246 West 17th Street

New York, NY

Revised Proposal

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Structural Option

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Executive Summary

Purpose

The purpose of this report is to propose an alternative solution to the current design of 246 West 17th Street. The current structural design for the new stories (above the 3rd Floor) utilizes a flat plate slab system with concrete columns. These have been added atop the existing three stories of historic steel framing and load-bearing masonry structural system. The masonry façade of the original building has largely been left intact, although large openings have been added for windows. The new façade incorporates glass and aluminum curtain walls, metal paneling, and brick veneer on metal stud backing.

Proposal Statements

Structural Breadth
The current concrete system allows for an irregular column grid that works well with the interior architecture; however, the weight of this system prohibits that the historical steel be used to its full potential. The existing steel was encased in concrete to structurally reinforce the members against gravitational loading, and these members were not considered for use in the lateral load resisting system. Instead, concrete shear walls were used to resist lateral loads. The addition of concrete floors, columns, and shear walls greatly increased the weight of the structure, ultimately increasing seismic loading and requiring a redesign of the existing foundation.

To decrease the building weight and utilize the existing steel structure, the use of an alternate system consisting of steel framing shall be explored. Through reducing the gravitational loads on the garage structure, and through implementing steel lateral resisting systems, it is anticipated that the historic structure will be successfully integrated into the load-resisting framing system.

Architectural Breadth
As a result of the new structural layout, it is anticipated that the architectural floor plans will have to be redesigned. In order to keep with the integrity of the current condominium design, all structural elements shall be hidden within architectural elements.

Acoustical Breadth
Acoustical quality will be implemented in the new interior design to ensure that sound isolation is achieved between individual condominium units and between floors. Sound transmission between units will be kept to acceptable levels through sound absorptive properties of the interstitial materials.

Please Note
To clearly distinguish between the various structures present and proposed in 246 West 17th Street, the terms *existing*, *historic*, and *original* shall refer to the 1925 structure. The terms *current*, *as-designed*, and *new* shall refer to the 2008 renovation design. The term *proposed* and *alternate* shall refer to the proposed thesis design.

Table of Contents

Introduction

The base structure of 246 West 17th Street in New York, NY is a three-story brick garage built in 1925. The current project includes an architectural renovation of the existing building along with the addition of seven stories atop the original structure to transform this garage into a 34-unit, high-end condominium building.

Building Overview

Architecture

As with the original building, the cellar of 246 West 17th Street contains garage parking with added mechanical and storage spaces. The 1st floor has been altered to include three condominium units and two recreational spaces in addition to a central lobby. The 2nd and 3rd floors of the original garage building each accommodate five condo units. The 4th floor – the start of the new construction – steps back from the brick structure below, providing residents in each of the three units on this floor with a personal terrace space. The 5th, 6th, and 7th floors have identical floor plans: each holds four units, and each unit features a balcony. The 8th floor again steps back, providing terrace spaces for each of the two condo units. The 9th and 10th floors feature two condo units as well, each with personal balconies. The floor-to-floor heights range between 10'-7½" on a majority of the middle floors to 16'-6" on the first floor.

Building Envelope

The addition features a mix of glass and aluminum curtain walls, metal paneling, and dark brick veneers, adding a modern look to the upper two-thirds of the structure. The structural backing to the paneling and veneer systems typically consists of cold-formed metal framing filled with batting insulation; However, areas around the seismic joint are backed by a concrete wall and the parapets are backed by 6" CMU to account for the higher seismic and wind loading on these areas, respectively.

The original mass masonry wall of the base garage building spans from the cellar level to the third floor. This wall has been opened up through the use of large glass and aluminum punched windows to allow for more light and air into the condominiums.

The addition adds a modern look to the upper two-thirds of the structure, while the brick and original ornamentation of the lower half holds fast to the charm and historical context of the surrounding area. The addition also brings 246 West 17th Street up to the heights of the adjacent buildings, which sit tightly on either side of the site.

Foundation

The soils under the existing slab of 246 West 17th Street are considered to be stable and have high bearing pressures when classified according to the NYCBC. The geotechnical investigation provided by Pillory Associates found there to be a layer of fill soil directly below the existing slab, followed by Glacial Alluvium and Mica Schist Bedrock below this. The bearing pressure of the Glacial Alluvium is rather high at 3.5 tons/sf (7000 psf), and Pillory states in their report that any new slab may hence be designed as slab-on-grade. The geotechnical engineers specifically recommend the use of either a footing foundation or a mat slab to replace the existing slab on grade. Ultimately, after the original slab was removed, both systems were utilized on site: Spread footings measuring 3'-10" thick were placed on a 2" rat slab on gravel on the southern half of the cellar, while a 3'-10" thick mat slab was placed on the same 2" rat slab on gravel on the northern half of the cellar.

Fortunately, no underpinning was required for the project because the cellar walls and perimeter foundations were kept intact.

Floor Systems

There are two distinct floor types within 246 West 17th Street: those with steel framing (the existing garage structure) and those without (the new construction).

The existing floor systems (floors 1, 2, and 3) consist of a steel frame with an 8" concrete slab on deck. The frame is comprised of steel w-shape beams (sizes unknown) at 5'-6" O/C framing into 24" to 26" deep steel girders at 20'-8" O/C. The typical bay size is 20'-8" by 35'-8", with the girders spanning the entire 35'-8" length. The original girders frame into steel columns on the interior and into mass brick piers on the perimeter edge. Both of these vertical elements have been reinforced in the new design.

The top existing floor system (floor 3) has been structurally reinforced through the addition of new steel long-span beams and diagonal angle bracing beneath the slab level. The redundancy of these new beams will help the original long-span girder beams act as transfer beams to carry the weight of the seven new stories above.

The addition stories (floors 7 through 10) are constructed of 8" two-way, concrete, flat-plate moment frames. Circular concrete columns between 14", 16" or 18" in diameter are placed throughout the interior on a relatively irregular pattern due to the various condominium layouts. Rectangular concrete columns flank the perimeter, and range in size between 10"x18" and 24"x24".

Roof System

Multiple set-backs in 246 West 17th Street provide a variety of private terraces for the condominium owners. Façade set-backs occur at the 2nd, 4th, and 8th floors, in addition to a large decrease in the floor plan area at the roof level, as the building narrows around the stair and machine room bulkhead area. This decrease in area provides penthouse tenants with a private roof terrace. Each of these terraces is finished with concrete pavers and wrapped by 3'-8" tall glass railings or a 5' tall parapet.

The typical roof system of 246 West 17th Street – which includes these terrace areas – features a single-ply EPDM roofing membrane topped with 4" of extruded polystyrene insulation, filter fabric, and 2'x2' pavers on adjustable pedestals to ensure that the interior finish level matches that of the outside terrace. This system rests on a low-slope topping slab, which is supported by the structural slab below.

Lateral System

The lateral load resisting system consists of concrete shear walls. Although the building is constructed as a concrete flat plate system with concrete columns, the shear walls were designed to take the entire lateral load; the existing steel framing and the mass masonry walls were not depended on for lateral load resistance. The four primary shear walls (shown in pink in Figure 1 on the next page) are 10" thick and constructed of 5950psi concrete. Two of these shear walls run north-south along the east and west exterior walls, while the other two run east-west at the interior of the structure, encompassing the vertical transportation core. One of these east-west shear walls has 8" thick returns, hence forming a C-shaped shear wall group (shown in Figure 1 in the Appendix). These returns are also constructed of 5950psi concrete. The C-shaped shear wall group spans the entire height of the building, from the cellar to the top of the bulkhead. The remaining three shear walls span from the cellar to the roof.

Proposal Statements and Solutions

Structural Depth Study

The current concrete system allows for an irregular column grid that has been arranged in a way which will not interfere with the interior architectural design; however, this system adds a significant amount of weight to the building, ultimately requiring that the existing steel frame be encased in concrete to assist in its ability to bear gravity loads. Similarly, the existing steel was not used to resist lateral loads at all; instead, concrete was again added, and shear walls were implemented to resist lateral loading. While effective, the frequent use of concrete structural elements has resulted in a high building weight, thereby increasing seismic loading and requiring the utilization of a new and expensive foundation system.

This report proposes that a steel system be implemented in 246 West 17th Street as an alternative solution to the current design. It is expected that the reduction in building weight resulting from this system change will allow for the existing steel to be utilized in both the gravitational and lateral load resisting system. The proposed lateral system will incorporate the historic structural system while exploring the following lateral resistance options: design of steel plate "shear walls," design of steel cross bracing, and implementation of a moment frame through connection reinforcement and design. The proposed steel system shall also have a regular column grid with various "typical" floors which may be repeated at least twice throughout the building's multiple floor plans. This will limit the amount of necessary detailing while also making construction simpler.

Breadth Studies

Architectural Interiors Redesign

One of the anticipated ramifications to changing the structure above the 3rd floor from concrete to steel will be a regular column grid. For this reason, an investigation will be carried out regarding the impacts of the change in structural system and rearrangement of the column grid on the architectural floor plan and functionality of the apartment building.

The current structure of 246 West 17th Street was designed around the interior architecture; the use of a flat plate slab system – in which irregular column grids are typical – allowed for columns to be placed in the most architecturally convenient locations. With the implementation of a new steel framing system, there will be some flexibility as to the location of the structural grid, but in order to keep things efficient and to align the new structure with the historic structure, the interior architecture will have to be modified.

Acoustical Design

To ensure that the privacy of the condominium units is retained within the new architectural and structural design, architectural acoustics shall be incorporated into the new interior. Sufficient sound isolation shall be accomplished for the barriers between individual condo units as well as between subsequent floors. Calculations will be carried out to ensure minimum sound transmission, which will be achieved through the use of materials and systems with good sound absorptive properties.

Integrated Program Requirements

In order to apply the knowledge obtained from the Integrated Bachelors/Masters Program, computer modeling will be used in the analysis of 246 West 17th Street. Specifically, RAM will be used for its lateral analysis capabilities, as learned in “Computer Modeling of Frame Structures.” Seismic analysis shall also be applied to this project, using methods learned in “Earthquake Engineering.”

Proposed Solutions Schedule

Structural Depth Tasks

***S1**. Gather and document member information regarding the historic structure*

a) Sort through historical plans dating from the original garage design to obtain the sizes of existing steel beams (historic column sizes already provided on current column schedule).
b) Document beam and column sizes.

***S2**. Research historic steel shapes*

The original structural plans from 1925 will have to be looked at closely to determine the existing beam sizes. Column sizes are already provided on the column schedule of the current structural plans. The supplementary CD for the *AISC Manual of Construction* (13th Edition) has a historic shapes database that will be used to gather shape information and material strengths for these members.

***S3**. Make a computer model; Framing plan design*

The new framing system and column layout shall be designed within the computer model, with basic design checks being performed by hand. The floors shall be designed with the current architectural plan in mind so that architectural layout changes will be minimal. RAM will be used to model the new structural design for 246 West 17th Street. This will allow for an in-depth look at the lateral system and design.

To represent the historic shapes in RAM, a modern member with similar stiffness properties shall be used. If a shape with such properties is not already in the steel shapes database, a new shape will be created for use in the program. The historic mass masonry wall will also be taken into account and represented in the model.

a) Make a computer model of the historic structure.
b) Implement a regular and repeatable column grid (wherever possible) within the newer stories based on the regular grid of the first three stories and cellar.
c) Propose and model new beam layout.

__S4__. Design new floor system; Update model

Based on the proposed beam layout, a slab-on-deck floor system will be designed using the United Steel Deck catalogue in combination with the previously calculated floor live and superimposed dead loads. New dead loads will have to be calculated based on the chosen design and materials. In addition, fireproofing requirements for floor-to-floor separation shall be met per the New York City Building Code and ASCE7-05 and considered in the floor system design.

a) Calculate dead loads and determine live loads that shall be applied to each floor
b) Design slab/deck system for each floor based on span and loads applied
c) Update RAM model to include this system

__S5__. Design new steel beams

With the new floor system inserted into the RAM model, the loading will be more accurate when designing the steel beams using the program. Hand calculations will be used as design checks using the *AISC Manual of Steel Construction* (13th Edition).

a) Design steel beams using RAM model
b) Perform select hand calculations to confirm design

__S6__. Design new steel columns

Columns will be initially designed for gravitational loading in the RAM model. Lateral load requirements based on ASCE7-05 will also be factored into the design, in which case the lateral system will be looked at more closely. Any hand calculations will reference *the AISC Manual of Steel Construction* (13th Edition).

a) Design new columns using RAM model
b) Perform select hand calculations to confirm design

__S7__. Perform gravitational strength analysis of existing steel framing system

Once the new stories have been designed, the RAM model with be used to check the stresses in each existing member. If the allowable stresses are exceeded, the members will be reinforced or strengthened. The long-span beams in the 3rd floor – which will be acting as transfer beams for the levels above – will have to be looked at carefully, for they will certainly need to be structurally reinforced.

a) Run RAM analysis based on gravity loading.
b) Strengthen or reinforce existing transfer beams as necessary.
c) Re-run RAM model with beam alterations.
d) Strengthen or reinforce existing columns as necessary.

***S8**. Lateral system design*

After the new steel members have been sized and the existing members have been checked and/or strengthened, the structural system will be loaded laterally with loads required per ASCE7-05. The following solutions will be explored for lateral load resistance: steel plate shear walls, diagonal steel cross-bracing, and establishing a moment frame through connection design.

Hand calculations will be carried out using the *AISC Manual of Steel Construction Manual* (13th Edition) as a design reference standard.

a) Run RAM analysis based on lateral loading.
b) Explore steel plate shear walls for lateral load resistance
c) Explore diagonal steel cross-bracing for lateral load resistance
d) Explore the creation of moment frames through connection design for lateral load resistance
e) Implement chosen lateral load resistance system in structural design
f) Design lateral load transfer system for 3rd floor

***S9**. Integration of existing and new structural systems*

The interface between the historical structure and the new systems must be looked at carefully to ensure that loads will be transferred as assumed. The stiffness changes significantly at the 3rd floor level, with the lower portion being much stiffer than the newly added portion. The existing floor system is most likely not strong enough to transfer the loads here, so lateral reinforcement will have to be added at this level. In addition, the connections between the new and existing members will also be designed and detailed.

a) Design lateral load transfer system for the 3rd floor
b) Design connections at the interfaces between new and existing members

***S10**. Fireproofing*

Per ASCE7-07 and the New York City Building Code, fireproofing for the steel shall be specified to meet minimum requirements.

***S11**. Evaluate effects on the foundation system*

The as-designed foundation system shall be re-evaluated to determine if a substantial reduction in size or thickness may be made to the mat slab and spread footings.

Architectural Breadth Tasks

***Ar1**. Design new architectural floor plans*

Although the current interior layout will be considered during the design of the new steel structure, it will be necessary to redesign the floor plans so that the structure will remain hidden beneath the architectural skin. The typical floor plans will be devised:

Typical plan for floors 2 and 3 typical plan
Typical plan for floors 4, 5, 6, and 7
Typical plan for floors 8, 9, and 10

***Ar2**. Design new architectural floor plans around regular column grid*

The cellar, first floor, and roof plans (non-typical plans) will have to be designed according to the proposed, regular column layout.

Acoustical Breadth Tasks

***Ac1**. Design acoustical system between condominium units*

The structural and architectural elements between apartments will be designed using guidelines in the text *Architectural Acoustics* by M. David Egan. The goal shall be maximum sound absorption (and minimum sound transmission) between units.

***Ac2**. Design acoustical isolation system between condominium floors*

The structural floor elements between floors containing condominium units will be designed using guidelines in *Architectural Acoustics* by M. David Egan. The goal shall be maximum sound absorption (and minimum sound transmission) between floors.

Overall Task Schedule

Proposed Schedule	Jan 12 - Jan 18	Jan 19 - Jan 25	Jan 26 - Feb 1	Feb 2 - Feb 8	Feb 9 - Feb 15	Feb 16 - Feb 22	Feb 23 - Mar 1	Mar 2 - Mar 8	Mar 9 - Mar 15	Mar 16 - Mar 22	Mar 23 - Mar 29	Mar 30 - Apr 5	Apr 6 - Apr 12	Apr 13 - Apr 19
Structural Depth														
S1. Gather Structural Information														
S2. Research														
S3. Computer Model / Framing Plan														
S4. New Floor Design														
S5. New Beam Design														
S6. New Column Design														
S7. Gravity Analysis / Member Reinforcement														
S8. Lateral System Design														
S9. System Integration														
S10. Fireproofing														
S11. Foundation Effects														
Architectural Breadth														
Ar1. Typical Floor Plans														
Ar2. Atypical Floor Plans														
Acoustical Breadth														
Ac1. Soundness Between Units														
Ac2. Soundness Between Floors														
Thesis Assignments														
Report												*		
Presentation													*	
Important Thesis Dates														
Report Officially Due (April 8th)														
My Presentation (April 13th)														

Progress Report Dates: February 9, 16, 23; March 16

* Self-established Report due-date of April 2nd

* Self-established Presentation due-date of April 10th

Milestones

The following milestones have been established based on the proposed schedule and progress report dates above:

February 9th Milestones

Structural Depth Tasks:

S1. Structural information gathered and complete (by January 20th)
S2. Research complete (by January 20th)
S3. Computer model of current design complete; New framing plan complete
S4, S5, & S6. New floor design, beam design, and column design complete
S7. Begin gravity analysis

Architectural Breadth Tasks:

Ar1. Typical floor plans complete
Ar2. Atypical floor plans complete

Acoustical Breadth Tasks:

Ac1 & Ac2. Acoustical design underway (50% completion)

February 16th Milestones

Structural Depth Tasks:

S4, S5, & S6. Reiterations of new floor, beam, and column design complete (if necessary)
S7. First iteration of gravity analysis/design complete; Member reinforcement design underway (50%)
S8. Begin lateral system design

Architectural Breadth Tasks:

(Previously completed)

Acoustical Breadth Tasks:

Ac1 & Ac2. Acoustical design complete

February 23rd Milestones

Structural Depth Tasks:

S7. Member reinforcement design complete
S8. Lateral system design underway (30%)

Architectural Breadth Tasks:

(Previously completed)

Acoustical Breadth Tasks:

(Previously completed)

March 16th Milestones

Structural Depth Tasks:

S8. Lateral system design complete (by March 9th)
S9. System integration underway (at least 30%)

Architectural Breadth Tasks:

(Previously completed)

Acoustical Breadth Tasks:

(Previously completed)

Conclusion

The current structure is efficient and architecturally effective, but the existing steel is not used to its full potential. This proposal focuses on utilizing the existing historical steel and making subsequent changes to the architecture as needed. The acoustical properties of the interior will also be improved upon to ensure that this aspect of the design matches the quality of the rest of the structure.

Any deficiencies in the existing structure will be addressed as they arise, and required strengthening methods will be implemented. All analysis and conclusions will be drawn and gathered by the second week in April 2009.

Appendix

Additional Figures

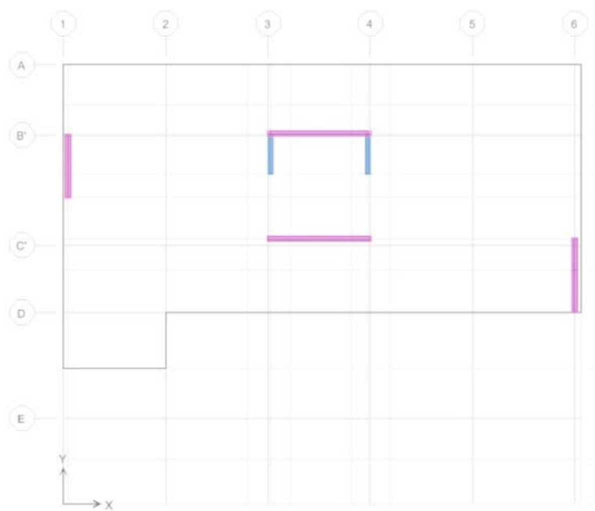

Figure 1 Shear Wall Layout on Typical Floor Plan

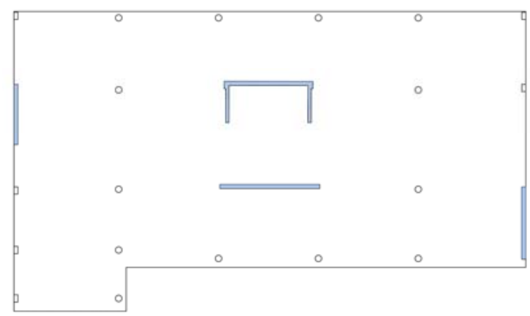

Figure 2 Typical Floor Plan showing Column and Shear Wall Layout

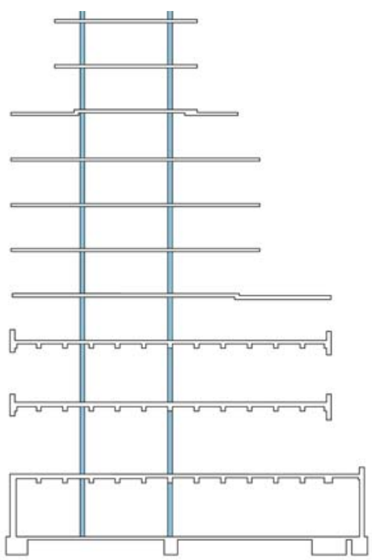

Figure 3 Elevation Looking West with Lateral Elements Highlighted (in blue)

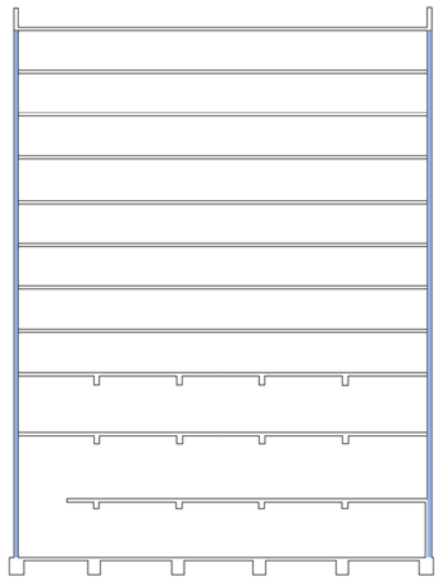

Figure 4 Elevation Looking West with Lateral Elements Highlighted (in blue)