Pennsylvania College Of Technology
Dauphin Hall
Williamsport, Pennsylvania

Aubert Ndjolba
Structural Option

AE Senior Thesis- 2011
Thesis Advisor: Dr. Boothby

Existing Building

Overview

- ❑ Introduction
- ❑ Existing Structural System
- ❑ Thesis Proposal
- ❑ Structural Depth
  - Proposed Solution
  - Slab Design
  - Reinforced masonry Design
- ❑ Architectural Breadth
- ❑ Conclusion

Proposed Building

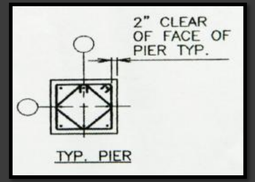
Dauphin Hall – Penn College of Technology

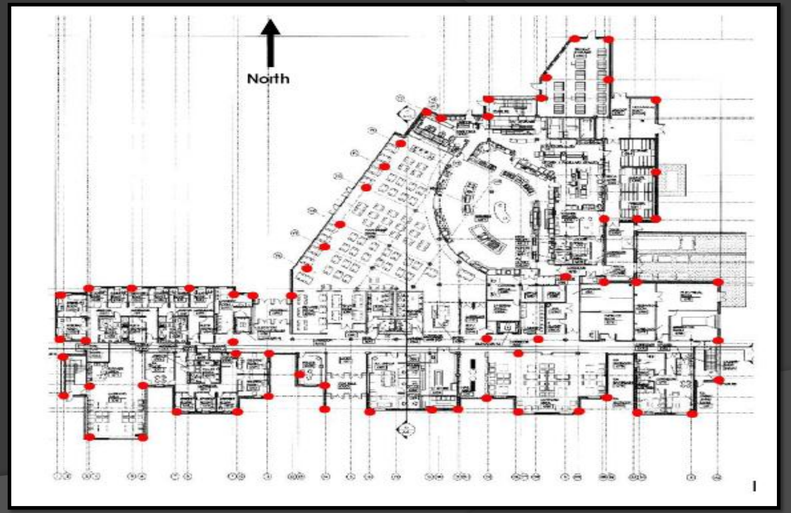
Building Introduction

- Location: Williamsport, PA
- Owner: Penn College of Technology
- Architect: Murray Associates Architects, PC
- General Contractor: IMC Construction, Inc.
- Number of Stories: 4 Above Grade (70 feet tall, 316 feet long and 210 feet wide)
- Seize: 123,676 GSF
- Cost: $ 26,000,000
- Construction: October 2008 – August 2010
- Delivery Method: Design-Bid-Build

Existing Structural System

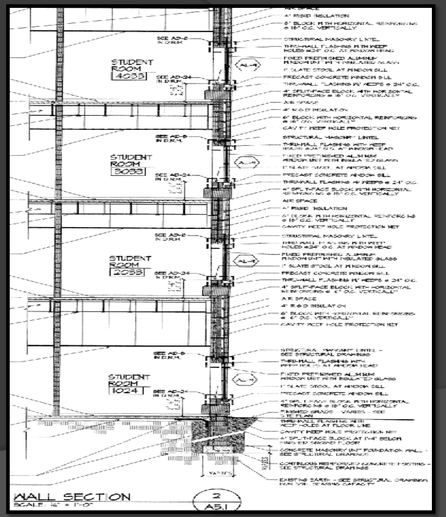
- **Foundation:**
  - Shallow Foundation
  - Stone Piers (18” – 36”)
  - (8) #8’s



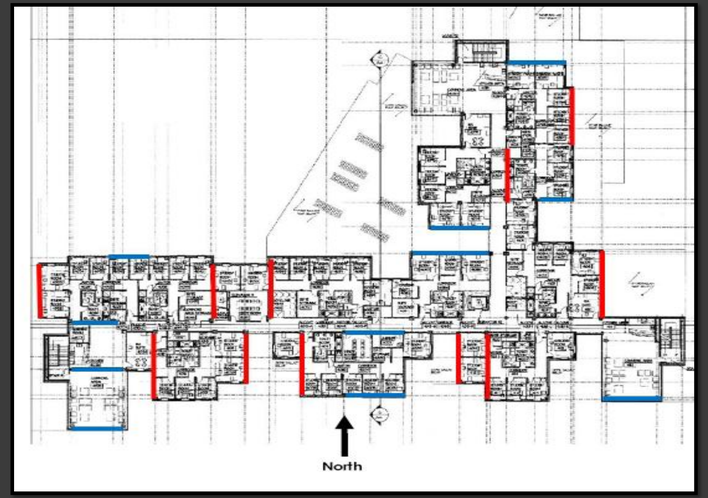


Existing Structural System

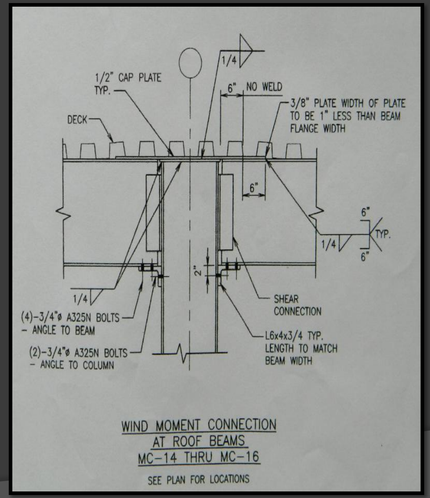
- **Gravity System:**
  - 4” Light Weight Concrete Slab, reinforced with 1 ½” – 20 gage Vulcraft composite deck
  - Open Web K-series bar Joists @ 2’-0” O.C.
  - Exterior walls: non-loadbearing CMU with brick Veneer
  - Interior Partitions: 4” Clay Brick
  - Columns: W8’s – W10’s
  - Beams: W18’s – W24’s

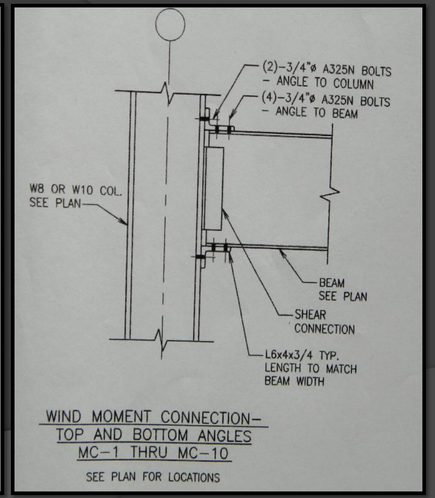


Existing Structural System

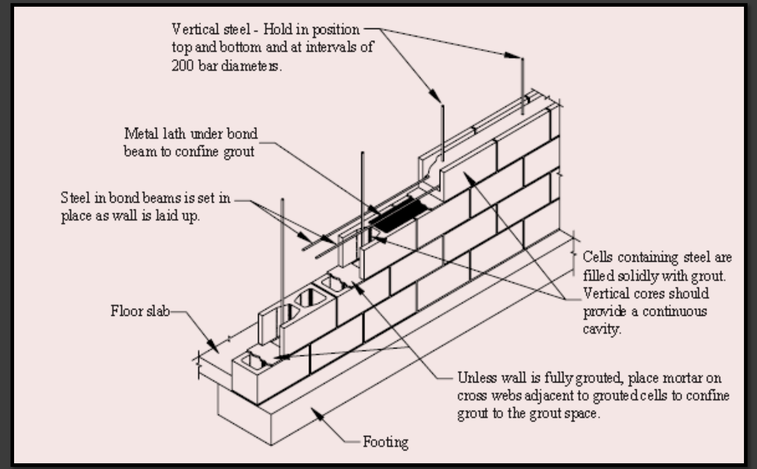


- **Lateral System:**
  - Wind Moment Connections in Both East/West and North/South Direction
  - 22 Total per floor

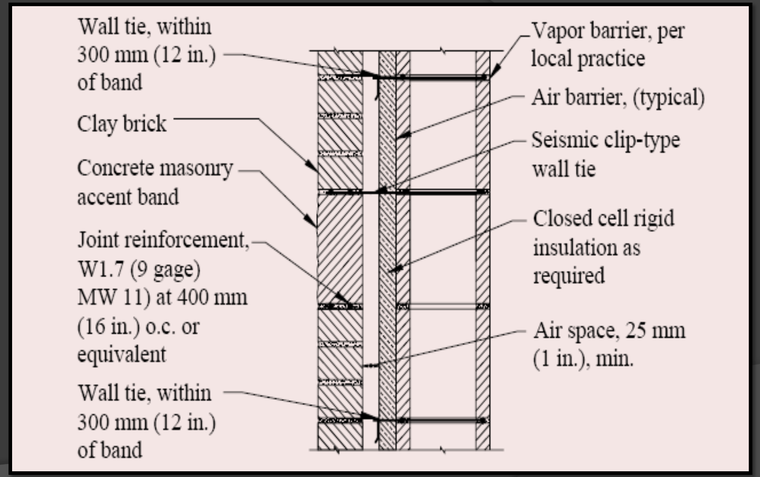




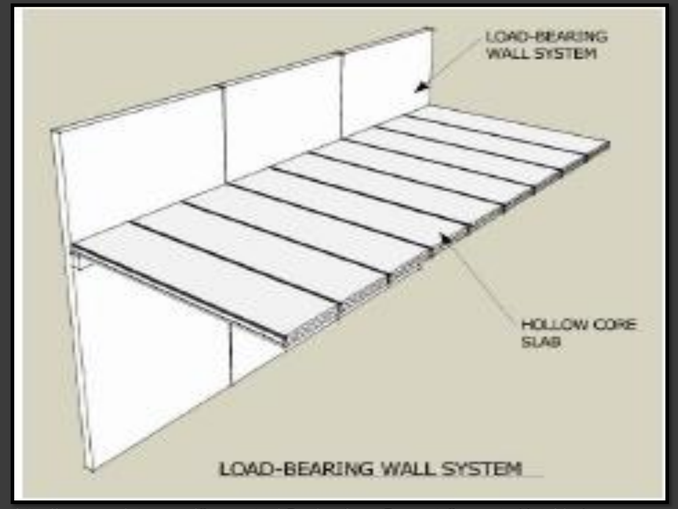
Thesis Proposal



- **Structural Depth**
  - Redesign structure using reinforced concrete masonry loadbearing walls
  - Precast Hollow core planks
  - Design for seven stories
- **Construction Management Breadth**
  - Compare cost of existing versus proposed design
  - Generate project schedules
- **Architectural Breadth**
  - Modify existing floor plans
  - Propose an efficient layout that promotes student collaboration



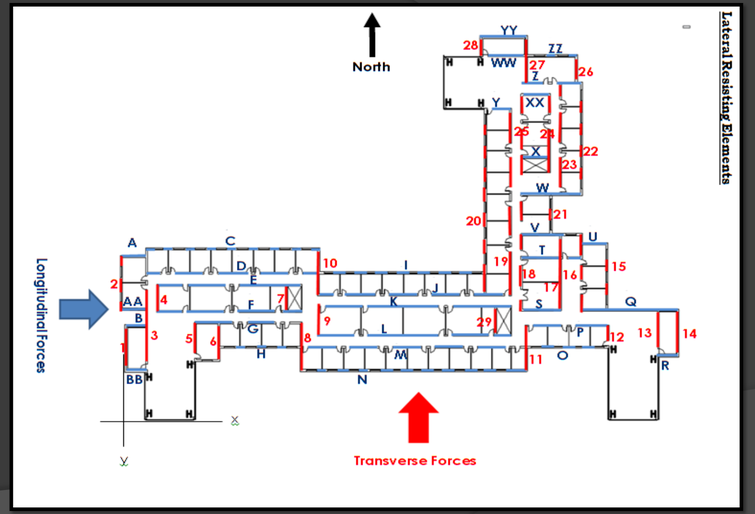
Structural Depth

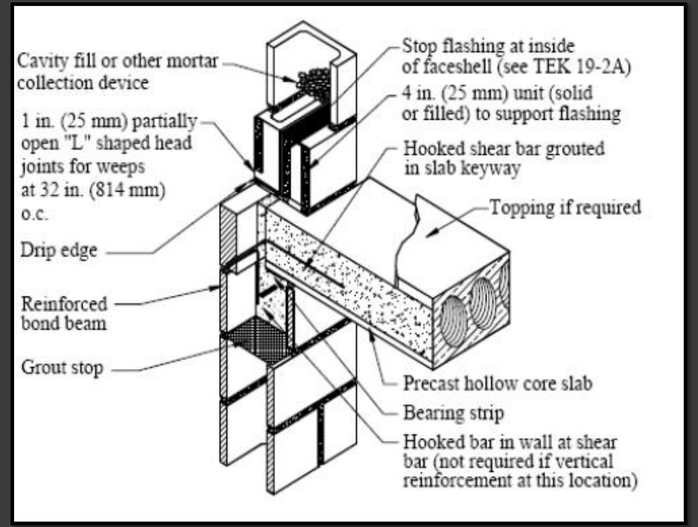


http://www.we-inter.com/Conceptual-Design-for-a-Precast-Concrete-Hotel-in-Iraq.aspx

Solution:

- ❑ Gravity System:
  - Precast hollow core planks
  - Reinforced masonry loadbearing walls
  - 4” Clay brick partitions
- ❑ Lateral System:
  - Reinforced masonry walls as shear walls
- ❑ Three additional floors
  - 70 feet tall
- ❑ Proposed Shear Wall Layout





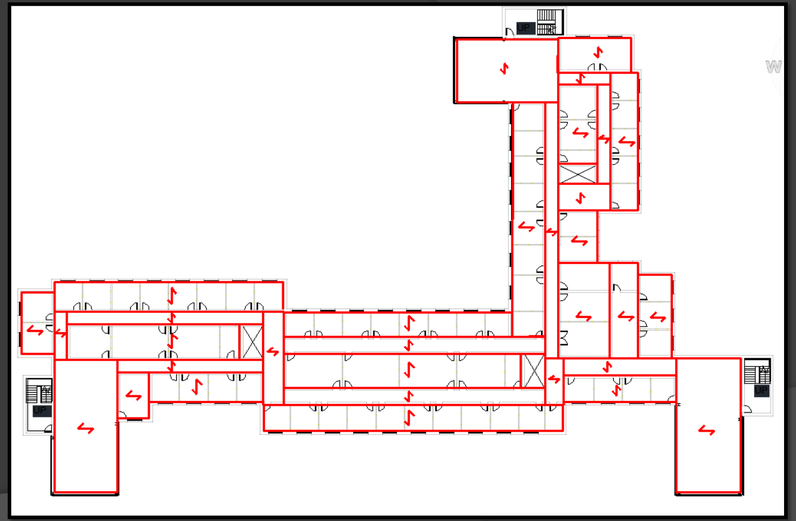
Courtesy of Nitterhouse

Structural Depth – Floor Design

Precast Hollow Core Planks

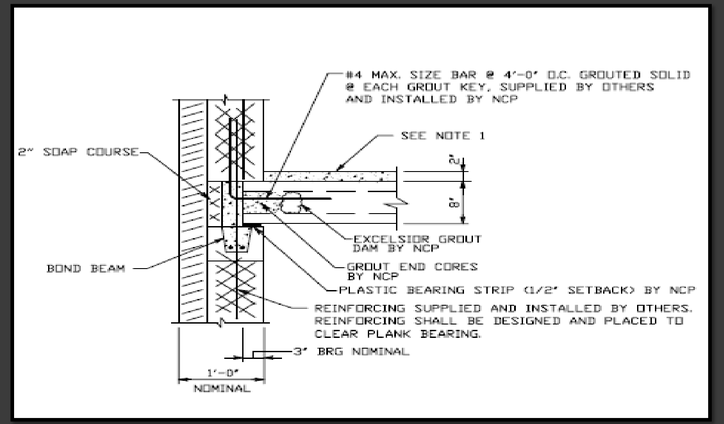
- ❑ Typical (Max.) Span = 19 feet
- ❑ Dead & Live loads from IBC 2009
- ❑ Selection from catalog (Nitterhouse)
  - Total Factored Loads
    W= 190 psf ≤ 214 psf → OK
- ❑ Check Deflection:
  - Δ_{Actual}= 0.16" ≤Δ_{Limit}=L/360 =0.63" $\therefore OK$

Use 4-1/2” Strand 8” x 4’-0” hollow core planks with 2” normal weight concrete topping

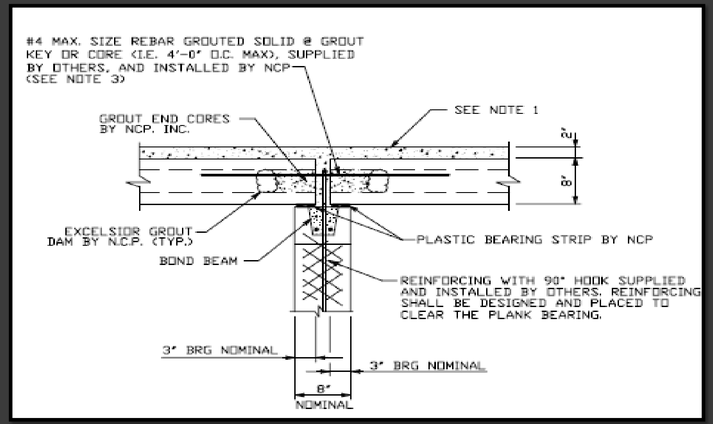


Structural Depth – Floor Design

Precast Hollow Core Planks Connection Details



Courtesy of NCMA



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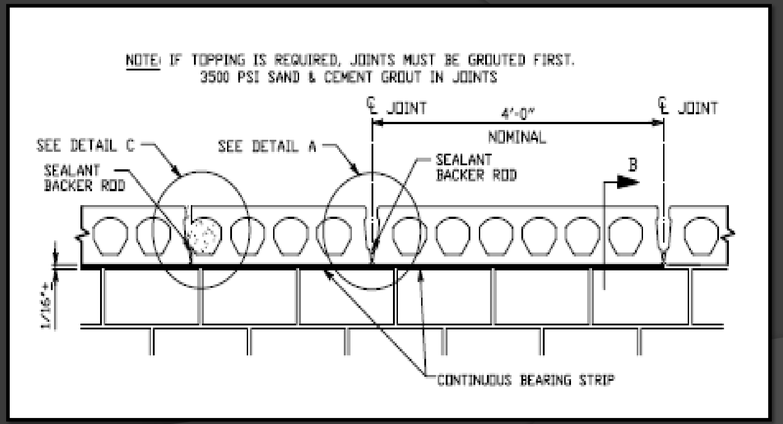


Courtesy of NCMA

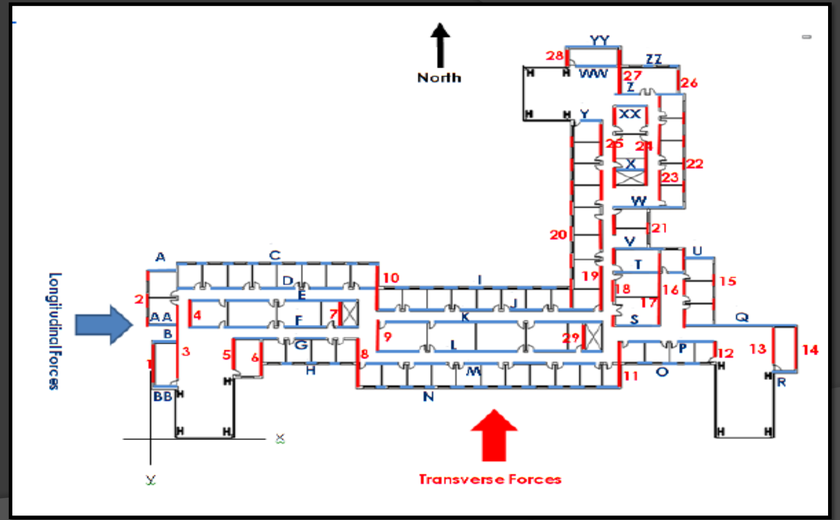
Structural Depth – Shear Wall Design

Reinforced masonry loadbearing walls:

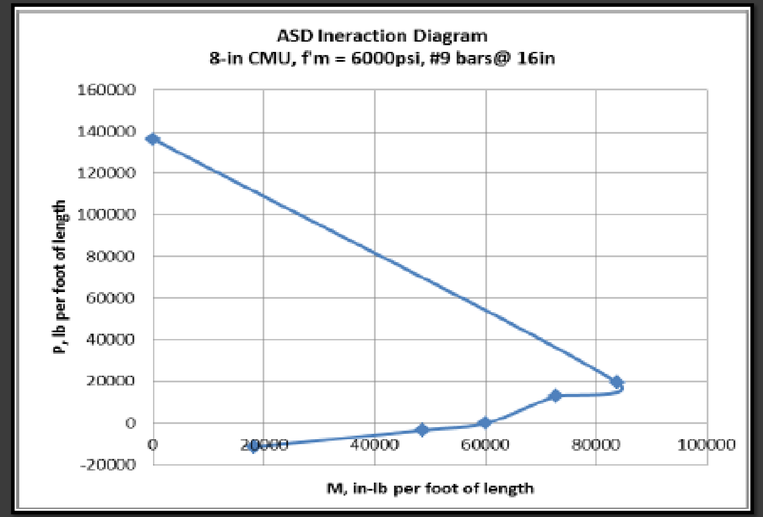
- ❑ Mostly Corridor and Exterior walls

Assumptions:

- ❑ f'm = 6000psi
- ❑ 8" thickness
- ❑ Fs = 24000 psi
- ❑ Fy = 60000 psi



Structural Depth – Shear Wall Design



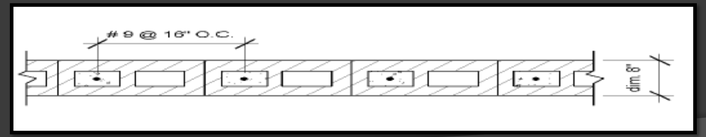
Reinforced masonry loadbearing walls:

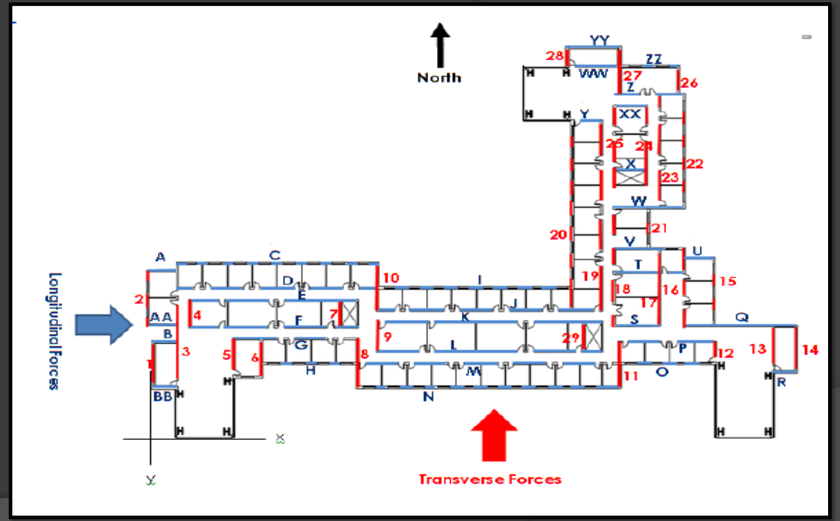
- ❑ Designed under gravity loads first
- ❑ At level 1 (base)
- ❑ Load Combination (ASD): D + L
- ❑ Max. Loads P,M = (27.3 kips, 36.40 ft-kips)

Final Design

Area steel required: As = 0.85 in^2

- ❑ Use (1) # 9 @ 16" O.C.*
- ❑ Or use (2) # 6's @ 16" O.C.

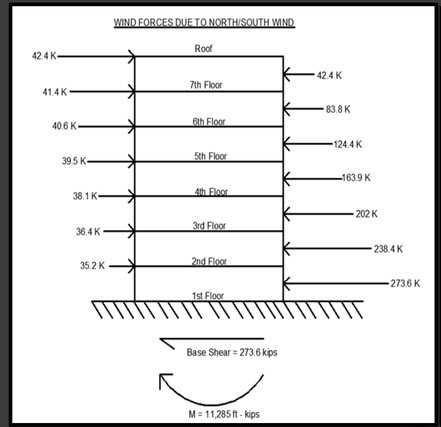


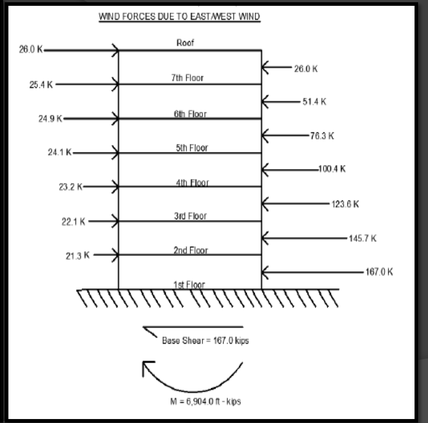


Structural Depth – Shear Wall Design

Wind Loading:

- ❑ Same as existing structure (no change in story height)
- ❑ ASCE 7-05 Wind load cases applied
- ❑ Controlling Case: Load Case 1
- ❑ Longitudinal direction controls
- ❑ Base Shear = 263.6 Kips
- ❑ Overturning Moment = 11,285 ft-kips



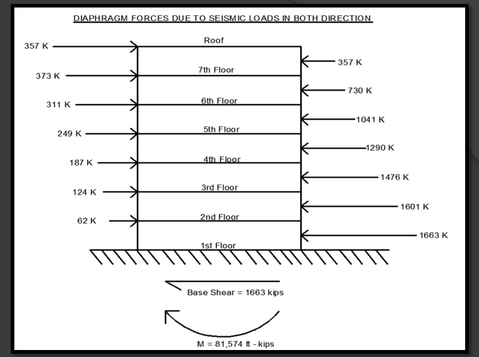


Structural Depth – Shear Wall Design

Seismic Loading:

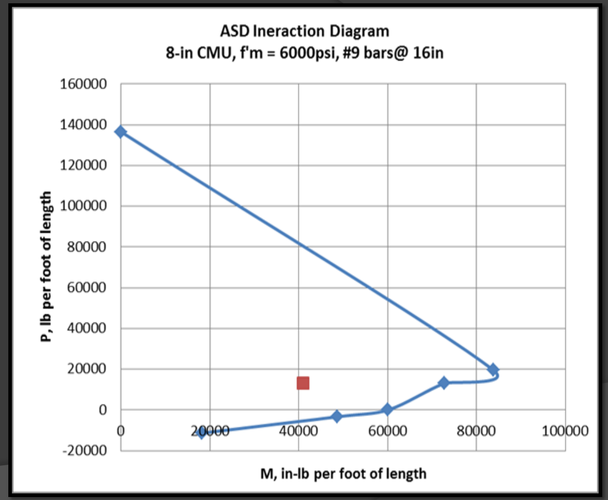
- ❑ Base shear recalculated due to additional weight of building
- ❑ Original response modification factor R = 3
- ❑ Intermediate reinforced masonry shear walls R = 3.5
- ❑ Accidental torsional effects = ±0.05%
- ❑ Drift checked against 0.001hsx

	Base Shear (Kips)	Overturning Moment (ft-kips)
Wind	273.6	11,285
Seismic	1663	81,574



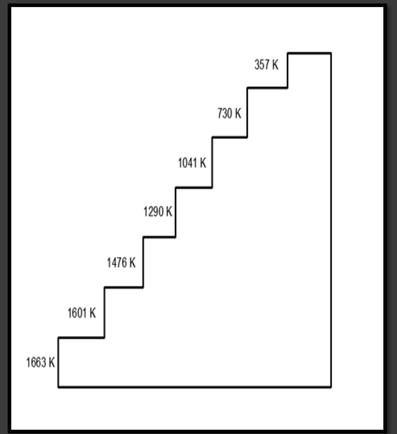
Structural Depth – Shear Wall Design

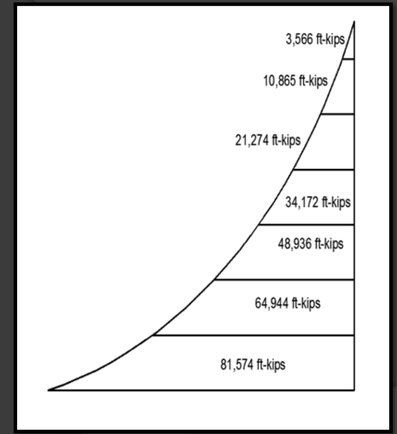
- Check Shear Wall Under Seismic
  - Controlling Load Combination:
    D + 0.7E (ASCE 7-05)
  - Plot (P,M) = (13,300 lbs; 41,000 lbs-in)



Structural Depth – Shear Wall Design

- Drift Calculations
  - Top Story Drift
    $\Delta = 0.023" \leq \Delta_{Limit} = 0.01h_{SX} = 0.7" \rightarrow$ OK
  - Frist Story Drift
    $\Delta = 0.00025" \leq 0.7" \quad \rightarrow$ OK





Structural Depth – Shear Wall Design

- Shear Strength Check
- MSJC 2008
- Where M/Vd < 1:
  - $F_v = \left(\frac{1}{3}\right)\left[4 - \left(\frac{M}{Vd}\right)\right]\sqrt{f'm} \leq 80 - 45\left(\frac{M}{Vd}\right)$
- Where M/Vd ≥ 1:
  - $F_v = \sqrt{f'm} \leq 35$ psi
- If Shear reinforcement is provided
  - As = VS/(Fsd)

No Shear reinforcement is needed

Shear Strength Check on Level 1, Longitudinal Direction

Wall No.	L (in)	M (kip-in)	V (k)	d (in)	M/Vd	f'v (psi)	Fv (psi) w/out reinf [min of two #]		Check
A	168	634.3	13	165	0.30	10	95	67	OK
AA	168	634.3	13	165	0.30	10	95	67	OK
B	132	398.4	8	129	0.38	8	93	63	OK
BB	132	398.4	8	129	0.38	8	93	63	OK
C	576	3454.2	70	573	0.09	16	100	76	OK
D	768	4718.5	96	765	0.06	16	101	77	OK
E	840	5187.7	106	837	0.06	17	101	77	OK
F	768	4718.5	96	765	0.06	16	101	77	OK
G	540	3214.1	66	537	0.09	16	100	76	OK
H	264	1313.1	27	261	0.19	13	97	72	OK
I	552	3294.2	67	549	0.09	16	100	76	OK
J	864	5343.7	109	861	0.06	17	101	77	OK
K	1128	7049.5	144	1125	0.04	17	101	78	OK
L	1056	6585.7	134	1053	0.05	17	101	78	OK
M	984	6121.0	125	981	0.05	17	101	78	OK
N	768	4718.5	96	765	0.06	16	101	77	OK
O	240	1435.9	29	237	0.21	16	97	71	OK
P	408	2918.2	59	405	0.12	19	99	75	OK
Q	648	5549.8	113	645	0.08	23	100	77	OK
R	144	704.3	14	141	0.35	13	93	64	OK
S	264	1564.7	32	261	0.19	16	97	72	OK
T	348	2314.4	47	345	0.14	18	99	74	OK
U	168	840.5	17	165	0.30	14	95	67	OK
V	288	1801.9	37	285	0.17	17	98	72	OK
W	396	2718.4	55	393	0.12	18	99	74	OK
X	168	746.9	15	165	0.30	12	95	67	OK
Y	120	369.2	8	117	0.42	8	92	61	OK
Z	276	1685.4	34	273	0.18	16	98	72	OK
XX	168	746.9	15	165	0.30	12	95	67	OK
ZZ	420	2922.6	60	417	0.12	19	99	75	OK
YY	288	1626.6	33	285	0.17	15	98	72	OK
WW	288	1626.6	33	285	0.17	15	98	72	OK

Shear Strength Check on Level 1, Transverse Direction

Wall No.	L (in)	M (kip-in)	V (k)	d (in)	M/Vd	f'v (psi)	Fv (psi) w/out reinf (X 1.33) [min of two #]		Check
1	300	2658	54	297	0.2	24	98	73	OK
2	168	1075	22	165	0.3	17	95	67	OK
3	480	4763	97	477	0.1	27	100	75	OK
4	156	937	19	153	0.3	16	94	66	OK
5	204	1501	31	201	0.2	20	96	69	OK
6	228	1790	36	225	0.2	21	97	70	OK
7	156	937	19	153	0.3	16	94	66	OK
8	300	2658	54	297	0.2	24	98	73	OK
9	192	1357	28	189	0.3	19	96	68	OK
10	300	2755	56	297	0.2	25	98	73	OK
11	288	2372	48	285	0.2	22	98	72	OK
12	120	530	11	117	0.4	12	92	61	OK
13	240	1864	38	237	0.2	21	97	71	OK
14	312	2762	56	309	0.2	24	98	73	OK
15	240	1997	41	237	0.2	23	97	71	OK
16	300	2755	56	297	0.2	25	98	73	OK
17	492	5080	104	489	0.1	28	100	75	OK
18	492	5200	106	489	0.1	28	100	75	OK
19	972	11495	235	969	0.1	32	101	78	OK
20	720	8378	171	717	0.1	31	101	77	OK
21	144	892	18	141	0.3	17	93	64	OK
22	336	3711	76	333	0.1	30	98	73	OK
23	480	5725	117	477	0.1	32	100	75	OK
24	408	4754	97	405	0.1	31	99	75	OK
25	360	4075	83	357	0.1	31	99	74	OK
26	156	1208	25	153	0.3	21	94	66	OK
27	300	3473	71	297	0.2	31	98	73	OK
28	108	578	12	105	0.5	15	90	59	OK
29	192	1327	27	189	0.3	19	96	68	OK

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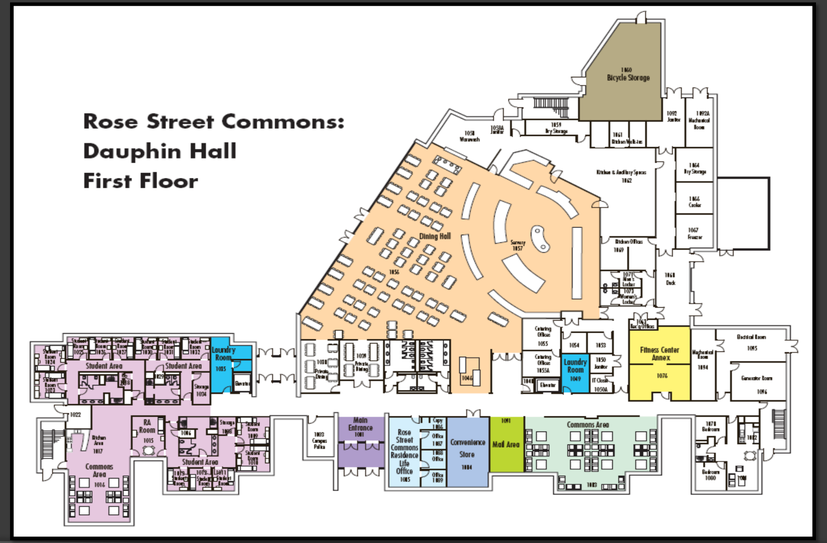
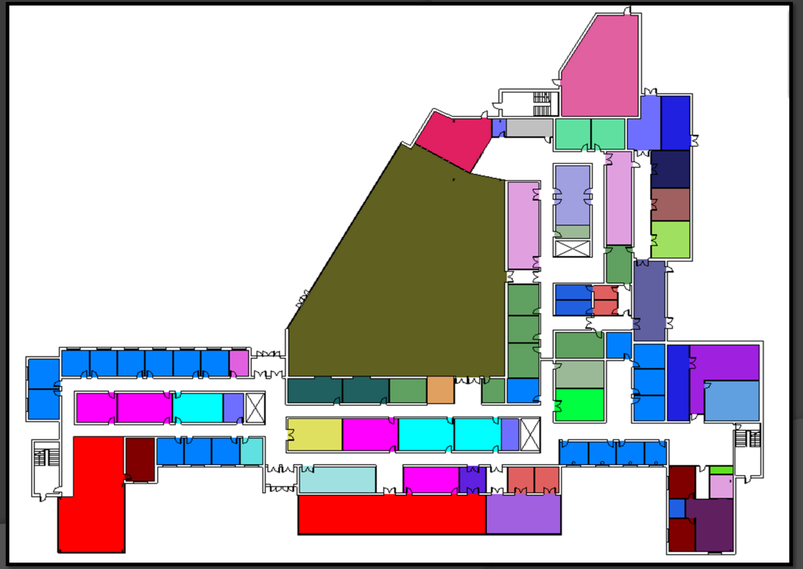


Courtesy of pct.edu

Architectural Breadth

- Floor plans
  - Ceiling height = 10 ft
  - Long corridor
  - More study rooms
  - 124 additional rooms



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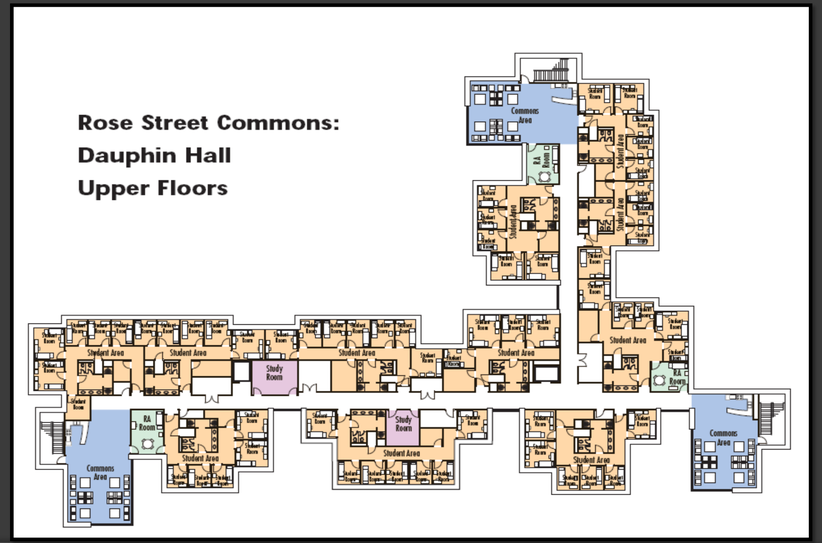

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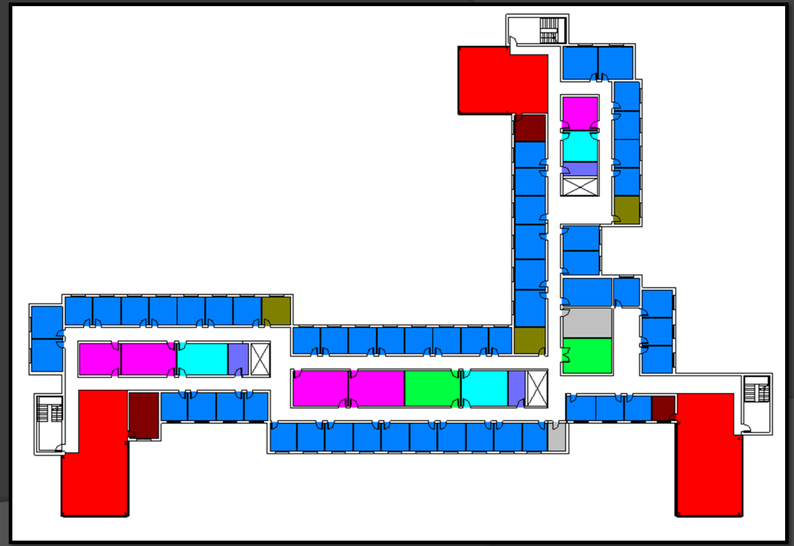

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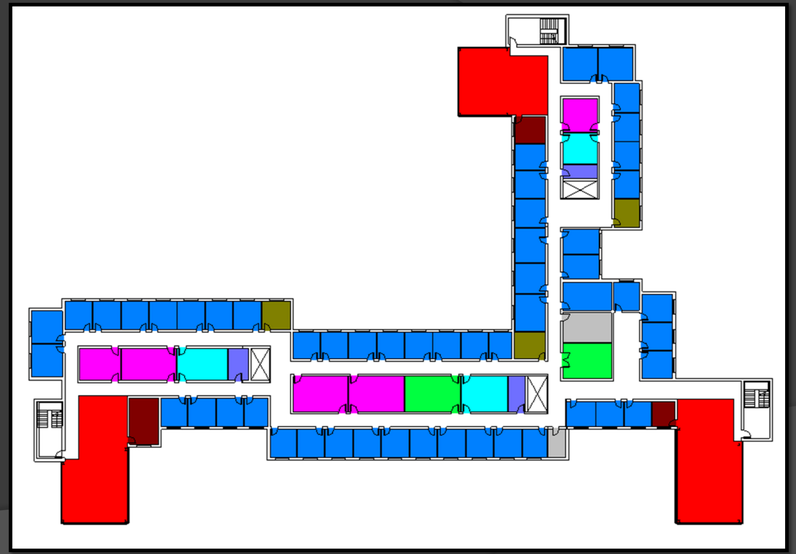
Architectural Breadth

- Codes
  - Corridor width = 6’ min
  - Minimum number of Exists = 3 (392 <500)
  - Dead-Ends
  - Travel distance < 250 ft



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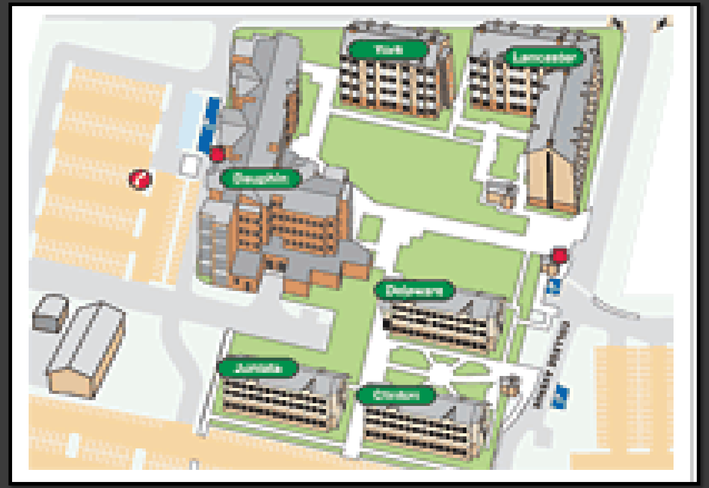

Courtesy of pct.edu

Conclusion

- Goals
  - Structural implementation feasible
  - Longer construction time frame
  - Additional cost
- Recommendations:
  - Foundation would need to be checked and resized

Dauphin Hall – Penn College of Technology

Questions/Comments

Acknowledgements:

- Murray Associates Architects, P.C
- Dr. Bill Martin (Owner representative)
- Penn State AE Faculties
- Friends/Family