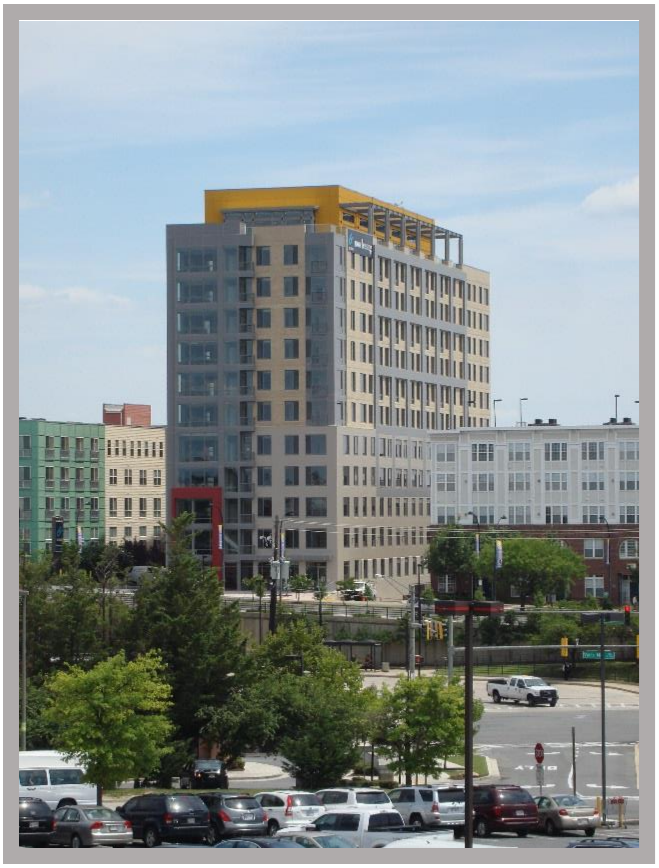

11141 Georgia Avenue

Located in Wheaton, MD

Thesis Proposal

Samantha deVries

Structural Option

Advisor: Ali Said

December 12, 2014

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Executive Summary

11141 Georgia Avenue, located in Wheaton, MD, is a 1960's concrete office building on which a 7-story steel addition was completed in August 2014 for $20 million. The building is a high rise apartment building with one and two bedroom studios, a rooftop terrace and penthouse, and is conveniently located next to the metro station.

The thesis work in the spring semester will include a structural focus with breadth topics in the discipline areas of Construction Management and Mechanical. The proposed thesis will include a redesign of the addition's gravity and lateral systems using wood as the alternative framing material. This work will recognize that taller wood structures do not quite meet code in the United States, and thus take an academic approach to the topic. Thesis work will include researching the feasibility of wood as a material for use in taller buildings as well as studying current research on the fire-resistance of wood framing assemblies.

The construction management breadth in the proposed thesis will include both a cost and schedule analysis of both the existing addition and the alternate wood-framed addition. The mechanical depth will involve work to determine any changes to mechanical system requirements as a result of a different construction type due to wood construction. This depth will also cover the cost and schedule implication of any changes to the mechanical systems.

The proposed thesis work will include topics to meet the MAE requirements. Computer modeling of the building's alternate framing system will be completed using reference material from AE 530: Advanced Computer Modeling of Building Structures. RAM structural system will be the primary software used in the analysis of the gravity and lateral systems redesign.

This thesis will also be used to meet the Schreyer Honors College thesis requirements. To do so, proposed work will include studying current work and research towards the practical use of wood in taller buildings. This will include various papers and resources available on the internet as well as seeking advice from professionals such as Walter Schneider in the design of wood buildings, SOM in their conceptual design work of a wooden skyscraper, and other researchers in the field.

Purpose and Introduction

The Purpose of this proposal is to describe the thesis work to be completed in the spring semester. Included is the description of the existing building conditions from the first technical report. The proposal will discuss the choice and justification of wood as an alternate framing material for the redesign on the addition. Included as well is a description of work to be completed for the breadths including a construction management and mechanical breadths. The proposal will also provide information on how the MAE and Schreyer Honors College requirements will be met with this thesis.

Building Overview

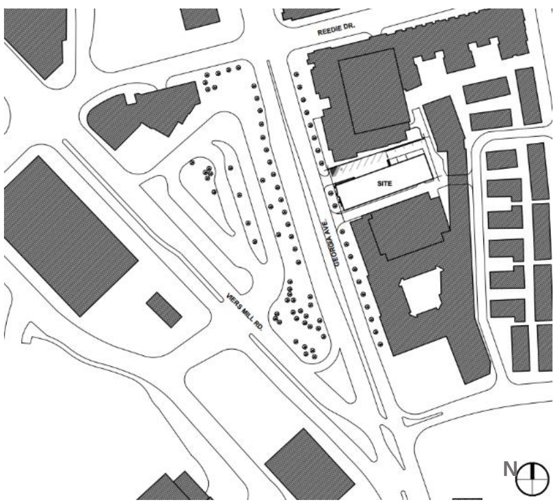


Figure 1: Building Location on Site

11141 Georgia Ave is a high-rise residential apartment building. The original building, built in the 1960's, was a 5 story concrete office building with 2 basement levels. When the building changed owners, rather than tearing down the old building, it was expanded to meet the needs of the new owner. Construction of a 7 story addition in steel framing on top of the existing building began in February of 2013 and was completed in August of 2014 at a cost of $20 million for the addition.

The residential units are one and two-bedroom studio apartments. There is a rooftop terrace with a small wading pool, nice views, and a penthouse lounge for residents of the building, which includes dining areas, kitchen space for events, a fitness center, and a game room. There is a location to store and repair bikes in the building, and the site is closely located to the Wheaton Metro Station. The building is located near the corner of Reedie Drive and Georgia Avenue in Wheaton, MD, as shown in figure 1.


Figure 2: View of Building from nearby mall garage

Structural Systems Overview

The original structure was built in concrete on spread footing foundations. The addition to the structure was built in steel. The foundations include spread footings and a retaining wall, which required a few modifications due to layout changes. The original building is framed with structural two-way slabs and concrete columns. The original floor framing also required modifications to account for changes in the layout of stairwells and elevators, and the addition of other openings for new utilities, trash chutes, etc. The new addition of 7 stories is framed in steel with columns that match the original building's concrete column grid. The floors are framed with W-shapes and composite joists, and the roof is framed with joists. The lateral system of the original building is concrete moment frame. Some columns required expansion to resist additional lateral forces from the building's increased height. The steel addition has steel moment frames to resist lateral loads. Many of the connections and joint details include tie-in to the original building. The following sections will cover the buildings structural systems in further detail, covering the original building, its modifications, and the new addition's structure.

Materials

Structural materials and their specifications used in the building are listed below in Figures 3, 4, and 5. These are the strengths which will be referenced in future technical reports and re-design comparisons.

Concrete and Reinforcing		
Use	Strength (psi)	Weight (pcf)
Misc. Foundations	3000	145
Slabs-on-Grade (Interior)	3000	145
Slabs-on-Grade (Exterior)	4500	145
Fill on Metal Deck	3500	145
Topping	3000	145
Use	Grade	
Deformed Reinforcing Bars	ASTM A615, Grade 60	
Welded Wire Fabric (WWF)	ASTM A185	

Figure 3: Concrete and Reinforcing Specifications, from S/0.01

Structural Steel and Steel Deck		
Member/ Item	Grade	Fy (ksi)
Rolled Shapes	ASTM A992	50
Channels, Angles, and Plates	ASTM A36	36
Structural Tubing (Square and Rectangular HSS)	ASTM A500	46
High Strength Bolts	ASTM A325-N (unless otherwise noted)	
Smooth and Threaded Rod	ASTM A36	36
Headed Shear Studs	ASTM A108	45
Welding Electrodes	AWE A5.1 or A5.5, E70XX	
Adhesive Anchors	Hilti Hit HY-150 Maz w/ Hit-TZ Rods System	
Expansion Anchors	Hilti Kwik Bolt TZ	
Nuts	ASTM A563	
Washers	ASTM F436	
Non-Shrink Grout	ASTM C-11.07 Euclid Dry Pack Grout	
Galvanized Metal Deck	ASTM A653	
Painted Phosphated Metal Fl. Deck	ASTM A611	

Figure 4: Structural Steel and Steel Deck Specifications, from S0.01

Masonry		
Material	Grade	Strength (psi)
Load Bearing Concrete	Hollow and Solid: ASTM C90, NW	1900
Brick	ASTM C55	2000
Mortar (Above and Below Grade)	ASTM C270 – Type S	
Grout	ASTM C476	2000
Horizontal Joint Reinforcing	ASTM A82, 9 Gage Truss-Type Galv.	
Masonry		1500

Figure 5: Masonry Specifications, from S/0.01

Foundation System

The foundation system contains the original construction in the 1960's and well as some modifications to account for additional modified layout requirements and new loads. Both will be discussed in the following sections.

Original Foundation System Prior to Addition

The original foundations of 11141 Georgia Ave were designed for 8000 psf from columns lines 1-5 and 4000 psf from column lines 6-12. The foundations consist of spread footings with a pier, on top of which rests the structural column (See Figure 6.) Larger combined footings are used along column lines C and D (See Figure 7 for example of combined footing.)

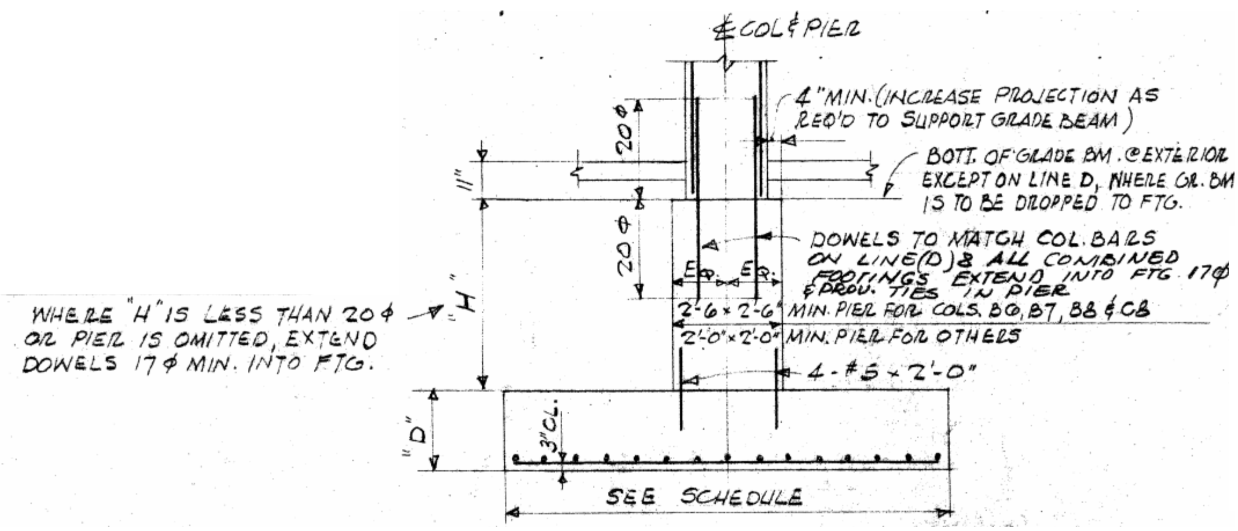


Figure 6: Typical Detail of Pier and Footing, from S1

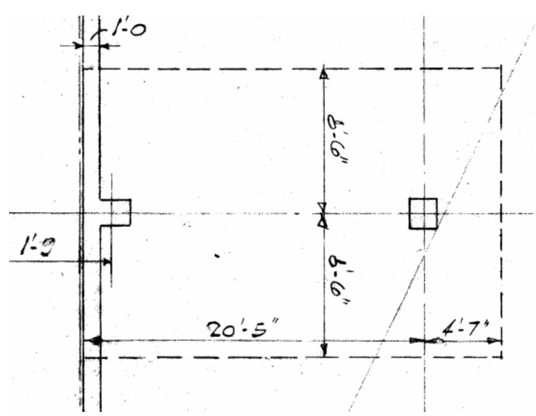


Figure 7: Typical Combined Footing Shown Dashed in Plan, from S1

The building is built on a slight hill. (See figure 8 for relationship between lower levels and hill.) Therefore, there is a basement retaining wall in the basement structure along the north side of the building. Figure 9 shows a section through the cantilevered retaining wall on the north side of the building, and figure 10 shows a section through the retaining wall at the west edge of the lowest level.

Figure 8: Section through Hillside and lower levels, from A3.01

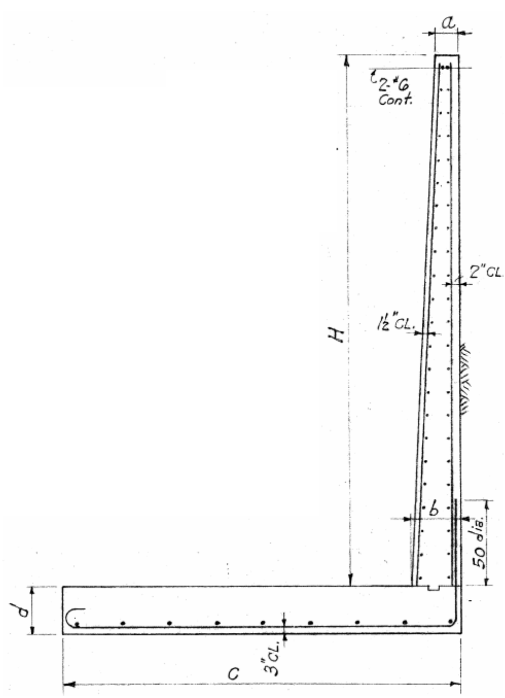


Figure 9: Section through Retaining Wall on North Side of building, from S1

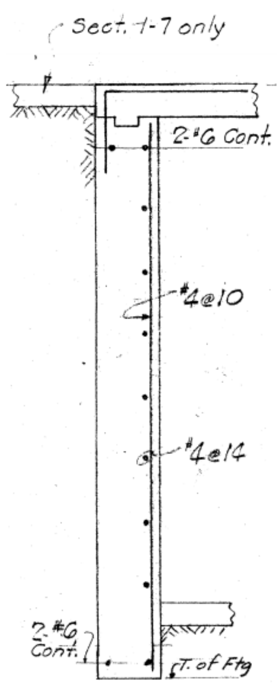


Figure 10: Section through Typical Retaining Wall at Level Step ups, sect. 1-7 on S1

Modifications to Foundations (and Lower Levels)

In November 2011, ATC Associates confirmed through geotechnical exploration the 4000 psf and 8000 psf values from the original 1960 drawing set. The Existing Footings at Columns A-7 and B-7 required underpinning due to the addition of an elevator pit to accommodate 3 new elevators (See Figures 11, 12, and 13). The lowest basement level slab was filled in where the 2 original elevators were removed. The existing stairwell was removed, and 2 new stairwells were added. New load bearing walls were added to support the slab edge at the new openings for the stairs and elevators.

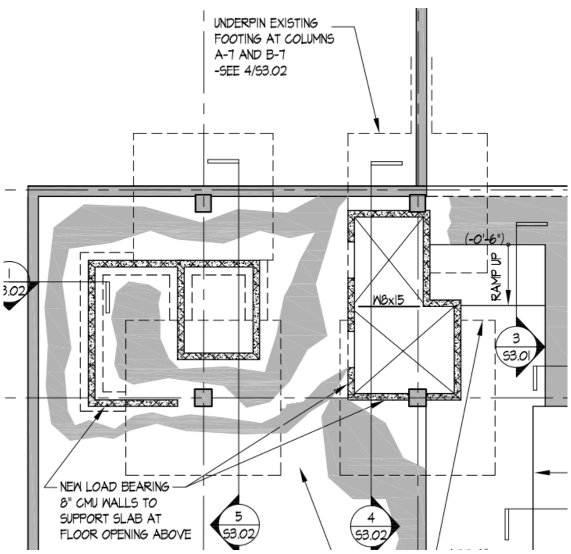


Figure 11: Location of new elevator pit and foundation underpinning shown in plan, S1.01

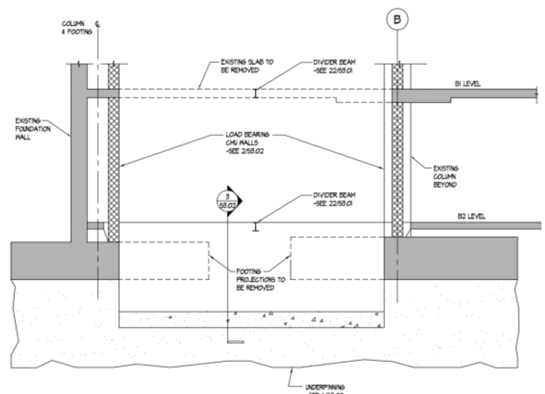


Figure 12: Section showing demo of slab and footing projects with underpinning locations, 4/S3.02

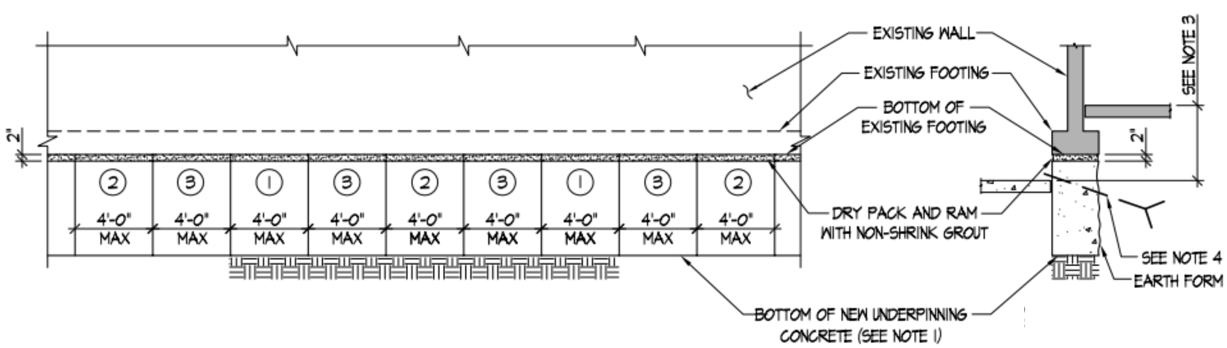


Figure 13: Section showing existing footing and new underpinning (right) and Elevation of sequence for underpinning: All units numbered 1 must be fully installed before excavating for placement of all units numbered 2, etc. (left), 6/S3.02

Gravity System

The existing portion of the building is flat plate slab construction with drop panels at the columns and perimeter beams. Due to differences in the occupancy type of the original building and the new structure, the gravity live loads are smaller. Also, the original penthouse structure was removed. Due to the new live loads, the removal of the penthouse, and the use of steel for the addition which is significantly lighter construction than concrete, very little work on the foundations was required for gravity loads despite the 7-story addition in steel. The original stair and elevators were removed, and 2 new stairs and an elevator pit were added, resulting in modifications to location of slab openings and the addition of slab edge bearing walls. The addition was built out of steel to impose a lighter dead load on the original structure than if it were built out of concrete.

Original Building Floor System

The original building is a concrete structure. The layout consists of a square column grid of 3 bays by 10 bays, each bay approximately 21' by 20', with a single row of 25.5' bays on the west end of the building. See figure 15 on the next page for a typical floor plan.

Level B1 has a 6 ½", the first floor has a 6 ½" slab in the office area, and a 7" slab everywhere else, and all other floors (2nd – 5th) have a 6 ½" slab. The roof has a 9" slab in the penthouse to support the mechanical equipment, and all other areas of the roof as well as the penthouse roof have the typical 6 ½" slab. (See figure 14 for slab thicknesses). There are 7'x7'x3/4" drop panels typical at the columns.

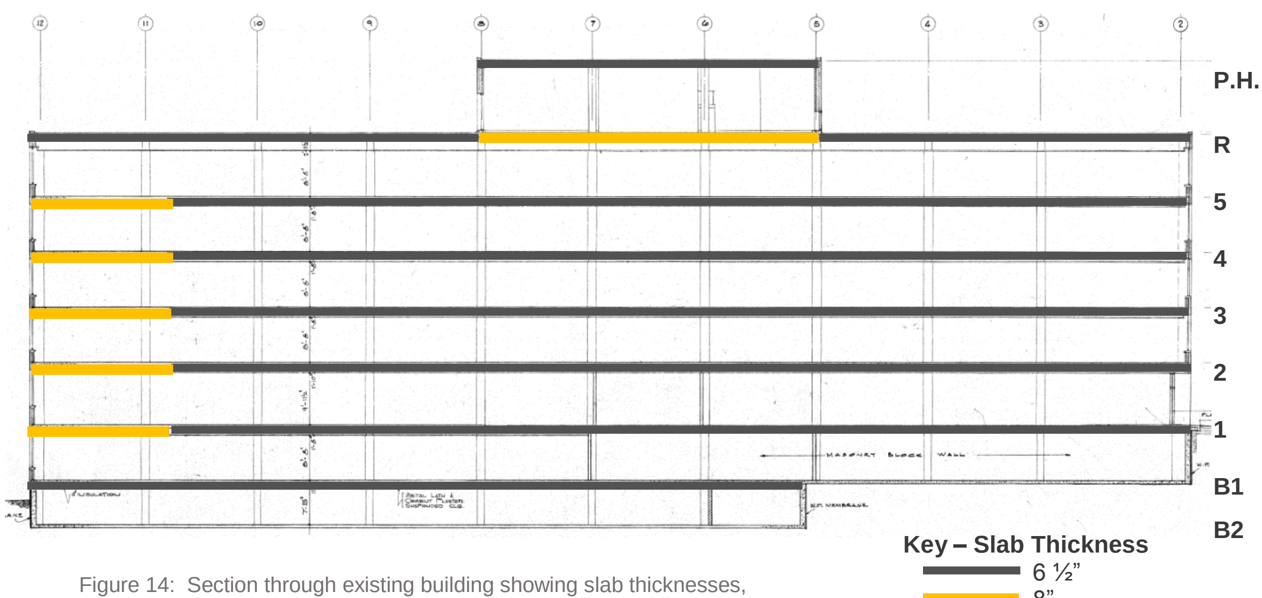


Figure 14: Section through existing building showing slab thicknesses, base section from A10

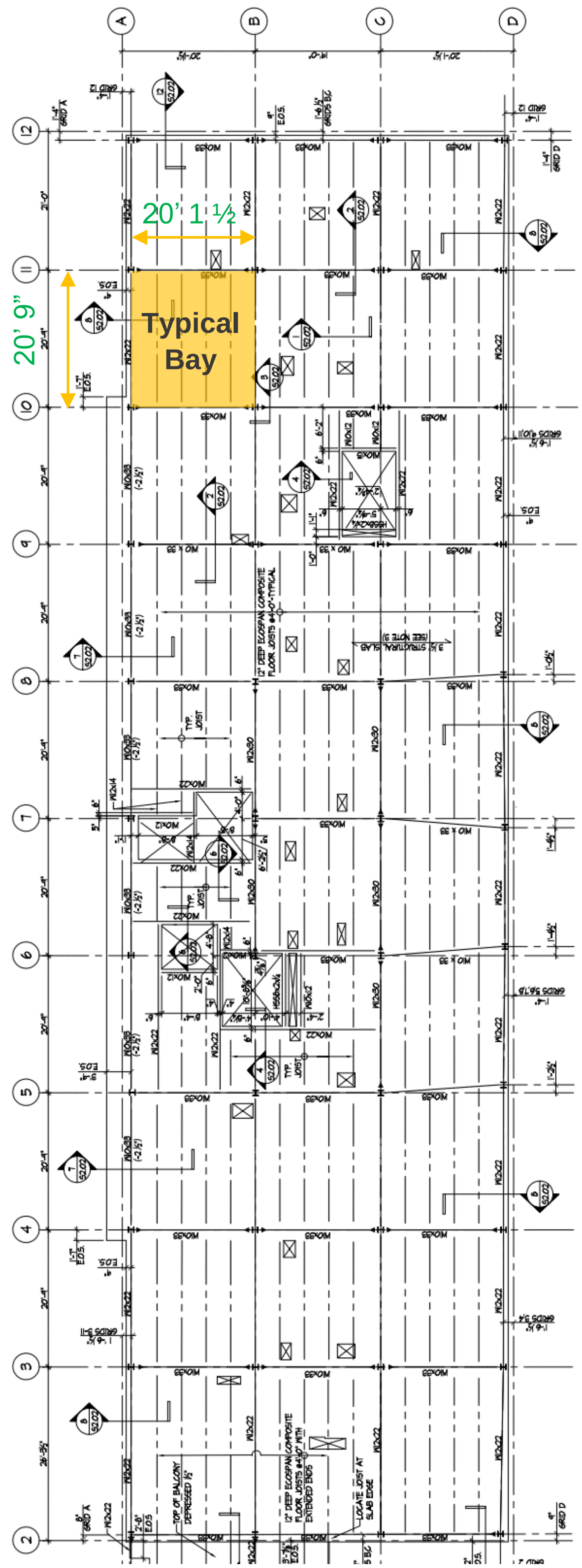


Figure 15: Typical Floor Plan, Grid in new steel floors matches original building's grid, S1.07

Modifications to Floor System

A few modifications were made to the slabs to accommodate layout changes and new openings. Typical on all floors were the demolition of slab to create new openings for new elevator and stairwell positions. A combination of load bearing CMU walls and new steel W-shapes were used to support the slab edges around the new openings. (See figure 16 for section through new CMU walls.) Existing openings at the old elevator and stairwell were filled in with new slab. In spots where new openings were added in drop panels and close to columns, (such as the openings for trash chutes), carbon fiber reinforcement was added. Several new shaft openings were cut in the slab more towards the inner portion of their respective bays and did not receive additional reinforcement. See figure 17 on the next page for locations of typical modifications on a typical floor plan.

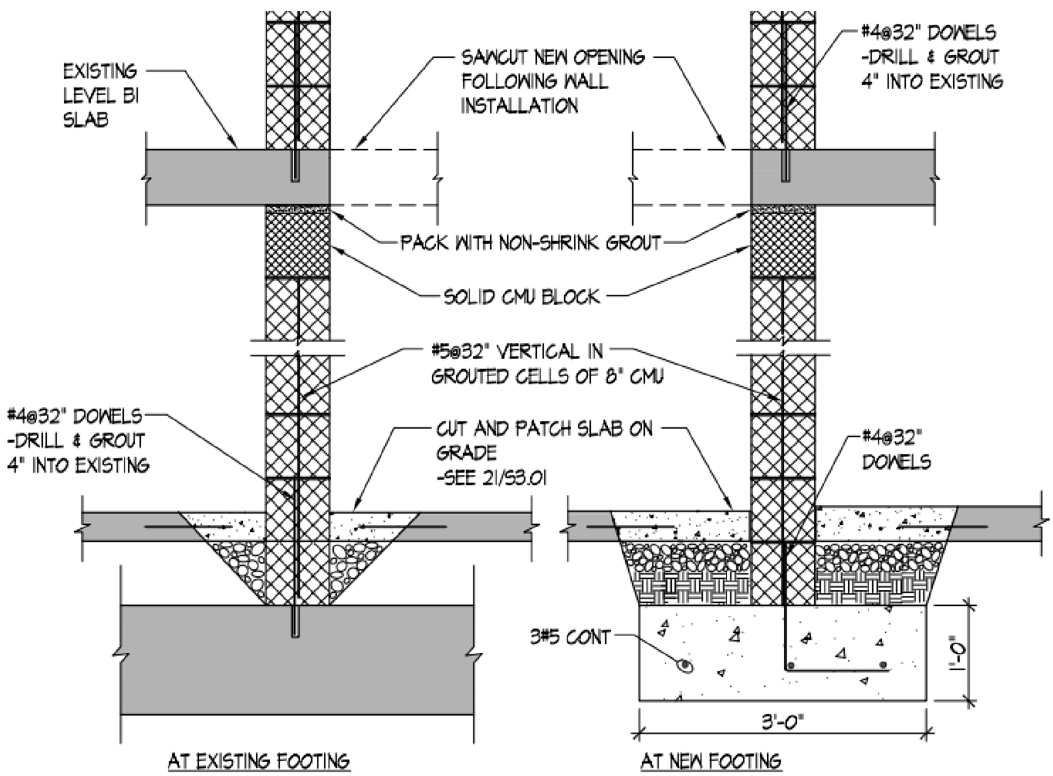


Figure 16: Section through new Load-Bearing CMU Walls. Existing slab was cut to allow walls to bear on existing footings. 1/S3.02

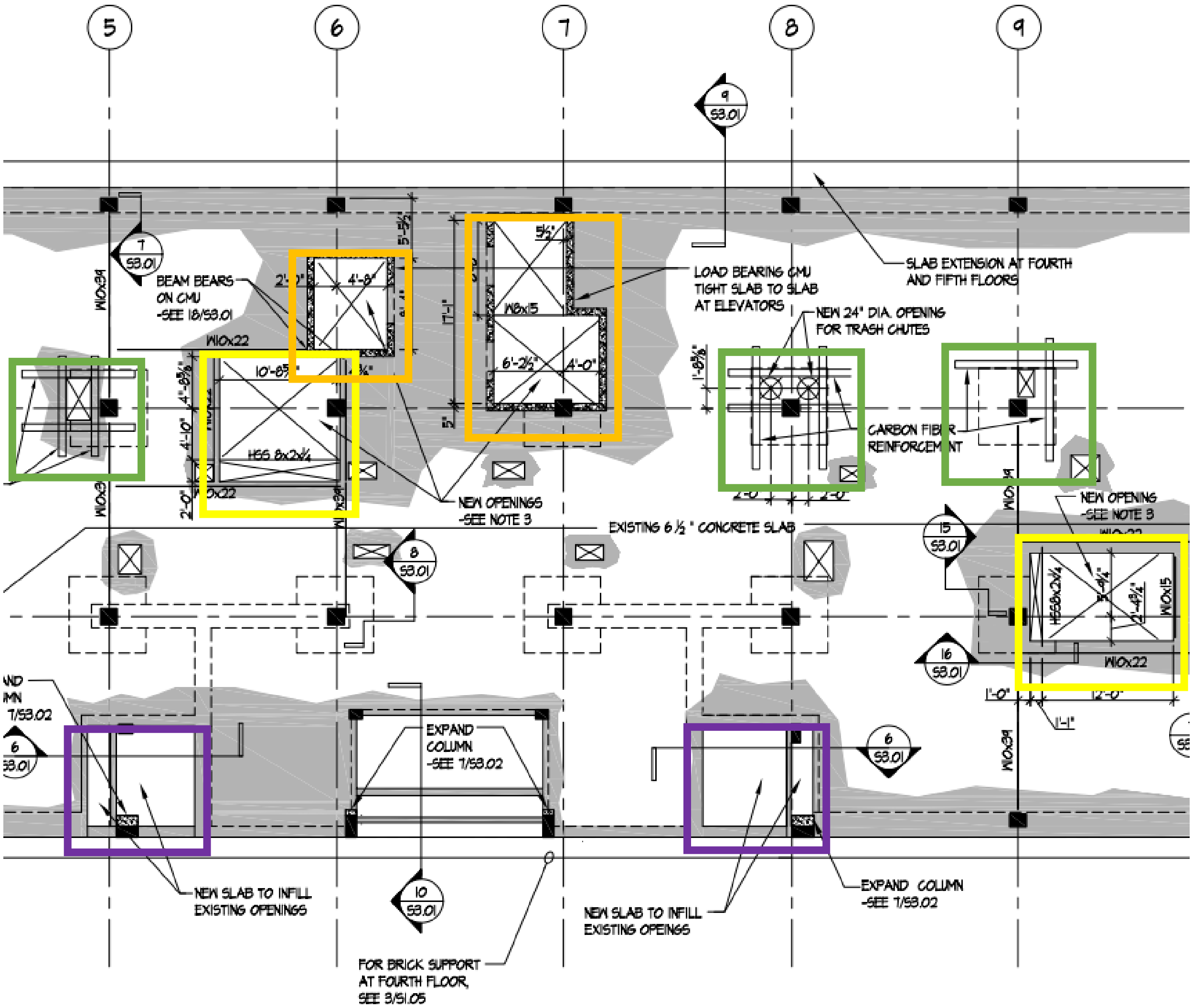


Figure 17: Portion of Typical Floor Plan Shown where Modifications to slab and layout occur in original building's slabs, S1.05

KEY

- Location of Carbon Fiber Reinforcement
- W-shapes added to support slab edge at new openings
- CMU Load Bearing walls added to support slab edge at new openings
- New Slab to Infill Existing Openings

Addition Framing

The 7-story addition is framed in steel with the column layout of W-shapes directly match the original concrete column layout. The typical girder size spanning south to north is a W10x33 due to the small bay size and lower residential live loads. The joists spanning east to west are typically 12" deep ecospan composite floor joists at 4' on center with W12 shapes typical along the column lines. The structural slab consists of a 1" steel deck with 2 ½" of normal weight concrete topping reinforced with welded wire fabric.

Lateral System

This section will provide a brief overview of the lateral system, which will be studied more extensively in a future report. The original building's lateral system and its modifications as well as the new addition's lateral system will be discussed in the following sections.

Original Building Lateral System and its Modifications

The original building resisted lateral loads through its concrete moment frame structure. The addition of multiple stories resulted in increased shear and wind loading on the existing building's concrete moment frames. Therefore, CMU shear walls were added around the stair and elevator cores up to the top of the concrete portion of the building. (See Figure 18 for Load Bearing CMU Wall Details.)

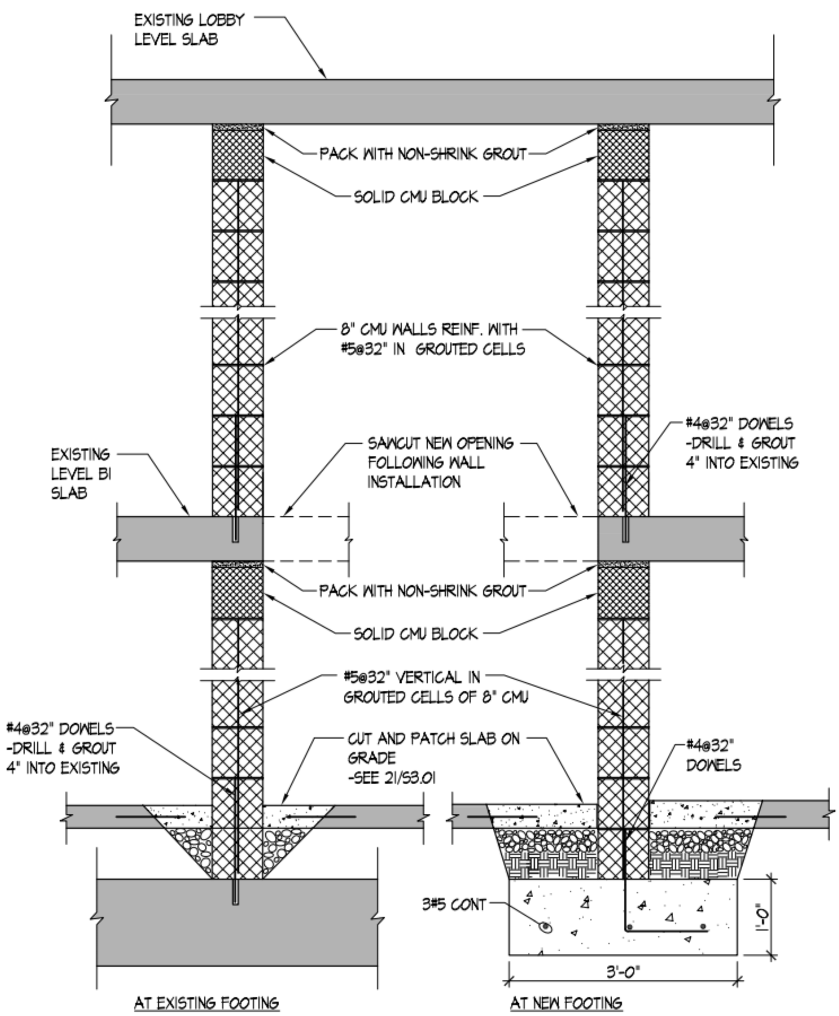


Figure 18: Section through new load bearing CMU walls. 1/S3.02

Addition Lateral System

The new steel frame addition has several moment frames which resist lateral loads. See Figure 19 for typical floor plan with highlighted locations of moment frames.

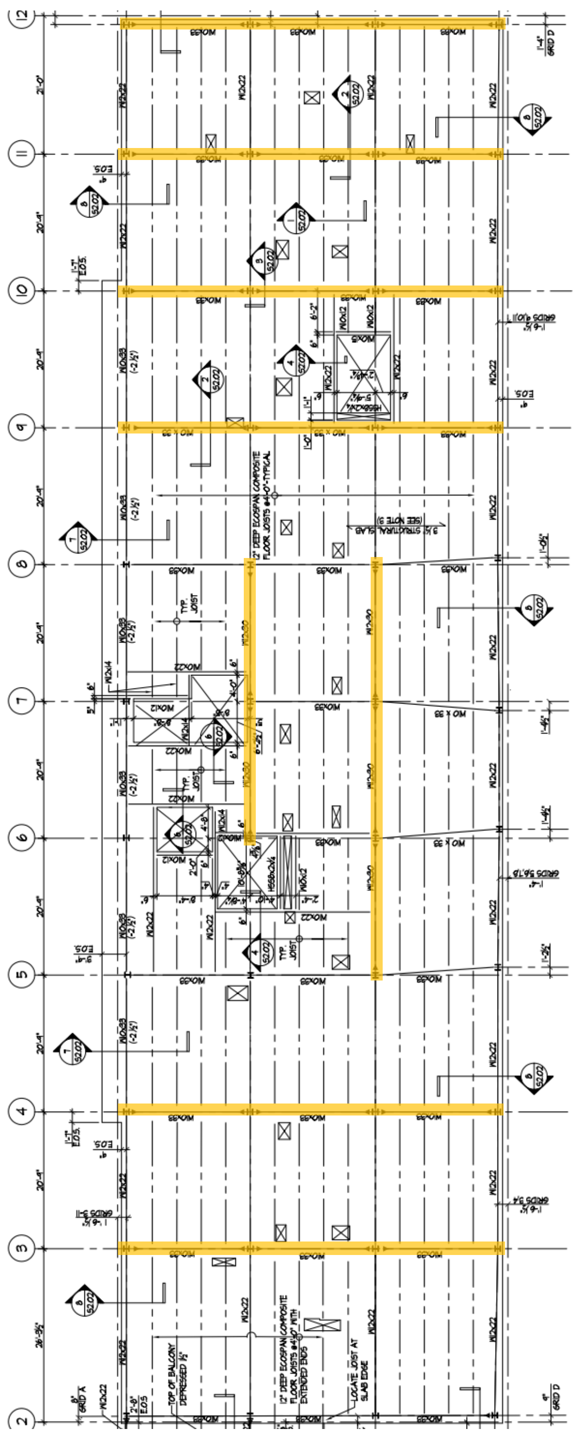


Figure 19: Typical Floor Plan, moment frames shown highlighted, S1.07

Joint Details

This building includes typical connections such as framed beam connections, stiffened beam connections, and fully restrained moment connections in the new steel addition, and the connection of new steel beams, columns, or new concrete to existing concrete members. It is typical for any connection into the existing building to involve drilling out a hole and embedding and grouting the rebar or bolt which will serve to tie in the new member.

Typical Beam Connections

A typical connection of a beam to a supporting member involves a steel angle which is welded and/or bolted at the flange of the beam. (See figure 20 for typical detail.) A stiffened seat beam connection has a stiffener plant and an angle to increase the stiffness of the connection. (See figure 21 for typical detail.)

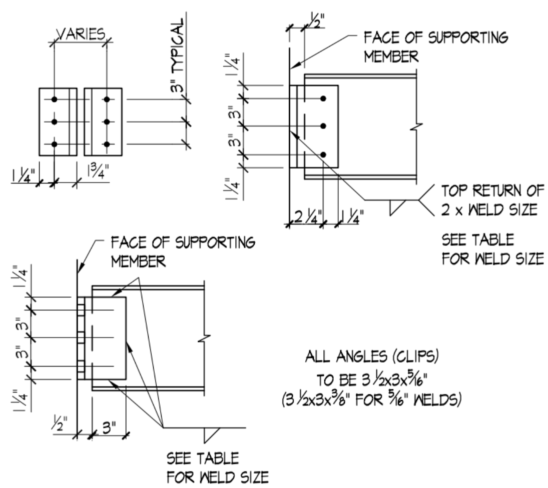


Figure 20: Typical Framed Beam Connections Detail, 1/S2.01

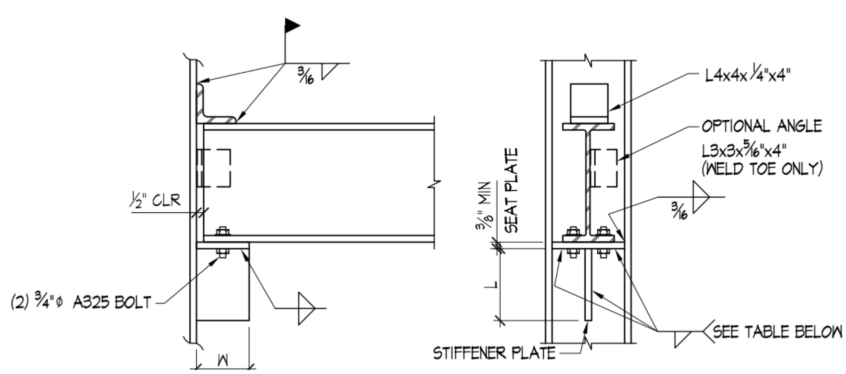


Figure 21: Typical Stiffened Seat Beam Connections Detail, 2/S2.01

Typical Moment Connection

The lateral system in the steel addition includes the use of several moment frames. Figure 22 shows a detail of a typical moment connection, both when the beam frames into the flange, and also when it frames into the web. In both cases, the webs must be bolted or welded depending on the strength required, and the flanges must be welded using a complete penetration groove weld.

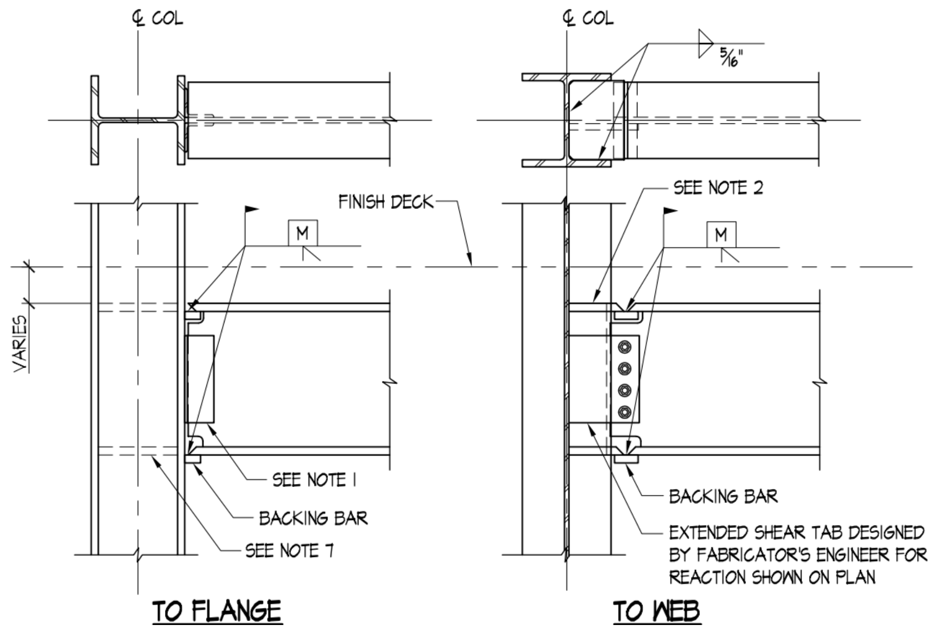


Figure 22: Typical Fully Restrained Moment Connection Detail (Beam to Column), 3/S2.01

Typical Connection of New Steel Beam to Existing Concrete

Where large new openings in the slab exist for elevators or stairwells, the slab edge must be supported. At the lower levels, CMU load bearing walls are used to accomplish this, but from the second floor slab and up, steel W-shapes are added to support the slab edges. In this cases, the steel shape must be anchored properly into the existing column up against the bottom of the slab. (See Figure 23 for detail of new beam connection to existing concrete column.) In the case that a drop panel exists at a column, the W-shape must be custom-shaped to fit tight against the drop panel and the slab (see Figure 23 on next page for detail of beam at drop panel location.)

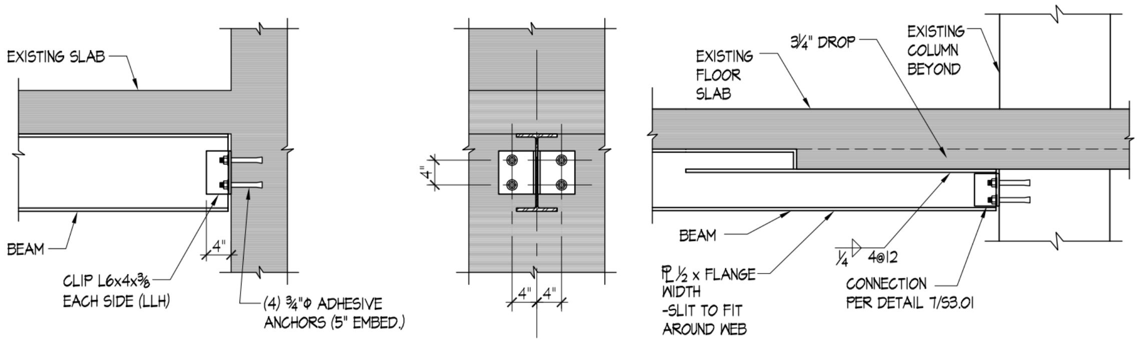


Figure 23: Steel Beam to Existing Concrete Beam of Column Typical Detail (Left) and to Column at Drop Panel (Right),7 & 15 on S/3.01

Typical Column Connection to Existing and New Piers

At the existing roof level, which is now the 6th floor, piers were required to serve as a connection base for the new steel columns above the existing concrete columns. The original columns at the penthouse level were demolished down to a portion that could be used as an existing pier. At all other column locations, a new pier was built and tied-into the original structure. See Figure 24 for details of both the existing and new piers and the connection of the new steel column.

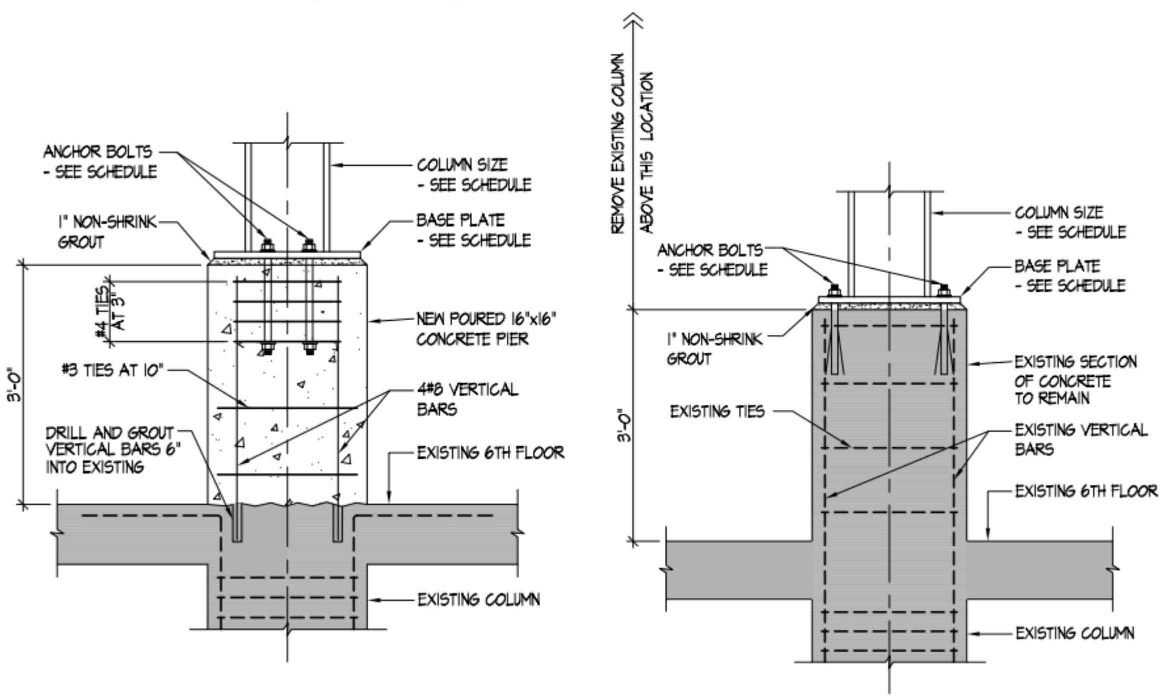


Figure 24: Column Base Typical Detail – New Pier (Left) and Existing Pier (Right), 3 & 4 on S/4.01

Note: Building Drawing sets and images pulled from those sets which appear in this report are courtesy of Rathgeber Goss Association and Bonstra Haresign Architects.

Problem Statement

The newly completed seven story addition to 11141 Georgia Avenue is currently a rolled steel framed system with floor joists. For next semester's work, the original design problem of an existing concrete building, upon which seven stories will be added, was kept the same. The work completed will therefore include a study and analysis of a wood structure as an alternative framing system for the addition. This work will be completed with an academic perspective, since there is increasing interest in constructing taller wood structures in the building industry.

Wood shows great potential to be more sustainable than steel or concrete with new ecoforestry methods which attempt to harvest forests in such a way that the ecosystem can be maintained through selective forestry. Furthermore, with the development of engineered glulam wood products, smaller trees can be used in constructing large structural members rather than resorting to the harmful practice of cutting down old growth forests. Wood used in construction also has the ability to sequester carbon, effectively removing it from the atmosphere for the lifetime of the building. Next semester's study of a wood framing alternate will include a review of the sustainability benefits of wood construction.

Currently, wood construction generally does not meet code for buildings taller than about four stories, so it is possible that the final wood design will not be immediately plausible with regard to current codes. Next semester's work will design a wood addition for the existing concrete building which will meet code as closely as possible. Then it will be determined what would need to happen for the addition to be acceptable with the code, whether that be that fire-resistance research, changes in perceptions, or changes in the code itself. There is already research being carried out which hopes to show that wood construction can meet fire-rating standards for taller building construction, and other countries have successfully built tall wood structures.

Proposed Solution

The proposed new wood-framed building will include a design similar to the existing steel-framed addition. The 20'x20' bay size will be kept since a smaller bay will be beneficial for span when designing a wood framing system. An initial investigation of floor assemblies' fire ratings found that for higher fire ratings the floor system will require a minimum floor thickness somewhere around an inch with wood joists that are at least 2x10's spaced at 16 inches on center and two layers of ceiling drywall.

A wood framed building will also require a different lateral system than the current steel moment frame system. Therefore, the elevator core shear walls, which currently extend only until the top of the original concrete building, will be carried through to the top floor. The existing CMU shear walls will be kept as they are currently. The portion of the shear wall extending to the roof will be either CMU continued or a wood shear wall. The design work and research will look into the feasibility of wood shear walls.

Solution Method

The design of the wood floor system for gravity loads will be based on the Western Lumber Product Use Manual as well as information from AE 401: Design of Steel and Wood Structures and BE 462: Design of Wood Structures. The CMU shear wall design option will be based on the Masonry Building Code. The wood shear wall design alternative will use information from existing research on the topic. Modeling of the structure will be completed in RAM Structural Systems. The research methods for this thesis work will also include seeking the advice of Professor Walter Schneider, Ph.D., P.E., as well as professionals currently researching the use of wood in tall buildings and those designing and implementing tall wood buildings.

Breadth Topics

Both breadth topics will be connected back to the selection of wood as a framing alternate. Included in the breadths will be a construction management analysis that includes a cost comparison and schedule comparison. Furthermore, the change to wood at the very least will change the construction type of the building, and so a mechanical breadth will explore any changes in mechanical system requirements to meet code for a different construction type.

Construction Management

In the construction management breadth, cost and schedule analysis will both be completed for the existing and new addition. The cost analysis will provide a basis for investigating the economic feasibility of a wood-framed addition compared to the costs of the existing steel addition. The schedule analysis will help determine scheduling differences between the methods in order to identify any major differences in schedule and how wood construction could be used in the construction of taller buildings.

Mechanical

The wood framed building means that the structure will become a different construction category. The mechanical breadth will look at any differences in requirements for the mechanical systems in the building and any changes in types or sizes of mechanical equipment. If there are any major differences that would affect cost or schedule, this will be considered in the construction management depth as well.

MAE Coursework Requirement

The redesign of 11141 Georgia Avenue will incorporate requirements of the Graduate School of the Pennsylvania State University. Referenced course work will include AE 530: Advanced Computer Modeling of Building Structures and BE 462: Design of Wood Structures. Referenced information from AE 530 will be used to create a full building three-dimensional Bentley RAM model of the redesign. Other software such as ETABS or SAP2000 may also be used to analyze components of the building and redesign. The modeling will be completed with the goal of better understand the building respond to loads. Referenced material from BE 462 will be used to assist in the design of the alternative wood framed addition.

Schreyer Honors College Requirement

This thesis will be submitted to fulfill requirements set by the Schreyer Honors College and the Department of Architectural Engineering. To meet the requirements, a study of tall wood building construction will be carried out, including the sustainability of wood construction, economic feasibility, a review of current fire code research, and any other topics as deemed relevant. A comparison will be made between 11141 Georgia Ave in Wheaton, MD and the alternative wood framed addition design. This work will be completed to gain professional-level understanding of the overall feasibility of tall wood buildings. A working structural engineer may soon encounter this design type as research displays promise for practical use of wood in tall buildings.

Tasks and Tools

1. Tall Wood Building Research
    a. Research lumber and wood product sustainability
    b. Study current research on fire-resistivity of wood systems
    c. Study general research of tall wood buildings and case studies

2. Research Computer Modeling Programs
    a. Research computer modeling approaches for wood design
    b. Determine modeling approach for chosen floor system analysis
    c. Determine modeling approach for chosen lateral system analysis

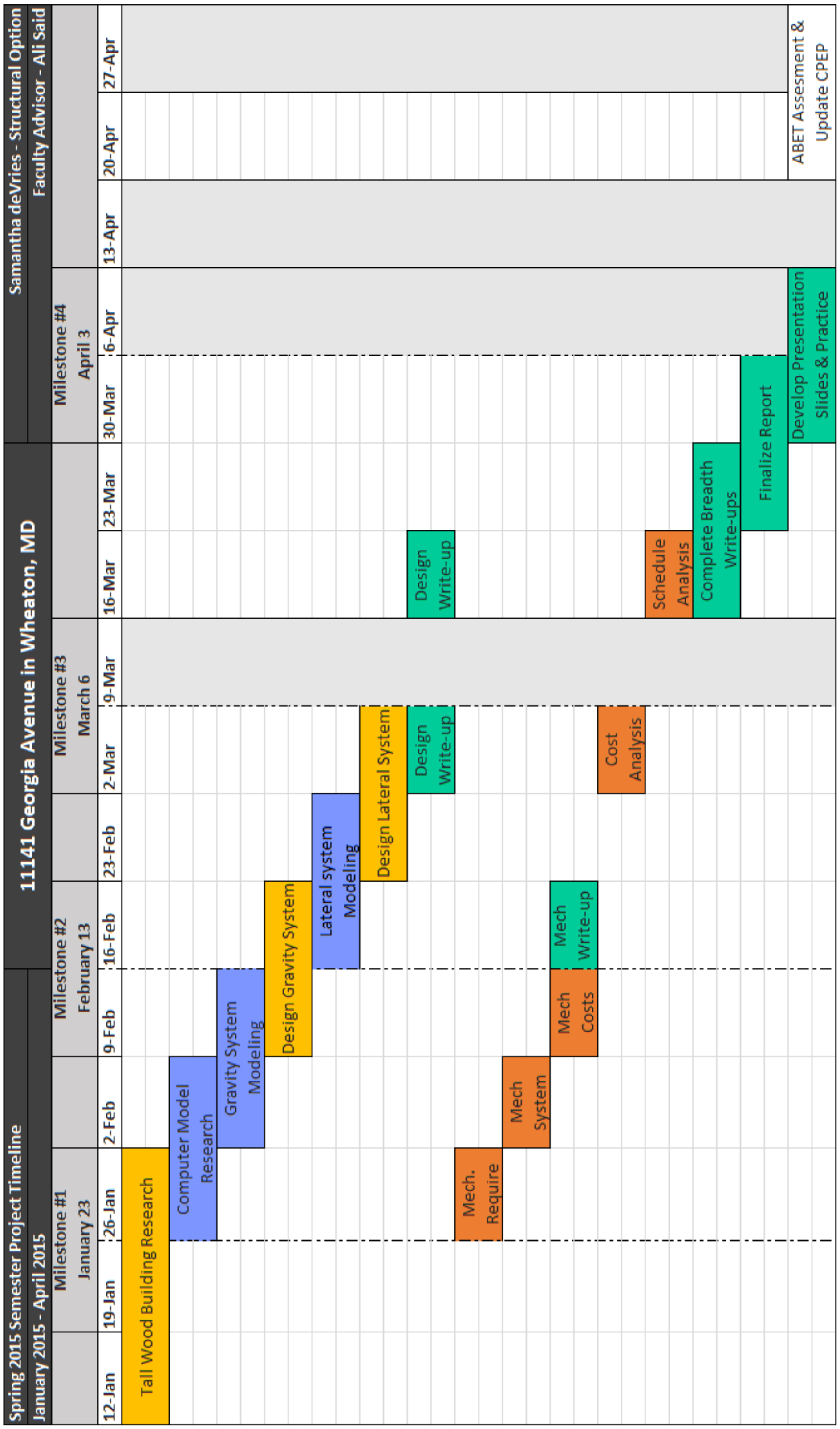
3. Design New Addition
    a. Design gravity system
        i. Design floor system
        ii. Design Columns for gravity loads
    b. Design lateral system
        i. Determine wind and seismic loads based on ASCE 7-10
        ii. Design Shear Walls
        iii. Confirm design of shear walls in RAM
    c. Gravity and lateral system write-up

4. Breadth Topic: Construction Management
    a. Cost analysis of existing system
    b. Cost analysis of alternate system
    c. Schedule analysis of existing system
    d. Schedule analysis of alternative system

5. Breadth Topic: Mechanical
    a. Research new code requirements for alternate construction type
    b. Mechanical equipment alterations for differences in requirements
    c. Cost and schedule study for mechanical changes

6. Final Report and Presentation Preparation
    a. Outline final report
    b. Prepare and finalize report
    c. Outline final presentation
    d. Prepare and finalize presentation
    e. Practice presentation
    f. Submit report and present to jury

Schedule



Legend

- Structural Depth
- Computer Modeling
- Construction Management Breadth
- Mechanical Breadth
- Report Write-up Presentation
- Other/ Course Maintenance

Milestone Activity Summary

Milestone #1: Initial research for both the structural depth and the breadth topics is complete	Milestone #2: Selection of structural and façade systems is complete and computer modeling research is complete
Milestone #3: Research and design for all topics is complete in preparation to work on write-ups after spring break	**Milestone #4:** Final Report is finished and presentation should be mostly developed with only revisions and practicing the presentation as tasks left to complete

Conclusion

Next semester's work will include a wood-framed redesign of the addition to 11141 Georgia Ave in Wheaton, MD. The addition redesign will include the design of both the gravity and lateral systems. The breadth topics will cover construction management and mechanical disciplines. Included in the construction management breadth is a cost and schedule analysis of both the existing and alternate wood-framed additions to the original concrete building. The mechanical breadth will evaluate any changes in the mechanical system requirements due to the different construction type created by the wood alternate. Finally the proposed thesis will include a study of current research and work related to advancing wood's practical use in tall building construction and the primary framing material.