

# Technical Report 1

October 28, 2013

## **La Jolla Commons Phase II Office Tower**

San Diego, California

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## Executive Summary

La Jolla Commons Phase II Office Tower is a 13 story office building in San Diego, California. Each floor is about 40,320 square feet, and the structure reaches 198 feet from ground level to the top of the penthouse. With two levels of underground parking, the building extends about 20 feet below grade. Serving as an office building for LPL Financial, the building has open floor plans and large areas of glass curtain wall. La Jolla Commons Tower II received a LEED-CS Gold Certification and is the nation's largest and most advanced net-zero office building.

The building's gravity system begins with a mat foundation, two stories below grade. The mat foundation was chosen for its constructability, when compared to a system of footings and grade beams. The super structure consists of two-way, flat plate, concrete slabs on a rectangular column grid. A typical bay is 30 feet by 40 feet. Each level varies in thickness, ranging from 12 to 18 inches with reinforcing, as required, by code. Camber was used for the slab at each level, excluding Lower Level 2 where the mat foundation serves as the floor. The designers determined that the large construction loads would cause the slab to crack; therefore, slab deflections were calculated for a cracked slab section. As a result, the deflections calculated for post-construction loading were significant. The maximum camber applied to the slab is 2 ¼" at the center of a bay.

Laid out at the core of the building, the lateral system of La Jolla Commons Tower II consists of reinforced concrete shear walls. Due to the high shear forces associated with earthquake loading in this Seismic Category D structure, the diaphragm alone is not relied upon to transfer lateral loads to the shear wall system; instead, collector beams are used to aid in the transfer of lateral loads at levels below grade in the north-south direction.

La Jolla Commons Tower II has two unique structural and architectural features. The north and south sides of the building feature 15 foot cantilevers that start at Level 3 and continue up to the roof level. The structure of each cantilever is similar to that of the rest of slab; though, it does have additional reinforcement. Also, the building has a plaza area on the Ground Level which carves out a portion of Ground Level 1 and Level 2. Main building columns are exposed here, and additional 18 inch columns are added to support the slab edge above.

La Jolla Commons Tower II was designed using the 2010 California Building Code which corresponds to ASCE 7-05 and ACI 318-08. CBC 2010 and ASCE 7-05 were used to calculate live, wind, and earthquake loads. ACI 318 – 08, Chapter 21, references the design of concrete Earthquake-Resistant structures, and ASCE 7-05, Chapter 12, details the Seismic Design Requirements for Building Structures. Both of these documents were used heavily in the design of LJC II in order to account for seismic loading and detailing.

La Jolla Commons Phase II Office Tower is full of educational value. It has several structural challenges and unique conditions: punching shear, seismic loading and detailing, concrete shear wall design, and computer modeling. The following report explains the building structure, design codes, and design loads in more detail.

## Building Introduction

### Purpose and Scope

The purpose of this technical report is to demonstrate an understanding of the structural systems associated with La Jolla Commons Phase II Office Tower located in San Diego, California. The scope of this report includes thorough descriptions of the physical existing conditions of the building and its structural systems including the foundation, gravity system, lateral system, and joint details. It will also cover important codes and sources of load information.

### Building General Description

La Jolla Commons Phase II Office Tower (LJC II), rendered in Figures 1 and 2, is a thirteen story, high-rise structure located in San Diego, California. This Seismic Category D structure reaches 198 feet above grade with 462,301 square feet of floor space, including two underground parking levels. LJC II is a very



Figure 1 | North East Elevation (Hines & AECOM)



Figure 2 | South East Elevation (Hines & AECOM)

modern style and open building, featuring flat plate reinforced slabs on a rectangular column grid. This creates a very spacious office area for the building tenant, LPL Financial. LJC II features 13 stories of office space, a penthouse, and two underground levels of parking. Appendix A includes an 11x17 version of a typical floor plan and North-South building section for reference.

La Jolla Commons Phase II Office Tower is very similar in architectural style to its sister building, Tower I. Although identical in architectural style, Tower I has a steel structure unlike Tower II. Figure 3 shows the two towers side by side, while Tower II is under construction. The two towers help to unite the La Jolla Commons Campus around a green space and pedestrian area. Eventually, the campus will feature two acres of park space, surrounding the existing and proposed buildings. The campus will also eventually include a restaurant, bar, spa, gym, and meeting spaces.

LJC II is built underneath a flight path, controlled by the Federal Aviation Administration (FAA); therefore, the building's height is limited based on the distance from the flight path. After negotiations, the building's height was limited to its current height of 198 feet.

For more general building information, see Figure 4-6 below. Figure 4 shows the site plan for the La Jolla commons campus. Also, Figure 5 and 6 offer some overall dimensions for LJC II.

The façade of LJC II consists of a unitized curtain wall panel system on 2 3/4" x 6" framing members. Dimensional stone, traditional windows, monumental storefront, and structural glass are also used on the building's façade, mostly at the building base.



Figure 3 | South East Elevation (Hines & AECOM)

After LJC Tower I achieved a LEED-CS Gold rating in 2008, Tower II was expected to reach a prestigious level of sustainability as well. LJC II includes features such as reclaimed water reuse, under-floor air distribution system, double pane glazing with low emissivity coating, and energy efficient lighting systems. Furthermore, LJC II is the first Class A, Net-Zero office building in the United States, and it is the nation's largest carbon-neutral office building to date. Through methods of reduced consumption and

onsite generation, LJC II will actually return more power to the grid than it will use annually. LJC II also received a LEED-CS Gold Certification upon structure and shell completion.



Figure 4 | Building Site Plan (Hines)

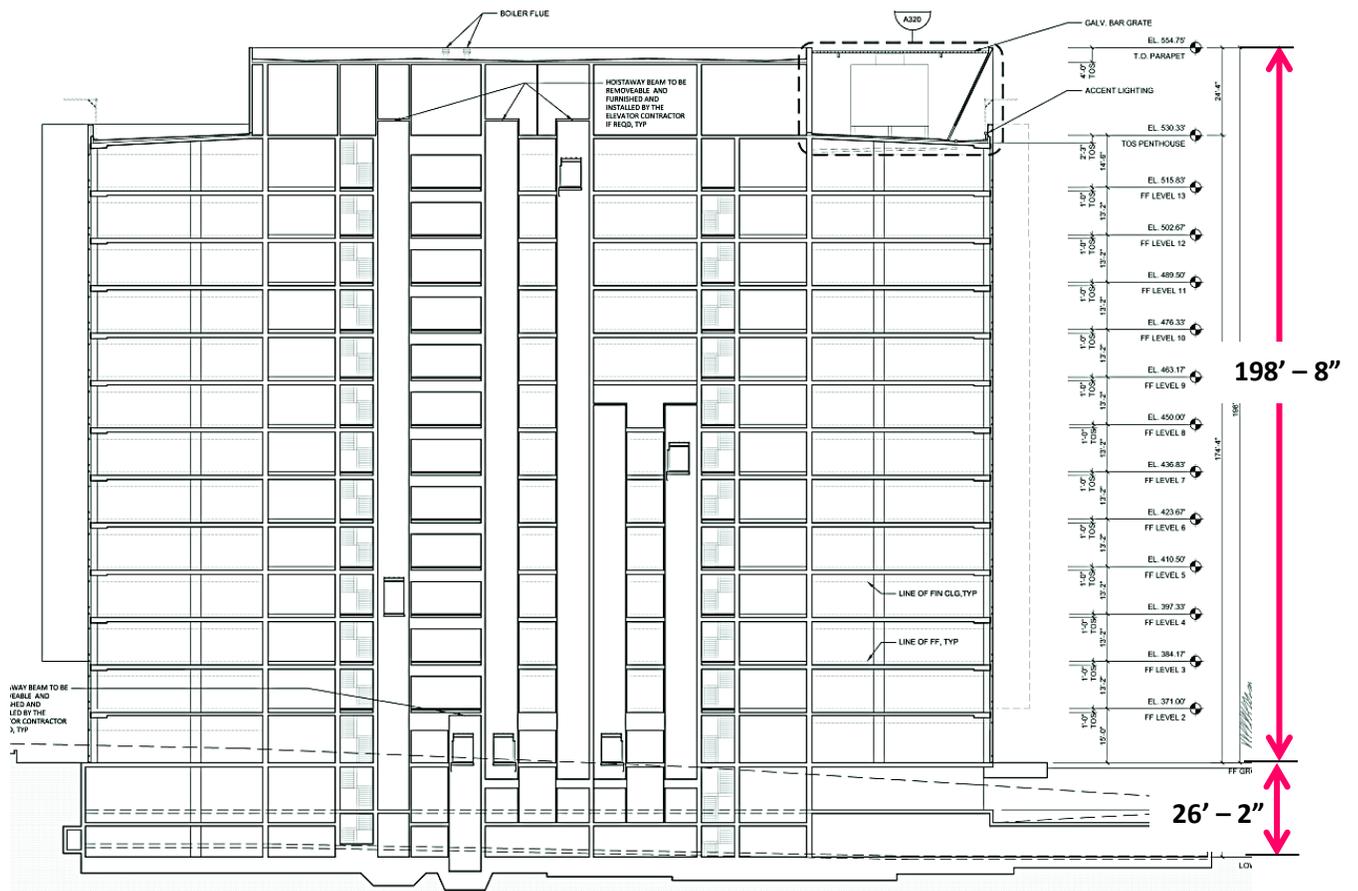


Figure 5 | North-South Building Section - A310

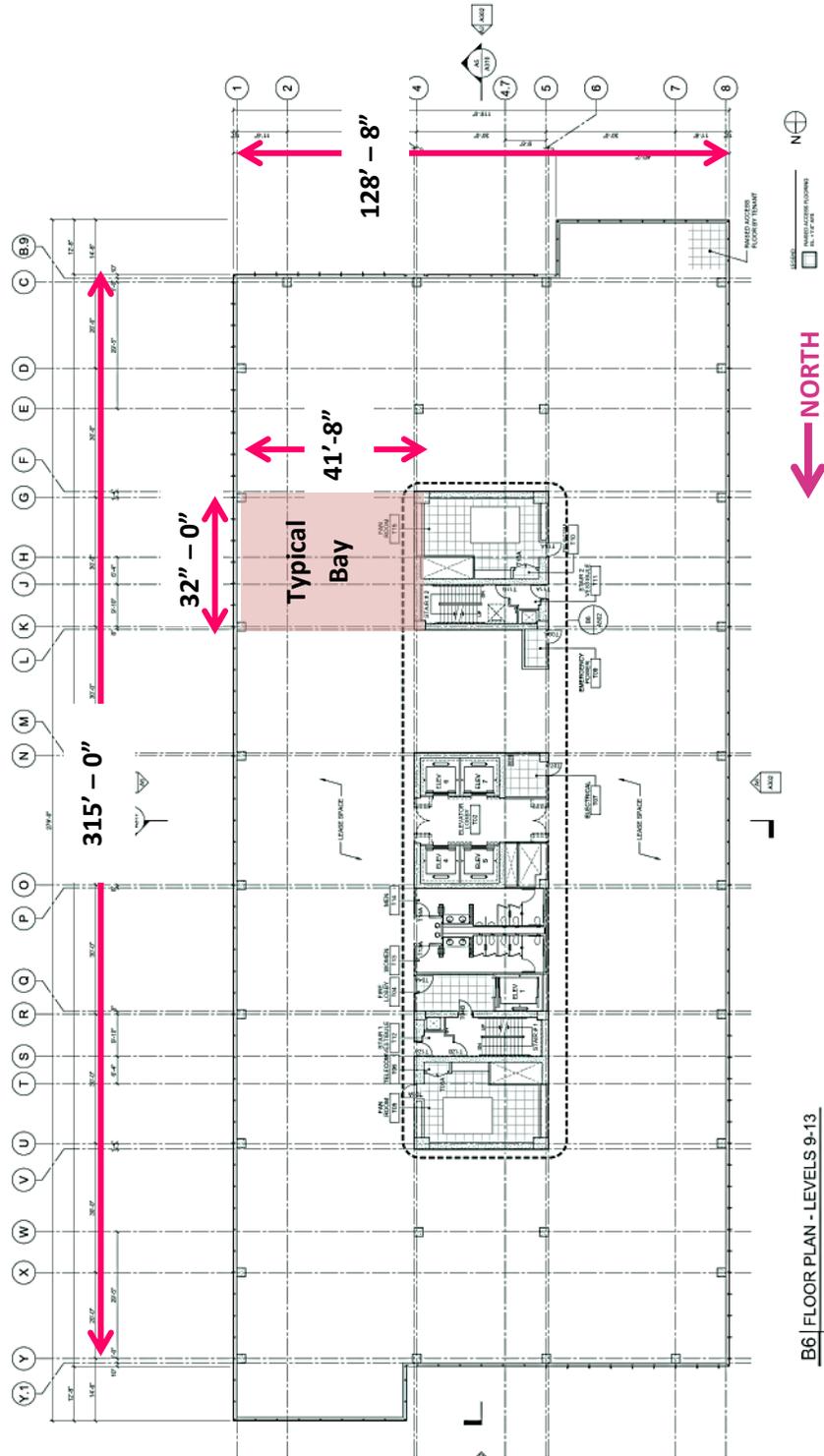


Figure 6 | Typical Floor Plan - A109

## Structural System

### Structural Framing Summary

La Jolla Commons Tower II is a, cast-in-place concrete structure using mild reinforcing. The foundation consists of a concrete mat, ranging in thickness from 3 feet to 6.5 feet. The gravity system consists of two way, flat plate, reinforced concrete slabs supported by a rectangular grid of reinforced concrete columns. The lateral system is a series of shear walls located at the building’s core. Also, due to high seismic loading (seismic category D), the lateral system includes collector beams on the Ground Level and Lower Level 1, which are used to transmit the earthquake loads from the diaphragm into the shear walls. The building also features two 15 foot cantilever sections at the North and South ends. The mechanical penthouse, located on the roof, is framed in steel wide-flanges and hollow structural steel members with a moment frame acting as the lateral system. All of the items mentioned in this summary are described in detail in the following sections of this report.

### Materials

La Jolla Commons Phase II office tower, primarily a concrete structure, employs several concrete and reinforcing types, shown in Tables 1 and 2, depending on the use in the building. Although concrete is the main structural material, information regarding steel is provided in Table 3 for the penthouse framing.

Concrete Strengths (at 28 days, 0.5 max cement ratio)		
Slab on Grade	3500 PSI	Normal Weight
Foundations	5000 PSI	Normal Weight
Shear Walls	6000 or 7000 PSI (per plans)	Normal Weight
Slabs and Beams	5000 PSI	Normal Weight
Columns	6000 or 7000 PSI (per plans)	Normal Weight
Basement Retaining Walls	5000 PSI	Normal Weight
Cantilever Retaining Walls	5000 PSI	Normal Weight
Built-up Slabs	4000 PSI	Light Weight (110 PCF)
All Other Concrete	4000 PSI	Normal Weight

Table 1 | Concrete Usage and Strengths

Steel Reinforcement	
Typical Reinforcing Bars	ASTM A-615, Grade 60
Shear Wall and Diaphragm Reinforcing	ASTM A-706
Welded Rebar	ASTM A-706

Table 2 | Steel Reinforcement and Standards

Structural Steel	
All Structural Steel	ASTM A-572, Grade 50 OR ASTM A992
Steel Braced Frame Beams and Columns	ASTM A992
Structural Tubing	ASTM A-500, Grade B (Fy = 46000 PSI)
Structural Piping	ASTM A-53, Grade B (Fy = 35,000 PSI)

Table 3 | Structural Steel and Standards

**Foundation**

The foundation system design was provided by Nabih Youssef Associates, the structural consultant for LIC II, after review of the geotechnical report and recommendations of the geotechnical engineer, Christian Wheeler Engineering. The final design consisted of a reinforced mat foundation system.

**Geotechnical Report and Recommendations**

The geotechnical report provided by Christian Wheeler Engineering, San Diego, California, was released on January 24, 2012. Along with soil tests, they tested the feasibility of a 5-foot-thick, mat foundation, proposed by Nabih Youssef Associates. After performing six subsurface explorations using Core Penetration Tests and coordination with Nabih Youssef Associates, Christian Wheeler Engineering created the soil map shown in Figure 7. The area in pink represents the area of the mat expected to be supported by formational soil, and the orange shading represents the area previously undercut to 300 foot elevation. The numbers in blue represent the subgrade modulus of the soil in pounds per cubic inch which is often used when deflection of the foundation is critical.

After testing was complete, Christian Wheeler Engineering provided the structural engineer with some recommendations for the mat foundation system. Due to unique soil properties at the southeast corner of the parking level, it is recommended that steps be taken to reduce settlement effects in the area highlighted in red in Figure 8. This can be done by placing fill prior to mat construction. Results of testing indicated an estimated settlement of 2.4 inches at the southeast corner, due to large surcharge loads and saturated soils. About 23 feet of new fill will be used to reduce this settlement.

Results of testing indicated a settlement of 0.7 inches and an average mat pressure of about 2,500 pounds per square foot. In the final mat foundation layout, a factor of safety of two was applied. Other soils information can be found in Table 4.

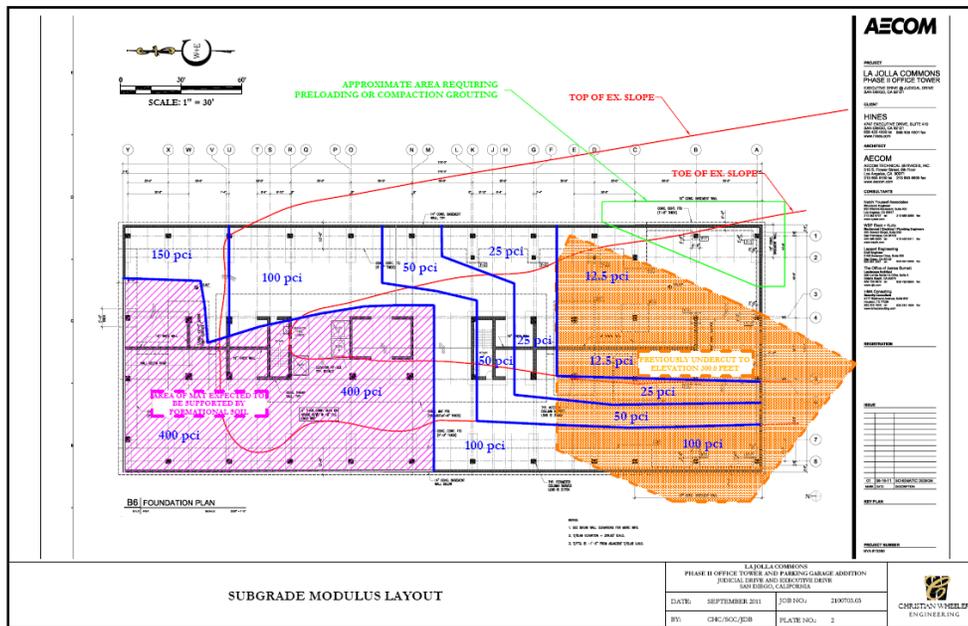


Figure 7 | La Jolla Commons Tower II Subgrade Modulus Layout – CPT Testing



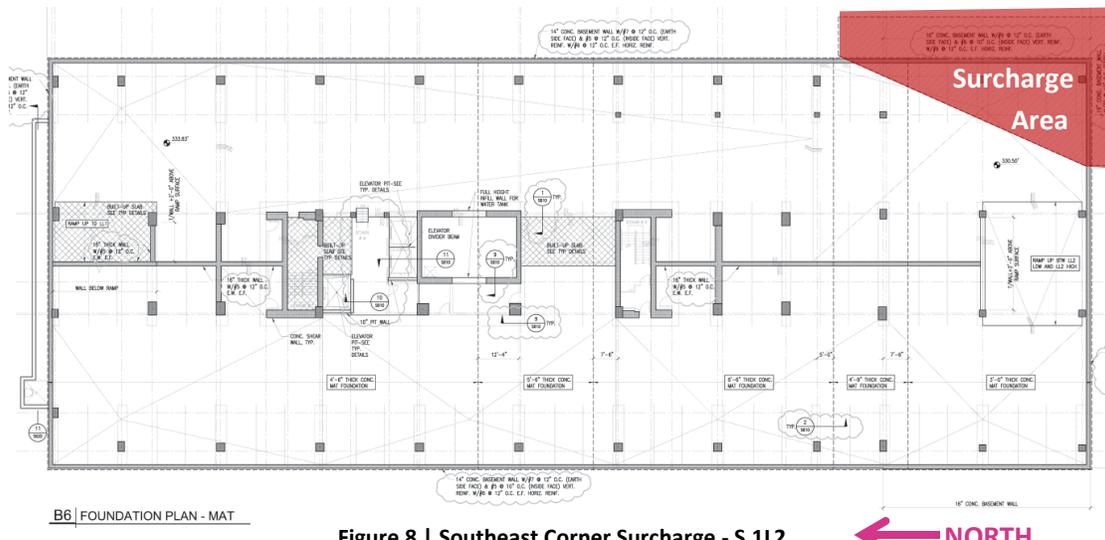


Figure 8 | Southeast Corner Surcharge - S.1L2



**Soil Data: Office Tower II**

**Soil Site Class – C**  
**Report Date – January 24, 2012**  
**Soil Engineer – Christian Wheeler Engineering**

<b>Fp</b>	4000	Psf (fill)	<b>Subgrade Modulus</b>	Varies- See Figure 10
<b>Fp max</b>	8000+	Psf (formation)	<b>Friction Coefficient</b>	0.30
<b>Pa unrestrained</b>	40	Psf/ft	<b>Liquefaction</b>	No
<b>Pa restrained</b>	60	Psf/ft	<b>Groundwater</b>	No
<b>Pp</b>	350	Psf/ft	<b>Corrosive</b>	No
<b>Pa seismic</b>	8	Psf/ft inverted (kh=0.10g)		

Table 4 | Soil Data – S001

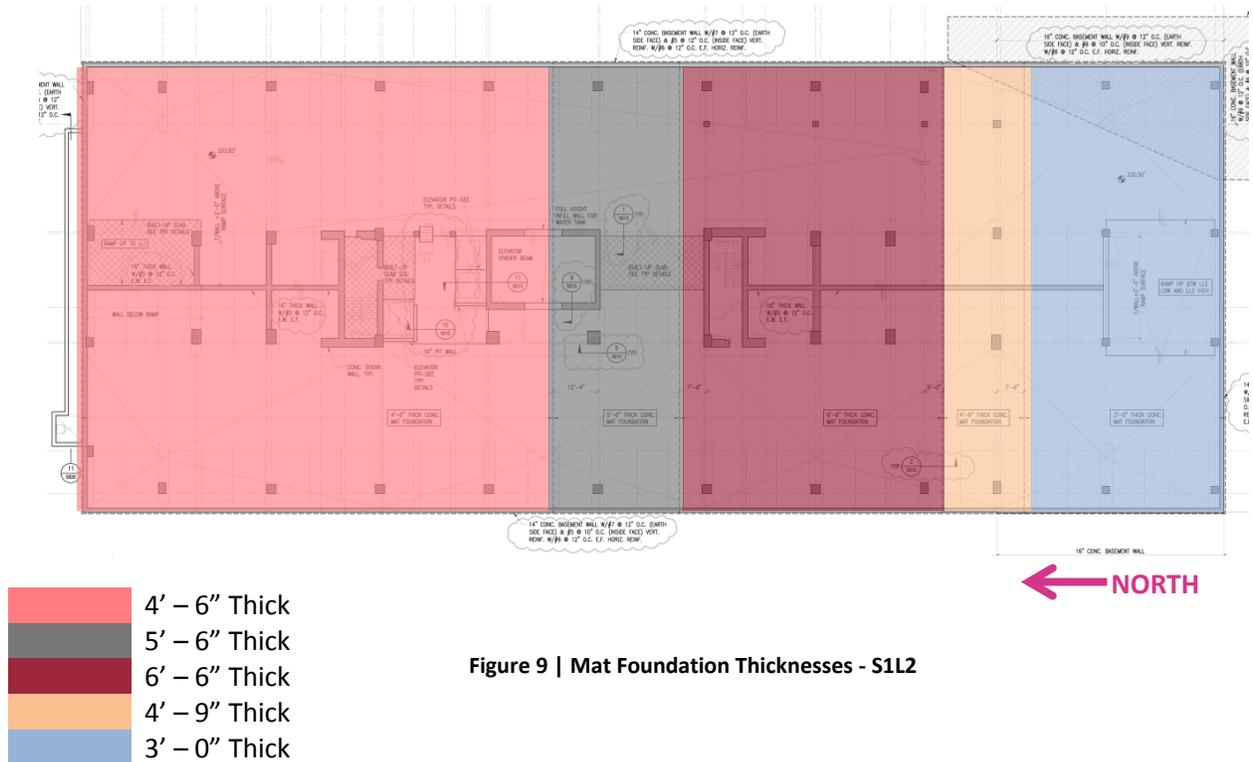
**Foundation Walls**

As stated above in the General Building Description, La Jolla Commons Tower II has two levels of underground parking. As a result, concrete foundation walls were utilized around the building perimeter to hold back soil loads. Typical foundation walls are 14” thick concrete with #7 bars at 12 inches on center (o.c.) at the exterior and #5 bars at 12 inches o.c. at the inside face, vertical reinforcement. Also, #6 bars at 12 inches o.c. were provided for horizontal reinforcement.

The southeast corner, the area requiring surcharge loading has 16 inch foundation walls with #9 vertical bars at 12 inches o.c. (outside face) and #6 bars at 10 inches o.c. (inside face). Also, #6 horizontal bars were provided at 12 inches o.c. The thicker walls are necessary due to increased soil pressures due to soil saturation. This area is highlighted in red in Figure 8.

**Mat Foundation Design**

The foundation for La Jolla Commons Phase II Office Tower was designed as a reinforced concrete mat foundation with varying thicknesses and reinforcement. Originally, a system of footings and grade beams were considered for the foundation. The mat foundation was chosen for several reasons. First, the large area it covers helps to reduce the soil pressure created by the overturning moment associated with seismic loads. Second, the construction of one large mat was simply easier than forming all of the footings and grade beams required for the alternative system. Figure 9 shows the variation in mat thickness across the foundation.



**Figure 9 | Mat Foundation Thicknesses - S1L2**

The Typical Mat Reinforcing Schedule in Figure 10 shows the various reinforcing layouts that were used for the different areas of the mat foundation. Along with this typical reinforcing, additional bottom reinforcing bars were used at the building’s central core near the lateral shear walls.

TYP. MAT REINFORCING SCHEDULE				
MAT THICKNESS	TOP		BOTTOM	
	E-W	N-S	E-W	N-S
3'-0"	#9 @ 16"	#9 @ 15"	#10 @ 18"	#10 @ 18"
4'-6"	#9 @ 10"	#9 @ 10"	#10 @ 18"	#10 @ 18"
4'-9"	#9 @ 16"	#9 @ 18"	#10 @ 18"	#10 @ 10"
5'-6"	#9 @ 8"	#9 @ 8"	#10 @ 18"	#10 @ 18"
6'-6"	#9 @ 12"	#9 @ 16"	#10 @ 14"	#10 @ 10"

**Figure 10 | Mat Reinforcement Schedule – S1L2A**

The mat foundation also utilizes a system of hairpin reinforcing. This is used to transmit shear forces to the foundation from the shear walls at the core. It is important to note that hairpin reinforcing could be eliminated by increasing the foundation thickness; however, because of the already significant depth of the mat, it was decided that hairpin reinforcing would be a more efficient way to transmit the shear forces. Figure 11 shows an example of the hairpin reinforcing layout.

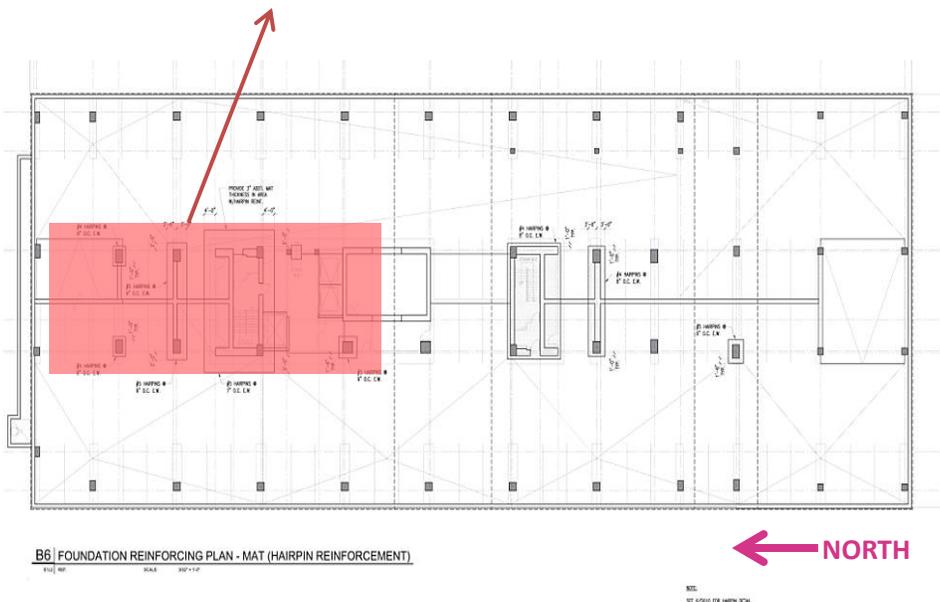
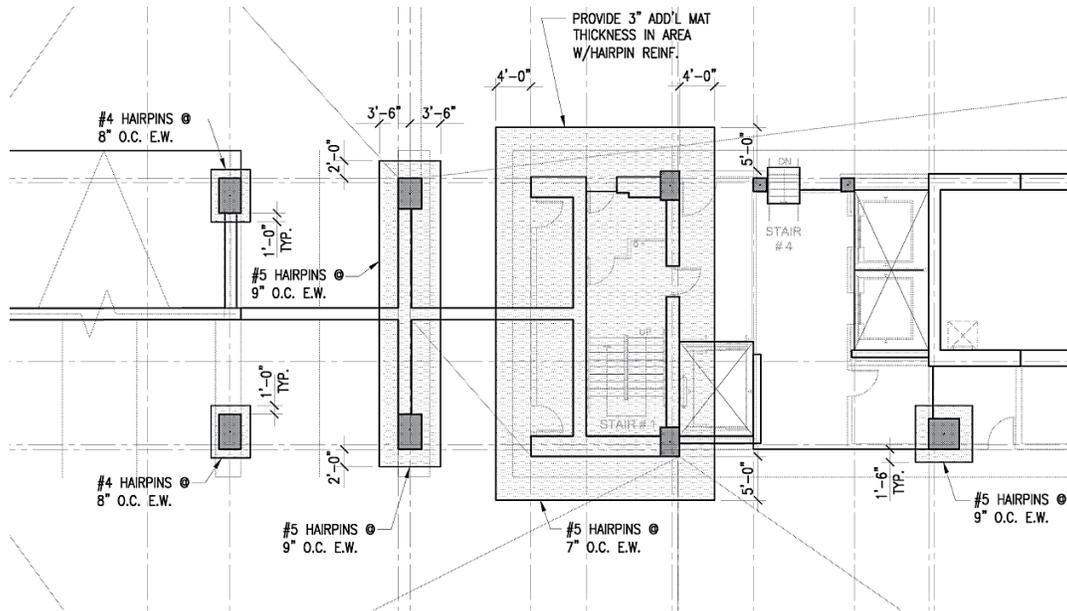
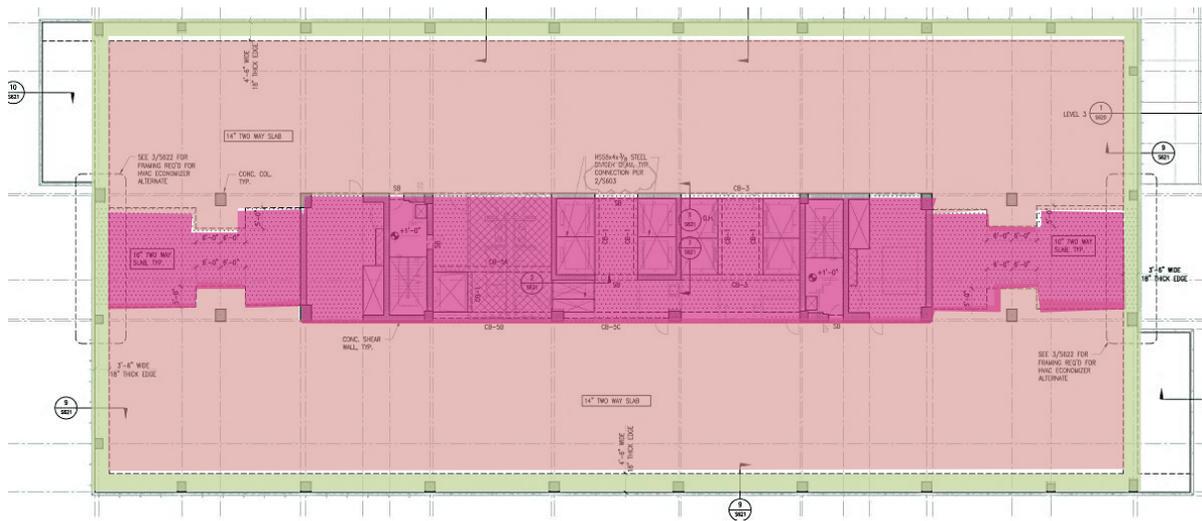


Figure 11 | Hairpin Reinforcing Plan – S1L2C

**Gravity System**

**Floor System Overview**

La Jolla Commons Tower II is rectangular building that is 315 feet long by 123 feet 8 inches wide. The building features a flat plate, two-way slab system on a rectangular column grid. As shown in Figure 12, the slab varies in thickness from 10 inches to 14 inches. The exterior edge of the slab at each level is framed by an 18 inch spandrel beam. The north and south beams are 4.5 feet wide, and the east and west beams are 3.5 feet wide. This spandrel beam helps to reduce the effects of tension on the slab edge due to diaphragm deformation during seismic loading; these spandrel beams are referred to as chords.



- 18" Thick Spandrel Beam
- 10" Thick Core Slab
- 14" Thick Slab



**Figure 12 | Typical Two Way Slab Thickness Layout – S103**

Reinforcing of the slab varies based on direction and slab thickness, which can be seen in Figure 13. The plans also call out additional bars on the plans as required. As with the mat foundation, the floor system has increased sizes and frequency of rebar near the core (where the shear walls are located).

Reinforcing also varies based on column strip and middle strip locations. As required by ACI 318-08, reinforcing for the slab cannot exceed a spacing of 18 inches.

TYP. SLAB REINFORCING SCHEDULE				
SLAB THICKNESS	TOP		BOTTOM	
	E-W	N-S	E-W	N-S
10"	#6 @ 16"	#6 @ 16"	#5 @ 12"	#5 @ 12"
14"	#6 @ 16"	#6 @ 16"	#5 @ 6"	#5 @ 6"

**Figure 13 | Typical Two-Way Slab Reinforcing Schedule – S103A**

Shown in Figure 14, typical bay sizes are 30 feet by 40 feet at the east and west sides of the core. Bay sizes in the core vary due to shear wall placement. Also, column spacing at the core does not exactly match that of the exterior columns; however, the largest core bay size is 30 feet by 30 feet.

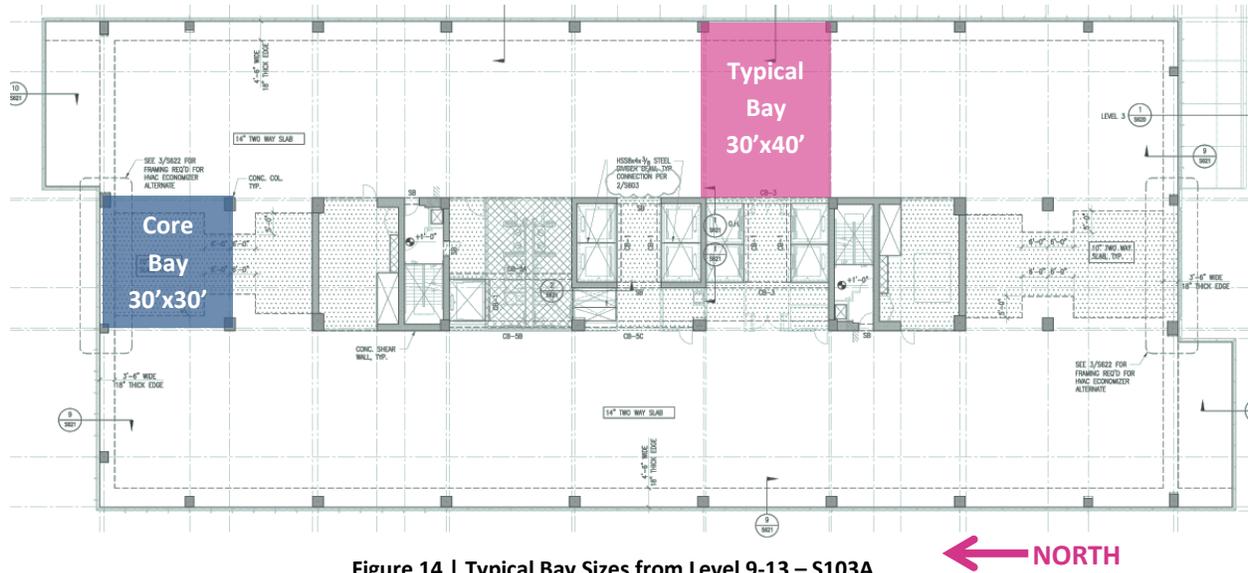


Figure 14 | Typical Bay Sizes from Level 9-13 – S103A



Camber of the structural slabs is used extensively for La Jolla Commons Tower II, a sample of which can be viewed in Figure 15. Due to the fast construction of LJC II, construction loads were significant and played a major role in the design. Designers assumed that the slab would be loaded to the limit during construction, causing some cracking. The slab was then analyzed for creep as a cracked section to determine the worst possible conditions; deflections were great enough that camber was required. Nabih Youssef Associates consulted documents such as ACI 435 to determine creep and shrinkage.

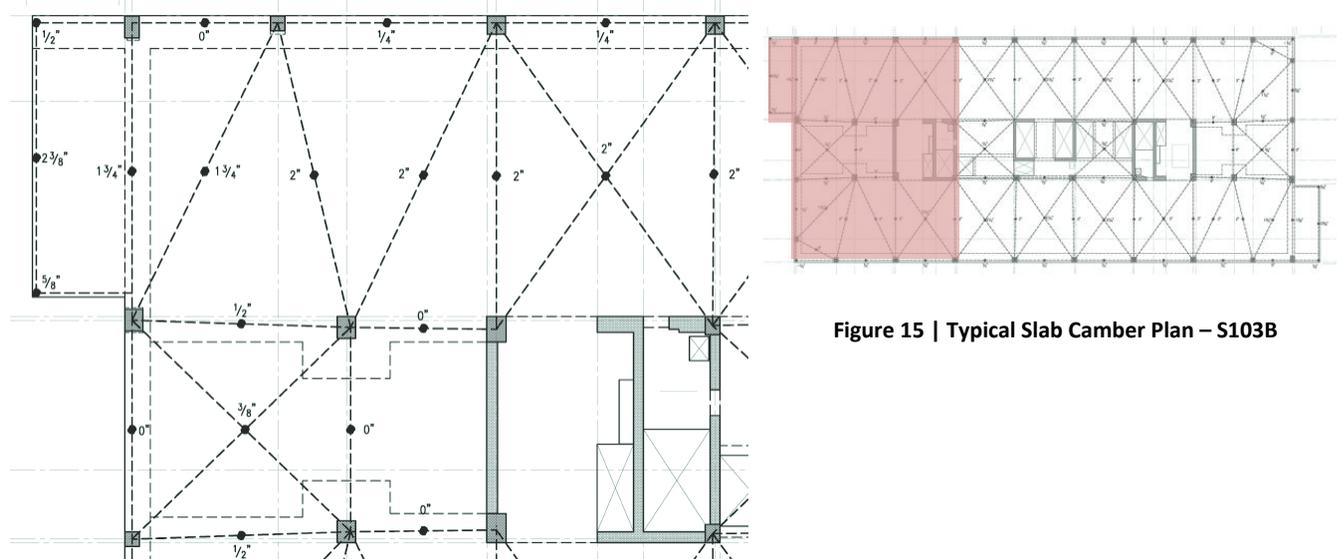


Figure 15 | Typical Slab Camber Plan – S103B

### Floor System - Typical Bay

A typical 30 foot by 40 foot bay was selected from the framing plan for Levels 3 – 7 and can be seen highlighted in pink on Figure 14. This typical bay is a 14 inch two-way slab. It also has a 4.5 foot by 18 inch spandrel beam

The slab follows the typical slab reinforcing schedule which was shown previously in Figure 13. Additional reinforcement was needed at the column strips in both directions of the slab. See Figure 16 for additional bar frequency, size, and location. “B” indicates bottom bars at the middle strip. “T” indicates top bars at the middle strip. All the listed frequencies are spaced equally along the width of the strip.

Also, note that 90 degree hooks are used to terminate the bars in the spandrel beam. The shear walls also create a unique condition, requiring an increase in reinforcing to transmit shear forces. A detail of the slab reinforcing, shown in Figure 17, shows the layout of bars in the column strip and middle strip cross-sections.

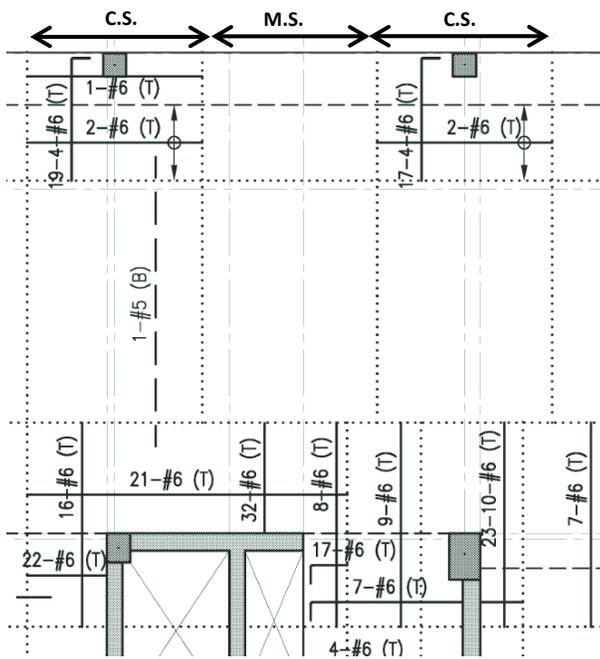


Figure 16 | Typical Bay Column Strip Reinforcing – S109A

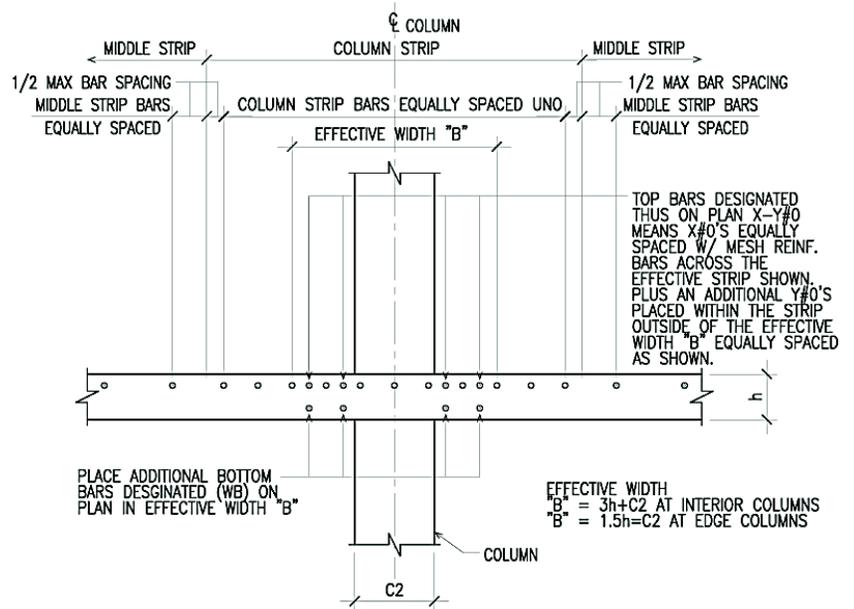


Figure 17 | Typical Flat Slab Reinforcing Placing Detail – 12|S602

As previously mentioned, the typical bay has a cambered slab. This particular bay has a maximum camber of 2 ¼ inches at the center of the span and a minimum camber of ¼ inch at the exterior edge of the bay which can be seen in Figure 18. Camber values at all column and wall supports are taken as zero.

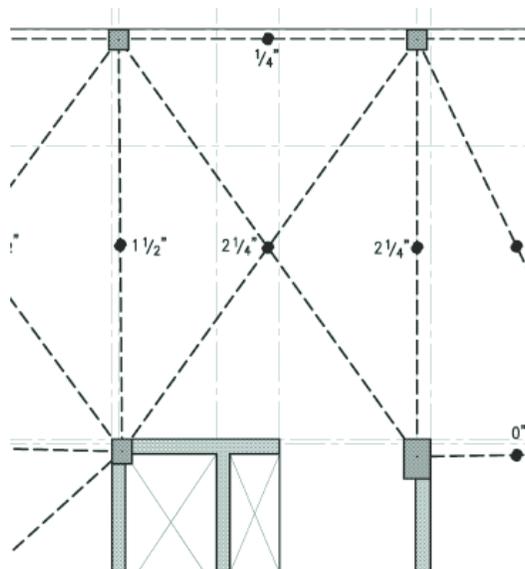
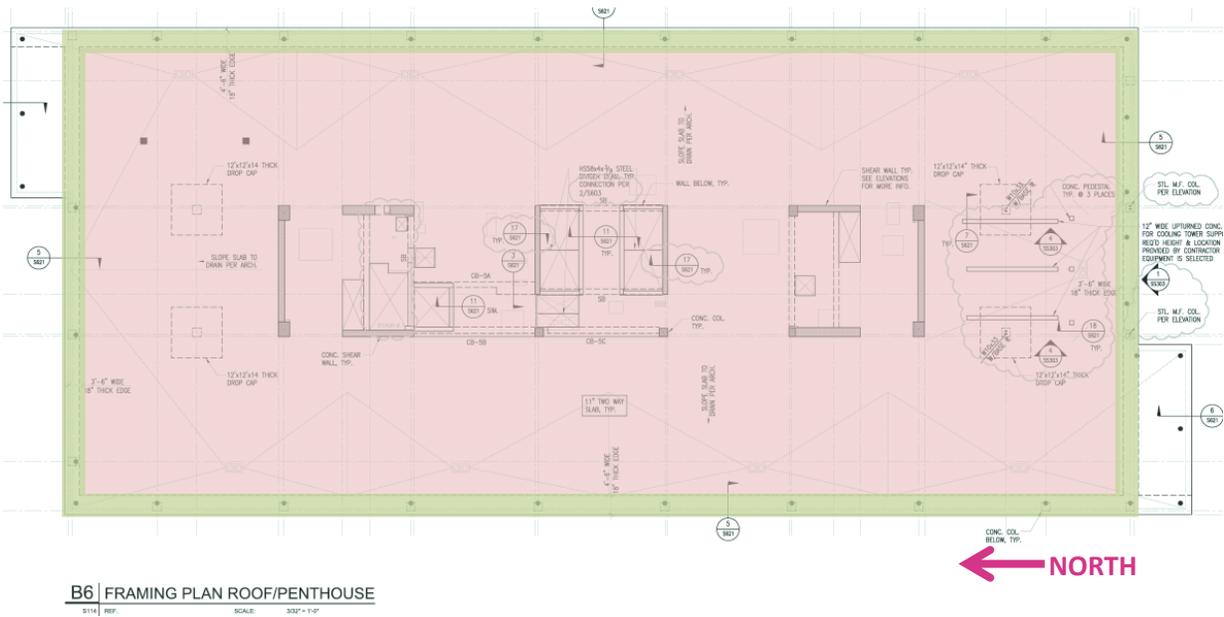


Figure 18 | Typical Bay Camber Plan – S109B

### Penthouse Floor/Roof Framing

The penthouse/roof level is located above the thirteenth floor of LJC II. The roof slab is designed to behave similarly to the floor systems below. As is shown in Figure 19, the flat plate, two-way slab is 11 inches thick with an 18” deep spandrel beam framing the slab edges. Like the floor system, the beam is 3.5 feet wide at the north and south edges and is 4.5 feet wide at the east and west edges.



- 18” Thick Spandrel Beam
- 11” Thick Slab

Figure 19 | Roof/Penthouse Slab Thickness – S114

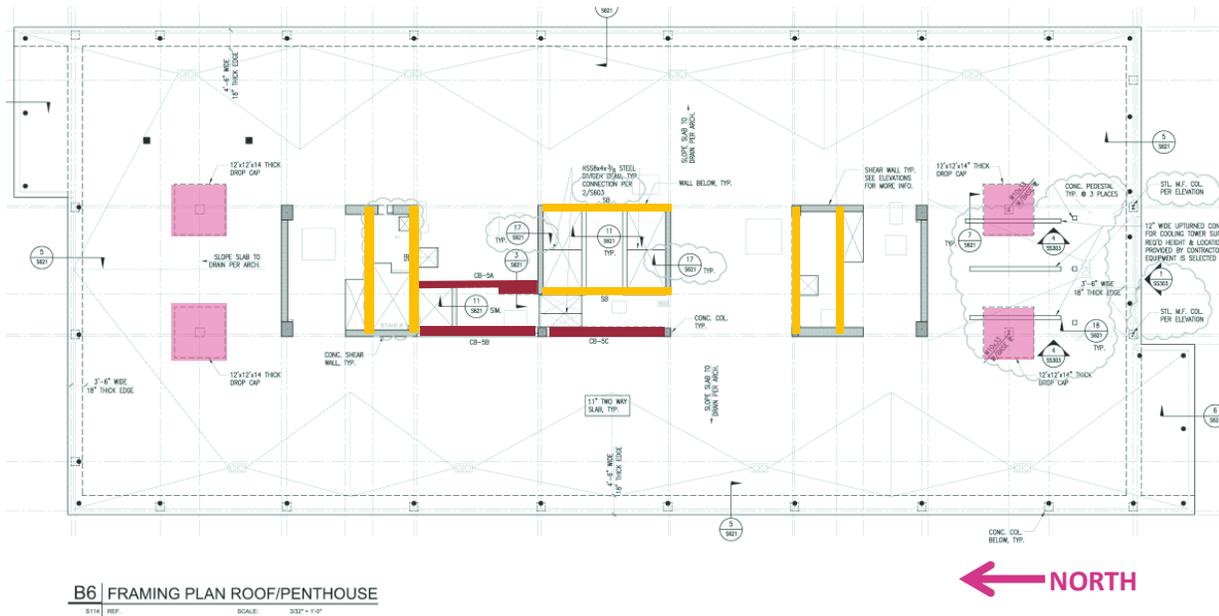
Much like the floor, the roof/penthouse slab has a typical reinforcing schedule as seen in Figure 20. It also has additional supplemental reinforcing as required by loads. Longitudinal reinforcing is terminated at spandrel beams with 90 degree hooks.

TYP. SLAB REINFORCING SCHEDULE					
SLAB THICKNESS	TOP		BOTTOM		EXTENT
	E-W	N-S	E-W	N-S	
11"	#6 @ 16"	#6 @ 16"	#5 @ 8"	#5 @ 8"	EAST OF LINE 4 / WEST OF LINE 5

Figure 20 | Roof/Penthouse Slab Reinforcing Schedule – S114

Again, like the floor system, camber is utilized on the roof system. Camber of the roof/penthouse slab ranges from ¼ inch at the edges to 3 ½ inches at the center of each bay.

Unlike the floor system, the roof slab is supplemented with drop panels along column lines E and W, highlighted in pink in Figure 21, to support increased shear, flexure, and deflections due to high roof loads and long spans. There are four of these drop panels, and they are each 12 feet x 12 feet x 14 inches thick. The final component of the roof/penthouse consists of concrete beams and spandrel beams used to frame around the elevators, stairways, and shear walls, which are highlighted in red and yellow in Figure 21.



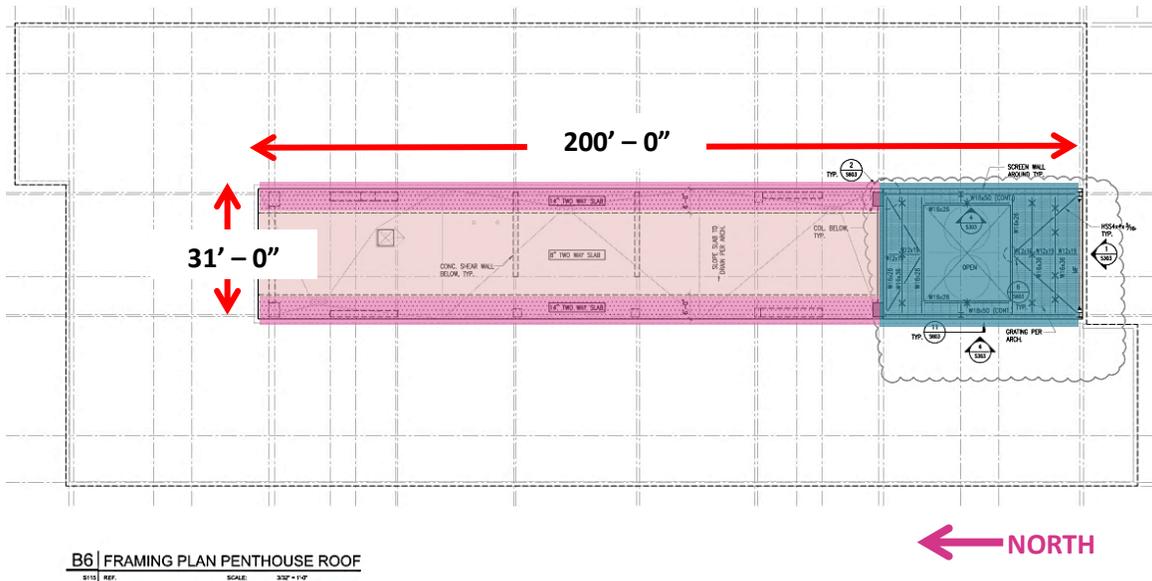
B6 | FRAMING PLAN ROOF/PENTHOUSE  
S114 REF. SCALE: 3/32" = 1'-0"

- Drop Panels
- Spandrel Concrete Beams
- Regular Concrete Beams

Figure 21 | Roof/Penthouse Drop Caps and Concrete Beams – S114

### Penthouse Roof Slab and Framing

The penthouse roof is framed using a combination of flat plate, two-way slabs and structural steel framing. Wide flange beams and hollow structural steel members are used to frame the roof over the cooling tower at the south end of penthouse which is highlighted in blue in Figure 22. Metal bar grating is used to span between beams above the cooling tower, and moment frames and bracing support the south portion of the penthouse. Flat plate, two-way slabs that are 8 inches thick and 14 inches thick are used for the rest of the roof framing. Figure 22 provides more information on the roof gravity system layout, and Figure 23 offers a closer view of the steel framing at the south end.



- 14" Two Way Slab
- 8" Two Way Slab
- Steel Framing and Grating (at cooling tower)

Figure 22 | Penthouse Roof Framing Systems – S115

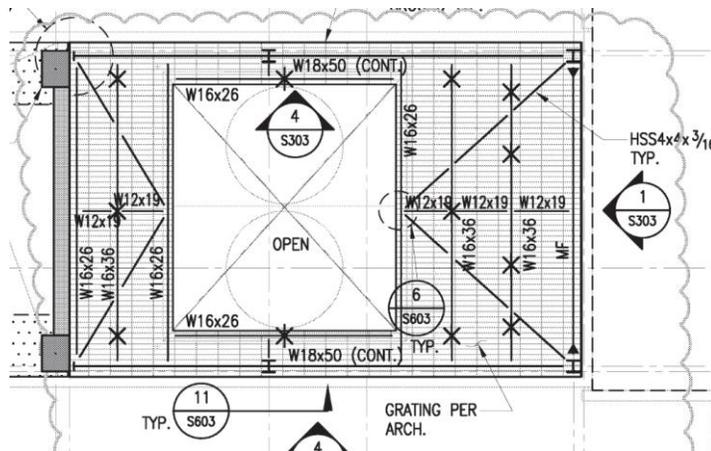
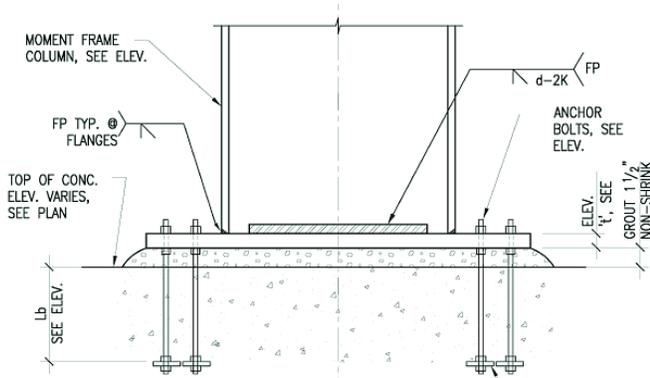


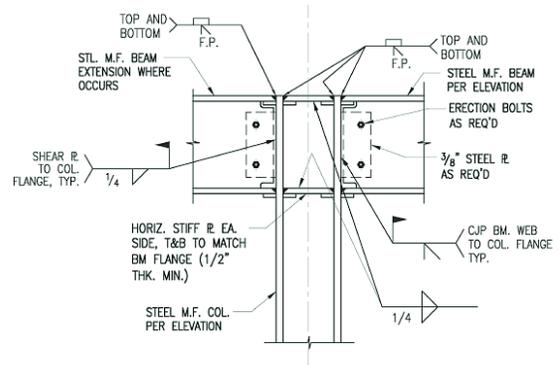
Figure 23 | Penthouse Steel Framing (Highlighted in Blue in Figure 26) – S115

**Roof Steel Framing Connections**

As mentioned above, the penthouse is made up of steel framing, including wide-flange and hollow structural steel sections. Most connections for the penthouse are pinned, except for the moment frame. The fixed connection between the base of the moment frame and the concrete slab is shown in Figure 24. The column-beam moment connection is shown in Figure 25.



**Figure 24 | Steel Column Moment Connection – 3 | S303**

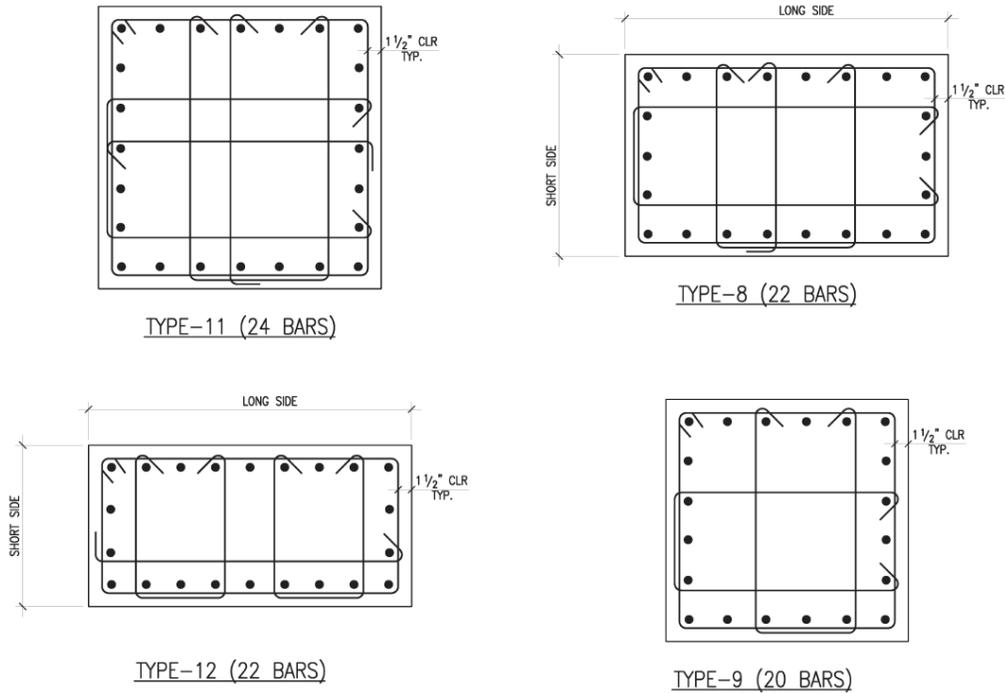


**Figure 25 | Steel Column to Beam Moment Connection 2 | S303**

Concrete Columns

The entire gravity system is supported by a series of columns of various sizes on a rectangular column grid. Column sizes range from a maximum size of 42 inches by 42 inches at Lower Level 2 (lowest level of the underground parking garage) to a minimum size of 24 inches by 24 inches at the penthouse. Vertical reinforcing varies significantly based on column height, dimensions, and location. However, all columns have #5 ties spaced at 4 to 6 inches on center. Minimum requirements from ACI 318-08 (CBC 2010) for spacing and quantity of reinforcement have been met. There are twelve types of concrete column layouts for LJC II; four examples are provided below in Figure 26. Column types vary with the column height and location.

When the columns were designed, they were considered fixed when applying only gravity loads to account for any eccentricity in the loading. However, when the lateral system was designed, the columns were considered pinned. In the event of an earthquake, the column bases would crack and create a pinned condition; the columns would, therefore, take minimal lateral load.



TYPICAL GRAVITY COLUMN SCHEDULE, DETAIL AND TYPES

SCALE: NTS

Figure 26 | Typical Gravity Column Types – S613

**Concrete Column Connections**

As shown in Figure 27, the concrete columns are connected to the mat foundation by continuous vertical bars that extend into the foundation and terminate with 90 degree hooks. The connection is fixed in a gravity loaded condition. However, as mentioned above, the bases of the columns are assumed to crack in the event of an earthquake, creating a pinned condition. As a result, the columns will take minimal lateral load.

The edge column to spandrel beam connection is critical due to punching shear and slab deflection concerns under seismic loading. The beam rests on the column below; at this column to slab interface, a spandrel beam is introduced with shear reinforcement. Figure 28 is a typical detail of the spandrel beam-column connection. Due to increased punching shear concerns and considerations for seismic-load-induced diaphragm deflection causing tension at the slab edge, the spandrel beam is provided with additional longitudinal and shear reinforcement. Column to slab connections are typically made through the use of continuous or lap spliced rebar matching slab reinforcement and stud rails.

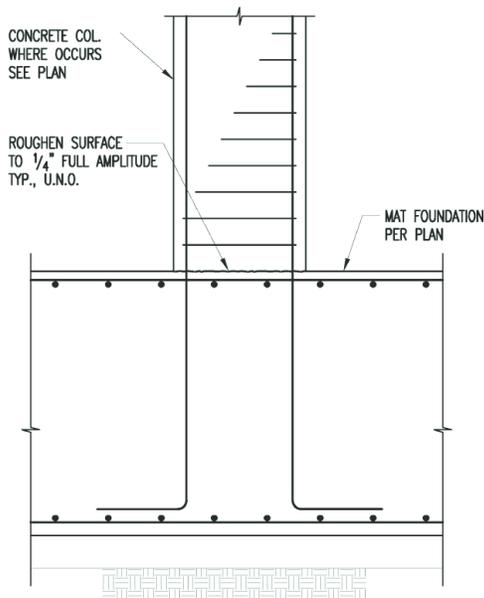


Figure 27 | Column to Mat Foundation – 9 | S610

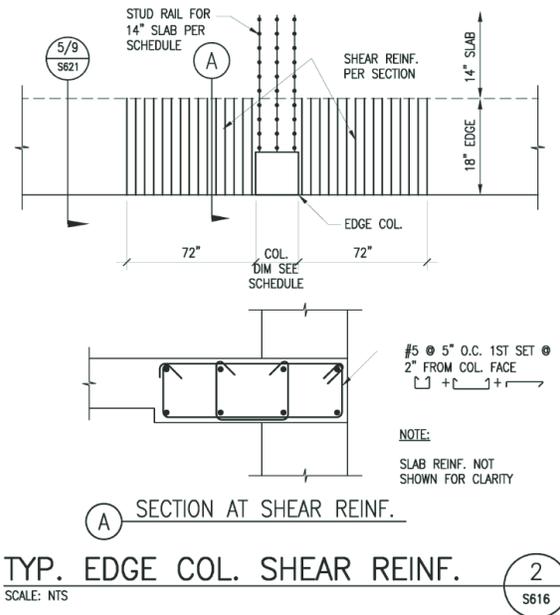


Figure 28 | Edge Column and Spandrel Beam Detail – 2 | S616

**Lateral System**

**Shear Walls and Moment Frame**

La Jolla Commons Phase II Office Tower has a lateral system of concrete shear walls; moment frames are utilized for the lateral support of the penthouse at the roof cooling tower. All lateral systems were designed and detailed following Chapter 21 of ACI 318-08 for earthquake loading. See Figure 29 for the concrete shear wall layout for the lateral force resisting system. Sheets S103, S300, S301, and S302 are included in Appendix B. These plans show details of all shear walls, including reinforcement, thickness, and location on plan. S103 is a typical structural plan to aid in locating the shear walls. Figures 30 and 31 provide more information regarding the penthouse moment frame.

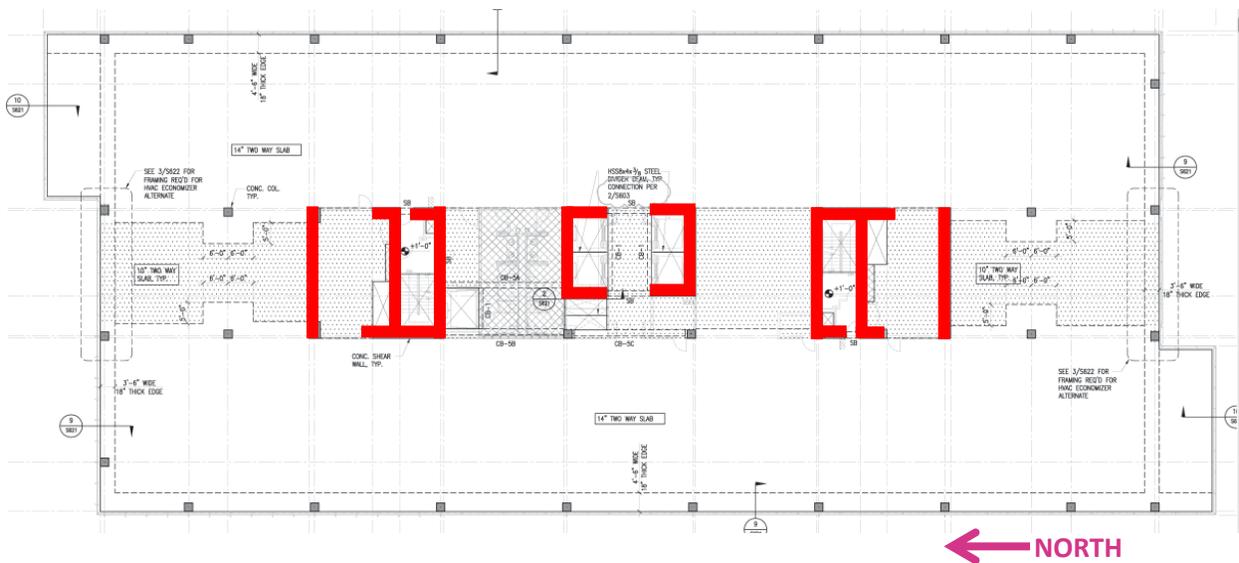


Figure 29 | Typical Shear Wall Layout – S109

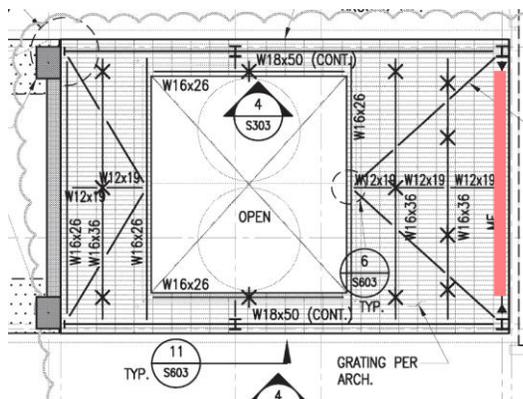


Figure 30 | Penthouse Moment Frame Layout – S109

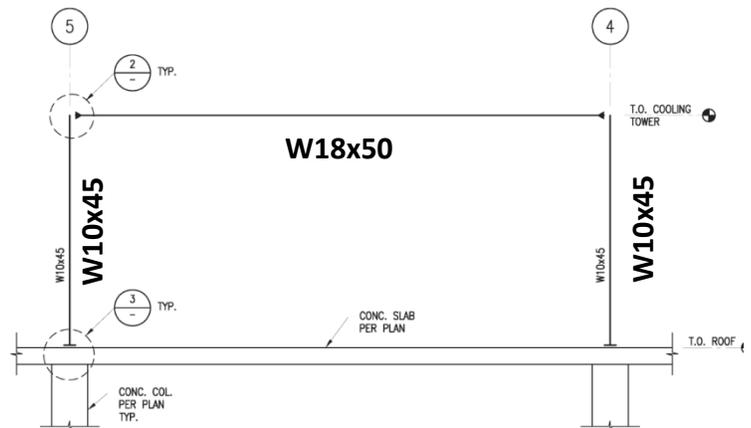
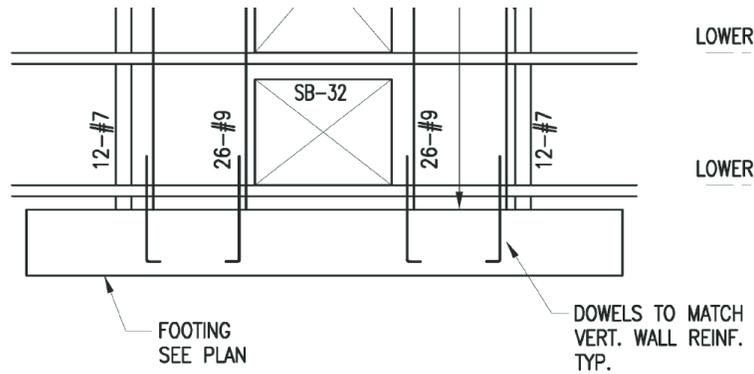


Figure 31 | Penthouse Moment Frame – S303

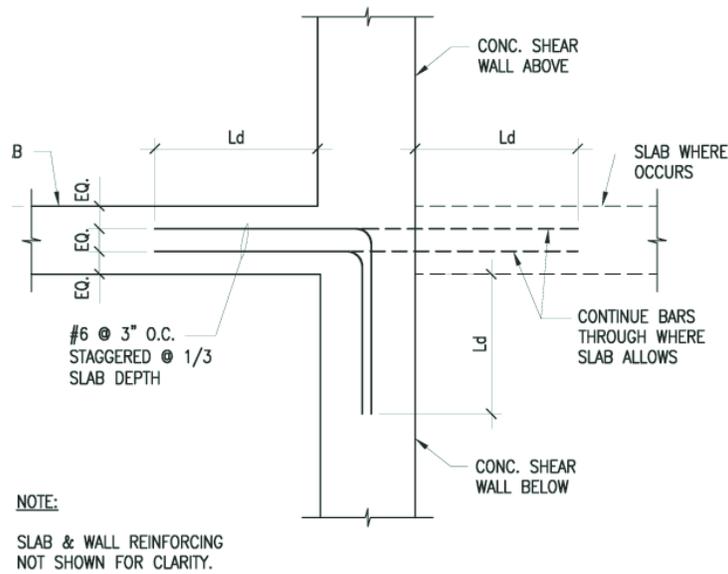
**Shear Wall Connections**

The connection between the shear walls and the mat foundation is critical to the lateral system. The shear walls must be moment connected to the foundation. This is accomplished through the use of dowels that are embedded into the shear walls and hook down into the mat foundation with a 90 degree hook. Figure 32 shows a detail of dowels placed to match the vertical wall reinforcing.

The slab and shear walls are poured monolithically and are connected by means of bent #6 bars at 3 inches on center, as shown in Figure 33. This rebar is in addition to the rebar already required for the walls and the slab.



**Figure 32 | Shear Wall Connection to Mat Foundation – 2 | S300**



**Figure 33 | Shear Wall Connection to Slabs – 7 | S601**

**Collector Beams**

Collector beams are utilized on Lower Level 1 (upper level of parking) and the Ground Level of LJC II. Collector beams are used in high seismic areas to transmit earthquake forces into the main lateral system components. These elements give you the stiffness to transmit the forces through the diaphragm which cannot efficiently transmit the earthquake loads to the lateral system on its own. Figure 34 is a schedule of the collector elements. Refer to Figures 35 and 36 for the locations of the collector elements on the levels below grade; the colors on the plan correspond to the collector type on the schedule in Figure 34.

As shown in Figures 35 and 36, collector beams mainly run in the north-south direction, except for the four Type A collector beams in the east-west direction on the Ground Level. Collector elements provide a direct path for the lateral loads from the diaphragm into the shear walls. This is especially important if the shear walls are not continuous, are spaced far apart, or are minimal. If collectors are not used, shear stresses in the diaphragm can become too great, causing failure. As shown in Figure 29, the shear walls in the north-south direction are broken up along the length of the core; this discontinuity creates a need for collector elements in order to gather lateral loads and distribute them appropriately to the shear walls. In contrast, the shear walls in the east-west direction have no breaks or spaces; therefore, collector elements are not necessary. ACI 318-08 covers the requirements of collector elements in great detail in Section 21.11.

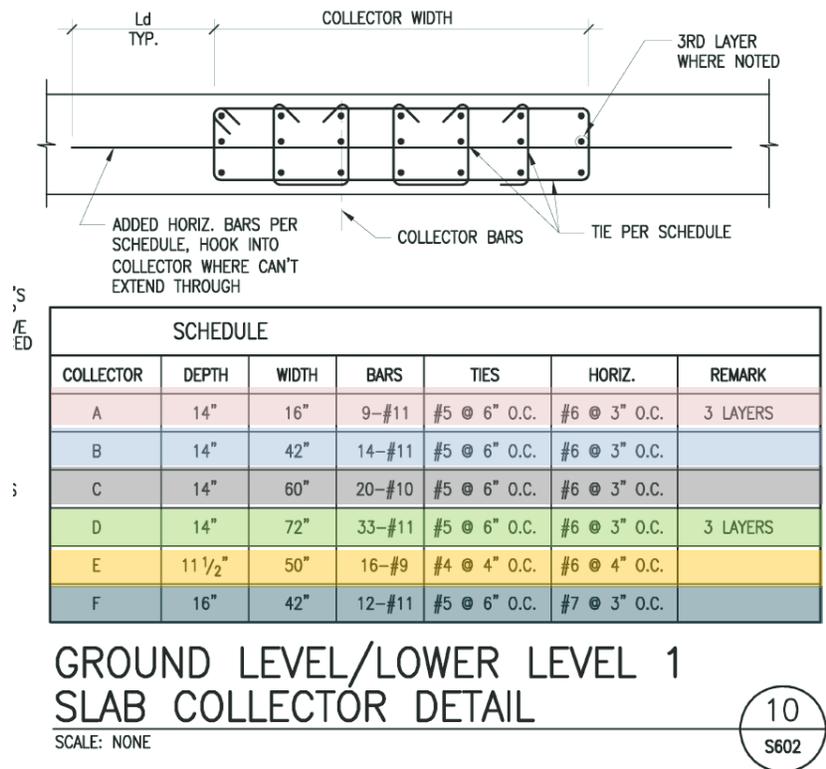
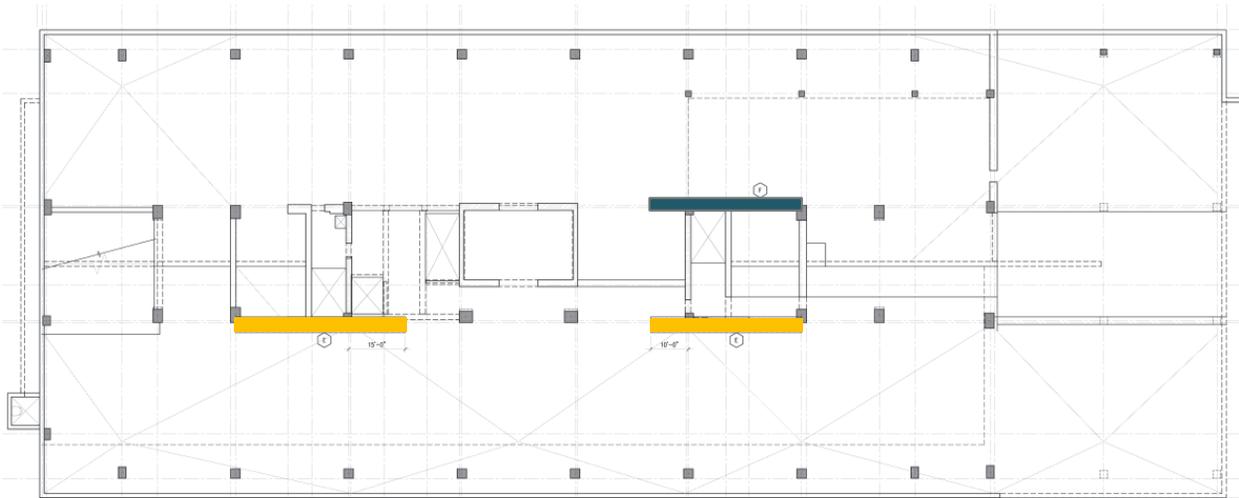
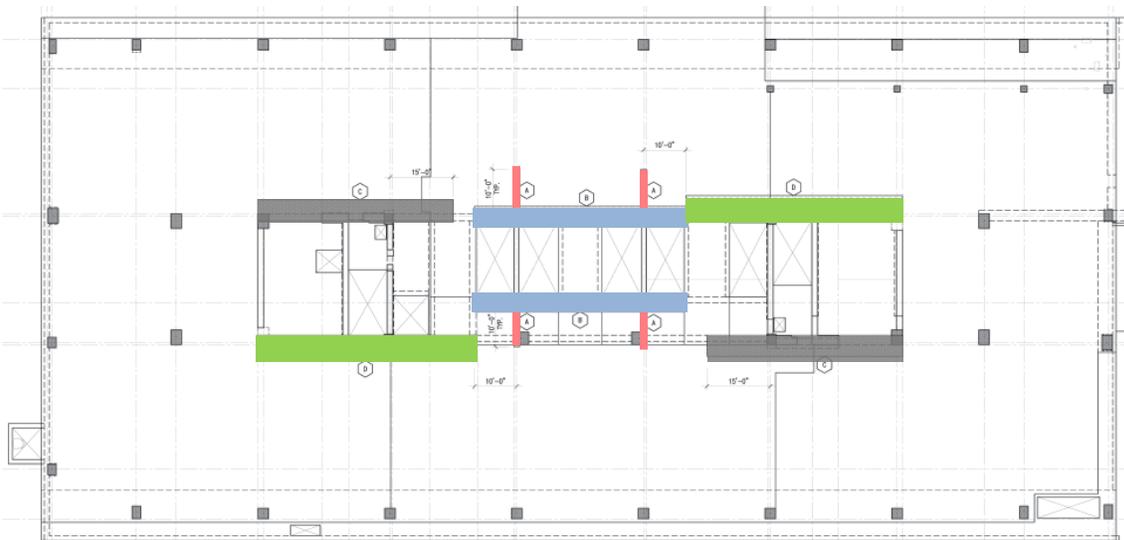


Figure 34 | Collector Beam Reinforcing Detail and Schedule – 10 | S602



B6 | COLLECTOR PLAN LOWER LEVEL 1  
S11 | REF. SCALE: 3/32" = 1'-0"

Figure 35 | Lower Level 1 Collector Beams – S111C



B6 | COLLECTOR PLAN GROUND LEVEL

Figure 36 | Ground Level Collector Beams – S111C

**Special Features**

**North and South Cantilevers**

From Level 3 up to the Roof level, the north and south ends of the building each feature a 15 foot cantilever. The framing of each cantilever is similar; therefore, this report will focus on the cantilever at the southwest end of the building as shown in Figure 37. The two way slab is 14 inches thick with an 18 inch thick spandrel beam framing the cantilever.

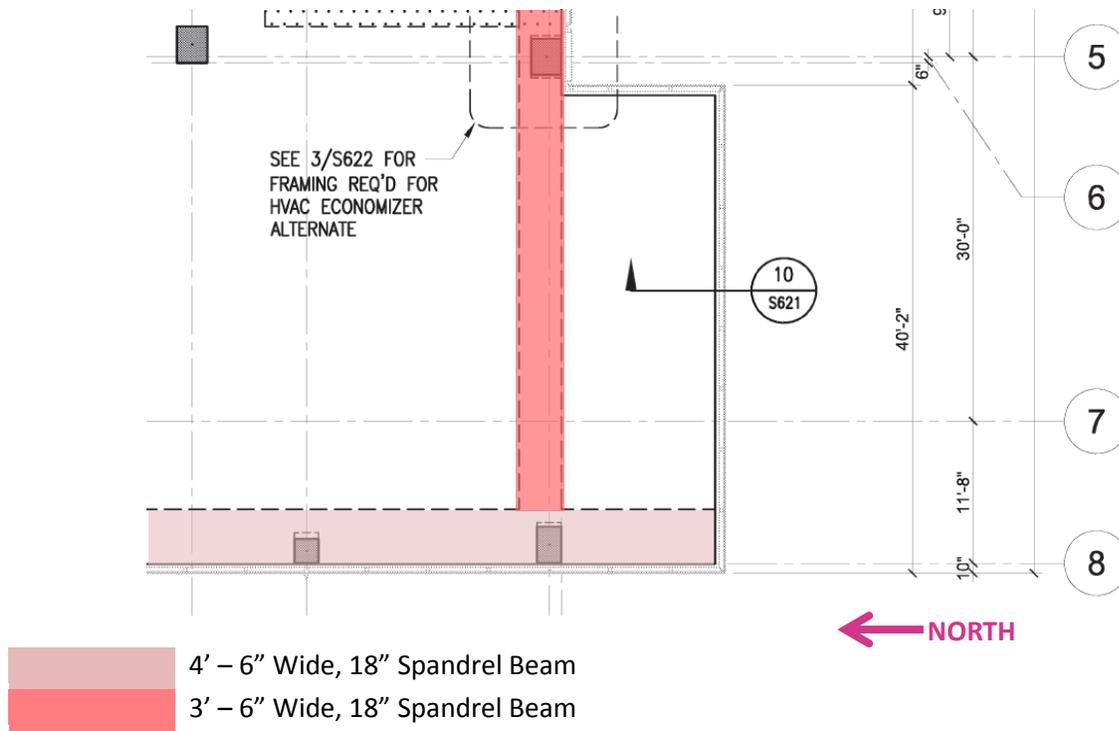


Figure 37 | South West Cantilever Plan – S103

Reinforcement in this area follows the reinforcement schedule shown in Figure 13; however, additional #6 top bars running in the north-south direction are used as well as #5 bottom bars running in the east-west direction. All bars are ended with a 90 degree hook.

Figure 38 illustrates the camber of the slab at the cantilevers.

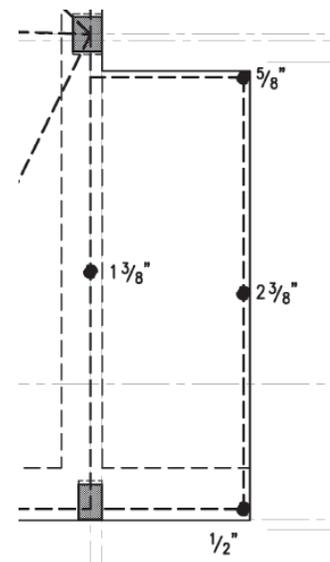
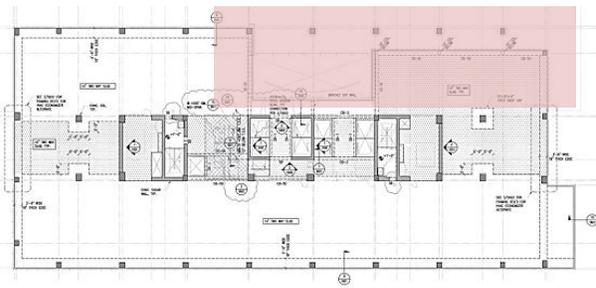
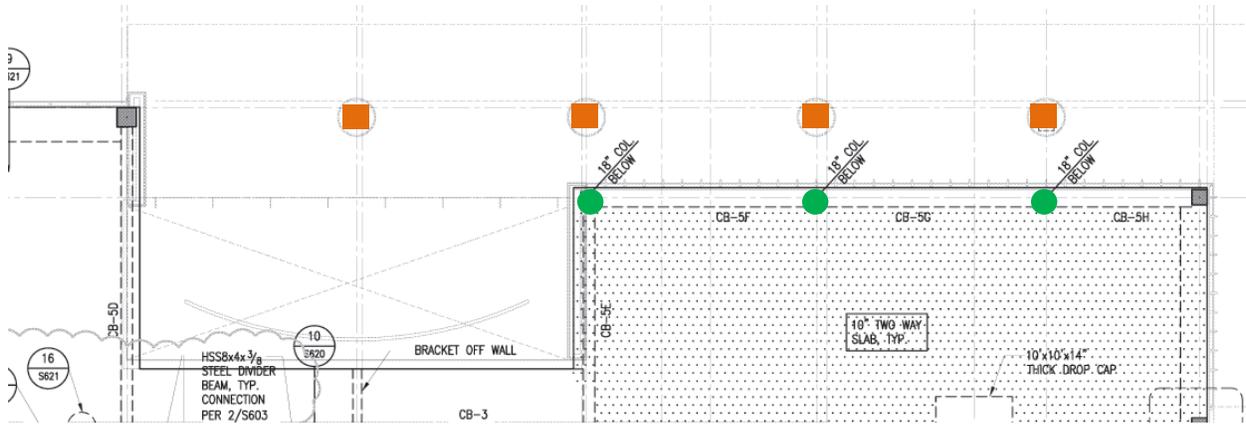


Figure 38 | South West Cantilever Camber Plan – S103B

**Ground Floor Plaza Area**

The ground floor features a covered plaza area at the building’s main entrance, cutting out a section of the Ground Level and Level 2 at the east side. The main building columns, highlighted in orange in Figure 39, continue through this space and down to the lower parking levels to the foundation. Where the slab is terminated at Level 2, 18 inch columns, highlighted in green in Figure 39, begin at Level 2 and continue down to the Ground Level. They then continue down through to the foundation system. Concrete beams frame the edge of the slab.



**Figure 39 | Level 2 Framing at Plaza – S102**

## Design Codes and Standards

### Codes and Standards

- ✓ *California Building Code 2010* (CBC 2010 Adopts IBC 2009 with some additions and changes)
- ✓ *Metal Building Manufacturers Association*
  - MBMA Recommended Design Practice Manual
- ✓ *American Iron and Steel Institute*
  - Applicable sections of the AISI Specifications
- ✓ *American Society of Civil Engineering*
  - ASCE 7-05 (as Adopted by IBC 2009) – Minimum Design Loads for Buildings
- ✓ *American Concrete Institute*
  - ACI 318 – 08 (as Adopted by IBC 2009) – Building Code Requirements for Structural Concrete

### Special Seismic Code Considerations

ACI 318 – 08 Chapter 21 is referenced quite often in the design of LJC II. This chapter is for the design of concrete Earthquake-Resistant Structures. This section discusses detailing requirements for all aspects of earthquake resistant building components, including structural and non-structural elements.

ASCE 7 – 05 Chapter 12 is also used quite often in the design of LJC II. This chapter details the Seismic Design Requirements for Building Structures, including system selection and load analysis. Based on this section, LJC II has a Type 1A Torsional Irregularity, which would need to be considered.

## Design Loads

### National Code for Live Loads and Lateral Loadings

Live and lateral loads were calculated following CBC 2010 which adopts IBC 2009 and ASCE 7 -05. Ultimately, ASCE 7 – 05 is used to calculate all wind, seismic, snow, and soil loads. Live loads come from a modified table of live loads in Section 1607 of CBC 2010. The building was designed using Strength Design methods.

### Description of Loads and Method of Determination

#### Live Loads

Most live loads correspond to those provided in CBC 2010, Section 1607. Some loads are higher than the code listed values. Also, some loads are not discussed in CBC; the sources for these loads are discussed below in Table 6. Other types of live loads on this project include roof, office, lobby and corridors, exit stairs, outdoor loading, and fitness center (as outlined in the general notes).

<b>250 PSF (Core above level 1)</b>	The developer, Hines, wanted to allow for flexibility. So although the building is currently occupied by one tenant, the core was designed for the egress live loads required for multi-tenant buildings. The core contains the stairways, hallways, and elevators for LJC II
<b>200 PSF (Mechanical)</b>	When designing mechanical spaces, this value was used for rooms with unknown equipment layouts. When the layout and equipment weights were known, the engineer went back and checked the design for the actual loads.
<b>100 PSF (Cafeteria)</b>	This load was determined based on the assumption of high traffic, large groups of people, and egress requirements.
<b>100 PSF (Conference Center)</b>	This load was determined based on the assumption of high traffic, large groups of people, and egress requirements.
<b>250 PSF (Data Center)</b>	When designing data center spaces, this value was used for rooms with unknown equipment layouts. When the layout and equipment weights were known, the engineer went back and checked the design for the actual loads.

Table 6 | Live Loads *not* included in CBC 2010

#### Wind Loads

Wind loads were calculated using 2010 California Building Code, Section 1608, which follows ASCE 7 – 05 directly. The structural engineer specifically indicated that ASCE 7 – 05 was utilized most often for wind load calculations.

### *Seismic Design Loads*

Seismic Design loads are based on the 2010 California Building Code, Section 1613. This section states that structures shall be designed to resist the effects of earthquake motions in accordance with ASCE 7, excluding Chapter 14 (Material Specific Seismic Design and Detailing Requirements) and Appendix 11A. Seismic design loads were calculated with the aid of the geotechnical report provided by Christian Wheeler Engineering. These loads were calculated using the Response Spectrum Analysis Method, with a Seismic Category D.

### *Snow Loads*

Snow loads were found using 2010 California Building Code, Section 1608, corresponding to requirements of ASCE 7 – 05.

### *Soil Loads*

Soil loads were determined using 2010 California Building Code, Section 1610, along with the geotechnical report provided by Christian Wheeler Engineering.

### *Dead Loads*

Dead loads were determined using industry standard values and engineering judgment. Assumptions were used for flooring, ceiling, MEP, fire protection, and other items. However, because the floor is essentially hollow for the under-floor air distribution system, 2x2 concrete tiles on metal pedestals were attached to the bottom of the slab to decrease echoing and such associated with the hollow floor. This causes a considerable increase in the floor dead load.

## **Gravity Load Path**

The gravity system, as discussed in detail above, consists of a two way, flat plate slab on a rectangular grid of concrete columns, which tie into the mat foundation below grade.

### *Floor Loads*

Floor loads will contact the two way, concrete slab first. The loads will then be transferred by the slab to the columns directly below at the core and perimeter. This will occur at each floor, causing the columns to accumulate more dead and live load as we proceed down the building (hence the increase in column sizes and reinforcing). When the columns reach the mat, loads will be transferred to the mat foundation. The column loads will be spread out by the mat to meet the bearing capacity of the soil.

### *Curtain Wall*

The curtain wall is typically hung from the spandrel beams framing the concrete slab edges. The beam transfers the exterior wall load to the exterior columns, which will direct the loads down to the foundation in a similar manner to the floor loads.

## Lateral Load Path

### *Wind Loads*

Wind pressures will be collected on the building enclosure. The building enclosure will then transmit these forces into the diaphragm. Because wind shear forces are small enough, the diaphragm can transmit these shear forces into the shear walls at the building's core. Lateral loads are collected at each level and carried down to the foundation by means of the shear walls.

### *Seismic Loads*

*North South Direction:* Inertial seismic forces will be calculated as story shears at each level of the building. These forces will initiate at the center of mass of each level. Because the earthquake induced shear is so high for this building, the diaphragm alone cannot be relied upon to transmit the shear forces to the lateral system in the north-south direction at the levels below grade. Therefore, north-south seismic loads will be transmitted to collector elements near the building's core. These elements will transfer the lateral load to the shear walls. For the levels above grade, the lateral forces will be transmitted through the slab directly to the shear wall system. These lateral loads will be collected at each level and carried down to the foundation by the means of the core shear walls.

*East West Direction:* Inertial seismic forces will be calculated as story shears at each level of the building. These forces will initiate at the center of mass of each level. The earthquake induced forces in the east-west direction will be transmitted through the diaphragm to the shear walls. These lateral loads will be collected at each level and carried down to the foundation by means of the core shear walls.

## Conclusion

This report has analyzed the existing conditions for the building structure for La Jolla Commons Phase II Office Tower in San Diego, California. The structural systems, design loads, and design codes have been discussed in detail. LJC II offers several challenges moving forward.

This LEED Certified, net-zero, office building features large open office spaces, 13 foot floor-to-floor heights, and large expansions of exterior glass. When redesign is performed, these features should be considered and maintained if possible. Another challenge for LJC II is the building's height limit imposed by the FAA due to flight path regulations. The building's current 198 foot height is at the maximum allowable height; therefore, when redesign is performed, the building height cannot increase without more collaboration with local authorities.

The gravity system for LJC II consists of a two-way, flat plate, slab system on a rectangular column grid. Punching shear is a critical failure mode associated with this system. As building systems are changed in the future, the effect of punching shear, slab deformations, and other failure mechanisms must be considered.

Looking at the building's lateral system, the seismic design and detailing of the concrete shear walls will have a significant effect on future analysis and redesign. Being that the structure is Seismic Category D, any changes should be checked against the proper codes. Important references for seismic considerations will include ACI 318 – 08 Chapter 21 and ASCE 7 – 05 Chapter 12. Furthermore, LJC II was designed using CBC 2010 which references IBC 2009 (ACI 318-08 and ASCE 7-05). The most recent version of the California Building Code is CBC 2013 which references IBC 2012 (ACI 318-11 and ASCE 7-10). In future redesign assignments, code changes may need to be explored.

La Jolla Commons Tower II has several inherent modeling challenges. When models are created in the future, the integration of lateral and gravity system models should be carefully considered. For example, when analyzing the lateral shear walls for seismic loading, should the concrete columns and slab be included? How accurate will the model or the design be based on the model created? Great care must be taken to make sure the building functions correctly under earthquake and gravity loading; the model should strive to mimic the structural behavior that is desired.

La Jolla Commons Phase II Office Tower will prove to be an educational challenge due to its height, seismic loading, intricate detailing, and modeling concerns.