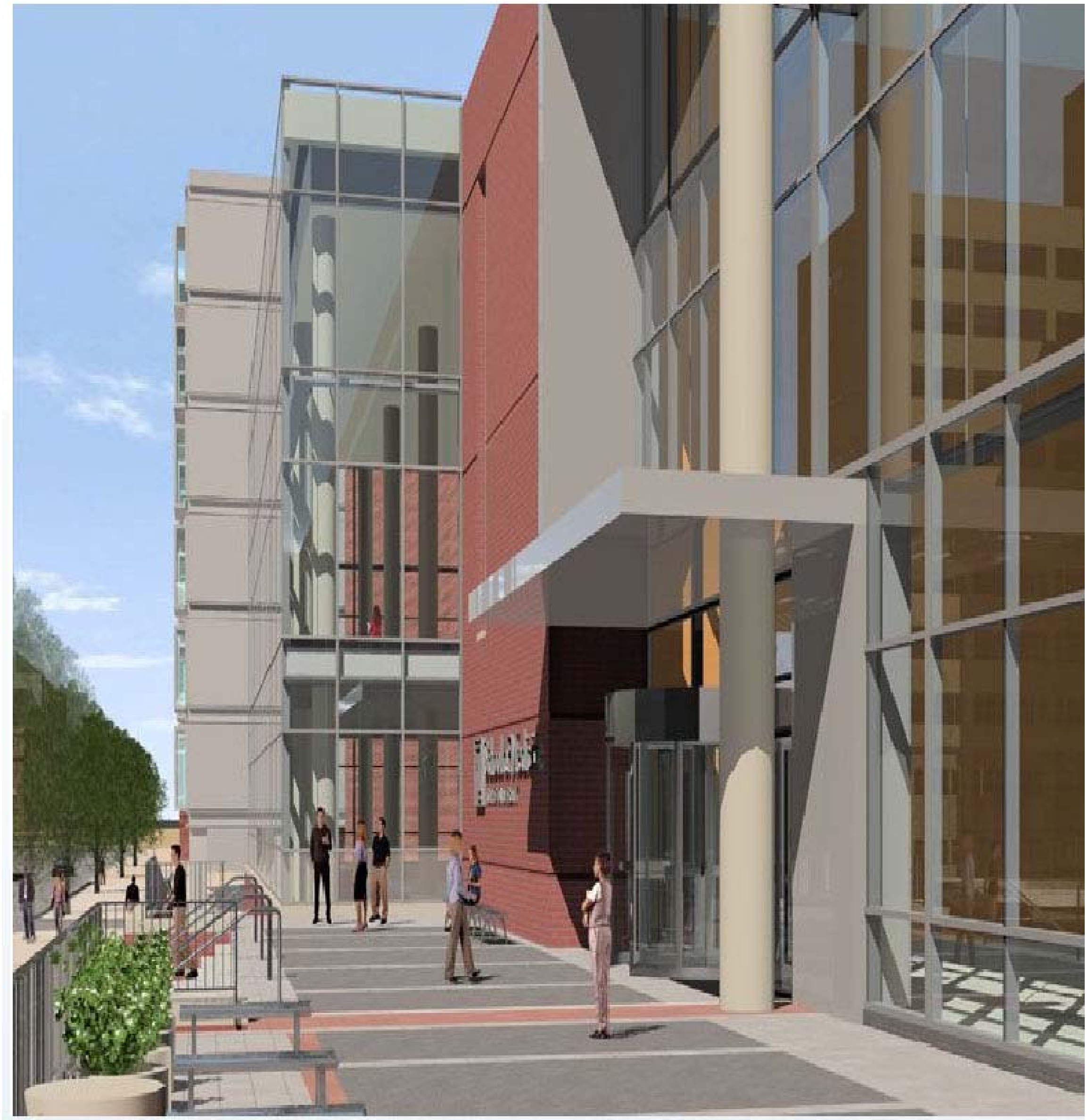
Temple University

3500 N. Broad St. Philadelphia, Pennsylvania 19140
Michael Wiegmann

Multipurpose Health Science Center



[THESIS PROPOSAL]

Michael Wiegmann – Structural Option – Faculty Advisor Prof. Hanagan

Table of Contents

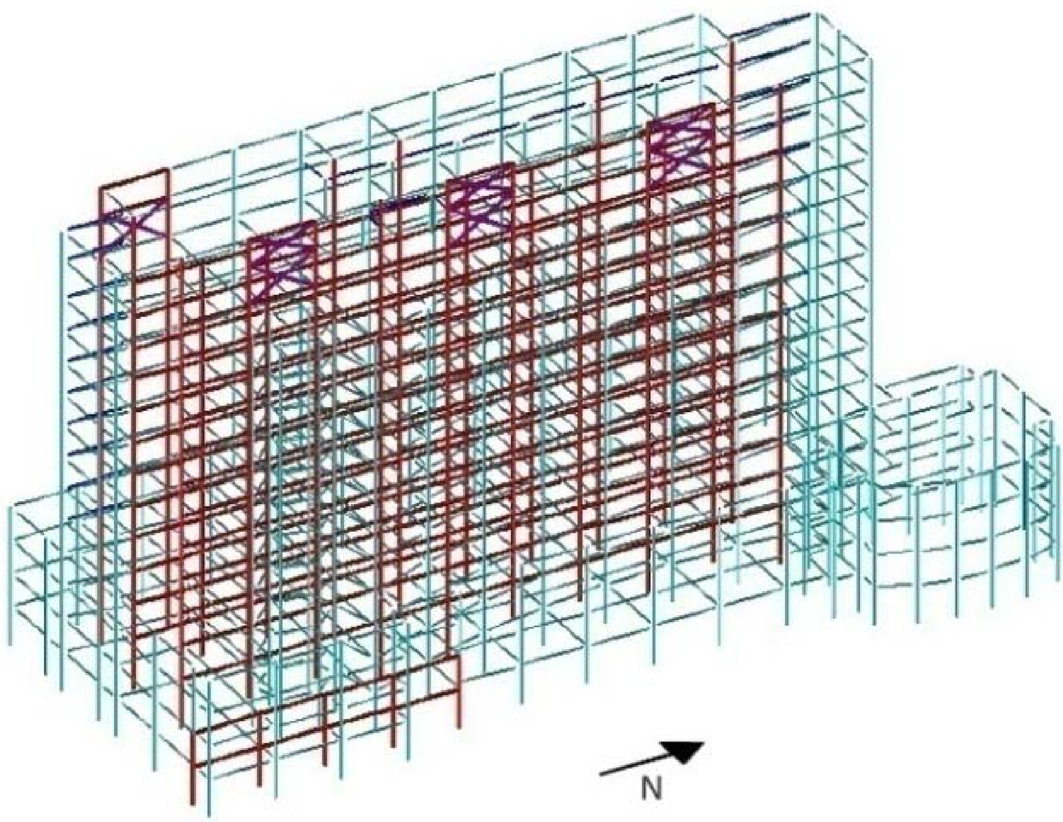


Figure 0: Ram Structural Model

Executive Summary

The purpose of this report is to form a proposal for the structural redesign of the Temple University Multipurpose Health Science Center, along with two breadth studies. The basis of the proposal is a scenario in which the building owner has expressed the need for significant expansion, requesting the addition of five levels to the existing design. Secondly, the owner has requested an in depth study into the addition of a green roof for the building to increase the amount of green space available to occupants. The addition and green roof fulfill the need for an in-depth structural analysis, as well as breadth topics in architecture, construction management, and sustainability.

The center is a new, 13 story, 480,000 square foot, $150 million addition to Temple University's medical campus north of Center City Philadelphia, Pennsylvania. The current educational and medical research facility is a steel frame structure utilizing braced frames and moment frames to resist wind loading.

The addition consists of adding five levels of laboratory/classroom and office space, including several bays controlled by special vibration requirements. This will require a redesign of the gravity columns and foundations, and include changing the mixed system of braced and moment frames to an all braced frame system.

The urban location provides an excellent opportunity to add green space on the roof with the addition of green roofs to approximately 9,000 square foot of fourth story roof area (including an accessible rooftop garden), and 20,000 square feet of penthouse roof area. Benefits of the green roof include reduced and cleaner runoff, a reduction in the heat island effect, and increased R-values for the roof areas.

The added stories and green roof call for architectural design and planning. The new areas will compliment the original aesthetic intentions, and will also meet the program requirements of added occupied space. The green roof also calls for a cost and scheduling analysis to determine if long term benefits outweigh the short-term costs.

Background

The Temple University Multipurpose Health Science Center is a new 480,000 square foot, $150 million addition to Temple University's medical campus north of Center City Philadelphia, Pennsylvania. The 13 story building contains offices, a café, a large library (building area 8), and three level atrium (area 10) with spaces primarily allocated to laboratories, classrooms, and their support facilities. The architectural features are governed by the concept of expressing internal functions externally, where the curved glass façade of the east elevation indicating the office areas (area 5) with the brick rectangle behind it expressing the laboratories and classrooms (area 1 and 2), and the oval tower expressing student meeting and studying spaces.

Built on a previous parking lot, the steel framed building will connect to an existing building via a bridge and tunnel. Foundations consist of 40% footings and 60% caissons which terminate at solid bedrock, present at 30' to 50' depths. The lateral system consists of concentric braced frames in the E-W direction, with moment frames in the N-S direction, all of which are supported by caissons. The floor system consists of composite steel decking spanning steel beam and girders.

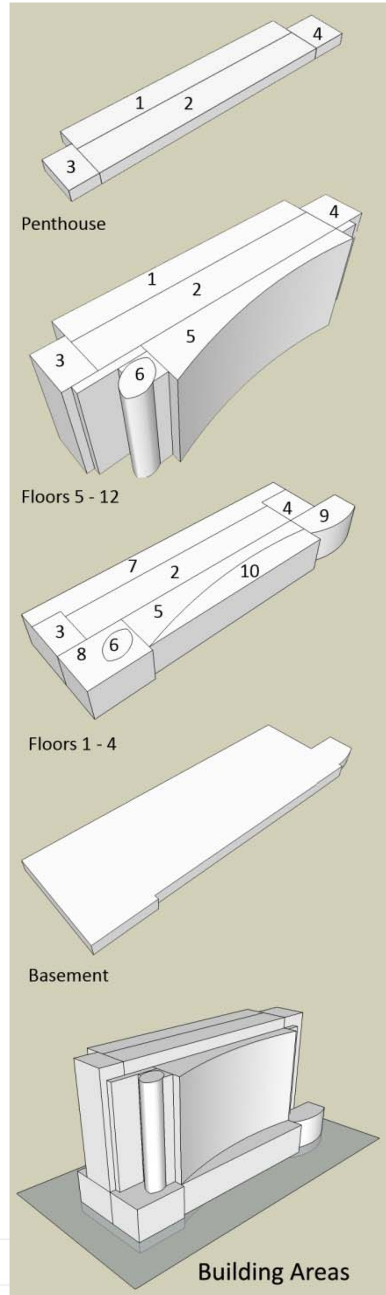


Figure 1: Building Areas

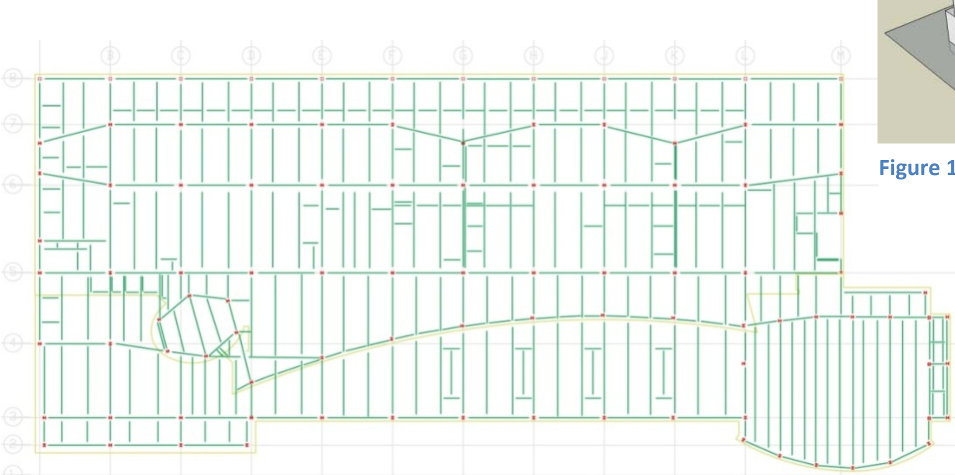


Figure 2: Framing Layout

Problem Statement

The Multipurpose Health Science Center is a new, state of the art facility within the heart of Philadelphia. The great urban location comes with a primary shortcoming: lack of space. Therefore, the owner has expressed the need for significant expansion, requesting the addition of five levels to the existing design, as well as a feasibility study into the addition of a green roof, with an accessible garden above the library. This will alleviate the constriction of urban green space while giving the medical campus room to grow.

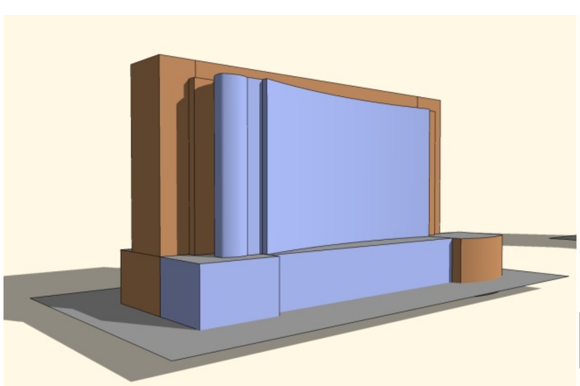
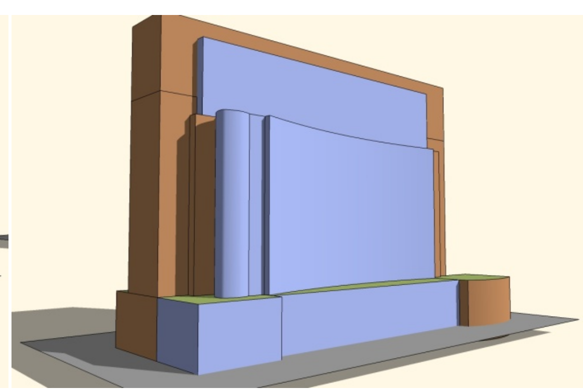
The addition of five levels will include several laboratories with especially sensitive laboratory equipment, requiring a vibration analysis. This analysis will need to be done in addition to a redesign of the gravity columns and foundations, as well as the lateral force resisting system. Architecturally, this addition will need to be designed to merge with the existing in terms of aesthetics, programming, and egress capacities.

The green roof feasibility study will need to take into account the additional loading on the structure, especially in the green roof garden area, as well as a cost and schedule analysis. Both short-term and long-term benefits will need to be taken into account in the study to insure accuracy. Additionally, the garden area will need to be designed and incorporated into the existing building

Proposed Solution

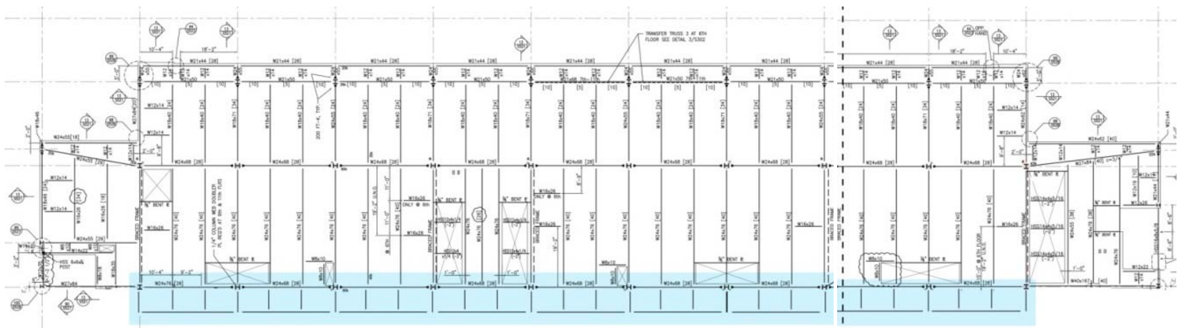
The Addition:

The addition of five levels of occupied space will be accomplished by cutting the existing building -seen below left- at the 12th floor penthouse level. Five additional levels of usable space will be inserted here creating floors 12-16. The penthouse, including its mezzanine level will be moved to the 17th floor, creating the new building form seen below, right.

Architecturally, the programming will remain similar to the existing tower floors. The large administrative offices will be eliminated to keep space for the laboratories and their support areas. A check will need to be made using the IBC 2006 to ensure that egress requirements are met.

The building form will continue up with a flat façade instead of the curve to accentuate the layering of the building. This will allow most of the existing structural framing to continue upward unchanged, with the exception of the cantilevered area, highlighted in blue.



There are several options which will be analyzed for achieving this cantilever, such as a hanging structure, moment connections, or continuous girders. The best option will be picked by a rough cost estimate of the different systems.

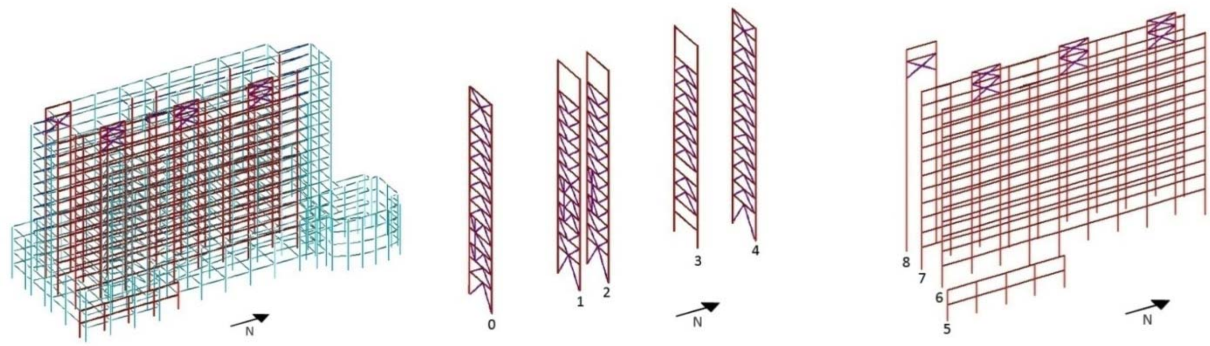
Special Bay:

It is assumed that two of the laboratories per floor will be contain especially sensitive lab equipment and will need to be designed for vibration control. Design Guide 11 will be used in conjunction with RAM modeling software to design this floor area, with hand check calculations coming from the design guide.

Lateral System:

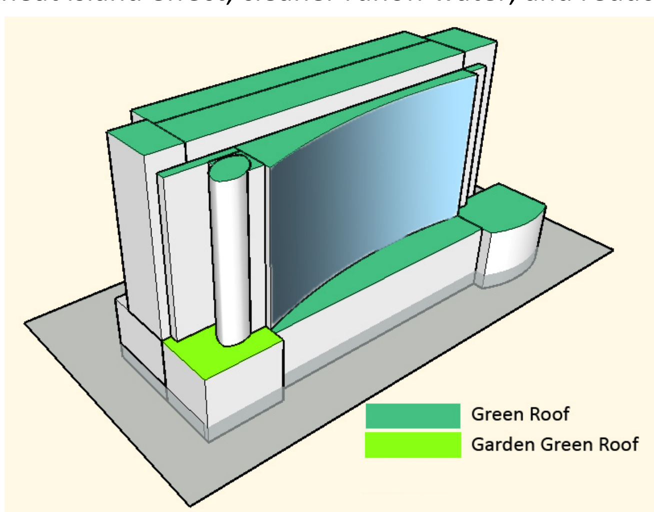
The increase building height will require a close look at the building's lateral system in both directions. The existing braced frames in the E-W direction will have to be redesigned to meet the higher building loads, while the moment frames in the N-S direction will be redesigned as braced frames with the hope of decreasing the frame cost. The image on the next page shows the existing frames and locations.

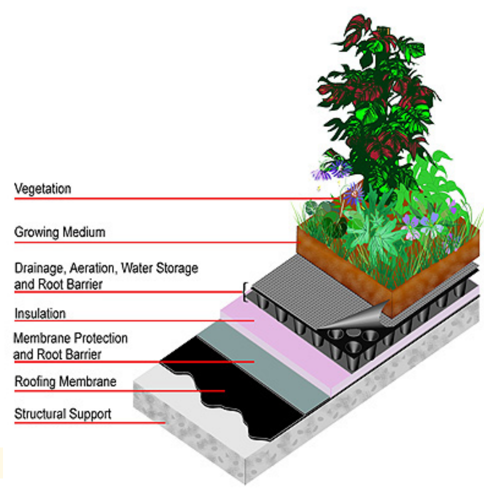
The design of this system will be accomplished by reanalyzing the already determined wind and seismic loads calculated through the ASCE 2007 design code. Next, the frames will be modeled and analyzed using RAM structural system. Hand checks will be performed to determine the accuracy of the results.



Green Roof:

The feasibility study will look into the application of intensive green roofs to most of the building's roof surfaces, with the 4th floor roof over the library designated as an extensive green roof garden for building occupant use. This would result in approximately 1400sf of usable space and 4800sf of green roof area. The soil thickness would be thicker in the garden area, but the basic construction of the two systems –seen in figure 4- is similar. The garden will insure an enduring green space for the medical campus community, while the green roof will also provide other benefits, such as a higher R-value for thermal insulation, a reduction in the heat island effect, cleaner runoff water, and reduced runoff volume.





The green roof will require a redesign of the affected structural system, especially the system supporting the garden area, which will have a new 100psf live load.

These structural changes, as well the costs of purchasing the more expensive green roof system will result in higher first costs for the project; however, a long term cost analysis needs to be conducted to discover long term benefits, such as energy and electricity reductions. This may lead to a relatively short payback period.

Solution Method

First the programming and schematic design phase needs to be completed. This includes choosing what system will be used to achieve the cantilever (moment connections, a hanging system or cantilevered girders) and basic design requirements of the green roof. The decision between the two cantilever floor systems will be reached by creating a relative cost estimate between the systems.

Next, the preexisting RAM model will have to be altered to incorporate the extra levels, which will include continuing up the existing E-W braced frames and changing the moment frames in the N-S direction to braced frames. To analyze and design these frames, an updated wind and seismic load calculation will be required to account for the additional floors and weight, using the ASCE7-05 code. In order to perform the gravity analysis, the new green roof loads will need to be added to the structure, including the live loads for the garden area. This will provide a sizing for the gravity columns, foundations and braced frames. These will need to be checked by hand spot checks using guidelines from the ASCE7-05 and AISC Steel Construction Manual.

The design for the special bay will be done using RAM, in which a vibration analysis can be done; however, this will also be compared to a hand check of the system, which will be accomplished through use of the Design Guide 11.

Once the structural analysis phase is completed, the architectural design will be finalized, and a cost and schedule estimate of the green roof will be made. This will be completed by contacting green roof professionals for estimating guidelines, as well as comparing these estimates to an RSMeans estimate of the existing built-up roof system.

Tasks and Tools & Schedule

Tasks & Schedule – Overview

1. Add Programming (5 days) Milestone – February 22
2. Design Special Bay (5 days) Milestone – February 29
3. Design Lateral System (5 days) Milestone – March 14
4. Design Gravity Columns (5 days) Milestone – March 14
5. Design Foundations (3 days) Milestone – March 19
6. Finish Structural Design (3 days) Milestone – March 24
7. Finish Architecture Design (2 days) Milestone – March 26
8. Finish Green Roof (4 days) Milestone – April 1
9. Presentation (7 days) Milestone – April 11

Tasks & Schedule – Details

1. Add Programming (5 days) Milestone – February 22
    a. Add 5 levels to building/define programming (1day)
        i. Retain existing upper level layout layout?
    b. Add Special bay (1 day)
        i. Decide on programming/define system
    c. Add/Edit lateral braced frames (2 days)
        i. Research existing E-W building frames
            1. Possible to simplify geometry?
        ii. Add N-S frames
            1. Use already computed center of gravity/ rigidity values to determine locations to minimize torsion
    d. Add Green Roof (1 day)
        i. Decide on programming/define system
        ii. Obtain system information: detailing, loading, cost, contractors
    e. Check life safety capacity (1 day)
    f. Other Architecture needs?
    g. Schematic Architecture ideas

2. Design Special Bay (5 days) Milestone – February 29
    a. Determine requirements
        i. Find Equipment
        ii. Vibration and deflection requirements
    b. Design System – Computer model/hand calcs
    c. Check, Q&A, reanalyze
3. Design Lateral System (5 days) Milestone – March 14
    a. Check N-S Frame locations for torsion issues,
    b. Edit & add to RAM model
        i. Possible to reconfigure E-W geometry?
    c. Check and reanalyze wind and earthquake
    d. Analyze Lateral
        i. Review Results, check against code limits
        ii. Contact Structural engineer for design drift values
    e. Check, Q&A, reanalyze
4. Design Gravity Columns (5 days) Milestone – March 14
    a. Edit & Add to RAM model
    b. Analyze Gravity
    c. Check, Q&A, reanalyze
5. Design Foundations (3 days) Milestone – March 19
    a. Check existing locations for additional capacity
    b. Redesign where necessary: RAM model
    c. Check, Q&A, reanalyze
6. Finish Structural Design (3 days) Milestone – March 24
    a. Hand checks: Lateral, gravity, foundation
    b. Finish analysis
7. Finish Architecture Design (2 days) Milestone – March 26
    a. New elevations
    b. Model
8. Finish Green Roof (4 days) Milestone – April 1
    a. CM Cost Estimate
    b. MEP study: energy savings, detailing, waterproofing
        i. Also include research into the added levels?
9. Presentation (7 days) Milestone – April 11
    a. Compile Booklet
    b. Final Presentation Slides
    c. Practice

Add Programing	Feb 22
Design Special Bay	Feb 29
Design Lateral System	March 14
Design Gravity Columns	March 14
Design Foundations	March 19
Finish Structural Design	March 24
Finish Architectural Design	March 26
Finish Green Roof	April 1
Presentation Work	April 11