Cambria Suites Hotel

Pittsburgh, PA

Thesis Proposal

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Professor Linda Hanagan
December 10, 2010

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Executive Summary

The following is a proposed study for the redesign of the existing structure of the Cambria Suites Hotel. Cambria Suites Hotel is approximately 120,000 square foot and is 7 levels above grade. The superstructure consists primarily of reinforced concrete masonry walls and precast hollow-core concrete planks, as well as an interior steel frame. Each story height ranges from 10' to 14', topping out at an overall building height of 102'-2". Typical 10" concrete planks with topping vary in span length from 20' to 40'. The lateral force resisting system is comprised of masonry shear walls which are located around the staircases, elevator shafts, and other exterior building locations. The foundation incorporates drilled cast-in-place concrete caissons and grade beams to support the load bearing walls and columns.

After reviewing the existing conditions through the examination of alternate floor systems and verifying the current lateral system, it was determined the structural system meets all standards required by code. For the proposed design, the site location will remain the same as it serves as a popular attraction to visitors of the City of Pittsburgh and the new CONSOL Energy Center.

This thesis proposal thoroughly outlines the entire process of obtaining an optimized building design for the Cambria Suites Hotel. For the structural depth, the current concrete masonry structure will be modified to an all steel frame system which will still incorporate the use of precast concrete plank as the floor system. The lateral system will consist of shear walls which surround the staircases and elevator shaft, with the possible use of braced frames for extra lateral support. The exterior shear walls will be replaced by either a curtain wall system or a structural panel façade. In addition, the existing foundation will be checked for the proposed structural design.

Breadth studies will focus on the architectural, cost, and scheduling impact of the proposed structural design. Due to the steel redesign, an architectural study will be conducted as it may result in minor architectural layout changes. In addition, a new façade will be chosen due to the elimination of the exterior masonry walls. A second breadth will cover construction management issues such as the construction schedule and cost of the building.

To stay organized and to be able to accomplish the proposed design on time, a complete breakdown of the tasks is provided within the proposal.

Introduction: Cambria Suites Hotel

Cambria Suites Hotel is the newest, upscale, contemporary all-suite hotel located at 1320 Center Avenue in Pittsburgh, Pennsylvania. This luxury hotel is built adjacent to the new CONSOL Energy Center, home to the Pittsburgh Penguins hockey team, and numerous concerts and special events. The 142-suite hotel contains a total of 7 levels above grade and was built on a quite challenging site. The hotel will have a variety of room suites, such as the double/queen suite, king suite, one bedroom suite, deluxe tower king suite, and hospitality suite.

The Plaza Floor level will mainly consist of a few bistro-style restaurants which open to an outdoor terrace which will overlook the city of Pittsburgh and the CONSOL Energy Center. At the Hotel Floor level, guests will be greeted by an airy two-story lobby where they can take part in a state-of-the-art fitness center or the relaxing indoor pool and spa. There are also two meeting rooms and a board room for guest use, as well as, a large kitchen/bar off of the lobby entrance. At the North end of the Second Floor level, a steel Porte Cochere will be cantilevered to cover part of the main entrance. In addition, the property will feature an 1800 square foot presidential suite with one of a kind skyline view of downtown Pittsburgh and a 7th floor concierge lounge that will offer a wet bar and lounge space for guests to use and enjoy.

The hotel is fully landscaped and will also have an exclusive 143 space onsite parking garage with access to the CONSOL Energy Center for event patrons staying at the property. The Hotel Floor level will have a precast concrete pedestrian bridge leading to the top level of the parking garage. The bridge is supported by the hotel and the garage. The South end of the bridge will be supported by the garage on slide-bearings to allow for differential lateral movement between the two structures. The exterior of Cambria Suites Hotel is mainly brick and cast-stone veneer, architectural decisions made to resemble the bordering CONSOL Energy Center. A lighter color brick is used from the 2nd-Roof Floor levels, with the addition of a cast-stone band at Floor levels 2 and 7. The darker color brick is used from the 2nd Floor level and below, as well as vertical strips to separate window pairings and to accent building corners.

The thesis proposal will suggest an alternate structural system for the Cambria Suites Hotel. Detailed comparisons will be provided between both the existing and proposed system to determine which system is a more efficient and effective solution for the hotel. A timeline of the tasks performed to complete the proposed solution is provided.

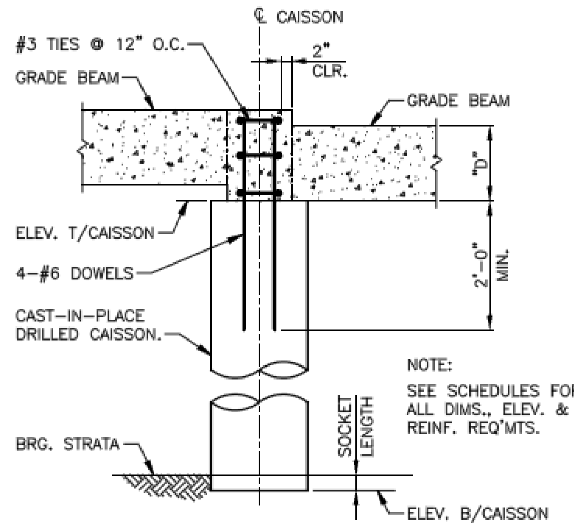
Existing Structural System

Foundation

The geotechnical engineering study for the Cambria Suites Hotel was completed by GeoMechanics Inc. on December 29, 2008. In the study, the site of Cambria Suites Hotel is underlain by sedimentary rocks of the Conemaugh group of rocks of Pennsylvania age. The Conemaugh group is predominantly comprised of clay stones and sandstones interbedded with thin limestone units and thin coal beds. The soil zone conditions consisted of materials of three distinct geologic origins: man-made fill, alluvial deposits, and residual soils. The fill in the hotel test borings was placed in conjunction with the recent demolition and regarding of St. Francis Hospital in order to build Cambria Suites and CONSOL Energy Center. Ground water exists locally as a series of perched water tables located throughout the sol zone and new the upper bedrock surface. Excavations in soils and bedrock can be expected to encounter perched water. The volume of inflow into excavations should be relatively minor, should diminish with time and should be able to be removed by standard pump collection/pumping techniques. The report also states that the most economical deep foundation solution for Cambria Suites included a system of drilled-in, cast-in-place concrete caissons with grade beams spanning between adjacent caissons to support the anticipated column and wall loads of the structure. With varying types of bedrock on site, the allowable end bearing pressure ranges from 8, 16, and 30 KSF. As for the floor slab, GeoMechanics Inc. recommended to place a ground floor slab on a minimum six-inch thick granular base and to provide expansion joints between the ground floor slab and any foundation walls and/or columns. This is done to permit independent movement of the two support systems.

As a result of GeoMechanic's geotechnical study, the foundation of Cambria Suites Hotel incorporates a drilled cast-in-place concrete caissons and grade beams designed to support the load bearing walls and columns. The ground floor is comprised of a 4" concrete slab on grade, as well as, 10" precast concrete plank in the Southern portion of the building. The 4" concrete slab on grade is reinforced with 6x6-W1.4 welded wire fabric and has 4000 PSI normal weight concrete. The slab increases to 8" in thickness with #5 @ 16" O.C. in the South-West corner of the building, and increases to 24" with #5 @ 12" O.C. within the core shear walls where the elevator shaft is located. For the majority of the slab on grade, the slab depth is 14'-0" below finish grade.

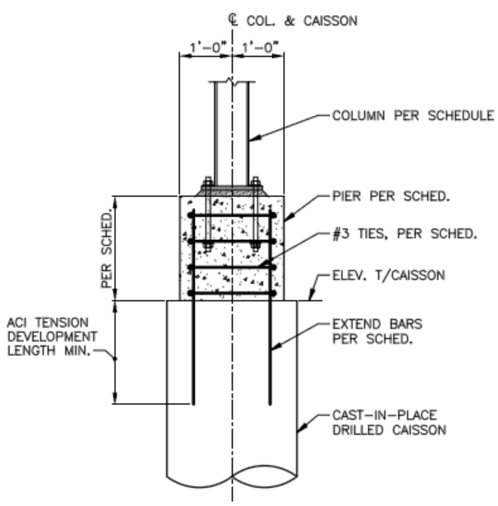
The drilled cast-in-place caissons extend anywhere from 20-30 feet deep below grade and are socketed at least 3' into sound bedrock. Caisson end bearing capacity is 30 KSF (15 ton/SF) on Birmingham Sandstone bedrock. The caissons are designed with a compressive strength of 4000 PSI, range from 30-42 inches in diameter, and are spaced approximately between 15' and 30' apart (refer to Appendix A). Typical caissons terminate at the Plaza level and are tied into a grade beam with #3 ties @ 12" O.C. (horizontal reinforcement) and 4-#6 dowels (vertical reinforcement) embedded at least two feet into the drilled caisson. Where steel columns are located, a pier is poured integrally with the grade beam and reinforced with 8-#8 vertical bars and #3 @ 8" O.C. horizontal ties. (As shown in Figures 1.1 & 1.2)



Typical Caisson & Grade Beam Detail

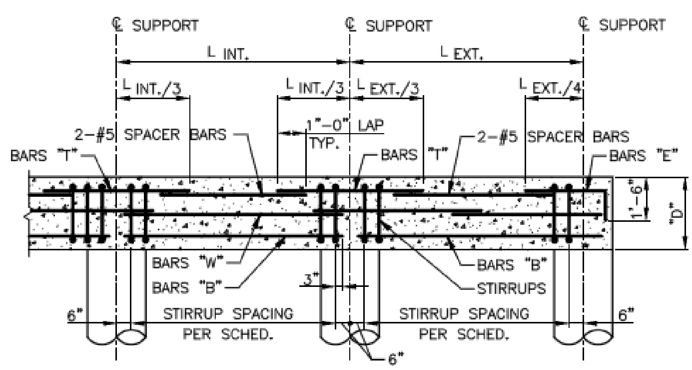
Figure 1.1

The grade beams have a compressive strength of 3000 PSI and range from 30-48 inches in width and 36-48 inches in depth. Each grade beam is reinforced with top and bottom bars which vary according to the size of the beam. Grade beams span between drilled cast-in-place caissons which transfer the loads from bearing walls, shear walls, and columns into the caissons. From the caissons, the loads are then transferred to bedrock. (As shown in Figures 1.1 & 1.3)



Typical Caisson Cap Detail

Figure 1.2



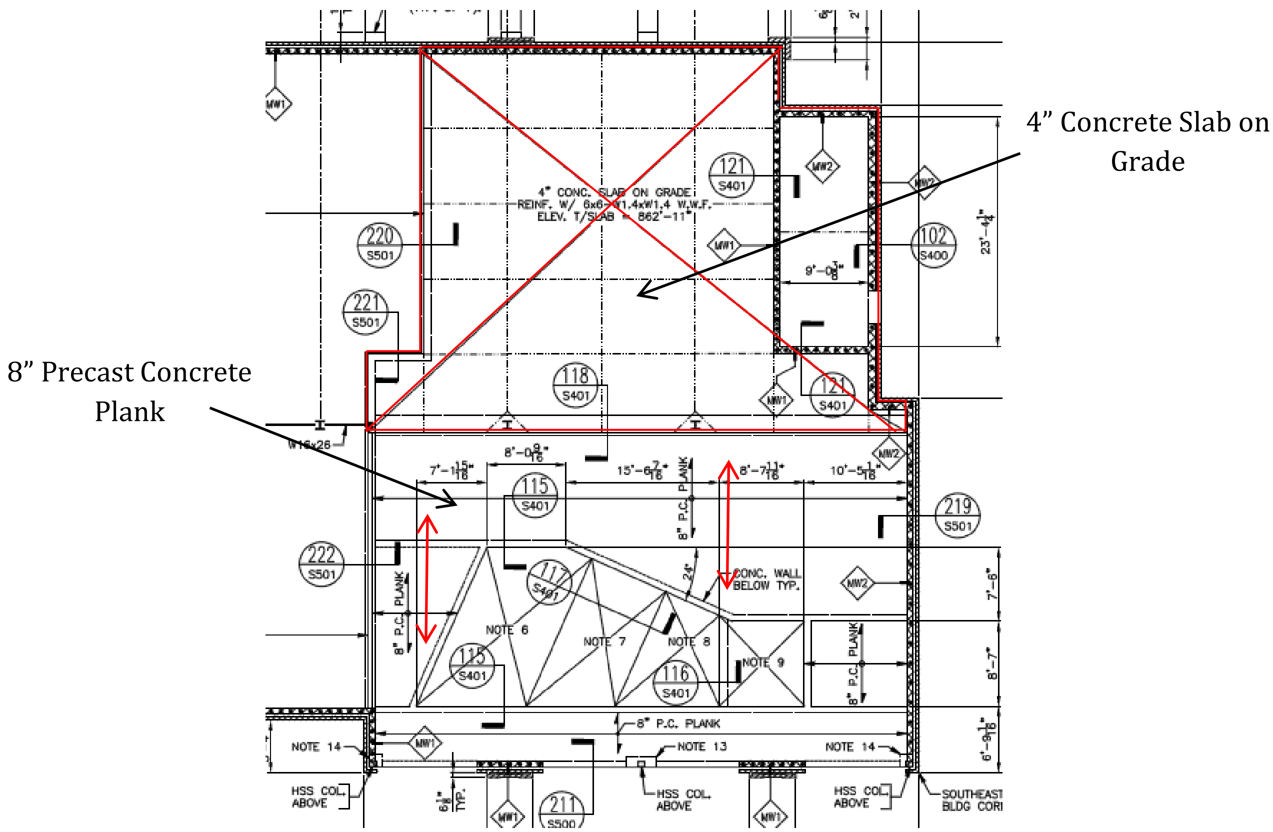
Typical Grade Beam Reinforcing Detail

Figure 1.3

Superstructure System

The typical floor system of Cambria Suites Hotel consists of 10” precast hollow-core concrete plank with 1” leveling topping. The precast plank allowed for quicker erection, longer spans, open interior spaces, and serves as an immediate work deck for other trades. Concrete compressive strength for precast plank floors is 5000 PSI and uses normal weight concrete. The typical spans of the plank floors range from 30’-0” to 40’-0”. The floor system is supported by exterior load bearing concrete masonry walls, as well as, interior steel beams and columns.

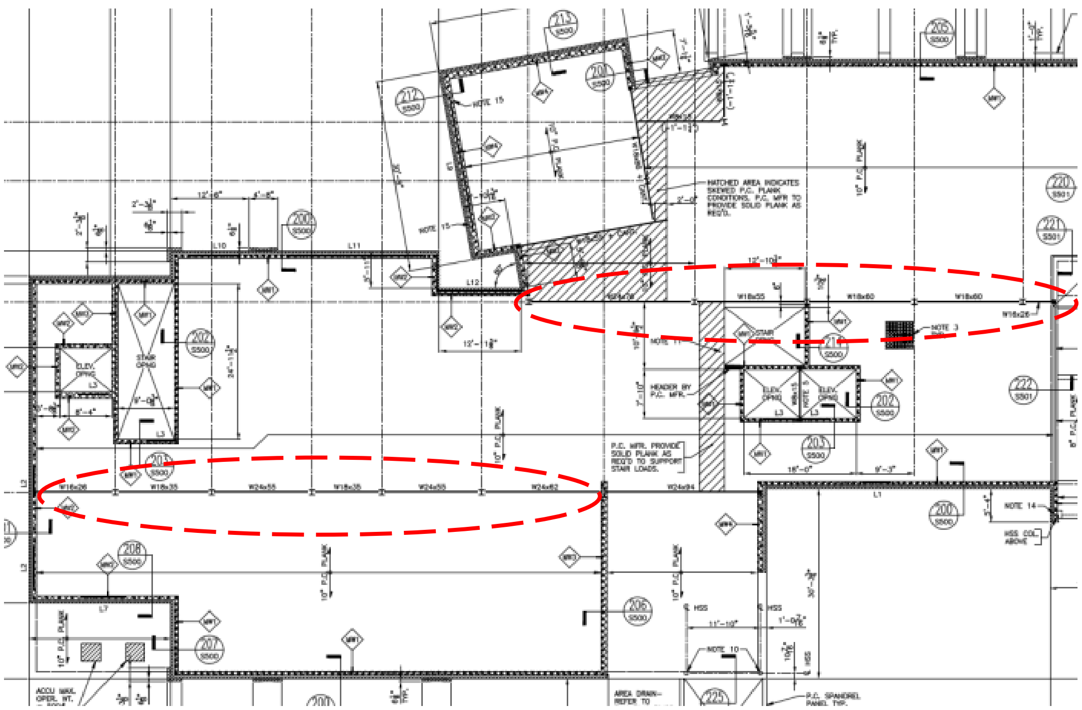
The Plaza level floor system is a combination of 10” precast concrete plank, 8” precast concrete plank and 4” slab on grade. Since there is no basement in the North-East section of the hotel due to the fitness center and pool, the site was excavated properly in order to place the 4” slab on grade and 8” precast concrete plank. The 4” slab on grade will be for the fitness center where as the 8” concrete plank will surround the pool area. (As shown in Figure 2.1)



Partial Hotel Level Floor Slab

Figure 2.1

Since the masonry bearing walls are typically located on the perimeter of the hotel, steel beams and columns were needed thru the center of the building to support the precast concrete plank floors. Steel beam sizes range from W16x26 to W24x94, and steel column sizes range from W8x58 to W18x175. Each column connects into concrete piers within the grade beams via base plates which vary in size. Base plates use either a 4-bolt or 8-bolt connection, typically using 1" A325 anchor bolts which extend 12" or 18" respectively into the concrete pier. The steel beams vary in length from 13'-0" to 19'-0" and typically span in the East-West direction. Exterior bearing masonry walls and the steel beams will take a reaction load from the precast concrete plank flooring, as well as other loads from levels above, which will then transfer thru steel columns and exterior bearing walls and thus transferring all loads to the foundation system. (As shown in Figure 2.2)



Typical Partial Floor Plan

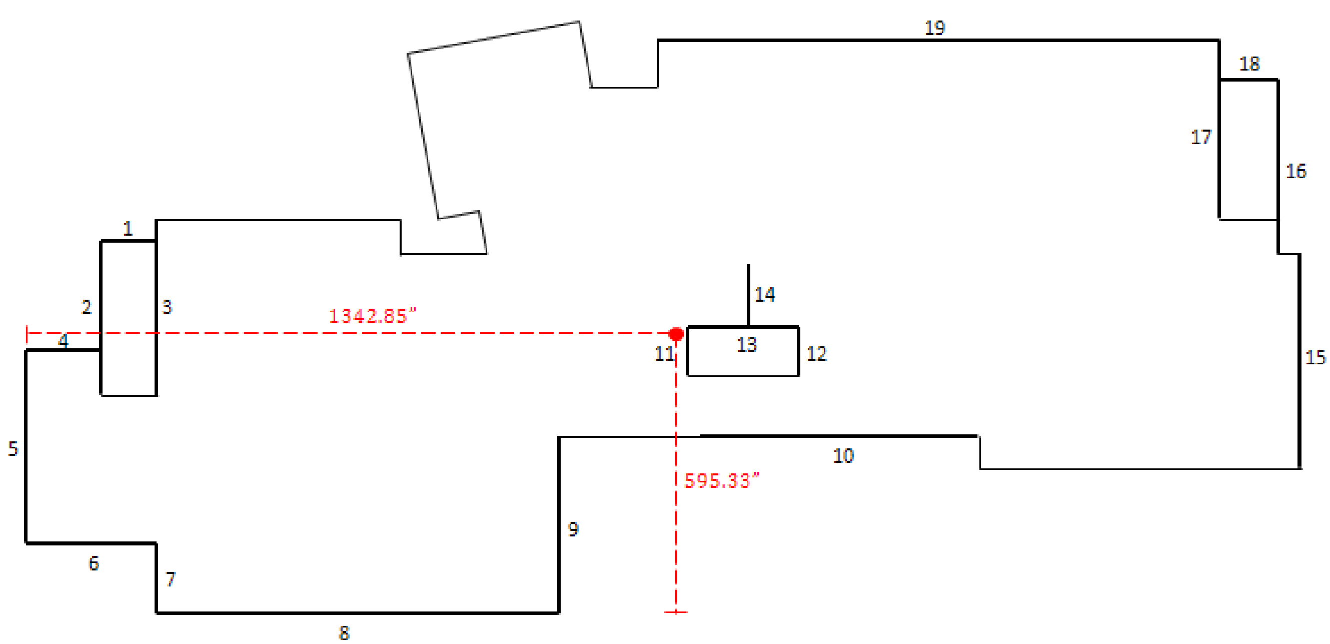
Figure 2.2

The roof structural system at both the Second level and main Roof level uses untopped 10" precast concrete plank. Reinforced concrete masonry extends passed the Roof level to support a light gauge cornice which wraps the entire building. A high roof is constructed for hotel identification purposes and uses 10"-16 GA light gauge roof joists @ 16" O.C., supported by 8"-20 GA light gauge wall framing below. W8x21 hoist beams support the top of the elevator shaft which rest on ½"x7"x7" base plates. There are a total of eight drains located on the roof for the drainage system. (As shown in Appendix A)

Lateral System

The lateral system for the Cambria Suites hotel consists of reinforced concrete masonry shear walls. The exterior shear walls, as well as the core interior shear walls, are constructed of 8" concrete masonry, with the exception of a few 12" concrete masonry walls on the lower floor levels. All shear walls are solid concrete masonry walls which extend the entire height of the structure without openings for windows or doors. The core shear walls are located around the staircases and elevator shafts. The exterior shear walls are scattered around the perimeter of the building. (As shown in Figure 3.1) Shear walls supporting the Plaza level to the Third Floor level have a compressive strength of 2000 PSI. All other shear walls support a compressive strength of 1500 PSI. In addition, all concrete masonry shall be grouted with a minimum compressive strength of 3000 PSI. Typical reinforcement for all shear walls is comprised with #5 bars at either 8" O.C. or 24" O.C.

Wind and seismic loads, as well as gravity loads, are transferred to the foundation by first traveling thru the rigid diaphragm; the precast concrete plank floor system. Loads are then transferred to the concrete masonry shear walls. From there, loads are transferred down to the preceding floor system and/or transferred the entire way to the grade beam foundation, finally travelling thru the concrete caissons which are embedded in bedrock.

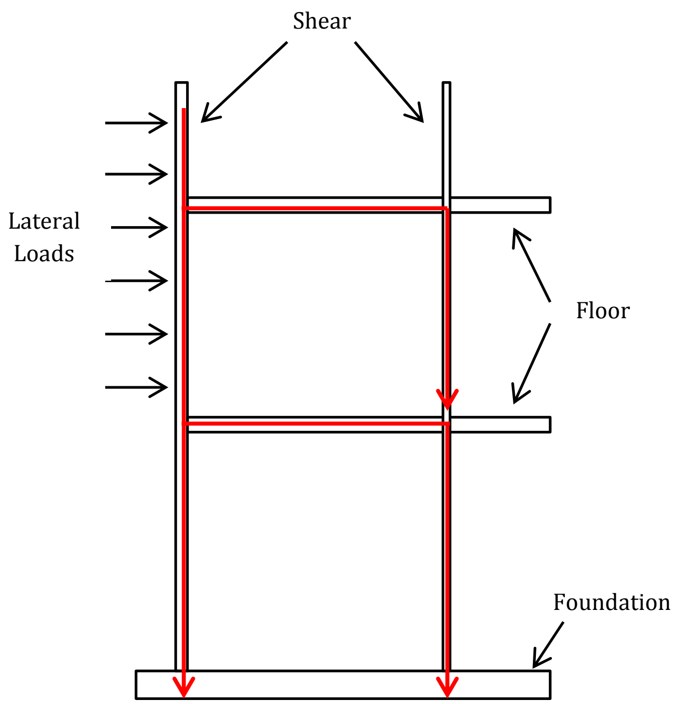


Lateral Shear Wall System
Figure 3.1

Load Distribution

Load Path

Lateral force resisting systems transfer lateral loads (wind and/or seismic) to the building's foundation where the loads dissipate. This load path is assumed to be governed by the concept of relative stiffness, which states that the most rigid members in a building draw the most forces to them. In the case of Cambria Suites Hotel, the lateral forces come in contact with the exterior of the building, are then transmitted through the rigid diaphragms, to the masonry shear walls, and lastly down into the foundation (grade beams and caissons). This load path is shown in Figure 7.1. The exterior shear walls with longer spans resist the majority of the lateral forces because they have minimal assistance from the slab. The steel frame which extends through the middle of the building only transfers gravity loads to the foundation.



<u>Load Path Diagram</u>
Figure 7.1

Problem Statement

Upon the completion of analyzing the gravity and lateral force resisting systems present in the Cambria Suites Hotel, it is clear that the existing structural system chosen by the design team is currently the most efficient possible. It was also determined that the structural system meets all architectural, strength, and serviceability requirements governed by code. The gravity system, consisting of concrete masonry walls and an interior steel frame, were sufficiently designed to support the precast concrete planks. In addition, the current concrete shear walls were also efficient in keeping a minimal building deflection and resisting the torsional affects.

In Technical Assignment 1, the design of all the structural components of Cambria Suites Hotel were analyzed and determined to exceed the design requirements according to ASCE 7-05. In Technical Assignment 2, three alternate floor systems were compared to the existing system and ultimately determined that the existing precast concrete plank floor system proved to be the most efficient and effective. In Technical Assignment 3, an in-depth analysis of the existing lateral force resisting system was performed. It was confirmed that the lateral system was sufficient to carry the controlling lateral loads that were present on the structure. After evaluating all Technical Assignments, it is clear that the design of the Cambria Suites Hotel meets all code requirements with respect to its location and zoning. With the excellent performance of the current system, it will be difficult to find a comparable system which will replace the existing system. Therefore, when considering an alternative system design, the final design may not prove to be more efficient and/or effective compared to the existing system. That being said, a redesign of Cambria Suite's structural system will be designed in an attempt to find an equally effective and efficient building system.

In regards of the foundation system, it was verified that the existing design for the building was sufficient to transfer all loads for the specified soil class. However, the possibility of increased loads and other effects due to the proposed redesign will require foundation checks to verify it is sufficient for these changes.

To determine whether a different building system is equally effective or efficient, it will be compared to the existing system in various categories. These categories will include code limitations, building performance, cost effectiveness, constructability, construction schedule, and material availability. The following proposal will explore an alternate system which may result in a more practical solution to the Cambria Suites existing structural system.

Proposed Solution

Structural Depth: New Framing System Design

The current site of the Cambria Suites Hotel is located adjacent to the new CONSOL Energy Center and within walking distance to other attractions in downtown Pittsburgh. This prime location attracts several visitors on a regular basis due to the CONSOL Energy Center, home to the Pittsburgh Penguins, and numerous concerts and special events. Therefore, the hotel will remain in its existing location for the practice of this assignment.

The existing concrete masonry wall structure is a heavier system by nature, whereas steel could result in a decreased building weight, creating a lower base shear. As a result, a feasible alternative structural system for the Cambria Suites Hotel would be steel framing. This change will initially affect the foundation and construction management issues like cost and schedule, as well as architectural features such as the building façade due to the removal of exterior masonry walls.

With the modification to a steel framing system, the lateral force and gravity resisting systems will have to be considered as well. The current floor system comprised of hollow-core concrete planks will remain, but will be integrated as a girder-slab system using specially designed D-Beams. This innovative D-Beam girder was designed to allow the precast slab to set in on its bottom flange concealing its top flange and web. Once the slabs are set, grout is easily placed flowing around the D-Beam and through its trapezoidal shape web openings and into the slab cores. This results in the removal of all load-bearing masonry walls in the building. The lateral force resisting system will be comprised of concrete shear walls surrounding the elevator shaft and staircases with the possible addition of braced frames or moment connections.

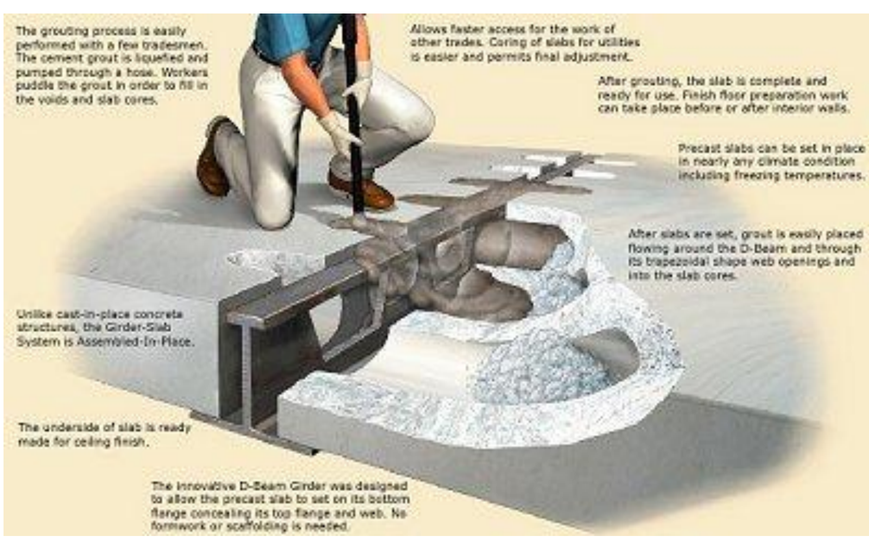


Figure: D-Beam System

Since the redesign of the structural system uses a different material than the existing system, the existing beams and columns will be altered. The plank span will remain unchanged, whereas the column and beam locations for the girder-slab system may change slightly to line up between rooms. This is done so that the exterior columns do not alter the existing location of the windows. The redesign will then be thoroughly compared to the existing design to determine whether the alternative system is a more effective and efficient design solution.

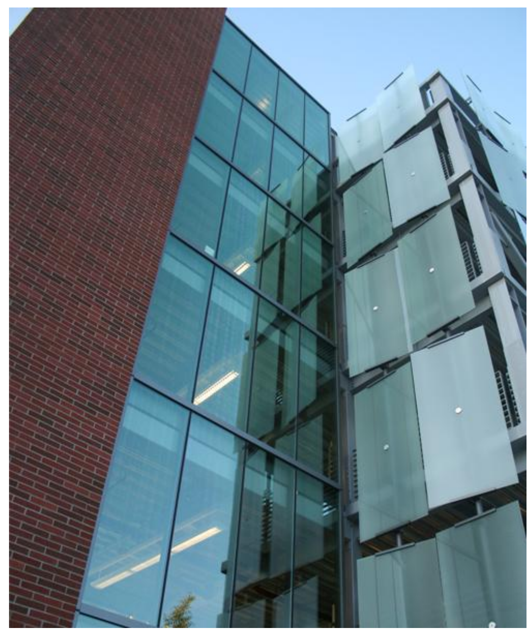
Solution Method

To determine whether the proposed structural system will be able to handle the loads imposed on the Cambria Suites Hotel, hand calculations will be performed to establish preliminary sizes. Hand calculations will be done with the use of ASCE 7-05, ACI 318-08, the Thirteenth Edition Steel Manual, and information provided by Girder-Slab Technologies. These sizes will then be placed into computer programs along with the calculated gravity and lateral loads. The gravity and lateral loads will be defined according to ASCE 7-05 and will be applied to the overall structure. RAM will be used to determine preliminary sized for beams and columns, whereas ETABS will be used to analyze the lateral effects on the building. Column axial loads will be calculated to determine the forces that will be acting to each auger cast pile in the foundation. An updated building weight will be calculated once new member sizes are determined. The concrete shear walls will be designed per ACI 318-08 and the new layout will be compared to the existing shear wall layout to determine if the modifications increased the shear capacity of the walls. Once the gravity and lateral systems are analyzed, hand calculations will be performed to verify the existing foundation is sufficient to withstand bearing, overturning, shear, and torsional affects.

Breadth Studies

Breadth Study I: Architectural Study

Due to the proposed alternate structural design, a study of how this modification will alter the existing architecture of the building will be conducted. Converting the structural system from a concrete masonry structure to a steel structure will change the architectural features of the building, especially the exterior façade design. Research will be performed on how a new architectural system could possibly create a more flexible layout and aesthetical look compared to the existing design. With the use of steel along the exterior of the structure, it could allow for the use of either a curtain wall system to allow more daylight into the building, structural wall panels, or non-load bearing masonry walls. Heat loss calculations will be compared between the existing and alternate facades, and the more efficient system will be determined.



Breadth Study II: Construction Management

The proposed alternate structural design is primarily made of steel, which creates two construction management issues due to the change in material. The two issues are project cost and construction schedule. Both issues will be addressed and compared for the existing, as well as the proposed alternative building system. Based on the results, conclusions will be made whether the proposed design is a feasible solution based on cost and time efficiency.

Tasks and Tools

I. *Structural Depth*
   A. Steel Framing
      1. Task 1: Determine loads applied to the steel members
         a. Determine DL and LL in accordance to ASCE7-05
         b. Apply loads to each level and determine distribution to each column using tributary areas
         c. Perform load take down on all columns
      2. Task 2: Build model in RAM to design steel members
         a. Place column grid into RAM model for gravity analysis
         b. Add columns for proposed redesign
         c. Input loads
         d. Determine steel member sizes
      3. Task 3: Perform hand calculations on steel members
         a. Spot check select members
         b. Verify new floor system is adequately designed
         c. Verify hand calculations with computer results
   B. Lateral System
      1. Task 4: Determine lateral loads applied to the lateral force resisting system
         a. Recalculate overall building weight
         b. Verify wind loads using ASCE 7-05
         c. Recalculate seismic forces with new building weights
      2. Task 5: Perform Lateral Analysis
         a. Perform hand calculations to analyze concrete shear walls
         b. Modify existing ETABS model if necessary
         c. Create ETABS model for proposed lateral system
         d. Compare results to determine if modifications provided sufficient shear resistance
   C. Foundation
      1. Task 6: Verify existing foundation can 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

II. *Breadth Study I: Architectural Study*

A. Task 7: Research existing architecture
   1. Compare architecture of surrounding buildings
   2. Determine if new structural system has impact on building layout
   3. Research impact of new facades

B. Task 8: Implement façade change
   1. Review existing concrete masonry facade
   2. Show proposed facade

C. Task 9: Perform heat loss comparison
   1. Calculate heat loss of existing concrete masonry system
   2. Calculate heat loss of proposed façade system
   3. Conclude on which system if more efficient and aesthetically appealing

III. *Breadth Study II: Construction Management*

D. Task 10: Determine cost and schedule of existing structural system
   1. If possible, find actual cost data or scheduling information from GC
   2. Determine any cost data not in RS Means
   3. Create mock schedule of construction implementing the existing structural system

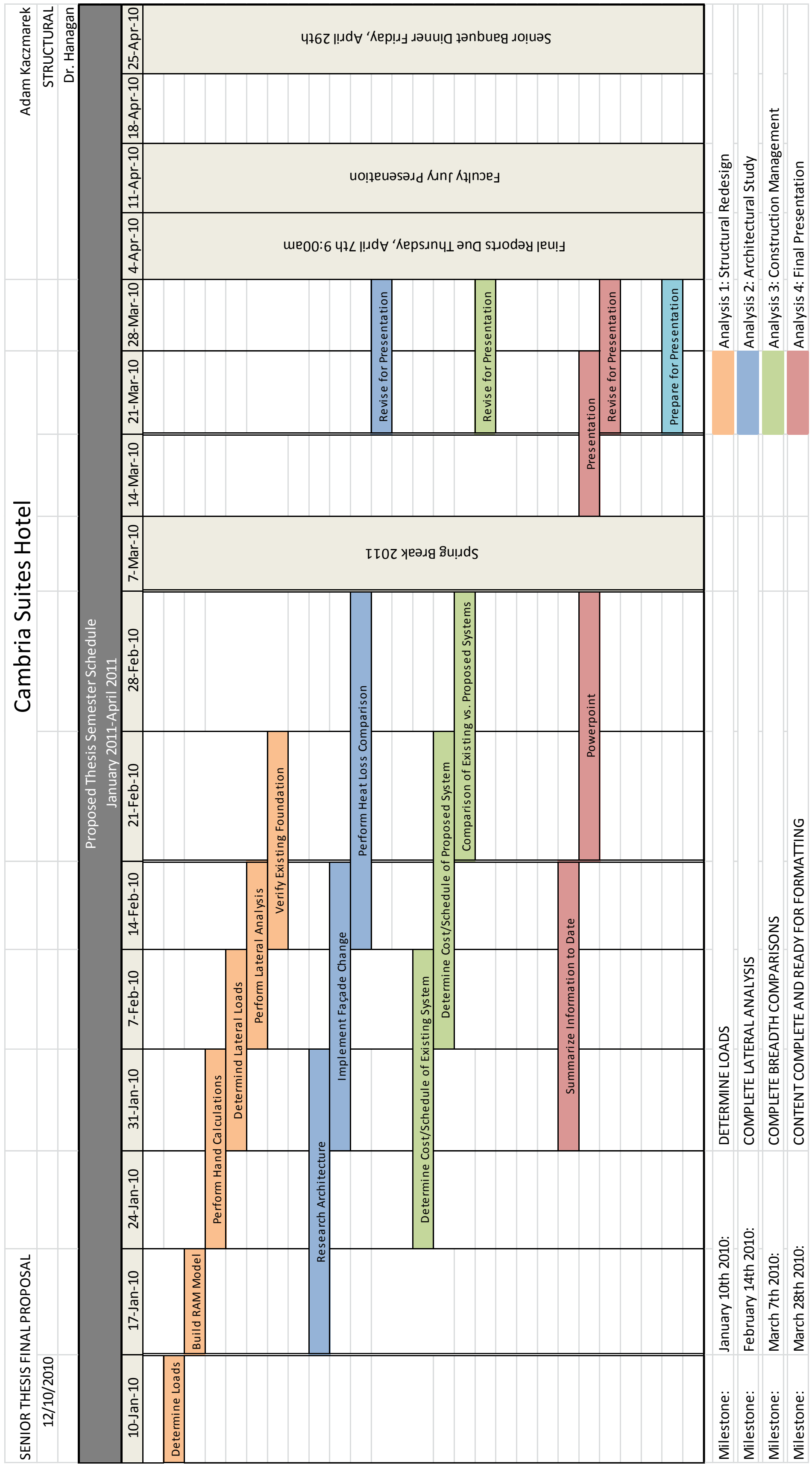
E. Task 11: Determine cost and schedule of proposed structural system
   1. Determine actual cost data for steel erection and scheduling information
   2. Determine labor and material costs from RS Means
   3. Create mock schedule of construction implementing the proposed structural system

F. Task 12: Compare Existing vs. Proposed Systems
   1. Compare cost information of the two lateral systems
   2. Compare schedules and total time of construction
   3. Conclude which system is a more feasible solution with respect to constructability

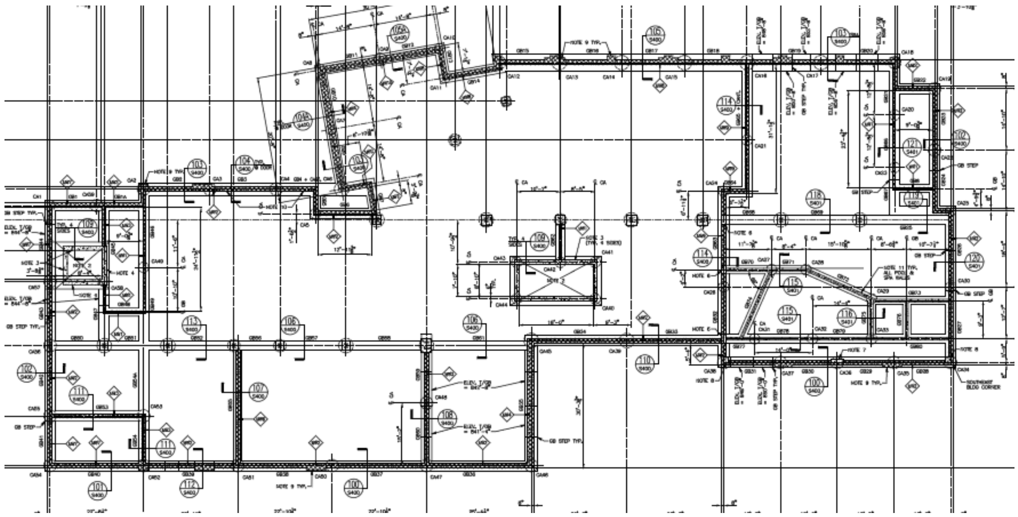
IV. *Presentation*

G. Task 13: Prepare final presentation
   1. 3-slide PowerPoint presentation
   2. Final Report
   3. Update CPEP web-site

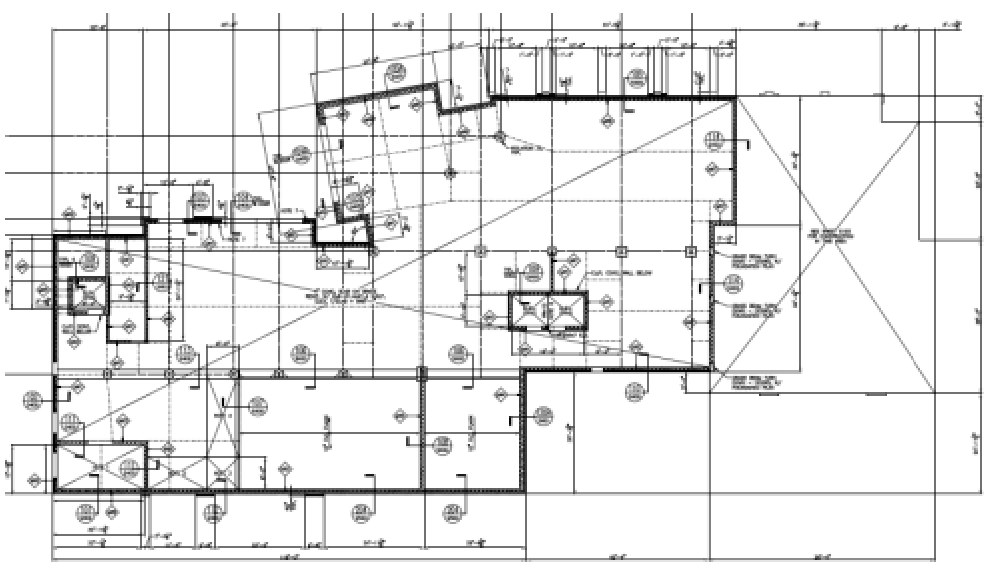
Timeline


Cambria Suites Hotel
Adam Kaczmarek
STRUCTURAL
Dr. Hanagan
SENIOR THESIS FINAL PROPOSAL
12/10/2010
Proposed Thesis Semester Schedule
January 2011-April 2011
10-Jan-10
17-Jan-10
24-Jan-10
31-Jan-10
7-Feb-10
14-Feb-10
21-Feb-10
28-Feb-10
7-Mar-10
14-Mar-10
21-Mar-10
28-Mar-10
4-Apr-10
11-Apr-10
18-Apr-10
25-Apr-10
Determine Loads
Build RAM Model
Perform Hand Calculations
Determind Lateral Loads
Perform Lateral Analysis
Verify Existing Foundation
Research Architecture
Implement Façade Change
Perform Heat Loss Comparison
Revise for Presentation
Determine Cost/Schedule of Existing System
Determine Cost/Schedule of Proposed System
Comparison of Existing vs. Proposed Systems
Revise for Presentation
Summarize Information to Date
Powerpoint
Presentation
Revise for Presentation
Prepare for Presentation
Spring Break 2011
Final Reports Due Thursday, April 7th 9:00am
Faculty Jury Presenation
Senior Banquet Dinner Friday, April 29th
Milestone: January 10th 2010: DETERMINE LOADS
Milestone: February 14th 2010: COMPLETE LATERAL ANALYSIS
Milestone: March 7th 2010: COMPLETE BREADTH COMPARISONS
Milestone: March 28th 2010: CONTENT COMPLETE AND READY FOR FORMATTING
Analysis 1: Structural Redesign
Analysis 2: Architectural Study
Analysis 3: Construction Management
Analysis 4: Final Presentation

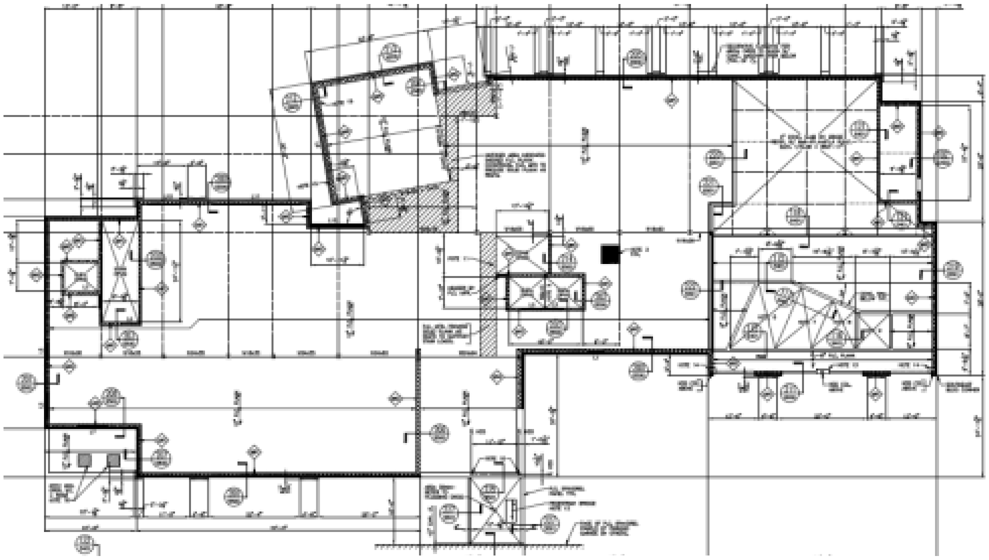
Appendix A: Building Layout



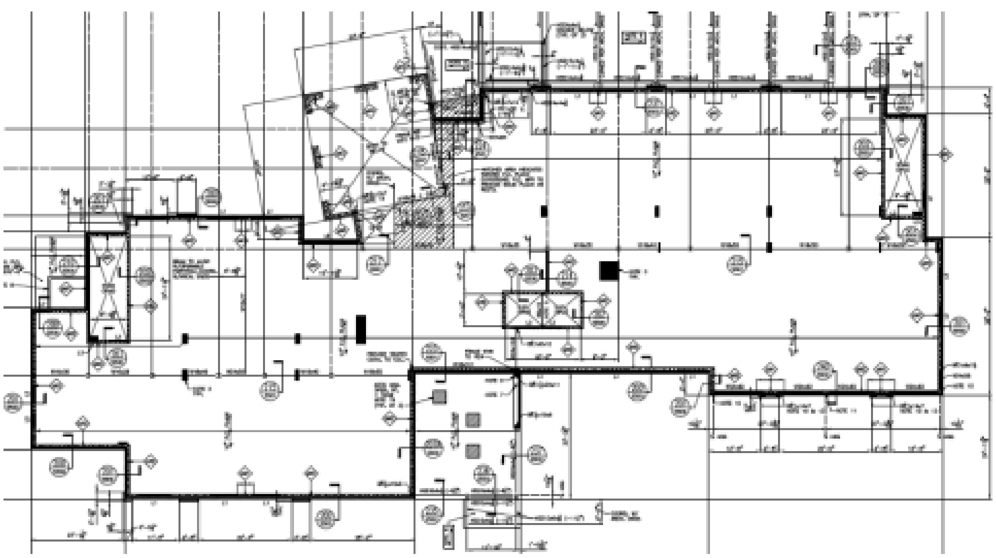
Foundation Plan



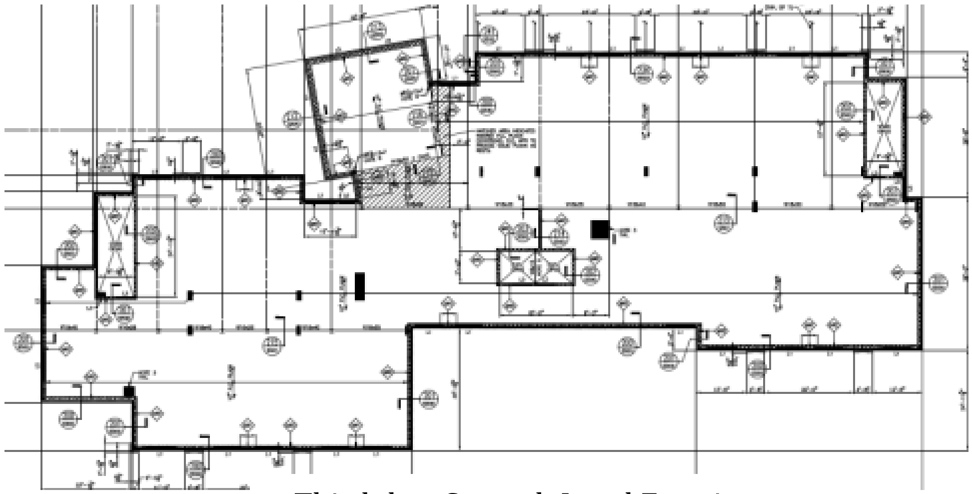
Plaza Level Framing Plan



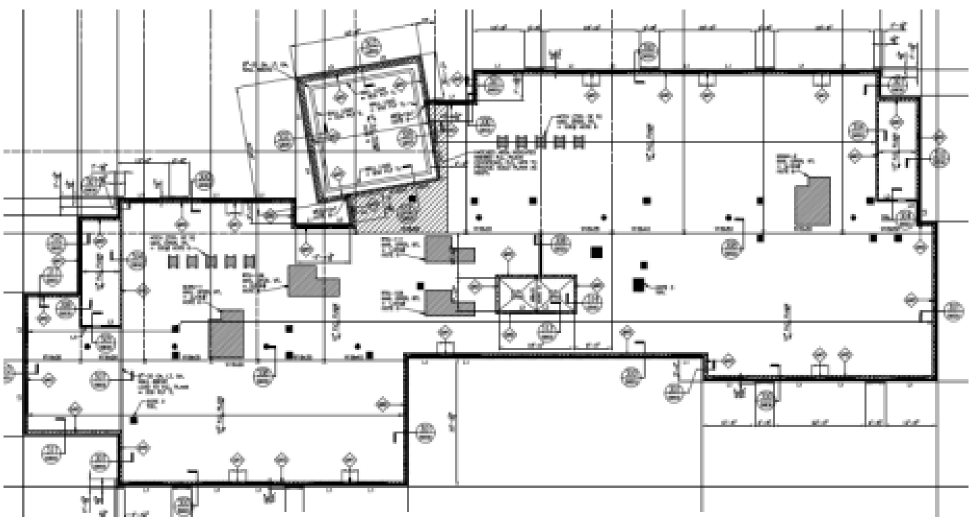
Hotel Level Framing Plan



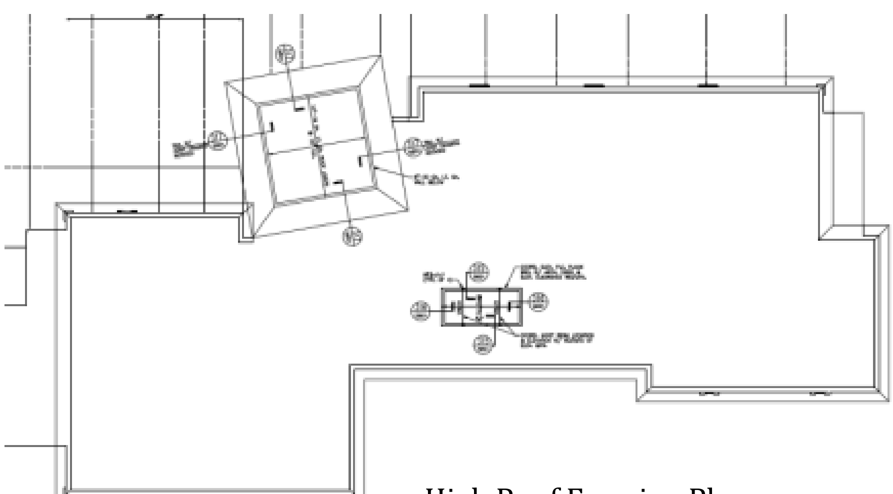
Second Level Framing Plan



Third thru Seventh Level Framing



Roof Framing Plan



High Roof Framing Plan