Spring Thesis Proposal

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Structural Option

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Orange Regional Medical Center

Middletown, NY

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EXECUTIVE SUMMARY

Peeling away the brick façade, the artwork, and the landscaping of this six story building leaves the intricate structural system of Orange Regional Medical Center, a 600,000 SF hospital in Middletown, NY. This intricate structural system is one of composite steel deck on a steel frame with over fifty lateral resisting braced frames and shear walls. This proposal explores alternative solutions for the structural design, in hopes of finding a system that would offer the most educational gain.

Fifty lateral frames for one structure creates quite a few complexities during the construction of this building. All heavy bracing connections and link stiffeners need to be inspected to ensure that the structure will properly carry lateral loads. Therefore, it may be prove more effective to erect a fully concrete structure, which can utilize moment frames as lateral resistance, hence eliminating the need for braced frames. As determined in technical report 2, the concrete two-way flat slab system will also allow for smaller floor to floor heights at a lower price. Due to the extensive benefits of the concrete system, it was determined that this would be the best alternative to explore for Orange Regional Medical Center.

This thesis will also explore two other disciplines as breadth studies. These include a cost and construction schedule analysis as well as an architectural examination. These breadths will highlight any impacts that a concrete structure would have on the original design, in order to gain a complete comparison between the two structural options.

INTRODUCTION

This thesis proposal explores the structural make-up of Orange Regional Medical Center. From previous findings, the areas where the existing structure could be improved will be addressed in the form of a structural depth analysis. To supplement this structural depth, two breath topics in other discipline areas will also be proposed. First, to gain a better understanding of the existing structure, some background information will be given in building introduction.

Building Introduction

The first hospital built in New York State in the last twenty-five years, Orange Regional Medical Center, can be found right off of Interstate 17 in the town of Middletown. This giant is 600,000 square feet spread over seven floors (six above grade and one below) and was designed anticipating future additions. As can be seen in *Figure 1*, this structure follows a pod design, allowing for future additions to be constructed in the voids on the fifth and sixth floor roofs. This feature appears in several areas throughout the building. For example, this hospital features a removable, full glass façade in multiple locations where future additions may be constructed. Later in this report, it will be shown that the structure had to be sized to account for these future loads.

***Figure 1**: Pod Construction*

When it comes to the building site, the original design had to be rotated 90 degrees to best fit the site. Although the design works better with the site grading, this change also moved the Emergency Room entrance to the back corner, on the opposite side from the street entrance (See *Figure 2*). This may be taken as an architectural drawback, but this can only be paired with a number of architectural

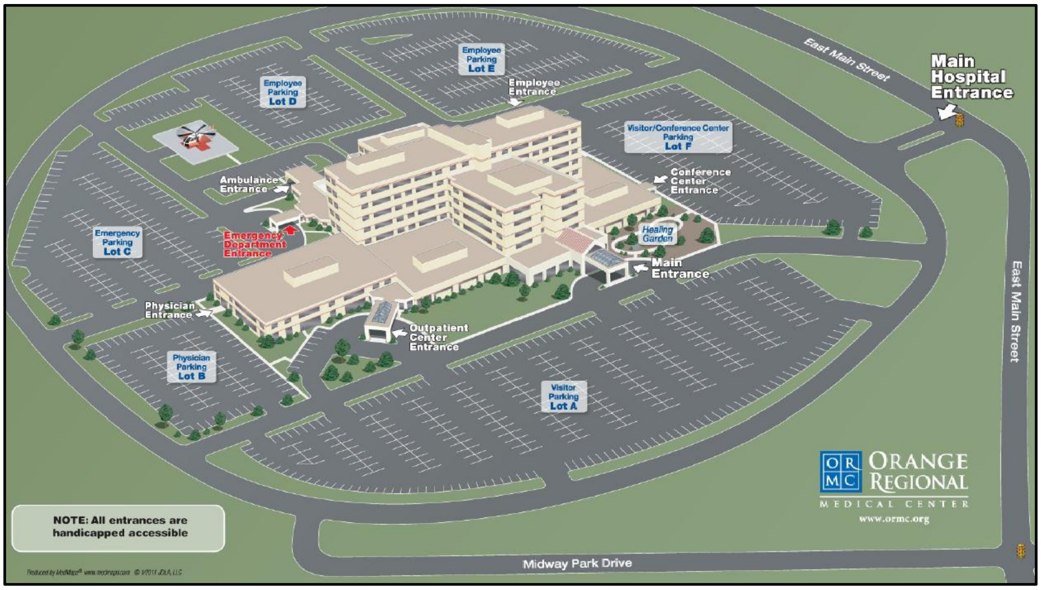


***Figure 2**: Hospital Site and Rotated Plan*

innovations in the healthcare field. Since the hospital's opening in August, patients have enjoyed rooms that rival that of hotels (See *Figure 3*). Carpeted hallways are also among some architectural features aimed at creating a quick recovery by creating comfortable, quiet spaces. Staying on the topic of architecture, this building has essentially been divided into two buildings: a healthcare building and a business administration building, each abiding by a separate set of codes, following later in this report. This separation is not so apparent in the façade, however. Tan brick with red soldier brick accents wrap completely around the building, leaving the EIFS façade of the lobby to stand apart as shown in *Figure 4*. The floor plan is also rather consistent from the second floor up. Each floor is in the shape of a Greek cross with the individual healthcare units branching off of the central elevator core, as seen in *Figure 5*. This not only allows for a uniform structural system, but it also allows first time visitors to be able to navigate the building with ease.

Top - Figure 3: *Patient Rooms*
Bottom - Figure 4: *Building Façade*

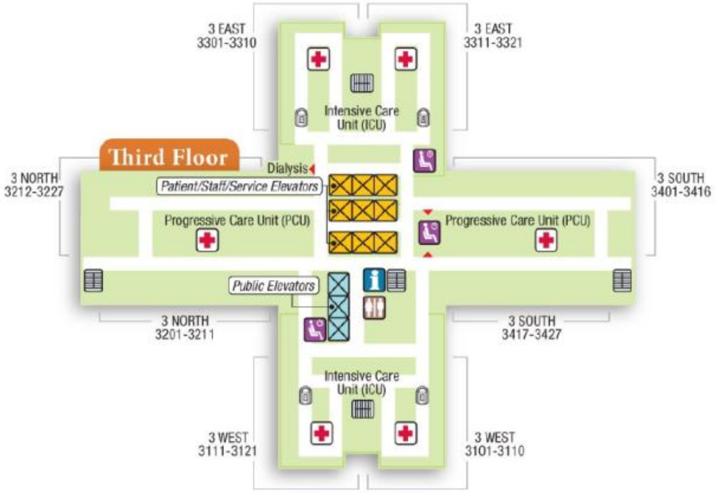


Figure 5: *Typical Floor plan*

Framing System

The steel frame of this structure comes in a variety of sizes. On the first floor alone, there are a total of twelve different wide flange beams used, but in general, W16x26's and W16x31's serve as the primary joists throughout the building with an average spacing of about 7 feet and an average span of about 26 feet. W18x35's and W21x44's are the most common choice for girders with spans ranging between 14' 8" and 27' 1". Following the load path to the columns, one will find just as much size dispersion. A majority of the columns are W12's with a small grouping of

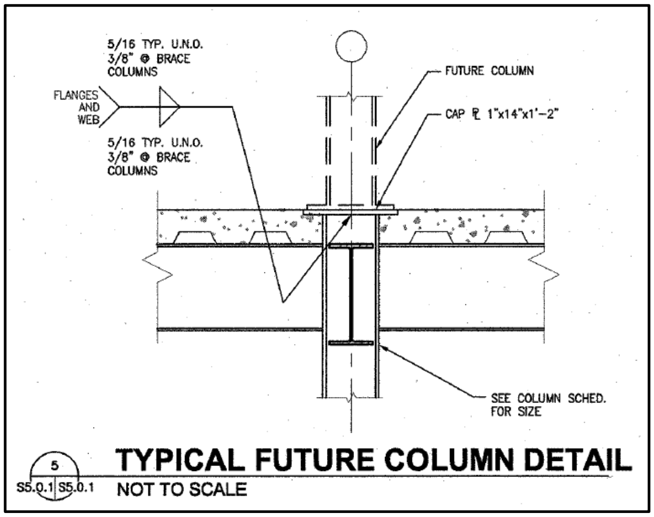


Figure 6: *Future column specified on column schedule*

W10’s and W8’s. As mentioned earlier, structural columns for the future additions are also shown on the column schedule (Detail shown in *Figure 6*). Traveling up the building, the columns continue to carry less of the building load and therefore, reduce in size. Typically, each column has two splices occurring just above the second and fourth floors. However, there are special cases where splices occur on the third and fifth floors instead. The structural notes specify that all splice connections must be slip critical connections. Looking further into the frame connections, the structural notes “detail steel beam connections as simple span beams, unless noted otherwise.” There are only a handful of moment frames specified throughout the building which must be considered as continuous beams.

Lateral Load Resisting Elements

To resist the lateral forces from wind and seismic activity, the structure utilizes concrete shear walls on the ground level. From the first floor and above, the lateral forces are then resisted by eccentrically braced steel frame as shown in *Figure 7*.

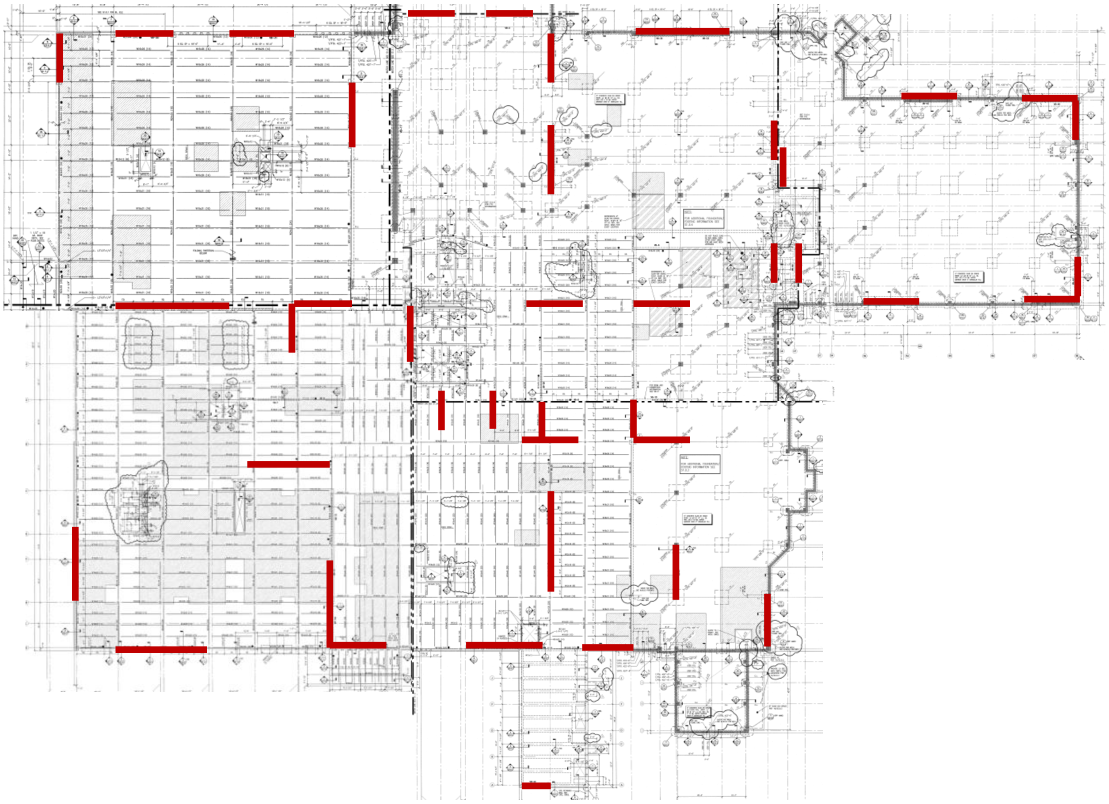


***Figure 7**: Braced Frames Location*

Floor System

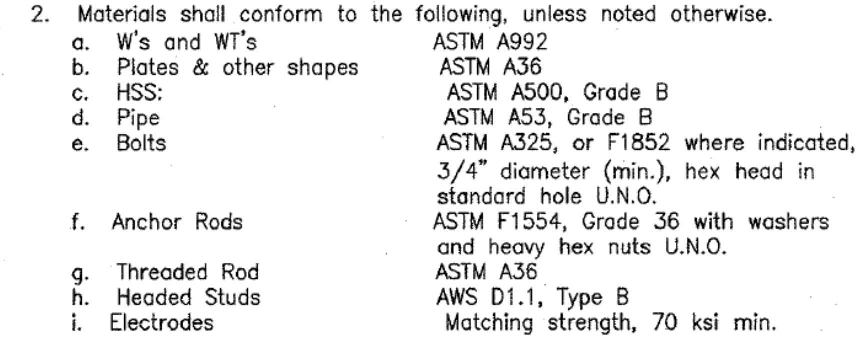
Out of the Vulcraft catalog, the floor system of ORMC consists primarily of 2VLI20 composite deck with 3¼” of light weight concrete, making for a total floor thickness of 5¼”. The decking runs three spans, perpendicular to the joists, where typical spans are in the range of 7’4”. However, as mentioned earlier, the decking may see longer spans due to the lack of bay size uniformity.

Foundations

The foundations are determined by the recommendations of the geotechnical report by Melick-Tully and Associates. Square, concrete spread footings are set on virgin soil or engineered, compacted soil with a bearing stress of 4000 psi.

GENERAL STRUCTURAL INFORMATION

For the existing building, the primary codes considered through the calculations were ASCE7-10 and AISC-14th Edition. ASCE was used for determining Live Loads and Lateral Loadings. It is important to note that the design team on this project had to follow the codes of New York State. This may contribute to discrepancy in values between the actual building and the calculated findings. Refer to *Figure 8* for grades of steel used for the particular structural elements in the existing building.



2. Materials shall conform to the following, unless noted otherwise.

a.	W's and WT's	ASTM A992
b.	Plates & other shapes	ASTM A36
c.	HSS:	ASTM A500, Grade B
d.	Pipe	ASTM A53, Grade B
e.	Bolts	ASTM A325, or F1852 where indicated, 3/4" diameter (min.), hex head in standard hole U.N.O.
f.	Anchor Rods	ASTM F1554, Grade 36 with washers and heavy hex nuts U.N.O.
g.	Threaded Rod	ASTM A36
h.	Headed Studs	AWS D1.1, Type B
i.	Electrodes	Matching strength, 70 ksi min.

***Figure 8**: Structural Materials*

PROBLEM STATEMENT

From earlier technical studies, it was found that the structure for Orange Regional Medical Center was sufficient to carry both gravity and lateral loadings. However, the structure had become rather complex to resist these loadings. Due to the cross shape of the floor plans, each leg had to be laterally reinforced to prevent the one leg from twisting more than another. This demanded for the placement of fifty lateral frames throughout the structure. The heavy bracing connections involved in each of these frames are rather complicated to ensure that all elements connect in a way as to prevent moment at the connection joint. Additionally, the eccentric frames require stiffeners at the link to prevent local buckling, which complicate the construction process and require additional inspections. Several of these eccentrically braced frames also tie into concrete shear walls at the first floor. These connections become rather difficult to ensure that the steel frames will be plumb and that the lateral load is being properly transferred down into the shear walls. Budget was a key factor in Orange Regional Medical Center's decisions, so if a cost comparable system existed that could effectively carry the loading with fewer lateral frames, such system may prove to be the more effective alternative.

PROBLEM SOLUTION

In technical report 2, it was found that a two-way flat slab would be a viable alternative floor system to the composite steel system of the existing building. In addition to lower costs, this concrete system offers small floor to floor heights and a lighter system. Of course, since these results stem from a preliminary design, a closer analysis would have to be performed to confirm these results. Still, a concrete flat slab system may be the solution, considering that with the correct reinforcement layout, a concrete system essentially offers moment frames for free. This would eliminate the need for braced frames or the addition of massive shear walls. Of course, the addition of a few shear walls may be necessary, pending lateral analysis, but it wouldn't be nearly as many frames as the existing steel system. Connections would also be easier since everything could be cast integrally rather than having to install steel base plates on top of the concrete shear walls.

In addition to solving the lateral issues of the steel structure, a concrete structure offers several other benefits over the steel structure. For one, time would be saved on fire protection since concrete requires no additional fireproofing. A flat slab system also makes the mechanical engineer's job easier since he or she would no longer need to coordinate with structural beams. Instead, ductwork can be run between the drop panels around the columns. Furthermore, a concrete structure removes the need for a steel erection crew and for steel inspectors.

Generally, concrete performs well under floor vibration, but this would be one area worth checking to ensure that the system will behave well in accordance to serviceability. Foundations would also be another area worth checking. If, in fact, this system is lighter than the steel system, then the required sizing of the foundations should be compared to that of the existing structure.

BREADTH STUDY I

As mentioned earlier, in technical report 2, the concrete flat slab system was found to be more cost effective than the existing system. As a breadth study, a more accurate cost determination will be performed for comparison purposes with the existing structure. Using RS Means, this cost analysis will include general conditions costs, structural costs, and any costs that may be accumulated from architectural changes, such as façade square footage. Additionally, concrete construction will follow a different construction schedule than the steel. Therefore, a schedule analysis will also be performed to compare with the existing steel timeline. This will show how a change to concrete may affect the critical path of construction.

BREADTH STUDY II

The second breadth study will take a look at the architectural effects of changing the structure to concrete. Some areas of interest may be the impact on the floor plan from the shear walls that may need to be added or the effect on the façade from the shortened story heights. The braced frames running through the windows seemed to be a big negative in the eyes of the building occupants, so this breadth study would also touch on the aesthetic of removing those braces. In addition to structural impacts on the architecture, this breadth study will also seek to rearrange floor plans to resolve space coordination concerns. These concerns were presented by the occupants of Orange Regional Medical Center. Rearranging medical departments may produce cases where structural spans will need to be changed. These changes will also be addressed in this breadth study.

TASKS AND TOOLS

Concrete Flat Slab System

Design Gravity System as Two-Way Flat Slab

1. Determine slab thickness and drop panel sizes from ACI 318-08
2. Determine trial column sizes
    a. Calculate self-weight and dead load
    b. Use live loads from Tech I
    c. Find column sizes needed

Design Lateral System of Concrete

1. Calculate new lateral loads
    a. Use MWFRS from ASCE7-10 to find wind loads
    b. Use ELF procedure from ASCE7-10 to find seismic loads
2. Model slab and columns in ETABS
    a. Run model to produce drift values
3. Analyze drift values and add shear walls if needed
    a. Determine new shear wall locations and thickness
    b. Recheck drift values until acceptable
4. Check that ETABS model sizes are adequate for gravity loading

Check Vibrational Behavior of Slab

1. Research methods for analyzing vibration
2. Perform analysis and check results

Determine Loading on Foundation

1. Find loads at base from ETABS
2. Design sample footing size
3. Compare with original footing size
4. Check building overturning moment

Construction Management Breadth

Perform Cost Analysis

1. Determine material, labor, equipment costs of concrete system
2. Determine material, labor, equipment costs of steel system
3. Compile numbers in spreadsheet and compare

Perform Schedule Analysis

1. Determine length of particular tasks
2. Plot timeline in MS Project for steel
    a. Determine critical path
    b. Determine proper sequence and overlap
3. Plot timeline in MS Project for concrete
    a. Determine critical path
    b. Determine proper sequence and overlap
4. Compare schedule results of the two systems

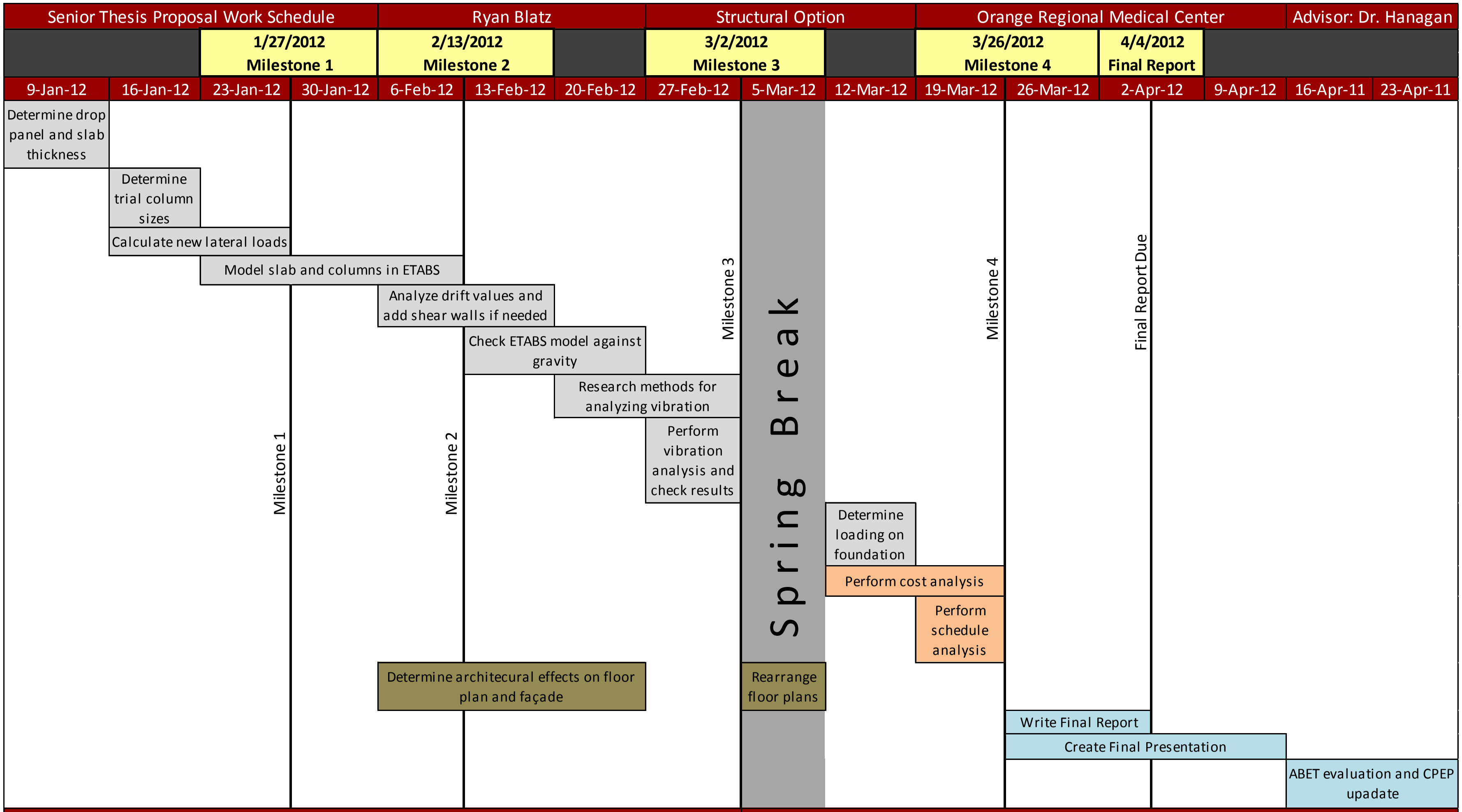
Architectural Breadth

Determine Effects on Floor Plan

1. Find locations where increased column size may cause issues
2. Examine effects of shear walls if any were added

Determine effects on façade

1. Investigate whether soldier brick banding is affected
2. Examine whether window sizes are affected
3. Comment on effects of removing bracing from windows



Milestones

1 Structural sizes determined and new loads calculated
2 ETABS model complete
3 Data gathered from ETABS and vibration analysis complete
4 Foundations analyzed, architectural and construction management breadths complete

Key

▢	Structural Depth	▢	CM Breadth
▨	Architectural Breadth	▢	Final Tasks

CONCLUSIONS

Given the findings from technical reports one through three, it was determined that the most valuable structural depth would include a redesign of the existing steel system into a concrete flat slab system. Not only would this further explore the advantages found from technical report 2, but it would also eliminate the need for braced frames. The concrete structure will serve as a moment frame with minimal shear walls to carry the lateral load. In addition to this future analysis, the new concrete system will also be analyzed for vibrations and for its effects on the foundations.

For breadth studies, it only seems appropriate to perform a cost and construction schedule comparison to determine how the concrete system measures up to the existing steel structure. The second breadth will focus on addressing any occupant concerns and any architectural impacts the structural change may generate. For example, if shear walls need to be added, this may impact the floor plans. The façade may also be affected by this change and will be an area worth checking. In its completion, the switch to a concrete system will yield the greatest educational gain. After exploring a steel system for the first semester of thesis, the implementation of a concrete system will create a balanced structural comprehension.