SLO Mixed Use Neighborhood 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

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Gravity System Description

The overall gravity system for this project consists of two distinct systems: a steel beams, girders, and column system with bays filled with timber I joists with a plywood diaphragm; and a timber I-joists and a bearing wall system tied together with a plywood floor diaphragm.

Timber framing (Figure 1) consist of 2x6 stud walls on the first floor of each building and 2x4 stud walls on all other levels with 16" stud spacing designed to withstand bearing loads coming from the I-joists. The timber I-joists are forms of engineered lumber consisting of top and bottom flanges and a web to provide outstanding shear resistance. I-joists found in this project can typically vary in depth anywhere from 9.5" to 12". I-joists are ideal for long spans, including continuous spans over intermediate supports, making them a perfect solution for residential and light commercial framing. The residentail spaces on this project have a typical joist span of 15 feet and frame into timber bearing walls. The beam and girder system is tied together by a plywood diaphragm which can be anywhere from 3/16" to 19/32" thick.

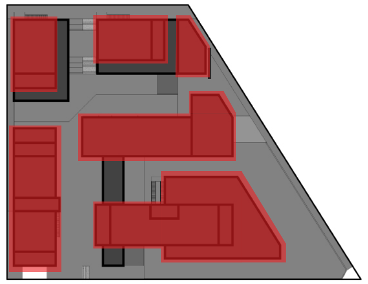
Steel framing (Figure 2) will be used quite sparingly on this project, but will be essential to creating the type of architecture desired in the office spaces and with structures suspended over the pool. Because residential spaces are stacked above commercial and retail spaces, including offices and restaurants, it will mainly be used to properly transfer gravity forces from bearing walls at residential levels to office and commercial levels.

The location of the timber and steel framing can be seen on the key plan.

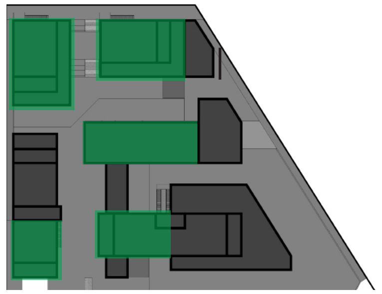
Figure 1

Figure 2

Key Plan



Key Plan



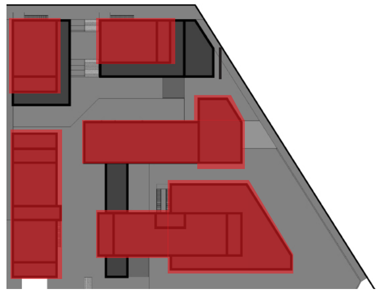
🟥 = Timber Framing

🟩 = Steel Framing

Note: Steel and timber shown in same location for some structures. See configuration slides for more information.

Lateral System Description

Key Plan



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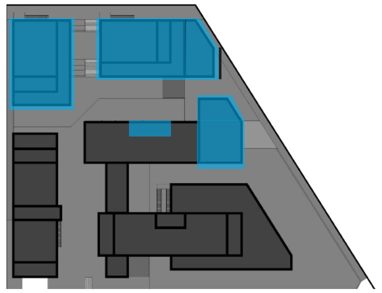

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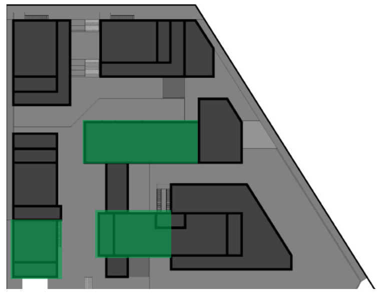


🟥 = Timber Shear Walls 🟦 = Concrete Shear Walls 🟩 = Steel Braced Frames

Note: Different lateral systems shown in same location for some structures. See configuration slides for more information.

Timber Shear Walls:

A timber shear wall system consists of two main part, the diaphragm and the shear walls. A diaphragm is a flat structural unit acting like a deep, thin beam, usually referring to roofs and floors. In timber construction, diaphragms are constructed using plywood tied together with the beam and roof system supporting the roof and floor to form a fairly rigid structural unit. A shear wall is simply a vertical, cantilevered diaphragm, consisting of 2x4 and 2x6 studs and plywood sheathing as seen in Figure 1. Plywood is applied to the stud wall typically to both sides of the wall with a thickness ranging between 1/4" to over 1/2" and gives it stiffness and strength against lateral loading. The shear walls are then connected to the foundation or diaphragm using hold-downs to resist overturning tension forces. Timber shear walls are the main lateral component in this project and are located in nearly every structure.

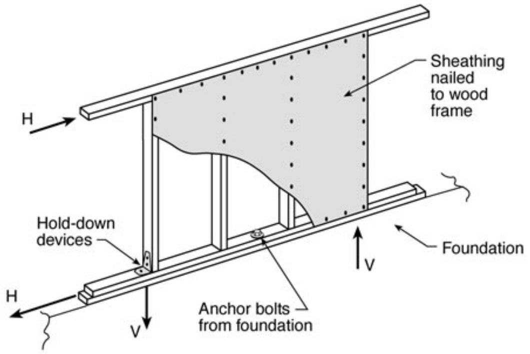


Figure 1

Concrete Shear Walls:

Concrete shears will be incorporated into this project to resist the shear forces from the upper story residential units and also to double as retaining walls. Concrete shear walls (Figure 2) are constructed using rebar as the wall reinforcement and encase it all with either concrete or a high quality alternative, such as shotcrete. Shear walls are traditionally used to only resist in-plane loads, but they can also resist out of plane loads when designed and detailed properly. Concrete shear walls are much stronger than timber shear walls and much less expensive than steel shear walls. These types of shear walls are typically constructed by forming a rebar cage and surrounding it with stacked 2x4's as formwork. Once the concrete is poured and cured, construction on other elements bearing on the shear wall can begin. These shear walls are also capable of resisting lateral soil loads, which is experience on the underground office walls and parking walls.

Figure 2

Braced Frames:

Our site has many cantilever structures scattered throughout its footprint and in order to create an open space beneath without closing it off with shear walls, steel braced frames, like the one below, are implemented. To be specific, steel braced frames will be incorporated in the community center and the residential/restaurant area where a portion of the structure resides over the pool. A number of steel members can be used to construct a braced frame, including anything from wide flanges to HSS (hollow structural sections). On this specific project, HSS members will be used because the lateral loads experienced by the braced frames won't require large members like wide flanges. In braced construction, beams and columns are typically only designed to withstand vertical load, while the bracing system is assumed to carry all the lateral load.

Figure 3

Parking System Description

An automated parking system, otherwise referred to as APS, is a mechanical system designed to minimize the area as well as the volume required for parking cars. Like a multi-story parking garage, an APS provides parking for cars on multiple levels stacked vertically to maximize the number of parking spaces while minimizing land usage. The APS, however, utilizes a mechanical system to transport cars back and forth between parking spaces as opposed to having a driver place the car in a particular spot. This mechanical transportation system eliminates much of the space wasted in a multi-story parking garage for things like driving lanes. While a multi-story parking garage is similar to multiple parking lots stacked vertically, an APS more closely resembles an automated storage and retrieval system for cars.

The parking system used in this particular project incorporates a revolving carousel system to transport and store cars. It is similar to the ones seen in Figure 1 and 2, but instead of having the carousel stacked vertically as seen in the pictures, the carousels will be oriented horizontally. There will be four carousel units below grade to accommodate the number of cars needed for this specific site and program. Each spot on the carousel can accommodate a car that fits within the 8' x 8' x 16' space per spot. Oversized and additional parking beyond capacity can utilize street parking along Branch St. The parking entrance can be seen on the key plan.

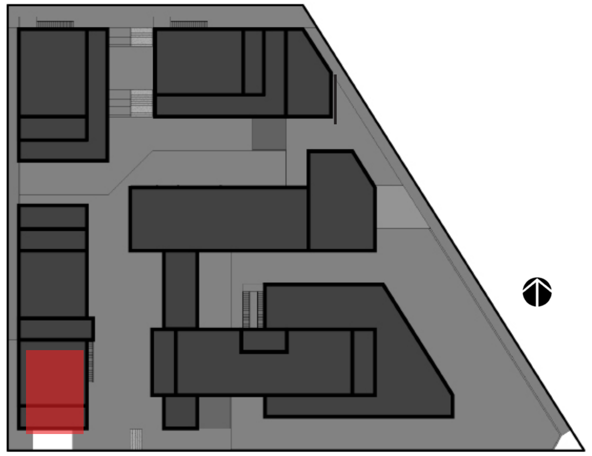
This system is very distinct from a system known as mechanical parking. Mechanical parking often refers to a smaller scale of parking system, typically a two or three level lift system built above grade to save space within an already existing parking lot, as seen in Figure 3. The lift rises the car to a level or two higher than the ground level, which allows two to three cars to be stacked on top of one another. This system is ideal to double parking spaces for both indoor and installations. This system is also simple to operate and comes with a relatively low cost and low maintenance. However, unlike automated parking system, this requires all the work related to parking be placed on the driver. Automated parking only requires the driver drive into a particular spot, punch in a code, and the system does the rest to place the car in a spot within the system.


Figure 1

Figure 2


Figure 3

Key Plan



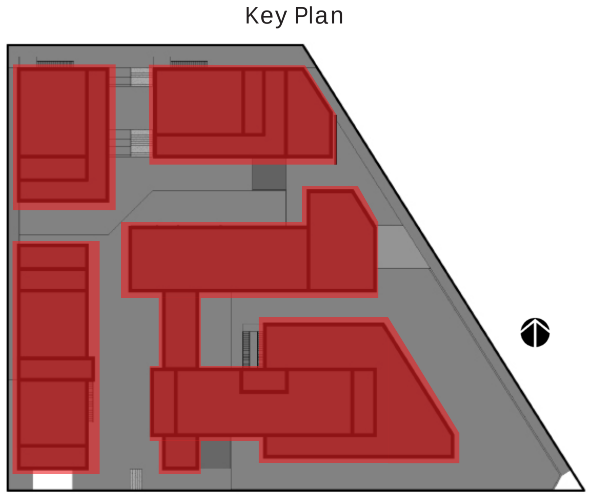
🟥 = Parking Entrance

Foundation System Description

Mat foundation, also known as a raft foundation or floating foundation, is a way of giving extra support to a building. Mat foundations (Figure 1) are constructed as a large slab which works as the base for the building. The building then rests on this foundation, providing more strength and stability to the structure than pad footings or piles could offer. The mat foundation is also reinforced with many bars inside it which run perpendicular to each other, as seen in Figure 2. Such reinforcements make it a very strong base, which is ideal for large buildings. The mat foundation is usually the same size as the footprint of the building, but can extend past the footprint if needed. The site where the structure has to be constructed is first excavated. When the site has been leveled and dried up, the slab of the mat foundation is laid down. This gives the building a foundation which is strong and durable and the construction starts on the slab.

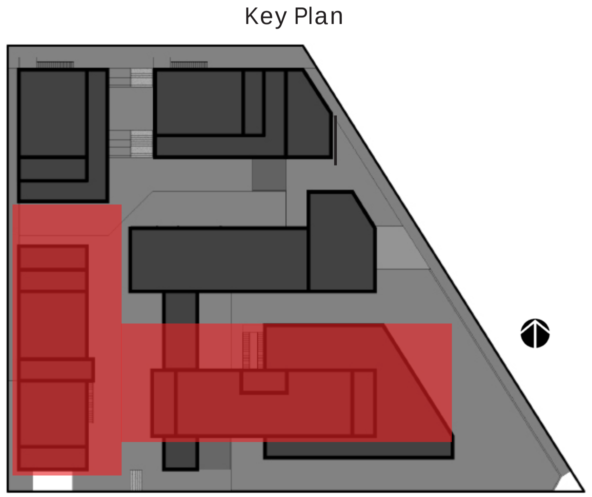
Mat foundation is typically used where soil does not have adequate bearing strength to support the structure. Our site has soil with very low bearing pressure and there is also a high chance for liquefaction in the area, which makes using mat foundations a sensible choice. Building a structure directly on soil such as this can be very dangerous. Using a mat foundation can help combat these issues.


Figure 1



🟥 = Building Foundation Location


Figure 2



🟥 = Parking Foundation Location

Gravity System Selection

Timber Framing:

Building Program: Timber framing is most commonly used in residential programs to create a more closed floor layout. The advantage to timber framing is that it is easily customizable when it comes to floor plans and repairs can be easily made, while also create shorter spans for framing members. Adding insulation or thickening member/sheathing can reduce unwanted sound and acoustics.

Constructability: Compared to steel, timber construction is much easier when it comes to construction. No prefabrication is needed like steel and requires much less equipment for construction than steel.

Aesthetics: Wood construction also lends itself to almost unlimited options when it comes to aesthetics. From exposing the wood natural warm and rich beauty to using the wood as a platform for decorative ceiling elements or even exterior embellishments, timber construction can create spaces with optimal look, feel and function. It is also adaptable when it come to different facades which will be incorpoates into this project, like stucco and natural wood facades.

Fire: Timber is by far the most combustible construction material available, but this shortcoming can be easily combatted by adding fire resistive gypsum board or fireproofing insulation. Fire seperation will be provided with additional plywood/gypsum board to seperate different occupancies. The residential units will also have a concrete topping over the plywood diaphragm to combat fire.

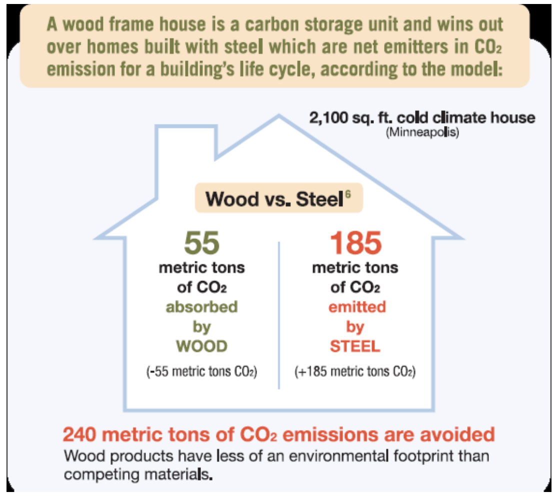
Cost: The cost of material and construction for wood is the cheapest of any material.

Sustainability: Since wood is a natural material, timber construction reduces the use of energy while having one of the lowest CO2 emissions, air pollution and water pollution of an building methods (Figure 1) Not only does timber construction emit less CO2, it has the capability to absorb CO2, causing wood to have a smaller environmental impacts than steel.

Sustainability of Building Materials	Wood (Including Western Red Cedar)	Steel	Concrete
Total Energy Use	Lowest	140% more	70% more
Greenhouse Gases	Lowest	45% more	81% more
Air Pollution	Lowest	42% more	67% more
Water Pollution	Lowest	1900% more	90% more
Solid Waste	Lowest	36% more	96% more
Ecological Resource Use	Lowest	16% more	97% more

Source: The Athena Sustainable Materials Institute

Figure 1



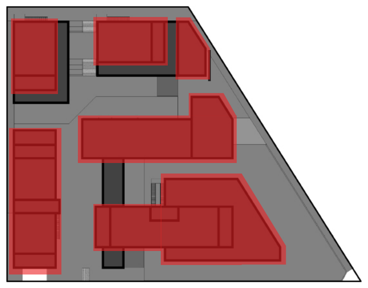
A wood frame house is a carbon storage unit and wins out over homes built with steel which are net emitters in CO_2 emission for a building's life cycle, according to the model:

240 metric tons of CO_2 emissions are avoided

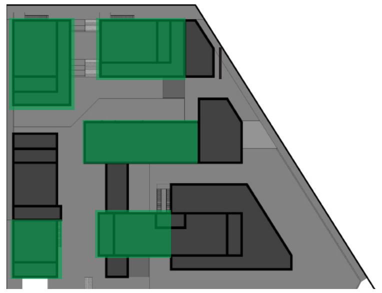
Wood products have less of an environmental footprint than competing materials.

Figure 2

Key Plan



Key Plan



🟥 = Timber Framing 🟩 = Steel Framing

Note: Steel and timber shown in same location for some structures. See configuration slides for more information.

Steel Framing:

Building Program: Steel framing can create large open floor layout that can accommodate a multitude of environments such as offices, retail, and restaurants, while allowing the shear forces from the residential timber shear walls above to transfer the force down to the lower lateral systems.

Constructability: Even though timber is a better material to work with, steel is required on this project to achieve the architectural form and open spaces that are desired, but is only required in a few specific locations (mainly the pool and offices), meaning the majority of construction will be with timber.

Aesthetics: Steel structures are also able to give off the impression that a space look bigger or make a structure look lighter than what it actually is. Using steel in the office space will create a larger, more open work environment as opposed to having multiple timber walls inruding on the space.

Fire: Steel is not the best when it comes to fire resistivity, but there are many forms of fireproofing that can prevent this shortcoming, while also not taking away from the aesthetic.

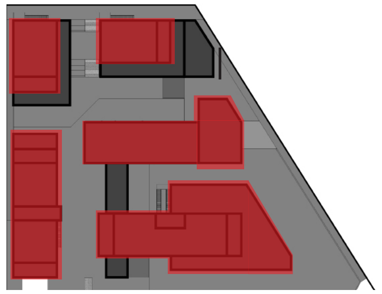
Cost: While steel is not as budget friendly compared to wood, it is still less expensive than most concrete building construction. Prefabrication of connections can also save on the cost of construction as well as scheduling.

Sustainability: When it comes to the environment, steel is completely recyclable and cases less pollution than concrete construction and is comparable with wood (Figure 1).

Conclusion: With timber being stacked on top of the office spaces and being suspended above the pool and parking area, loads from bearing walls above can be transferred to steel beams and girders, while also providing a greater span between column support. This

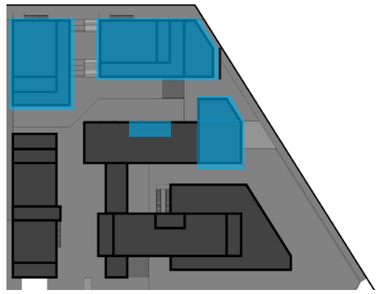
Lateral System Selection

Key Plan



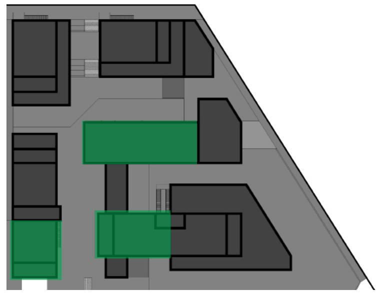
🟥 = Timber Shear Walls

Key Plan



🟦 = Concrete Shear Walls

Key Plan



🟩 = Steel Braced Frames

Note: Different lateral systems shown in same location for some structures. See configuration slides for more information.

Timber Shear Walls:

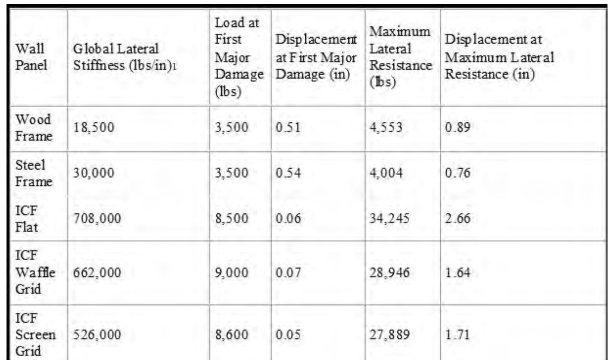
Building Program: The closed layout associated with residential floor plans lends itself to timber shear wall to separate different spaces within the home.

Cost: The cost per square foot of timber shear wall ($2.84) is nearly 3 times less than concrete walls ($8.78) according to Figure 2. Also, timber, being a natural resource, is more readily available than other structural alternatives like steel and concrete. Also, the labor associated with timber construction is between three to four times less costly than concrete construction (Figure 3).

Earthquake performance: As seen in Figure 1, wood framed shear walls have the lowest global lateral system of the three materials, but it is nearly equivalent to steel in loading at first damage and displacements. It also has the ductility of steel as opposed to the rigidity of concrete.

Compatibility: Given that the diaphragm of the residential structures are almost all plywood diaphragms, timber shear wall are the most compatible given the timber gravity system in place with the residential program.

Conclusion: With regards to building program and cost, timber shear walls was a sensible selection for the residential units.



Wall Panel	Global Lateral Stiffness (lbs/in)[1]	Load at First Major Damage (lbs)	Displacement at First Major Damage (in)	Maximum Lateral Resistance (lbs)	Displacement at Maximum Lateral Resistance (in)
Wood Frame	18,500	3,500	0.51	4,553	0.89
Steel Frame	30,000	3,500	0.54	4,004	0.76
ICF Flat	708,000	8,500	0.06	34,245	2.66
ICF Waffle Grid	662,000	9,000	0.07	28,946	1.64
ICF Screen Grid	526,000	8,600	0.05	27,889	1.71

Figure 1

Concrete Shear Walls:

Building Program: These retaining wall will also double as shear walls for the office structures and retail spaces built below grade.

Cost: With concrete shear walls ($8.78) costing three times more than timber shear walls ($2.84) and concrete labors hours (0.129) greatly exceeding timber (0.039), concrete is not the most budget-friendly material, but it necessary when building the office and retail spaces below grade because it has to resist lateral soil loads. This is becuase retaining walls are need to resist the soil pressure.

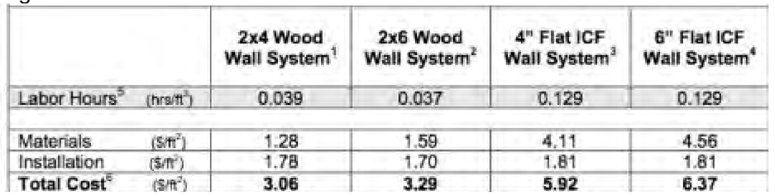
Earthquake performance: Concrete shear wall systems have some of the highest global lateral stiffnesses of any system (Figure 1) which is beneficial when using this system on the first level of a multi-story structure. Because these walls are also being used as retaining walls, minimizing displacement is of great concern and concrete's stiffness helps achieve this goal.

Compatibility: Concrete shear walls are very adaptable when it comes to compatibility with the gravity system. It can seamlessly support a concrete beam system and even steel and timber systems with the help of certain connections and detailing. These conditions are exhibited in the office spaces and some retail spaces.

Conclusion: Having these walls resist both lateral and out of plane soil loads makes concrete shear walls very efficient and the most sensible solution to

Wall type	Cost per sf wall area	Cost per sf living	% cost of whole house
ICF 6" ($20,185.00)	$8.78	$6.73	7*
2x6 Frame ($6537.00)	$2.84	$2.18	2*

Figure 2



	2x4 Wood Wall System[1]	2x6 Wood Wall System[2]	4" Flat ICF Wall System[3]	6" Flat ICF Wall System[4]
Labor Hours[5] (hrs/ft^2)	0.039	0.037	0.129	0.129
Materials $(\$/ft^2)$	1.28	1.59	4.11	4.56
Installation $(\$/ft^2)$	1.78	1.70	1.81	1.81
Total Cost[6] $(\$/ft^2)$	**3.06**	**3.29**	**5.92**	**6.37**

Figure 3

Steel Braced Frame:

Building Program: The building program in place for this project looks to create a group of mixed use structures while not intruding greatly on the ground floor footprint of the site and braced frames help contribute to the overall feel of the environment.

Cost: The cost associated with braced frame construction can become expensive due to the detail in connections, but it is a much more economical option as compared to steel moment frames. Also, steel construction typically has quick installation periods, which can lower labor costs (Figure 4).

Earthquake performance: Braced frames are an excellent option to resist lateral loads and limit deflections, while keeping the weight of the structure down to a minimum.

Compatibility: The braced frames will all be supported by a steel composite deck with concrete fill acting as the diaphragm, making the lateral system very compatible with the gravity system being supported.

Conclusion: To create the open spaces desired around the pool and parking areas, steel braces frames can support the stories above without closing the area off with shear walls or spending too much money on moment frames.

STEEL vs **WOOD**

WARRANTY 50 year structural & 30 year paint	NO WARRANTY when a contractor puts up a wood frame for you
QUICK INSTALL	LENGTHY INSTALL
NO WASTE all materials are pre-welded & sized appropriately	WASTE materials must be measured & cut to size
NO TERMITES	TERMITES
ENERGY EFFICIENT we can achieve R72 in the roof & R38 in the walls giving you more energy efficiency for less	ENERGY EFFICIENT yes, wood buildings can also be energy efficient but why pay more when you don't have to?
LOWER INSURANCE COST money saved yearly makes the slightly higher up-front cost worth it	HIGHER INSURANCE COST wood buildings can burn and as a result will cost more to insure
LOWER LABOR COST not only is labor cost lower, but 50-60% of our customers are able to put up their own buildings	HIGHER LABOR COST contractors for wood buildings are expensive and not many people can build their own
NO CROSS TRUSSES with steel buildings you get cathedral type ceilings at no additional charge, giving you more valuable head room	CROSS TRUSSES in a wood building you will have cross trusses at the save height you select, limiting your head room

Figure 4

Foundation System Selection

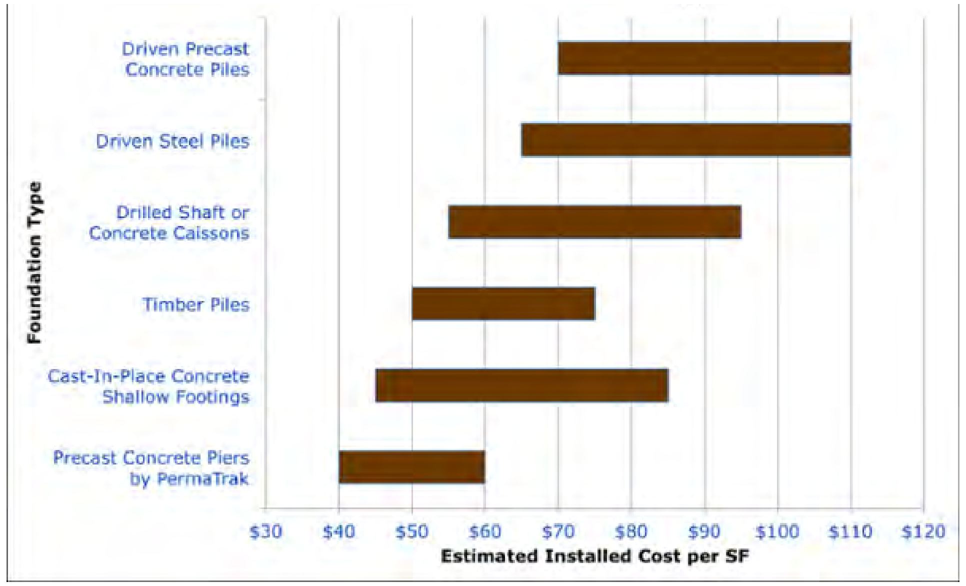
Building Program/Site: As stated previously, mat foundations are commonly used in areas with expansive clay soil, particularly in California and Texas. Our sight has some very expansive soil and the San Luis Obispo area has a moderate to high chance for liquefaction. Both of these factors are more than enough to justify the use of a slab-on-grade system for this project.

Cost: In addition to the soil conditions, a mat foundation system is also very beneficial when it comes to cost. From excavation to formwork, each aspect of constructing a mat foundation is much cheaper compared to other foundation types. Given that a mat foundation is in the category of cast-in-place shallow footings with regards to cost, mat slabs are one of the most cost-effective foundation solution, making them cheaper than drilled or driven piles. While it is not the cheapest option available and prices could vary as seen on the graph, it is still one of the cheapest options and other factors help to justify the selection. Also, our site has varying levels throughout the footprint of or site (10 feet max level differential) to combat the substantial existing slope. This could lead to an increased cost in the long run, but the benefits of this system greatly outweigh the drawbacks and concerns.

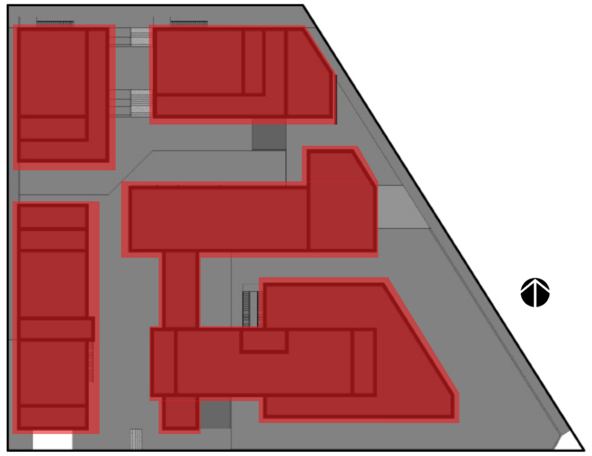
Constructability: A mat slab system is constructed monolithically, meaning that the foundation is poured all at once. This process can save quite a bit of time on construction because no extensive excavations is required and less forms are required like when pouring shallow pad footings. The top soil is removed and if the soil underneath is stable enough, the slab is poured directly without any additional digging needed. However, our projects proposal consists of varying grade levels throughout and

Sustainability: Mat foundations can receive LEED points in the categories Energy & Atmosphere, Materials and Resources, and Innovation and Design Process. Since use of an on-grade mat foundation typically results in a 20% - 30% reduction in concrete compared to pad footings and piles, a similar or even greater reduction in carbon emissions and air emissions will also occur. Reduced carbon emissions benefit the global carbon cycle, while reduced air quality emissions benefit the local environment of the job site and area where the cement is manufactured. Furthermore, the basic nature of an on-grade mat is to utilize less raw materials, including, cement, water, aggregate, sand etc. This means the system is proven to provide a more sustainable environment while limiting required resources.

Conclusion: When expansive soil conditions are present, certain foundation types are better than others. Mat foundations provide a sturdy base to support the structure while also combating issues commonly seen with expansive soils like liquefaction and settlement.

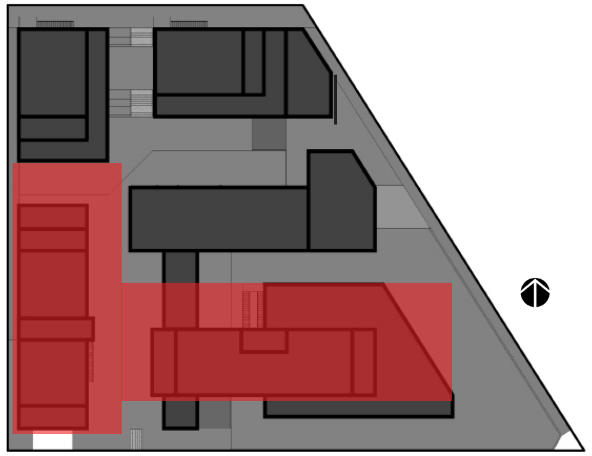


Key Plan



🟥 = Building Foundation Location

Key Plan



🟥 = Parking Foundation Location

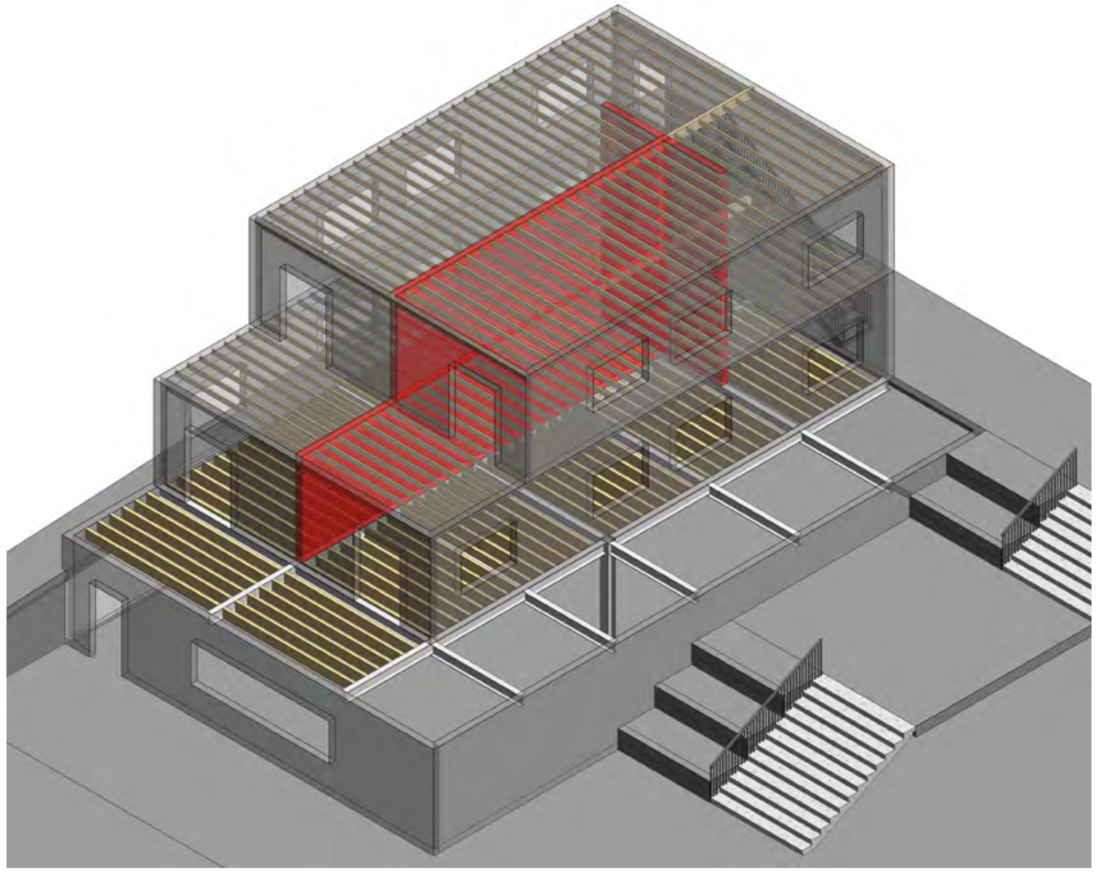
Gravity Configuration: Residential and Office Space #1

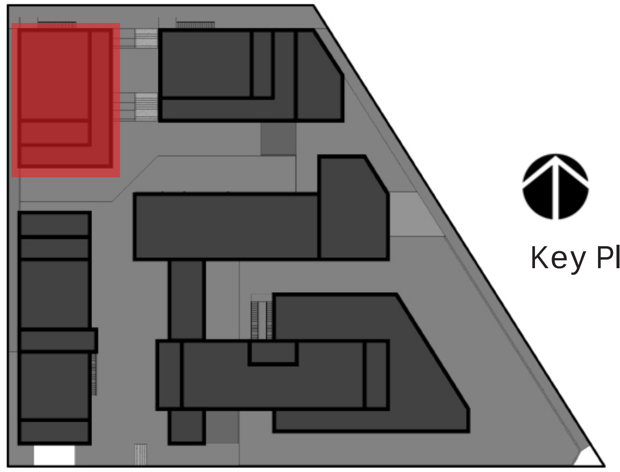
This unit incorporates concrete shear/retaining walls at the 1st floor office level and has a gravity system consisting of steel wide flanges acting as beam, girders, and columns. The second and third stories use timber bearing walls and transfer their forces to the steel beams and girders below and is framed using timber I-joists.

The gravity system for this residential/office space was determined by creating the shortest spans possible with timber I-joists and a central bearing wall running down the center of the residential units. The office space configuration was determined by bearing wall locations of the residential units above.

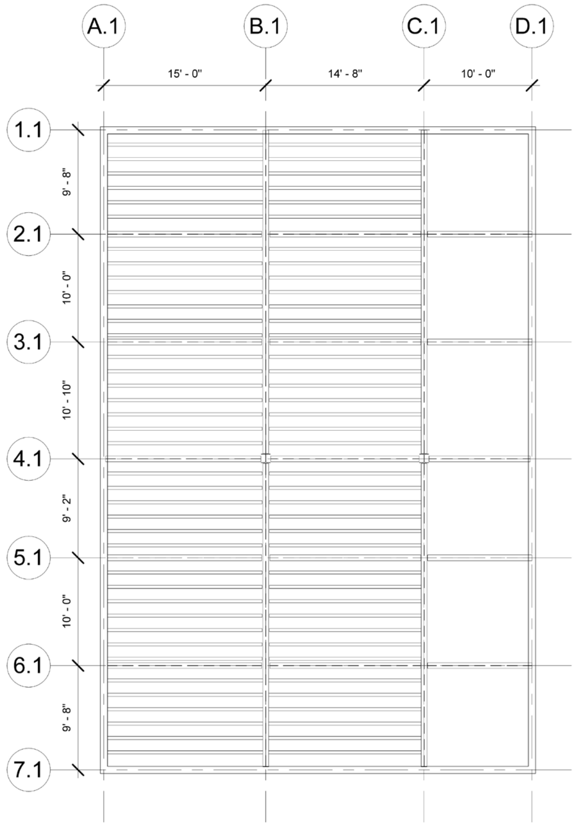
The residential units have a bearing wall running directly down the middle of each unit and divides the 30' wide units into 15' bays. The timber I-joists are spaced 16" on center and span 15', connecting to either the bearing wall or a girder which spans for the end of the bearing wall to the edge of the exterior walls.

The office space has two 15' wide bays to support the bearing walls on the residential levels above and an additional 10' wide bay for the setback between the office and residential space. The steel beams typically span 15' to 25' and frame into supporting girders and columns and perimeter concrete bearing walls. The bays of steel framing are then filled with timber joists and a plywood diaphragm as opposed to using steel composite deck.

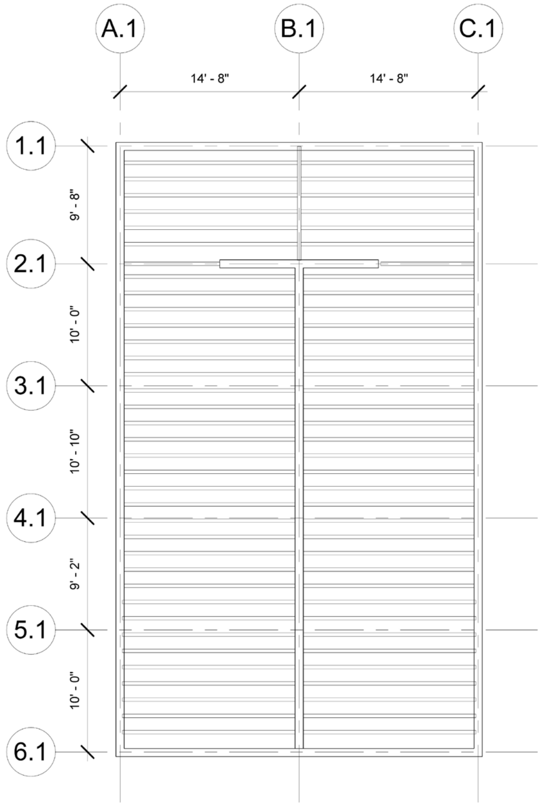




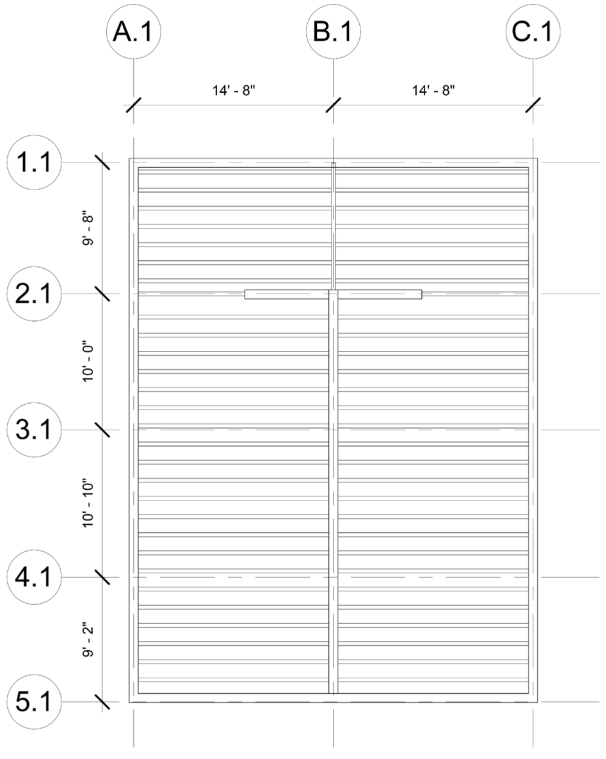
Key Plan



First Floor Configuration



Second Floor Configuration



Third Floor Configuration

Gravity Configuration: Residential and Office Space #2

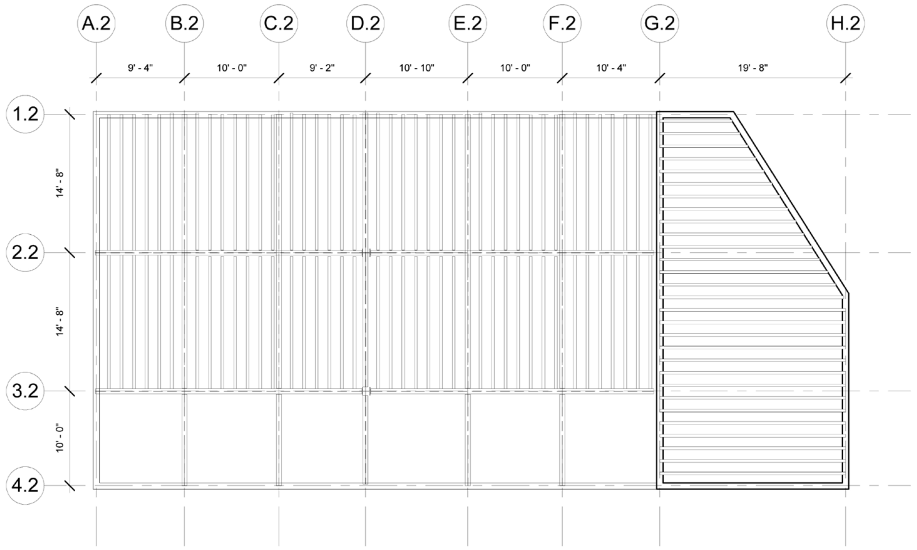
This unit incorporates concrete shear/retaining walls at the 1st floor office level and has a gravity system consisting of steel wide flanges. The second and third stories use timber bearing walls and transfer their forces to the steel beams and girders below and is framed using timber I-joists. The retail space adjacent to the office space consists of concrete shear/retaining walls and is framed with timber I-joists.

The gravity system for this residential/office space was determined creating shortest spans possible with timber I-joists and a central bearing wall running down the center of the residential units. The office space configuration was determined by bearing wall locations of the residential units above.

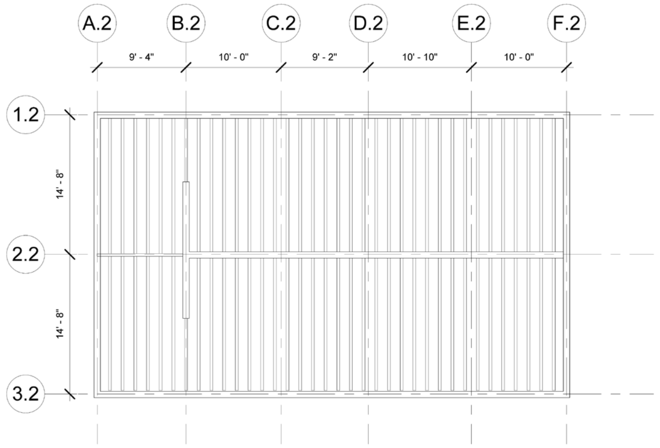
The residential units have a bearing wall running directly down the middle of each unit and divides the 30' wide units into 15' bays. The timber I-joists are spaced 16" on center and span 15', connecting to either the bearing wall or a girder which spans for the end of the bearing wall to the edge of the exterior walls.

The office space has two 15' wide bays to support the bearing walls on the residential levels above and an additional 10' wide bay for the setback between the office and residential space. The steel beams typically span 15' to 25' and frame into supporting girders and columns and perimeter concrete bearing walls. The bays of steel framing are then filled with timber joists and a plywood diaphragm as opposed to using steel composite deck.

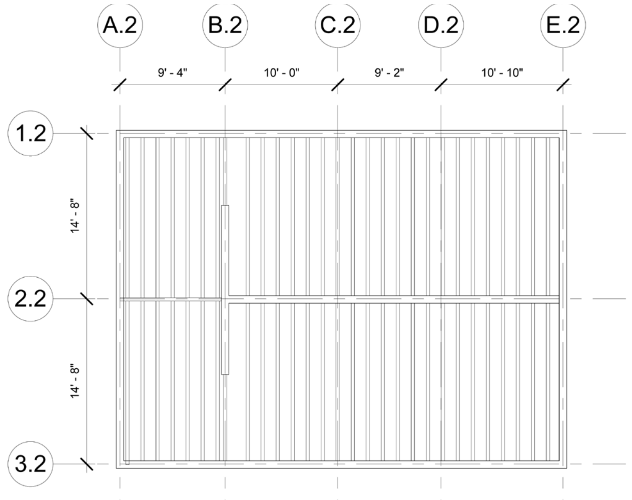
The adjacent residential unit was thin enough to where I-joist could span the short side of the building without drastically increasing the span length. This eliminated the need for girders and columns in the framing system.



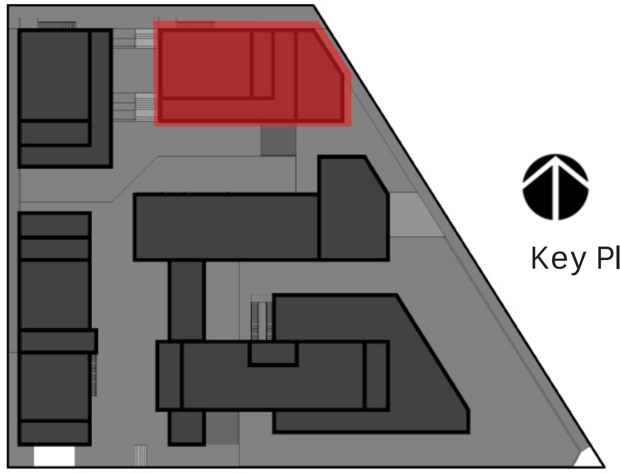
First Floor Configuration



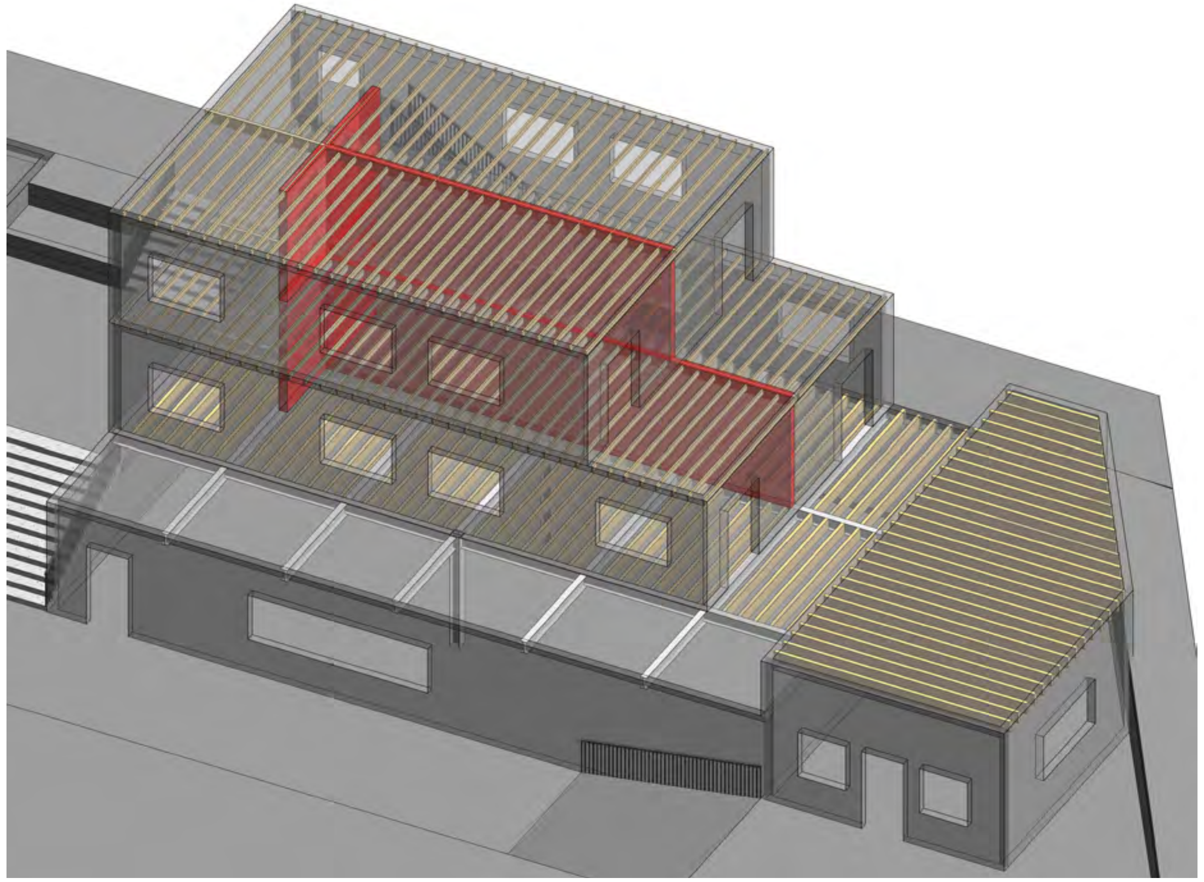
Second Floor Configuration



Third Floor Configuration



Key Plan



Gravity Configuration:

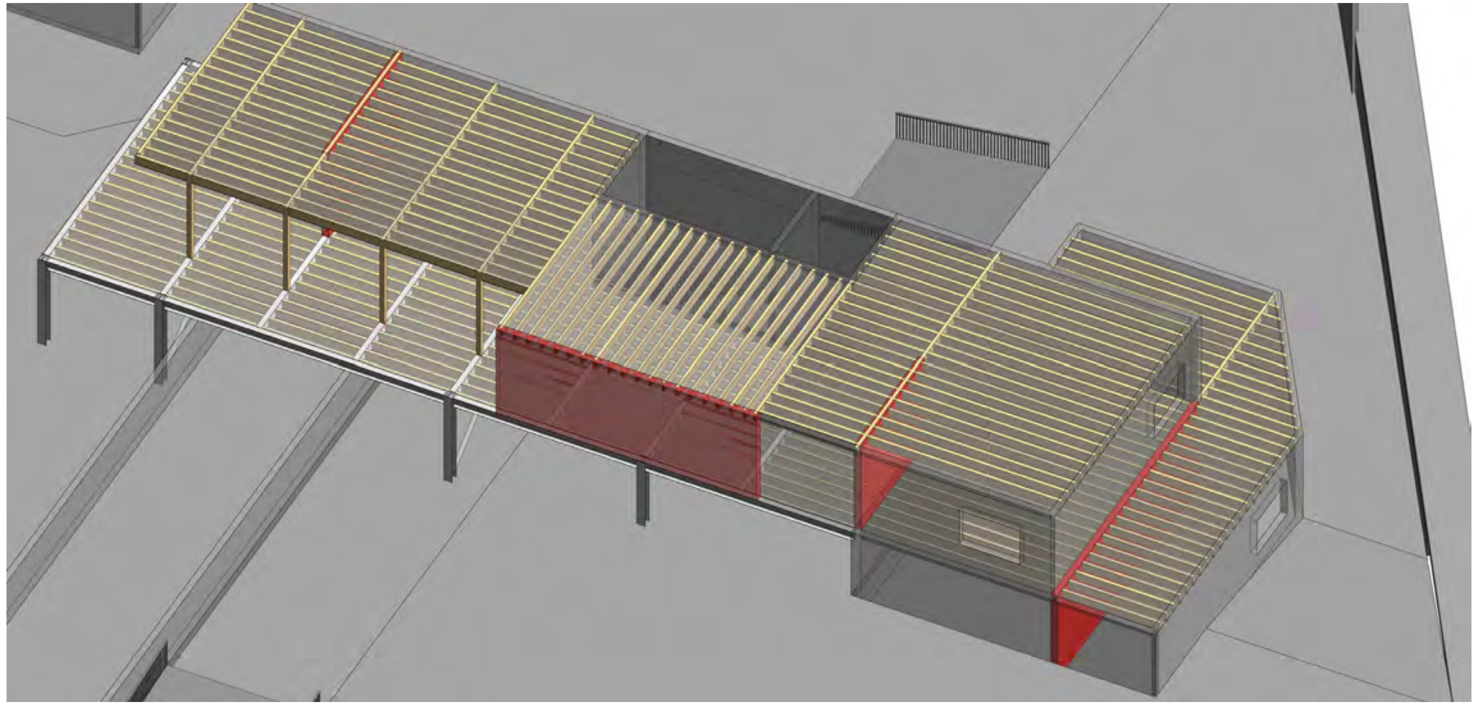
Community Center

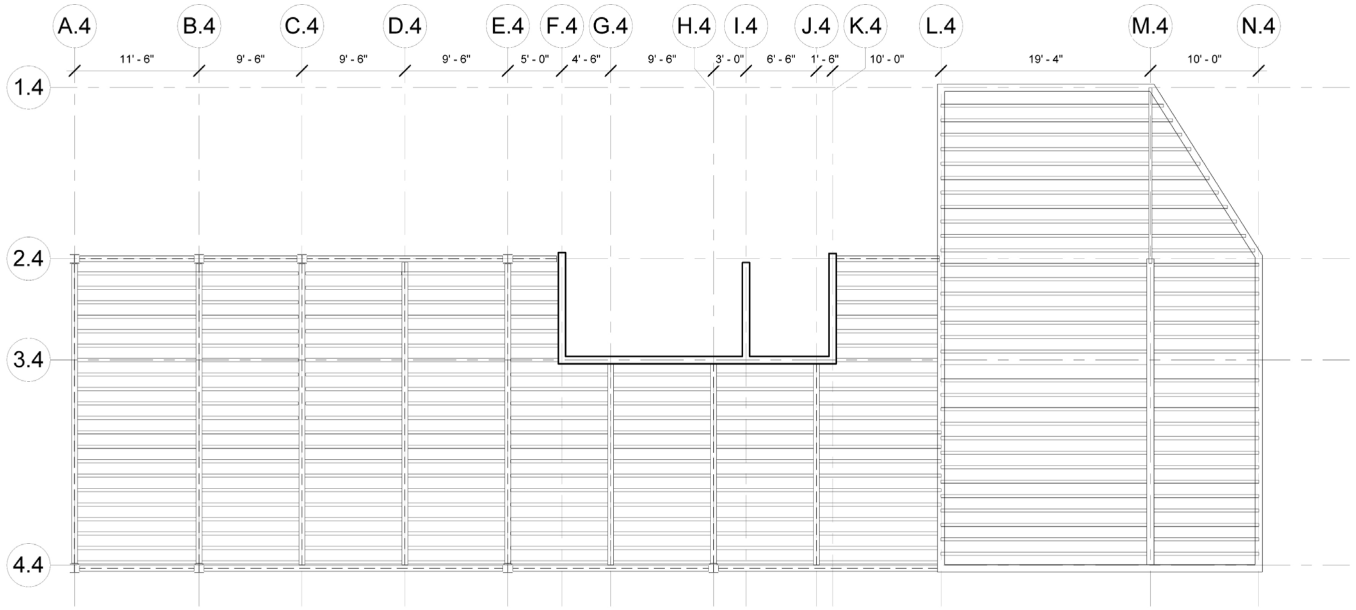
On the first floor, this unit incorporates concrete shear/retaining walls in the circulation tunnel and along the perimeter of the retail building on the far right hand side. Braced frames are place below the steel composite deck to provide lateral resistance for the cantilever. The retail space is framed using timber I-joists. On the second floor, the roof is framed using timber I-joists and the roof is offset inward to create an open walkway along the southwest perimeter of the building.

The gravity system for the retail space was determined by creating shortest spans possible with timber I-joists. A bearing wall is incorporated in the retail space and is aligned with the eastern most wall of the community center to assure adequate transfer of forces. This interior bearing wall allows beam spans to be decreased to one bay of 20' spans and another of 10' spans. A girder runs from the end of the bearing wall and runs to the end of the northern most wall in the unit.

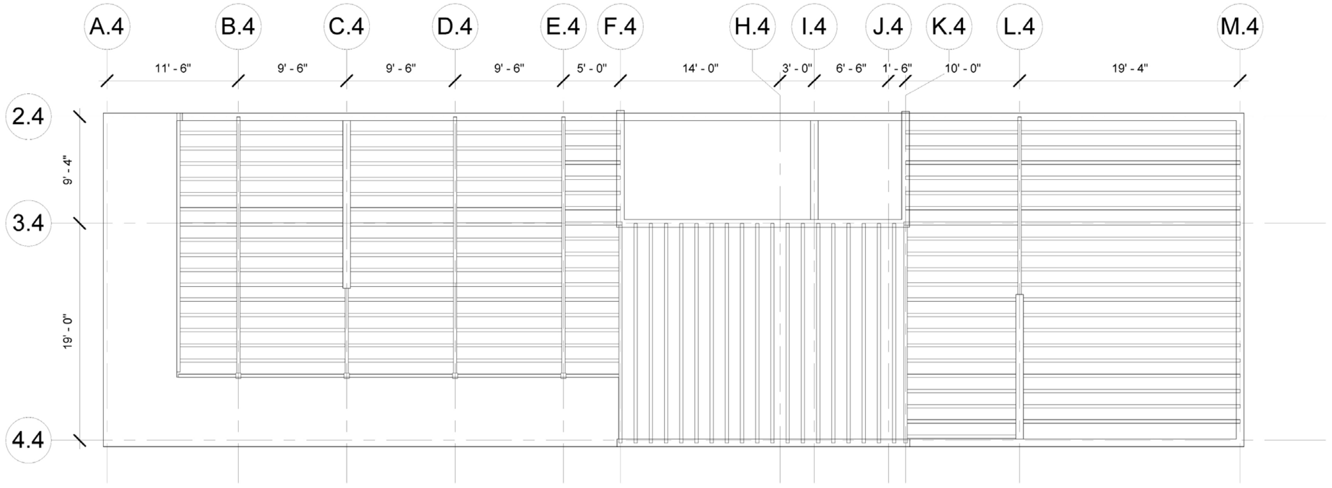
The community center configuration was determined by leaving the space as open as possible with the exception of a few bearing walls. Joists span anywhere from 6' to 20', but the majority of spans are between 12' and 20'. The joists will then frame into glulam beams with spans ranging from 6' to 20'. Two bearing walls are place on the east and west sides of the interior of the building and are 15' long. These bearing walls reduced the span of the beams and decreased the length of girder needed in those areas.

The steel structure supporting the community center over the pool consist of wide flange beams spanning 28' and bays that are 12' wide. The bay will be filled with timber I-joists spanning the width of each bay and will be tied together using a plywood diaphragm.

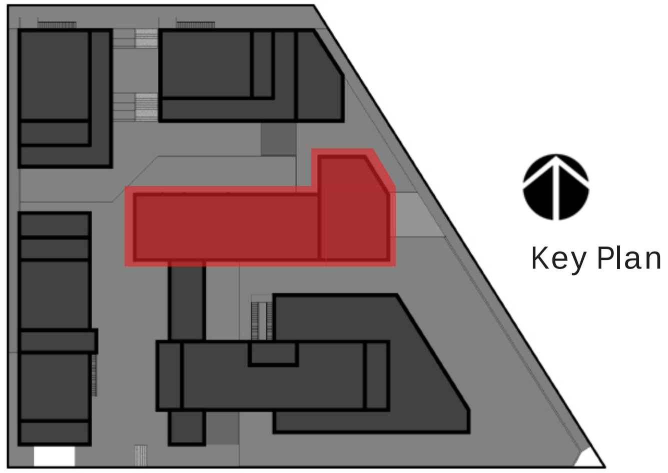




First Floor Configuration



Second Floor Configuration



Gravity Configuration:

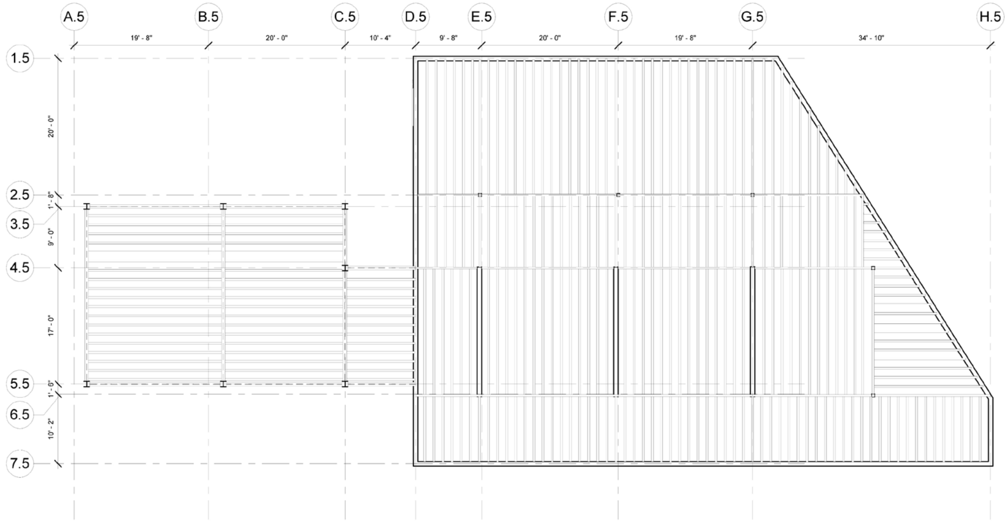
Residential and Restaurant Space

This unit incorporates timber bearing walls at the 1st floor restaurant level and has a gravity system consisting of timber I-joists supporting the residential spaces on the second floor and glulams supporting the roof garden. The second and third stories (residential) also use timber bearing walls and are framed using timber I-joists. The residential spaces above the pool will be supported by a steel beam and girder system and steel braced frames.

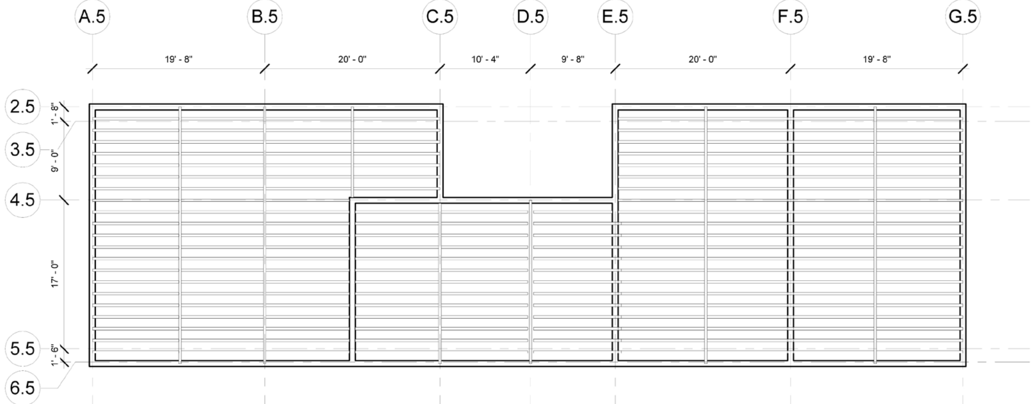
The gravity system for restaurant space was determined creating shortest spans possible with timber I-joists and glulams while also keeping the space as open as possible. There are three central bearing walls in the center of the restaurant to satisfy adequate transfer of gravity loads from the residential units above. The bearing walls on this level are about half the length of the bearing walls above, so to combat this issue, columns were place below the ends to the residential bearing walls to support additional loading and resist overturning. The typical span of beams and girders in the restaurant vary in size but are typically spanning anywhere between 10' to 20'.

The restidential units have bearing walls which separate units from one another and divide each unit in to 20' to 30' wide spaces. The timber I-joists are spaced 16" on center and vary between 10' and 15' in span length, connecting to either the bearing wall or a girder which spans the length of the unit. Additional interior shear walls will be incorporated to reduce the span of the girders in each unit.

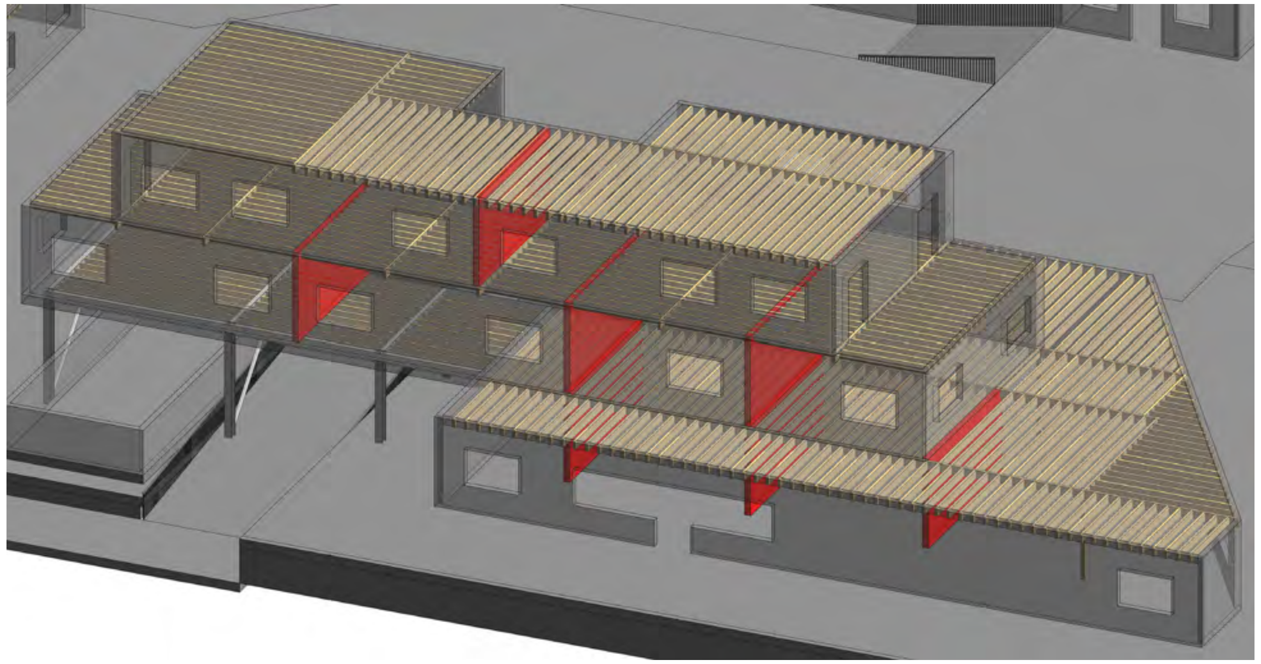
The steel structure supporting the residential units over the pool consist of wide flange beams spanning 28' and bays that are typically 12' wide. Each bay will be filled with timber I-joists spanning the width of each bay and will be tied together using a plywood diaphragm.

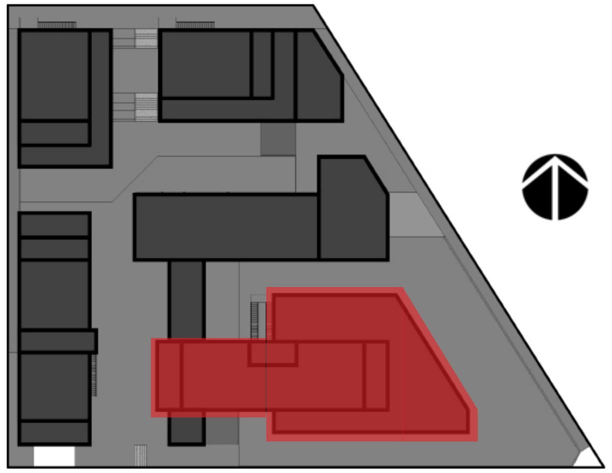


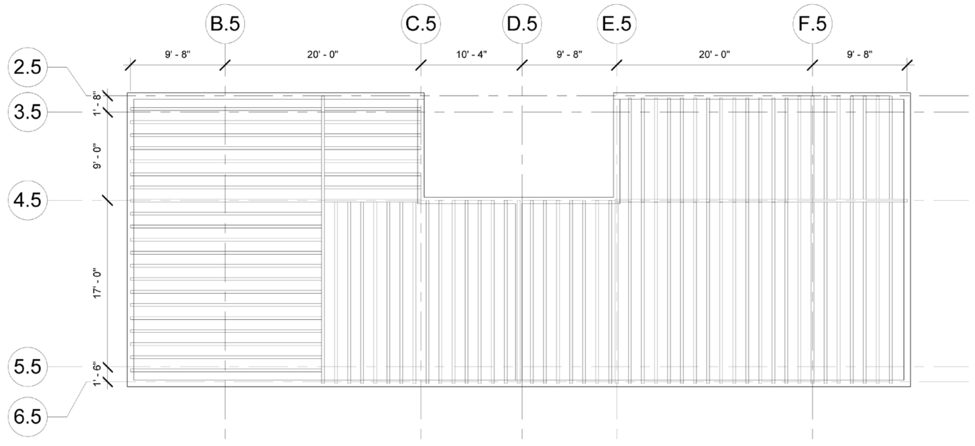
First Floor Configuration



Second Floor Configuration







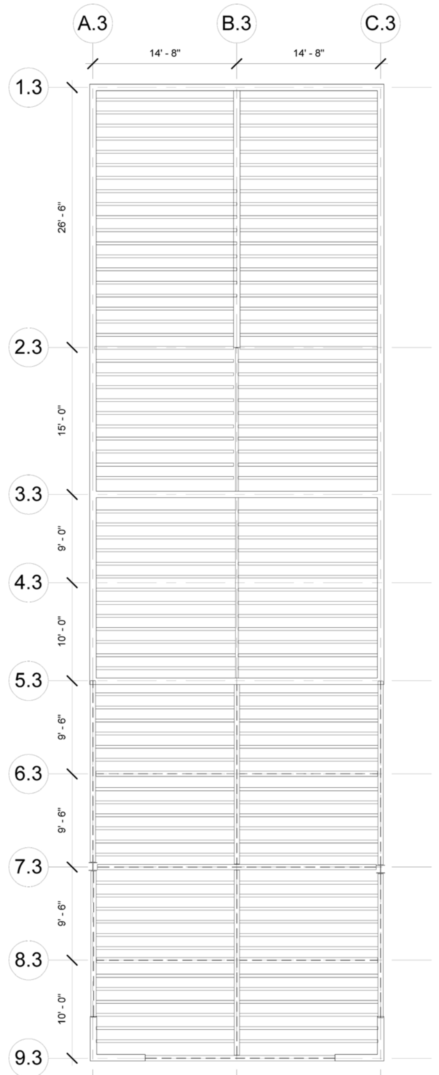
Third Floor Configuration

Gravity Configuration:
Residentail Space (SW Corner)

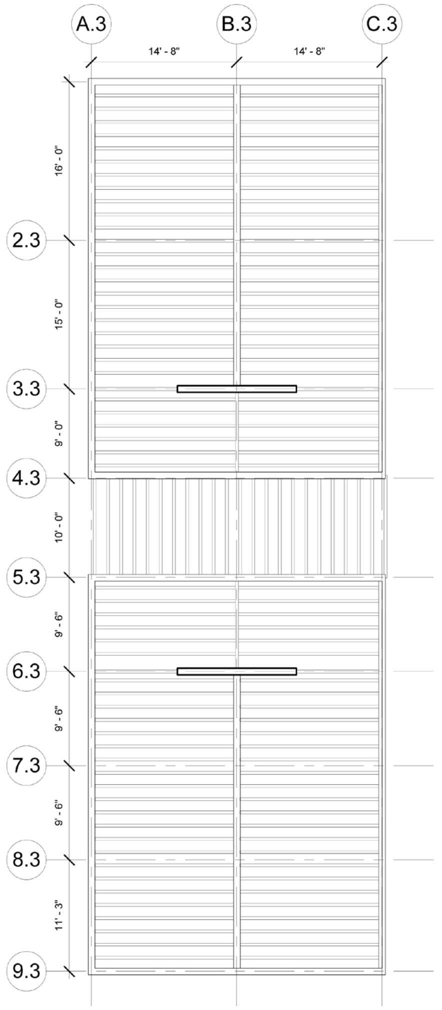
This unit contains all residential units on all three floors. Each floor consists of timber bearing walls and is framed using timber I-joists. The units over the parking entrance will be supported by concrete shear walls towards the south side of the building. There will be a steel beam and girder system on the second level of the residential unit over the parking entrance to create a more open space for cars to enter.

The residential units have a bearing wall running directly down the middle of each unit and divides the 30’ wide units into 15’ bays. The timber I-joists are spaced 16” on center and span 15’, connecting to either the bearing wall or a girder which spans from the end of the bearing wall to the edge of the exterior walls.

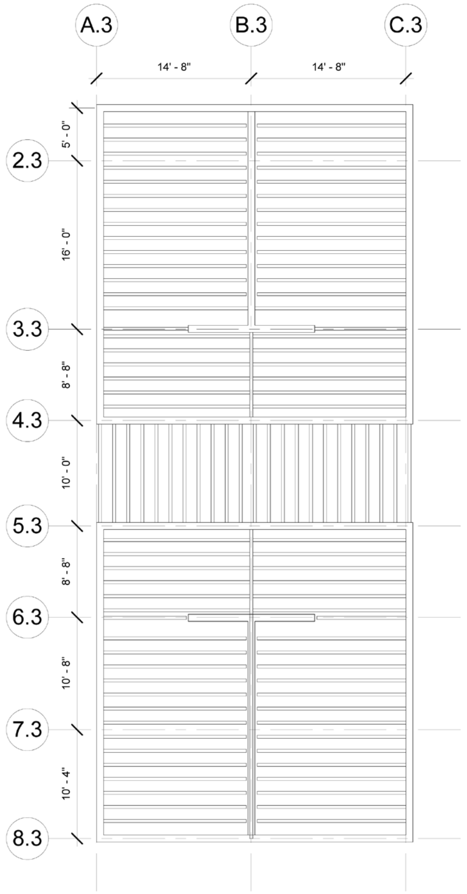
The steel structure supporting the residential units over the parking entrance consists of wide flange beams spanning between 15’ to 20’ with bays that are 9.5’ x 15’. The bay will be filled with timber I-joists spanning the width of each bay and will be tied together using a plywood diaphragm.



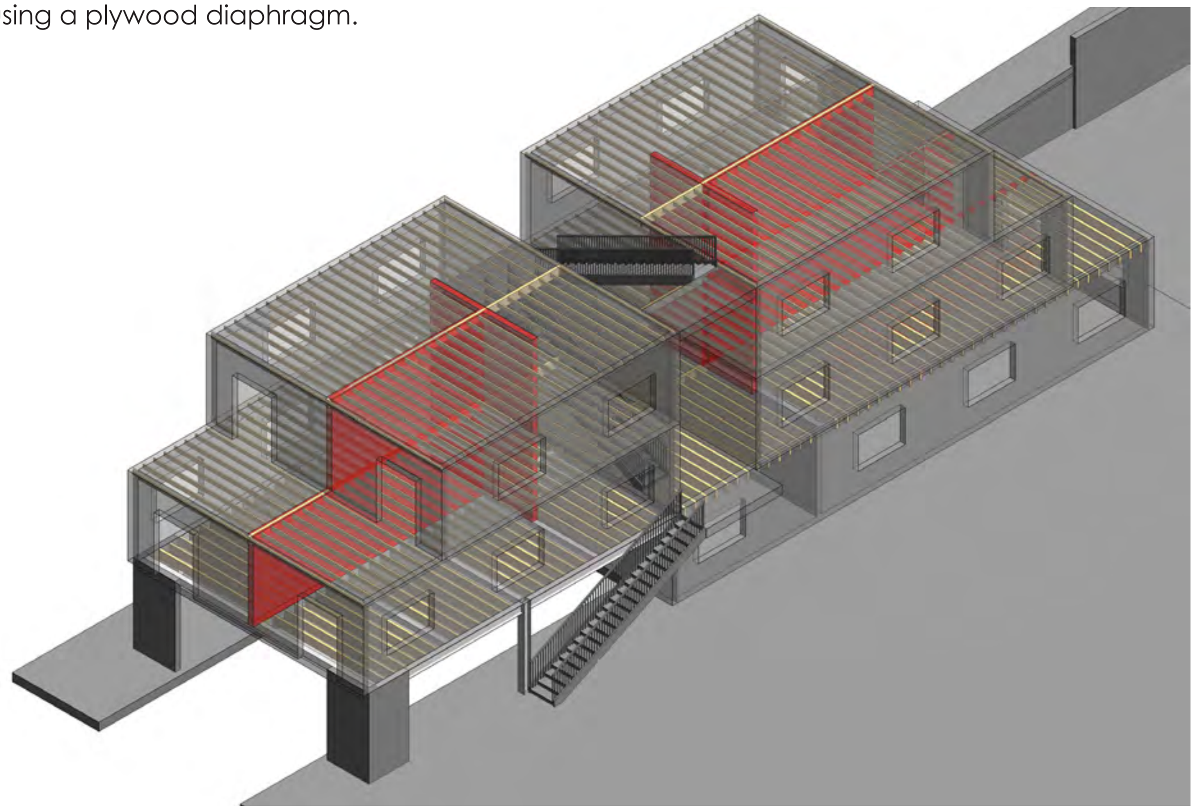
Second Floor Configuration

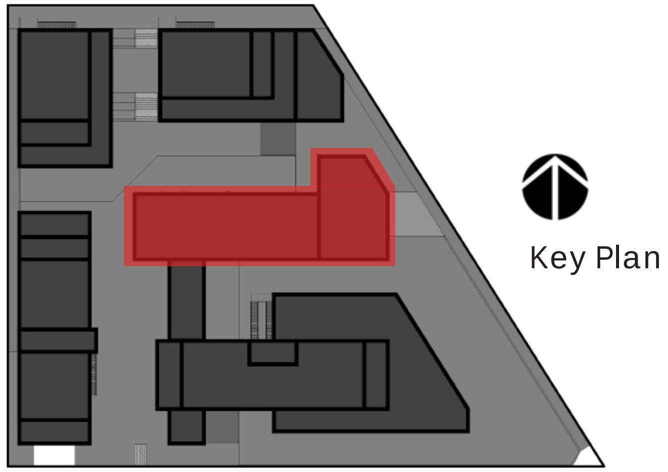


Second Floor Configuration



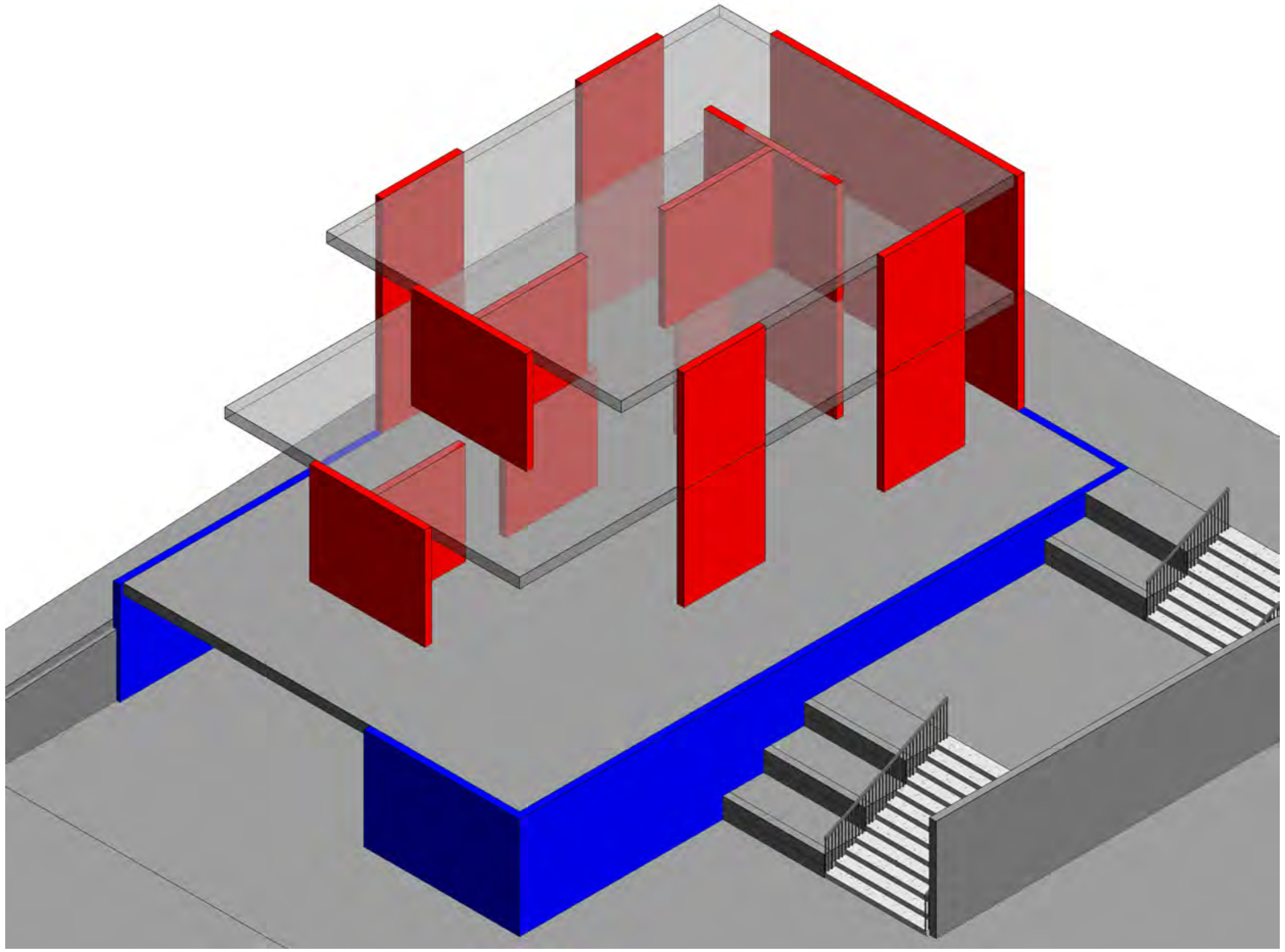
Second Floor Configuration





Key Plan

Lateral Configuration:
Residential and Office Space #1

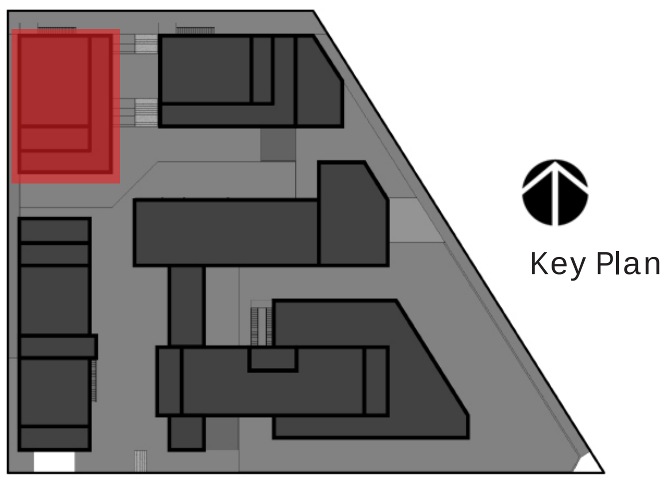


The lateral system for this residential/office space is a shear wall system with lateral elements located along the perimeter of the building and one central element in the residential units running along perpendicular axes. The residential units have 6 shear walls along the perimeter of the building and vary in length from 10' to 24' wide. Each shear wall is supported by a shear wall directly underneath it to assured adequate transfer of forces and to prevent in-plane offset irregularities.

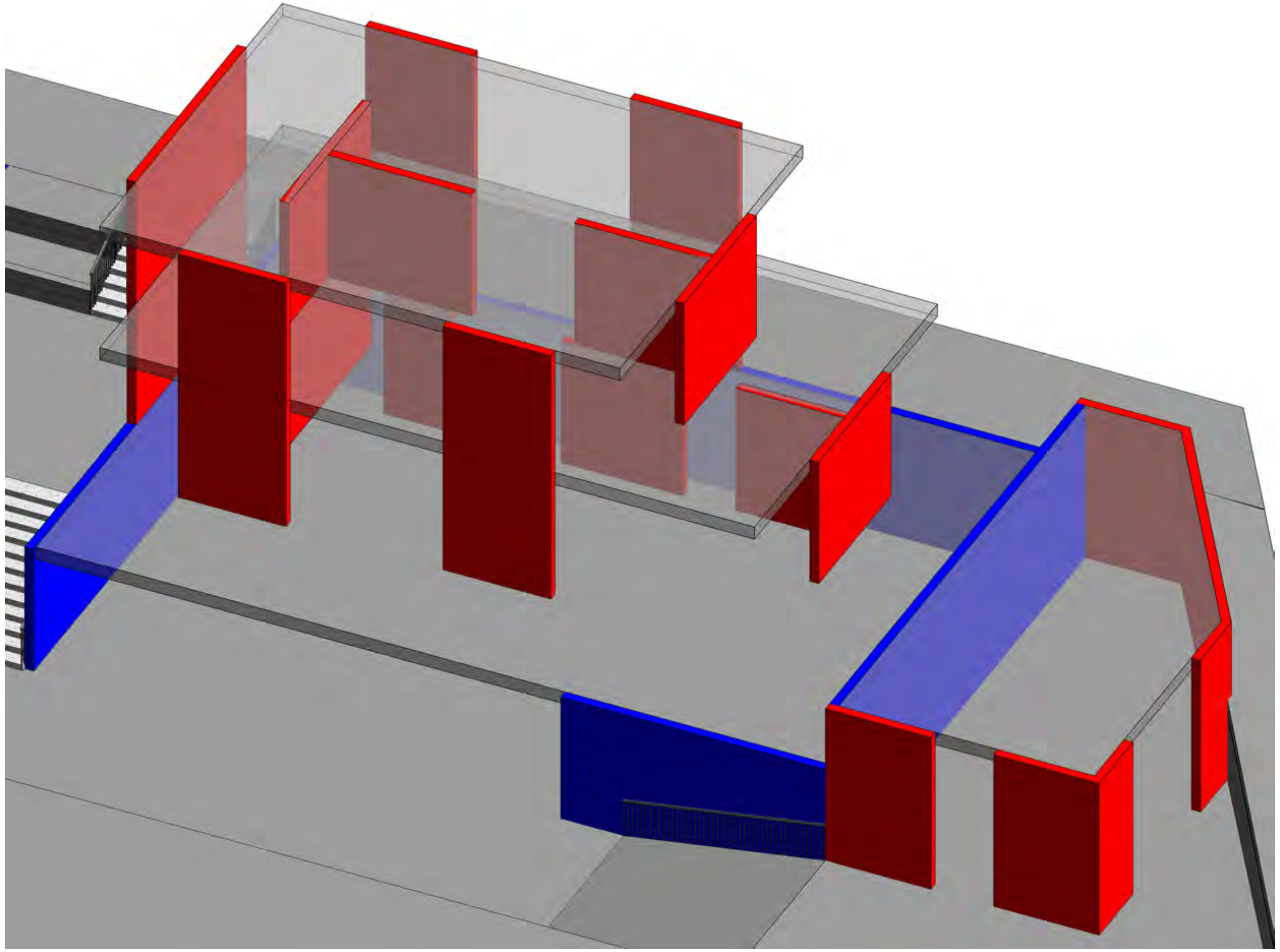
The shear walls on the office level are concrete and double as a retaining wall to resist soil pressure. With the exception of the south office facade, the north, west, and east concrete shear walls are continuous along the 50' length of the building.

This structure has a typical rectangular outline with 10' setbacks as its sole irregularity. In this case, collectors shall be provided for shear transfer. Because the office has more of an open layout, the steel wide flanges noted in the gravity system will be incorporated to transfer shear from the interior shear walls of the residential units to the lateral elements along the perimeter of the office space.

🟦 = *Concrete Shear Wall*
🟥 = *Timber Shear Wall*



Lateral Configuration: Residential and Office Space #2



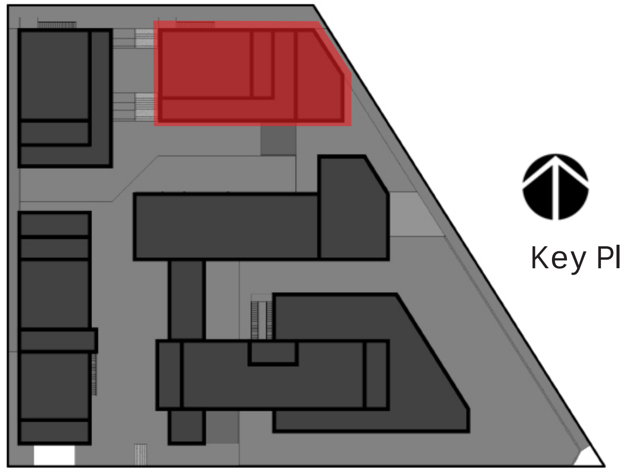
The lateral system for this residential/office space is a shear wall system with lateral elements located along the perimeter of the building and one central element in the residential units running along perpendicular axes. The residential units have 6 shear walls along the perimeter of the building and vary in length from 10' to 24' wide. Each shear wall is supported by a shear wall directly underneath it to assured adequate transfer of forces and to prevent in-plane offset irregularities.

The shear walls on the office level are concrete and double as a retaining wall to resist soil pressure. With the exception of the south office facade, the north, west, and east concrete shear walls are continuous along the 50' length of the building.

This structure has a typical rectangular outline with 10' setbacks as its sole irregularity. In this case, collectors shall be provided for shear transfer. Because the office has more of an open layout, the steel wide flanges noted in the gravity system will be incorporated to transfer shear from the interior shear walls of the residential units to the lateral elements along the perimeter of the office space.

The retail space adjacent to the office space will also use concrete shear walls to resist lateral loads. The retail space shares the same walls as the office space (west and north walls) and are raised 2.5' to accommodate the difference in roof levels.

🟦 = *Concrete Shear Wall*
🟥 = *Timber Shear Wall*



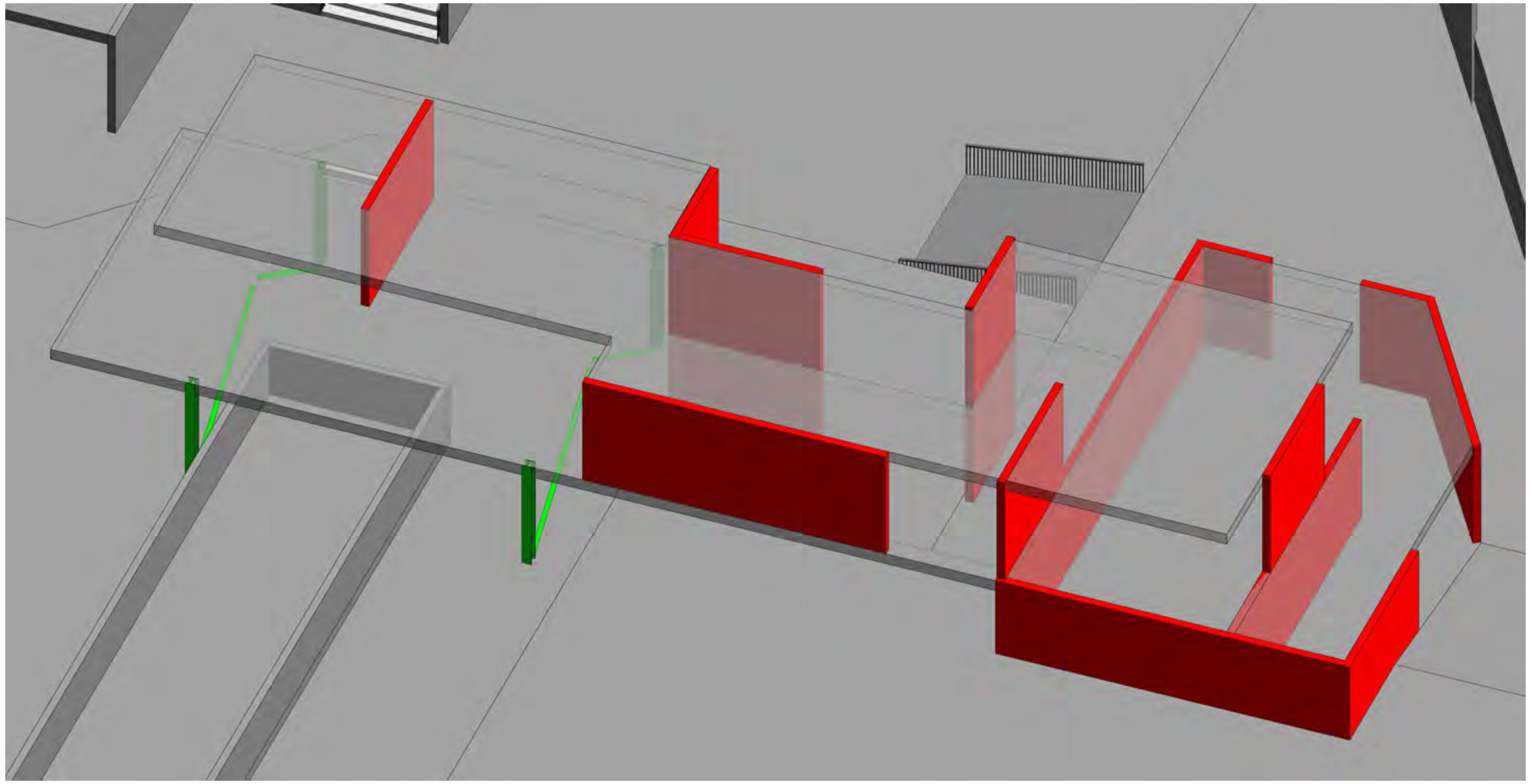
Key Plan

Lateral Configuration:
Community Center

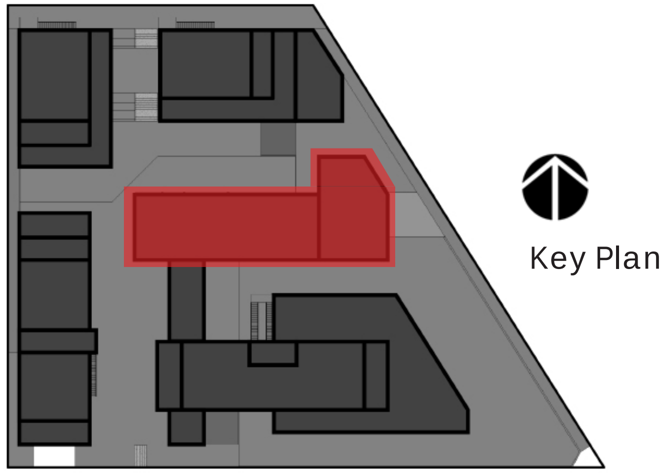
The lateral system for this community space on the second floor is a timber shear wall system with lateral elements located along the perimeter of the building and one shear wall shifted in 15’ on the west side. The shear walls vary in length from 10’ to 25’. All shear walls are continuous down to the foundation with exception the the west and south walls. These walls are supported by steel beam and girders in order to resist overturning and adequately transfer forces to shear walls on the first level.

The shear walls on the retail level are also timber shear walls and are located mostly around the perimeter with one located near the center to serve adequate load transfer from the shear walls above. The length of shear walls on this level typically vary between 15’ to 30’ long. There are also braced frames located on the first floor on the west side. This is to support the community space suspended over the pool as well as to bring the center of mass and the center of rigidity closer together, the reducing torsional eccentricities.

In addition to the 10’ setback irregularity located on the east side of the community space, there is also a nonparallel system irregularity along the north east side of the retail space on the first floor.

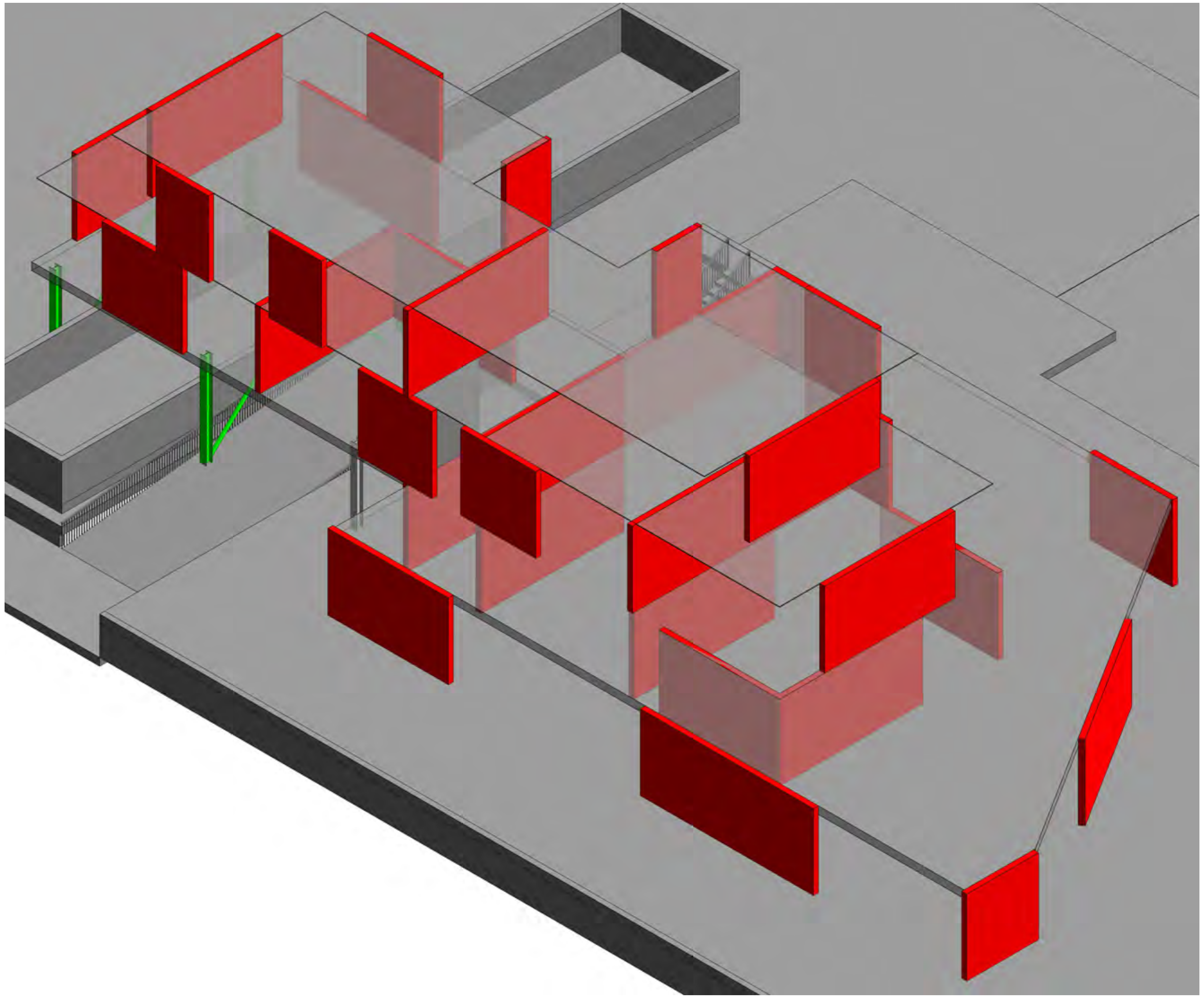


🟥 = *Timber Shear Wall*
🟩 = *Steel Brace Frame*



Lateral Configuration:

Residential and Restaurant Space



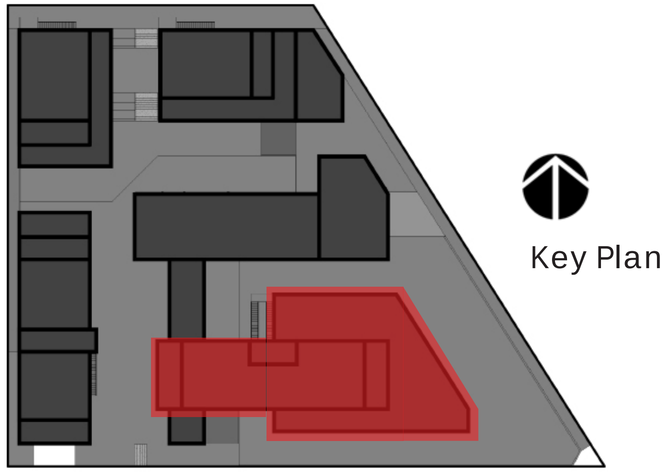
The lateral system for this residential spaces is a timber shear wall system with lateral elements located along the perimeter of the building and contains additional shear wall elements which separate units in the residential complex running in the north/south direction. The shear walls along the north and south sides of the building will typically vary between 9’ and 12’ while the lateral elements along the east and west side of the building vary from 15’ to 20’ long. Many shear walls in the north/south direction as well as quite a few in the east/west direction experience in-plane offset irregularities and require collectors and stronger beams supporting them to resist lateral/overturning forces.

The shear walls on the restaurant level are also timber shear walls and are located mostly around the perimeter with a few located in the center to serve adequate load transfer from the shear walls above. The length of shear walls on this level typically vary between 12’ to 25’ long. There are also braced frames located on the first floor on the west side. This is to support the residential units suspended over the pool as well as to bring the center of mass and the center of rigidity closer together, the reducing torsional eccentricities.

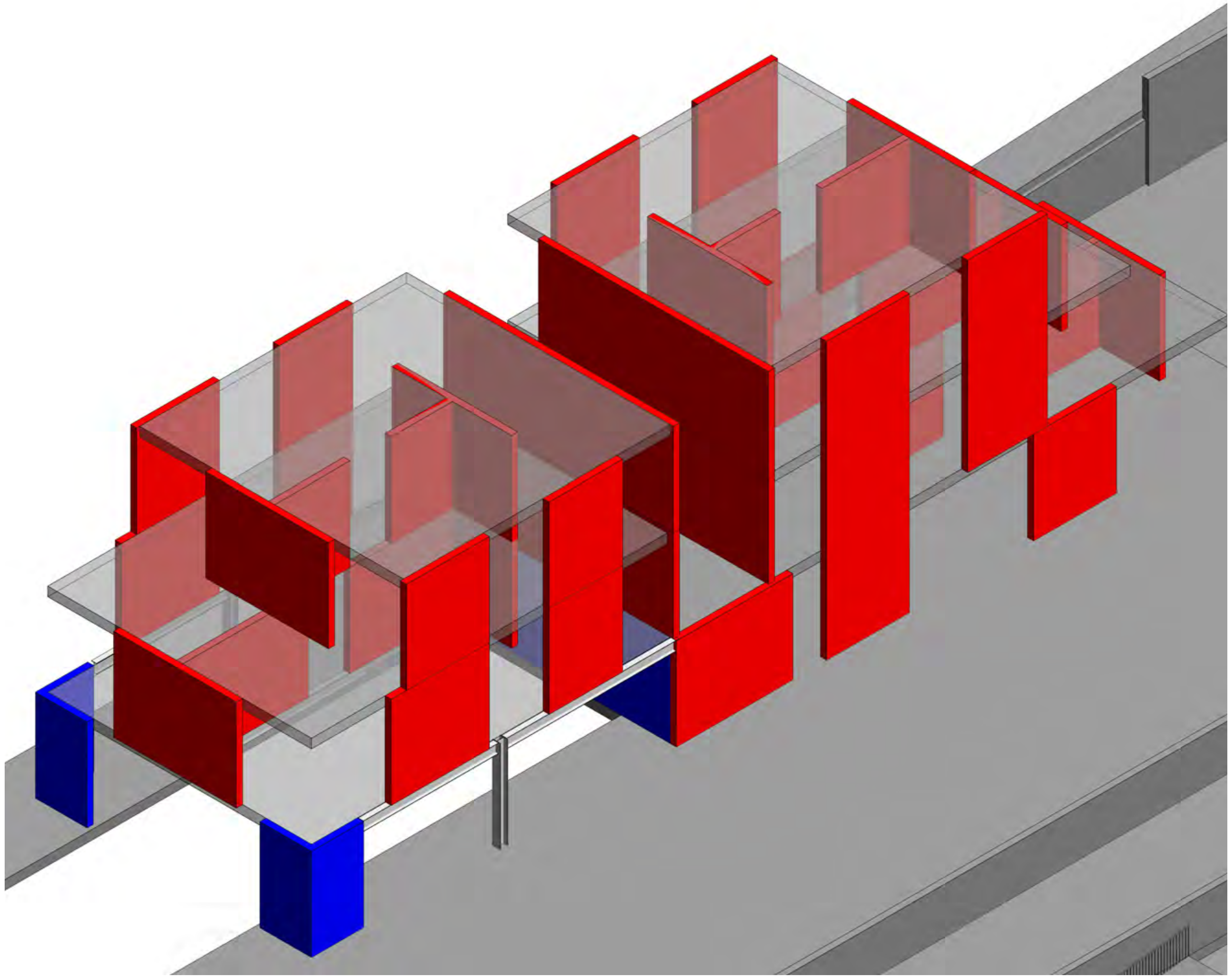
In addition to the 10’ setback irregularity as mentioned before, there is also a nonparallel system irregularity along the east side of the first floor.

. In this case, collectors shall be provided for shear transfer. Because the office has more of an open layout, the steel wide flanges noted in the gravity system will be incorporated to transfer shear from the interior shear walls of the residential units to the lateral elements along the perimeter of the office space.

🟥 = *Timber Shear Wall*
🟩 = *Steel Brace Frame*



Lateral Configuration:
Residentail Space (SW Corner)

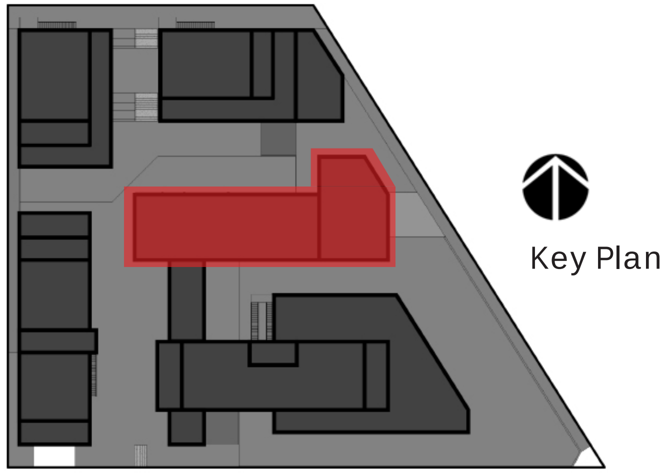


The lateral system for this residential space is a shear wall system with lateral elements located along the perimeter of the building and one central element in the residential units running along perpendicular axes. The residential units have 6 shear walls along the perimeter of the building and vary in length from 10’ to 24’ wide. Most shear walls are supported by a shear wall directly underneath it to assured adequate transfer of forces. However, some shear walls still exhibit in plane offset irregularities.

The shear walls on the first floor are a mix of concrete and timber shear walls. Timber shear walls are located along the perimeter of the first floor residential unit while the concrete shear walls are located towards the south near the parking entrance. Concrete shear walls were selected because of their compatibility with the steel beam and girder gravity system.

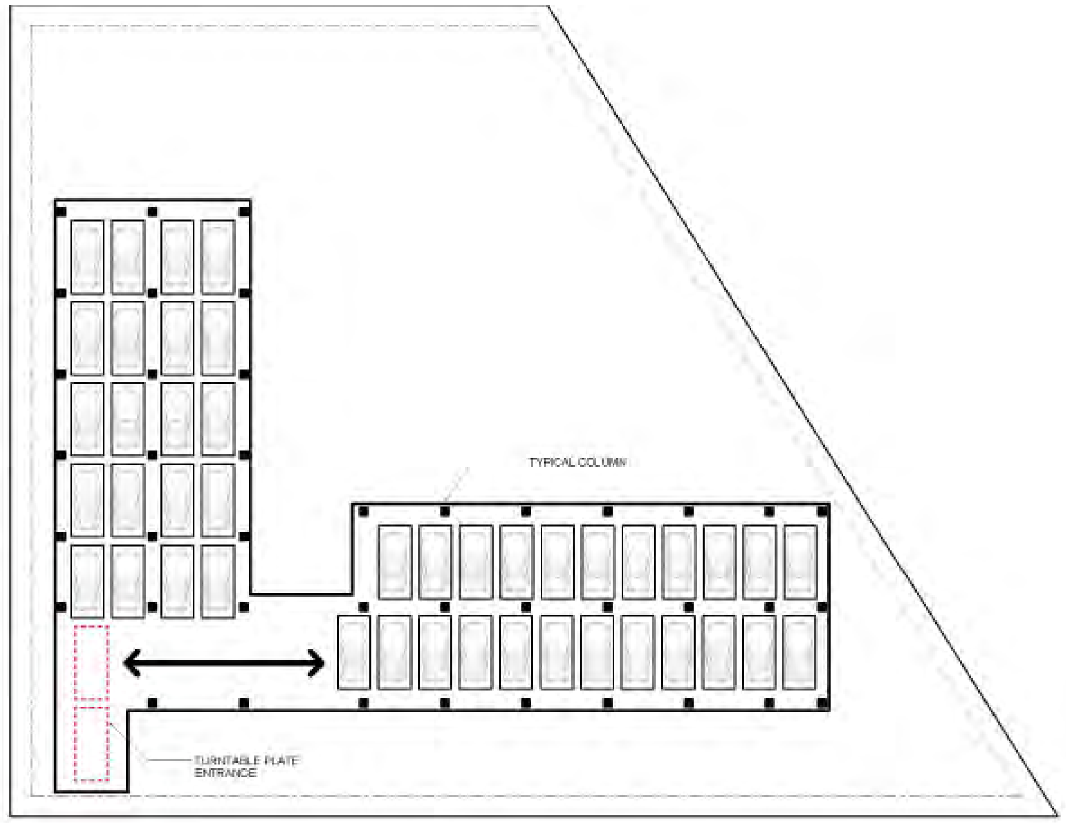
This structure has a typical rectangular outline with 10’ setbacks, causing in plane and out of plane offsets irregularities. In this case, collectors shall be provided for shear transfer. The steel wide flanges above the parking entrance noted in the gravity system will be incorporated to transfer shear from the shear walls of the residential units above to the lateral elements along the perimeter of the first floor residential unit and the concrete shear walls on the south side.

🟦 = *Concrete Shear Wall*
🟥 = *Timber Shear Wall*

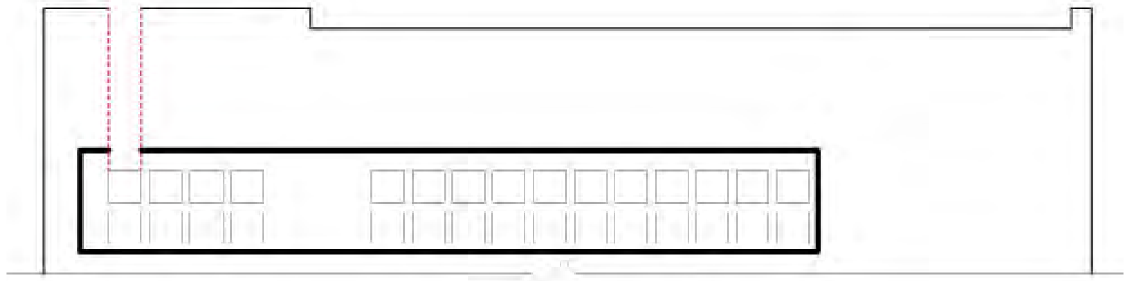


Key Plan

Parking System Configuration



Plan View

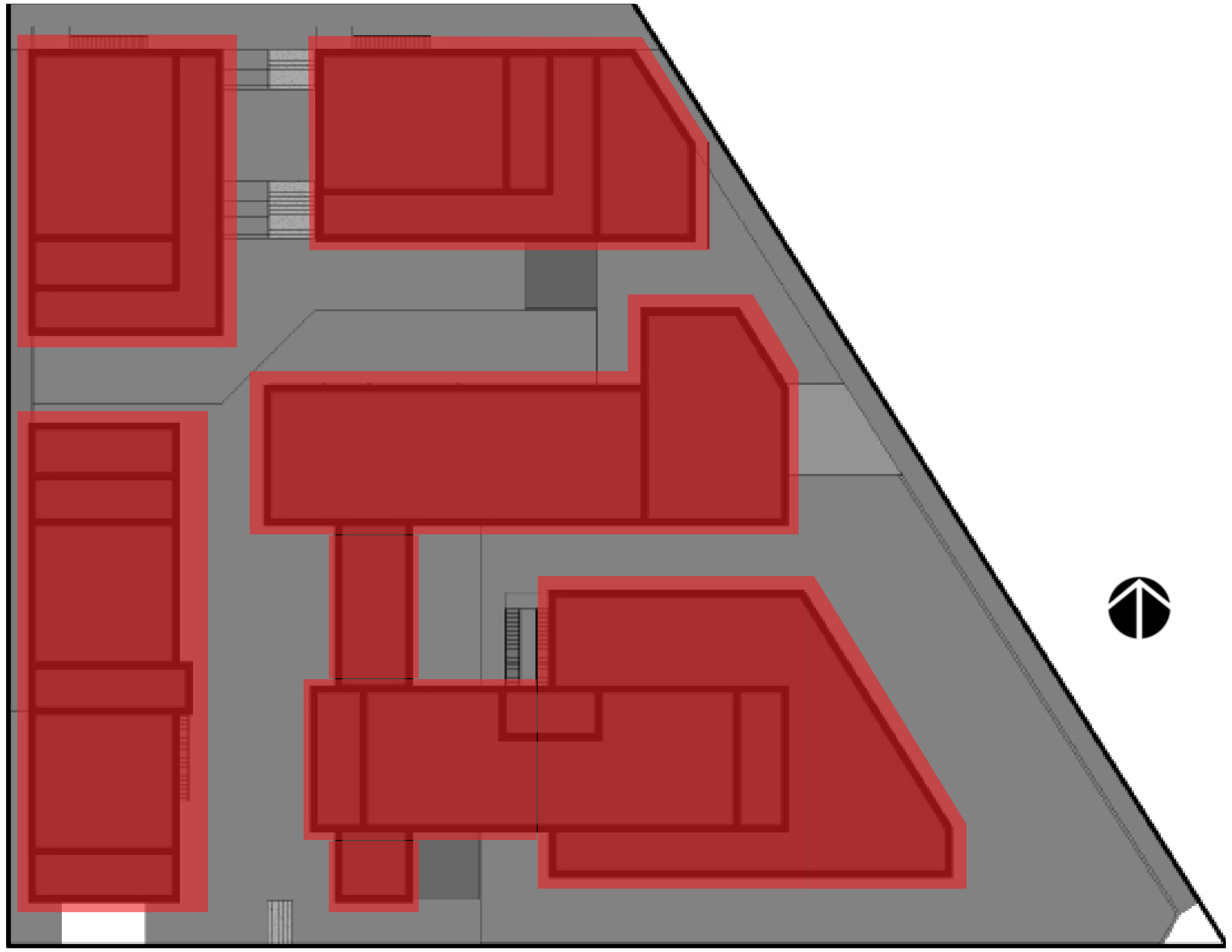


Section View

The automated parking system will be located along the west and south sides of the site. Drivers will enter the parking space by driving on a turntable plate located under the residential units in the southwest corner, which will lower the car into the parking area under the site. From there, the plate will direct the car to one of four rotating carousel assemblies to place the car in a designated spot. The carousels are incorporated to eliminate the need for drive lanes that transport the car. Because there are no drive lanes, less space is need to properly operate the automated parking system. The parking lot itself can accommodate 90 parking spaces with additional street parking for oversized and any additional vehicles.

The structural system supporting the underground parking consists of reinforced concrete beams and columns. Columns are spaced 20' on center. Some columns are in line with structural columns from the structures above grade to allow loads to properly transfer into the ground, while other columns have no their forces bearing on it besides the foundation itself. The configuration of the parking space was determined by trying to stack as many columns as possible with the structures above to prevent eccentric loading.

Foundation System Configuration



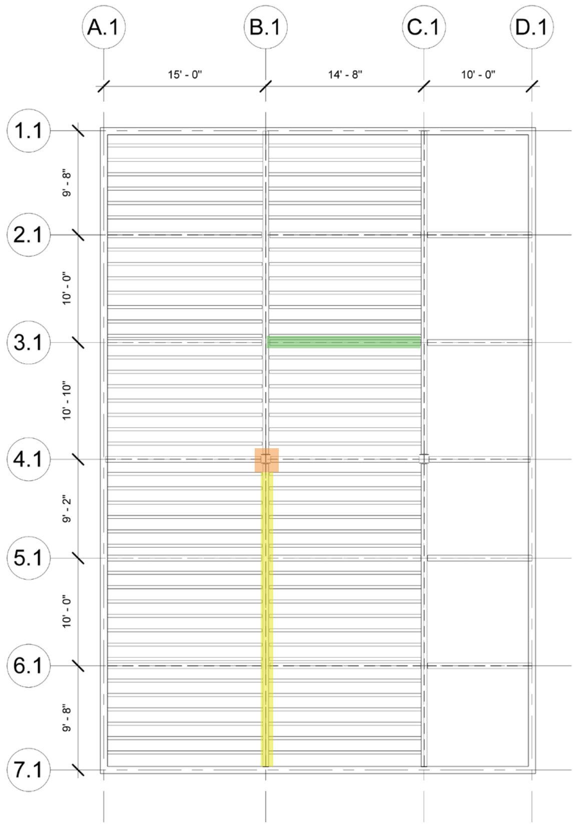
Site Map

Mat foundations are usually the same size as the footprint of the building, but can extend past the footprint if needed, typically extending a few feet from the edge of the building if need be. The thickness of a mat slab can vary depending upon the size of the building being constructed, but for a project of this size, mat foundations can range anywhere from 12 to 20" deep. The rebar within the slab is also variable and depends on the loads transferred by the columns and bearing walls.

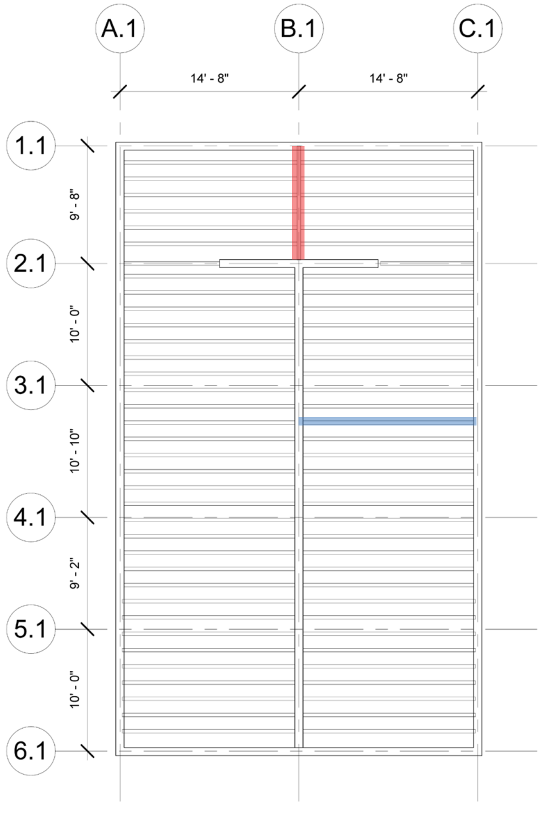
Gravity Sizing:

Residential and Office Space #1

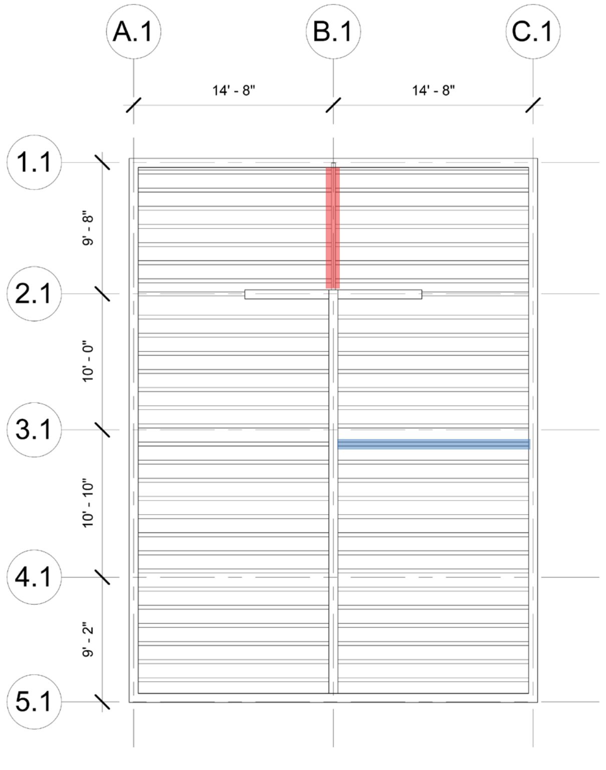
Live Load = 40 PSF (2nd and 3rd Floor), 20 PSF (Roof)
(Loading based on ASCE 7-10)
(Refer to Appendix for calculations)



First Floor Configuration



Second Floor Configuration



Third Floor Configuration

🟦 = *Typical Wood Joist*
🟥 = *Typical Wood Beam*
🟧 = *Typical Steel Coulmn*
🟨 = *Typical Steel Girder*
🟩 = *Typical Steel Beam*

__Residentail Floor Framing Summary:__

Typical Beam: 9 1/2" TJI 110 Joist
Typical Girder: 3 1/8" x 10 1/2" DF-L Glulam
Typical Stud Size: 2x4 studs

__Residentail Roof Framing Summary:__

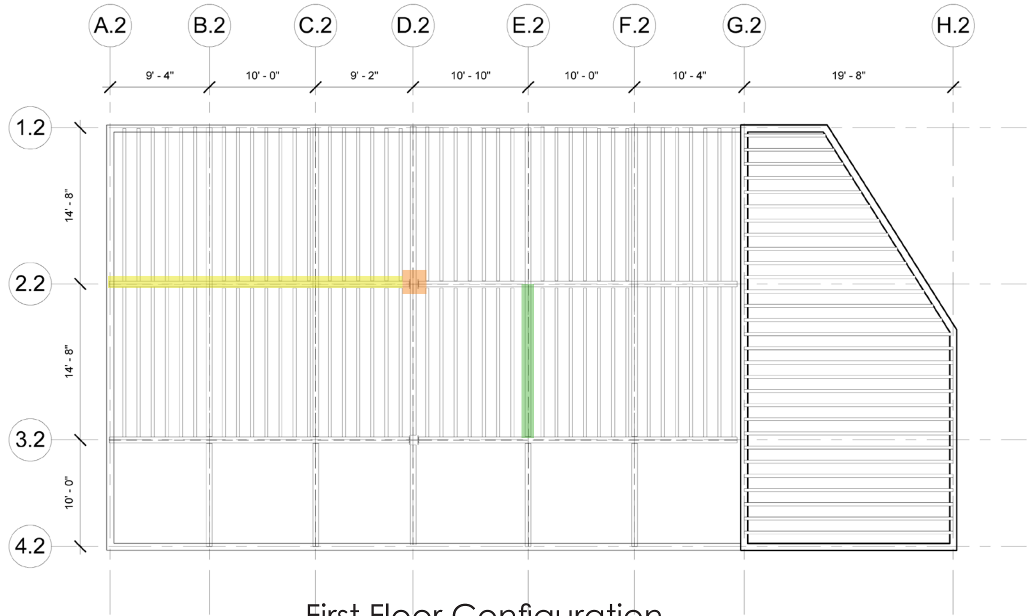
Typical Beam: 11 7/8" TJI 360 Joist
Typical Girder: 3 1/8" x 12" DF-L Glulam
Typical Stud Size: 2x4 studs

__Office Steel Framing Summary:__

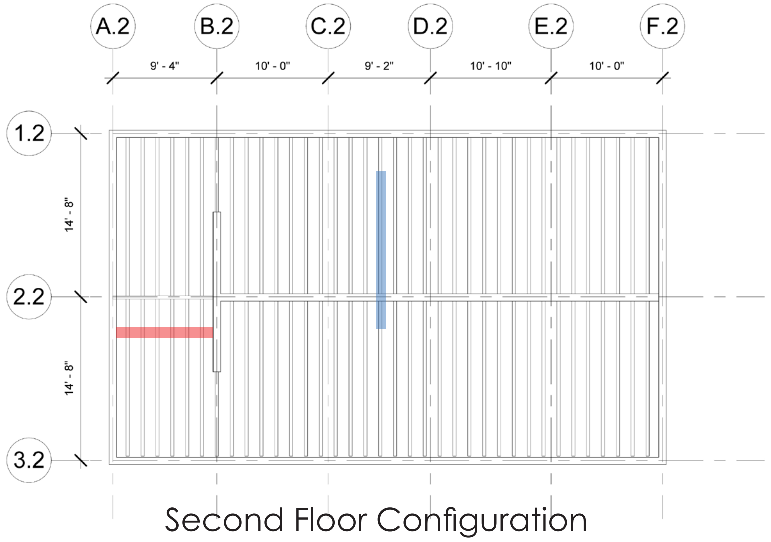
Typical Beam: W24x62
Typical Girder: W24x62
Typical Column: W10x33

Gravity Sizing:
Residential and Office Space #2

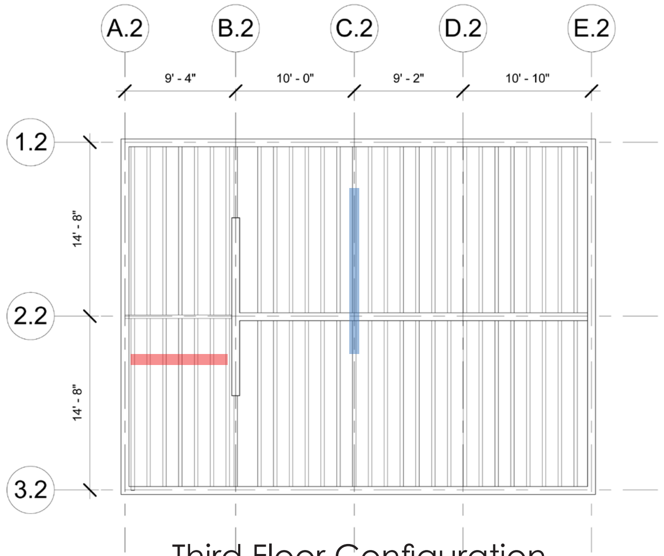
Live Load = 40 PSF (2nd and 3rd Floor), 20 PSF (Roof)
(Loading based on ASCE 7-10)
(Refer to Appendix for calculations)



First Floor Configuration



Second Floor Configuration



Third Floor Configuration

🟦 *= Typical Wood Joist*
🟥 *= Typical Wood Beam*
🟧 *= Typical Steel Coulmn*
🟨 *= Typical Steel Girder*
🟩 *= Typical Steel Beam*

__Residentail Floor Framing Summary:__

Typical Beam: 9 1/2" TJI 110 Joist
Typical Girder: 3 1/8" x 10 1/2" DF-L Glulam
Typical Stud Size: 2x4 studs

__Residentail Roof Framing Summary:__

Typical Beam: 11 7/8" TJI 360 Joist
Typical Girder: 3 1/8" x 12" DF-L Glulam
Typical Stud Size: 2x4 studs

__Adjacent Reatil Roof Framing Summary:__

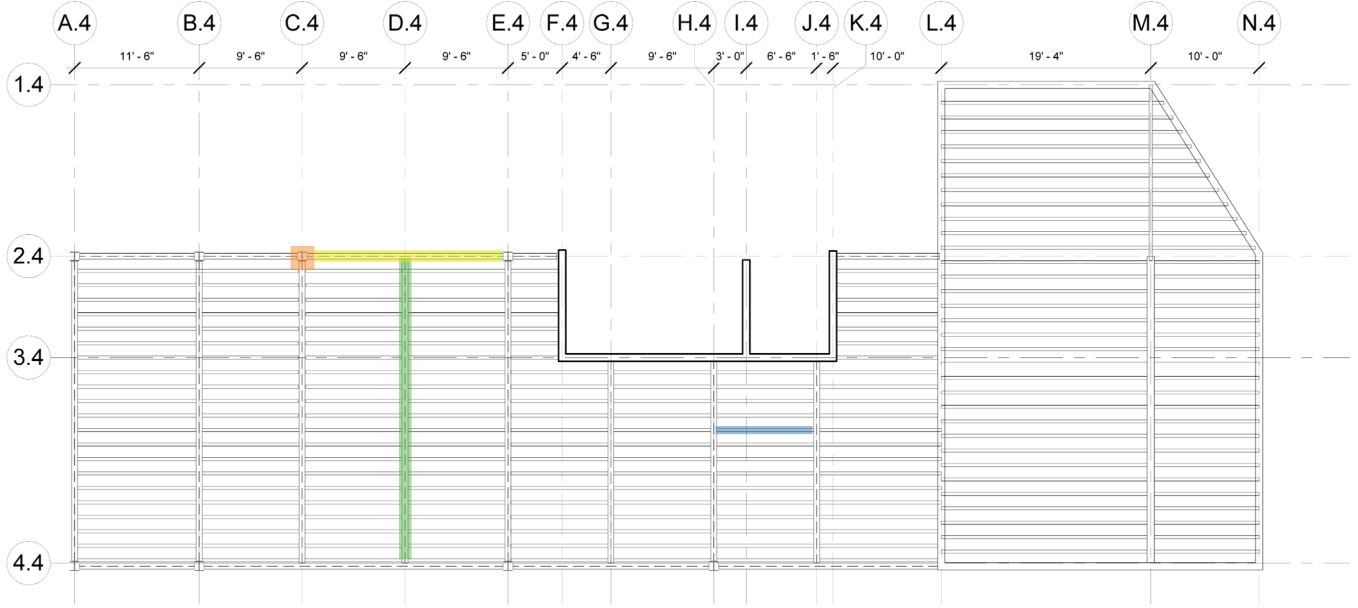
Typical Beam: 9 1/2" TJI 110 Joist
Typical Stud Size: 2x4 studs

__Office Steel Framing Summary:__

Typical Beam: W24x62
Typical Girder: W24x62
Typical Column: W10x33

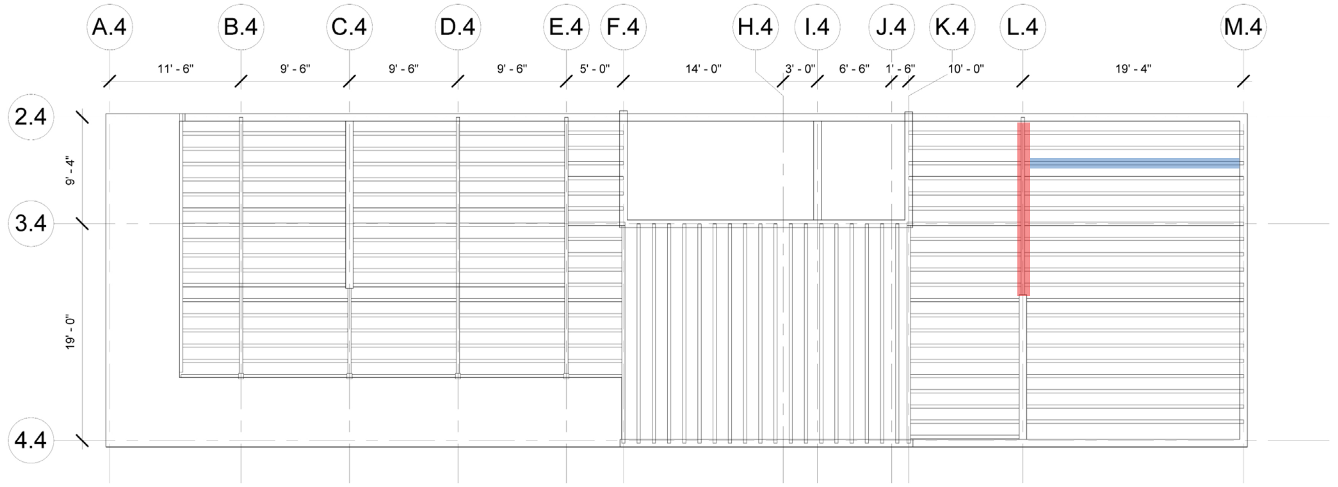
Gravity Sizing:
Community Center

Live Load = 75 PSF (2nd and 3rd Floor), 20 PSF (Roof)
(Loading based on ASCE 7-10)
(Refer to Appendix for calculations)



First Floor Configuration

🟦 = *Typical Wood Joist*
🟥 = *Typical Wood Beam*
🟧 = *Typical Steel Coulmn*
🟨 = *Typical Steel Girder*
🟩 = *Typical Steel Beam*



Second Floor Configuration

__Community Center Floor Framing Summary:__

Typical Beam: 9 1/2" TJI 110 Joist
Typical Girder: 3 1/8" x 10 1/2" DF-L Glulam
Typical Stud Size: 2x4 studs

__Community Center Roof Framing Summary:__

Typical Beam: 11 7/8" TJI 360 Joist
Typical Girder: 3 1/8" x 12" DF-L Glulam
Typical Stud Size: 2x4 studs

__Adjacent Reatil Roof Framing Summary:__

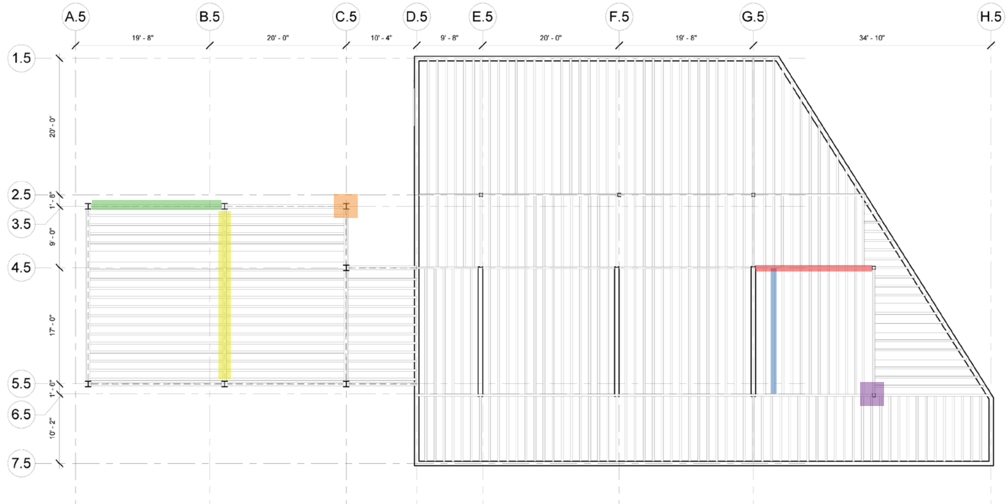
Typical Beam: 9 1/2" TJI 110 Joist
Typical Stud Size: 2x4 studs
Typical Stud Size: 2x4 studs

__Community Center Steel Framing Summary:__

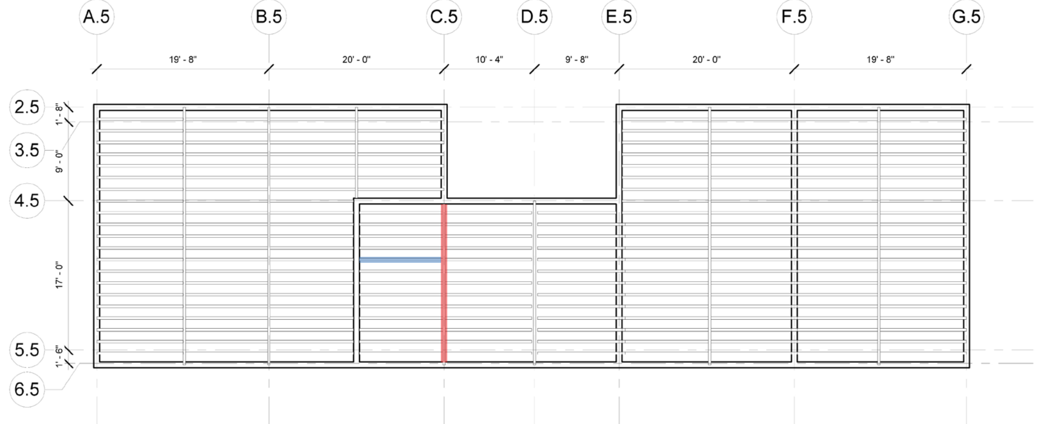
Typical Beam: W24x62
Typical Girder: W24x62
Typical Column: W10x33

Gravity Sizing:
Residential and Restaurant Space

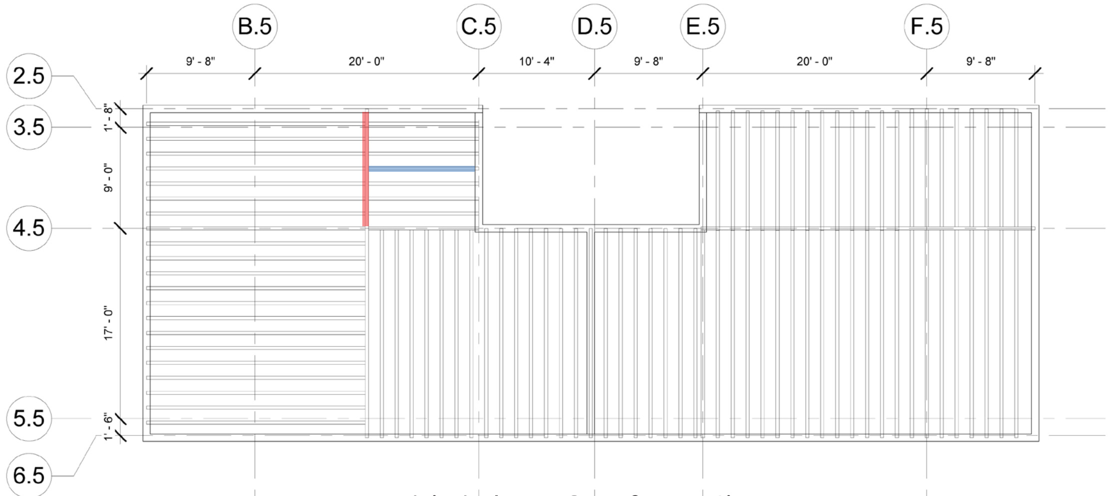
Live Load = 40 PSF (2nd and 3rd Floor), 20 PSF (Roof)
40 PSF (Roof Garden/Same As Occupancy Served)
(Loading based on ASCE 7-10)
(Refer to Appendix for calculations)



First Floor Configuration



Second Floor Configuration



Third Floor Configuration

🟦 *= Typical Wood Joist*
🟥 *= Typical Wood Beam*
🟪 *= Typical Wood Coulmn*
🟧 *= Typical Steel Coulmn*
🟨 *= Typical Steel Girder*
🟩 *= Typical Steel Beam*

Residential Floor Framing Summary:

Typical Beam: 9 1/2" TJI 110 Joist
Typical Girder: 3 1/8" x 10 1/2" DF-L Glulam
Typical Stud Size: 2x4 studs
Typical Steel Beam: W24x62
Typical Steel Girder: W24x62
Typical Steel Column: W10x33

Residentail Roof Framing Summary:

Typical Beam: 11 7/8" TJI 360 Joist
Typical Girder: 3 1/8" x 12" DF-L Glulam
Typical Stud Size: 2x4 studs

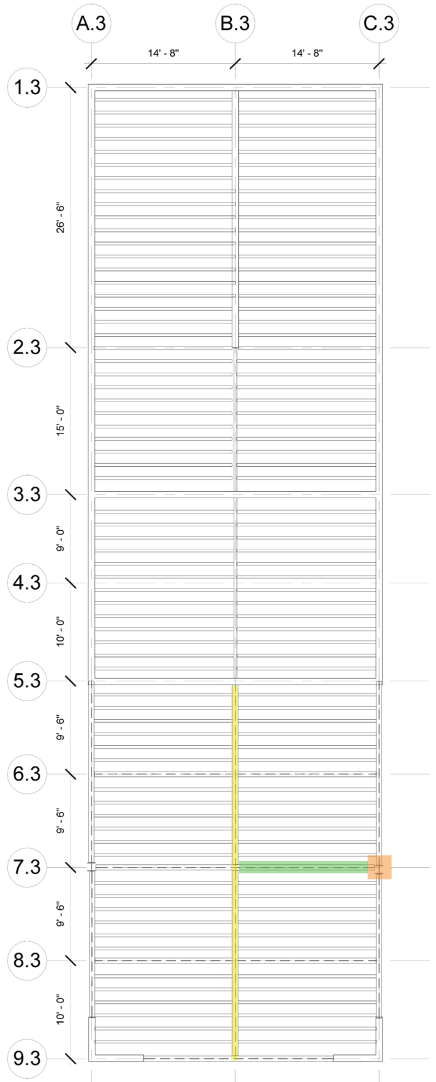
Restaurant Roof Garden Framing Summary:

Typical Beam: 5 1/8" x 10 1/2" DF-L Glulam
Typical Girder: 6 3/4" x 18" DF-L Glulam
Typical Stud Size: 2x6 studs
Typical Column Size: 6x8 DF-L

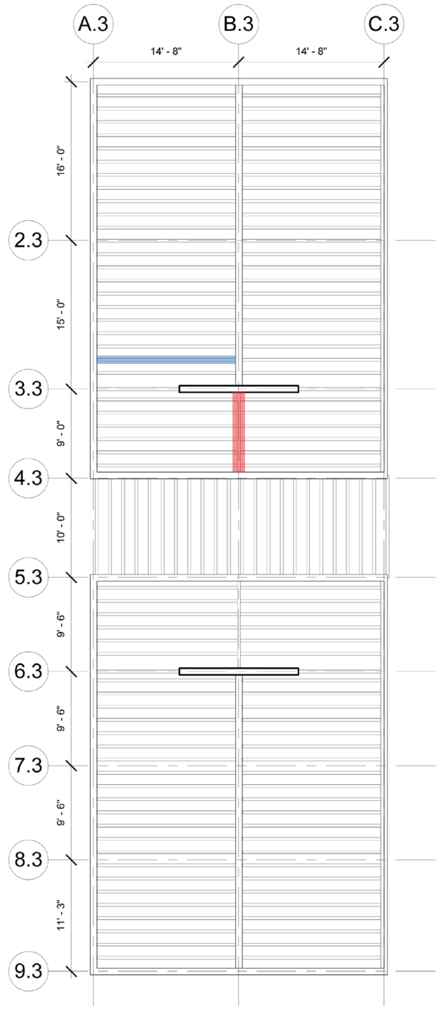
Gravity Sizing:

Residentail Space (SW Corner)

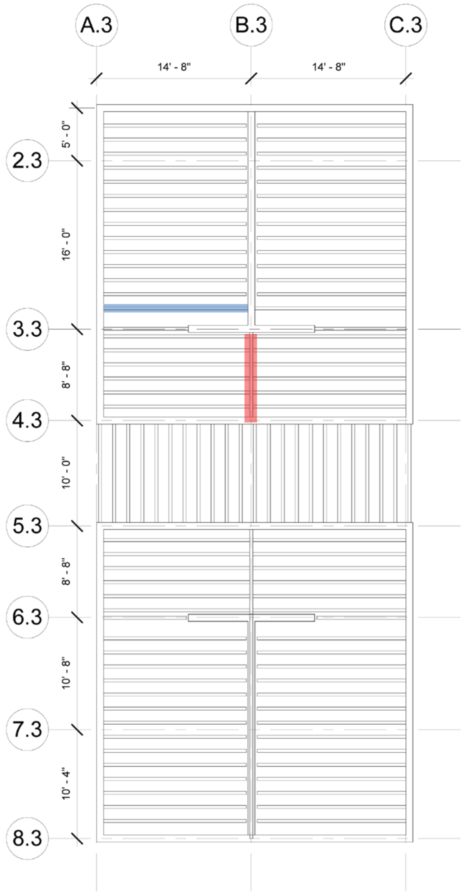
Live Load = 40 PSF (2nd and 3rd Floor and Roof)
(Loading based on ASCE 7-10)
(Refer to Appendix for calculations)



First Floor Configuration



Second Floor Configuration



Third Floor Configuration

🟦 = *Typical Wood Joist*
🟥 = *Typical Wood Beam*
🟧 = *Typical Steel Coulmn*
🟨 = *Typical Steel Girder*
🟩 = *Typical Steel Beam*

Residentail Floor Framing Summary:

Typical Beam: 9 1/2" TJI 110 Joist
Typical Girder: 3 1/8" x 10 1/2" DF-L Glulam
Typical Stud Size: 2x4 studs (2x6 First Level)

Residentail Roof Framing Summary:

Typical Beam: 11 7/8" TJI 360 Joist
Typical Girder: 3 1/8" x 12" DF-L Glulam
Typical Stud Size: 2x4 studs

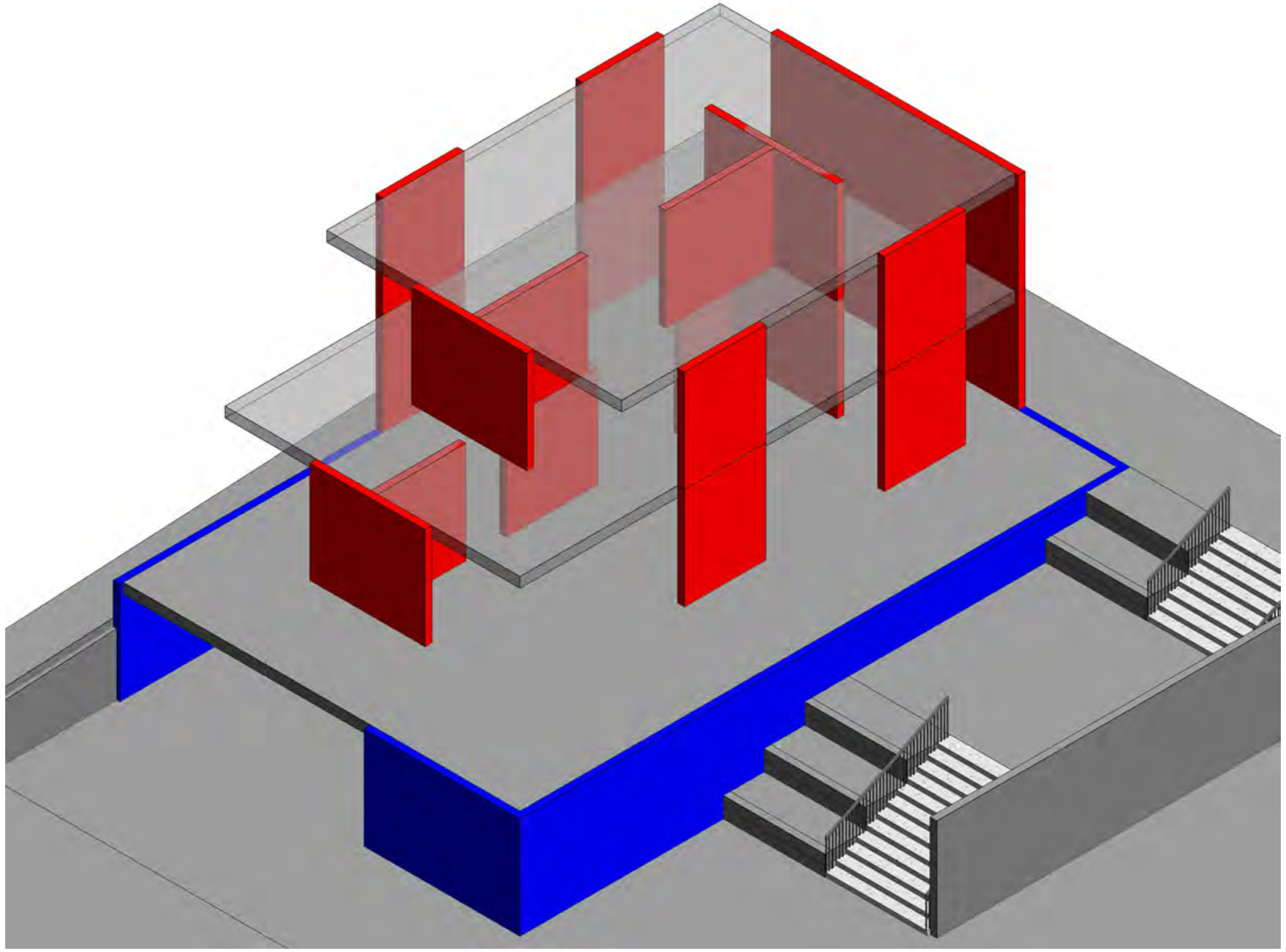
Parking Steel Framing Summary:

Typical Beam: W24x62
Typical Girder: W24x62
Typical Column: W10x33

Lateral Sizing:

Residential and Office Space #1

Building Weight =236.7 k
Base Shear = 31.68 k
(Refer to Appendix for calculations)



First Floor Lateral System Summary:

Shear Wall Length Sufficient
Concrete Retianing Wall Thickness: 12"
(See Appendix for calculations)

Second Floor Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

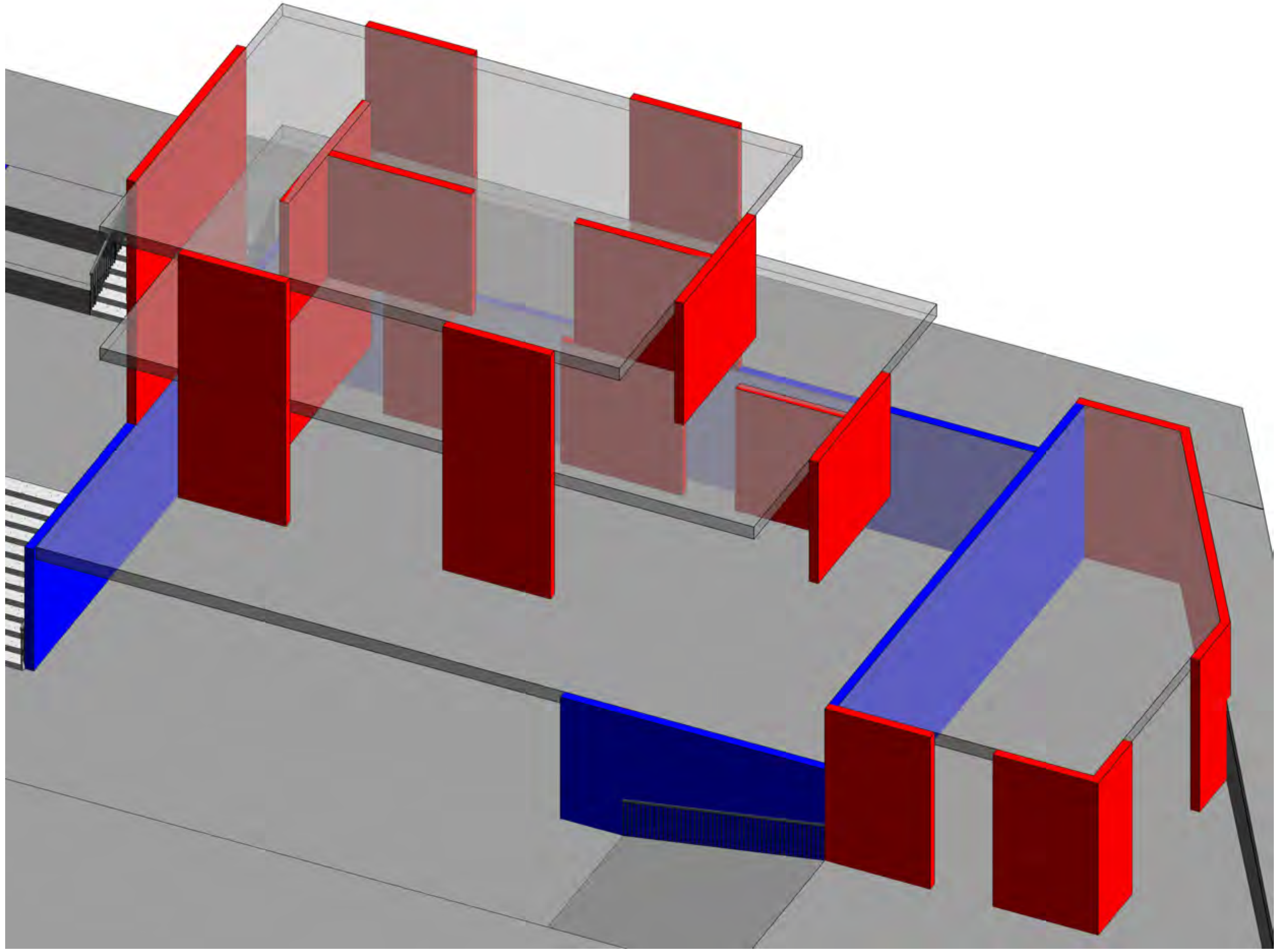
Roof Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

Lateral Sizing:

Residential and Office Space #2

Building Weight = 236.7 k
Base Shear = 31.68 k
(Refer to Appendix for calculations)



First Floor Lateral System Summary:

Shear Wall Length Sufficient
Concrete Retianing Wall Thickness: 12"
(See Appendix for calculations)

Second Floor Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

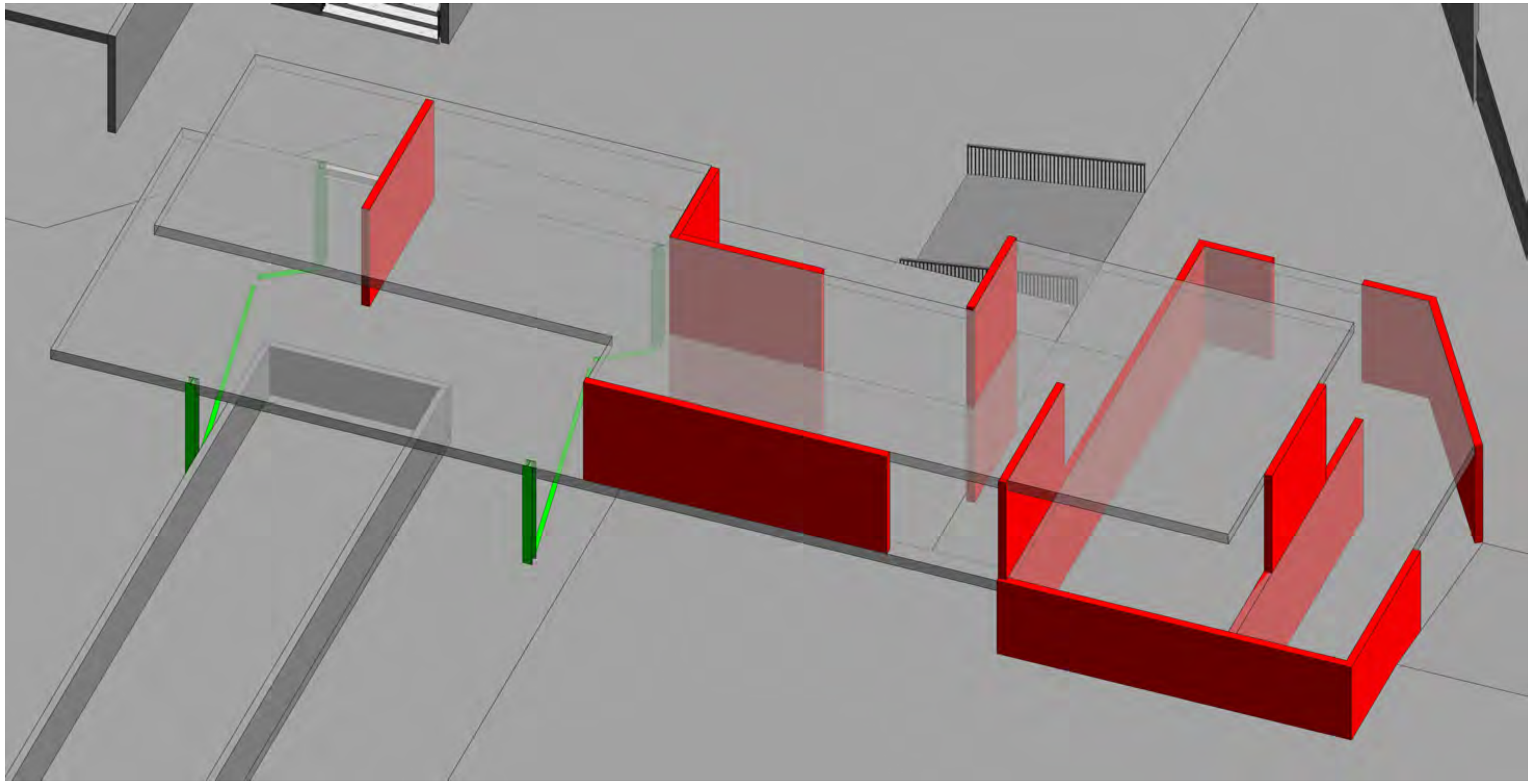
Roof Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

Lateral Sizing:

Community Center

Building Weight = 260 k
Base Shear = 32 k
(Refer to Appendix for calculations)



__First Floor Lateral System Summary:__

Shear Wall Length Sufficient
(See Appendix for calculations)

Brace Frame Size: HSS 4 1/2" x 4 1/2" x 3/8"

__Second Floor Lateral System Summary:__

Shear Wall Length Sufficient
(See Appendix for calculations)

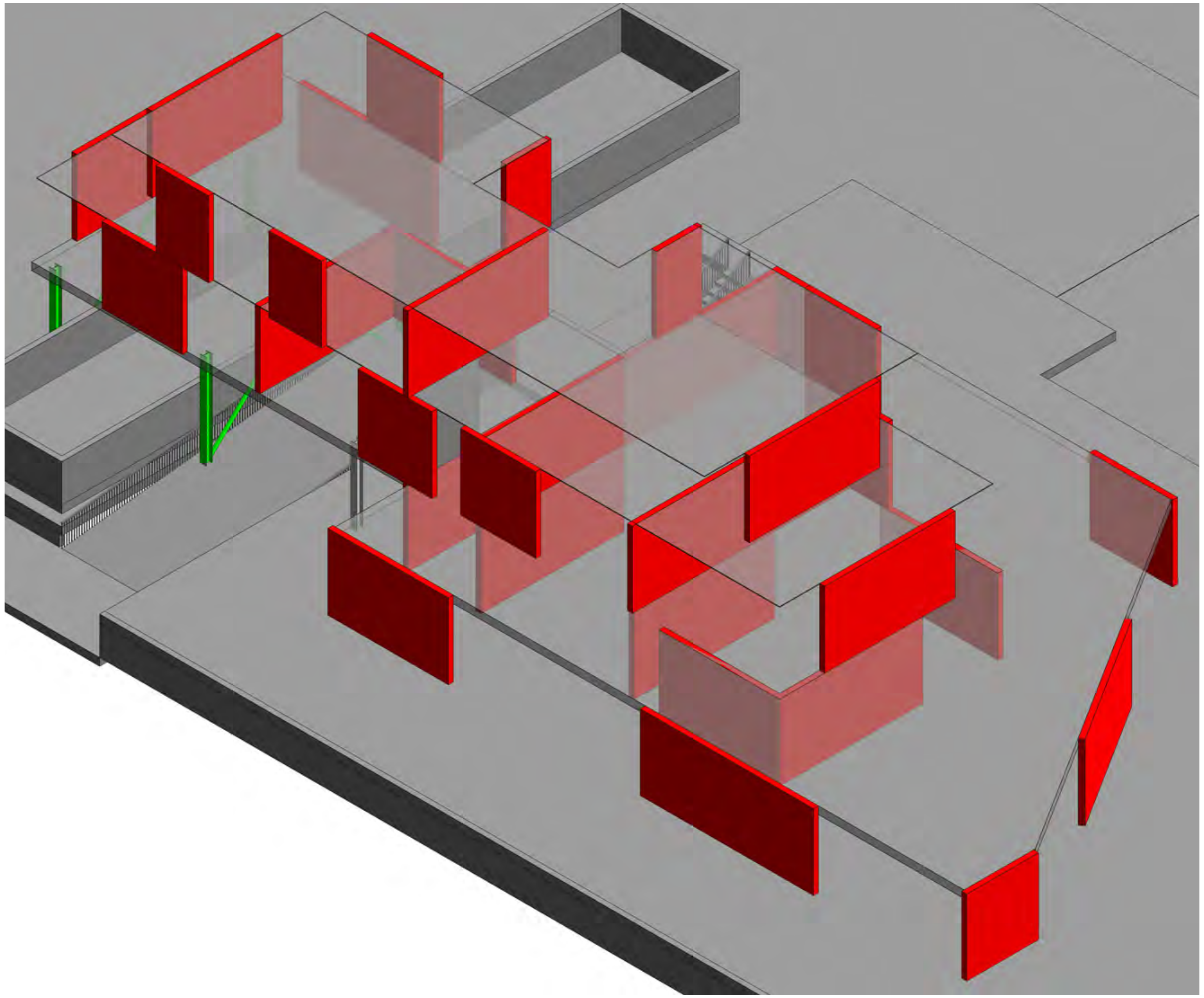
__Roof Lateral System Summary:__

Shear Wall Length Sufficient
(See Appendix for calculations)

Lateral Sizing:

Residential and Restaurant Space

Building Weight = 542 k
Base Shear = 66.67 k
(Refer to Appendix for calculations)



First Floor Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

Brace Frame Size: HSS 5 1/2" x 5 1/2" x 1/4"

Second Floor Lateral System Summary:

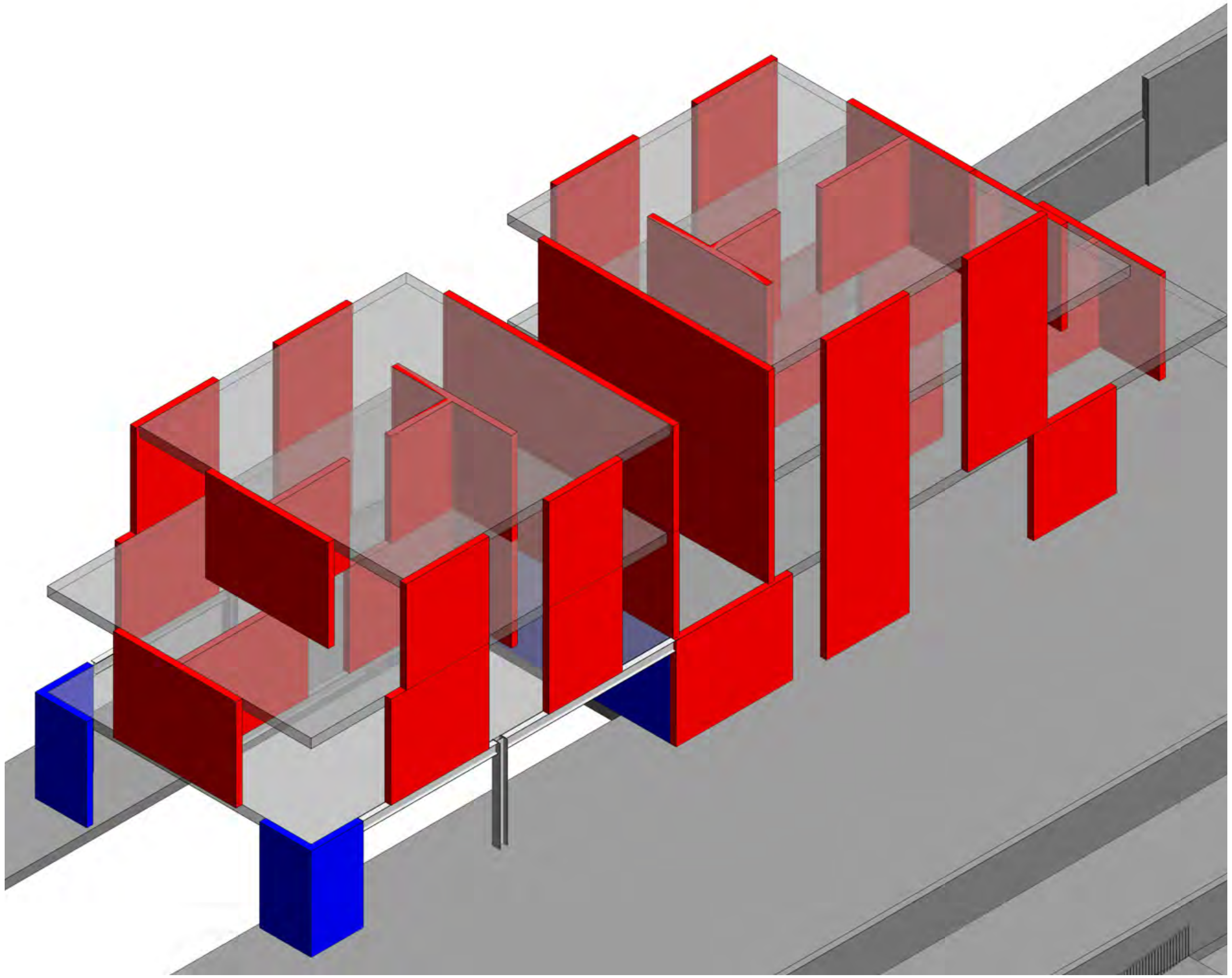
Shear Wall Length Sufficient
(See Appendix for calculations)

Roof Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

Lateral Sizing:

Residentail Space (SW Corner)



Building Weight = 185.4 k
Base Shear = 22.82 k
(Refer to Appendix for calculations)

First Floor Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

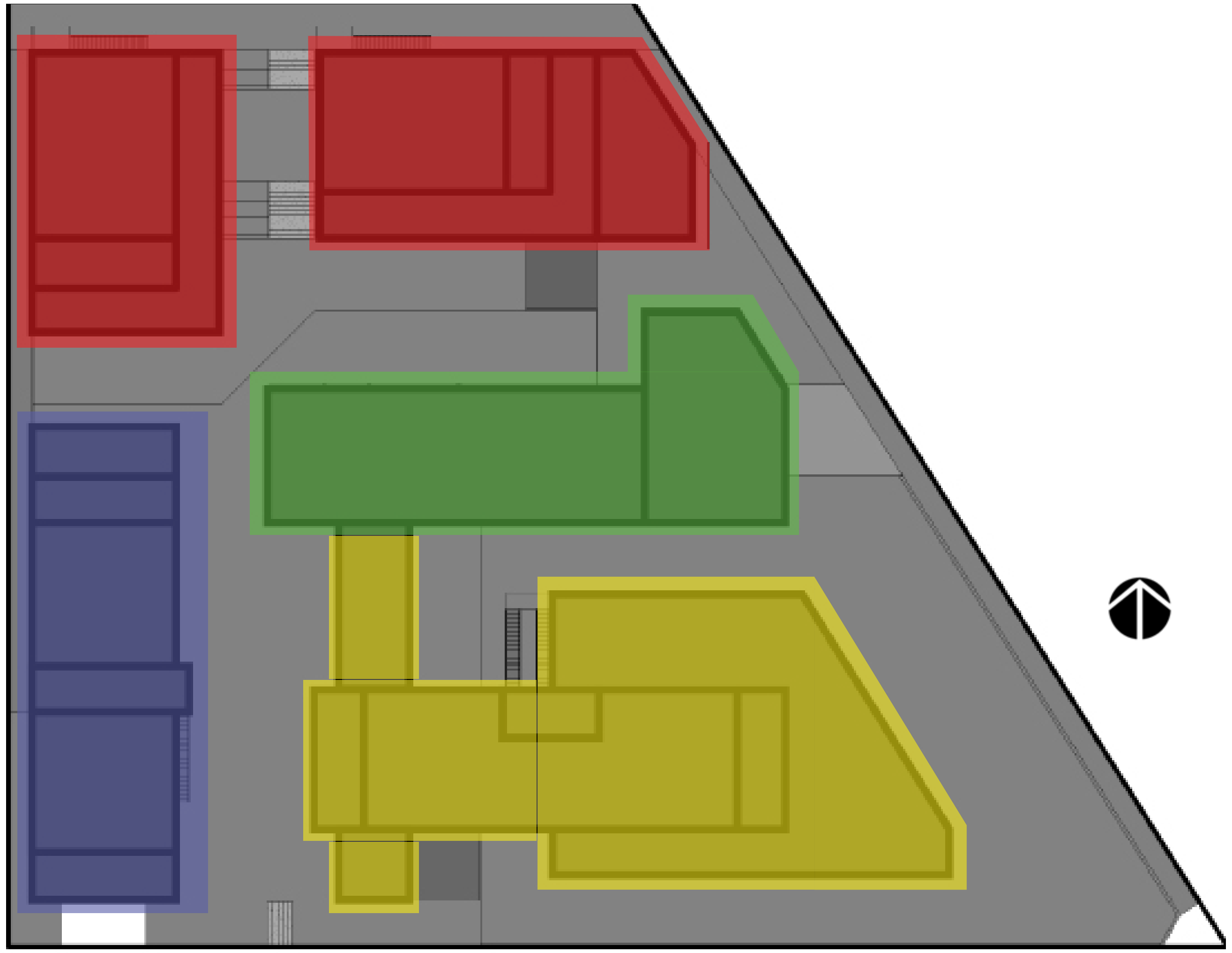
Second Floor Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

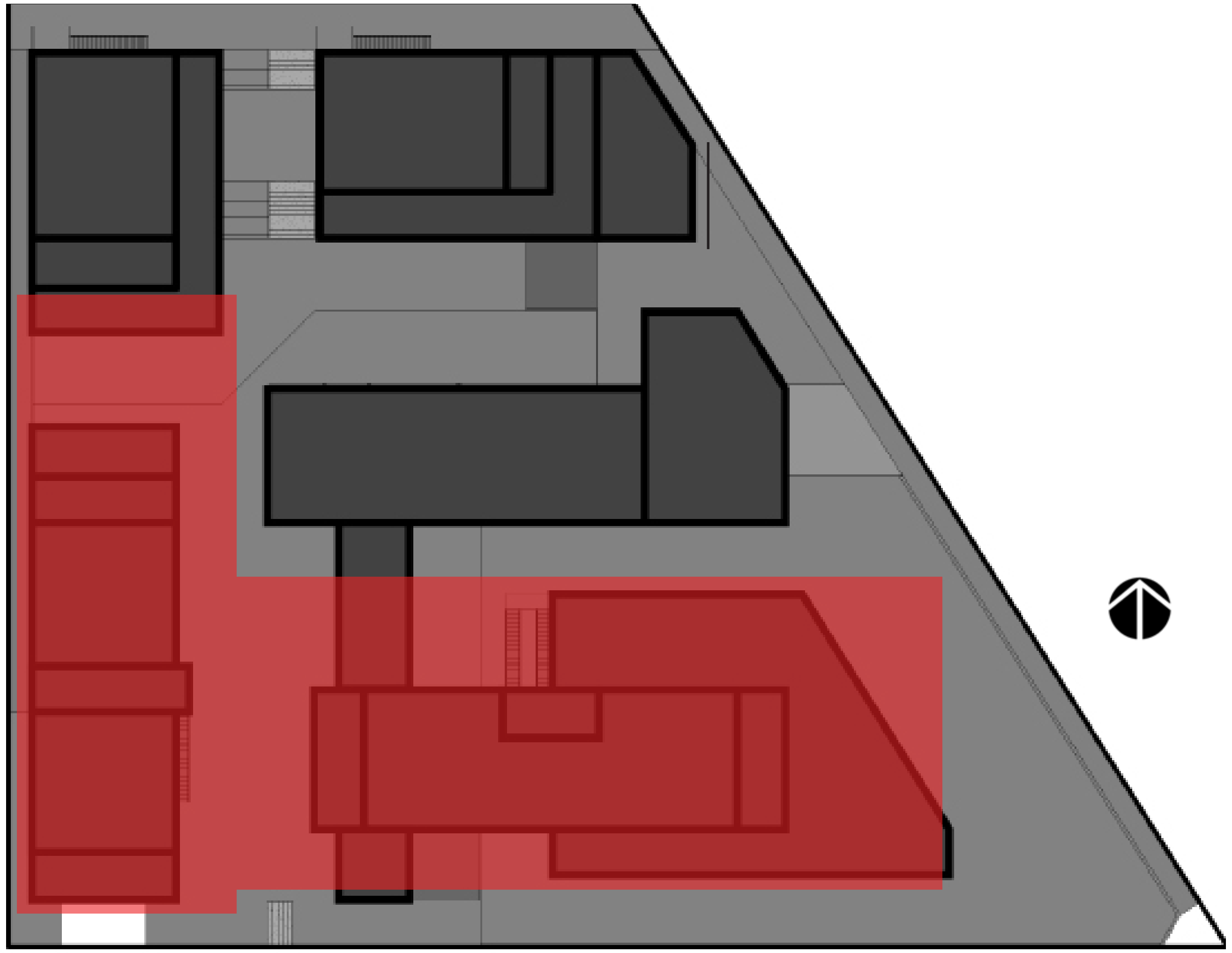
Roof Lateral System Summary:

Shear Wall Length Sufficient
(See Appendix for calculations)

Foundation Sizing:



Building Foundation Plan



Parking Foundation Plan

Mat Foundation Summary:

Foundation 1 = 20" Thick
Foundation 2 = 16" Thick
Foundation 3 = 12" Thick
Foundation 4 = 16" Thick

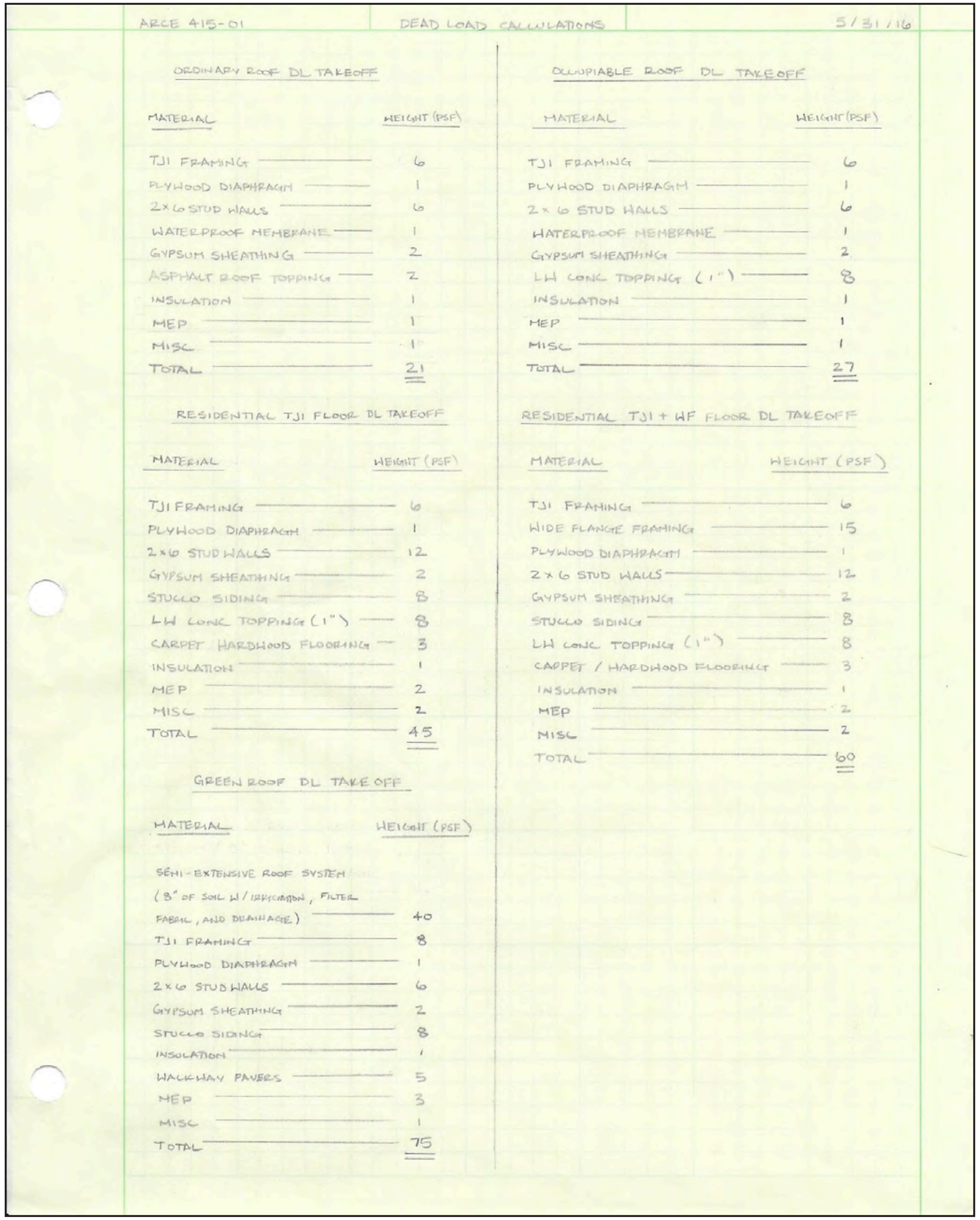
(All assuming normal weight concrete)

Foundation 1 = 🟥
Foundation 2 = 🟩
Foundation 3 = 🟦
Foundation 4 = 🟨

Appendix - Calculations

Sizes were determined using sizing tables from the following sources:

1) www.woodbywy.com/document/tj-4000/
2) http://www.aitc-glulam.org/pdf/Capacity/DF_28.PDF



ARCE 415-01 | DEAD LOAD CALCULATIONS | 5/31/16

ORDINARY ROOF DL TAKEOFF

MATERIAL	WEIGHT (PSF)
TJI FRAMING	6
PLYWOOD DIAPHRAGM	1
2×6 STUD WALLS	6
WATERPROOF MEMBRANE	1
GYPSUM SHEATHING	2
ASPHALT ROOF TOPPING	2
INSULATION	1
MEP	1
MISC	1
TOTAL	21

RESIDENTIAL TJI FLOOR DL TAKEOFF

MATERIAL	WEIGHT (PSF)
TJI FRAMING	6
PLYWOOD DIAPHRAGM	1
2×6 STUD WALLS	12
GYPSUM SHEATHING	2
STUCCO SIDING	8
LW CONC TOPPING (1")	8
CARPET HARDWOOD FLOORING	3
INSULATION	1
MEP	2
MISC	2
TOTAL	45

GREEN ROOF DL TAKE OFF

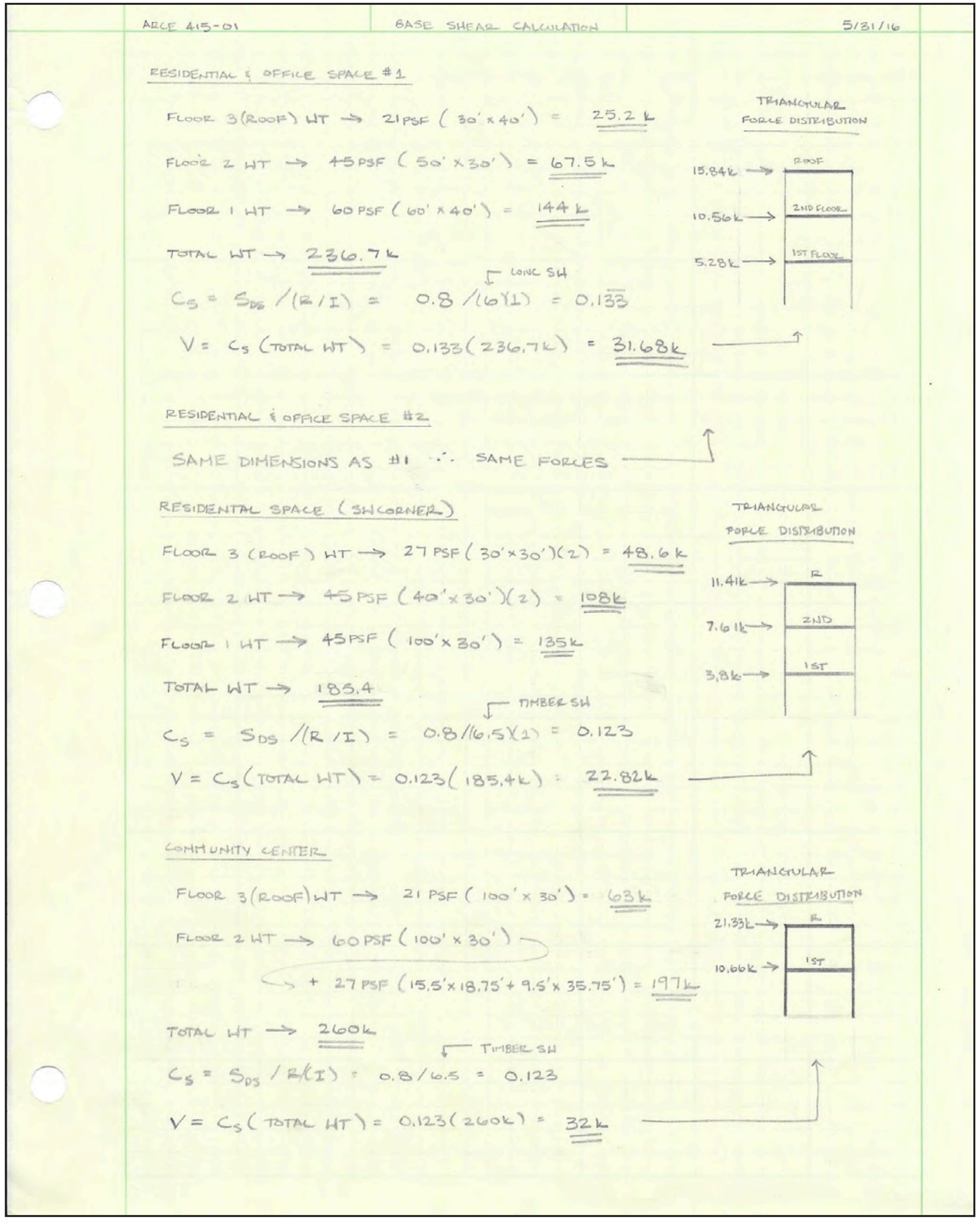
MATERIAL	WEIGHT (PSF)
SEMI-EXTENSIVE ROOF SYSTEM (8" OF SOIL W/ IRRIGATION, FILTER FABRIC, AND DRAINAGE)	40
TJI FRAMING	8
PLYWOOD DIAPHRAGM	1
2×6 STUD WALLS	6
GYPSUM SHEATHING	2
STUCCO SIDING	8
INSULATION	1
WALKWAY PAVERS	5
MEP	3
MISC	1
TOTAL	75

OCCUPIABLE ROOF DL TAKEOFF

MATERIAL	WEIGHT (PSF)
TJI FRAMING	6
PLYWOOD DIAPHRAGM	1
2×6 STUD WALLS	6
WATERPROOF MEMBRANE	1
GYPSUM SHEATHING	2
LW CONC TOPPING (1")	8
INSULATION	1
MEP	1
MISC	1
TOTAL	27

RESIDENTIAL TJI + WF FLOOR DL TAKEOFF

MATERIAL	WEIGHT (PSF)
TJI FRAMING	6
WIDE FLANGE FRAMING	15
PLYWOOD DIAPHRAGM	1
2×6 STUD WALLS	12
GYPSUM SHEATHING	2
STUCCO SIDING	8
LW CONC TOPPING (1")	8
CARPET / HARDWOOD FLOORING	3
INSULATION	1
MEP	2
MISC	2
TOTAL	60



ARCE 415-01 | BASE SHEAR CALCULATION | 5/31/16

RESIDENTIAL & OFFICE SPACE #1

FLOOR 3(ROOF) WT → 21 PSF (30' × 40') = 25.2 k

FLOOR 2 WT → 45 PSF (50' × 30') = 67.5 k

FLOOR 1 WT → 60 PSF (60' × 40') = 144 k

TOTAL WT → 236.7 k

CONC SW

$C_s = S_{DS}/(R/I) = 0.8/(6)(1) = 0.1\overline{33}$

$V = C_s(\text{TOTAL WT}) = 0.133(236.7k) = 31.68k$

TRIANGULAR FORCE DISTRIBUTION

15.84k → ROOF
10.56k → 2ND FLOOR
5.28k → 1ST FLOOR

RESIDENTIAL & OFFICE SPACE #2

SAME DIMENSIONS AS #1 ∴ SAME FORCES

RESIDENTIAL SPACE (SW CORNER)

FLOOR 3 (ROOF) WT → 27 PSF (30'×30')(2) = 48.6 k

FLOOR 2 WT → 45 PSF (40'×30')(2) = 108k

FLOOR 1 WT → 45 PSF (100'×30') = 135k

TOTAL WT → 185.4

TIMBER SW

$C_s = S_{DS}/(R/I) = 0.8/(6.5)(1) = 0.123$

$V = C_s(\text{TOTAL WT}) = 0.123(185.4k) = 22.82k$

TRIANGULAR FORCE DISTRIBUTION

11.41k → R
7.61k → 2ND
3.8k → 1ST

COMMUNITY CENTER

FLOOR 3(ROOF) WT → 21 PSF (100' × 30') = 63k

FLOOR 2 WT → 60 PSF (100' × 30') + 27 PSF (15.5'×18.75' + 9.5'×35.75') = 197k

TOTAL WT → 260k

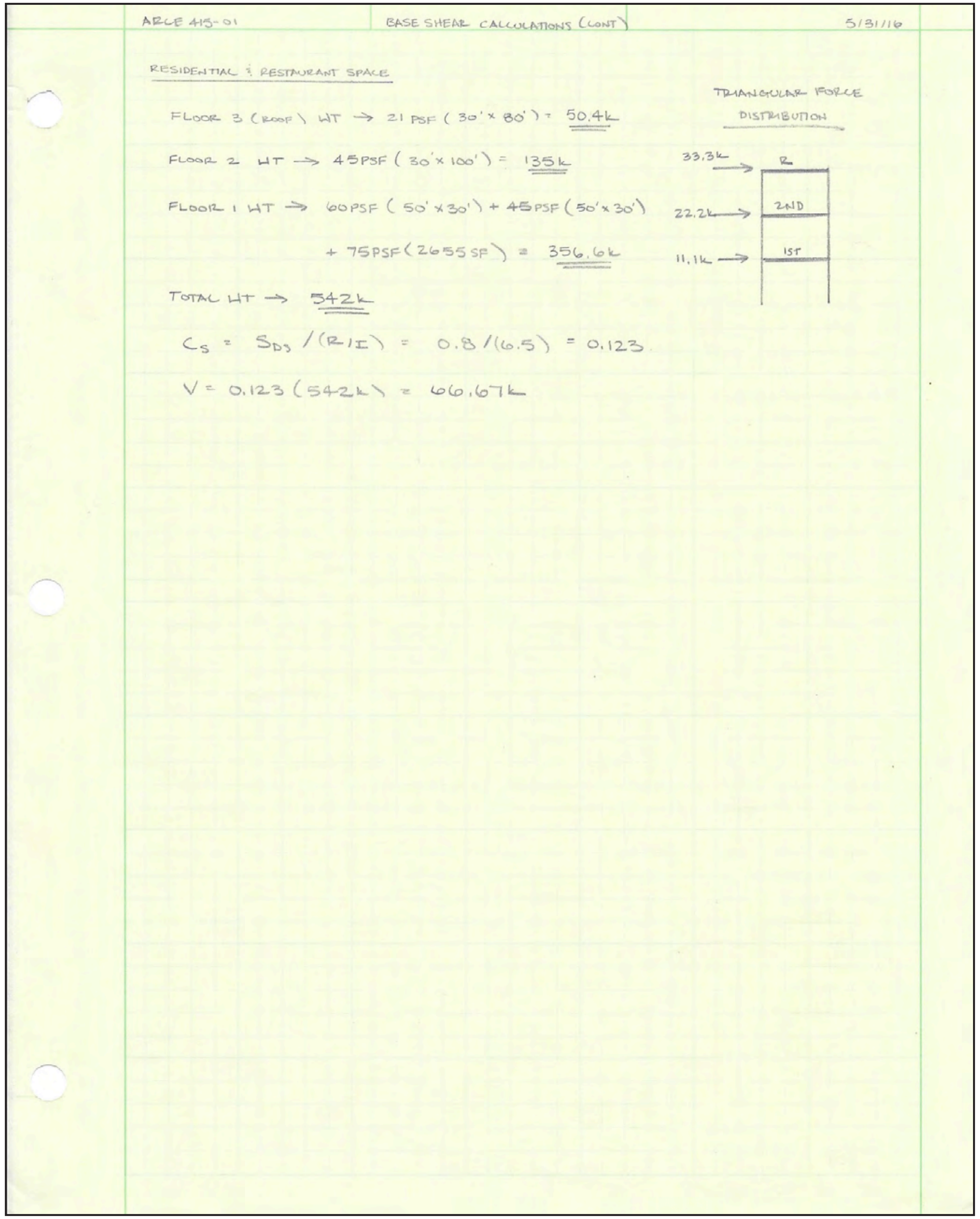
TIMBER SW

$C_s = S_{DS}/R(I) = 0.8/6.5 = 0.123$

$V = C_s(\text{TOTAL WT}) = 0.123(260k) = 32k$

TRIANGULAR FORCE DISTRIBUTION

21.33k → R
10.66k → 1ST



ARCE 415-01 | BASE SHEAR CALCULATIONS (CONT) | 5/31/16

RESIDENTIAL & RESTAURANT SPACE

FLOOR 3 (ROOF) WT → 21 PSF (30' × 80') = 50.4k

FLOOR 2 WT → 45PSF (30' × 100') = 135k

FLOOR 1 WT → 60PSF (50' × 30') + 45PSF (50' × 30')

+ 75PSF (2655 SF) = 356.6k

TOTAL WT → 542k

$C_S = S_{DS} / (R/I) = 0.8/(6.5) = 0.123$

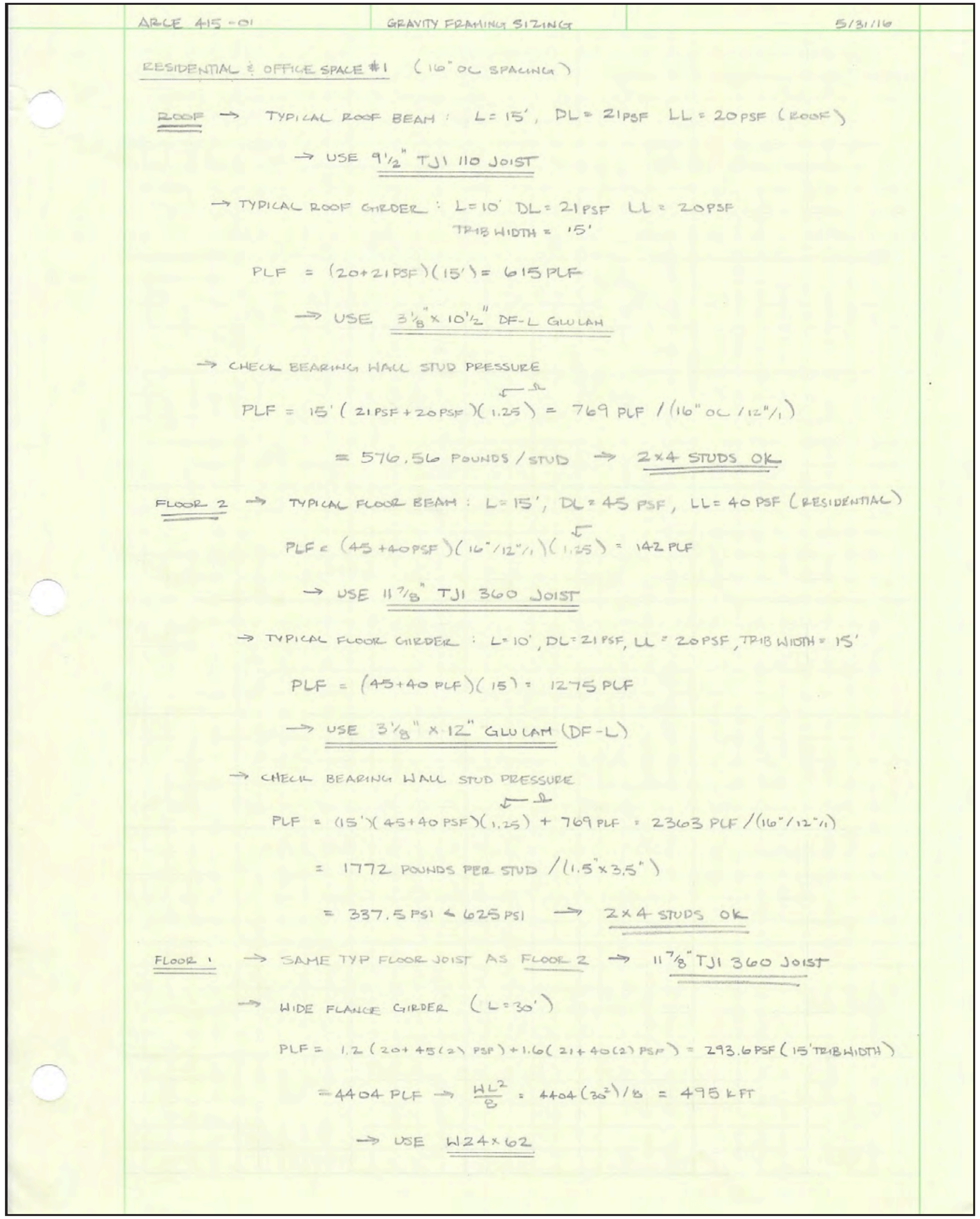
$V = 0.123 (542k) = 66.67k$

TRIANGULAR FORCE DISTRIBUTION

33.3k → R

22.2k → 2ND

11.1k → 1ST



ARCE 415-01 | GRAVITY FRAMING SIZING | 5/31/16

RESIDENTIAL & OFFICE SPACE #1 (16" OC SPACING)

ROOF → TYPICAL ROOF BEAM : L = 15', DL = 21PSF LL = 20PSF (ROOF)

→ USE 9 1/2" TJI 110 JOIST

→ TYPICAL ROOF GIRDER : L = 10' DL = 21PSF LL = 20PSF
TRIB WIDTH = 15'

PLF = (20+21PSF)(15') = 615 PLF

→ USE 3 1/8" × 10 1/2" DF-L GLULAM

→ CHECK BEARING WALL STUD PRESSURE

PLF = 15' (21PSF + 20PSF)(1.25) = 769 PLF / (16" OC / 12"/1)

= 576.56 POUNDS / STUD → 2×4 STUDS OK

FLOOR 2 → TYPICAL FLOOR BEAM : L = 15', DL = 45 PSF, LL = 40 PSF (RESIDENTIAL)

PLF = (45 + 40PSF)(16"/12"/1)(1.25) = 142 PLF

→ USE 11 7/8" TJI 360 JOIST

→ TYPICAL FLOOR GIRDER : L = 10', DL = 21 PSF, LL = 20PSF, TRIB WIDTH = 15'

PLF = (45+40 PLF)(15) = 1275 PLF

→ USE 3 1/8" × 12" GLULAM (DF-L)

→ CHECK BEARING WALL STUD PRESSURE

PLF = (15')(45+40 PSF)(1.25) + 769 PLF = 2363 PLF / (16"/12"/1)

= 1772 POUNDS PER STUD / (1.5" × 3.5")

= 337.5 PSI < 625 PSI → 2×4 STUDS OK

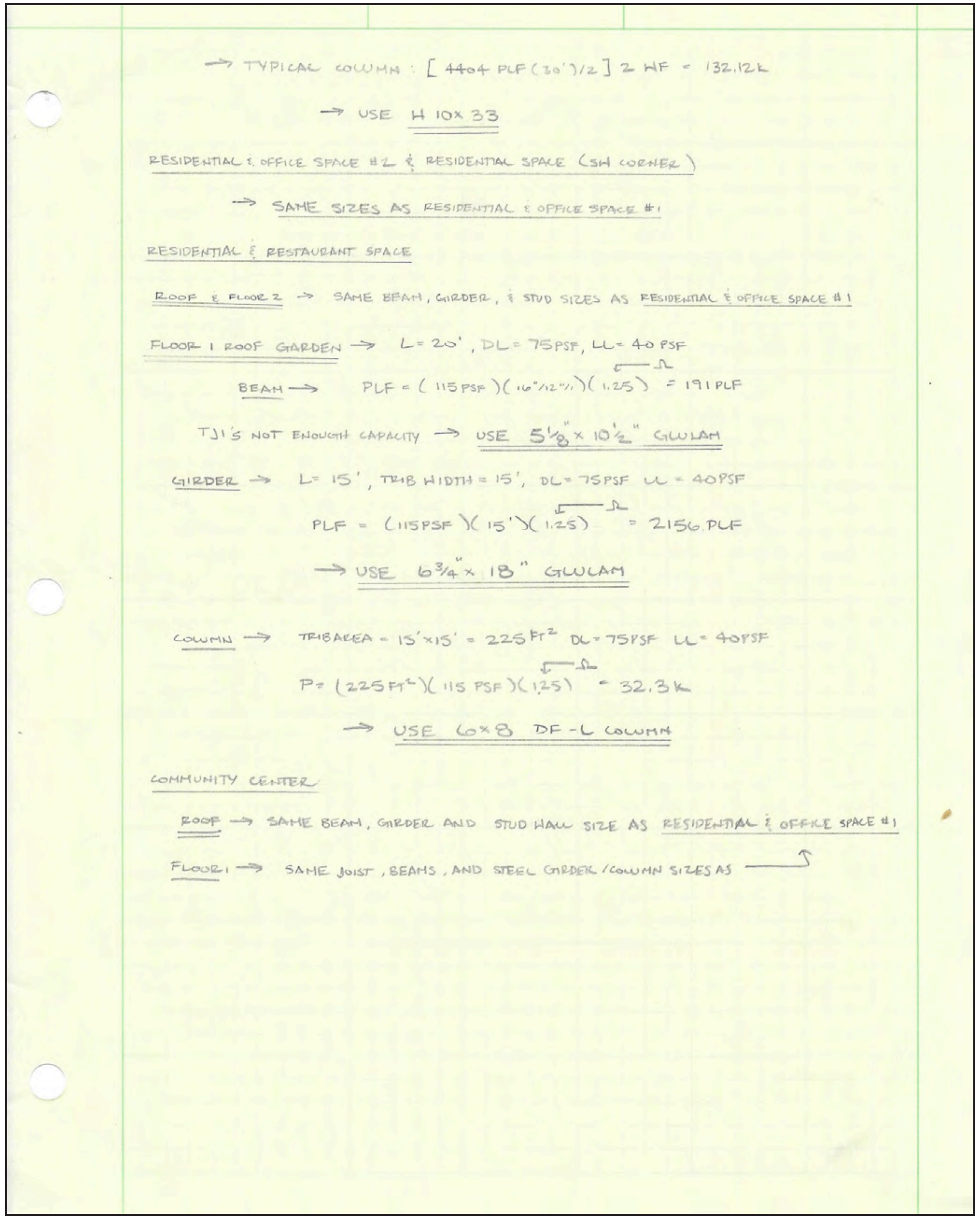
FLOOR 1 → SAME TYP FLOOR JOIST AS FLOOR 2 → 11 7/8" TJI 360 JOIST

→ WIDE FLANGE GIRDER (L = 30')

PLF = 1.2 (20 + 45(2) PSF) + 1.6 (21 + 40(2) PSF) = 293.6 PSF (15' TRIB WIDTH)

$= 4404 \text{ PLF} \rightarrow \frac{WL^2}{8} = 4404(30^2)/8 = 495 \text{ K FT}$

→ USE W24×62



→ TYPICAL COLUMN : [4404 PLF (30')/2] 2 WF = 132.12K

→ USE H 10x 33

RESIDENTIAL & OFFICE SPACE #2 & RESIDENTIAL SPACE (SW CORNER)

→ SAME SIZES AS RESIDENTIAL & OFFICE SPACE #1

RESIDENTIAL & RESTAURANT SPACE

ROOF & FLOOR 2 → SAME BEAM, GIRDER, & STUD SIZES AS RESIDENTIAL & OFFICE SPACE #1

FLOOR 1 ROOF GARDEN → L = 20', DL = 75PSF, LL = 40 PSF

BEAM → PLF = (115 PSF)(16"/12"/1)(1.25) = 191 PLF

TJI'S NOT ENOUGH CAPACITY → USE $5\frac{1}{8}" \times 10\frac{1}{2}"$ GLULAM

GIRDER → L = 15', TRIB WIDTH = 15', DL = 75PSF LL = 40PSF

PLF = (115PSF)(15')(1.25) = 2156 PLF

→ USE $6\frac{3}{4}" \times 18"$ GLULAM

COLUMN → TRIBAREA = 15'x15' = 225 FT^2 DL = 75PSF LL = 40PSF

P = (225 FT^2)(115 PSF)(1.25) = 32.3K

→ USE 6x8 DF-L COLUMN

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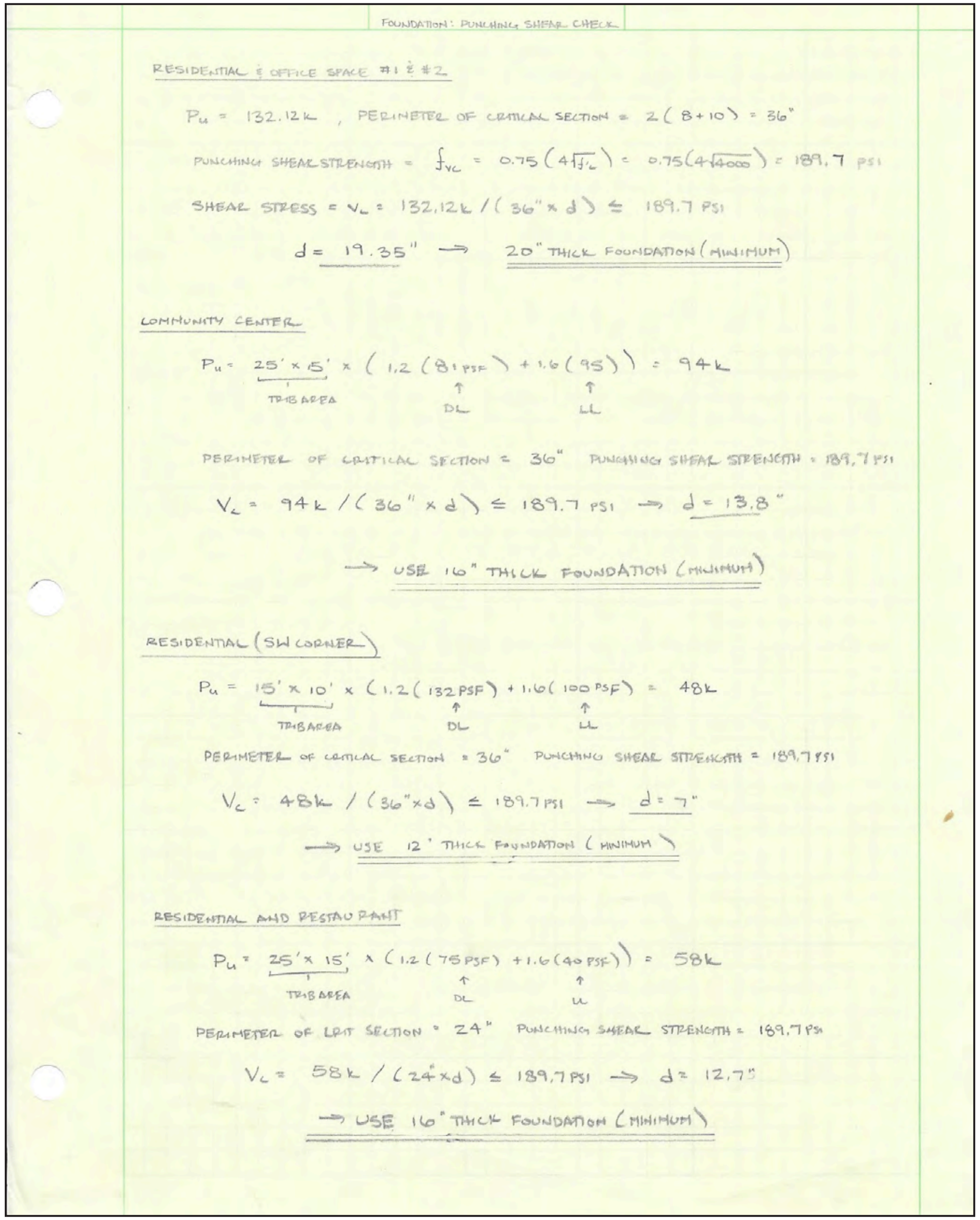
ROOF → SAME BEAM, GIRDER AND STUD WALL SIZE AS RESIDENTIAL & OFFICE SPACE #1

FLOOR 1 → SAME JOIST, BEAMS, AND STEEL GIRDER / COLUMN SIZES AS ⟶



FOUNDATION: PUNCHING SHEAR CHECK

RESIDENTIAL & OFFICE SPACE #1 & #2

P_u = 132.12K , PERIMETER OF CRITICAL SECTION = 2 (8 + 10) = 36"

PUNCHING SHEAR STRENGTH = $f_{vc} = 0.75(4\sqrt{f'_c}) = 0.75(4\sqrt{4000}) = 189.7$ PSI

SHEAR STRESS = V_c = 132.12K / (36" x d) ≤ 189.7 PSI

d = 19.35" → 20" THICK FOUNDATION (MINIMUM)

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$$P_u = \underbrace{25' \times 15'}_{\text{TRIB AREA}} \times \left(1.2(\underset{\text{DL}}{\underset{\uparrow}{81\text{ PSF}}}) + 1.6(\underset{\text{LL}}{\underset{\uparrow}{95}})\right) = 94\text{K}$$

PERIMETER OF CRITICAL SECTION = 36" PUNCHING SHEAR STRENGTH = 189.7 PSI

V_c = 94K / (36" x d) ≤ 189.7 PSI → d = 13.8"

→ USE 16" THICK FOUNDATION (MINIMUM)

RESIDENTIAL (SW CORNER)

$$P_u = \underbrace{15' \times 10'}_{\text{TRIB AREA}} \times \left(1.2(\underset{\text{DL}}{\underset{\uparrow}{132\text{ PSF}}}) + 1.6(\underset{\text{LL}}{\underset{\uparrow}{100\text{ PSF}}})\right) = 48\text{K}$$

PERIMETER OF CRITICAL SECTION = 36" PUNCHING SHEAR STRENGTH = 189.7 PSI

V_c = 48K / (36" x d) ≤ 189.7 PSI → d = 7"

→ USE 12' THICK FOUNDATION (MINIMUM)

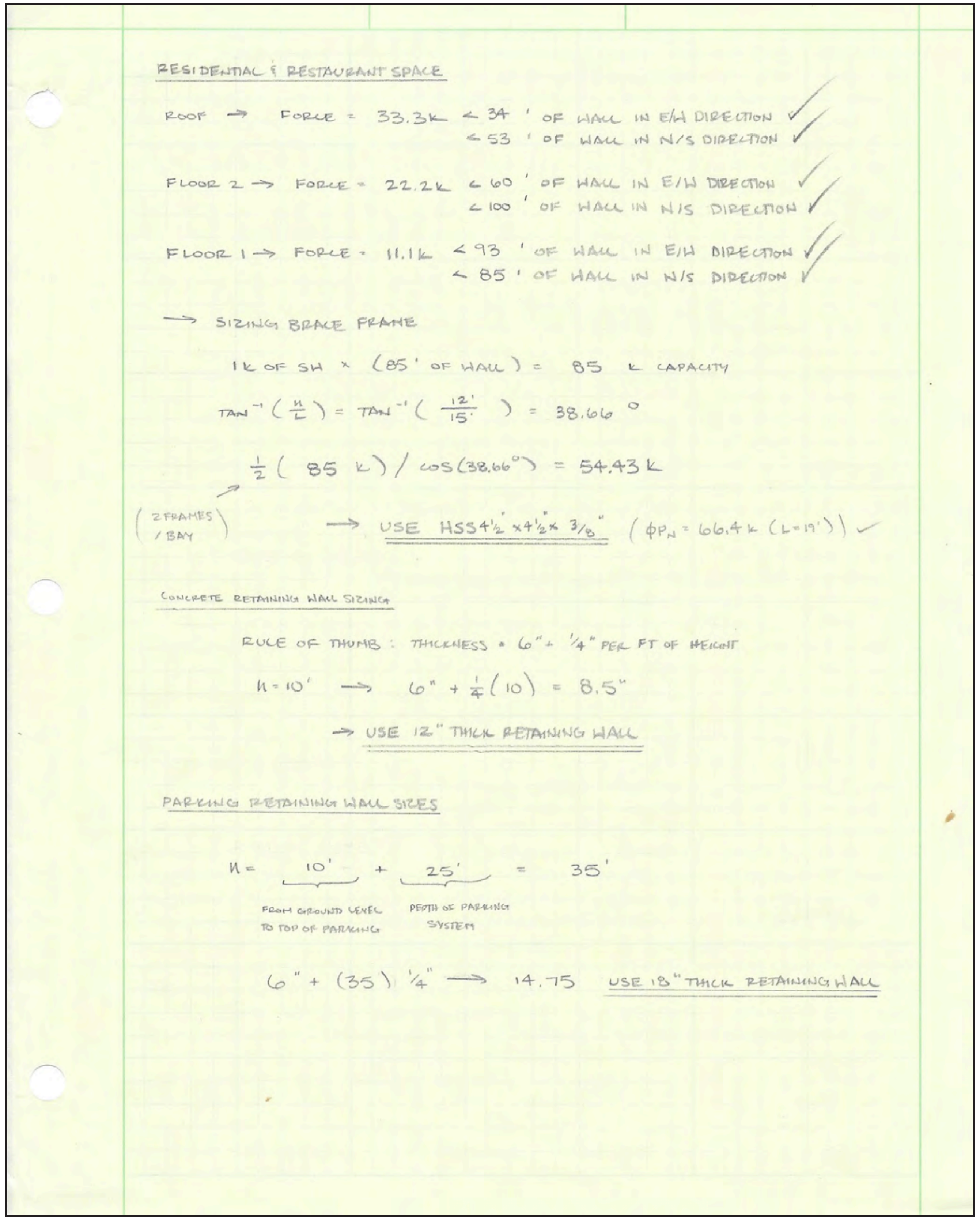
RESIDENTIAL AND RESTAURANT

$$P_u = \underbrace{25' \times 15'}_{\text{TRIB AREA}} \times \left(1.2(\underset{\text{DL}}{\underset{\uparrow}{75\text{ PSF}}}) + 1.6(\underset{\text{LL}}{\underset{\uparrow}{40\text{ PSF}}})\right) = 58\text{K}$$

PERIMETER OF CRIT SECTION = 24" PUNCHING SHEAR STRENGTH = 189.7 PSI

V_c = 58K / (24" x d) ≤ 189.7 PSI → d = 12.7"

→ USE 16" THICK FOUNDATION (MINIMUM)



RESIDENTIAL & RESTAURANT SPACE

ROOF → FORCE = 33.3K < 34 ' OF WALL IN E/W DIRECTION ✓
< 53 ' OF WALL IN N/S DIRECTION ✓

FLOOR 2 → FORCE = 22.2K < 60 ' OF WALL IN E/W DIRECTION ✓
< 100 ' OF WALL IN N/S DIRECTION ✓

FLOOR 1 → FORCE = 11.1K < 93 ' OF WALL IN E/W DIRECTION ✓
< 85 ' OF WALL IN N/S DIRECTION ✓

→ SIZING BRACE FRAME

1K OF SW × (85 ' OF WALL) = 85 K CAPACITY

$$\tan^{-1}\left(\frac{h}{L}\right) = \tan^{-1}\left(\frac{12'}{15'}\right) = 38.66°$$

$$\frac{1}{2}(85\text{ K}) / \cos(38.66°) = 54.43\text{ K}$$

(2 FRAMES / BAY)

→ USE HSS4½"x4½"x 3/8" (ϕP_N = 66.4 K (L=19')) ✓

CONCRETE RETAINING WALL SIZING

RULE OF THUMB : THICKNESS = 6" + 1/4" PER FT OF HEIGHT

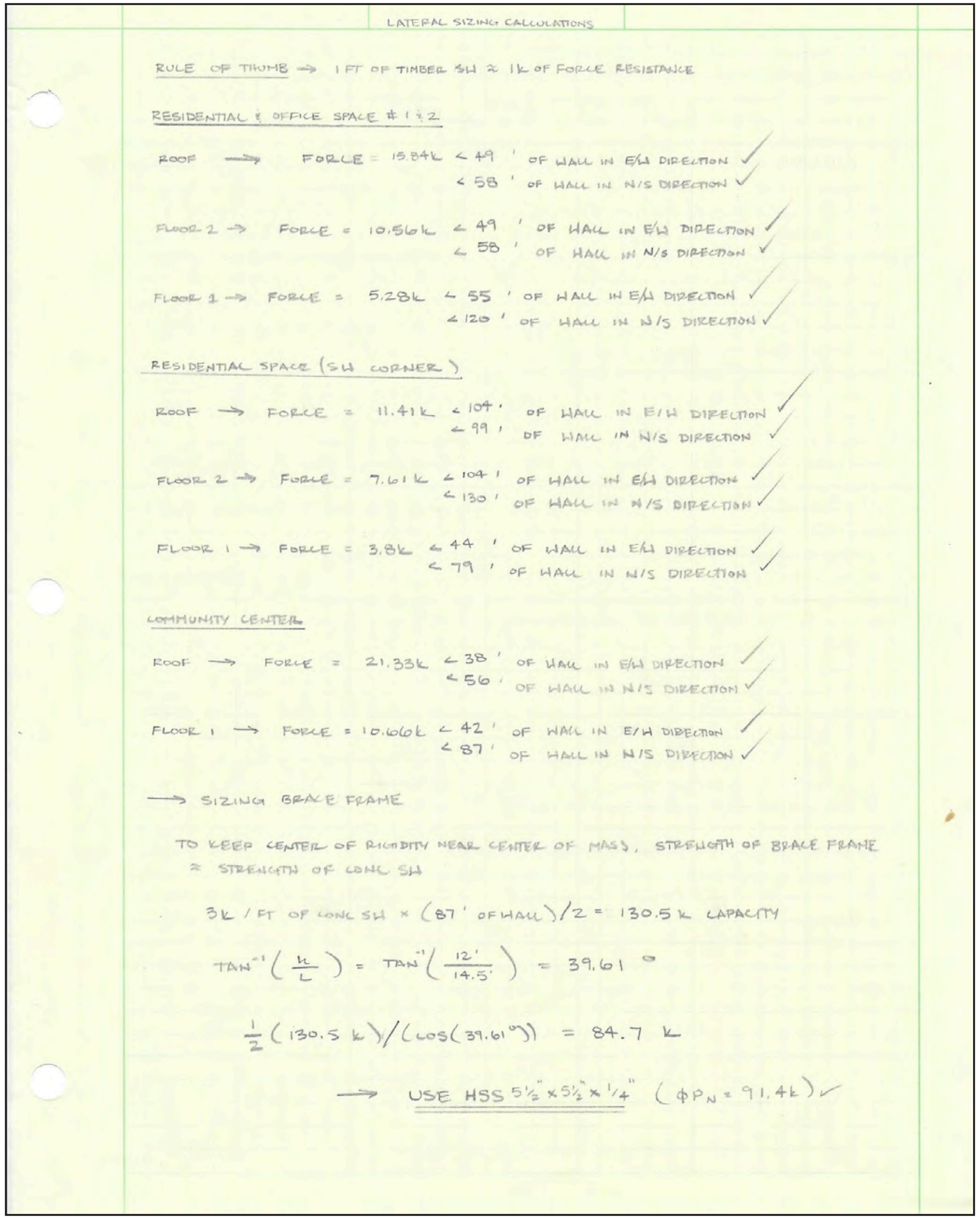
$h = 10'$ → $6" + \frac{1}{4}(10) = 8.5"$

→ USE 12" THICK RETAINING WALL

PARKING RETAINING WALL SIZES

$$h = \underbrace{10'}_{\text{FROM GROUND LEVEL TO TOP OF PARKING}} + \underbrace{25'}_{\text{DEPTH OF PARKING SYSTEM}} = 35'$$

6" + (35) 1/4" → 14.75 USE 18" THICK RETAINING WALL



LATERAL SIZING CALCULATIONS

RULE OF THUMB → 1 FT OF TIMBER SW ≈ 1K OF FORCE RESISTANCE

RESIDENTIAL & OFFICE SPACE # 1 & 2

ROOF → FORCE = 15.84K < 49 ' OF WALL IN E/W DIRECTION ✓
< 58 ' OF WALL IN N/S DIRECTION ✓

FLOOR 2 → FORCE = 10.56K < 49 ' OF WALL IN E/W DIRECTION ✓
< 58 ' OF WALL IN N/S DIRECTION ✓

FLOOR 1 → FORCE = 5.28K < 55 ' OF WALL IN E/W DIRECTION ✓
< 120 ' OF WALL IN N/S DIRECTION ✓

RESIDENTIAL SPACE (SW CORNER)

ROOF → FORCE = 11.41K < 104 ' OF WALL IN E/W DIRECTION ✓
< 99 ' OF WALL IN N/S DIRECTION ✓

FLOOR 2 → FORCE = 7.61K < 104 ' OF WALL IN E/W DIRECTION ✓
< 130 ' OF WALL IN N/S DIRECTION ✓

FLOOR 1 → FORCE = 3.8K < 44 ' OF WALL IN E/W DIRECTION ✓
< 79 ' OF WALL IN N/S DIRECTION ✓

COMMUNITY CENTER

ROOF → FORCE = 21.33K < 38 ' OF WALL IN E/W DIRECTION ✓
< 56 ' OF WALL IN N/S DIRECTION ✓

FLOOR 1 → FORCE = 10.66K < 42 ' OF WALL IN E/W DIRECTION ✓
< 87 ' OF WALL IN N/S DIRECTION ✓

→ SIZING BRACE FRAME

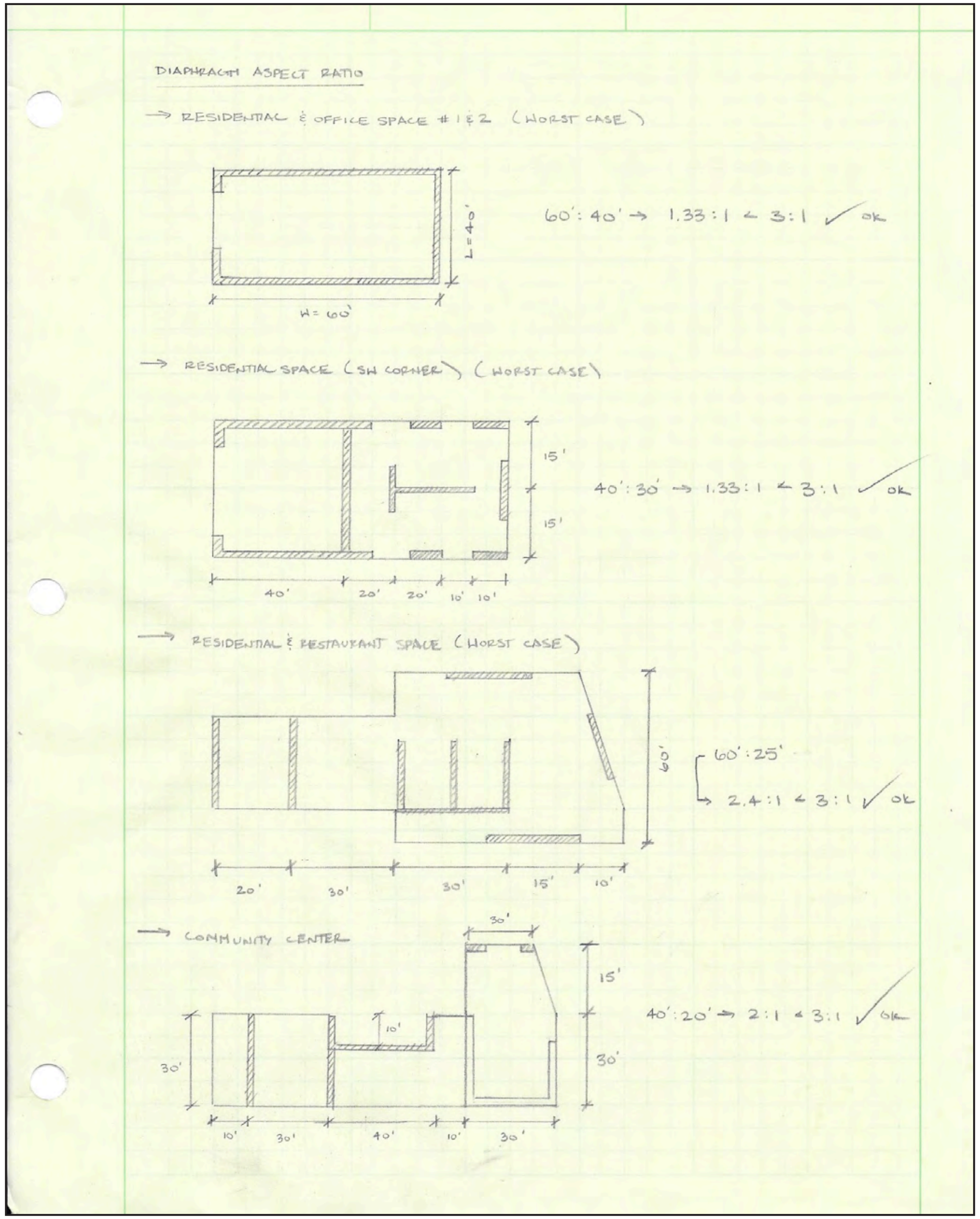
TO KEEP CENTER OF RIGIDITY NEAR CENTER OF MASS, STRENGTH OF BRACE FRAME ≈ STRENGTH OF CONC SW

3K / FT OF CONC SW × (87 ' OF WALL)/2 = 130.5 K CAPACITY

$$\tan^{-1}\left(\frac{h}{L}\right) = \tan^{-1}\left(\frac{12'}{14.5'}\right) = 39.61°$$

$$\frac{1}{2}(130.5\text{ K})/(\cos(39.61°)) = 84.7\text{ K}$$

→ USE HSS 5½"x5½"x 1/4" (ϕP_N = 91.4K) ✓



DIAPHRAGM ASPECT RATIO

→ RESIDENTIAL & OFFICE SPACE #1 & 2 (WORST CASE)

60' : 40' → 1.33 : 1 < 3 : 1 ✓ ok

→ RESIDENTIAL SPACE (SW CORNER) (WORST CASE)

40' : 30' → 1.33 : 1 < 3 : 1 ✓ ok

→ RESIDENTIAL & RESTAURANT SPACE (WORST CASE)

60' : 25'
→ 2.4 : 1 < 3 : 1 ✓ ok

→ COMMUNITY CENTER

40' : 20' → 2 : 1 < 3 : 1 ✓ ok