

Mountain State Blue Cross Blue Shield Headquarters

Parkersburg, WV



Department of Architectural Engineering
The Pennsylvania State University

PRESENTATION OUTLINE

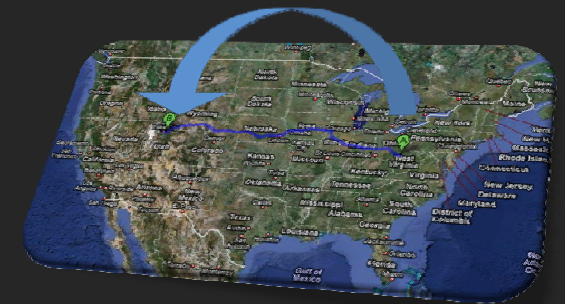
- THESIS GOALS
- BUILDING INTRODUCTION
- STRUCTURAL DEPTH
 - ADDITIONAL FLOOR
 - RELOCATION TO UTAH
- ARCHITECTURAL BREADTH
 - COLUMN GRID ADJUSTMENT
 - CHANGES TO FLOOR PLAN
- CONSTRUCTION MANAGEMENT BREADTH
 - SCHEDULE IMPACT
 - COST ANALYSIS
- SUMMARY RECOMMENDATIONS
- THANKS
- QUESTIONS

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THESIS GOALS

- ADD FLOOR FOR MORE OFFICE SPACE
- RELOCATE THE BUILDING TO SALT LAKE CITY, UTAH
- REDESIGN LATERAL SYSTEM
- INVESTIGATE FOUNDATIONS
- SCHEDULE IMPACT
- COST ANALYSIS



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BUILDING STATISTICS

OFFICE BUILDING
4 FLOORS - 128,496 SQ. FT.
TOTAL COST - 18 MILLION - DESIGN BID BUILD
(ADDING FLOOR FOR THESIS REQUIREMENT)

STRUCTURAL SYSTEM

COMPOSITE STEEL FRAMING
4 CONCENTRICALLY BRACED FRAMES
(2 IN EACH DIRECTION)
TYPICAL BAY SIZE - 30' X 30'

PROJECT TEAM

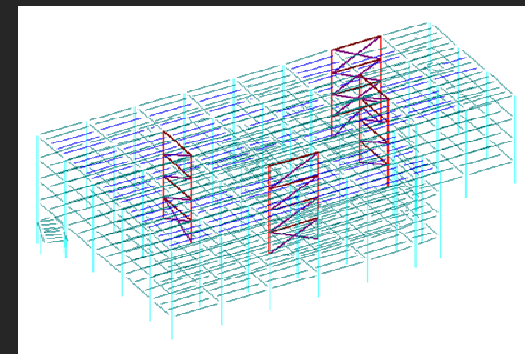
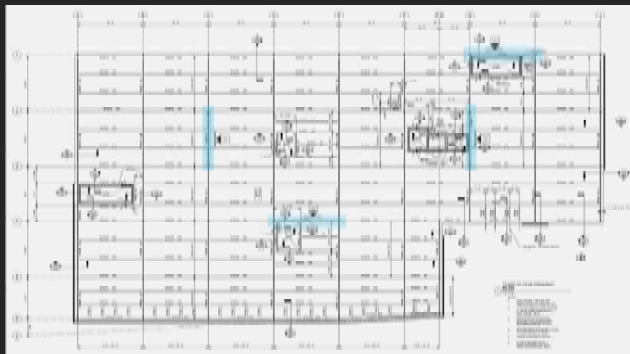
OWNER: WOOD COUNTY DEVELOPMENT AUTHORITY
ARCHITECT: BURT HILL
STRUCTURAL: ATLANTIC ENGINEERING SERVICES
CONTRACTOR: G.A. BROWN



PHOTO COURTESY OF ATLANTIC
ENGINEERING SERVICES

PRESENTATION OUTLINE

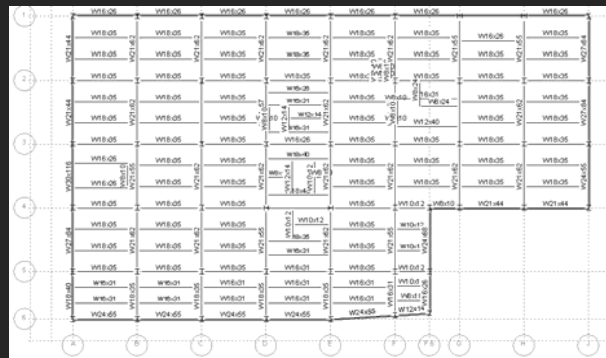
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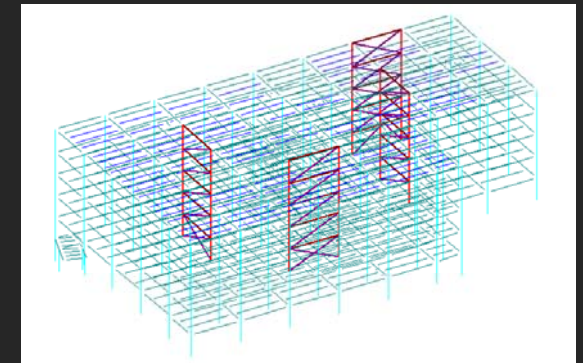
RAM STRUCTURAL SYSTEM

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RAM STRUCTURAL SYSTEM

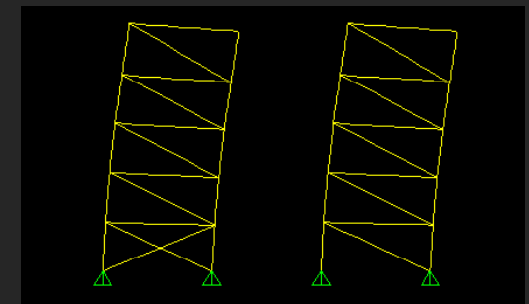


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Frame 1						
X Direction	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Level						
Roof	0.48	0.49	56.49	57.46	0.387	148.4
5th	0.46	0.45	57.46	58.37	0.280	208.2
4th	0.32	0.40	57.23	57.95	0.183	316.3
3rd	0.60	0.20	51.43	52.23	0.102	513.6
2nd	0.05	-0.23	54.51	54.33	0.038	1437.3
Total of Sum of Forces				288.84		
Relative Stiffness				0.55		

Frame 3						
X Direction	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Level						
Roof	0.77	0.77	41.80	43.34	0.387	111.9
5th	0.65	0.65	40.31	41.61	0.280	148.4
4th	0.50	0.50	47.03	48.03	0.183	262.2
3rd	0.57	0.57	46.62	47.76	0.102	469.6
2nd	-0.04	-0.04	46.59	46.51	0.038	1230.4
Total of Sum of Forces				206.85		
Relative Stiffness				0.45		



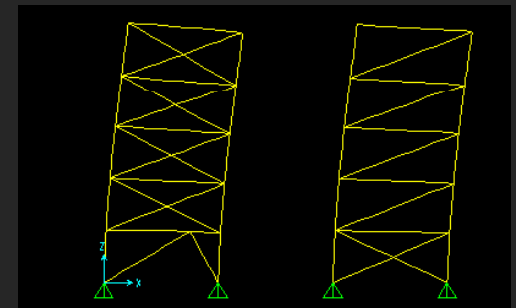
FRAME 1
FRAME 3
(30' SPAN FOR EACH BRACED FRAME)

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Y Direction						
Frame 2						
Level	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Roof	1.01	1.01	43.54	45.56	0.439	103.8
5th	1.14	1.14	47.34	49.62	0.320	155.2
4th	0.70	0.70	48.11	49.51	0.205	241.6
3rd	0.76	0.76	48.08	49.60	0.115	430.2
2nd	0.06	0.06	42.77	42.89	0.046	942.6
Total of Sum of Forces				228.96		
Relative Stiffness				0.47		

Y Direction						
Frame 4						
Level	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Roof	1.07	1.07	53.07	55.21	0.439	125.8
5th	1.21	1.21	47.92	50.34	0.320	157.5
4th	0.73	0.73	49.01	50.47	0.205	246.3
3rd	0.81	0.81	48.76	50.38	0.115	436.9
2nd	0.05	0.05	56.99	57.09	0.046	1254.7
Total of Sum of Forces				267.39		
Relative Stiffness				0.53		



FRAME 4

FRAME 2

(30' SPAN FOR EACH BRACED FRAME)

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X DIRECTION

X Direction					
Direct Shear	V* R_i / ΣR		Torsional Shear	V*e* R_i *C/ ΣR *C ²	
V (k)	Frame 1	Frame 3	V (k)	Frame 1	Frame 3
55.24	30.38	24.86	55.24	4.31	7.42
164.74	90.61	74.13	164.74	12.73	22.29
113.74	62.56	51.18	113.74	9.08	14.99
66.88	36.78	30.10	66.88	5.57	8.45
22.65	12.46	10.19	22.65	2.11	2.54
Total Shear				423.17	

Y DIRECTION

Y Direction					
Direct Shear	V* R_i / ΣR		Torsional Shear	V*e* R_i *C/ ΣR *C ²	
V (k)	Frame 2	Frame 4	V (k)	Frame 2	Frame 4
55.25	25.97	29.28	55.25	5.44	5.66
164.36	77.25	87.11	164.36	16.01	17.03
113.39	53.29	60.10	113.39	11.14	11.65
66.69	31.34	35.35	66.69	6.70	6.69
22.65	10.65	12.00	22.65	2.61	2.25
Total Shear				422.47	

X DIRECTION

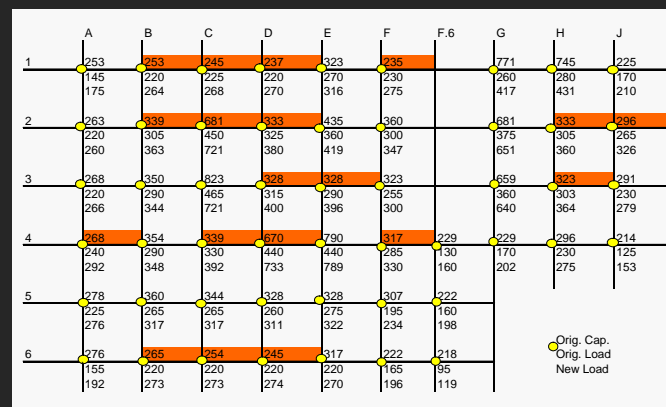
Controlling Seismic Drift X Direction							
Story	Story Ht. (ft.)	Story Displacement (ft.)	Story Drift (ft.)	Allowable Story Drift (ft.) Δ_{DISMAC}°	Total Drift (ft.)	Allowable Total Drift (ft.) Δ_{DISMAC}°	
				0.025H _s		0.025H _s	
Roof	67.30		0.0900	0.00435	<	0.34	Acceptable
5th	53.83		0.0800	0.00483	<	0.35	Acceptable
4th	39.83		0.0583	0.00476	<	0.33	Acceptable
3rd	26.67		0.0358	0.00436	<	0.33	Acceptable
2nd	13.33		0.0150	0.00366	<	0.33	Acceptable

Y DIRECTION

Controlling Seismic Drift Y Direction							
Story	Story Ht. (ft.)	Story Displacement (ft.)	Story Drift (ft.)	Allowable Story Drift (ft.) Δ_{DISMAC}°	Total Drift (ft.)	Allowable Total Drift (ft.) Δ_{DISMAC}°	
				0.025H _s		0.025H _s	
Roof	67.30		0.0942	0.00455	<	0.34	Acceptable
5th	53.83		0.0800	0.00483	<	0.35	Acceptable
4th	39.83		0.0583	0.00476	<	0.33	Acceptable
3rd	26.67		0.0358	0.00436	<	0.33	Acceptable
2nd	13.33		0.0150	0.00366	<	0.33	Acceptable

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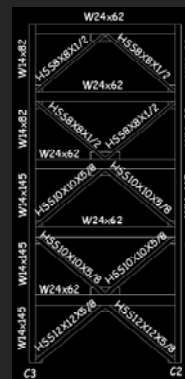
Changes to Foundations		
Caisson	Additional Feet	Kips
A4	7	299
B1	3	265
B2	5	365
B6	3	276
C1	6	269
C2	4	735
C4	10	396
C5	5	274
D1	9	272
D2	9	381
D3	15	402
D4	7	735
D6	8	276
E3	14	397
F1	13	280
F4	4	333
H2	6	365
H3	9	370
J2	7	333

Building Comparison of Cubic Yards of Conc.	
Original Building	1227
Added Floor	1273
Total Difference	46

4% INCREASE

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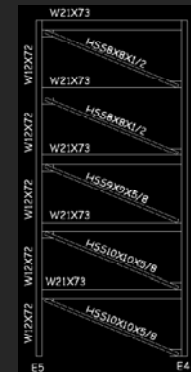
NEW DESIGN



WV DESIGN



NEW DESIGN



WV DESIGN



NEW DESIGN

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NEW DESIGN



NEW DESIGN



WV DESIGN



NEW DESIGN



WV DESIGN

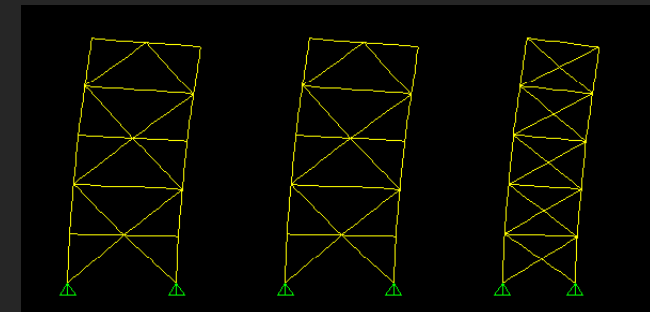
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Frame 1							
Y Direction	Level	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
	Roof	4.81	4.81	354.33	363.95	1.599	227.6
	5th	5.19	5.19	333.78	344.16	1.150	299.2
	4th	1.95	1.95	441.86	445.76	0.713	625.5
	3rd	6.07	6.07	337.15	349.29	0.403	867.8
	2nd	-1.51	-1.51	446.94	443.92	0.130	3425.3
				Total of Sum of Forces	1635.08		
				Relative Stiffness	0.39		

Frame 2							
Y Direction	Level	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
	Roof	3.19	3.19	417.06	423.44	1.599	264.8
	5th	3.96	3.96	322.76	330.68	1.150	287.5
	4th	-0.54	0.54	394.68	394.68	0.713	553.9
	3rd	4.86	4.86	338.52	348.24	0.403	865.2
	2nd	-1.87	-1.87	365.21	361.47	0.130	2789.1
				Total of Sum of Forces	1854.53		
				Relative Stiffness	0.37		

Frame 3							
Y Direction	Level	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
	Roof	1	1	208.26	210.26	1.599	131.5
	5th	2.85	2.85	317.35	323.05	1.150	280.8
	4th	-0.85	-0.85	157.82	156.12	0.713	219.1
	3rd	4.02	4.02	292.31	300.35	0.403	746.2
	2nd	-2.11	-2.11	196.44	192.22	0.130	1483.2
				Total of Sum of Forces	1158.99		
				Relative Stiffness	0.24		



FRAME 1

FRAME 2

FRAME 3

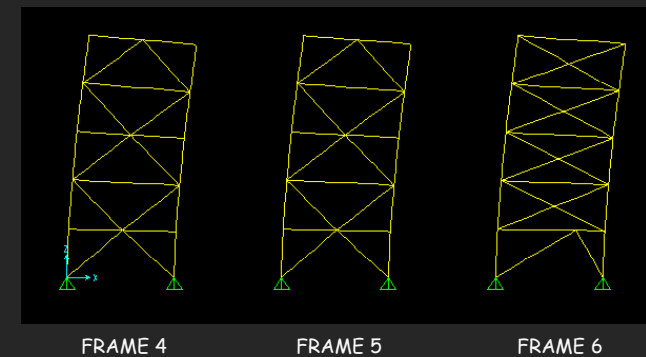
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Frame 4						
X Direction	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Roof	1.29	1.29	294.67	297.25	1.501	198.1
5th	1.31	1.31	234.82	237.44	1.077	220.5
4th	0.57	0.57	331.75	332.89	0.680	489.5
3rd	2.13	2.13	220.32	224.58	0.379	592.7
2nd	-0.84	-0.84	344.45	342.77	0.122	2805.0
Total of Sum of Forces				1636.89		
Relative Stiffness				0.29		

Frame 5						
X Direction	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Roof	3.01	3.01	366.92	372.94	1.501	248.5
5th	2.86	2.86	350.15	355.87	1.077	330.5
4th	0.99	0.99	414.63	416.61	0.680	612.7
3rd	4.70	4.70	354.29	363.69	0.379	959.9
2nd	-1.36	-1.36	421.55	418.83	0.122	3427.4
Total of Sum of Forces				1636.84		
Relative Stiffness				0.39		

Frame 6						
X Direction	Left Col Shear	Right Col Shear	Hor. Component of Brace	Sum of Forces	Floor Deflection	Relative Rigidity
Roof	3.46	3.47	321.06	327.99	1.501	218.5
5th	3.17	3.13	398.74	405.04	1.077	376.2
4th	1.29	1.58	245.63	248.50	0.680	365.4
3rd	4.83	3.36	401.92	410.11	0.379	1082.4
2nd	-1.39	-2.46	240.31	236.46	0.122	1935.0
Total of Sum of Forces				1636.80		
Relative Stiffness				0.33		



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X DIRECTION

X Direction							
Direct Shear	V* R_i / ΣR			Torsional Shear	V*e* R_i *C/ ΣR *C ²		
V (k)	Frame 4	Frame 5	Frame 6	V (k)	Frame 4	Frame 5	Frame 6
249.95	71.77	96.52	81.67	55.24	0.65	4.03	4.51
756.70	217.27	292.19	247.24	164.74	1.56	11.49	13.91
548.38	157.46	211.75	179.17	113.74	1.05	7.90	9.62
338.53	97.20	130.72	110.61	66.88	0.34	4.23	5.91
145.09	41.66	56.02	47.41	22.65	0.14	1.46	1.99
Total Shear							2041.73

Y DIRECTION

Y Direction							
Direct Shear	V* R_i / ΣR			Torsional Shear	V*e* R_i *C/ ΣR *C ²		
V (k)	Frame 1	Frame 2	Frame 3	V (k)	Frame 1	Frame 2	Frame 3
249.95	97.48	92.48	59.99	55.24	5.62	1.39	5.26
756.70	295.11	279.98	181.61	164.74	17.32	3.68	15.44
548.38	213.87	202.90	131.61	113.74	12.93	1.62	10.06
338.53	132.03	125.26	81.25	66.88	7.66	0.89	5.87
145.09	56.59	53.68	34.82	22.65	3.13	0.21	1.65
Total Shear							2039.26

X DIRECTION

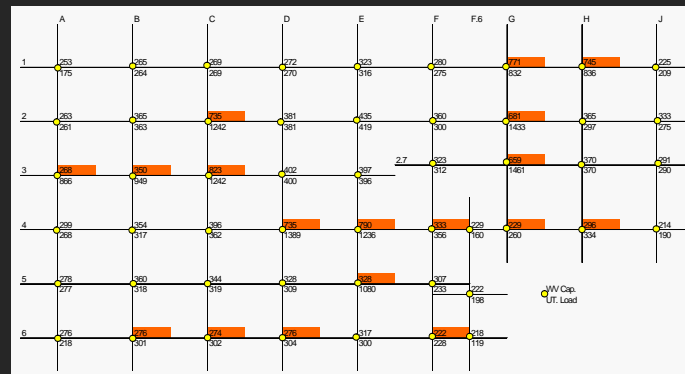
Controlling Seismic Drift X Direction						
Story	Story Ht. (ft.)	Story Displacement (ft.)	Story Drift (ft.)	Allowable Story Drift (ft.) Δ_{SDSAC}	Total Drift (ft.)	Allowable Total Drift (ft.) Δ_{TSDSAC}
				= 0.025H _w		= 0.025H _w
Roof	67.30	0.1480	0.00220	< 0.34 Acceptable	0.0094	< 1.68 Acceptable
5th	53.83	0.1290	0.00240	< 0.35 Acceptable	0.0072	< 1.35 Acceptable
4th	39.83	0.0967	0.00243	< 0.33 Acceptable	0.0048	< 1.00 Acceptable
3rd	26.67	0.0575	0.00216	< 0.33 Acceptable	0.0023	< 0.67 Acceptable
2nd	13.33	0.0023	0.00017	< 0.33 Acceptable	0.0002	< 0.33 Acceptable

Y DIRECTION

Controlling Seismic Drift Y Direction						
Story	Story Ht. (ft.)	Story Displacement (ft.)	Story Drift (ft.)	Allowable Story Drift (ft.) Δ_{SDSAC}	Total Drift (ft.)	Allowable Total Drift (ft.) Δ_{TSDSAC}
				= 0.025H _w		= 0.025H _w
Roof	67.30	0.1530	0.00227	< 0.34 Acceptable	0.0102	< 1.68 Acceptable
5th	53.83	0.1220	0.00227	< 0.35 Acceptable	0.0080	< 1.35 Acceptable
4th	39.83	0.0875	0.00220	< 0.33 Acceptable	0.0057	< 1.00 Acceptable
3rd	26.67	0.0530	0.00199	< 0.33 Acceptable	0.0035	< 0.67 Acceptable
2nd	13.33	0.0200	0.00150	< 0.33 Acceptable	0.0015	< 0.33 Acceptable

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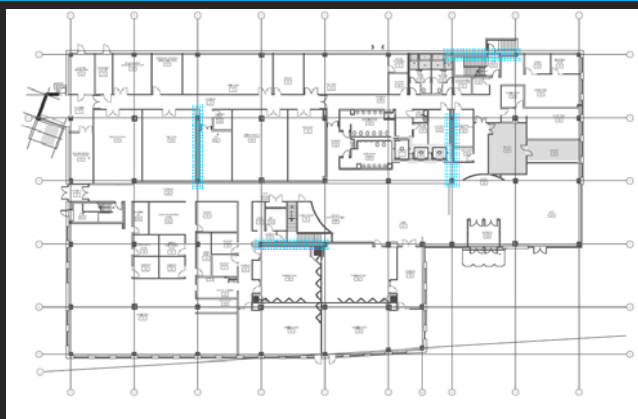
Changes to Foundations			
Caisson	Diam. Change	Additional Feet	Kips
A3	36" to 66"	none	889
B3	42" to 66"	8	954
B6	none	7	303
C2	60" to 72"	13	1244
C3	66" to 72"	17	1244
C6	none	8	303
D4	60" to 72"	22	1399
D6	none	8	307
E4	66" to 72"	30	1243
E5	42" to 72"	20	1088
F4	none	5	360
F6	none	2	229
G1	none	5	837
G2	60" to 76"	23	1489
G2.7	60" to 76"	25	1489
G4	none	8	261
H1	none	6	837
H4	none	8	338

Building Comparison of Cubic Yards of Conc.	
WV - 5 Stories	1273
UT - 5 Stories	1661
Total Difference	388

29% INCREASE

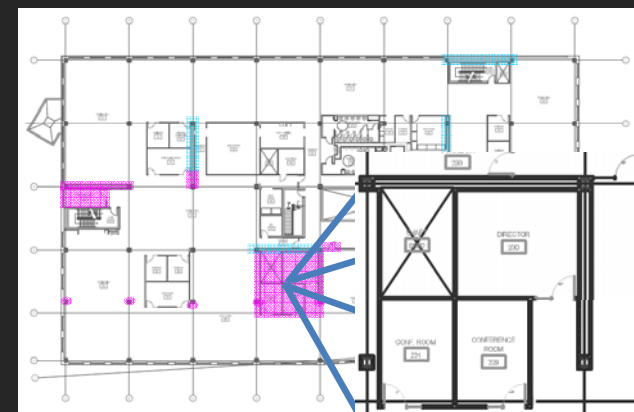
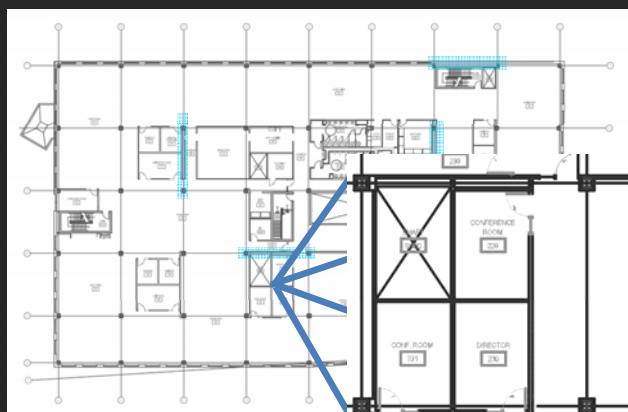
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 - ADDITIONAL FLOOR
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TOTAL DURATION

Super Structure	Days to Complete One Floor	Original Building	Additional Floor
Steel Fabrication	36	144	180
Steel Erection A-C	7	28	35
Steel Erection C-E	10	40	50
Steel Erection E-J	6	24	30
Deck and Detail A-C	14	56	70
Deck and Detail C-E	14	56	70
Deck and Detail E-J	30	120	150
Conc. Slab	32	128	160
Total Days	149	596	745

RESULTS

Total Difference	149
Percent Increase in Duration	20%
Critical Schedule (Original)	200
Critical Schedule (Addition)	240

40 ADDITIONAL DAYS



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Structural Component	Original Building	WV Addition	UT Building
Beam / Joists	696392 lbs	879530 lbs	864401 lbs
Studs	14684 lbs	19548 lbs	19325 lbs
Columns	107416 lbs	141560 lbs	125413 lbs
Frame Members	87880 lbs	125061 lbs	211465 lbs
Floor Decking	93966 ft ²	125288 ft ²	125288 ft ²
Roof Decking	31322 ft ²	31322 ft ²	31322 ft ²
Slab On Deck	1523 yd ³	2030 yd ³	2030 yd ³
Slab On Grade	387 yd ³	387 yd ³	387 yd ³
Caisson Drilling	3153 Lin. Ft.	3297 Lin. Ft.	3512 Lin. Ft.
Caisson Concrete	1227 yd ³	1273 yd ³	1661 yd ³

Structural Component	Cost
Steel Cost per Ton	\$4,117.00
Decking Cost per ft ²	\$2.28
Slab On Deck Cost per yd ³	\$319.00
Slab On Grade Cost per yd ³	\$621.00
Caisson Drilling Cost per Lin. Ft.	\$122.74
Caisson Conc. Cost per yd ³	\$154.60

Building	Total Cost for Super Structure	Cost per ft ²
Original Building	\$3,454,297.29	\$22.06
WV Addition	\$4,246,040.83	\$22.59
UT Building	\$4,445,426.38	\$23.65

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STRUCTURAL

- ✓YES DESIGN ADDITIONAL GRAVITY FLOOR
- ✓YES REDESIGN LATERAL SYSTEM FOR UTAH
- ✓YES INVESTIGATE FOUNDATIONS

ARCHITECTURAL

- ✓YES REDESIGN COLUMN GRID LAYOUT
- ✓YES MINIMIZE CHANGES TO FLOOR PLAN

CONSTRUCTION MANAGEMENT

- ✓YES DETERMINE SCHEDULE IMPACT
- ✓YES COST ANALYSIS

- ✓YES RECOMMEND IF SITUATION WAS PRESENTED

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PROF. HOLLAND
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I WOULD ALSO LIKE TO STATE THAT BODYBUILDING REALLY HELPED ME STAY FOCUSED AND TAUGHT ME A LOT OF DISCIPLINE. STRICT WORKOUT SCHEDULES AND DIETING FOR 16 WEEKS IS A COMMITMENT IN ITSELF. I BELIEVE IT HELPED ME A GREAT DEAL TO STAY FOCUSED THROUGHOUT THIS THESIS AND ON TASK.

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QUESTIONS ?

