Weill Cornell Medical Research Building
413 E. 69th Street
New York, NY

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Structural Option

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Thesis Proposal

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Executive Summary

The Weill Cornell Medical Research Building is a 19 story, 455,000 square foot, 294'-6" tall building located on East 69th Street in New York City. The building features three stories below grade and eighteen, plus a penthouse and an interstitial floor, above grade.

This thesis proposal is designed to outline a course of study for the spring semester of 2012. This course of study will include a depth study related to the building's structure, as well as two breadth studies investigating the effects of the new structure on MEP systems and cost.

The structural depth for this thesis will be focused around changing the floor system from a two-way flat plate slab to a post-tensioned slab. First, the new system will be designed and a computer model created. Next, the new floor system's effects on the required size of the 14x72 columns in row D in order to meet deflection requirements in the cantilever will be investigated. A further study will be undertaken to examine the results of removing column row B on deflections and sizes of the remaining structural system.

While this structural depth study is accomplished, two breadth studies will also be performed. The first will be a mechanical breadth which will integrate the new floor system with the existing requirements of the laboratories and mechanical floors of the Medical Research Building for shafts with MEP equipment running between floors. The second breadth study will be a cost comparison of the various redesign scenarios brought about by the structural depth study.

Introduction

The Weill Cornell Medical Research Building is the newest addition to the campus of the Weill Cornell Medical College on the upper east side of Manhattan. Located at 413 East 69th Street in New York City, the Medical Research Building is adjacent to other Weill Cornell buildings. The Weill Greenberg Center on its northeast side is an educational facility designed by the same architects as the Medical Research Building. Olin Hall to the east, and the Lasdon House to the north are residential buildings that house students of the medical college. 69th Street slopes down to the east across the site of the Medical Research Building and the utilities run under it. The Con. Edison power vaults are also located under 69th Street and the sidewalk in front of the building.

The $650 million Medical Research Building is approximately 455,000 square feet with three stories below grade and eighteen, plus a penthouse and an interstitial floor, above grade. The total height of the building above grade is 294'-6." Floors 4-16 are dedicated to laboratory space. The first basement level, as well as the interstitial floor between floors 16 and 17, and the 17th and 18th floors are designated as mechanical floors. The bottom two levels of the basement contain the MRB's animal facility. Service and freight elevators and vertical circulation are located on the west side of the building next to the loading docks on the 69th Street side. Passenger elevators and vertical circulation are nearer the center of the building where the two story lobby atrium welcomes people into this hub of scientific exploration.

In the rear of the building, adjoining the second floor, there is a terrace that bridges the gap between the rear façade of the MRB and the Lasdon House. A grand staircase leads from the lobby on the ground floor up to the enclosed lounge on the second floor that opens onto the terrace. There are two entryways from the Lasdon House to the terrace so anyone living in that building and working in the Medical Research Building would have easy access. The terrace also wraps around the side of the Lasdon House and connects to a stairway leading down to the sidewalk on 70th street.

The building is defined visually by the undulating glass sunshade curtain wall across the front of the building. This curtain wall is attached to the floor slabs that are cantilevered out approximately 9'-8" from the exterior row of columns to meet it. The curtain wall itself has two layers. The outer layer features the glass sunshade wall with aluminum mullions. This wall is tied to the inner layer of insulated glass (also with aluminum mullions) by aluminum struts. The inner layer is anchored to the slab either directly through the mullion or with a steel outrigger.

Structural Systems

Foundation System

The foundation system consists of spread footings bearing on undisturbed bedrock. Strap beams are provided as necessary around the perimeter. This undisturbed bedrock is expected to support 40 tons per square foot. According to the geotechnical report, there are two types of bedrock encountered on the site. One type supports 40 tsf and the other 60 tsf, but it is recommended by Langan Engineering and Environmental Services that the footings be designed to rest on 40 tsf bedrock. The slab on grade is a 6" concrete slab resting on a 3" mud slab on 24" of crushed stone. The perimeter concrete walls of the basement are 20" thick with strip footings. Below, Figure 1 is an image of the foundation plan.

The geotechnical report also states that the water table is approximately 50 feet above the foundation level. This poses the problem of seepage through the rock and also uplift on the foundation. A few different design solutions are presented in the geotechnical report. The resolution of this problem comes in the form of 4-50 ton rock anchors located at the bottom of Stairwell B on the East side of the building to resist the uplift.

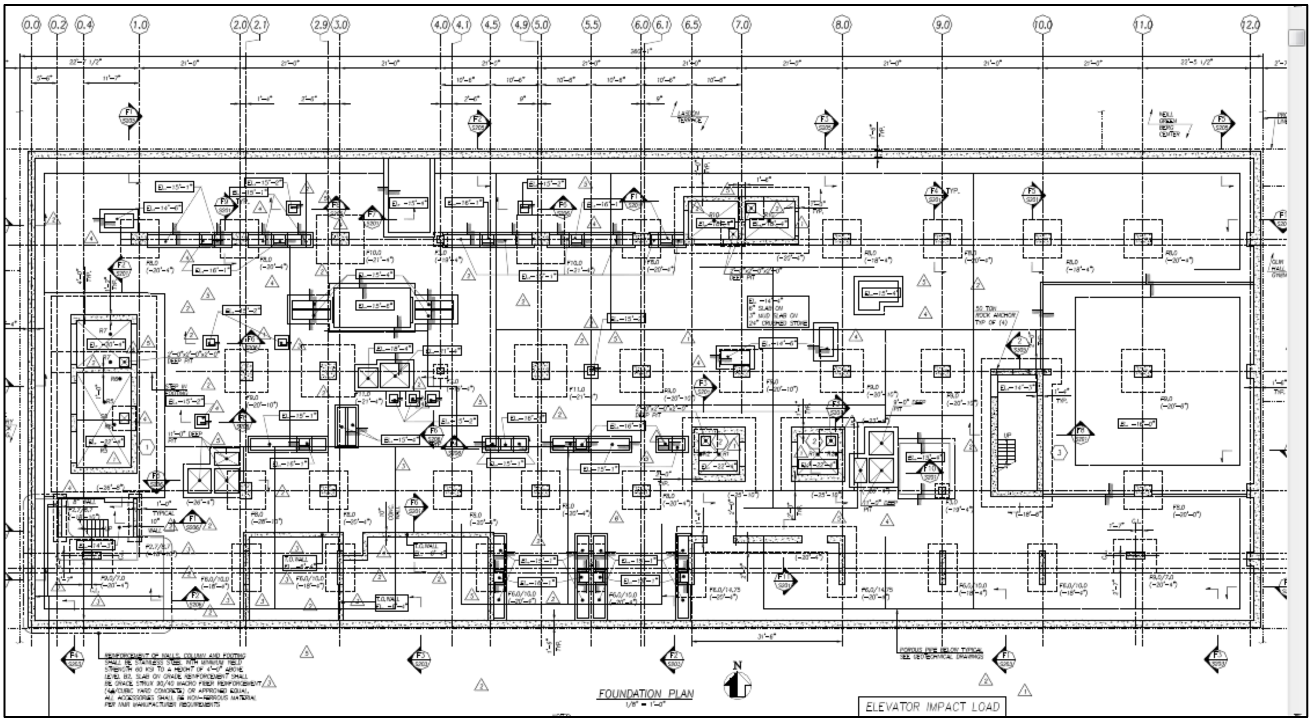


Figure 1: Basement Level 3 – Foundation Plan

Floor System

The floor system in the Medical Research Building is 2 way flat plate concrete slabs. These slabs vary in depth from floor to floor (see Figure 2 below). The bottom reinforcement is typically #5 bars at 12." Top reinforcement and additional bottom reinforcement varies as needed throughout the building. The slabs are especially thick in this building because much of the design was constrained by strict vibration requirements of the medical and research equipment in the building. Laboratory floors were designed to limit vibration velocities to 2000 micro-inches per second. Walking paces were assumed to be moderate (75 footfalls per minute) in the labs and corridors and fast (100 footfalls per minute) only in public areas such as the lobby. There are also vertical HSS members at alternate floors through the middle of the building where the laboratories are located. These members serve no structural load bearing purpose, they are simply meant to tie each floor to another floor to further limit vibrations by forcing any impact to excite vibrations in two floors instead of just one.

Floor	Slab Depth (in)
B3	6
B2	12.5
B1	12.5
1	11
2	12
3	12.5
4	12.5
5	12.5
6	12.5
7	12.5
8	12.5
9	12.5
10	12.5
11	12.5
12	12.5
13	12.5
14	12.5
15	12.5
16	12.5
Interstitial	10.5
17	10.5
18	12.5
19	10.5

Figure 2: Slab Depth per Floor

The front of the building features a cantilever slab extending approximately 9'-8" from the center of column line D. The glass sunshade curtain wall is connected to the edge of the slab. The slab is the same thickness as the rest of the floor, but is cambered up to reduce deflections caused by the curtain wall load. On the second floor, the slab is cambered 1" upward. For the third through the interstitial floors, the slab is cambered 5/8" upward.

Lateral System

Lateral loads, such as seismic and wind loads, are primarily resisted by 14"-16" reinforced concrete shear walls located around the stairwells and elevator cores. A couple of these shear walls step in at the second floor. Extra precautions were taken to make sure that the lateral moment still has a viable path to travel through that step in. Severud, the structural engineers for the project, desired to transfer lateral loads toward the perimeter of the building. In the front of the building there are massive 14 x 72 inch columns from which the slabs cantilever out and the glass sunshade curtain wall is hung. These columns also take some of the lateral loads. See the sketch in Appendix E for the location of lateral system elements on a typical floor.

Beams and Columns

There is a very wide variety of beam and column sizes in this building. There are almost forty different sizes of columns with dimensions ranging from 12” to 84,” with the most common column being 24 x 36. There are also approximately fifty five different sizes of beams ranging from 8 x24 to 84 x 48. Except on the laboratory floors, which are quite uniform, the column sizes tend to change from floor to floor. Reinforcement was provided to ensure the continuity of the load path through these column transfers.

Columns are located on the specified grid of 4 major rows in the East-West direction for the majority of the floors—except the first floor and below grade, which have a fifth row in the back of the building. Bay sizes are 27’-7,” 25’-0,” and 16’-3” in the North-South direction and the typical bay in the East-West direction is 21’-0” with end spans approximately 22’-6.” Beams, however, are only placed where they are needed. They are rarely in the same place from floor to floor and each floor has a different number of beams. The fourth floor has the fewest with 6, and the second floor has the most with 33. Below in Figure 3 is a typical framing plan for the 5th-15th floors.

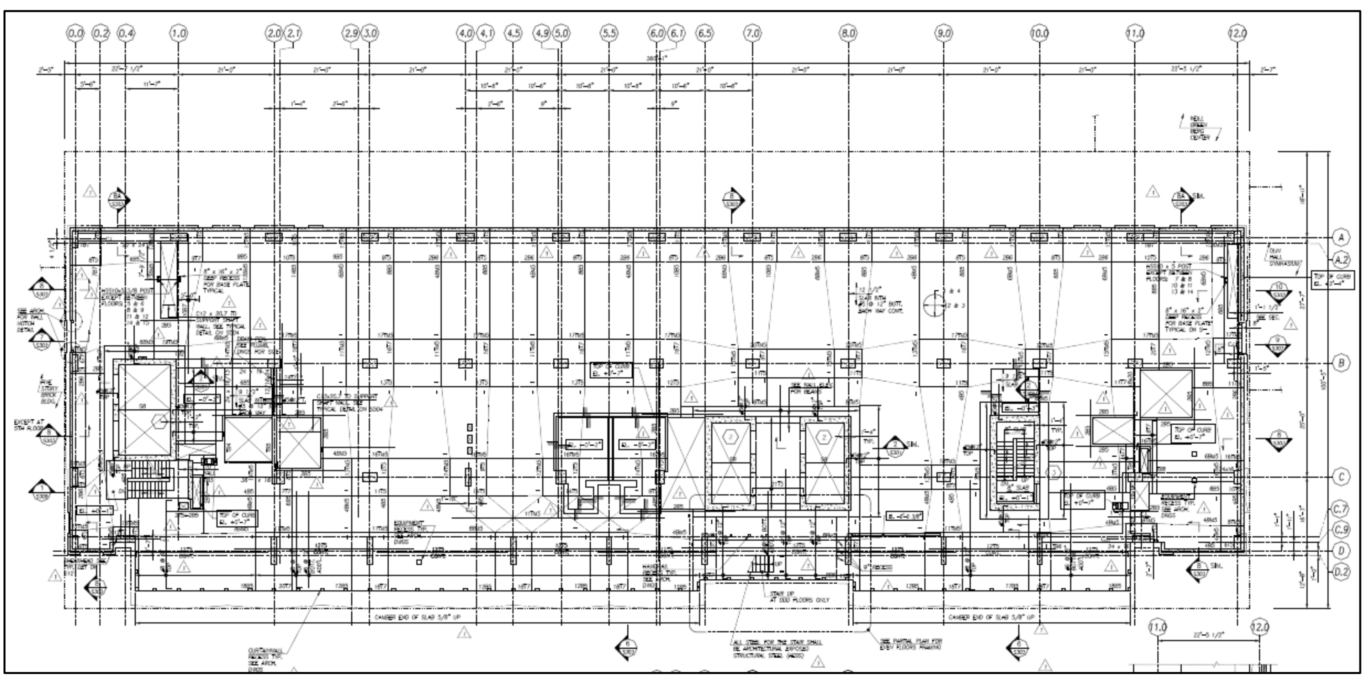


Figure 3: Typical Framing Plan – 5th-15th Floors

Design Codes and Standards

The Weill Cornell Medical Research Building was designed according to the 1968 New York City Building Code based on the UBC. In 2008 New York City updated their building code, which is now based on the IBC. For this report, the new 2008 code for analysis and design is being used; which references ASCE 7-02, ACI 318-02, etc. For relevance, ASCE 7-05, ACI 318-08, and the AISC Steel Construction Manual 14th ed. will be referenced in this report. The design for the Medical Research Building was submitted in 2008 and the project team decided to file under the old code. The MRB is located in New York City's zoning district R8, the use group is 3 (college), the construction class is I-C, and the occupancy group is D-2.

Structural Materials

The Medical Research Building is a predominantly concrete structure. The f'_c of the concrete varies throughout. See the table below in Figure 4 for the strength of concrete per floor.

On the roof and penthouse levels, there are structural steel members that frame platforms for mechanical equipment (cooling towers on the roof level), and also the window washing platform on the penthouse level. This penthouse level platform provides the means from which the window washing apparatus are hung and operated.

Steel members include W14s as horizontal framing members and HSS 10x8x5/8 for the perimeter. Columns, some of which extend down to the 19th floor (on the west side of the building) and some which continue to the 18th floor (on the east side) are HSS 8x8x3/8. The cooling tower platform consists of horizontal members ranging from W8s – W18s and HSS 8x8s as the columns. Figures 5 and 6 show the window washing platform and 19th floor framing plans.

Floor	f'_c Beams and Slabs(psi)	f'c Columns (psi)
B3	4000	8000
B2	5950	8000
B1	5950	8000
1	5950	8000
2	5950	8000
3	5950	8000
4	5950	8000
5	5950	8000
6	5000	5950
7	5000	5950
8	4000	5000
9	4000	5000
10	4000	4000
11	4000	4000
12	4000	4000
13	4000	4000
14	4000	4000
15	4000	4000
16	4000	4000
Interstitial	4000	4000
17	4000	4000
18	4000	4000
19	4000	4000

Figure 4: Concrete Strength per floor

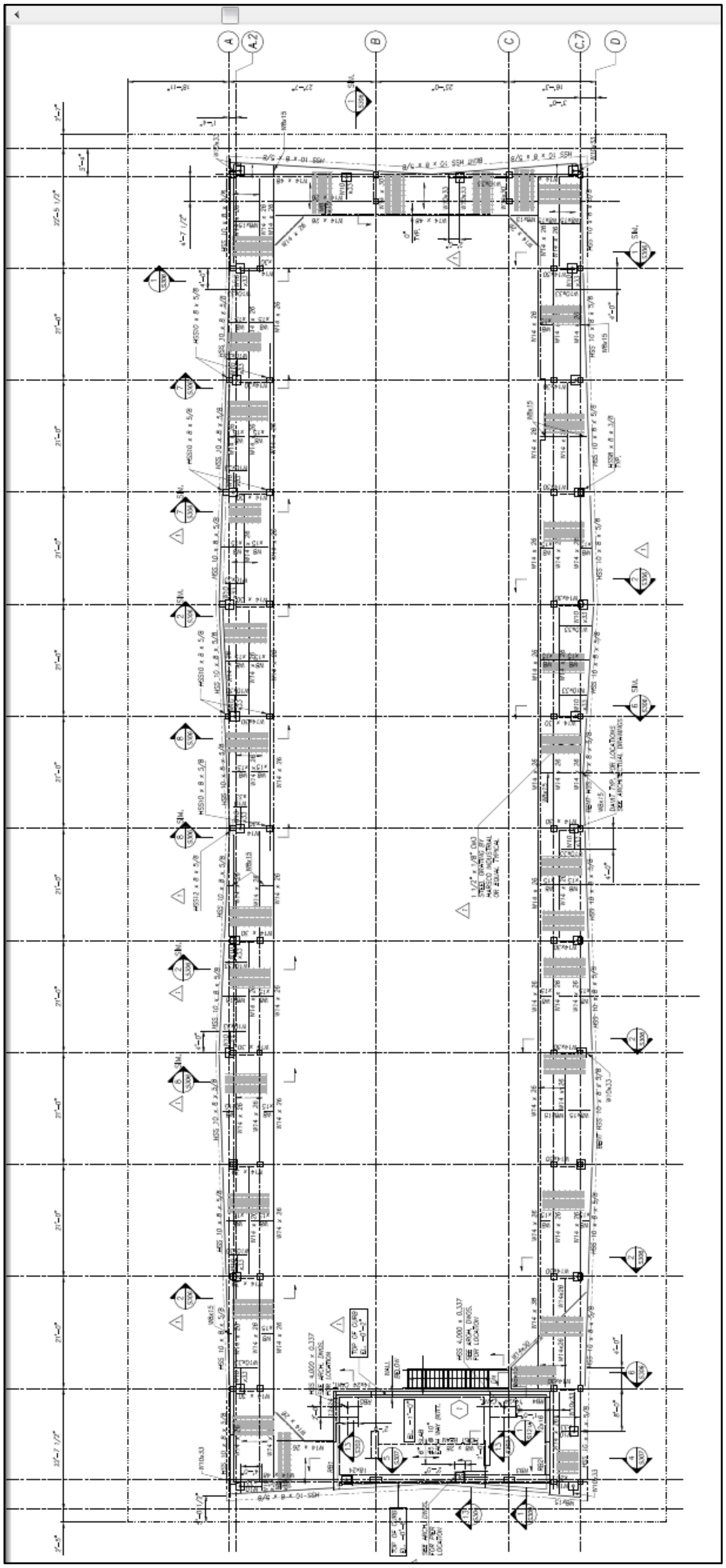


Figure 5: Window Washing Platform Framing Plan

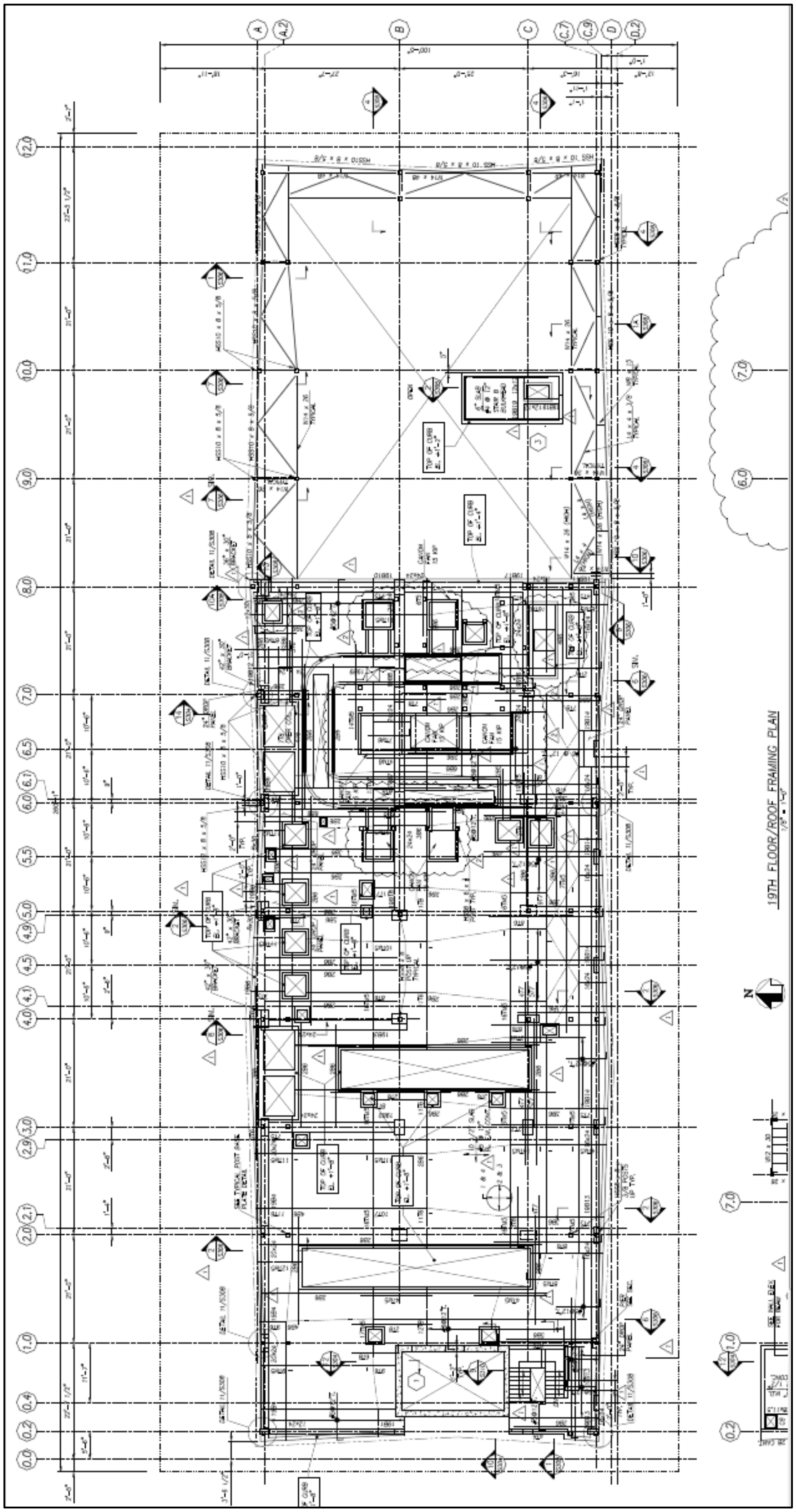


Figure 6: 19th Floor/Roof Framing Plan

Problem Statement

Technical Reports one, two, and three showed that the structural systems of the Weill Cornell Medical Research Building are adequate for both strength and serviceability requirements. One potentially problematic aspect of the design involves the solution of a two-way flat plate slab for the floor system, which includes the nearly ten foot cantilever on the front of the building from which the curtain wall is hung. The slab is cambered in the cantilever portion to resolve deflection issues. The two-way flat plate system was chosen to limit floor to floor heights; however this solution requires cambering concrete, which is not an exact science. If another floor system could be designed to eliminate the need for manually cambering a concrete slab, while still meeting deflection requirements for the cantilever section and keeping floor to floor heights at a minimum, this system would be a viable alternative.

Problem Solution

In the second technical report, multiple floor systems were assessed based on structural and non-structural criteria and it was deemed that a post-tensioned system was the best alternative to the two-way flat plate slab system. A post-tensioned slab system will be investigated. This system's inherent deflection-reducing characteristics make it a good choice for the cantilever. A post-tensioned floor system is also easier from a constructability point of view than a cambered two-way slab.

Due to the post-tensioned system's ability to cover large spans, a couple of options will be assessed regarding the column layout. First, it will be determined if the 14x72 columns that support the cantilever can be reduced in size while still maintaining deflection requirements. Since these columns take lateral loads as well, if they change in size, the building's lateral system will also need to be reevaluated. Second, the impact of removing column row B in the laboratory spaces will be considered. This will create an elongated span adjacent to the cantilever span and could help balance deflections. Eliminating a row of columns will also potentially have effects on the sizes of the remaining columns. The magnitude of these effects will also be investigated.

MAE Course Related Study

Information acquired in AE 597A will be applied in order to model the building in either ETABS or SAP. Understanding the methods by which the computer program arrives at its solution allows for a better analysis and scrutiny of results.

Breadth Topic 1

Redesigning the floor system of the Medical Research Building will potentially have an impact on the size and location of various mechanical shafts for the laboratory and mechanical floors of the building. An investigation into the extent that the change from a typical reinforced concrete slab to a post-tensioned slab affects the MEP equipment running between floors will be performed.

Breadth Topic 2

The second breadth investigation will be a cost comparison of the various alternatives the depth study provides. This will include comparisons of the cost of the post-tensioned floor system, as well as any impacts resulting from changing or removing columns, with the cost of the existing floor system and column design.

Tasks and Tools

Structural Depth

Task 1: Redesign floor system

- Design post-tensioned floor system for strength and serviceability requirements according to ACI 318-08.
- Create computer model of building with new floor system (in ETABS, SAP, or RAM).

Task 2: Resize 14x72 columns

- Investigate relationship between the size of columns in row D and the deflection of the slab in the cantilever using the computer model.
- Determine optimal size of columns in row D.
- Investigate effects of new size of columns on the lateral system using the computer model.

Task 3: Remove column row B

- Investigate relationship between removal of column row B and the deflection of the floor system for the now elongated span and cantilever.
- Redesign floor system and gravity columns as necessary for new distribution of loads.

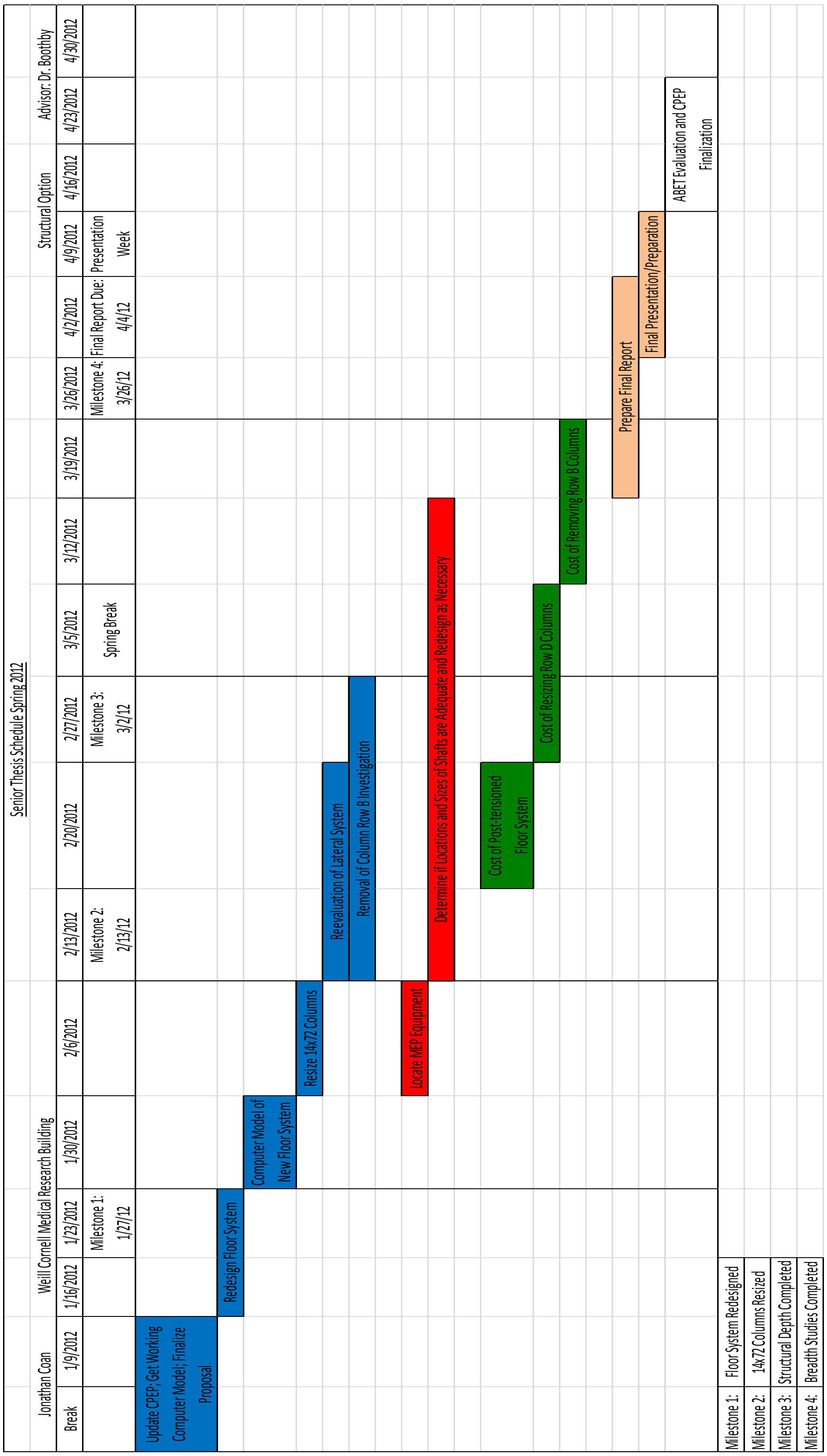
Breadth Topic 1 - Mechanical

- Locate MEP equipment passing through openings in the slabs for the laboratory and mechanical floors.
- Determine if locations and sizes of shafts are adequate for the new floor system.
- Change sizes and locations of shafts as well as organization and location of MEP equipment passing through them.

Breadth Topic 2 – Cost Analysis

- Determine cost of post-tensioned floor system using RS Means.
- Determine cost of alternative column sizes in row D and potential alterations to lateral system using RS Means.
- Determine cost of removing column row B and consequent adjustments to column sizes and floor system design using RS Means.
- Compare cost alternatives.

Thesis Schedule



Conclusion

The structural depth for this thesis will be focused around changing the floor system from a two-way flat plate slab to a post-tensioned slab. First, the new system will be designed and a computer model created. Next, the new floor system's effects on the required size of the 14x72 columns in row D in order to meet deflection requirements in the cantilever will be investigated. A further study will be undertaken to examine the results of removing column row B on deflections and sizes of the remaining structural system.

While this structural depth study is accomplished, two breadth studies will also be performed. The first will be a mechanical breadth which will integrate the new floor system with the existing requirements of the laboratories and mechanical floors of the Medical Research Building for shafts with MEP equipment running between floors. The second breadth study will be a cost comparison of the various redesign scenarios brought about by the structural depth study.

The final results and conclusions of these investigations will be summarized in a final report on or before April 4, 2012.