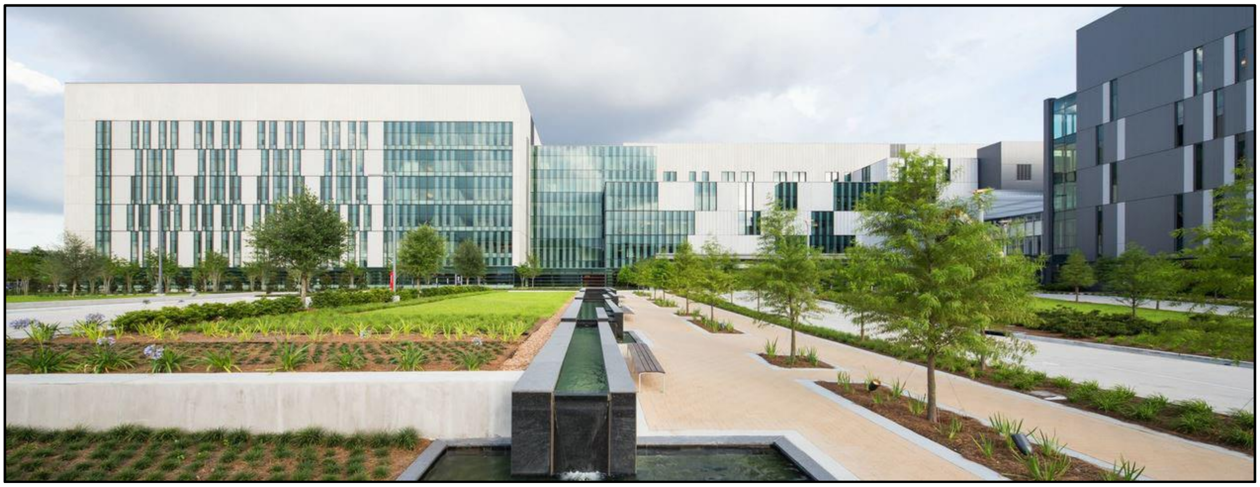
The Medical Center | Southeast, USA

Structural Proposal

Structural Assignment 5



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Executive Summary

The Medical Center is a 570,000 square foot hospital located at the cornerstone of an expanding medical district. The building site is woven into the urban fabric of Southeast, USA. The urban context of the site, totaling 37 acres in size, influences the boundaries of design of this building project. Programmatically, The Medical Center houses 446 hospital beds as well as inpatient facilities such as medical offices, intensive care units, and dietary facilities. A high degree of programmatic intuition is demonstrated through the relationship between the environmental concerns of the region and the location of all mission-critical components within the building. The Medical Center was budgeted at $190 million.

Comprised of three identical, structurally isolated, L-shaped inpatient towers, The Medical Center is designed utilizing a reinforced concrete (RC) structural system. The structure features concrete slabs with pan joists, RC beams, RC girders, and vertical RC columns. These structural elements frame into composite timber piles and pre-cast, prestressed concrete piles, by means of a varied pile cap system, which are driven into the earth until a depth, below the original grade, of 62 ft. Concrete moment frames and concrete walls serve as the lateral force resisting system.

NBBJ Architects and Blitch Knevel Architects served as the joint-venture architects on this building project. Structural, MEP, and Fire Protection engineering services were provided by URS Corporation (recently AECOM), and IBA Consultants served as the exterior envelope design experts. The project was delivered by means of design-bid-build contract, and Skanska served as the Construction Manager at Risk on the project. The Medical Center began construction in December 2012 and is scheduled to be completed in November 2015.

The Medical Center was designed based on the Southeast, USA Building Code, associated with the International Building Code (IBC), 2009 edition. The American Society of Civil Engineers (ASCE) 7-05 was utilized as a reference standard for structural loading. The building is scheduled to be completed in August 2015.

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[1] <u>Introduction</u>

1.1 Purpose

This report functions as a detailed description of the existing structural systems in The Medical Center. The contents within this preliminary building narrative represent a foundation of technical information, upon which a deeper understanding of the existing structural system can be established. The documented knowledge within this introductory narrative will serve as a practical aid for the drafting of subsequent technical reports.

1.2 Scope

The content of this report is divided into three major sections: framing system elements, load determination, and connection details. Within these primary divisions, this building narrative features individual building components of the structural design, including technical commentary on elements such as typical bays, columns, lateral force resisting elements, and secondary structural elements. Additionally, the narrative will include technical commentary regarding the national code requirements and load classifications applied to this building project.

1.3 General Building Description

The Medical Center consists of three 7-story inpatient towers. Identical in aesthetic and almost identical in design, the complex of inpatient towers totals 570,000 square feet in size. Housing 424 hospital beds, the hospital program includes non-mission critical facilities, multiple floors of nursing units, non-intensive care units, and a roof level mechanical space (as seen in Figure 1).

The Medical Center sits at the cornerstone of an expanding medical district, contributing to an expansive network of hospitals in Southeast, USA. Nestled in between pockets of urban residential construction, The Medical Center briefly interrupts the major urban grid of the existing environment. Existing as a mission-critical facility, the building's proximity to a major network of highways enhances its public accessibility. The urban context of the site influences the boundaries of design of this building project (as seen in Figure 2 and Figure 3).

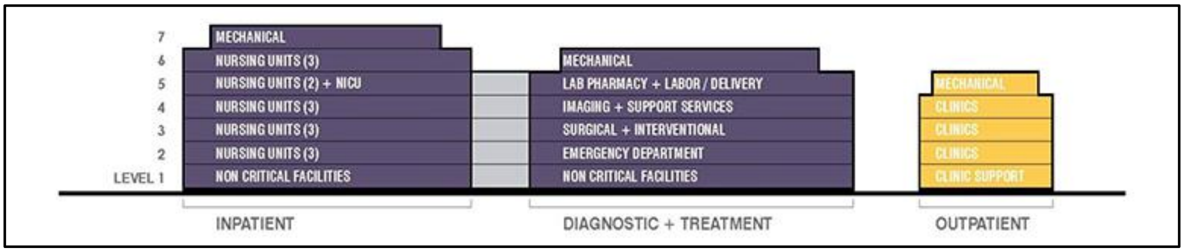


Figure 1 - Program Building Section

Figure 2 - Site Context (Macro) [Courtesy of Google Maps]

Figure 3 - Site Context (Micro) [Courtesy of Google Maps]

NBBJ Architects were the lead architects on the project and worked closely with the engineering design services, provided by URS Corporation, to produce a state-of-the-art medical facility that will function as both a working hospital and medical education research hub. Delivered as a design-bid-build project, the design and construction was budgeted at $190 million and the construction was on pace to be completed by August 2015.

1.4 Brief Description of Structural Framing System

The Medical Center is a concrete frame structure with a structural assembly including horizontal joist, beam, and girder members and vertical column members. Cast-in-place jointed reinforced concrete slabs provide the structural flooring of the building. The building foundation consists of grade beams spanning between pile caps built on precast, prestressed concrete piles as well as timber composite piles. Intermittent slab depression are introduced into the slab on grade.

The location of the building project site warrants special consideration of the foundation of The Medical Center. The composition and stiffness of the clayey site soil changes based on the subgrade elevation, generating a soil matrix of weak and highly compressible units. Poor soil conditions, inclusive of Pleistocene, beach, interdistributary, and marsh deposits as well as various fill material, dictate the classification of the site soil as soil site class E and govern the design of the building foundation. In addition to the design challenges presented by the poor site soil, the climate of the region warrants special hurricane and flood design considerations; therefore, the framing of the building must be designed to allow for minimum clearance above the assumed flood elevation and to withstand category 3 hurricane wind loading. To resist such lateral forces, The Medical Center features a concrete moment frame and concrete wall lateral load resisting system.

[2] Structural Framing System

This section outlines the structural framing system of The Medical Center. Detailed descriptions of the building elements that constitute the gravity force system and the lateral force system are provided in this section. The structural framing system overview will begin with an explanation of the typical bay framing within the building.

2.1 Typical Bay Framing

The efficient geometry of The Medical Center generates a typical bay framing scheme. The typical bay framing in this building is classified into two bay categories: ordinary bay framing and corridor framing. An ordinary bay is approximately 30’-4” x 32’-0”, and a corridor bay is approximately 10’-6” x 32’-0” (as seen in Figure 4). The horizontal framing members are rectangular in section and vary in width and depth between dimensions as small as 8 in. and as big as 56 in, depending on adherence to module or required size for the purpose of strength and serviceability. The member sections complement the module, enabling consistent member spacing and matching member depth to floor assembly depth, wherever possible. All joists, beams, and girders are reinforced concrete members, yielding a compression strength value of 4000 psi. All instances of structural framing depend on span and loading conditions.

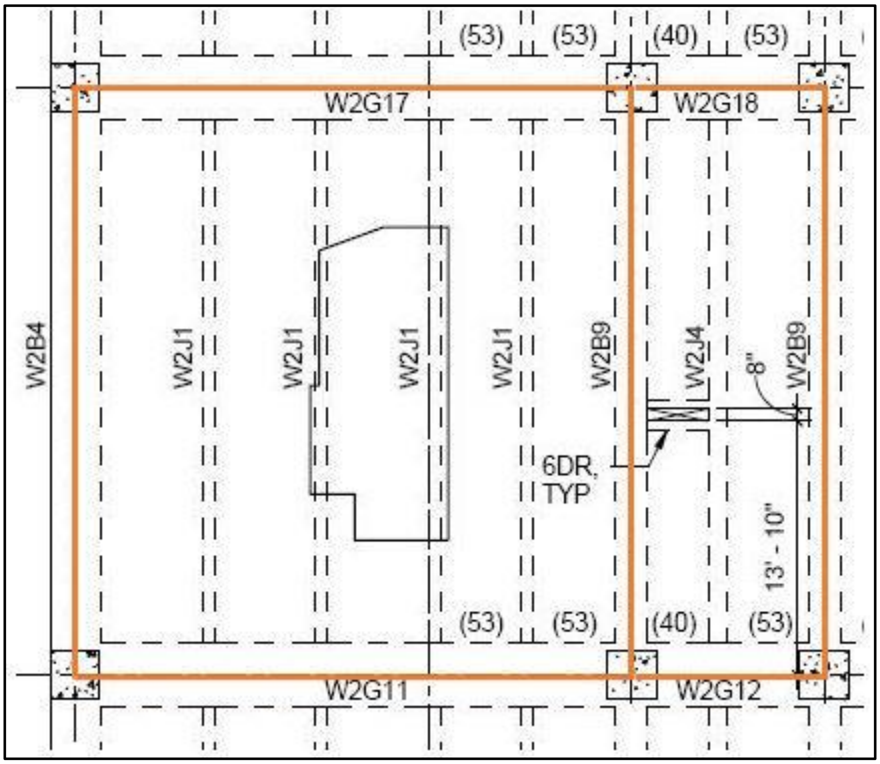


Figure 4 - Typical Ordinary and Corridor Bay Framing

2.2 Floor and Roof Framing

The typical floor framing construction comprises of a 16 in. deep wide module NWC pan joist system with 5 ¼ in. slab. The total thickness of the structural floor assembly, representative of the effective beam depth, including both slab thickness and pan depth, is 21 ¼ in., and the pan joist system is spaced at 66 in. Intermittent ¾ in. slab depressions, due to programmatic and engineering details, break the continuous plane of the structural concrete slab. The typical roof framing construction comprises of a 4 in. NWC slab on a 2 in. 20 gage composite deck. The total thickness of the structural roof assembly is 6 in.

2.3 Foundation System

The foundation system of The Medical Center consists of timber composite piles and precast, prestressed concrete piles connected by reinforced grade beams.

The timber composite piles are classified as D-25 untreated and designed to support an estimated loading capacity of 25 tons. The composite character of this foundation element is achieved by filling a 12" nominal light gage corrugated can section with 5000 psi concrete (as seen in Figure 5). The geometry of the composite timber pile varies along its length, measuring a minimum of 7" in width at the tip and 13" in width at the butt. The tip of the composite timber pile was required to be driven 62 ft. below the original grade. The timber composite piles are activated within the gravitational load path, facilitating the transfer of loading from the above grade columns to the bearing soil.

The precast, prestressed (PCPS) concrete piles assist the timber composite piles in transferring the load from the above grade building structural elements into the ground. Additionally, the PCPS concrete piles, in conjunction with the above grade lateral force resisting elements, aid the resistance of the lateral forces, anchoring and stabilizing the overall structure. Similar in design, the PCPS concrete piles are sleeved with corrugated grout ducts that are configured to match the layout of the pile vertical reinforcement. The ducts are filled with 4000 psi grout. A typical detail for the connection and embedment of the PCPS concrete piles in the column pile caps is shown below (as seen in Figure 6).

Based on the building footprint geometry as well as site soil characteristics, deep foundation piles were grouped and capped into groupings of 4, 5, 6, 9, 10, 11, 12, 17, 20, and 35 piles. Typical spacing between piles within each grouping varied from 2'-0" to 4'-0", affecting the group action characteristic of the deep foundation piles involved in the resistance of axial and lateral forces.

The reinforced concrete grade beams, unless otherwise noted, are designed as 24in. x 24in. member sections utilizing (4) #8 top and bottom and #4 stirrups spaced at 8in. o.c. Per structural design documentation, the top reinforcement was required to lap at the midpoint of the member and the bottom reinforcement was required to lap at the supports of the member.

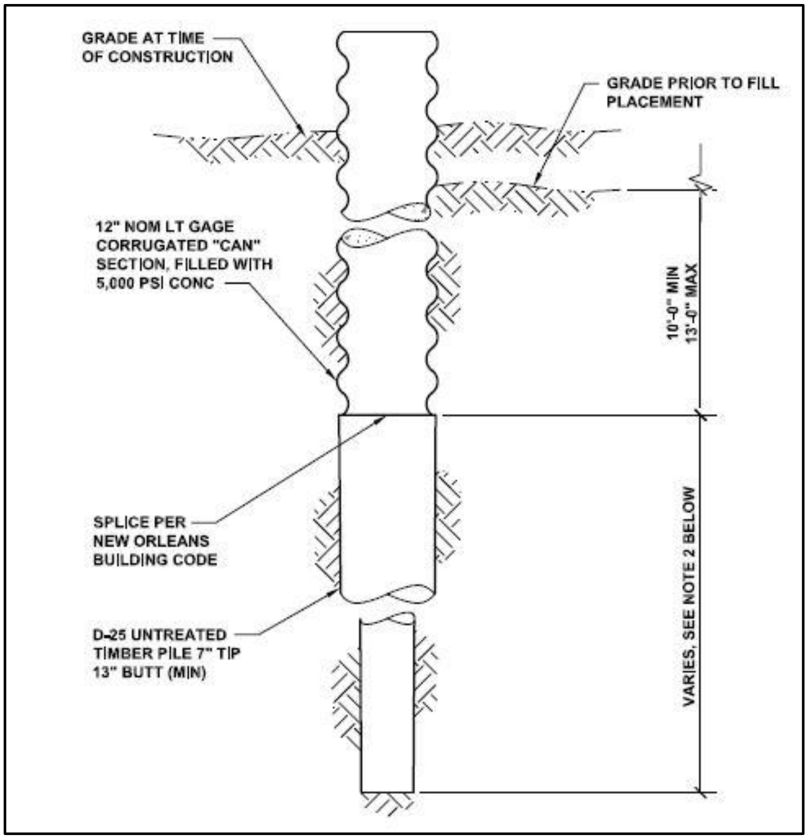


Figure 5 - Composite Timber Pile Section

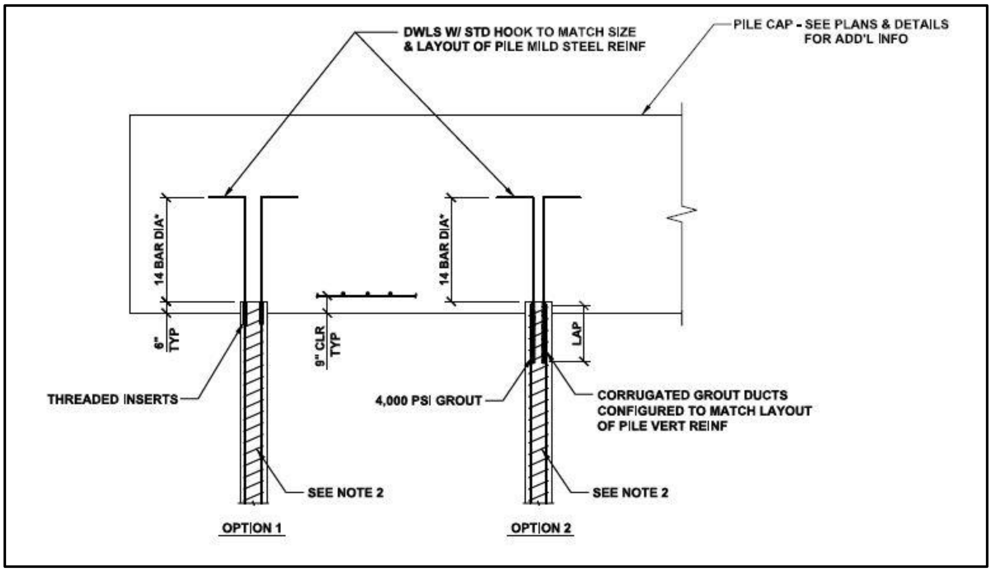


Figure 6 - Typical Detail for PCPS Piles at Column Pile Caps

2.4 Columns

The columns utilized in the structural framing design of The Medical Center are square in section (as seen in Figure 7 – note that section IV details a column size used in the pedestrian bridge structure) and range in size from 20” x 20” to 32” x 32”. The column sizes range between these two square sections in incremental modules of 4 in. Varying in material property through the vertical length of the building, the columns are spliced at the interface between the 3rd and 4th floors. The columns that run vertical from the 1st floor to the 3rd floor have a compressive strength of 5000 psi, and the columns that run vertical from the 4th floor to the roof have a compressive strength of 4000 psi. All structural columns are reinforced, with varying vertical reinforcement and #4 bar column ties, typical.

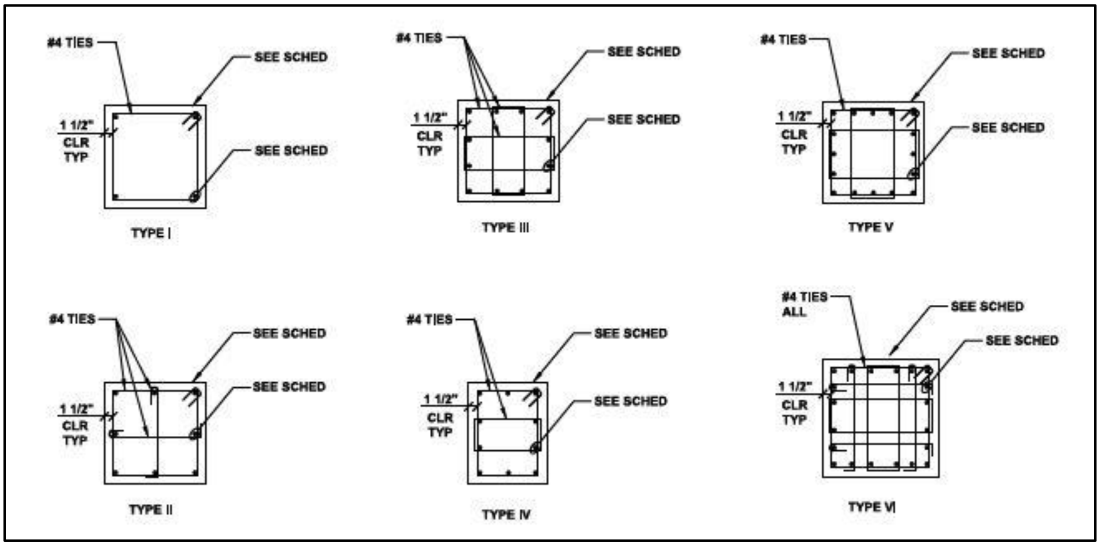
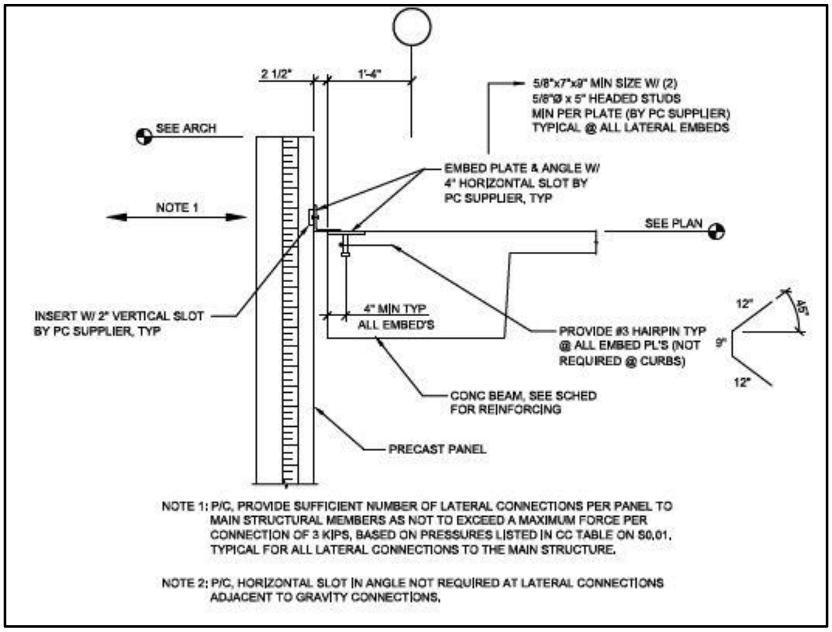


Figure 7 - Typical Concrete Column Cross Section Types

2.5 Lateral Load Resisting Elements

The lateral load resisting elements of The Medical Center are a natural product of the material characteristics and framing scheme of the building engineering design. The pure geometry of The Medical Center allows for typical bay framing within the building. As a result, concrete intermediate moment frames (IMF) define the lateral framing scheme of the engineered design solution. These concrete IMF frame the building footprint, reducing the torsional effects of lateral loads on the building structure. The grid of concrete IMF generates a lateral load resisting system that is designed to resist wind loads resulting from severe environmental conditions, such as a Category 3 hurricane. The concrete IMF are detailed to include designed lateral connections at the interface of column and beam as well as lateral connections at the interface of the building envelope and primary structure (as seen in Figure 8). A more in-depth description of the load considerations for The Medical Center will be discussed in section three.



NOTE 1: P/C, PROVIDE SUFFICIENT NUMBER OF LATERAL CONNECTIONS PER PANEL TO MAIN STRUCTURAL MEMBERS AS NOT TO EXCEED A MAXIMUM FORCE PER CONNECTION OF 3 KIPS, BASED ON PRESSURES LISTED IN CC TABLE ON S0.01, TYPICAL FOR ALL LATERAL CONNECTIONS TO THE MAIN STRUCTURE.

NOTE 2: P/C, HORIZONTAL SLOT IN ANGLE NOT REQUIRED AT LATERAL CONNECTIONS ADJACENT TO GRAVITY CONNECTIONS.

Figure 8 - Section Detailing Lateral Connection of Façade to Main Structural Member

2.6 Load Paths

In determining the load paths of the engineered structural design, two load classifications must be considered: gravity and lateral.

In terms of applicable gravity loads, such as dead, live, snow, and rain, a simplified load path can be defined. These gravity loads are resisted by the roof or floor diaphragms, transmitted to the girders by means of pan joists and framing beams, and transferred to the foundation elements through vertical columns. The timber composite piles and precast, prestressed concrete piles receive the gravity loads from the vertical columns, through pile cap collectors, and transfer these vertical forces into the ground. The foundation piles are driven 62 ft. below the original grade and designed to transfer 25 tons of force from the building structure into the ground.

In terms of applicable lateral loads, such as wind, seismic, and flooding, additional load paths can be defined. Wind loads are applied to the exterior surfaces of the building; therefore, wind loads are transferred through the building façade to the roof or floor diaphragms. On another note, seismic loads result from the building's inertial response to ground accelerations; therefore, seismic loads are transferred, in the form of story shear forces, either directly, or indirectly depending on the segment of building, to the lateral force resisting systems. Concrete frames receive the shear forces, and reactive moment forces, and translate these forces through vertical columns to the foundation and into the ground. By means of deep embedment into the earth, building foundation system is designed to resist significant uplift forces resulting from the overturning moments caused by lateral loads.

[3] Loads

This section outlines the relationship between the governing, recognized design code authorities and structural design loads, as applied to the building design process. A brief overview of the application of each design load is discussed within this section.

3.1 National Codes

The national codes and standards used to design The Medical Center are governed by the Southeast, USA City Building Code. The associated national codes and standards as well as a breakdown of structural design loads are provided in this section.

Table 1 - Applicable Codes

Category	Associated Code/Reference Standard
Building Code	International Building Code (IBC) 2009 Edition
Concrete Design	American Concrete Institute (ACI) 301, 315, 318
Load Determination	American Society of Civil Engineers (ASCE) 7-05

3.2 Dead Load

The following design dead loads were determined on the basis of material characteristics and manufacturer data. The primary design dead loads are listed in Table 2. Building component dead load will vary on a case to case basis (as seen in Table 2).

Table 2 – Dead Loads

Dead Load	Load Value
Building Components	Self-weight
Hung Load Allowance (Typical Floors)	8 psf
Hung Load Allowance (Main Roof)	13 psf
Roofing Allowance (W/O Pavers)	12 psf
Roofing Allowance (W/ Pavers)	37 psf

3.3 Live Load

The following design live loads were determined on the basis of the reference standard ASCE 7-05. The primary design live loads are listed in Table 3.

Table 3 - Live Loads

Live Load	Load Value
Lobbies/Stairs	100 psf
First Floor	100 psf
First Floor Temporary Construction	125 psf
Patios	100 psf
BH Deck – T2 & T3	100 psf
Typical Floors	80 psf
Corridors	80 psf
Mechanical Rooms	125 psf (or equipment weight)

3.4 Wind Loads

The following design wind loads were determined on the basis of the reference standard ASCE 7-05. Wind loads are applied on the basis of "Components and Cladding" pressure zones defined in ASCE 7-05 (as seen in Figure 9). The primary design wind load information and applicable design wind load pressures can be seen in Table 4 and Table 5, respectively.

Table 4 - Wind Load Classification Information

Category	Applicable Information
Basic Wind Speed (3 Second Gust)	150 mph
Wind Load Importance Factor	1.15
Wind Exposure Category	Exposure C
Internal Pressure Coefficient	± 0.18

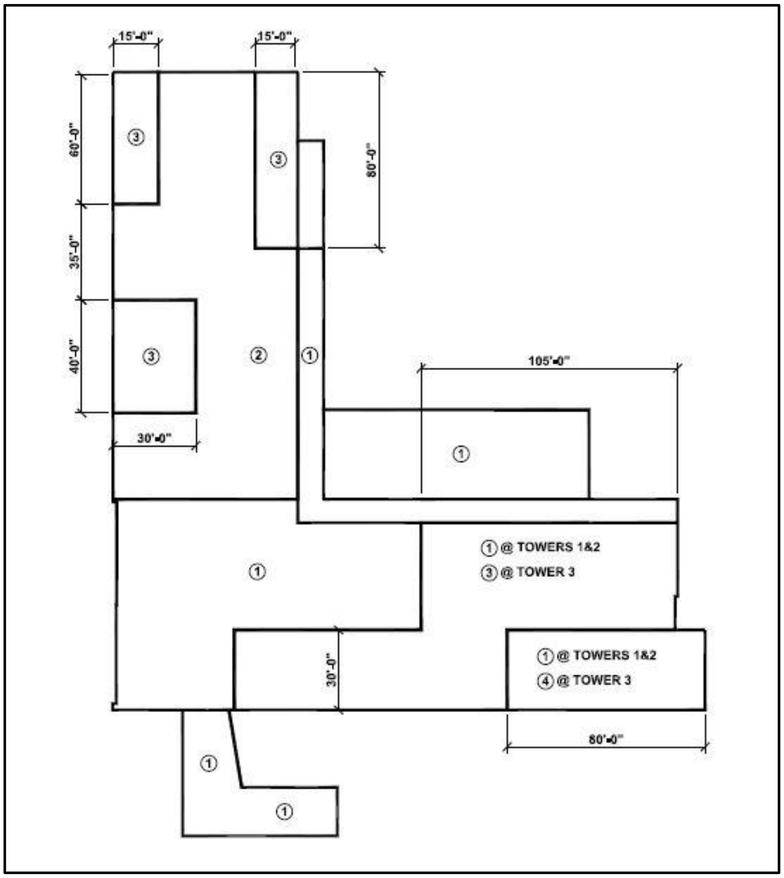
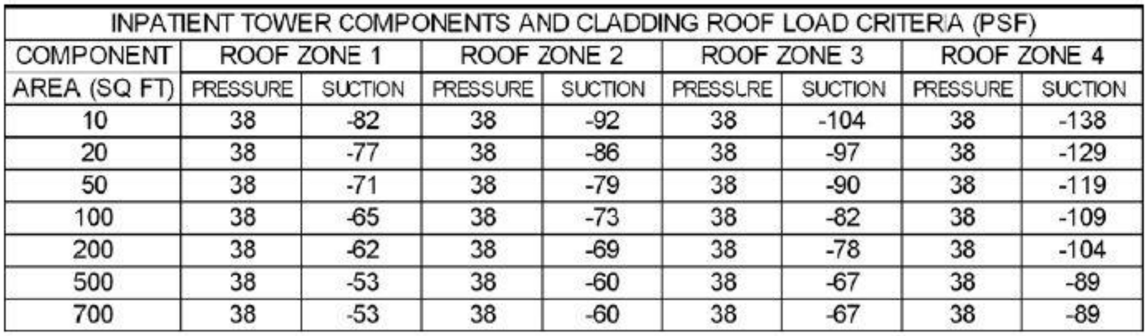


Figure 9 - Components & Cladding Roof Pressure Zones

Table 5 - Components and Cladding Roof Pressures



INPATIENT TOWER COMPONENTS AND CLADDING ROOF LOAD CRITERIA (PSF)								
COMPONENT	ROOF ZONE 1		ROOF ZONE 2		ROOF ZONE 3		ROOF ZONE 4	
AREA (SQ FT)	PRESSURE	SUCTION	PRESSURE	SUCTION	PRESSURE	SUCTION	PRESSURE	SUCTION
10	38	-82	38	-92	38	-104	38	-138
20	38	-77	38	-86	38	-97	38	-129
50	38	-71	38	-79	38	-90	38	-119
100	38	-65	38	-73	38	-82	38	-109
200	38	-62	38	-69	38	-78	38	-104
500	38	-53	38	-60	38	-67	38	-89
700	38	-53	38	-60	38	-67	38	-89

3.5 Seismic Loads

The following design seismic loads conform to section 1613 of IBC 2009. Seismic loads are applied on the basis of the equivalent lateral force procedure. The primary seismic design parameters are listed in Table 6. Further investigation is necessary to determine whether wind forces (due to high basic wind speed) or seismic forces (due to poor soil site class) will control lateral system design.

Table 6 - Seismic Design Parameters

Design Parameter	Applicable Information
Soil Site Class	E
S_S	11.0%
S_1	4.8%
S_{DS}	18.3%
S_{D1}	11.2%
Building Occupancy Category	Group IV
Seismic Design Category	C
Seismic Load Importance Factor	1.5
Story Drift Limit (Code Maximum)	0.01 * Story Height

3.6 Flood Loads

Due to the climate of the region, flood load provisions must be considered. Structure designed for hydrodynamic flow conforms to reference standard ASCE 24-05. Basic flood design assumptions were executed during the design process. The assumed flood level was set at 15 ft. above mean sea level, and the assumed flow velocity was defined as 10 ft/sec.

3.7 Snow Loads

The following design snow load parameters conform to section 1608 of IBC 2009. The primary snow load design parameters are listed in Table 7.

Table 7 - Snow Load Design Parameters

Design Parameter	Applicable Information
Ground & Flat Roof Snow Load	0 psf
Snow Exposure Factor	1.0
Snow Thermal Factor	1.0
Snow Load Importance Factor	1.2
Minimum Roof Live Load Used in Design	50 psf

Note: The high value used for the minimum roof live load used in design can be attributed to a combination of the habitable space located on the roof and the environmental factors of the site.

[4] Joint Detail and Connections

Focusing on the local joint connections as well as the holistic building joints, this section outlines the various joint details and special connections that exist within the structure of the building. Further connection detail will be provided in subsequent reports.

4.1 Building Expansion Joints

The Medical Center consists of three 7-story inpatient towers. Due to the architectural continuity and geometric adjacency of these three inpatient towers, building expansion joints are utilized within the structural design of the building. By constructing building expansion joints, each of the three inpatient towers remain structural independent from one another. The building expansion joints reduce translation of load between each structure and counterattack the thermal effects and stresses, alike, generated by the inherent differences in the material properties of a variety of building elements.

The Medical Center exists as a component of a larger medical campus. Connecting the inpatient towers to the diagnostic hospital and treatment facility are three pedestrian bridges, spanning between each of the structures. Although these walkways are structural connected to the inpatient towers, building expansion joints are used to structurally isolate the pedestrian bridges from the diagnostic hospital and treatment facility. The orthogonal geometry of the architecture allows the building expansion joints to achieve linearity and continuity through building section (as seen in Figure 10).

Figure 10 - Inpatient Towers Building Expansion Joints [Courtesy of NBBJ Architects]

4.2 Construction Joints

The structural design of The Medical Center utilizes construction joints in order to ease the process of construction. The pre-cast concrete building material requires the use of construction joints in order to set and join the individual structural building elements. These construction joints counterattack the local translation and stresses affecting the concrete building material, responding to the applied forces of the environment. The construction joints must be appropriately detailed in order to structurally perform as designed (Figure 11 & Figure 12).

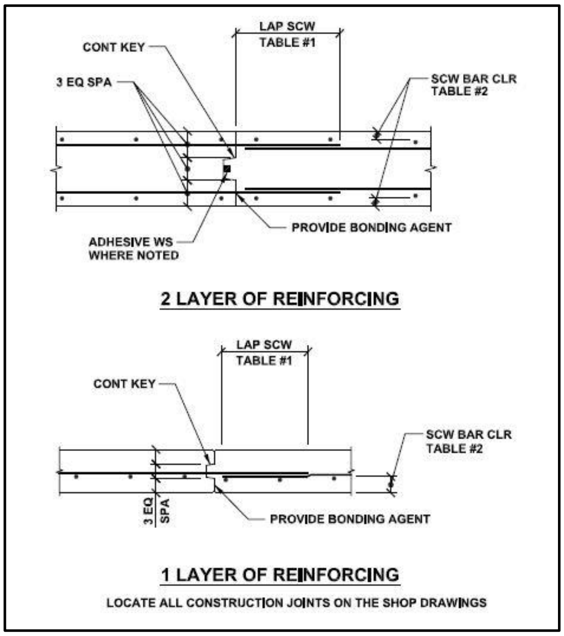


Figure 11 - Typical Concrete Wall or Slab Construction Joint

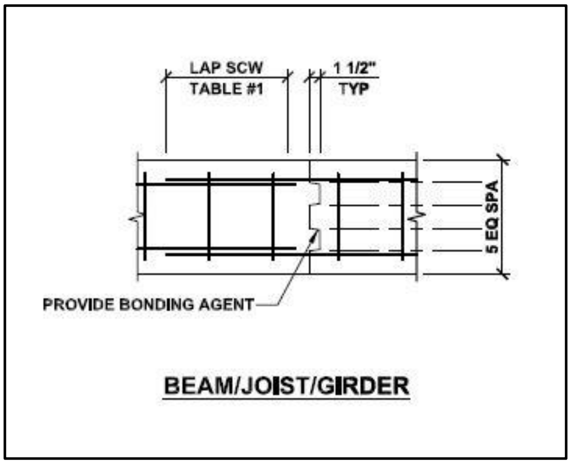


Figure 12 - Typical Concrete Horizontal Construction Joint

4.3 Beam/Column

The structural design of The Medical Center involves the design of the structural joint at the interface of beam and column. There exists two typical design approaches to configuring this joint: one layer of reinforcement or two layers of reinforcement (Figure 13). In the former case, one layer of reinforcement is used to provide adequate capacity and ductility to the structural joint. In the latter case, two layers of reinforcement is used if the design requires extra tensile capacity or ductility within the section. The addition of an extra layer of reinforcement generates a more congested joint, increasing the importance of both configuration and detailing within the design of the structural joint. In both cases utilization of standards hooks, if necessary to achieve sufficient development of the reinforcement, and proper lapping patterns may be required to design a strong and stable joint.

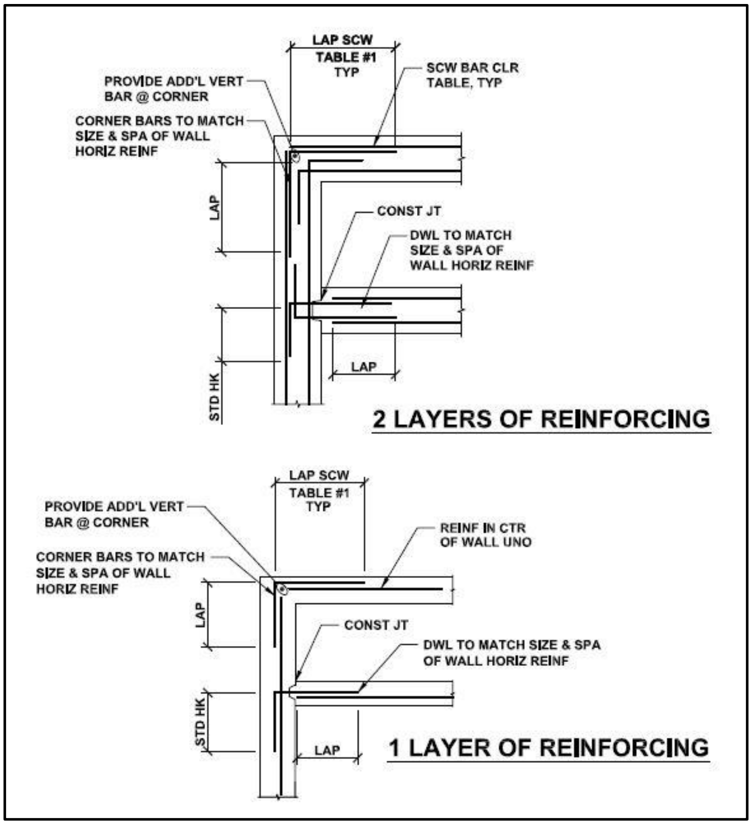


Figure 13 - Detail of Horizontal Structural Element to Vertical Structural Element Connection

4.4 Pile Cap/Pile

The configuration of the structural connection between pile cap and pile is essential for the transfer of load from the above grade structure to the below grade foundation. The design of the structural joint at this interface is dictated by the seismic design category (SDC) of the building. Due to the conditions of design, per IBC 2009 Chapter 18 requirements for SDC C, precast pile vertical reinforcement was required to be fully developed into the pile cap. Two design options exist for the execution of this code-governed requirement: use of threaded reinforcement inserts or use of corrugated grout ducts (Figure 14). The threaded reinforcement inserts were required to be designed to resist 125% of the yield strength of the reinforcement. Additionally, the threaded reinforcement inserts were required to be directly coupled to or lapped with the pile vertical reinforcement. The use of corrugated grout ducts requires the use of 4000 psi grout, configured in such a manner to match the layout of the pile vertical reinforcement.

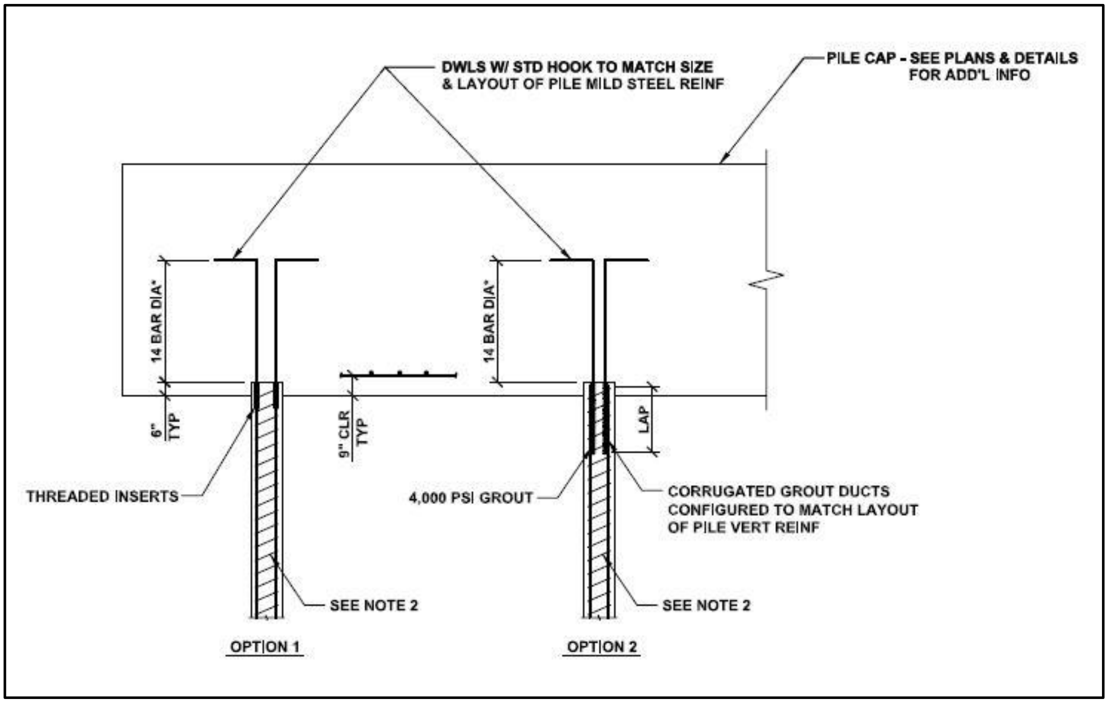


Figure 14 - Detail of Pile Cap to Pile Connection

[5] Alternative Design Proposal

Upon completion of the initial analysis of The Medical Center, based on information asserted in previous reports, the current designs of the building's gravity framing and lateral framing systems have been proven to be sufficient to meet the strength and serviceability requirements set forth by the governing building code and associated references and standards. Due to the proficiency of structural design of The Medical Center, further effort will be exerted to investigate an alternative framing scheme. A new scenario, in which the owner and architect prefer the use of composite steel rather than structural concrete, has been proposed. Although energy will be invested in the preservation of the geometry of framing, in order to provide an optimal design, certain facets of the structural design will be altered to complement the alternative gravity framing and lateral framing systems.

5.1 Structural Depth

The alternative composite steel structure featured within The Medical Center will utilize the existing column grid as well as typical bay dimensions of the current design (30’-4” x 32’-0”). In order to investigate a more economic option, the design of the alternative composite steel structure will alter the orientation of the infilling structural elements. A composite steel system was selected as a viable design alternative for its anticipated ductility and economic use of material.

The lateral system will utilize a steel braced frame or alternating braced frame scheme. The structure of The Medical Center will utilize this type of lateral force resisting system in both the N-S and E-W directions.

The alternative composite steel structure will affect the entirety of the general structural design of the building, inclusive of particular consideration to the building foundation. The consideration of deep foundation alternatives will be investigated and executed as a component of the Schreyer Honors College senior thesis study.

5.2 Façade – Mechanical Breadth

A façade investigation and alternate façade proposal will be executed, altering the mechanical properties of the building envelope. A mechanical properties analysis, inclusive of thermal and moisture consideration, will be conducted in response to the proposal of an alternate façade. The coordination between system alterations will be verified, demonstrating an integrated design.

5.3 Façade – Daylighting Breadth

A façade investigation and alternate façade proposal will be executed, altering the daylighting scheme of the building envelope. An alternative daylighting scheme will be proposed, and an analysis of the proposed scheme will be conducted, prioritizing task-oriented and occupant comfort parameters over other additional considerations. A seasonal solar study, with respect to the building site, will be performed, ultimately driving the design of the alternative daylighting scheme.

5.4 Façade – Architectural Implications

A façade investigation and alternate façade proposal will be executed, altering the architectural fabric of the building envelope. Due to the building’s simple geometric form, the façade or architectural “skin” of the building represents a majority of the visual identity of the building. Through the adoption of an alternative structural framing system as well as the consequential modification of the mechanical properties and daylighting scheme associated with the alteration of façade and overall building envelope, architectural impacts will be experienced. In coordination with the alternative façade proposal, consideration will be given to the architectural context of the building site.

5.5 MAE Requirements

The execution of design of an alternative composite steel structural system will require the utilization of graduate level coursework. The redesign of the gravity force resisting and lateral force resisting systems will require the execution of three-dimensional modeling, using computer-aided techniques learned in AE 530 – "Computer Modeling of Building Structures." ETABS will primarily be used as an analysis and design software to construct the three-dimensional model. Validation will be performed by means of two-dimensional analysis of data and technical output extracted from SAP 2000. Due to the alteration of structural material within the design of the gravity force resisting and lateral force resisting systems, knowledge learned in AE 534 – "Analysis and Design of Steel Connections" will be utilized to reanalyze, and if necessary redesign, the essential structural connections of the framing system. The coursework being applied to this thesis study has been learned prior to the commencement of redesign.

5.6 Schreyer Honors College Requirements

In a response to the proposal of an alternative composite steel structural system, consideration of deep foundation alternatives will be investigated and executed. Building upon the research performed prior to and during the investigation of an alternative composite steel structural design, deep foundation techniques will be utilized to select and design the most appropriate structural foundation system, complementary to the design of the above grade structural system. Structural modeling techniques will be utilized to further analyze, and if necessary redesign, the deep foundation structural system utilized within The Medical Center. Priority will be given to strength and serviceability requirements set forth by the governing code, but other factors, such as durability and environmental impact, will be considered in the analysis and selection of an alternative deep foundation system. CE 397A – "Geotechnical Engineering for AE Majors" will be taken concurrently with AE 897G; therefore, coursework from this course, as applicable, will be applied to this Schreyer Honors College thesis study.

5.7 Tasks and Tools

1. **Research**
    a. Identify essential components of design context regarding new structural system
    b. Collect necessary governing code, references, standards, design guides, etc.
    c. Study relevant case studies to gain further education in composite steel design
    d. Study relevant case studies to gain further education in extreme wind condition design
    e. Research mechanical properties (thermal, moisture, etc.) of façade alternatives
    f. Research daylighting schemes (glazing, orientation, etc.) of façade alternatives
    g. Research architectural value (aesthetic, form, color, etc.) of façade alternatives
    h. Research architectural context of building site
    i. Research integrated design approaches

2. **Structural Depth**
    a. Gravity Force Resisting System Design
        i. Design
            1) Identify new gravity structural loading conditions and estimate values
            2) Design infilling structural element
            3) Design primary beam structural members
            4) Design primary girder structural members
            5) Design columns
        ii. Design Verification and Details
            1) Verify design in elementary analysis software
            2) Develop three-dimensional model in ETABS
    b. Lateral Force Resisting System Design
        i. Design
            1) Calculate new seismic load of alternative structure
            2) Define controlling lateral loading condition
            3) Manipulate ETABS model to reflect configuration and condition of design
            4) Analyze lateral system configuration
            5) Modify lateral force resisting elements (as necessary, per iterative process)
            6) Design
        ii. Design Verification and Details
            1) Verify design and validate functionality of ETABS model

3. **Façade – Mechanical Breadth**
    a. Thermal Analysis
        i. Complete thermal analysis and determine thermal performance of façade
    b. Moisture Analysis
        i. Complete moisture analysis and determine moisture performance of façade

4. **Façade – Daylighting Breadth**
    a. Solar Analysis
        i. Complete seasonal solar analysis and use results in the selection of façade

5. **Façade – Architectural Implications**
    a. Architectural Context Analysis
        i. Complete architectural context analysis and use results in the selection of façade
    b. Architectural Value Analysis
        i. Complete architectural value analysis and determine architectural value of façade

6. **Documentation**
    a. Generate template for final report submission
    b. Generate template for final presentation submission
    c. Complete final report document
    d. Complete final presentation file
    e. Format final thesis documentation per SHC requirements and submit for review
    f. Update CPEP website during the progression of milestone completion

5.8 Work Schedule

The work schedule (as seen below) represents a comprehensive overview of time management and work flow conditions applied to this thesis study. Two work schedule progress plans are presented: milestone progress schedule and visual task timeline schedule.

Table 8 - Milestone Progress Schedule

Milestone #1		
Task	**% Completion**	**Notes/Comments**
Structural Depth	33%	Research and gravity force resisting sysem design complete
Façade - Mechanial Breadth	25%	Research complete
Façade - Daylighting Breadth	25%	Research complete
Façade - Architectural Implications	25%	Research complete
Documentation	N/A	CPEP site updated
Milestone #2		
Task	**% Completion**	**Notes/Comments**
Structural Depth	50%	Computer modeling complete
Façade - Mechanial Breadth	50%	Thermal analysis complete
Façade - Daylighting Breadth	67%	Seasonal solar analysis in progress
Façade - Architectural Implications	75%	Architectural context analysis complete
Documentation	N/A	CPEP site updated
Milestone #3		
Task	**% Completion**	**Notes/Comments**
Structural Depth	95%	Lateral force resisting system design complete
Façade - Mechanial Breadth	75%	Moisture analysis complete
Façade - Daylighting Breadth	95%	Seasonal solar analysis in complete
Façade - Architectural Implications	95%	Architectural value analysis complete
Documentation	N/A	CPEP site updated
Milestone #4		
Task	**% Completion**	**Notes/Comments**
Structural Depth	100%	Miscellaneous tasks complete (tables, figures, etc.)
Façade - Mechanial Breadth	100%	Comparative façade study complete
Façade - Daylighting Breadth	100%	Miscellaneous tasks complete (tables, figures, etc.)
Façade - Architectural Implications	100%	Miscellaneous tasks complete (tables, figures, etc.)
Documentation	N/A	Final report and presentation completed, formatted, and submitted to SHC

Table 9 - Visual Task Timeline Schedule

Visual Task Timeline Schedule

Spring 2015 Semester

Milestone #1 22-Jan		Milestone #2 12-Feb			Milestone #3 4-Mar			Milestone #4 1-Apr				Document Review & Presentation 8-Apr → 11-Apr → 14-Apr			
11-Jan	18-Jan	25-Jan	1-Feb	8-Feb	15-Feb	22-Feb	Feb-29	7-Mar	14-Mar	21-Mar	28-Mar	4-Apr	11-Apr	18-Apr	25-Apr
🟧 Research								SPRING BREAK							SENIOR BANQUET
🟧 Design GFRS															
	🟧 Computer Validated Design Checks														
		🟧 Model GFRS													
			🟧 Investigate and Configure LFRS												
					🟧 Design LFRS										
🟩 Research															
						🟧 Computer Validated Design Checks									
		🟩 Thermal Analysis													
			🟩 Investigate Existing Façade Thermal Prop												
					🟩 Moisture Analysis										
🟨 Research															
						🟩 Investigate Existing Façade Moisture Prop									
		🟨 Model Solar													
									🟩 Comparative Façade Study						
					🟨 Seasonal Solar Analysis										
									🟨 Synthesize Outputs						
🟦 Research															
		🟦 Contextual Analysis													
		🟦 Investigate Existing Contextual Relation			🟦 Arch. Value Analysis										
					🟦 Investigate Existing Arch. Value										
									🟦 Produce and Apply Arch. Grade Scale						
									⬜ Produce Report and Presentation						
	⬜ CPEP Update			⬜ CPEP Update			⬜ CPEP Update				⬜ CPEP Update	⬜ SHC Review			

🟧	Structural Depth
🟩	Mechanical Breadth
🟨	Daylighting Breadth
🟦	Arch. Implications
⬜	Documentation

Important Dates

Date	Description - Notes and Comments	Date	Description - Notes and Comments
4-Mar	SHC Mandatory Thesis Format Review	11-Apr	Thesis Presentations & SHC Final Thesis Submission
30-Mar	AE Presentation Slide Outline	12-Apr	Depart to Orlando for AISC Steel Conference
8-Apr	AE Final Thesis Submission	29-Apr	AE Senior Banquet

[6] Summary

The Medical Center consists of three 7-story inpatient towers, totaling 570,000 square feet in size. Existing as a concrete structure, The Medical Center will be constructed on a wind exposure class C and seismic soil class E site. Each inpatient tower is identical in appearance but structurally independent from one another. The L-shaped inpatient towers house 424 hospital beds and support a medical program featuring medical offices, nursing units, non-intensive care units, and mechanical spaces. The Medical Center demonstrates strong architectural patterning and features large curtain walls along the length of its façade. This building project sits at the cornerstone of an expanding medical district, promoting the rejuvenation of the downtown urban fabric of Southeast, USA.

6.1 Conclusion

The proposal of an alternative design scenario has consequential effects on the engineering systems of The Medical Center. The alternative structural design will utilize composite steel framing. The alternative lateral system will utilize a steel braced or alternating braced framing scheme.

In response to the alteration of the primary structural system, a façade investigation will be conducted. In order to address the consequential effects of an alternate façade design solution, mechanical, daylighting, and architectural considerations will be investigated. Thermal, moisture, solar, contextual, and value studies will be performed in order to optimize the architectural and engineering value and performance, respectively, of the alternate façade design.

Graduate level coursework will be utilized in an above-and-beyond fashion in order to sufficiently meet the requirements set forth by the graduate program and Schreyer Honors College.