40 Gold Street Residential Building

New York, New York

THESIS PROPOSAL

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Executive Summary

40 Gold Street is an impressive building that offers retail and residential space in lower Manhattan, which is one of the fastest growing residential sections of New York City. The construction of 40 Gold Street began in March 2009 and will conclude in January 2010. The building replaces an old two story brick building and is nestled tightly between two existing structures, a narrow alley (Eden's Alley), and Gold Street. Rising 175' above grade, the 40 Gold Street building consists of a 14 story structure comprised of 5,900 square feet of retail space and 62,000 Square feet of residential space. The lowest two floors are primarily dedicated to retail space and serve as a podium for the slender 14 story residential tower.

The existing structural system consists of light weight concrete slab on composite metal deck and steel framing. The lateral force resisting system is comprised of 5 braced frames and 4 moment frames. Although the owner preferred a concrete structural system, the steel framing system was selected to maintain a low overall building weight, which was essential in minimizing settlement potential.

40 Gold Street is a high quality residential building; however, several key areas of improvement can be achieved by redesigning the gravity system. As a result, the floor system will be redesigned as a two way flat plate with rectangular concrete columns. Not only will this redesign satisfy the client's original request, but it will improve both floor-to-ceiling height and vibration/sound control. By changing the dominant structural material from steel to normal weight concrete, a significant increase in building weight is expected. Therefore, an additional area of focus will require evaluation and possible redesign of the existing foundation system. With poor site conditions and closely located existing foundations, underpinning and soil remediation processes will be considered as additional ways to stabilize the foundations and prevent settlement.

Of course, when modifying the structural system of a building, the construction process and costs will be directly affected. In order to fully understand the impact of the gravity system redesign, constructability, material availability, construction cost, and labor union issues will be taken into account. After acquiring the schedule and any related construction or cost information regarding the existing building, they will be compared to the new schedule and 4D phasing model created by Microsoft Project and Navis Works (4D model only if time permits).

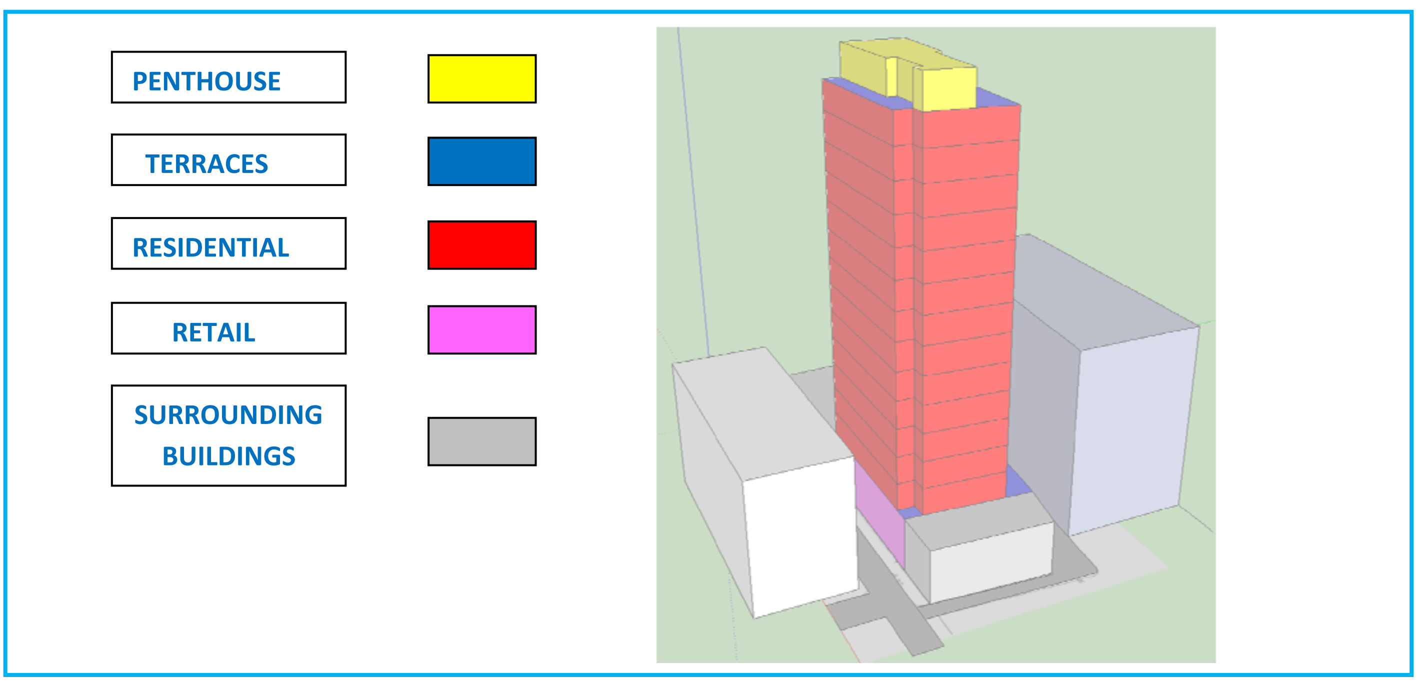
Finally, in order to demonstrate the improved residential environment resulting from the redesigned gravity system, sound and vibration control studies will be conducted. In regards to the acoustic control study, various wall and floor assemblies will be analyzed and assigned STC and NR ratings. With the aid of extensive research, a report and several charts will be made to show how the existing and the two way flat plate system compare in sound and vibration control. This will also include an in depth examination of how the architecture will be affected in order to maintain adequate sound and vibration control.

Introduction

40 Gold Street is an impressive building that offers retail and residential space in lower Manhattan, which is one of the fastest growing residential sections of New York City. The construction of 40 Gold Street began in March 2009 and will conclude in January 2010. The building replaces an old two story brick building and is nestled tightly between two existing structures, a narrow alley (Eden's Alley), and Gold Street. The constricted area presented special restrictions and challenges that greatly affected the final design and construction process.

Standing 175' above grade, the 40 Gold Street Building is a 14 story structure comprised of 5,900 square feet of retail space and 62,000 Square feet of residential space. The lowest two floors are primarily dedicated to retail space and serve as a podium for the slender 14 story residential tower. The lowest floor, referred to as the cellar, is below grade and functions as extra retail space as well as space for mechanical and electrical equipment. Retail spaces are appropriately located at the ground level and are highlighted with traditional floor to ceiling storefront windows to attract customers from the nearby streets and sidewalks. The storefront glazing is accompanied by a pre fabricated assembly of dark stone cladding and a large bronze plaque that boldly recognizes the building as 40 Gold Street. In addition to retail space, there is a residential lobby and mailroom.

The residential tower is comprised of 12 residential floors. Identical in layout, floors 2-9 are comprised of 2 studio apartments and 3 2 bedroom apartments that all encompass the vertical circulation node located at the core of the tower. Two elevators and a stairwell serve as the building's vertical circulation. Floors 10-13 are identical as well, but have 4 2-bedroom apartments and no studio apartments. At the top of the building, a level referred to as the penthouse provides the building's residents with two spacious recreational terraces sheltered by a gold painted metal trellis, a large recreational room enclosed by a window wall system, a kitchenette, a laundry room, and bathrooms.



F -1

Introduction Continued

The trapezoidal shape of the building closely reflects the shape of the site, which is to be expected when working with such a constricted space. The interior spaces are laid out in a rectangular manner, and the exterior shell is also rectangular. The residential tower boasts a sleek modern appearance with metal exterior cladding and gold toned trespa paneling.

Overall, the final design solution created by Architects Meltzer/Mandl and Structural Engineers Severud Associates makes the most of a small site, and is certainly playing a major role in the successful rebuilding of Lower Manhattan.

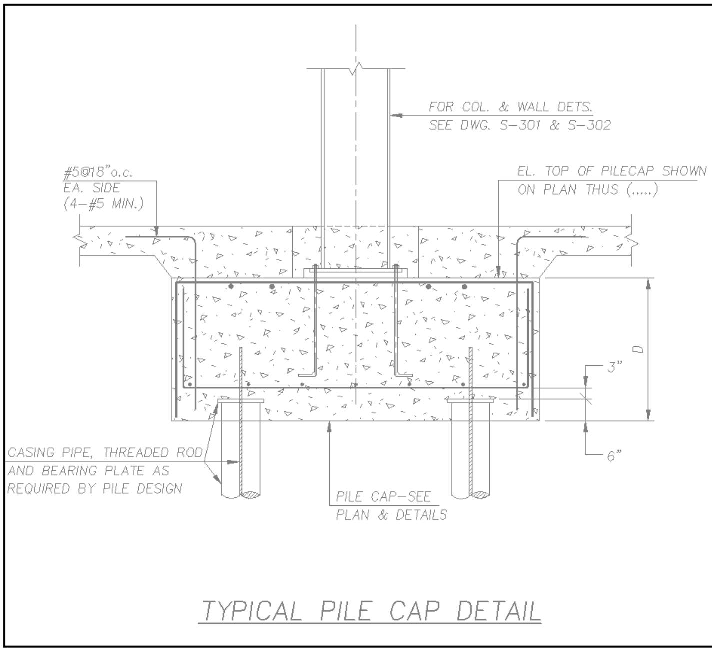
Structural System Overview

Foundations

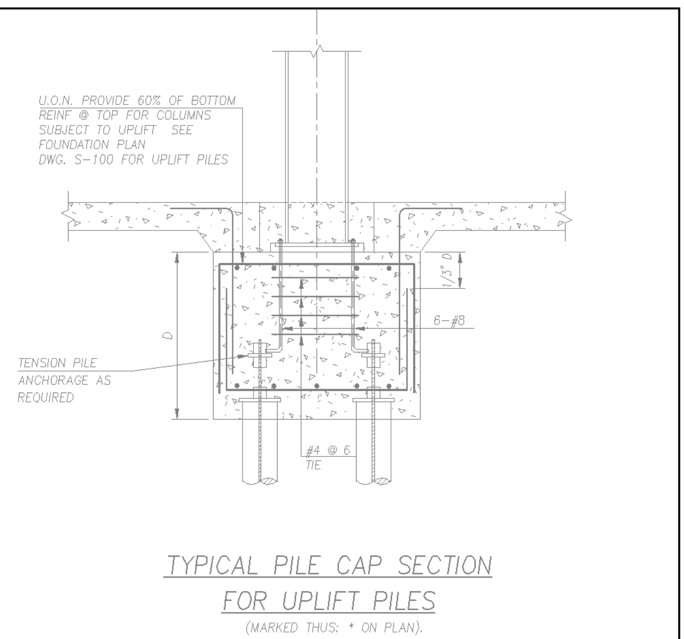
The site excavation and foundation work required a great deal of design work and creative planning compared to the average building project. As mentioned in the introduction, the site is very constricted with two existing structures against the property line, and two streets (Eden's Alley and Gold Street) are in close proximity. During excavation and foundation work, the adjacent streets required bracing and shoring for temporary and long term support. In addition, a major foundation design goal was to circumvent the need to underpin the adjacent existing structures. As a result, the depth of the various foundation components varies based on location relative to the surrounding structures and existing foundation systems.

The foundation employs a system of 101 strategically positioned micro piles. There are (88) 75 Ton compression capacity piles that are 35' long and (13) 35 Ton compression capacity piles that are 25' long. Various pile caps are used to distribute building loads to the piles: they generally range from 36"-39" in depth.

The cellar floor system is an 8" slab on grade with #5 bars @ 12" O.C. top/bottom running both directions. Resting on 6" of crushed stone, the slab on grade is attached to the pile caps via an assortment of connections. As seen in figure S-1, the typical pile cap is anchored to the column base plates by 6-#8 bars, and the pile caps are directly anchored to the floor slab by #5 @ 18" on each side of the column (minimum of 4 - #5 required per side). The pile caps subjected to uplift require tension pile anchorage as seen by figure S-2.



S-1



S-2

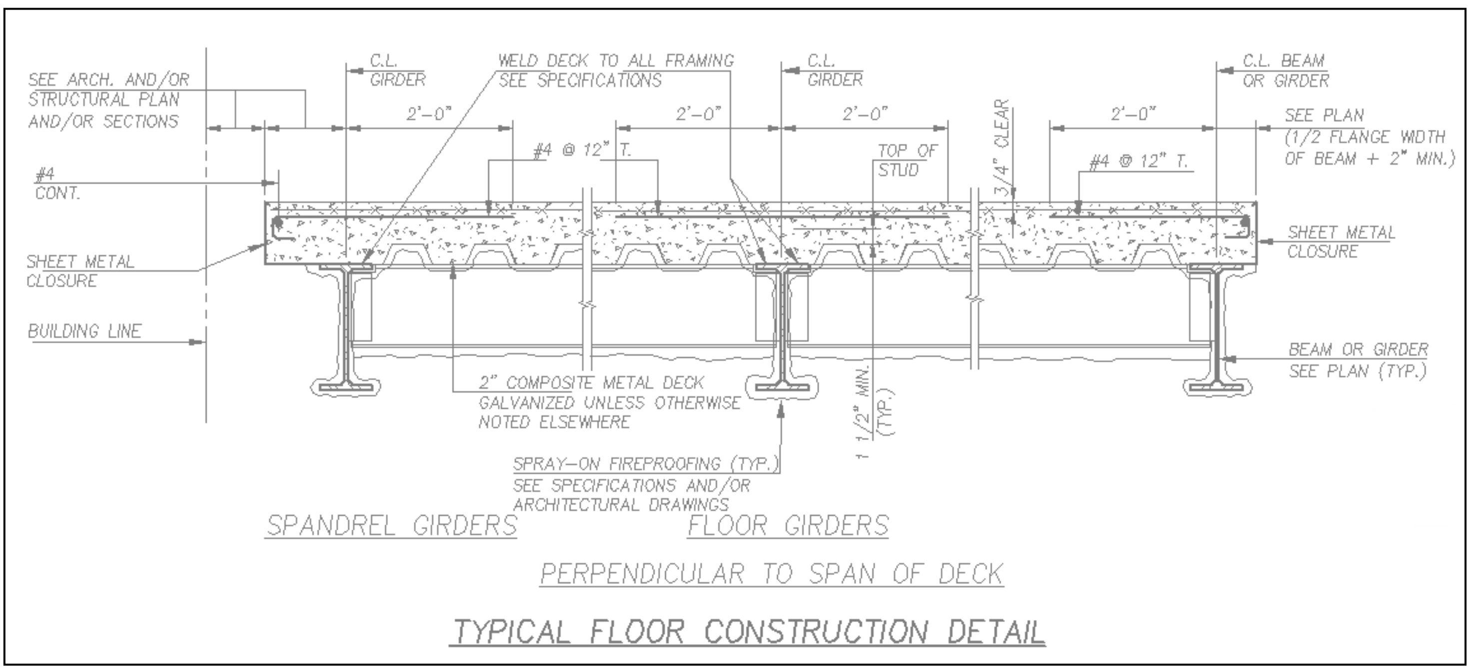
Floor System

The floor system employed in the 40 Gold Street building design is primarily slab on composite metal decking. Aside from the cellar floor system, the floor system is a 2" – 18 gage metal decks with 2 ½" light weight concrete topping as shown below in figure S-3. This one-way floor system operates to transfer gravity loads down to the supporting beams, girders, and columns.

The floor slab is reinforced with #4 @12" bars, and 6x6 / W3 x W3 welded wire fabric is used with a ¾" clearance from top of slab. All concrete used has 4000 psi design strength. In several cases throughout the building, masonry partitions rest directly on the floor system. The areas where the partitions run parallel to the deck span, 2 - #6 bars are required to run on each side of the wall the full length of the wall to the first support beyond each end of the wall. Also, for the situation where the masonry partitions run perpendicular to the deck span, # 4 reinforcement bars run the full extent of the wall in each flute of the metal deck floor system.

The concrete is attached to the metal decking by equally spaced shear connectors. The shear studs extend a minimum of 1 ½" above the top of the metal decking. For the most part, the floor system throughout the building requires ¾" headed shear connectors @ 1' 0" or less.

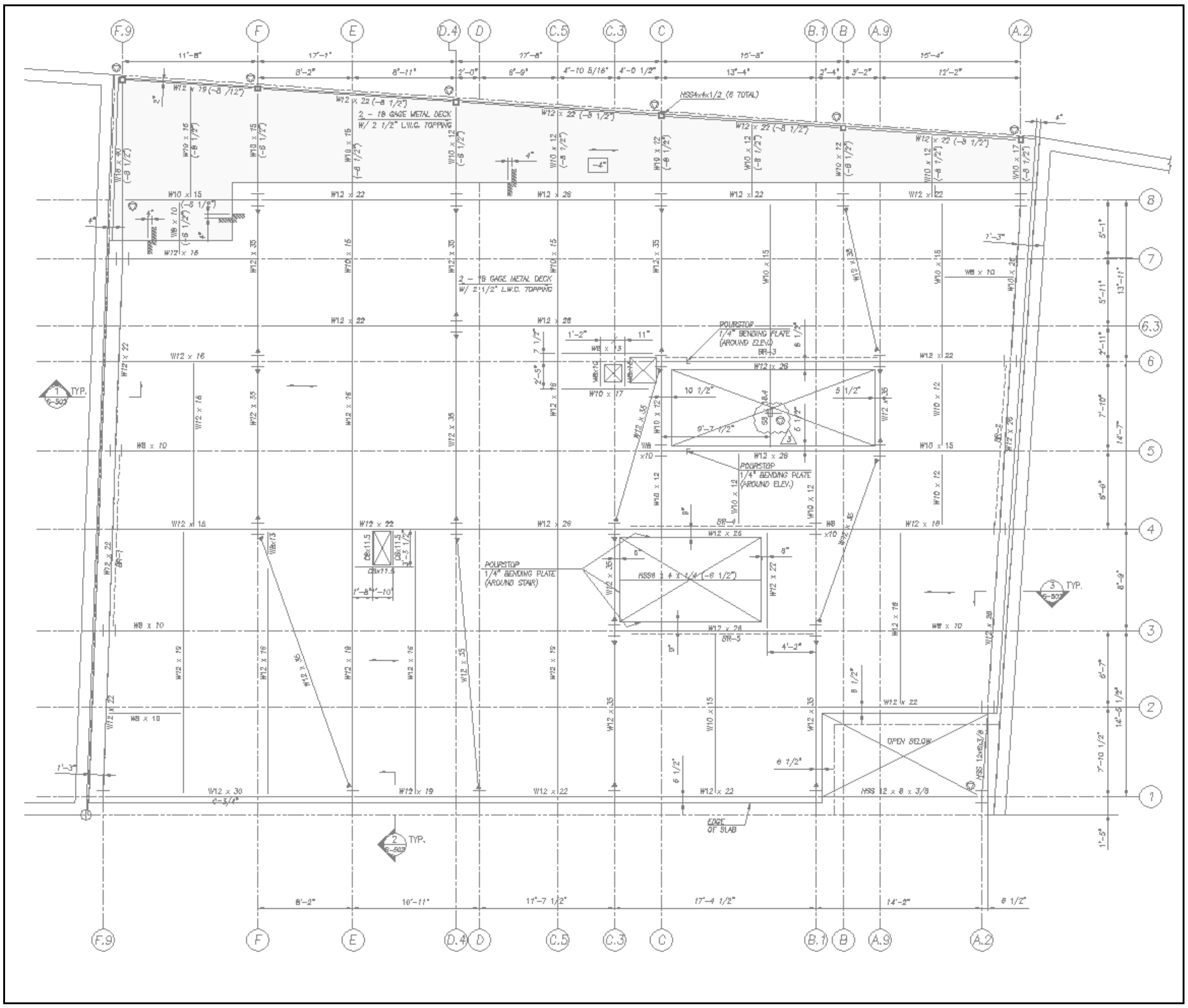
The cellar floor consists of a two-way 8" slab on grade with #5 @ 12" on center, top and bottom each way. The cellar slab rests on a 6" layer of crushed stone. More importantly, the cellar floor which is sub grade required a change in elevation as a consequence of closely surrounding structures and foundations. At the exterior sections of the cellar floor, the slab is raised up relative to the adjacent existing foundation. A slab depression of approximately 8'0" exists, allowing the center part of the cellar floor to rest much lower below grade.



S-3

Floor Framing

The floor system is supported by a uniform grid like layout of W-shape beams and girders. As seen below in figure S-4, there are only a few irregularities, in which beams span diagonally across the plan. These beams are designed with moment connections, and serve as a part of lateral resisting moment frames. Figure S-4 represents the floor framing at level 2, and this same general layout is repeated throughout the rest of the building. Although the bay sizes vary, the average bay size is approximately 15' 8" x 14' 0".



S-4

Level 2 Framing Layout

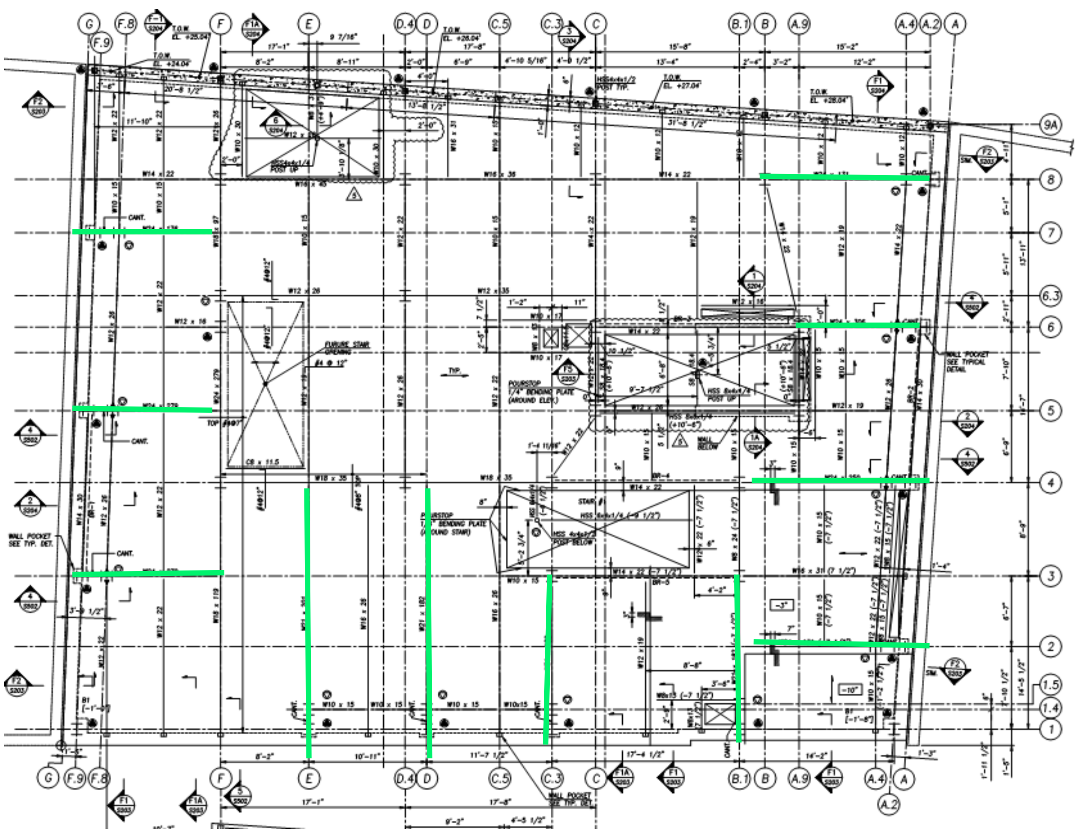
Gravity System

The gravity loads are resisted by a steel frame system. Figures F-2 and F-3 provide a close up look at the unfinished steel frame structure. The majority of the vertical structural elements are W-shapes aside from a few HSS4/4/3/8. The column sizes are nearly constant from level to level, but a slight reduction in size is observed near the top of the structure. The column splices are all located at 2' -6" above each finished floor. Almost all columns rise two floors. The steel frame not only resists the gravity loads transferred from the floor system, but also supports the entire exterior envelope. The beams and girders are all W-shapes and are all treated with spray on fireproofing. The beams and girders range from W10's to W14's; however, at the second level several beams project 2 feet outward and behave as cantilevers to support the 13 stories above. Each cantilever is highlighted in figure S-5. These members are as large as W24x279's.

F-2

Figures F-2 and F-3: 40 Gold Street under construction

F-3



S-5

Highlighted Beams Cantilever outward 2 feet

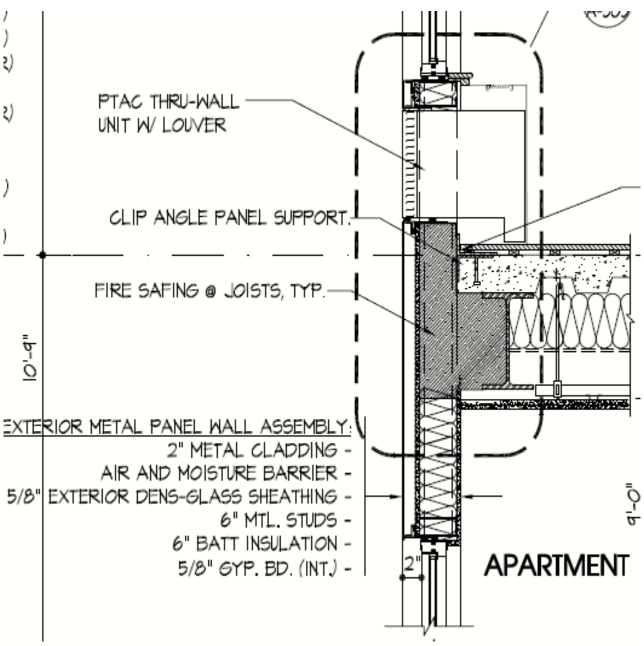
Sustainability

Although the overall design wasn't driven by sustainability, the 40 Gold Street building includes several green features throughout the design. The apartments are equipped with energy star appliances. In addition, the windows are assembled with low-emissive glass. The roofing materials are designed to prevent or minimize the heat island effect, and the building envelope is highly proficient for thermal and moisture protection. The exterior façade also has an 8" metal fin projecting out from above each of residential windows, which serves as a shade device.

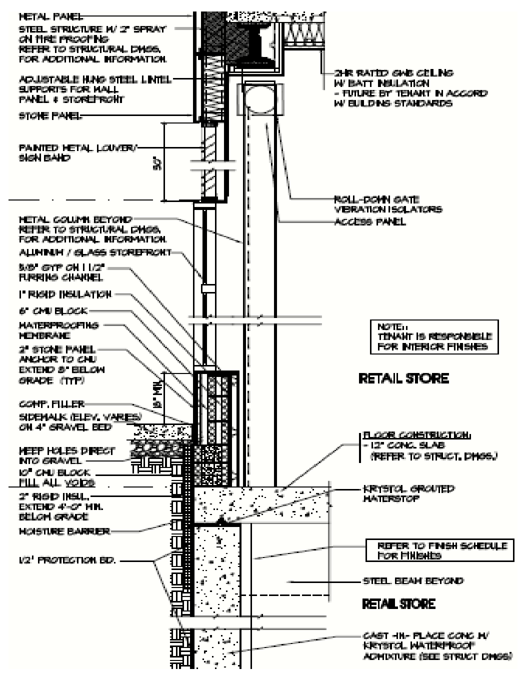
Building Envelope

Floors 2-14 are enclosed by a basic non-bearing exterior metal panel wall assembly. The general composition of the wall shown in figure S-6 is 2" metal cladding (exterior), air and moisture barrier, 5/8" exterior dens-glass sheathing, 6" metal studs, 6" batting insulation, and 5/8" gypsum board (interior).

The sub grade spaces, also referred to as the cellar, are enclosed by a cast-in-place concrete wall. A detail of the enclosure can be seen in Figure S-7. Retail areas on the street level are enclosed by a large aluminum and glass storefront anchored to a basic CMU wall assembly which consists of 2" stone panel (exterior), waterproofing membrane, 6" CMU, 1" rigid insulation, 5/8" gypsum on 1 ½" furring channel (interior). The storefronts are also equipped with a roll-down gate for security purposes.



S-6



S-7

Typical Building Envelope for Residential Tower

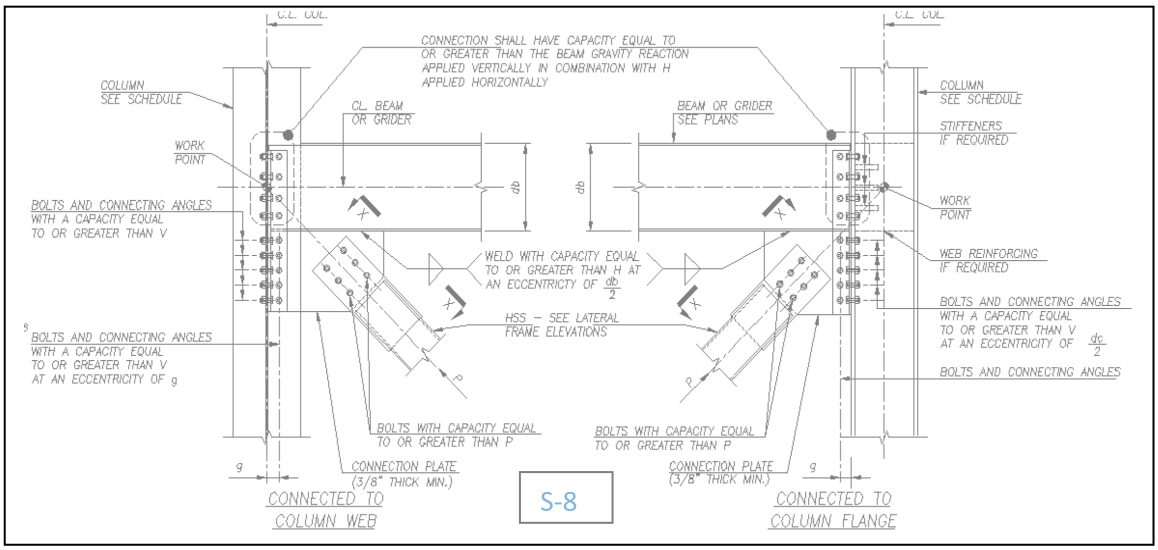
Typical Building Envelope for Ground Floor

Roof System

40 Gold Street features an ordinary flat roof, whose framing is comprised primarily of W12x22 and W12x30 beams supporting the typical 2” – 18 gage metal decks with 2 ½” light weight concrete topping. Mechanical equipment is located on the roof and C channels are used for additional support. The roof terraces feature a slight different assembly. The terraces feature the Inverted Roof Membrane Assembly (IRMA) that works in conjunction with 2’x2’ Concrete Pavers on pedestals. The insulation layer is an extruded polystyrene layer placed over the roofing membrane.

Lateral System

The lateral system of 40 Gold Street consists of 5 braced frames and 4 moment frames. Figure S-10 shows the moment frames, which span east to west across the building, in red. The braced frames are shown in green. The moment frames are skewed since several of the building's footings are offset to avoid disturbing the adjacent structural foundations. The moment frame along column line A.9 is skewed due to architectural constraints. Figure S-8 illustrates the typical connections and structural members that form the braced frames, and figure S-9 provides an elevation view of the braced frames spanning from the foundation up to the roof level. The cross brace elements that form the braced frames are HSS shapes. The lateral system is laid out symmetrically. In addition, the building's shape and weight distribution is symmetrical. As a result, assuming the rigidity of each lateral resisting frame is not too variable; the center of rigidity is located near the center of mass. In consequence, the potential for torsion effect due to seismic load is lessened.



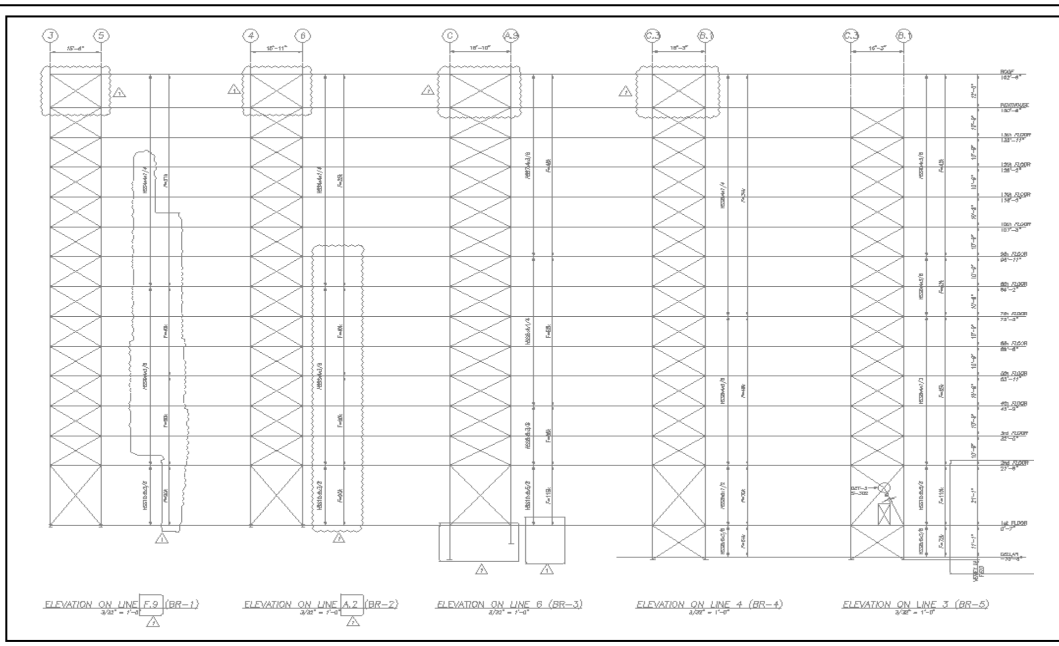
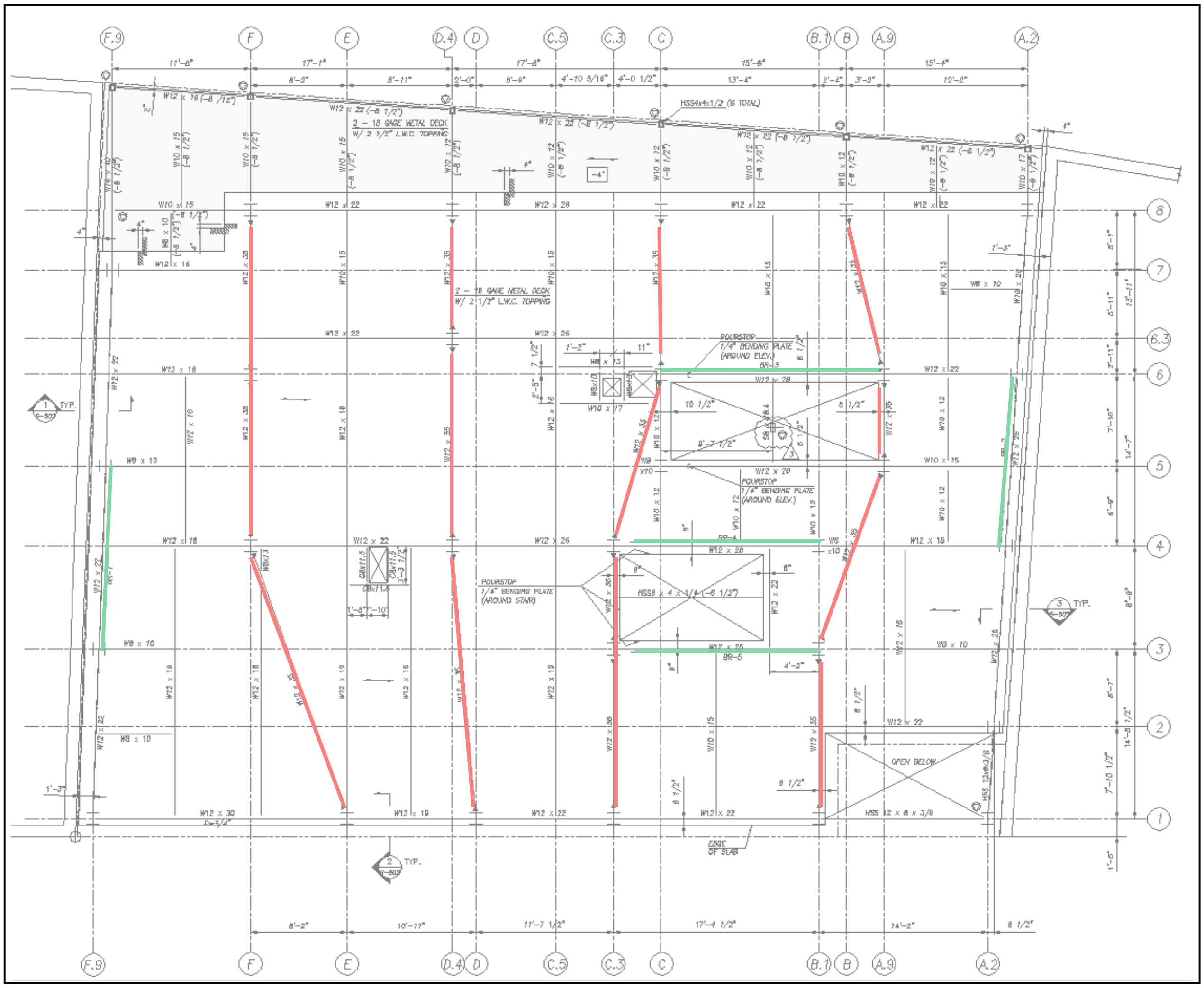


Figure S-6 details the typical brace frame.

Figure S-7 shows the five braced frames in elevation

S-9

LATERAL SYSTEM LAYOUT



S- 10

Moment Frames

Braced Frames

Problem Statement

Project Goal: Redesign the structural system to optimize the buildings performance as a residential structure without significantly deviating from the final product envisioned by the owner.

40 Gold Street's existing structural system consists of steel framing and lightweight slab on composite metal decking. Located on a site with poor soil conditions, significant settlement potential exists. With two existing structures located within great proximity of the 40 Gold Street building, the ramifications of settlement would be profound. Structural design engineers, Severud, determined that a steel structural system was necessary to minimize total building weight and avoid disturbing the neighboring structures.

Although the existing steel structural system sufficiently meets the various requirements associated with a residential building, several aspects of the design require improvement in order to optimize the building's performance. With the current steel frame structural system, a larger total floor construction depth results in a poor floor-to-ceiling height. Also, the existing system requires additional fireproofing (spray on) and interferes with critical spaces often reserved for MEP equipment and raceways. Unlike the existing steel frame system, alternative concrete structural systems offer superior vibration and acoustic control. Most importantly, Werber Management, the 40 Gold Street owners, expressed that, if practical, a concrete structural system was their first preference.

In summary, the challenge of this study requires designing and evaluating an alternative structural system that meets the clients request for a concrete system and appropriately addresses the potential settlement issues without sacrificing the building performance.

Proposed Solution

Proposal: To redesign the 40 Gold Street building using a two way flat plate system. This will also involve a redesign of the foundation system and devising a plan for soil remediation and underpinning.

After evaluating several concrete structural systems in Technical Report 2, the two-way flat plate system was identified as the best alternative structural system. With small average bay sizes of approximately 14'-0" x 16'-0" and the low residential live load (40 psf), preliminary design calculations revealed a two way flat plate floor depth of 8" could be achieved. This is a significant reduction from the existing 1'-7" floor depth. With the improved floor to ceiling height, owners and designers are presented with the option to include additional stories or higher ceilings without improving the total building height. The two-way flat plate system is also attractive because it requires simple construction, simple formwork, and widely available materials. Additional advantages include flexibility for partition location, superior vibration and acoustic control, and no additional fire resistance is required. Perhaps the most significant advantage is the ability to utilize the floor system as both an architectural and structural element. The concrete slab is commonly left exposed and serves as finished floors and ceilings in residential spaces.

In order to both verify and demonstrate that the two-way flat plate structural system improves the buildings overall performance in providing a good residential environment, a detailed continuation of the comparison study from Technical Report 2 will be conducted.

Based on the initial analysis conducted in Technical Report 2, a redesign of the structural system as a two-way flat plate system will result in a total building weight that greatly exceeds the current weight of 4,681,330 lbs. In fact, an 8" normal weight concrete slab weighs approximately 100 psf, which is nearly 3 times the weight of the current floor structure (34 psf). Therefore, an additional area of focus will involve a redesign of the foundation system to accommodate for the additional building weight. Currently, the foundation consists of a system of 101 strategically positioned micro piles. Following the redesign of the structural system, new design loads will be calculated and used to design a deep foundation system capable of withstanding the increased building weight.

To supplement the foundation redesign, both underpinning of existing foundations and soil remediation will be considered. With the additional building weight and a constricted site, the new foundation system will likely require excavation and construction activities that will render nearby existing foundations as unstable. Through research and consultation of the structural engineers, Severud, various systems and methods of underpinning will be considered and compared. Systems of helical piers, bracket piles, screw piles, jacked piles and mini-piles will be evaluated.

After reviewing the geotechnical report and consulting ASCE7-05, the site class was determined as D. The current soil is composed primarily of medium dense silty sands and required a robust liquefaction analysis. Although it was ultimately determined that liquefaction is unlikely to occur during seismic ground shaking, soil remediation processes will be considered to reduce settlement potential.

By changing the gravity system to a concrete structural system, the lateral system will be affected. No redesign of the lateral system will be conducted; however, research will be done to determine what type of lateral system should be employed. With the two-way flat plate system, the most logical option would be a series of shear walls at the core and perimeter. The core shear walls would be located around the elevator shaft and stair wells to avoid interfering with the residential spaces and hallways.

Proposed Solution Method

In order to properly complete the proposed solutions, a series of specific steps were formulated summarizing the tasks and tools required. First, with the aid of preliminary design calculations from Technical Report 2, a 3D ETABS model will be created to model the floor system. Upon modeling the floor system, basic statics checks and troubleshooting procedures will be carried out to ensure the model is accurate. Next, the two way flat plate will be designed via hand calculations according to ACI . Hand calculations will provide slab thickness, flexural reinforcement sizing and layout. Flexural, shear, and deflection checks will all be included in the hand calculations. If necessary, shear reinforcement will be designed as well.

Next, column design will be done using PCA column and hand calculations. The design loads will be calculated, and account for the new floor system weight. After considering special structural areas and completing the entire gravity system redesign, the increased building weight will be calculated. With the new loads, the existing foundation system will be modified or redesigned to account for the increased loading. The foundation redesign will consist of employing a deeper foundation system consisting of a series of micro piles. Additionally, extensive research will be done on soil remediation and underpinning.

Breadth Topics

In addition to the structural proposal, two non-structural aspects of 40 Gold Street will also be investigated. With the redesign of the gravity system and foundation system, significant changes pertaining to construction management and architecture are expected.

Breadth 1: Construction Management Study

In order to properly evaluate how a two way flat plate system will affect the project, cost and schedule will be taken into consideration. By changing the current system to a two way flat plate, the construction process and materials will be completely different. Prior to beginning this investigation, research and an interview with the project manager will be conducted to acquire any pertinent information regarding the projects construction process such as constructability issues, material availability, material costs, cost of labor, construction phasing, and construction time. With the aid of Microsoft Project and Navis Works, a schedule and 4D phasing model (4D model only if time permits) will be to created to determine how constructability and overall project costs are affected.

Breadth 2: Acoustic and Vibration Control Study

A major feature of a high quality residential building is the ability to provide tenants with living spaces that have sufficient sound and vibration control. Various floor and wall assemblies will be compared to determine the best option for sound control and vibration control. The two way flat plate system will also be compared to the current floor framing system to demonstrate how the redesign improves sound and vibration control. STC ratings, which represent an approximated performance of a material in reducing the transmission of speech, will be determined for the various wall and floor assemblies including the two way flat plate and existing system. In addition, NR values will be considered to compare how well various floor and wall assemblies can isolate a residential space (receiving room) from an adjacent room (source).

MAE Course Related Study

As required for this project, important concepts and skill sets pertaining to MAE coursework are integrated into the proposed solution. Computer modeling software and techniques used in AE 597A will play an integral role in the redesign of the gravity and foundation systems. Basic concepts such as rigid diaphragm modeling, rigid end offsets, insertion points, shear deformations, property modifiers (ie. 50% of gross section properties for cracking), and shell elements will be applied to SAP2000 and ETABS modeling.

Tasks and Tools

Primary study – structural

1.) Design two-way flat plate system
   a. Create 3D ETABS-model
   b. Hand calculations – Direct Design Method ACI 318-08 Chapter 13
      i. Determine slab thickness
      ii. Determine flexural reinforcement (sizing, length, layout)
      iii. Shear check: wide beam action and two-way punching shear
      iv. Design shear reinforcement (if necessary)
   c. Check flexure and deflection
   d. Consider special structural locations (existing system has several locations with non-typical load paths)
      i. First floor cantilever beams in existing system
      ii. Transfer beam

2.) Design concrete columns
   a. Maintain a column layout as similar to current layout as possible (compare structural and architectural drawings to ensure proper coordination)
   b. Determine new loads and self weight of new floor system (Loads: ASCE7-05)
   c. Hand calculations – ACI 318-08
   d. PCA Column – model and design critical columns
   e. ETABS – Design typical columns
   f. Compare hand calculations with computer model output (for verification of design

3.) Design foundation system
   a. Determine loads and total building weight
   b. Check current foundation system for new loads
   c. Redesign mini-piles and pile caps according to new loads (if necessary)
   d. Conduct Research
      i. Topic – Soil remediation (will require thorough review of geotechnical report)
      ii. Topic – Underpinning
         1. Determine if it will be required
         2. Establish what methods and/or types of underpinning are most applicable

4.) Analyze improved floor-to-ceiling height
   a. Determine Current Total Floor Depth, Story Heights, and Total Building Height
   b. Determine new total floor depth
   c. Review Building Height Limitations and Set Backs
   d. Evaluate the various benefits of the improved total floor depth
      i. Consider additional stories
      ii. Consider a shorter building
      iii. Consider higher ceilings (more spacious apartments)
      iv. Compare pros and cons of each

Breadth 1: Construction Management Study

1.) Acquire schedule, cost, and other construction related information for existing building.
   a. Interview (by phone or in person) project manager
   b. Research and gather related information and documents
2.) Create schedule for proposed building
   a. Research
   b. Microsoft Project – create schedule
   c. Navis Works – create a basic 4D model demonstrating phasing and time management (if time permits)
3.) Research Labor Unions (specifically in New York)
4.) Compare existing building to proposed design
   a. Cost (material/labor)
   b. Schedule and time constraints
   c. Constructability
   d. Material and laborer availability

Breadth 2: Acoustic and Vibration Control Stud

1.) Research the acoustic control performance of the existing floor system and two way flat plate system
2.) Determine STC and NR ratings for each system
3.) Sound control comparison study
4.) Repeat process for various wall assemblies (as well as modifications of two way flat plate)
5.) Research vibration control performance of the existing floor system and two way flat plate system
6.) Vibration control comparison study
7.) Gather data and make report explaining both the magnitude and significance by which the proposed concrete structural system can improve the buildings sound and vibration control.

Schedule

TASKS	DATES	Jan 11 - Jan 15	Jan 18 - Jan 22	Jan 25 - Jan 29	Feb 1 - Feb 5	Feb 8 - Feb12	Feb 15 - Feb 19	Feb 22 - Feb 26
Create 3D ETABS Model								
Hand Calcs - Slab Thickness / Flexural Reinforcement / Shear, Flexure, Deflection Checks / Shear Reinforcement								
Consider Special Structural Locations								
Begin Column Design - Determine Final Column Layout, Tributary areas, self weight, and new loads								
Hand Calculations								
Create PCA Model - Design Columns								
Hand Calcs - Design Typical Columns								
Hand Calcs 0 Design Critical Columns								
Verify and compare PCA model results with Hand Calcs								
Begin Foundation Evaluation and Redesign								
Determine Loads and Total Building weight								
Check Current Foundation system for new loads								
Research Other Foundation Systems								
Redesign Foundation System For New Loads								
Conduct Research - Soil Remediation								
Conduct Research - Underpinning								
Make Conclusions Regarding Applicability and Practicality of soil remediation / underpinning								
Begin Construction Management Study - Acquire Schedule and Cost information for existing building								
Contact Construction Manager / Set Up Phone Interview								
Conduct Interview to Obtain Other Important Details								

TASKS	DATES	Mar 1 - Mar 5	Mar 8 - Mar 12	Mar 15 - Mar 19	Mar 22 - Mar 26	Mar 29 - Apr 2	Apr 5 - Apr 9	Apr 12 - Apr 16
Microsoft Project - Create Schedule For proposed building design								
Navis Works - Create basic 4D Model of proposed building design and associated scheduling and phasing								
Research Labor Unions (Specifically in New York City)								
Begin Acoustic and Vibration Control Study								
Research								
Determine STC and NR Values								
Determine Vibration Control performances								
Create Report and Charts Demonstrating Improvements of two way flat plate over existing system								
Create Final Report and Presentation								
THESIS PRESENTATION								

Concluding Remarks

Located in lower Manhattan, 40 Gold Street is an impressive 14 story building that features a highly efficient structural system and showcases an impressive modern style of architecture. The current gravity resisting system consists of steel framing and a light weight concrete slab on composite metal decking. In order to improve the residential environment of 40 Gold Street, the structural system will be redesigned as a two way flat plate system with rectangular concrete columns. With an expected slab thickness of just 8", the floor-to-ceiling height will be significantly better. More importantly, the two way flat plate system is a concrete structural system which the owner preferred.

As a consequence of redesigning the gravity system, the building weight will most likely exceed the original foundation design loads. Therefore, the foundation system will be redesigned to account for the increase in load. With poor soil conditions and close by existing foundations, soil remediation and underpinning will be considered, if necessary, to prevent settlement.

Additional areas of focus will include a cost and schedule analysis as well as a vibration and acoustic control analysis. It is also important to note that several concepts and skill sets pertaining to AE coursework will be utilized to complete the proposed solution process. Specifically, AE 597 A concepts and computer modeling software (SAP2000 and ETABS) and AE 431 Software (PCA) will be used for design.