SENIOR THESIS

SPRING 2006

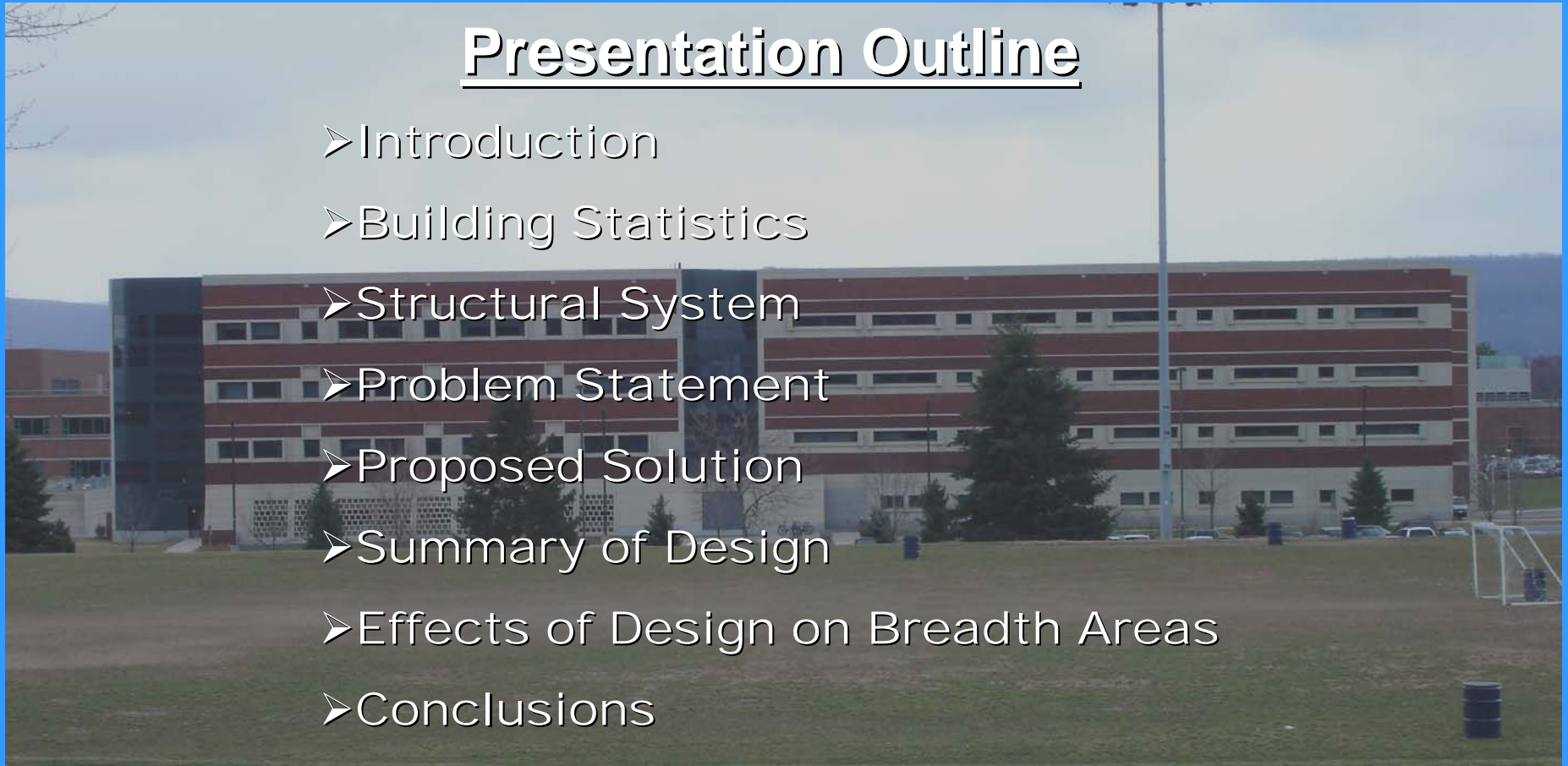**EARTH AND ENGINEERING SCIENCES BUILDING**

UNIVERSITY PARK, PA

JUSTIN STRAUSER

STRUCTURAL OPTION

Presentation Outline

- Introduction

- Building Statistics

- Structural System

- Problem Statement

- Proposed Solution

- Summary of Design

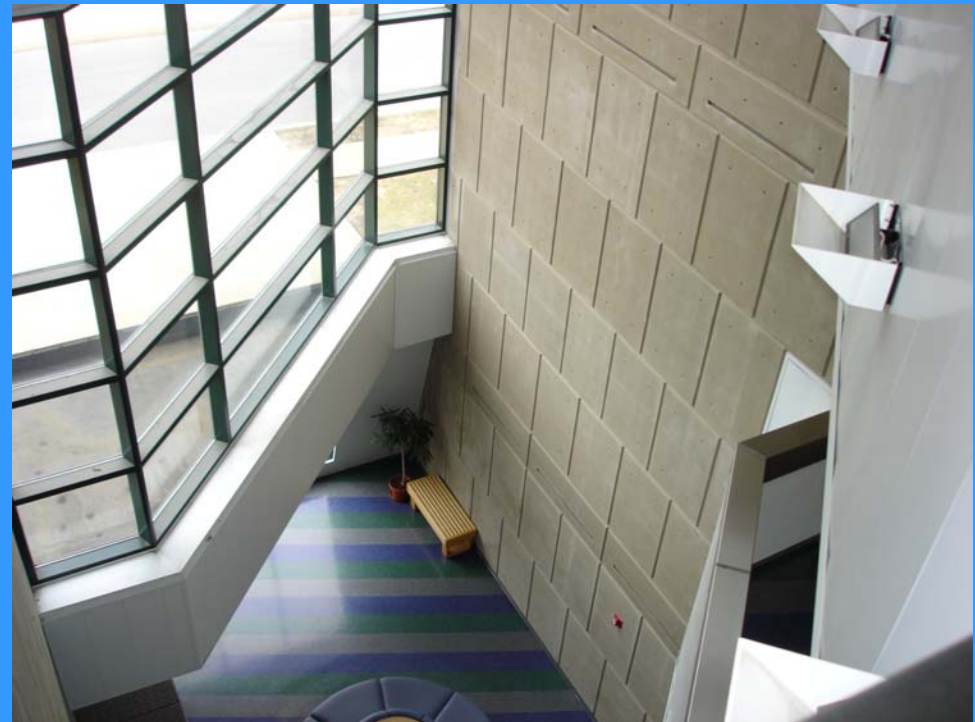- Effects of Design on Breadth Areas

- Conclusions

Introduction

- ➢Location

- ➢Design Team

  - •Owner

  - •Architect

  - •Engineer

  - •Contractor

- ➢Construction Dates

- ➢State Funding

Building Statistics

106,000 Square Feet

Building Height : **66'-4"**

Mean Roof Height : **61'-4"**

Floor to Floor Height:

- 1st Floor : 17'-4"

- 2nd – 4th Floors : 14' – 8"

Educational and Laboratory Facility

Special Features:

- Cray Supercomputer

- Automated Fire Door

- Lobby Space

- Auditorium Space

Structural System

Gravity System

•A36 Grade Steel Frame(50 ksi in specific locations)

•Fully Composite Slab on Deck

▪20 gauge galvanized steel deck 3" deep with 3 ¼" lightweight concrete topping

Lateral System

•Concrete Shear Walls

▪12" thick reinforced concrete shear walls, #5 @ 8" EW EF

•Location of Walls and Connection Methods

•Moment Frame
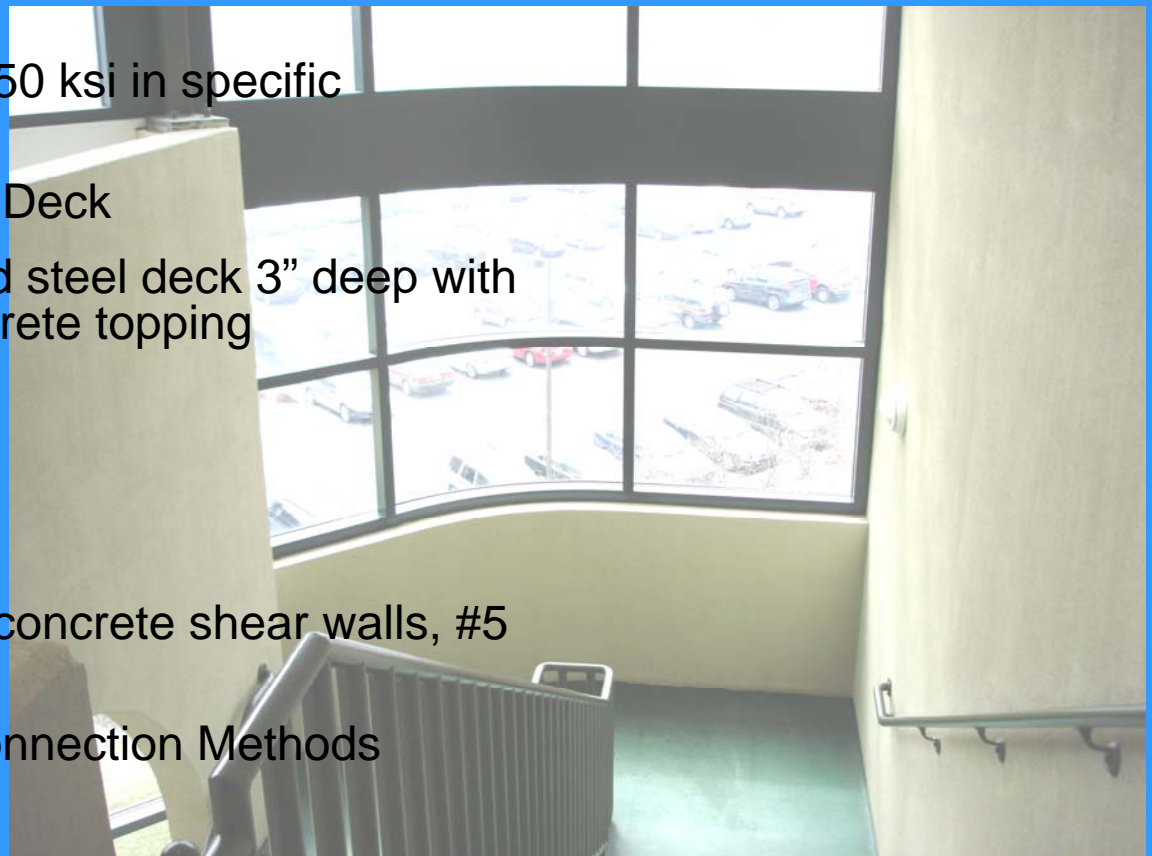
Problem Statement

- Mechanical Equipment Location

- Height Restrictions

- Architectural Appearance

- Lateral Considerations

- Full Basement Added to Accommodate Equipment

- Delayed Construction

- Increased Cost

Proposed Solution

- Eliminate the Basement Space

- Reduce Mean Roof Height

    - Change to a more shallow floor system

    - Increase steel strength to 50 ksi steel

    - Maintain same floor to ceiling height

- Place Air Handling Units on the Roof

- Increase the Height of the Parapet Walls to Mask the Units

- Alter the façade as needed

Summary of Design

- Pre-stressed Hollow Core Plank design for 10' to 20' spans

    (Nitterhouse Concrete Products)

- Steel Design by RAM Structural

- Lateral Analysis in concordance with ASCE 7-05

- Parapet Design in concordance with Masonry Design Guide

Hollow Core Plank

- Design Tables

- Loads Applied

- Connection Method

STRAND PATTERN		SPAN (FEET)																					
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flexure	4 — 1/2"ø	610	550	499	457	399	341	294	255	222	195	171	151	133	117	103	92	82	72	66	58	49	43	
Shear	4 — 1/2"ø	441	393	354	321	294	270	249	231	215	201	188	177	160	145	132	120	110	101	95	90	82	75	
Flexure	6 — 1/2"ø	885	800	726	667	586	509	437	382	334	296	263	234	208	187	168	151	136	122	111	100	90	81	73
Shear	6 — 1/2"ø	459	411	370	337	308	283	282	243	228	211	197	185	174	164	155	147	139	131	120	111	102	94	87

NITTERHOUSE
CONCRETE [N] PRODUCTS

This table is for simple spans and uniform loads. design data for any of the span-load conditions is available on request. Individual designs may be furnished to satisfy unusual conditions of heavy loads, concentrated loads, cantilevers, flange or stem openings and narrow widths.

Steel Frame

- General Changes Made to Steel Frame

- Loads Applied (specifically at roof level)

- Summary of Differences between   New and Existing

Summary of Beam and Girder Sizes Typical to Each Story						
	Story					
		1	2	3	4	Roof
Beam 1			W18x35	W18x40	W18x40	W21x44
Beam 2			W18x40	W21x44	W21x44	W21x44
Beam 3			W21x48	W21x48	W21x48	W21x44
Girder			W24x55	W24x55	W24x55	W24x55
Column 1			W10x49	W10x49	W10x33	W10x33
Column 2			W12x58	W12x58	W12x40	W12x40

W18x40

W21x48 c=1/2"   W21x48 c=1/2"   W21x48 c=1/2"

W24x55

W18x40 c=1/2"   W18x40 c=1/2"   W18x40 c=1/2"

W18x35
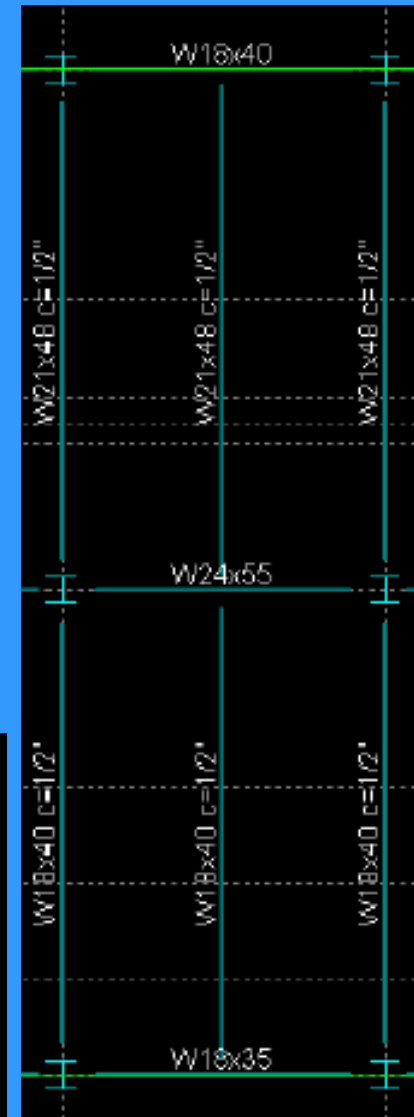
Lateral System

• Lateral Analysis Performed According to ASCE 7-05

• Higher Shear Forces Found at Roof Level

• Shear Walls analyzed to be reused

• Shear Walls found Acceptable

• Moment Frame in Southern Wall left as well

• Problems at Roof level

Parapet Design

- Design Height : 8'-6"

- Analyzed as a Cantilevered Wall

- 8" CMU fully grouted

- Found to need #6 @ 40" to resist wind loading

- Seismic Loads at roof level

Façade Alterations

- Remove 3 courses of Brick at each Level
- Add Brick or Pre-cast Panel to Parapet
- Adjust Window Levels in Pre-cast Panels

Effects of Design on Breadth Areas

•New AHU's needed

•Placement of Equipment

•Impact on Ductwork

•Cost

| AHU	Supply Air (cfm)	Total Cooling Capacity (MBH)	Ton
1	30,245	1741	145
2	21,990	1266	106
3	16,895	1219	102
4	18,960	1093	91
5	14,255	997	83

Selection Guide

QUICK SELECT TOOL – OPTIMAL SIZES

CFM	H	W	COIL AREA	AF SQ. FT AREA	RF/FF SQ. FT AREA	MAX FC FAN	MAX AF FAN	MAX SWSI FAN
900	27	27	1.8	4.4	-	7x7	-	-
1500	30	33	2.9	4.0	3.3	9x9	-	-
2000	36	33	4.0	6.0	4.0	12x9	-	-
2500	33	45	5.2	8.9	6.0	10x10	-	12
3500	36	48	6.9	11.1	6.0	12x12	12	12
4500	36	60	9.2	16.0	8.0	12x12	12	14
5500	42	60	10.8	16.0	10.7	15x15	15	18
6000	42	66	12.2	18.7	10.7	15x15	15	18
7000	42	72	13.5	26.7	13.3	15x15	15	18
8000	48	72	15.6	26.7	15.0	18x18	18	25
9000	48	78	17.9	35.6	15.0	18x18	18	25
10000	51	78	19.5	35.6	18.9	20x20	20	25
11500	57	78	21.8	35.6	22.7	22x22	22	28
13500	60	84	26.5	36.0	24.0	22x22	22	28
16500	66	95	32.1	53.3	31.1	28x28	28	35
19500	66	114	39.0	57.8	38.9	28x28	28	35
22500	72	120	45.0	62.2	45.0	32x32	32	39
26500	78	126	53.4	80.0	48.3	32x32	32	44
30500	90	120	60.0	93.3	60.0	36x36	36	49
34500	96	126	67.3	106.7	64.4	40x40	40	49
38500	108	126	75.2	106.7	77.3	40x40	40	49
42500	108	138	83.1	110.0	85.3	40x40	40	49
46500	114	144	94.0	151.1	91.7	40x40	40	49
50500	120	144	98.5	151.1	91.7	40x40	40	49
51500	126	144	103.0	151.1	104.7	40x40	40	49

State College Wind Rose
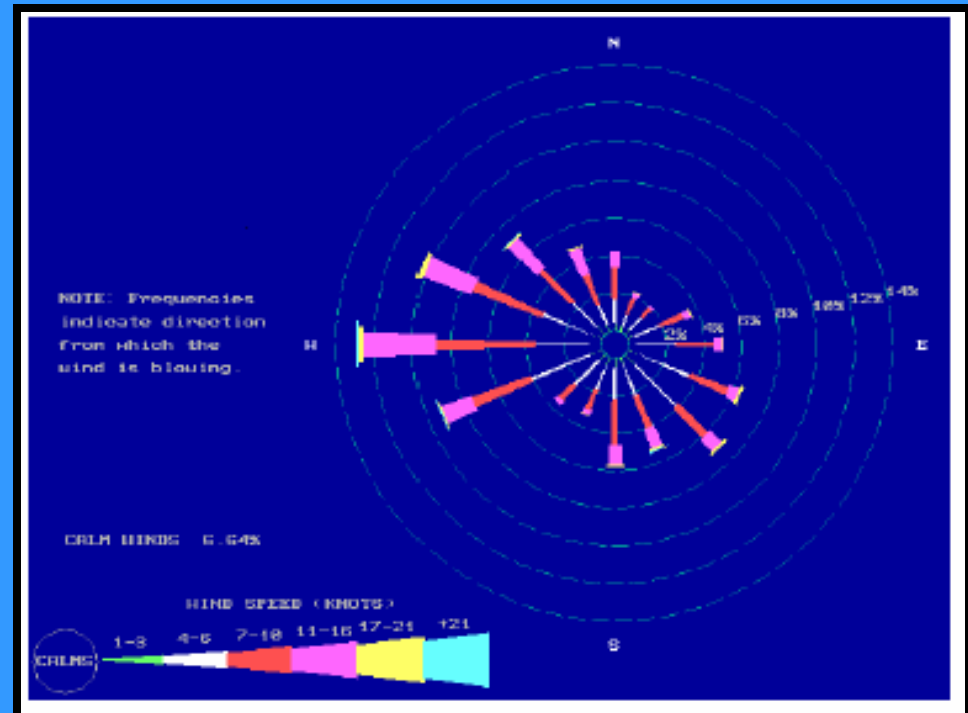
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Cost Analysis

Eliminated Items		
Steel	1,346 LF	$34,589
Excavation-Backhoe	7,826 CY	$10,956
Excavation-Hauling	7,827 CY	$17,295
Slab on Deck	70,308 SF	$735,737
Roof Deck	19,034 SF	$22,269
12" CMU wall	8,704 SF	$49,265
Original Steel	12,570.5 LF	$283,018
		$1,153,129

Net = $216,848

Added Items		
Slab on Grade	13,206.5 SF	$18,489
Hollowcore Plank	76,136 SF	$605,281
8" CMU Wall	2,952 SF	$12,044
Steel	10,135.5 LF	$300,467
		$936,281

(According to R.S. Means and Costworks)

Earth and Engineering Sciences Building
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Conclusions

- Solution is feasible

- May not have been the most practical

- Created additional problems to fix the original problem

- Overall an educational experience

Questions???????