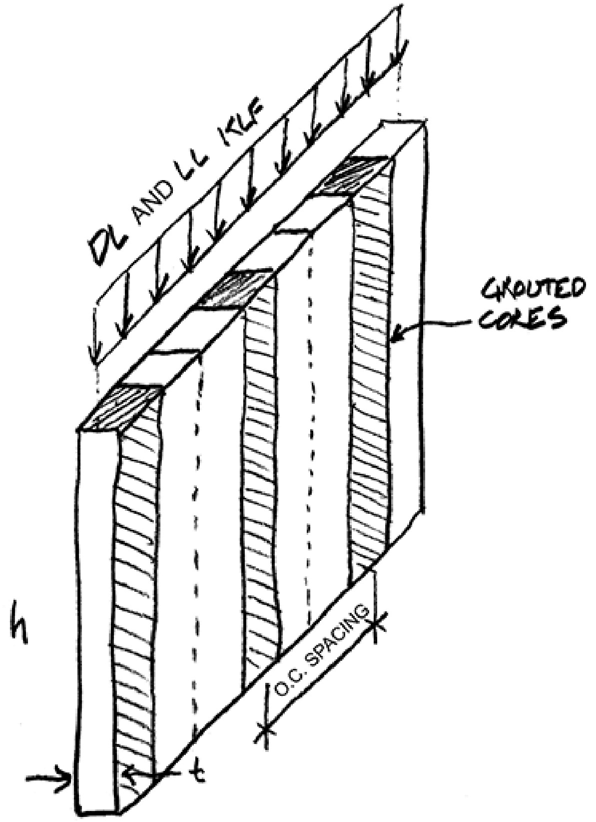


Figure 3—Horizontal and Vertical Cross-Sections



Provide the solution for the assignment – **HW11**

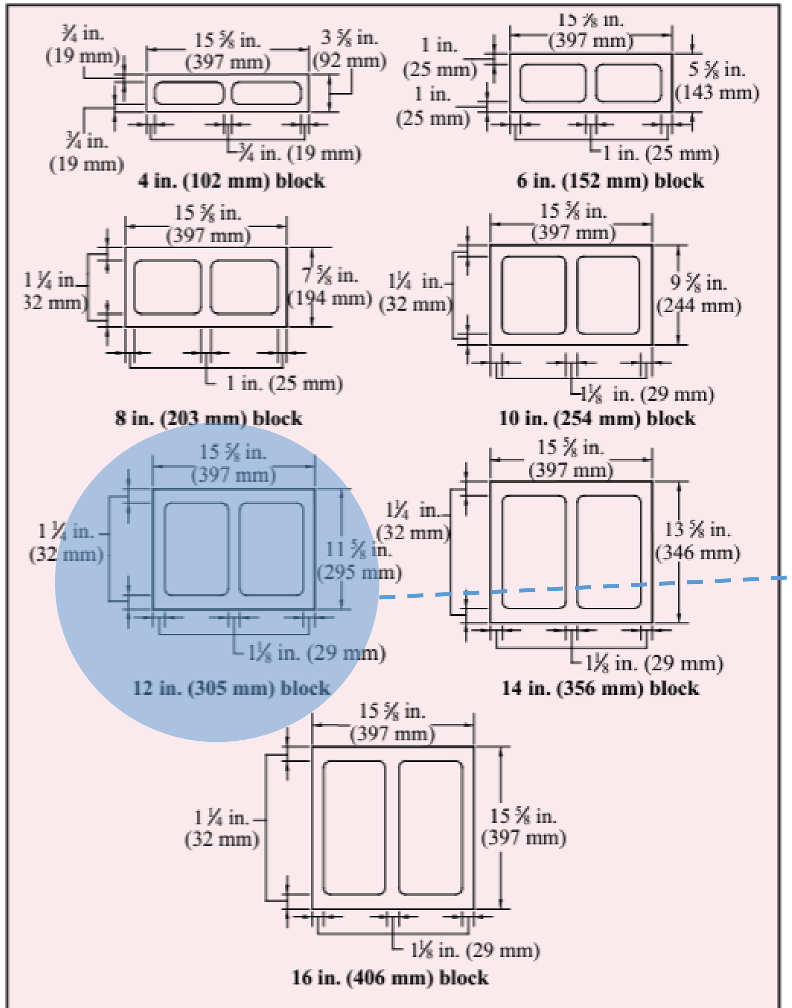
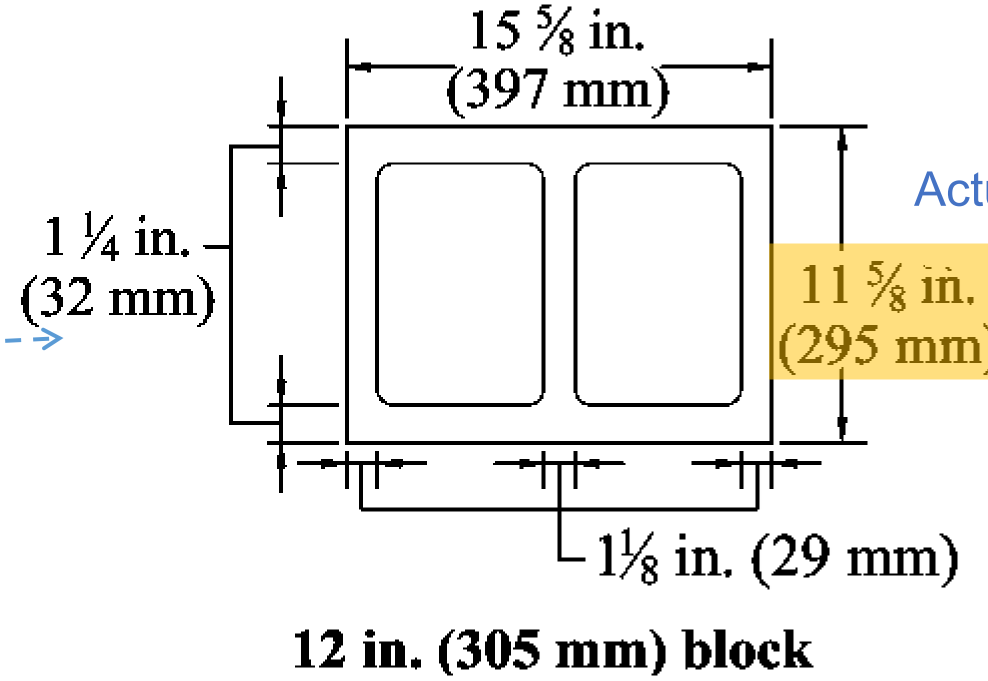


Figure 1—Specified Block Dimensions and Minimum Face Shell and Web Thicknesses (ref. 4)

TEK 14-1B
Structural (2007)



Actual wall thickness

= 11.625 IN

Q1

Nominal thickness of wall in problem description: 12 inch

Provide the solution for the assignment – **HW11**

Net area per foot of wall, An

Net moment of inertia per foot of wall

Table 5—12-inch (305-mm) Single Wythe Walls, 1¹/₄ in. (32 mm) Face Shells (standard)

5a: Horizontal Section Properties (Masonry Spanning Vertically)

Unit	Grout spacing (in.)	Mortar bedding	Net cross-sectional properties[A] A_n (in.²/ft)	I_n (in.⁴/ft)	S_n (in.³/ft)	Average cross-sectional properties[B] A_{avg} (in.²/ft)	I_{avg} (in.⁴/ft)	S_{avg} (in.³/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:

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

Q4

⑤ Ratio of h/r:

$$\frac{25 \times 12}{4.1482} = 72.32 \ \text{unitless} < 99 \rightarrow (Eq.\ 9\_11)$$ ⑥

Q5

(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

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

⑦ nominal axial strength, P_n

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

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

in^2 PSI $\left(\frac{lb}{in^2}\right)$

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

Q7

Provide the solution for the assignment – **HW11**

Factored nominal axial strength

(8) $\phi P_n = 0.9 \times 41.31447 = 37.1830$ KLF

ϕ → 0.9

Q8

Axial strength required by loads, Pu

(9) $P_u = 1.2(DL) + 1.6(LL)$

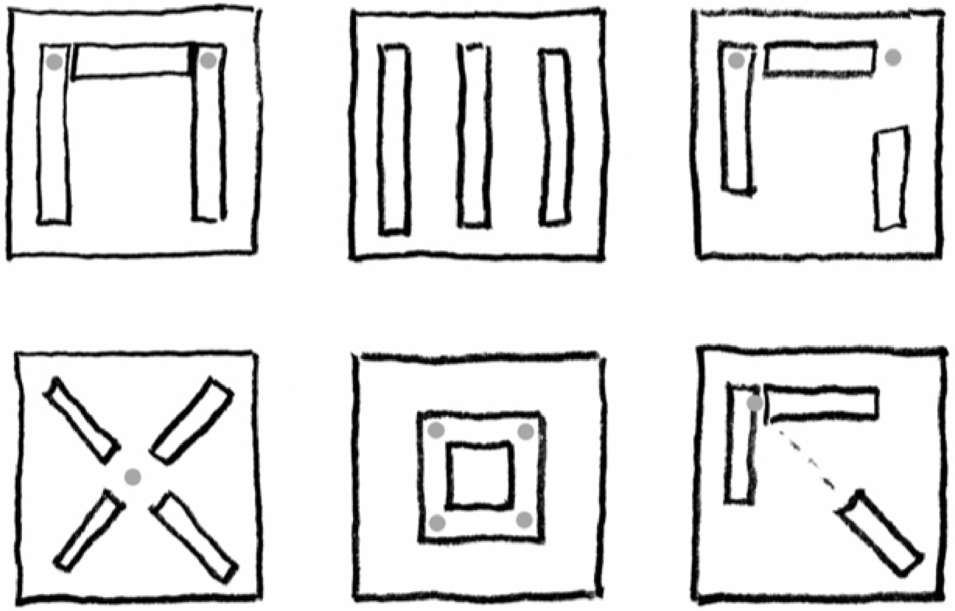
$= 1.2(13) + 1.6(10) = 31.6$ KLF $< \phi P_n = 37.18$ KLF

o.k. ✓

Q9

Q10

Lab : Lateral Stability



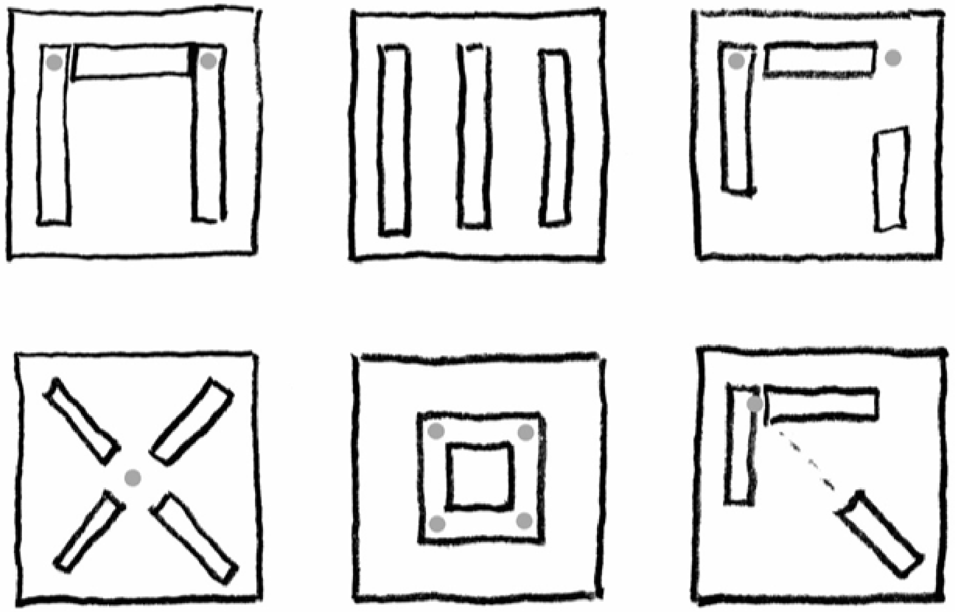
Description

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 patters
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

Thank you.

Any question?

Please feel free to ask questions.

Contact: Mohsenv@umich.edu