1/11/2010

THESIS PROPOSAL

FAIRFIELD INN & SUITES, MARRIOT PITTSBURGH, PA

Amanda Smith | Advisor: Dr. Ali Memari Structural Option

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EXECUTIVE SUMMARY

The Fairfield Inn and Suites is located on an approximately 8,616 ft^2 parcel of land located on Federal Street directly across from PNC Park in Pittsburgh. The footprint of the building is 93'-7" by 85'-10" and the building has an overall height of 124'-8" from the basement to the top of the penthouse roof structure. The lobby has an 18'-0" floor to ceiling height. While, the typical floor to ceiling height for the rest of the building is 9'-4". The spans are 26'-0" and 31'-0". A total of 136 guest rooms are contained within this building and the plans vary according to type of guest room. The hotel is a 10 story, 78,803 gross ft^2 building with an indoor pool on the main level.

After reviewing the existing conditions, through examination of alternate flooring systems and verifying the current lateral system, it was determined that the structural system meets architectural, strength, and serviceability requirements. The current site of the hotel was chosen by the owner because its location being directly next to PNC Park and within walking distance to Heinz Field, the new Pittsburgh casino, and downtown Pittsburgh being a prime location. For these reasons, the hotel will be kept on the existing site.

This thesis proposal outlines steps that will be taken in order to optimize the existing structural system for the Fairfield Inn and Suites. For the structural depth, the framing system will be redesigned using steel framing members as opposed to the current concrete masonry shear walls. The lateral system will then consist of the core shear walls surrounding the staircases and the strength serviceability of the system will be checked. The hollow core plank floor will remain as the floor system and will now sit on non-composite steel beams, with the current spans. The exterior shear walls will in turn be replaced by non-load bearing walls or a curtain wall system due to the steel framing along the exterior perimeter of the building. The foundation will be checked under the new steel framing system.

An architectural breadth topic will be investigated due to the introduction of the steel framing exterior perimeter and interior beams. The steel may have an effect on the current layout of the building. Without the use of exterior load bearing shear walls, a curtain wall system could be introduced accentuating the façade of the hotel and allow more light into guest rooms, as well as open up the lobby space in addition to its 18' ceiling. A construction management breadth topic will be studied as well. The use of steel framing members will alter the construction schedule and cost of building.

Within this proposal, a complete preliminary breakdown of the tasks that will be performed in order to ensure the proposed alternative design is properly analyzed and accomplished throughout next semester.

INTRODUCTION: Fairfield Inn & Suites

Fairfield Inn and Suites is a 10-story hotel. The hotel is located in the heart of Pittsburgh within walking distance to downtown Pittsburgh, Heinz Field (football stadium), the new Rivers casino, plus many other Pittsburgh attractions. The hotel's closest attraction, directly across the street, is the Pittsburgh Pirates baseball stadium, PNC Park. Being in such a prime location, this hotel with accommodate thousands of guests visiting the area throughout the year making it an essential addition to the community.

The hotel occupies 135 guest rooms in addition to an indoor pool and fitness center for its guests. There will be a variety of typical king/queen size rooms to king/queen suites to satisfy the needs of all guests. Guests to the hotel will enter into an 18' lobby off of Federal St. where the main entrance exists. The lobby consists of a large reception desk for check-in/out, a breakfast area, and a large seating area featuring a cherry finished wood fireplace. The hotel holds a basement below grade that consists of the electrical, mechanical, and maintenance rooms, along with the laundry room and break room for employees.

The façade of the building is similar for all views. Cast-stone decorates the exterior levels one thru four. Brick veneer than extends to the roof of the building. As one approaches the 18' lobby entrance a glass curtain wall system surrounds the entrance doors and extends above the entrance two stories adding verticality to the building. The entrance is then emphasized by a large steel supported, tempered glass awning shading the lobby. On street level, the lobby is lined by additional high glass windows also shaded with smaller glass awnings. From the highway that passes the buildings north façade, one will notice the hotel by its large illuminated sign placed inside a 56'x18' bond-face brick detailed rectangle accenting this view.

The structural system for the hotel is primarily hollow-core precast concrete plank floors on load bearing masonry walls, while shear walls resist the lateral forces against building. Steel transfer beams at the second floor transfer the loads of the load bearing walls to columns supporting the 18' lobby. The ground floor is a concrete slab on grade that transfers the gravity loads of the building to a foundation system that is composed of auger cast piles and steel grade beams.

This thesis proposal will suggest an alternative structural system for the Fairfield Inn and Suites. It will compare all existing features of the structural system of the building with possible more efficient and effective structural system for the hotel. A breakdown of how the analysis of a new structural system for the building will be conducted to create an efficient timeline of completing the proposed solution.

STRUCTURAL SYSTEM

Foundation

A geotechnical soils report was conducted for the Fairfield Inn and Suites site on November 27, 2007 by Construction Engineering Consultants. In the study, it was found that the typical soil found on site is brown silt, clay, and sand. The reported water level was approximately 25'-0" on site. The depth of the basement is 12'-8" below grade, therefore there should not be a concern regarding the uplift pressures on the foundation due to the water level. Due to the moderate depth to bedrock and precaution taken in regards to water level, the deep foundation system consists of auger cast friction piles and grade beams. With the foundation not extending below 33 ft., the net allowable bearing pressure on site is 200 psf.

The ground floor rest on a 6" concrete slab which is 5 ksi normal weight concrete (NWC). The slab increases in thickness from 6" to 12" within the core shear walls where the elevator pit and area well are located. The slab reinforcement consists of W/ 6x6-W1.2xW1.2 welded wire fabric and #5 bars located 12" o.c. top and bottom and each way. The slab depth is approximately 12'-8" below grade, while the elevator pit extends to 17'-5" below grade.

The piles extend 12'-8" deep below grade and are spaced approximately between 26' to 31' apart (refer to Appendix A). The typical size of the pile caps is a 7'-6" square approximately 4' deep with four 16" diameter piles per cap. The core shear walls incasing the stairs and elevator have additional rectangular pile caps and piles for more support. Pile caps are reinforced with #8 bars at 6" o.c. The typical column piers extending from the pile caps are composite 24"x24" columns with horizontal ties and vertical bar reinforcement. (See Figure 1.1)

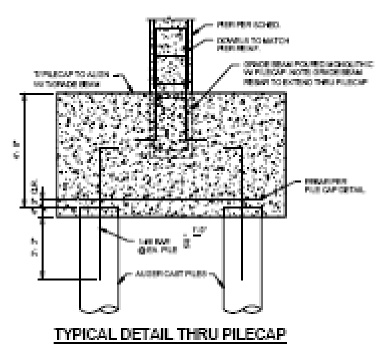

Figure 1.1

Grade beams run between pile caps transferring the loads from the façade of exterior shear walls, and interior shear walls to the foundation (refer to Figure 1.2). Depth of beams ranges between 36" and 48" depending on location. Reinforcement and size varies per grade beam.

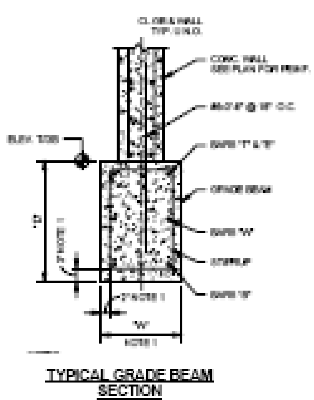

Figure 1.2

Floor System

Fairfield Inn and Suites typical floor system is a precast concrete plank floor with a thickness of 8" untopped. The hollow core concrete plank floor allows for the building to be supported without the use of columns on floors two thru ten and longer plank spans. Concrete compressive strength for floors is f'c=5000 psi. The typical span of the precast plank floors are 31'-0" and 26'-0". The floor system is supported by load bearing concrete masonry walls.

The floor system for the first floor is a combination between 4" slab on grade and the 8" precast concrete plank floor. There is no basement below the first floor running along the south wall and the entrance on the west wall of the building (see Figure 2.1). Due to a pool being located in this area, the hollow core of the typical plank floor would not be sufficient in supporting the weight of the pool and lobby live loads. Therefore, the floor system is a 4" slab on grade with W/6x6-W1.4xW1.4 weld wire fabric reinforcement.

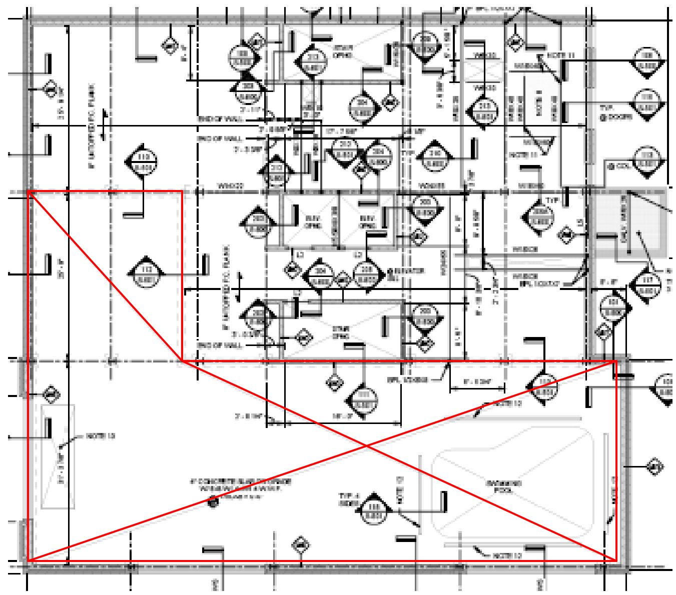

Figure 2.1: Partial First Floor Slab

Since the floor system is a precast plank floor, there are a limited number of steel beams girders throughout the structure. These transfer beams range in size from W 33x118 to W 40X149.With no columns to support floors two thru ten, the majority of the beams present are transfer beams on the second floor that transfer loads from the floors above to the columns extending from the pile caps and thus transferring all loads to the foundation system. The transfer beams run along the back of the elevator shafts from the west wall to the east wall, and along the back of south wall of stair B extending from the west wall to the east wall (see Figure 2.2). Transfer beams range in size from W 33x118 to W 40x149. Girders run along the first floor supporting mechanical equipment loads and tying into the beams and shear walls supporting the first floor. Girders and beams throughout the building are non-composite systems.

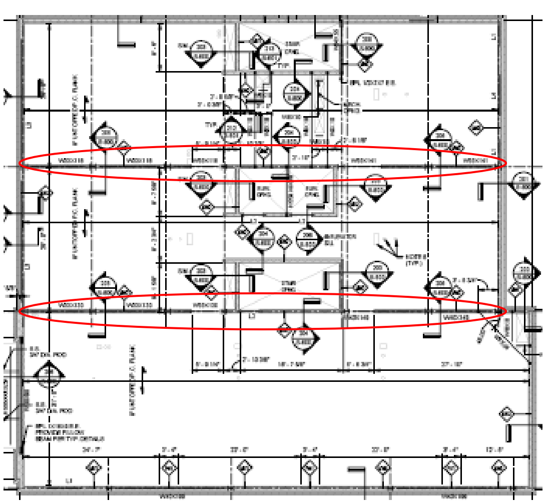

Figure 2.2: Second Floor Transfer Beams

The roof system and smaller high roof system are the same use the same 8" untopped precast concrete plank floor. W8x28 beams run along the shear walls enclosing the elevator and stair shaft while W8x18's extend outward from the corners of the shear walls enclosing the shaft. Hoist beams support the top of the elevator shaft in high roof system. There are a total of six drains located on the roof for the drainage system. (Refer to Appendix A)

Columns

The only columns used in the Fairfield Inn and Suites are the ones extending from the pile caps to the second floor supporting the 18' first floor. The columns range in size from W10x100's to W 12x120's depending on location. All columns connect into the pile caps where the weight each column supports transfers the load down to the foundation (refer to Figure 3.1). The base plates are ½" thick and typically 14"x14". Each plate utilizes a standard 4 bolt connection using 1" A325 bolts.

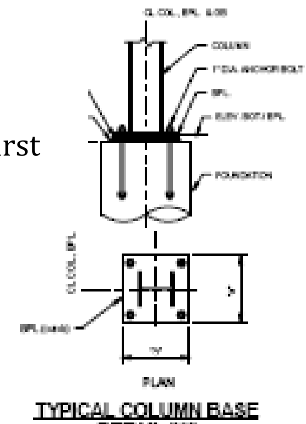

Figure 3.1

Lateral System

The lateral system for the Fairfield Inn and Suites is a combination of ordinary reinforced concrete masonry shear walls. The exterior shear walls are 10" concrete masonry and the core shear walls are 8" concrete masonry. The core shear walls surround the staircases and elevator shaft. On floors two thru ten, two additional load bearing masonry walls extend from the west wall to the east wall running along the south wall of staircase B and the north wall of the elevator shafts (see Figure 4.1). Elevations of each of these shear walls can be found in Appendix B.

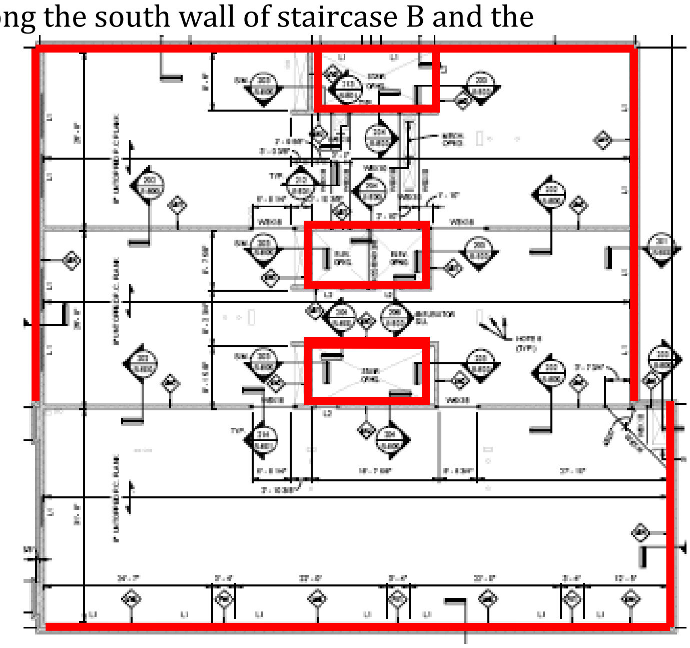

Figure 4.1: Lateral Shear Wall System

Shear walls supporting the ground floor to the fourth floor support a compressive strength of f'c=8000 psi. All other shear walls support a compressive strength of f'c=5000 psi. The typical vertical reinforcement in both the 10" and 8" shear walls is #5 bars at 16" o.c., 24" o.c., or 32" o.c. with bars centered in wall and solid grout wall.

With the majority of the exterior walls being shear walls, the center of rigidity stays pretty central between the East and West walls. Due to the core shear walls not be centered in the building, the center of rigidity shifts slightly north. When the center of rigidity is not in line with the resultant lateral force, eccentricity and moments due to torsion become a factor.

Load Path of Existing Lateral System

The wind and seismic loads that act against the building need a way of traveling through the structure into the foundation, ultimately reaching the ground. This load path is assumed to be governed by the concept of relative stiffness. The members that are most rigid in a building draw the forces to them. As the lateral forces come in contact with the building, the loads are transmitted through the rigid diaphragms, to the shear walls, and then down into the mat foundation. (See Figure 5.1) The shear walls that have minimal assistance from the slabs resist the majority of the lateral forces. The columns on the first level only transmit the gravity loads from the transfer beams that hold the weight of the floors above.

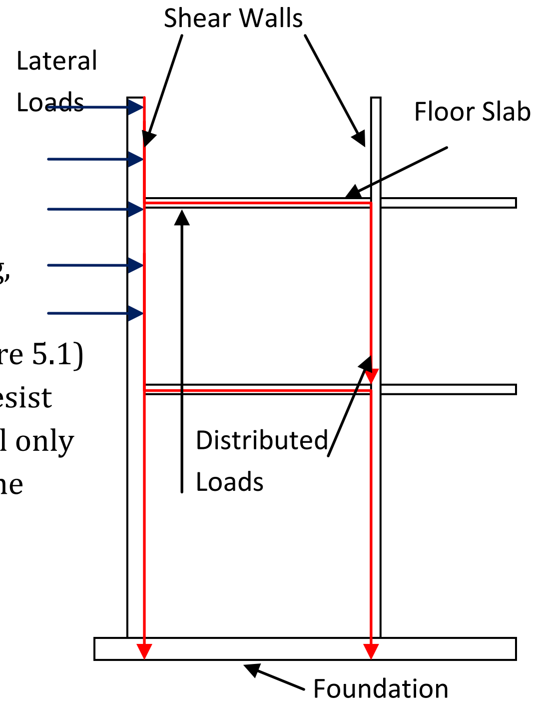

Figure 5.1 – Load path diagram

Building Design Summary

BUILDING DESIGN BREAKDOWN				
Building site = 8616 ft^2				
Floor	**Gross Area (ft^2)**	**Total Guest Rooms**	**Floor Height (ft.)**	**Slab Thickness (in.)**
Basement	3915	0	12.0	6
1	7735	0	18.0	8 / 4
2	7739	15	9.33	8
3	7739	15	9.33	8
4	7739	15	9.33	8
5	7739	15	9.33	8
6	7739	15	9.33	8
7	7739	15	9.33	8
8	7739	15	9.33	8
9	7739	15	9.33	8
10	7739	15	9.33	8
Roof	7739	-	-	8

PROBLEM STATEMENT

Upon completion of studying the structural system with respect to gravity and lateral loads, it was determined that the existing structural system meets architectural, strength, and serviceability requirements for the Fairfield Inn and Suites. The lateral shear walls and plank floor system is the most efficient design on several levels. The nature of this site has a significant impact on the structural design of the building.

Based on the field and laboratory test data within the geotechnical report for the site, it was determined that the soil on site is poor and classified as soil class D. This significantly impacted the base shear value, leading to a seismically controlled building even when torsion effects were considered. The design of the foundation system for the building was designed to best fit this criterion and support the building in this soil class. The possibility of increased loads and other implications resulting from the implementation of any new system, will require checks to be done at the foundation to verify it is sufficient to withstand changes or if alterations must be made if at all feasible.

In Technical Assignment 1, the design of the framing members, floor system, and lateral system all exceeded the design requirements as per ASCE 07. In Technical Assignment 2, it was confirmed that the existing hollow core plank floor system proved to be the most efficient and effective of the four floor systems analyzed. Technical Assignment 3 proved that the lateral force resisting system in the Fairfield Inn and Suites was sufficient to carry the controlling lateral loads that act upon the structure. The design of the building meets all code requirements concerning physical restrictions on the building due to its location and zoning. Therefore, when considering an alternative design to this building, the final decision may not prove to be more effective compared to the existing design. However, a further investigation of other options to the building design should be considered. A redesign of the structural system of the existing Fairfield Inn and Suites will be designed in an attempt to find an equally effective and efficient building system.

To determine whether a different system is equally efficient and effective, it will be compared to the existing system in a number of categories. The comparison categories will include code limitations, building standards, performance, cost effective, ease of constructability, construction schedule and material availability. This proposal will research an alternate system that could be a more viable solution than the existing system according to its comparisons.

PROPOSED SOLUTION

Theme: Use of steel framing design and optimized lateral system

Structural Depth: New Framing System Design

The current site of the Fairfield Inn and Suites was chosen by the owner because its location being directly next to PNC Park and within walking distance to Heinz Field, the new Pittsburgh casino, and downtown Pittsburgh making it very attractive to visitors of the city of Pittsburgh to want to stay in this hotel while visiting, as it is in a prime location. For these reasons, the hotel will be kept on the existing site.

Due to the nature of the soil, steel may be the best viable solution for the design of the structural system. Concrete is a heavier material by nature, therefore the steel could only decrease the weight of the building, creating a lighter base shear value. As a result, a viable alternative structural system for the Fairfield Inn and Suites is altering the framing to an entire steel frame. This consequently will affect the footings and construction management issues like schedule and cost. The architecture of the building could also be impacted without the exterior shear walls present. In addition, since the controlling lateral load case is seismic, changing the building frame to steel may reduce those loads due to stiffness.

With a steel framing system, an alteration to lateral force resisting system and gravity resisting system will be considered. The current hollow core plank floor system will remain as it proved to be the best floor system solution. The plank floor system will sit on steel non-composite girders rather than the existing load bearing masonry walls. The load bearing masonry walls will be eliminated from the structural design. The shear walls will only remain in the core of the building surrounding the staircases and elevator shaft. And will make up the lateral force resisting system. The steel moment frames will resist the gravity loads placed on the building. The purpose of making these alterations to the structure is simply to investigate the overall affects they have on the project, whether the results a positive or negative.

All relative structural elements of the building will have to be considered throughout this alternate design. Since the redesign incorporates a different primary material for the building, steel, the existing columns and transfer beams will be altered. The floor spans and location of the floor framing members will remain unchanged. The location of the interior load bearing masonry walls will be replaced by steel columns and non-composite moment frames. Instead of steel columns extending from the auger cast piles to the second floor transfer beams, they will now extend to the roof of the building. This will ultimately eliminate the use of transfer beams at the second floor.

The design results of this alternate system will be thoroughly compared with the design of the existing system in hopes that this design proves to be a more efficient and effective alternate design solution.

SOLUTION METHOD

The gravity loads will be defined according to ASCE 7-05 and applied to the overall structure. Column load take downs will be required to determine the forces that will be applied to each auger cast pile in the foundation. Once new members are defined for each location, the updated building weight will be calculated. All aspects of the steel design will be based on the Manual of Steel Construction. The lateral loads will be in accordance with ASCE 7-05. Hand calculations will be computed using ACI 318-08 with the assumption that the shear walls withstand 100% of the lateral loads. The alternate shear wall layout will be compared to the original shear wall layout to determine if the modifications increased the shear capacity of the walls.

The design software ETABS was used in the analysis of the lateral system for the Fairfield Inn and Suites in Technical Assignment 3. The program was a very good method for analysis at that point in the thesis study. As for the alternate design of the structural system, the primary means of computer design for this study will be Staad.Pro. A model of the Fairfield Inn and Suites alternative design will be created in Staad and all steel structural members will be sized according to the calculated loads that will be applied to the structure. The design and analysis performed through the use of Staad will include both gravity and lateral loads applied to the structure. An ETABS model of the proposed lateral system will also be modeled to compare results of the ETABS model with the original lateral system.

After obtaining the values of the loads transmitted through the gravity system and the lateral system, hand calculations will be done to verify if the existing foundation is able to withstand the forces due to bearing, overturning, shear, and torsion. Supporting calculations and suggestions will be made if a change to the foundation is required.

BREADTH STUDIES

In addition to the structural depth study, two additional breadth topics are required in an area outside of the structural engineering requirements. The first study to be considered is an investigation of the facade of the alternate design. The second study will be an involved investigation of the construction management issues.

Breadth Study I: Architectural Investigation

Due to the proposed alternate structural design of the building, an investigation of the impact this design has on the architecture of the building will be performed. Converting the building system from all concrete to steel may alter the architectural features of the hotel. Research will be done in regards to the impact the current architecture has on the building and how a new architectural system can improve the layout and look of the building. The use of steel, as opposed to the load bearing masonry shear walls used along the exterior, will affect the exterior façade of the building. With the use of steel, this could allow the building to make use of either a curtain wall system that provides natural day lighting into the hotel, or non-load bearing shear walls. To provide more natural day lighting to the 18 foot lobby of the hotel, the curtain wall system could be utilized along this entire level. The curtain wall system could be continued up the façade of the building or removed and the concrete masonry façade will continue up the entire height of the building. Heat loss calculations will be provided for the existing concrete masonry shear wall system and for the new exterior façade system. Conclusions will then be drawn on which system is more efficient for the Fairfield Inn and Suites.

Breadth Study II: Construction Management

Due to the proposed alternate design of the Fairfield Inn and Suites, the primary material used will now be steel. Two issues that will now be targeted are project cost and construction schedule due to the impact the steel material will have on the construction process of the building. These issues will be compared for both the existing and proposed alternative building system. The cost estimate will be influenced by the construction schedule, material availability, construction financing, and the project deadline. Conclusions will then be drawn based on viability of the new structural system with respect to cost and time efficient constructability.

TASKS AND TOOLS

I. *Structural Depth*

A. Steel Framing
    1. Task 1: Determine the loads applied to the steel members
        a. Determine dead loads and live loads in accordance with ASCE 7-05
        b. Apply correct loads to each level and determine distribution to each column using tributary areas
        c. Perform a load take down on all columns
    2. Task 2: Build Model in Staad to design new steel structure
        a. Set up existing column grids (since building geometry will be unchanged)
        b. Add columns in locations identified from new structural design
        c. Add steel moment frames at every column lines A,B,C,&D
        d. Input loads from Task A-1 and B-1
        e. Determine steel member sizes
    3. Task 3: Perform hand calculation on steel members
        a. Do spot checks on select members
        b. Verify the floor system is still adequately designed
        c. Verify the hand calculations with computer tabulated results

B. Lateral System
    1. Task 4: Determine lateral loads to be applied to lateral force resisting system
        a. Recalculate the overall building weight with the addition of the steel framing system
        b. Verify the wind loads determined using ASCE 7-05
        c. Recalculate the seismic forces with the updated building weight
    2. Task 5: Perform optimization study
        a. Assuming 100% of lateral load resisted by shear walls, perform hand calculations to analyze shear walls
        b. Use ETABS to model original lateral system model
        c. Use ETABS to model the modified shear walls
        d. Compare the results to determine if modifications provided significant improvement of the shear resistance of the building

C. Foundation
    1. Task 6: Verify existing foundation can adequately carry all loads due to proposed design
        a. Hand calculate loads applied to foundation due to shear and torsion
        b. Determine if overturning moment creates uplift in building

II. Breadth Study I: Architectural Investigation

A. Task 7: Research the existing architecture
    4. Compare the architecture of the building to the surrounding buildings and typical architecture of the area
    5. Determine if new structural system has impact on layout of building
    6. Research the impact a façade change may have on the building

B. Task 8: Implement Façade Change
    1. Review details of existing concrete masonry façade on building
    2. Model building to show curtain wall extending up the building

C. Task 9: Prepare Heat Loss Comparison
    1. Calculate the temperature change across the existing concrete masonry system
    2. Calculate the temperature change across the curtain wall system
    3. Draw conclusions on which system would provide more comfort to hotel guests

III. Breadth Study II: Construction Management

A. Task 10: Determine the cost & schedule of the existing structural system
    1. Inquire to CM about any actual cost data or scheduling information that may be available
    2. Determine any cost data that was unavailable per RS Means
    3. Create a mock schedule of construction implementing the existing structural system

B. Task 11: Determine the cost and schedule of the proposed structural system
    1. Determine actual cost data for steel erection and scheduling information
    2. Determine labor and material costs per RS Means
    3. Create a mock schedule of construction implementing the proposed structural system

C. Task 12: Comparison of Existing vs. Proposed System
    1. Compare cost information of the two lateral systems obtained in Tasks A and B
    2. Compare schedules and total time of construction obtained in Tasks A and B and determine advantages and disadvantages
    3. Determine which system is more feasible with respect to constructability

IV. Presentation

A. Task 13: Prepare presentation
    1. Powerpoint presentation
    2. Final Report
    3. Updating CPEP site with any final information

TIMELINE

TASK		WEEK							
		Jan. 11 - 15	**Jan. 18 - 22**	**Jan. 25 - 29**	**Feb. 1 - 5**	**Feb. 8 - 12**	**Feb. 15 - 19**	**Feb. 22 - 26**	**Mar. 1 - 5**
1	Determine loads applied to steel members								
2	Build Model in Staad								
3	Perform hand calculations on steel members								
4	Determine lateral loads to be applied								
5	Perform optimization study								
6	Verify existing foundation can carry proposed design loads								
7	Research architecture								
8	Implement façade change								
9	Prepare heat loss calculation								
10	Determine cost and schedule of existing system								
11	Determine cost and schedule of proposed system								
12	Comparison of existing system vs. proposed system								
13	Prepare presentation								

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29 - 2</th><th>Apr.
5 - 9</th><th>Apr.
12 - 16</th></tr>
<tr><td>1</td><td>Determine loads applied to steel members</td><td rowspan="13">Spring Break</td><td></td><td></td><td></td><td></td><td rowspan="13">Presentations</td></tr>
<tr><td>2</td><td>Build Model in Staad</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Perform hand calculations on steel members</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Determine lateral loads to be applied</td><td></td><td></td><td></td><td></td></tr>
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<tr><td>8</td><td>Implement façade change</td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Prepare heat loss calculation</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>Determine cost and schedule of existing system</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>Determine cost and schedule of proposed system</td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Comparison of existing system vs. proposed system</td><td></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>Prepare presentation</td><td></td><td></td><td></td><td></td></tr>
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APPENDIX A

Existing Building Layout

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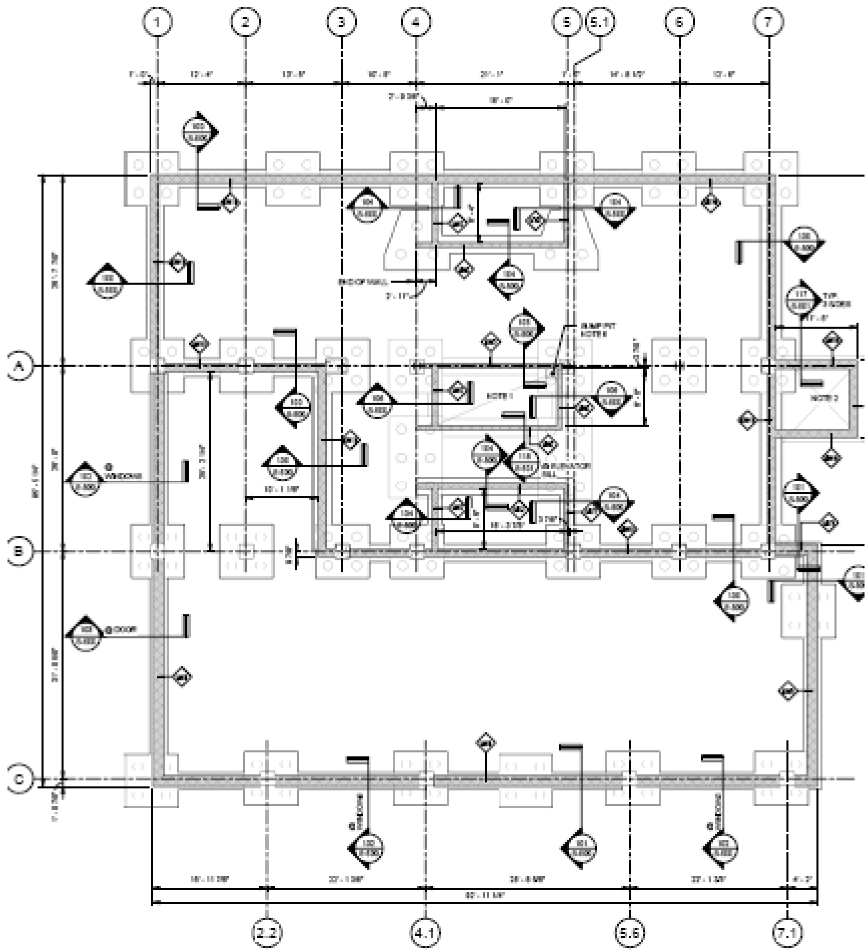
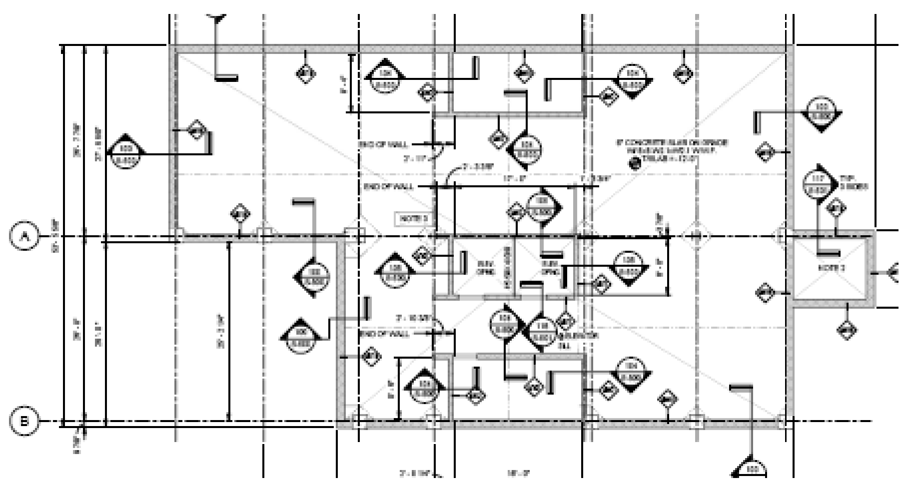
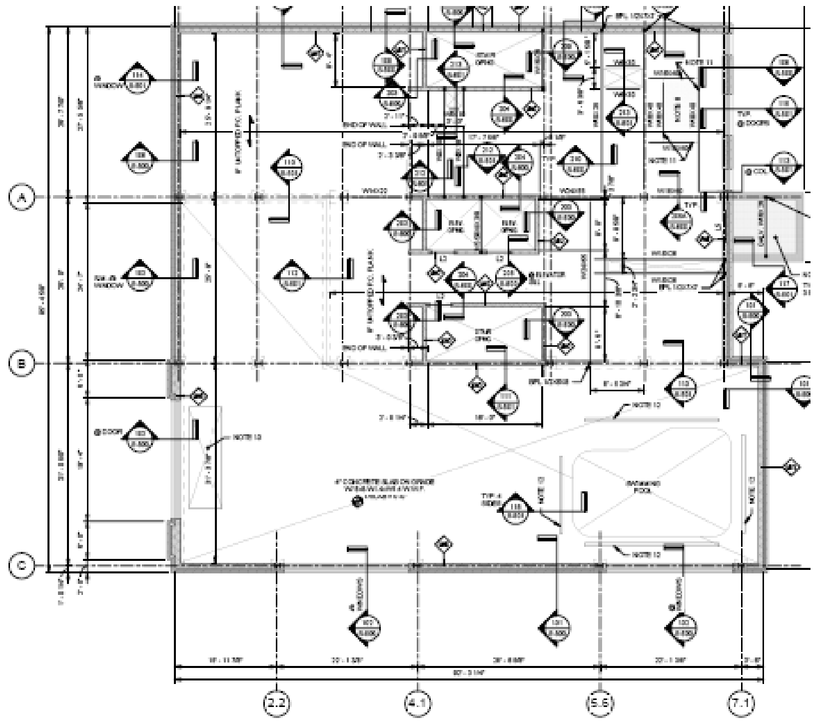


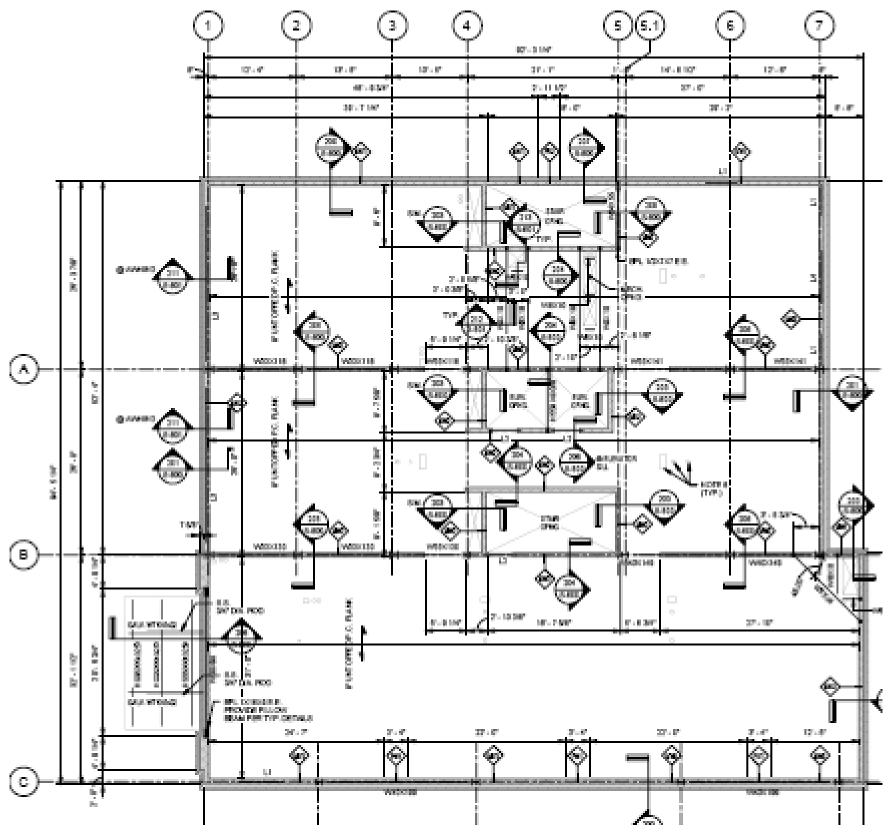
Foundation Plan



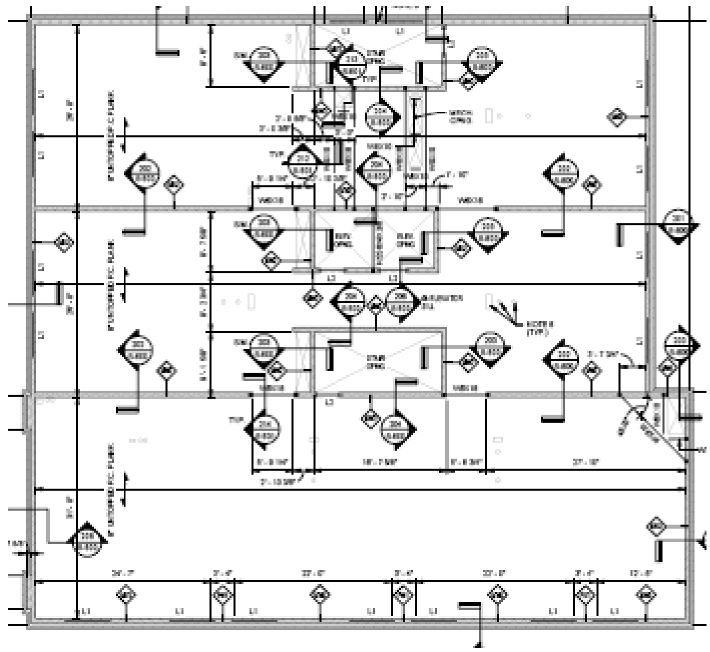
Basement Plan



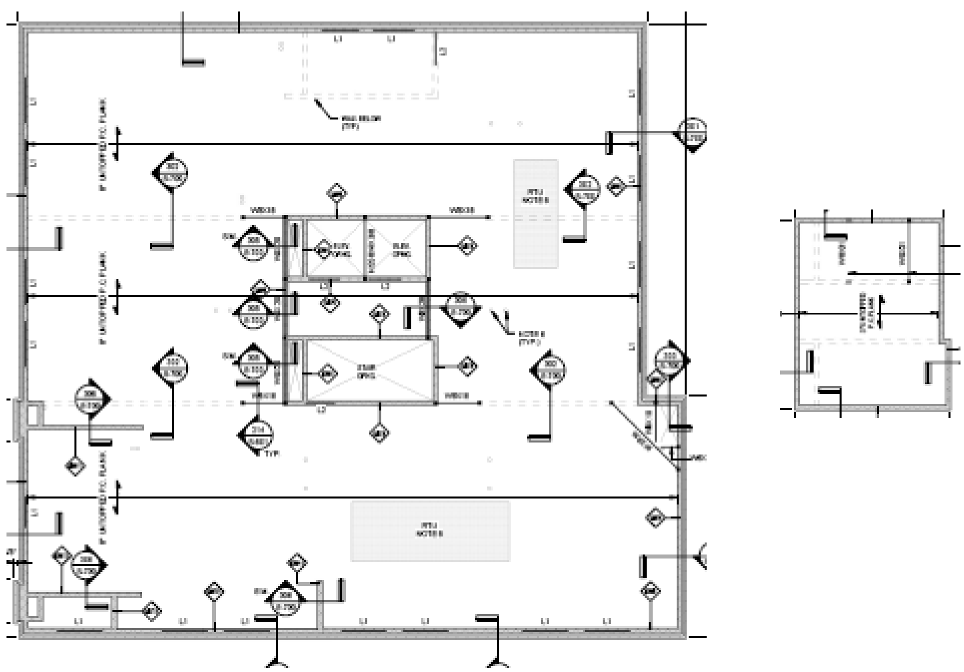
First Floor Framing Plan



Second Floor Framing Plan



Third thru Tenth Floor Framing Plan



Roof/Penthouse Roof Plan