

# THESIS PROPSAL

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*CityFlatsHotel - Holland, Michigan*

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## Executive Summary

The following is a proposed study for the redesign of the existing structure of the CityFlatsHotel. The CityFlatsHotel is approximately 65,000 square feet and 5 levels above grade. The superstructure consists primarily of reinforced concrete masonry walls and precast hollow-core concrete planks, with interior steel frames when appropriate. Each story height ranges from 14' to 12', topping out at an overall building height of 67'-2". The typical 8" concrete planks with topping vary in span length. The lateral force resisting system is comprised of masonry shear walls, which are located around the staircases, elevator shafts, and other exterior building locations.

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 near downtown Holland, Michigan. So for the proposed design, the site will remain unchanged.

This thesis proposal outlines the entire process of optimizing the existing structural system for the CityFlatsHotel. For the structural depth, the concrete masonry structure will be redesigned using steel framing members. The precast hollow-core plank floor will remain as the floor system and will now sit on the non-composite steel beams. The lateral system will consist of shear walls that surround the staircases and elevator shafts, with the possible use of braced frames for extra lateral support. As a result of utilizing a steel frame exterior, a curtain wall or structural panel façade will replace the exterior shear walls. The foundation will be checked under the new steel framing system.

Breadth studies will focus on architectural, cost, and scheduling impacts of the proposed structural design. Due to the steel redesign, an architectural study will be conducted as minor layout changes may occur, as well as a new façade design. A construction management breadth will cover issues related to the construction schedule and cost of the building.

A complete preliminary breakdown of tasks that will be used in order to ensure that the proposed alternative design is properly analyzed on time is provided within the proposal.

## Introduction: CityFlatsHotel

CityFlatsHotel is the latest eco-boutique hotel located at 61 East 7<sup>th</sup> Street in Holland Michigan. This environmentally friendly hotel has been awarded LEED Gold and is only the third eco-boutique hotel to achieve such status in the United States and is the first of its kind to earn such recognition in the Midwest. Located on the outskirts of downtown Holland, which was named the second happiest place in America in 2009, the 56-guest room hotel is a unique place to stay. Not only are the hotel rooms decorated in a variety of ways, so that no two rooms are alike, this 5-story hotel offers many additional features to keep visitors satisfied. Accommodations include guest rooms, junior suites, master suites and more. Coupled with being located close to top of the line shopping, fine dining and extravagant art venues CityFlatsHotel is the place to stay when visiting Holland and its surrounding unique attractions.

The ground floor houses the main lobby for the hotel, a fitness suite and the CitySen Lounge. Also available is office space, high-tech conference rooms, and a digital theater for those who may want to conduct business meetings or private get-togethers. The remaining floors of the building are occupied by the various hotel rooms, with the top floor mostly reserved for CityVu Bistro restaurant and City Bru bar. The views from the restaurant of downtown Holland and Lake Macatawa are spectacular, which go well with the diverse fresh entrees served at CityVu Bistro.

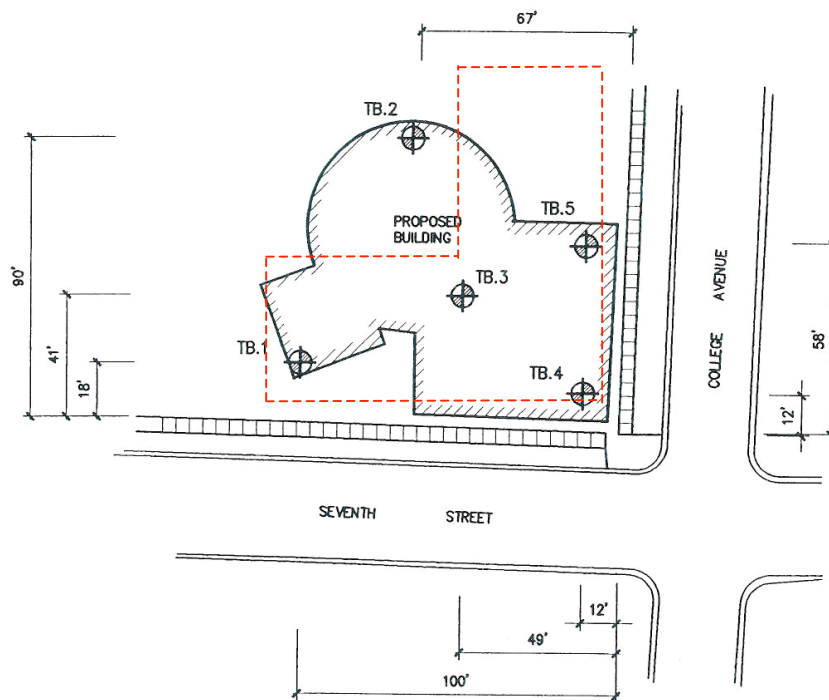
The exterior of CityFlatsHotel consists of multiple materials. Mainly covered in glass, other features including brick accents, metal panels, and terra cotta finishing make up the building seen at the intersection of College Ave and 7<sup>th</sup> Street. The contrast in simple materials leaves an appealing building image and gives it a sense of modernity, which is continued throughout the entire hotel. Accompanying the exterior image and fascinating interior design, efficient features can be found in every room. Such features include but are not limited to cork flooring, occupancy sensors, low flow toilets and faucets, fluorescent lighting, Cradle-to-Cradle countertops, and low VOC products.

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

## Existing Structural System

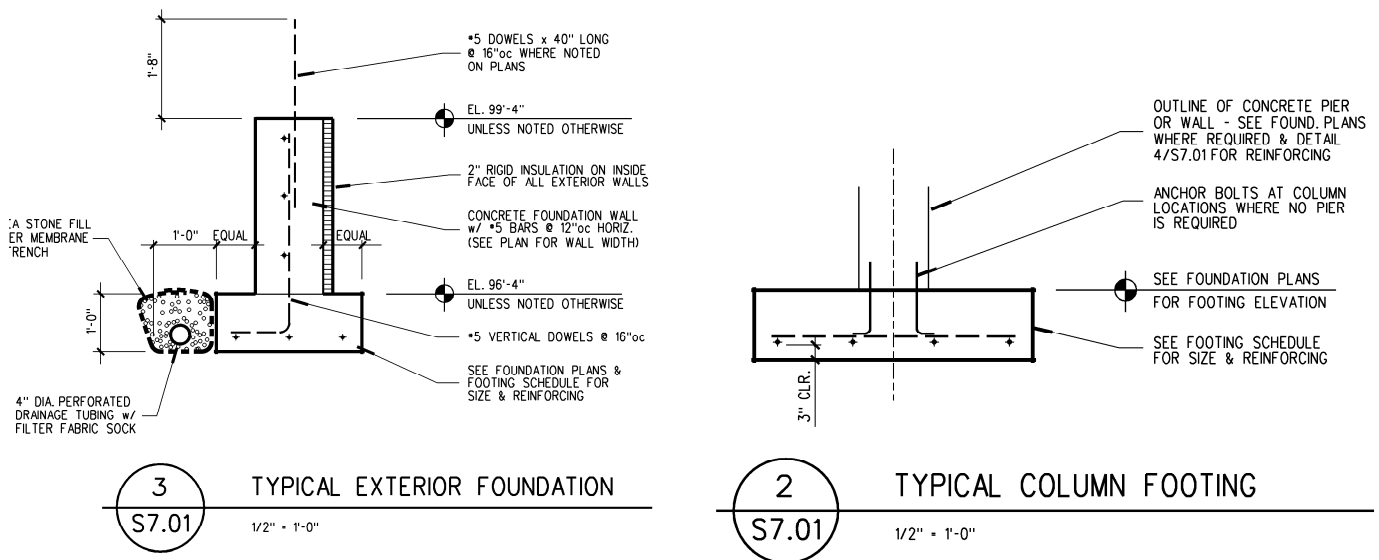
### *Foundation*

Soils & Structures Inc. completed the geotechnical engineering study for the CityFlatsHotel on July 16, 1998. A series of five test borings were drilled in the locations shown in the proposed plan (Figure 1.1). Each test boring was drilled to a depth of 25 feet in order to reveal the types of soil consistent with the location of the site. The results showed that the soil profile consisted of compact light brown fine sand to a depth of 13.0 to 18.0 feet over very compact coarse sand and compact fine silt. In test boring two a small seam of very stiff clay was discovered at 20.0 feet. Groundwater was encountered at a depth of 14.0 feet. From these findings it was recommended that a bearing value of 4000 psf be used for design of rectangular or square spread foundations and a value of 3000 psf be used for strip foundations. Since the test boring was performed in a relatively dry period, it was noted that the water table might rise by as much as 2.0 to 3.0 feet during excessive wet periods.



**FIGURE 1.1:** This is a plan view of the Five Test Boring Locations  
Note: The layout of the building here was the proposed shape. The actual building takes on an L-shape as can be seen later in Figure 1.8.  
Image supplied by GDK Construction.

Based on the conclusion from the geotechnical report it was decided to have all sand and/or sand fill be compacted to a density of 95 percent of its maximum density as determined by ASTM D1557. By compacting the soil through methods of vibration allowed the soil bearing capacity to be set at 8000 psf for footings. The basement floor consists of 4" concrete slab on grade that has a concrete compressive strength of 3000 psi and is reinforced with 6x6 W2.9xW2.9 welded wire fabric. Examples of the foundation and footings can be seen in Figures 1.2 and 1.3 respectively. This typical layout is consistent throughout the entire foundation system.

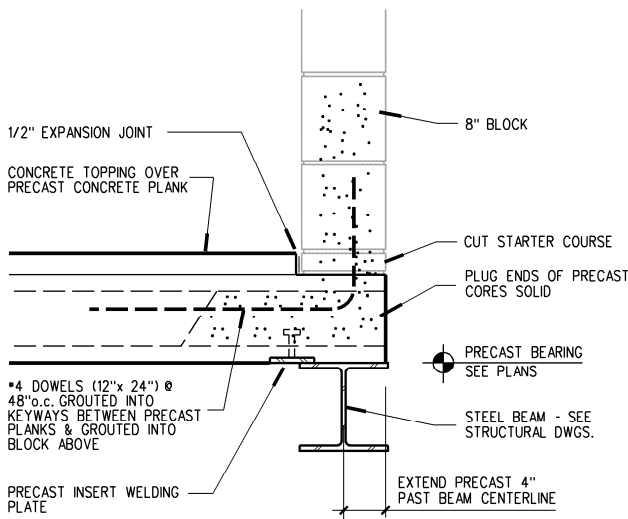


**Figure 1.2:** Typical Exterior Foundation.  
 Image supplied by GDK Construction.

**Figure 1.3:** Typical Column Footing.  
 Image supplied by GDK Construction.

### Superstructure

Due to the relatively "L" shape of CityFlatsHotel, the buildings framing system is able to follow a simple grid pattern. The overall building is split into two rectangular shapes that consist of 6 and 7 bays. The typical grid size is between 18'-0" to 18'-8" wide and 22'-6" to 30'-2" long. The main floor system used is an 8" precast hollow-core concrete deck with 2" composite concrete topping. The concrete topping is normal weight concrete and has a compressive strength of 4000 psi. The floor system is then supported by steel beams, which range in size and include W30x173's for exterior bays and W8x24's for interior corridors. Details for these two beam connections can be seen in Figure 1.4 below.

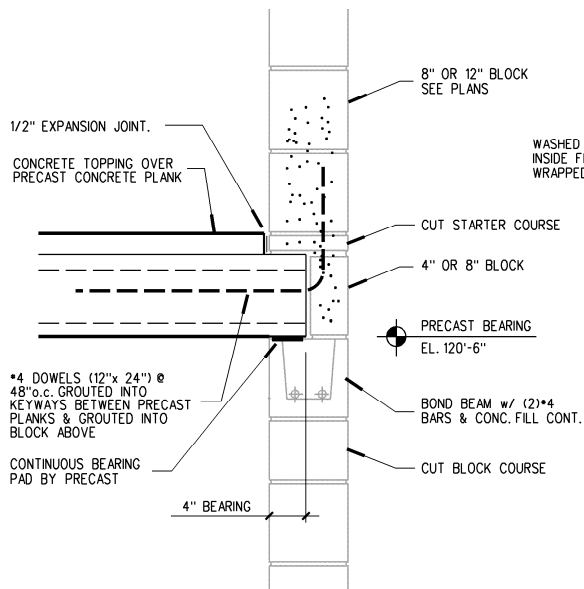


10 PRECAST BEARING DETAIL  
 S7.01 1" - 1'-0"

Figure 1.4: Typical Steel Beam Support Detail.  
 Image supplied by GDK Construction.

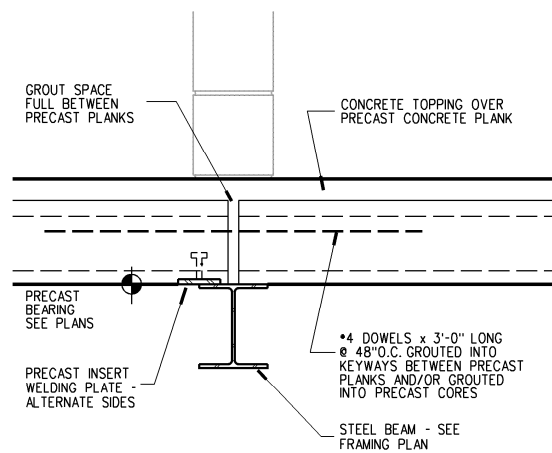
The precast plank allows for quicker erection, longer spans, and open interior spaces. The use of precast plank is typical for all floors other than the basement floor and specific areas of the ground floor, which utilizes slab on grade. All floor slabs on grade are 4" thick except for radiant heat areas, which require the slab to be 5" thick. Both of these slabs are reinforced with 6x6 W2.9x2.9 welded wire fabric.

Masonry walls are also used throughout the building layout to hold up the precast concrete plank floors. Refer to Appendix A for wall locations. These walls simply consist of concrete masonry units that are reinforced with #5 bars vertically spaced at 16" o.c. and extend the full height of the wall (Figure 1.5). In order to connect the precast planks with the masonry block, 4" dowels, typically 3'-0" long spaced at 48" o.c., are grouted into keyways and used to connect the two members together (Figure 1.6).



9 PRECAST BEARING DETAIL  
 S7.01 1" - 1'-0"

Figure 1.5: Typical Masonry Wall Reinforcing .  
 Image supplied by GDK Construction. Detail



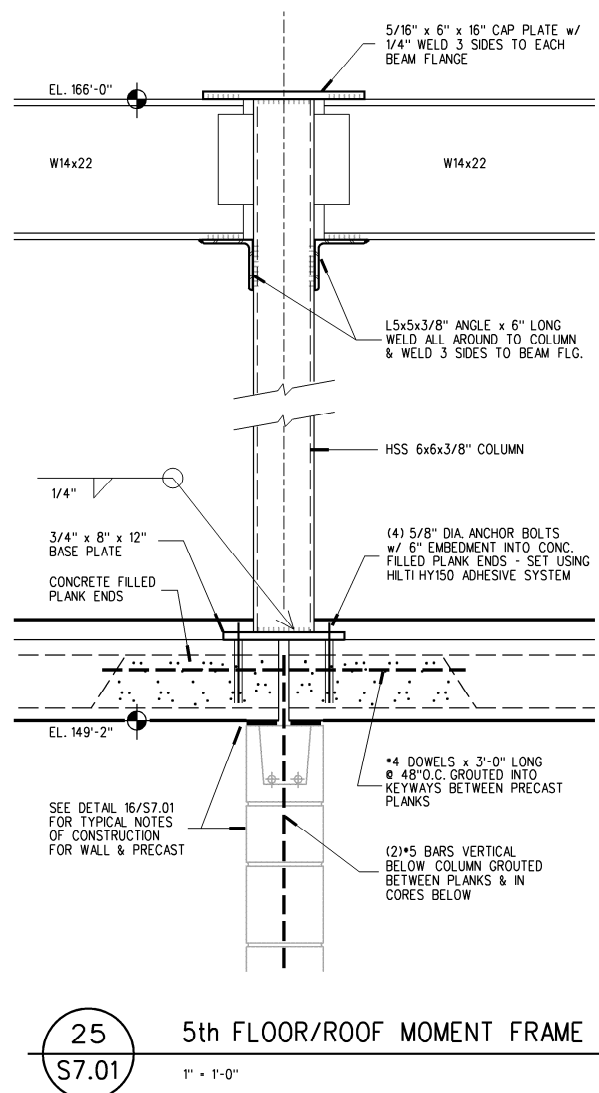
22 PRECAST BEARING DETAIL  
 S7.01 1" - 1'-0"

Figure 1.6: Typical Member Connection Detail.  
 Image supplied by GDK Construction.

Columns add the final support and are typically HSS columns located around the perimeter of the building as well as along the corridors of the hotel. Refer to Appendix A for plans with column locations. HSS 8x8x3/8" columns were typically used on the exterior and HSS 8x8x1/2" columns were used in the interior. HSS 12x12x5/8" were used in order to support the larger beams and greater tributary areas. All load bearing masonry walls and steel beams will take the reaction load from the precast concrete plank flooring, as well as any additional loads from upper levels, and transfer the loads thru the columns and exterior walls thru to the foundation system.

### Lateral System

The main lateral system for the CityFlatsHotel consists of the concrete masonry shear walls. The exterior as well as the interior walls are constructed with 8" concrete masonry, which extend the entire height of the building. The core shear walls are located around the staircases and elevator shafts. The average spacing between these walls are 18'-6" and they extend between 22'-6" to 25'-6" in length. In addition to the masonry walls there are steel moment connections in the southeast corner of the building similar to (Figure 1.7), which allows for additional lateral support of the two-story entrance atrium. Moment connections are also utilized on the top floor again similar to (Figure 1.7). This is in order to support the large amounts of glazing that is present, as an architectural feature for the restaurant located there. On floors three to five there are lateral braces used again in the southeast corner of the building that help with resisting the lateral load, which is prominent in the North/South direction. This will be expressed later when calculating wind loads.



**Figure 1.7:** Typical Moment Frame Connection. Image supplied by GDK Construction.



### *Roof System*

The roof framing system like the floor framing system is laid out in a rectangular grid. It consists of 1.5B 20-gauge metal decking supported by K-series joists. The typical joists that are used range between 12K1 and 20K5, which have depths of 12" and 20" respectively. These K-series joists span between 16'-6" to 30'-8". The roof deck spans longitudinally, which is perpendicular to the K-series joists. The joists are spaced no further than 5'-0" apart and typically no shorter than 4'-0".

## Load Distribution

### Load Path

In order to get the lateral loads that are applied to the building, either wind or seismic loads, through the building and into the ground there needs to be a clear path. This load path is 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 CityFlatsHotel, lateral wind forces come in contact with the exterior of the building, are then transmitted through the rigid diaphragms, to the masonry shear walls, and down into the foundation in order to disperse into the ground. This load path is shown in Figure 1.15. The exterior shear walls with longer spans resist the majority of the lateral forces due to the minimal resistance the slab provides. The steel columns that are scattered throughout the building only transfers gravity loads from the transfer beams to the foundation.

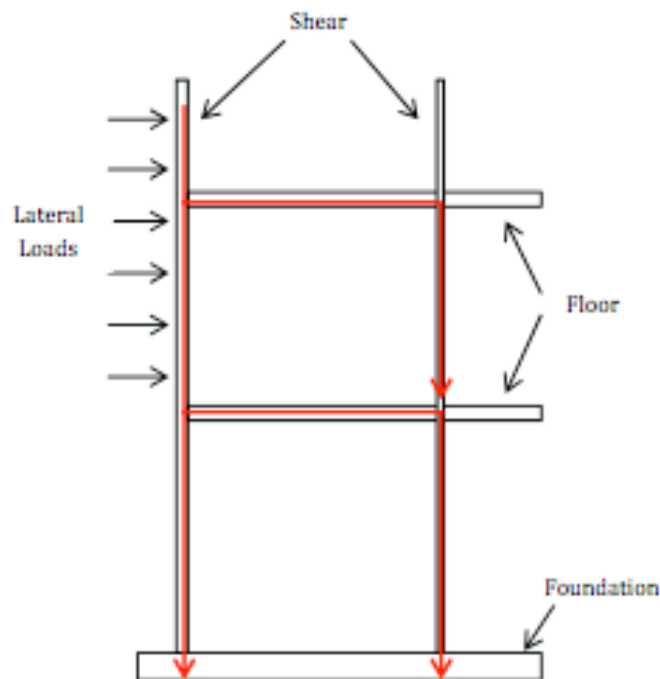


Figure 1.15: Load Path Diagram

## Problem Statement

Upon the completion of analyzing the structural system of the CityFlatsHotel, it was determined that the existing system is currently the most efficient possible, as well as meets all architectural, strength, and serviceability requirements governed by code. The gravity system, consisting of concrete masonry walls, was sufficiently designed to support the precast hollow-core concrete planks. In addition, they 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 the CityFlatsHotel were analyzed and clarified to exceed the design requirements as per ASCE 7-05. In Technical Assignment 2, three alternate floor systems were examined, but ultimately it was confirmed that the existing precast concrete plank floor system was the most efficient and effective system analyzed. Technical Assignment 3 proved the lateral force resisting system of the CityFlatsHotel is sufficient to carry the controlling lateral loads present on the structure. After the complete evaluation of the CityFlatsHotel it is clear that the design meets all code requirements with respect to its location and zoning. Due to the excellent performance of the current system, an alternative design may not be comparably more efficient or effective. That being said, a redesign of the CityFlatsHotel 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 implications resulting from the implementation of a new system will require foundation checks to verify it is sufficient to withstand these alterations.

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 include code limitations, building performance, cost effectiveness, constructability, construction schedule, and material availability. This proposal will investigate an alternate system that may result in a more viable option than the existing structural system of the CityFlatsHotel.

## Proposed Solution

### **Structural Depth: New Framing System Design**

The owner chose the current site of the CityFlatsHotel due to its location near the downtown Holland area, which is in close proximity to multiple attractions. This prime location is very attractive for guests of Holland to want to stay in this hotel while visiting. Therefore, the hotel will remain in its existing location for the practice of this assignment.

Concrete is a heavier material by nature, whereas steel could result in a decreased building weight, creating a lower base shear value. As a result, a feasible alternative structural system for the CityFlatsHotel would be to utilize steel framing. This consequentially will affect the foundation and construction management issues such as schedule and cost. Additionally, architectural features such as the building façade may be affected 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. The current hollow-core concrete plank floor system will remain, but will be integrated as a girder-slab system using non-composite girders. 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. The purpose of making these alterations is to investigate the overall affects of such changes, whether positive or negative.

As a result of the redesign incorporating a different primary material as compared to the existing system, any existing beams and columns will be altered. The floor spans will remain unchanged, whereas the location of the interior load bearing masonry walls will be replaced by steel columns and non-composite moment frames. The redesign results will be thoroughly compared to the existing systems to determine whether the alternative system proves to be 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 CityFlatsHotel, hand calculations will be performed to establish preliminary sizes. Hand calculations will be done with the use of ASCE 7-05, ACI 318-08, and the Thirteenth Edition Steel Manual. Gravity loads will be defined according to ASCE 7-05 and applied to the entire structure. An updated building weight will be calculated once new member sizes are defined for the building. Column and axial loads will be calculated to determine the forces that will be acting on the foundation. All lateral loads will be in accordance with ASCE 7-05, while concrete shear walls will be designed per ACI 318-08. The redesign will be compared to the existing shear wall layout to determine if the modifications increased the shear capacity of the walls.

The components of the alternate system will be designed using computer software. RAM will be used to determine preliminary sizes for beams and columns based on the calculated loads that will be applied to the structure. Then a model of the new proposed CityFlatsHotel will be created in ETABS in order to analyze the lateral effects on the building. 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. 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 façade of the alternate design. The second study will be an involved investigation of the construction management issues.

### **Breadth Study I: Architectural**

Due to the proposed alternate structural design, an investigation of how these modifications impact the existing architecture of the building will be conducted. Converting the structural system from a concrete masonry structure to a steel structure may alter the architectural features of the hotel, especially the exterior façade design. Research will be performed in regards to the impact the current architecture has on the building and how a new architectural system may create a more flexible layout and aesthetical look. With the use of steel alone, the exterior may utilize 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 evaluated for the existing and alternate facades. A comparison of the two systems will determine which design is the more efficient system.

### **Breadth Study II: Construction Management**

The proposed alternate structural design is primarily made of steel, which impacts two construction management issues. The two issues that will be targeted based on the use of steel are project cost and construction schedule. These issues will be addressed and compared for both the existing and the proposed alternative building system. The construction schedule, material availability, construction financing, and project deadline will all have an influence on the cost estimate. It is important to analyze both issues together in order to achieve the best results. Based on the viability of the new structural system with respect to cost and schedule, a conclusion will be made as to whether the proposed design is a feasible solution.

## 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 to ASCE 7-05
  - b. Apply the correct loads to each level and determine distribution to every column using tributary areas
  - c. Perform load take downs on all columns
2. Task 2: Build a model in RAM to design the new steel members
  - a. Place the column grid into the RAM model for gravity analysis
  - b. Add columns for the proposed redesign
  - c. Input loads previously calculated
  - d. Determine the steel member sizes from model results
3. Task 3: Perform hand calculations on the chosen steel members
  - a. Complete spot checks on select members
  - b. Verify the floor system is still adequately designed
  - c. Verify the hand calculations with the computer results

#### B. Lateral System

1. Task 4: Determine lateral loads applied to the lateral force resisting system
  - a. Recalculate overall building weight using the new steel members
  - b. Verify wind loads using ASCE 7-05
  - c. Recalculate the seismic forces with the new overall building weight
2. Task 5: Perform Lateral Analysis
  - a. Perform hand calculations to analyze the concrete shear walls.
  - b. Modify the existing ETABS model if necessary
  - c. Create an ETABS model for proposed lateral system
  - d. Use the results to determine if the modifications provide sufficient shear resistance

#### C. Foundation

1. Task 6: Verify that the existing foundation can adequately carry all the loads resulting from the proposed design
  - a. Hand calculate the loads applied to the foundation due to shear and torsion
  - b. Determine if overturning moment creates uplift on the building

## II. Breadth Study I: Architectural Study

### A. Task 7: Research the existing architecture

1. Compare architecture of surrounding buildings and typical architecture of the area
2. Determine if the new structural system has impact on the existing building layout
3. Research the impact of a new façade

### B. Task 8: Implement façade change

1. Review the details of the existing concrete masonry façade
2. Show the proposed façade

### C. Task 9: Perform heat loss comparison

1. Calculate heat loss of the existing concrete masonry system
2. Calculate heat loss of the proposed façade system
3. Conclude which system is more efficient and aesthetically appealing

## III. Breadth Study II: Construction Management

### A. Task 10: Determine the cost and schedule of the existing structural system

1. If possible, find actual cost data or scheduling information from construction manager
2. Determine any cost data that is unavailable in 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 from RS Means
3. Create a mock schedule of construction implementing the proposed structural system

### C. Task 12: Compare existing vs. proposed systems

1. Compare the cost information of the two lateral systems
2. Compare the schedules and total time of construction
3. Determine advantages and disadvantages of the two lateral systems
4. Conclude which system is a more feasible solution with respect to constructability

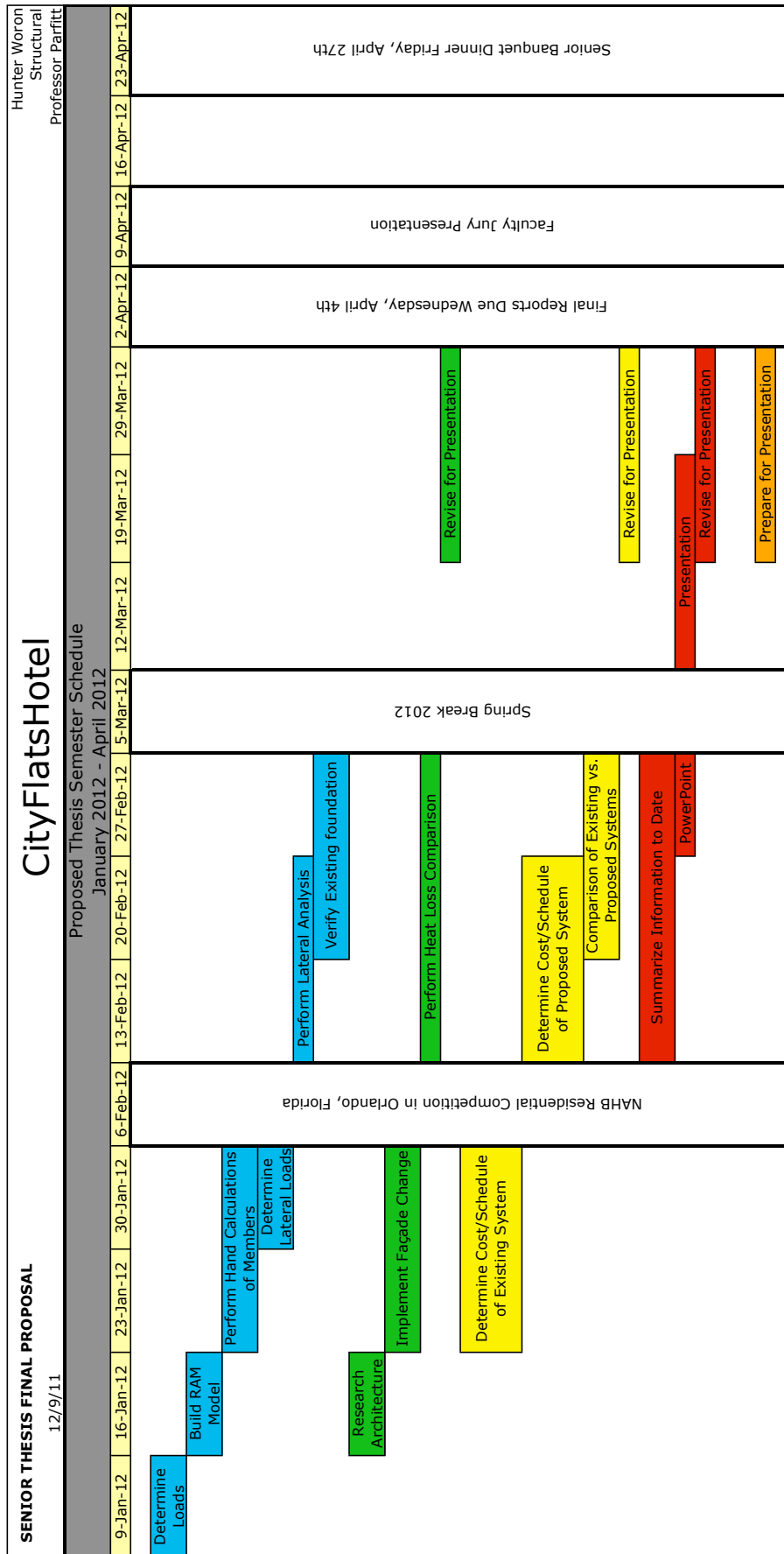
## IV. Presentation

### A. Task 13: Prepare final presentation

1. 3-slide PowerPoint presentation
2. Final Report
3. Update CPEP web-site and finalize all information

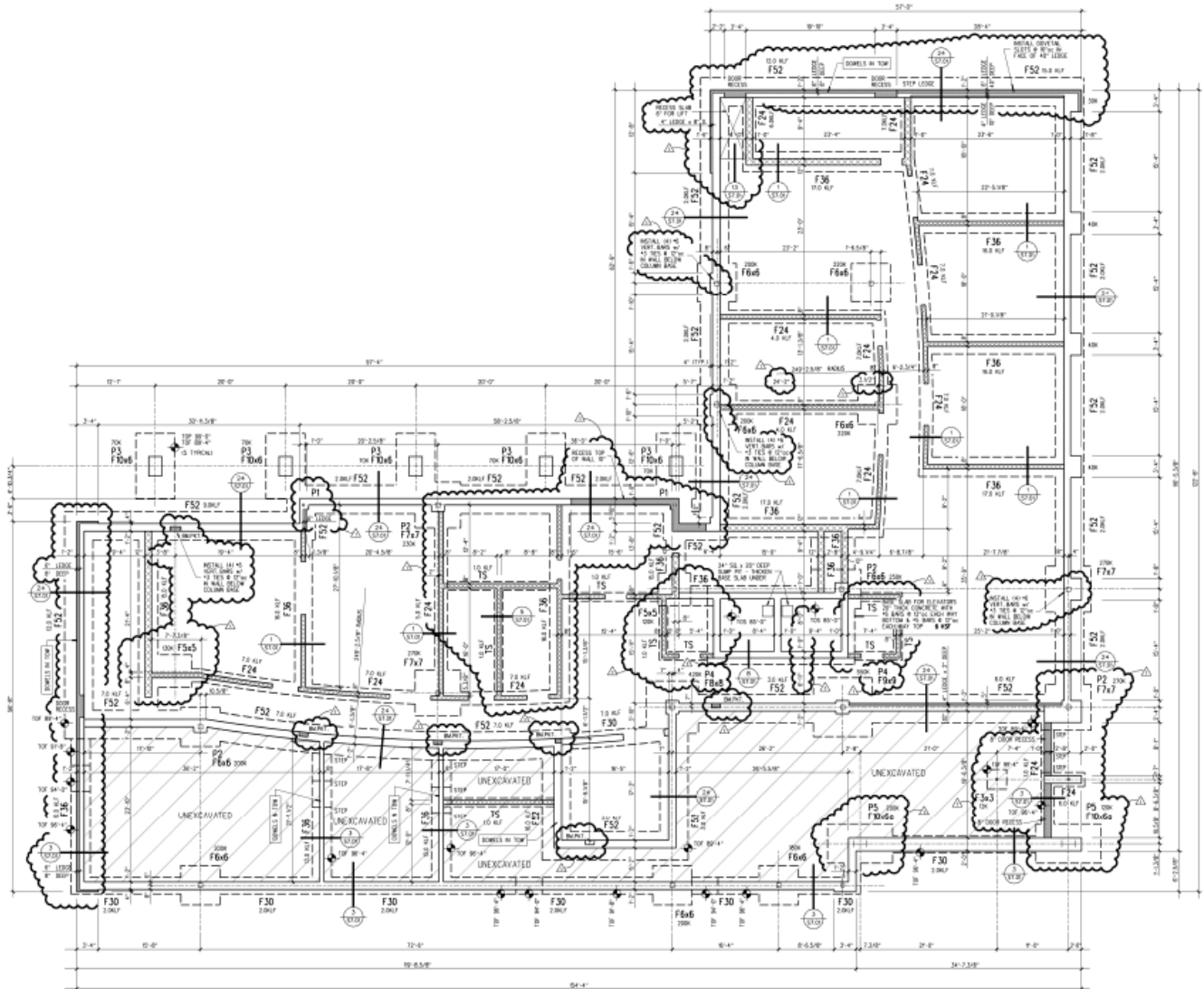


**Timeline**



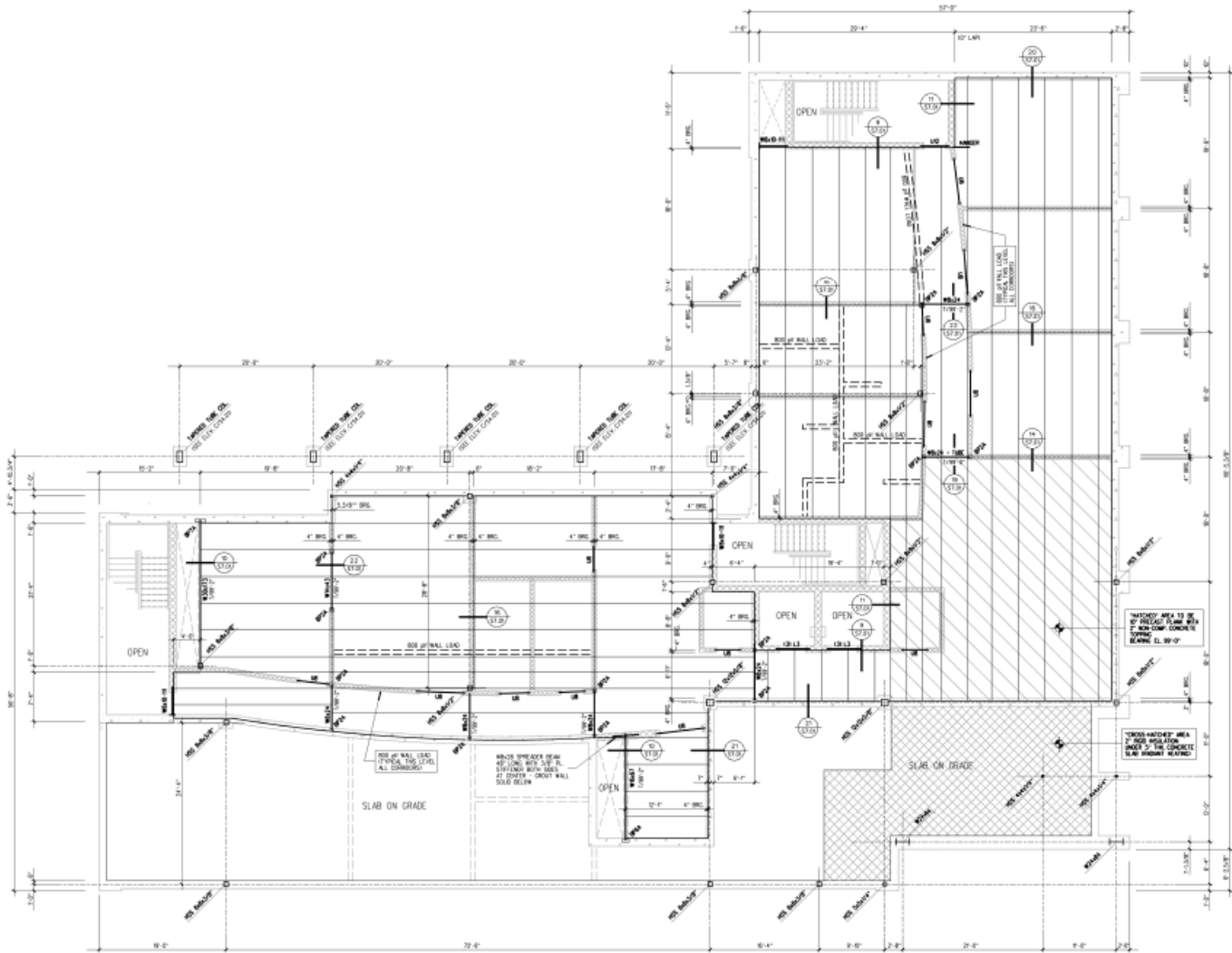
Milestone: January 27th 2012: Determine Loads  
 Milestone: February 13th 2012: Implement Façade Change  
 Milestone: March 2nd 2012: Complete Breadth Comparisons  
 Milestone: March 26th 2012: Content Complete and Ready for Formatting

## Appendix A: Plans



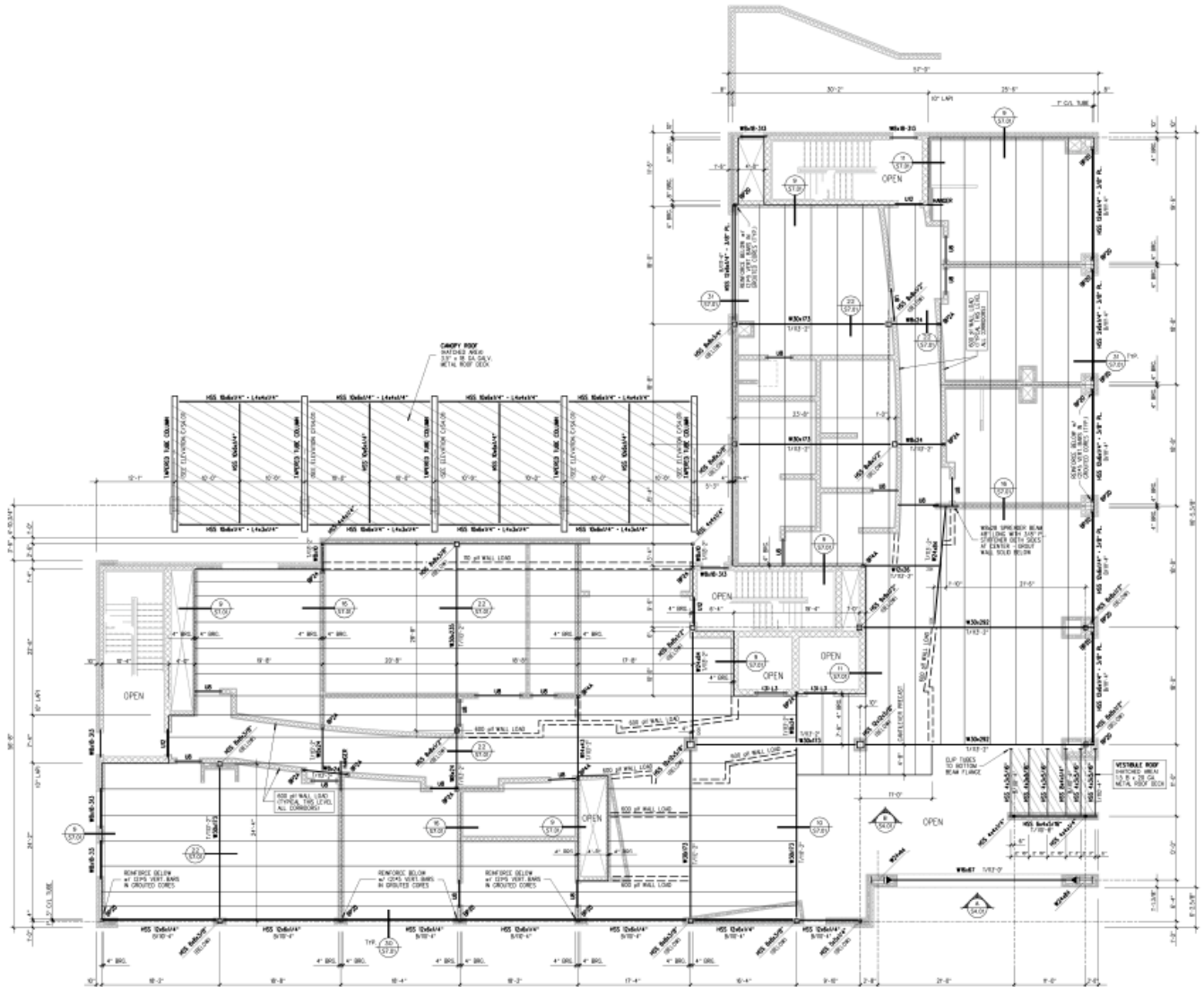
CityFlatsHotel  
Foundation Plan

Floor Plan supplied by  
GDK Construction



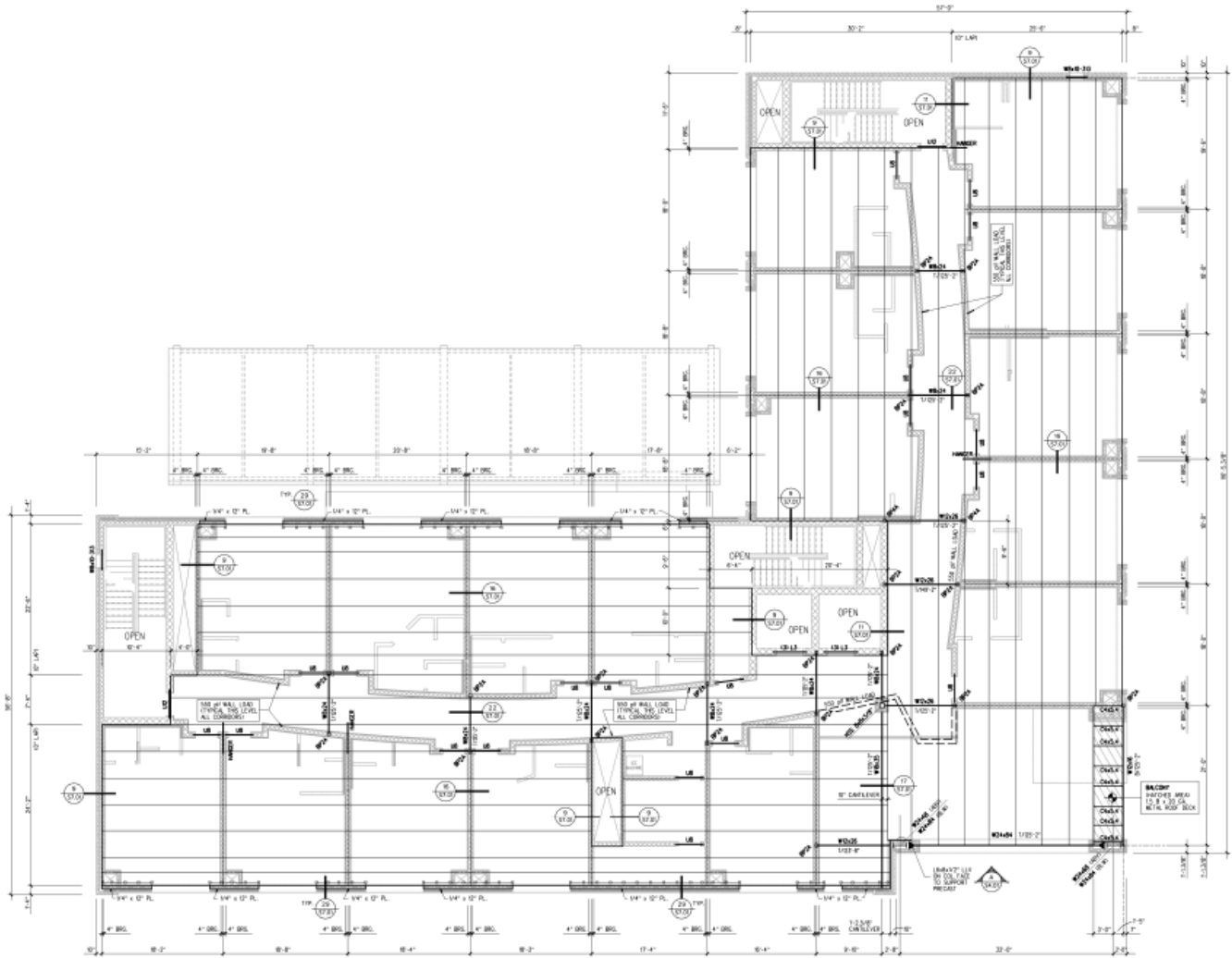
CityFlatsHotel  
First Level Framing Plan

Floor Plan supplied by GDK  
Construction



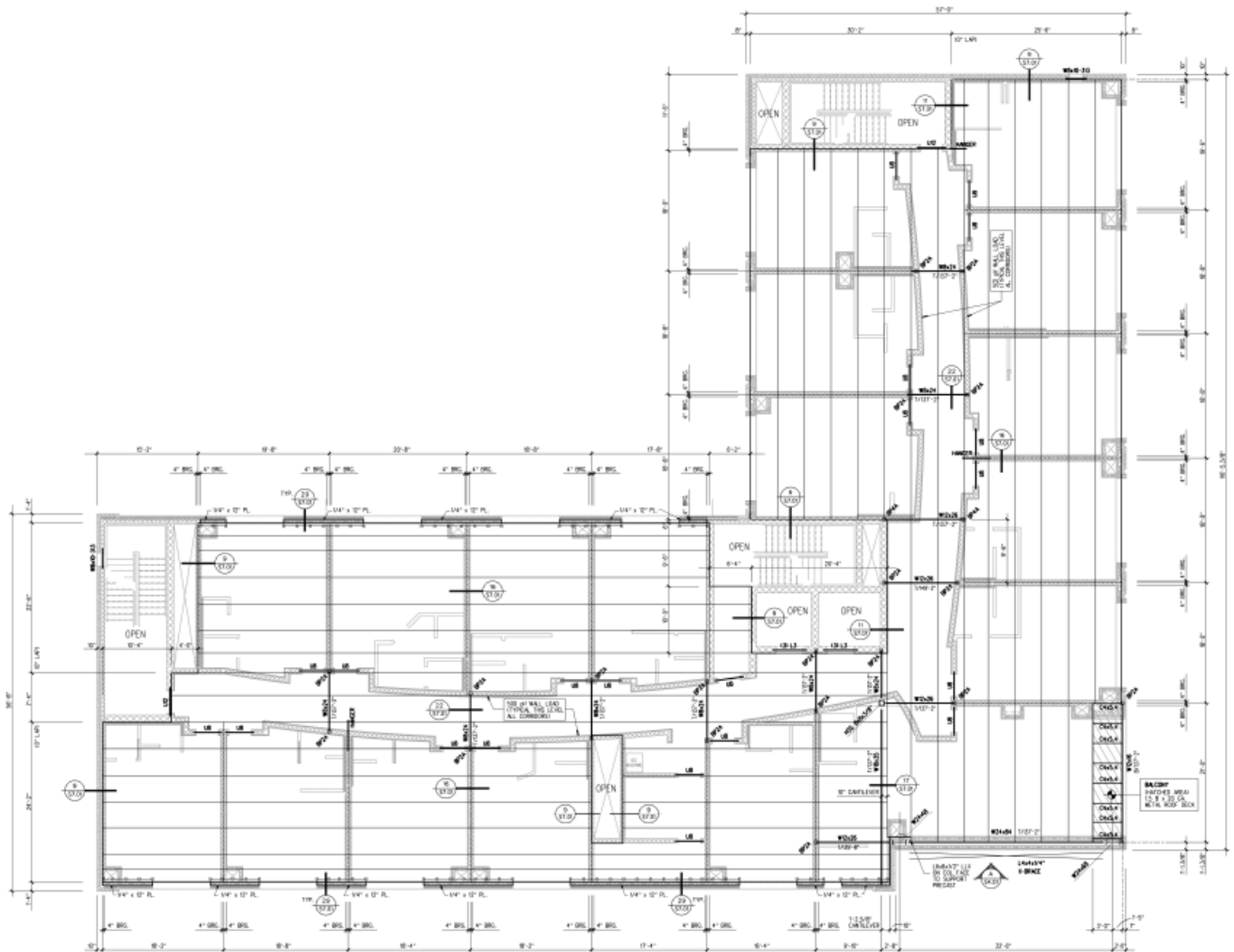
CityFlatsHotel  
Second Level Framing Plan

Floor Plan supplied by GDK  
Construction



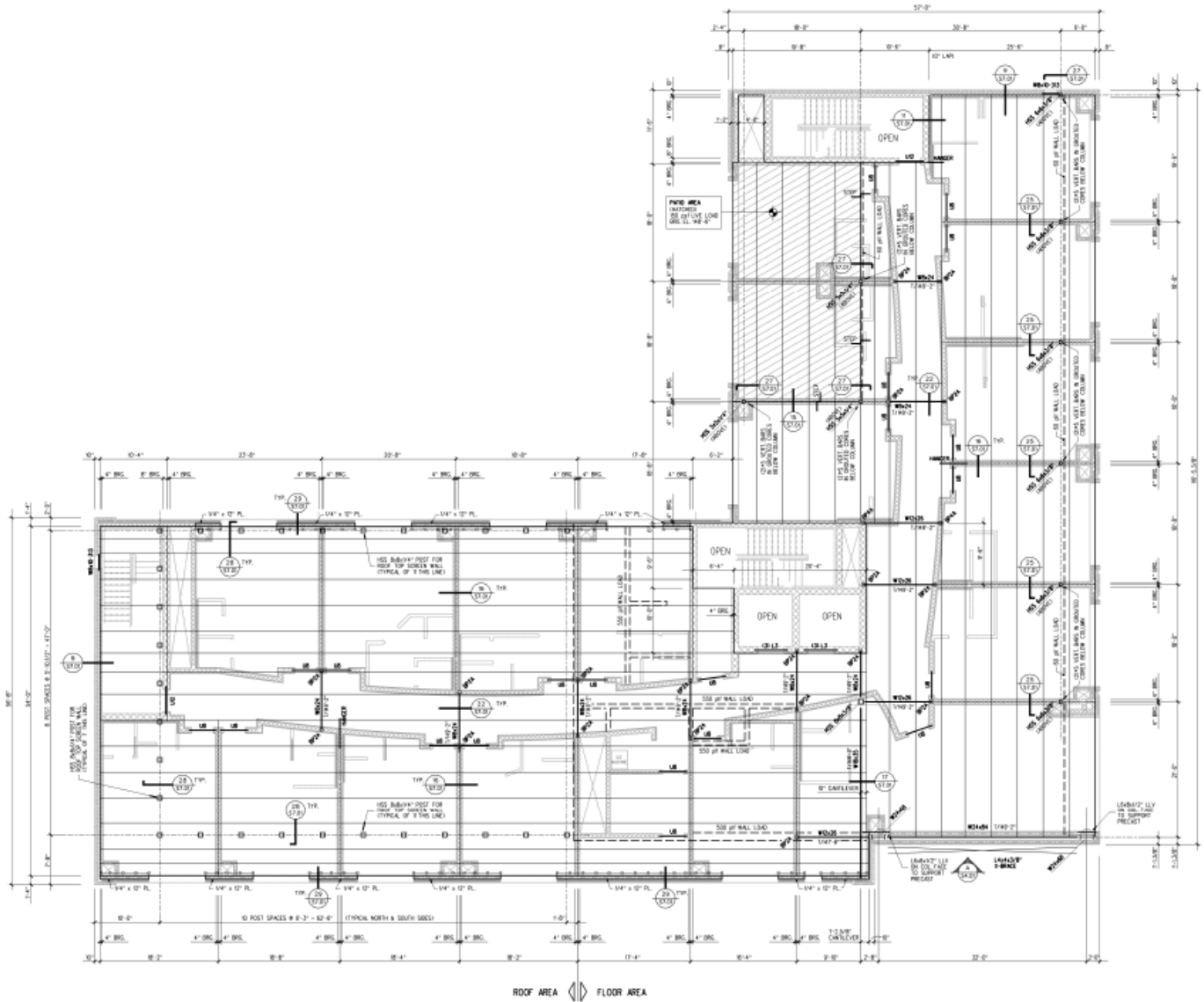
CityFlatsHotel  
Third Level Framing Plan

Floor Plan supplied by GDK  
Construction



CityFlatsHotel  
Fourth Level Framing Plan

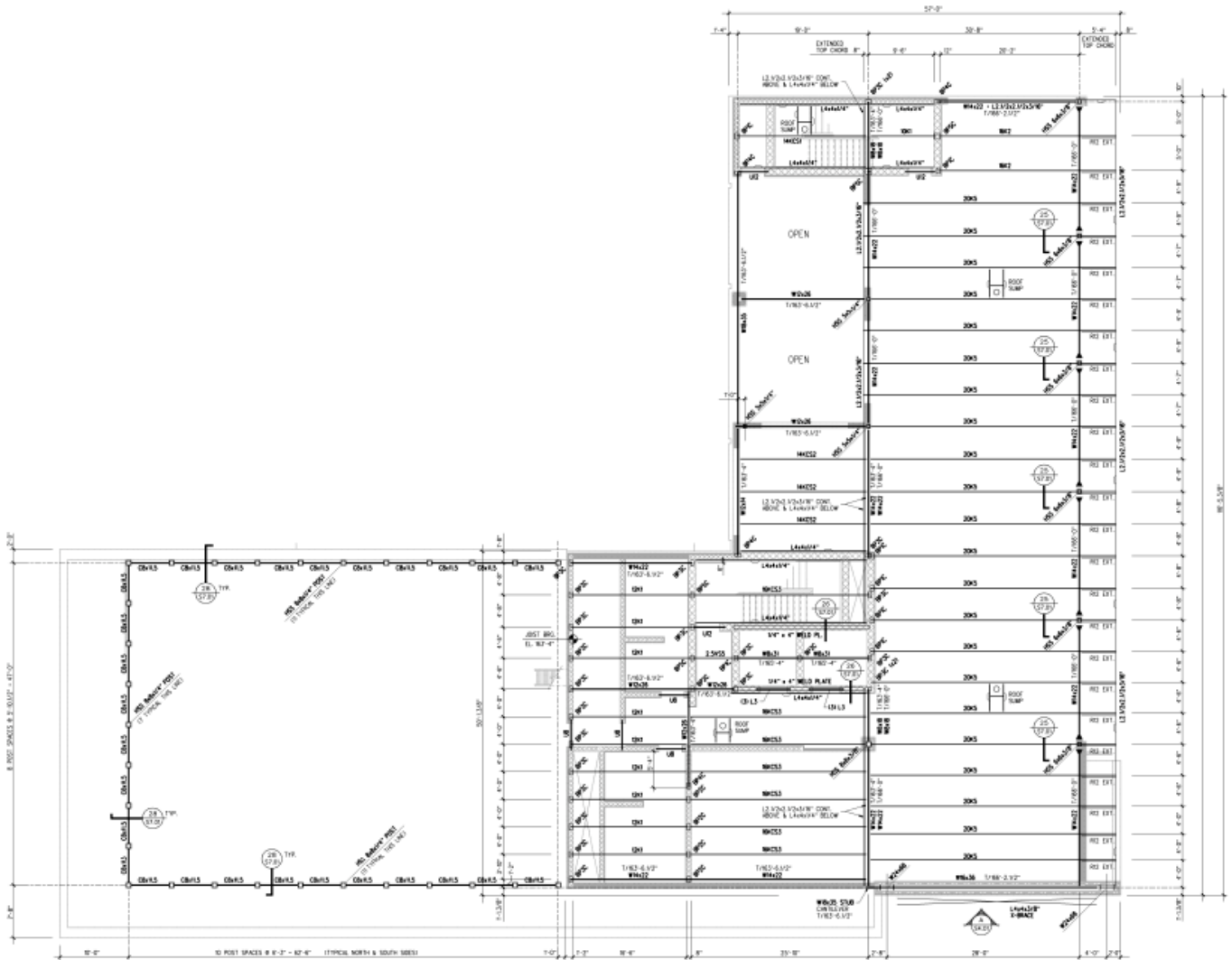
Floor Plan supplied by GDK  
Construction



CityFlatsHotel  
Fifth Level Framing Plan

Floor Plan supplied by GDK  
Construction





CityFlatsHotel  
Sixth Level (Upper Roof) Framing Plan

Floor Plan supplied by GDK Construction