Milton S. Hershey Medical Center Biomedical Research Building

Joshua Zolko, Structural Option

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Introduction

- The Biomedical Research Building (BMR) is located in Hershey, Pennsylvania.
- 245000 sq. ft, in 7 stories above grade
- Built between 1991-1993
- Cost $49 million
- Used a Bid-Build project delivery method
- Used for Education and Laboratory space

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Architecture

- Façade of the BMR consists of long horizontal concrete and limestone slabs, and black glazing
- Façade designed to relate to buildings already existing on campus
- Cylinder and Planar wall on corners add to the otherwise flat building

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Structure

- The BMR is a monolithic concrete structure, using a one-way flat plate system with the average column size about 22” by 22”
- Building sits on a deep foundation system of caissons 3 to 7 feet in diameter

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Structure

- Analysis shows that columns have an extra 35% capacity for applied loads
- Design of the lateral system maintained symmetry, resulting in only a 6" eccentricity.

Process

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- Based on extra capacity of columns, goal was to be adding 3 extra stories to top of building, top story floor to floor height to be 24.6' instead of the average 12.3'
- This extra space would serve for a studio or recreational setting for students.

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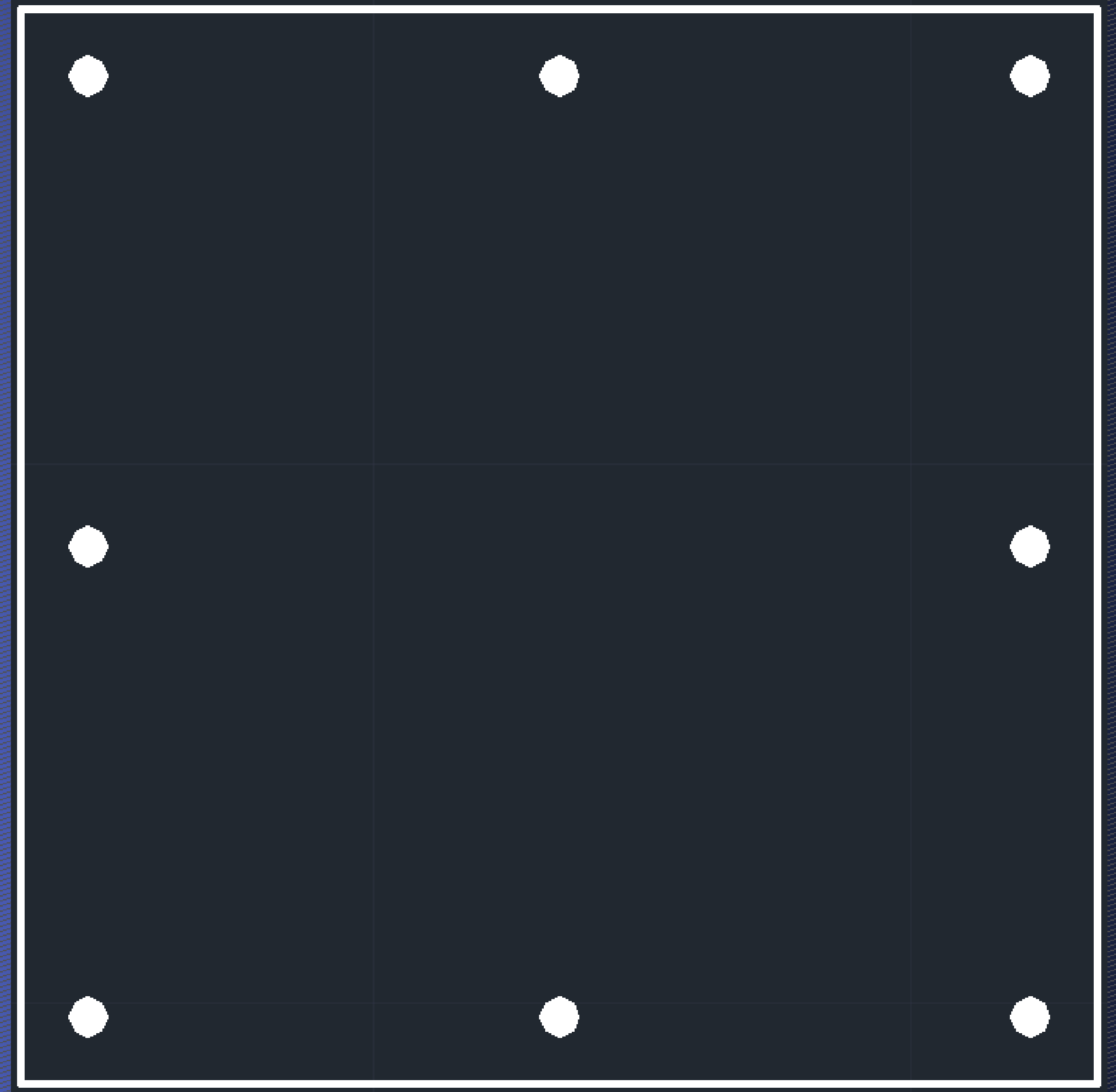
Process

- Assumed gravity loads were to be:
  - 150 PSF dead
  - 40 PSF snow
  - 15 PSF superimposed
  - 80 PSF live
- Self weight of the columns and bracing beams factored in as well

Typical Column Section



Process

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- Axial Loads calculated for a typical column over a 21' by 35' bay area.
- As loads increase, they approach total capacity
- This does not allow much room for applied moments from lateral or asymmetrical loading

Typical Column Axial Load		
Floor	Load	Capacity
10th	143.4K	2230K
9th	435.4K	2230K
8th	652.7K	2230K
7th	870K	2000K
6th	1164K	2000K
5th	1458K	2242K
4th	1752K	2242K
3rd	2046K	2855K
2nd	2340K	2855K
1st	2634K	2855K
Ground	2928K	4708K

Process

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- Loads were calculated again for the 1st, 2nd and 3rd floors, using live load reduction of 53%
- Exceptions were used for live loads over 100 PSF, per IBC, at 20%
- Allows more room for moments

Adjust Axial Load		
Floor	Load	Capacity
3rd	1782K	2855K
2nd	1855K	2855K
1st	1928K	2855K

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Process

- Loads were calculated again for the 1st, 2nd and 3rd floors, using live load reduction of 53%
- Exceptions were used for live loads over 100 PSF, per IBC, at 20%
- Allows more room for moments
- Minimum allowance: 32% for 31%

Example Calculation

$$.25 + \frac{15}{\sqrt{4(735)}} = .53$$

Adjust Axial Load		
Floor	Load	Capacity
3rd	1782K	2855K
2nd	1855K	2855K
1st	1928K	2855K

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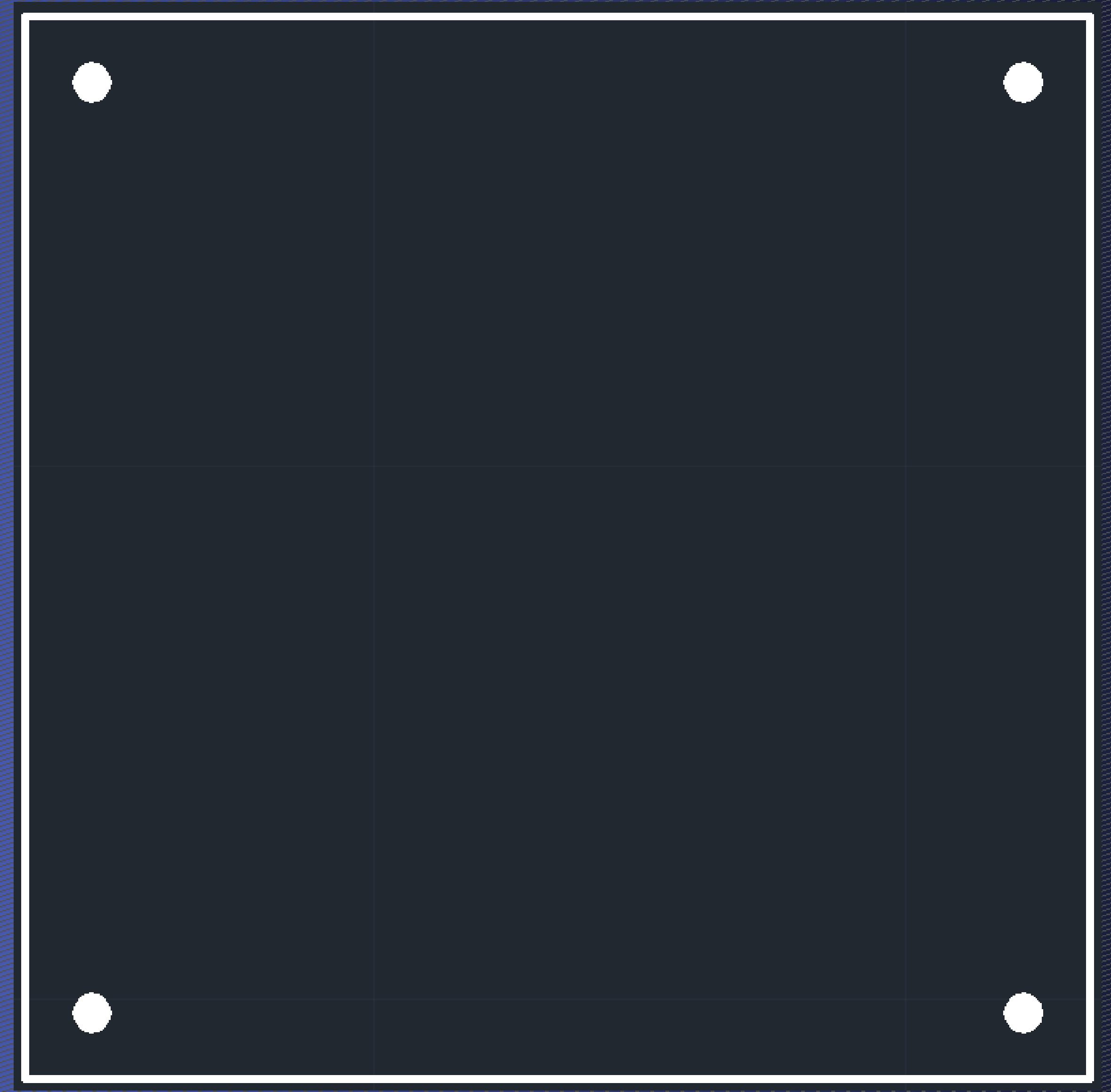
Process

- Bracing beams were necessitated through exceptionally long columns, about 22’ in height
- Beams were chosen to be 24” by 24” to match column sizes
- Would allow for an architectural feature on the top floor.

Bracing Beam Section



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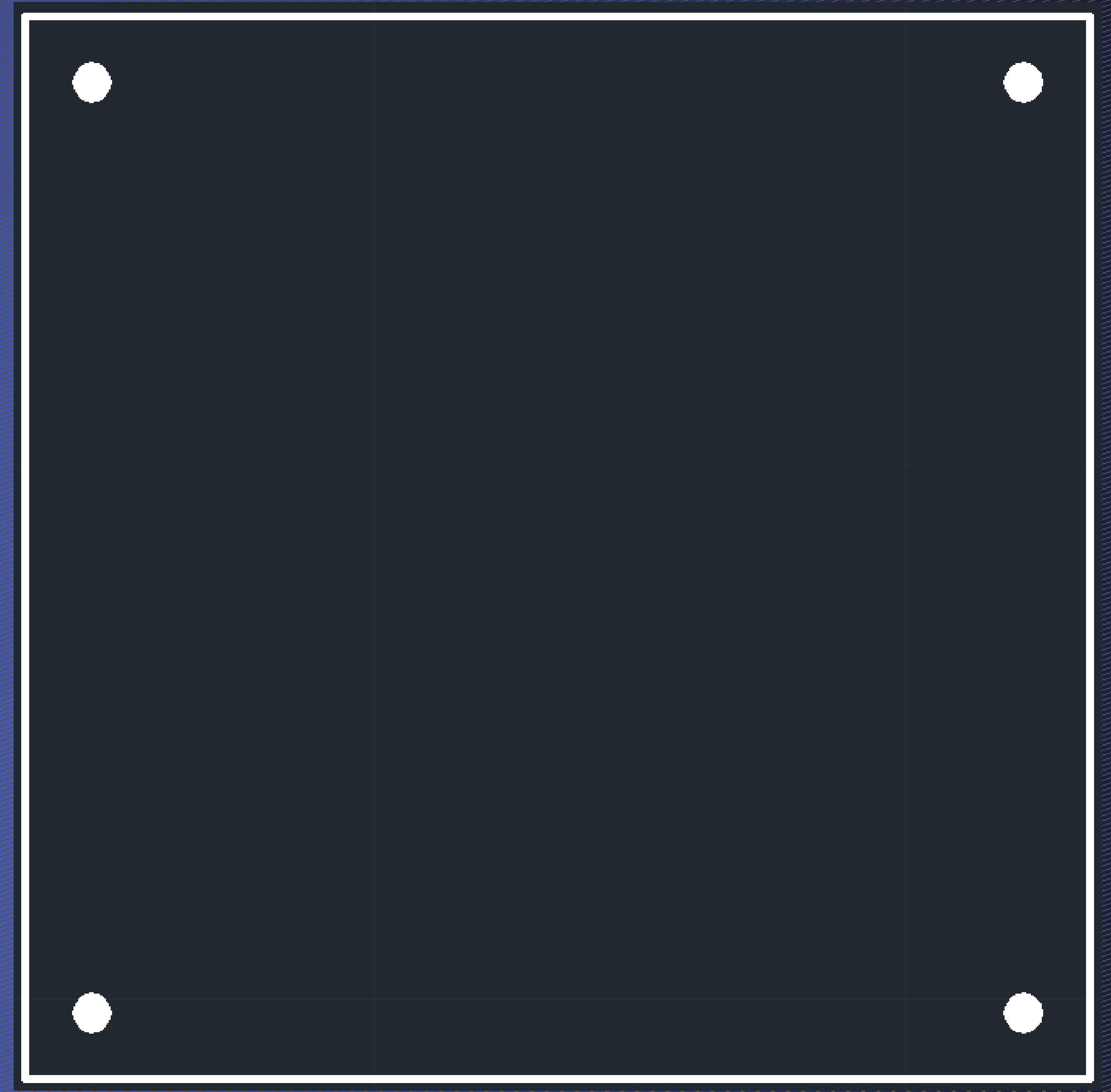
Process

- Assumed a 15 PSF superimposed load for mechanical and electrical equipment
- 600 PLF dead load.
- 66 and 96 ft*kip moments necessitate 4 #7 rebar
- Torsion and shear reinforcement was found to be negligible according to ACI

Bracing Beam Section



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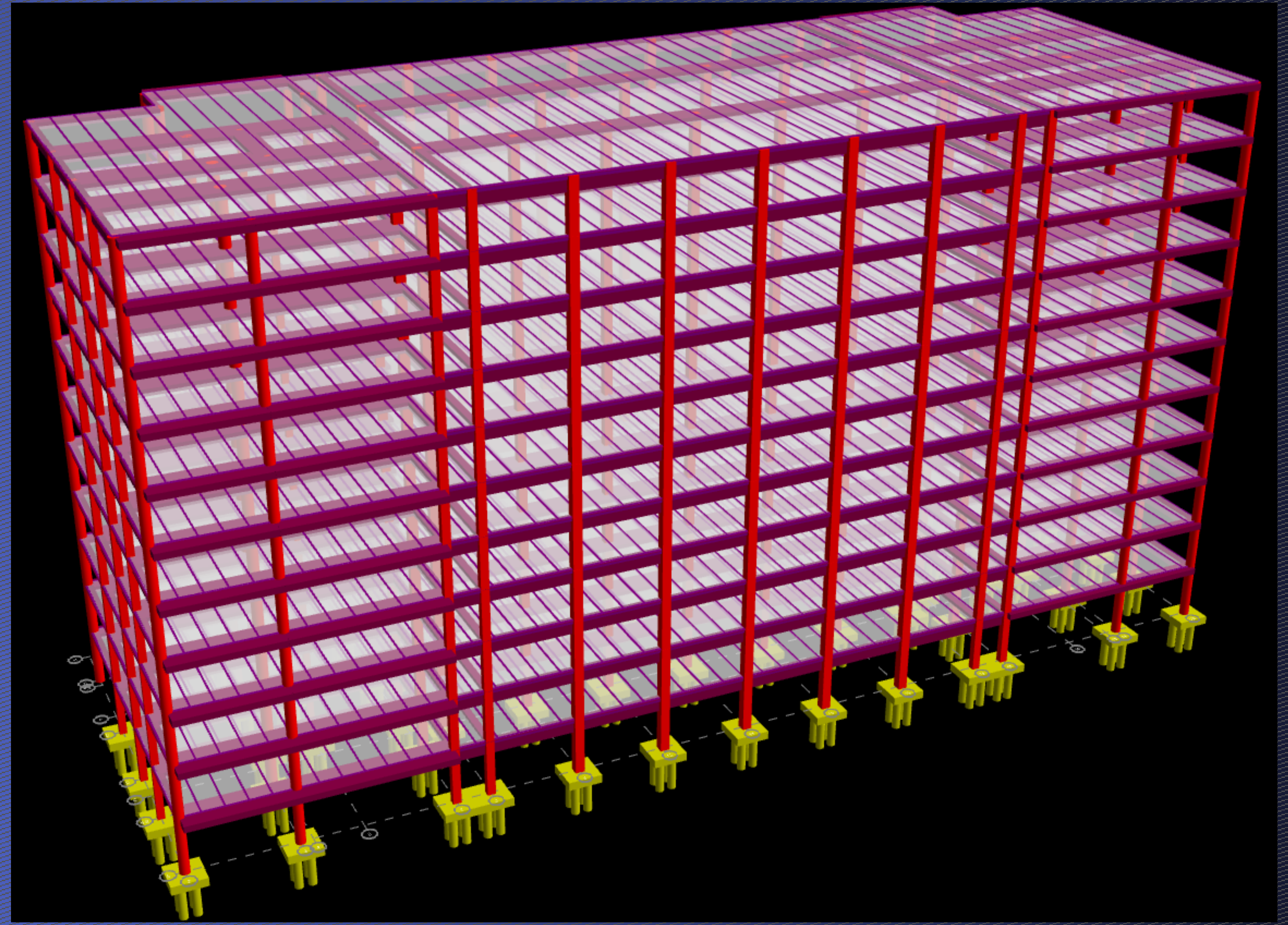
Process

- A RAM Model was developed to analyze the effect of controlling wind and earthquake forces.
- Addition was designed maintaining symmetry and negligible eccentricity as rest of building, minimizing unusual torsional effect and forces

RAM Model



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Process

- Distributing story shear forces across all columns on a story by a factor of 1.5%, lead to a shear force of 9 kips
- Moment of 111 ft*kips per column
- Story and Total drifts are well within acceptable H/400 limits
- Overturning is controlled by gravity loads

Story Drifts

Story Drift						
	Controlling Wind			Seismic		
Floor	X	Y	Allowable	X	Y	Allowable
10	0.04	0.003	0.74	0.04	0.02	5.94
9	0.14	0.010	0.37	0.14	0.03	2.97
8	0.17	0.012	0.37	0.17	0.04	2.97
7	0.22	0.016	0.37	0.22	0.06	2.97
6	0.26	0.020	0.37	0.26	0.07	2.97
5	0.30	0.024	0.37	0.30	0.08	2.97
4	0.35	0.029	0.37	0.35	0.10	2.97
3	0.38	0.031	0.37	0.38	0.12	2.97
2	0.39	0.032	0.38	0.39	0.14	3.04
1	0.25	0.027	0.41	0.25	0.12	3.28

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Process

- Distributing story shear forces across all columns on a story by a factor of 1.5%, lead to a shear force of 9 kips
- Moment of 111 ft*kips per column
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- Overturning is controlled by gravity loads

Story Drifts

Drift						
	Controlling Wind			Seismic		
Floor	X	Y	Allowable	X	Y	Allowable
10	2.50	0.204	4.12	2.50	0.78	33.05
9	2.46	0.201	3.38	2.46	0.76	27.11
8	2.32	0.191	3.01	2.32	0.73	24.14
7	2.15	0.179	2.64	2.15	0.69	21.17
6	1.93	0.163	2.27	1.93	0.63	18.2
5	1.67	0.143	1.90	1.67	0.56	15.23
4	1.37	0.119	1.53	1.37	0.48	12.26
3	1.02	0.090	1.16	1.02	0.38	9.29
2	0.64	0.059	0.79	0.64	0.26	6.32
1	0.25	0.027	0.41	0.25	0.12	3.28

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Story Drifts

X Direction Overturning							
						Resisting Moment	
	Wind	Seismic	Arm	Moment		Self Wt	Arm
1	33.39	53.89	13.7	457.4	738.3	38300	47.5
2	129.7	56.12	26.3	3411.1	1476.0		
3	127.16	56.12	38.7	4921.1	2171.8		
4	124.36	56.12	51	6342.4	2862.1		
5	121.28	56.12	63.3	7677.0	3552.4		
6	58.9	56.13	75.7	4458.7	4249.0		
7	113.78	56.12	88	10012.6	4938.6		
8	108.96	56.12	100.3	10928.7	5628.8		
9	104.28	56.19	112.6	11741.9	6327.0		
10	51.65	56.43	124.9	6451.1	7048.1		
Total				66402	38992	1819250	Good

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- Moment of 111 ft*kips per column
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- Overturning is controlled by gravity loads

Story Drifts

Y Direction Overturning							
						Resisting Moment	
	Wind	Seismic	Arm	Moment		Self Wt	Arm
1	10.25	53.89	13.7	140.4	738.3	38300	140
2	19.77	56.12	26.3	520.0	1476.0		
3	19.29	56.12	38.7	746.5	2171.8		
4	18.77	56.12	51	957.3	2862.1		
5	18.19	56.12	63.3	1151.4	3552.4		
6	17.54	56.13	75.7	1327.8	4249.0		
7	16.79	56.12	88	1477.5	4938.6		
8	15.89	56.12	100.3	1593.8	5628.8		
9	14.95	56.19	112.6	1683.4	6327.0		
10	14.52	56.43	124.9	1813.5	7048.1		
Total				11412	38992	5362000	Good

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HVAC (Breadth 1)

- Calculated CFM requirements for the addition were found to be 86000 CFM
  - 4050 people at 20 CFM and 81000 sq ft at .06 CFM
- BTU Loads for CFM and people and insulation were found to be 5 million BTU/HR for both heating and cooling

Insulation

Enclosure		
Insulation:	Thickness	R-Value
Limestone	4.5"	0.8
Insulation	2"	8
CMU	7.625"	1.11
Insulation	2"	8
GWB	.625"	0.56
Total:	16.75"	18.47

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Lighting (Breadth 2)

- For a recommended 500 lux for a work space, the total room of 90’ by 210’ with its 12 bays requires 200 luminaries, allowing 18 per bay
- Two systems were developed, one at 12.3’ high, and one at ceiling for the top story, but ceiling height would cast shadows

Typical Luminaire

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Acoustics (Breadth 3)

- Acoustical tile was initially placed on ceiling, beams, columns, and carpeting was used.
- Created a “dead space” which would have been disconcerting to occupants
- Toned back acoustical insulation to just beams and columns, as well as carpeting

Calculations

$$10log\frac{19660+400}{400}=17\ dB$$

$$10log\frac{11223+400}{400}=15\ dB$$

Questions?