706 Madison Avenue | New York, USA

Structural Proposal

Structural Assignment 5

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Executive Summary

706 Madison Avenue is a 48,500 square-foot, high-end retail building located on the southwest corner of Madison Avenue and 63rd Street of the upper east side of Manhattan, New York. The building consists of a 3-story existing landmarked building and a five-story horizontal extension on two sides.

The existing landmarked building was built in 1920 and was initially constructed with masonry walls, steel columns, cinder concrete slabs, and marble and brick façades. Back in the 1920s, building codes didn't require seismic design for structures. So the old building wasn't designed to resist seismic load; however, the masonry walls and core stairwells in the building have been designed for wind.

Construction began on March 2015. It is still under construction and scheduled to be done in January 2016. The structural system of the addition consists of steel columns, concrete slab with composite metal deck, a mat foundation and moment frames for the lateral load resisting system. Since it's difficult to rebuild the old building with the new building codes, the lateral system of existing building is kept. The addition's lateral load resisting system is designed independently from the existing building.

The building's design was based on the 2008 New York City Building Code. Additionally, the exterior of building needed to meet the historical requirements, which are regulated by Landmark Preservation Commission (LPC).

The proposed thesis will include an investigation of a concrete rigid frame structure, a one-way concrete slab system and a reinforced concrete moment frames. The redesign will also propose a reconstruction of the whole building as opposed to an addition of two separate buildings. The façade of existing building will be preserved in order to meet the historical requirements and Landmark Preservation Law.

In addition to an in-depth structural analysis, the historic facade preservation and the alternative building enclosure system will be studied with redesigning the building in the spring 2016 semester.

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[1] <u>Introduction</u>

1.1 Purpose

This report has been written to develop a detailed description of the existing structural system in the 706 Madison Avenue. The building's technical information and challenges have been indicated so that readers can learn the fundamental information of building quickly through the introductory narratives. More detailed structural information of the building has been introduced in subsequent sections, which provide a deeper understanding of the existing structural system of the building.

1.2 Scope

In order to fulfill the objective indicated above, the content of this report will focus on the general and structural aspects, which include an overview of the building, structural framing systems, lateral resisting systems, foundation systems, joint connections, load determination and load paths. In addition, the other aspects related to the building will be briefly described in this report. These include the building enclosure/façade, code requirements and the historical requirements.

1.3 General Building Description

706 Madison Avenue consists of a three-story existing landmark and a five-story new addition on two sides. The existing building is protected under the Landmark Law and a very important part of the City's heritage and that LPC (Landmark Preservation Commission) must approve in advance any alternation, reconstructions, demolition, or new construction. The total area of the building is 48,500 square feet. As shown in the Figure 1, the existing building is rectangular shape on the up-right corner and about 72' x 40'. The new enlargement is L shape and dimensions of all perimeters are shown in the figure. The building was converted from a bank to a high-end retail use, which includes a sub-cellar floor with storage and mechanical spaces, multiple floors of retail clothing stores, and an outdoor-café roof terrace as shown in the Figure 2 below

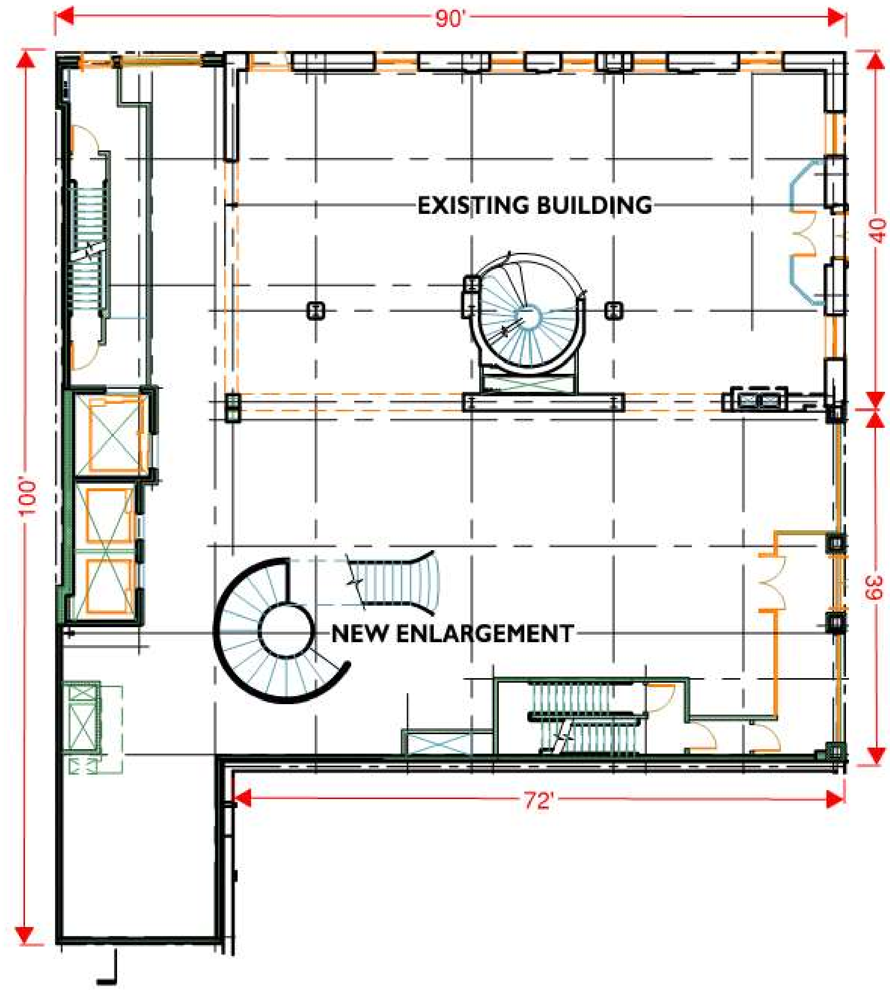


Figure 1 – Building Floor Plan

Figure 2 - Building Section from 63 Street

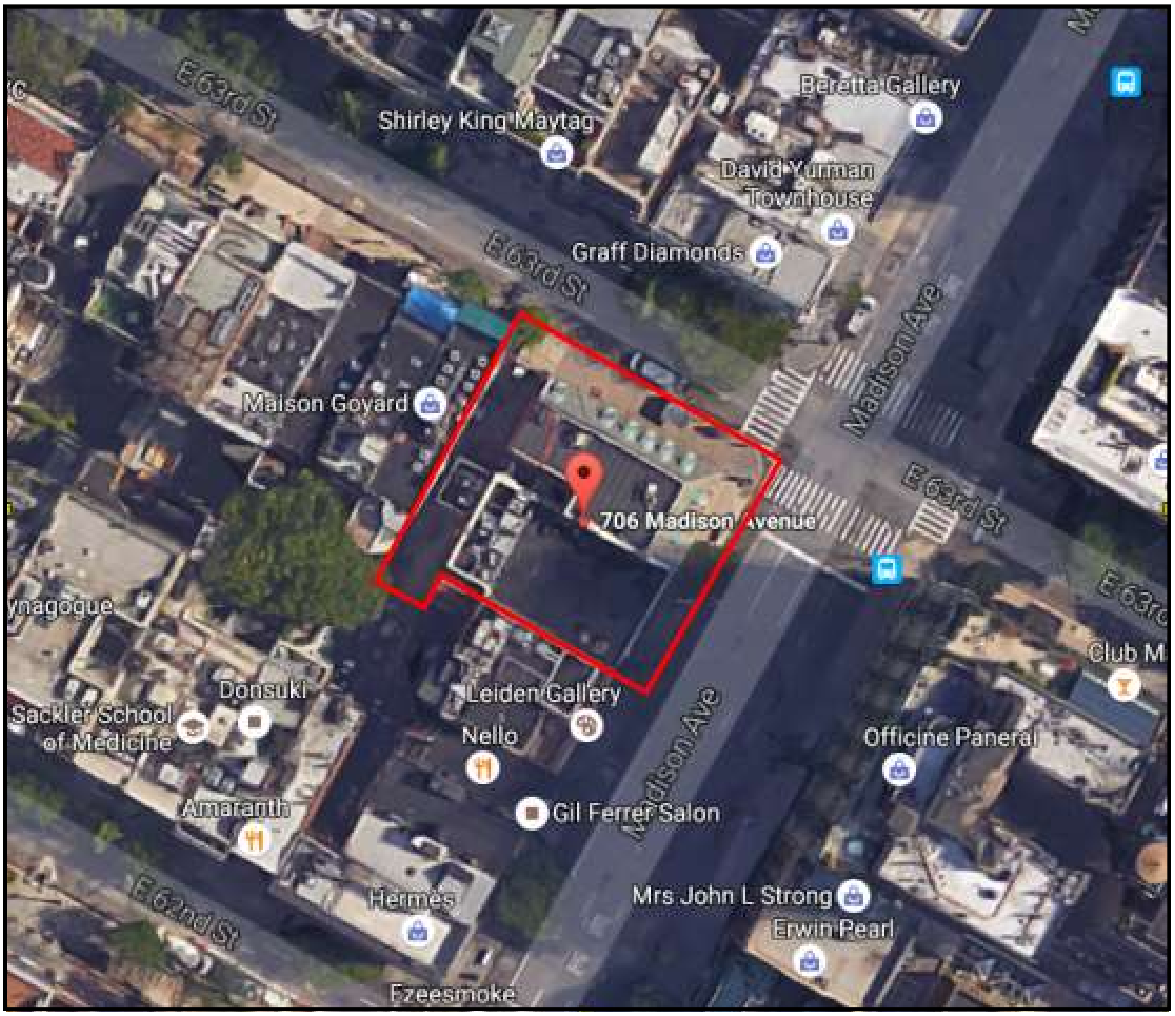


Figure 2 - Building Site [Courtesy of Google Maps]

As shown in the Figure 2 above, 706 Madison Avenue is located at the southwest corner of Madison Avenue and East 63rd Street, which is in an historical district at the upper east side of Manhattan, New York. The district preserves and reinforces the unique retail and residential character of Madisonn Avenue an the surrounding area. Since the building is in the historical district, the historical requirements for buildings influence the design of this building, especailly in building façade design.

This building started design development in March 2015 and will be finished in January 2016. The project delivery method is design-bid-build and the cost of the project is estimated to be $1000 per square foot without design fees. The building is designed by Page Ayres Cowley Architects and the structural consultant is Simpson Gumpertz & Heger (SGH). JRM construction has been chosen to be the construction management team cooperating with the designers and individual contractors to construct the building on site.

1.4 Structural Framing System Overview

In the 1920s, the existing landmarked building was built to be a steel frame structure with a structural assembly including beams, columns, cinder concrete slabs, masonry walls and a masonry core. Cinder concrete slab construction became one of the most dominant structural slab systems used from the 1920s to the 1940s. However, the cinder concrete slab cannot span longer since the steel draped wire mesh in the slab is not able to provide enough tension force. Therefore, it's replaced by the composite deck with concrete slab. The columns in the center of the building are able to be tear out to have a more open space for retail use. Considering the lateral system in the existing building, the exterior masonry walls and interior stairwells were designed to resist wind loads.

The addition is structurally independent from the existing building. The structure of the addition is comprised of composite metal deck with concrete slab, moment frames as a lateral load resisting system and mat-slab foundation. The doorways are adjoin two building which are separated by four inches spacing. . The addition will be analyzed in the following reports due to its height, complexity and accessibility.

The design of the new addition was challenging due to the constrained site conditions. The building has two below-grade stories where the new excavation is adjacent to historic townhouses. Because of multiple unforeseen conditions, including a tangent-pile wall misalignment, below-grade protrusions at the adjacent buildings, and high ground water, the team needed to re-design the foundations and lateral system of the addition several times as the construction proceeded.

[2] Structural Framing System

In this section, the detailed structural framing systems within the building will be introduced and discussed, including typical bay framing, floor and roof framing, foundation system, columns, lateral load resisting system, and load paths.

2.1 Typical Bay Framing

The typical bay framing in this building is classified into two bay categories: ordinary bay framing in the addition and the renovated bay framing in the existing building as shown in the Figures 4 and 5 below. The dimensions of the bay in the addition is approximately 29'-0" x 16'-0" and the dimension of the renovated bay is approximately 17'-7" x 19'-7". Two bays are both framed by steel beams, steel columns, and a composite metal deck with concrete slab.

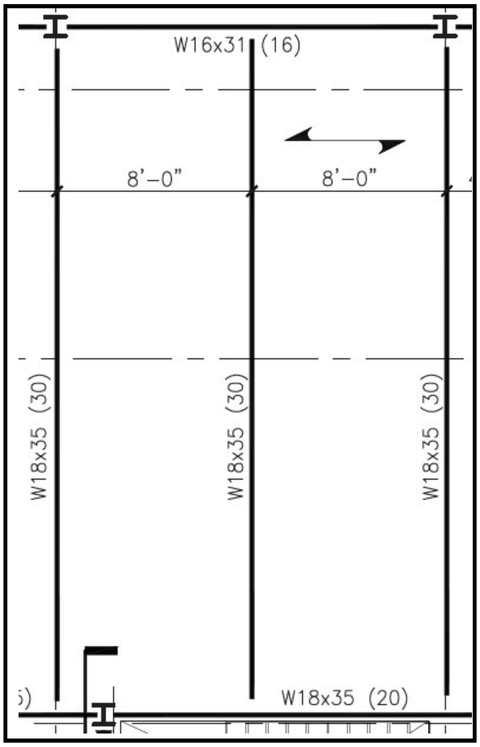


Figure 4 - Bay Framing in the Addition

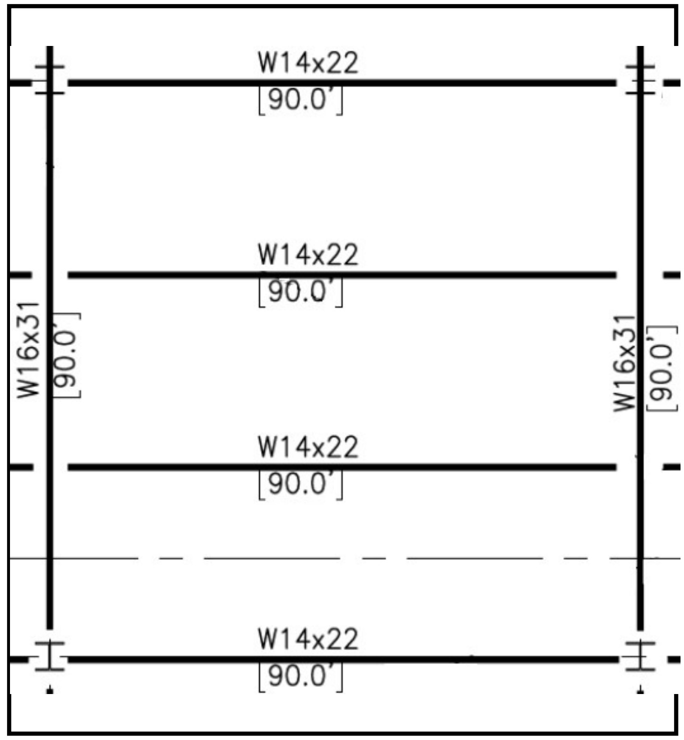


Figure 5 - Bay Framing in Existing

2.2 Floor and Roof Framing

The cinder concrete slab construction in the existing building is replaced by a concrete slab on composite metal deck, which is made of by 3 ¼" lightweight concrete over 1 ½"-18GA metal deck reinforced with welded wire fabric (WWF4x4). The addition adopts similar slab/deck system; however, it uses 3"-16 GA. metal deck to accommodate longer slab spans. Furthermore, headed shear studs are arranged to be 1 stud per foot in order to provide a composite construction for the slab and the steel beams. A typical detail for the reinforcement of the concrete slab is shown below in Figure 6.

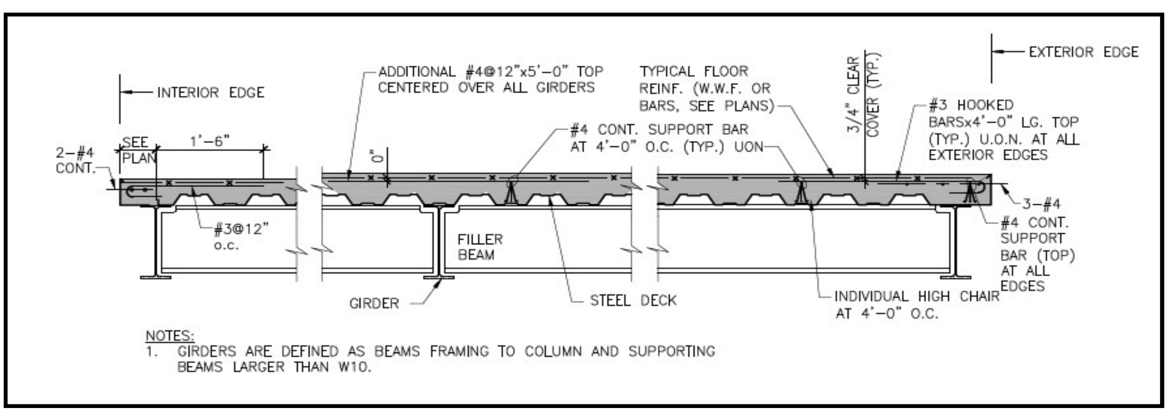


Figure 6 - Typical Floor section

2.3 Foundation System

The foundation system of 706 Madison Avenue addition is comprised of 2'-6" thick mat slab reinforced with steel reinforcements at the top and bottom. Shear reinforcement is also provided around the steel column and base plate to prevent the foundation from cracking due to shear. Figure 7 shows a detailed diagram of the reinforcement of the foundation slab as well as the 24" concrete pile wall along the slab step. The minimum reinforcement in slab is at least 0.0018 times the area of the concrete in each direction. The minimum concrete clear cover is 3" at the bottom of the mat slab and 2" at the top of the mat slab.

The concrete slab that runs horizontally and vertically through the foundation has a compressive strength of 5000 psi. According to a recommendation given by geotechnical engineers, the mat slab is designed for a maximum allowable bearing of 2.5 KSF typically and 4 KSF in the southwest corner of new addition.

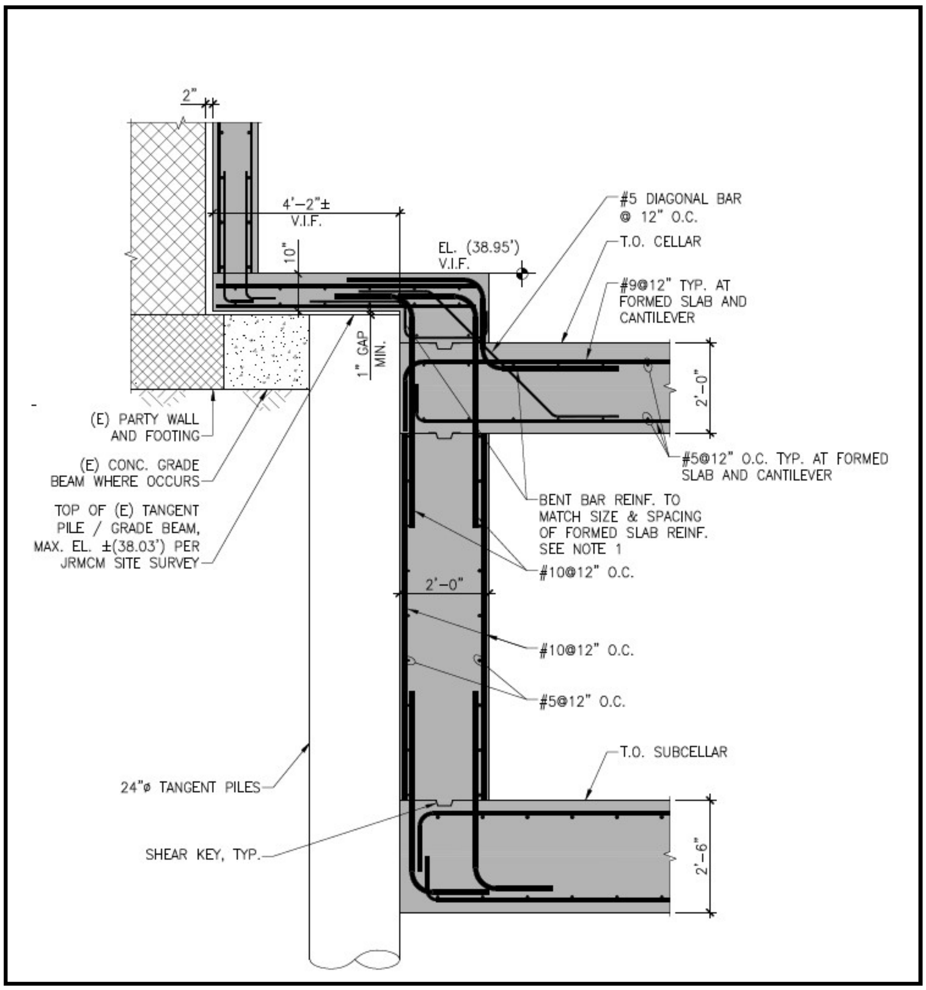
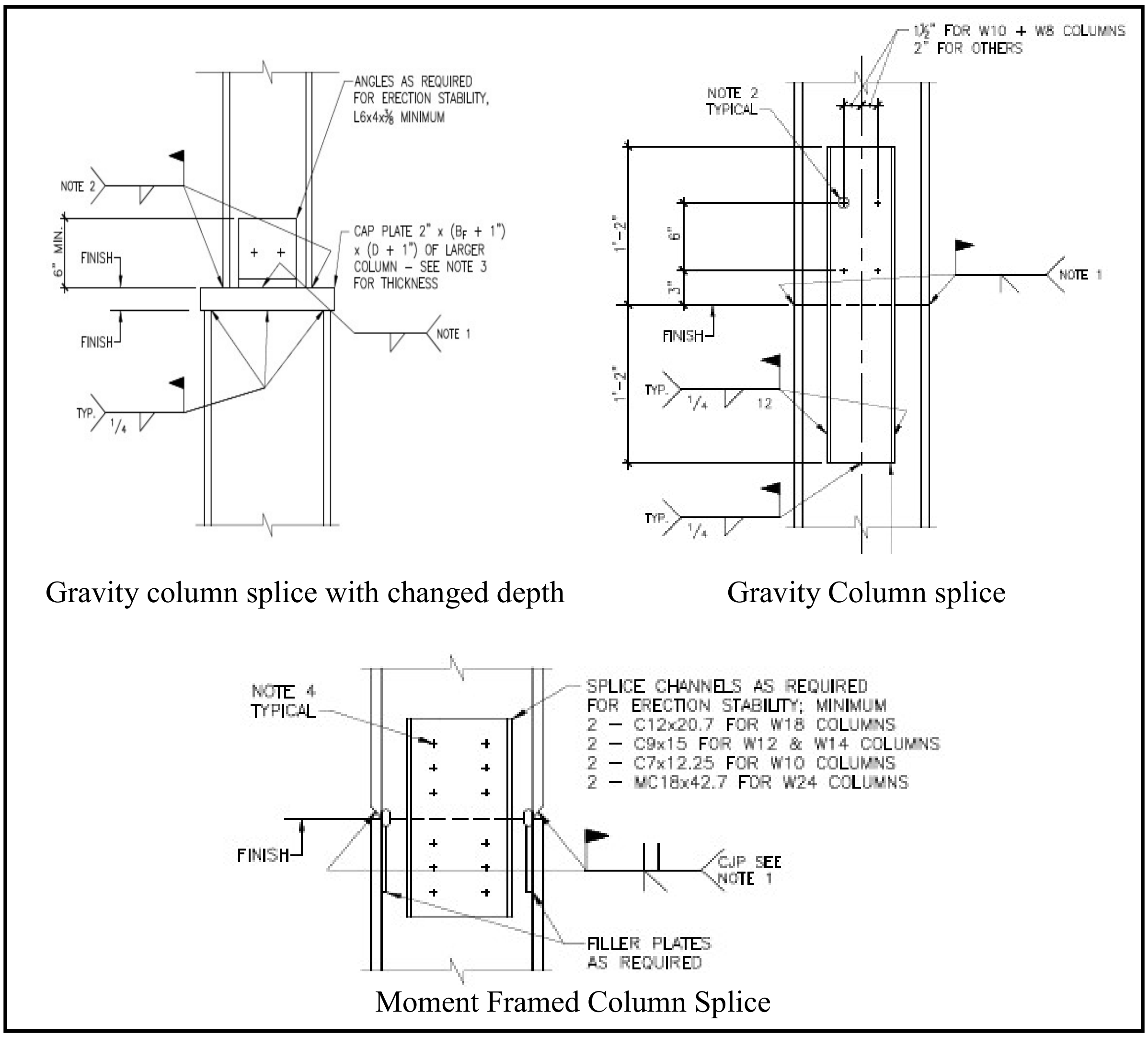


Figure 7 - Slab Step Section

2.4 Columns

The structural columns specified in structural framing design of the 706 Madison Ave are mostly W-Shape ASTM A992/A992M steel columns and a small group of HSS ASTM A500 hollow steel columns in the corridor or around stairwells. Most columns from sub-cellar level to cellar level are W10. Column size is in a range between W10 to W14 and the largest size of the column utilized in this building is W14x176.

The columns are typically spliced at the interfaces between the 1st and 2nd floors, 3rd and 4th floors, and 5th floors and roof. Three different splices utilized in column connection design are gravity column splice, gravity column splice with changed nominal depth, and moment frame column splice as shown in Figure 8. Most of column splice constructions are welded. Moreover, at the foundation all columns will be welded onto ASTM A36 steel base plates and be connected to the foundation mat by anchor bolts.



Gravity column splice with changed depth

Gravity Column splice

Moment Framed Column Splice

Figure 8 - Typical Column Splices

2.5 Lateral Load Resisting System

As mentioned in Section 1.4, the exterior masonry walls and the interior masonry stairwells both serve as the lateral load resisting system for the existing building. All lateral load resistance and stability of the new addition is provided by steel moment frames that are shown in Figure 10. The new addition is seismically independent from the existing building as a result of 4" seismic gap between the addition and the existing building. This is provided in order to accommodate an expansion joint assembly. The moment frames are detailed to include designed lateral connection at the surface of the column and beam as shown in Figure 9.

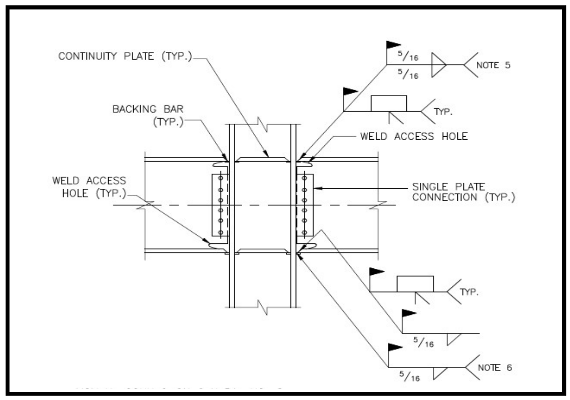


Figure 9 – Ordinary Moment Frame Connection

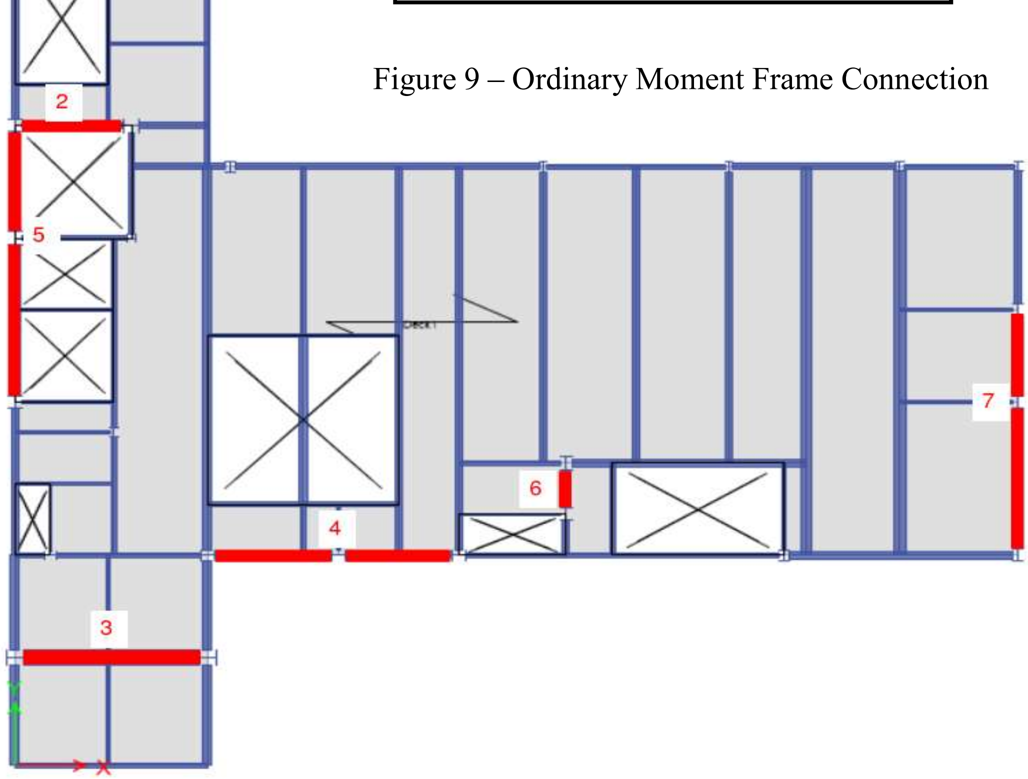


Figure 10 – Ordinary Moment Frame Connection

2.6 Load Paths

In order to determine the load path of the structural design, two load classifications must be considered: gravity and lateral.

The typical gravity loads, including dead, live, snow, and rain will be resisted by the roof or floor slabs transmitted to the steel girders through the beams, and transferred to the mat slab through the steel columns. The mat slab then spreads the gravity load out into the ground. The foundation is designed to prevent the slab from cracking and to prevent differential settlement caused by gravity loads.

Gravity loads are not only type of load that is considered when designing a structure. Lateral loads including wind and seismic loads must also have a complete load path to transfer them to the ground. Unlike gravity loads, which act in a downward direction, lateral loads can act in a horizontal direction or even cause an uplift effect. Wind loads act on the exterior facade of the building directly. Seismic loads are caused by an earthquake. When an earthquake occurs, the earth accelerates and it causes structure to move. The seismic loads are caused by acceleration and mass of the building and horizontally distributed on the structure. Because wind loads and seismic loads hit the building horizontally, they accumulate within the diaphragm, or floor, of a building. As they accumulate, they follow their load path according to stiffness within the structure. In this building, the composite concrete on metal deck floors serves as a horizontal diaphragm that distributes the lateral wind and seismic forces from exterior facades to the lateral elements, which are moment frames. Moment frames then carry the applied lateral loads to the building foundation. The foundation is designed to resist uplift resulting from the overturning moments caused by lateral loads.

[3] <u>Loads</u>

This section focuses on a description of loads that have been used to design 706 Madison Ave and how they were determined per the national codes, standards and design codes.

3.1 Building Codes and Reference Standards

All the building codes, standards and structural design codes used to design 706 Madison Avenue have been listed in the table below (Table 1).

Table 1 – Applicable Codes

Category	Building Codes/Reference Standards
Building Codes	New York City Building Code (NYCBC) 2008
Load Determination	American Institute of Civil Engineers (ASCE) 7-02
Concrete Design	American Concrete Institute (ACI) 301-306, 315, 347
Steel Design	American Institute of Steel Construction (AISC) 360-05
Seismic Design	American Institute of Steel Construction (AISC) 341-05
Welding Design	American Welding Society (AWS)
Composite Deck	Steel Deck Institute (SDI)

3.2 Dead Load

The design dead loads were determined based on the materials' characteristics and manufacturer's data. The structural drawings describes dead load as "All permanent stationary construction". Therefore, dead loads are determined by the self-weight of the building components.

3.3 Live Load

The following design live loads were determined on the basis of the reference standard ASCE 7-02. The primary design live loads haven been found in structural drawings and listed in the table below (Table 2).

Table 2 – Live Loads

Live Load	Load value
1. Retail - 1st Floor	105 psf
2. Retail - Upper Floors (2nd , 3rd, and 5th floors)	75 psf
3. Public Assembly space (4th floor, including setback roof terrace)	100 psf
4. Stairs and Exits	125 psf
5. Storage (Sub-cellar and Cellar)	600 psf
6. Elevator Machine Room	125 psf

3.4 Snow Loads

Where appropriate, drifting snow loads have been considered in accordance with Section 1608 of the Building Code. The primary design snow load information has been found in the structural drawings and listed in the table below (Table 3).

Table 3 – Snow Loads

Snow Load	Load Value
1. Ground Snow Load, P_g	25 psf
2. Flat Roof Snow Load, P_f	20 psf
3. Snow Exposure Factor, C_e	0.9
4. Snow Load Importance Factor, I_s	1.0
5. Thermal Factor, C_t	1.0

3.5 Wind Loads

The following design wind loads are determined on the basis of the reference standard ASCE 7-02. The primary design wind load information has been found in the structural drawings and listed in the table below (Table 4).

Table 4 – Wind Loads

Wind Load	Load value
1. Basic Wind Speed (3 sec gust), V	98 mph
2. Wind Importance Factor, I_w	1.0
3. Wind Exposure	B
4. Internal Pressure Coefficient	+/-0.18

3.6 Seismic Loads

The following design seismic loads are determined on the basis of the reference standard AISC 341-05. The primary design seismic load information has been found in the structural drawings and listed in the table below (Table 5).

Table 5 – Seismic Loads

Seismic Load	Load Value
1. Seismic Importance Factor, I_E	1.0
2. Spectral Response Acceleration, S_s	0.365
3. Spectral Response Acceleration, S_1	0.071
4. Site Class	D
5. Spectral Response Coefficient, S_{DS}	0.367
6. Spectral Response Coefficient, S_{D1}	0.114
7. Seismic Design Category	C
8. Design Base Shear, V	164,000 Ibs
9. Seismic Response Coefficient, C_s	0.16
10. Response Modification Factor, R	3
11. Seismic Force Resisting System	
a. Steel Moment Frames	
b. Ordinary Reinforced Concrete Shear wall	

[4] <u>Joint Details and Connections</u>

Joints and connections are very important components of the building construction because they provide a smooth or flexible place for the building to expand, contract, and move without overstressing the structure and causing cracking problems. This section outlines two different type of joint systems and briefly introduces steel connections.

4.1 Building Expansion Joints

The seismic joint between the new addition and the existing building serves as an expansion joint, which can not only absorb the heat-induced expansion and contraction of concrete slabs or walls, but also provides a space where the concrete slab can move due to the seismic or wind load without overstressing the concrete and causing cracking problems. As shown in Figure 11, the 4" seismic joint, formed with soft material, located between two concrete buildings will allow one of the two buildings to move independently from the other during a seismic or wind event without imposing force on the other building.

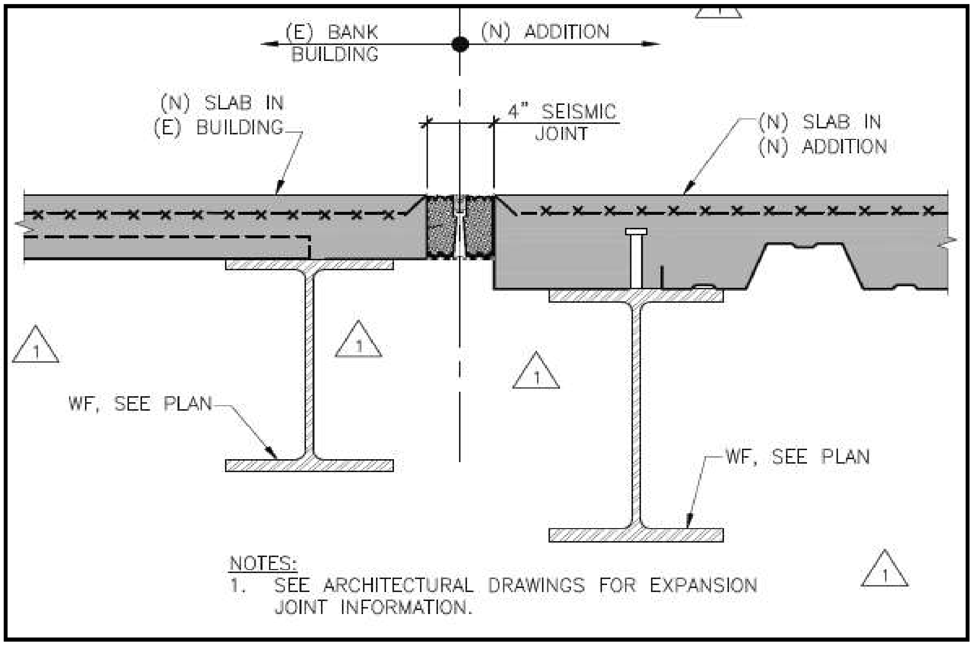


Figure11 – Seismic Joint Between Addition and Existing Building

4.2 Construction Joints

As shown in the figure below (Figure 12 & 13), two type of construction joints are utilized to design the connection of 706 Madison Avenue: the horizontal wall construction joint and the vertical construction joint. As shown in the figure below (Figure 11), the CONT. 1x2 or 12" LONG KEY @ 24" acts as a construction joint and is located at predetermined pour stops or where the first pour stops and the second pour will occur. The joint is to help provide continuity between pours to help maintain structural integrity in shear and reduce cracking.

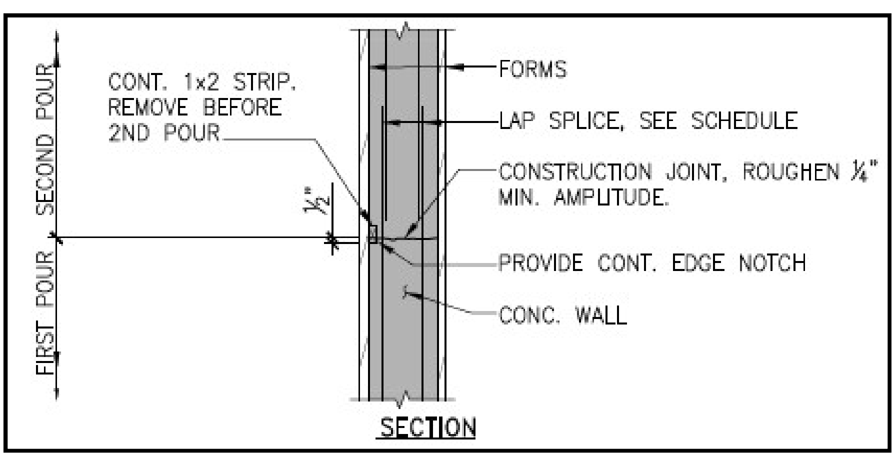


Figure 12 – Horizontal Wall Construction Joint

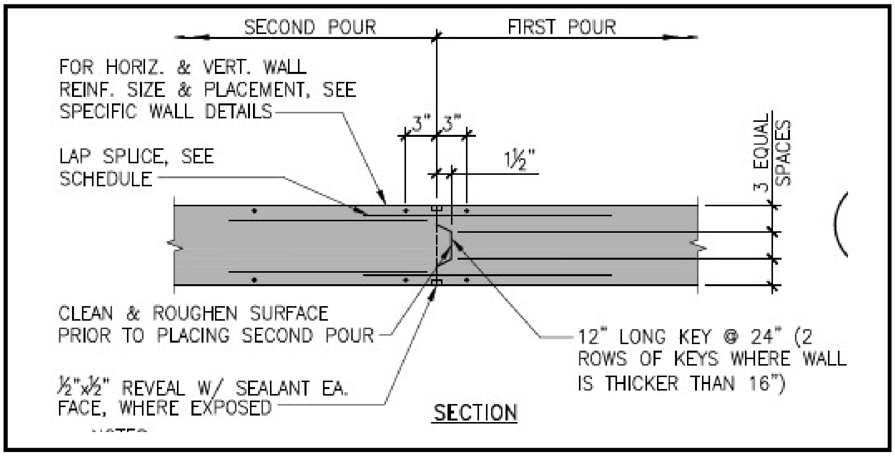


Figure 13 – Vertical Wall Construction Joint

4.3 Steel Connections

706 Madison Ave consists of a series of steel connections, which includes the beam shear connection, typical beam framing to spandrel Beam connection, beam-to-beam moment connection, wide flange column with web parallel to beam web, wide flange column with web perpendicular to beam web, typical moment frame connection and bolted wide flange brace connection, etc. Figure 14 indicates some types of steel connections and details of welding and bolting.

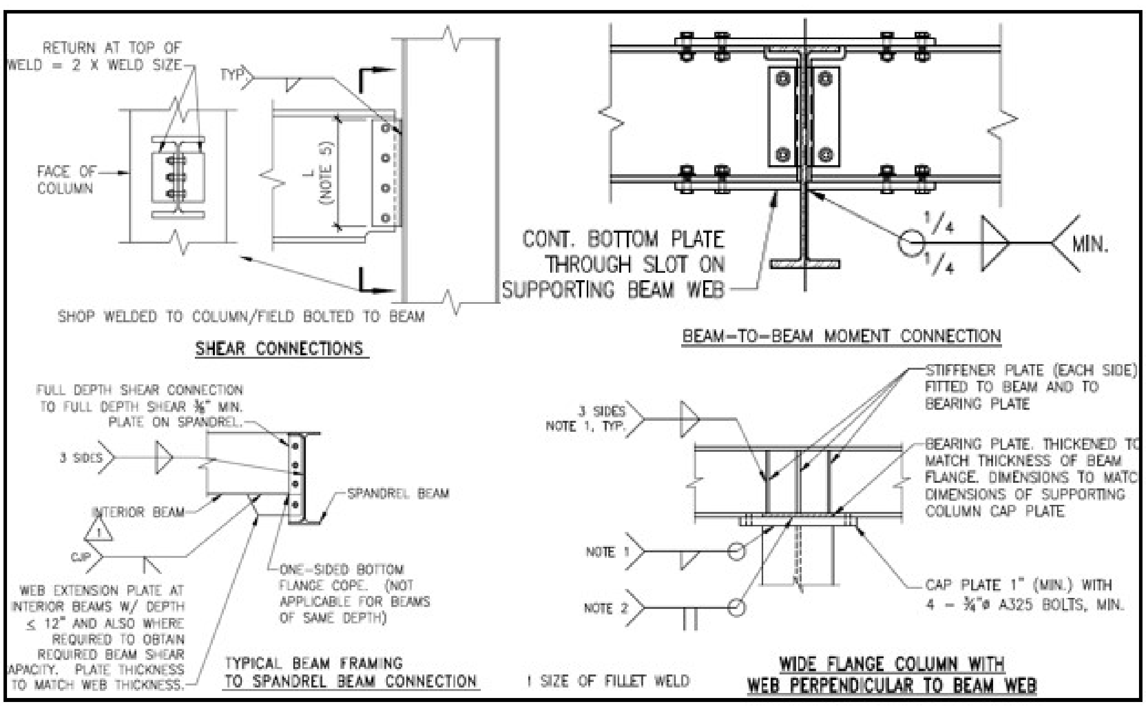


Figure 14 – Details of Steel Connections

[5] <u>Proposal</u>

5.1 Problem Statement

Upon completion of the initial analysis of 706 Madison Avenue, based on the information indicated in the previous reports, the current designs of the building have been proven to be sufficient to meet all necessary strength, code, and serviceability requirements. Additionally, the building meets the historical requirements.

The addition has been designed literally to meet owner's request that was to have a commodious room for retail use. The request has been fulfilled by eliminating interior columns and using transfer girders; however, the space in the addition is not capacious enough to be used efficiently for retail use. As shown in the typical floor plan in the previous reports, the area on the left is kind of narrow and wasted. Moreover, due to use of the transfer girders, the structural layout of the floors are irregular. It causes the structural design of the building impossibly having an alternative solution.

To continue to fulfill this request and pursue an alternate design solution, some design constraints must to be relaxed. My proposal is to have a reconstruction of the whole building as opposed to an addition of two separate buildings. The façade of existing building will be preserved in order to meet the historical requirements and Landmark Preservation Law. In addition, the spring 2017 will propose one-way slab concrete system rather than structural steel for consideration of durability, finical saving, resource efficiency and energy efficiency.

5.2 Proposed Solution

The original walls between two buildings will be eliminated in the redesign of the building. Two column lines will be added in E-W direction and four column lines will be added in N-S direction. The columns are distributed uniformly. The 23' x 27' new typical bay size and concrete flat slab gravity system will be utilized for the redesigned structure. Preliminary beam and column sizes will be explored further to meet strength and serviceability requirement. For the lateral force resisting system, reinforced concrete moment frames will be utilized in the similar location where existing steel moment frame were. The façade of existing building will be temporarily supported during the construction and the pitched roof will be moved off and reuse at the end of the construction.

Methods of this approach will be discussed in Section 5.3. Research on the preservation of historic façade will be conducted as a breath topic in Section 5.4. The 2008 New York Building Code and minimum design loads from ASCE 7-02 will be referenced for the solution proposed above.

5.3 Solution Method

The design of the one-way slab system will be based on Chapter 5, 7, 8, 22 and 24 of ACI 318-11 Building Code Requirement for Reinforced Concrete. Computer analysis of gravity loads will utilized the programs SP Slab, SP Beam and SP Column. Trial sizes, as outlined above will be input into the computer program. The design of reinforced concrete moment frames will follow Chapter 21 of ACI 318-11, and will be analyzed in the computer program Etabs. Throughout the gravity and lateral design process, notes from concrete design classes (AE 402 & AE 431) and other architectural engineering courses will be used as a reference. AE faculty members with relevant expertise will also be a resource for the redesign and historic preservation of the building.

5.4 Breadth Topics

5.4.1 Historic Façade Preservation (Facadism)

The construction of temporary structure to support the historic façade will be conducted in this breath. In order to preserve the façade of the building, the critical path of construction will be altered. The method and material of the temporary structure will also be discussed. Due to the new critical path of construction – in addition to the new cost of material and labor - might affect the overall project cost. Cost and schedule analysis will be used to determine the feasibility of the proposed project.

5.4.2 Building Enclosure

A façade investigation and alternate façade proposal will be executed in the building enclosure breath. An efficient façade design is based on both the mechanical property and the structural property. The mechanical property analysis consists of thermal and moisture consideration and the structural property analysis includes the earthquake consideration. Both of the analysis will be conducted in response to the proposal of an alternate enclosure system. In addition, the façade of the addition will be designed to coordinate with the preserved façade.

5.5 MAE Coursework

The redesign of the gravity force resisting and lateral force resisting systems of the proposed concrete structure will require the execution of three-dimensional modeling. The three-dimensional model will be constructed in Etabs, which have been learned from AE 530 – "Computer Modeling of Building Structures." SAP will also be utilized to verify a two-dimensional structures. Modeling the building in three dimensions will provide a greater understanding of building behavior and the outputs from it can be utilized to verify manual calculation. Additionally, coursework from AE 538: Earthquake Resistant Design of building will be used to provide seismic reinforcing detailing for the concrete moment frames.

5.6 Tasks and Tools

1. Research Phase

- Research modeling approach for design of concrete one-way slab
- Research modeling approach for design of concrete moment frame
- Research necessary governing code, references, standards, design guides, etc.
- Research the feasibility of reconstruction of historic buildings
- Research temporary structures to support historical building façade
- Research mechanical properties (thermal, moisture, etc.) of façade alternatives
- Research structural properties (earthquake, etc.) of façade alternatives
- Research architectural context of building site
- Research integrated design approaches

2. Structural Depth | Concrete Redesign

- Gravity Force Resisting System Design
  - i. Design
    1. Identify new gravity loading conditions based on ASCE 7 - 10
    2. Design one-way concrete slab system based on Chapter 7 of ACI 318-11
    3. Design primary beam members based on Chapter 5 of ACI 318-11
    4. Design primary girder structure members
    5. Design columns based on Chapter 11 of ACI 318-11
  - ii. Model
    1. Verify design in SP slab, SP beam and SP column
    2. Develop three-dimensional model in ETABS

- Lateral Force Resisting System Design
  - i. Design & Model
    1. Calculate new wind and seismic loads based on ASCE 7-10
    2. Define controlling lateral loading condition
    3. Design preliminary concrete moment frame based on Chapter 21 of ACI 318-11
    4. Analyze wind and seismic loads in Etabs
  - ii. Verification
    1. Validate Etabs model with manual calculations
    2. Verify reinforcing detail with seismic detailing from AE 538

3. Historical Façade Preservation Breath

- Construction Issues
  - i. Determine the construction challenges
  - ii. Select method and material of temporary structure

iii. Determine schedule of preservation of façade coordinating with redesign alternative

- Cost Analysis
    i. Calculate construction cost of preservation of façade
- Assess feasibility of redesign based on cost and difficulties

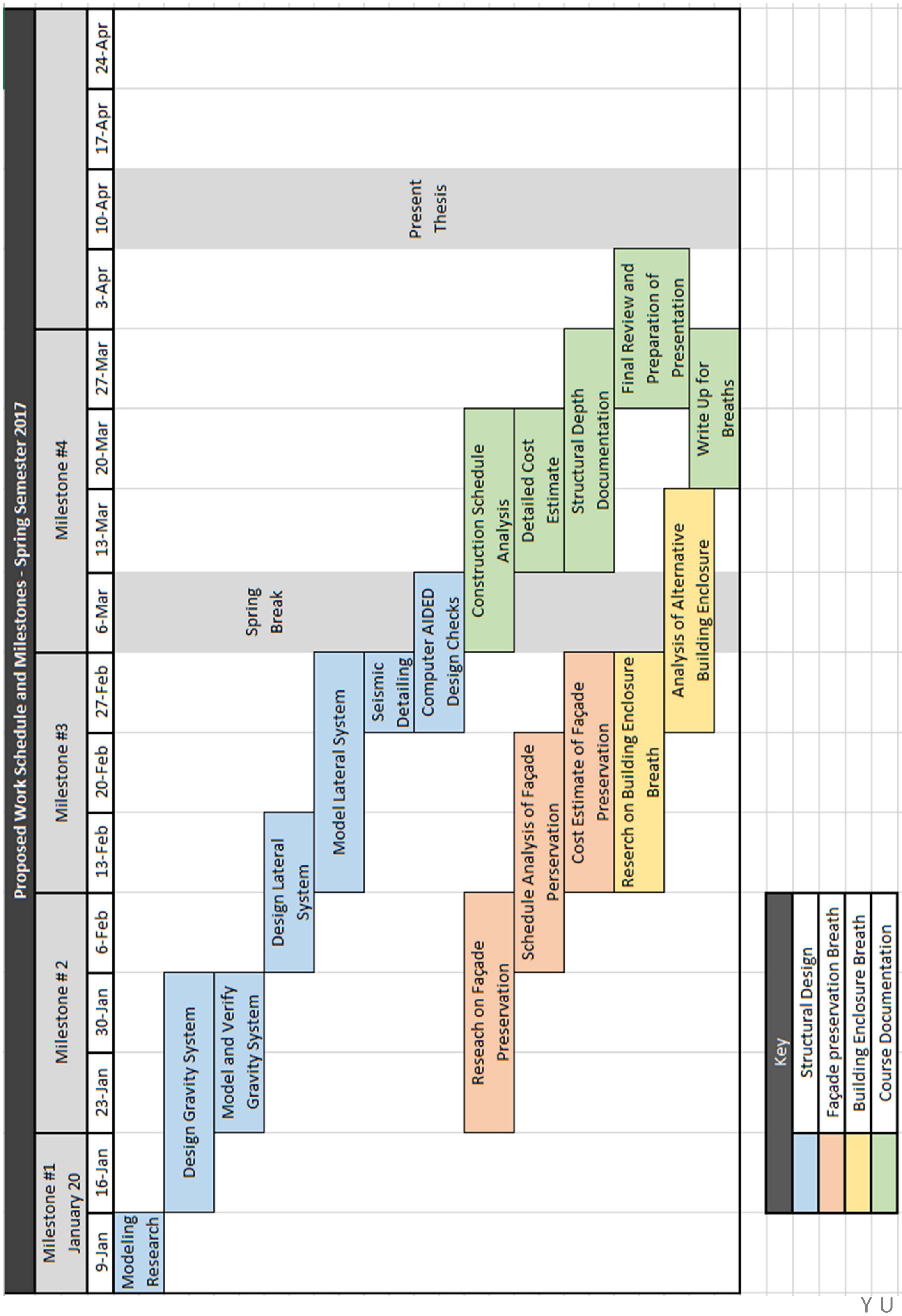
4. Building Enclosure Breath

- Thermal Analysis
    i. Complete thermal analysis and determine moisture thermal performance of façade
- Moisture Analysis
    i. Complete moisture analysis and determine moisture performance of façade
- Seismic Analysis
    i. Complete seismic analysis and determine seismic resisting performance of façade

5. Documentation

- Outline final report for BAM/MAE requirements
- Generate template for final presentation submission
- Complete final report document
- Complete final presentation file
- Update final documents on CPEP website
- Submit and present final documentation to jury

5.7 Schedule



Proposed Work Schedule and Milestones - Spring Semester 2017
Milestone #1 January 20
Milestone # 2
Milestone #3
Milestone #4
9-Jan
16-Jan
23-Jan
30-Jan
6-Feb
13-Feb
20-Feb
27-Feb
6-Mar
13-Mar
20-Mar
27-Mar
3-Apr
10-Apr
17-Apr
24-Apr
Modeling Research
Design Gravity System
Model and Verify Gravity System
Design Lateral System
Model Lateral System
Seismic Detailing
Computer AIDED Design Checks
Spring Break
Reseach on Façade Preservation
Schedule Analysis of Façade Perservation
Cost Estimate of Façade Preservation
Reserch on Building Enclosure Breath
Analysis of Alternative Building Enclosure
Construction Schedule Analysis
Detailed Cost Estimate
Structural Depth Documentation
Write Up for Breaths
Final Review and Preparation of Presentation
Present Thesis
Key
Structural Design
Façade preservation Breath
Building Enclosure Breath
Course Documentation

[6] Conclusion

706 Madison Avenue consists of a 3-story existing landmarked building and a 5-story addition with a total size of 48,500 square foot. The building is located in a historic district of New York City, so the future design will also be limited by the historical requirements. The structural system of the building is comprised of steel beams, columns, composite metal deck framing systems, moment frame lateral load resisting systems as well as a mat foundation. The addition's lateral load resisting system is independent from the existing building, so any future calculation for the wind and seismic design will be complicated.

The existing structural condition of 706 Madison Avenue have been analyzed from the introduction to the body: structural framing systems, lateral load resisting systems, load determination related building and design code, and joints and connections. All information and figures included in this report were found from drawings, specifications and building codes. In addition, many new building components including expansion joints, construction joints, transfer girders and a mat foundation have been studied as well. This initial investigation will give me foresight to know the challenges that I should focus on when I get into the calculation parts of the project.

Feasibility of the redesign will be evaluated by its impact on construction cost and difficulties of reconstructing the building with a preservation of historic façade.