Thesis Proposal

St. Joseph Hospital of Orange Patient Care Center & Facility Service Building

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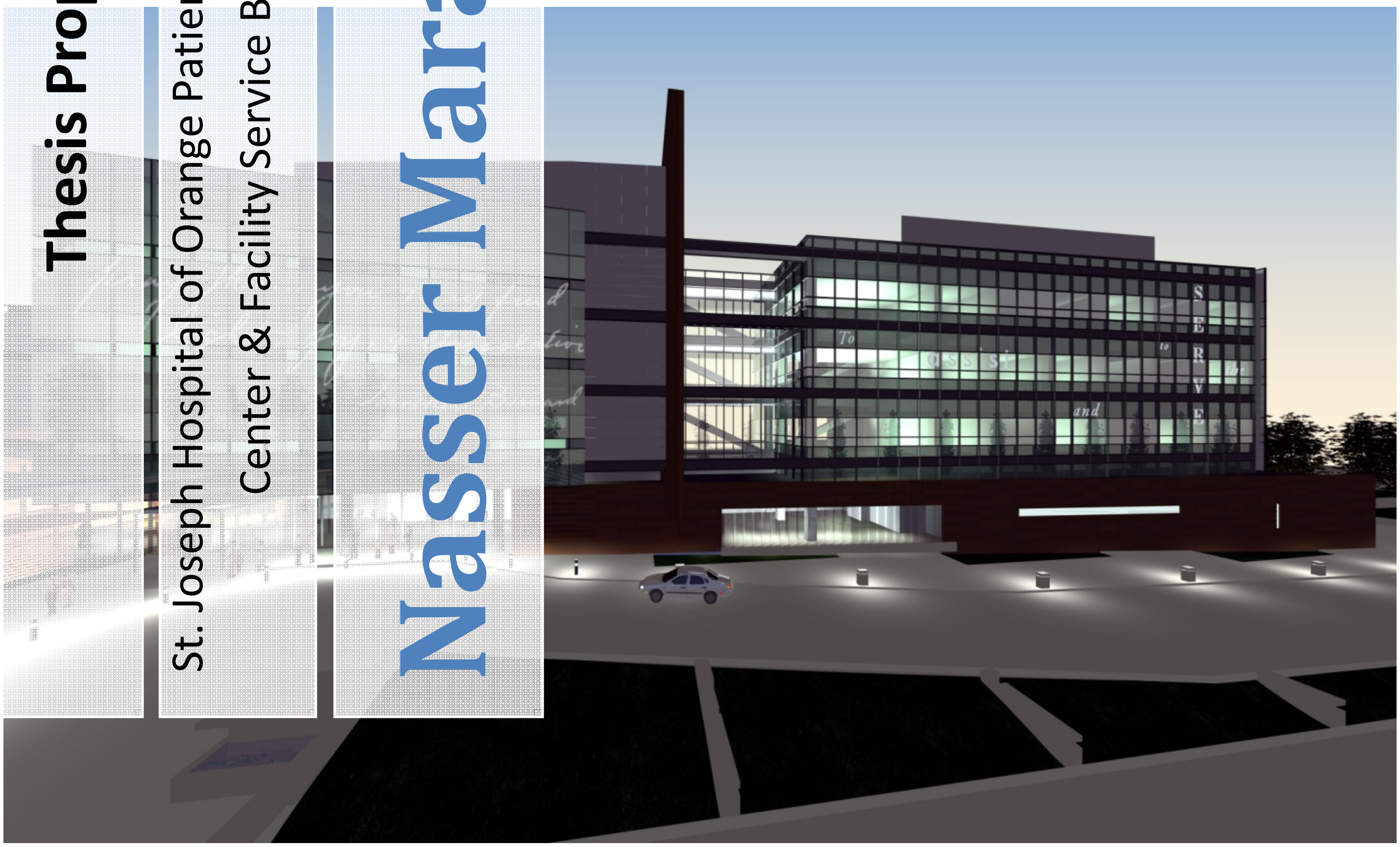

Proposal

Professor Andres Lepage
STRUCTURAL OPTION

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Executive Summary

During the upcoming semester, a complete redesign of the main lateral force resisting system will be performed using steel eccentrically braced frames. The redesign will evaluate the economical implications of using this system as opposed to the concentric braces designed in the original design. The breadth study will then evaluate the cost and scheduling effects of the redesign and comparisons will be made to the original design. The final breadth study will be a lighting redesign of the central courtyard located on the second floor, which will evaluate the use of the space during the day and night before and after the redesign.

These tasks will have major outcomes after being performed and will prepare my skills for the start of my career in structural engineering as well incorporate my creative skills that I have gained throughout the pursuit of my degree.

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Introduction

St. Joseph Hospital of Orange Patient Care Center & Facility Service Building is to be built within Saint Joseph Hospital Campus serving the healthcare needs of the Orange county community in Orange, CA. The Patient Care Center is linked to the main hospital through an underground tunnel and through a lobby to further serve the patients' needs. The building consists of four stories with basement that gives 252,712 square foot of additional hospital space. The buildings is approximately 285'-0" by 198'-0" on Level 1 and 2 and then the floor plan is reduced to 240'-0" by 198'-0" on Level 3, 4 and the roof.

The main entrance to the lobby is connected to the adjacent hospital reception area. The Patient Care Center consists of operating rooms to expand the surgical capacity of the main hospital. Operating rooms are equipped with latest innovative technology and medical equipment. To help further serve the main hospital, the Patient Care Center also has additional room for incoming patients and rooms for patients requiring intensive care.

The Patient Care Center has a central sterile plant located on the basement level with MEP equipment. The first level of the hospital consists of surgical rooms, administrative rooms and the lobby. The upper floors are separated by the central courtyard located on level 2. The west side consists of patient rooms and the east side consists of intensive care units. The remaining mechanical equipment is located on the roof level.

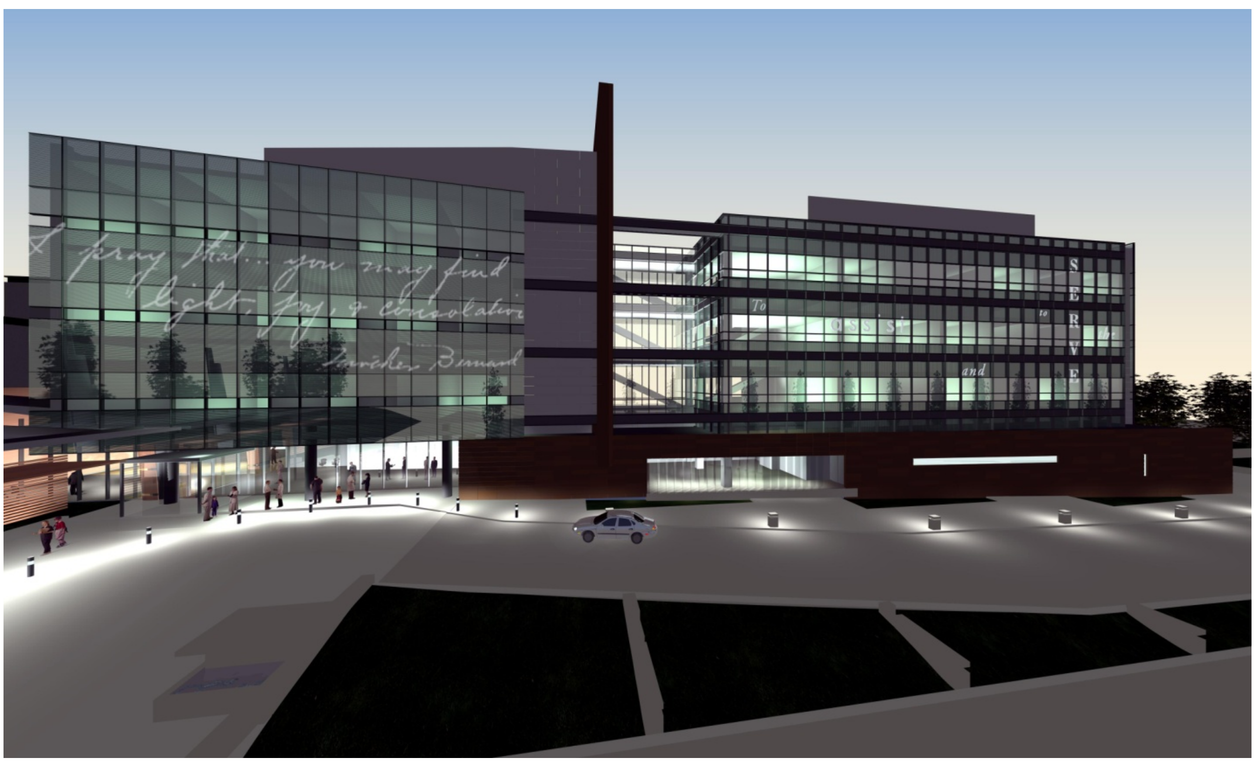

Figure 1. Computer rendering of Patient Care Center's North elevation.

Structural Systems

Floor Framing

There are minor variations to the floor framing through the Patient Care Center. The typical floor system is a composite steel framing using lightweight concrete and a total thickness of 6¼", 3" composite deck is used with 5" long, ¾"diameter shear studs for composite action. The typical infill beam is a W16x31, 30'-0" long spaced at 10'-0" on center, which frame onto a W24x68 30'-0" long. Variations from the typical floor system are based on the use of the space. Light weight concrete was used in the typical steel deck configuration to reduce shear and overturning moment during seismic events.

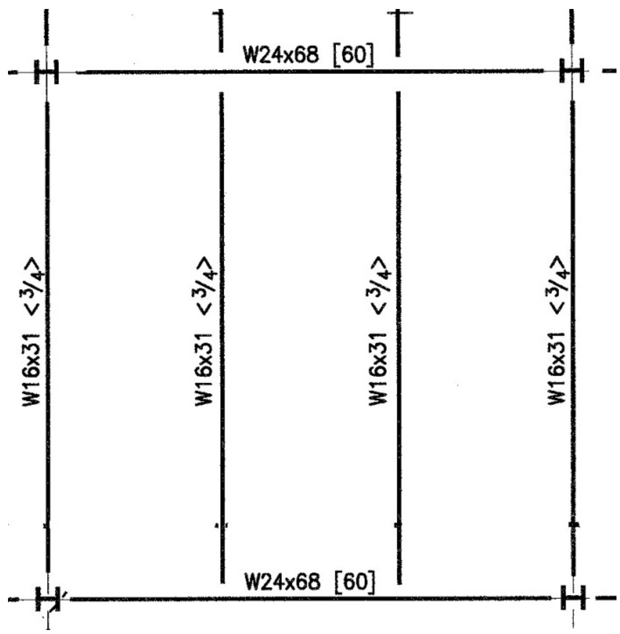

Fig2. Typical 30'-0"x30'-0" bay located on Levels 2, 3 and 4

First floor

The floor framing plan on the first floor differs from the rest due to different loading criterion used. Typical infill members used are W18x35 framing into W24x68 girders. Composite steel framing is used with normal weight concrete and a total thickness of 7½", 3" composite deck with 5" long, ¾" diameter shear studs.

Second floor

There is a central courtyard which is supported by the second floor framing system. Due to the high loading W21x111 infill beams are used which frame into W30x148. A composite steel framing system is also used with normal weight concrete and a total thickness of 9", 3" composite deck with 5" long, ¾" diameter shear studs.

Roof

Due to the location of air handling units on the roof, members with a higher loading capacity are required. Therefore the member sizes change to a W18x40 for beams and W24x84 for girders. A 9" composite steel system exists similar to the second floor courtyard but covered with rigid insulation.

Lateral Resisting System

The lateral system consists of 6 sets of braced frames located both along the N-S and E-W planes. It ranges from 2 bays to as long as 6 bays framing vertically to the roof of the structure. These braces are supported by shear walls at basement level. The braced frames are typically X-bracing while a whole set running E-W is diagonally braced. Both configurations are considered concentrically braced frames. X-Braced frames are a TS shaped with a gusset plate slipped in and welded. The gusset plate is then welded onto the column and beam, allowing the brace to buckle out of plane to dissipate energy at time of an earthquake. While diagonally braced member consists of a W Shape section which has its web and flanges welded to a plate which are all then welded onto the gusset plate. The plates attached to the flange are slipped in the gusset plate and welded.

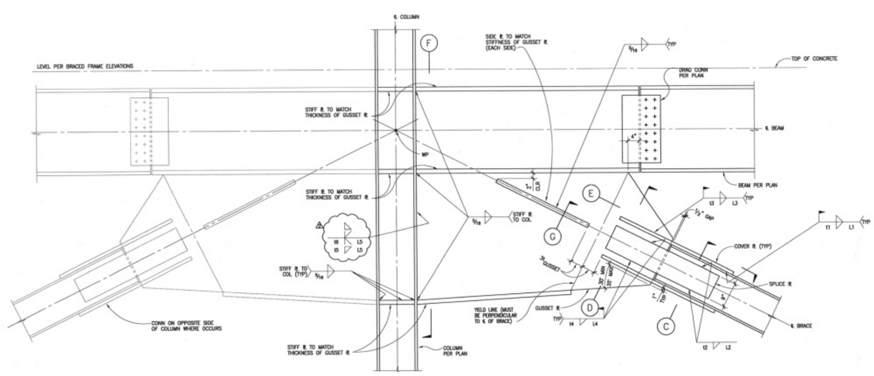

Fig3. Diagonal Brace Connection Detail

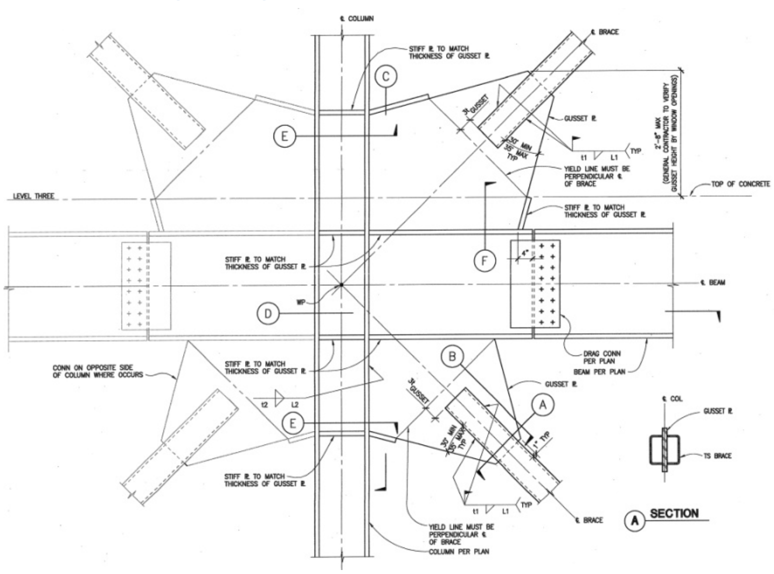

Fig4. X Brace Connection Detail

Foundation system

Gravity columns at the basement level are supported by concrete footings. These footings range depth from 1'-6" to 3'-6" and their size ranges from 2'-0"x2'-0" to 16'-0"x16'-0". While the shear walls are supported by continuous deep footings typically 5'-0" deep and 7'-0" wide from each face of the wall. The majority of the foundation is considered shallow as advised by the geotechnical engineer. While the main entrance canopy is supported by piles capes each connected to 4 piles.

Columns

There are two columns sets per gridline intersection which are usually spliced at 5'-0" from the Level 2. Typical columns sizes are W14x99 on the upper levels (Level 2 to Roof); while the lower columns are W14x145 or W14x132 depending on location and there loadings. Columns existing in the braced frame are usually W14x145 except the end columns which are W14x211 on the top and W14x311 at the bottom. These columns have greater strength capacities due to the excess axial tension and compression they carry from the bracing system induced moment.

Connections

Beams and Girders are typically connected to each other using bolted connections on the beams with steel plates and welded on the girder. The gravity girders have similar connections to the columns, where a shear plate is welded on the column flange.

Identification of other structural elements

There are several areas in the building that were not discussed in depth in this report. These include the underground tunnel connecting to the adjacent hospital, and the canopy at the building's main entrance.

Architectural Plans

The following are architectural floor plans of the building.

1st Floor plans

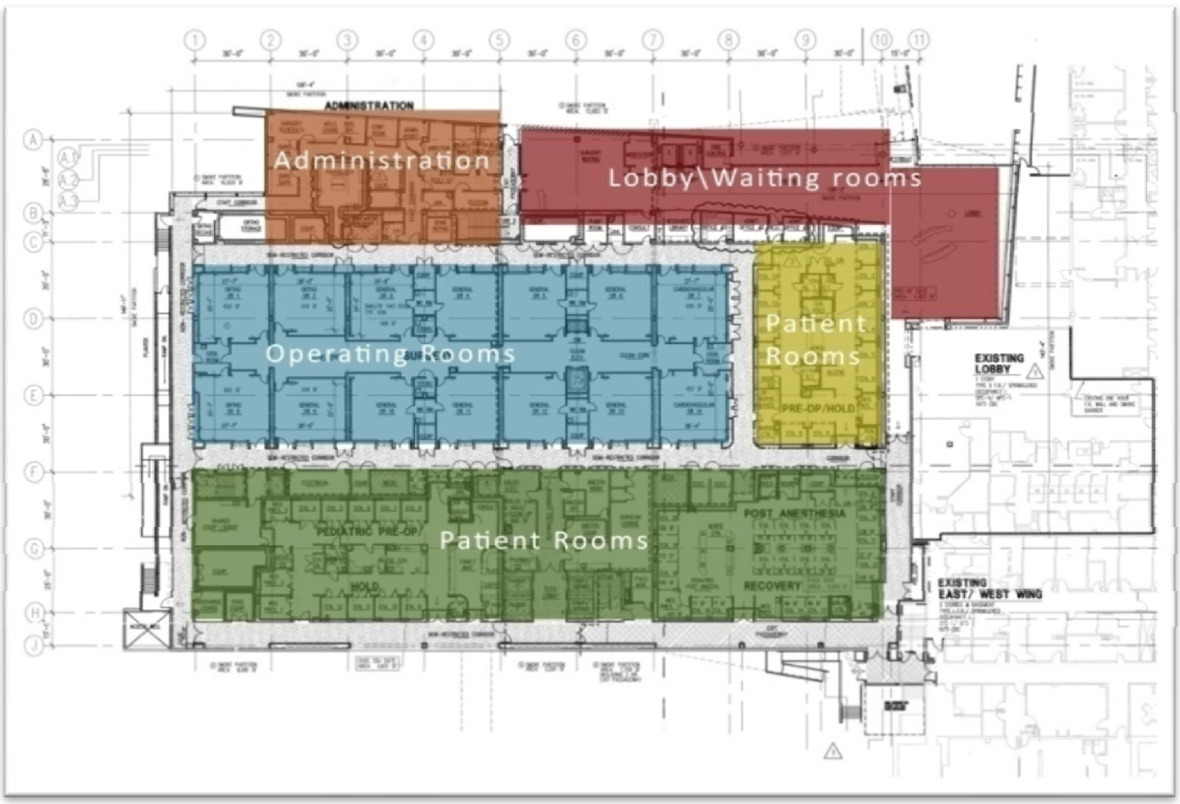

Fig5. First floor plan showing occupant use.

2nd Floor Plan

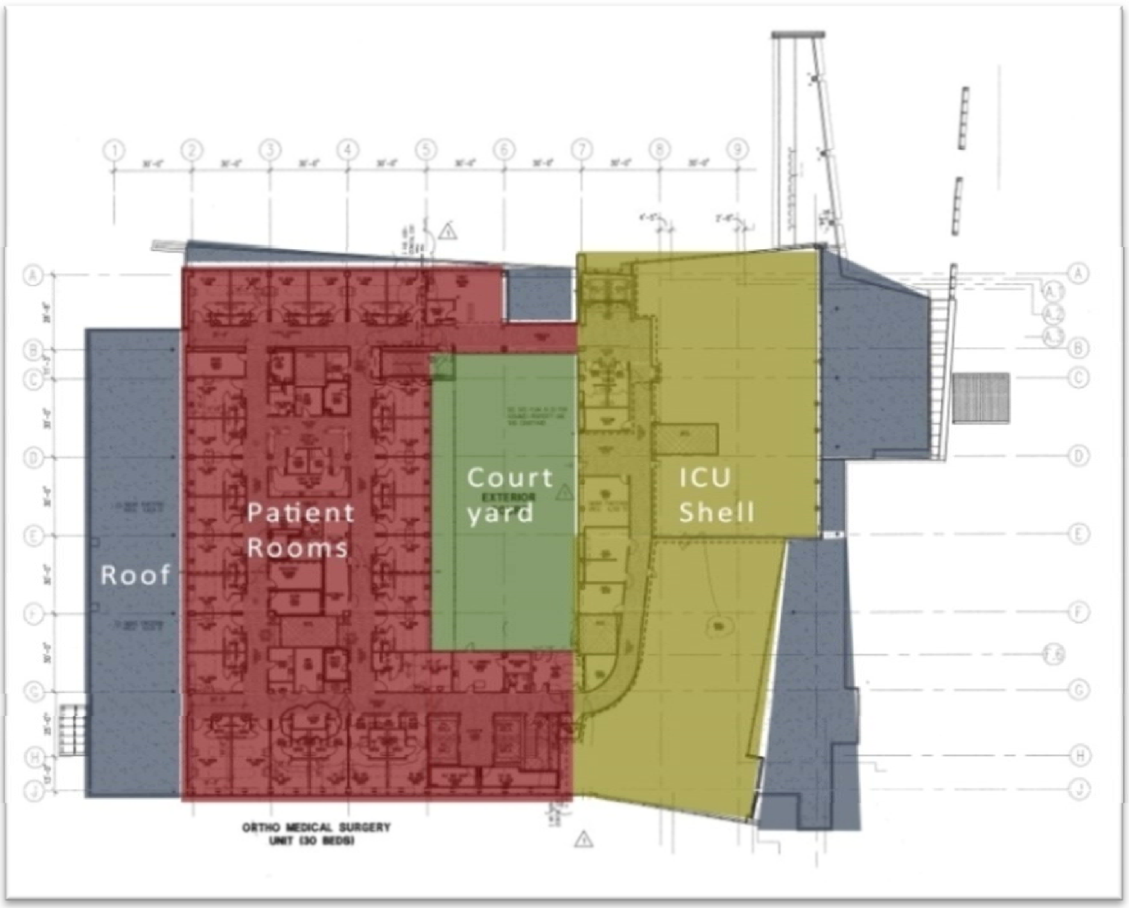

Fig7. 2nd floor plan showing occupant use.

3rd Floor plan.

3rd and 4th floor plans are similar in layout.

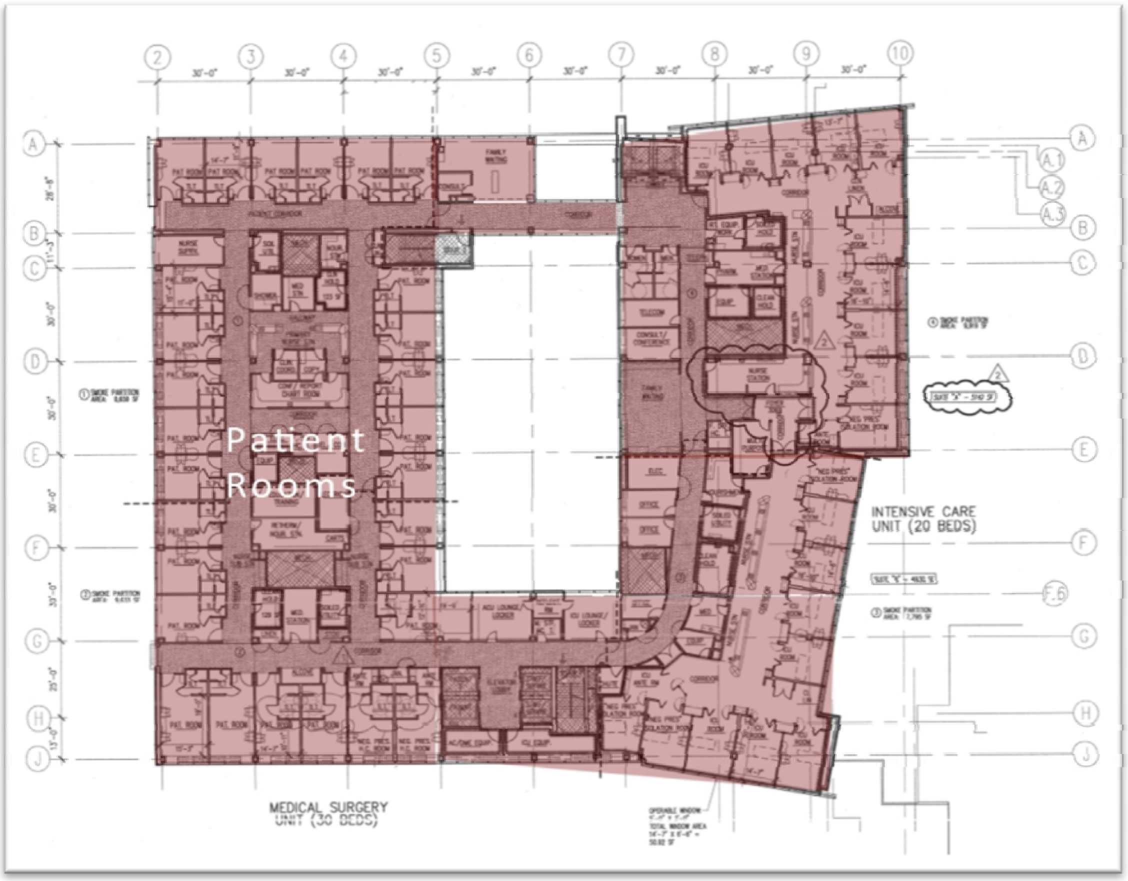

Fig9. 3rd Floor Plan showing occupant use.

Problem Statements

After careful analysis of the lateral force resisting frames with code provisions from ASCE 7-05, it was determined that the lateral resisting frames have been over designed. This may have been due to different assumptions taken by the designer when using the UBC 1997. When checking members for their Demand Capacity Ratio, most columns and braces were within 25% to 75% ratio, again this is due to an overdesigned structure. If the designer were to use a less rigid lateral force resisting system than designed, he would have been able to increase the fundamental period of the structure hence reducing the spectral response acceleration while also meeting drift limits. This can essentially reduce the base shear of the structure; hence reduce the lateral force required to be resisted by the braced frames and columns connecting to them. Refer to Technical Assignment 3 for further justification to this conclusion.

Proposed Solution

Structural Depth

The designer also decided to use concentrically braced frames for the lateral system due to reason beyond our knowledge. But after quick calculations based on the code provisions from ASCE 7-05, it is permissible to conclude that the use of eccentrically braced frames with moment connection at columns away from links; will reduce the base shear to more than 50% of the original design. The use of a larger response modification coefficient permitted by code; a longer approximate fundamental period, will essentially reduce the amount of steel required in the lateral force resisting system hence save time and cost.

Changing the lateral system from diagonal and X braces to eccentric braces will have impact on the architectural drawings. After referring to the architectural drawings, it can be concluded that most braces are situated next to a door or wall opening. This issue would have to be addressed when placing the eccentric braces.

Breadth Studies

Construction Management Breadth

Problem Solution

The decision to use eccentric braced frames would have impact on scheduling and construction cost. Therefore a detailed cost analysis would have to be done to see how much money would have been saved if this system was first implemented. The addition of moment connections required at the columns and the beams would have impact of construction time, therefore this design would require a detailed scheduling analysis to be done so that a recommendation can be made regarding if this system provides the optimal solution.

Lighting Electrical

Problem Statement

After careful inspection of the lighting plans for the patient care center, it seemed that a deficiency of light fixtures is present at the second floor court yard. The space seems to be very welcoming and relaxing for incoming patients and time can be spent there after sun down for the patients while also providing a stress free environment.

Proposed Solution

The second floor court yard will be looked at with light approaching in during the day and night time conditions. Appropriate light fixtures will be selected and placed at areas to accentuate architectural features and landscaping at the courtyard space. The lighting fixtures will help provide the use of outdoor space that is safe for the patients while not distracting patient rooms that are facing the court yard space. The courtyard is also visible from the north face of the building. Therefore the overall effects on the building's front façade will be analyzed and incorporated into the final lighting design. The space will be modeled using AGI-32, a lighting design software for calculations and visualizations. This will provide renderings of the final design that can be presented to the client for approval.

Tasks and Methods

Phase 1: Structural Depth of the Main Lateral Force Resisting System

Task 1: Verify building loads with Technical Report 3

Verify live loads

Verify dead and super imposed dead loads

Verify building self weight

Verify diaphragm properties and extension

Task 2: Determine lateral Loads

Determine seismic loads based on ASCE 7-05 and the 2007 California Building Code

Task 3: Preliminary Design of eccentric braces

Determine location of the eccentric braces and check if compliant with architectural drawings

Design Eccentric braces using hand calculations

Determine trial sizes for members

Task 4: Model Lateral Resisting System using ETABS

Compare results to manual findings

Finalize member sizes

Check to see if compliant with building codes.

Task 5: Determine forces required to design connections

Task 6: Determine the effects on other building elements

Redesign the continuous footings

Evaluate the existence of the shear walls in the basement. (Shear walls are located below the braced frames)

Identify elements that still require further redesign.

Phase 2: Construction Management Breadth

Task1: Detailed Cost Analysis

Perform a detailed cost analysis of existing structures lateral force resisting system

Perform a detailed cost analysis of the new lateral force resisting system

Task 2: Construction Sequence

Determine construction sequence of the new system and old system

Task 3: Construction Schedule

Create Schedule of the new system and old system

Compare the constructability of both lateral force resisting systems

Phase 3: Lighting Electrical Breadth

Task 1: List courtyard space design criteria

Design per IESNA handbook and the 2007 California Building Code

Task 2: List lighting goals

Determine design lighting features that are going to be implemented

Task 3: Select lighting hardware

Obtain photometric data

Task 4: List light loss factors and assumptions

Task 5: Model space using AGI-32

Provide renderings of the courtyard

Task 6: Electrical Plan

Determine how the new light fixtures are controlled and circuited

Schedule

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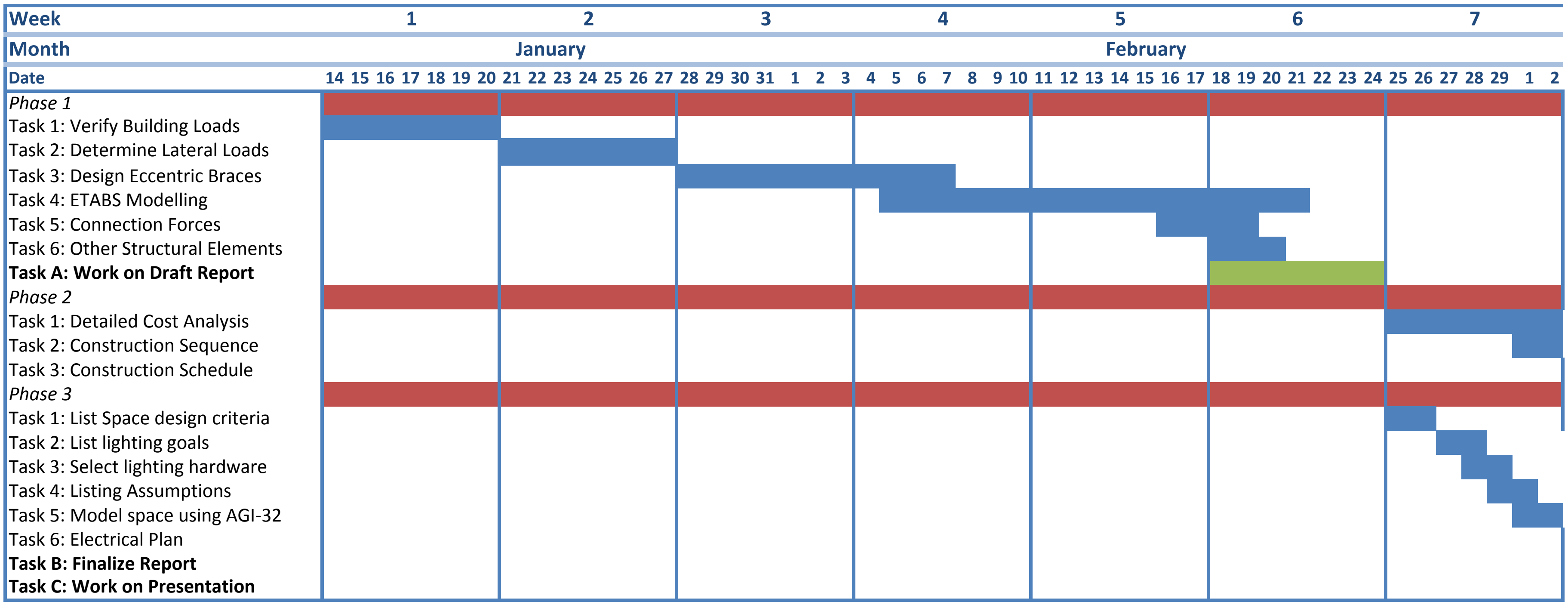
Schedule

The following timeline indicates which task will during each week of the semester.



Schedule

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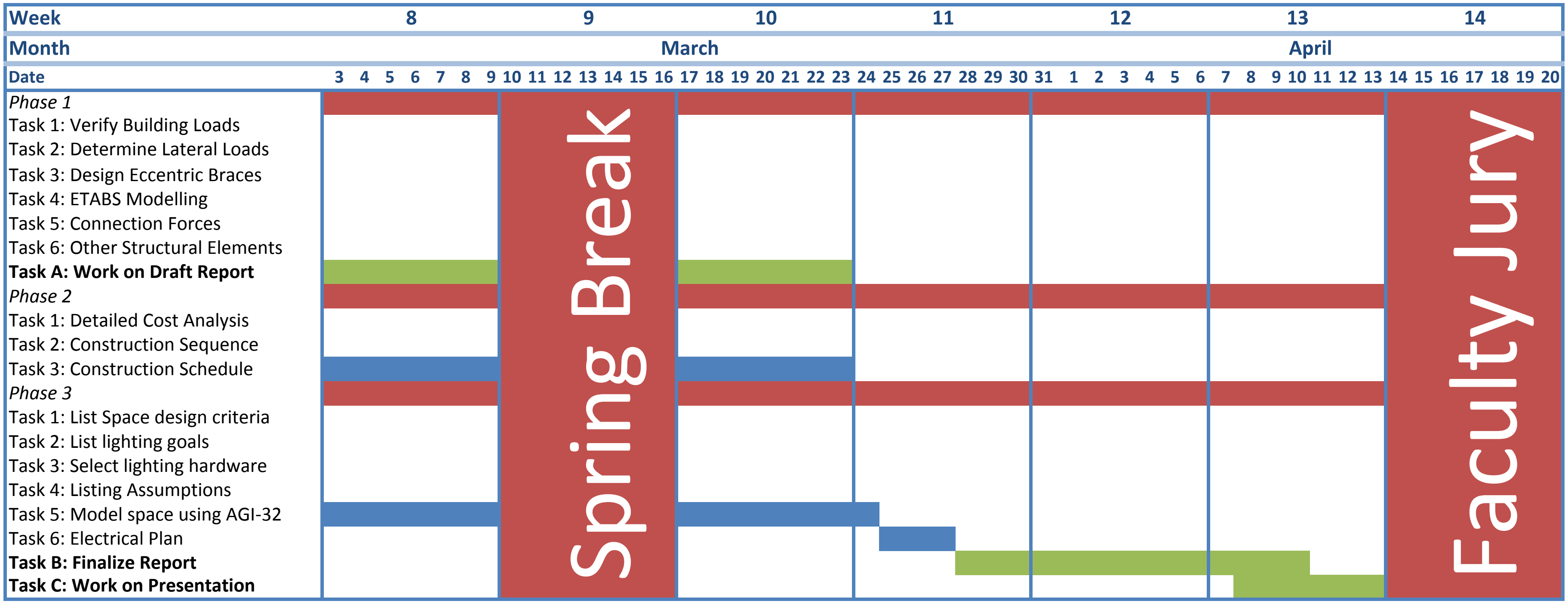

Conclusion

During the upcoming semester, a complete redesign of the main lateral force resisting system will be performed using steel eccentrically braced frames. The redesign will evaluate the economical implications of using this system as opposed to the steel concentrically braced frame designed in the original design. The breadth study will then evaluate the cost and scheduling effects of the redesign and comparisons will be made to the original design. The final breadth study will be a lighting redesign of the central courtyard located on the second floor, which will evaluate the courtyard occupancy use during the day and night before and after the redesign.

These tasks may have major outcomes after being performed. Firstly, the redesign of the main lateral resisting system will gain my experience in the design of steel structures in earthquake prone regions. The experience will diversify my abilities and help me prepare for practicing engineering after graduation. The second task will gain my experience in cost and schedule implications of choosing different structural systems. The task will help develop the construction management side of choosing different structural systems which outcomes a well-rounded structural engineer. Finally, the lighting breadth study will gain me experience in the creativity of lighting design, it will also incorporate the knowledge that I have gained through the numerous architectural courses I have completed through the pursuit of the architectural engineering degree with an architecture study minor.