Depth Work

Staggered Truss Design

Compares Precast Concrete Plank to a Steel Joist Floor System

Introduction

The Erie Convention Center and Sheraton Hotel is currently being constructed of a steel frame with a hollow core precast plank flooring system. This steel system is comprised of columns, beams, and girders, with lateral forces resisted by moment connections in the East/West direction, and braced frames in the North/South direction. This system is effective in resisting lateral loads, while fitting the typical grid of a hotel building.

When examining possible alternatives to a structural system, a staggered truss system, often used in hotels and apartment buildings, appears to be the most appropriate alternative. Through the use of this system, low floor to floor heights can be obtained when used in conjunction with hollow core precast plank. In addition, column-free areas as large as 60-70 feet can be obtained because of the staggered floor to floor height truss configuration. These trusses will resist the lateral loads in the N/S direction, while moment connections will resist lateral loads in the E/W direction.

The following sections will include the design criteria used for the gravity and lateral loading of the staggered truss system. Two alternative floor systems used in conjunction with the staggered truss system will also be analyzed: a hollow core precast plank floor similar to the one used in the existing building, and a floor system comprised of open web steel joists with metal deck and a concrete slab. The theory and design of the staggered truss system will also be discussed, along with the results of the design and final conclusions.

Gravity Design Loads and Floor Design

The following gravity loads were used in order to design the two floor systems being analyzed in conjunction with the staggered truss framing system: hollow core precast plank, and steel joist with metal deck and concrete slab.

Live Loads: (IBC 2003 Table 1607.1, unless noted otherwise)

- Public Rooms and Corridors = 100 psf
- Private Rooms and Corridors = 40 psf
- Stairs = 100 psf
- Mechanical Spaces (Assumed) = 150 psf
- Ground Snow Load p_g (Fig. 1608.2) = 30 psf

C_e=0.8 (fully exposed, exposure category D)
C_t=1.0
I=1.0 (Building category II)
$p_f=0.7\ C_e\ C_t\ I\ p_g=16.8$ psf

Precast Hollow Core Floor-

See Appendix 1 for hollow-core plank design charts of 8” precast hollow core plank with 2” topping.

Dead Loads: (Assumed in conjunction with AISC Staggered Truss Framing Systems Design Guide)

- Structural Steel = 5 psf
- 8” precast hollow core plank with 2” topping (PCI Design Handbook) = 81 psf
- Metal Stud Walls with 5/8” gypsum wall board = 10 psf
- MEP = 10 psf
- Carpet = 1 psf
- Ceiling Finishing = 1 psf

Total Dead Loads = 108 psf

Steel Joist Floor with Metal Deck and Concrete Slab-

Joists are 3’ o.c. (57’ wide with joist at 3’o.c→ 19 spaces, 20 joists)

22K7 (floor 2)
18K4 (floors 3-11)

See Appendix 2 for joist design.

Dead Loads: (Assumed in conjunction with AISC Staggered Truss Framing Systems Design Guide)

- Structural Steel = 5 psf
- Metal Stud Walls with 5/8” gypsum wall board = 10 psf
- MEP = 10 psf
- Carpet = 1 psf
- Ceiling Finishing = 1 psf
- Concrete Slab and Deck = 39 psf
- Joist (conservative estimate) = 4 psf

Total Dead Loads = 70 psf

Lateral Design Loads

The following design conditions and lateral loads, both wind and seismic were calculated using ASCE 7-02. Similar calculations were completed as part of Technical Assignment #3. Full final calculations are available upon request.

Wind Loads:

Basic Wind Speed	90 mph
Exposure Category	D
Enclosure Classification	Enclosed
Building Category	II
Importance Factor	1.00

Seismic Loads:

Seismic Use Group	I
Occupancy Importance Factor	1.0
Site Classification	E
0.2s Acceleration (Figure9.4.1.1a)	0.13
1s Acceleration (Figure 9.4.1.1b)	0.059
Site Class Factor, F_a (Table 9.4.1.2.4a)	2.5
Site Class Factor, F_v (Table 9.4.1.2.4b)	3.5
Response Modification Factor (E/W)	3.5 (for ordinary steel moment frames)
Response Modification Factor (N/S)	3.0 (conservative for staggered truss)

A response modification factor of 3.0 was chosen for seismic design in the N/S direction, which is the direction of the staggered trusses. An R of 3.0 is the most conservative value, which does not require special detailing for seismic forces. Even though an R factor of 7 or 8 could be applied if the staggered truss system is considered to act as an eccentrically braced frame, using an R of 3, is the most conservative.

Shown below are two tables containing the story forces and story shears for the staggered truss system with the hollow core precast plank floor system. It can be seen that in the N/S direction, wind forces control, while in the E/W direction, the seismic forces control. This is expected that the wind will control in the N/S direction, because of the large surface area that the wind is in contact with.

Plank Design Story Forces (kips)				
	N/S		E/W	
Floor	Wind	Seismic	Wind	Seismic
roof	28.13	27.15	7.70	20.49
11	55.93	64.66	15.18	48.27
10	55.59	56.17	15.18	41.44
9	55.15	47.99	15.47	34.94
8	54.70	40.15	14.88	28.79
7	53.81	32.67	14.51	23.03
6	52.69	25.61	14.13	17.68
5	52.02	19.00	13.83	12.80
4	59.10	12.94	15.70	8.44
3	76.93	7.53	20.30	4.69
2	86.17	2.98	22.55	1.72
1	39.87	0	10.36	0

Plank Design Story Shear (kips)						
	N/S			E/W		
Floor	Wind	Seismic	Φ_h (%)	Wind	Seismic	Φ_h (%)
roof	0.00	0.00	0.0	0.00	0.00	0.0
11	28.13	27.15	4.3	7.70	20.49	8.5
10	84.06	91.82	14.6	22.88	68.76	28.4
9	139.65	147.99	23.5	38.05	110.20	45.5
8	194.80	195.97	31.1	53.52	145.13	59.9
7	249.50	236.12	37.5	68.40	173.93	71.8
6	303.30	268.79	42.7	82.91	196.96	81.3
5	355.99	294.40	46.7	97.04	214.64	88.6
4	408.01	313.41	64.7	110.87	227.44	93.9
3	467.11	326.34	74.1	126.57	235.87	97.4
2	544.04	333.87	86.3	146.87	240.56	99.3
1	630.21	336.85	100.0	169.42	242.28	100.0

Shown below are two tables containing the story forces and story shears for the staggered truss system with steel joist and slab floor system. It can be seen that in the N/S direction, wind forces control, while in the E/W direction, the seismic forces control. This is expected that the wind will control in the N/S direction, because that is when it is hitting the wide side of the building. Notice that the seismic forces for the joist floor system are less than the design forces for the plank floor system because of the decrease in building weight.

Joist Design Story Forces (kips)				
	N/S		E/W	
Floor	Wind	Seismic	Wind	Seismic
roof	28.13	26.57	7.70	20.01
11	55.93	42.25	15.18	31.48
10	55.59	36.70	15.18	27.02
9	55.15	31.36	15.47	22.78
8	54.70	26.23	14.88	18.78
7	53.81	21.35	14.51	15.02
6	52.69	16.73	14.13	11.53
5	52.02	12.42	13.83	8.35
4	59.10	8.45	15.70	5.50
3	76.93	4.92	20.30	3.06
2	86.17	1.95	22.55	1.12
1	39.87	0.00	10.36	0.00

Joist Design Story Shear (kips)						
	N/S			E/W		
Floor	Wind	Seismic	Φ_h (%)	Wind	Seismic	Φ_h (%)
roof	0.00	0.00	0.0	0.00	0.00	0.0
11	28.13	26.57	4.2	7.70	20.01	12.2
10	84.06	68.82	10.9	22.88	51.49	31.3
9	139.65	105.52	22.2	38.05	78.52	47.7
8	194.80	136.88	30.9	53.52	101.30	61.5
7	249.50	163.11	39.6	68.40	120.08	72.9
6	303.30	184.46	48.1	82.91	135.10	82.0
5	355.99	201.19	56.5	97.04	146.63	89.1
4	408.01	213.61	64.7	110.87	154.98	94.1
3	467.11	222.06	74.1	126.57	160.48	97.5
2	544.04	226.98	86.3	146.87	163.54	99.3
1	630.21	228.93	100.0	169.42	164.66	100.0

Load Combinations

The following seven LRFD load combinations were considered for the design of the structure:

- 1.4 D
- 1.2 D + 1.6 L + 0.5 R
- 1.2 D + 1.6 R + L
- 1.2 D + 1.6 W + L + 0.5 R
- 1.2 D + 1.0 E + L + 0.2 S
- 0.9 D + 1.6 W
- 0.9 D + 1.0 E

Seismic forces control in the E/W direction, which is resisted by moment connections. Because of these high seismic forces, the load combination 1.2 D + 1.0 E + L + 0.2 S controls. In the direction of the trusses, N/S, the load combination 1.2 D + 1.6 W + L + 0.5 R controls due to the large surface area on the longitudinal side of the building.

Truss Theory and Design

A staggered truss system uses the concept of the building acting as a cantilevered wide flange resisting a point load. This is carried out through the use of floor to floor height trusses located on alternating column lines, which eliminates interior columns, leaving only two column lines along the long dimension of the building. Figure 4 demonstrates how when wind acts against the long direction (E/W) of the building, the column lines act as the flanges, while the trusses act as the web.

Alternating column lines that the trusses span means that the trusses alternate floors. This system is more clearly shown in the 3-D picture in Figure 5. The basic staggered truss layout in Figure 6 shows how the trusses will span in the N/S direction along the original column lines so that the interior architecture of the building will not be altered. The floor system spans in the E/W direction between column lines. The top chord of a truss supports one side of the floor system, while the other side is supported by the bottom chord of the adjacent truss.

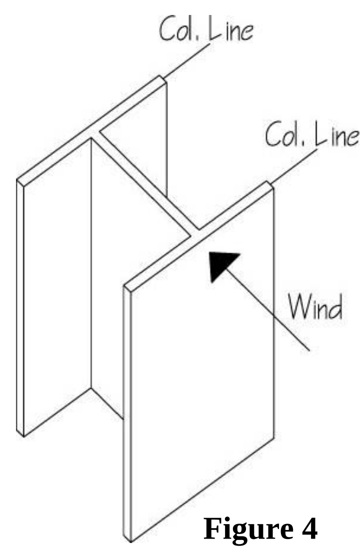

Figure 4

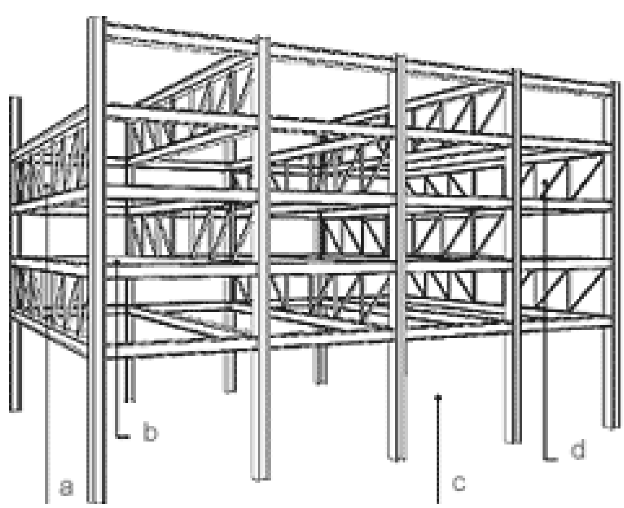

Figure 5: A 3-D example shows how the floor plan is free of interior columns for two-bay widths.

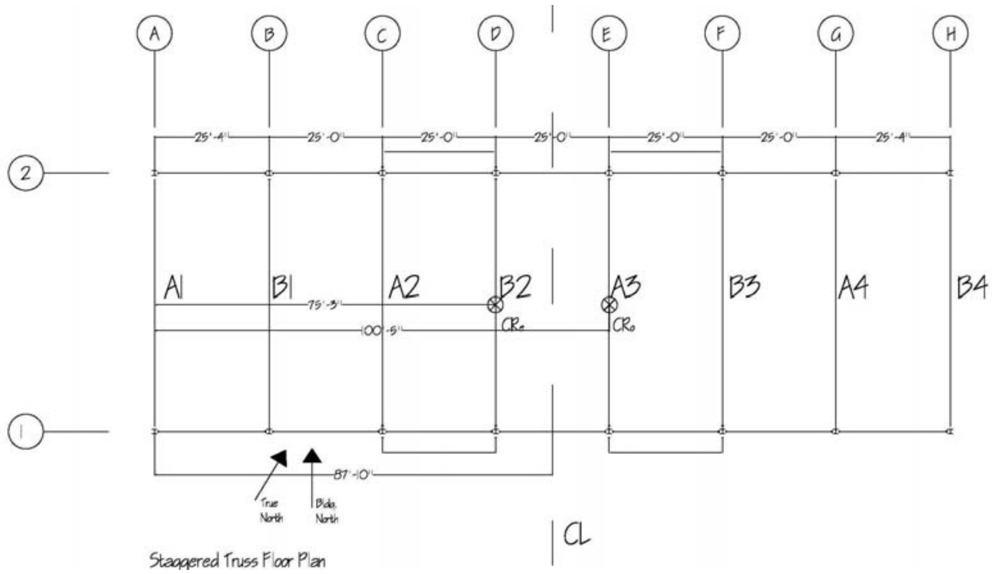

Figure 6: It can be seen in the floor plan above, that only the columns along column lines 1 and 2 remain. The trusses on the even floors are represented by A1, A2, A3, and A4, while B1, B2, B3, and B4 represent trusses on odd floors.

The trusses themselves are Pratt trusses typically composed of W-shape chords with hollow structural section diagonal members. There must be an open Vierendeel panel in the center to allow for a corridor. Gravity loads from the floor system are applied to the top and bottom chords. The trusses will provide resistance to lateral loads in the N/S direction, while moment connections will resist lateral loads in the E/W direction. The truss frames are considered to have pin joints, assuming that no moment is transferred through the joints or between members. Figure 7 shows a typical truss. Welded gusset plates provide the connection between the web members and truss chords.

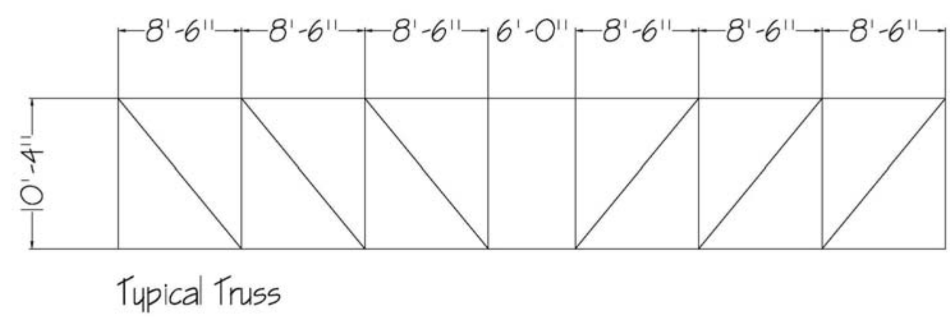

Figure 7: The floor-to-floor height trusses that span the N/S direction, resist both gravity loads and lateral loads acting in the N/S direction.

To begin the design process of the staggered truss system, the distribution of lateral forces through rigid diaphragm action was initially investigated. The assumption is made that each truss has approximately the same shear rigidity. Lateral loads are transferred from truss to truss through the diaphragm at each floor, carrying the lateral loads from the top of the building, to the ground. To resist the lateral load, it is assumed that each of the four trusses on each floor take an equal amount of the load. This load is then transferred through the diagonal members of the trusses to the diaphragm, which then transfers the shear load to the trusses on the next floor. Because of the staggered arrangement, each of the interior trusses is responsible for resisting two bays of lateral load. Figure 8 demonstrates this distribution of horizontal forces.

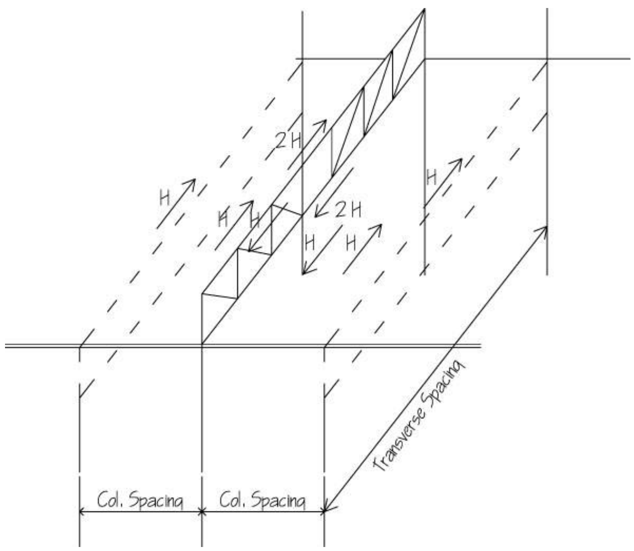

Figure 8: Per column spacing, each truss takes two bays of the lateral force, H.

Both the precast plank floor system and the steel joist floor system act as a rigid diaphragm, causing the same load distribution. Since the wind load case controls in the N/S direction, the base shear is the same for both floor systems, thus there is the same amount of shear on each truss.

The torsional rigidity of the structure can be determined by taking the distance from the trusses to the center of rigidity. These values for the trusses on the even floors can be seen in the chart below (Assume that the equation is multiplied by a constant stiffness factor, R, for each truss).

Torsional Rigidity			
Truss	**x_i**	**x_i^2**	
A1	-75.25	5662.563	
A2	-24.92	621.0064	
A3	25.08	629.0064	
A4	75.08	5637.006	
	Σ=	**12549.58**	**ft^2**

The torsional shear for each truss can then be calculated using the equation $V_{TORS} = Rx/\Sigma Rx^2 * M_T$, where $M_T = V_{BASE\ WIND}$ * (distance from center of rigidity to center line). The base torsion is found by multiplying the base shear by the eccentricity due to an accidental torsion of 5%. Note that the torsional shear components have opposite signs on each side of the center line which says that they are in opposite directions, opposing the moment created by the direct force offset from the center of the building.

Torsional Shear					
Truss	**Rx**	**ΣRx^2**	**$Rx/\Sigma Rx^2$**	**M_T**	**V_{TORS}**
A1	-75.25	12549.58	-0.006	7877.59	-47.24
A2	-24.92	12549.58	-0.00199	7877.59	-15.64
A3	25.08	12549.58	0.001998	7877.59	15.74
A4	75.08	12549.58	0.005983	7877.59	47.13

Base Torsion, T				
V_{base}	**e_e**	**e_o**	**T_e**	**T_o**
630	21.36	-3.8	13461.23	-2394.79

Finally, the design shear for each of the trusses can be calculated by adding the shear on each truss due to a direct load ($V_S = V_{BASE}/4$) to the torsional shear. The values for the trusses on the second floor are shown in the following table. Figure 9 demonstrates the directions of the shear forces in the trusses due to the direct forces and the torsional forces. The direct forces all run in the same direction, while the torsional forces create a moment by acting in opposite directions on each side of the center of rigidity. This accounts for the larger shear values in trusses A3 and A4.

Shear Force in Each Truss due to Lateral Loads (Bottom Floor)								
Truss	**x_i**	**V_s**	**T_e= 13461.23**		**T_o=-2394.79**		**Design Shear V (kips)**	**Φ_{ecc}**
			V_{TORS}	V_i	V_{TORS}	V_i	V_i	
A1	-75.25	210.07	-47.54	162.53	-47.54	162.53	**162.53**	1.00
A2	-24.92	210.07	-15.74	194.33	-15.74	194.33	**194.33**	1.20
A3	25.08	210.07	15.84	225.91	15.84	225.91	**225.91**	1.39
A4	75.08	210.07	47.43	257.50	47.43	257.50	**257.50**	1.58

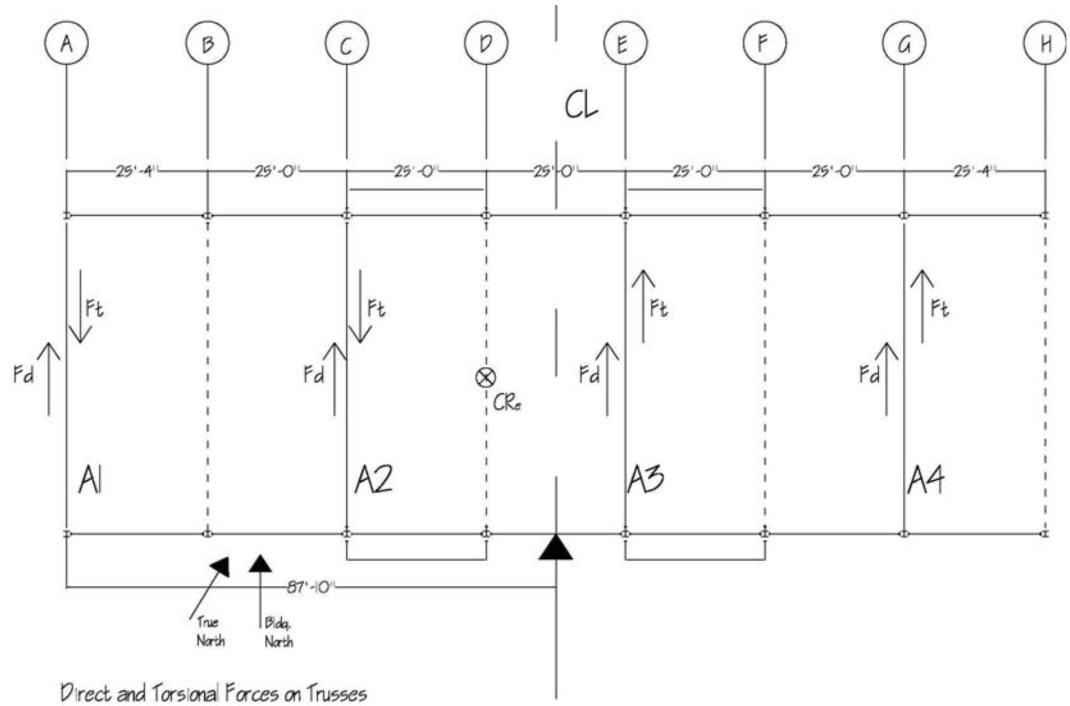

Figure 9: The lateral load causes direct shear forces, F_d, in each of the trusses. Because the load is offset from the center of rigidity, a moment is also induced, creating the torsional shear components, F_t.

Truss Member Sizes

For the design of the actual members of the building, a 3-D computer model was built using ETABS. The basic geometry for the building and truss size and location was entered along with the application of seismic and wind forces including load combinations for design.

The structural system of the staggered truss system is comprised of three parts: the spandrel beams, which run in between and perpendicular to the trusses on the exterior of the building in the E/W direction, the columns, which are only located on the exterior edges of the building in the E/W direction, and the trusses. Each truss is erected as a single piece and is connected to the columns.

Typical spandrel beams for the precast plank floor system range from W18×50 to W36×182, with the most common beam size as a W21×55. The W36×182 beams are located on the bottom floor. While these beams seem like they are sized large, there is an 18' story height above and below these beams. These beams are most likely sized large for stiffness to resist lateral forces. The most common size for the spandrel beams for the joist system is a W18×50.

Columns are designed for combined axial and bending forces due to truss axial deformation and vertical deflection due to gravity loads. Columns for both floor systems range from W12×96 on the top floors, to large W14's on the bottom floor. These columns are large partly due to the 18' height of the bottom two floors. In addition, where hangers are present on the second floor, the first diagonal to column connection will carry three floors of load. This column layout can be seen more clearly in the 3-D image in Figure 10.

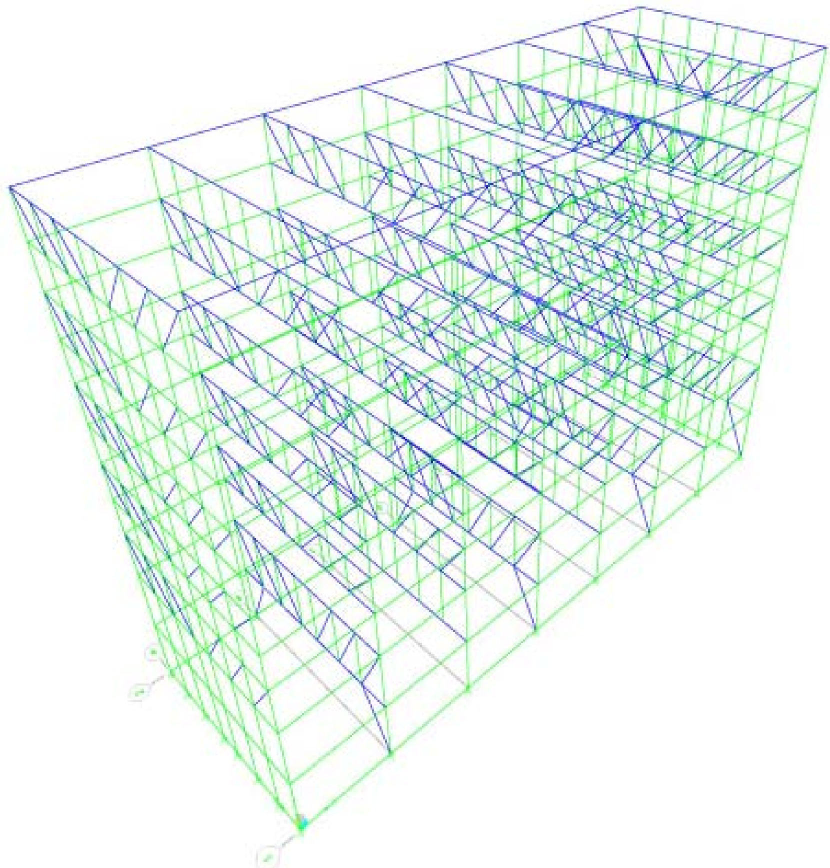

Figure 10: This is a 3-D model of the staggered truss system designed for the Erie Convention Center and Sheraton Hotel created in ETABS. Here, a better view of the open first floor can be seen.

The N/S elevations, once the trusses are fully erected, are shown in Figure 11. Type A and Type B configurations are located on adjacent column lines and are referenced in the floor plan in Figure 6. The chords, labeled U2, U2, U3, L1, L2, and L3 in Figure 11 are W10 shapes, the most common one being a W10×33. These chords are designed using the member forces due to gravity and wind loads, where the maximum moment is located in the Vierendeel panel. The diagonal (d1, d2, d3) and vertical (v1, v2, v3) members are hollow structural sections, the most common size being HSS 10×6×5/16. The diagonal and vertical members on the left and right side of the truss are the same due to symmetry. These vertical and diagonal members are designed by solving the member forces individually due to gravity loads applied at panel points, and lateral loads applied at story heights, and combining them to size the members. The first floor for the Type A elevation needs additional supports or hangers, which are HSS 10×6×5/16, located at each of the panel points of the truss on the second floor. For the Type B layout, HSS 10×6×5/16 posts are needed on the eleventh story. In addition, diagonal W-shape braces are needed on the first floor of the Type B layout for lateral support.

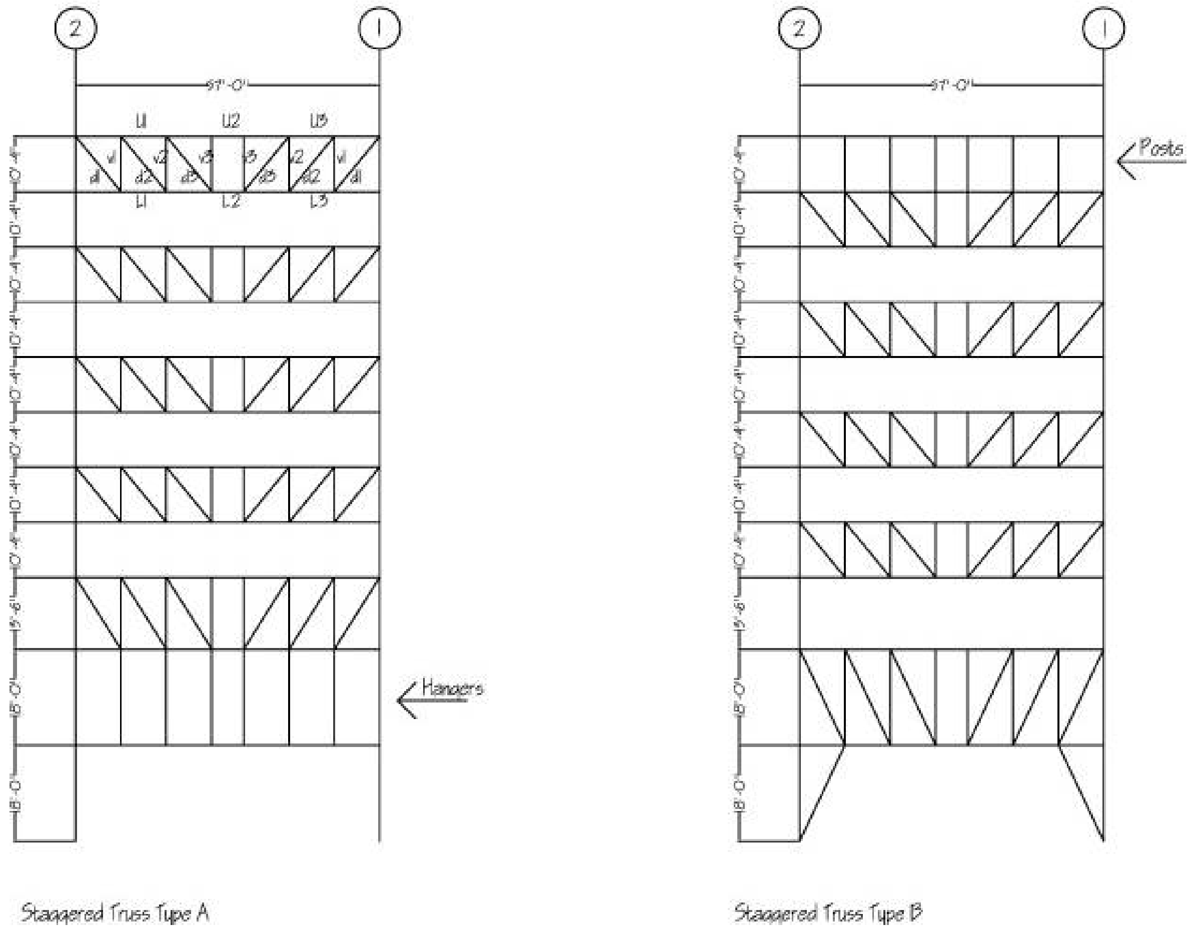

Figure 11: These are two section elevations of the layout of the staggered truss system for the odd floors (Type A), and the even floors (Type B). Full results and member sizes can be found in Appendix 3.

<u>Building Drift due to Lateral Loads</u>

Under the controlling load combination 1.2 D + 1.6 W + L + 0.5 R in the N/S direction, the maximum drifts are as follows:

- Precast Plank System– 2.7”
- Steel Joist System– 1.68”

The allowable drift for serviceability due to wind is Δ= H/400 = 132’(12”/1’)/400 = 3.96”. The drift in the N/S direction for both floor systems, meets this criterion.

For the controlling load combination 1.2 D + 1.0 E + L + 0.2 S in the E/W direction, the allowable drift per floor must not exceed two percent of the story height. The following tables conclude that the drift of the building in the E/W direction under the controlling seismic load combination is acceptable.

Seismic Drift Check (Plank)				
Story	Height (ft)	Displacement	Drift	Drift/(Ht*12)
11	10.33	3.884507	0.051647	0.0004166
10	10.33	3.83286	0.190002	0.0015328
9	10.33	3.642858	0.155166	0.0012517
8	10.33	3.487692	0.257941	0.0020808
7	10.33	3.229751	0.242519	0.0019564
6	10.33	2.987232	0.328583	0.0026507
5	10.33	2.658649	0.288337	0.002326
4	10.33	2.370312	0.367117	0.0029616
3	13.5	2.003195	0.45148	0.0027869
2	18	1.551715	0.642712	0.0029755
1	18	0.909003	0.909003	0.0042083

Seismic Drift Check (Joist)				
Story	Height (ft)	Displacement	Drift	Drift/(Ht*12)
11	10.33	4.490514	0.02905	0.0002343
10	10.33	4.461464	0.145588	0.0011745
9	10.33	4.315876	0.130601	0.0010536
8	10.33	4.185275	0.22455	0.0018115
7	10.33	3.960725	0.194364	0.001568
6	10.33	3.766361	0.2728	0.0022007
5	10.33	3.493561	0.234066	0.0018882
4	10.33	3.259495	0.330678	0.0026676
3	13.5	2.928817	0.475886	0.0029376
2	18	2.452931	0.974549	0.0045118
1	18	1.478382	1.478382	0.0068444

Precast Plank vs. Steel Joists

Between the two floor systems considered, the precast plank floor system appears to be the better choice. While some of the members in the structural system with the steel joist floor system are smaller, on average the members are the same when compared to the precast plank floor system members. Using a steel joist floor system will have other drawbacks. The joists are sized at 22K7 and 18K4, which have depths of 22" and 18" respectively. Once these are topped with a 4" slab, the total depths will be 26" and 22". The precast plank floor system uses 8" deep plank with a 2" topping. This difference of 12" on the majority of the floors of the building will cause an overall building height increase of 11 ft. This increase in height will further impact other factors negatively, such as increased wind loads, an increase in cost for the skin of the building, and an impact on the exterior architecture of the building. Using steel joists instead of the precast plank also gives the possibility of increased floor vibrations. The use of steel joists also will require more fireproofing as well as an increase in the amount of steel pieces to install than the use of a precast plank floor system.

Additional Factors

Erection and Coordination of Trades:

In order to construct a hybrid system, the steel structure of a staggered truss system must be erected alternating with the installation of the floor system, which will be assumed to be precast plank. A staggered truss system provides both advantages and disadvantages for erection. Structural stability during erection is a concern of a staggered truss system. Typically, columns start out as two to three stories in height to start the staggered truss pattern. Because of this instability, temporary steel braces or tension cables are used. Additional structural stability, however, is gained through the attachment of spandrel beams along the strong axis of the building. Once the spandrel beams for the bottom floors are erected, the trusses, which are delivered to the site in one piece can be set and bolted into place. The precast planks are then attached to the top chord of one truss and the bottom chord of the adjacent truss. The plank weld plates will provide some bracing, enough so that approximately nine or ten stories can be completed without grouting or applying the topping to the plank. This is very beneficial in the winter months, because the steel erection is not slowed by the need to coordinate with the "wet" trades, and can be completed. This process is continued for the full eleven stories.

Coordination of trades concerning the shop drawings produced as well as coordination during erection is a concern. The steel and plank drawings must be coordinated to consider steel pieces such as weld plates that might be embedded in or attached to the plank. Appropriate dimensions must be agreed on by both parties so that the most efficient and effective design is obtained. During erection, the workers laying the precast plank must work quickly and efficiently around the steel erectors so that there is no delay.

Foundations:

The columns of a staggered truss system are located only along the long edge of the building, therefore reducing the number of foundations needed by eliminating all of the foundations on the interior of the building. Even though the foundations may need to be bigger in size, there will be fewer caissons to be drilled. The size of the foundations may not need to be increased much though because the staggered truss system is lighter in weight. Also, because all of the gravity load is concentrated at a few columns, this force will most likely exceed the uplift forces created by lateral forces without any concern for additional resistance.

Fire Resistance:

The layout of the staggered truss system keeps most of the steel at the trusses, which allows fireproofing to be completed easily and efficiently. Fire protection of the trusses can be done by enclosing them with a fire-rated enclosure, such as light-gage metal studs and gypsum board, or by fire-proofing each member with either a cementitious spray-applied fireproofing, a paint on fireproofing, or a fireproofing to be trowel finished. The method of fireproofing depends on the aesthetics required. The trusses in the Erie Convention Center and Sheraton Hotel will all be enclosed within the appropriate fire-rated wall construction.

Architecture:

While the exterior architecture of the Erie Convention Center and Sheraton Hotel will not be affected by the use of a staggered truss system, there is a negative affect on the interior architecture on the second floor. Figure 11 previously showed that hangers will need to be installed in one bay, while the truss will occupy the adjacent bay. Most of the second floor will not be affected by this configuration because there are walls along these lines. There is one open area in the existing system that would have exposed columns around the grand stair case leading from the ground floor to the second floor. The floor plan would have to be altered to allow for a wall between the stair case and the adjacent sitting area.

Outweighing this negative affect however, is the lack of interior columns on the first floor. Located on the first floor of the hotel are meeting rooms and the dining room. These areas will now be free of the exposed interior columns, creating a more free-flowing space.

Structural Conclusions

This report has shown that a staggered truss system is a feasible option for the structural design of the Erie Convention Center and Sheraton Hotel. A determining factor to consider when choosing a structural system to use is cost. The installed costs per ton were estimated from an 8-story project completed in New Jersey. Using these numbers, an approximate overall cost comparing the two systems can be calculated. The following two tables show the costs of the existing system and the staggered truss system with precast plank. Since I have already ruled out the joist floor system as a possibility, this system will not be included in the comparison. This also allows for only the cost of the steel members to be compared, since the precast plank design did not change from the existing structure to the staggered truss system.

Existing System				
	weight (lbs)	tons	pricing	total cost
Columns	511765.29	255.8826	$2,000.00	$511,765.29
Beams	481446.34	240.7232	$2,000.00	$481,446.34
Cross Bracing	101888.98	50.94449	$2,200.00	$112,077.88
				$1,105,289.51

Staggered Truss with Plank				
	weight (lbs)	tons	pricing	total cost
Transverse Beams	242967.54	121.48	$2,500.00	$303,709.43
Col. Line 1	142171.76	71.09	$2,000.00	$142,171.76
Col. Line 2	142171.76	71.09	$2,000.00	$142,171.76
Truss Elevation A	47839.93	23.92	$2,200.00	$52,623.93
Truss Elevation B	50478.00	25.24	$2,200.00	$55,525.80
Truss Elevation C	48181.93	24.09	$2,200.00	$53,000.13
Truss Elevation D	49425.36	24.71	$2,200.00	$54,367.89
Truss Elevation E	47839.93	23.92	$2,200.00	$52,623.93
Truss Elevation F	49059.16	24.53	$2,200.00	$53,965.07
Truss Elevation G	48181.93	24.09	$2,200.00	$53,000.13
Truss Elevation H	47421.16	23.71	$2,200.00	$52,163.27
				$1,015,323.08

Comparing the total costs of the two structural systems shows that the staggered truss system is $89,966.43 less expensive than the existing system.

Another benefit of the staggered truss system is the time schedule for erection. Both designs are efficient in the length of erection time because of the use of precast plank floors. While the lead time may be slightly longer because of the prefabrication of the trusses, the erection time in the field is shortened. The lead time is also not a huge factor because of lead time needed for the precast plank as well. In the existing system, the braced frames will be installed in the field, while the trusses, which replace the bracing, are installed in one piece. Also, there are fewer columns and beams to erect in the staggered truss system because of the elimination of interior columns and beams.

Considering the cost and schedule savings, as well as the feasibility of the staggered truss system and benefits of the free floor plan on the first floor, I recommend this system as an alternative to the existing steel frame structure. While other factors may need to be considered such as additional cost due to prefabrication of the steel trusses in relation to the proximity of the site, these do not seem to be large enough to outweigh the benefits.