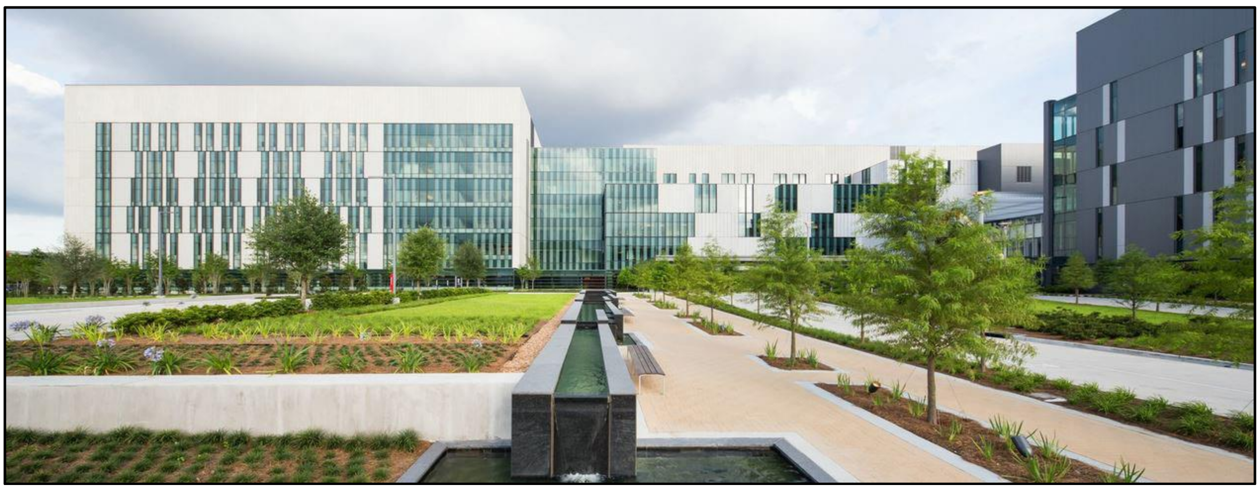
The Medical Center | Southeast, USA

Structural Existing Conditions Report

Structural Assignment 1



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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. Due to the region's environmental characteristics, the building site's poor soil condition warrants the classification of seismic design category E.

Comprised of three identical 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, 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.

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. The building is scheduled to be completed in August 2015.

Table of Contents

[1] Introduction

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).

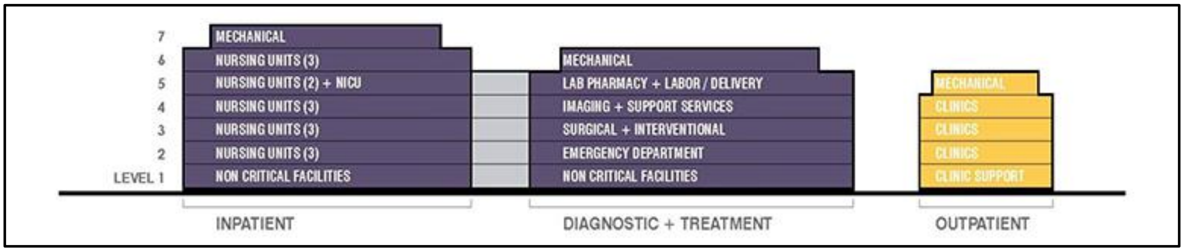

Figure 1 - Program Building Section

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. Concrete slabs provide the structural flooring of the building. The building foundation consists of grade beams spanning between 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. Poor soil conditions, classified as soil site class E, 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 as wind, 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. 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.

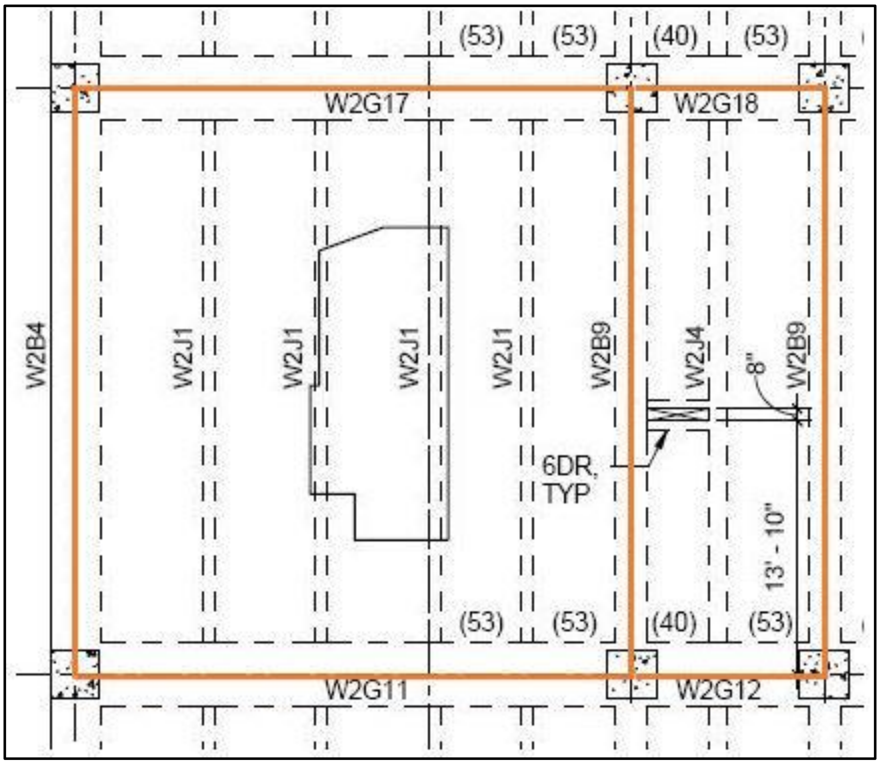

Figure 4 - Typical Ordinary and Corridor Bay Framing

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 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 shall be driven 62 ft. below the original grade.

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. 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).

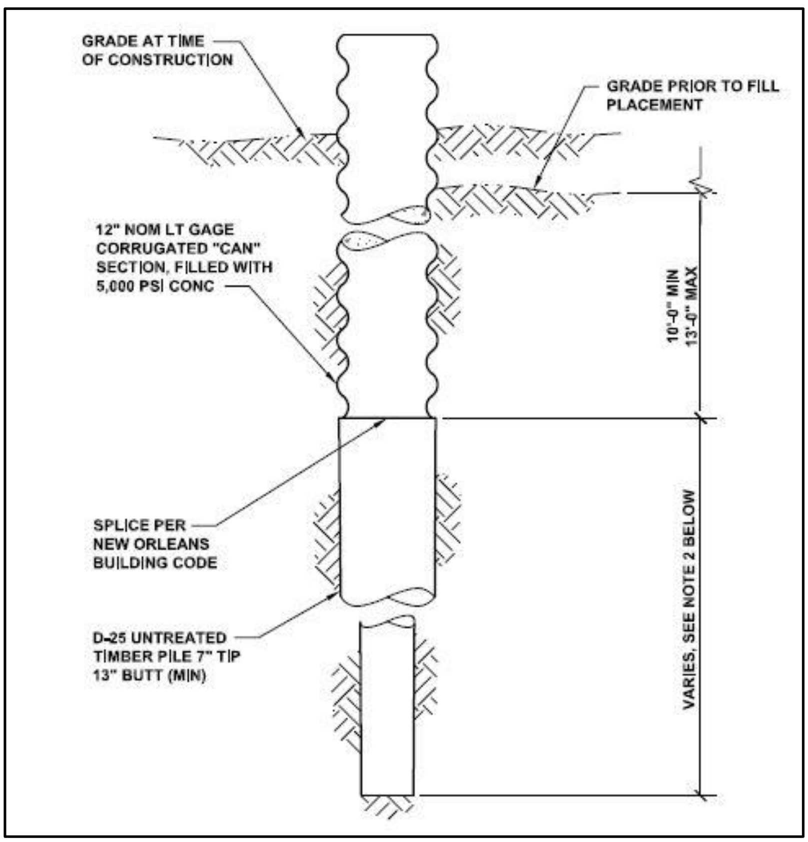

Figure 5 - Composite Timber Pile Section

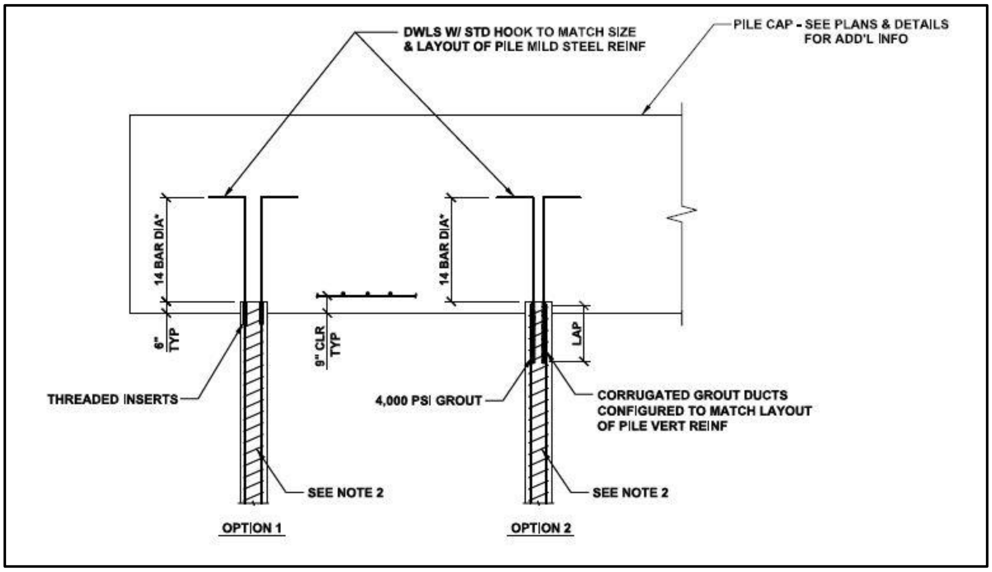

Figure 6 - Typical Detail for PCPS Piles at Column Pile Caps

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. For technical clarity, a full column schedule can be referenced in Appendix A.

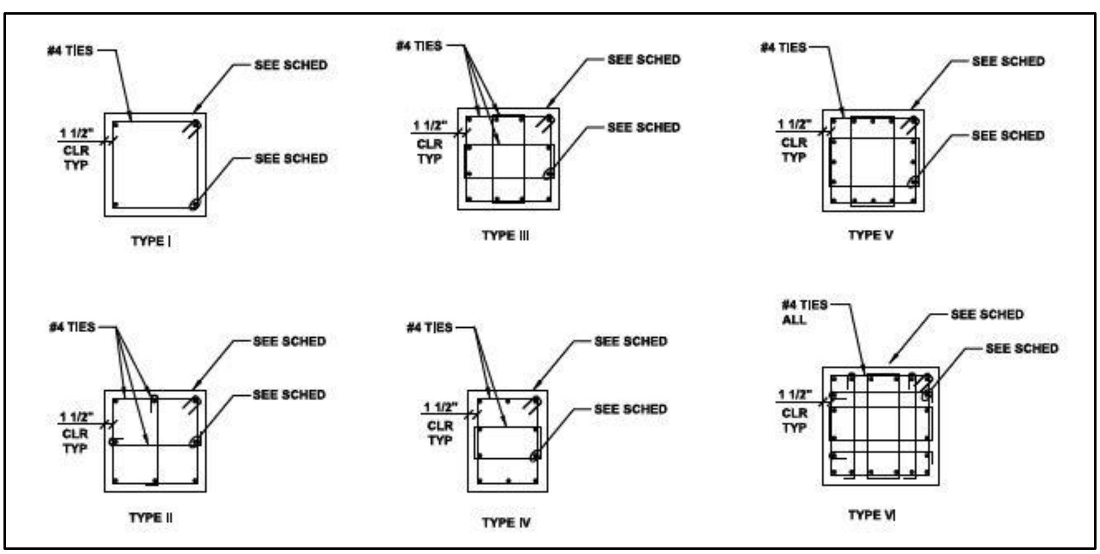

Figure 7 - Typical Concrete Column Cross Section Types

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 moment frames define the lateral framing scheme of the engineered design solution. These concrete moment frames frame the building footprint, reducing the torsional effects of lateral loads on the building structure. In addition, concrete walls contribute to the resistance of lateral forces acting on the building. The combination of concrete moment frames and walls 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 frames are detailed to include designed lateral connections at the interface of column and beam (as seen in Figure 8). A more in-depth description of the load considerations for The Medical Center will be discussed in section three.

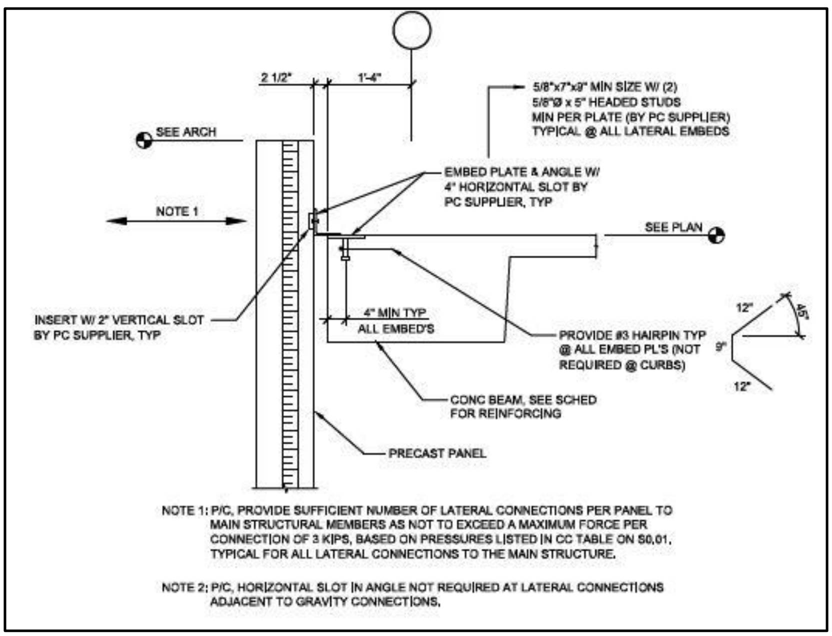

Figure 8 - Section Detailing Lateral Connection

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 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 and concrete walls 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. 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 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

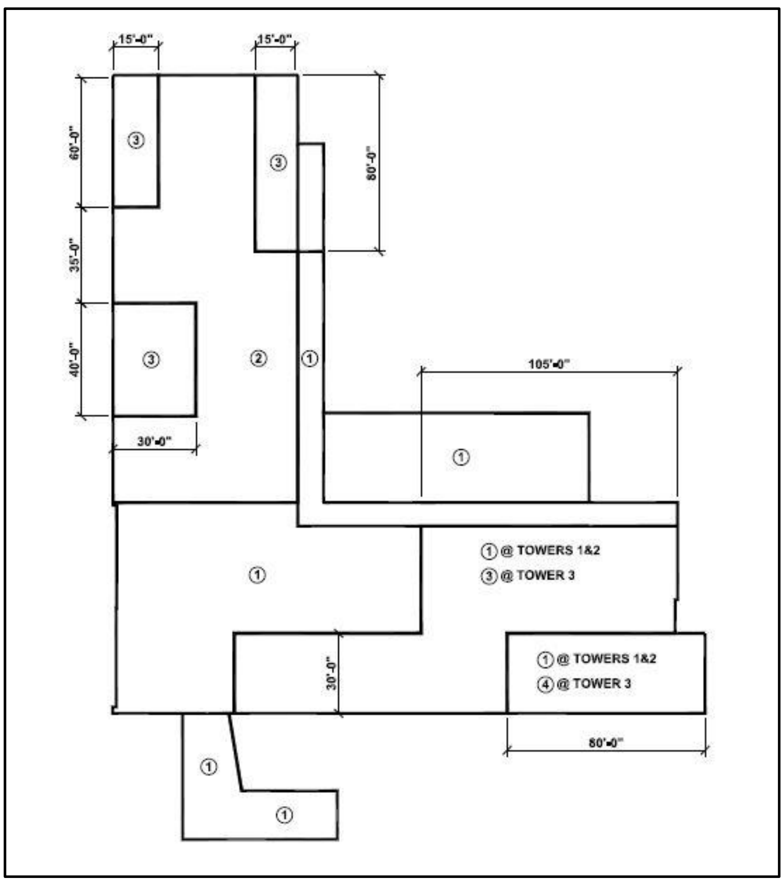

Figure 9 - Components & Cladding Roof Pressure Zones

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

[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 (as seen in Figure 11 and Figure 12).

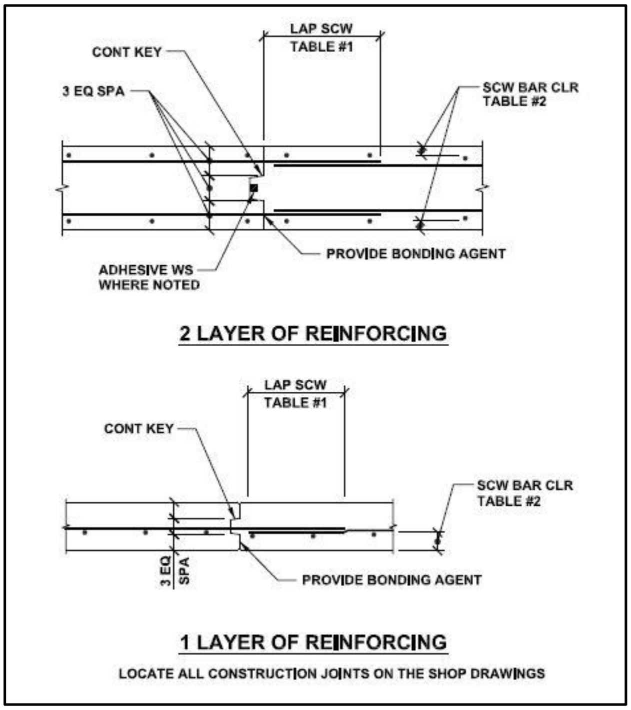

Figure 11 - Typical Concrete Wall or Slab Construction Joint

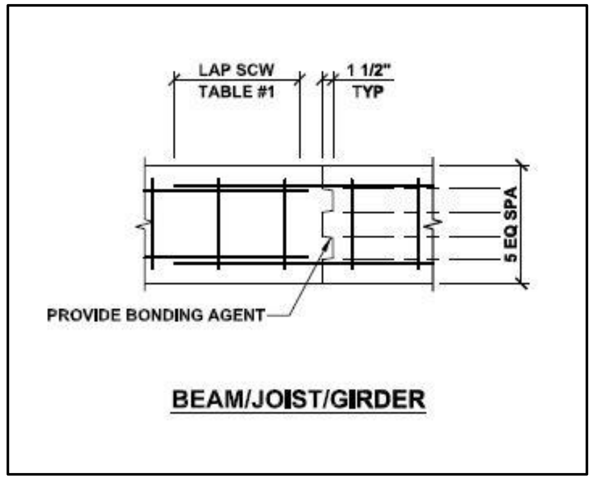

Figure 12 - Typical Concrete Horizontal Construction Joint

[5] 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 aesthetic 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.

5.1 Conclusion

After a brief preliminary analysis of the existing conditions of the medical campus and corresponding site, the initial scope of study – the inpatient towers – seems reasonable in size and complexity when considering the allotted time of study. Due to the high level of similarity between each building, the opportunity to study all three inpatient towers exists. By limiting the focus of study to the inpatient towers, a more detailed and comprehensive analysis can be achieved. The pure form and streamlined geometry of the inpatient towers allow for an investigation in varied structural systems, while the climate and soil site class of the region present special conditions for further consideration.