The Towers at Greenville Place

Tower 'B'

Wilmington, DE

Thesis Proposal

Shawn Brandt
Structural Option
Consultant: Dr Behr
December 2009

Table of Contents

Executive Summary

Tower 'B' is a 180,000 square foot building consisting of 89 different apartment units. It is located in Wilmington Delaware and is one of three identical towers in the Greenville Place apartment complex. This upscale, seven-story apartment tower was completed in 2007.

The current structural system is 8 inch precast hollow plank resting on 8 inch reinforced CMU walls. Due to its weight, seismic load effects are the most crucial in lateral load considerations. The current design is very conservative and handles the loads flawlessly, but is very heavy.

This thesis will study and design an alternative system based around the technology used by *Infinity Structures*. The redesign will substitute lightweight metal stud framing for the current masonry. The ultimate goal will be to reduce the weight of the structure while maintaining or improving the timeline and cost of the project.

In the process, it will be necessary to redesign all elements of the building. Floor and Lateral systems will be accounted for when designing for the Infinity Structures system. The façade of the building will require further investigation, as it will not be part of the structural system in the thesis design. After the thesis design is complete a time and cost comparison of the existing and proposed system will be conducted to determine viability of the redesign.

Introduction

Tower 'B' of The Towers at Greenville Place is one of three virtually identical buildings. The towers, 'A', 'B', and 'C', are all directly neighboring upscale apartment buildings in Wilmington, Delaware. The project was completed in July of 2007 at an overall cost of $11.5 Million by a Design-Bid-Build delivery method. It is owned and managed by Pettinaro Real Estate Development Company.

The 180,000 square foot building consists of 89 different apartment units. One level is partially below grade and, on top of that, there are seven floors. The partially below grade ground floor is 12' and houses the lobby, exercise room, game room/café, storage, housekeeping, and electrical room. The ground floor lobby entrance opens to ground level, as where the opposite side of the building is nearly entirely below grade. The first floor is 10' and begins the typical apartment unit layout. Floors two through seven are also typical in layout, but only rise 9 feet and 4 inches each. The roof, though accessible, is virtually bare and houses no mechanical equipment.

Figure 1: North-west view of Tower 'B', showing canopy entrance.

Structural System Overview

Foundation

Foundations were designed according to recommendations on the geotechnical engineer's reports prepared by Advanced Geoservices Corp. The building's foundation is made up of a combination of spread and continuous reinforced cast-in-place concrete footings. The design was based on an allowable soil bearing capacity of 3000 psf and calls for 3000 psi concrete.

The ground floor slab is 4 inch slab on grade laid on 4 mil poly vapor barrier and 4 inches of crushed stone. It is reinforced with 6x6 W1.4xW1.4 welded wire fabric (WWF). The slab on grade is designed to have a strength of 3500 psi.

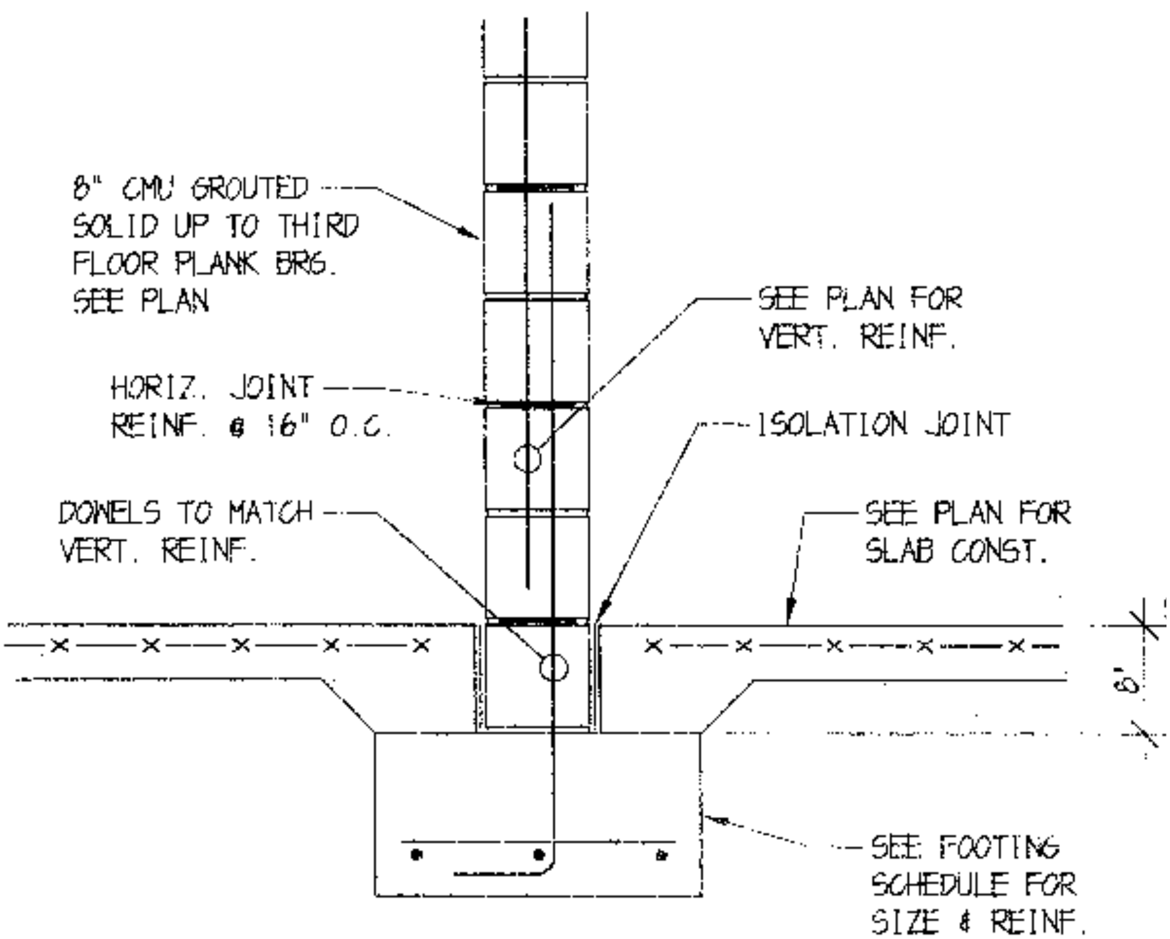


Figure 2: Typical interior foundation sections.

Shear Walls

The shear walls are 8 inch CMU with reinforced grouted cells that go all the way down to the foundation. Tower 'B' has three different strengths of shear walls. Each shear wall is essentially laid out the same, only differing slightly by the size and spacing of steel reinforcing used, depending on which level they reside. These walls each have two different spacing criteria. As seen in Figure 3, the reinforcing at the ends of the walls are spaced more tightly than that compared to the middle portion.

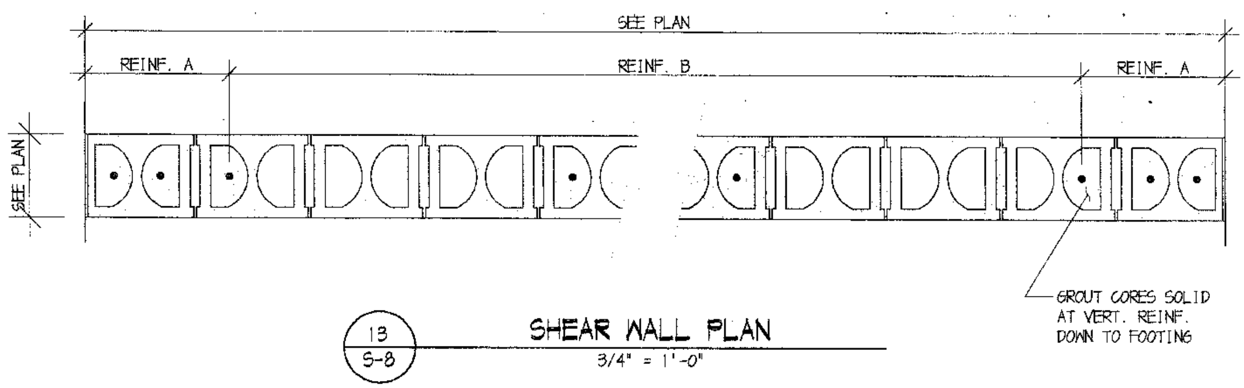


Figure 3: Typical shear wall plan.

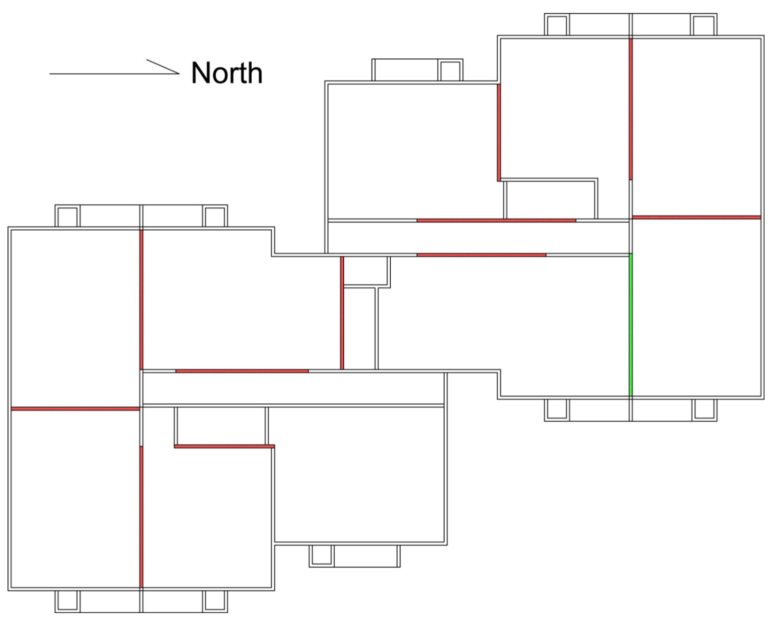


Figure 4: Layout of shear walls. Green wall indicated shear wall absent on floors 1 and 2.

Typical Wall

Nearly every wall in Tower 'B' contributes to supporting the gravity loads. With the exception of cast in place concrete on the partially below grade ground floor, every wall is CMU. Figure 5 shows all load bearing CMU walls have regularly spaced reinforcing in grouted cells. Walls on floors 1 through 3 call for #4 reinforcing bar spaced at 32 inches on center. Walls on floors 4 through 7 call for #4 reinforcing bars spaced at 48 inches on center.

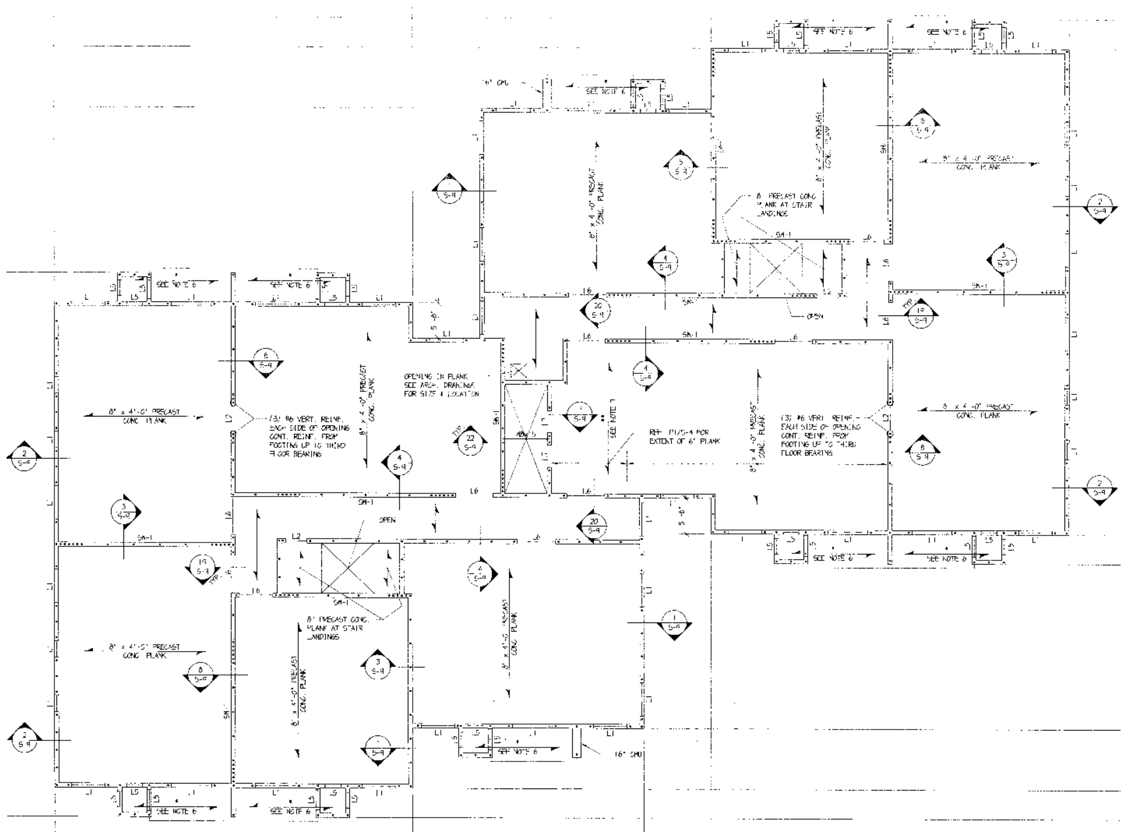


Figure 5: Typical plan layout showing reinforced CMU walls.

Floor System

The floors of Tower 'B' are precast hollow core concrete plank. The corridor floors are 6 inch plank and all others are 8 inch plank. Referring back to figure 5, the planks span one direction each, but alternate per floor section. Special attention was given to certain plank joints due to the camber and direction of the planks. Said joints were off level where mid spans met perpendicularly with plank ends. Joints and level corrections were filled solid with 3000 psi flowable grout.

The support for the floor planks, as stated before, comes from the CMU walls. At the top of each level's CMU wall is a CMU bond beam with one continuous #5 reinforcing bar. The planks sit directly on a 3 inch bearing strip on the top of the wall. The floors are tied in using #4 reinforcing bars spaced at 48 inches and bent to suit each locations condition. Figures 7 through 9 display a variety of floor plank to wall connection conditions.

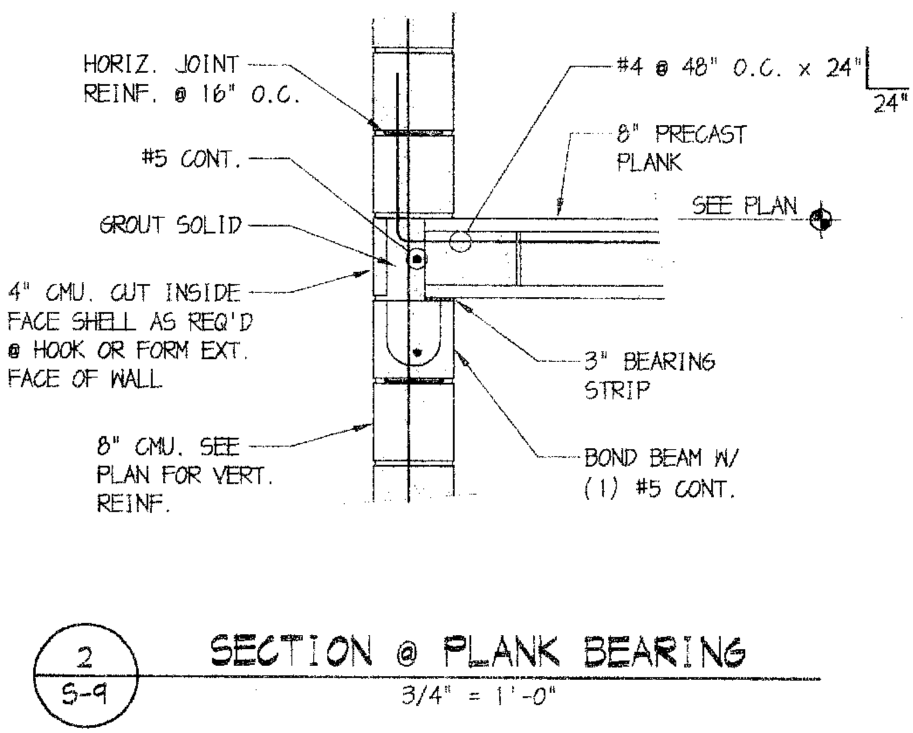


Figure 7: Detail of floor plank bearing on CMU wall.

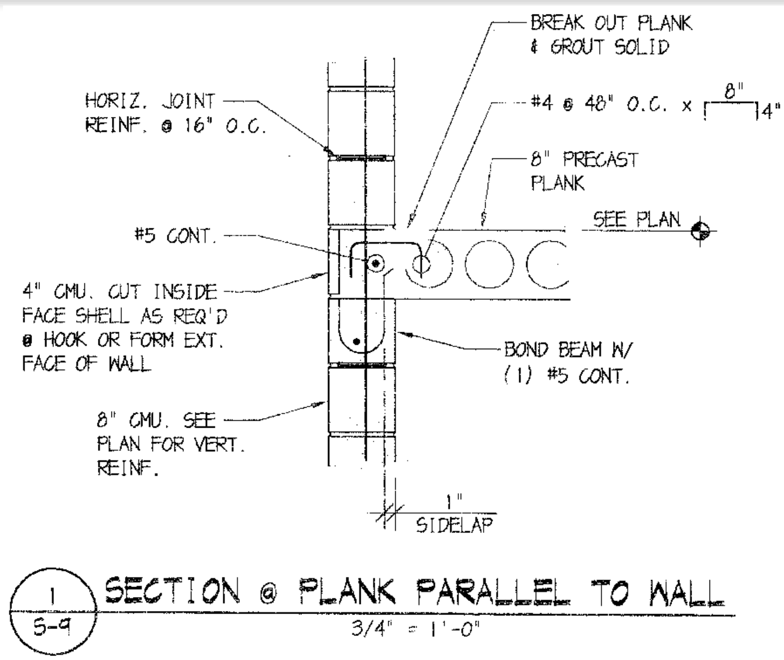


Figure 8: Detail of floor plank running parallel to wall connection.

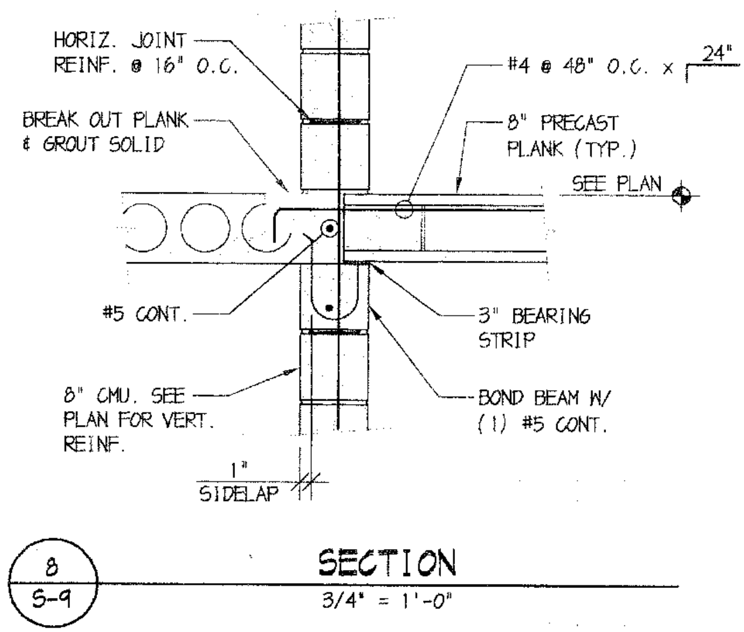


Figure 9: Detail of both bearing and parallel connection conditions.

Roof System

The roof of Tower 'B' is the same basic design as the typical floor system. It is accessible but the layout is mostly empty. Much like the other floors, the roof consists of 8 inch plank throughout except over the corridors where it is 6 inch plank and bears on the CMU wall. Joints, again, are filled solid with 3000 psi flowable grout. Figures 10 and 11 show two connection conditions.

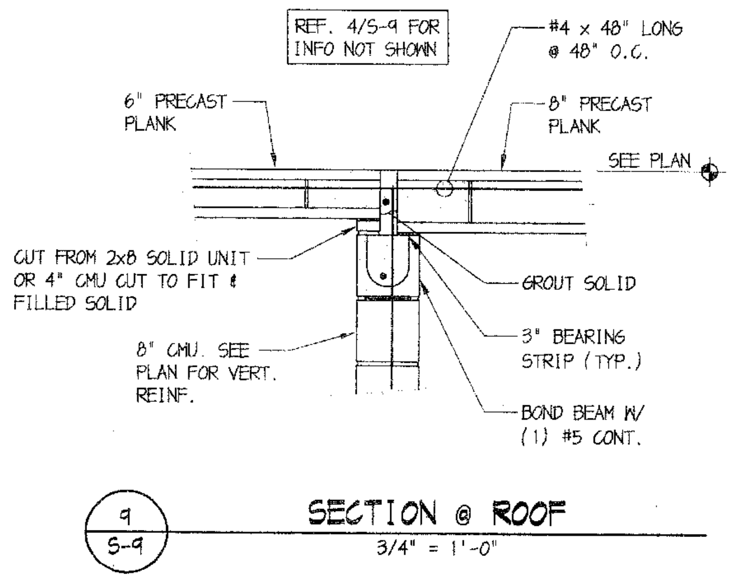


Figure 10: Detail of roof floor connection.

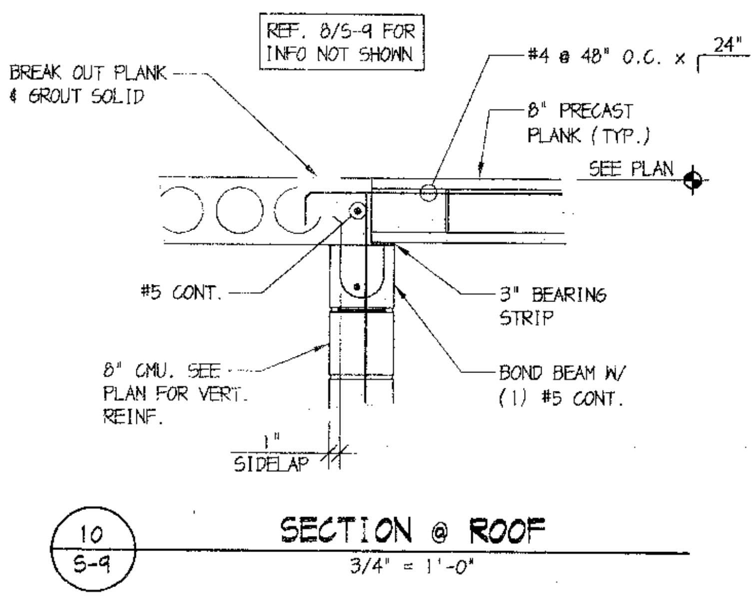


Figure 11: Detail of roof floor connection.

Problem Statement

The analysis performed in Technical Report 1 determined that the controlling lateral load was seismic. In Technical Report 3 it was determined that the lateral system was designed well within the required limits. While the building was designed to adequately handle these forces, the magnitude of the load is caused by the buildings heavy design and self weight. All load bearing and lateral load resisting walls are reinforced CMU. The masonry design offers many structural advantages and consistency in design, and us relatively simple to construction. However, with such weight comes more seismic concern. Tower 'B' is designed virtually identical to multiple neighboring apartment towers and is part of a residential complex.

Proposed Solution and Methods

Since the critical lateral load was created by the self weight of the building, a lighter structural system may be more beneficial and economical. By replacing the heavy masonry construction with a light, steel based design, the lateral seismic load can be greatly reduced while maintaining required strength. This will require an overhaul of the entire structural system.

To reduce weight and maintain ease of design and construction use of *The Infinity Structural System* is proposed. Infinity Structures is a type of prefabricated framing system. The walls are made of "pre-panelized" load-bearing 14 gage metal studs typically spaced at 12 inches on center. Lateral loads are resisted by "shear panels" which are essentially load bearing stud walls with Grade 55 steel rods crossing diagonally through the wall, making an "X". These panels will be stacked floor to floor and bolted together thru the floor to create a continuous later load resisting frame from the foundation and up. "Pre-panelized" sections can also be made to incorporate rigid insulation.

The floor system used in Infinity Structures fortunately will maintain a similar depth to the current system. It will essentially be a slab on deck design. Though slightly different in composition, in Technical Report 2 it was determined that a slab on deck design self weight was comparable to that of the current floor system. This will work well with the effort to reduce self weight seismic load considerations. Spans can be maintained, greatly due to fact that it will only be sized for residential Live Loads. Span reducing supports may need to be added if further analyses indicate as such.

Breadth Topics

Architecture

Due to the fact that the original design of Tower ‘B’ used every wall, including the decorative exterior wall, as part of its structural system, it will be necessary to include architecture and building envelope considerations into this project. An effort can be made to maintain a façade similar to the original since it is part of a complex of identical buildings.

Construction Management

A cost comparison of the proposed and original systems should be conducted to further investigate the economics of design. This comparison shall include how the schedule is affected, as well as the material, construction, and transportation costs. Overall efficiency and cost will then indicate whether the proposed alternative is a viable option.

Tasks and Organization

Main Topic

1. Design of framing and layout
    a. Find live and dead loads
2. Design of floor system from loads and layout
    a. Check spans and deflections
3. Establish a computer model
4. Lateral system design
    a. Establish lateral loads from code
    b. Determine loads per floor
    c. Determine shear wall (shear panel) locations and sizes
    d. Deflection
5. Perform analysis of new foundation requirements
    a. Determine building weight
    b. Check uplift and overturning
6. Presentation Preparation

Breadth

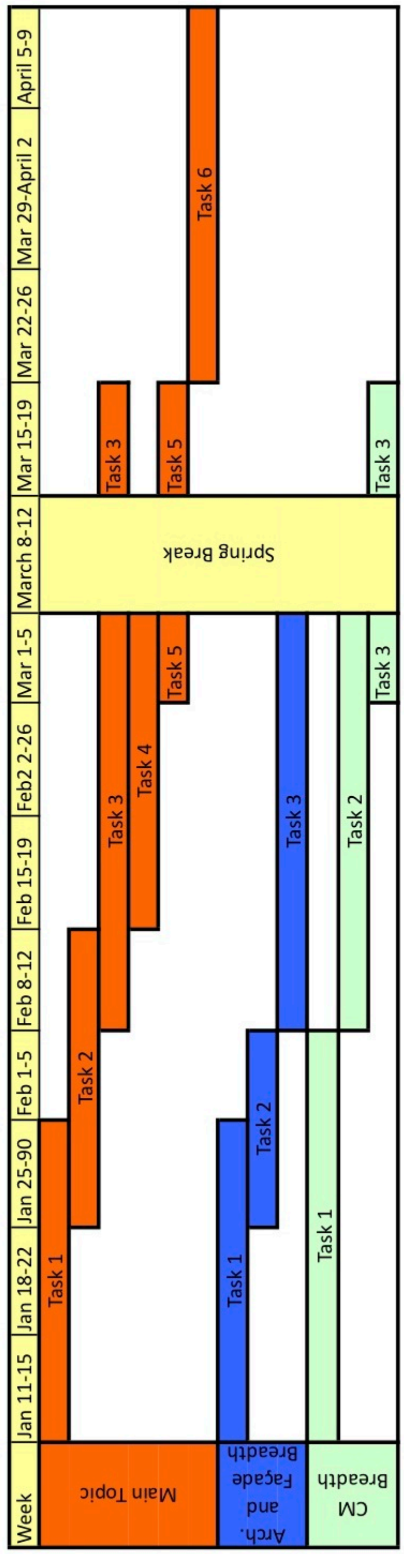
Architecture and Façade considerations

1. Establish new layouts (if necessary)
2. Check design requirements
3. Façade development and design

Construction Management:

1. Develop Schedule for existing and proposed systems
2. Establish cost estimates for existing and proposed systems
3. Compare existing and proposed systems

Time Table


Week
Jan 11-15
Jan 18-22
Jan 25-90
Feb 1-5
Feb 8-12
Feb 15-19
Feb2 2-26
Mar 1-5
March 8-12
Mar 15-19
Mar 22-26
Mar 29-April 2
April 5-9
Main Topic
Arch. and Façade Breadth
CM Breadth
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Spring Break

Conclusion

During the spring semester the proposed system will be designed and will then be compared to the existing system. The overall goal will be to reduce the weight of Tower 'B' and, in turn, reduce the seismic load and its effect on the lateral system. Systems from *Infinity Structures* will be used to achieve this as was briefly described in the body. Necessary hand and/or computer model calculation will be performed. The existing and proposed systems will then be compared to determine viability.

Acknowledgments

Proposed structural system uses technology by:

Infinity Structures, INC.
6250 Shiloh Road
Suite 210
Alpharetta, Georgia 30005

(678) 513-4080

www.infinitystructures.com