Hakuna Resort

AE Senior Thesis 2015

All Hakuna Resort photos in courtesy of LMN Development LLC

Young Jeon

Structural Option

Advisor: Heather Sustersic

Presentation Outline

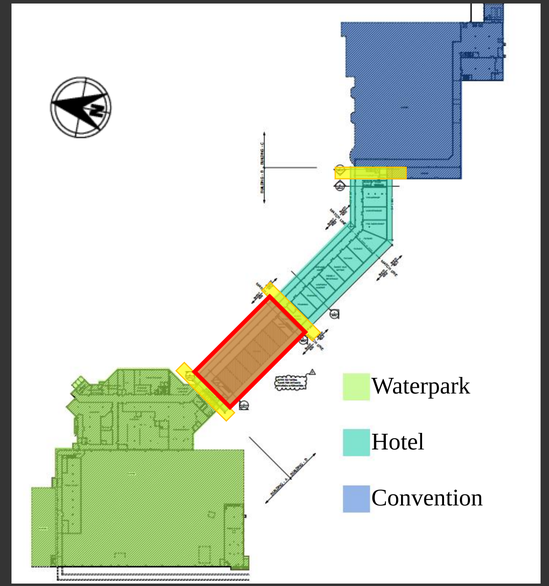
- I Introduction
- E Existing Structure
- T Thesis Topics
- S Structural Depth
- A Architectural Breadth
- C Conclusion

I
E
T
S
A
C

Building Statistics

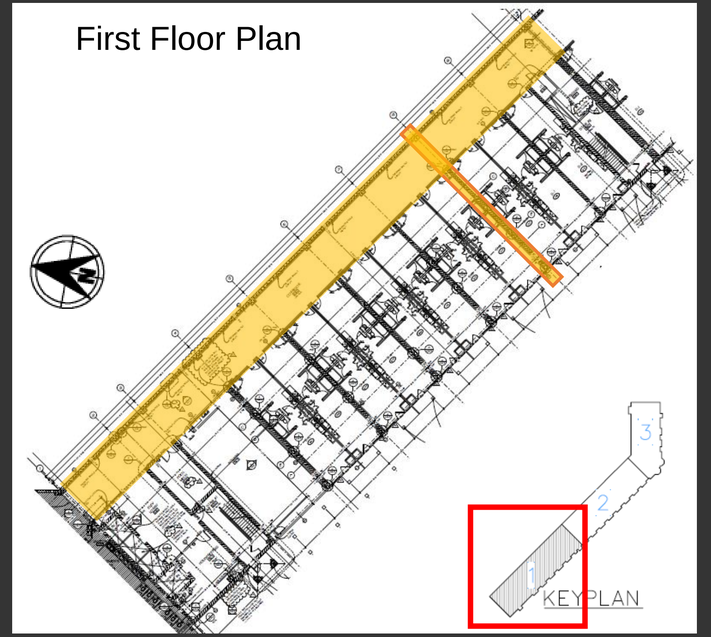
- Hakuna Resort (fictitious)
- Swiftwater, PA (fictitious)
- Function type: Residential (R-1)
- Project total SF: 786,125 SF
- Focused SF: 143,107 SF
- 8 story tall
- Date of construction: March 2014 – Summer 2015
- Project Total Cost: $230 million

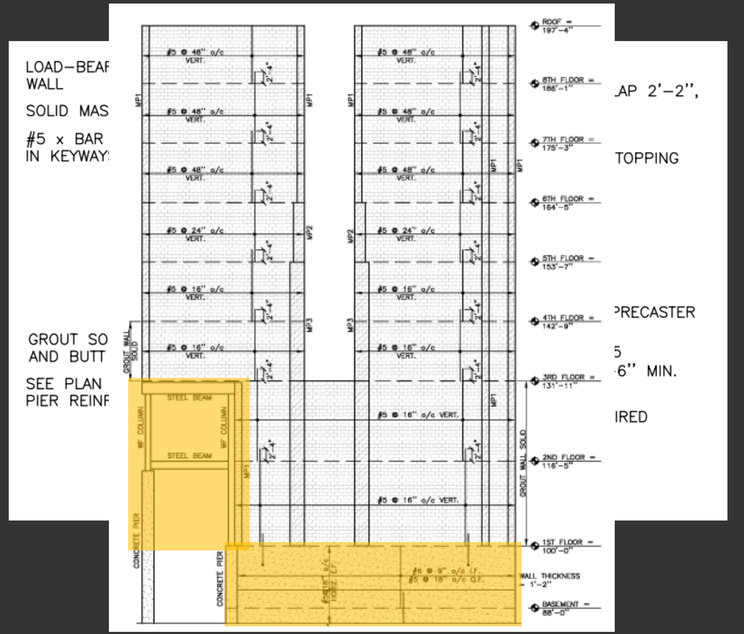
Owner	LMN Development, LLC
Architect	Architectural Design Consultants
GC	Kraemer Brothers, LLC
MEP/Structural	Harwood Engineering Consultants
Civil	Pennoni Associates, INC.



Existing Structure

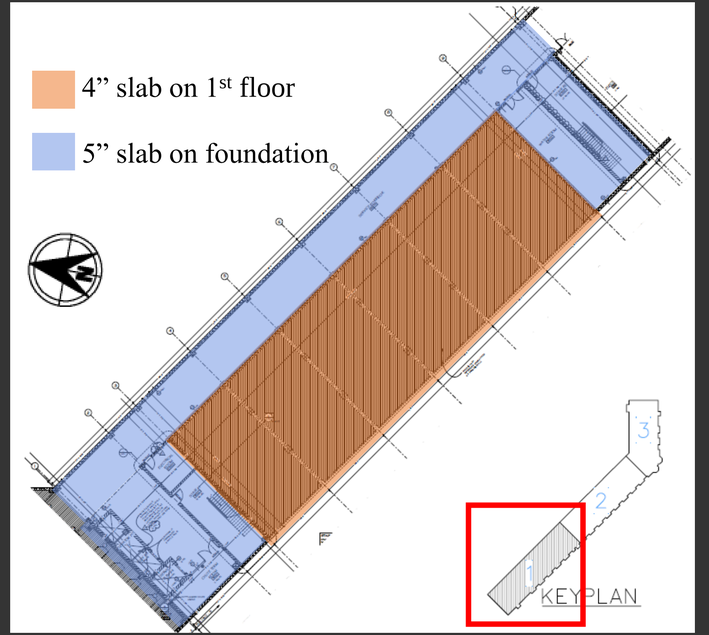
- 10” & 12” Precast Prestressed Hollow Core Planks with 3” composite topping
- Load bearing masonry shear walls
- Reinforced concrete shear walls
- Steel moment frames

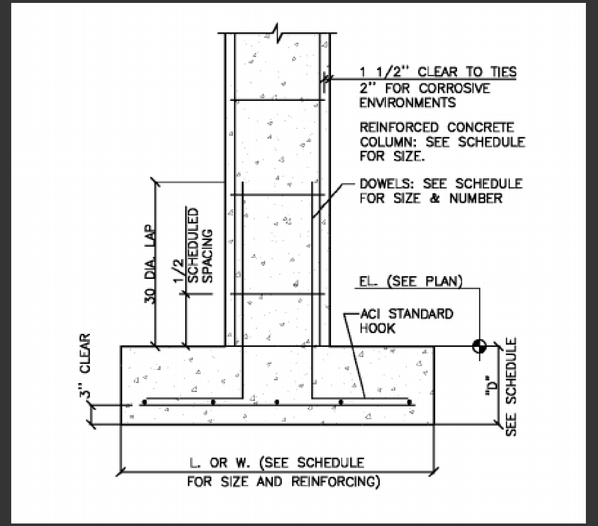




Foundation

- Portion unexcavated
- Strip footing for concrete walls
- Spread footing for concrete columns
- Footing thickness varies from 2’ to 3’-6”
- #9 to #11 reinforcements





I E T S A C

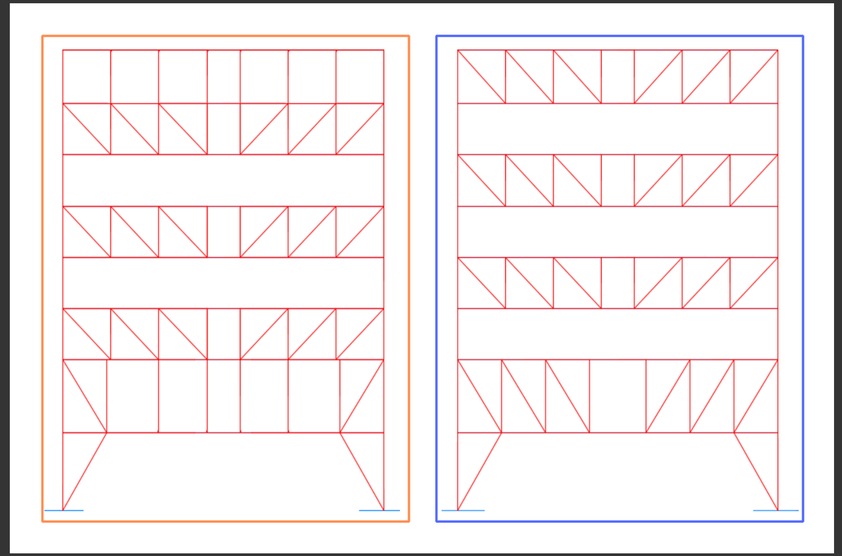
Structural Depth

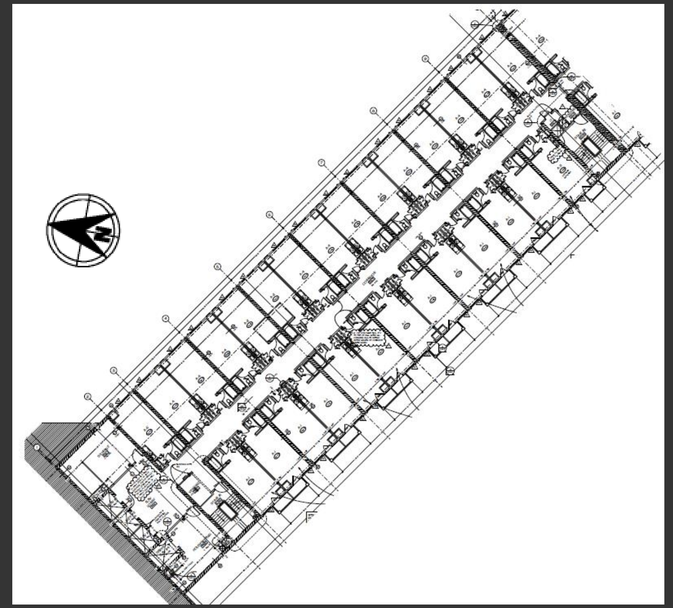
Purpose:

- To compare staggered truss system with existing load bearing masonry shear wall

Advantages:

- Repetitive floor layout
- Works well with existing hollow core planks
- Potential for change in cost and schedule





I
E
T
S
A
C

Structural Depth

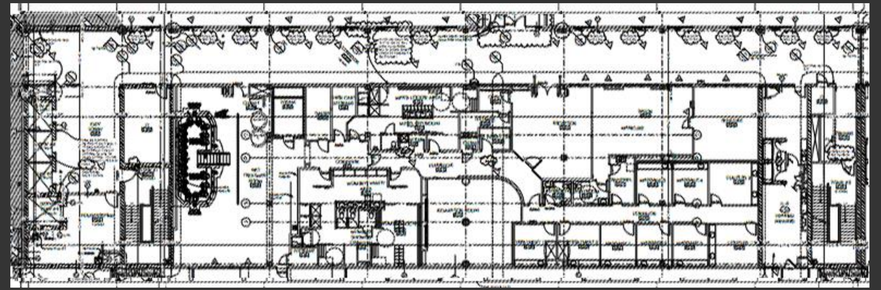
Purpose:
- To compare staggered truss system with existing load bearing masonry shear wall

Advantages:
- Repetitive floor layout
- Works well with existing hollow core planks
- Potential for change in cost and schedule

Architectural Breadth

Purpose:
- To redesign first and second floor
- To redesign exterior façade

Reasons:
- First and second floor requires open spaces for service areas
- Existing façade is boring. Add more exciting features



I
E
T
S
A
C

Structural Depth

Purpose:
- To compare staggered truss system with existing load bearing masonry shear wall

Advantages:
- Repetitive floor layout
- Works well with existing hollow core planks
- Potential for change in cost and schedule

Architectural Breadth

Purpose:
- To redesign first and second floor
- To redesign exterior façade

Reasons:
- First and second floor requires open spaces for service areas
- Existing façade is boring. Add more exciting features

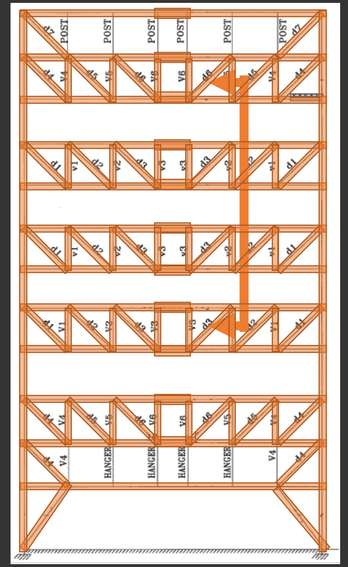
Construction Breadth

Evaluate the new project construction schedule and cost with the staggered truss system and compare the outcomes

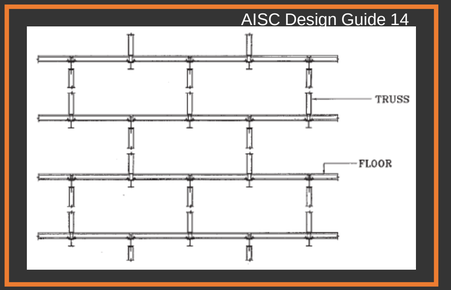
Staggered Truss System

AISC Design Guide 14 – Staggered Truss Framing Systems was used for basic understanding of the system and hand calculation procedure guidance

Central Vierendeel panel for corridor
W-shape chords
W-shape columns
HSS-shape verticals and diagonals



Example Truss Frame from AISC Design Guide 14

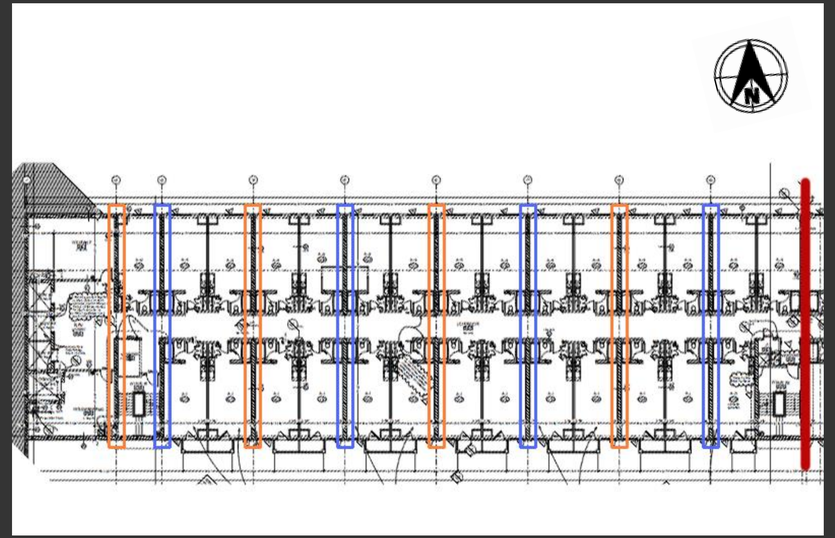


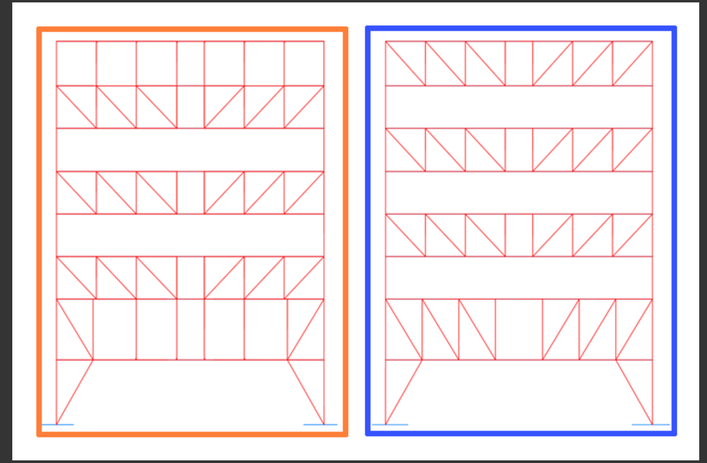
Representation of staggering of the trusses, allowing more square footage without blocking of walls at each level at every structural gridlines.

Staggered Truss System

Dead Load
- 68 psf – hollow core planks
- 37.5 psf – composite topping
- 10 psf – super imposed load

Live Load
- 40 psf – hotel rooms
- 100 psf – corridor
- 100 psf – lobby area



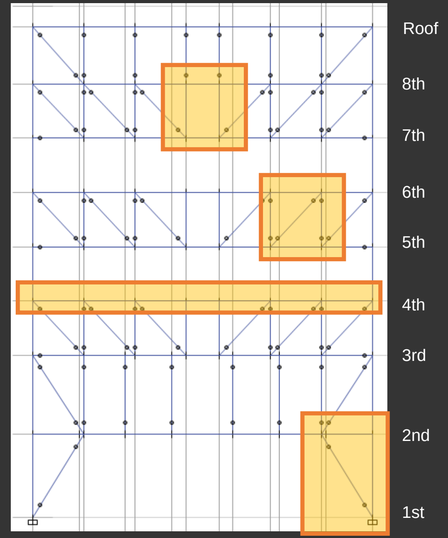


Truss 1 Truss 2

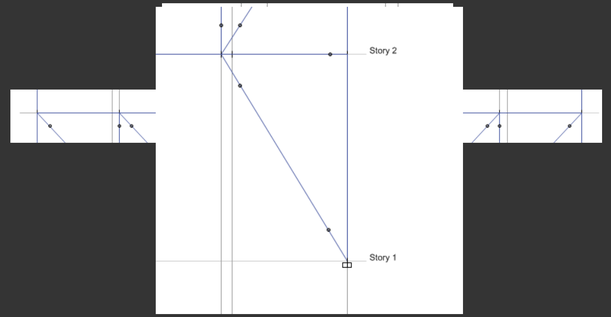
Staggered Truss System

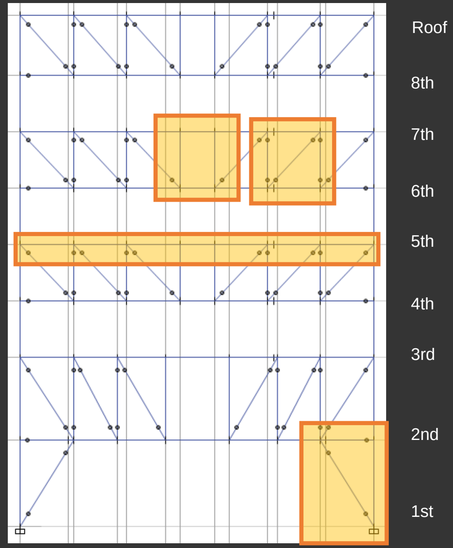
Finish Designs

Floor	Chord	Diagonal	Column
	Section	Section	Section
Roof	W10x60	HSS8x6x1/2	W12x65
8	W10x60	HSS8x6x1/2	W12x65
7	W10x77	HSS8x6x1/2	W12x87
6	W10x77	HSS8x6x1/2	W12x87
5	W10x88	HSS10x8x1/2	W12x120
4	W10x88	HSS10x8x1/2	W12x120
3	W10x112	HSS10x8x1/2	W12x152
2	W10x112	HSS10x8x1/2	W12x152



- Chords continuous and fixed at the ends
- Diagonal and vertical members pinned at both ends
- Vierendeel panels all fixed
- Fixed base

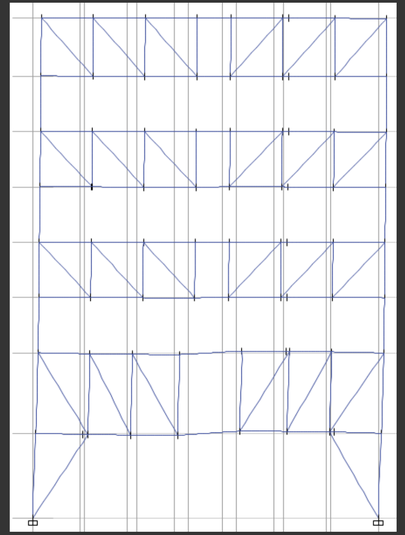


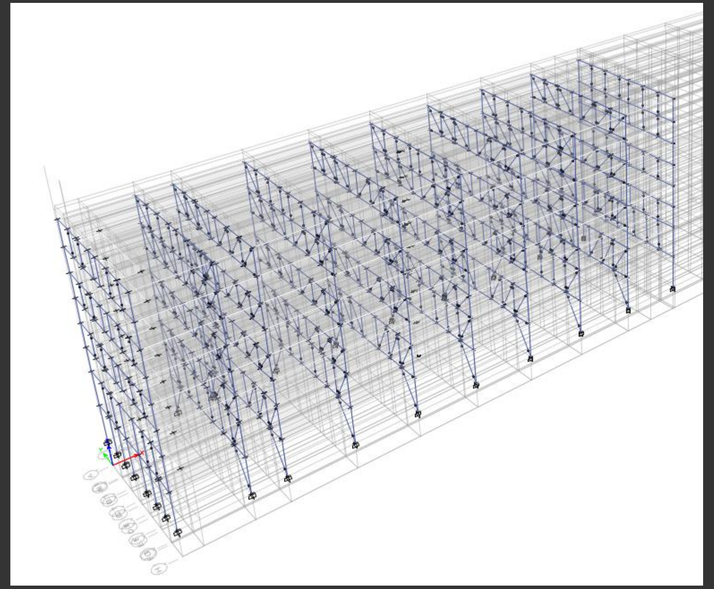


Deflections

Chord deflection
- Largest deflection = 0.919” < L/240 = 3.35”
- Largest LL deflection = 0.29” < L/360 = 2.23”

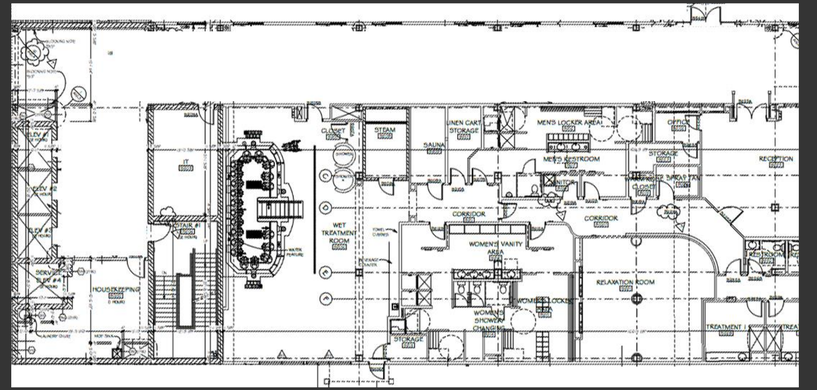
Column lateral deflection (wind)
- Roof displacement = 0.526” < L/400 = 2.01”



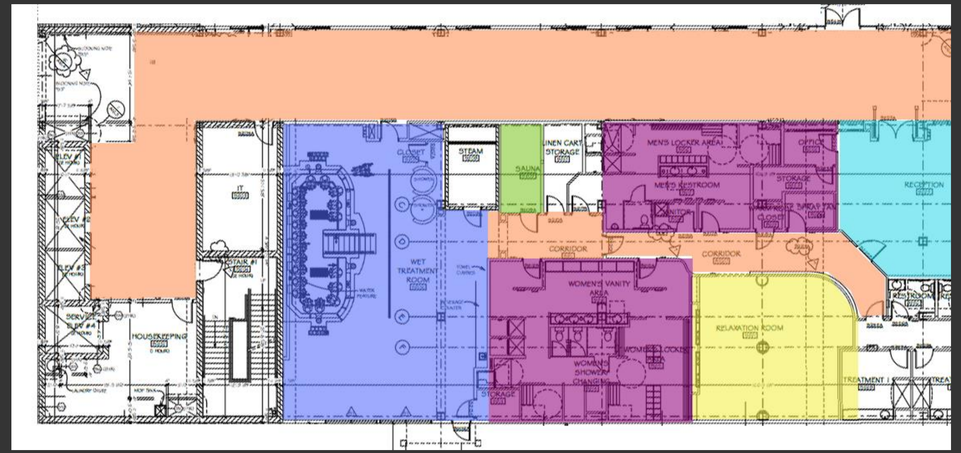


Architectural Breadth

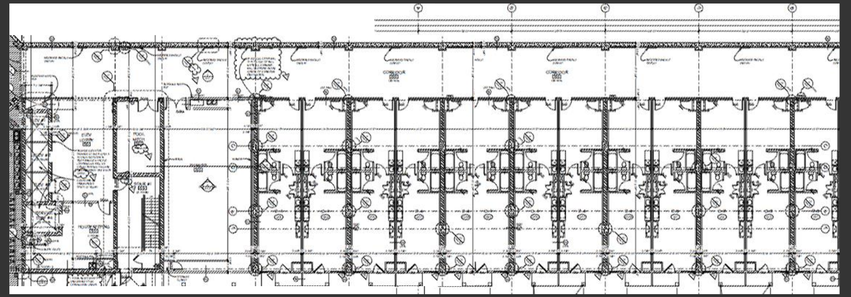
- Redesign lower levels floor layout to accommodate the restrictiveness of truss opening.
- Redesign the façade to catch people’s attention when they first encounter the resort

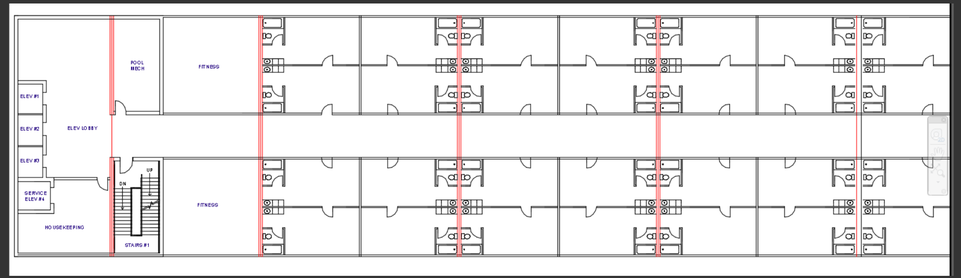


Floorplan Redesign

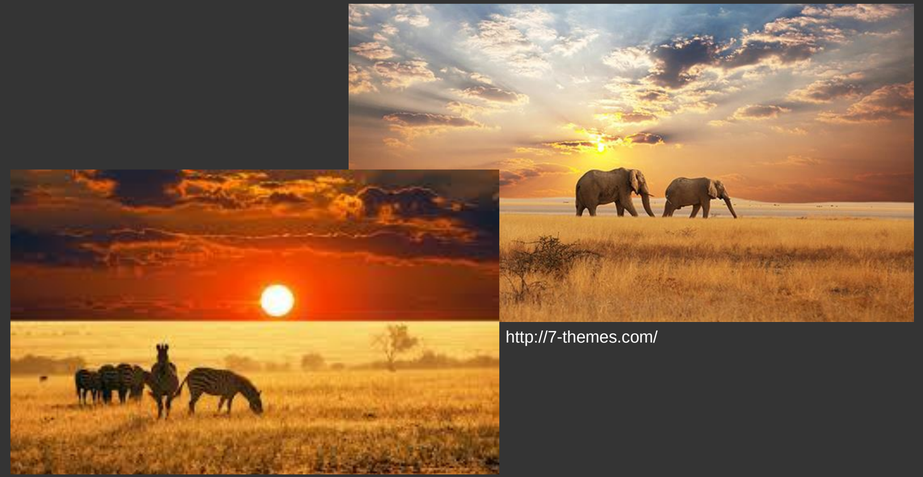


Floorplan Redesign



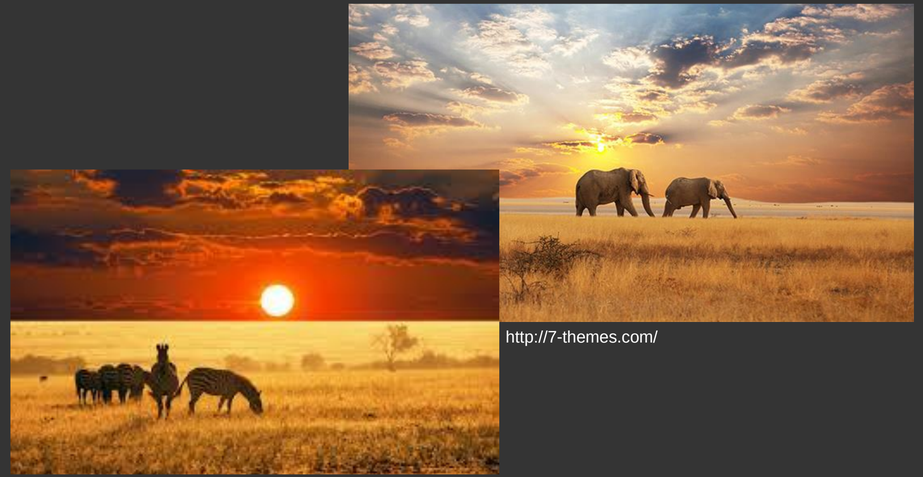


Façade Redesign



http://7-themes.com/

Façade Redesign

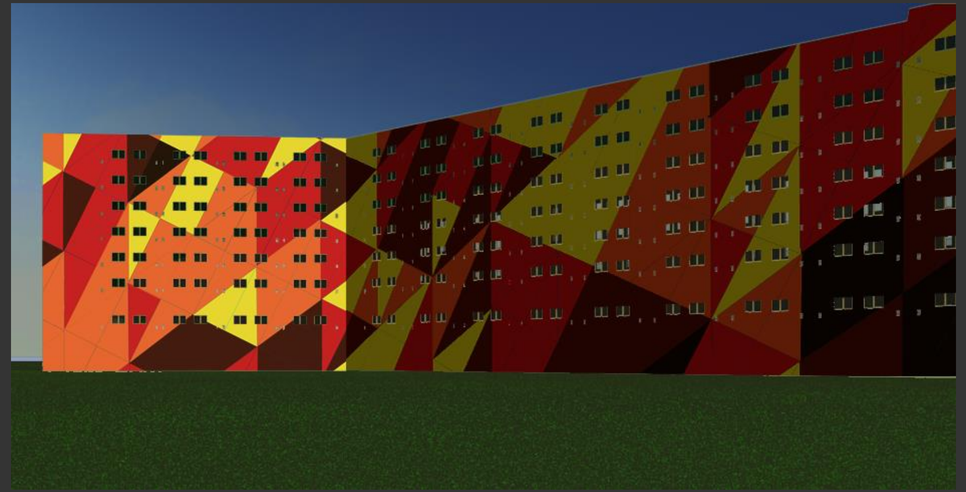


http://7-themes.com/

http://www.fibrosan.com.tr/

United Cargo Headquarters
Sydney: Condell Park
http://www.e-architect.co.uk/

Façade Redesign



I
E
T
S
A
C

Conclusion

Structural

- Staggered truss system is feasible design
- Successfully resist gravity loads and lateral loads in the N-S direction
- Great educational experience

Architectural Breadth

- Floor layout adjusted according to staggered truss frame layout
- May not be the best layout for the service area for privacy
- Redesigned hotel façade to be more exciting when encountered

Construction Breadth

- Overall cost increased by $200,000 (0.09% of total project cost)
- Schedule reduced by 3 days

Special Thanks to…

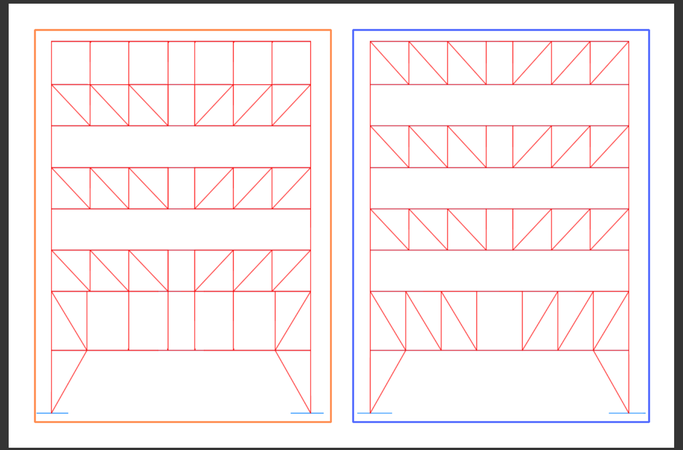
NITTERHOUSE CONCRETE PRODUCTS

LMN Development, LLC

All AE Structural Faculty members
Especially Prof. Sustersic

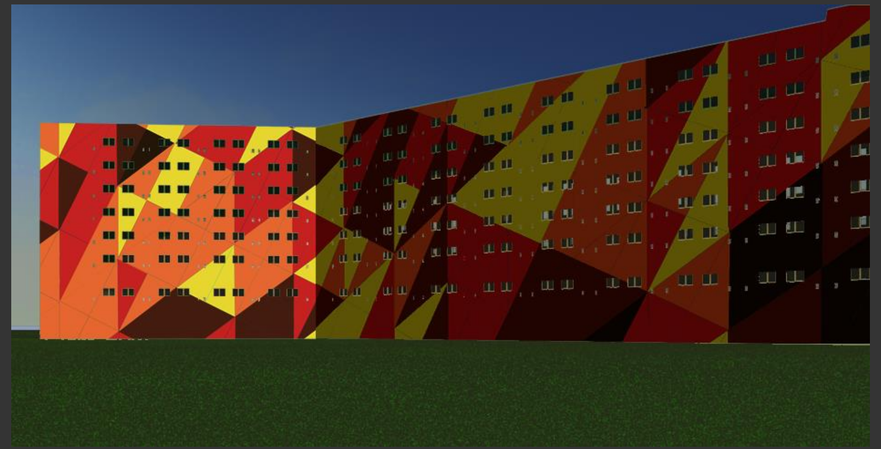
My family and friends

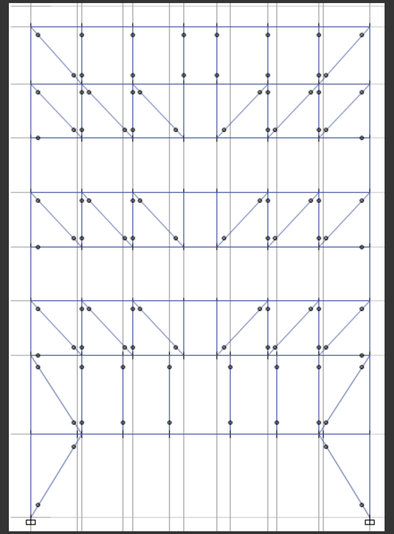
Heavenly Father and His Son
Jesus Christ

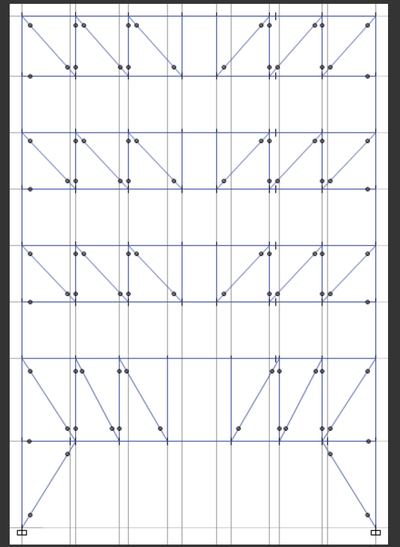


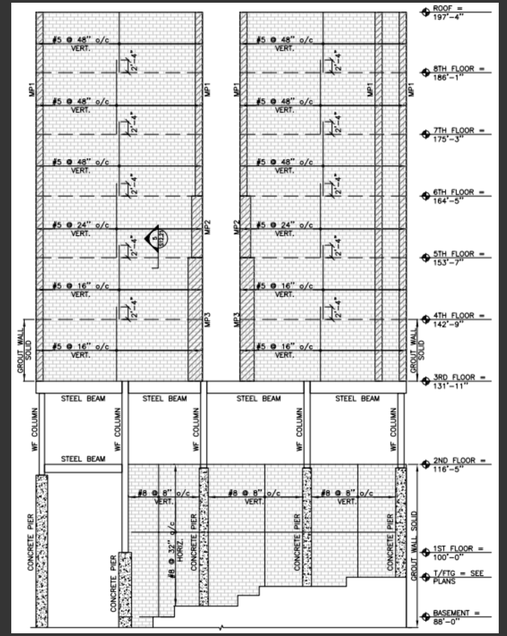
Thank you!

Questions?








ROOF = 197'-4"
8TH FLOOR = 186'-1"
7TH FLOOR = 175'-3"
6TH FLOOR = 164'-5"
5TH FLOOR = 153'-7"
4TH FLOOR = 142'-9"
3RD FLOOR = 131'-11"
2ND FLOOR = 116'-5"
1ST FLOOR = 100'-0"
T/TTG = SEE PLANS
BASEMENT = 88'-0"
#5 @ 48" o/c VERT.
#5 @ 24" o/c VERT.
#5 @ 16" o/c VERT.
#8 @ 8" o/c VERT.
#8 @ 32" o/c HORIZ.
MP1
MP2
MP3
GROUT WALL SOLID
STEEL BEAM
WF COLUMN
CONCRETE PIER

Truss Chord						
Floor	phi	M_{ug}	M_{uw}	Mu	Pu	Section
Roof	9%	44.4	27.25	71.65	476.4	**W10x60**
8	24%	44.4	72.78	117.18	476.4	**W10x60**
7	36%	44.4	109.83	154.23	476.4	**W10x77**
6	48%	44.4	146.17	190.57	476.4	**W10x77**
5	60%	44.4	181.68	226.08	476.4	**W10x88**
4	72%	44.4	216.23	260.63	476.4	**W10x88**
3	85%	44.4	256.78	301.18	476.4	**W10x112**
2	100%	44.4	302.34	346.74	476.4	**W10x112**

Diagonal Member								
	wind		seismic		Load Combinations			Section
Floor	phi	Applied Load (kips)	phi	Applied Load (kips)	1.2D+.8W	1.2D+1.6 W+L	1.2D+E+L	
Roof	9%	13.80	25%	44.70	99.48	149.42	**172.04**	**HSS8x6x1/2**
8	24%	36.85	43%	76.27	117.92	186.30	**203.61**	**HSS8x6x1/2**
7	36%	55.61	59%	103.62	132.93	216.31	**230.96**	**HSS8x6x1/2**
6	48%	74.00	72%	126.77	147.64	**245.74**	254.11	**HSS8x6x1/2**
5	60%	91.98	82%	145.78	162.03	**274.51**	273.12	**HSS10x8x1/2**
4	72%	109.47	91%	160.72	176.02	**302.49**	288.06	**HSS10x8x1/2**
3	85%	130.00	97%	171.64	192.44	**335.34**	298.98	**HSS10x8x1/2**
2	100%	153.07	100%	177.00	210.90	**372.25**	304.34	**HSS10x8x1/2**
Gound								

Column 6A

	Axial Forcs						Moment	Load Combinations				Section
	floor		Ext Wall	total		Ext Wall	DL	1.4D		1.2D+1.6L		
Floor	DL	DL+RLL		DL	DL+RLL			Pu	Mu	Pu	Mu	
Roof	207	264	16	207	264	16	55	289.8	77	**351.032**	66	**W12x65**
8			16	207	264	32		289.8	0	**370.232**	0	**W12x65**
7	207	264	16	414	528	48	65	579.6	91	**721.2641**	78	**W12x87**
6			16	414	528	64		579.6	0	**740.4641**	0	**W12x87**
5	207	264	16	621	792	80	77	869.4	107.8	**1091.496**	92.4	**W12x120**
4			16	621	792	96		869.4	0	**1110.696**	0	**W12x120**
3	207	264	16	828	1056	112	82	1159.2	114.8	**1461.728**	98.4	**W12x152**
2			16	828	1056	128		1159.2	0	**1480.928**	0	**W12x152**
Gound	207	264	16	1035	1320	144	97	1449	135.8	**1831.96**	116.4	

Lateral Story Drifts (in)		
Level	1.2D+L+1.6W	1.2D+L+E
Roof	0.009	0.017
8	0.014	0.024
7	0.025	0.032
6	0.027	0.035
5	0.031	0.034
4	0.043	0.063
3	0.147	0.115
2	0.23	0.182
1	0	0
Total	0.526	0.502

Gravity Deflections (in)		
Chord Size	1.2D+1.6L	1.6L
W10x60	0.919	0.29
W10x77	0.883	0.243
W10x88	0.854	0.18
W10x112	0.691	0.183