Broad and Branch Mixed Use Development

A Senior Project

presented to

the Faculty of the Architectural Engineering Department

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

by

Angelica Quach and Jorge Neve

June, 2016

© 2016 Angelica Quach and Jorge Neve
Executive Summary.

The city of San Luis Obispo has some unique characteristics that make it special. The weather, well known university, open spaces, closeness to beaches, etc. Nonetheless, there are some key factors that have presented a challenge to the city, housing one of the most important.

Broad and Branch is a project that tries to keep the balance that the city of San Luis Obispo needs when it comes to jobs and housing. The development of 2115 Broad Street, located in the vibrant and diverse Railroad District, is a mixed-use project that includes mechanized parking solutions, bicycle parking, roof decks, restaurants, offices and residential units.

The design process depends on the input of the owner/developer and the design team, confomed by Architecture and Architectural Engineering students. The design proposed intends to meet the needs of the client, the city and the Living Building Challenge petal certification.

J&J’s proposal strives to fulfill pre-established goals: Provide open spaces for the residential units • Bring natural light inside the buildings • Hide the Parking • Create an interior Courtyard • Open the building to the surroundings with balconies, terraces and roof garden. J&J intends to provide the city of San Luis Obispo an example of mixed-use, high density housing that could possibly be the first of many developments that help bring the balance of housing back to the city.

Letter to Client.

Stacey White
2115 Broad Street
San Luis Obispo, CA 93405

Dear Stacey White.

The members of J&J want to take this opportunity to thank you for selecting J&J Architects and Engineers to develop a schematic design proposal for the 2115 Broad Street Parcel APN: 003-746-033. The design team has experience for almost half a decade of integrated design experience and access to some of the newest design tools to make this project a reality.

J&J strive to meet your expectations. We approach every project with the same amount of seriousness that will allow us to deliver the design proposal that the client needs. As an integrated team, the comprehensive proposal will attempt to maximize your investment without cutting on key design factors of the Broad and Branch project.

Sincerely,

J&J Architects and Engineers.
The location of the project becomes an important factor when it comes to the initial design approach of the building. The diverse neighborhoods allow for a connection with the history of the area and the new needs of mixed-use projects. Relating the material exposure to a more industrial look in some areas and a dynamic and open shape, the project that once was shaped out of two cubes is able to look at the elements in the surroundings.

The intent is to have a project that addresses the needs of the city by creating a housing + commercial program in the site. The buildings will help shape the interior spaces to create a courtyard and interesting views for the users. The residential units will populate the higher levels and by separating every unit, openings that allow the entrance of light and private balconies/terraces become the shaping factor of the Broad and Branch facades.
The South Broad Street Area Plan reflects the community’s desire to improve the area’s transportation safety, encourage mixed land uses, increase affordable housing, and enhance the area’s appearance as a gateway to Downtown.

The City’s General Plan identifies the South Broad Street area as a Special Design Area that should have an area plan to encourage innovative design concepts that help revitalize and beautify the area. It is also identified as an area suitable for housing production.

The South Broad Street Area Plan implements these General Plan policies with three primary tools: a new land use vision, an emphasis on higher-density infill housing and mixed-use, and form-based codes.
Most of the noise comes from Broad street. Graphs taken from ClimateConsultant 6.0.
SITE ANALYSIS

SEISMICITY

Los Osos Fault

Type of Fault:
normal, reverse, and thrust faulting all represented within the zone

Length:
about 45 km

Nearest Communities:
Los Osos, Edna, and San Luis Obispo

PROXIMITY TO SITE:
~8,000 feet away

Surface Rupture

Surface rupture can endanger lives and property when structures or lifeline facilities are located on, or near, a fault. The Los Osos Fault is one of the closest active fault to the San Luis Obispo area, located near the intersection of Los Osos Valley Road and Foothill Boulevard. It has been classified as active within the last 11,000 years.

Settlement and Liquefaction

Liquefaction is the sudden loss of the soil’s supporting strength due to groundwater filling and lubricating the voids in the soil as a result of ground shaking. In extreme cases of liquefaction, structures have the ability to tilt, break apart, or even sink into the ground. The soils in the San Luis Obispo area are the most susceptible to settlement and liquefaction due to underlain alluvial soils where shallow groundwater is located.

EXCAVATION

Figure 1: Proximity Map to Known Faults

Figure 2: Spectral Acceleration in San Luis Obispo

Figure 3: Spectral Acceleration in San Luis Obispo

Information from OSHA Safety and Hazard Regulations for Construction Subpart: Excavations

In order to excavate to a 15 foot depth, supported (or shored) vertical supports must be utilized. Depending on where the excavation is placed in relation to the property line, excavation may be sloped.

Common Excavation Technique
Featuring Timber Lagging and Steel Piles
SOIL AND FOUNDATION

SITE SOIL CONDITIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing</td>
<td>1000 psf</td>
</tr>
<tr>
<td>Lateral passive</td>
<td>100 pcf</td>
</tr>
<tr>
<td>Friction</td>
<td>130 psf</td>
</tr>
<tr>
<td>Eqvl. Fluid Pressure</td>
<td>40 pcf</td>
</tr>
<tr>
<td>Expansion Index</td>
<td>126 (High)</td>
</tr>
<tr>
<td>Soil Classifications</td>
<td>Clay (CH)</td>
</tr>
<tr>
<td>Per Table 18-I-A of the 1997 UBC</td>
<td>D</td>
</tr>
<tr>
<td>Land Capability Class</td>
<td>3e</td>
</tr>
</tbody>
</table>

ENGINEERING DATA FOR FOUNDATIONS

All footings shall bear 27” minimum to natural grade. Slabs on grade shall be a minimum of 4” thick and above 4” of clean sand.

WATER TABLE

A subsurface creek may run through adjacent parcels. Exact location has not been determined but may need to be accounted for.

ISSUES AND CONSTRAINTS

A high expansion index means we need to be careful that rain will not collect around the perimeter of the building. This could cause the soil to swell and put excess load on foundations and bearing walls.

The USDA site also states that the soil in our area has moderate corrosion of concrete and steel, something to keep in mind when designing underground elements.

DESIGN STRATEGIES TO DEAL WITH EXPANSIVE SOILS:

For piles - may want to pre-wet the soil in order to account for the highest expected level of expansion, but when soil shrinks, piles will still be able to withstand loads.

For slab-on-grade/mat foundation - post-tensioning of steel in the slab will make the slab stiffer and therefore, less likely to crack, building will then be able to move as one object.

POTENTIAL PROBLEMS:

Expansive soil may cause additional pressure on retaining walls when the soil becomes saturated. Therefore, the height of retaining walls may need to be limited and the walls must be able to withstand the additional load.

The swelling of expansive soil may cause issues with slabs as well. As shown in the image to the right, corners of a slab may lift up due to the reduced confinement in these locations in conjunction with the swelling movement of the soil.

Throughout the site, soil may expand at different rates, which could cause cracking in the building if shallow foundations are used. Ideally, a foundation that produces uniform settlement should be used.
LIGHT ENTRANCE ON EVERY UNIT
DIFFERENT AND OPEN VIEWS
WIND CIRCULATION THROUGHOUT THE PROJECT
Accessibility

Four different entrances connect Broad and Branch, making it an open, accessible and desirable project to visit.
Courtyard

A central courtyard becomes the heart of the project, turning it into one of the most active and interesting space for everyone in the complex.
Building Openings

The buildings have separations between each unit, resulting in a more open, illuminated well-ventilated and dynamic project.
Parking

Underground Mechanical parking is available for cars on the Branch entrance. The open bike parking space is located on the side of Broad street.
Circulations

The project has multiple staircases and elevators that efficiently connect most of the units directly with an amenity.
Every unit in the building has the option of amazing views of the city, not even the interior of the project prevents the users to enjoy the view.
PROGRAM

Level 1

Level 2

Level 3

Level 4

Residential Units
Office Space
Restaurant / Cafe / Convenience Store
PROGRAM

Residential Units
- 3 Studio Residences
- 4 one bedroom units
- 6 two bedroom units
- 2 three bedroom units

Office Space
- 4293 SF

Restaurant + Convenience Store + Cafe
- 5039 SF

Public Roof Terraces

Branch
Broad St.
Site Plan

Scale: 1/32" = 1'-0"
PLANS

Studio

1 Bedroom Units
PLANS

2 Bedroom Units

[Diagram of 2 Bedroom Units]
PLANS

3 Bedroom Unit

3 Bedroom Unit

3/64" = 1'-0"
Scale: 1/16" = 1'-0"
INTERIOR ELEVATIONS

Interior Elevation West
1/8" = 1'-0"

Scale: 1/8" = 1'-0"
**LIVING BUILDING CHALLENGE STRATEGIES**

- **Active Shading**
  Perforated panels and basic building massing

- **Green Roofs**
  Insulating effect, drought resistant plants

- **Wastewater treatment plant**
  Reuse as gray water and for irrigation.

- **Solar Thermal Panels**
  Hot water and electricity demands.

- **Stormwater Collection**
  Mixed with waste water to reuse in the building

- **High efficiency fixtures**
  Reduced water and energy usage

- **Alternative Transportation**
  Bikes, shared car, reduced number of permits

- **Light Pollution Reduction**
  Illumination directed directly to the building.
1 ½" LW Concrete Topping Slab on ½" Steel Deck
10" Deep Cold-Formed Steel Channel Joists
W10 x 39 Beams Typical
HSS 4 x 4 x 3/8" Columns
OR
Metal Stud Bearing Walls

Ground Floor Plan
Second Floor Plan
Third Floor Plan
Fourth Floor/Roof Plan

Typical Shear Wall Locations
Cold-Formed Steel Shear Walls with Sure-Board Shoring
**Seismic Joint**

**Structural Systems**

- 1 1/2” LW Concrete Topping Slab on 1/2” Steel Deck
- 10” Deep Cold-Formed Steel Channel Joists
- W10 x 39 Beams Typical
- HSS 4 x 4 x 3/8” Columns
- OR
- Metal Stud Bearing Walls

Ground Floor Plan  
Second Floor Plan  
Third Floor Plan  
Fourth Floor/Roof Plan

Cold-Formed Steel Shear Walls with Sure-Board Sheathing

Typical Shear Wall Locations

1. 1/2" LW Concrete Topping Slab on 1/2" Steel Deck
2. 10" Deep Cold-Formed Steel Channel Joists
3. W10 x 39 Beams Typical
4. HSS 4 x 4 x 3/8" Columns
5. OR
6. Metal Stud Bearing Walls

Ground Floor Plan  
Second Floor Plan  
Third Floor Plan  
Fourth Floor/Roof Plan

Cold-Formed Steel Shear Walls with Sure-Board Sheathing

Typical Shear Wall Locations
THANK YOU
Broad and Branch Mixed Use Development

Additional Structural Package

by

Angelica Quach
The gravity system consists of cold-formed steel throughout the project with hot-rolled shapes where necessary.

The diaphragm is composed of a 1.5” thick lightweight concrete topping slab above a 1/2” thick steel deck. The steel deck rests on 10” deep cold-formed steel channel joists (figure 1) at about 16” o.c. Joists will span a maximum of 20 feet. The joists are supported by hot-rolled steel beams. Joists will be attached as shown in figure 3.

The beams frame into wide flange columns or load-bearing metal stud walls. Wide flange columns will be approximately W10x39. Metal stud walls will generally be 3.5 inches thick and will be composed of CEMCO studs screwed onto a CEMCO track above and below (figure 2). At areas where sound transmission is a problem, stud walls will be 5.5 inches thick.
The lateral system will consist of cold-formed steel shear walls. This system will be able to utilize areas in which bearing walls were already required by using them to also function as shear walls. Similar to all other walls in the project, CEMCO CFS studs will be screwed into a track on the top and bottom of the wall and will be about 3.5 inches thick. Shear walls will require holdowns to transfer overturning forces. Simpson Strong-Tie holdowns will be used to achieve this, as shown in figure 2. Another option to provide resistance to overturning is a CEMCO holdown stud, as shown in figure 1.

For the sheathing, Sure-Board will be used in place of traditional plywood sheathing or metal sheets. Sure-Board is a composite sheathing option that is created with a combination of gypsum-based and substrate panels as well as steel. See figure 3 for additional composition information.
DESCRIPTION

A mat foundation will be utilized for the entire structure, including the below ground parking structure. 3 ksi concrete will be used. The foundation will be approximately 12 inches thick below the building. The mat foundation below the parking structure will be about 16 inches thick due to the additional loading of the mechanical parking system. Because of the geometry of the building, each portion of the building will require a separate mat foundation. Location of separate foundations will be shown on page 10.

In order to construct the foundation for the below grade parking structure, excavation will be required. On the north, west, and south faces of the structure, there is a minimum 20 foot setback from the property line, which means that a slope, as shown in figure 2, can be used when excavating. The 18 foot deep foundation at the south side would require at least 13'6" of horizontal distance from the edge of the parking structure. On the north side of the site, the excavation would amount to only 10 feet, which would not require a sloped edge.

The east side of the building borders Broad street. However, this should not cause much impact on the construction, because the maximum excavation depth on this side is only 10 feet and decreases to 0 feet as you move towards Branch street.

Figure 1: Mat Foundation Examples
Figure 2: Excavation Slope Required
Figure 3: Shoring Option
The Parkmatic Optima system is a space-saving alternative to the traditional parking lot scheme. The mechanical parking allows residents and visitors to access the parking system from the ground floor, but hides the cars from view. Once the car is driven onto the platform, the Optima system will rotate the car to line up with the mechanical system and lower the car into the below ground structure, as shown in figure 1. The system will then shift the cars that are already in the structure to accommodate the additional car. There will be a single access to the Parkmatic Optima system that will serve as the entrance and exit. There will be a keypad system to access cars from the mechanical parking structure.

In addition to the side-to-side arrangement of cars, the Optima system allows the design team to utilize multiple rows as well (figure 2). Forward-and-backward movement is possible to allow even more cars to be accessed by the single entrance and exit platform.

Concrete retaining walls will enclose the entirety of the below grade parking system and will sit on a concrete mat foundation slab. Intermediate concrete columns will support the roof of the structure and the roof slab will act as the floor slab for the building and courtyard above.
Building Program:

With a 3-story structure and a 20 foot maximum span, cold-formed steel was the preferred choice. The closed layout of the residences and offices allowed for metal stud bearing walls surrounding the perimeter of each space. Occupancy of the building changes from retail/restaurant on the first floor to residential on the second and third floor. The concrete topping slab of the diaphragm between each floor will help dampen sound transmission between occupancies. Concrete will be used for the foundation and retaining walls of the first floor in order to adequately deal with the site slope and consequent partial underground areas along Broad Street.

Aesthetics:

Located in the railroad district of San Luis Obispo, the architect would like the Broad and Branch project to be reminiscent of the area’s industrial past. To achieve this aesthetic goal, exposed cold-formed steel cantilevered walkways will surround the central courtyard. However, as seen in figure 1, the residential units will still be able to have a warm, homey atmosphere due to the light framing and varied finishes.

Fire Resistance:

With the assembly, business, and residential occupancies present in the building, a 1-hour fire separation is required, assuming that the building will be sprinklered. Cold-formed steel is a non-combustible material and falls under type I construction. Therefore, a 3 hour fire rating is required for the structural framing and bearing walls.

Sustainability:

Cold-formed steel (CFS) construction produces much less waste onsite in comparison to timber construction. According to the American Iron and Steel Institute, nearly 88% of steel is recycled. So not only will this project use recycled materials, it will be able to be recycled into other steel products as well. Another benefit of CFS over timber is its durability. CFS is not susceptible to termites or rot. Overall, CFS is a great choice for achieving a sustainable structure.

Constructability:

Construction of cold-formed steel is similar to timber construction. Materials are light and easily maneuverable onsite. Screws are used to fasten the members of the wall assembly. In comparison to structural steel, CFS significantly reduces the amount of labor and equipment required.

Cost:

To achieve the industrial aesthetic, cold-formed steel was a much more cost-effective option than hot-rolled steel. CFS construction should be comparable to timber framing. Light framing is generally preferred for projects like this one, because of the significant cost difference and the relatively low demands on the structure.

Conclusion:

The relatively small size and closed layout make CFS a great option for the gravity system. Not only is this material sustainable, easily constructed and cost effective, but CFS also revives the industrial past of the San Luis Obispo railroad district.
**Seismic Performance:**

Although the site is in a high seismic area, cold-formed steel shear walls should be adequate due to the relative lightness of the materials used in the structure. Additionally, the building is relatively small. Because of the many exterior walls that will be required for architectural purposes, these walls can be utilized as lateral force resisting elements.

According to ASCE 7-10 Table 12.2.1 (figure 1), light-frame walls with shear panels of all materials, excluding wood structural panels and steel sheets, are permitted in seismic design category D for buildings up to 35 feet in height. Therefore, this system is adequate for this project.

| Table 12.2-1 Design Coefficients and Factors for Seismic Force-Resisting Systems |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| ASCE 7 Seismic Category          | Response Modification Coefficient, R' | Overstrength Factor, γL  | Deflection Amplification Factor, C2 | Seismic Design Category |
| Structural System Limitations Including Structural Height, L (in) | B | C | D | E | F |
| A. BEARING WALL SYSTEMS | | | | | |
| 30. Light-frame (cold-formed) steel walls sheathed with wood structural panels, nailed for shear resistance or steel sheets | 14.1 | 0.4 | 3 | 4 | NL | NL | 0.65 | 0.65 | 0.65 |

Sure-Board not only allows for better architectural flexibility with installation of finishes, but it provides a shear capacity greater than wood structural panels or steel sheets, as shown by figure 2. With C-studs at 16” o.c. and #10 screws, this system can provide up to about 5 kips per linear foot of wall.

**Conclusion:**

Because cold-formed steel bearing walls were used for the gravity system, the clear choice for the lateral system was CFS shear walls. Also, the closed layout of the building allows for many options in terms of lateral system configuration. In addition to the relatively low cost, CFS shear walls with Sure-Board sheathing are able to provide adequate capacity for the high-seismic area.

---

**Building Program:**

The closed layout of the building allows the bearing walls to also be used as shear walls. Because the residential units above are isolated from other units, the number of walls that can be used as shear walls increases. No additional elements will need to be added to act as the lateral system, which decreases the impact on the architectural layout and program.

**Compatibility with Gravity System:**

Because metal stud bearing walls are already being utilized for the gravity system, using these walls as shear walls also is ideal. Walls will need to be strengthened in order to ensure sufficient lateral strength, but no additional elements will need to be included. Therefore, the lateral system is ideal as far as compatibility with the gravity system.

**Cost:**

In general, shear walls are much less expensive than moment frame systems and are comparable to braced frames. However, shear walls certainly make less architectural impact than braced frames. All elements required to provide lateral strength in the bearing walls will be added within the walls themselves. Therefore, there is little additional labor involved with this lateral system.

---

**SURE-BOARD®**

SURE-BOARD® is a proprietary sheet material used as a substitute for wood structural panel in shear walls. It is designed specifically for seismic design in regions with high seismic activity. The material is composed of steel and engineered wood composite, providing both strength and ductility. The shear capacity of Sure-Board is greater than that of wood structural panels or steel sheets, as shown in figure 2. With C-studs at 16” o.c. and #10 screws, this system can provide up to about 5 kips per linear foot of wall.

**Conclusion:**

Because cold-formed steel bearing walls were used for the gravity system, the clear choice for the lateral system was CFS shear walls. Also, the closed layout of the building allows for many options in terms of lateral system configuration. In addition to the relatively low cost, CFS shear walls with Sure-Board sheathing are able to provide adequate capacity for the high-seismic area.

---

**SURE-BOARD®**

SURE-BOARD® is a proprietary sheet material used as a substitute for wood structural panel in shear walls. It is designed specifically for seismic design in regions with high seismic activity. The material is composed of steel and engineered wood composite, providing both strength and ductility. The shear capacity of Sure-Board is greater than that of wood structural panels or steel sheets, as shown in figure 2. With C-studs at 16” o.c. and #10 screws, this system can provide up to about 5 kips per linear foot of wall.
The site soil is composed of incredibly expansive clay soils, as shown in figure 1. Expansive soil can cause many problems in foundation systems due to the shrinking and swelling. Through analysis of site conditions and neighboring areas, a mat foundation was determined to be the preferred foundation system for this project.

### Deep Foundations:

To determine whether to use shallow or deep foundations, two main factors were taken into account: impact on the community/neighbors and structural viability.

When considering driven piles, sound and vibration were recognized as potential problems on this project. The site is adjacent to many residences as well as businesses, which would be very sensitive to such disruption. Disturbance of this area would result in poor community relations, which would contradict the architectural goals of the project.

The other option for deep foundations is drilled piles, which may rely heavily on skin friction for their capacity. In expansive soils, capacity may be sufficient during swelling periods, but soil will shrink during the dry season. This shrinking will decrease the skin friction between the soil and the pile and decrease the capacity of the pile.

Therefore, driven and drilled piles are not the most desirable options for this project.

### Shallow Foundations:

In comparison to shallow pad and strip footings, a mat foundation would be a better option for this project.

The poor bearing capacity of the clay soil would result in incredibly large pad and strip footings. The foundation could possibly be so large that the individual footings would end up merging into a combined, or even mat, footing.

Settlement is also a large concern with the shrinking and swelling of expansive soil. If pad or strip footings were used, the building could possibly experience varying degrees of settlement in different areas of the building. This could cause cracking in the foundation or even the building itself, as shown in figure 3.

To combat this issue, a mat foundation would be able to settle uniformly or tilt in such a way that the building would experience the movement as a single object rather than a system of separate elements. Ideally, no cracking would occur in these situations.

### Conclusion:

The expansive soil of the site creates many difficulties in the foundation system. For deep foundations, skin friction is an unreliable source of capacity. Additionally, the poor soil would not allow for much bearing capacity. A mat foundation would ensure adequate bearing and would alleviate the effects of differential settlement.

With the decision to keep the existing soil on the site, a mat foundation is the preferred system for this project.
Cold-formed steel channel joists for this project span from 6 feet to 20 feet. Beams may span up to 20 feet as well. Because the ground level of the project is to be used for retail purposes, there are very few interior walls that may by used as bearing walls. Consequently, wide flange steel columns were added to the interior ground floor spaces to minimize the span of the beams and decrease the story height.

A few of the main architectural features of the Broad and Branch project are its cantilevered walkways and many outdoor balconies/terrace areas for the residences. Most of these areas will require the beam to cantilever with a maximum cantilever distance of 10 feet.

The cantilever walkways that surround the central courtyard will expose the structure, which will require weatherproofing to avoid rust and other weather damage. The remainder of the cantilevered areas will not be exposed to weather.
CONFIGURATION

Shear walls are distributed throughout the project and all act as bearing walls. Most walls extend from the foundation to the roof in order to avoid a vertical discontinuity, as shown in figure 1. However, there are a few areas where vertical discontinuities exist. In these locations, the shear forces must be transferred through the diaphragm. In some cases, columns may be able to transfer overturning forces. However, transfer girders will be required in a few areas.

The L-shaped building on the west and south sides of the site creates a reentrant corner irregularity. To remove this irregularity, a seismic joint will be placed as shown on figure 2. This will allow the buildings to act separately. Another seismic joint will be placed at the end of the walkway connecting the south of the L-shaped building to the east building along Broad street. As a result of these joints, the building will be analyzed as 3 separate structures, as shown by the 3 colors, green (building 1), blue (building 2) and red (building 3).

When placing shear walls, the center of mass (CoM) and center of rigidity (CoR) were taken into account. A large factor when determining shear wall locations was minimizing the distance of the eccentricity between the CoM and CoR for each building. Additionally, the capacity of the shear wall assembly in comparison to the base shear in each direction helped to determine the length of shear walls required for each building.
The mat foundation for the building and the parking structure will be completely separate. The design does not require the ground floor to change elevation, which means that the foundations will not need to be stepped. The foundation for the building will be cast as 3 separate mats, as shown in figure 1, due to the fact that each of the buildings is independent of the others. Foundations 1, 2, and 3 will support 3-story structures and will each be about 12 inches thick.

There will be one free-standing retaining wall on site shown in figure 1, will require a separate foundation. This will be a shallow foundation of about 2 feet thick.

The parking structure will have a mat foundation as well. It will be about 16 inches thick, because of the increased weight coming from the concrete structural system as well as the possibility of a fully occupied parking structure. With each car weighing about 4,000 pounds, the foundation would need to be able to support about 288 kips of live load from a fully-occupied parking system, not including the mechanical equipment required to operate it.

Due to the existing slope on the site and the decision to make the building floor completely level, some portions of the building on the north and east faces will be below grade. Therefore, retaining walls will be required, as shown in figure 3.
The total depth of the parking structure is 18 feet, which can house two levels of cars. See figure 3. In order to accommodate the 72 cars required for this project, the concrete structure will be 36 feet long for the three rows of cars and 96 feet wide to allow for 12 cars per row. Location of the parking structure in relation to the rest of the building can be seen in figure 2.

The parking structure will be composed entirely of concrete with a two-way slab sitting on concrete columns and a concrete mat foundation. Concrete retaining walls will surround the parking.

To access the mechanical parking feature of this project, residents and visitors will enter the site on Branch street and drive through a short drive aisle to get to the entrance platform. The platform actually resides inside the building envelope, as shown in figure 1. The exit path from the structure would be the same.

The parking was placed in this location to ensure the least amount of car impact on the site. This access point keeps cars on the exterior part of the building and only requires a short drive aisle. Therefore, there will be nearly no car traffic through the site. This creates a more pedestrian- and bike- oriented community.
### Typical Joist Sizing:

**JOIST SPAN TABLE: 8” MIN. HOLE OFFSET FROM BEARING SUPPORT**

<table>
<thead>
<tr>
<th>Joint Designation</th>
<th>25 psf Dead Load and 40 psf Live Load</th>
<th>30 psf Dead Load and 40 psf Live Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Span</td>
<td>Spacing in (in)</td>
</tr>
<tr>
<td>13</td>
<td>2.5</td>
<td>17”</td>
</tr>
<tr>
<td>15</td>
<td>2.7</td>
<td>15”</td>
</tr>
<tr>
<td>18</td>
<td>2.3</td>
<td>10”</td>
</tr>
<tr>
<td>24</td>
<td>2.3</td>
<td>12”</td>
</tr>
</tbody>
</table>

**STRUCTURAL PROPERTIES AND LOAD CAPACITIES OF SURE-SPAN® JOIST: 7.25” TO 14” WEB**

<table>
<thead>
<tr>
<th>Sector Designation</th>
<th>Dimensions</th>
<th>Gross Section Properties</th>
<th>Torsional Properties</th>
<th>Net Section Properties</th>
<th>Capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10000SC200056</td>
<td>10.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>19.00</td>
</tr>
<tr>
<td>10000SC200054</td>
<td>10.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>20.00</td>
</tr>
<tr>
<td>10000SC200057</td>
<td>10.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>18.00</td>
</tr>
</tbody>
</table>


### Typical Beam Sizing:

**USE HSS 4” x 4” x 3/8”**

**USE W10x39**

### Typical Column Sizing:

**USE W10x45**

### Floor Load Takeoff:

<table>
<thead>
<tr>
<th>Item</th>
<th>Calculations</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5” LW Conc on Steel Deck</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Wall (incl. partition)</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>MEP</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Misc</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>TOTAL TO JOISTS</td>
<td></td>
<td>31</td>
</tr>
<tr>
<td>CFS Joists</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>TOTAL TO BEAMS</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>Steel Beams (W10x45)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>TOTAL TO COLUMNS</td>
<td></td>
<td>36</td>
</tr>
</tbody>
</table>

The load takeoff is estimated to apply to every floor/roof because roof surfaces act as terraces and occupiable spaces. Live load for all floors will be 40 psf.

Typical joist, beam, and column sizing is based on the worst case situations in the project in order to account for the greatest depth. Beam is sized with a pin-pin connection despite being a continuous beam with cantilevered portions, because the pin-pin condition should still account for the worst case situation. Nontypical sizes may be smaller than typical, but none will be larger.
SIZING

Seismic Base Shear:

<table>
<thead>
<tr>
<th>Building</th>
<th>Floor</th>
<th>Floor Area (SF)</th>
<th>Total Sq Footage</th>
<th>Building Weight (k)</th>
<th>Seismic Base Shear (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>2nd Floor</td>
<td>110' x 40'</td>
<td>4400</td>
<td>10450</td>
<td>387</td>
</tr>
<tr>
<td></td>
<td>3rd Floor</td>
<td>110' x 30'</td>
<td>3300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roof</td>
<td>110' x 25'</td>
<td>2750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 2</td>
<td>2nd Floor</td>
<td>170' x 40'</td>
<td>6800</td>
<td>13600</td>
<td>503</td>
</tr>
<tr>
<td></td>
<td>3rd Floor</td>
<td>100' x 40'</td>
<td>4000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roof</td>
<td>70' x 40'</td>
<td>2800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 3</td>
<td>2nd Floor</td>
<td>80' x 50'</td>
<td>4000</td>
<td>9404</td>
<td>348</td>
</tr>
<tr>
<td></td>
<td>3rd Floor</td>
<td>80' x 50'</td>
<td>4000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roof</td>
<td>3 x (18' x 20')</td>
<td>1404</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{BASE SHEAR} = \frac{V}{C_2} = C_4\frac{V}{w} = \frac{C_4}{(2.5+1)} = 0.12A 
\]

(See Table 1)

Table 1: ASCE 7-10 Response Modification Factor

<table>
<thead>
<tr>
<th>Building</th>
<th>Wind Base Shear (k) N-S</th>
<th>Wind Base Shear (k) E-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>15</td>
<td>93</td>
</tr>
<tr>
<td>Building 2</td>
<td>126</td>
<td>32</td>
</tr>
<tr>
<td>Building 3</td>
<td>69</td>
<td>81</td>
</tr>
</tbody>
</table>

Wind Base Shear:

\[
\text{ASCE 7-10 Table 27.9-1} \\
\text{STEP 1: } R_{oa} \text{ Category III} \quad [\text{Table 1}] \\
\text{STEP 2: } V = 100 \text{ mph} \quad [\text{Table 26.6-1A}] \\
\text{STEP 3: } \text{Equivalent Category C} \\
\quad \mu = 1.0 \quad \text{Extended} \\
\text{STEP 4: } \text{For } 1R = 0.5 \quad [\text{Table 27.6-1}] \\
\]

Governing Base Shear:

<table>
<thead>
<tr>
<th>Building</th>
<th>Seismic Base Shear (k)</th>
<th>Wind Base Shear (k) N-S</th>
<th>Wind Base Shear (k) E-W</th>
<th>Governing Base Shear (k) N-S</th>
<th>Governing Base Shear (k) E-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>48</td>
<td>15</td>
<td>93</td>
<td>48</td>
<td>93</td>
</tr>
<tr>
<td>Building 2</td>
<td>62</td>
<td>126</td>
<td>32</td>
<td>126</td>
<td>62</td>
</tr>
<tr>
<td>Building 3</td>
<td>43</td>
<td>69</td>
<td>81</td>
<td>69</td>
<td>81</td>
</tr>
</tbody>
</table>
SIZING

Length of Shear Walls:

<table>
<thead>
<tr>
<th>Building</th>
<th>Governing Base Shear (k) N-S</th>
<th>Required Length (ft) Double Sided N-S</th>
<th>Actual Shear Wall Length (ft) N-S</th>
<th>Governing Base Shear (k) E-W</th>
<th>Required Length (ft) Double Sided E-W</th>
<th>Actual Shear Wall Length (ft) E-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>48</td>
<td>16</td>
<td>37</td>
<td>93</td>
<td>31</td>
<td>50</td>
</tr>
<tr>
<td>Building 2</td>
<td>126</td>
<td>42</td>
<td>43</td>
<td>62</td>
<td>21</td>
<td>53</td>
</tr>
<tr>
<td>Building 3</td>
<td>69</td>
<td>23</td>
<td>44</td>
<td>81</td>
<td>27</td>
<td>55</td>
</tr>
</tbody>
</table>

SIZING

Seismic Joint Sizing:

Based on allowable story drift:

\[ \Delta_s = \frac{Q_n}{W_n} = 0.025 \times 12 = 0.3 \text{ ft} \]

For joint between two buildings:

\[ \Delta_s = 3.6 \text{ ft} \]

\[ \text{max displacement} = 2 = 3.6 \times 0.5 = 7.2 \text{ in} \]

USE SEISMIC JOINT WIDTH = 8"
SIZING

Mat Foundation Sizing:

\[ P = \frac{1.2(57 \text{ psf}) + 1.6(40 \text{ psf})}{18 \times 15} = 24.4 \text{kN} \]

\[ P_w = 3(24.4) = 73.2 \text{kN} \]

CHECK TWO-WAY SHEAR

\[ V_e = \frac{42 + \frac{7}{3} + \frac{1}{3}}{b_d} \]

\[ b_w = 2d_w + 2b_w + 4d \]

\[ = 2(4) + 2(4) + 4d \]

\[ \frac{V_e}{\phi} = \frac{4(1.0)\frac{10000}{10000}}{(16 + 4d)} \]

\[ = 4000 d + 1012 d^2 \]

\[ 1012 d^2 + 4000 d = 112 d = 0 \]

\[ d = 9 \text{ in} \]

CLC: COVER = 3".

USE 12" THICK MAT FOUNDATION

Two-Way Slab Sizing Above Parking Structure:

\[ \text{Span} = 20 \text{ ft} \]

\[ \text{Loading} = 180 \text{ psf} \text{ dead weight} \]

\[ \text{ESTIMATE} \]

\[ \rightarrow \text{SLAB THICKNESS} = 16" \]

Free-Standing Retaining Wall Sizing:

The retaining wall at the location shown in figure 3 is 10 feet tall. The wall changes thickness about halfway up the wall with the bottom half being 18" thick and the top half being 10" thick, as shown in figure 4.

Parking Structure Retaining Wall Sizing:

The 18 foot high retaining walls surrounding the parking structure shall be about 18" thick using table 1 as a reference.
The proposal strives to fulfill pre-established goals:

- Provide open spaces for the residential units
- Bring natural light inside the buildings
- Hide the parking
- Create an interior courtyard
- Open the buildings to surroundings with terraces, balconies, and roof gardens

**Indoor / Outdoor Relationships**

**Circulations**
The project has multiple staircases and elevators that efficiently connect most of the units directly with an amenity.

**Accessibility**
Four different entrances connect Broad and Branch, making it an open, accessible, and desirable project to visit.

**Courtyard**
A central courtyard becomes the heart of the project, turning it into one of the most active and interesting spaces for everyone in the complex.

**Parking**
Underground Mechanical parking is available for cars on the Branch entrance. The open bike parking space is located on the side of Broad street.

**View Axis**
Every unit in the building has the option of amazing views of the city, not even the interior of the project prevents the users to enjoy the view.
The diverse neighborhoods allow for a connection with the history of the area and the new needs of mixed-use projects. Relating the material exposure to a more industrial look in certain areas and a dynamic open shape, the project responds to the immediate surroundings and local needs.
GRAVITY SYSTEM

1 ½” LW Concrete Topping Slab on ½” Steel Deck

10” Deep Cold-Formed Steel Channel Joists

W10 x 39 Beams Typical

HSS 4 x 4 x 3/8” Columns

OR

Metal Stud Bearing Walls

FOUNDATION

Ground Floor Mat Foundation Locations

Parking Garage Mat Foundation Location
LATERAL SYSTEM

MECHANICAL PARKING SYSTEM

SITE SLOPE