Broad Street Apartments

Senior Project

Architectural Engineering Department

California Polytechnic State University, San Luis Obispo

By

Carla Simental (Architectural Engineering)

Viviana Sanchez (Architecture)

June, 2016

BROAD STREET APARTMENTS

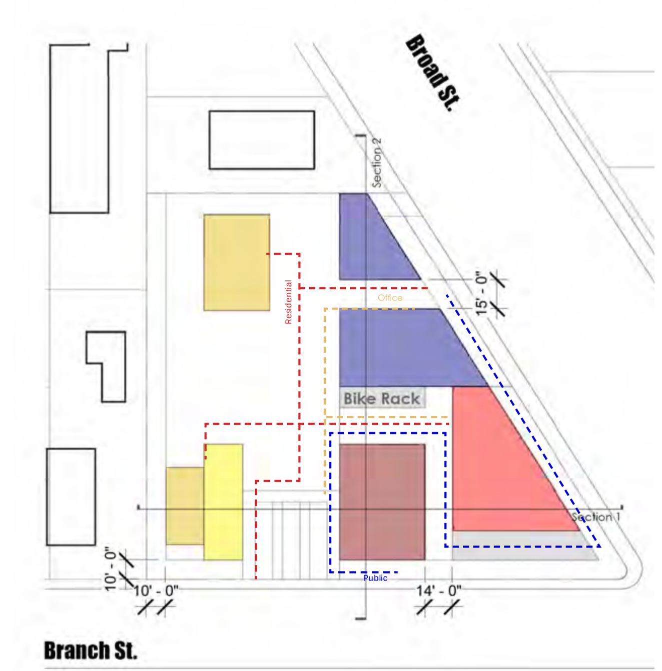
COMMUNITY PLAZA

PROJECT GOALS

ENCOURAGE PEDESTRIAN TRANSPORTATION
- Safe bicycle lanes
- Concealed parking
- Amenities for residents and neighborhood within walking distance

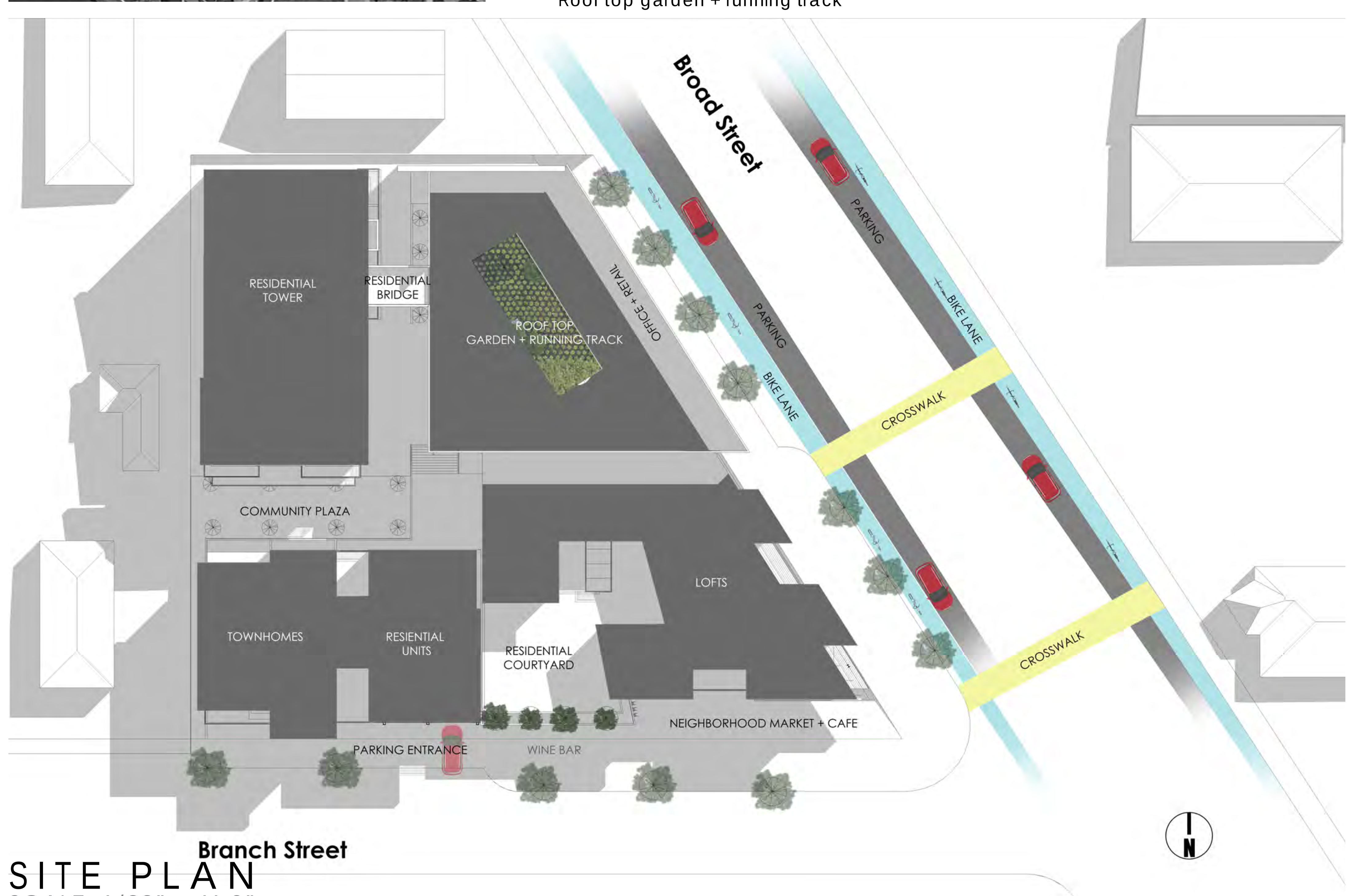
HAPPY PLACE TO LIVE
- Natural lighting
- Gardens + private outdoor areas
- Community support
- Great views
- Safety

AMENITIES
- Community Plaza
- Retail Spaces
- Hair Salon
- Wine Bar
- Neighborhood market + cafe
- Residential gym
- Roof top garden + running track



SITE CIRCULATION

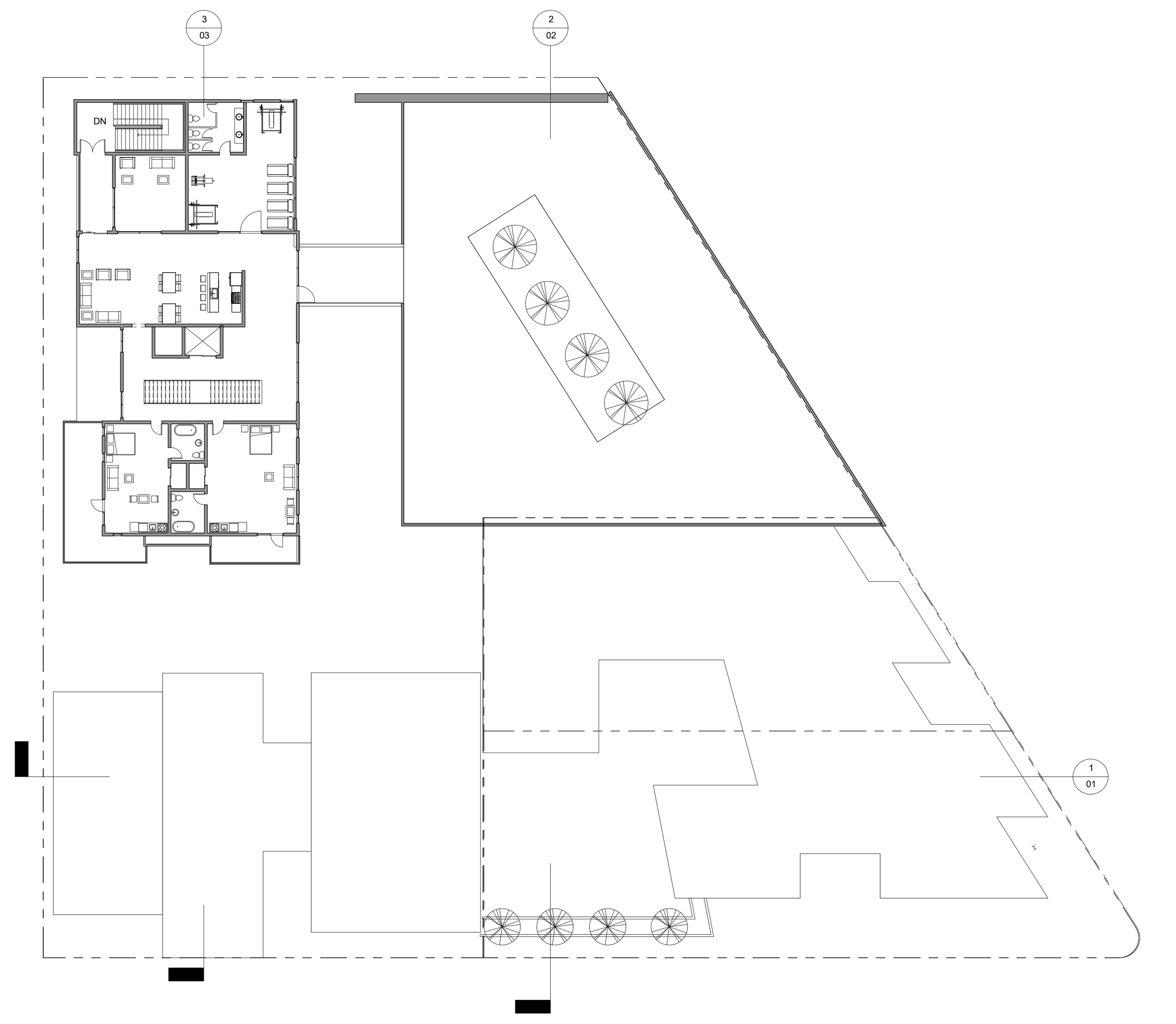
PARKING + PLAZA ENTRANCE



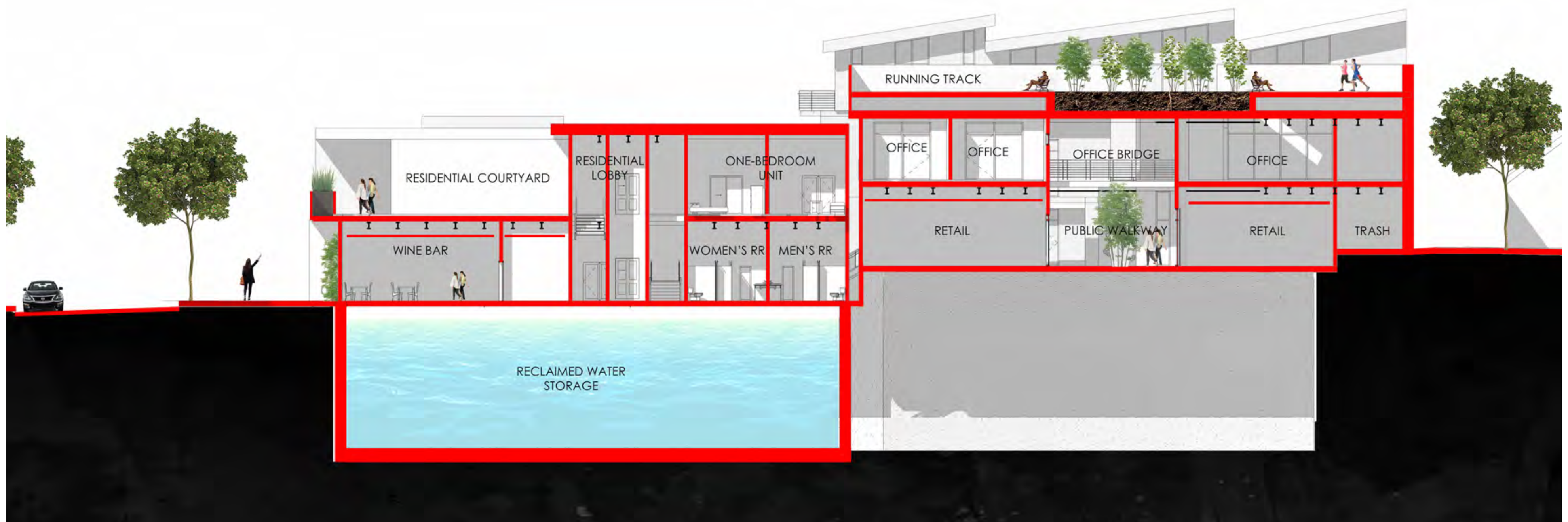
SITE PLAN
SCALE: 1/32" = 1'-0"

BRANCH STREET

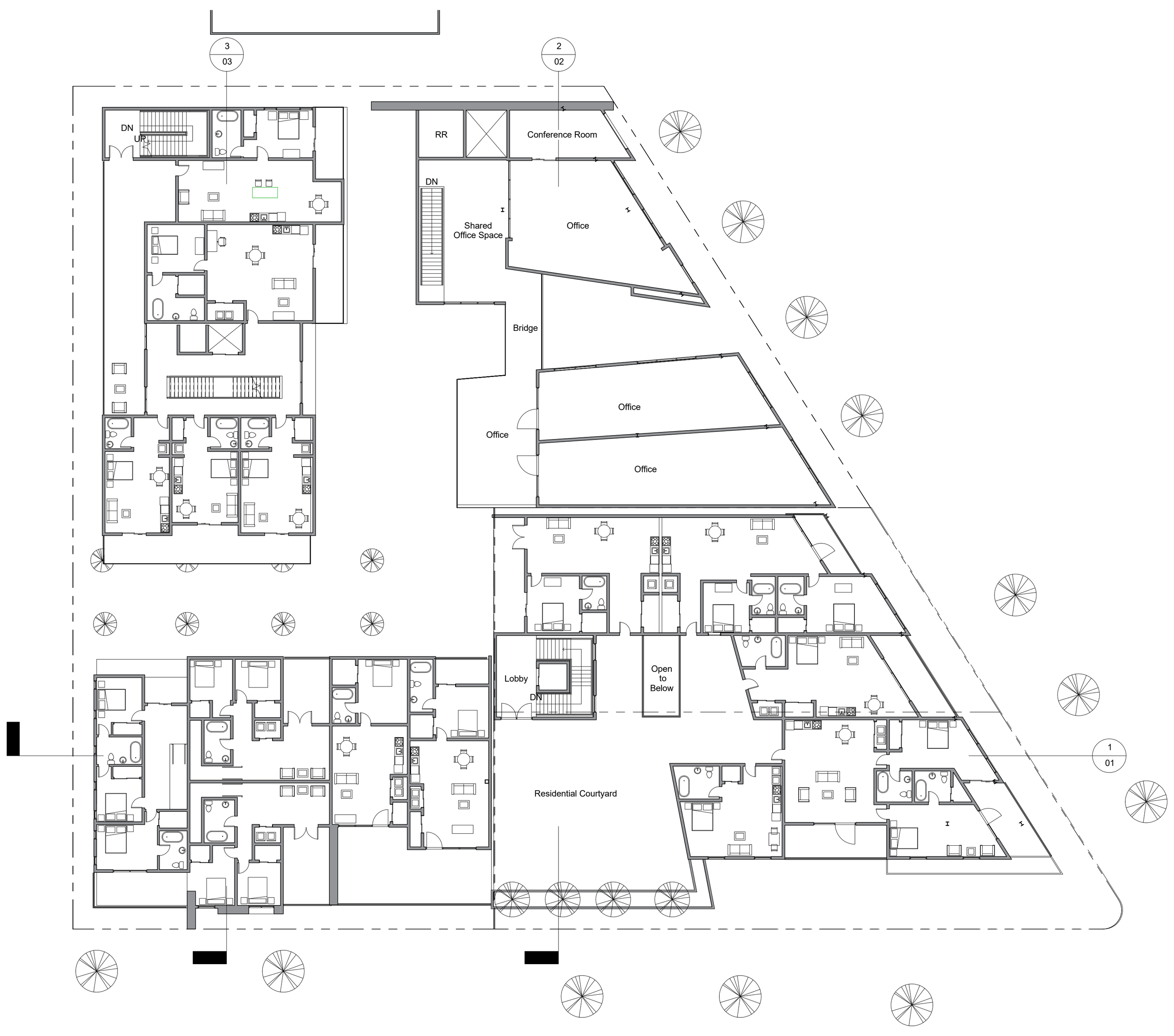
FLOOR PLANS



THIRD FLOOR PLAN
SCALE: 1/32" = 1'-0"

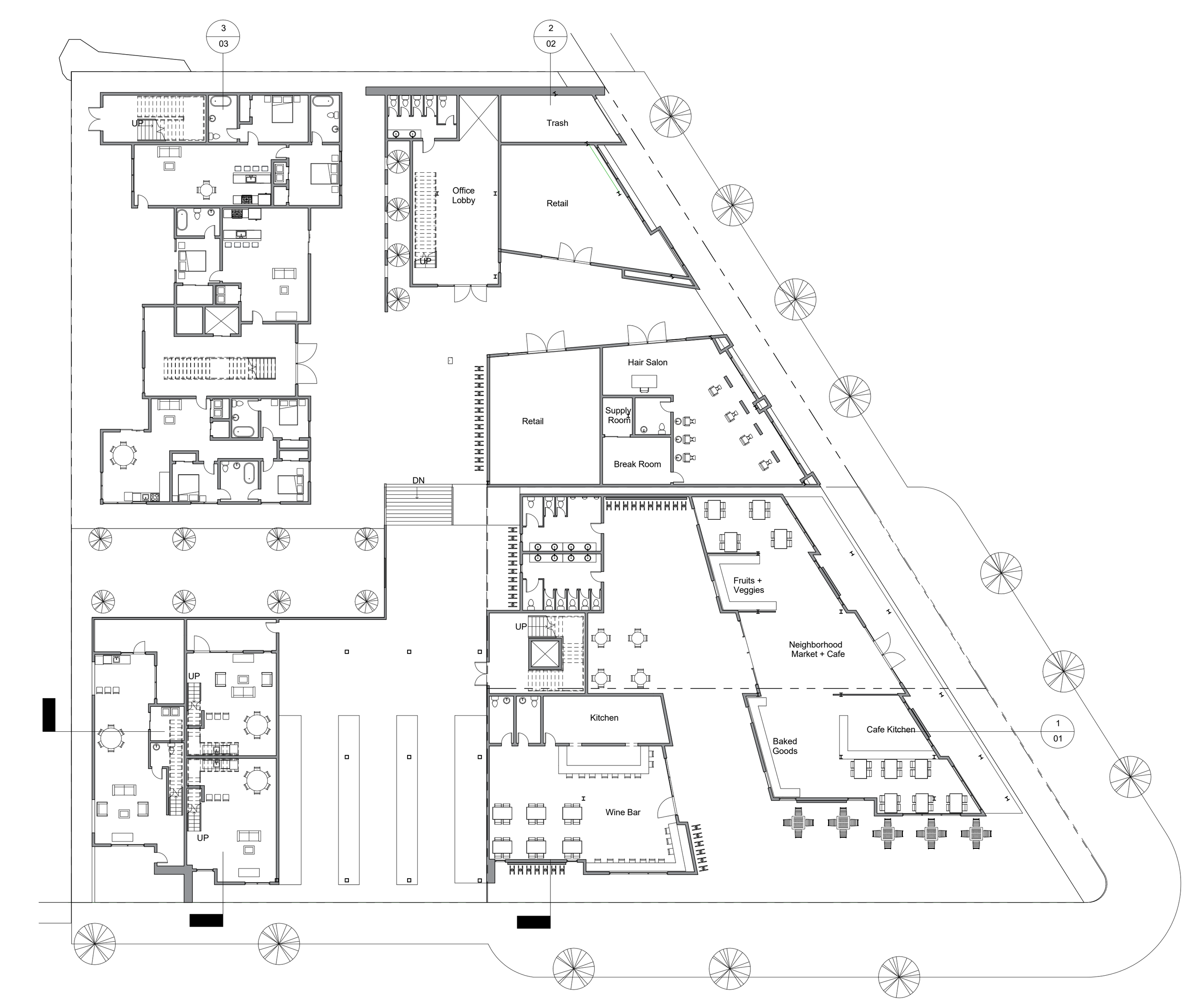


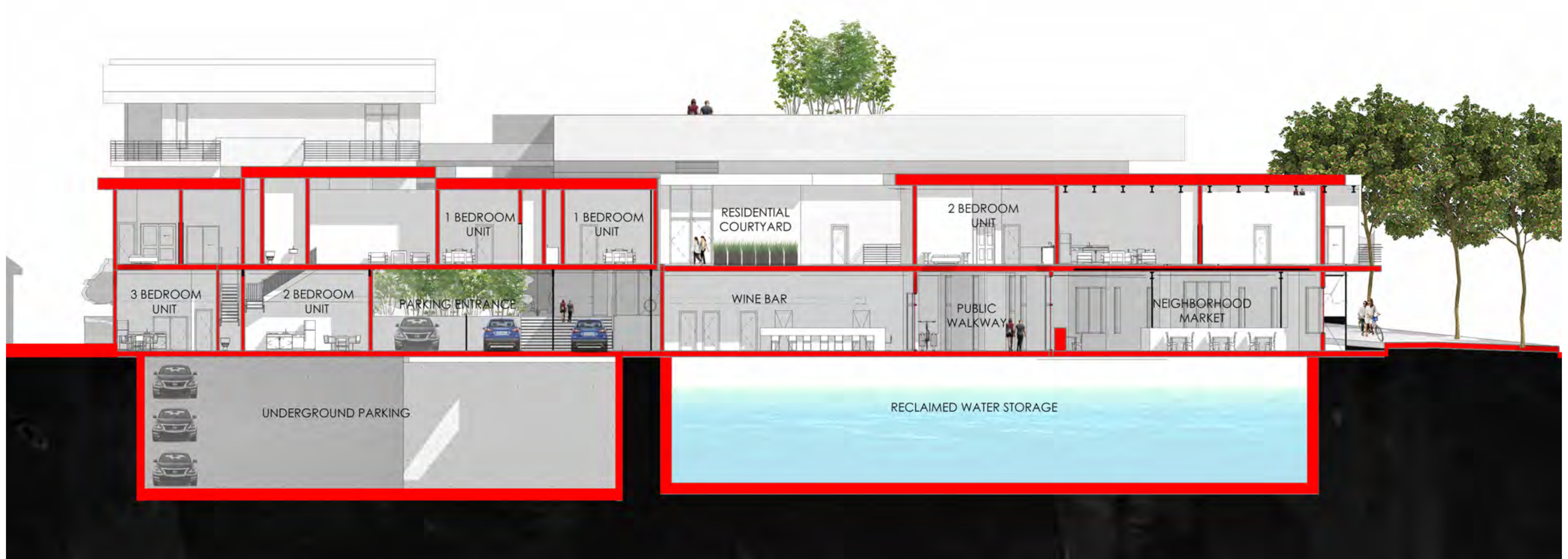
BROAD STREET SECTION
SCALE: 1/32" = 1'-0"



SECOND FLOOR PLAN
SCALE: 1/32" = 1'-0"

RESIDENTIAL TOWER SECTION
SCALE: 1/32" = 1'-0"

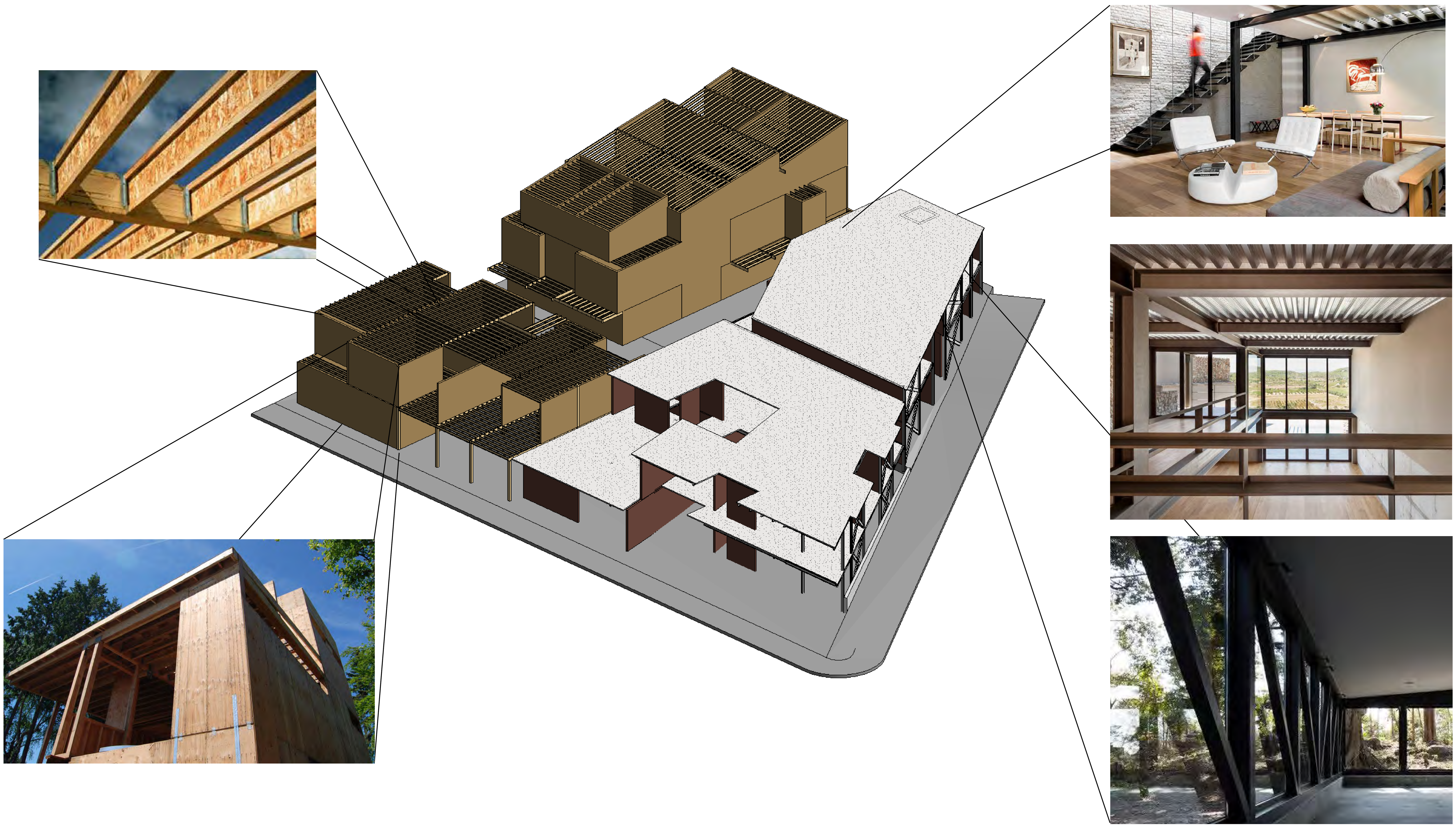




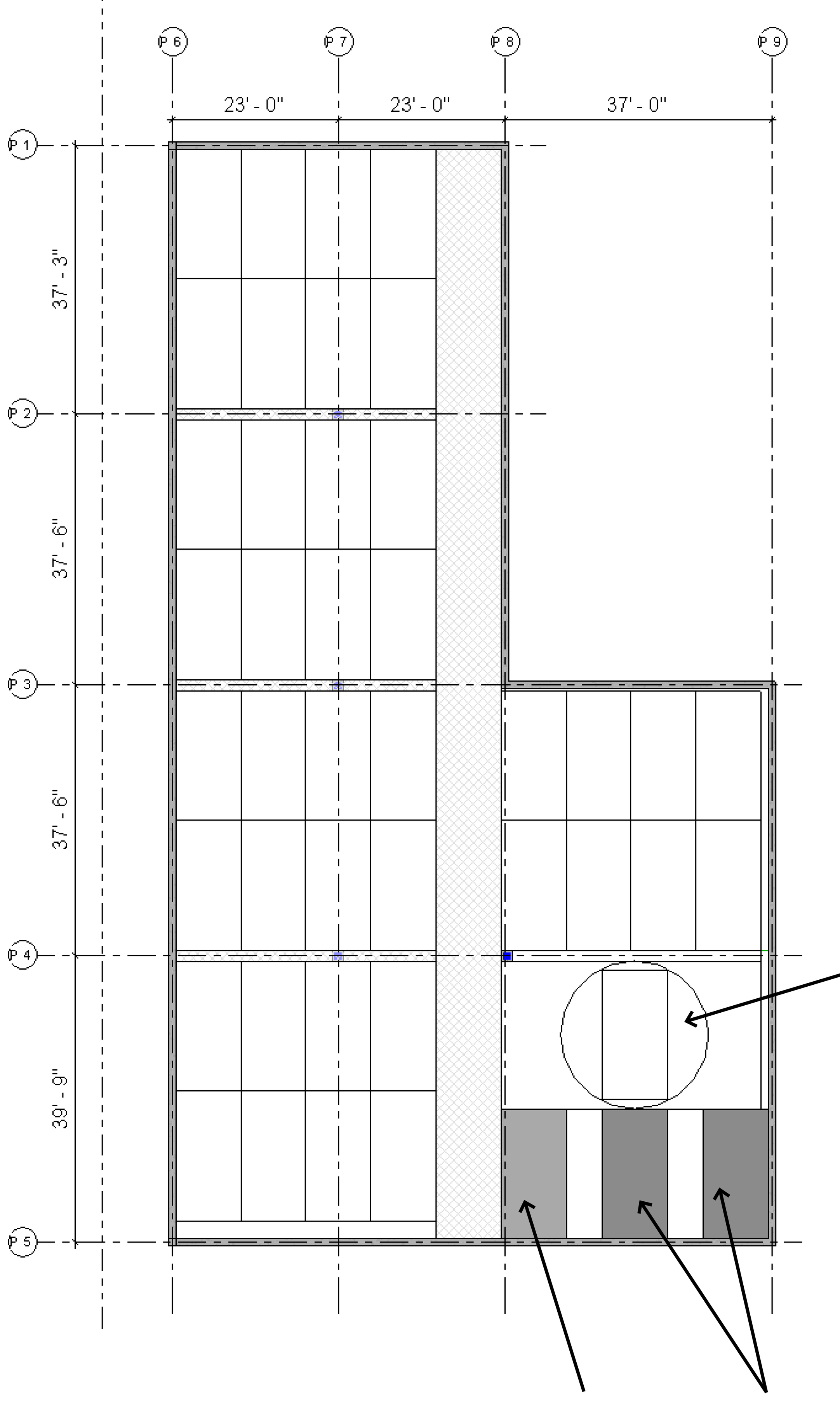
BRANCH STREET SECTION
SCALE: 1/32" = 1'-0"

Structural Systems

Carla Simental



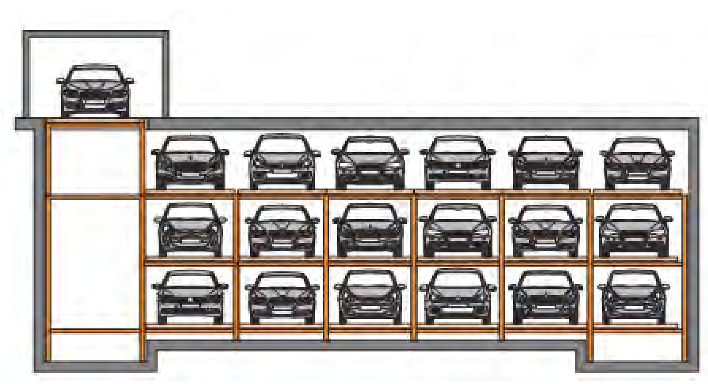
Underground Automated / Mechanical Parking

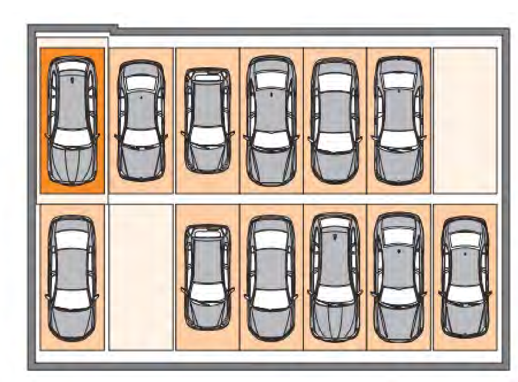


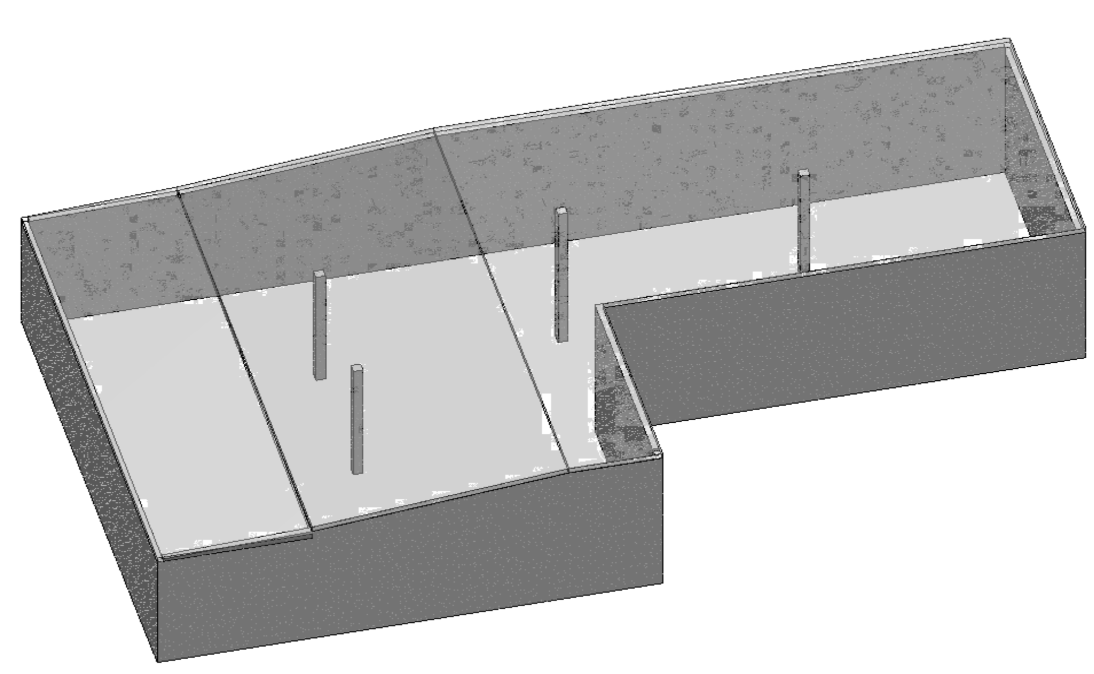
3 layers of 5 subsystems each holding 7 parking spaces

105 parking spaces total

Turn table rotates vehicle upon entering so vehicle is ready for exit.

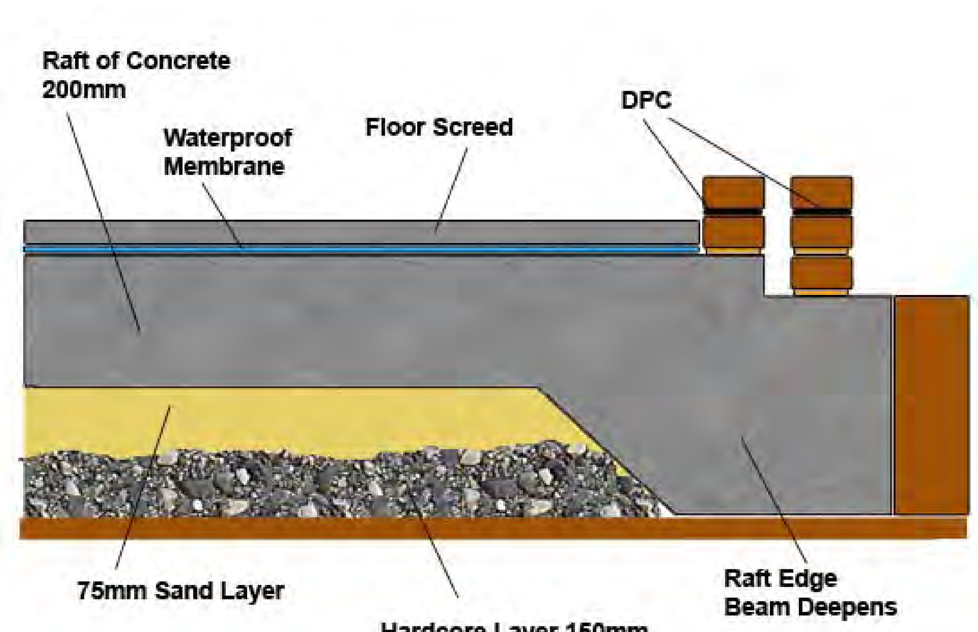




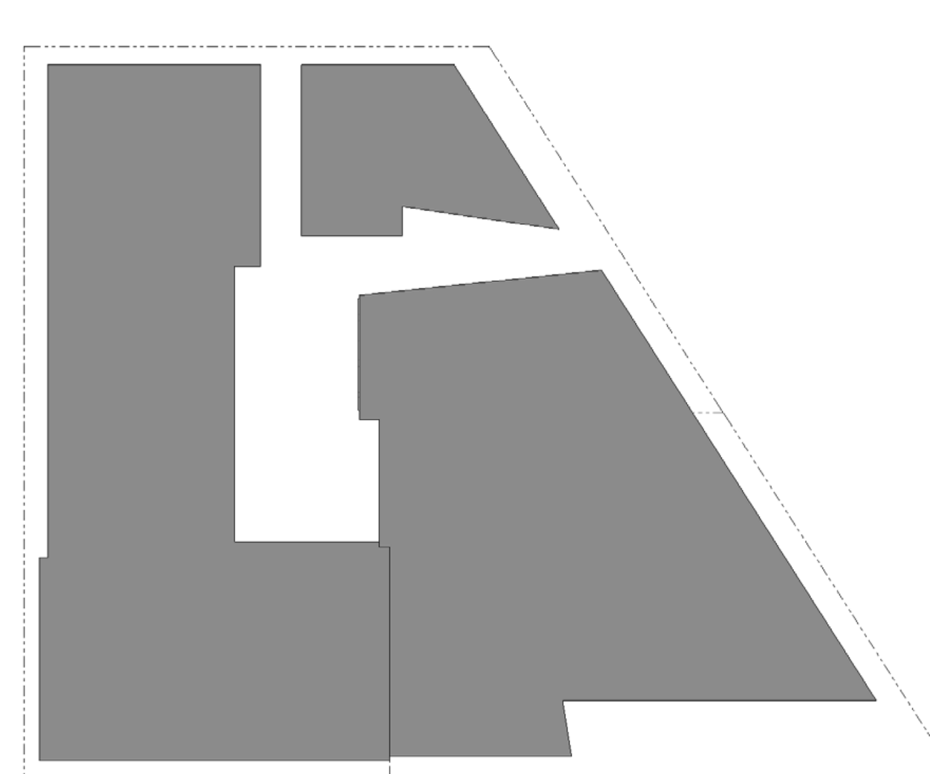


Mat Foundation

Example of Mat Foundation Construction



Example of Mat Foundation Section

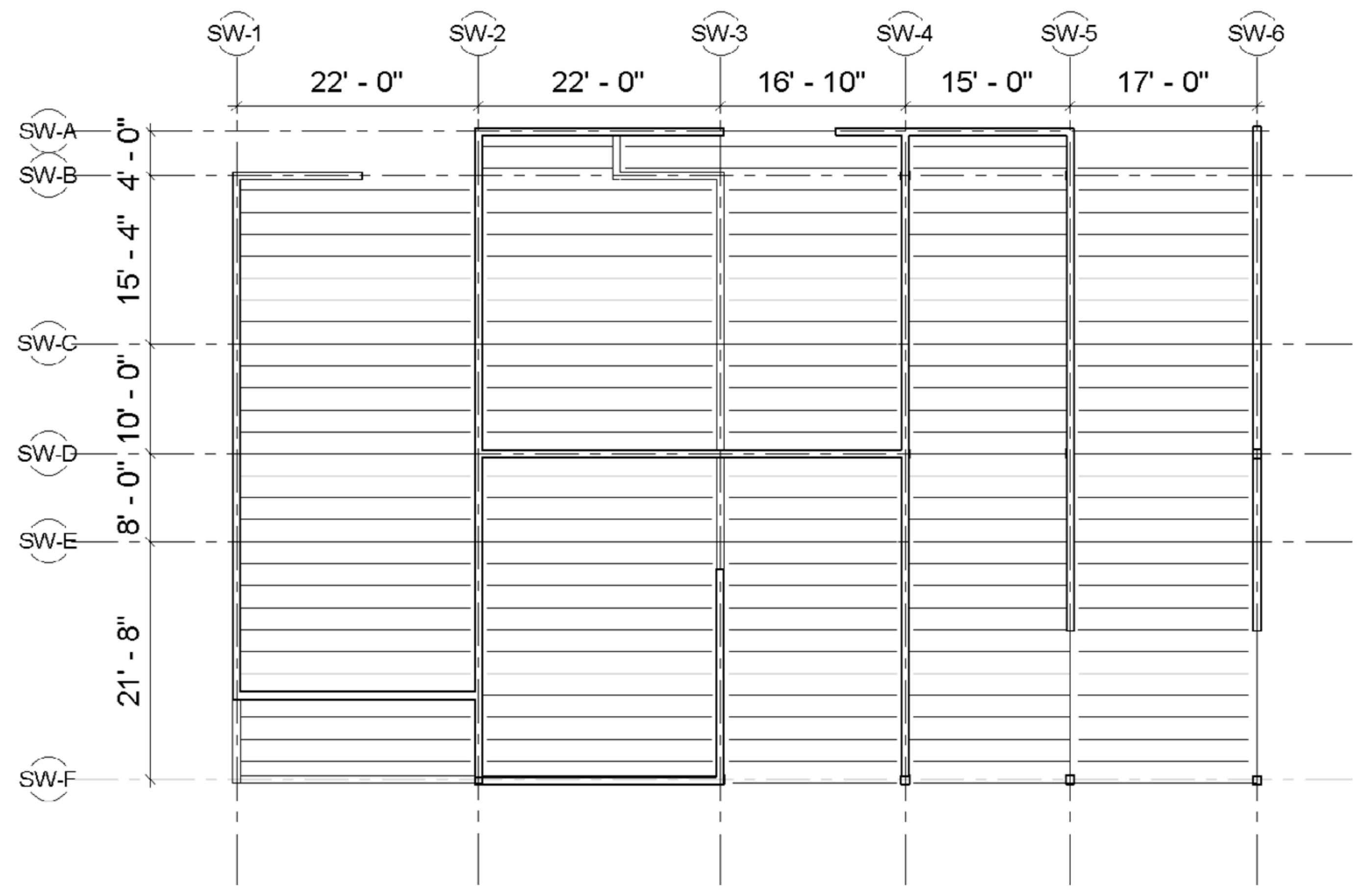


Mat Foundation Layout

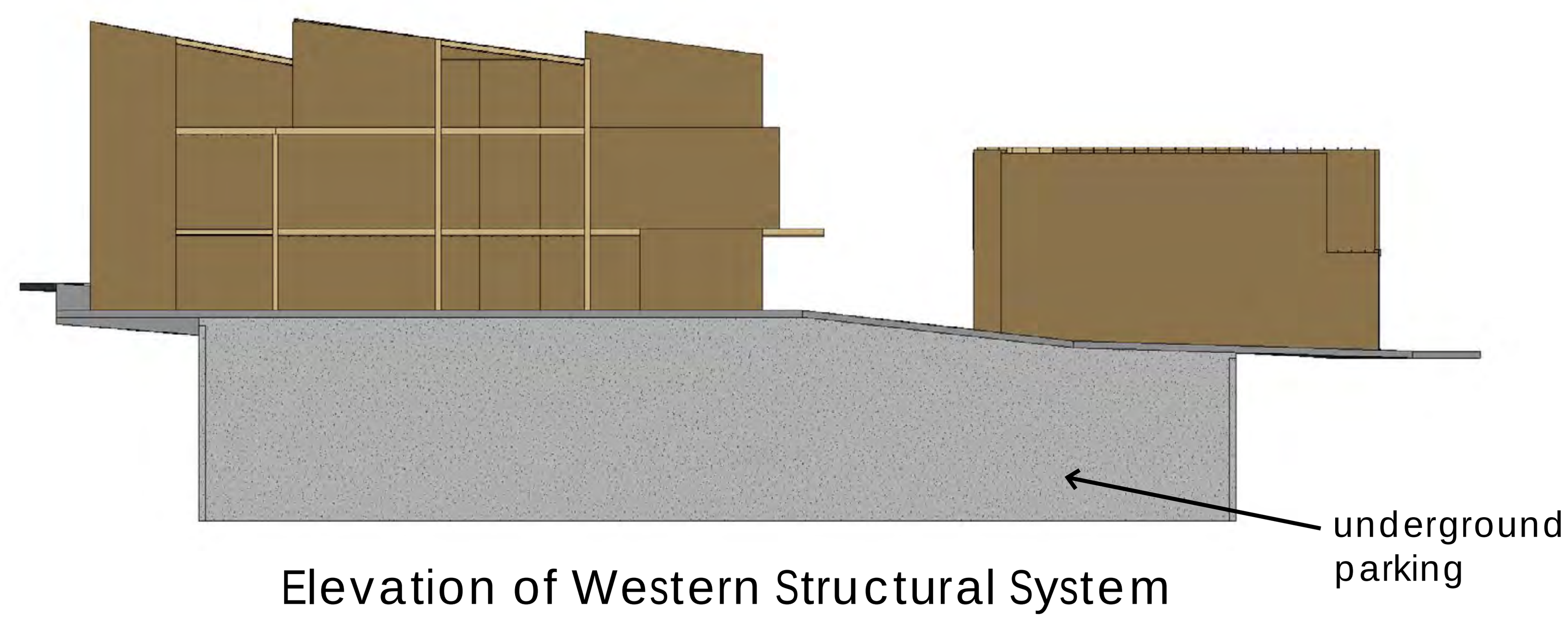
Western Structural System

Carla Simental

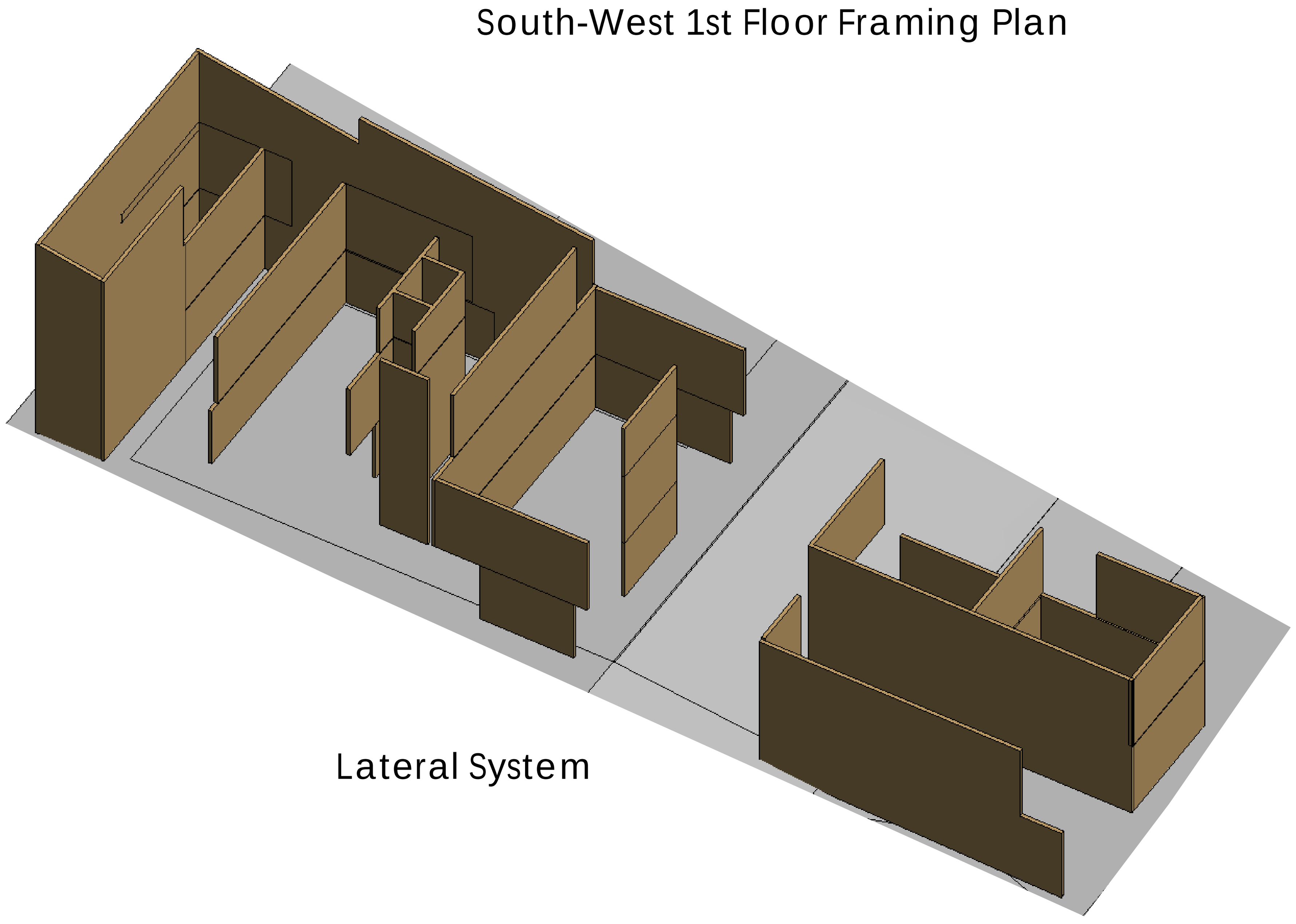
Light-weight Concrete on Steel Deck | I-Joist | LVL | Wood Shear Walls | Wood Posts



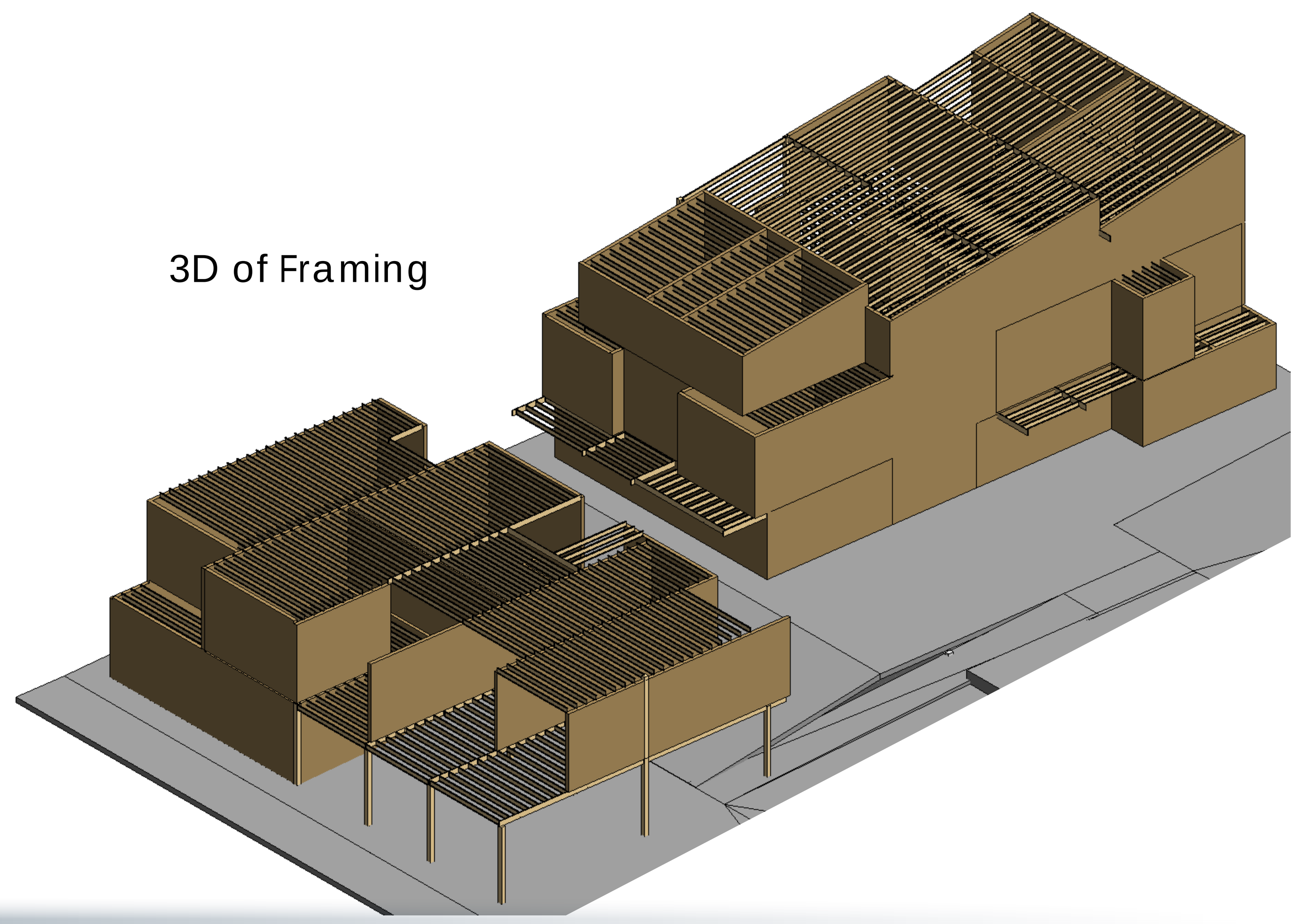
South-West 1st Floor Framing Plan



Elevation of Western Structural System



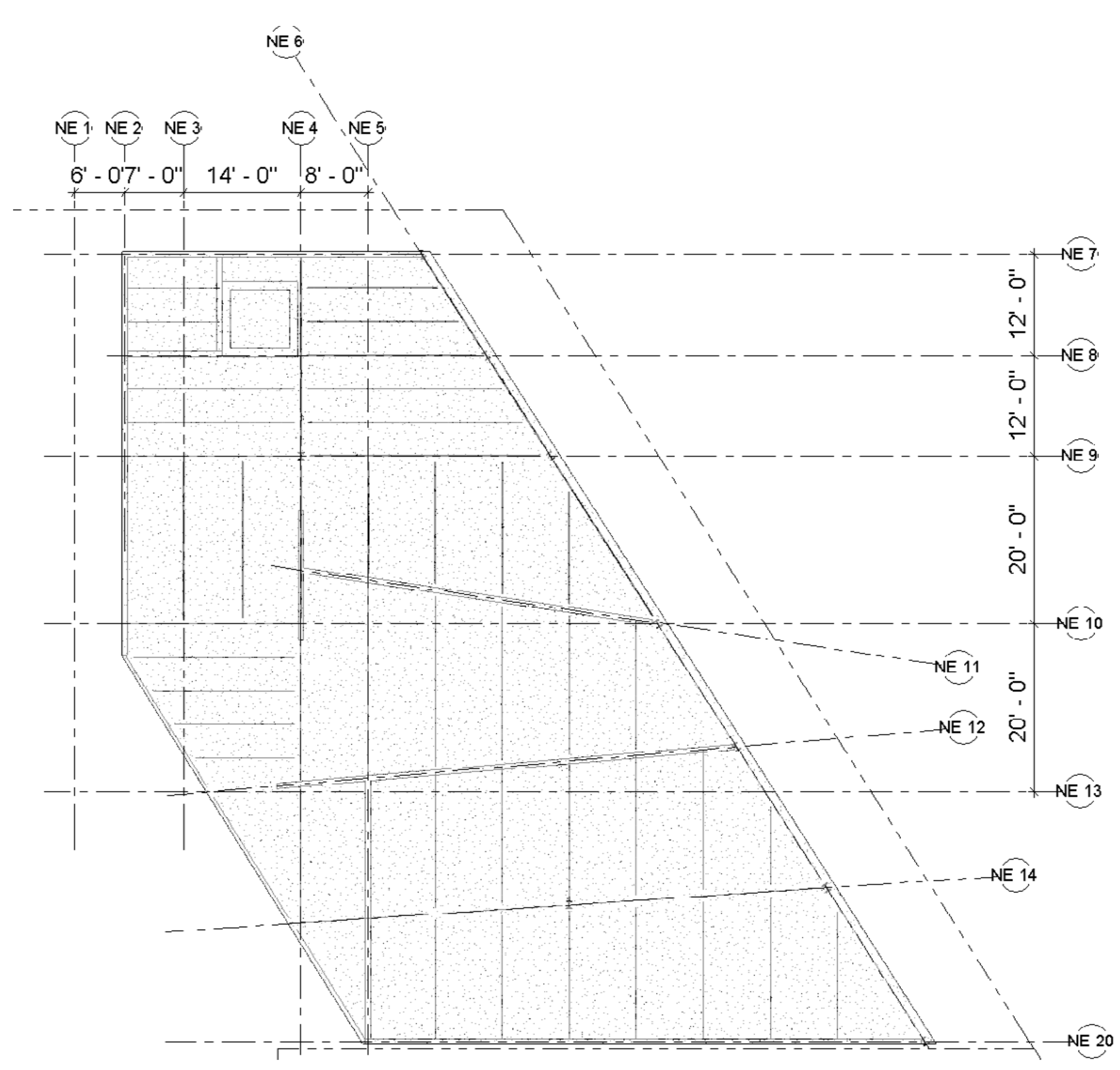
Lateral System



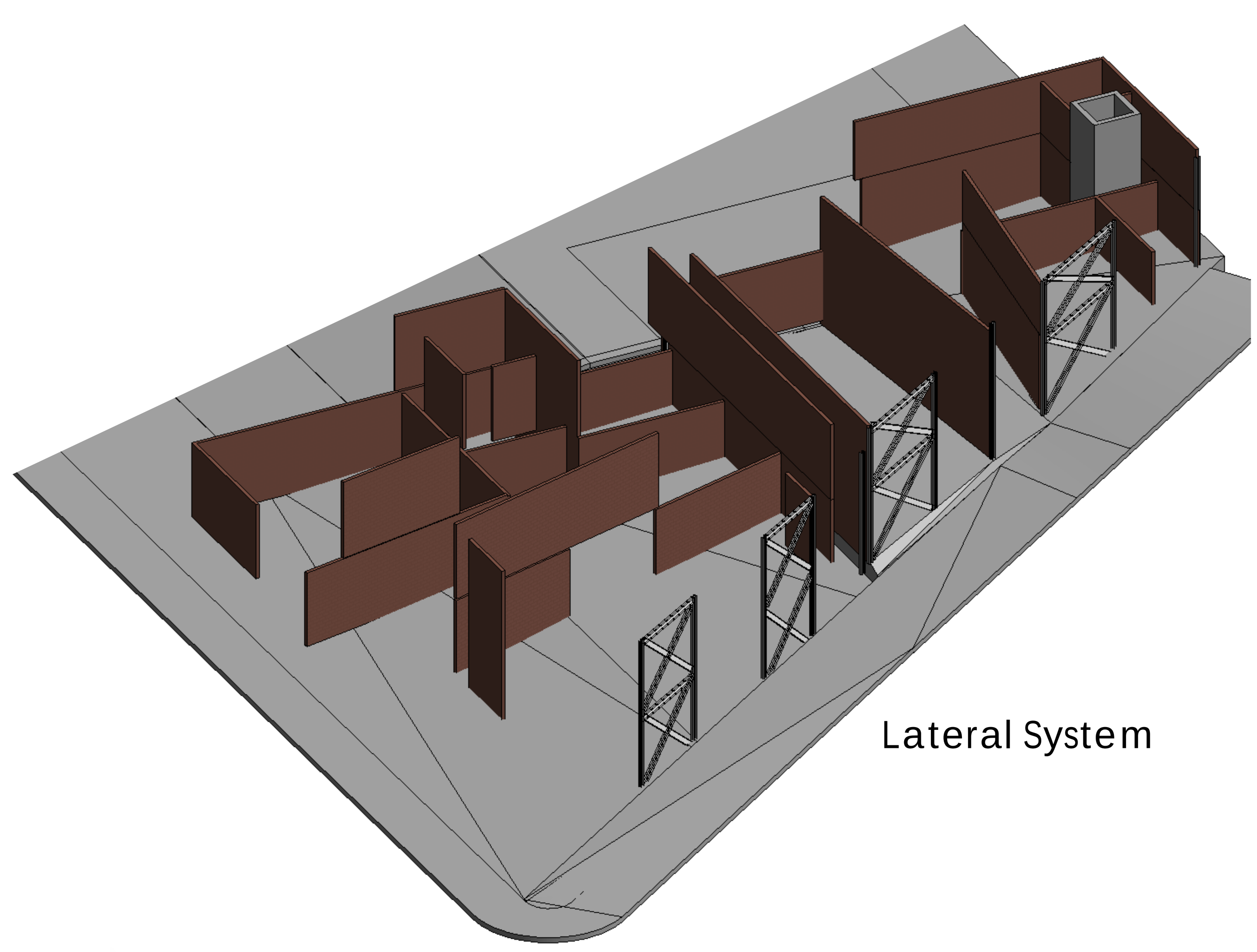
3D of Framing

Eastern Structural System

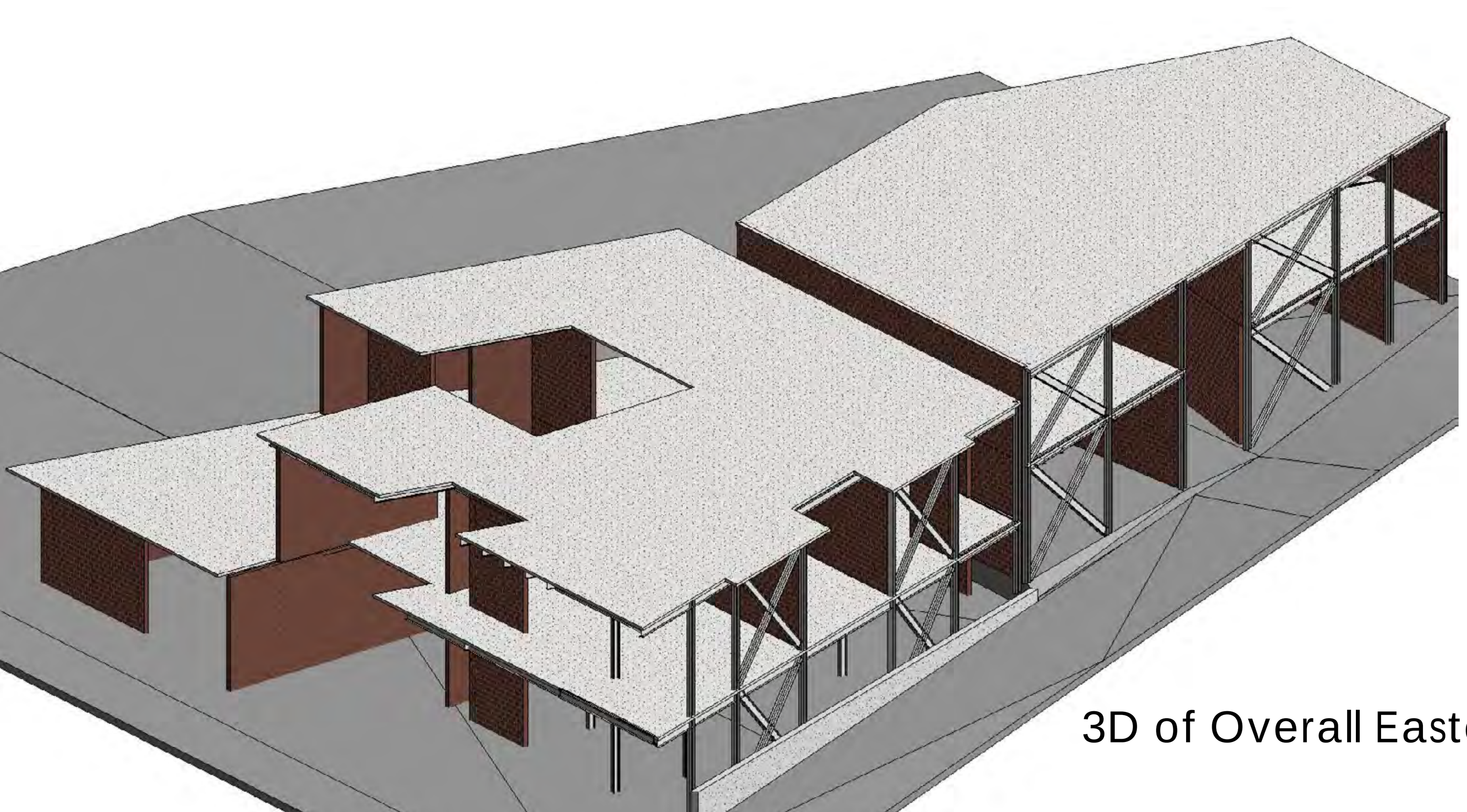
Concrete on Steel Deck | Wide-flange Beams & Columns | Masonry Shear Walls | Steel Braced Frames



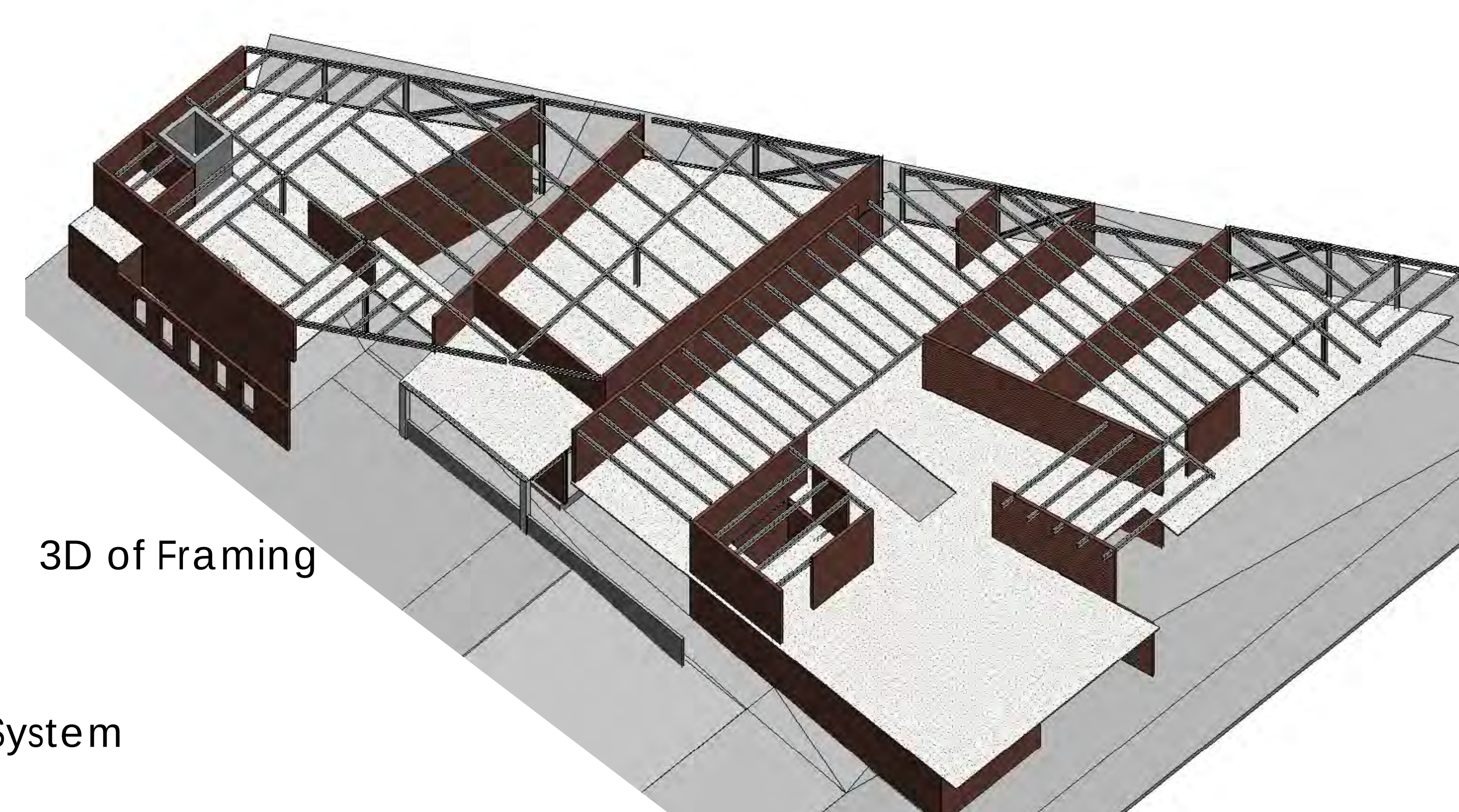
North-East Roof Framing Plan



Lateral System



3D of Overall Eastern System



3D of Framing

Supporting Documentation

Gravity System Description

Carla Simental
June 3, 2016

Western System

Light-weight concrete on steel deck | I-Joists | Laminated strand lumber | Wood posts

This system is timber construction. The light-weight concrete on steel deck rests on I-Joists which transfer load to the Laminated Strand Lumber (Figure S-1). This connection is used for the residential roof and floor framing. Timber bearing walls and timber posts carry the loads down to the floors below or to the foundation.

The I-Joist has two main parts, the web and the flange. The "I" shape is formed by sandwiching the web with flanges on the top and bottom. The flange is typically Laminated Strand Lumber (LVL) or solid sawn lumber and resists bending. The web is made of plywood or OSB and resists shear.

The commonly used I-Joists on this project are TJI 230 and TJI 560 spaced at 2' o.c. Depths of these I-Joist types are both 11-7/8". The typical spans used on this project are between 12' and 22'.

Figure S-1

http://www.apawood.org/residential-construction

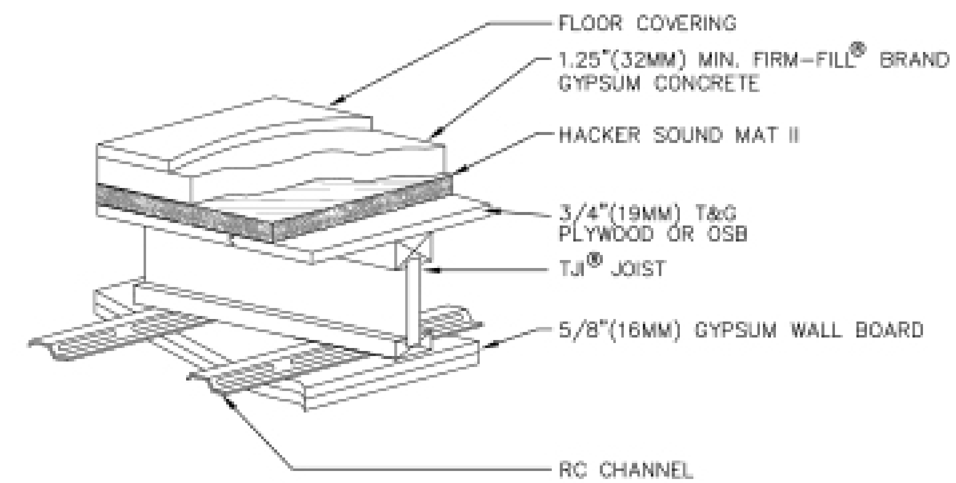


Figure S-2

http://www.hackerindustries.com/architects-cad.shtml

Eastern System

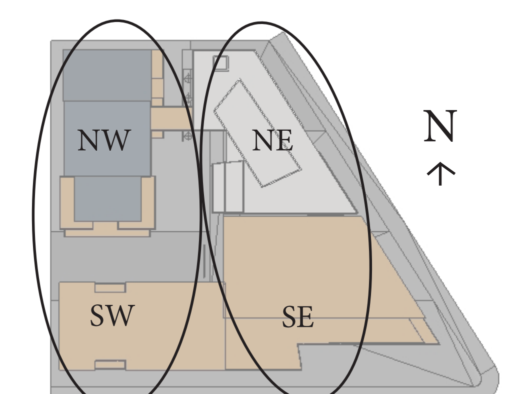
Light-weight concrete on steel deck | Wide-flange beams and columns | Masonry bearing walls

Figure S-3

http://www.wallpaper.com/architecture/m-house-in-catalo-nia-bridges-modernity-and-tradition

The structural system is uses a combination of steel framing members and masonry bearing walls which are exposed. The steel deck roof and floor have a concrete cover. The deck rests on the steel beams which transfer load to the steel columns and masonry bearing walls. The masonry walls act as both gravity bearing and lateral members.

The steel deck with light-weight concrete fill is 6-1/4" on the roof levels and 5-1/4" on the floor levels. The steel wide-flange beams are spaced at 4 ft and 8 ft on center. Roof level beams are typically W21x44s and W16x33s with some girders as W18x50. Floor level beams are typicall W12x14s. Typical columns are W8x48s and masonry bearing walls are 8".



Lateral System Description

Carla Simental
June 3, 2016

Western System

Wood shear walls

This system consists of wood walls which act to resist both bearing and lateral loads. The walls require sheathing so that it may act as one member (Figure S-4). Additionally, steel straps between shearwalls helps to transfer the tension forces to the walls adjacent or underneath so that they may act together (Figure S-5).

The roof and floor wood diaphragms transfer shear onto the shear wall which then transfers shear forces down to the floor or foundation below.

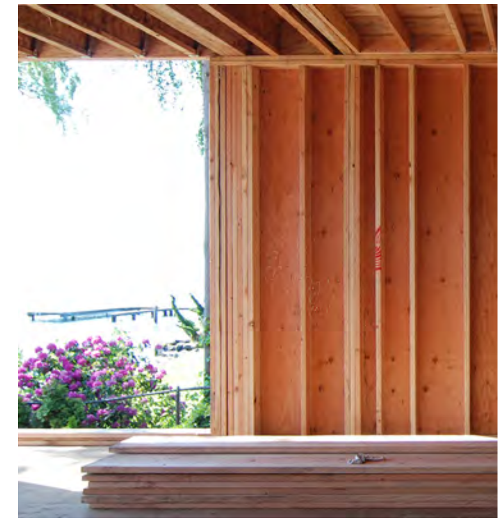


Figure S-4

Figure S-5

http://blog.buildllc.com/2014/05/shearwalls-101-why-you-cant-have-a-window-there/

Eastern System

Masonry shear walls | HSS Braced Frames

Figure S-6

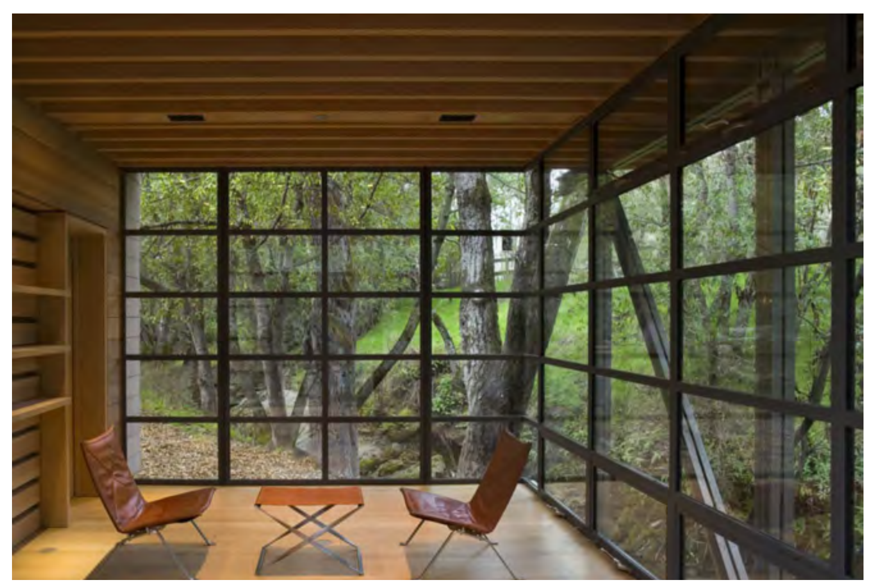
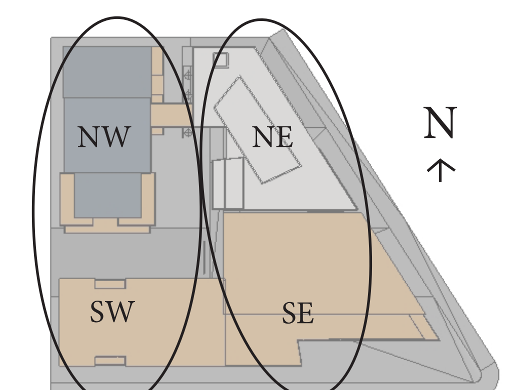


Figure S-7

http://blog.buildllc.com/2013/12/windows-roof-overhangs-and-headers/

The Eastern System contains masonry shear walls and HSS braced frames. The interior exposes the structural system, making the structure part of the architecture. The braced frames are crossed and concentric, running along the Broad face of the structure. They are HSS 5x5x1/2 members. The masonry shear walls are 8" thick.



Foundation System Description

Carla Simental
June 3, 2016

Figure S-8

http://www.irvinegeotech.com/projects.htm

Mat Foundation

The mat foundation is used on expansive, rocky, or hydro collapsible soils. This site has very expansive soil so a mat foundation is a good choice to prevent the buildings from tilting due to expansion in soil on one end.

The mat foundation consists of a 15" thick reinforced concrete slab that covers the entire area of the bottom of the structure like a floor. It possesses great stiffness and strength to resist swelling. It usually requires little or no gravel, sand, or moisture barrier.

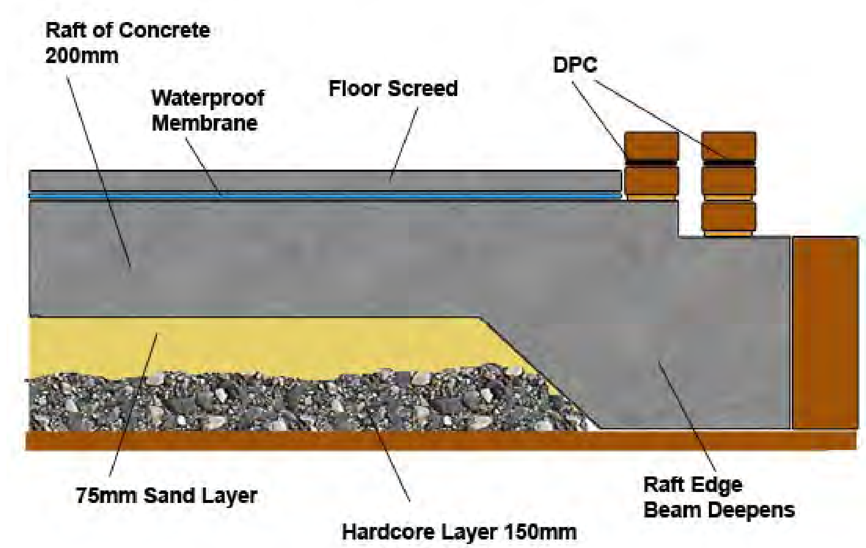


Figure S-9

http://www.diydoctor.org.uk/projects/rafts.htm

Parking System Description

Carla Simental
June 3, 2016

Figure S-10

http://www.multiparking.com/index.php?Layer-system-MasterVario-F2-F3

Mechanical Parking / Automated Parking System

The underground mechanical parking system being used on this project is fully automatic. This system is a two-row surface system with elevator and horizontal conveying units (Figure S-11). There are 5 subsystems on each layer holding 7 vehicles each and a total of three layers. Thus, a total of 105 vehicles are held in the project. The lift is a horizontal and vertical conveyor unit (Figure S-12)

The driver of the vehicle drives onto a automated lift, exits the vehicle, and retrieves a card that is used for retrieval of the vehicle at a later time. The lift moves the vehicle underground where it can enter one of the 15 subsystems wherever a parking space is available. If no spaces are available, the parking system will inform the driver that none are available. During the retrieval period, the driver inserts the card in a machine which recognizes the vehicle and automatically retrieves the vehicle onto the exit loading area.

The advantages of using this type of system include optimal access times, accomodation of vehicles in safety, anti-theft and damage protection, safe access to car park without narrow ramps or dark access routes, the enclosed area can be half of that of a conventional parking system, and reduced construction time.

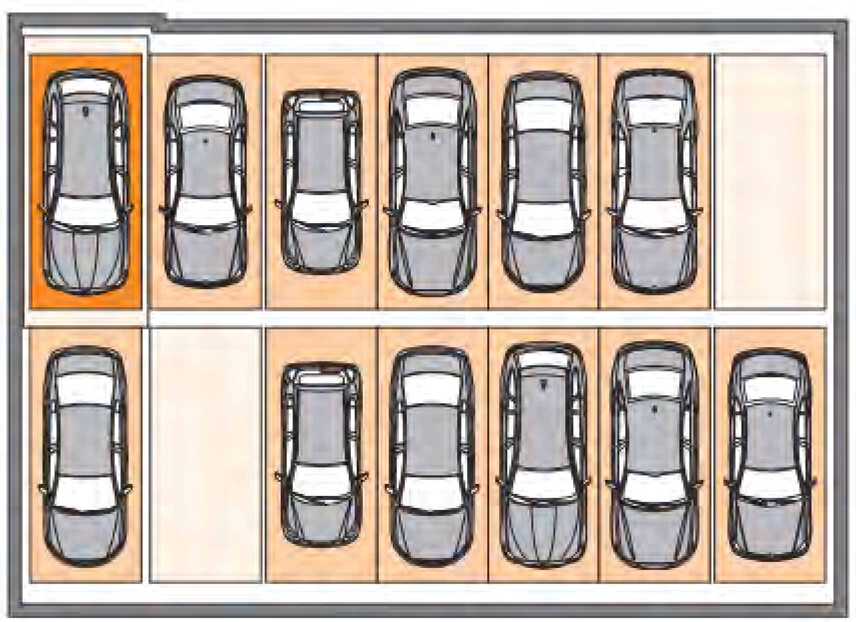


Figure S-11

http://www.multiparking.com/index.php?Layer-system-MasterVario-F2-F3

Figure S-12

http://www.multiparking.com/index.php?Layer-system-MasterVario-F2-F3

Figure S-13

http://www.multiparking.com/index.php?Layer-system-MasterVario-F2-F3

Gravity System Selection

Carla Simental
June 3, 2016

Western System

Light-weight concrete on steel deck | I-Joists | Laminated strand lumber | Wood posts

Building Program:
Since dimensional lumber is limited to smaller depths and lengths, this project uses I-Joists to span larger distances to reduce the need for less interior columns or bearing walls.

Constructability:
I-Joists are lightweight and provide easyinstallation for residential and light commercial projects.

Sustainability:
Since small garden areas will exist on the upper floors near residential units, beams with larger bending capacities will be used in these areas to support heavier loads (i.e. I-Joists instead of dimensional lumber). The I-Joist has great strength in relation to its size and weight. The I-Joist uses less lumber than a dimensional solid wood joist to carry heavy loads, making this construction process more sustainable than traditional dimensional lumber.

Conclusion:
The use of I-Joists as opposed to dimensional lumber reduces number of columns or bearing walls needed, reduces the amount of lumber used on the project, provides lower installation costs, and are easier to use for construction.

Eastern System

Light-weight concrete on steel deck | Wide-flange beams and columns | Masonry bearing walls

Building Program:
The ability to span large distances provides more open spaces, which are generally desired for commercial spaces. Additionally, steel is preferred in settings such as offices since the stiffness and mass prevent unacceptable vibrations and deformations.

Aesthetics:
Steel framing members and masonry walls were choosen to provide aesthetically appealing environments by exposing the materials. The use of masonry walls on the West side will provide a greater sense of separation between the residential units on the Western side and the North-East system for offices and retail.

Sustainability:
The use steel columns without walls on two ends creates an open layout which will allow for ample lighting in the day for the retail stores and offices. This will in turn reduce energy consumption for businesses.

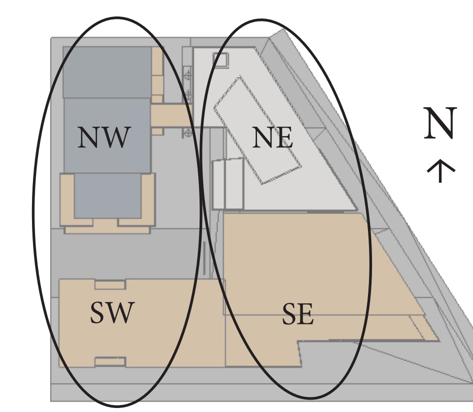
Conclusion:
Though more expensive, the use of steel for offices and retail stores is preferred because of the reduction in vibrations, the open layout, the natural lighting, and reduced energy consumption by businesses.

Figure S-14

http://www.2015interiordesign.com/decoration-ideas/exposed-brick-and-steel-produce-backdrop-for-contemporary-residence/

Figure S-15

https://www.pinterest.com/pin/498915083425852 51/



Lateral System Selection

Carla Simental
June 3, 2016

Western System

Wood shear walls

Compatibility with Gravity System:
Given that residential units have many closed areas, it is an efficient way to use walls as shear walls wherever possible without restricted the layout of the building.

Cost:
Using OSB structural sheathing for shear wall panels reduces labor costs due to less cutting and reduces waste due to related disposal costs.

Conclusion:
Because the gravity system already has many enclosed spaces with timber bearing walls, it is easy to treat the walls as shear walls due to the low cost and ease of constructability.

Figure S-16

http://kr.123rf.com/photo_877961_construction-jobsite-with-house-under-construction-showing-framing-stage-with-some-shear-on-the-wall.html

Eastern System

Masonry shear walls | HSS Braced Frames

Figure S-17

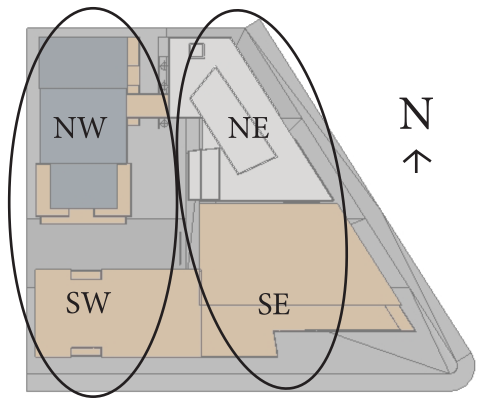
http://assets.dwell.com/sites/default/files/willis-residence-san-francisco-erica-severns-garage-dining-living-area-white-oak-flooring.jpg

Building Program:
The desire to have open views to Broad Street for the downstairs retail stores drove the selection of braced steel frames with the combination of masonry walls as part of the gravity system.

Seismicity:
Steel braced frames develop resistance to lateral forces by working together with beams and columns in a manner similar to a truss. The selection of having braced steel frames located near the extremities of the structure is due to the need of resisting torsional effects due to seismic forces.

Aesthetics:
Although the use of only steel for vertical framing members is possible as part of the lateral system, the use of masonry shear walls provides a more welcoming environment when exposing structural elements which may be of importance to restaurant owners.

Conclusion:
The use of steel braced frames and masonry shear walls together in the same building allows for the use of open areas along store fronts and the use of more cost efficient masonry walls for the areas that do not require great openings. Additionally, the combination of masonry shear walls and steel braced frames provides a potential aesthetic value and economic benefit when dealing with seismic design.



Foundation System Selection

Carla Simental
June 3, 2016

Mat Foundation

Compatibility with Site:
The site has very expansive soil and a subsurface creek may be running through adjacent parcels. A mat foundation would provide more resistance to the swelling of clay since it allows the structure to have uniform settlement rather than the possible differential settlement that may occur if using pad footings. If the soil is to expand, the mat foundation will cause the entire structure to move as a whole, thus, reducing cracks that form when one portion of the structure settles relative to another portion (Figure S-18). Additionally, the use of pad footings on this project would not be recommended due to the low soil bearing pressure of only 1000 psf present on site. The pad footings would need to be very large and cover over 50% of the foundation area, making a mat foundation a good option.

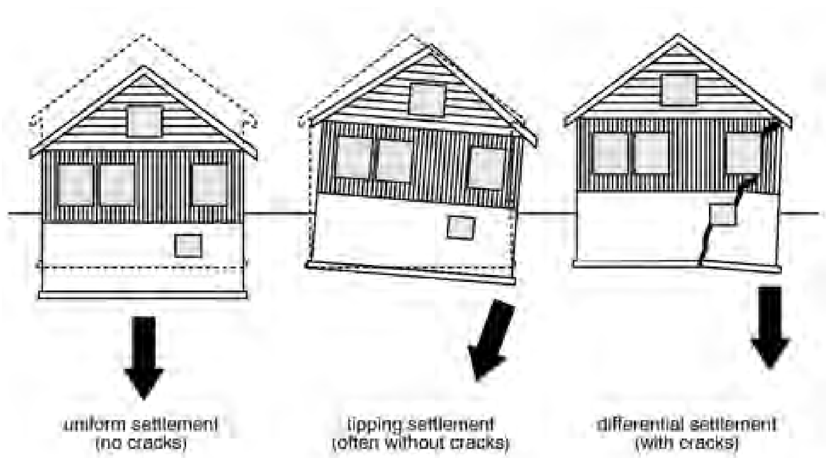


Figure S-18

http://www.ashireporter.org/photos/thumbnails/2004-2002/types-of-settlement.gif

Cost:
Since the soil capacity is poor, either mat foundations or pile foundations are options. The downsides to using pile foundations is that they are expensive and the construction time is increased due to the number of steps needed. For this particular project, the building is light and the soil should have a uniform surface so a mat foundation is most appropriate given the expensive and time consuming alternative of pile foundations.

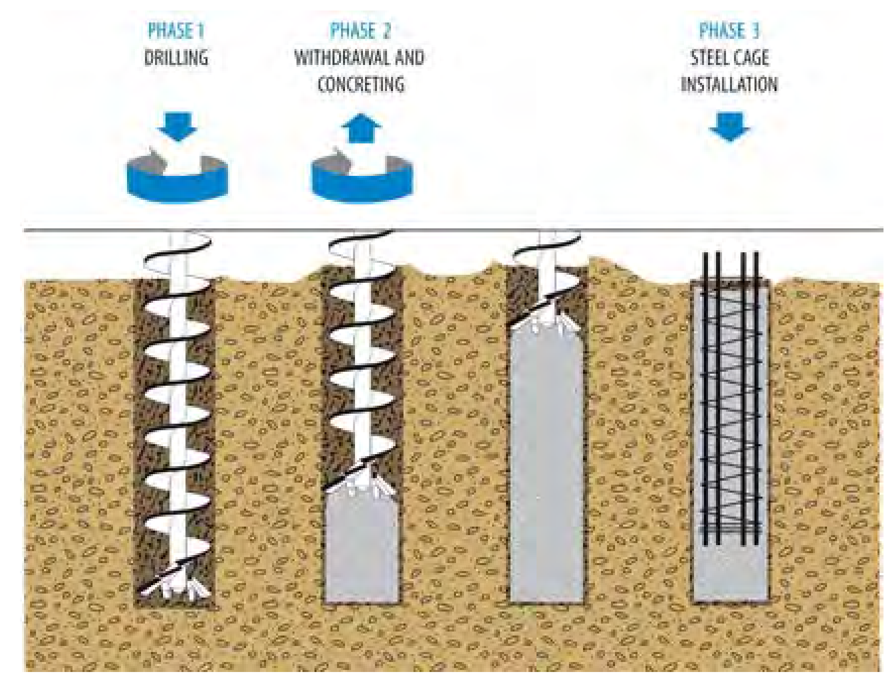


Figure S-19

http://houseunderconstruction.com/foundation/what-pile-foundation.html

Gravity System Configuration

Carla Simental
June 3, 2016

Western System

Light-weight concrete on steel deck | I-Joists | Laminated strand lumber | Wood posts

Timber bearing walls are located continuously throughout all levels in most areas (Figure S-20). The Southern area where the parking entrance is located has timber bearing walls on the 2nd floor but no walls below. In these locations, steel beams and concrete columns may be necessary to carry all of the loads from the residences above the open parking area down to the slab above the underground parking. Where the roof is sloped in the Northern residential area, the I-Joists span along the sloped direction while the girders span perpendicular in a horizontal plane. Where large cantilevers are present, a steel beam will be used to carry load and limit deflections.

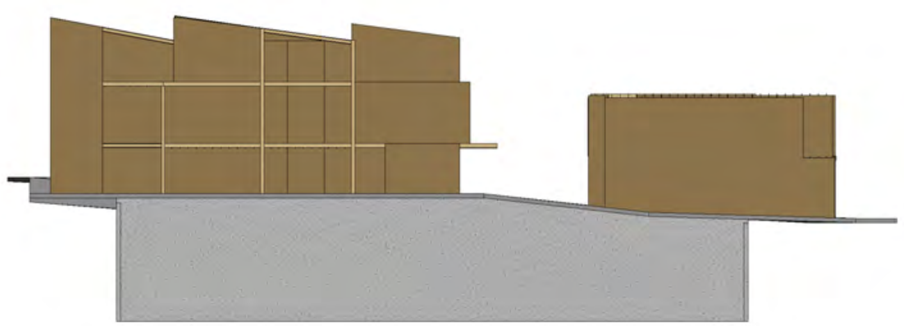


Figure S-20

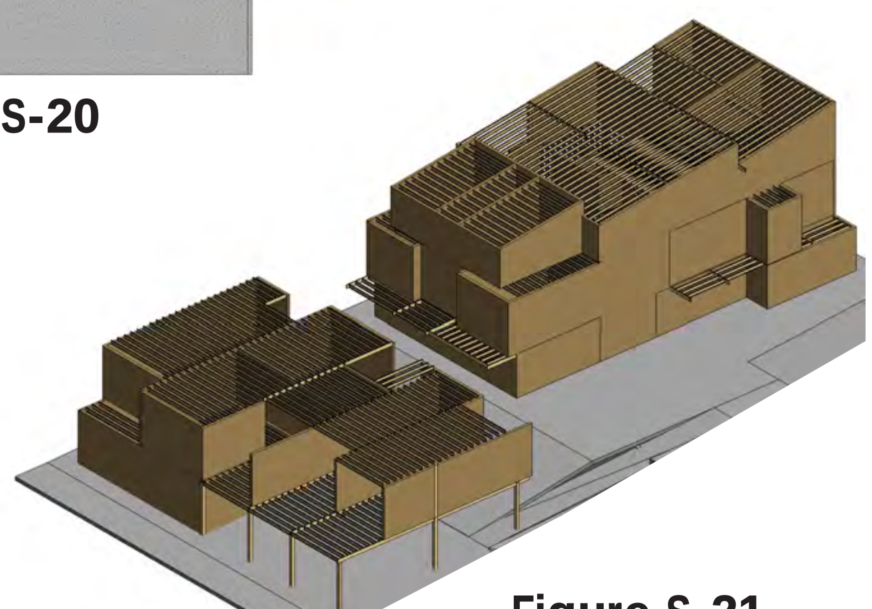


Figure S-21

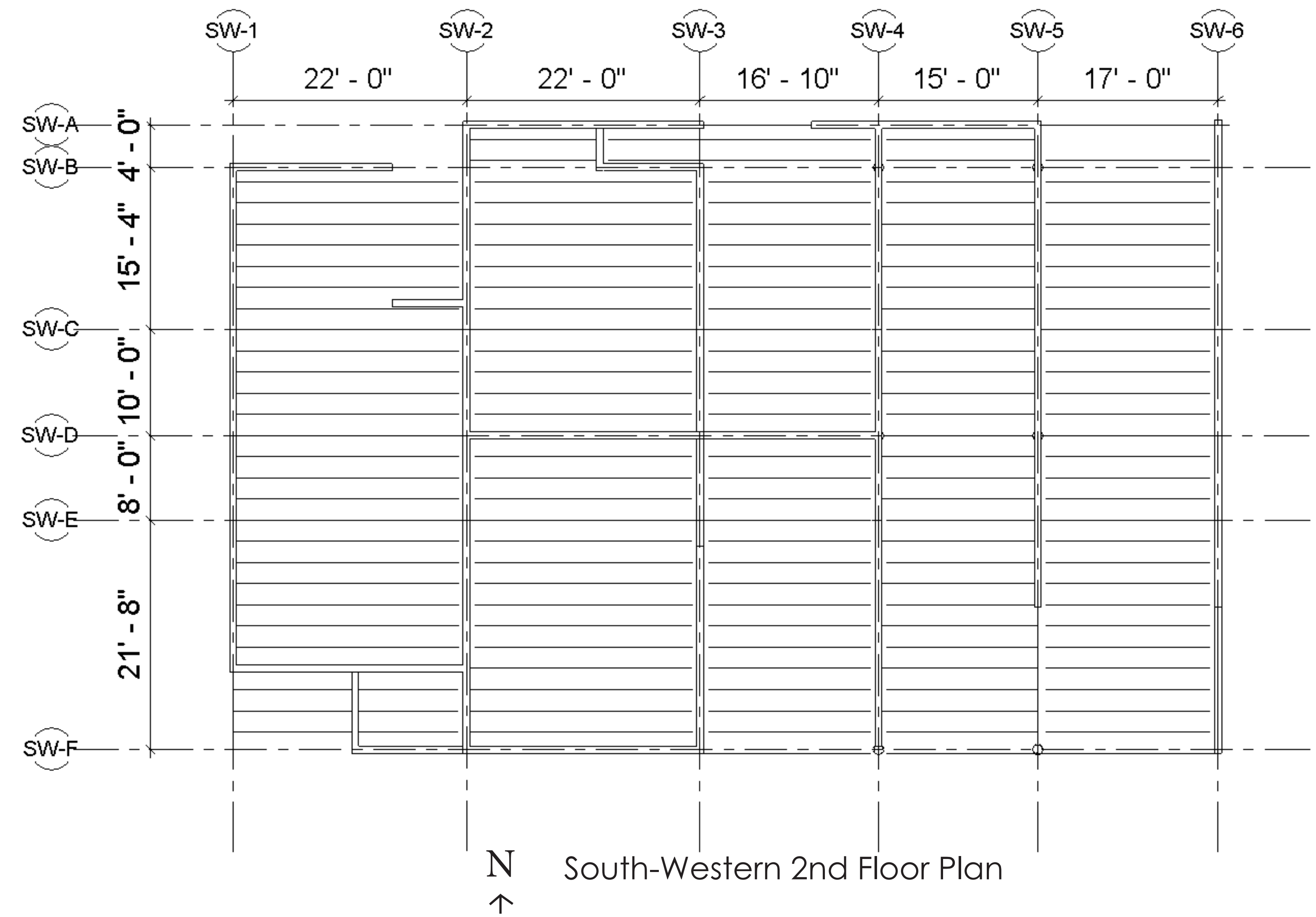


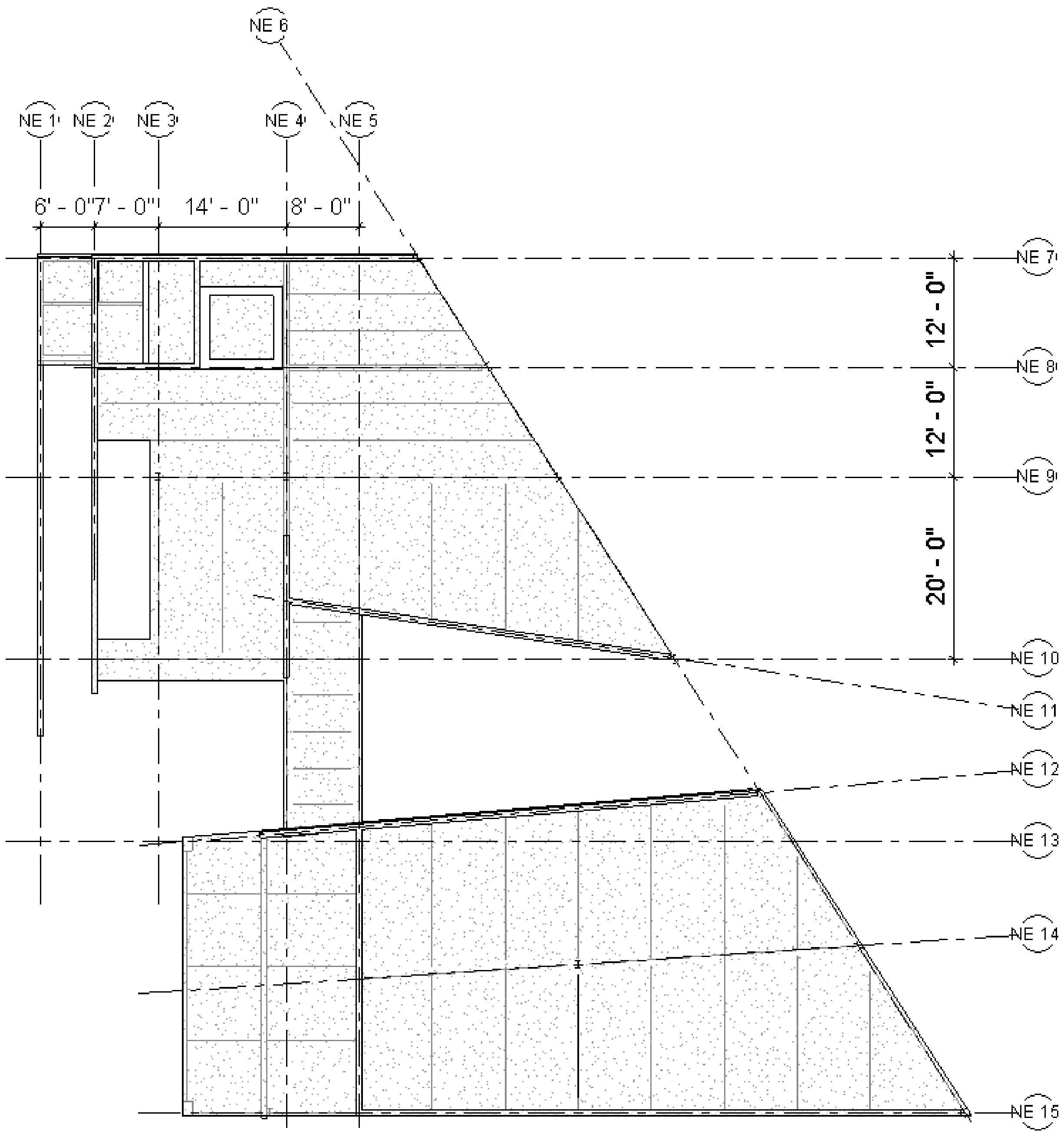
Figure S-22

Gravity System Configuration

Carla Simental
June 3, 2016

Eastern System

Concrete on steel deck | Wide-flange beams and columns | Masonry bearing walls



North-Eastern 2nd Floor Plan

Figure S-23

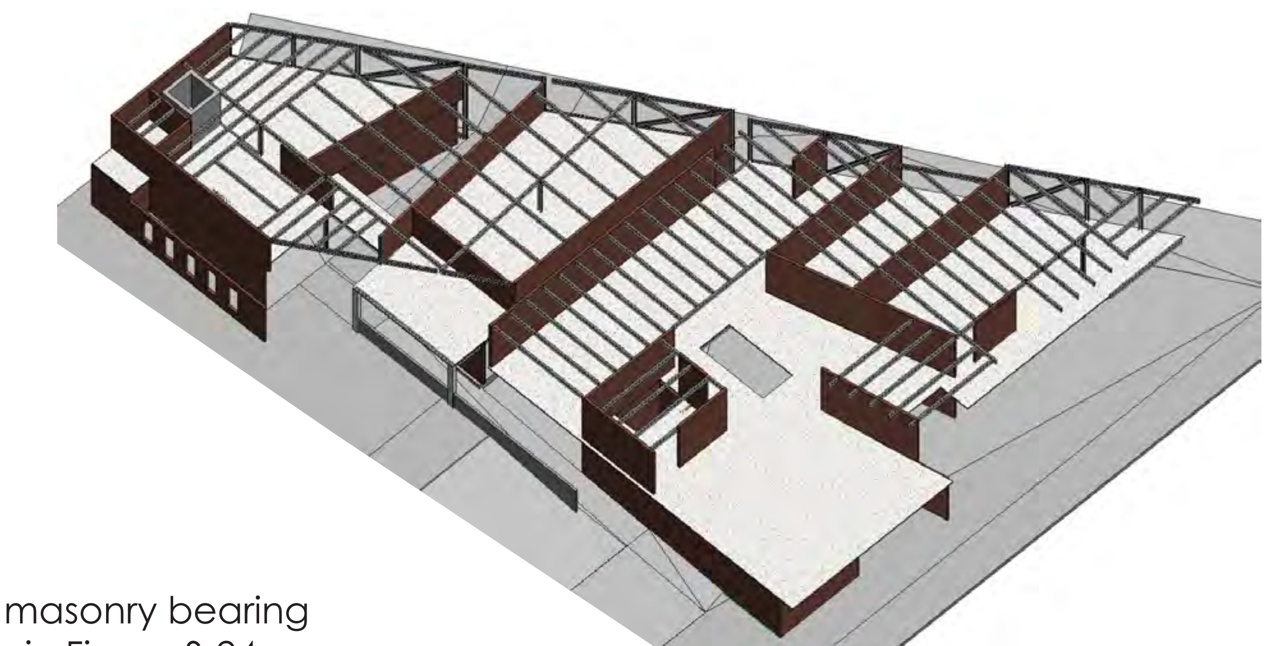
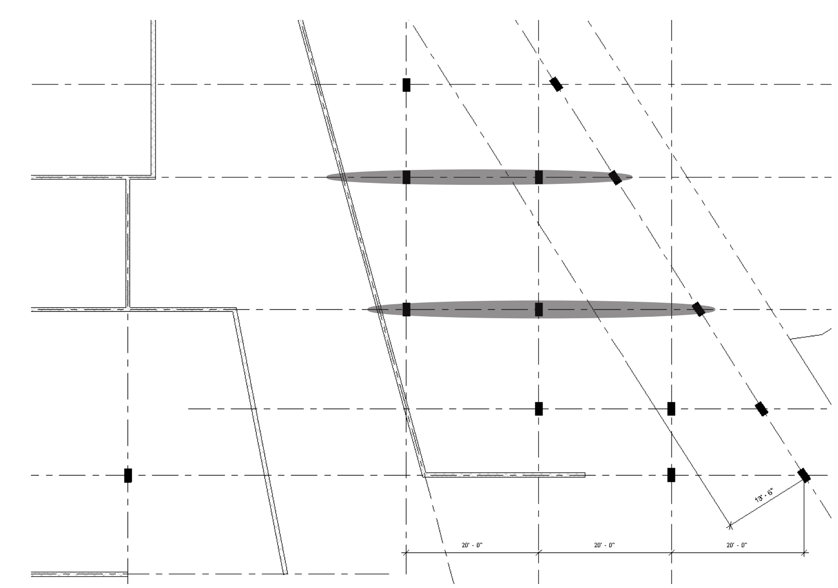


Figure S-24

Wide-flange columns and masonry bearing walls are located as shown in Figure S-24. Wide-flange girders span in the East-West direction from bearing walls to columns. Wide-flange beams span in the North-South direction between girders. All bearing walls on the 2nd floor are located above a wall on the 1st floor except where indicated in Figure S-25. In these locations, the bearing alls rest on girders which then transfer the gravity loads to the columns below.



South-Eastern 1st Floor Plan

N

Figure S-25

Lateral Sytem Configuration

Carla Simental
June 3, 2016

Western System

Wood shear walls

Timber shear walls are placed on the perimeters of both the North and South Western structures and in some interior locations as shown in Figure S-26. Where shear walls are located on the 2nd floor but not on the 1st floor right below, columns are placed to resist the overturning of the shear walls (Figure S-27). Where shear walls are not vertically aligned, straps are used to tie the walls together so they may act as a continuous shear wall.

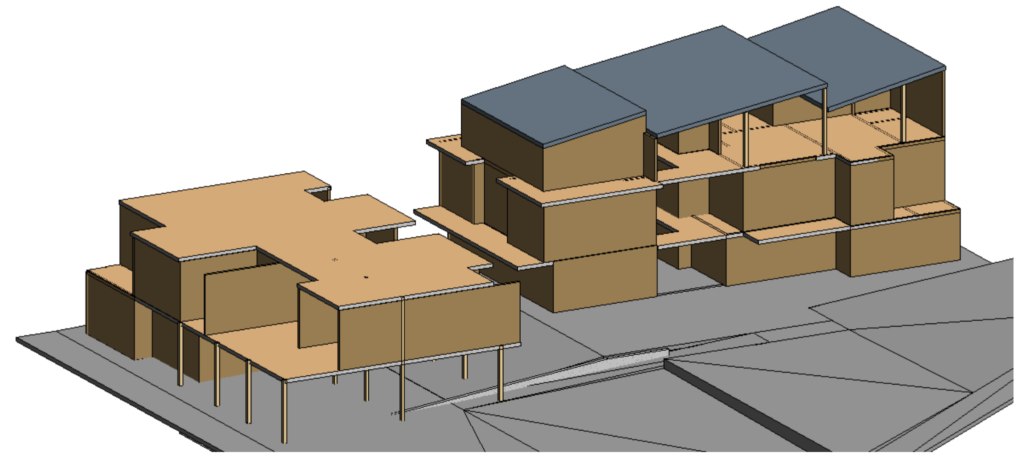


Figure S-26

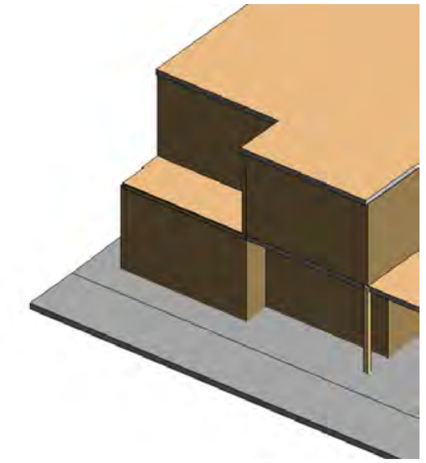


Figure S-27

Eastern System

Masonry shear walls | HSS Braced Frames

Masonry shear walls and braced steel frames are located as shown on Figure S-28 and S-29. The masonry shear walls are mostly located in interior spaces and toward the back of the building on the North and West sides. The braced steel frames are located toward the storefront and on the Broad facing areas on the East and South ends. In some locations, architectural walls are located on the 2nd floor but walls are not architecturally desired underneath on the 1st floor. In these instances, steel braced frames are located on both levels to allow for adequate transfer of shear forces from one level to the next without a change in stiffness. Since the 2nd floor areas are intended to be more private and more walls are desired, a masonry veneer is used on the 2nd floor for privacy wherever a steel braced frame is located but not architecturally desired. This configuration allows for flexibility between architectural intent and structural needs.

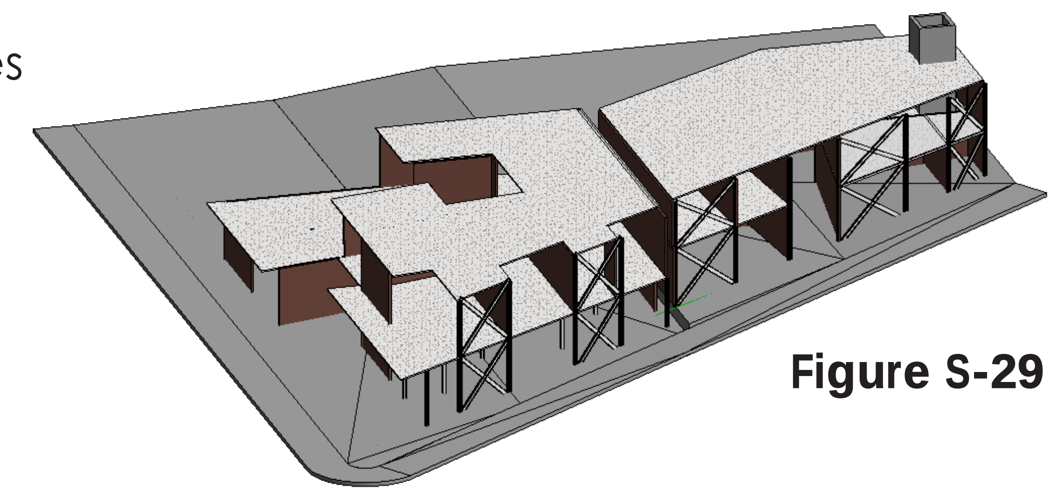


Figure S-29

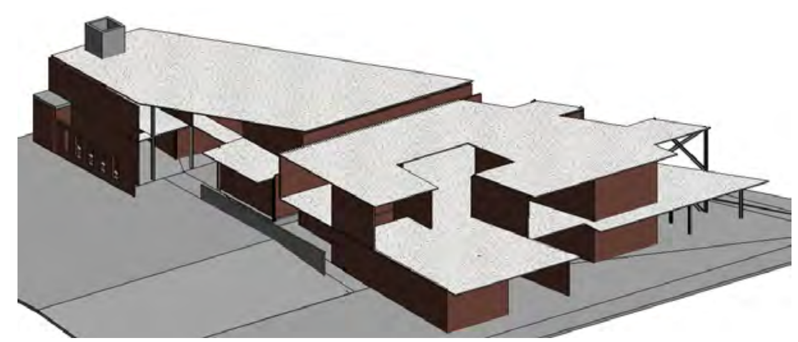
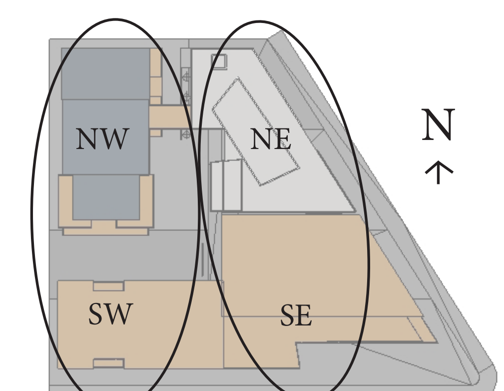


Figure S-28



Foundation Sytem Configuration

Carla Simental
June 3, 2016

Mat Foundations

During the Phase 1 construction, three mat foundations are poured as shown in Figure S-30. The mat foundation located on the West most side is long because of the parking structure located under ground (Figure S-31). During the Phase 2 construction phase, the mat foundation will be poured and integrated to the existing mat foundations. For the West side of the Phase 1 construction, the mat foundations will be placed below the parking and below the timber portion of the structure as shown. For the East side of the Phase 1 construction, the top of the mat foundation will be located at grade level. Similarly, for the Phase 2 construction, the mat foundation will be integrated with the existing mat foundations located at grade level.

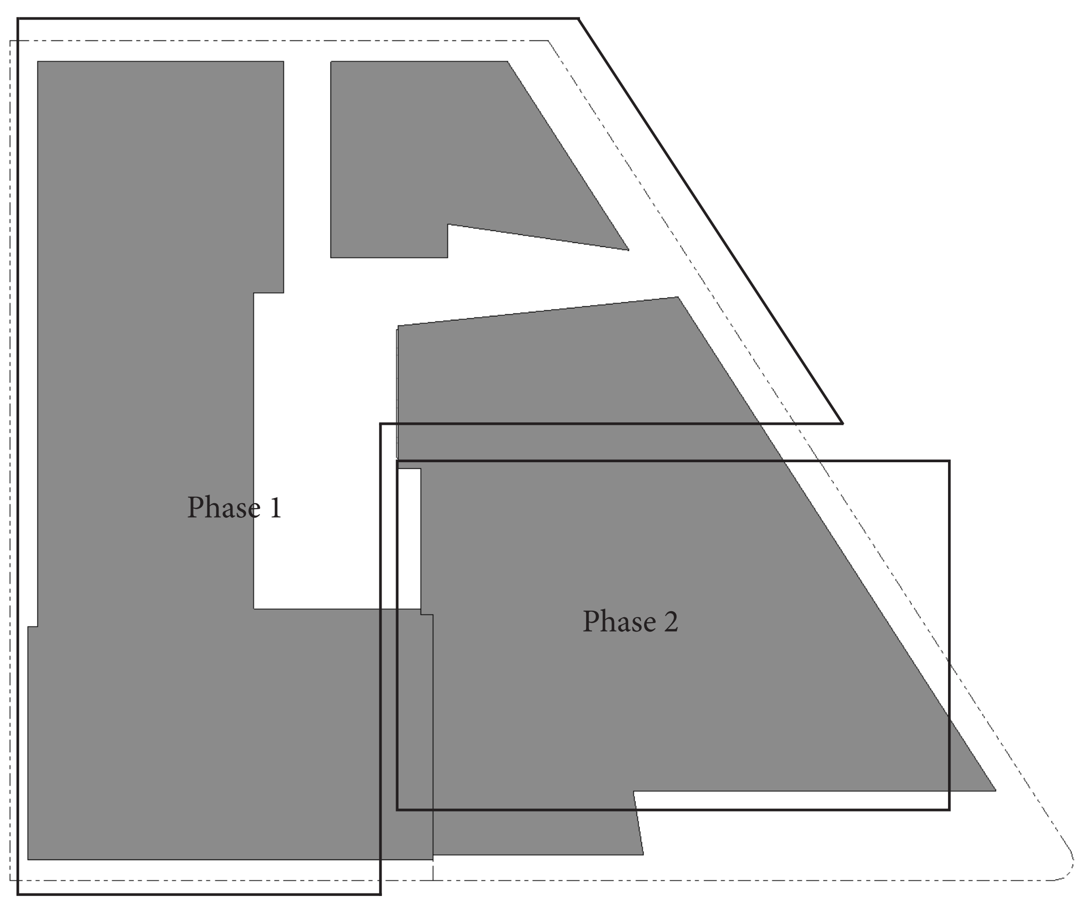


Figure S-30

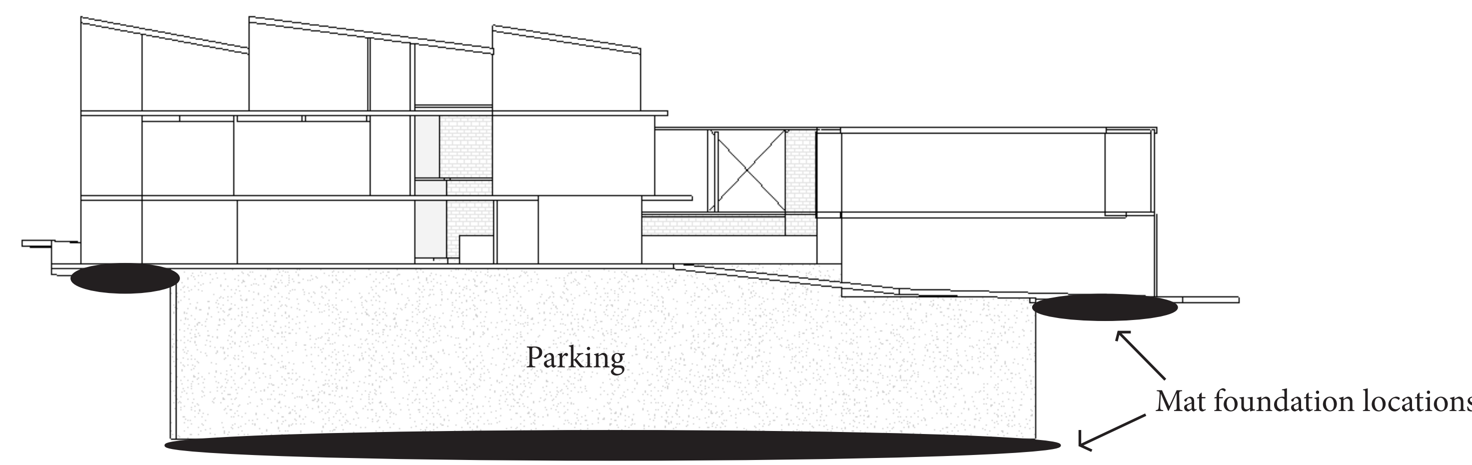


Figure S-31

Parking Sytem Configuration

Carla Simental
June 3, 2016

Mechanical Parking / Automated Parking System

In this Automated Parking System (APS), a waiting zone is available just before the automated lift region. The waiting zone area is intended to help reduce the on street traffic that may occur due to multiple vehicles entering the autmoated parking at once. The automated lift is located north of the waiting zone. Once on the automated lift and all people have exited, the vehicle moves automatically underground.

The vehicle then goes onto a rotation area where it is rotated 180 degrees before being parked. It is then placed into one of the 10 two-row surface subsystems with an open parking space. There are two levels of subsystems with five on each level. A total of 114 parking spaces are available with this configuration.

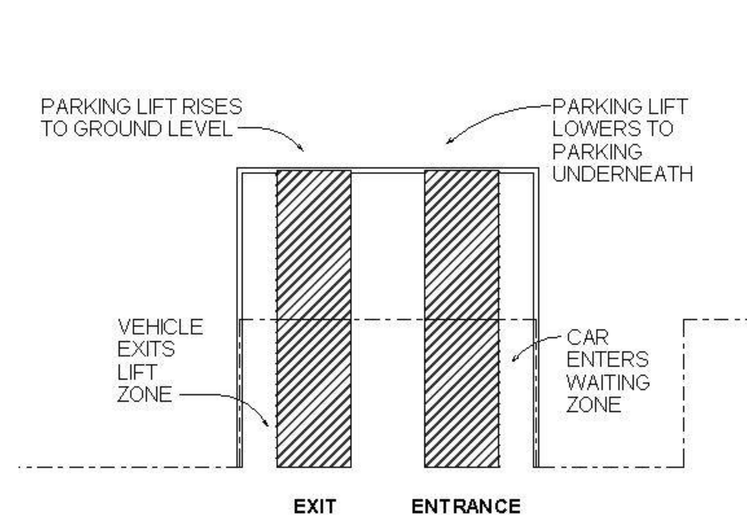


Figure S-32

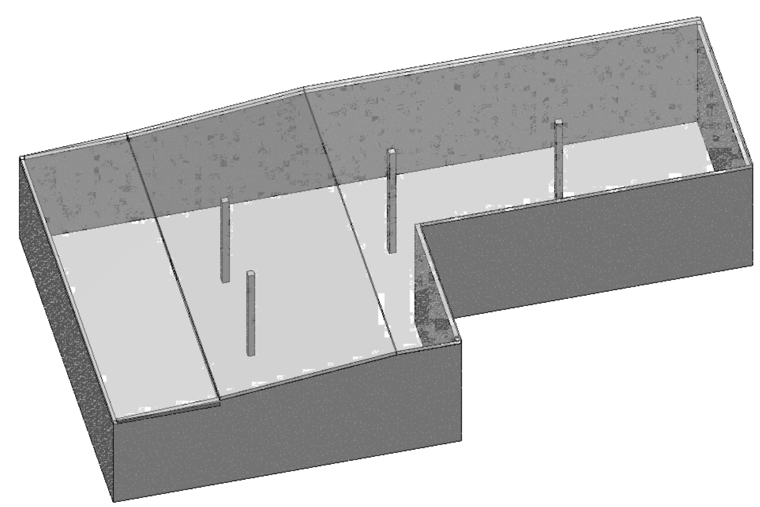


Figure S-33

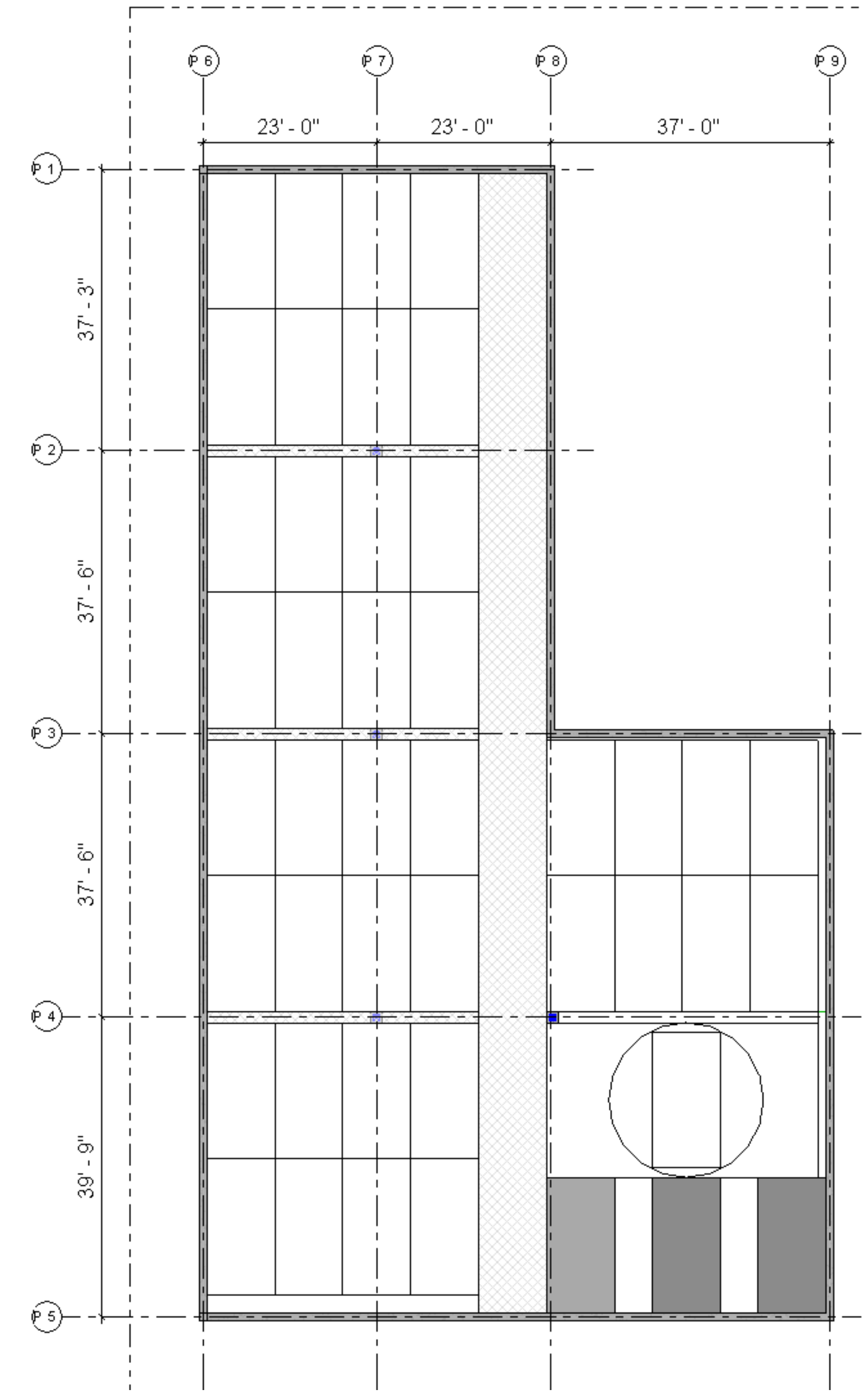
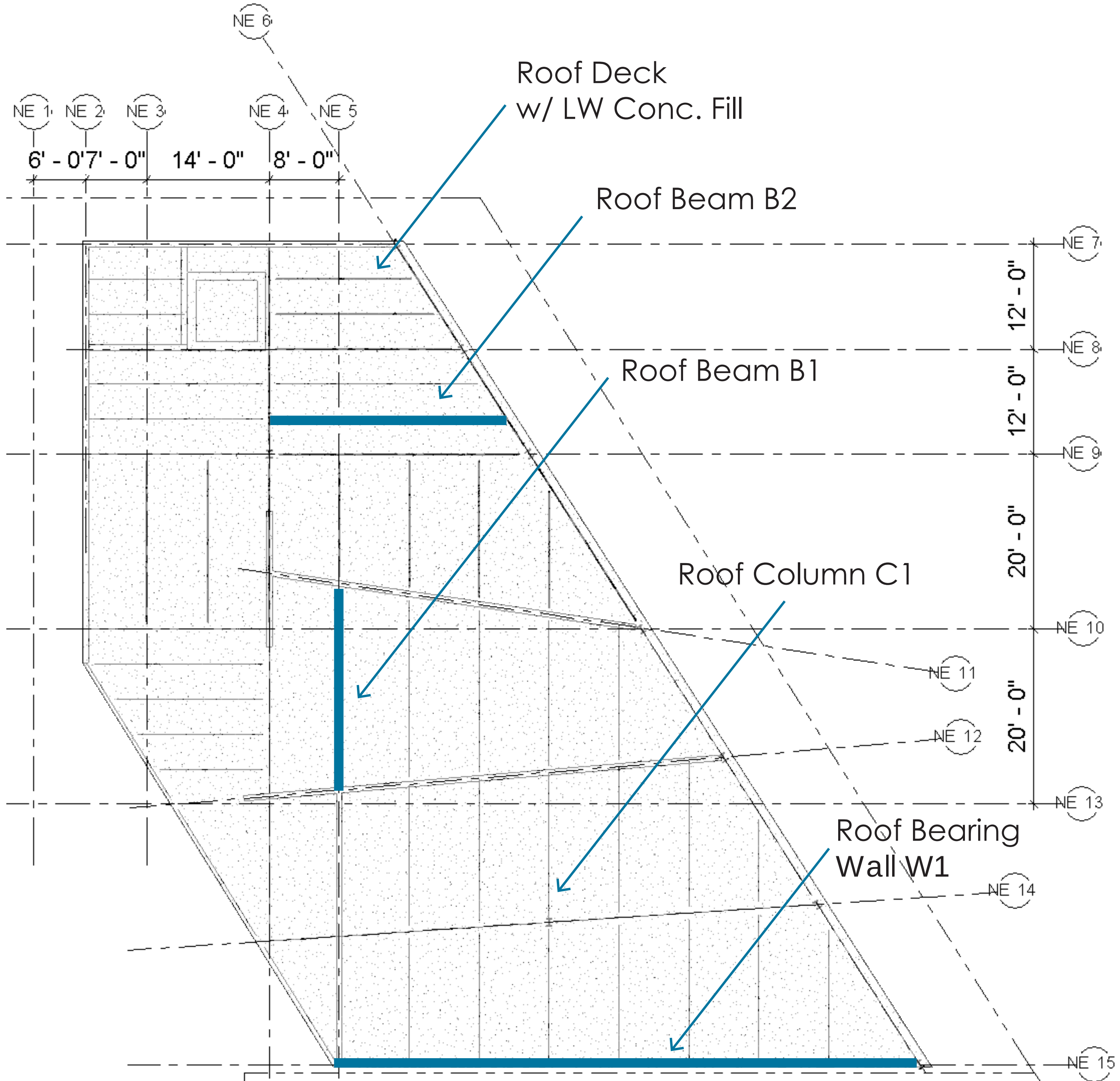


Figure S-34

Carla Simental
June 3, 2016

Gravity System Sizing

Eastern System



N

North-Eastern Roof Plan

Figure S-35

Roof Beam B1

(D) $w_D = (8ft)(333.4psf) = 2667plf$

(L) $A_T = (8ft)(24ft) = 192ft^2 < 200ft^2$

$w_{Lr} = (8ft)(97.8psf) = 782plf$

LOAD CASE #1: $w = 1.4D = (1.4)(2667plf) = 3{,}734plf = 3.7klf$

LOAD CASE #3: $w = 1.2D + 1.6L_r = (1.2)(2667plf) + (1.6)(782plf) = 4452plf = 4.5klf$

$M_u = (4.5klf)(24ft)^2/8 = 324kft < \phi M_p = 358kft$

⇒ USE W21x44 @ TYP ROOF BEAM B1

Roof Beam B2

(D) $w_D = (4ft)(333.4psf) = 1334plf$

(L) $A_T = (4ft)(27ft) = 108ft^2 < 200ft^2$

$w_{Lr} = (4ft)(97.8psf) = 391plf$

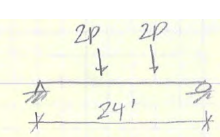
LOAD CASE #1: $w = 1.4D = (1.4)(1334plf) = 1868plf = 1.9klf$

LOAD CASE #3: $w = 1.2D + 1.6L_r = (1.2)(1334plf) + (1.6)(391plf) = 2226plf = 2.2klf$

$M_u = (2.2klf)(27ft)^2/8 = 201kft < \phi M_p = 203kft$

⇒ USE W16x31 @ TYP ROOF BEAM B2

Roof Girder B3



$P = (1.3klf)(18ft) = 23.4k$

$M_u = (2)(23.4k)(8ft) = 374kft < 379kft$

⇒ USE W18x50 @ GIRDER B3

Roof Deck w/ LW Conc. Fill

$D + L = 61psf + 100psf = 161psf$

TRY 6 1/4" LW CONC SLAB ON PLW2 22 GAGE DECK

@ 6ft SPAN → 400psf > 161psf ✓

Roof Bearing Wall W1

$P_u = (7)(16ft/2)[(1.2)(8ft)(333.4psf) + (1.6)(8ft)(97.8psf)] = 249k$

$f'_m = 1500psi$

$A = (65ft)(8in)(12in/ft) = 6240in^2$

$P_n = (0.8)(0.8)(1500psi)(6240in^2)/1000lb/k = 5991k$

$\phi P_n = (0.6)(5991k) = 3595k > P_u = 249k$

⇒ USE 8" THICK WALL

Roof Column C1

$P_u = (3.5)(34ft/2)[(1.2)(8ft)(333.4psf) + (1.6)(8ft)(97.8psf)] = 265k$

$\phi P_n = 283k$ @ $KL = 12ft > P_u = 265k$ ✓ W8x31

CHECK W/ 2ND FLOOR COLUMN C1

⇒ USE W8x48 @ ROOF COLUMN C1

Gravity System Sizing

Carla Simental
June 3, 2016

Eastern System Continued

2nd Floor Beam B1

(D) $w_D = (8ft)(60.3\ psf) = 482plf$

(L) $A_T = (8ft)(18ft) = 144ft^2 < 200ft^2$

$w_L = (8ft)(59psf) = 472plf$

LOAD CASE #1: $w = 1.4D = (1.4)(482plf) = 675plf$

LOAD CASE #2: $w = 1.2D + 1.6L = (1.2)(482plf) + (1.6)(472plf) = 1334plf$

$M_u = (1.3klf)(18ft)^2/8 = 52.7kft < M_p = 65.3kft$

⇒ USE W12 x 14 @ 2ND FLOOR BEAM B1

2nd Floor Beam B2

(D) $w_D = (4ft)(60.3psf) = 241plf$

(L) $A_T = (4ft)(27ft) = 108\ ft^2 < 200\ ft^2$

$w_L = (4ft)(59psf) = 236plf$

LOAD CASE #2: $w = (1.2)(241plf) + (1.6)(236plf) = 667plf$

$M_u = (0.7klf)(27ft)^2/8 = 64\ kft < 65.3k$

⇒ USE W12 x 14 @2ND FLOOR BEAM B2

2nd Floor Bearing Wall W1

$P_u = (7)(16ft/2)[(1.2)(8ft)(60.3psf) + (1.6)(8ft)(59psf)] + 249k = 324k$

$f'_m = 1500psi$

$A = (65ft)(8in)(12in/ft) = 6240in^2$

$P_n = (0.8)(0.8)(1500psi)(6240in^2)/1000lb/k = 5991k$

$\phi P_n = (0.6)(5991k) = 3595k > P_u = 324k$ ✓

⇒ USE 8" THICK WALL

2nd Floor Girder B3

2P 2P
↓ ↓
24'

$P = (1.3klf)(18ft) = 23.4k$

$M_u = (2)(23.4k)(8ft) = 374\ kft < 379kft$

⇒ USE W18x50 @ GIRDER B3

2nd Floor Deck w/ Conc. Fill

$D + L = 47.7psf + 59psf = 106.7psf$

TRY 5 1/4" LW CONC SLAB ON PLW2 22 GAGE DECK

@ 6ft SPAN → 400psf > 106.7psf ✓

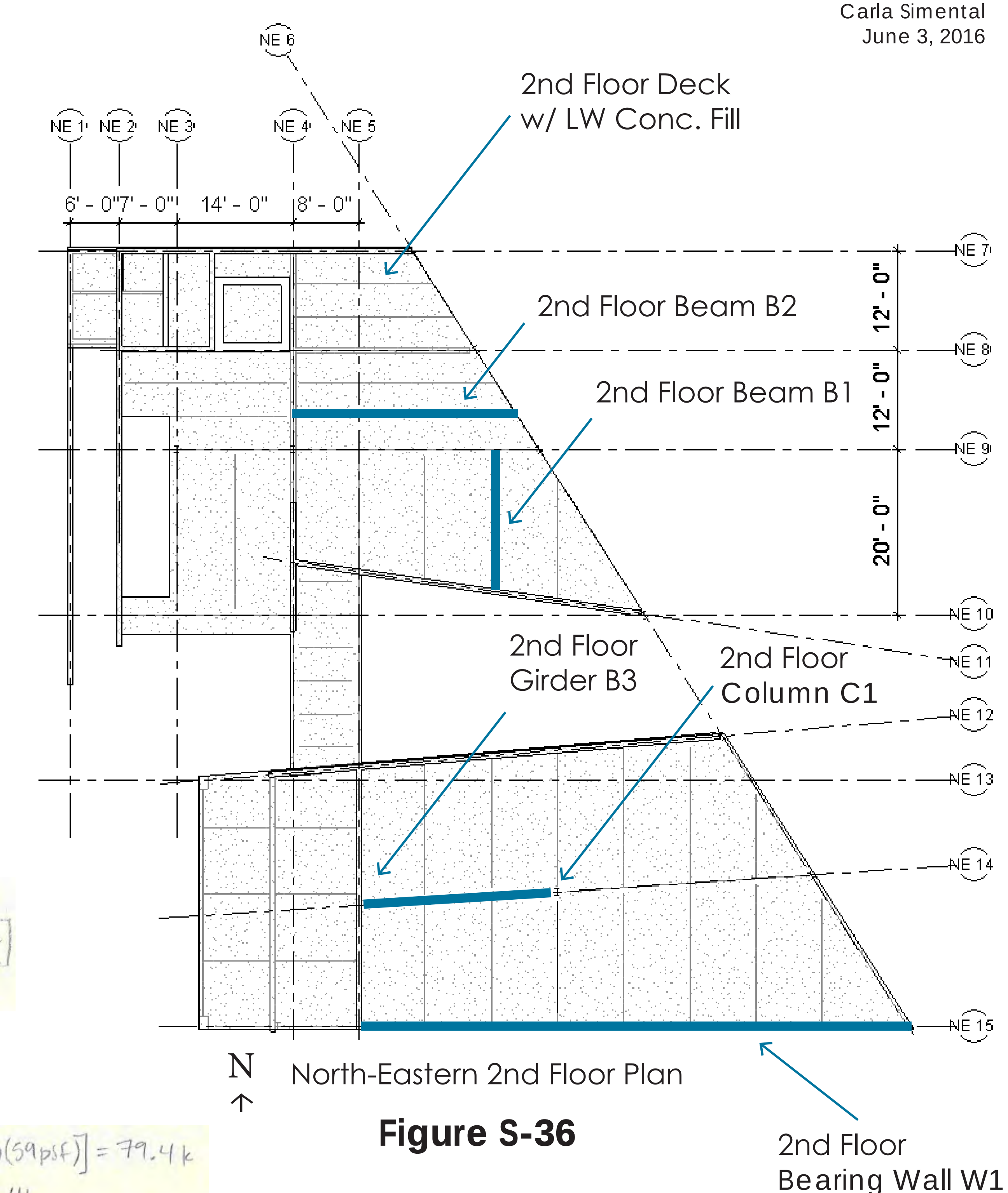
2nd Floor Column C1

$P_{2ND} = (3.5)(34ft/2)[(1.2)(8ft)(60.3psf) + (1.6)(8ft)(59psf)] = 79.4k$

$P_u = P_{ROOF} + P_{2ND} = 265k + 79.4k = 344.4k$

$\phi P_n = 367k$ @ $KL = 15ft > P_u = 344.4k$ ✓

⇒ USE W8x48@ @ 2ND FLOOR C1



North-Eastern 2nd Floor Plan

Figure S-36

Carla Simental
June 3, 2016

Gravity System Sizing

Western System

Roof Deck w/ LW Conc. Fill

D + L = 35 psf + 20 psf = 55 psf

TRY [3 1/2" LW CONC FILL AND PLB 22 GAGE DECK]

@ 4 ft SPAN → 400 psf > 55 psf ✓

Roof Joist B1

SLOPE: 4:26 → 1:6.5

$w = (35psf)(6.576/6.5) + 20psf = 55.4\ plf$

$M_u = (55.4plf)(24ft^2)/8 = 3989\ ft\cdot lb < M_c = 4{,}215\ ft\text{-}lb$ ✓

⇒ USE [11 7/8" TJI 230 @ 2 ft o.c.]

Roof Beam B2

$w = (55psf)(15ft + 24ft)(1/2) = 1073\ plf < 1{,}132\ plf$ ✓

⇒ [USE 13' LONG 3 1/2" x 16" LSL]

Roof Column C1

$P_u = (1/2)(15ft + 24ft)(1/2)(26ft)(55psf) = 13{,}943\ lbs$

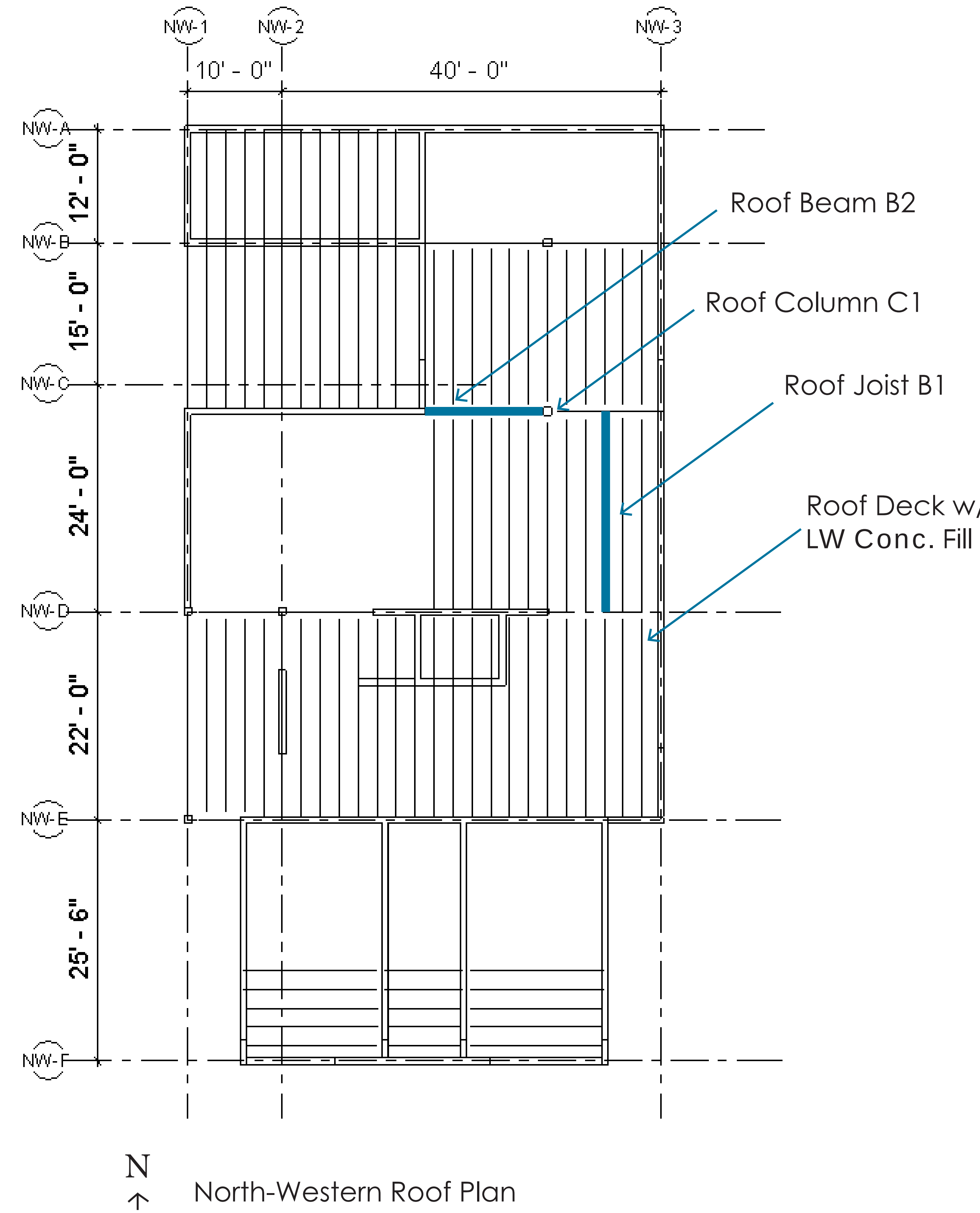
$f'_c = 13{,}943\ lbs/(7.5in \times 7.5in) = 248\ psi$

$F'_c = F_c \times C_D \times C_M \times C_t \times C_F \times C_i \times C_P$
$= (1000psi)(1.25)(1.0)(1.0)(1.0)(1.0)(0.703) = 562.4\ psi > 248\ psi$ ✓

$F_{cE} = 0.822E'_{min}/(l_e/d)^2 = (0.822)(580{,}000psi)/(12\times12/7.5)^2 = 1293$

$$C_P = \frac{1 + (1293/1250)}{(2)(0.8)} - \sqrt{\left[\frac{1 + (1293/1250)}{(2)(0.8)}\right]^2 - \frac{(1293/1250)}{0.8}} = 0.703$$

⇒ USE [8"x8" SAWN LUMBER POST @ 12 ft HEIGHT]



North-Western Roof Plan

Figure S-37

Gravity System Sizing

Carla Simental
June 3, 2016

Western System Continued

2nd Floor Deck w/ LW Conc. Fill

$D+L = 31psf + 52psf = 83psf$

TRY [3½" LW CONC FILL AND PLB 22 GAGE DECK]

@ 4ft SPAN → 400psf > 83psf ✓

2nd Floor Joist B1

$D+L = 41psf + 52psf = 93psf$

$W = (93psf)(2ft) = 186plf$

$M = (186plf)(22ft)^2/8 = 11{,}253\ ft\text{-}lb$

TRY [14" TJI 560 @ 2ft o.c]

$M_u = 11{,}253\ ft\text{-}lb < M_c = 11{,}275\ ft\text{-}lb$ ✓

2nd Floor Bearing Wall W1

$w_u = (22ft)(93psf) + (22ft)(55psf) = 3256plf$

$P_u = (3256\ plf)(16in/stud)/(12in/ft) = 4341\ lb/stud$

$f'c = 4341\ lb/(2.5in \times 3.5in) = 496\ psi$

$F'c_{\perp} = F_{c\perp} \times C_M \times C_t \times C_i \times C_b$

$= (625psi)(1.0)(1.0)(1.0)(4in + 0.375/4in) = 684psi > 496\ psi$ ✓

$F'c = F_c \times C_D \times C_M \times C_t \times C_F \times C_i \times C_p$

$= (1500psi)(1.0)(1.0)(1.0)(1.15)(1.0)(1.0) = 1{,}725psi > 496psi$ ✓

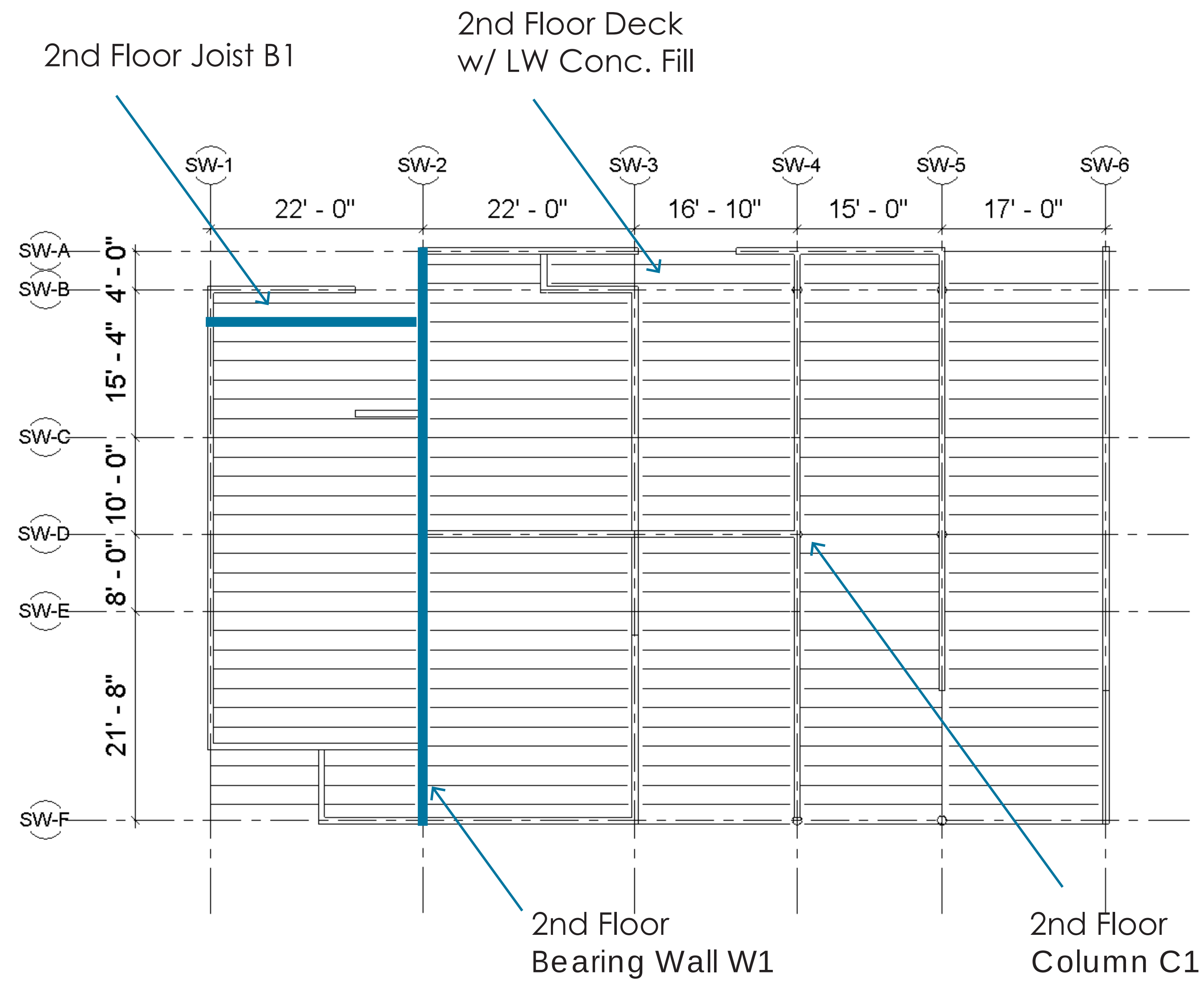
⇒ [USE NO 1. STRUCTURAL DOUGLAS-FIR LARCH 2x4 SILLS AND STUDS]

2nd Floor Concrete Column C1

$P_u = (16.83ft + 15ft)(14.83ft + 12.67ft)(93psf + 55psf) = 129.5k$

$\phi P_n = (0.85)(0.75)[(0.85)(2500psi)(6in)^2(\pi)] = 153k$

⇒ [USE 12" ϕ CIRCULAR COLUMN W/SPIRALS]



N ↑ South-Western 2nd Floor Plan

Figure S-38

Carla Simental
June 3, 2016

Lateral System Sizing

Eastern System

Base Shear

$A_{ROOF} = (43')(42') + (1/2)(24')(42') + (1/2)(35')(50') + (32')(50') + (1/2)(33')(50') = 5610\,ft^2$

$A_{2ND} = (37')(44') + (1/2)(24')(44') + (20')(8') + (32')(75') = 4716\,ft^2$

$L_{WALL\,ROOF} = 44' + 29' + 40' + 15' + 56' + 35' + 70' = 289\,ft$

$L_{WALL\,2ND} = 44' + 35' + 44' + 51' + 40' + 56' + 35' + 70' = 375\,ft$

$W_{ROOF} = (333.4\,psf)(5610\,ft^2) + (289\,ft)(120\,pcf)(8/12\,ft)(12\,ft) = 2148\,k$

$W_{2ND} = (60.3\,psf)(4716\,ft^2) + (375\,ft)(120\,pcf)(8/12\,ft)(15\,ft) = 734\,k$

$C_s = \dfrac{S_{DS}}{\left(\frac{R}{I_e}\right)} = \dfrac{0.804g}{\left(\frac{5}{1.0}\right)} = 0.161$

$V_b = (0.161)(2148k + 734k) = 464k$

Story Forces

$F_x = C_{vx} V$ (ASCE 7-10 EQN 12.8-11)

$C_{V\,ROOF} = \dfrac{(2148)(12)}{(2148)(12) + (734)(15)} = 0.7$

$C_{V\,2ND} = \dfrac{(734)(15)}{(2148)(12) + (734)(15)} = 0.3$

$F_{ROOF} = (0.7)(464k) = 325k$

$F_{2ND} = (0.3)(464k) = 139k$

Brace Stiffnesses

$k_{A1} = \dfrac{EA}{L}\cos^2\theta = \dfrac{(29000\,ksi)(7.88\,in^2)(14.5/20.9)^2}{(20.9 \times 12\,in)} = 439\,k/in$

$k_{A2} = \dfrac{(29000\,ksi)(7.88\,in^2)(14.5/18.8)^2}{(18.8 \times 12\,in)} = 603\,k/in$

$k_{B1} = \dfrac{(29000\,ksi)(7.88\,in^2)(24/28.3)^2}{(28.3 \times 12)} = 484\,k/in$

$k_{B2} = \dfrac{(29000\,ksi)(7.88\,in^2)(24/26.8)^2}{(26.8 \times 12\,in)} = 570\,k/in$

$k_{C1} = \dfrac{(29000\,ksi)(7.88\,in^2)(22/26.6)^2}{(26.6 \times 12\,in)} = 490\,k/in$

$k_{C2} = \dfrac{(29000\,ksi)(7.88\,in^2)(22/25.1)^2}{(25.1 \times 12\,in)} = 583\,k/in$

$k_{UPPER\,BRACE\,LINE} = (2)(603 + 570 + 583\,k/in) = 3512\,k/in$

$k_{LOWER\,BRACE\,LINE} = (2)(439 + 484 + 490 + 490\,k/in) = 3806\,k/in$

Wall Stiffnesses

$k_{WALL\,A1} = \dfrac{Et}{\left(\frac{h}{L}\right)\left[\left(\frac{h}{L}\right)^2 + 3\right]} = \dfrac{(0.4)(900)(1500\,psi)(8\,in)}{\left(\frac{15}{32}\right)\left[\left(\frac{15}{32}\right)^2 + 3\right]} = 2862\,k/in$

$k_{WALL\,A2} = \dfrac{(0.4)(900)(1500\,psi)(8\,in)}{\left(\frac{12}{32}\right)\left[\left(\frac{12}{32}\right)^2 + 3\right]} = 3668\,k/in$

$k_{WALL\,B1} = \dfrac{(0.4)(900)(1500\,psi)(8\,in)}{\left(\frac{15}{30}\right)\left[\left(\frac{15}{30}\right)^2 + 3\right]} = 2658\,k/in$

$k_{WALL\,C1} = \dfrac{(0.4)(900)(1500\,psi)(8\,in)}{\left(\frac{15}{8}\right)\left[\left(\frac{15}{8}\right)^2 + 3\right]} = 354\,k/in$

$k_{WALL\,C2} = \dfrac{(0.4)(900)(1500\,psi)(8\,in)}{\left(\frac{12}{8}\right)\left[\left(\frac{12}{8}\right)^2 + 3\right]} = 545\,k/in$

$k_{UPPER\,WALL\,LINE} = 3668 + (2)(545) = 4758\,k/in$

$k_{LOWER\,WALL\,LINE} = 2862 + 2658 + (2)(354) = 6228\,k/in$

$k_{UPPER\,TOTAL} = 3512 + 4758 = 8{,}270\,k/in$

$k_{LOWER\,TOTAL} = 3806 + 6228 = 10{,}034\,k/in$

Forces to Brace Lines

$F_{UPPER\,BRACE\,LINE} = (325k)\left(\dfrac{3512\,k/in}{8270\,k/in}\right) = 138k$

$F_{LOWER\,BRACE\,LINE} = (464k)\left(\dfrac{3806\,k/in}{10{,}034\,k/in}\right) = 176k$

Lateral System Sizing

Carla Simental
June 3, 2016

Eastern System Continued

Steel Brace Capacities

HSS 5x5x1/2 BRACES

AXIAL COMPRESSION CAPACITIES (AISC TABLE 4-4)

$L_{A1} = 20.9\text{ft}: \phi P_n = 57.0\text{k} \rightarrow P_H = (57\text{k})(14.5/20.9) = 39.5\text{k}$

$L_{A2} = 18.8\text{ft}: \phi P_n = 69.6\text{k} \rightarrow P_H = (69.6\text{k})(14.5/18.8) = 53.7\text{k}$

$L_{B1} = 28.3\text{ft}: \phi P_n = 29.9\text{k} \rightarrow P_H = (29.9\text{k})(24/28.3) = 25.4\text{k}$

$L_{B2} = 26.8\text{ft}: \phi P_n = 34.5\text{k} \rightarrow P_H = (34.5\text{k})(24/26.8) = 30.9\text{k}$

$L_{C1} = 26.6\text{ft}: \phi P_n = 34.5\text{k} \rightarrow P_H = (34.5\text{k})(22/26.6) = 28.5\text{k}$

$L_{C2} = 25.1\text{ft}: \phi P_n = 37.2\text{k} \rightarrow P_H = (37.2\text{k})(22/25.1) = 32.6\text{k}$

AXIAL TENSION CAPACITIES (AISC D2-1)

$\phi P_n = 0.9 F_y A_g$

$\Rightarrow \phi P_n = (0.9)(46\text{ksi})(7.88\text{in}^2) = 326\text{k}$

$A_1 \rightarrow P_H = (326\text{k})(14.5/20.9) = 226\text{k}$

$A_2 \rightarrow P_H = (326\text{k})(14.5/18.8) = 251\text{k}$

$B_1 \rightarrow P_H = (326\text{k})(24/28.3) = 276\text{k}$

$B_2 \rightarrow P_H = (326\text{k})(24/26.8) = 292\text{k}$

$C_1 \rightarrow P_H = (326\text{k})(22/26.6) = 269\text{k}$

$C_2 \rightarrow P_H = (326\text{k})(22/25.1) = 286\text{k}$

BY INSPECTION, BRACES ADEQUATE FOR SEISMIC LOADS

Masonry Wall Capacities

MSJC-13: 9.3.4.1.2.1

$V_{nm} = \left[4 - 1.75\left(\frac{M_u}{V_u d_v}\right)\right] A_{nv}\sqrt{f'_m} + 0.25 P_u$

$V_{nm} = [4 - 1.75] A_{nv}\sqrt{f'_m}$

$= (2.25)(8)(30)(12)\sqrt{1500} = 251\text{k} > 187\text{k}$

$\Rightarrow$ BY INSPECTION, ALL WALLS ADEQUATE

Diaphragm Aspect Ratios

Diaphragm 1

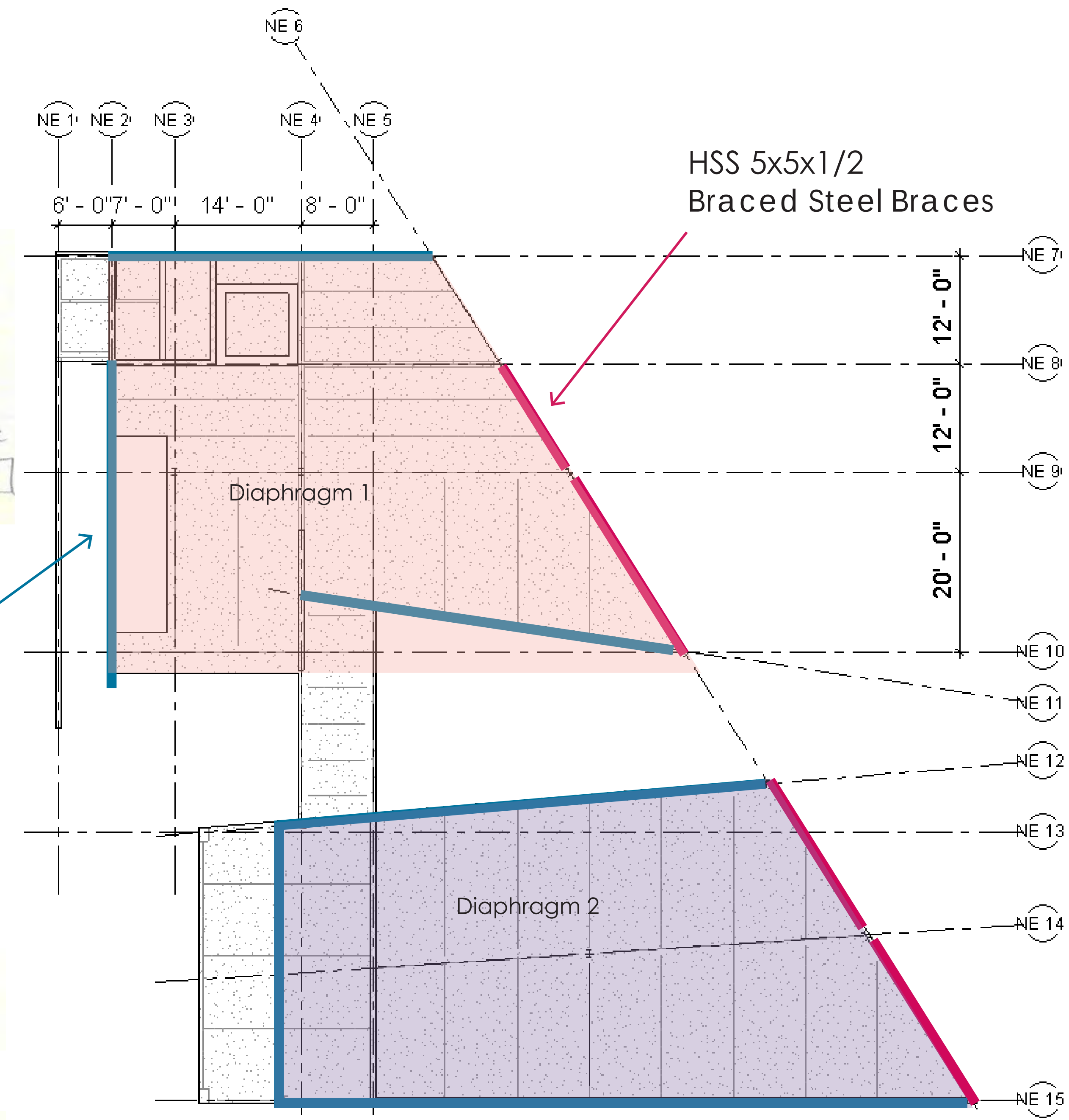
N-S EQK: $l/h = 63/44 = 1.43:1 < 3:1$ ✓

E-W EQK: $l/h = 44/63 < 3:1$ ✓

Diaphragm 2

N-S EQK: $l/h = 77/31 = 2.48:1 < 3:1$ ✓

E-W EQK: $l/h = 31/77 < 3:1$ ✓



N

North-Eastern 2nd Floor Plan

Figure S-39

Lateral System Sizing

Carla Simental
June 3, 2016

Western System

Base Shear

$A_{R\ or\ 2ND} = (4' + 15.33' + 10.66' + 21.66')(22' + 22' + 16.83' + 15.83' + 17') = 4838\ ft^2$

$W_R = (35psf)(4838\ ft^2) + (6psf)(4838\ ft^2) = 198.4k$

$W_{2ND} = (41psf)(4838\ ft^2) + (12psf)(4838\ ft^2) = 256.4k$

$C_S = \dfrac{S_{DS}}{\left(\frac{R}{I_e}\right)} = \dfrac{0.804g}{\left(\frac{6.5}{1.0}\right)} = 0.124$

$V_b = (0.124)(198.4k + 256.4k) = 56.4k$

Check Shear Wall Capacities

BASED ON NDS TABLE 4.3A

15/32 STRUCTURAL 1 SHEATHING BLOCKED W/ 10d 6/6/12

$V_S = (0.8)(680plf) = 544plf$ (LRFD)

⟹ LENGTH OF WALL REQD = $V_b/V_S = 56.4k/0.544klf = 104\ ft$

NORTH-SOUTH DIRECTION: $(60ft)(4) - 8ft = 232ft > 104ft$ ✓

EAST-WEST DIRECTION: $(22ft)(5) = 110ft > 104ft$ ✓

⟹ SUFFICIENT SHEAR WALL LENGTHS

Diaphragm Aspect Ratios

Diaphragm 1

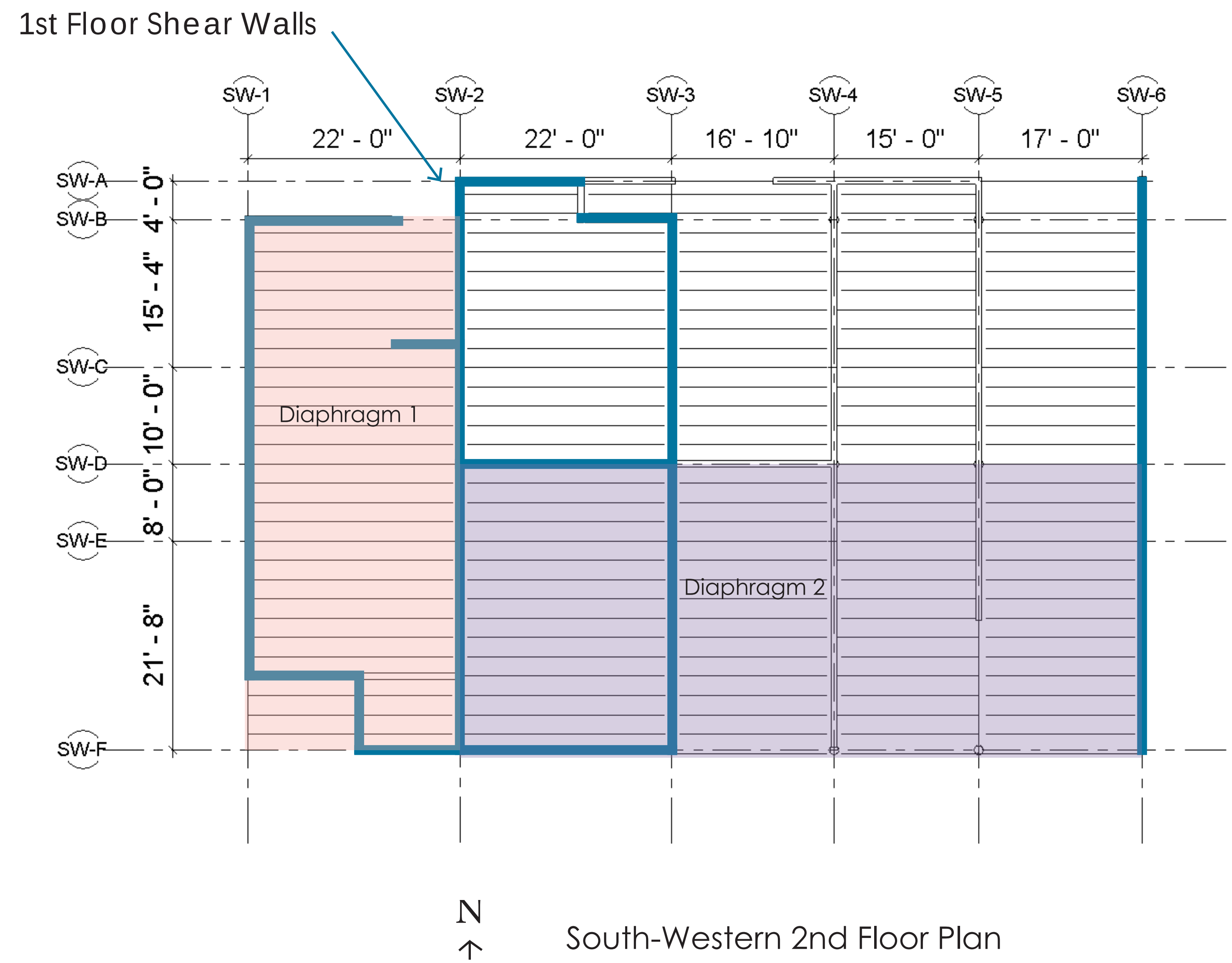
N-S EQK: SPAN/DEPTH = 22/55 < 3:1 ✓

E-W EQK: SPAN/DEPTH = 55/22 = 2.5:1 < 3:1 ✓

Diaphragm 2

N-S EQK: $l/h = 70.83/29.83 = 2.37:1 < 3:1$ ✓

E-W EQK: $l/h = 29.83/70.83 < 3:1$ ✓



South-Western 2nd Floor Plan

Figure S-40

Foundation System Sizing

Demand from Interior Column

$$P_{u\,TOTAL} = [(1.2)(31psf)+(1.6)(52psf)][(4925ft^2)(3)+(4838ft^2)]$$
$$+[(1.2)(35psf)+(1.6)(20psf)][4925ft^2+4838ft^2]$$
$$+(6ft)[4925ft^2+4838ft^2]$$
$$+(12psf)[(2)(4838ft^2)+(3)(4925ft^2)]$$
$$+(60psf)(9850ft^2)+(150pcf)(0.5ft)(9850ft^2)$$
$$+(470ft)(150pcf)(8/12\ ft)(18ft) = 5612k$$

$$P_{u\,COLUMN} = \left(\frac{5612k}{9850ft^2}\right)(1159ft^2) = 661k$$

Check Punching Shear

ACI 318-14: TABLE 22.6.5.2

$$\phi V_c = \phi 4 \lambda \sqrt{f'_c}\, B_o\, d$$

$$B_o = \pi r^2 = \pi(24in/2)^2 = 452in^2$$

$$\phi V_c = P_u$$

$$\phi 4 \lambda \sqrt{f'_c}\, B_o\, d = P_u$$

$$d = \frac{P_u}{\phi 4 \lambda \sqrt{f'_c}\, B_o}$$

$$= \frac{661k \times 1000lb/k}{(0.75)(4)(1.0)(\sqrt{3000psi})(452in^2)} = 9\ in$$

PER ACI, 6in REQ'D BELOW REINF'T

⇒ USE 15" MAT FOUNDATION

Basement Walls

18 ft TALL WALLS

BASED ON BASEMENT WALL SCHEDULE

USE 16" THICK WALLS

BASEMENT WALL SCHEDULE				
WALL REINFORCING				
WALL THICKNESS	'H' (MAX.)	'A' BARS	'B' BARS	'C' BARS
12"	12'-0"	#4 @ 12"	#4 @ 10"	#5 @ 10"
14"	15'-0"	#5 @ 16"	#5 @ 16"	#6 @ 8"
16"	20'-0"	#5 @ 16"	#5 @ 16"	#8 @ 10"
18"	20'-0"	#5 @ 12"	#5 @ 12"	#7 @ 8"
20"	20'-0"	#5 @ 12"	#5 @ 9"	#8 @ 9"
24"	23'-0"	#6 @ 16"	#6 @ 9"	#9 @ 9"
30"	28'-0"	#6 @ 12"	#6 @ 8"	#10 @ 8"
36"	33'-6"	#6 @ 12"	#7 @ 8"	#11 @ 8"

Figure S-41

Project Document for Client

Broad Street Apartments

Table of Contents

Letter to the Client

June 02, 2016

Broad Street Developer
2115 Broad Street
San Luis Obispo, CA 93401

Proposal for Broad Street Apartments

Dear Ms. White,

Activated Facades is an interdisciplinary student team that consists of an architecture student and an architectural engineering student from California Polytechnic State University, San Luis Obispo. We are proud to present to you our design of Broad Street Apartments.

We have collaborated to create a mixed-use project that provides residents a sense of community with a balance of privacy along Broad and Branch street. The project includes professional offices and amenities like a café, neighborhood market, wine bar, and hair salon for local San Luis Obispo residents. Included in this design is an occupiable roof deck with shared garden area, community plaza, and private balconies for residents.

Activated Facades would like to thank you for this opportunity to help develop existing site to modern, sustainable, and affordable apartments. The new development of Broad and Branch will incorporate safe bike lanes and safer walkways, as well as neighborhood amenities to encourage community interaction.

Sincerely,

Activated Facades
Carla Simental
Viviana Sanchez

Executive Summary

As an integrated studio of architecture and architectural engineering students at California Polytechnic University San Luis Obispo, we have collaborated to design mixed-use apartments in San Luis Obispo which include housing, professional offices, retail spaces, and outdoor plazas to encourage community interaction and act as a central hub which encourages pedestrian transportation. As a team we are working to design a space that feels inviting to the public and private to the residents and implementing a transition of structural materials from the public spaces to the private spaces.

Our goal is to create an interactive community garden for the residents and have public plaza for the neighborhood. We want these public spaces and amenities to feel inviting to the public given that our site is at the corner of Broad and Branch Street near the big South Street Intersection. We want people to leave their vehicles behind and enjoy the public amenities which include a wine bar, café, neighborhood market, and hair salon. We want to implement safer crosswalks and safer bike lanes along Broad street to encourage community interaction. By providing public and private outdoor spaces, we can give the residents a sense of privacy within their unit with balconies, and within the resident community itself with roof garden that can also become a running track.

The current site consists of a restaurant, a liquor store and a large area of asphalt for parking. The site has the potential to become a great transition between the commercial side along Broad Street and the residential side along Branch Street. However, the lack of crosswalks along Broad Street is inconvenient and hinders people from feeling safe to cross. The surrounding residents have become accusation to these conditions, yet other San Luis residents might not feel enticed to cross Broad Street to our site. I order to maximize the development of the site; we plan to implement underground mechanized parking as well as proposing a 30% parking reduction for the site. In order to promote biking, we propose safer bike lanes and propose safe bike parking on site.

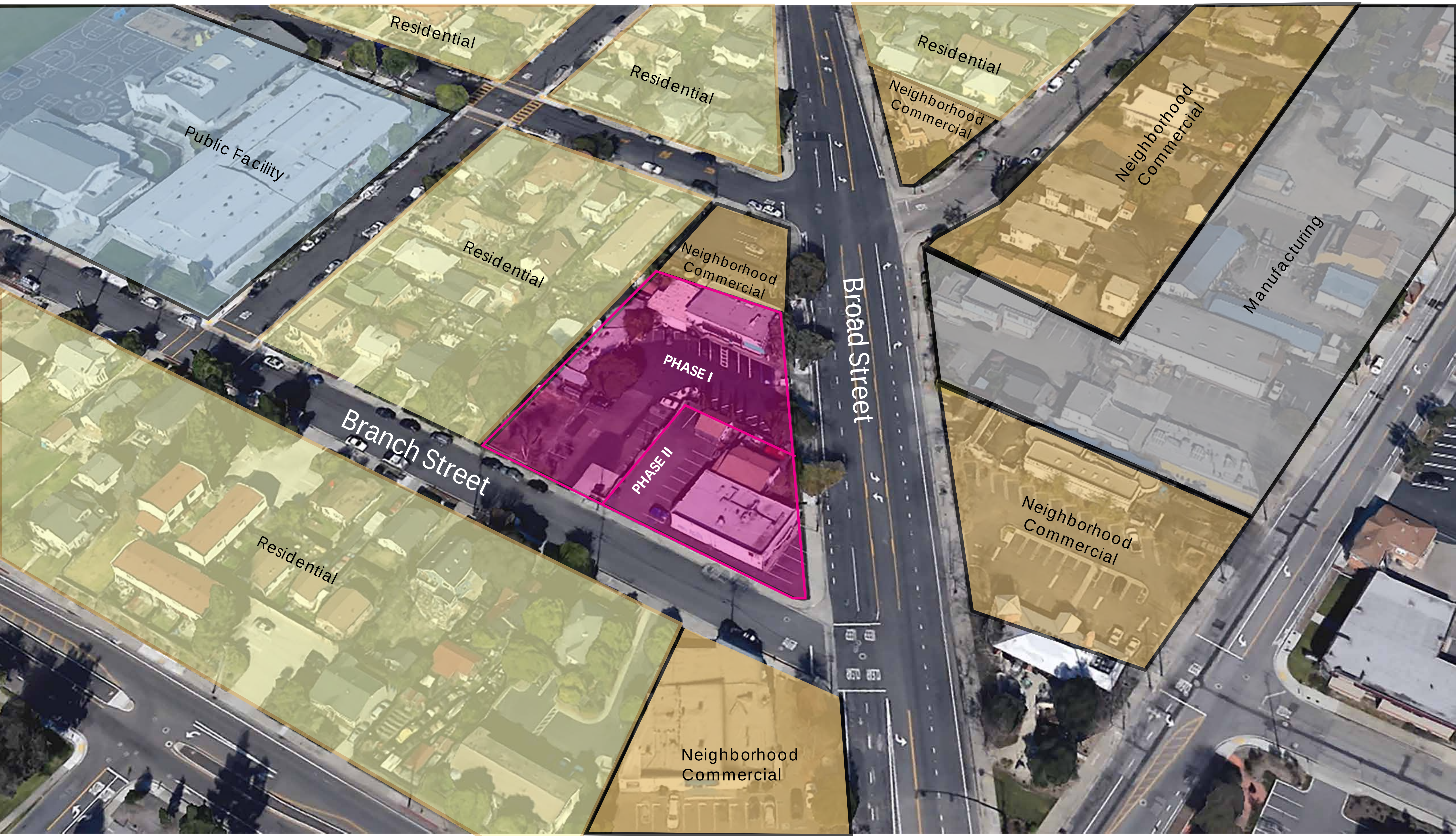
We are proposing an interactive environment by connecting San Luis Obispo residents to local café, wine bar, hair salon, neighborhood market, professional offices and green landscape spaces while implementing sustainable strategies such as solar panels, reduced parking and 100 percent water collection on site. We plan to create a happy living space for residents through beautifully lit apartments, Private outdoor area, community support, great views, and safety.

Design Intent

Our intent is to create sustainable, modern and affordable housing with public amenities to activate the corner of Broad and Branch Street while maintaining a balanced transition between public and private spaces. The current site can seem intimidating to the public who is not familiar with the area. Our goal is to address this issue by creating an inviting, pedestrian friendly public hub of amenities with attention to public transportation. Creating a pedestrian culture is a main driver in implementing professional offices, public gardens, neighborhood market, café, hair salon and wine bar. While creating these public spaces for the community, we also want to provide residents with private amenities.

The apartments range from studios to three bedroom layouts. Providing each unit with sufficient daylighting, open living, dining, kitchen concepts, as well as private balconies are essential to creating an ideal living space. The residents will have access to a common floor which includes, a large open kitchen, dining room, activity center, gym, roof top garden, as well as outdoor running track. These features will provide the residents a sense of community within themselves. The vegetation grown on the roof garden can be sold at the neighborhood market located at the corner of Branch and Broad street. These amenities can be run by the community of Broad Street Apartments for the community San Luis Obispo. The idea behind this mixed-use project is to provide local work opportunities for the neighborhood through these retail spaces and professional offices while inviting the all San Luis Obispo locals to enjoy these amenities.

Site: 2115 BROAD STREET + ADJACENT PARCELS



Project Goals

ENCOURAGE PEDESTRIAN TRANSPORTATION

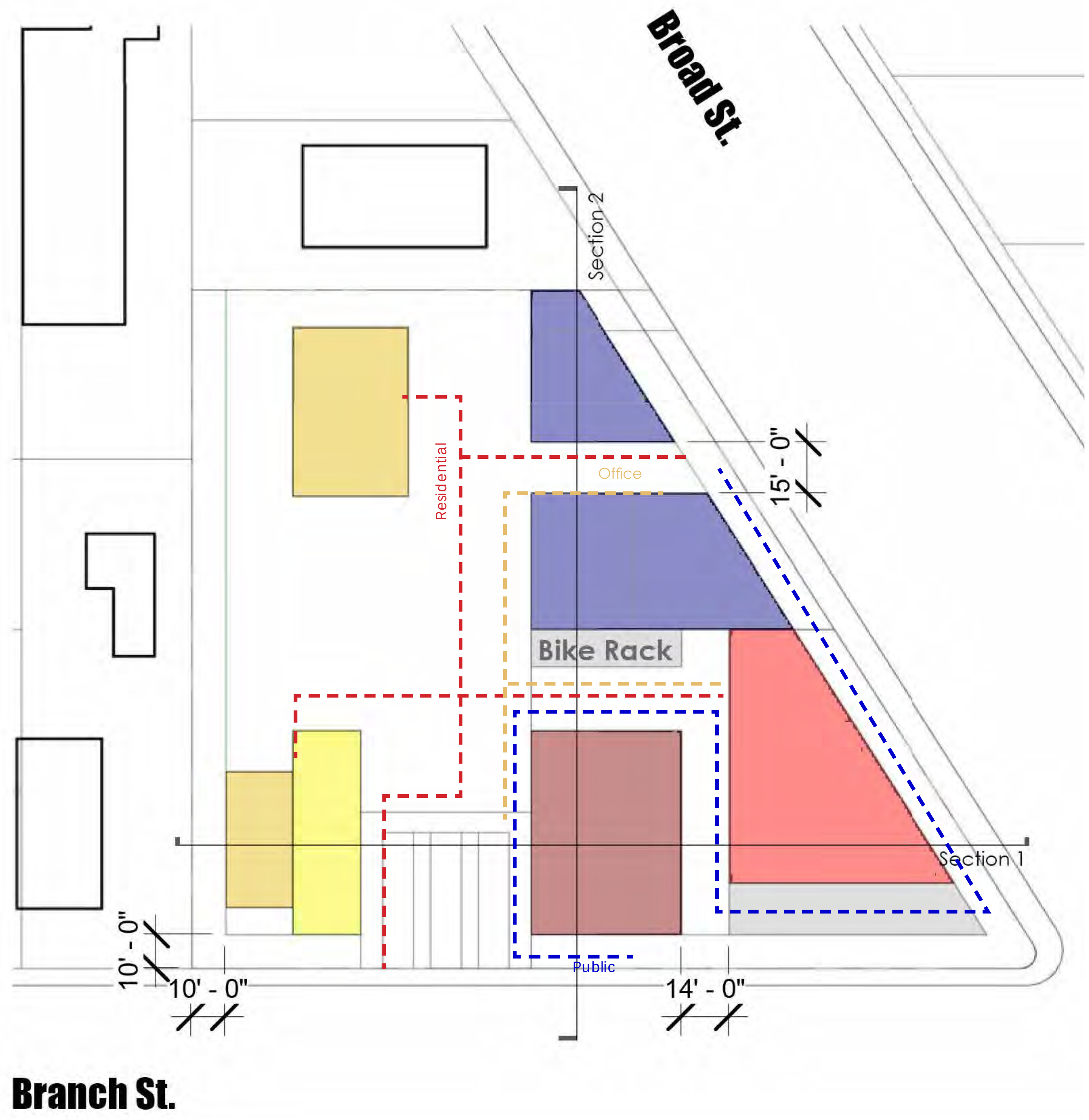
- Safe bicycle lanes
- Concealed parking
- Amenities for residents and neighborhood within walking distance

HAPPY PLACE TO LIVE

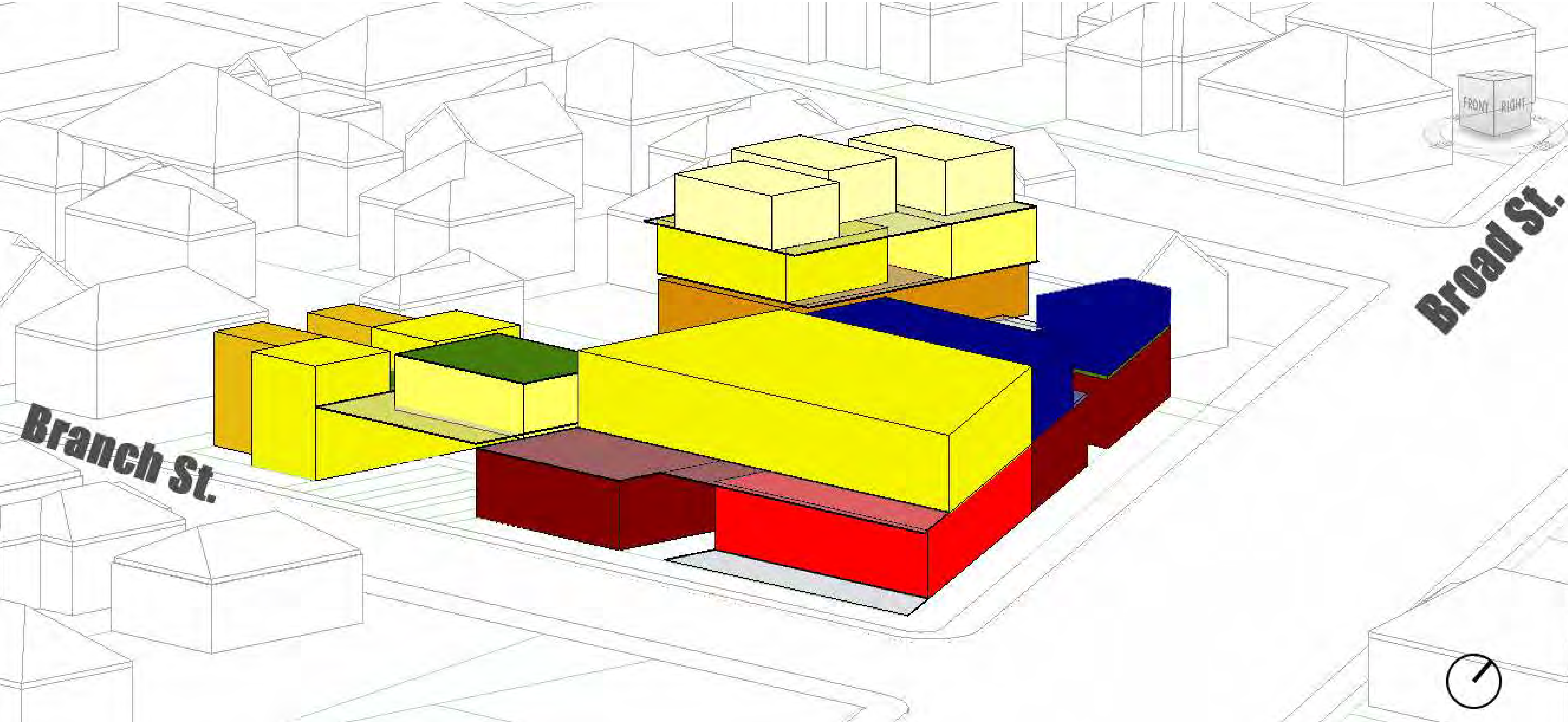
- Natural lighting
- Gardens + private outdoor areas
- Community support
- Great views
- Safety

AMENITIES

- Community Plaza
- Retail Spaces
- Hair Salon
- Wine Bar
- Neighborhood market + cafe
- Residential gym
- Roof top garden + running track



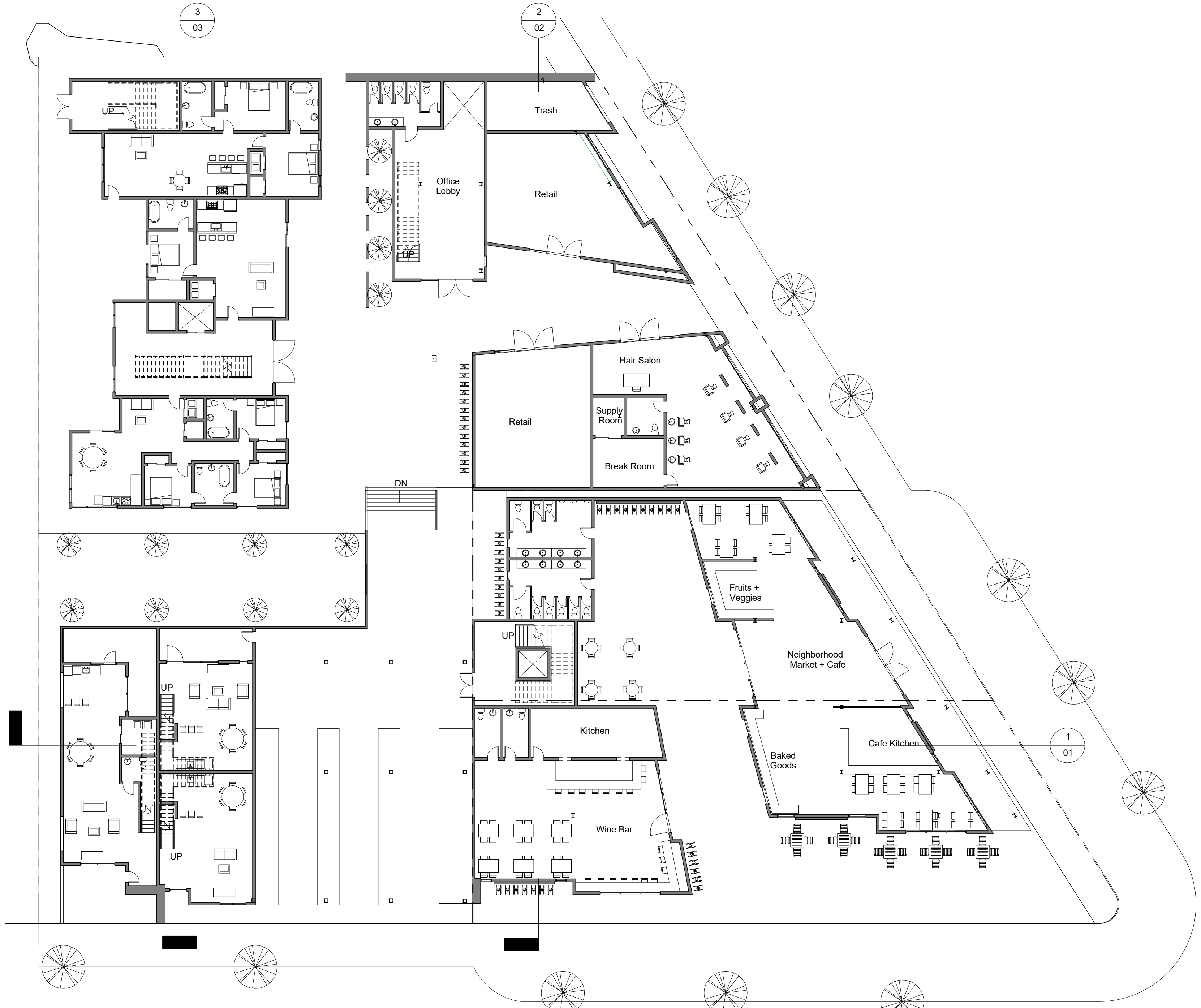
Site Circulation



Program

Site Plan

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

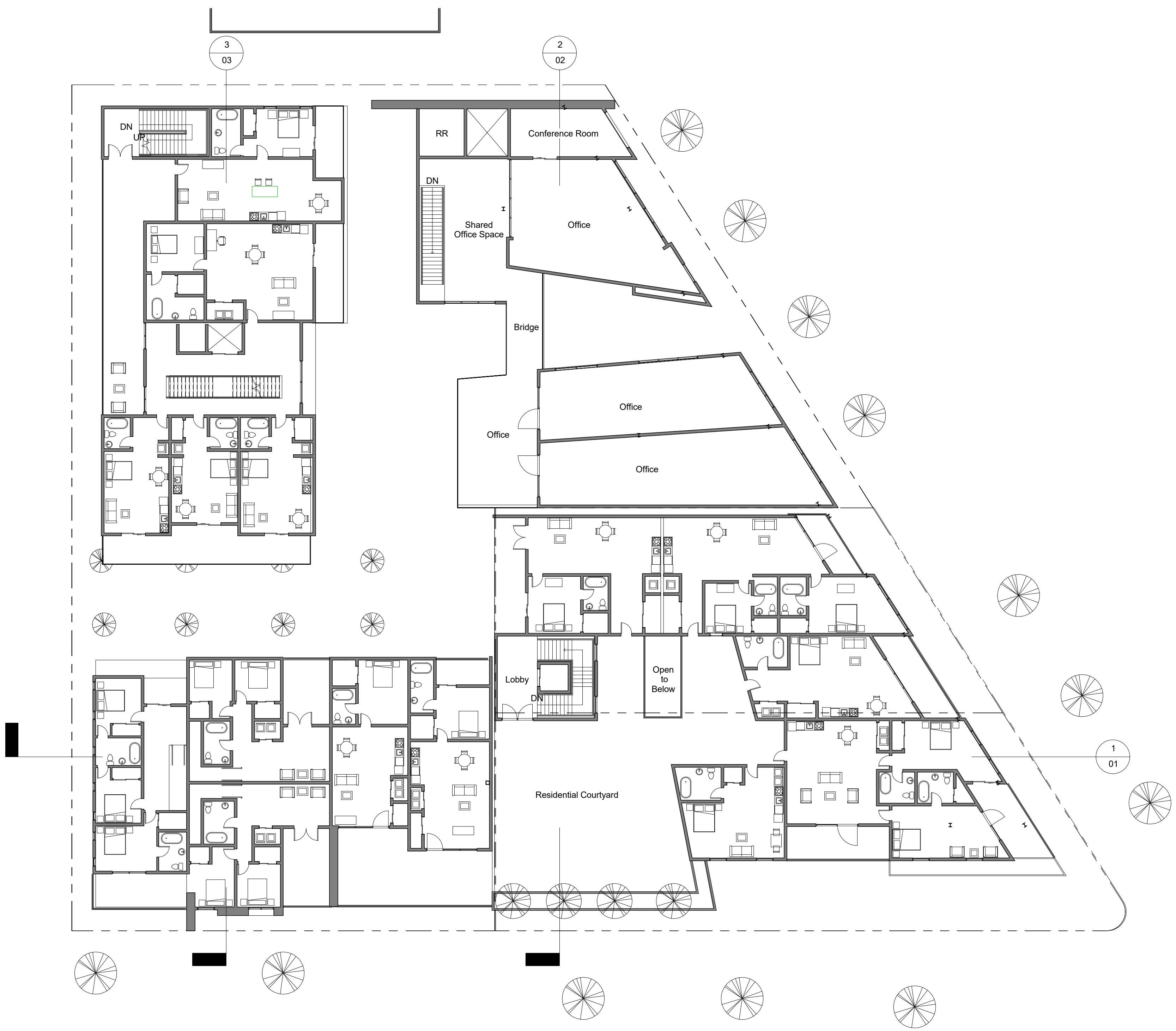


Floor Plan-Level 1

Scale: 1/32” = 1’-0”

Kurve 7 | Stu/D/O Architects

Kreation Juice | Santa Monica

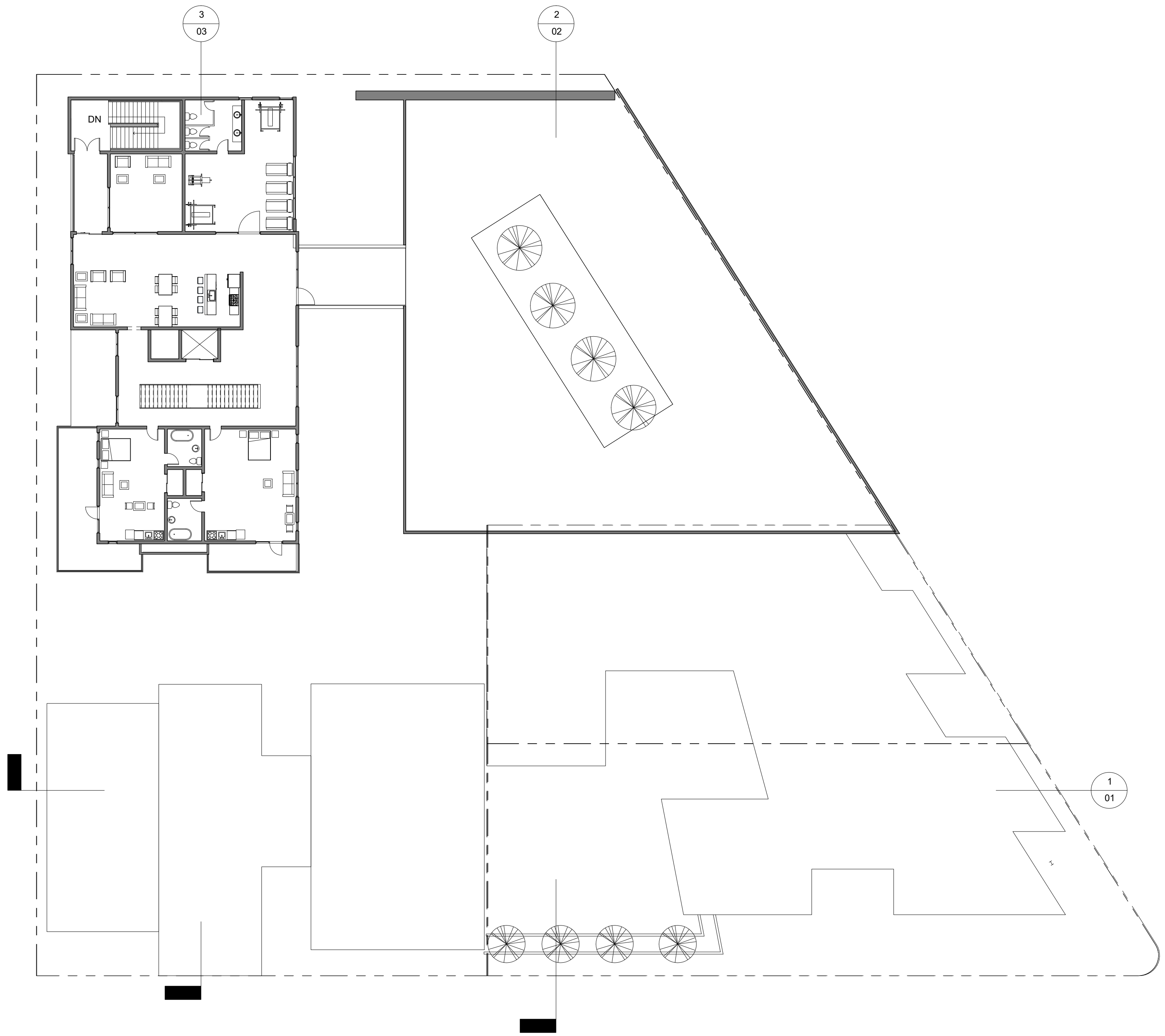


Floor Plan Level 2

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

offices in Jakarta | Airmas Asri Architects

Blog ASSIM eu gosto



Floor Plan Level 3

Scale: 1/32” = 1’-0”

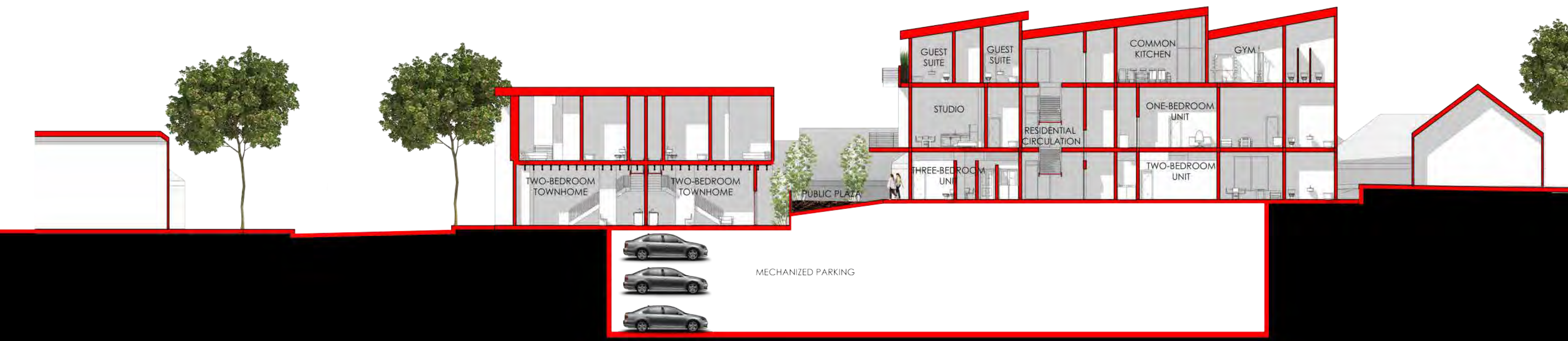
White House / Studio MK27
Marcio Kogan + Eduardo Chalabi - 2

Branch Street Section

Scale: 1/32” = 1’-0”

Broad Street Section

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



Residential Tower Section

Scale: 1/32” = 1’-0”

Broad Street Elevation

Branch Street Elevation

Parking + Pedestrian Entrance

Community Courtyard

Broad Street Enhancement Plan

Parking System Description

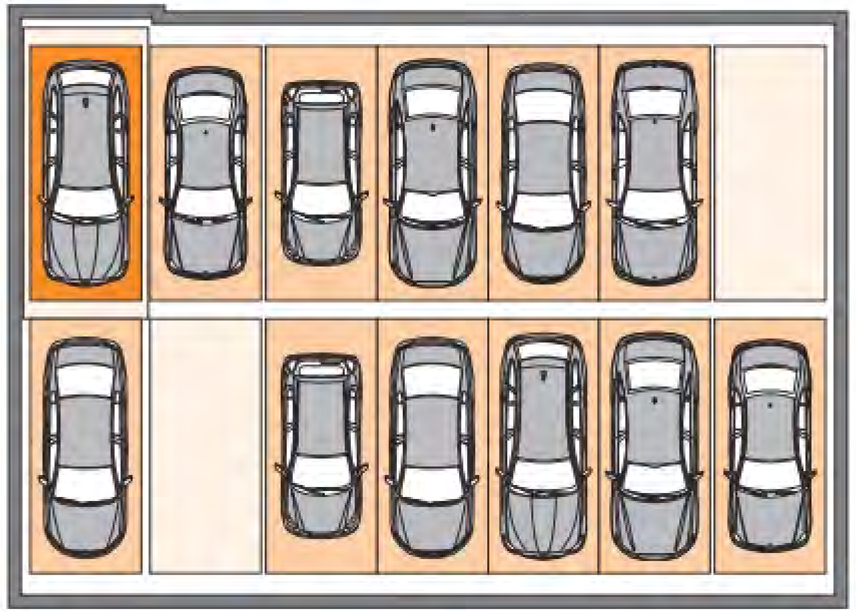
http://www.multiparking.com/index.php?Layer-system-MasterVario-F2-F3

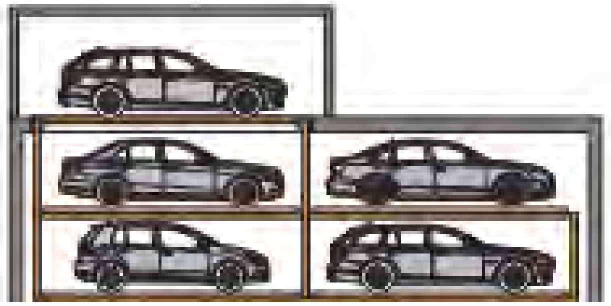
Mechanical Parking / Automated Parking System

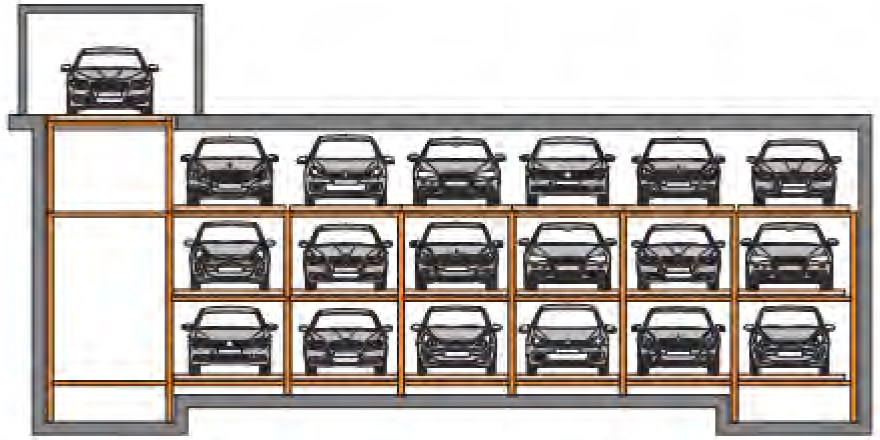
The underground mechanical parking system being used on this project is fully automatic. This system is a two-row surface system with elevator and horizontal conveying units. There are two layers of these parking systems with six of them holding 13 vehicles and four of them holding 7 vehicles. Thus, a total of 114 vehicles are held in the project. The lift is a horizontal and vertical conveyor unit.

The driver of the vehicle drives onto a automated lift, exits the vehicle, and retrieves a card that is used for retrieval of the vehicle at a later time. The lift moves the vehicle underground where it can enter one of the 12 systems wherever a parking space is available. If no spaces are available, the parking system will inform the driver that none are available. During the retrieval period, the driver inserts the card in a machine which recognizes the vehicle and automatically retrieves the vehicle onto the exit loading area.

The advantages of using this type of system include optimal access times, accomodation of vehicles in safety, anti-theft and damage protection, safe access to car park without narrow ramps or dark access routes, the enclosed area can be half of that of a conventional parking system, and reduced construction time.





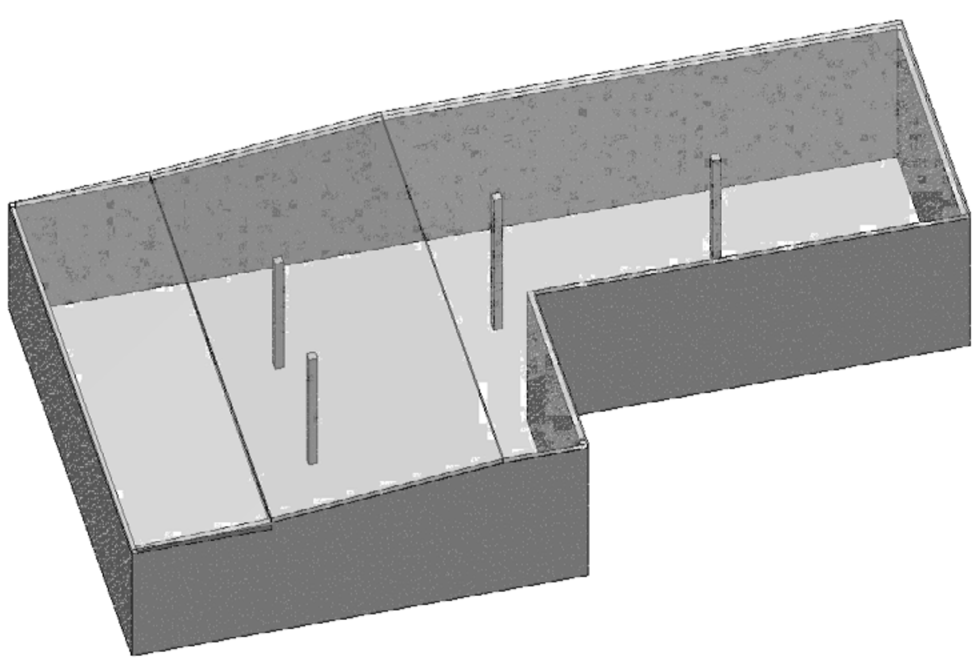


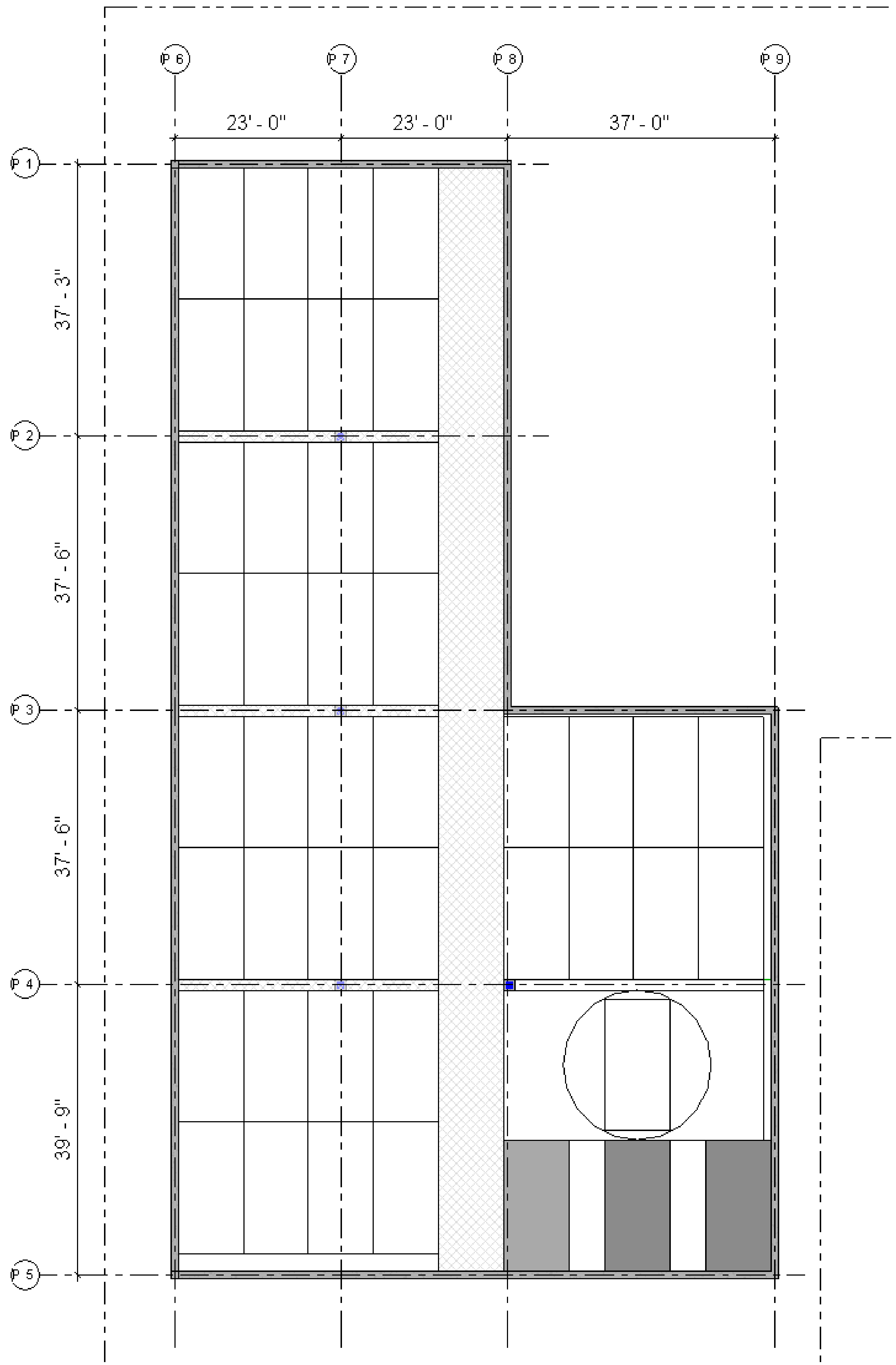
Parking Sytem Configuration

Mechanical Parking / Automated Parking System

In this Automated Parking System (APS), a waiting zone is available just before the automated lift region. The waiting zone area is intended to help reduce the on street traffic that may occur due to multiple vehicles entering the autmoated parking at once. The automated lift is located north of the waiting zone. Once on the automated lift and all people have exited, the vehicle moves automatically underground.

The vehicle then goes onto a rotation area where it is rotated 180 degrees before being parked. It is then placed into one of the 15 two-row surface subsystems with an open parking space. There are three levels of subsystems with five on each level for a total of 105 parking spaces available.



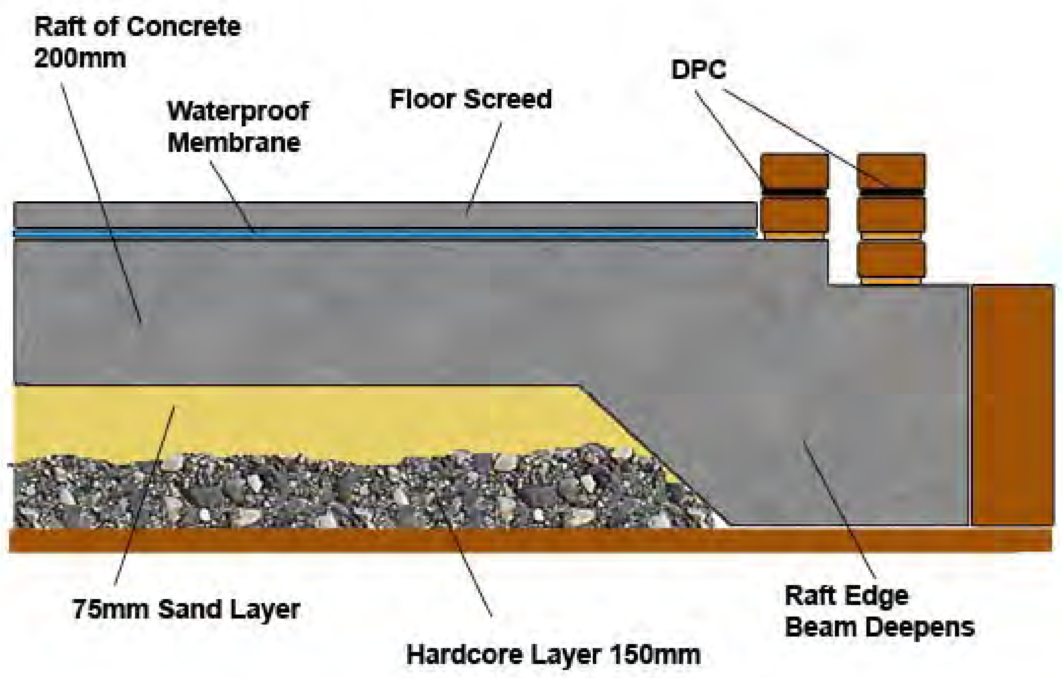


Foundation System Description

Mat Foundation

The mat foundation is used on expansive, rocky, or hydro collapsible soils. This site has very expansive soil so a mat foundation is a good choice to prevent the buildings from tilting due to expansion in soil on one end.

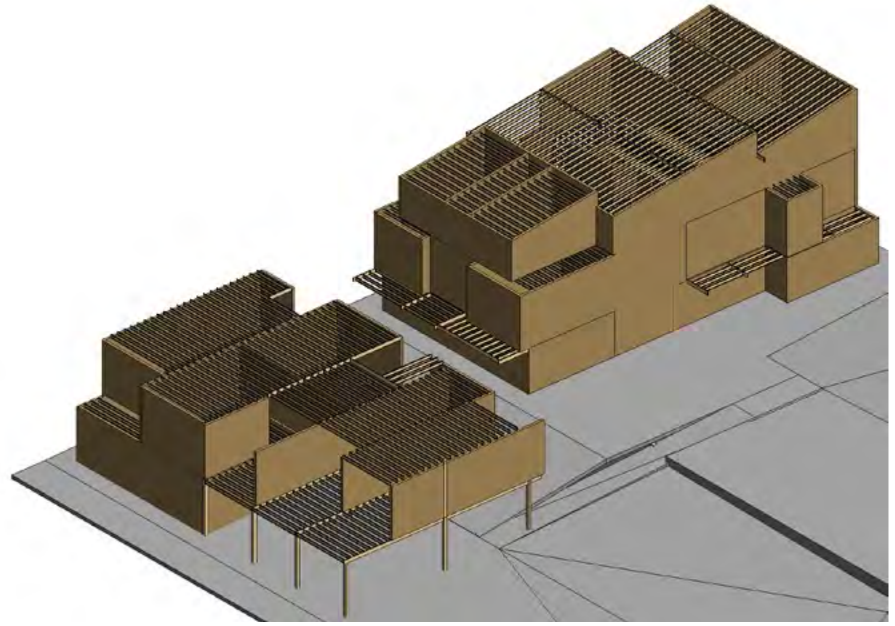
The mat foundation consists of a thick reinforced concrete slab that covers the entire area of the bottom of the structure like a floor. It possesses great stiffness and strength to resist swelling. It usually requireds little or no gravel, sand, or moisture barrier.

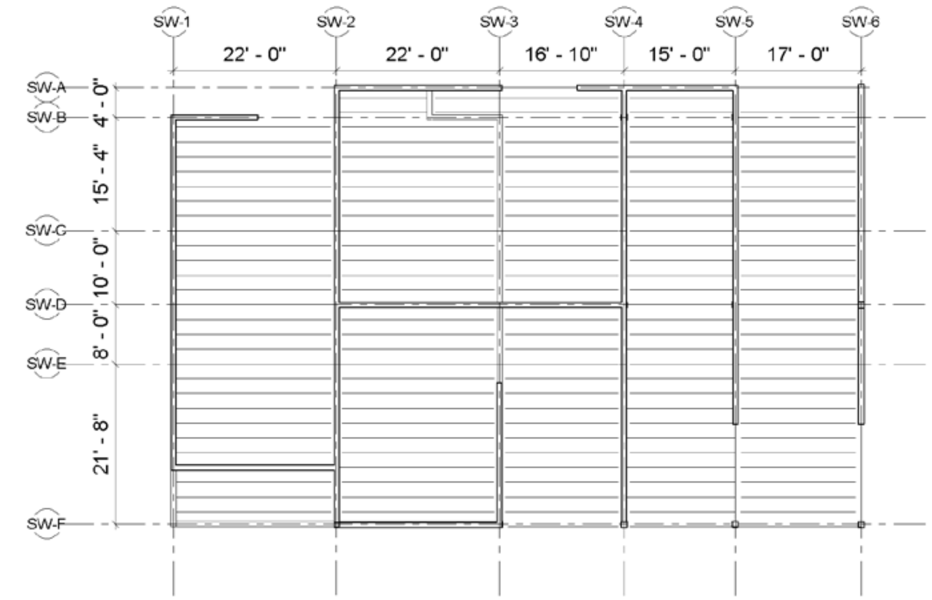


Gravity System

Western System

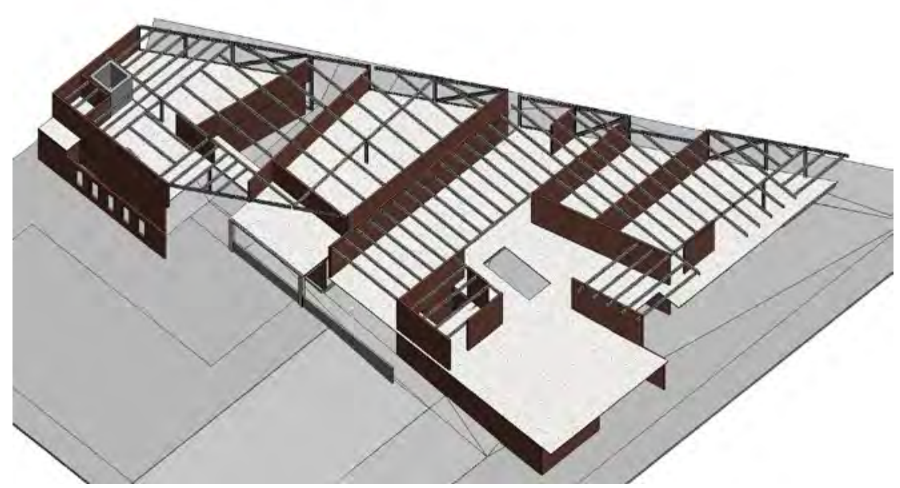
Light-weight concrete on steel deck | I-Joists | Laminated veneer lumber | Wood posts

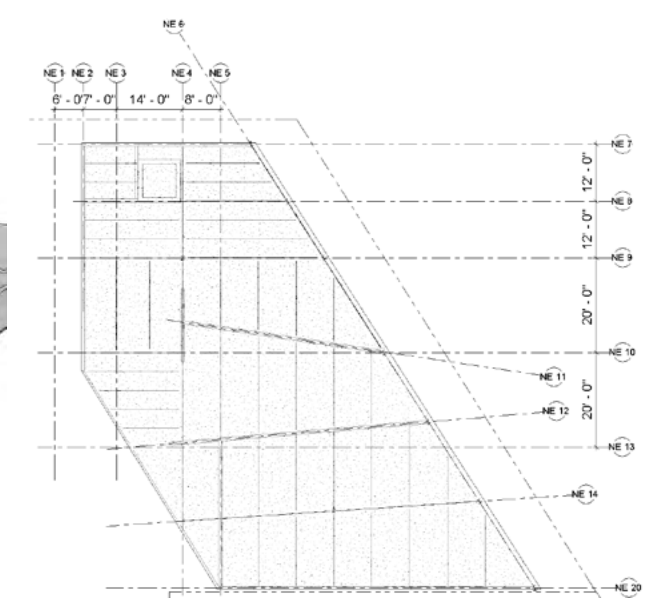


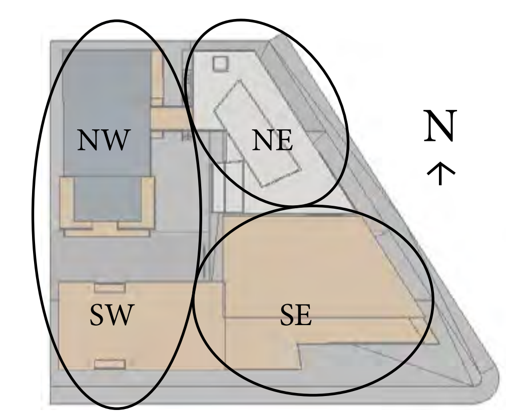


Eastern System

Concrete on steel deck | Wide-flange beams and columns | Masonry bearing walls



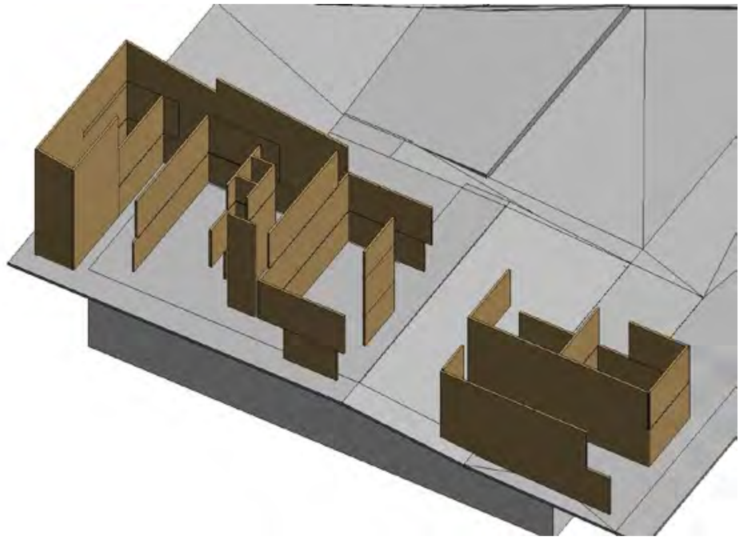


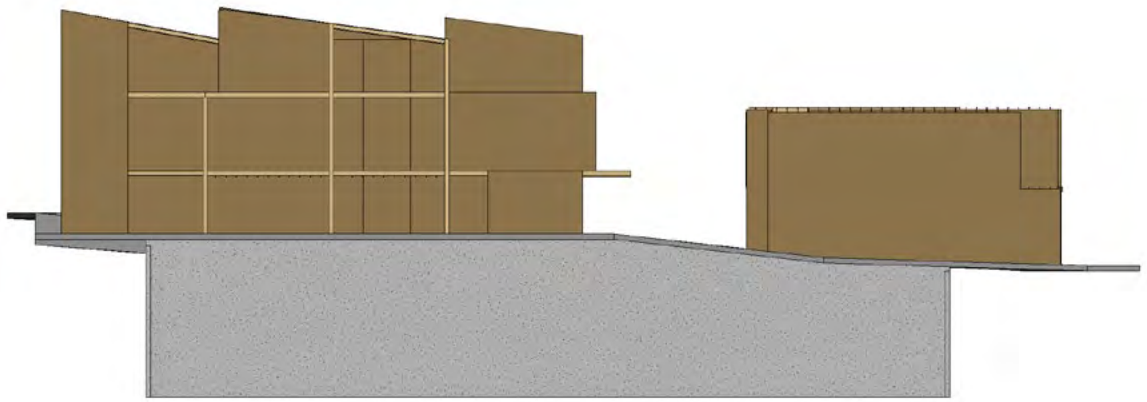


Lateral System

Western System

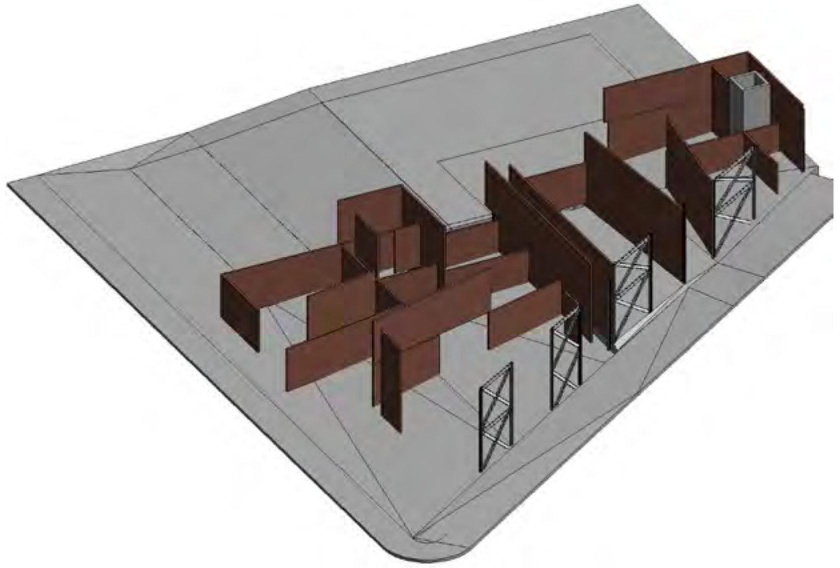
Wood shear walls

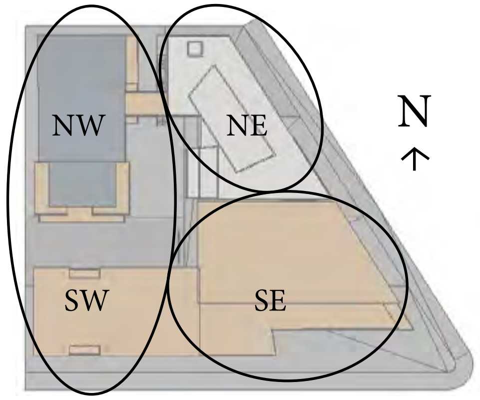




Eastern System

Masonry shear walls | Steel braced frames





TEAM GOALS:

Our goals this quarter are to discuss new ideas of the project throughout the design process to determine if solutions are possible early on. Coordination between architect and engineer early in the project to determine grid lines, major dimensions, and structural restrictions to help advance the project efficiently. Along with learning to work through the design process from an engineering and architectural perspective, we want to be able to recognize important structural features that can be showcased in the project rather than trying to hide all structure. From an architectural perspective, I want to view and incorporate a structural element as aesthetic pieces and showcase the best of both worlds. We plan to meet frequently to recap work, coordinate, and plan future work to help achieve our goals.

ACTIVATED FACADES