

Caitlin Behm

Structural Option
Senior Thesis

Advisor: Dr. Boothby



**Nemours Children's Hospital
as a part of
The Nemours Foundation**

Orlando, Florida

Presentation Outline

Introduction

Existing Structural System

Problem Statement

Proposed Solution

Thesis Redesign

Daylighting Analysis

Conclusion



Courtesy: The Nemours Foundation



Courtesy: Oxblue.com



Courtesy: Oxblue.com



Courtesy: Oxblue.com

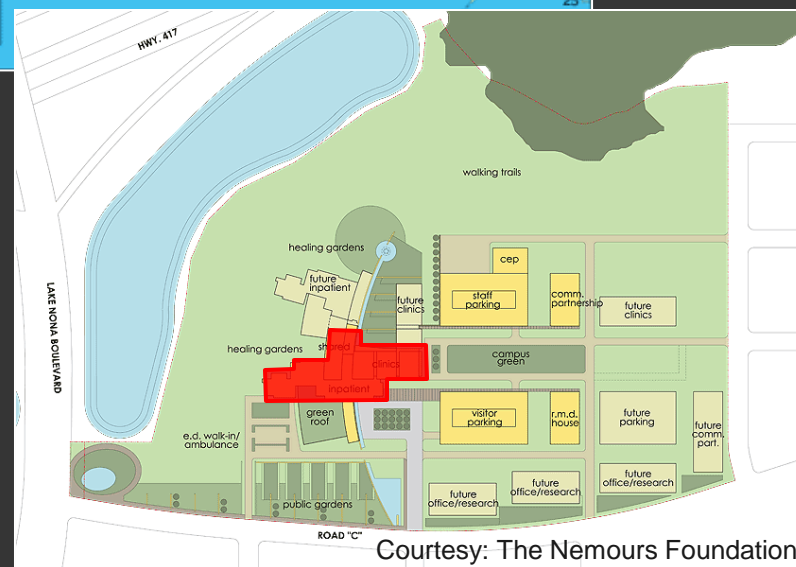
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Introduction

Nemours Children's Hospital *as a part of*
The Nemours Foundation
Orlando, Florida



Project Team

Owner: The Nemours Foundation

Construction Manager: Skanska USA Building

Architect: Stanley Beaman & Sears
Perkins + Will

Landscape Architect: AECOM

Structural Designer: Simpson, Gumpertz, & Heger

Civil Engineer: Harris Civil Engineers

MEP: TLC Engineering for Architecture

Courtesy: Noel Rodriguez



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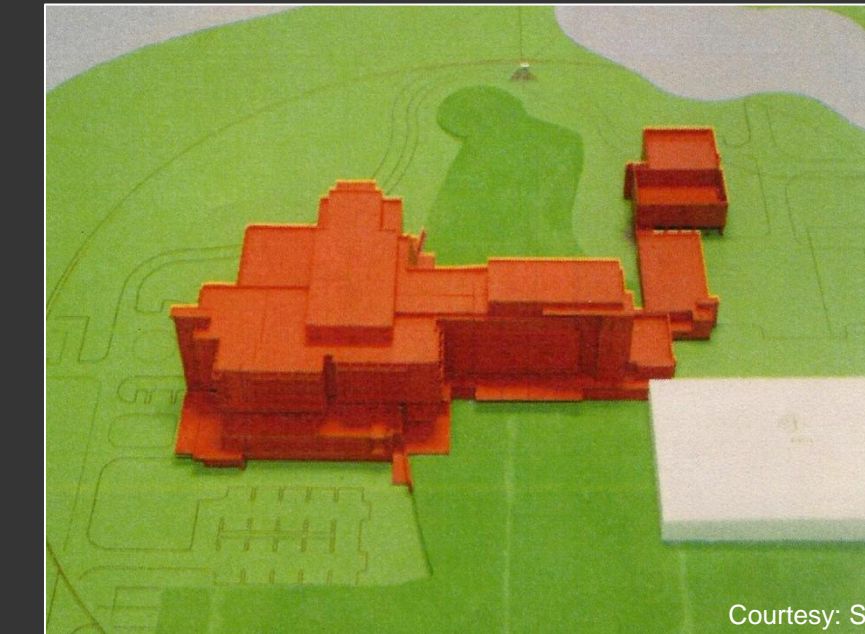
Introduction

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Enhanced Hurricane Protection Area (EHPA)

“The EHPA shall provide emergency shelter and protection for people for a period of up to 8 hours during a hurricane”
- Florida Building Code

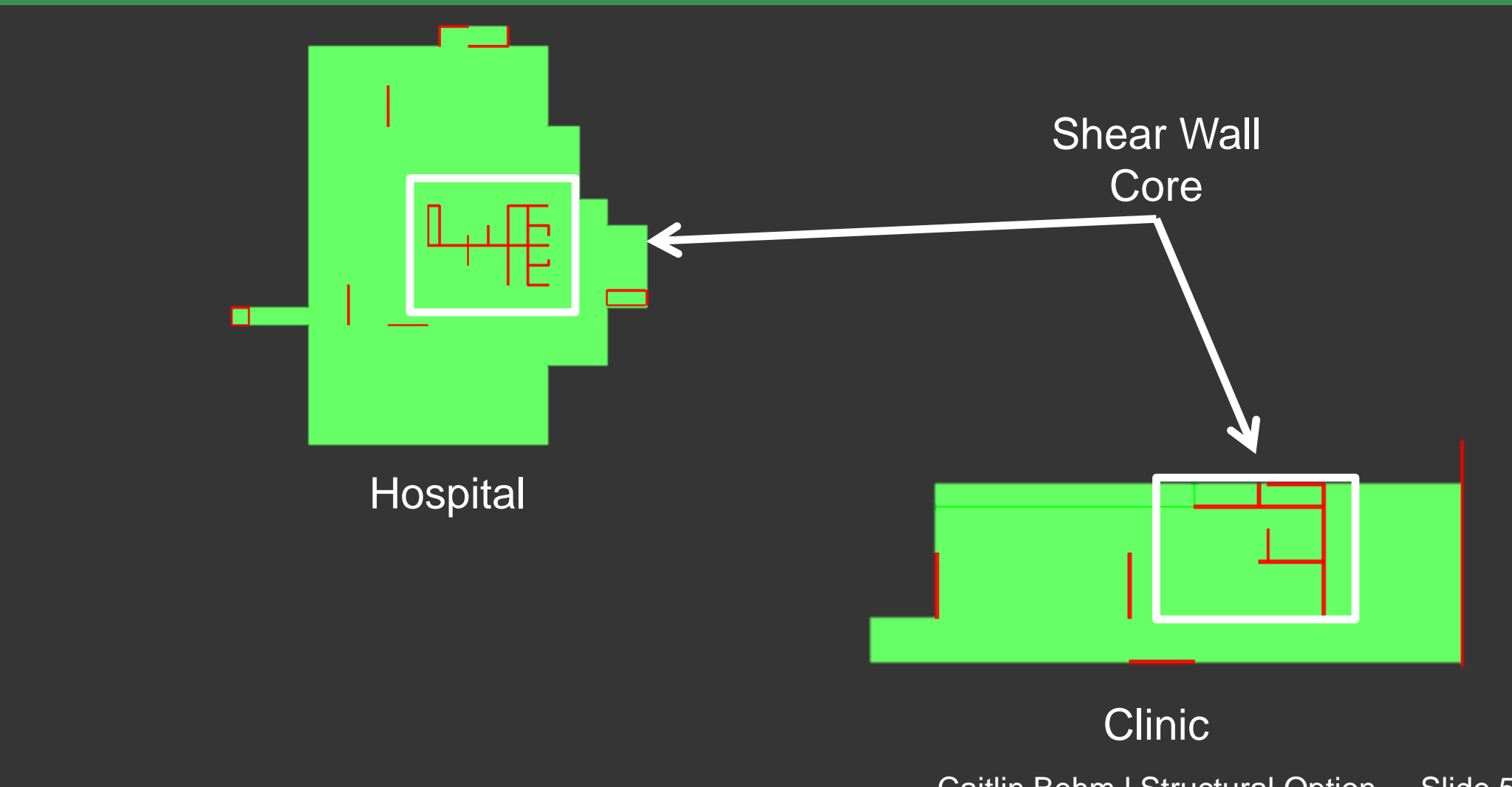
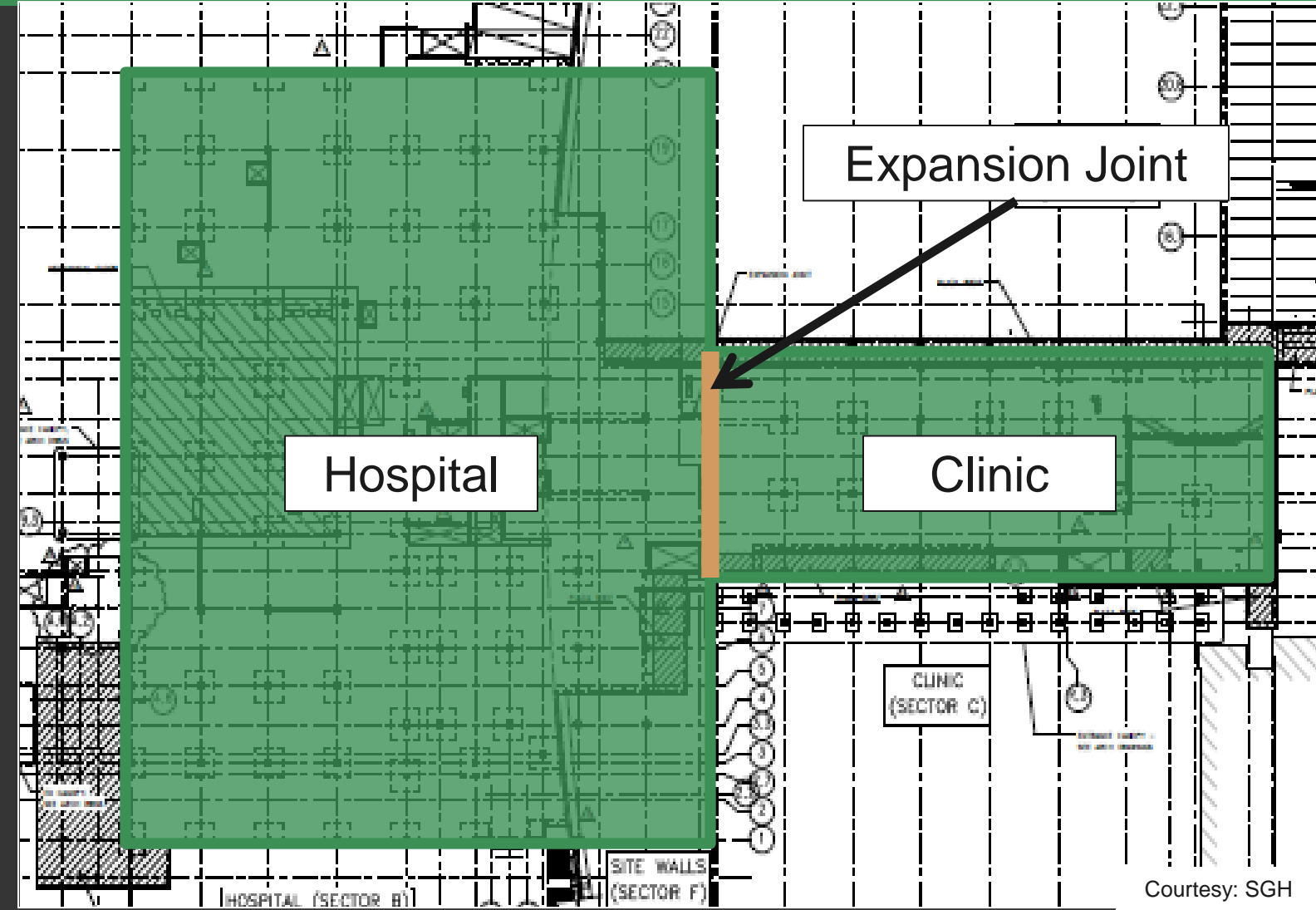
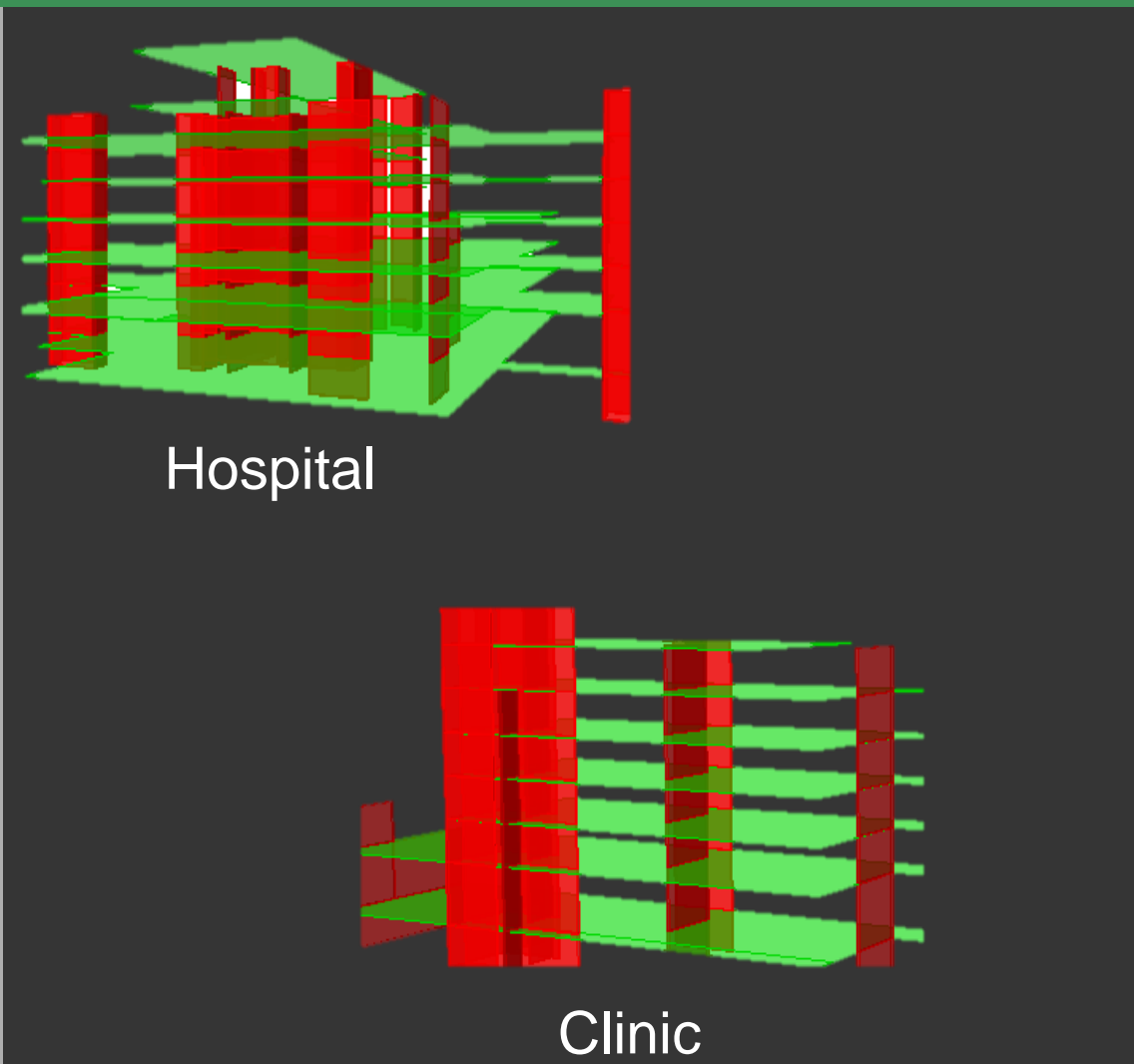


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Existing Structural System

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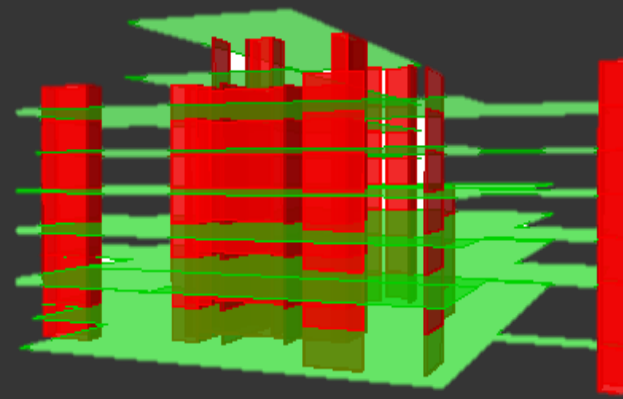
Thesis Redesign

Daylighting Analysis

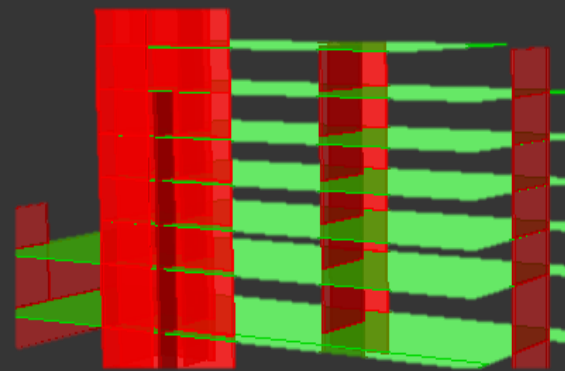
Conclusion

Existing Structural System

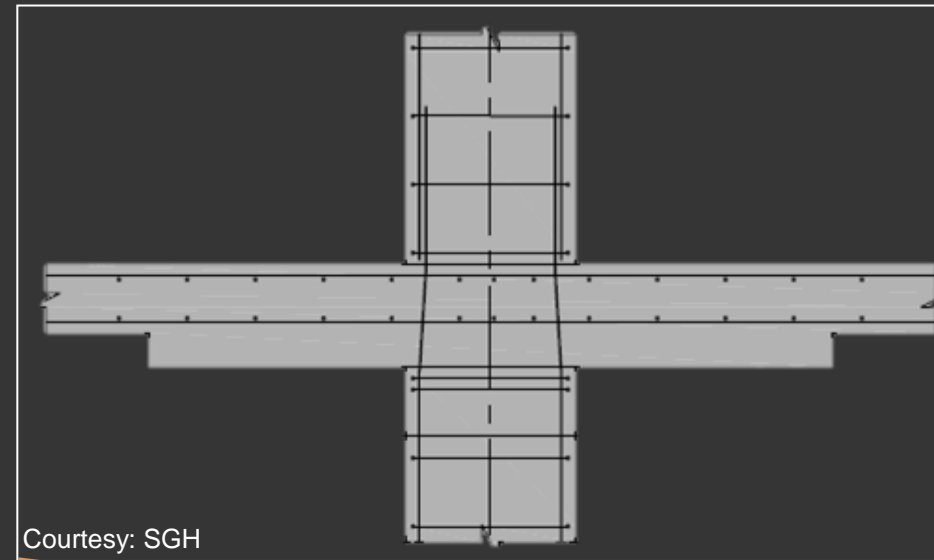
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Hospital

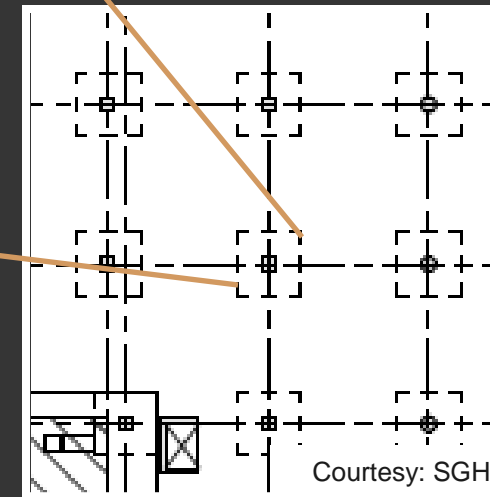


Clinic



Courtesy: SGH

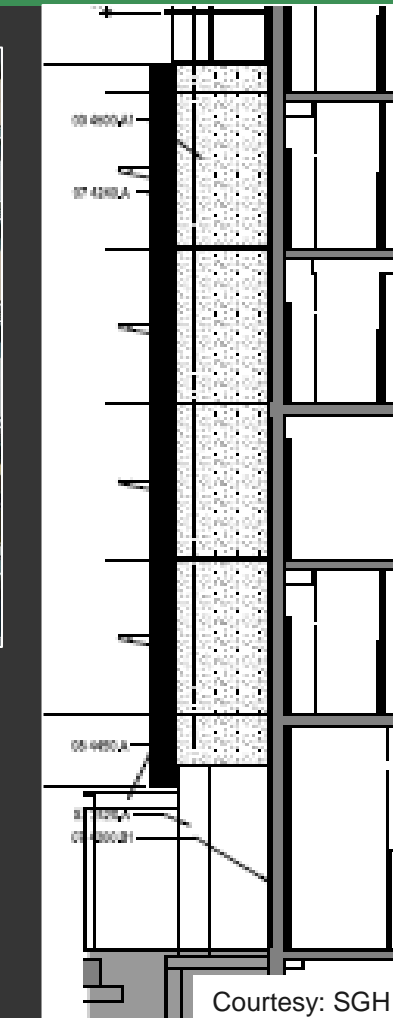
Floor System



Courtesy: SGH

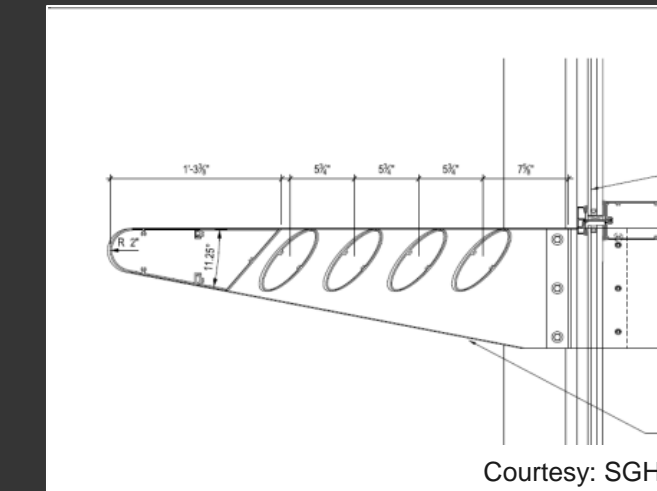


Courtesy: SGH



Courtesy: SGH

Building Façade



Courtesy: SGH

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Problem Statement

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- Restricted floor plan flexibility
- Coordination with MEP systems
- Additional formwork required for drop panels
- Extremely high design wind speed



Presentation Outline

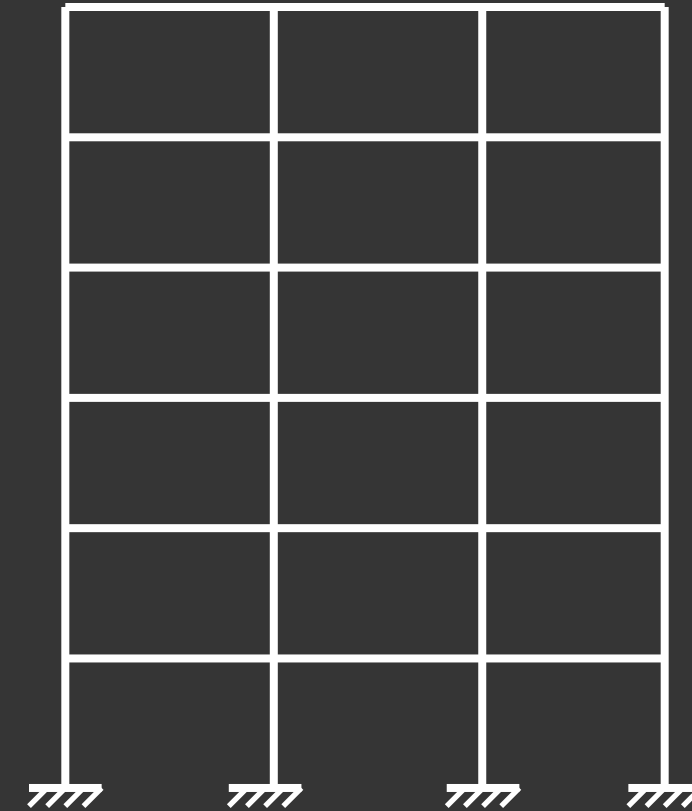
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Proposed Solution

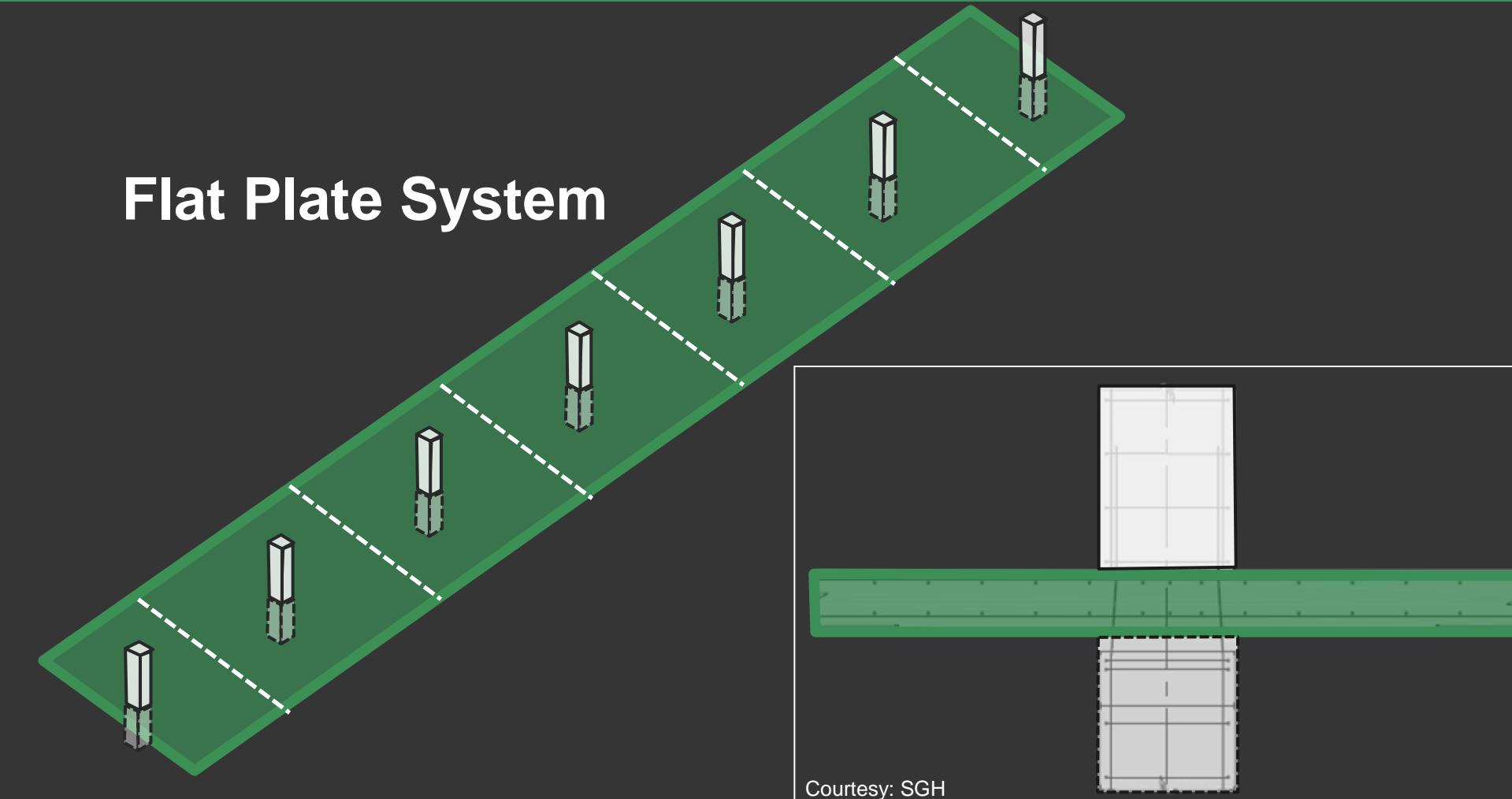
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Design Goals

- Analyze feasibility of concrete moment frames
- Increase amount of useable space per floor
- Eliminate drop panels
- Evaluate louvers for daylighting control and EHPA criteria



Concrete Moment Frames



Presentation Outline

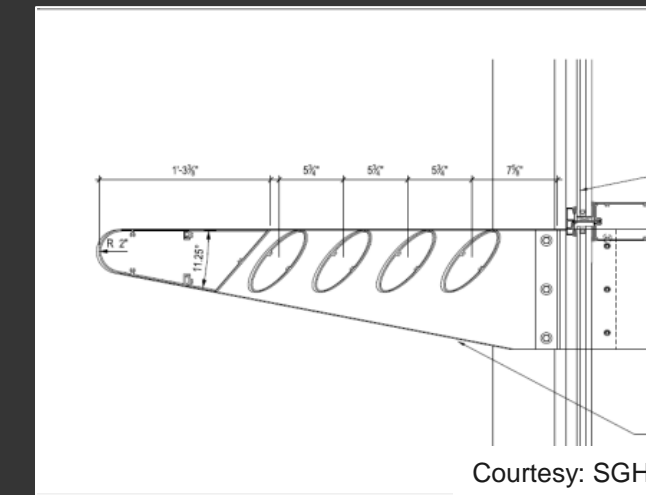
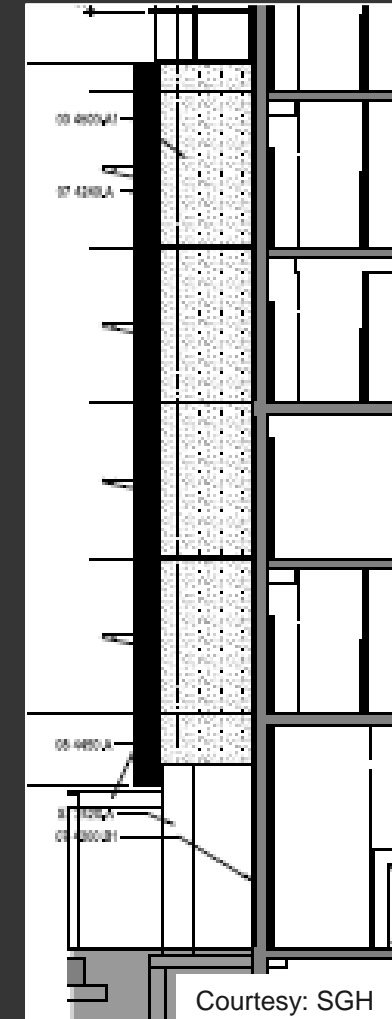
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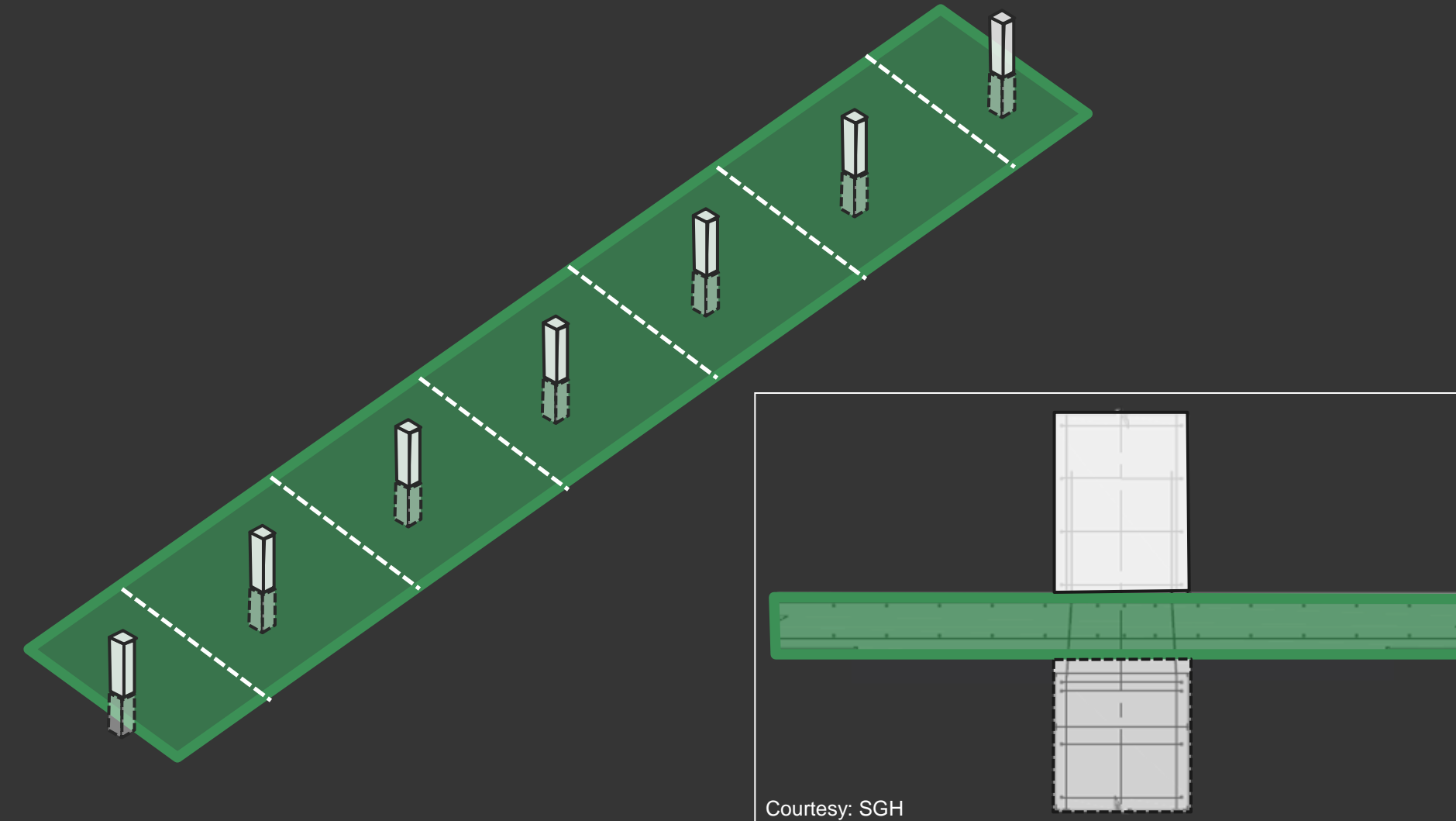
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Thesis Redesign

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Moment Frame Research

- < 8-10 stories
- Flat plate study
- Recommended β -value



Courtesy: SGH

Table 13-7 Recommended α and β values for the flexural stiffness of slab-beam elements

Region of the slab	α -value (for effective width αl_2)	β -value (for $I_e = \beta I_g$)
Positive bending regions	0.5	0.5
Negative bending regions (interior columns)	0.5	0.5, for gravity analysis only 0.33, for lateral-load analysis
Negative bending regions (exterior columns)	0.2 to 0.5 (function of edge beam stiffness)	0.33

Wight & MacGregor 2008

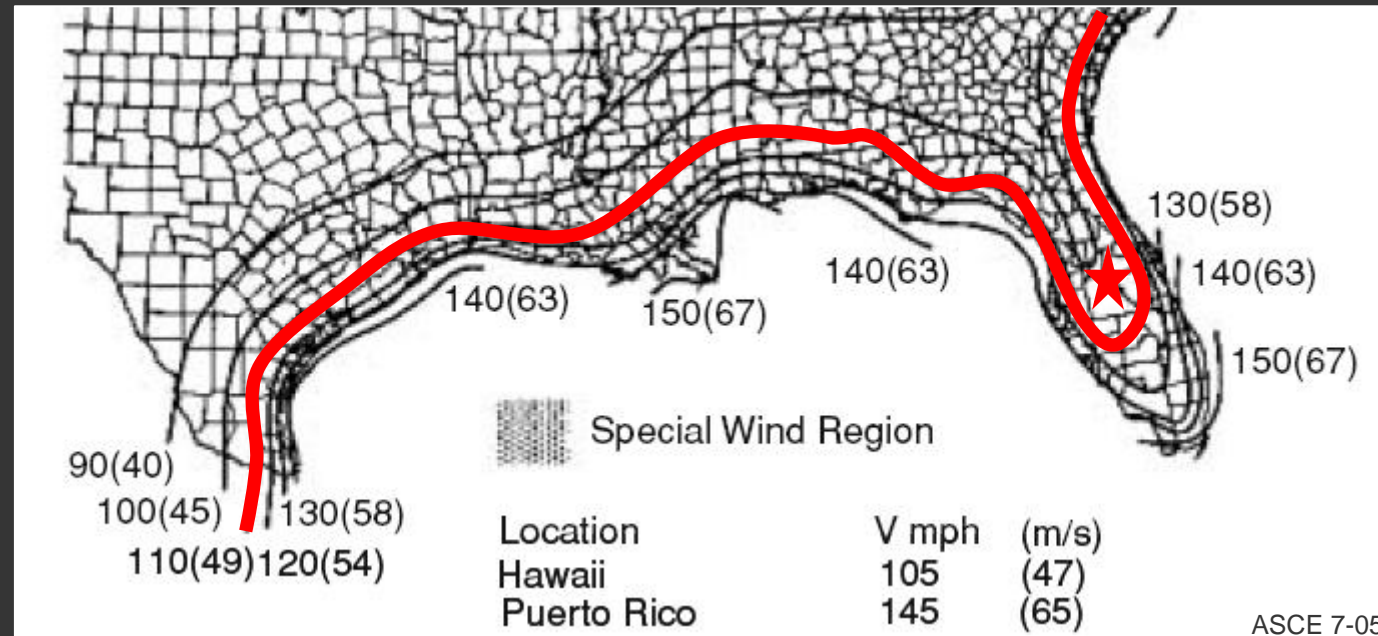
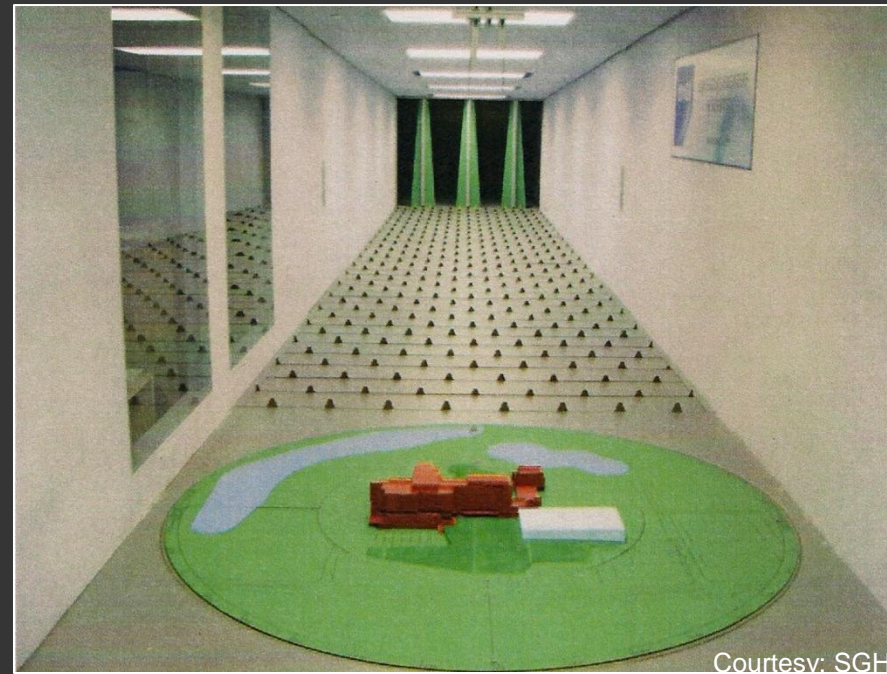
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Wind Research



	YRS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN													
Florida		DR	SP	DR	SP	DR	SP	DR	SP	DR	SP	DR	SP	DR	SP												
APALACHICOLA, FL	48	E	48	E	42	E	54	SE	51	SE	47	E	55	N	63	NE	59	E	67	NW	56	SE	47	SE	42	E	67
DAYTONA BEACH, FL	57	26	43	20	44	24	58	18	46	22	48	33	40	34	43	15	69	11	58	5	53	50	39	34	40	15	69
FORT MYERS, FL	54	25	40	25	39	35	46	20	39	32	44	31	48	18	45	14	50	5	92	35	62	30	32	33	35	5	92
JACKSONVILLE, FL	25	30	38	30	39	22	44	32	46	29	34	28	39	26	57	11	38	80	46	21	31	33	38	31	40	26	57
KEY WEST, FL	29	27	41	12	57	22	54	1	58	13	46	18	40	12	61	18	61	12	62	15	71	12	47	26	39	15	71
MIAMI, FL	48	24	46	19	55	4	46	24	35	32	52	13	37	25	43	12	86	6	69	15	69	7	38	32	38	12	86
ORLANDO, FL	56	25	42	25	46	24	46	2	50	35	51	32	64	14	46	12	79	60	61	5	48	26	46	20	35	12	79
PENSACOLA, FL	33	31	40	13	40	16	39	33	43	12	30	29	46	27	76	14	56	12	77	22	39	21	35	20	36	12	77
TALLAHASSEE, FL	46	23	46	9	40	27	48	15	35	29	40	3	44	22	39	2	58	8	46	20	32	16	40	28	37	2	58
TAMPA, FL	53	32	44	32	50	29	43	28	44	36	46	31	67	32	58	11	38	34	56	21	40	25	40	36	45	31	67
WEST PALM BEACH, FL	50	29	48	11	48	27	51	32	55	27	45	5	71	34	46	13	86	26	64	13	83	10	39	36	38	13	86

Max Wind Speed: 79 mph
(based on 1 min avg)



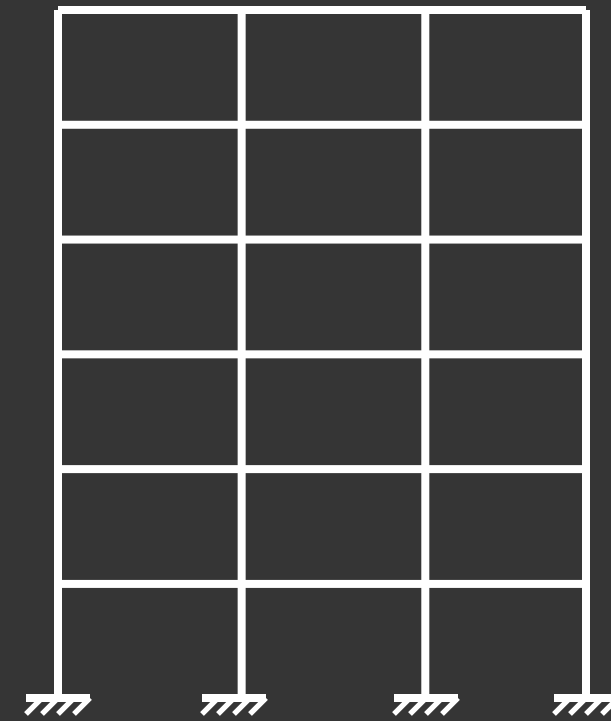
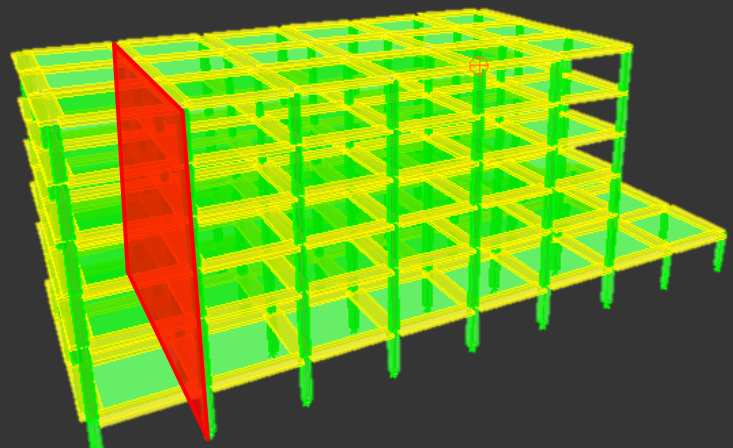
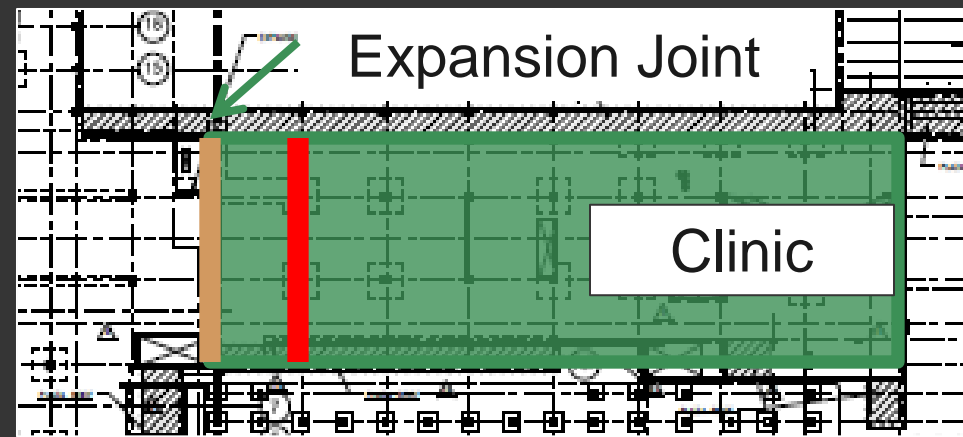
Max Wind Speed: 102 mph
(based on 3s gust)

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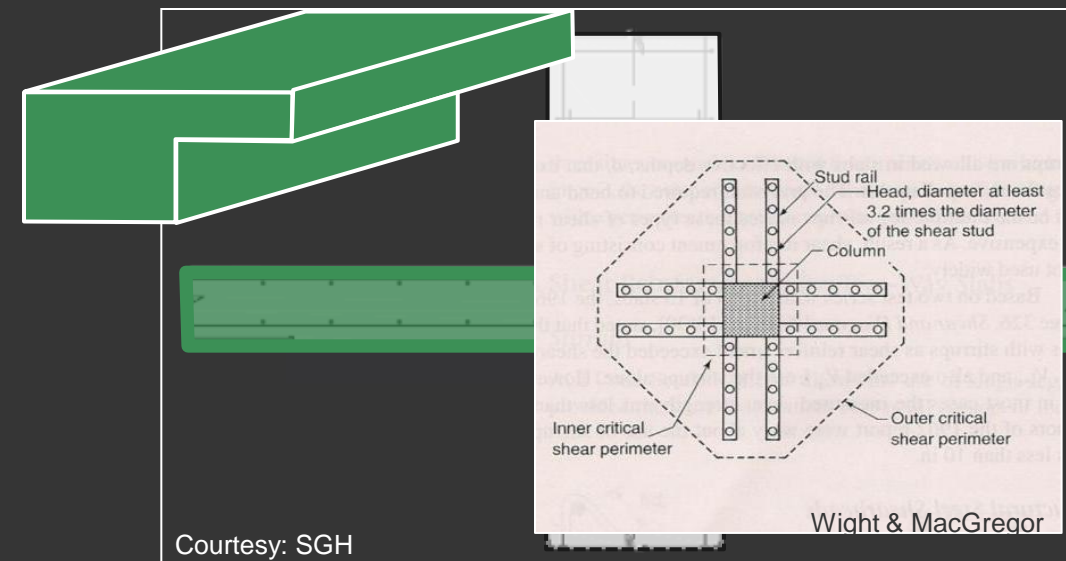
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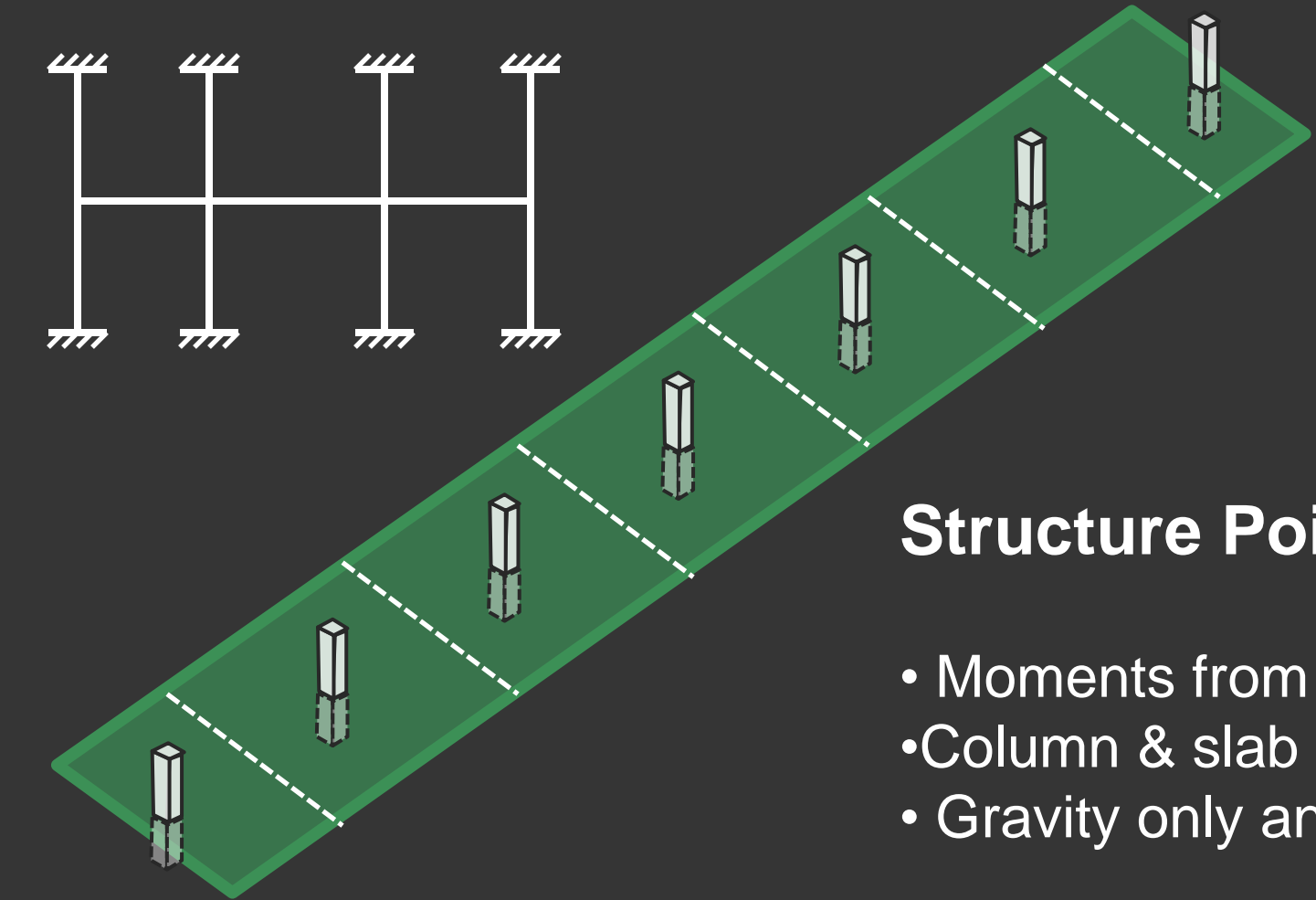


Portal Frame Method

- Lateral only analysis
- Moment transfer
- Shear solutions



Courtesy: SGH



Structure Point

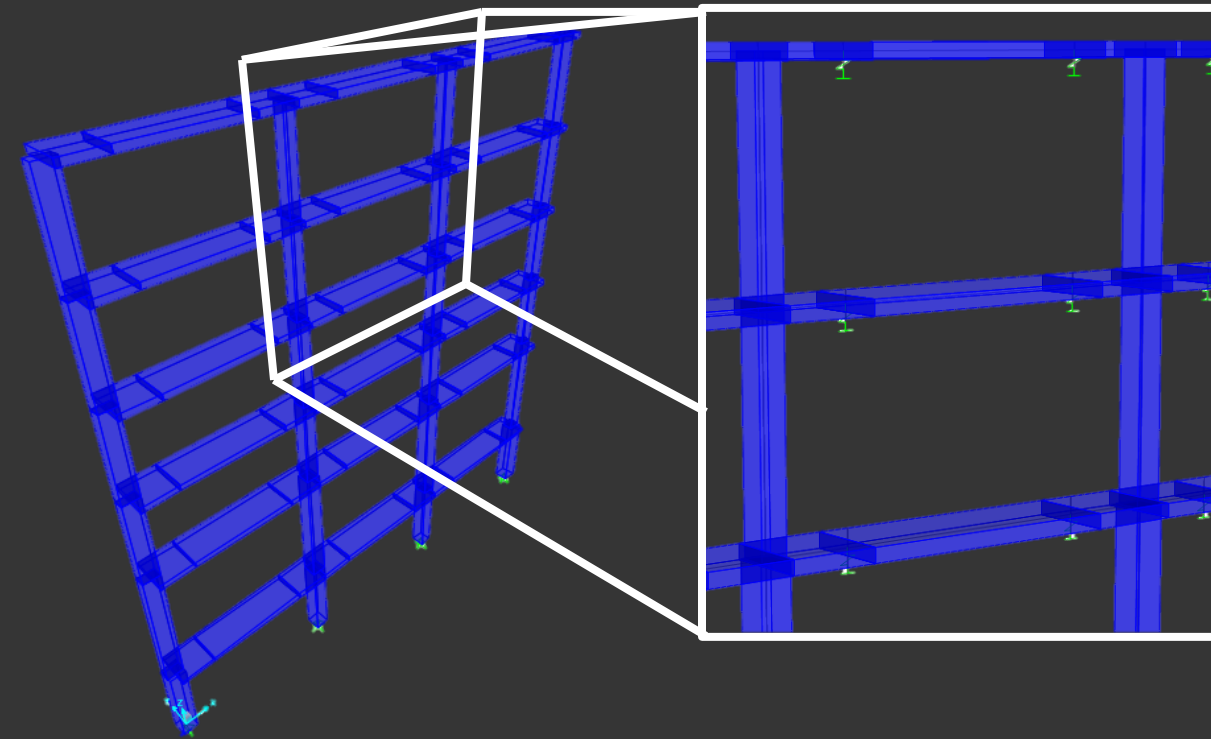
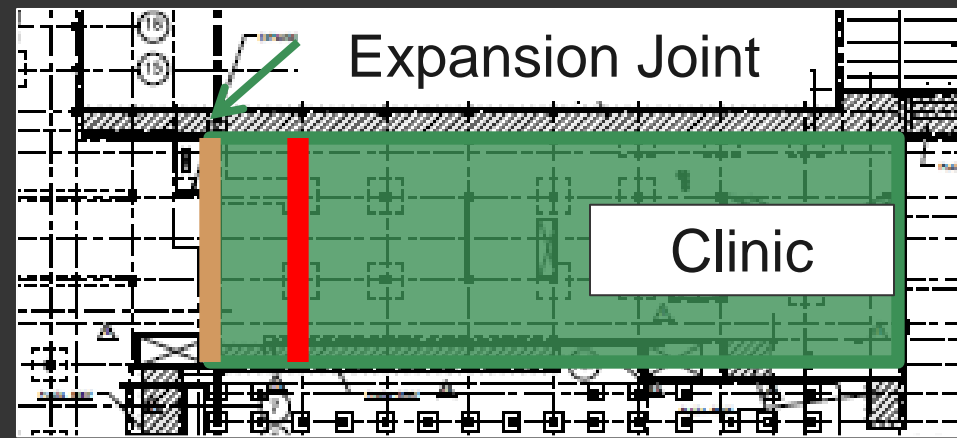
- Moments from portal method
- Column & slab studies
- Gravity only analysis

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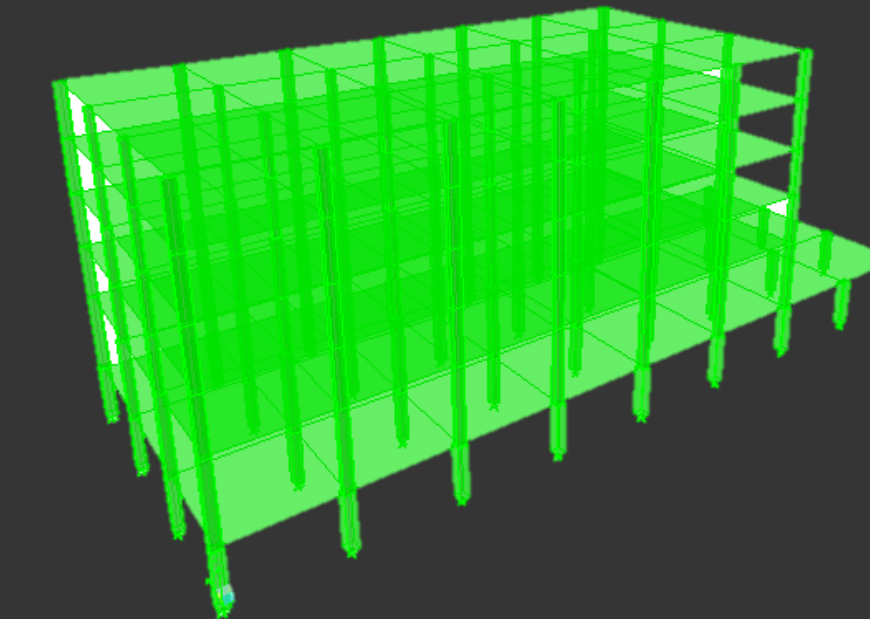
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SAP

- Column sizes from spColumn
- Link element
- Lateral and gravity analysis

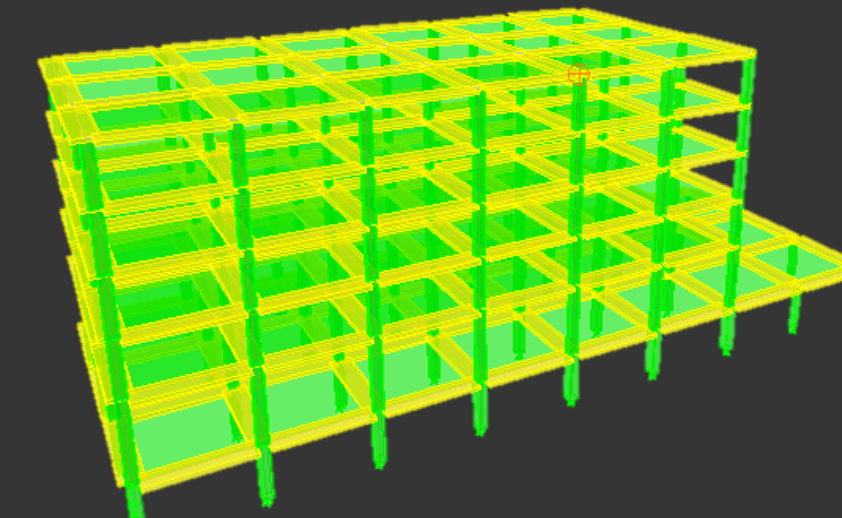


Conclusion

Edge beams with flat plate slab
With 110 mph wind design speed

ETABS

- Two models
- Lateral and gravity analysis
- Capacity checks
- Deflection check

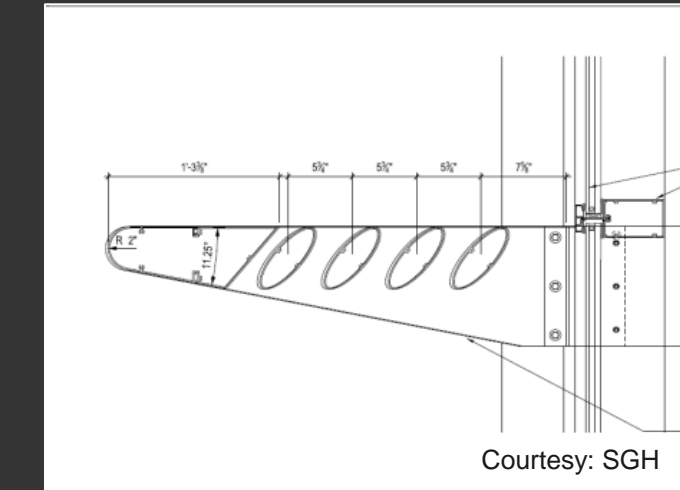
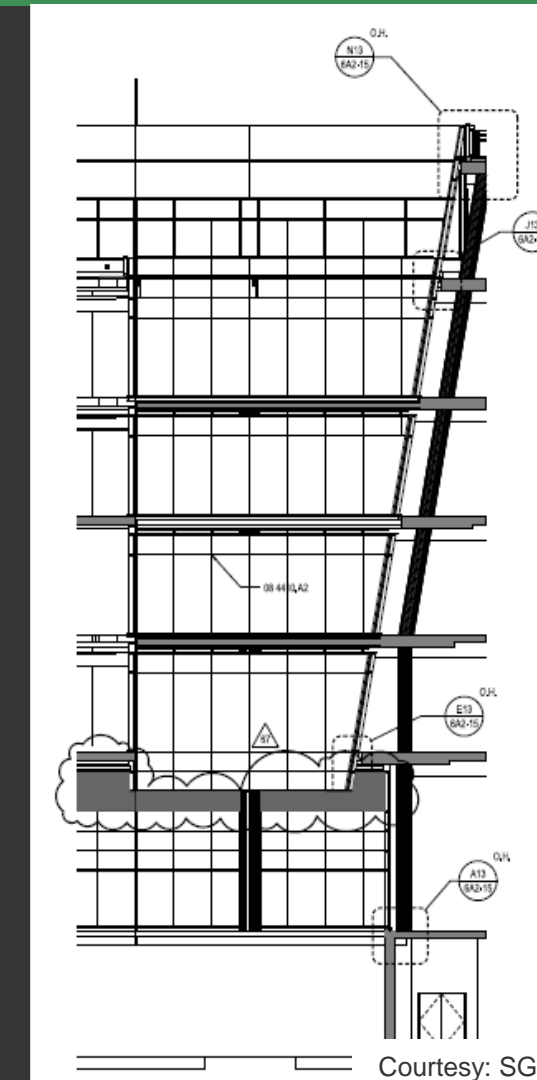
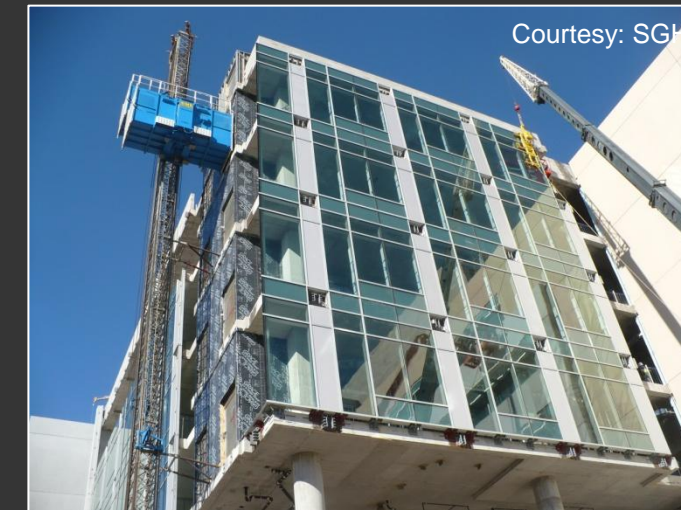


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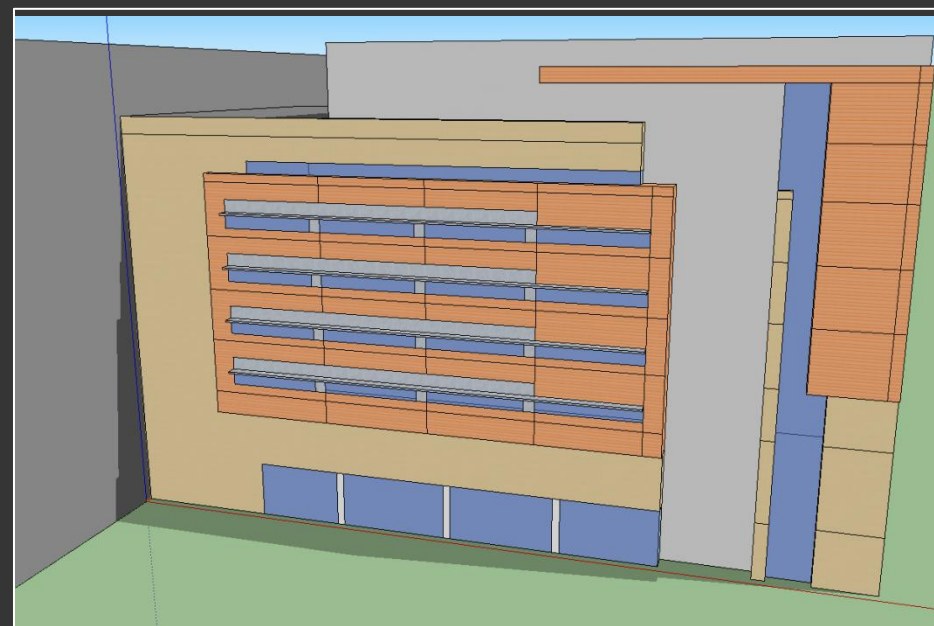
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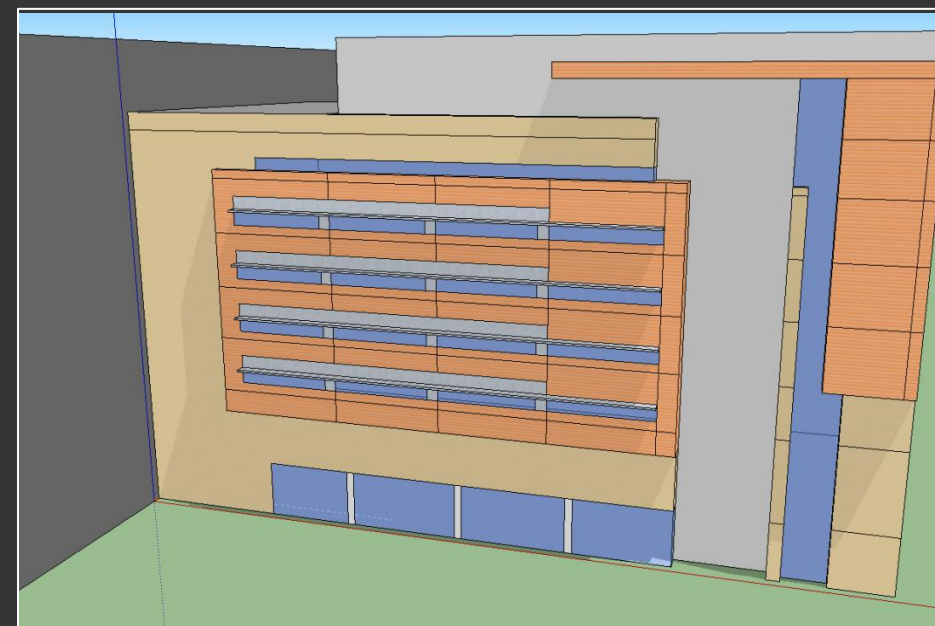
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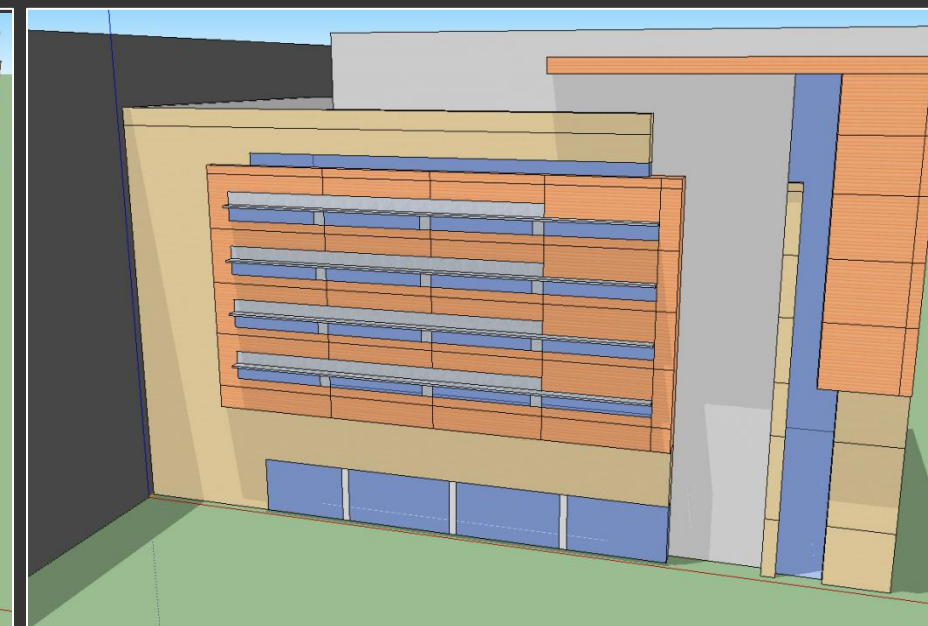
Summer Solstice



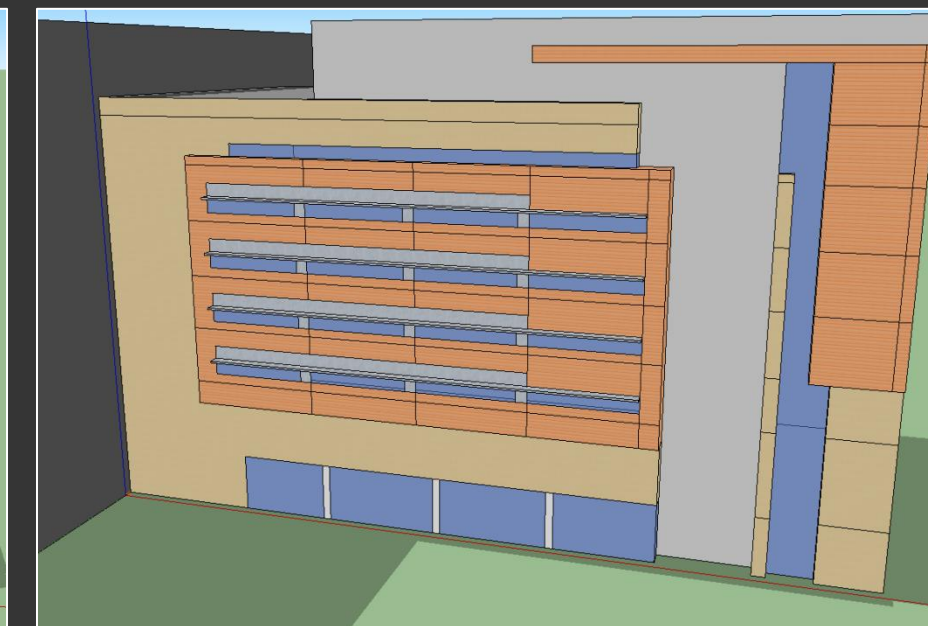
9 AM



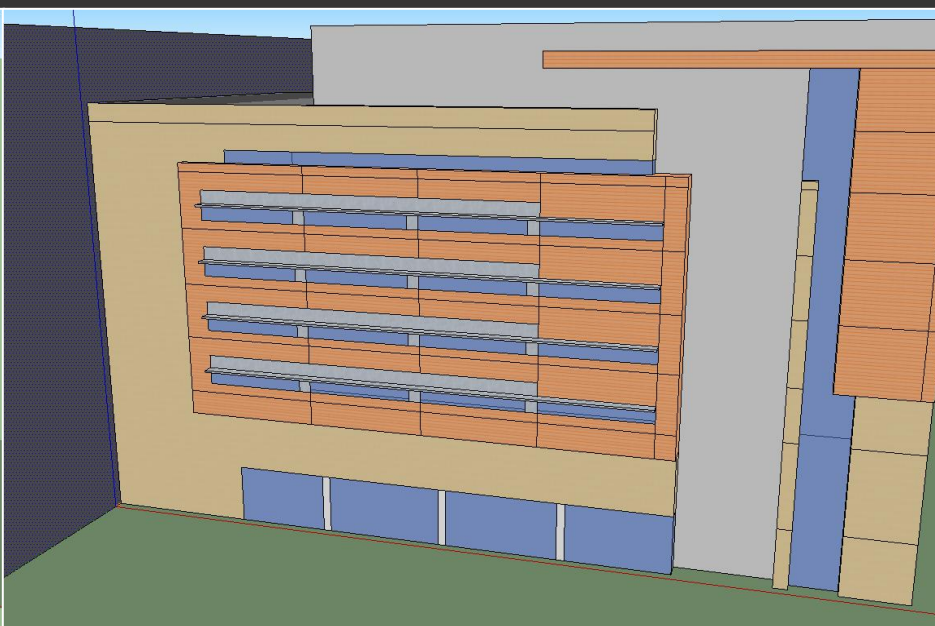
11 AM



1 PM



3 PM



5 PM

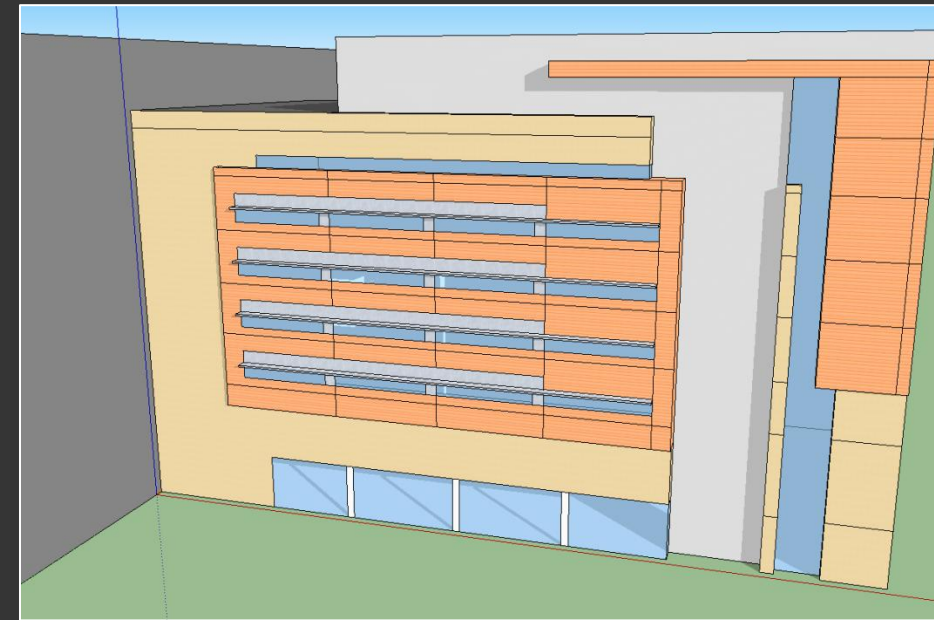
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Winter Solstice



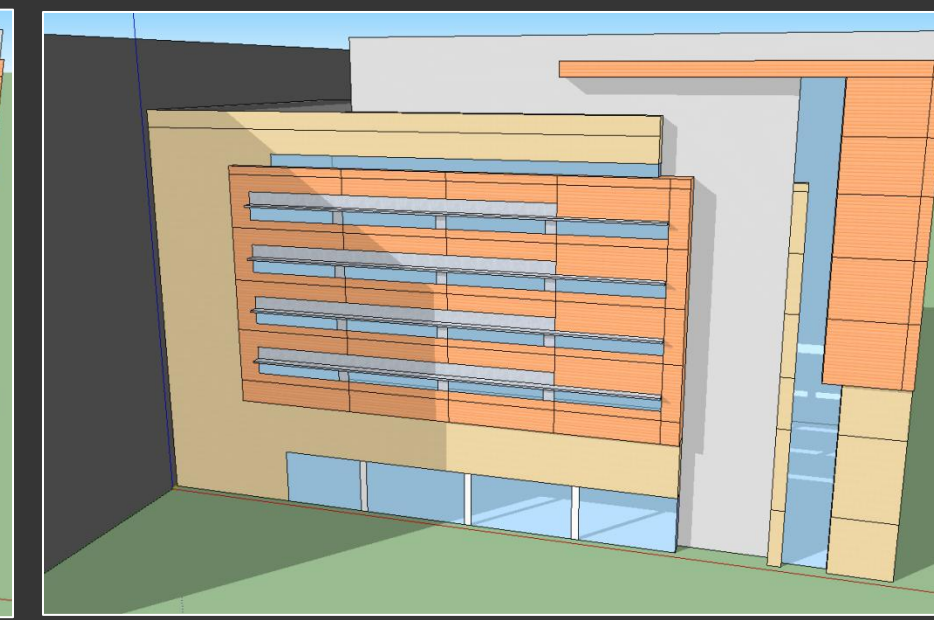
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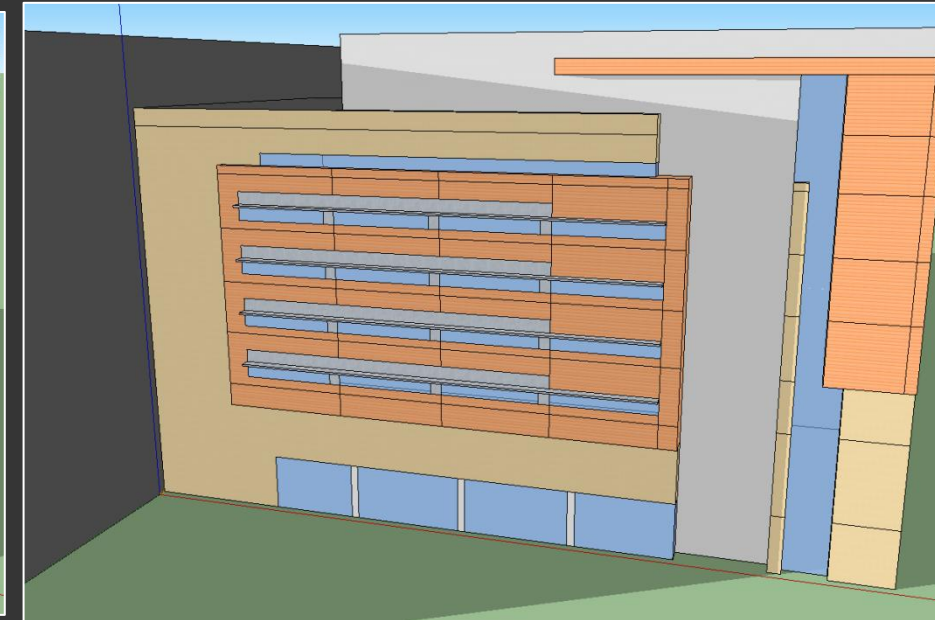
11 AM



1 PM



3 PM



5 PM

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Sheer



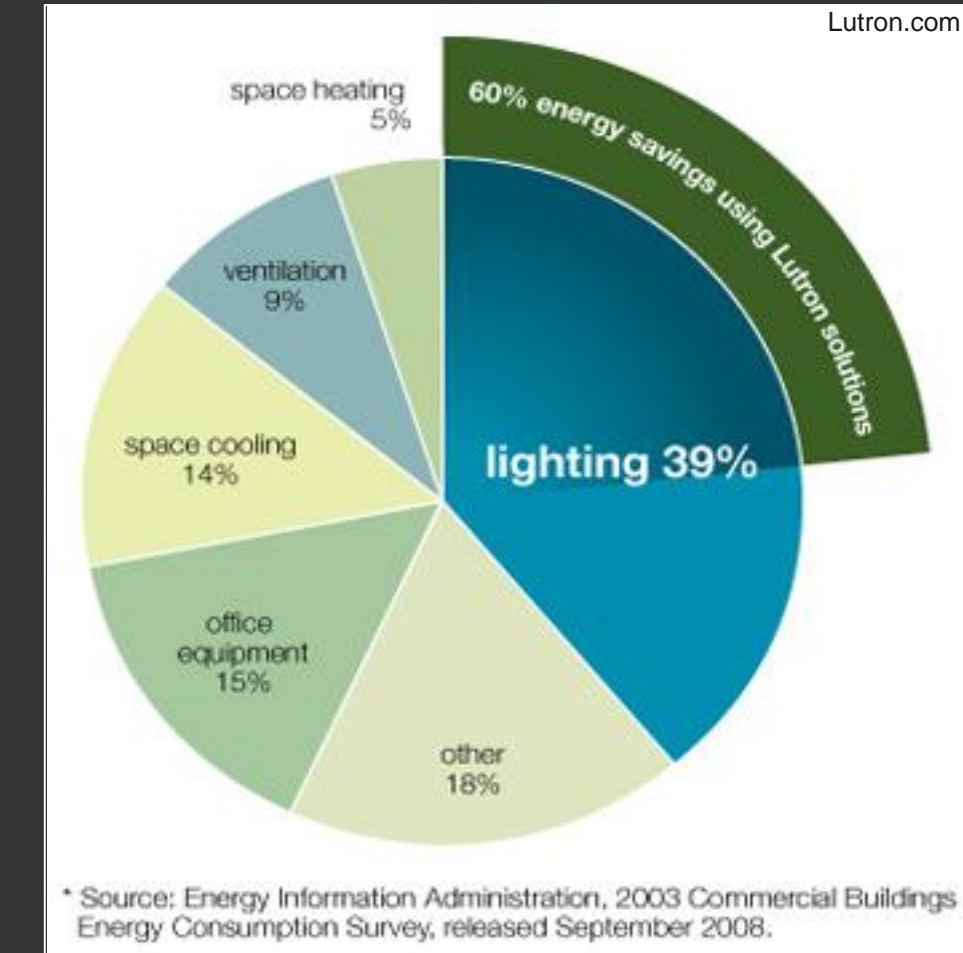
Dim-Out



Blackout



Lutron.com

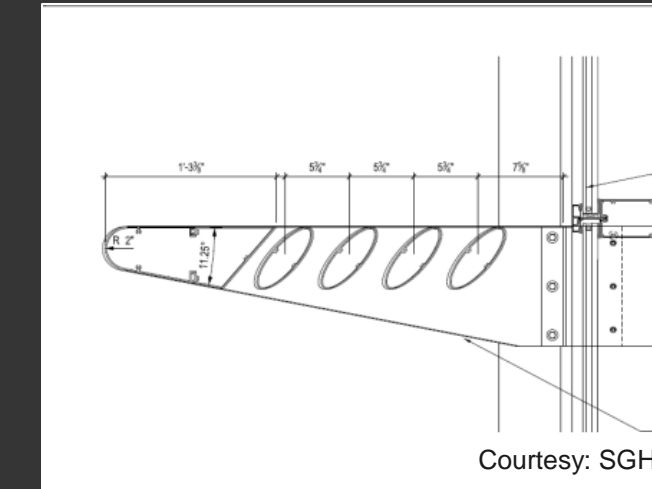
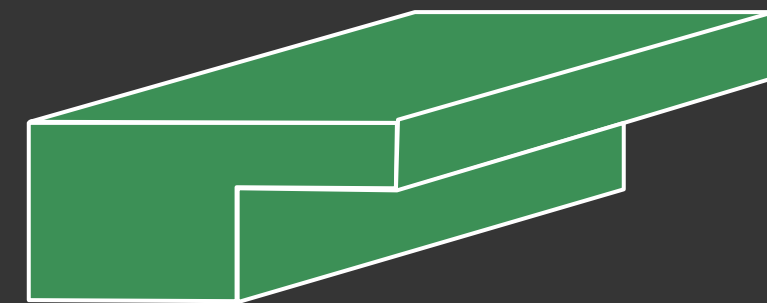
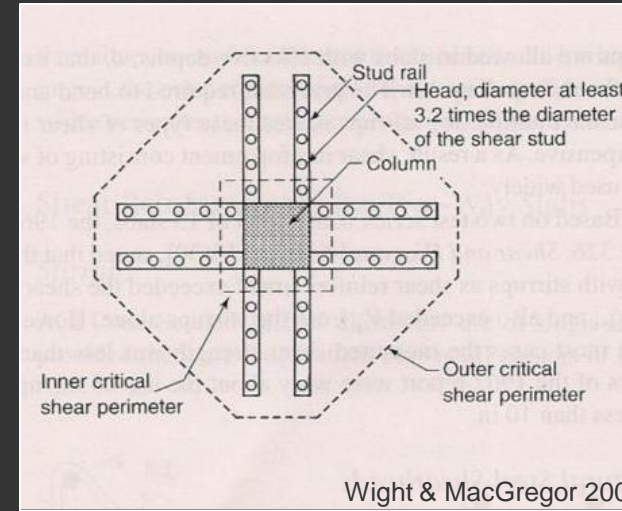
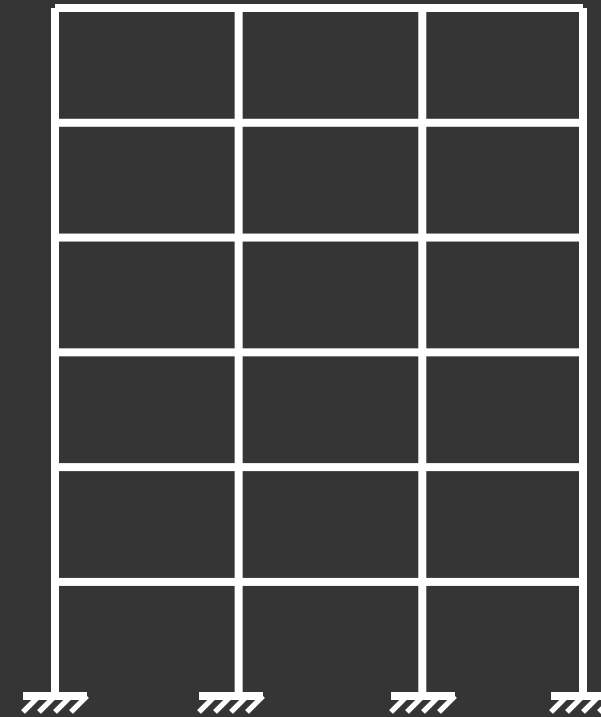


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Summary

- Concrete moment frames not feasible for 157 mph
- Shear studs or edge beams required for moment transfer
- Edge beams required to mitigate excessive deflection
- Louvers not adequate for winter solstice
- Instead, use interior sun shades, also meeting EHPA criteria

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Comments
- or -
Questions?



Nemours Foundation
Simpson Gumpertz & Heger
-Cynthia Staats
-Michael Bolduc
The Pennsylvania State University Architectural
Engineering Department
-Advisor: Dr. Thomas Boothby
Family and friends

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Appendix

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Ordinary concrete shear wall: R=5
Ordinary concrete moment frame: R=3

ETABS		
Material	f'c	Ig
Column	6	0.7
Slab (72" wide)	5	0.25
		***pinned base
		*** shell element

SAP		
Material	f'c	I
Column	6	0.7
Slab (72" wide)	5	Ie=0.25
		Ig=0.25
		***pinned base
		*** shell element

Deflection		
	SAP (in)	ETABS (in)
Story 6	2.92	3.38
Story 5	2.50	3.21
Story 4	1.99	2.93
Story 3	1.46	2.52
Story 2	0.93	1.98
Story 1	0.41	0.87
	Code Limit	2.93