Spring 2020

SCU Faculty & Staff Housing Development

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I HEREBY RECOMMEND THAT THE
SENIOR DESIGN PROJECT REPORT PREPARED
UNDER MY SUPERVISION BY

Ayo Ogunfunmi, Deirdre Bonitz, Rachael Han & Spencer Saito

ENTITLED

SCU FACULTY & STAFF HOUSING DEVELOPMENT

BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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Thesis Advisor, Dr. Laura Doyle — Date

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Thesis Advisor, Dr. Edwin Maurer — Date

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Thesis Advisor, Dr. Hisham Said — Date

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Thesis Advisor, Dr. Reynaud Serrette — Date

6/10/2020
Department Chair, Dr. Edwin Maurer — Date

SCU FACULTY & STAFF HOUSING DEVELOPMENT

By

Ayo Ogunfunmi, Deirdre Bonitz, Rachael Han & Spencer Saito

SENIOR DESIGN PROJECT REPORT

Submitted to
the Department of Civil, Environmental, and Sustainable Engineering

of

SANTA CLARA UNIVERSITY

in Partial Fulfillment of the Requirements
for the degree of
Bachelor of Science in Civil, Environmental, and Sustainable Engineering

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SCU FACULTY & STAFF HOUSING DEVELOPMENT

Ayo Ogunfunmi, Deirdre Bonitz, Rachael Han & Spencer Saito

Department of Civil, Environmental, and Sustainable Engineering
Santa Clara University, Spring 2020

Abstract

Due to the high housing costs in the Bay Area, Santa Clara University's (SCU) faculty and staff have to live further away from campus where the housing market is more affordable, ultimately increasing their commute time and increasing the environmental impact due to transportation. Therefore, SCU has expressed the need to provide affordable housing for their faculty and staff who do not earn enough income to be able to live in the City of San Jose or County of Santa Clara. The project proposed in this report represents the efforts of SCU Civil Engineering students to adhere towards the social, sustainable, and economic concerns held by the Civil, Environmental and Sustainable Engineering (CESE) Department in the design and construction of a proposed housing development for Santa Clara University faculty and staff. The team of civil engineering students, RADS Construction, LLC., has provided design recommendations for the 1200 Campbell Avenue development.

The team gained initial inspiration from the Planned Development Zoning Submittal that was received from the City of San Jose, which contained architectural drawings provided by Studio TSquare. The team also received a map of the water facilities at the proposed project site from San Jose Water. Using the architectural drawings and a map of the water facilities on site, RADS Construction designed the structural and stormwater management plans for the development; designed potable water and wastewater piping layouts; and created a construction schedule, waste management plan, and a Building Information Modeling (BIM) model. The team decided to change the originally proposed incubator space, as displayed in the architectural drawings, into a commercial space to allow shops and other small businesses to use this new building. This change helped to address the concerns of the stakeholders in the proximity of the project site since they wanted to benefit from this new building to help compensate for bringing in more traffic into the neighborhood. Through these deliverables, RADS Construction met both social and economic needs of SCU's faculty and staff, as well as fulfilling the CESE Departmental and School of Engineering standards for socially, economically, and environmentally sustainable engineering.

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Introduction

Initial Research/Background

The housing crisis in the Bay Area is becoming worse as property prices increase while incomes remain stagnant. Due to limited space in urban areas, the City of San Jose is not reaching its housing production goals. In 2018, San Jose set an annual housing production goal of 3,986, but only 2,973 properties were constructed (Kendall, 2019). Expanding to a broader geography, the San Jose-Sunnyvale-Santa Clara Housing Market Area has a total demand of 4,800 sales units and 11,100 rental units but only 1,800 sales units and 3,475 rental units were under construction as of August, 2017 (U.S. Department of Housing and Urban Development, 2017). This housing crisis not only has the possibility of discouraging potential employees of Santa Clara University (SCU) from accepting employment, but current faculty and staff are facing the pressures of the increasingly unaffordable housing market. Santa Clara University conducted a study on current staff. Santa Clara University does have 48 university owned apartments and 41 single-family homes that are offered to faculty and staff on a month-to month lease, but the existing housing still cannot capture all of SCU's needs.

To offset this issue, Santa Clara University has proposed to the City of San Jose a seven-story mixed-use faculty & housing development near Santa Clara University. Santa Clara University wanted a project site that was in proximity to SCU's campus, reputable school districts, transit stations, and retail to make it more convenient to the individuals that use the features of this development (Figure 1). Therefore, faculty and staff at Santa Clara University were the primary client. In May 2019, Santa Clara University conducted a survey on potential faculty and staff who would rent an apartment unit from this proposed development to determine how long they would plan to live there. The results of this survey are displayed in Figure 2.

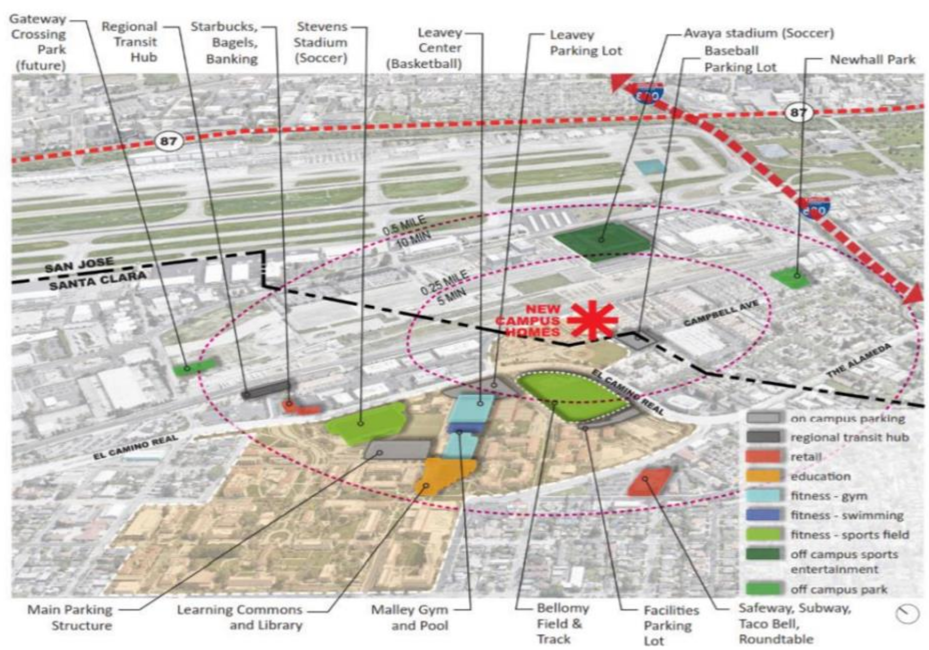

Figure 1. Project Site with Respect to SCU's Campus.

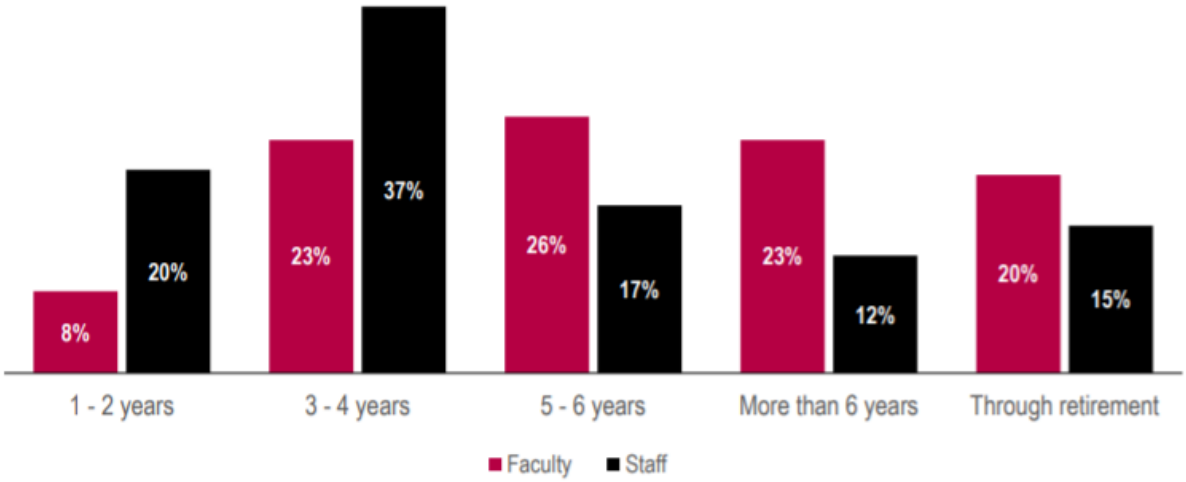

Figure 2. Market Survey on SCU's Faculty & Staff: Years Living in University Owned Housing.

The results from the faculty and staff housing demand analysis conducted by Santa Clara University made the team aware that affordable housing was an important need in the community. RADS Construction, the design-build team for this project, met with Chris Shay, Don Akerland, and Marissa Pimentel, from SCU Operations Department. They provided important feedback, helped to inform the team about the progress of the actual project, and directed the team to contacts that would be useful for this project. They helped to answer any questions about the project and to keep the team informed of what type of development that Santa Clara University desires. The team also attended a community stakeholders meeting in August 2019 that was hosted by Robert Rivera from the City of San Jose to receive input from current SCU faculty and staff, as well as nearby residents & business owners. This meeting gave the team more information on potential unforeseen positive and negative impacts of this development, such as distribution of privacy for the neighboring residences, and traffic issues that could arise by developing this size of a building in this neighborhood.

General Site Description

The current site is located on three different addresses (1200, 1202, 1250 Campbell Avenue), two separate parcels (230-14-009, 230-14-004), and zoned as a Heavy Industrial (HI) District. Figure 3 displays a panoramic street view of the site from Campbell Avenue. Santa Clara University was in the process of combining the two parcels into one parcel and rezoning it to a Planned Development (PD) Zoning District use when this project began. Due to time constraints, the team had to assume that SCU was able to properly rezone this site and continued with the design process. The proposed project is located at 1200 Campbell Avenue in San Jose, California, and it is directly adjacent to the Santa Clara University Villas Residence Hall and across from Stephen Schott Stadium. The project site is located on an area of about 3.07 acres. No geotechnical study was conducted, therefore a site class D was assumed to design this building based on the recommendations from ASCE 7-16, Section 11.4.3 (American Society of Civil Engineers, 2017). As evidenced by Santa Clara Water Valley Groundwater Well

07S01W02G024, the groundwater table at the site is very high. During peak rainfall seasons, the well detected groundwater levels are only one to two (1-2) feet below the ground surface (Santa Clara Valley Water District). A map of the design area including surrounding streets, landmarks, and buildings is shown in Figure 4.

Figure 3. Panoramic Street View of Current Site from Campbell Avenue.

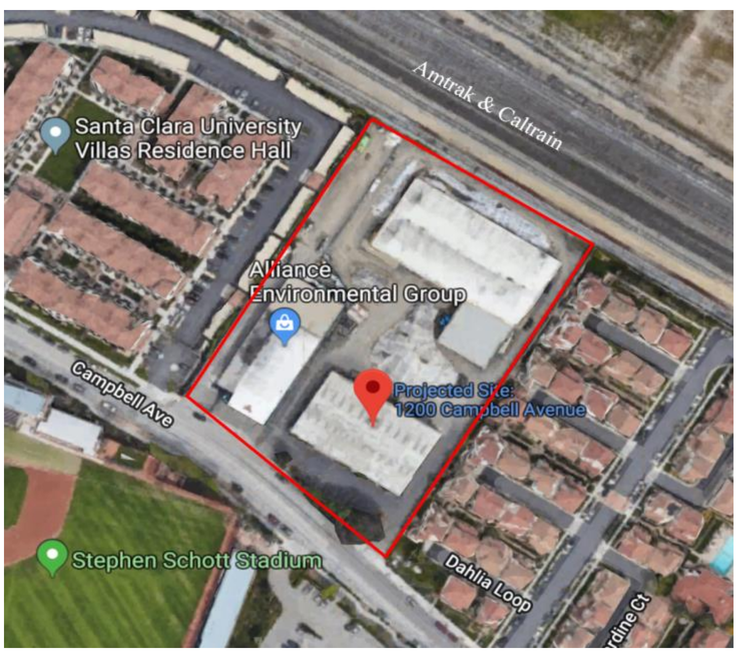

Figure 4. Map of Development Area.

Scope of Work

Structural Engineering

Material research and an alternative analysis were conducted to determine which construction materials would be most effective for the design of this development, while also considering how much design knowledge that the structural engineering students contained. The structural engineering team member designed a comprehensive structural system of the housing development to abide by the local building codes, minimum seismic design standards with economic and sustainable considerations, and other reference manuals, as mentioned in the Design Criteria and Standards section of this report. An analysis of the lateral and gravity system was conducted to ensure that this development can withstand the loads acting in different directions onto the building, such as the occupancy, wind, and seismic loads. A set of the architectural drawings for the project was provided by the architect, Studio TSquare, which contained the architectural layout of each floor of the building and other project logistics.

Due to constraints resulting from the University's transition to no face-to-face meetings and online classes, the project scope was modified to omit the following design items:

- Foundation
- Parking garage ramps
- Elevated concrete slab gravity load for the parking garage
- Connection details
- Non load bearing structural components
- Steel Braced Frames

AutoCAD was used to determine where to place the gravity system: gravity beams & columns, as well as the lateral system: special concentric steel braced frames, special reinforced concrete shear walls, and special steel moment frames. The team referred to the 2019 California Building Code (CBC) and ASCE/SEI 7-16 to determine the flat weights (dead and live loads) of the building. The architectural floor layouts were imported into AutoCAD to ensure accuracy of where the gravity and lateral system were placed. After determining the placement of the entire gravity and lateral system in AutoCAD, Enercalc was used to size all of the gravity beams and columns, and the tributary widths and areas acting on the gravity system were generated in AutoCAD. Revit was used to construct a 3D model of the development, which aided the structural team member with visualizing the different detail components that were needed and the construction team member with the overall cost estimate. Through this entire design process, the structural design team developed a structural calculation package for the entire structure by primarily using Microsoft Excel to generate calculation spreadsheets. The calculation spreadsheets supplemented the calculations that were performed in other structural analysis design software, such as Enercalc. In particular, beam and column loads were calculated in Microsoft Excel but were designed in Enercalc.

The final product that will be provided to the owner, architect, general contractor, and other contractors that are involved with this project is a digital copy of the structural design calculations package (Appendix C) and a digital copy of the drawing set (Appendix B) for construction.

Spencer Saito was responsible for this scope of work, and he worked in collaboration with Ayo Ogunfunmi for the design layout of the structure. Rachael Han and Deirdre Bonitz collaborated with Spencer Saito to ensure that the structural design coincided with their scope of work, such as making sure that the member sizes were adequate enough for the piping layout throughout the building.

Potable Water and Wastewater Management

The potable water and wastewater demands for the building, including residential demands, commercial demands, and fireflows, were calculated using a baseline calculation as well as a decreased flow calculation using higher efficiency fixtures from the Green Building Initiative's Water Consumption Calculator (Green Building Initiative, 2020). Based on the calculations, pipes were sized to meet the demands for both the baseline and decreased flow. Calculations for these flows are provided in their respective sections of this report. In efforts to create a more environmentally and economically sustainable structure, the cost of using the baseline demand and infrastructure were compared to the decreased flow and water efficient infrastructure to determine how economically sustainable it was to include more water efficient features in this project.

Using the layout of the structure, the topography, and the location of municipal main lines, the wastewater and potable water lines were laid out on the project site to connect to their respective mains located on Campbell Avenue.

In compliance with the California Fire Code (California Building Standards Commission, and International Code Council, 2019), fire hydrants were placed around the project site, and the demand for each of those hydrants was met in the water demand.

Deirdre Bonitz was responsible for this scope of work.

Stormwater Management

An alternative analysis was conducted for the best Low-Impact Development (LID) approach for managing on-site runoff. Bioretention was chosen based upon multiple criteria that are explained in the alternative analysis portion of the report. Both the design of the bioretention and a physical experimental model were created.

The design of the bioretention included determining the placement of the bioretention, identifying the flow direction due to the existing topography, creating drainage areas to place inlets, calculating maximum flow rates in each drainage area based on a two-year storm, designing pipes connecting inlets to pop-up emitters, calculating the area of each bioretention to achieve a desired ponding depth, designing the underdrain, and modifying the cross-section based on city-approved construction drawings. CAD drawings of the site layout, connections from the bioretention outflow pipes to the storm drain, and elevation and section views of the bioretention were created.

A physical bioretention model was constructed to test the ability of three bioretention sections with varying layers of bio soil and gravel to filter out contaminants. One section had layers consistent with the C.3 Stormwater Handbook (SCVURPPP, 2016), one section exceeded code, and another section broke code. Prior to constructing the bioretention, the design of the model was completed using geotechnical engineering methods to calculate lateral and vertical earth pressures based on measured saturated unit weights. These pressures were used to choose plywood, timber planks, strong ties, bolts, nuts, and a metal cart that met the flexural and compressive strength demands of upholding a saturated bioretention model. Detailed construction drawings were created in AutoCAD to prototype the initial design and to increase the efficiency of the construction process. These drawings included two section views, three elevation views, and one plan view and are included in the design drawings package in Appendix B. The construction process took about 40 hours total, including time taken to gather materials, cut acrylic and wood pieces to size, assemble the components together, and waterproof leaks using caulk. After waterproofing, the proposed experimental procedure was to flush the bioretention three times until it reached equilibrium, and then use lab-created run-off to test the percentage reduction of contaminants due to each bioretention model. While the team was able to successfully waterproof the bioretention and ensure the sod took root in the bio soil, the experiment could not begin due to the shelter-in-place restrictions that began on March 16, 2020. The bioretention is currently located in Alameda Hall at Santa Clara University, where it is receiving plenty of rain and sunshine, so it may be used for a future senior design project or civil engineering class at SCU.

Rachael Han was responsible for this scope of work, and worked in collaboration with Deirdre Bonitz for piping layouts. All members of the team helped construct the bioretention model.

Green Construction Management

Material analysis was performed to determine the cost effectiveness. Throughout the project, Ayo Ogunfunmi was working with the structural team member, as well as the bioretention team member, to assist with the design and implementation of key aspects related to the feasibility of construction. The construction team member integrated construction knowledge within the design process to bridge the gap between concept and reality as it pertained to this project. Aspects such as total cost, duration, and complexities associated with construction were thoroughly reviewed by the construction team member. The same assumption and design limitations listed by the structural and water resource engineering students were utilized by the construction engineering student throughout the design process.

To communicate the design intent of this site, a construction schedule, a 3D model, material quantity takeoff, and cost estimate were created to represent each of the design scopes used within this project. The 3D model utilized AutoDesk Revit and AutoCAD software to place concrete, steel, and other structural elements. Microsoft Project was used to plan duration for the placement of concrete, steel, and typical scopes. A combination of Revit, Bluebeam, and RSMeans assisted the construction engineering team member with cataloguing the total cost of materials and labor. Synchro Pro was used in coordination with the Revit model and Microsoft Project schedule to create a 4D model of the project.

The final product that will be provided to the owner, architect, general contractor, and other contractors that are involved with this project include the construction schedule, cost estimate, and a 4D model digitally submitted in Appendix F

Ayokunmi Ogunfunmi was responsible for this scope of work and worked closely with Spencer, Deirdre, and Rachael to implement their design and costs into the schedule, cost estimate, and 4D model.

Organization of this Report

This report will begin with outlining the non-technical considerations that needed to be taken into account in this project. These considerations include the ethical considerations, sustainable considerations, social-political impacts, environmental impacts, and health and safety impacts.

Following this section will be the analysis of alternatives for the building material and stormwater management system. These analyses aimed to determine the best solutions for specific aspects of the project by comparing different alternatives based on a list of criteria determined to be of importance for each respective area.

The completion of the alternative analyses leads into the design criteria and standards. For each scope of the project, constraints, key values, codes, and assumptions for the designs are presented.

The next section is Description of Designed Development, which is where the design process and the results of the designs are presented. In the Summary of the Site Layout section, a brief overview of the site and project is presented. Following that are the Structural Design, Potable Water Design, Wastewater Management Design, Stormwater Management Design, Stormwater Management Model & Construction, and Construction Management Program. In each of these sections, designs, calculations, and results are provided or referenced to a different section of this report.

The report ends with a conclusion of the results and impacts on the project, as well as a cost estimate.

Non-Technical Considerations

Ethical Considerations

One of the main ethical concerns with the project was how the new development will impact the local community. This SCU Faculty & Staff Housing development is located right next to a residential community not affiliated with SCU, and those living in that community have expressed concerns about this project. These residents have an important stake in the outcome of this project. Their concerns were expressed at the community meeting held by the City of San Jose on August 19, 2019 at Santa Clara University's Locatelli Center. The main concerns that were expressed about the project were the infringement on their privacy that may come with a high rise building, the impacts of traffic congestion in the area, and parking. It is especially important to note that some of the residents may be elderly or have health problems, and the increase in traffic congestion can impact emergency vehicles from accessing the neighborhood as noted in community meetings anecdotally.

This lot lies on land that was owned by the indigenous Muwekma-Ohlone and Ohlone tribes, until the settlements from the colonial Spanish missions during the 18th-19th centuries, were established. To honor the historical and cultural significance of this land, prior to starting construction, the Muwekma-Ohlone and Ohlone tribes should be consulted. During the grand opening of the development, representatives from these tribes should be invited to speak to raise awareness about the colonial past of the land, their vibrant cultures, and significant practices.

This SCU Faculty & Staff Housing Development serves as an incredibly valuable resource to many who have been impacted by the rising cost of living in the area. At the same time, the needs and concerns of the local communities should not be ignored in order for this development to progress. Those concerns were addressed in the design and construction of the development. Maximizing setbacks on the property, onsite parking, and commercial spaces accessible to the public and tenants of this development are some of the ways that the project will improve and form a relationship with the neighboring communities. Since a traffic and transportation analysis was not included in RADS Construction's project scope, those issues were not directly addressed. As the project does move forward, however, it will be critical for a transportation team to find solutions and mitigations to address the increase of population in the area.

Economic Considerations

An economic concern for this project was whether spending money on this project was the best use of Santa Clara University's money. Santa Clara University will be funding and managing this new housing development. The money allocated to this project could also be used to fund other campus projects, as there are other aspects of campus that could use improvement.

On campus, there are buildings that are currently in use, but are in need of renovation. Additionally, over the past years there have been movements on campus to better support adjunct lecturers and workers at Benson Center (Santa Clara University's dining hall). There are many other campus issues that require University funding, so determining if spending money on this Faculty & Staff Housing Development is the best use of campus funds is in question.

The Faculty & Staff Housing Development seeks to address this economic concern through the benefits this project will have for faculty and staff at Santa Clara University, as well as the students. This development can improve relations with adjunct lecturers and non-tenured professors on campus by providing them with an affordable place to live close to campus. An issue that Santa Clara University has been having is both keeping and attracting quality professors and lecturers because the cost of living in the area is so high. By providing more affordable housing, Santa Clara University is making it more reasonable for lecturers, professors, and staff to work and continue to work at the University. While funding this development will not directly improve other buildings and academic space on campus, it has the potential to boost the overall success of the University by attracting and keeping high quality faculty and staff. This continued success can then help to fund other campus projects in the future.

Sustainable Considerations

Sustainability was a primary criteria throughout the design of this project. The project's goal was to abide by Leadership in Energy and Environmental Design (LEED) v4 guidelines (U.S. Green Building Council, 2013). For the structure, steel was the primary material used. Steel relies on nonrenewable resources, therefore it will be a priority to use the least amount of steel possible, while ensuring that the design meets and exceeds the minimum design requirements per the code and regulations. Further, this project attempted to use local resources and materials. To do this, the LEED guidelines were followed, which states that materials are to be extracted, harvested or recovered, and manufactured within a 500 mile radius of the project site. Being conscious of material procurement will not only increase demand for regional materials, but it will also reduce the environmental impacts that come with the transportation of materials. Low impact development (LID) in the form of bioretention was included in the development design to manage water onsite, allow groundwater infiltration, and increase the quality of urban runoff.

Sustainability was not only important to consider for environmental impacts, but also social impacts. A crucial aspect of social sustainability was to ensure basic needs were met for all people. "All people" in this project means the faculty and staff at Santa Clara University who are the main users of this development. The most dire need of the faculty and staff is affordability, because the point of the housing development is to provide housing that is nearby SCU and within their salaries. Per the Engineering Design Processes and Practice for Civil Engineering Projects Handbook, compiled by Dr. Sukhmandar Singh, a sustainable design should use less energy, use less material, fail less often, pollute less, be reusable, and be recycled (Singh, 2012). By installing a bioretention system onsite, the amount of stormwater from the site and sent to water treatment plants is decreased, therefore lowering the amount of embodied energy of this development. Exploring more water efficient options for potable water and wastewater demands helps to conserve more water and potentially decrease the amount of infrastructure and energy needed by decreasing the water demands. Energy usage is correlated with pollution, since the majority of the energy is not sourced renewably yet, so decreasing energy usage also decreases the overall pollution. Using steel as the building material also decreases failure rates in seismic conditions, which is relevant to the location of this project site. Additionally, steel promotes reuse and recycling by melting and reforming the steel for new uses, contributing to a sustainable and circular economy.

Social-Political Impact

During the planning and design of this Faculty and Staff Housing Development, the design team took as many different considerations into account as possible on how this project will affect the society nearby. One of the key points that was brought to the team's attention numerous times in the community meeting on August 19, 2019, was the social impact of having a seven-story residential apartment complex in the proximity of existing residential neighborhoods. Many of the residents who live in houses in the Encanto community, the housing community adjacent to the project site, are accustomed to a one-story industrial zoned building next to their house and expressed concern that their privacy will be taken away once this tall housing complex is constructed.

To address this issue, the team used the site layout provided by the architects (Studio TSquare) of this project and made suggestions on how to address the neighbors' concerns. One aspect of the design that serves as a solution to the privacy issues was the offset of the building footprint from the Encanto neighborhood community. There will be a driveway in between the proposed building and the existing neighborhood community. According to the 2019 California Building Code, the driveway must be a minimum of 20 feet wide (California Building Standards Commission, and International Code Council, 2019), and a 26 foot wide driveway was proposed to be incorporated into the design of this development, further separating the two developments from each other.

The team also recognized that the construction of this new mixed-use residential development will be an issue for nearby residents and businesses, especially since this site is located on a one-way in and one-way out street. In efforts to minimize the number of delays and road closures, the team examined and determined the best method of constructing this building and transporting materials and equipment to the job site. Especially taking into account rush hour, or commute time, when people leave and come back from work, the team would not schedule any activities that will block the road during these times.

During the planning of this project, the first two floors of the building consisted of a parking garage, incubator space, and five floors of residential units above it. Gaining feedback from the stakeholders of this project, the team decided to change the mixed-use aspect of this building by replacing the concept of an incubator space to be commercial space for a coffee shop and/or retail store(s). The stakeholders addressed that they did not see the need for an incubator space and wanted to have a space that was designated for a shop that they would be able to go to and actually make good use of. Especially taking into consideration that nearby residents and businesses that are not affiliated with Santa Clara University are not technically allowed to use the school's facilities, having a store nearby that they could use is more pleasing to them and helps to suit some of their needs.

The overall goal of this housing development was to construct apartment complexes that fall within the budget of Santa Clara University's staff and faculty in the area. While RADS Construction will not be setting rent prices for this housing development, the cost of construction will impact the rental prices as Santa Clara University attempts to recoup the cost accrued during construction. This cost will ultimately depend on Santa Clara University's ability to pay for this building. Given the goal of making this development LEED v4 certifiable, the initial cost of construction was expected to be higher than a traditional construction project. SCU may propose cheaper alternatives to the LEED guided practices to stay within budget and reduce the initial cost, however this comes at a higher cost throughout the project's lifetime.

As with recent archaeological discoveries, Santa Clara University and its surrounding properties have been built on the land of the Ohlone and the Muwekma Ohlone people (Santa Clara University, 2019). It is important to recognize the impact that the new development will have on the surviving members of those tribes whose land has already been paved over with concrete. While it is impossible to rectify the infrastructure built on this land, RADS Construction took this into consideration when implementing design elements, such as using native plants to the area and installing natural groundwater recharging methods in the surrounding areas of the site.

Environmental Impact

Construction and the industry that it affects is reportedly responsible for the depletion of "40% of global resources, 12% of potable water reserves, 55% of wood products, 45–65% of produced waste, 40% of raw materials, and the emission of 48% of harmful greenhouse gases" (Suzer, 2015). Construction itself exacerbates the effect that global warming has and given the increased pace of construction, the harmful byproducts of construction will continue to spread if left unchecked.

As a preventative measure, some countries like the United States and the United Kingdom have developed guidelines for construction projects centered around reducing emissions, using renewable energy, and utilizing environmentally conscious practices throughout the entirety of a construction project. In the Housing Development project proposed by RADS Construction, the United States' green construction building codes and LEED were used for the entirety of this project. Not only did it allow RADS Construction to implement environmentally friendly products into the building, but it gave RADS Construction clear goals to lessen the building's environmental impact.

Currently, the proposed project site is zoned as a heavy industrial site. This classification potentially has serious impacts on the quality of the soil, as oils and other substances may have saturated the soil, which could qualify this site as a brownfield. Additional testing of the soil may be required to determine the extent of potential contamination, which in turn could have time and cost impacts for the development. The team also considered the impact that the proposed construction will have on the heavy industrial site in terms of emission and waste produced by the vehicles and equipment on-site. A detailed construction waste management plan highlighting key ways to incorporate existing materials, such as metals and crushed concrete, was included within this project scope.

Health & Safety Impact

In the field of civil engineering, there are numerous reasons behind why infrastructure can potentially end up failing. One of the main failures that occurs is due to poor design of the infrastructure, which can greatly impact the safety of the individuals who are directly involved with the project and nearby residents. The 2019 California Building Code (CBC) and ASCE 7-16 were referenced to ensure that the proposed development met the minimum standards when designing this development. Enercalc SEL, a structural calculation software, was utilized to design the columns and beams for this development, alongside hand calculations to verify the values that were output from these programs to decrease the chances of human error.

This housing development would be classified as a Type III risk category due to the high volume of residents that will occupy this site. The team incorporated live & dead loads, wind loads, and seismic considerations into the design of the housing complex that adhere to the 2019 California Building Code (CBC) requirements.

To account for possible material failure, the main construction materials for this development will be concrete for the first two floors and hot-rolled steel for the five floors above. These two materials can be thoroughly inspected by a trained professional and can be created in a controlled environment, such as at a concrete plant or steel manufacturing plant. Reinforcement bars are used to help strengthen the concrete and increase the factor of safety as the concrete begins to crack across its lifespan. Also, the target compressive strength (f'_c) was specified for the project to ensure that the concrete can withstand the lateral and axial loads.

Steel is another material that has high structural strength and integrity, which will increase the safety of the overall building. It is impervious to pests and resistant to fires, after fire protection of the steel. One of the main drawbacks of using steel is its risk of being penetrated by moisture, which is mitigated by using insulation, moisture barriers, and high-quality coatings. Steel has the structural stability to withstand high winds and a large amount of seismic activity (Whirlwind). This development is being built in California, so choosing a material that will have less chances of failing in the event of a seismic event is preferred to ensure the safety of the residents and neighbors.

Analysis of Alternatives

For each alternative analysis, a list of criteria was developed. Each criteria was weighed on a scale from one to 10 based on how important each criteria was to RADS Construction and the client (Santa Clara University): one being not important at all to 10 being very important to implement in this project. RADS Construction presented different alternatives and scored them based on how well each alternative met the criteria using a one to five rating system: one meaning that the alternative did not meet the criteria at all and five meaning that the alternative definitely met the criteria. The score was then multiplied by the weights to incorporate how important each criteria was, and the sum of the scores for each alternative was computed. The alternative with the highest score represented the best alternative and was implemented into the overall design of the project.

Material Analysis

An alternative analysis of three different materials was conducted to justify which material will be used for Santa Clara University's faculty & staff housing development at 1200 Campbell Avenue in San Jose, California. The three material options that were considered in this analysis were concrete, steel, and timber.

Concrete is a chemically stabilized structural material used in construction. Concrete forms to whatever mold that it is placed in which allows for the creation of unique structures of varying shapes and sizes. It excels in compression and is generally unfavorable in tension. The combination of widely used Portland cement and water makes it a relatively inexpensive building material. Concrete is one of the most common building materials due to its versatile use in foundations, columns, elevated slabs, beams, and walls.

Steel consists of carbon and iron alloys, which makes it very durable and is often used as a construction material. Although steel production emits CO_2 it is still environmentally friendly and sustainable. Steel is generally recyclable and is very ductile compared to other materials, such as concrete and timber (Worldsteel). Appropriate actions have been taken to continue to decrease the amount of harmful emissions that are generated from steel. Steel, if exposed to the elements, will require consistent maintenance either through painting a protective layer over it or by installing sacrificial anodes. Steel has a very high initial cost due to the material and labor but depending on the project, the amount of material that is needed can be reduced and the overall life span of the project increases. Also due to the different layouts of the apartments, large beam spans will be required for this development, which is possible to accomplish with steel and the ability to pre-camber steel beams if needed. Pre-cambering will allow the material tolerance of the steel to be altered, ultimately allowing the use of lighter, cheaper, and possibly thinner members.

Timber is wood that has been processed into material that can be used for structural purposes. It is often used as a building material since it uses less water and energy to create, is renewable from well managed forests, and has a lower carbon footprint compared to other building materials, such as steel. Wood is also relatively inexpensive especially if outsourced from countries like China, which is responsible for 44% of all timber imports (PR Newswire: Press Release Distribution, Targeting, Monitoring and Marketing, 2019). Timber has a great deal of flexibility, which makes it ductile and reduces the effects in the event of an earthquake. Timber is also a common building material, therefore it is used in most residential houses.

The criteria used to rate each system was weighted on a 1 to 10 scale, and the assigned weight for each criteria are listed as follows:

- Low Cost, 9/10
- Sustainability, 8/10
- Expertise, 7/10
- Aesthetics, 3/10
- Schedule Impacts, 5/10
- Seismic Resistance, 6/10

The weights for the material analysis were based on the needs from Santa Clara University, SCU's faculty and staff, and the overall site constraints. The stakeholders of this project were able to voice their opinions at the community meeting on August 18, 2019 and these criterias reflected their concerns. Each criteria was weighed and scored based off of the material's ability and effectiveness of meeting the criteria.

After applying the weights and criteria ratings to the alternatives (as shown in Appendix A, Table 1), the best material to build the structure was determined to be steel, with the exception of the first two floors constructed out of concrete for the parking garage. Steel received a score of 116 after assigning criteria ratings and multiplying by weights. The top four criteria were cost (9/10), sustainability (7/10), ease of constructibility (6/10), and schedule impacts (6/10), in order of highest weight. For cost, steel was the least affordable compared to concrete and timber. Steel, however, has a great long-term cost benefit due to its material properties (Pascal Steel, 2016), and RADS Construction has more design knowledge with steel compared to timber and concrete

Stormwater Management Analysis

Alternatives for onsite stormwater management were analyzed and compared to determine the best solution for Santa Clara University's faculty & staff housing development at 1200 Campbell Avenue in San Jose, California.

The stormwater management alternatives that were selected to be analyzed are based on the suggestions in the C.3 Stormwater Handbook and are listed as follows (SCVURPPP, 2016):

- Porous pavement
- Green roof
- Bioretention
- Flow through planters
- Rainwater catchment
- Nothing (status quo)

Eleven criteria were used to evaluate the alternatives, and each criterion was rated a weight from 1-10. A weight of one means the criteria is not important to the project to achieve affordability and sustainability. A weight of five means the criteria moderately influences the design of the project to achieve both affordability of sustainability. A weight of 10 means the criteria highly influences the design of the project to achieve both affordability and sustainability.

Porous pavement is a load-bearing, durable surface that allows water to infiltrate (Santa Clara Valley Urban Runoff Pollution Prevention Program, 2016). Porous pavement consists of layers of both fine and coarse aggregate for the water to filter through. Once the water goes through the aggregate, it reaches a perforated pipe where some of the runoff is taken to the storm drain system and some infiltrates into the subgrade soil. The important benefits of this system are its ability to filter fine particles and reduce runoff. Limitations of this alternative include susceptibility to clogging and higher installation costs than normal pavement (National Asphalt Pavement Association, 2020).

Green roofs are roof systems containing vegetation that function to “filter, absorb, and retain or detain the rain that falls upon them” (Suzer, 2015). The top layer of these roofs consist of planting media and vegetation. Structural components such as waterproofing and geofabrics lie underneath the top layer. Some benefits of this alternative are that it provides significant reduction to roof runoff, earns LEED credits, and is a highly aesthetically pleasing system. Some limitations of this alternative include high cost and impact on the structural design (EPA, 2020).

A bioretention area is a biotreatment design that uses soil and plants to filter and remove pollutants from urban runoff (SCVURPPP, 2016). A system typically consists of a detention area, plants, a layer of mulch, biotreatment soil, drain rock, and an underdrain. As water percolates through, it is treated and filtered by the varying layers before either infiltrating into the native soil or being sent to the storm drain through a perforated underdrain. Some benefits of this system are that it is low maintenance and it can conform with a variety of landscapes. Some limitations of this alternative include the need for irrigation for the first few years and the susceptibility to clogging (Whirlwind, 2017).

Flow through planters are similar to bioretention areas in terms of function, however, they do not allow for groundwater infiltration into the native soil. The system is completely contained by concrete or other planter walls, and they also have waterproof membranes. Some of their benefits include their ability to be adjacent to structures and they are low maintenance. Their limitations include head loss and susceptibility to clogging (SCVURPPP, 2016).

Rainwater catchment systems collect rainwater from the roof and other impervious surfaces. They are designed to collect and store the water for irrigation and other non-potable reuses. Benefits of this system include LEED credits and the reduction of runoff, especially roof runoff. Limitations of this system include cost of maintenance and installation and its usage of space (SCVURPPP, 2016).

The status quo alternative for this development would be no stormwater management or Low Impact Development aspects in place. This means that runoff flows directly into the storm drain system without any treatment or reduction efforts. Not implementing stormwater management on a site that contains more than 10,000 square feet of impervious area violates the C.3 Stormwater Handbook (SCVURPPP, 2016). This project site is 137,000 square feet which is greater than the 10,000 square feet minimum requirement. Due to the amount of impervious area on the site, it is necessary to follow the C.3 Stormwater Handbook, and there must be some onsite stormwater management to satisfy local and statewide regulations.

The three main constraints for stormwater management alternatives were run-off treatment, ability to fit on the project site, and compliance with the C.3 Stormwater Handbook (SCVURPPP, 2016). The criteria used to rate each system was weighted on a 1 to 10 scale, and the assigned weight for each criteria are listed as follows:

- Groundwater infiltration capacity, 6/10
- Runoff treatment effectiveness, 10/10
- Aesthetics, 5/10
- Impact on structure design, 8/10
- Space usage, 7/10
- Storm drain runoff reduction, 7/10
- Cost of construction, 10/10

- Feasibility of construction, 4/10
- Cost of maintenance, 8/10
- Feasibility of maintenance, 3/10
- Geographically appropriate, 6/10

After applying the weights and criteria ratings to the alternatives (as shown in Appendix A, Table 3), the best stormwater management system was a bioretention system. The bioretention system received a score of 308 after assigning criteria ratings and multiplying by weights. The top five criteria were effectiveness of runoff treatment (10/10), the cost of construction (10/10), impact on structural design (8/10), cost of maintenance (8/10), and storm drain runoff reduction (7/10), in order of highest weight. A bioretention system was the best alternative for a stormwater management system because the bioretention system had the highest scores for three of the top five weighted criteria. As an addition, the porous pavement could also be added for stormwater use onsite to help the bioretention system by reducing the total amount of impervious area on the project site. The less the impervious area is, the less volume the bioretention system will have to be. A smaller bioretention system will benefit this site since it is a large development on a smaller site in an urban area.

Design Criteria and Standards

Constraints

Before beginning the design of this Faculty and Staff Housing Development for Santa Clara University, RADS Construction communicated with representatives from Santa Clara University and Studio TSquare to identify the following constraints for this project:

- Project Site Area = 133,730 ft^2 = 3.07 acres
- Intended Use of Building = Mixed-Use
- Minimum Number of Apartments = 280 units
- Number of Floors = seven (7) floors
- Site Zone = Heavy Industrial District currently, proposal submitted for Mixed-Use
- Design knowledge of the design team
- Time & Online Schooling

Key Values, Applicable Codes, and Assumptions Used in Design Calculations

Structural:

The design of all of the structural components of Santa Clara University's Faculty and Staff Housing Development abided by the 2019 California Building Code (CBC) and ASCE/SEI 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures. According to the 2019 California Building Code (Table 1604.5) and the ASCE/SEI 7-16 (Table 1.5-1), this building was designed to be a risk category III structure since the failure of this building could pose a substantial risk to human life. This classification was assumed to be appropriate mainly due to the size of the overall structure and the overall occupancy of the building being greater than 280 people. There was also no geotechnical report provided for this project site yet, therefore the site was assumed to have a soil class D, according to ASCE/SEI 7-16 Section 20.1. Also due to not having a geotechnical report, ACI 318-19 was used to assume the thickness of the foundation slab to be nine inches.

According to the ASCE/SEI 7-16 (Table C3.1-1a), dead loads throughout the building were estimated based off of the typical materials that are used to construct a concrete parking garage and steel residential apartment units. The dead load for the commercial space was 104 psf, the parking garage was 108 psf, the residential units & corridors were 70 psf, and the roof was 51 psf. The dead loads were estimated by adding up the weight of the structural components, and five percent of the summation of the weights was added as a miscellaneous component and served as a factor of safety for the design.

Per the ASCE/SEI 7-16 (Table 4.3-1), live loads were assigned depending on the occupancy type. For the parking garage, a live load of 60 pounds per square foot (psf) was assigned, despite a minimum live load specification as stated for a passenger parking garage in ASCE/SEI 7-16 (Table 4.3-1) was 40 psf. A live load of 60 psf was used with anticipation that the parking garage can be used as an assembly area if needed. The residential units were assigned a live load of 40 psf, and all of the corridors were assigned a live load of 60 psf in case of people assembling in the hallways in an emergency, such as a fire. The live load for the commercial space was 100 psf, and the roof live load was 20 psf in anticipation that solar panels could be installed on top of the building in the future. Based on the 2019 California Building Code (Table 1604.3), the deflection limit for the floor members for only the live loads was L/360 and L/240 for dead and live loads respectively, where L is the length of each member (with units of inches) to ensure that the structural system and members were rigid enough to withstand the deflections.

Using the Equivalent Lateral Force method, the lateral force resisting system was designed based off of the estimated base shear and type of lateral system used. Special reinforced concrete shear walls, special steel concentric braced frames, and special steel moment frames were used to resist the lateral forces. To design the concrete shear walls, ACI 318-19 (Table 11.3.1.1) was used to determine the minimum thickness of the shear wall, which was eight (8) inches, and the minimum design requirements for the concrete shear wall. The base shear for concrete shear wall lateral system was 7,155 kips. To design the special reinforced concrete shear wall and special concentric braced frames, the Response Modification Coefficient (R) was 5 and the Deflection Amplification Factor (C_d) was 5 according to ASCE/SEI 7-16 (Table 12.2-1). To design the special steel moment frames and special concentric braced frames, as well as all of the other steel members, AISC 360-16 was used for steel section properties and design provisions. A stiffness of $8EI/L_3$ was assumed for the design of all of the columns for the special steel moment frames since it was a generally conservative assumption based on the project characteristics. The base shear for the steel moment frame lateral system was 2,932 kips. According to ASCE/SEI 7-16 (Table 12.2-1), the Response Modification Coefficient (R) was 8 and the Deflection Amplification Factor (C_d) was 5.5. All of the steel and concrete calculations were performed using Load and Resistance Factor Design (LRFD).

Potable Water and Wastewater Management:

The calculations for the potable water and wastewater sections were based on the 2019 California Fire Code (California Building Standards Commission, and International Code Council, 2019), 2019 California Plumbing Code (California Building Standards Commission, and International Code Council, 2019), LEED v4 (U.S. Green Building Council 2013), Green Building Initiative Green Globes Water Consumption Calculator (Green Building Initiative, 2020), and tables from *Water and Wastewater Engineering Design Principles and Practice* (Davis, 2010).

Stormwater Management:

To ensure that the development met the Bay Area stormwater requirements and abided by local San Jose codes, the C.3 Stormwater Handbook was used to design the bioretention (SCVURPPP, 2016). Santa Clara Water Valley provided data for groundwater table levels near the site to determine if the bioretention should allow for groundwater infiltration. The rainfall data was collected in San Jose (NOAA), and unit hydrographs were generated following federal guidance (USDA, 2007). City of San Jose design codes were used as well (San Jose Technical Documents).

In designing the bioretention, a few assumptions were made. The first assumption was that all rainwater onsite will be caught by inlet pipes. The second assumption was that earthwork should be minimal, but will be demanded if needed. The last assumption was that placing a bioretention outside of the property line is allowed because that adjacent property is also owned by Santa Clara University. All of the bioretention design was completed with the intention to significantly decrease the volume of untreated onsite run-off into storm drains.

Construction:

All design considerations for this project have been vetted with the guideline presented in Cal/Occupational Safety and Health Administration (OSHA) with regard to upholding safety standards (Allen). All cost data was compiled from the RSMeans Construction Cost Database (Mewis).

Description of Designed Development

Summary of the Site Layout

The location of this project site was thoroughly thought out by Santa Clara University since the site that was chosen was owned by the University, property size was adequate to construct a mixed-use development, and it was in the proximity of transit hubs (i.e. Caltrain, Amtrak, and VTA). RADS Construction communicated with Santa Clara University and the architect for this project, Studio TSquare, to determine what was the most beneficial site layout to design the structure on. Santa Clara University mentioned that they wanted a building that had a minimum of 280 residential units but also had some extra space for an incubator. RADS Construction did not see the purpose for an incubator space, as Studio TSquare originally proposed, and included a commercial space in the team's design instead. The commercial space will have stores that will be open to the general public. Therefore, this building design will counteract nearby stakeholder's, who are not affiliated with Santa Clara University, concerns about adding this development to the neighborhood. Finally, the team decided to place the driveway on the south side of the property (displayed in Figure 5), adjacent to the neighboring housing development that is not owned by the University. The driveway was placed in this location to provide some privacy to the neighboring residences. The driveway will wrap around the east side of the building and into the University Villas driveway on the north side of the property.

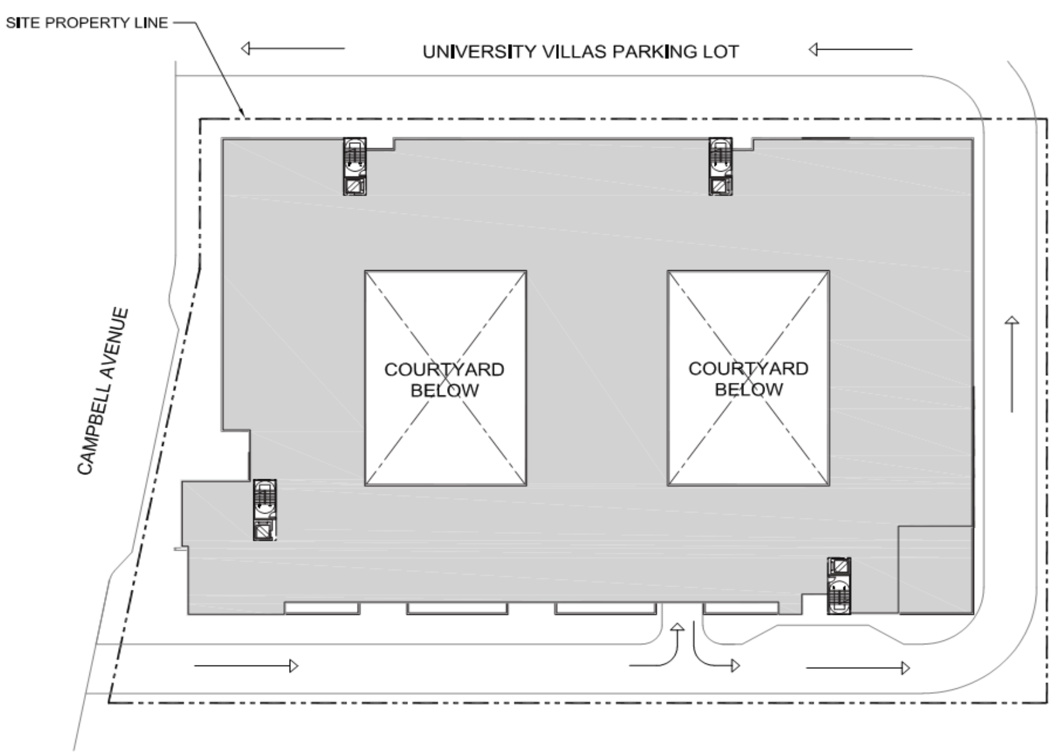

Figure 5. Site Layout Including Driveway Design.

The building consists of a total of seven floors above grade level. The first floor consists of a parking garage and approximately a 25,000 square foot commercial space. The second floor contains a parking garage and residential units. Floors three and four have residential units and a clubhouse, which is only accessible on the third floor. Floors five through seven have only residential units. There are four different unit layouts: Studio, One-bedroom, Two-bedroom, and Three-bedroom, as proposed by Studio TSquare in Figure 6. A unique feature of the entire layout of this building is the open courtyard (Figure 7) in the center of the building from the third floor and above.

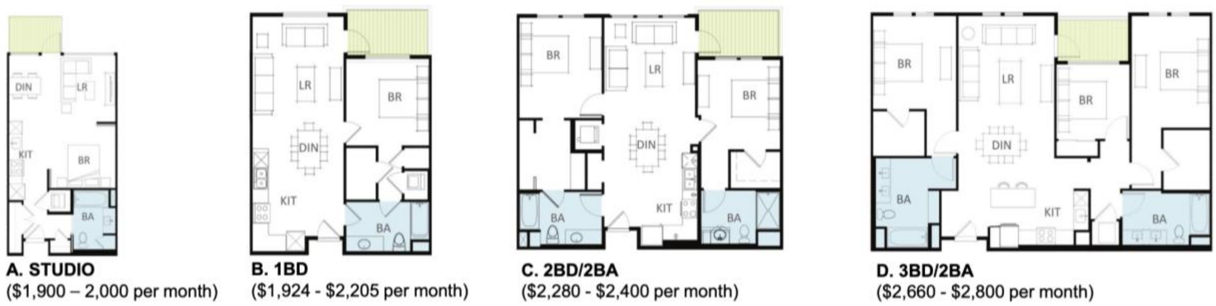

Figure 6. All Four Unit Layouts in the Building (Studio TSquare, 2019).

Figure 7. All Four Unit Layouts in the Building (Studio TSquare, 2019).

Structural Design

Based on the architectural drawings provided by Studio TSquare, the entire building is seven stories, contains 290 residential units, 286 parking spaces, commercial space and a clubhouse. The first two floors of the building consists of a parking garage and commercial or residential space. The upper five floors consisted of residential units and a clubhouse only accessible on the third floor of the building but is two floors high. The first two floors of the building have a floor area of 91,000 square feet, and the residential floors have a floor area of 68,000 square feet due to the courtyard in the interior of the building that starts on the third floor. The first two floors have a higher elevation than the upper five floors making sure that the floors are high enough in the parking garage and commercial space. The floors that have mainly residential units have a typical height of 10 feet on each floor. The entire building was designed to be 77 feet above grade, especially since the soil conditions were unknown and the scope of work consisted of tasks above the foundation concrete slab. After conducting an alternative analysis of different building materials to use to design Santa Clara University's Staff and Faculty Housing Development, the structural system was broken down into two types of sections based on the intended use of the space and building material chosen. The foundation slab and parking garage consisted of mainly concrete. Hot-rolled steel and metal decking with concrete fill were the main building materials used to design the commercial space, residential units, and clubhouse.

Due to the time constraints and the unknown classification of the soil on site, it was assumed that the first floor of the building would sit on top of a nine inch concrete foundation slab that is below grade level. This building also consists of four elevators and four stairwells that are located near the four corners of the building since this building is large and can contain more than 300 occupants.

AutoCAD was used to determine and layout the appropriate locations to place the gravity force resisting system with respect to the key elements of this development. The gravity force resisting system for the concrete portion of this building occured in the parking garage which consisted of simply supported rectangular concrete beams and circular concrete columns. For the commercial space, clubhouse, and residential units, simply supported w-section steel beams, girders, and steel columns were used. The beams and columns were grouped into sections in AutoCAD to make it easier to design the gravity force resisting elements of this building. The structural team determined the tributary width of gravity loads that were acting on the beams and the tributary area of gravity forces that were acting on the columns.

The gravity columns were designed based on the assigned section of the building and the largest tributary area acting on a column in that respective section. The gravity beams were grouped based on their span lengths, and each group was designed using the largest tributary width of gravity load acting on each respective group. In order to not block any open areas, such as living space and windows, there are sections of the structure that had long spanning gravity beams. Therefore, a pre-composite camber design was performed on the Microsoft Excel calculation spreadsheet that the structural design team member created for beams which had a span greater than or equal to 30 feet long. By cambering the beam, a lighter and more shallow beam was used since the beam was deflected in the vertical direction to help negate the impact of heavy loads acting on these long members. While performing the pre-composite camber design, a metal deck was chosen from the ASC Metal Decking Floor Catalog. The floor metal decking that was specified for all of the floors that consisted of steel had a total slab depth of 6.25 inches, use of light-weight concrete, and a two hour fire rating was used. The two hour fire rating metal deck will allow the occupants to have more time to exit the building in the event of a fire, especially due to the high density of this development. For the roof, a 1.5 inch metal deck with plywood was chosen from the ASC Metal Decking Roof Catalog since the dead loads on the roof was calculated to be 51 psf and would be mainly carrying the weight of mechanical, electrical, and plumbing (M.E.P.) equipment, which was not included in the scope of this project. The structural design team member knew that many of the columns and beams would be oversized but wanted to make all of the concrete columns the same size for ease of fabrication and construction. Table 1 displays the gravity loads that were applied depending on the intended use of the space. It is important to note that 5% of the total dead load for each intended space was added as miscellaneous to serve as a design factor of safety, taking into consideration the load assumptions that were made. It is also important to note that there are gravity columns that are not continuous to the grade level. This situation occurs on the third floor of the building, where steel columns were attached to the concrete floor diaphragm so the gravity loads can be effectively transferred to the columns and down to the ground. The design calculations for the gravity force resisting system can be found in the structural calculations package (Appendix C), and the structural details can be found in the drawing set (Appendix B).

Table 1. Flat Weights of the Building.

Intended Use of Space	Dead Load (psf)	Live Load (psf)
Parking Garage	108	60
Commercial Space	104	100
Residential Units	70	40
Residential - Corridors	70	60
Roof	51	20

Looking at the overall structure layout in AutoCAD after laying out the gravity force resisting system, the structural design team member analyzed what type of lateral force resisting system(s) that needed to be included in the design of this development. The lateral forces were determined to mainly act on all of the four exterior walls of the building and the walls of the building that are in the open courtyard. Therefore, the lateral systems were placed towards the outer walls, which would experience the majority of the lateral forces. The lateral systems were also placed as symmetrical from each other as possible to prevent the center of mass and rigidity from affecting how the overall building reacts to lateral forces.

Due to the two different building materials used for the first and second floor of the building, two different lateral force resisting systems were designed and a two-stage design process was implemented (Figure 8). According to ASCE 7-16, Section 12.2.3.2, a two-stage design process was permitted if the development contained a flexible upper portion above a rigid lower portion. Therefore as seen in Figure 9, the first two floors that have special reinforced concrete shear walls and special concentric braced frames make the structure rigid (highlighted in blue), while the upper floors contain special steel moment frames for the lateral system, which make the structure flexible (highlighted in pink). Special steel moment frames were selected for this design due to this site being in a high seismic region and the structure needed more ductility due to the size of the structure and being able to withstand large inelastic deformations.

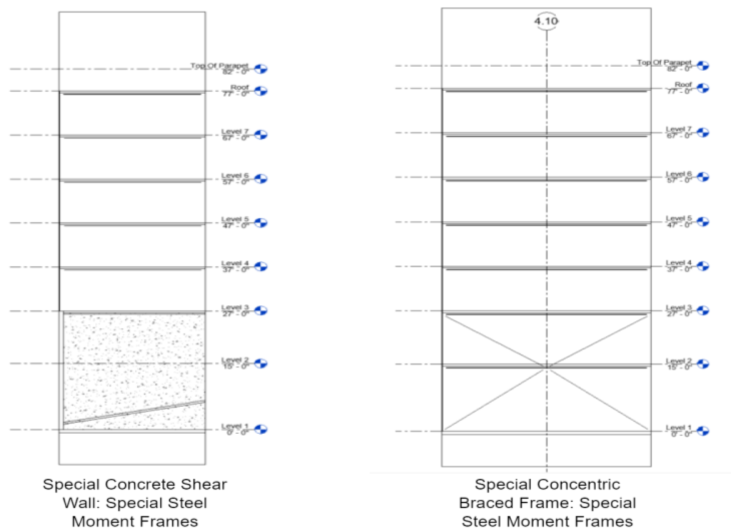

Figure 8. Lateral Force Resisting Systems.

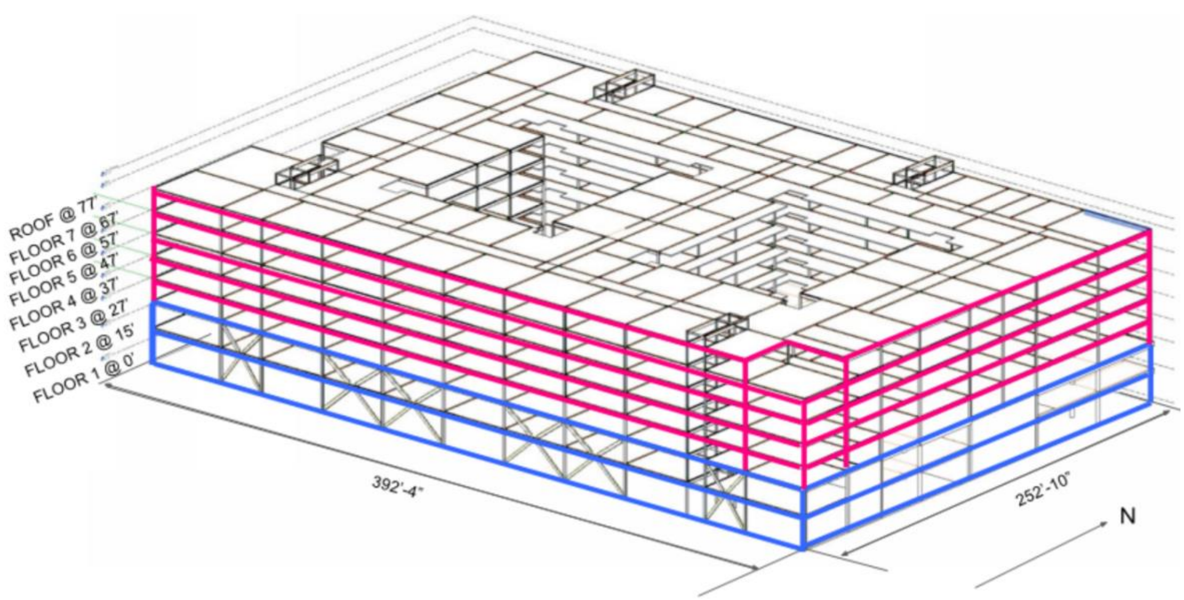

Figure 9. Rigid (Blue) Versus Flexible (Pink) Design of the Building.

Since there were two different diaphragm systems joining together on the second and third floor, special concentric braced frames and special reinforced concrete shear walls were chosen. Originally, the structural design team was planning to use special steel moment frames for the lateral system for the commercial space on the first floor and residential units on the second floor since special steel moment frames were being used on the floors above. But after considering how the building would react if it experienced lateral forces, the structural design team decided to use special concentric braced frames for the first two floors to provide more rigidity to the structure on the lower levels and choose a lateral system that had a similar Response Modification Factor (R) to special reinforced concrete shear walls. The special reinforced concrete shear walls and special concentric braced frames on floors one through three (Figure 10) were placed relatively near the sides of the building where the building was expected to experience the strongest lateral forces.

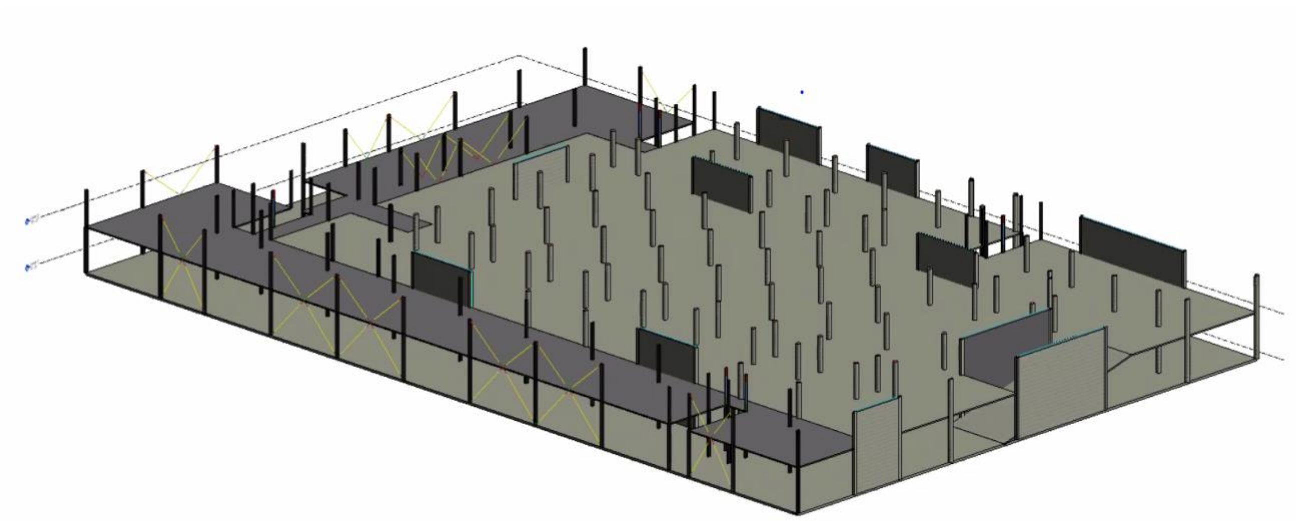

Figure 10. Lateral System for Floors One through Three.

The lateral system for the upper five floors (residential units and a clubhouse) consist of special steel moment frames (Figure 11). Steel special moment frames were chosen especially for the residential units to prevent the lateral system from hindering any key elements of the building, such as windows, rooms, etc. It is important to note that both of the lateral systems were designed to resist torsion acting on the building due to lateral forces.

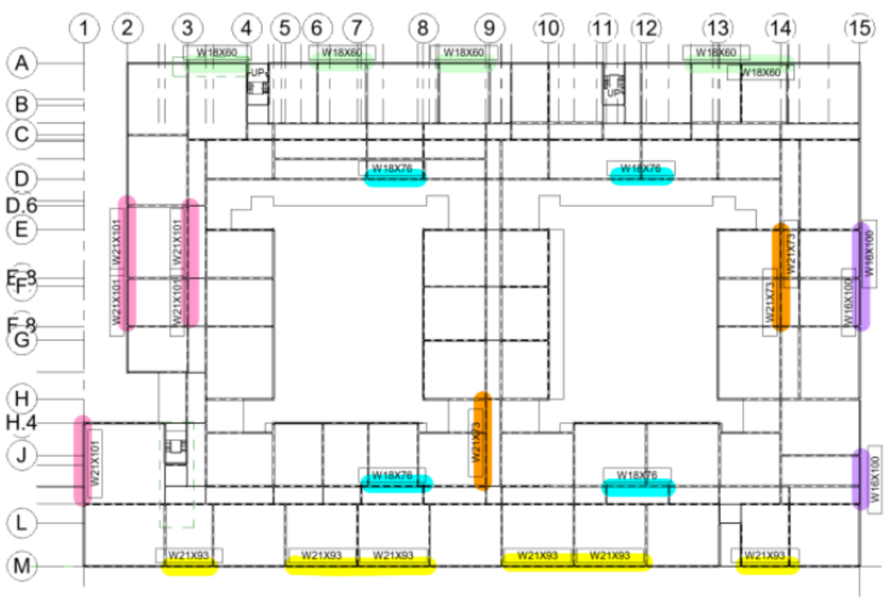

Figure 11. Lateral System for Floors Three to Roof.

All of the lateral force resisting systems, with the exception of the design of the special concentric braced frames since it was out-of-scope, were designed using the Equivalent Lateral Force Method and can be found in the structural calculations package in Appendix C. The lateral system details can be found in the drawing set in Appendix B. The two lateral systems were designed to meet the allowable story drift per ASCE 7-16, Table 12.12-1 and be able to withstand the base shear acting on the structure due to the lateral forces in each direction. Based on the response parameters of the site, the building was classified to have a Seismic Design Category (SDC) of D, and its Risk Category was III due to the high risk of human life.

The special steel moment frames were designed by calculating the amount of force that each frame experiences on each floor. The required moment of inertia for the columns was calculated, and the W-shaped properties in the AISC 360-16, Table 3-2 were referenced to find a column that had the capacity to contain the required minimum moment of inertia. The required moment of inertia for the beams in the moment frames were calculated, and the W-shaped properties in the AISC 360-16, Table 3-2 were referenced to find a beam that had at least the required moment capacity. A selection of the structural details for the lateral system can be found in Appendix B. The design calculations for the connections of the different members of the lateral system were not included in this scope due to time constraints and intensity of work. Figure 11 highlights the two lateral systems on two sides of the 3D model of the building, which was created using Revit.

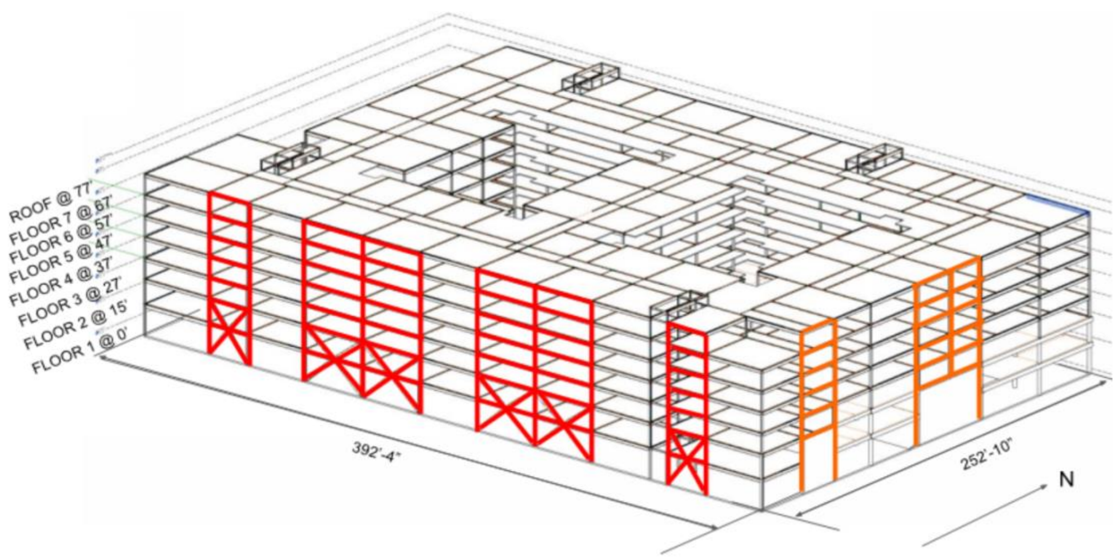

Figure 12. Two Lateral Systems Highlighted on the 3D Model on Two Sides of the Building.

Potable Water Management Design

Water Demand

The potable water demand for the project was calculated for baseline standards and water efficient products that reduce demand for comparison. Santa Clara University's Faculty and Staff Housing Development consists of both residential and commercial space, which require different calculations because of the different purposes they serve.

The potable water demand for the commercial space was determined first. Based on the 26,000 square foot (ft^2) commercial space available, it was expected that 104 people would be using this space daily, where 50% are male and 50% are female. For the baseline water demand, the flow rates of standard water closets, standard urinals, and conventional lavatories, sinks, and showers were used. For the reduced water demand, the flow rates of ultra low-flow water closets, waterless urinals, and WaterSense lavatories, sinks, and showers were used. These products are higher in water efficiency, as they use less water to function. The final calculations for both the baseline potable water demand and the reduced flow water demand of the commercial space are shown in Tables 2 and 3, respectively.

Table 2. Baseline potable water demand for commercial space of the project.

Commercial Space with 104 Occupants, 26,000 sf - Baseline Flow					
Flush Fixture	**Daily Uses**	**Flowrate (gpf)**	**Duration (flush)**	**Occupants**	**Water Use (gal)**
Standard Water Closet (Male)	1	1.60	1	52.00	83.20
Standard Water Closet (Female)	3	1.60	1	52.00	249.60
Standard Urinal (Male)	2	1.00	1	52.00	104.00
Standard Urinal (Female)	0	1.00	1	52.00	0.00
	Daily Uses	**Flowrate (gpm)**	**Duration (sec)**	**Occupants (gal)**	**Water Use (gal)**
Conventional Lavatory	3	2.50	12	104.00	156.00
Kitchen Sink	1	2.50	12	104.00	52.00
Shower	0.1	2.50	300	104.00	130.00
				Total Daily Volume (gal)	774.80
				Annual Workdays	260.00
				Total Annual Volume (gal)	201,448.00

Table 3. Reduced potable water flow for commercial space of the project.

Commercial Space with 104 Occupants, 26,000 sf - Reduced Flow					
Flush Fixture	**Daily Uses**	**Flowrate (gpf)**	**Duration (flush)**	**Occupants**	**Water Use (gal)**
Ultra Low-Flow Water Closet (Male)	1	0.80	1	52.00	41.60
Ultra Low-Flow Water Closet (Female)	3	0.80	1	52.00	124.80
Waterless Urinal (Male)	2	0.00	1	52.00	0.00
Waterless Urinal (Female)	0	0.00	1	52.00	0.00
	Daily Uses	**Flowrate (gpm)**	**Duration (sec)**	**Occupants (gal)**	**Water Use (gal)**
WaterSense Lavatory	3	1.20	12	104.00	74.88
Kitchen Sink	1	1.75	12	104.00	36.40
Shower	0.1	1.80	300	104.00	93.60
				Total Daily Volume (gal)	371.28
				Annual Workdays	260.00
				Total Annual Volume (gal)	96,532.80

After the potable water demand for the commercial space was completed, the potable water demand for the residential space was calculated. With the help of the Green Building Initiative's Green Globe's Water Calculator, the baseline and reduced flow cases for the water demand were calculated (Green Building Initiative, 2020). Like in the commercial space calculations, the baseline demand used the flow rates of standard water closets, sinks, lavatories, showers, and household appliances. The reduced flow for the residential space used the flow rates of low-flow toilets, WaterSense sinks, lavatories, and showers, and more efficient household appliances. The final calculations for the residential baseline potable water demand and reduced potable water demand are shown in Table 4. The complete calculations are shown in Appendix D.

Table 4. The total baseline (17,246,200 GPY) and reduced potable water demand (11,612,703 GPY) for the residential space of the building.

Residential Water Demand: Calculated Using GBI Green Globes Consumption Calculator		
Baseline Demand	17,246,200.00	GPY
Reduced Demand	11,612,703.00	GPY

In addition to the potable water demands from the commercial space and residential area, there was also a water demand required for fire flow. Per the California Fire Code, a structure of this size requires a capacity of 6,000 GPM for fireflow. This requirement was added to the water demand.

A peaking factor of 5.3 as recommended from the book *Water and Wastewater Engineering* was added to the commercial and residential demands for both the baseline and reduced (Davis, 2010). The commercial water demand, residential water demand, and fireflow demand for both the baseline and reduced were compiled and are shown in Tables 5 and 6, respectively.

Table 5. Total baseline potable water demand for the entire building.

Flow Type	**Demand**	**Units**
Indoor Residential Potable	17,246,300	GPY
Indoor Commercial Potable	201,448	GPY
Fireflow	6,000	gpm
Peak Hour	253,351	gpd
Max Day	109,945	gpd
Total Demand	**6,176**	**gpm**

Table 6. Total reduced potable water demand for the entire building.

Flow Type	Demand	Units
Indoor Residential Potable	11,612,703	GPY
Indoor Commercial Potable	96,533	GPY
Fireflow	6,000	gpm
Peak Hour	170,025	gpd
Max Day	73,784	gpd
Total Demand	**6,118**	**gpm**

The addition of more water efficient features in the building significantly decreases the water demand for the entire structure. Using these basic water reducing strategies will result in a 33% decrease in indoor water use for the building and can achieve a total of 2 points for the LEED Indoor Water Use Reduction Credit. This reduction is shown in Table 7.

Table 7. Annual indoor water use reduction in the building using water efficient features.

Water Reduction		
Annual Baseline	17,447,748	GPY
Annual Reduced	11,709,236	GPY
Percent Reduction	33%	

Pipe Sizing and Layout

Based on the size of the structure, California Fire Code requires a minimum of six (6) hydrants to be located on the site with each hydrant receiving 1,000 GPM of flow during the time of need (California Building Standards Commission, and International Code Council, 2019). Three (3) of the hydrants are located on the northwest side of the structure and the other three (3) are located along the southeast side of the structure.

The project has two potable water mains with one on the northwest side of the building and the other on the southeast side of the building. Since the 6,000 GPM fireflow dictates the demand for both the baseline demand and the reduced demand, each of the mains will be 14" ductile iron (DI) pipes with 8" DI laterals that connect to the fire hydrants. To determine these diameters, Equation 1 and Equation 2 were used. Equation 1 displays the equation for calculating the area of the pipe, and Equation 2 displays the equation for calculating the velocity. The velocity must be greater than 2 ft/s and less than 8 ft/s. These equations determine the diameters of the pipes for the potable water mains and hydrant laterals.

Potable Pipe Baseline

Total Demand =13.79 ft^3/sec

Split into two Mains: Demand in Each = $Q = 6.90\ ft^3/sec$

Mains 1 & 2:

Diameter = D = 14 inches

$$Equation\ 1: A = \frac{\Pi}{4}D^2 = \frac{\Pi}{4}[(14\ in)(\frac{1\ ft}{12\ in})]^2 = 1.07\ ft^2$$

$$Equation\ 2: V = \frac{Q}{A} = \frac{6.90\ ft^3/sec}{1.07\ ft^2} = 6.45\ ft/sec$$

Potable Pipe Reduced

Total Demand =13.63 ft^3/sec

Split into Two Mains: Demand in Each = $Q = 6.80\ ft^3/sec$

Mains 1 & 2:

Diameter = D = 14 inches

$$Equation\ 1: A = \frac{\Pi}{4}D^2 = \frac{\Pi}{4}[(14\ in)(\frac{1\ ft}{12\ in})]^2 = 1.07\ ft^2$$

$$Equation\ 2: V = \frac{Q}{A} = \frac{6.80\ ft^3/sec}{1.07\ ft^2} = 6.36\ ft/sec$$

Hydrant Pipes

Demand Per Hydrant = $1{,}000\ gpm = 2.23\ ft^3/sec$

Diameter = D = 8 in.

$$Equation\ 1: A = \frac{\Pi}{4}D^2 = \frac{\Pi}{4}[(8\ in)(\frac{1\ ft}{12\ in})] = 0.35\ ft^2$$

$$Equation\ 2: V = \frac{Q}{A} = \frac{2.23\ ft^3/sec}{0.35\ ft^2} = 6.39\ ft/sec$$

The locations of the potable water mains, the fire hydrants, and the fire hydrant laterals are shown in Figure 13.

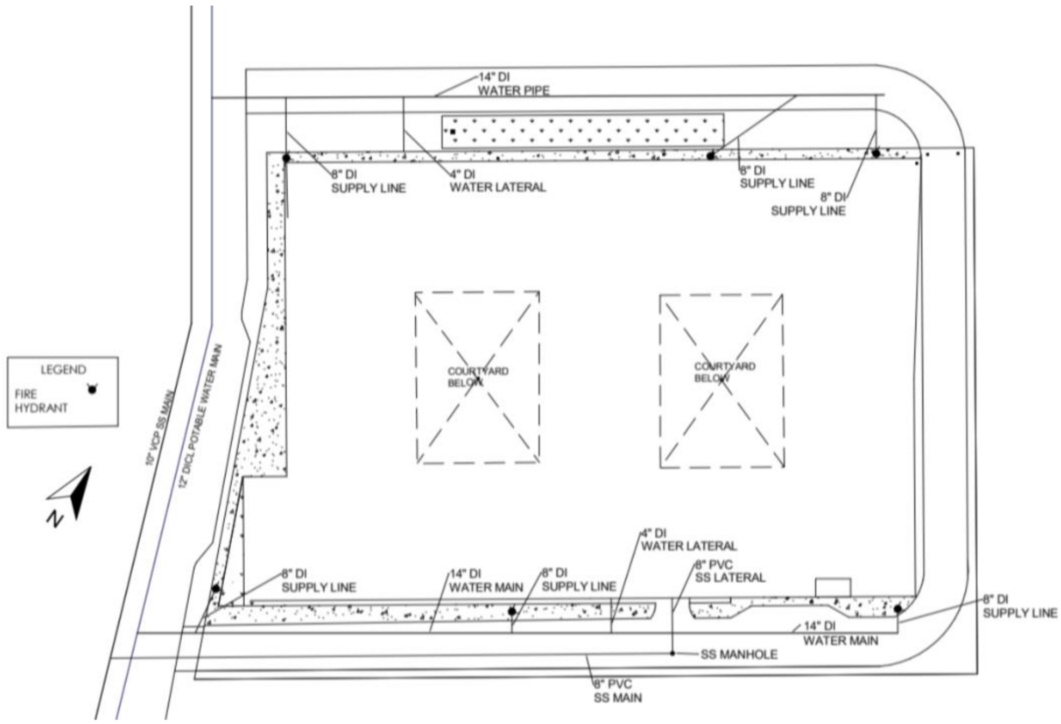

Figure 13. The layout of the potable water mains, fire hydrants, fire hydrant laterals, sanitary sewer main, and sanitary sewer laterals on the project site.

Wastewater Management Design

Wastewater Demand

Based on the potable water demands for both the residential and commercial spaces, the total wastewater demand was determined. For both the baseline and reduced demands, a peak hour factor of 4 was taken from Figure 14 and applied to the average daily demand.

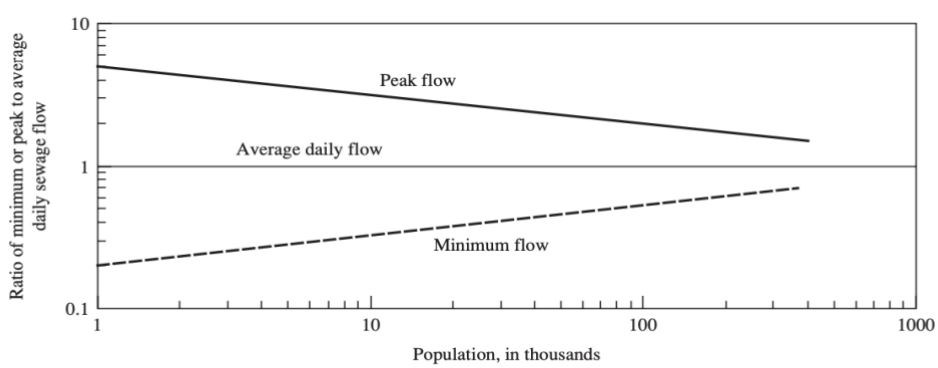

Figure 14. Peaking factor for wastewater demands. Sourced from (Davis, 2010).

With the addition of the peaking factor from Figure 14, the total wastewater demands for both the baseline and reduced demands are shown in Tables 8 and 9, respectively.

Table 8. Baseline wastewater demand for the entire building.

Flow Type	Demand	Units
Indoor Residential	17,246,300	GPY
Indoor Commercial	201,448	GPY
Total Building Demand	17,447,748	GPY
Peak Hour	191,208	GPD
Max Day	109,945	GPD

Table 9. Reduced wastewater demand for the entire building.

Flow Type	Demand	Units
Indoor Residential	11,612,703	GPY
Indoor Commercial	96,533	GPY
Total Building Demand	11,709,236	GPY
Peak Hour	128,320	GPD
Max Day	73,784	GPD

Pipe Sizing and Layout

To size the pipes for the stormwater demand, Bentley Systems' OpenFlows FlowMaster was used. This is a program that assists in performing hydraulic calculations for different kinds of flows. The maximum pipe flow capacity (y/D) was set to be at 60% capacity. A slope of 0.02 and a friction factor (n) of 0.013 based on using PVC pipe were used for the calculations. Additionally the velocity of the flow in the pipe was required to be greater than two (2) ft/s and less than eight (8) ft/s, and the flows must meet the demands. The calculations determined that for both the baseline and reduced water demand, the minimum eight inch (8") PVC pipe will meet the required demands. The inputs and calculations done in FlowMaster are in Appendix D. The sanitary sewer main will be located along the southeast side of the building with an eight inch (8") lateral connecting the building to the main. Figure 13 displays the layout of the sanitary sewer piping.

Connection

For this project, proper ways to connect the sanitary sewer lateral to the existing main on Campbell Avenue were researched. There is currently not a manhole located close enough in the street so that the main onsite can connect to the existing main on Campbell Avenue. Due to this fact, the team recommends that the project lateral connect to the existing main using a connection similar to the connection used in Figure 15. This detail uses a 45° connection to join the project lateral to the existing main.

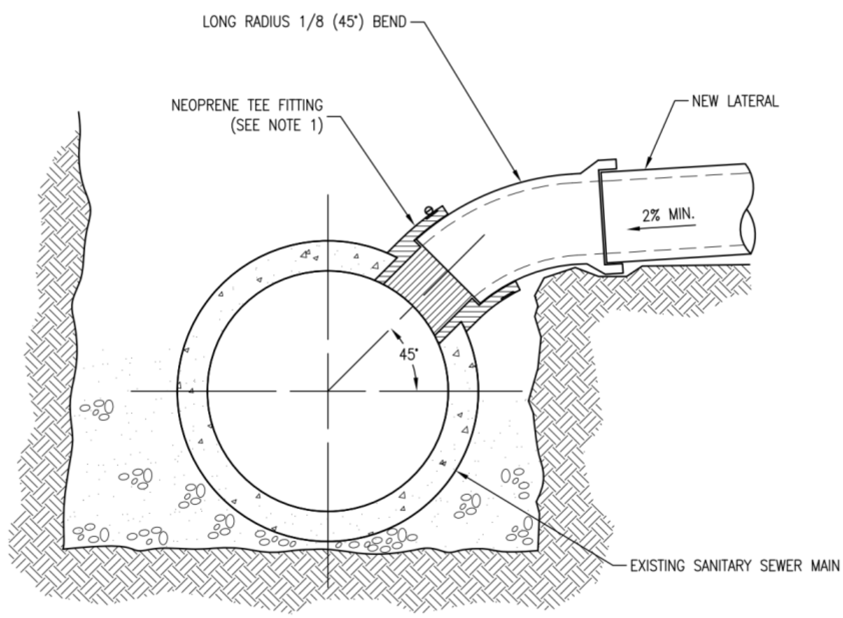

Figure 15. Example detail of how the sanitary sewer lateral on the project site should connect to the existing sanitary sewer main on Campbell Avenue. Sourced from (Tran, 2013).

Water Efficient Features Cost Analysis

Many of the water efficient fixtures that reduce the amount of indoor water demand for the project come at a higher cost. For this reason, many projects may initially veer away from using these efficient fixtures, not willing to sacrifice cost for sustainability. These water efficient fixtures do decrease the amount of water demand, though, which can decrease the amount of potable water that the building needs to purchase annually to use. If the decrease in the building's water bill can offset the initial cost of purchasing the more water efficient fixtures, it would be far more reasonable and beneficial to use in the project.

To determine the economic benefits of implementing water efficient fixtures rather than standard fixtures, a cost comparison between the two was completed. The first part of the cost comparison was determining the costs of each of the different fixtures for both the reduced water demand and the baseline water demand. The different fixtures used were shower heads, lavatory sinks, toilets, urinals, and kitchen sinks. The average costs of the standard and water efficient fixtures were determined, and the total number of fixtures needed in the project were calculated using the building floor plans. This section of the cost analysis solely looked at material costs, not labor and installation costs, since those were assumed to be the same for the standard and water efficient fixtures. Table 10 and Table 11 show the calculations for the total material cost of the standard fixtures and the water efficient fixtures.

Table 10. Total cost calculations for the use of standard fixtures in the building.

Using Standard Fixtures			
	Cost/Unit	# of Units	Cost for all Units
Standard Shower Head	$10.00	506	$5,060.00
Standard Lavatory Sink	$25.00	510	$12,750.00
Standard Water Closet	$99.00	514	$50,886.00
Standard Urinal	$125.00	3	$375.00
Standard Kitchen Sink	$27.00	292	$7,884.00
		Total Fixture Cost	$76,955.00

Table 11. Total cost calculations for the use of water efficient fixtures in the building.

Using Water Effecient Fixtures			
	Cost/Unit	# of Units	Cost for all Units
WaterSense Shower Head	$20.00	506	$10,120.00
WaterSense Lavatory Sink	$25.00	510	$12,750.00
Ultra Low Flow Water Closet	$134.00	514	$68,876.00
Waterless Urinal	$299.00	3	$897.00
WaterSense Kitchen Sink	$36.00	292	$10,512.00
		Total Fixture Cost	$103,155.00

As mentioned before, despite the difference in demand, both the baseline demand using standard fixtures and the reduced demand using water efficient fixtures required the same size and length of piping on the project site. Due to this, the pipe cost was excluded from the analysis.

The second part of the comparison calculated the cost to purchase potable water annually from the City of San Jose. At the location of the project it costs $5.13/one hundred cubic feet of water (City of San Jose, 2019). This cost was used to calculate the annual water purchasing cost for the baseline and reduced demand. The total costs for the two demands are shown in Tables 12 and 13.

Table 12. The calculations for the annual purchasing cost of potable water for the baseline demand.

Water Purchasing Cost for the Baseline Water Demand		
Potable Water Cost	$0.01	per gallon
Total Demand	17,447,748	gallons/year
Annual Purchasing Cost	$119,661.69	

Table 13. The calculations for the annual purchasing cost of potable water for the reduced demand.

Water Purchasing Cost for the Reduced Water Demand		
Potable Water Cost	$0.01	per gallon
Total Demand	11,709,236	gallons/year
Annual Purchasing Cost	$80,305.32	

The costs of both the fixtures and the water purchasing were compared between the baseline demand and the reduced demand. Table 14 depicts the cost differences between the two demands.

Table 14. Summary table comparing the costs of using standard fixtures versus using water efficient fixtures in the project.

	Fixture Costs	Water Purchasing Costs (1 year)
Standard Fixtures	$76,955	$119,662
Water Efficient Fixtures	$103,155	$80,305
Cost Difference	-$26,200	$39,356

Water efficient fixtures cost $26,200 more in unit costs than standard fixtures, however, when comparing the water purchasing costs, using water efficient fixtures results in a savings of $39,356. This results in a return on investment of less than one year. So while the water efficient fixtures have a higher upfront cost, the savings in the water bill pays off that additional cost in less than one year and keeps the project's water bill at a much lower rate. The savings have led the team to recommend that the project install water efficient fixtures in the building.

Stormwater Management Design

The C.3 Stormwater Handbook (SCVURPPP, 2016) was used as a reference for the design of the bioretention area on the project site. According to the C.3, any site with more than 10,000 ft^2 of impervious area must have onsite stormwater management. The total impervious area of the site is 133,645.77 ft^2. The handbook also states that the stormwater management area must be at least four percent of the total impervious surface area on the site. Four percent of that area is equal to 5,345.83 ft^2 and assuming there is no pervious area on the site, the bioretention area must be equal to that. The area of the bioretention can be later adjusted when following the bioretention sizing worksheet in Section IV, Appendix B of the C.3.

Based on the minimum area requirement for the bioretention and the existing topographic map, two bioretention options were designed. In addition to the minimum area requirement, a bioretention area must include a 10 foot setback from a structure if no waterproofing is present per SCVURPPP C.3 Ch 6.1. As mentioned in the General Site Description on page 9, the water table in the area is very high. Therefore, waterproofing must be installed. Both of the options met the minimum area and setback requirement but made different use of the site's space. The potential locations of the bioretention areas are shown below in Figure 16.

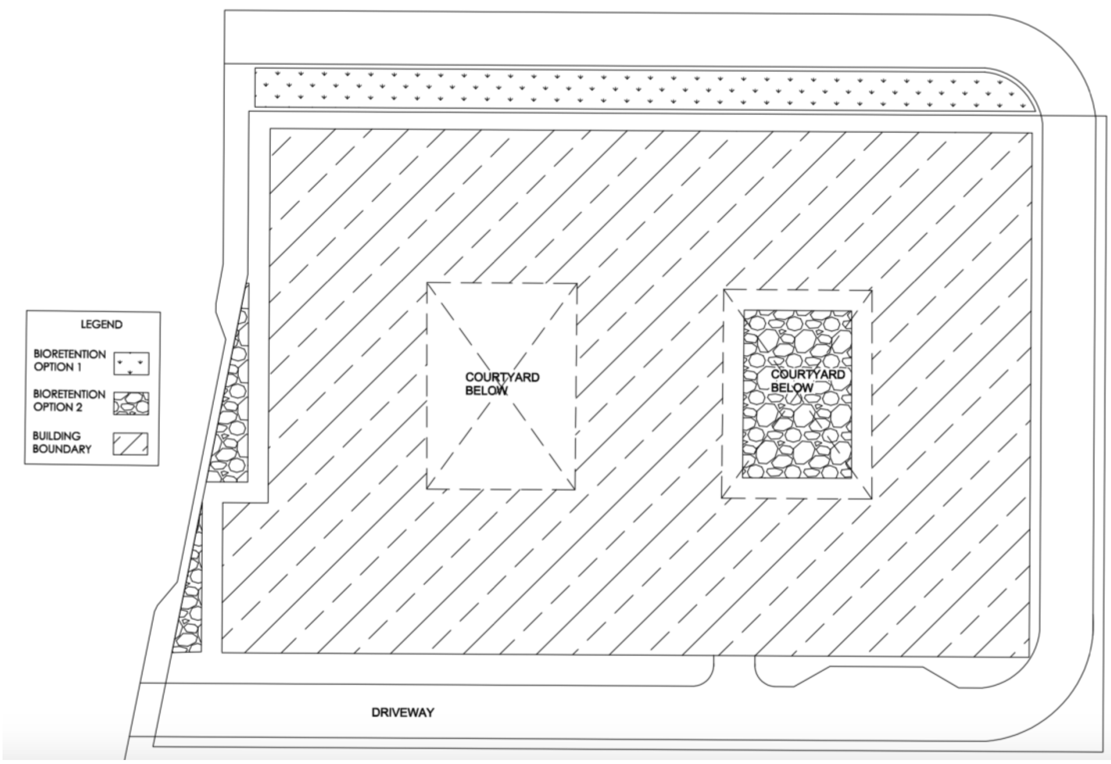

Figure 16. Layout of two bioretention placement options.

Option 1 was chosen because Option 2 requires an entire courtyard to be dedicated towards a bioretention instead of its intended use as a recreational area. To ensure that it is acceptable to place a bioretention outside of the property line, Jill Bicknell was consulted. Bicknell is a managing engineer at Environmental and Public Health Engineering and co-author of the C.3 Handbook. She stated that Option 1 was acceptable because both parcels of land are owned by Santa Clara University. While designing the pipes that lead from inlets to the bioretention in Option 1, another bioretention was determined to be required due to the unrealistic amount of earthwork needed to connect pipes from the inlets furthest south to the bioretention. Figure 17, below, shows the new layout of bioretentions on-site:

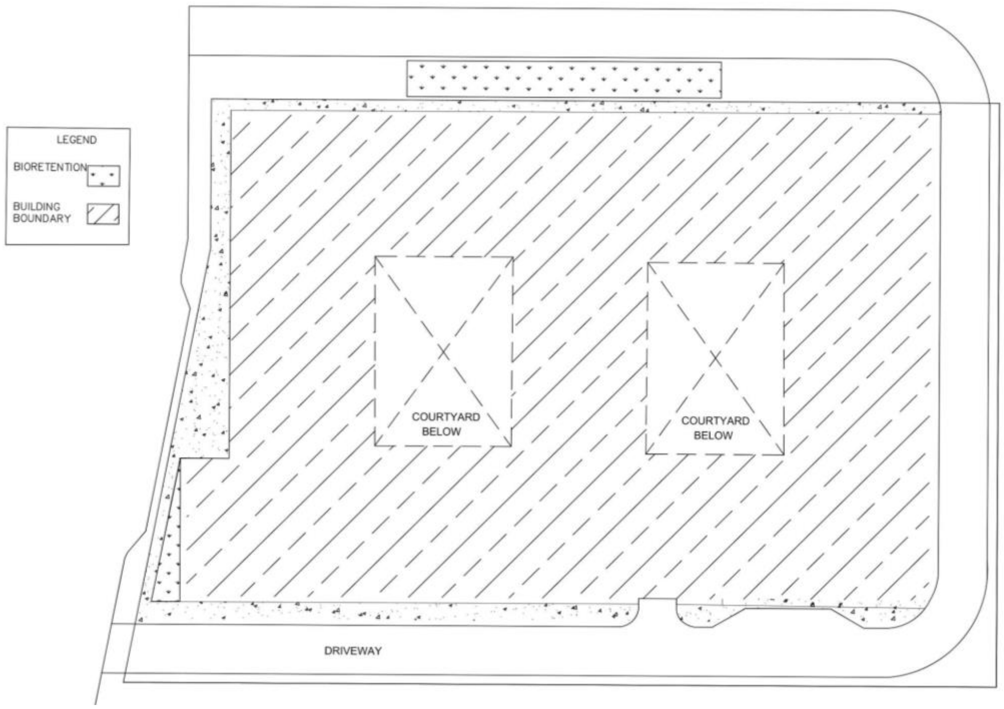

Figure 17. Revised layout of bioretention placement.

The site was broken up into small drainage basins, impervious and pervious, that were each assigned an inlet to flow into based on the existing topography. Drainage basins 5, 10, 11, 15, 18, 20, 21, 22, 23, 25, and 28 require earthwork fill to drain to Inlets I, E, and J. See Figure 18 below for a layout of the drainage basins and inlets. Inlets are the lettered squares, and drainage basins are numbered.

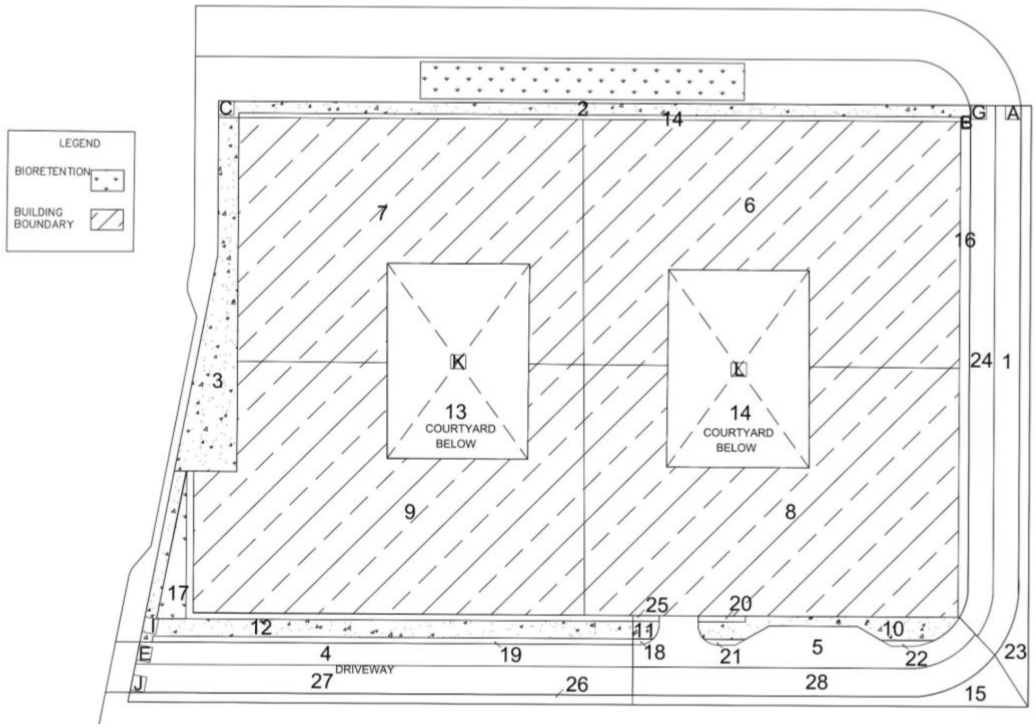

Figure 18. Layout of drainage basins and inlets.

The following inlets and drainage basins are draining into the north bioretention:

Table 15. Inlets and drainage basins for the north bioretention.

North Bioretention	
Inlet	**Drainage Basin**
A	1, 23
B	6, 8, 16
C	2, 3, 7, 9, 14
J	15, 26, 27, 28
K	13
L	14

The following inlets and drainage basins are draining into the west bioretention:

Table 16. Inlets and drainage basins for the west bioretention.

West Bioretention	
Inlet	**Drainage Basin**
E	4, 5, 12, 17, 19
I	10, 11, 18, 20, 21, 22, 25
J	15, 26, 27, 28

Using the NRCS Curve Number Method in the National Engineering Handbook, the runoff depth was calculated for both permeable and impervious surfaces (USDA, 2010). These runoff depths were used to find runoff volume for each inlet by multiplying the surface area of all drainage basins that flow into the inlet by the corresponding runoff depth. Below are the Curve Number calculations.

NRCS CN Method Calculations

From SCVWD Figure B-1 in C3 Manual, soil at 1200 Campbell Ave is Clay, Group D (SCVURPPP, 2016). From Gupta Table 4.11, CN = 98 for Group D for urban impervious areas. For fair open urban space, CN = 84.

$$CN = \frac{1000}{10+S} \text{ (Equation 4.19 from Gupta text)}$$

Impervious Area Calculations

CN = 98 = 1000 / (10+S)
S = 0.204 in

North
Rainfall intensity = 0.2 in/hr (Per the C.3)
Design Storm = 2.825 hr
Rainfall depth (P) = 2.825 hr x 0.2 in/hr = 0.565 in

$$\text{Runoff depth, } Q = \frac{(P-0.2S)^2}{(P+0.8S)} \text{(Equation 4.18 from Gupta text)}$$

Q = 0.377 in depth for impervious area for north bioretention

West
Rainfall intensity = 0.2 in/hr (Per the C.3)

Design Storm = 2.385 hr
Rainfall depth (P) = 2.385 hr x 0.2 in/hr = 0.477 in
Q = 0.297 in depth for impervious area for west bioretention

Pervious Area Calculations

CN = 84 = 1000 / (10+S)
S = 1.90 in

North
Q = 0.016 in depth for pervious area for north bioretention

West
Q = 0.0047 in depth for pervious area for west bioretention

After calculating the run-off depths, runoff volumes were found by multiplying each inlet's surface area by the pertaining pervious/impervious depth. Once the runoff volume for each inlet was calculated, the total runoff volume that each bioretention receives was determined by adding up the runoff volumes from the inlets assigned to that bioretention. The exact area of each bioretention was found by following Section IV in Appendix B of the C.3 Handbook, which uses a combined flow and volume approach (SCVURPPP, 2016). The approach takes into account a desired ponding depth of roughly six inches (6") and the volume of water that is determined to flow into each bioretention. The bioretention sizing results are below in Table 17.

Table 17. Bioretention sizes and depths.

	North Bioretention	West Bioretention
Surface Area (ft^2)	3150	570
Ponding Depth (ft)	0.50	0.51

Upon establishing the runoff volumes, Chapter 15 of Part 630 of the National Engineering Handbook (NEH) was used to calculate the time of concentration for each inlet (USDA, 2010). First, the total travel time was calculated using the following equation from NEH.

$$T_t = \frac{0.007(nl)^{0.8}}{(P_2)^{0.5}S^{0.4}} \qquad \text{(Eq. 15-8)}$$

where:
T_t = Travel time, h
n = Manning's roughness coefficient (Table 15-1)
l = Sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = Slope of land surface, ft/ft

According to the NEH, the Manning's coefficient for impermeable surfaces of concrete/asphalt is 0.011 and the coefficient for permeable surfaces of cultivated soils is 0.17 (15-6) . The sheet flow length for each drainage basin was determined by measuring the farthest reach from one end of the drainage basin to the inlet on AutoCAD. Using data from the National Oceanic and Atmospheric Administration, the 2-year, 24-hour rainfall depth for 1200 Campbell Avenue is 1.46 in. (NOAA, 2005). An estimated 2% slope was assumed as the slope of the land surface.

After calculating the travel time for each drainage basin, the time of concentration for each inlet was calculated by summing all travel times of drainage basins that led to each inlet.

$$T_e = T_{t1} + T_{t2} + T_{t3} + \ldots . T_{tn} \quad \text{(Eq. 15-7)}$$

where:

T_c = Time of concentration, h

T_{tn} = Travel time of a segment n, h

n = Number of segments comprising the total hydraulic length

After finding the time of concentration, the maximum flow rate at each inlet was calculated by using a USDA unit hydrograph transformer, seen in Appendix E-1. The unit hydrograph transformer uses the inputs of time of concentration (hr), drainage area (mi^2), and Peak Rate Factor (PRF). The PRF used was 484, based on the USDA National Engineering Handbook Part 630 Chapter 16. Table 18 presents the total area, time of concentration, and maximum flow rates for each inlet.

Table 18. Maximum flow rate at each inlet.

Inlet	Max CFS
A	0.212
B	1.704
C	1.224
E	0.307
G	1.44
I	0.195
J	0.156
K	8.424
L	8.521

Using Bentley Engineering's Flowmaster program, each inlet was sized according to the maximum flow rate at that inlet plus flow rates at upstream inlets, using the minimum 1% slopes, and a Manning's roughness coefficient of 0.013 for PVC (Table 14.4 in Gupta text). See Appendix E-1 through E-9 for the Flowmaster reports for all pipes. A two-year storm was used to calculate the maximum flow rates, so the maximum pipe flow capacity was set at 60%. Table 19 presents pipe sizes, slopes, and maximum flow capacity for each pipe connecting an inlet to the bioretention.

Table 19. Pipe sizes, slopes, and max fullness of pipes at each inlet.

	Max Flow Rate (cfs)	Flow Capacity (%)	Pipe Diameter (in)	Slope (ft/ft)
Inlet A	0.212	43.3	6	0.01
Inlet B	10.225	47	24	0.01
Inlet C	9.648	45.4	24	0.01
Inlet E	0.463	42.5	8	0.01
Inlet G	11.877	51.7	24	0.01
Inlet I	0.658	52.5	8	0.01
Inlet J	0.156	48	5	0.01
Inlet K	8.424	56	20	0.01
Inlet L	8.521	56.5	20	0.01

Elevations of inlets were checked upon finding slopes for pipes by using the City of San Jose's GIS data to find invert elevations of storm drain manholes located on Coleman Avenue (San Jose Spatial Team, 2015). The invert elevation of the storm drain manhole for the north bioretention is 63.07 ft. The base of pop-up emitters will connect to the pipes that drain from the inlet to the bioretention and rest on the layer of biosoil with the top protruding from the three inch (3") thick mulch layer. Assuming a minimum slope of the outflow pipe and underdrain of 0.5%, 36 inches of biosoil and gravel, and a 129.5 ft long outflow pipe and 148.5 ft long underdrain, the elevation of the base of the left pop-up emitter is 66.86 ft, and the elevation of the base of the right pop-up emitter is 67.35 ft. The invert elevation of the storm drain manhole for the west bioretention is 64.50 ft. Assuming a minimum slope of the outflow and underdrain of 0.5%, a 36 inch thick bioretention, and a 40 ft long outflow pipe, the elevation of the base of the sole pop-up emitter is 67.6 ft. See Tables 20 and 21 below for elevations at each inlet for both bioretentions.

Table 20. Elevations at each inlet draining into the north bioretention.

Location	Elevation (ft)	Pipe Length (ft)	Pipe Slope
Base of Pop Up Emitter Left	66.86		
		14.779	0.01
Corner	67.01		
		132.5075	0.01
Inlet C	**68.33**		
Base of Pop Up Emitter Right	67.35		
		14.3294	0.01
Corner	67.49		
		155.4771	0.01
Inlet G	69.05		
		8.2668	0.01
Inlet B	69.13		
		17.6677	0.01
Inlet A	**69.22**		

Table 21. Elevations at each inlet draining into the west bioretention.

Location	Elevation (ft)	Pipe Length (ft)	Pipe Slope
Base of Pop Up Emitter	67.7		
		13.8166	0.01
Inlet I	67.84		
		14.7727	0.01
Inlet E	67.99		
		15.6107	0.01
Inlet J	**68.14**		

Using an existing topography map obtained from the architects on the project, Studio TSquare, the elevations required for each inlet were checked. The elevations are above the existing topography, but do not require significant earthwork. The earthwork cut from digging the foundation will be used towards required fill of the site.

The underdrains were designed next. A flow rate was found for each underdrain by multiplying the infiltration rate of five (5) in/hr for biosoil by the surface area for each bioretention (Appendix B). Using the C.3 specified minimum slope of 0.5% , the flow rate and slope were imported into Bentley's Flowmaster with a Manning's roughness coefficient of 0.013 for PVC. Appendix E-10 to E-11 contains the detailed Flowmaster reports for the underdrains. The pipe flow capacity was allowed to be greater than 60% because the infiltration rates of the bioretention upon saturation remain the same regardless of the storm intensity or duration. See Table 22 for underdrain specifications for the north and west bioretentions.

Table 22. Underdrain detailing highlighted for north and west bioretentions.

North Bioretention		
Surface area	3150	sq ft
Q in underdrain	0.365	cfs
Slope	0.005	ft/ft
Pipe Diameter	6	in
Percent full	75	%
West Bioretention		
Surface area	570.84	sq ft
Q in underdrain	0.066	cfs
Slope	0.005	ft/ft
Pipe Diameter	4	in
Percent full	50	%

The outflow pipes followed a similar process, but required the use of a 10-year storm (Jill Bicknell, email communication). Using the storm durations of 2.825 hr and 2.385 hr for the north and west bioretentions, respectively, that were calculated in Figures 26 and 27, the intensities were found by interpolating two (2) hr and three (3) hr duration 10-year intensities found on NOAA for 1200 Campbell Avenue. Then, the impervious and pervious depths were found by repeating the NRCS Curve Number method in Figure 25 with the new intensities and corresponding rainfall depths. Upon finding the new CN flow depths, the new ponding depths in each bioretention using the 10-year storm and accompanying intensity were found following Section IV of the C.3 Handbook, similar to Figures 26 and 27. See below for the CN flow depth and ponding depth calculations.

Outflow Pipe Design

Data from NOAA for 1200 Campbell Ave, using a 10-year storm in Table 23 below:

Table 23. 10-year storm intensities for 1200 Campbell Ave.

	Intensity (in/hr)
2-hour Duration	0.457
3-hour Duration	0.373

Impervious Areas

North Bioretention
Design storm = 2.825 hr
Intensity = 0.3877 in/hr (extrapolated from data in Table 22)
Rainfall depth (P) = 2.825 hr * 0.3877 in/hr = 1.095 in

Using equation 4-18 from Gupta again,
Q = 0.883 in depth for impervious areas for north bioretention

West Bioretention
Design storm = 2.385 hr
Intensity = 0.425 in/hr
Depth (P) = 2.385 hr * 0.425 in/hr = 1.014 in

Q = 0.805 in depth for impervious areas for west bioretention

Pervious Areas

North Bioretention
Q = 0.195 in depth for pervious areas for north bioretention

West Bioretention
Q = 0.159 in depth for pervious areas for west bioretention

Following C.3 Appendix B, Section IV again, the ponding depth of the north bioretention using new depths are **1.069 ft for the north bioretention and 1.037 ft for the west bioretention**.

After finding the ponding depths due to a 10-year storm in each bioretention, the volume of overflow was calculated by multiplying the surface area by the difference between the 10-year and two-year ponding depth. The storm durations were calculated by adding the longest time of concentration to the original durations of 2.825 and 2.385 hrs. Referencing Table 3, the longest time of concentration for the north bioretention was 0.972 hr from Inlet C. For the west bioretention, the longest time of concentration was 1.516 hr from Inlet J. The maximum flow in the outflow pipes were calculated by dividing the volume of the overflow by the calculated storm duration and adding the maximum flow rate from the underdrain. The resulting flow rate, a Manning's roughness coefficient of 0.013 for PVC, and the minimum slope of 0.5% were used in Bentley's Flowmaster program to design the outflow pipes. Appendix E-12 to E-13 contains the detailed Flowmaster reports for the outflow pipes. See Table 24, below, for outflow pipe specifications for north and west bioretentions.

Table 24. North and west bioretention outflow pipe detailing.

North Bioretention			West Bioretention		
Surface area	3150	sq ft	Surface area	570.84	sq ft
Ponding Depth at 10 yr	1.069	ft	Ponding Depth at 10 yr	1.037	ft
Ponding Depth at 2 yr	0.500	ft	Ponding Depth at 2 yr	0.510	ft
Volume of overflow	1792.350	ft	Volume of overflow	300.833	ft
Duration of storm	3.797	hr	Duration of storm	3.901	hr
Q in outflow pipe	0.496	cfs	Q in outflow pipe	0.087	cfs
Slope	0.005	ft/ft	Slope	0.005	ft/ft
Pipe Diameter	8	in	Pipe Diameter	4	in
Percent full	55	%	Percent full	57.5	%

The site layout was then updated including all pipe lengths, diameters, slopes, and inlet elevations. See Figure 19 below for this layout.

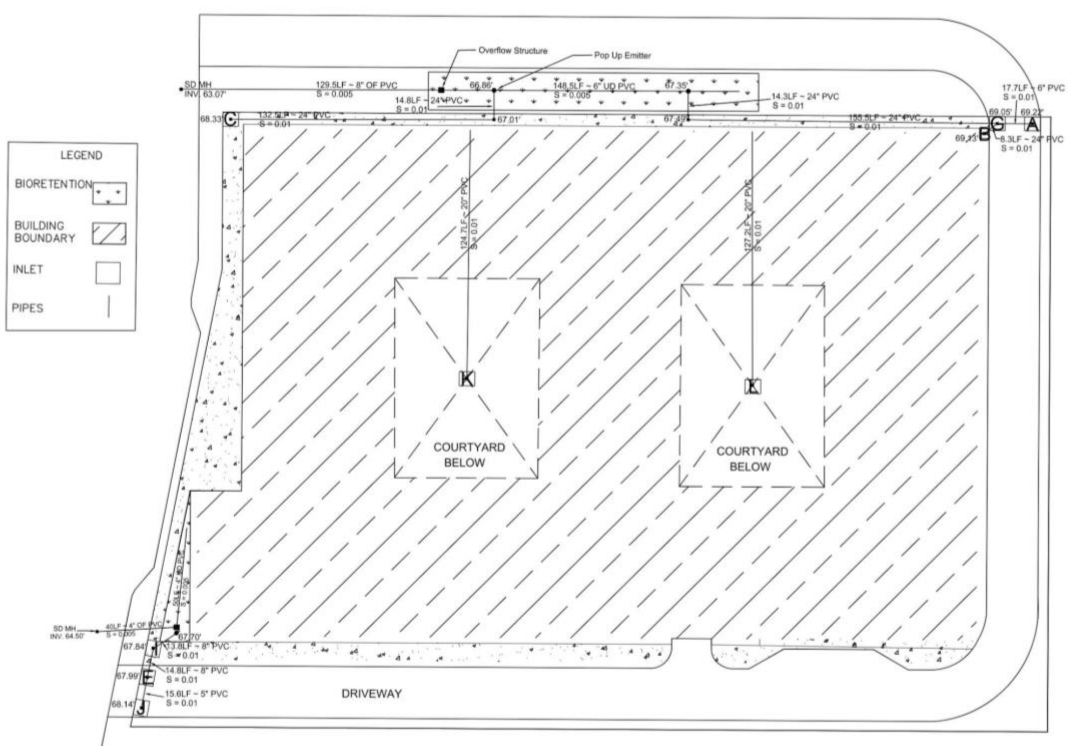

Figure 19. Final site layout including details of stormwater management components. See Appendix B for a larger drawing.

Using drawing SW-3 from Part 2 of the SCVURPPP Green Stormwater Infrastructure Handbook, the cross-sections for the bioretentions were designed. Drawing SW-3 is specifically for a street slope-sided bioretention with no parking with an underdrain. The drawings were edited to reflect the dimensions of the north and west bioretentions. See Figures 20 and 21 below for the AutoCAD cross-sections of the north and west bioretentions, respectively.

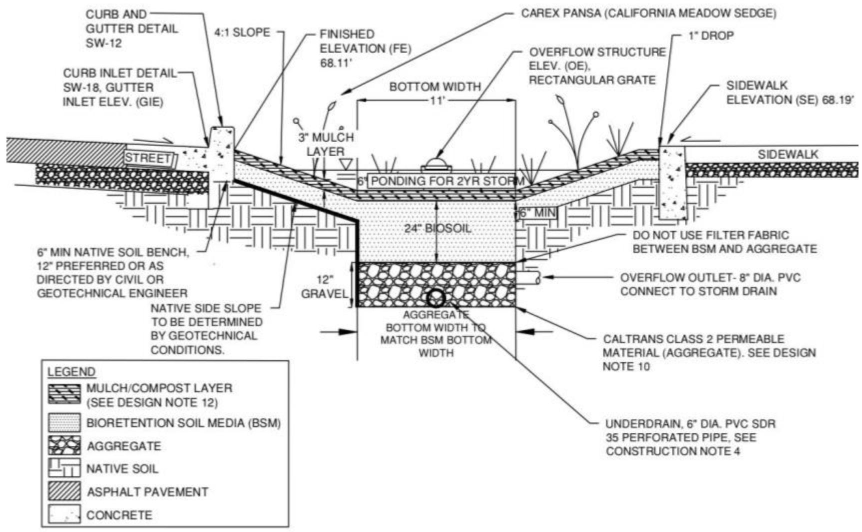

Figure 20. Cross-section of north bioretention (SCVURPPP Green Stormwater Infrastructure Handbook, 2019).

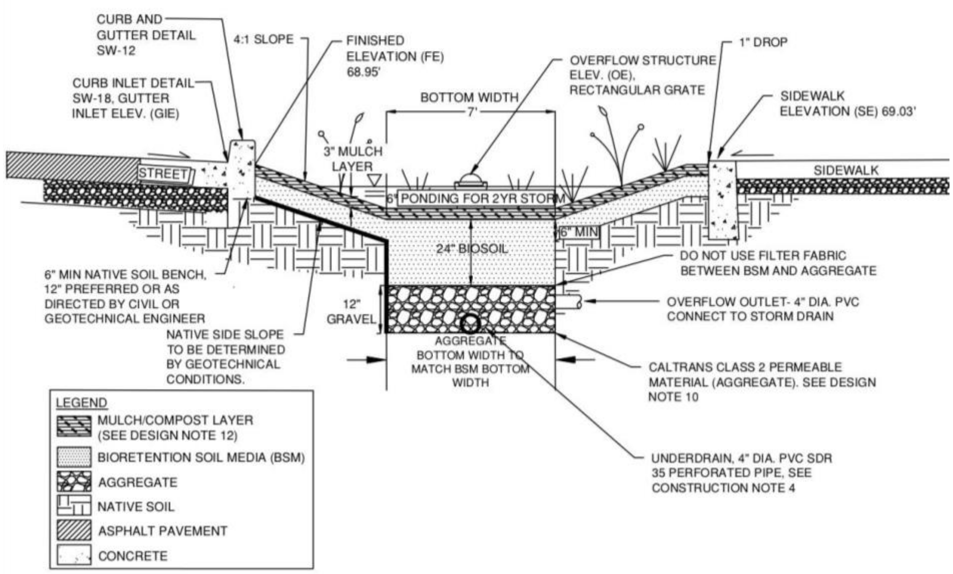

Figure 21. Cross-section of west bioretention (SCVURPPP Green Stormwater Infrastructure Handbook, 2019).

Using drawing BC 3.4 from Part 2 of the SCVURPPP Green Stormwater Infrastructure Handbook, the overflow structures for the bioretentions were designed. The details were adapted from the San Francisco Public Utilities Commission. See Figures 22 and 23 for the north and west bioretention overflow structure drawings.

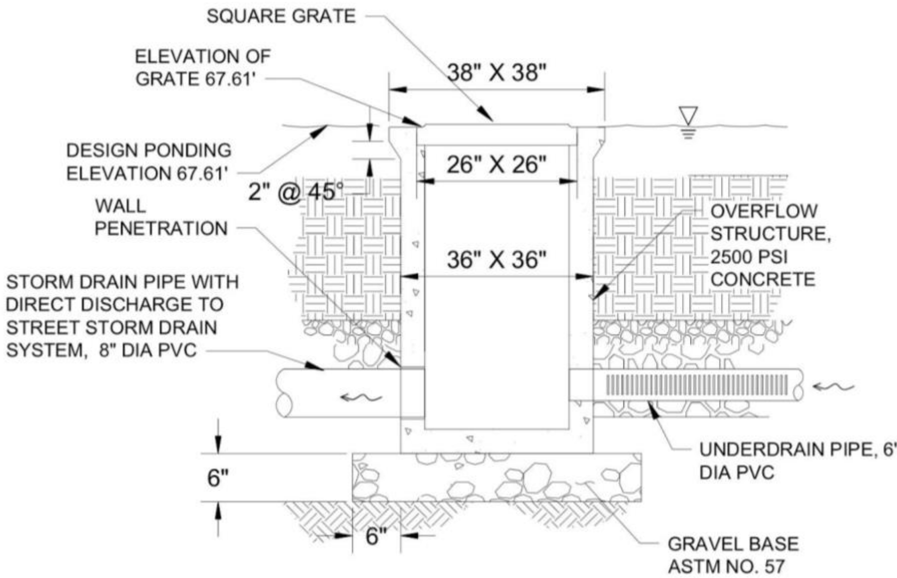

Figure 22. North overflow structure (SCVURPPP Green Stormwater Infrastructure Handbook, 2019).

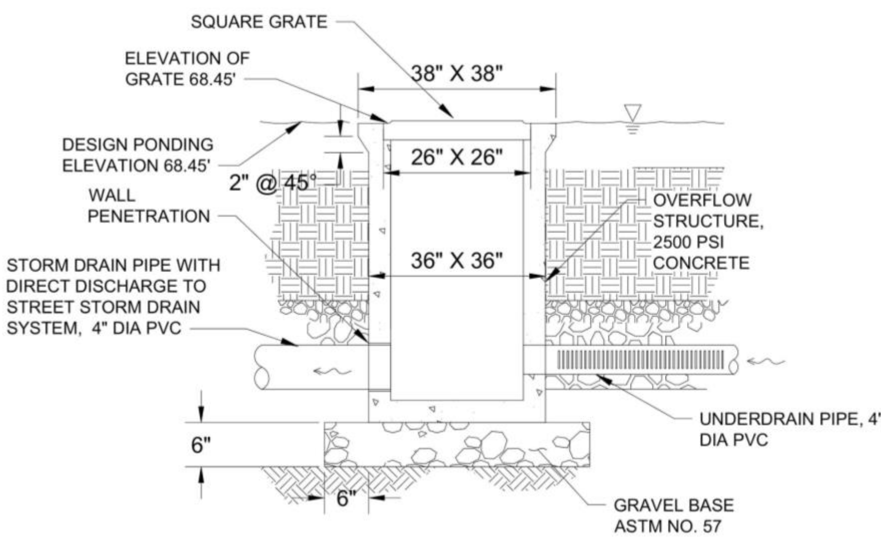

Figure 23. West overflow structure (SCVURPPP Green Stormwater Infrastructure Handbook, 2019).

Cost Estimate

Upon completing the bioretention cross-section and overflow structure drawings, a cost estimate was completed (RSMeans). Using the cross-section and overflow structure drawings (Figures 20-23), material estimates were found. See Tables 25 and 26 below for the material estimates.

Table 25. North bioretention material estimate.

North Bioretention		
	Quantity	
Biosoil	4338.35	cu. ft
1' Deep Gravel (in sq. ft)	1826.81	sq. ft
Gravel (in cu. ft)	1826.81	cu. ft
Mulch	799.07	cu. ft
3" Mulch	3196.28	sq. ft
Plants (24" apart, 12" from edges)	656	4" pots
Plants (4" pot = 0.125 gal)	82	gal
Waterproofing	4190.87	sq. ft
Overflow Structure (2500 psi Concrete)	24.05	cu. ft
Grate (26" x 26")	1	item
Outflow Pipe (8" PVC)	129.5	ft
Underdrain (6" PVC)	148.5	ft

Table 26. West bioretention material estimate.

West Bioretention		
	Quantity	
Biosoil	686.82	cu. ft
1' Deep Gravel (in sq. ft)	265.28	sq. ft
Gravel (in cu. ft)	265.28	cu. ft
Mulch	144.45	cu. ft
3" Mulch	577.8	sq. ft
Plants (24" apart, 12" from edges)	108	4" pots
Plants (4" pot = 0.125 gal)	13.5	gal
Waterproofing	148.1	sq. ft
Overflow Structure (2500 psi Concrete)	24.05	cu. ft
Grate (26" x 26")	1	item
Outflow Pipe (4" PVC)	40	ft
Underdrain (4" PVC)	50	ft

The material estimates were then imported into RSMeans to calculate the initial material estimate without the overflow structure concrete and grate, as those were added separately. The 2500 psi concrete quantities and grate cost estimates were added in separately using Excel, as the free version of RSMeans did not have the capability to do so. The material estimates for each overflow structure require 1.78 cubic yards of concrete and one 26” x 26” grate. The cost estimate for concrete for material and labor with overhead and profit is $445, and the cost estimate for the grate is $43.

The cost estimate from RSMeans was updated by adding the values from the overflow structures to the Material and Material + Labor costs. The 5% General Contractor Fee was added, along with the 15% Overhead & Profit and 1.219% City rates. The Total Cost including overhead and profit (O&P) is $91,645.59. Next, a 10-year maintenance fee was found using a 12% average market rate. Using an inflation rate of 7%, the yearly maintenance fees were calculated from Year 0 to Year 10. See Table 27, below, for a breakdown of annual maintenance fees.

Table 27. Yearly maintenance fees for both bioretentions.

	Yearly Maintenance Fee (7% Interest Rate)
Year 0	$946.27
Year 1	$1,012.51
Year 2	$1,083.39
Year 3	$1,159.22
Year 4	$1,240.37
Year 5	$1,327.19
Year 6	$1,420.10
Year 7	$1,519.50
Year 8	$1,625.87
Year 9	$1,739.68
Year 10	$1,861.46
TOTAL	$14,935.57

The maintenance fee total was added to the Total Cost including O&P to calculate the Total Cost including O&P and 10-Year Maintenance with inflation, equaling $106,581.15. See Table 28, below, for a more detailed final cost estimate breakdown for both bioretentions, and Figure 24 for a 10-year cash flow chart.

Table 28. Detailed cost estimate for both bioretentions.

	Material	Labor	Material + Labor	General Contractor Fee (5%)	Total Cost Including Overhead & Profit (15% + 1.219% City Rate)	Current 10-Year Maintenance Fee (12%)	10-Year Maintenance Fee with Inflation	Total Cost Including Overhead & Profit and 10-Year Maintenance
Cost	$57,897.11	$20,958.83	$78,855.94	$82,798.74	$91,645.59	$9,462.71	$14,935.57	$106,581.15

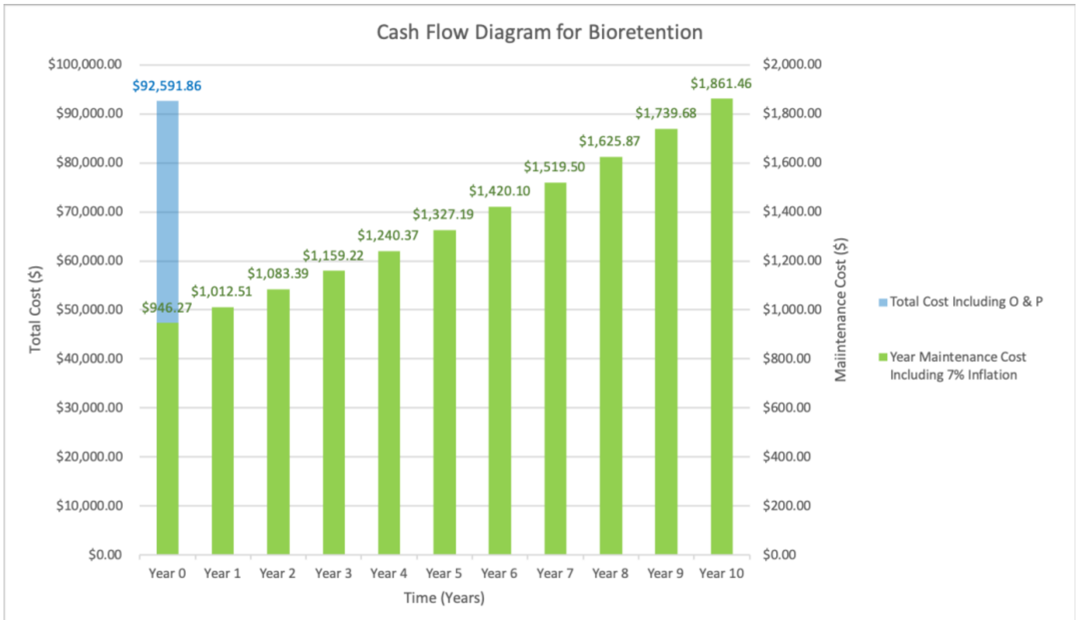

Figure 24. 10-year cash flow chart including initial construction cost and maintenance costs.

When comparing the cost of installing two bioretentions with another popular LID strategy of a green roof, the bioretention system is far more cost efficient. According to the Environmental Protections Agency, green roofs range from $10-$25/ft2 to install and $0.75-$1.50/ft2 to maintain. These rates were used to calculate a range of cost estimates if a green roof was chosen for the development over a bioretention. A 10-year span was used for maintenance, like the bioretention. See Table 29 for a preliminary green roof installation and maintenance cost estimate.

Table 29. Green roof cost estimate.

Green Roof Cost Estimate According to EPA		
Sq. Ft Roof	75945	ft2
Extensive Cost/Ft2	$10.00	
Extensive Maintenance Cost/Ft2	$0.75	
Intensive Cost/Ft2	$25.00	
Intensive Maintenance Cost/Ft2	$1.50	
Min Total Cost	$816,408.75	
Max Total Cost	$2,012,542.50	

As can be seen in Table 29, the minimum and maximum costs excluding contractor, profit, and city fees and inflation are $816,408.75 and $2,012,542.50, respectively. The minimum cost for a green roof is about eight times greater than the total cost for two bioretentions including contractor, profit, and city fees and inflation.

Stormwater Management Model & Construction

To begin creating the bioretention model, the SCVURPPP C.3 construction drawings for bioretentions were consulted to identify code minimums. To allow for groundwater infiltration, the code requires a minimum of 18” of biosoil and 12” of Class 2 Permeable Rock, with the underdrain running six inches (6”) minimum from the bottom. This combination of layer thicknesses was held as the control section of the model. The next section broke code with 16” of biosoil and 14” of gravel. The last section broke code with 20” of biosoil and 10” of gravel. The dimensions of 24” long x 36” wide x 36” tall were set for the bioretention model with 12” width for each section.

Next, geotechnical engineering and strength of materials were used to choose materials to construct with and check the capacity of the rolling cart the bioretention was to be resting on. The horizontal lateral earth pressure of the soil was calculated to be 4.35 psi, and the horizontal lateral earth pressure of the gravel was calculated to be 4.75 psi. One-half (½) inch thick plywood was found to be sufficient for the walls and the base of the bioretention, as the maximum flexural strength of the plywood is 350 psi. Three (3) mm thick acrylic was found to be sufficient for the clear sections of the bioretention, as the maximum flexural strength is 17,000 psi. The cart capacity is 3,600 lb, which is greater than the demanded 2,607 lbs calculated by adding material weights.

After confirming the materials to be used in the construction of the model, construction drawings were created to streamline the construction process, as well as to finalize details. See Appendix E-3 to E-8 for elevation, section, and plan views of the bioretention.

After securing materials, the team created section cuts into the 2” x 6” lumber using a Dado saw and cut the ½” plywood to match the construction drawings. The two inch (2”) bulkhead fittings were ordered on Amazon, and the flat-bed cart was ordered from McMaster-Carr. See Appendix E-4 for a more detailed list of materials purchased.

Construction began on February 11, 2020 and lasted for eight hours. Construction drawings were used as reference during construction. Biofiltration sod was picked up the same day from Payless Hardware, Rockery, and Nursery. See Figure 25 and 26 below for photos taken at the end of the day on February 11, 2020.

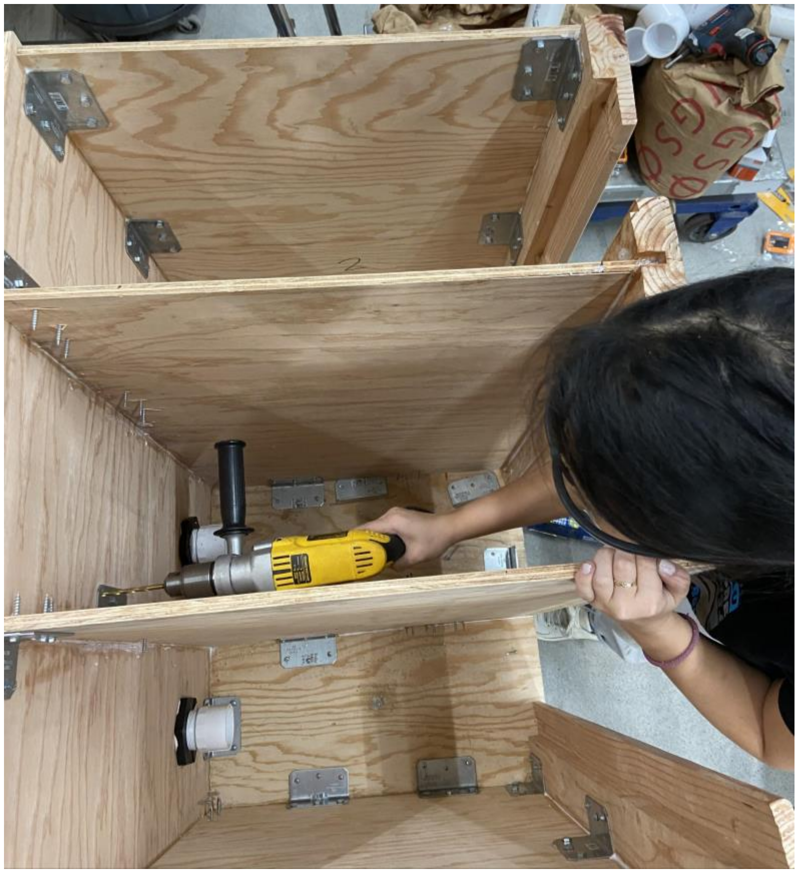
Figure 25. A mid-construction action shot.


Figure 26. A photo taken at the end of construction day one.

On February 13, 2020, the group returned to Alameda Hall, where the Civil Engineering lab is located, and spent another eight hours finishing the bioretention model. While filling up the model with soil, RADS realized they underestimated the amount of biosoil that was required, so the last section does not have the intended 20” of soil. See Figures 27 to 29 below for photos of the finished bioretention model.

Figure 27. Finished product! Pictured are Rachael and Deirdre.

Figure 28. Post-construction selfie with Brent, the team’s lab manager!

Figure 29. Bioretention model getting some sun in all its glory, post-first watering. Ain't she a beaut?

As seen in Figure 29, there were multiple leaks coming from the bottom of the bioretention. The next weeks were used to identify leaks and waterproof the bioretention using waterproof caulk. The last time the bioretention was able to be caulked was March 13, 2020, since the shelter-in-place took effect not long after. RADS believes, however, that the bioretention was effectively waterproofed as a result of the last caulking. See Figure 30 for the most recent photo of the bioretention taken on March 31, 2020 after receiving a couple weeks of sun and rain.

Figure 30. A well-watered and happy bioretention model.

Unfortunately, the next stage using the bioretention model of testing could not proceed due to the COVID-19 pandemic. The Hach lab kit, bentonite clay, sodium phosphate, and potassium nitrate were ordered to and located in the environmental lab in Alameda Hall prior to the shelter-in-place. The model was already built and the chemicals and pertaining test kits had been purchased, so the testing of the bioretention to identify percent reduction of contaminants due to different layer combinations could be continued as a senior design project for next year.

Construction Management Program

Throughout the design process, the construction team member worked to input and coordinate the structural, stormwater, and wastewater scopes as they would appear in construction. A considerable amount of time was spent becoming familiar with cost data resources found in 2019 RSmeans and 2020 Revit's Family Library, as the characteristics such as weight, length, and area proved integral for creating an accurate construction estimate. The goal of this focus was to ensure that all team members could succinctly visualize how their scopes fit into the building as well as identify and correct clashes before they appeared.

This project employed a Design-Build approach when it comes to the delivery of the completed project. Design-Build is a project delivery method that combines the design stakeholders with construction stakeholders under a single union. While this is a relatively new project delivery method, it has been proven to be particularly effective at decreasing the number of change orders, disputes, and implementation time that occur throughout the entire length of the project. Limiting the number of roadblocks throughout construction accelerates the overall schedule of the project and in this case, helps push the start of construction earlier with the help of purposeful design decisions. This Design-Build project will streamline communication between the contractor, design team, and the owner and will help reduce mis-communication. Figure 31 illustrates the completed model that represents the scope of this project.

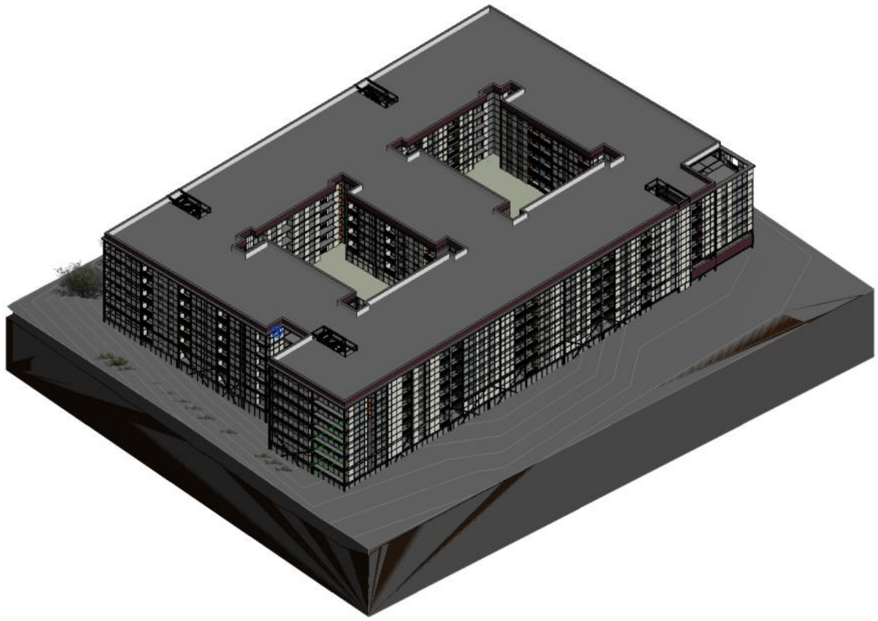

Figure 31. Revit 3D Model.

The construction management program is divided into three sections covering the BIM Model, the cost estimate, and the construction schedule.

BIM

Due to the limitations of the design team's knowledge as well as time restrictions for this senior design project, the construction cost estimate was broken down into three subcategories, each with different levels of detail. The first category, detailed unit cost, represents line items such as structural steel and walls that can be broken down into numerous labor, material, and finishing costs. A detailed estimate was performed for the items with the most definition of work scope and the highest level of design details. The second category, assemblies, represents common work items that typically have multiple trades associated with each. Work such as typical elevated concrete slabs can be estimated using national and local averages based on the total area covered. The final estimation technique utilizes a building function as well as overall square footage to determine the cost of other amenities. This type of estimate was used for items that are beyond the expertise of the project team, such as Mechanical, Electrical and Plumbing (MEP) systems, exterior glazing, and facades.

The design team heavily utilized the Revit Modeling system, as the framework of this project relies on the ability to synergize concept and form. As a result, the BIM Model was created concurrently with the structural design drawings, and any updates to the structural aspect of the project were always reflected in the model. This practice allowed each team member to visualize the project as a whole and prevent clashes of different scopes before they potentially occured. This BIM model has been modeled to Level of Detail (LOD) 200 which mirrors a schematic design typically associated with construction (BIM Level of Development).

This Campbell project is a mixed-use apartment complex with two levels of above-ground parking, six stories of residential, and a commercial space located on the ground floor. The construction and structural design teams first input the steel and concrete based on a design submitted by Studio TSquare, as the team determined that the preliminary drawings from Studio TSquare would be the basis of this project layout.

Changes to TSquare's initial placement of concrete and steel were made in order to cut cost as well as ease the complexities of construction. These changes included the sizing of walls, then placement of beams, and the layout of rooms and open areas. The goal of these changes was aimed at optimizing living space and fixing potential clashes with structural column placements within occupied spaces. Within the concrete parking garage, the placement of the concrete columns were laid out in AutoCAD to ensure that the columns would not get in the way of any of the parking stalls or the two-way road for vehicles that were a minimum of 24 feet long and the width of the parking stalls were still at least 8'-6" wide based on code guidelines. After consultation with the group's structural and construction advisors, the team ultimately decided to modify the layout of the Level 1 parking garage/mixed-use commercial space. The team believes in order to simplify the structural calculations as well as expedite the construction mobilizations, the footprint of the commercial space and parking garage located on Level 2 would be modified to mirror the residential space and parking garage on Level 2. This change proved beneficial in not only reducing the cost of construction but also allowed for the introduction of less complex structural connections between Level 1 and 2. The initial and final design changes for Level 1 and 2 have been illustrated in Figures 32 and 33, respectively.

Figure 32. Initial Level 1 Parking Garage Layout from Studio TSquare.

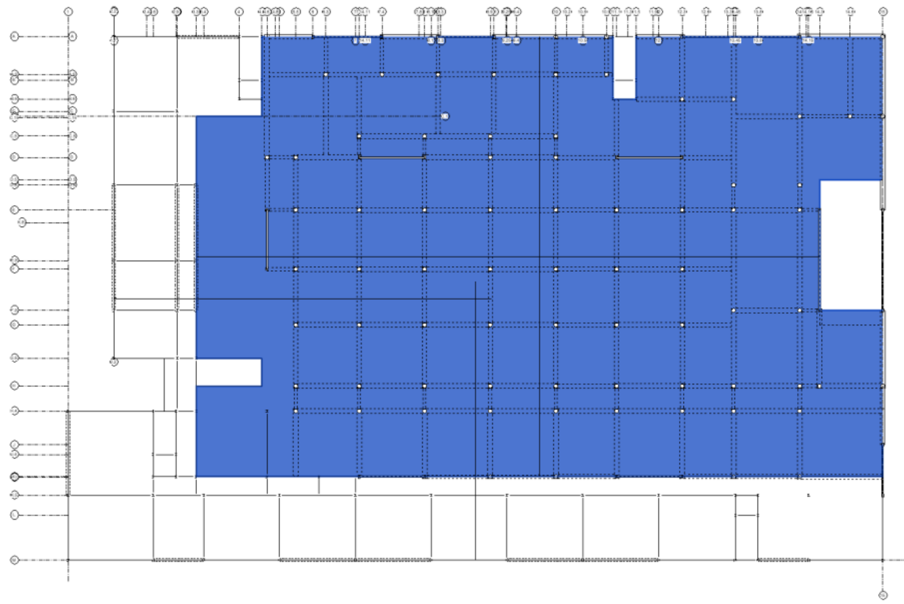

Figure 33. Final Level 1 Parking Garage Layout from Studio TSquare (Parking garage highlighted in blue).

Floors 3 through 7 make up the majority of the residential units within this project. Floor 4 includes a modified open area clubhouse accessible by all residents.

Cost Estimate

The second scope of this project covered the project estimate. The design team used quantity takeoff and material takeoff estimation to generate accurate costs. The use of Revit was instrumental in completing quantity takeoffs directly from the 3D model. In accordance with Design-Build practices, materials presented in the model offer a significant amount of value engineering, as throughout this project the design team was able to quickly compare scope items within the program without tedious modeling.

Each item has been categorized according to the MasterFormat construction division developed by CSI (MasterFormat). As mentioned above, three types of cost estimation techniques were used to categorize the cost associated with this project. Items contained within the superstructure including concrete foundations, concrete columns, concrete walls, and steel framing were estimated by a detailed unit cost. These items were detailed with this method, as they not only make up the core of this project and therefore should be appropriately estimated, but as they are structural elements, they are unlikely to be modified in a significant way after the initial structural design. Assembly cost estimation accounted for items within this development that typically make up an entire system. Items such as staircases and building excavation were modeled as assembly costs, as the practices involved with these activities are usually standardized. Items that were either modeled without a great level of detail or out of scope for this project, like the MEP systems in place, were estimated using general square footage measurements. These items were likely to change as the LOD increased as the project moved from schematic to detailed design.

In order to assist with the preparation of the cost, material properties such as volume, weight, length, and area were taken directly from the BIM model. Material schedules were created in Autodesk Revit for the purpose of organizing this information. An example of a material schedule for the Level 2 structural columns is listed in Figure 34.

<Structural Column Schedule Level 2>

A	B	C	D	E
Type	Base Level	Length	Volume	Weight
Level 2				
W12X45				
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45	Level 2	12' - 0"	0.04 CY	
W12X45: 22		264' - 0"	0.88 CY	
W12X65				
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65	Level 2	12' - 0"	0.06 CY	
W12X65: 9		108' - 0"	0.52 CY	
W12X106				
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106	Level 2	12' - 0"	0.10 CY	
W12X106: 12		144' - 0"	1.14 CY	
W18X76				
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76	Level 2	12' - 0"	0.07 CY	
W18X76: 9		108' - 0"	0.61 CY	
W18X97				
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97	Level 2	12' - 0"	0.09 CY	
W18X97: 13		156' - 0"	1.14 CY	
Level 2: 65		780' - 0"	4.29 CY	

Figure 34. Level 2 Structural Columns Schedule.

The design team was able to take the item properties listed in the created schedules and locate exact or similar items within Gordian's *Building Construction Cost with RSMeans Data* (Mewis, Robert W., and R.S. Means Company). Careful effort was invested in locating the exact or similar material within RSMeans. Items in Division 5, which covers Metals, contains numerous items that were estimated with a detailed unit cost. For example, looking at the W12X45 Steel Sections located on Level 2 Column Schedule, the total amount of steel is 264 linear ft. From RSMeans, a W12X45 is not directly listed as a categorized item. It can be assumed, however, that a W12X50, which is listed in Section 05-12-23.75-1560, will have similar costs associated with a W12X45. Within the RSMeans section, crew type, daily output, bare cost, and total cost are included with options to modify each parameter based on location using a city index multiplier (in the case of the project site location, this city index multiplier is 1.219). A list of the RSMeans data for Level 2 Structural Columns has been tabulated in Figure 35.

Level 2 Columns													0
W12x45	No	24	LF	05-12-23.75-1560	2019	132	E-2	750	LF		78.91	89	2136
W12X65	No	108	LF	05-12-23.75-1580	2019	132	E-2	750	LF		90.91	102	11016
12X106	No	144	LF	05-12-23.75-1740	2019	132	E-2	640	LF		133.51	150	21600
W18X76	No	108	LF	05-12-23.75-3940	2019	132	E-2	900	LF		116.96	132	14256
W18X97	No	156	LF	05-12-23.75-3960	2019	132	E-2	900	LF		131.96	148	23088

Figure 35. Level 2 Structural Columns.

Similar tables have been created for the three different types of estimates. A full cost breakdown listed in Appendix F.

The CSI Masterformat includes over 30 different construction divisions covering facility construction, facility services, site and infrastructure, and process equipment. For the SCU affordable housing development, certain divisions such as Masonry, Wood, Plastics & Composites, Specialities, Special Construction, and all divisions in the Process Equipment Subgroup will not be populated with cost information. This decision was made due to the limited level of design provided by the architect Studio TSquare, which this estimate uses as a basis of design. Major Divisions such as Division 23, 9, 5, and 12 contain the majority of the expensive scope items as expected.

The total cost of this project rests at $96,293,903.60 with major costs associated with Division 23, 9, 5 and 26. A design fee of 10% was added to account for initial modeling and LOD of BIM models. The overhead and profit sat at a modest 10% and 5%, respectively, with any savings split between the owner with 70% going to the owner and 30% returning to the design team.

Table 30. Project Cost Estimate.

Division	Scope	Amount	City Index	Adjusted Amount
1	General Requirements	$19,205,605.77	1	$19,205,605.77
2	Existing Conditions	$92,750.00	1.219	$113,062.25
3	Concrete	$3,977,645.71	1.219	$5,044,639.62
5	Metals	$8,102,951.86	1.219	$9,877,498.32
7	Thermal & Moisture Protection	$16,054.19	1.219	$19,570.06
8	Openings	$5,195,182.63	1.219	$6,332,927.62
9	Finishes	$9,644,781.95	1.219	$11,756,989.20
11	Equipment	$863,209.88	1.219	$1,052,252.84
12	Furnishings	$6,656,940.54	1.219	$8,114,810.52
14	Conveying Equipment	$1,266,000.00	1.219	$1,543,254.00
21	Fire Suppression	$2,770,463.40	1.219	$3,377,194.88
22	Plumbing	$3,862,469.92	1.219	$4,708,350.84
23	Heating, Ventilation, and Air Conditioning	$12,560,056.68	1.219	$15,310,709.09
26	Electrical	$5,550,701.08	1.219	$6,766,304.61
27	Communications	$925,988.78	1.219	$1,128,780.32
31	Earthwork	$404,215.55	1.219	$492,738.76
32	Exterior Improvements	$1,095,145.59	1.219	$1,334,982.47
33	Utilities	$93,709.96	1.219	$114,232.44
	TOTAL Project Value			**$96,293,903.60**

Schedule

The final section concerning project management involved the project schedule. Microsoft Project's scheduling tools were used to plan the project from the beginning to completion. Microsoft Project task links were used to formulate the logical path of construction. Each task is tied to other construction activities that precede and succeed the tasks. Each task is also broken up by level with Level 2 tasks succeeding Level 1 tasks, as is expected. In general, this schedule followed a clear sequencing; crews would start completing site work activities, followed by foundation work. After the foundation, the superstructure along with an MEP equipment would be installed. Finally the project finishes after the exterior and interior finishes are installed. For the sake of productivity, certain tasks like exterior and interior walls were scheduled in a way that allowed for the construction of both tasks simultaneously, albeit on different levels. This allowed for a more dynamic distribution of labor and resources while also allowing multiple tasks to complete sooner. Examples of this schedule structure have been illustrated in Figure 36.

106	**Exterior Walls**	**87 days**	**Mon 12/13/2**	**Tue 4/12/22**		
107	Level 1	3 days	Mon 12/13/2	Wed 12/15/2	98	108,165
108	Level 2	3 days	Mon 12/27/21	Wed 12/29/21	107,99	109
109	Level 3	5 days	Thu 1/20/22	Wed 1/26/22	108,100	110
110	Level 4	6 days	Mon 2/7/22	Mon 2/14/22	109,101	111
111	Level 5	6 days	Thu 2/24/22	Thu 3/3/22	110,102	112
112	Level 6	6 days	Mon 3/14/22	Mon 3/21/22	111,103	113
113	Level 7	6 days	Thu 3/31/22	Thu 4/7/22	112,104	114
114	Roof	2 days	Mon 4/11/22	Tue 4/12/22	113,105	157,158

Figure 36. Exterior Walls Schedule Task and Gantt Chart.

Task durations were calculated based on data found in RSMeans with regards to daily output. While RSMeans specified crew size and equipment, certain durations were optimized to make sure that crew sizes reflected the productivity that is expected of a fully staffed construction crew.

In total, the project spans 426 days. The expected project start is April 5, 2021 and the expected project end is November 29, 2022. The main project categories have been collected with the total of days for each summary task illustrated in Figure 37.

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Success
1		1200 Campbell	426 days	Mon 4/5/21	Mon 11/28/2		
2		Preconstruction Activity	63 days	Mon 4/5/21	Thu 7/1/21		
7		Site Utlities	20 days	Fri 7/2/21	Thu 7/29/21		12
11		Site Work	306 days	Fri 7/30/21	Thu 10/6/22		
18		Foundation	45 days	Tue 8/31/21	Wed 11/3/2		
32		Shell	383 days	Fri 6/4/21	Mon 11/28/2		
33		Level 1	23 days	Thu 11/4/21	Wed 12/8/2		
34		Concrete Garage	23 days	Thu 11/4/21	Wed 12/8/2		
35		Concrete Columns	20 days	Thu 11/4/21	Fri 12/3/21		
41		Concrete Shear Walls	23 days	Thu 11/4/21	Wed 12/8/2		
47		Open Space Mixed Use	19 days	Mon 11/29/2	Thu 12/23/2		
55		Level 2	45 days	Thu 12/9/21	Wed 2/9/22		
56		Concrete Garage	45 days	Thu 12/9/21	Wed 2/9/22		
57		Concrete Deck	19 days	Thu 12/9/21	Tue 1/4/22		
62		Concrete Columns	23 days	Wed 1/5/22	Fri 2/4/22	61	
68		Concrete Shear Walls	26 days	Wed 1/5/22	Wed 2/9/22	61	
74		Residential	383 days	Fri 6/4/21	Mon 11/28/2		
75		Steel Erect	77 days	Thu 11/4/21	Tue 2/22/22		
91		Stairs	50 days	Mon 11/15/2	Mon 1/24/22		
97		MEP Rough In	90 days	Mon 12/6/21	Fri 4/8/22		
106		Exterior Walls	87 days	Mon 12/13/2	Tue 4/12/22		
115		Electrical Branch In	49 days	Mon 12/13/2	Thu 2/17/22		
124		Concrete over Metal Deck	88 days	Fri 11/12/21	Wed 3/16/2		
153		Elevators	204 days	Fri 6/4/21	Tue 3/22/22		
156		Interior Partitions - Opening Frames	58 days	Wed 4/13/22	Fri 7/1/22		
173		Electrical Branch In	66 days	Wed 5/4/22	Wed 8/3/22	165	
182		MEP Finishes	58 days	Tue 5/10/22	Thu 7/28/22		
191		Interior Finishes	83 days	Thu 8/4/22	Mon 11/28/2		
192		Interior Flooring - Carpeting and Tiling	32 days	Thu 8/4/22	Fri 9/16/22		
200		Interior Paint - First Coat	35 days	Mon 8/8/22	Fri 9/23/22		
208		Façade Finishes	21 days	Mon 8/15/22	Mon 9/12/22	201	17
209		MEP Commissioning	14 days	Mon 9/26/22	Thu 10/13/2	207	210
210		Punchlist Items	32 days	Fri 10/14/22	Mon 11/28/2	209,16	

Figure 37. Project Schedule Overview.

Synchro Pro

Synchro Pro is a powerful virtual construction software that combined the BIM model with the project schedule and offered real time phasing of construction activities and durations. This presented an essential piece of value engineering, as stakeholders in this project will be able to plan ahead for the variety of scenarios before and during construction. For this development, the project schedule and the BIM model were used concurrently to create an interactive schedule based model in Synchro. Elements like structural steel members, interior walls, and windows were selected by level in Synchro and tied to their respective schedule tasks. Synchro then took that information, which included the task duration (presented in days), and constructed an animation of the item being installed or removed relative to the total time of the project.

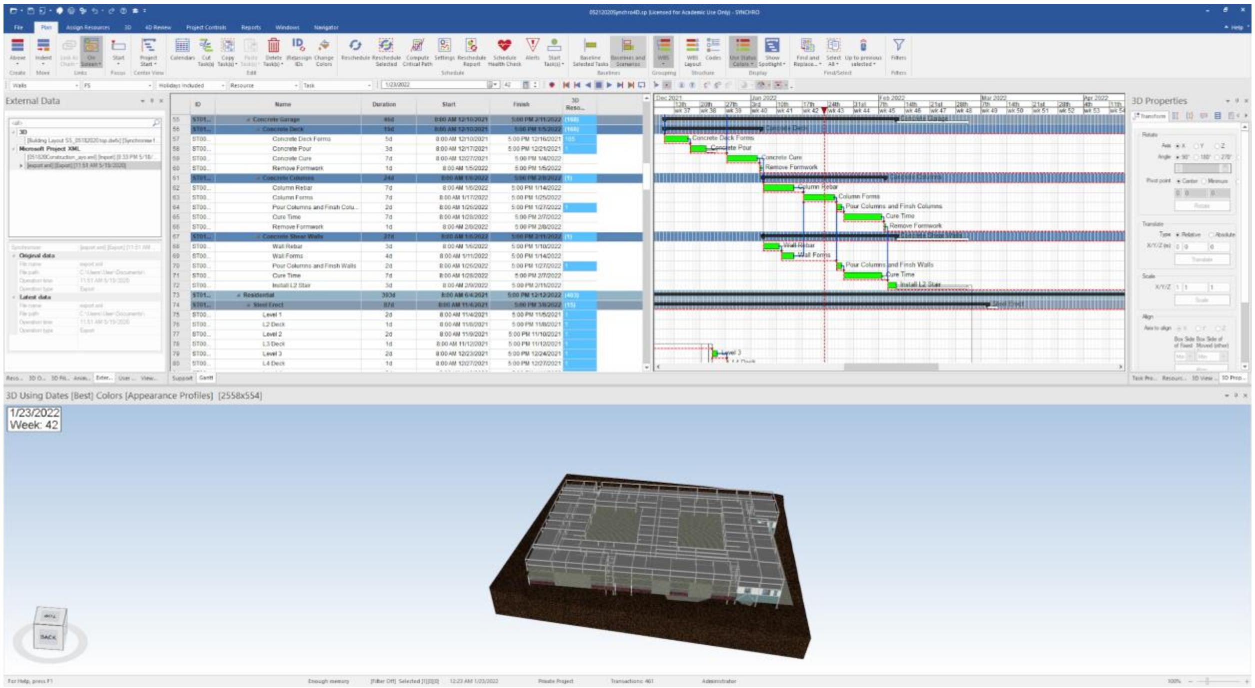

Figure 38. Synchro Pro Interface.

Each of the over 41000 elements modeled in Revit were assigned to schedule tasks in Synchro Pro. To simplify the assigned 3D elements, items were assigned to resources groups by level to mirror efforts made in the schedule.

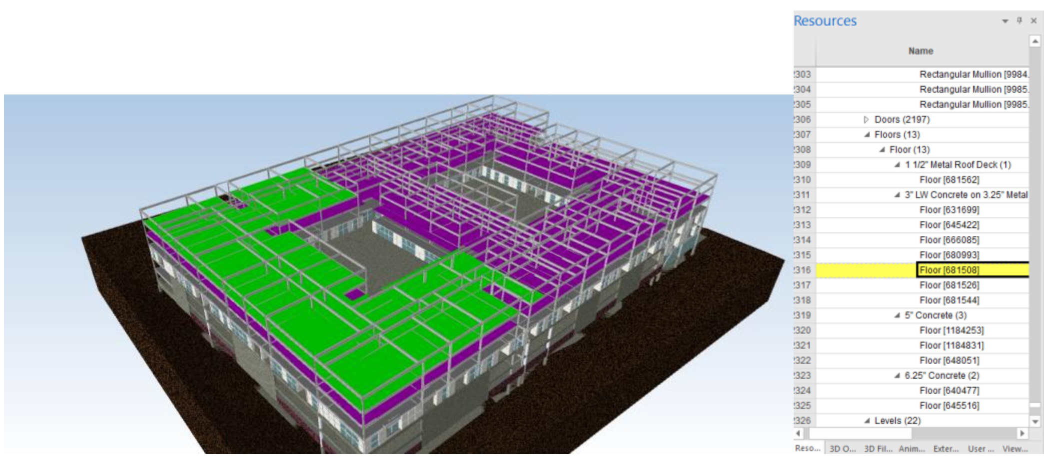

Figure 39. Synchro Resource Animation Creation.

Synchro Pro allowed the design team to create a full construction animation time lapse, that illustrated the flow of the project as construction progressed. Having this 4D modeling software was essential for scope collaboration as well as resource planning.

Conclusion

By conducting this project, RADS Construction was able to work closely with Santa Clara University and understand the importance of providing a housing development that is affordable to their Faculty and Staff, while improving the quality of the site. To effectively improve the quality of the site's stormwater runoff, two bioretentions were proposed; one placed on the west side of the property, and one placed on the north. Both bioretentions were designed in accordance with the SCVURPPP C.3 Handbook. Additionally, bioretentions are used throughout the rest of Santa Clara University's campus, and uniformity is very important to SCU as can be seen through the Spanish style buildings. For cost, locale, environmental, and aesthetic reasons, RADS Construction believes that this stormwater management proposal is the best LID strategy for this project.

The design drawings and supporting calculations that RADS Construction created can be used to compare to the design of the actual project that is still in the process of being developed. The team based the majority of the designs on the Planned Development Zoning Submittal that was provided by the City of San Jose, which also contained preliminary architectural drawings from Studio TSquare. Even though RADS Construction decided to design the structure out of concrete and steel, and the actual development was going to be designed using concrete and timber, it will be interesting to compare the different designs. All of the designs were established to meet the minimum requirements as presented in the 2019 California Building Code, ASCE/SEI 7-16, Santa Clara Valley *Urban Runoff* Pollution Prevention Program's (SCVURPPP) C.3 Stormwater Handbook, and other reference manuals.

The team also developed their own criteria, while adhering to Santa Clara University's design criteria and feedback from stakeholders who are in the proximity of the project site. One aspect of the architectural design that the team decided to incorporate in the design of the building was a commercial space instead of an incubator space. A commercial space will allow not only residents and people affiliated with Santa Clara University to use this aspect of the new development, but also nearby residents and businesses. This will ultimately help to decrease the concerns of nearby stakeholders for adding this size of a development in the neighborhood and will benefit everyone in some way.

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Appendices

Appendix A:

Alternative Analyses Justification & Matrices

Material Analysis

For the criteria concerning low cost, the life cycle analysis of each material was considered for the entirety of the project. The initial cost of the material was weighed at 9 out of 10 and it was higher than cost accrued over the lifecycle for this analysis because the initial cost will be used in the bulk of the estimate. Materials with a higher score have the least economic impact on the project. Below are the explanations of the criteria scoring:

1: High cost with price fluctuations based on market demand
2: Moderate cost with some consistent with market demand
3: Moderate cost with high life cycle cost analysis consideration
4: Low cost with life moderate cycle analysis cost consideration
5: Low cost with a net zero life cycle analysis cost consideration

Sustainability is a priority as it fulfills Santa Clara University's mission for sustainability. For RADS Construction, the materials sustainability factor is dependent on the potential negative impacts surrounding the material's use. While the ultimate goal is to have materials have little to no negative impact throughout the production, use, and demolition of the materials, RADS Construction recognizes that this may not be feasible. However, materials that do a considerable job in mitigating their negative environmental impacts receive a higher score for this project. Sustainability was weighed 8 out of 10 due to the goal of reaching LEED Gold. Analyzing how these different materials affect the environment was a very important factor in determining the score of each alternative. Below are the explanations of the criteria scoring:

1: Construction material contributes a negative effect to the environment with no positive benefits
2: Construction material contributes to negative effects felt by the environment with some added consideration for reducing that effect
3: Construction material contributes negatively in production but has benefits throughout its lifecycle
4: Construction material contributes minimally to negative environmental impacts in production and can positively impact the environment over time
5: Construction material has a net positive impact in production and use.

RADS Construction hopes to present a well rounded design of this proposed project that represents the expansive experience of its team. That being said, with the limited time that RADS Construction possesses, existing knowledge about materials and their properties associated with their production, cost, and construction implementation will be favored over materials that RADS Construction needs to perform more research on. While members in RADS Construction have taken steel and concrete analysis and design courses at Santa Clara University, no members have taken any Timber courses. The ability to fully deliver a comprehensive design hinges on the team's ability to communicate within their civil engineering knowledge so consequently, the rating reflects the material expertise of the team.

Below are the explanations of the criteria scoring:

1: Designer has no knowledge with this material at all
2: Designer has minimal knowledge on certain material
3: Designer has adequate knowledge on material production and acquisition

4: Designer has proficient knowledge with material production, acquisition, and design
5: Designer is very proficient knowledge with this material in all aspects

Aesthetics of the development is important. From an initial design charrette, keeping the design similar to other infrastructure that is owned by Santa Clara University, while also blending into the residential community is important to residents and neighbors. The aesthetics of the building will pertain to the exterior and interior to ensure that the building does not stand out with the rest of the infrastructure nearby. The criteria for the aesthetics of the building was weighed a 3 out of 10 compared to the other criteria due to the functionality of the overall building is more important than the aesthetic design and it does not have to be very fancy. The building mainly needs to blend in with the rest of the residential buildings in the proximity. Below are the explanations of the criteria scoring:

1: The design has no similarities to the existing designs and noticeably stands out
2: Some similarities to existing structures
3: Considers the aesthetics of existing structures with few inconsistencies
4: Blends into current landscapes, minor inconsistencies
5: Seamlessly mirrors existing design language, no inconsistencies

Scheduling impacts is important, especially due to the limited access and exit from this project site. Materials like steel generally can be constructed quickly, while materials like concrete are dependent on curing time or utilizing mixes with higher than required strength, albeit at a higher cost. Wood's schedule impacts are dependent on the availability of material as well as the complexity of the finished structure. Advancement in cross laminated timber have greatly accelerated the installation of structural elements and have made wood building construction greater than 85 ft possible (Kilkelly, 2018). The expected building height of the structure will be 95 feet. This criteria was weighed a 5 out of 10 due to the potential negative ramifications that could arise based on the material used in the building. It can add extra time to the proposed schedule, therefore increasing the cost of the entire project. Below are the explanations of the criteria scoring:

1: Adds a degree of instability to the project schedule due to variety of considerations (delivery, constructionability, material shortage)
2: Has the ability to complicates the scopes of other trades
3: Moderate impacts that could change the pace of construction
4: Minor impacts that can be accounted for in a well organized schedule
5: No schedule and has the potential to improve schedule estimates

Seismic resistance is an important criteria to consider when choosing a material to construct a building with. California is unique in that its building code strictly requires consideration for earthquakes as past events have shown that seismic events pose an extreme risk to the safety of the public. This criteria was weighed 6 out of 10 as with this being a residential housing unit, the ability of a proposed material to mitigate risk in an earthquake is important. During the design phase of this project, the minimum design code requirements will be used as a reference to improve the overall structural system of the building in case of natural disaster occurs. While each material has numerous seismic tests, RADS Construction has more knowledge about the performance of steel and reinforced concrete in the event of an earthquake. The weight of the material can add to the seismic force felt by the overall building and of the three materials proposed, timber is the lightest with concrete and steel being some of the heaviest materials. However, the weight of the material is just as important as the material properties that it exhibits during a seismic event; elasticity and plasticity are important properties to consider in a high magnitude earthquake as having high levels of both will give occupants more time to evacuate the building. While steel and timber both exhibit seismic responses that allow for elastic and plastic deformation during an earthquake, concrete deformation is usually permanent. Below are the explanations of the criteria scoring:

1: No seismic resistance for seismic resistance
2: Low degrees of seismic resistance
3: Moderate degrees of seismic resistance
4: Integral degrees of seismic resistance during a seismic event
5: High degrees of seismic resistance during and after a seismic event

Stormwater Management Analysis

Groundwater infiltration capacity was chosen because it is important for this project to recharge the groundwater aquifers in the area. Considering the project is located in Santa Clara County where 40% of the water is sourced locally from groundwater or reservoirs, it is especially important to consider a design that replenishes groundwater supply in the area (Santa Clara Valley Water). A weight of 6 out of 10 was given to this criteria to take into account the benefits that come with groundwater infiltration. Porous pavements and a bioretention system both scored a 5 because they both can be designed to allow for groundwater infiltration through perforated pipes. Green roof and rainwater catchment both scored a 1 because they both retain the collected stormwater to either be released in evapotranspiration or for use onsite. Flow through planters scored a 1 because the structure is enclosed and carries water out through a pipe to the storm drain. Do nothing also scored a 1 because all the water goes directly into the storm drain. Below are the explanations of the criteria scoring:

1: Alternative does not allow for any groundwater infiltration
2: Minimal to no groundwater infiltration
3: Some groundwater infiltration
4: A good amount of groundwater infiltration
5: High levels of groundwater infiltration

The effectiveness of runoff treatment measures the alternative designs' ability to provide a form of water treatment for the urban runoff. In San Jose, stormwater runoff typically goes into the storm water drain system which goes into creeks and then into the San Francisco Bay. Since this water will eventually flow into active bodies of water without treatment along the way, it is important to treat the water as much as possible before it enters the storm drain system to prevent pollution. Therefore, this criteria was rated 10 out of 10 because environmental sustainability and improving the water quality of urban runoff is a priority. The bioretention and flow through planters both received a score of 5 because the stormwater is highly treated as it goes through the biotreatment system that filters and removes pollutants from the water through a physical, biological, and chemical process (Santa Clara Valley Urban Runoff Pollution Prevention Program, 2016). The green roof received a score of 4 because the water receives substantial treatment, but not as much as the bioretention or flow through planters. The porous pavement received a score of 3 because only some runoff treatment occurs. The rainwater catchment and do nothing received a score of 1 because neither of the systems treat the water. Below are the explanations of the criteria scoring:

1: No water treatment occurs
2: Minimal amounts of runoff treatment occurs
3: Some runoff treatment occurs
4: Substantial amount of runoff treatment occurs
5: High levels of runoff treatment occurs

The aesthetics criteria seeks to address the needs of the faculty and staff of Santa Clara University, as well as the neighboring residents. A development that contains aesthetically pleasing features is important for those who will be inhibiting the building. Additionally, the development should benefit the overall neighborhood to satisfy the rest of the community. It is important to provide a quality product for the residents and surrounding community, however, it is not the most important criteria so it was given a weight of 5 out of 10. The green roof and the flow through planters scored a 5 because they add unique, highly aesthetically pleasing features to the project site. The bioretention received a score of 4 because it can provide a good amount of nature and native plants to the project site. Porous pavement received a score of 2.5 because depending on the types of pavement selected it has the potential to provide some aesthetic features. The rainwater catchment and do nothing received a score of 2 because they add very little aesthetic benefits to the site. Below are the explanations of the criteria scoring:

1: Provides no aesthetic benefits
2: Provides minimal aesthetics, but not highly special or noticable
3: Provides some aesthetically pleasing features
4: Provides a substantial amounts of aesthetic features
5: Provides highly aesthetically pleasing features

The impact that the stormwater management design has on the structural design of the development is evaluated because it is important to limit the influence the structural design and stormwater management designs have on each other. Situations that will impact the structural design or integrity such as additional loads to the structure or water infiltration into the foundation want to be avoided. Impacts on the structural design can cause both a hassle and an increase in cost of the structural frame. Because keeping the cost of the development low is crucial to the project, the impact of the stormwater management design on the structural design was given a higher weight of 8 out of 10. Porous pavement, flow through planters, and do nothing both scored a 5. Porous pavement does not impact the structural design since underdrains can divert the water away from the structure. The flow through planters do not impact the structural design since they do not add any additional loads, and they can be placed right up against a structure as long as there is a waterproof barrier in between the two (Santa Clara Valley Urban Runoff Pollution Prevention Program, 2016). Doing nothing does not have any impact on the structural design since there is nothing additional placed on the site. Bioretention received a score of 4 because there is a mandatory setback of 10’ if no waterproofing is present, and infiltration from the system can potentially impact the foundation. Rainwater catchment scored a 3 because depending on the design of the system, there is potential for the system to impact the structural loads. Green roof scored a 1 because the roof system will add additional loads to the structure and impact the structural design. Below are the explanations of the criteria scoring:

1: Alternative has a major impact on the structural design
2: Alternative has a substantial impact on the structural design
3: Alternative has some impact on the structural design
4: Alternative has minor impact on structural design
5: Alternative has no impact on structural design

The space usage criteria aims to ensure that the stormwater management design is making the best use of space on the project site. The design has to be reasonable to be used in a high density development in an urban area. The development is a large 7-story building on a lot size of about 3 acres. After including the fire lane access, setbacks, and recreation areas for the residents on the site, the amount of space leftover is limited. The stormwater management design must be able to work with the space criteria, which is why it was ranked higher with a weight of 7 out of 10. The porous pavement, flow through planters, and do nothing all scored a 5. The porous pavement can be used to replace impervious areas that will already be on the site, so there is no additional space needed. Likewise, the flow through planters take up minimal space since they can be placed directly up against the structure itself as long as there is a waterproof barrier in between the planter and the structure. Do nothing does not require any space since there is nothing being added. Bioretention scored a 3 because while it provides benefits to the site, without waterproofing it requires a setback that increases the minimum size. Rainwater catchment scored a 2 because for the San Jose area, a large storage tank would be needed, making inefficient use of space. Below are the explanations of the criteria scoring:

1: Alternative completely wastes space
2: Alternative does not use space efficiently and takes up unnecessary amount of space
3: Alternative takes up additional space, but provides benefits
4: Alternative makes positive use of space, but not the most efficient
5: Alternative makes the most efficient use of space and does not require addition space

Storm drain runoff reduction concerns the stormwater management design's ability to reduce the amount of runoff that is sent to the storm drain system. The water sent through the storm drain will eventually end up in the San Francisco Bay. Even if the water is filtered, there can still be complications with sending runoff water into the Bay. By limiting the amount of water sent to the Bay, the potential for environmental impact is reduced. Additionally, lowering the amount of storm drain runoff can save the project money by reducing both the quantity of runoff and the size of the lateral pipe that may need to be installed to connect to the main storm drain system. This criteria was given a weight of 7 out of 10. Bioretention and rainwater catchment scored a 4 for this criteria. The bioretention intakes the urban runoff and puts it through a biotreatment process, where a significant portion of that runoff will seep into the soil for groundwater recharge, and only some of the runoff will go to the storm drain. The rainwater catchment system catches most of the rainwater onsite and stores it for reuse rather than sending it to the storm drain. Porous pavement scored a 3.5 because the design can allow for some groundwater infiltration, but there is still water sent to the storm drain. The green roof scored a 3 because it retains the stormwater it catches on the roof, but cannot retain all stormwater on the project site. Flow through planters and do nothing both scored a 1. Flow through planters do not allow for infiltration, so all of the treated water gets sent to the storm drain. Do nothing collects the untreated runoff into the storm drain system. Below are the explanations of the criteria scoring:

1: Alternative provides no runoff reduction
2: Alternative provides minimal runoff reduction
3: Alternative provides some runoff reduction
4: Alternative provides significant runoff reduction
5: Alternative does not send any runoff into the storm drain system

The most important criteria for the end user and therefore the design is cost, which is why cost has a weight of 10 out of 10. Faculty and staff are struggling to find affordable housing in the Bay area, and this design is seeking to provide a solution to this problem. Since Santa Clara University is funding this project, keeping the project cost lower will reduce the return SCU will need from the development. A lower project cost will result in lower rent for the residents, especially considering the goal of providing affordable housing. While the project cost is important, the design must also be sustainable to meet LEED Gold certification, so the most effective yet cheapest stormwater management alternative should be provided. Porous pavement, bioretention, and do nothing scored a 4 for this criteria. Porous pavement only costs a bit more than normal pavement so it is considered to still be affordable. A bioretention area on the project site will add to the project cost, but is still a more affordable option. Flow through planters scored a 3.5 because they are similar to bioretention but they have an additional concrete cost. Rainwater catchment scored a 3 because depending on the size of system needed the storage tank cost can be higher. Green roof scored a 2 because both the cost of the materials and the impact on the structural system make it a more expensive option. Below are the explanations of the criteria scoring:

1: Very expensive
2: Expensive
3: Average
4: Affordable
5: Very affordable

The feasibility of construction should be considered in deciding between alternatives, but it is not the most important factor compared to direct costs and sustainability, which is why the criteria is assigned a 4 out of 10. However, it is still given a higher rating than a 1 because the feasibility of construction affects the scheduling. Each day added is an extra cost. Because cost is a priority, the harder a design is the construct, the more compensation will need to be paid to laborers. The doing nothing and porous pavement scored a 5 for this criteria. Both received this score because they do not require much extra installation. Flow through planters, bioretention, and rainwater catchment scored a 4 because they all are easy to construct and will not require extra time. Green roof scored a 2 because they can be more difficult to construct especially considering the reliance on the structural system. Below are the explanations of the criteria scoring:

1: Very hard to construct, affects schedule greatly
2: Hard to construct, affects schedule mildly
3: Moderate difficulty to construct, affects schedule mildly
4: Easy to construct, does not affect schedule
5: Very easy to construct, decreases predicted time in schedule

The cost of maintenance is assigned a weight of 8 out of 10 for similar reasoning as the cost weight of 10 out of 10. If the stormwater management design is expensive to maintain, the costs will fall onto the residents which are the faculty and staff. However, these end users are already strained on economic resources, which is why they need the housing development in the first place. If the bills are high to maintain the stormwater management design, that additional cost could be reflected in the rent and the users will not be satisfied. Doing nothing scored a 5 because after installation it hardly requires any maintenance. The bioretention and flow through planters scored a 4 for this criteria. Both of these systems require minimal maintenance aside for some irrigation in the first few years. Green roof and rainwater catchment both scored a 2. Green roofs can require extensive maintenance, especially in an area like San Jose where rainwater and irrigation is not present year-round which will be expensive. Rainwater catchment also requires more maintenance to ensure that the system is usable year-round. Porous pavement scored a 1 because it requires very expensive maintenance which includes declogging the system frequently. Below are the explanations of the criteria scoring:

1: Very expensive maintenance cost
2: Expensive maintenance cost
3: Average maintenance cost
4: Low maintenance cost
5: No additional maintenance cost

The feasibility of maintenance has a weight of 3 out of 10 because it does not influence the main priorities of cost and sustainability greatly. Feasibility of maintenance is still included in the alternative analysis because if a design is not easily maintained, the design may not be functional for its supposed design life. Do nothing, bioretention, and flow through planters scored a 5 for this criteria. Doing nothing hardly requires any maintenance at all. Bioretention and flow through planters require little maintenance and it is typically only for the first few years. Green roof and rainwater catchment both scored a 3 because they will need maintenance from time to time. Porous pavement scored a 1 because it can easily be clogged and will need to be unclogged for it to be effective. Below are the explanations of the criteria scoring:

1: Needs monthly maintenance
2: Needs yearly maintenance
3: Needs infrequent maintenance
4: Needs little maintenance
5: Does not need any maintenance

The geographical appropriateness of the stormwater management design is weighted a 6 out of 10. If a design is not appropriate, the maintenance of its functionality may add costs, which is why geographical appropriateness has a higher weight. Additionally, the chosen design should fit the site layout without intruding on the comfort of the residents. Porous pavement scored a 5 for this criteria because it can replace pavement that will already be in place and fits with the site layout. Bioretention and flow through planters scored a 4 because they incorporate native plants and can be adapted to fit within the site layout. Green roof scored a 2 because the limited rain California gets cannot support the green roof year round without additional irrigation. Rainwater catchment and do nothing both scored a 1. Due to California’s limited rain, a rainwater catchment system would need excessively large storage to be able to supply water year round, if it is even able to do so. Do nothing would violate local city and county codes therefore not being suitable. Below are the explanations of the criteria scoring:

1: Not suitable for the environment nor site layout
2: Mildly suitable for either the climate or site layout
3: Suitable for either the climate or site layout
4: Suitable for the climate and site layout
5: Very suitable for the climate and site layout

Overall Project

Constraints
7 stories
Fit in lot size
Minimum 280 units
Minimum LEED Gold
Meet demands of residents and potential commerical spaces
Knowledge of material

		How well do they meet criteria (0-5 Rating)			Score = WT * Rating		
Criteria	**Weights (1-10)**	**Alt 1: Concrete**	**Alt 2: Steel**	**Alt 3: Timber**	**Alt 1: Concrete**	**Alt 2: Steel**	**Alt 3: Timber**
Low Cost	9	3	2	4	27	18	36
Sustainability	7	2	3	4	14	21	28
Aesthetics	2	2	4	3	4	8	6
Schedule Impacts	5	2	4	3	10	20	15
Expertise	7	3	4	2	21	28	14
Seismic Resistance	6	2	3	2	12	18	12
					88	113	111

"Best" Alt = Alt 2: Steel

		Rating (1-5)			Score = WT * Rating		
Criteria	**Weights (1-10)**	**Alt 1: Concrete**	**Alt 2: Steel**	**Alt 3: Timber**	**Alt 1: Concrete**	**Alt 2: Steel**	**Alt 3: Timber**
Low Cost	9	3	2	4	27	18	36
Sustainability	7	2	3	4	14	21	28
Aesthetics	2	2	4	3	4	8	6
Schedule Impacts	5	2	4	3	10	20	15
Expertise	7	3	4	2	21	28	14
Seismic Resistance	6	2	3	2	12	18	12
					88	**113**	**111**

Overall Project

			How well do they meet criteria (0-5 Rating)						Score = WT * Rating					
Constraints	**Criteria**	**Weight (1-10)**	**Porous Pavement**	**Green Roof**	**Bioretention**	**Flow Through Planters**	**Rainwater Catchment**	**Nothing**	**Porous Paveme**	**Green Roof**	**Bioretention**	**Flow Through Planters**	**Rainwater Catchment**	**Nothing**
Treat runoff	Groundwater infiltration capacity	6	5	1	5	1	1	1	30	6	30	6	6	5
Fit on the site	Runoff treatment effectiveness	10	3	4	5	5	1	1	30	40	50	50	10	3
Comply with C.3	Aesthetics	5	2.5	5	4	5	2	2	12.5	25	20	25	10	5
	Impact on structural design	8	5	1	4	5	3	5	40	8	32	40	24	25
	Space usage	7	5	4	3	5	2	5	35	28	21	35	14	25
	Storm Drain Runoff Reduction	7	3.5	3	4	1	4	1	24.5	21	28	7	28	3.5
	Cost of construction	10	4	2	4	3.5	3	4	40	20	40	35	30	16
	Feasibility of construction	4	5	2	4	4	4	5	20	8	16	16	16	25
	Cost of maintenance	8	1	2	4	4	2	5	8	16	32	32	16	5
	Feasibility of maintenance	3	1	3	5	5	3	5	3	9	15	15	9	5
	Geographically appropriate	6	5	2	4	4	1	1	30	12	24	24	6	5
									273	193	308	285	169	122.5

"Best" Alt = Bioretention

		Rating (1-5)						Score = WT * Rating					
Criteria	**Weight (1-10)**	**Porous Pavement**	**Green Roof**	**Bioretention**	**Flow Through Planters**	**Rainwater Catchment**	**Nothing**	**Porous Pavement**	**Green Roof**	**Bioretention**	**Flow Through Planters**	**Rainwater Catchment**	**Nothing**
Groundwater infiltration capacity	6	5	1	5	1	1	1	30	6	30	6	6	5
Runoff treatment effectiveness	10	3	4	5	5	1	1	30	40	50	50	10	3
Aesthetics	5	2.5	5	4	5	2	2	12.5	25	20	25	10	5
Impact on structural design	8	5	1	4	5	3	5	40	8	32	40	24	25
Space usage	7	5	4	3	5	2	5	35	28	21	35	14	25
Storm Drain Runoff Reduction	7	3.5	3	4	1	4	1	24.5	21	28	7	28	3.5
Cost of construction	10	4	2	4	3.5	3	4	40	20	40	35	30	16
Feasibility of construction	4	5	2	4	4	4	5	20	8	16	16	16	25
Cost of maintenance	8	1	2	4	4	2	5	8	16	32	32	16	5
Feasibility of maintenance	3	1	3	5	5	3	5	3	9	15	15	9	5
Geographically appropriate	6	5	2	4	4	1	1	30	12	24	24	6	5
								273	193	308	285	169	122.5

Appendix B:

Structural Drawing Set

G WOOD NOTES

1. TO BE DEVELOPED

H MATERIAL DATA

INFORMATION BELOW IS SHOWN FOR STRUCTURAL DESIGN REFERENCE ONLY. SEE CALCULATION DESIGN PACKAGE FOR SPECIFIC MATERIAL SPECIFICATIONS.

REINFORCING STEEL YIELD STRENGTH:
F_y = 40 KSI (#3 AND SMALLER)
F_y = 60 KSI (#4 BARS)
Fy = 80 KSI (#5 AND LARGER)

CONCRETE 28-DAY ULTIMATE COMPRESSIVE STRENGTH:
F'_c = 6 KSI (CONCRETE FOUNDATION)
F'_c =4 KSI (CONCRETE FILL OVER METAL DECK)

STEEL YIELD STRENGTH:
F_y = 50 KSI (W SHAPES)
F_y = 50 KSI (BASE PLATES)
F_y = 36 KSI (ANGLES, CHANNELS, AND PLATES)
F_y = 50 KSI (MOMENT FRAME CONNECTION PLATES)

ABBREVIATIONS					
@	AT	HSS	HOLLOW STRUCTURAL SECTION	SMF	SPECIAL MOMENT FRAME
BM	BEAM	LWC	LIGHT WEIGHT CONCRETE	STL	STEEL
CL	CENTERLINE	MAX	MAXIMUM	SW	SHEAR WALL
COL	COLUMN	MIN	MINIMUM	TYP	TYPICAL
CJP	COMPLETE JOINT PENETRATION	O.C.	ON CENTER	UNO	UNLESS NOTED OTHERWISE
CLR	CLEAR	RCC	REINFORCED CONCRETE COLUMN	WF	WIDE FLANGE
DBL	DOUBLE	REINF.	REINFORCED		
DIA	DIAMETER	SAD	SEE ARCHITECTURAL DRAWINGS		
GA	GAGE or GAUGE	SCBF	SPECIAL CONCENTRIC BRACED FRAME		

C SPECIAL INSPECTIONS

CERTAIN ASPECTS OF THE BUILDING REQUIRES SPECIAL INSPECTION AND TESTING. THE INSPECTION AND TESTING MUST BE PERFORMED BY A CERTIFIED AGENCY AS DESCRIBED IN THE 2019 CBC, ASCE 7-16, AND OTHER DESIGN REFERENCE MANUALS FOR BUILDING STRUCTURAL ELEMENTS SUCH AS:

1. **SHOP FABRICATION OF STRUCTURAL LOAD-BEARING MEMBERS.** THE QUALIFIED FABRICATORS MUST SUBMIT A CERTIFICATE TO VERIFY THAT THEIR FABRICATION PROCEDURES ARE IN COMPLIANCE WITH THE 2019 CBC.
2. **CONCRETE CONSTRUCTION.** INCLUDES BUT NOT LIMITED TO REINFORCING STEEL, FORMWORK, CONCRETE MIX DESIGNS, CONCRETE PLACEMENT, AND CONSTRUCTION OF CONCRETE SHEAR WALLS. THE STRUCTURAL ENGINEER ON RECORD MUST INSPECT THE PLACEMENT OF ALL REBAR PRIOR TO THE PLACEMENT OF CONCRETE.
3. **STRUCTURAL STEEL CONSTRUCTION.** INCLUDES BUT NOT LIMITED TO MATERIAL IDENTIFICATION, WELDING IN THE SHOP OR ON THE FIELD, AND INSTALLATION OF ANY STEEL CONNECTIONS.
4. GEOTECHNICAL DATA. NO GEOTECHNICAL REPORT WAS PROVIDED FOR THIS PROJECT. THEREFORE, A LICENSED GEOTECHNICAL ENGINEER MUST CONDUCT A SOILS REPORT PRIOR TO CONSTRUCTION TO VERIFY THE ASSUMPTION OF CLASSIFYING THIS SITE OF HAVING A SOIL SITE CLASS D.

D STEEL NOTES

1. THE TOP OF STEEL ELEVATIONS ARE TO BE DETERMINED BY THE CONTRACTOR BASED ON THE ARCHITECTURAL AND STRUCTURAL DRAWINGS.
2. CHECK BEAM AND COLUMN SCHEDULE CAREFULLY. THE BEAMS WITH LONGER SPANS ARE CAMBERED.
3. ALL STEEL CONNECTIONS ARE NOT DESIGNED PER PLAN. ADDITIONALLY, ALL COLUMN SPLICES AND COLUMN TO BASE PLATE WELDS ARE CRITICAL. TYPICAL DETAILS ARE PROVIDED AS A SUGGESTION. A LICENSED STRUCTURAL ENGINEER MUST DESIGN THESE CONNECTIONS.
4. CRITICAL WELDS ARE INDICATED ON THE PLANS BUT NOT FULLY DESIGNED. A LICENSED STRUCTURAL ENGINEER MUST DESIGN THESE WELDS. A SUGGESTION WAS PRESCRIBED ON THE DRAWINGS.

E CONCRETE NOTES

1. CONCRETE FOUNDATION SLAB IS NOT DESIGNED PER THE SCOPE OF THIS PROJECT. A 9" CONCRETE FOUNDATION SLAB WAS ASSUMED BUT A LICENSED STRUCTURAL ENGINEER MUST ADEQUATELY DESIGN THE SLAB PRIOR TO CONSTRUCTION.
2. ANCHORAGE INTO CONCRETE WAS NOT DESIGNED PER THE SCOPE. A LICENSED STRUCTURAL ENGINEER MUST DESIGN THE ANCHORAGES PRIOR TO CONSTRUCTION. DETAILS DISPLAY A SUGGESTION OF HOW TO ANCHOR OBJECTS INTO CONCRETE.
3. THE CONTRACTOR MUST VERIFY MINIMUM EDGE DISTANCES, SPACES, AND THICKNESS ARE IN ACCORDANCE WITH THE SCHEDULE PRIOR INSTALLING ANY ANCHORAGES AND CONCRETE.

F COLD-FORMED STEEL FRAMING NOTES

1. TO BE DEVELOPED

A DESIGN CRITERIA

DESIGN CRITERIA: 2019 CALIFORNIA BUILDING CODE, TITLE 24, PART 2 (CBC), ASCE 7-16

FLOOR LIVE LOAD: PARKING GARAGE: 60 PSF, COMMERCIAL SPACE: 100 PSF, RESIDENTIAL: 40 PSF, RESIDENTIAL (CORRIDOR): 60 PSF

ROOF LIVE LOAD: 20 PSF

RISK CATEGORY: III

WIND DATA:
ULTIMATE WIND SPEED IN MPH: 99
WIND EXPOSURE CATEGORY: C
INTERNAL WIND PRESSURE COEFFICIENT (GCPI) = ±0.18
DESIGNED BY OTHERS SHALL COMPLY WITH "ASCE 7-16" DESIGN STANDARDS

EARTHQUAKE DATA:
SEISMIC IMPORTANCE FACTOR, I_e: 1.0
MAPPED SPECTRAL RESPONSE ACCELERATIONS: S_s =1.5; S_1 = 0.6g
SOIL SITE CLASS: D (ASSUMED)
SPECTRAL RESPONSE COEFFICIENTS: S_{DS} = 1.0g; S_{D1} = 0.6g
SEISMIC DESIGN CATEGORY: D
SEISMIC FORCE RESISTING SYSTEM(S): SPECIAL STEEL CONCENTRIC BRACED FRAMES (SCBF), SPECIAL REINFORCED CONCRETE SHEAR WALLS (SRCSW), STEEL SPECIAL MOMENT FRAMES (SMF)
RESPONSE MODIFICATION FACTORS(S): R = 6 (SCBF), R = 5 (SRCSW), R = 8 (SMF)
DESIGN BASE SHEAR: 7155k (SRCSW); 2932k (SMF)
SEISMIC RESPONSE COEFFICIENTS: C_s = 0.192 (SRCSW); C_s = 0.104 (SMF)
ANALYSIS PROCEDURE USED: EQUIVALENT LATERAL FORCE

MAXIMUM ANTICIPATED STORY DRIFT = 0.015 x HEIGHT

SCOPE: NEW 7-STORY MIXED-USE DEVELOPMENT, CONSISTING OF TWO FLOORS OF ABOVE GROUND PARKING GARAGE WITH COMMERCIAL SPACE OR RESIDENTIAL APARTMENT UNITS ON EACH FLOOR AND 5 FLOORS OF RESIDENTIAL APARTMENT UNITS ABOVE. THE PROJECT IS LOCATED AT 1200 CAMPBELL AVENUE IN SAN JOSE, CALIFORNIA. THE FIRST 2 FLOORS ARE APPROXIMATELY 91,320 SQ. FT. AND THE UPPER 5 FLOORS ARE APPROXIMATELY 68,880 SQ. FT.

B GENERAL NOTES

1. BUILDING DIMENSIONS SHOWN ARE FOR GENERAL REFERENCE ONLY. SEE ARCHITECTURAL DRAWINGS (SAD) FOR ALL ACTUAL BUILDING DIMENSIONS. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE ARCHITECT/ENGINEER SO CLARIFICATION CAN BE PROVIDED BEFORE THE WORK HAS BEGUN.
2. STRUCTURAL DRAWINGS SHALL NOT BE SCALED. ALL DIMENSIONS AND FIT SHALL BE DETERMINED AND VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCING WORK.
3. DETAILS NOT FULLY OR SPECIFICALLY SHOWN SHALL BE OF SAME NATURE AS OTHER TYPICAL CONDITIONS.
4. VERIFY WEIGHTS AND LOCATIONS OF MECHANICAL UNITS WITH THE MECHANICAL AND STRUCTURAL ENGINEER PRIOR TO PLACING THEM.
5. STRUCTURAL OBSERVATION IS REQUIRED FOR REINFORCING IN CONCRETE OVER METAL DECK AND STEEL FRAMING. PLEASE CONTACT RADS CONSTRUCTION, LLC. PRIOR TO CONDUCTING THESE TASKS.
6. FOR ANY STRUCTURAL INFORMATION THAT IS UNCLEAR, IMMEDIATELY NOTIFY THE STRUCTURAL ENGINEER FOR CLARIFICATION.

RADS CONSTRUCTION, LLC.
STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

GENERAL NOTES AND SPECIFICATIONS

Project number	20352	S.0
Date	April 25, 2020	
Drawn by	SAS	
Checked by	RS	

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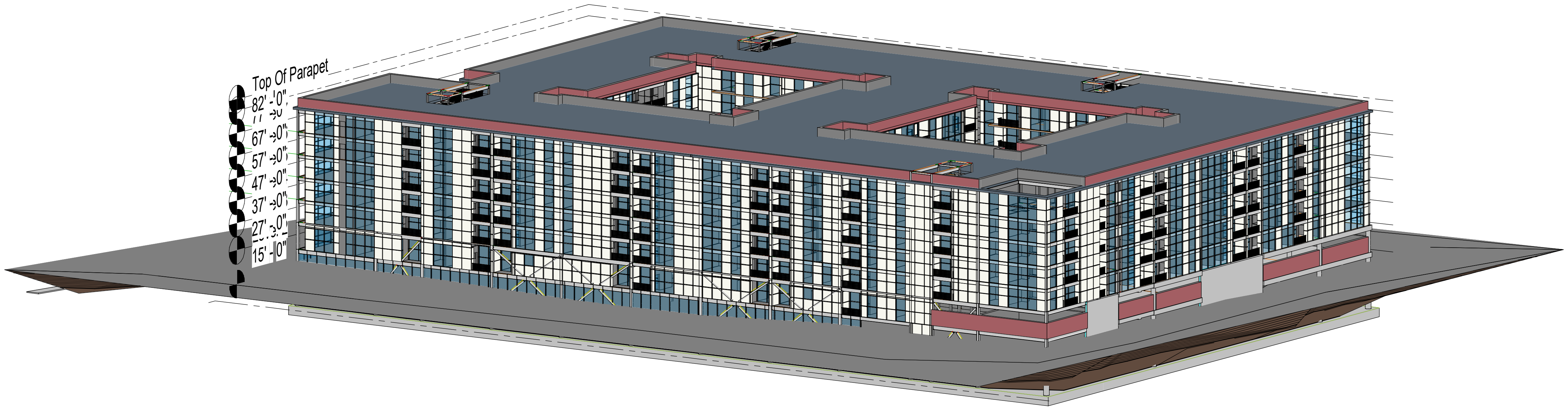

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

3D VIEWS OF BUILDING

Project number	20352	S.1
Date	April 25, 2020	
Drawn by	SAS/AO	
Checked by	RS	Scale 1" - 50'-0"

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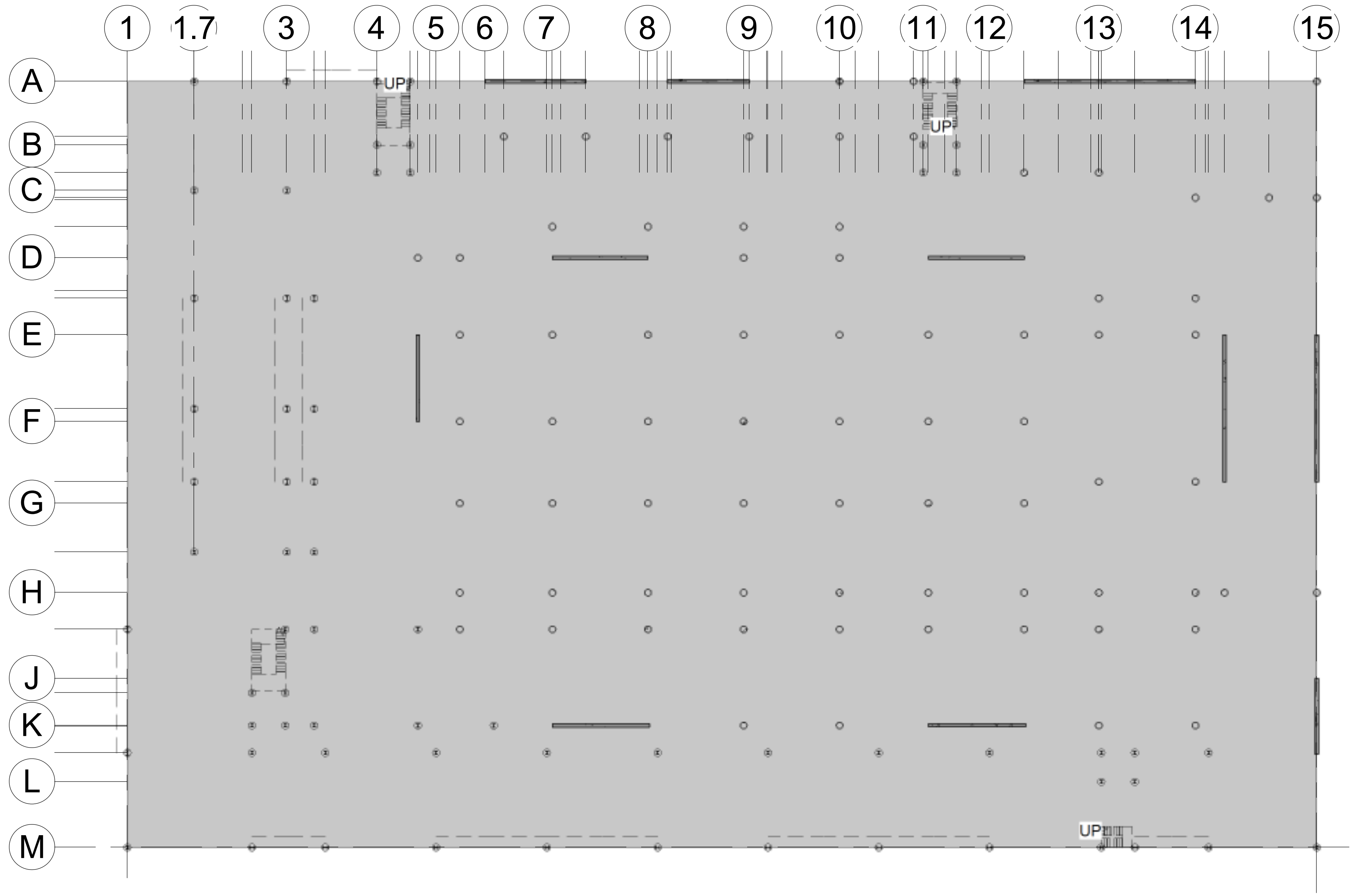


RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

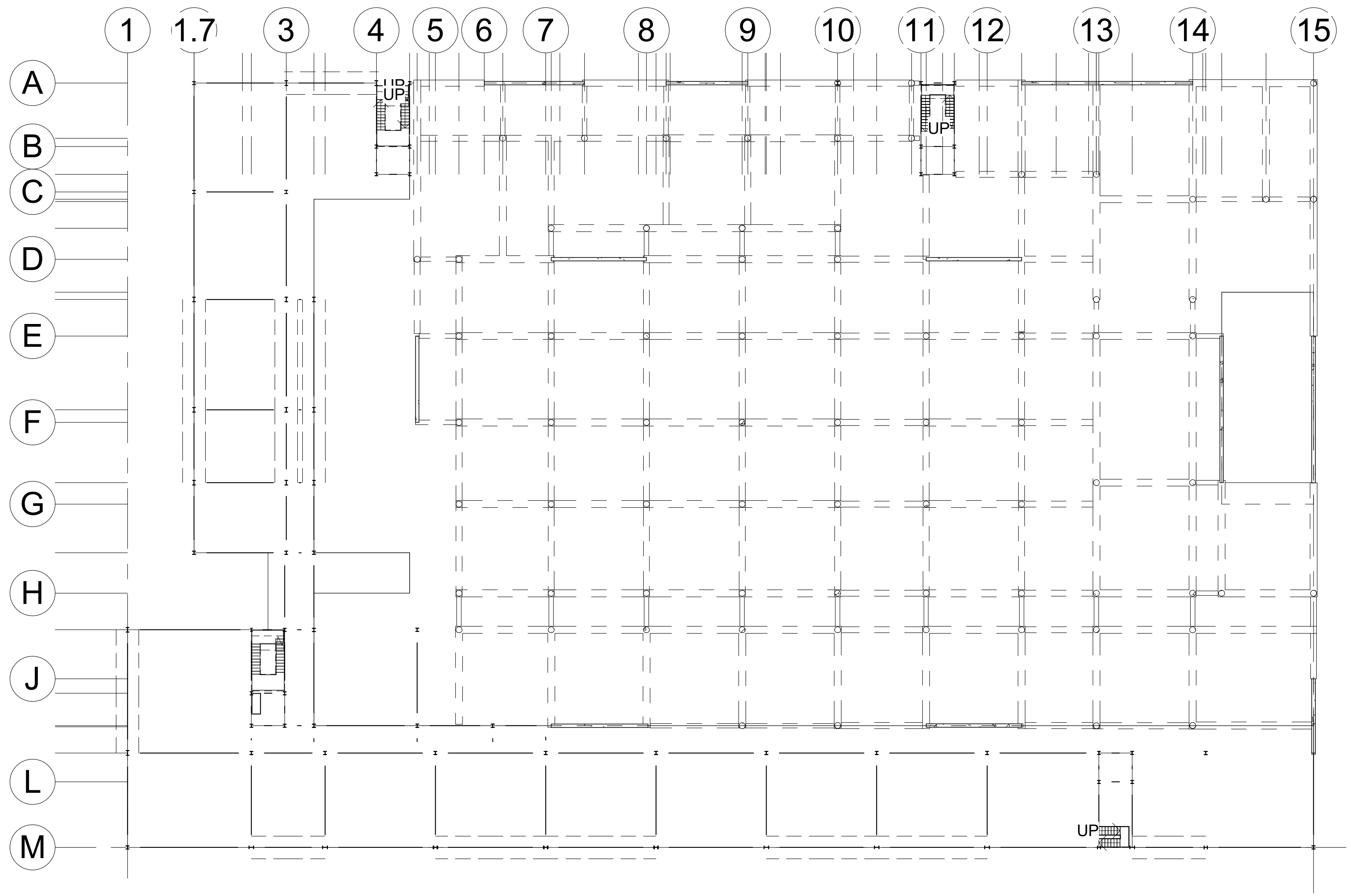
STRUCTURAL PLAN - LEVEL 1

Project number	20352
Date	April 25, 2020
Drawn by	SAS/AO
Checked by	RS

S.2

Scale 1" - 40'-0"

5/20/20 4:30:49 PM



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Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

STRUCTURAL PLAN - LEVEL 2

Project number	20352
Date	April 25, 2020
Drawn by	SAS/AO
Checked by	RS

S.3

Scale 1" - 40'-0"

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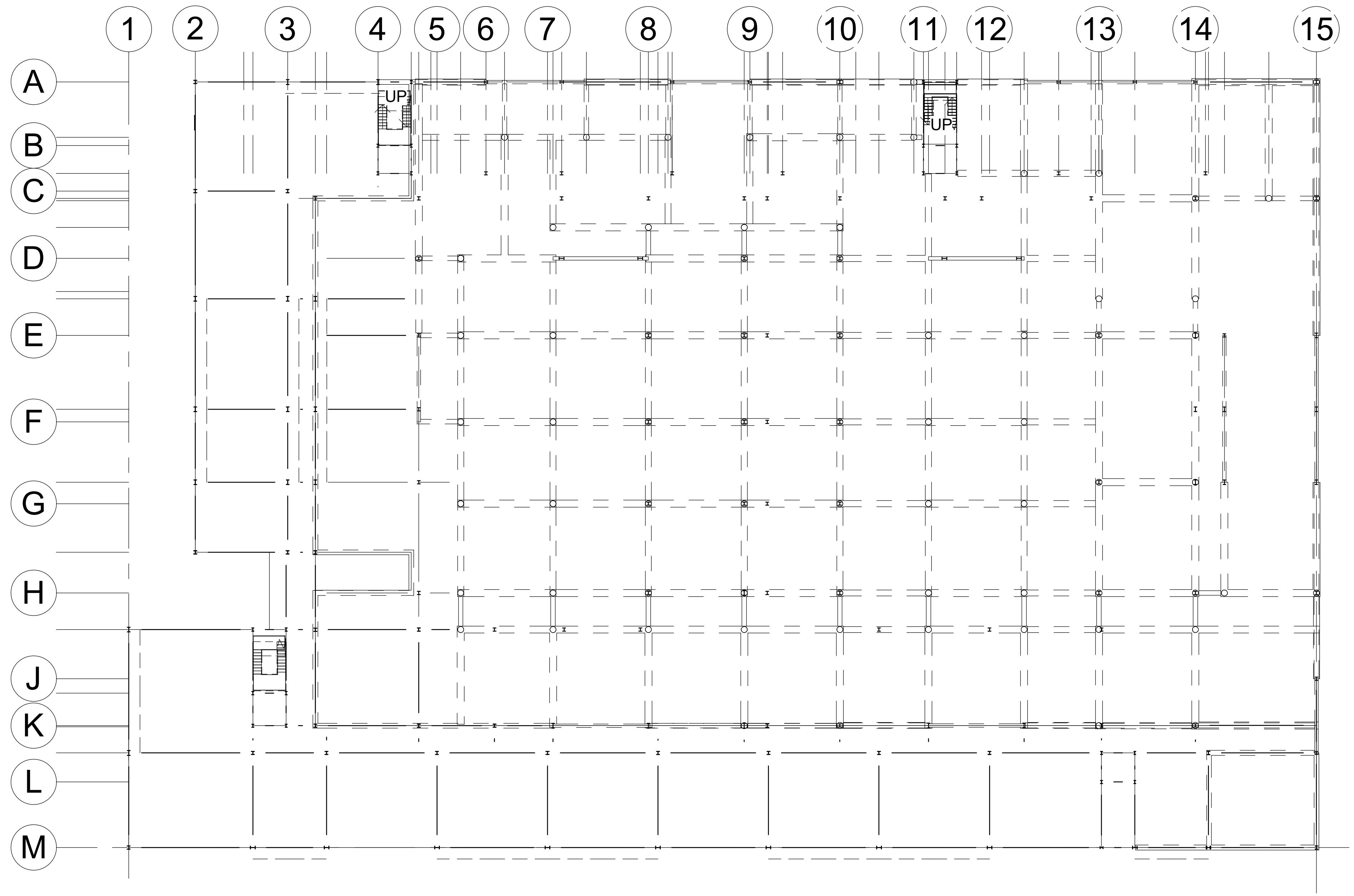

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STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

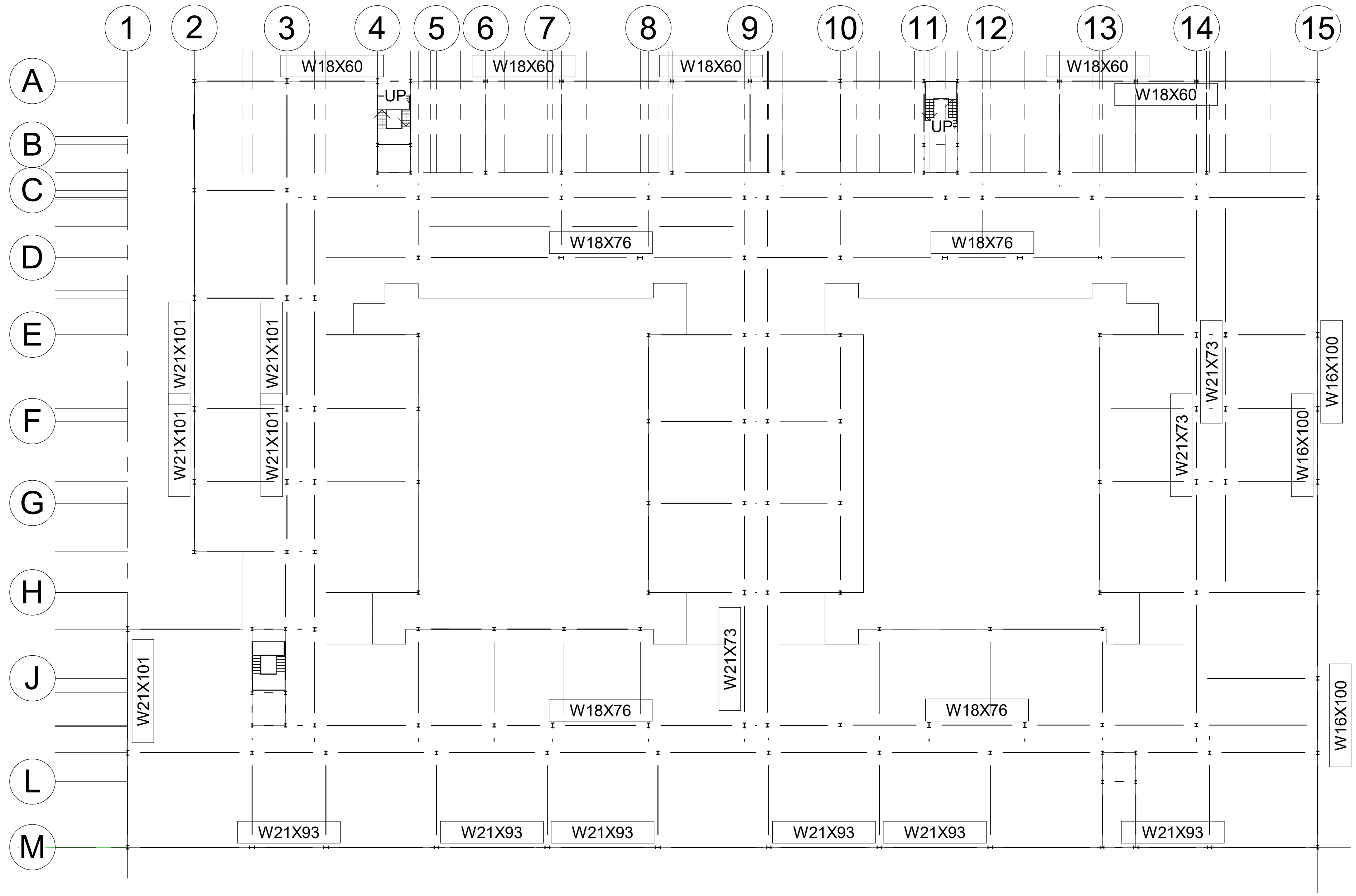
STRUCTURAL PLAN - LEVEL 3

Project number	20352
Date	April 25, 2020
Drawn by	SAS/AO
Checked by	RS

S.4

Scale 1" - 40'-0"

5/20/20 4:30:54 PM



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Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

STRUCTURAL PLAN - LEVEL 4

Project number	20352	S.5
Date	April 25, 2020	
Drawn by	SAS/AO	
Checked by	RS	Scale 1" - 40'-0"

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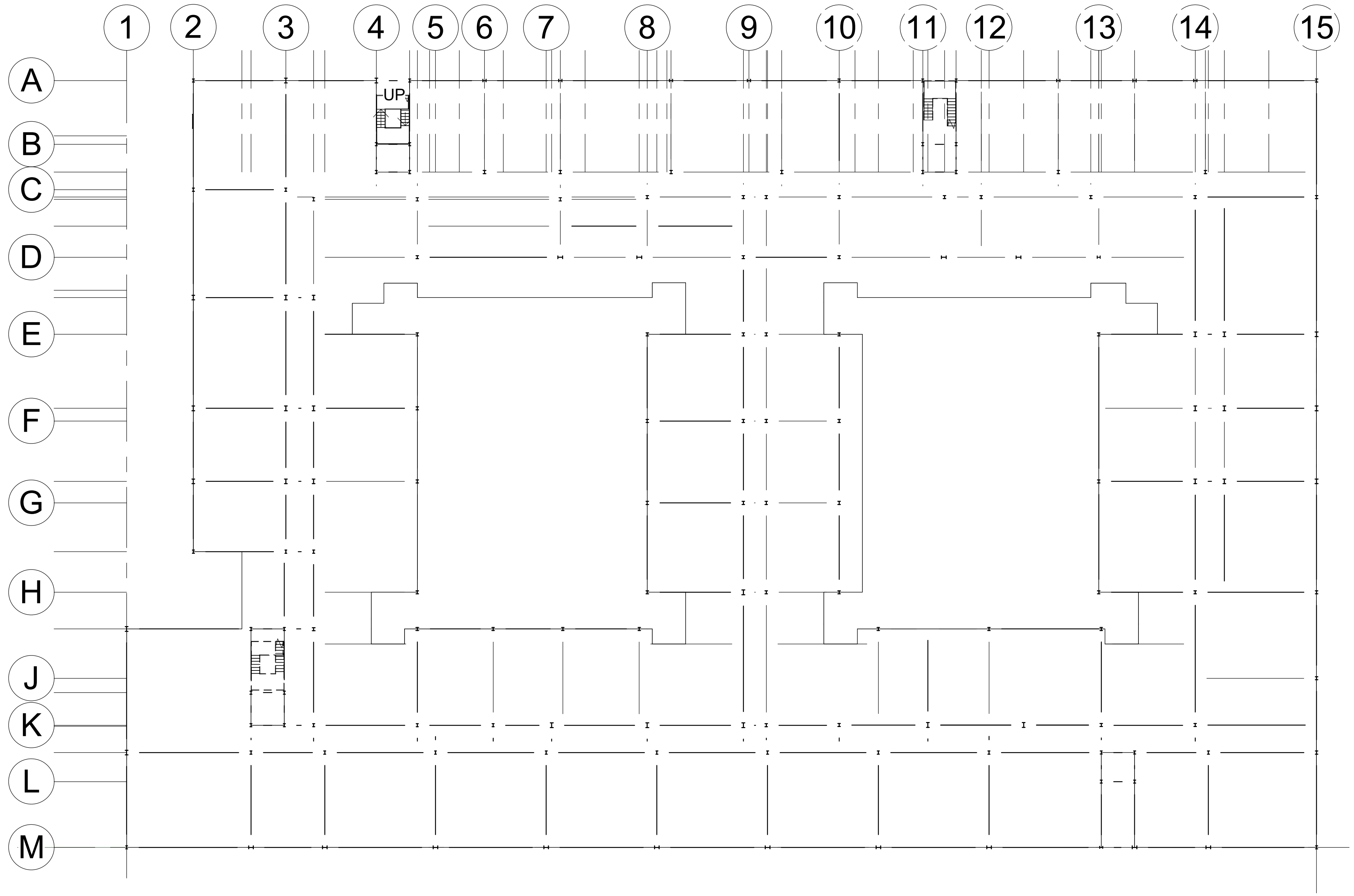

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STUDIO
T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

STRUCTURAL PLAN - LEVEL 5

Project number	20352
Date	April 25, 2020
Drawn by	SAS/AO
Checked by	RS

S.6

Scale 1" - 40'-0"

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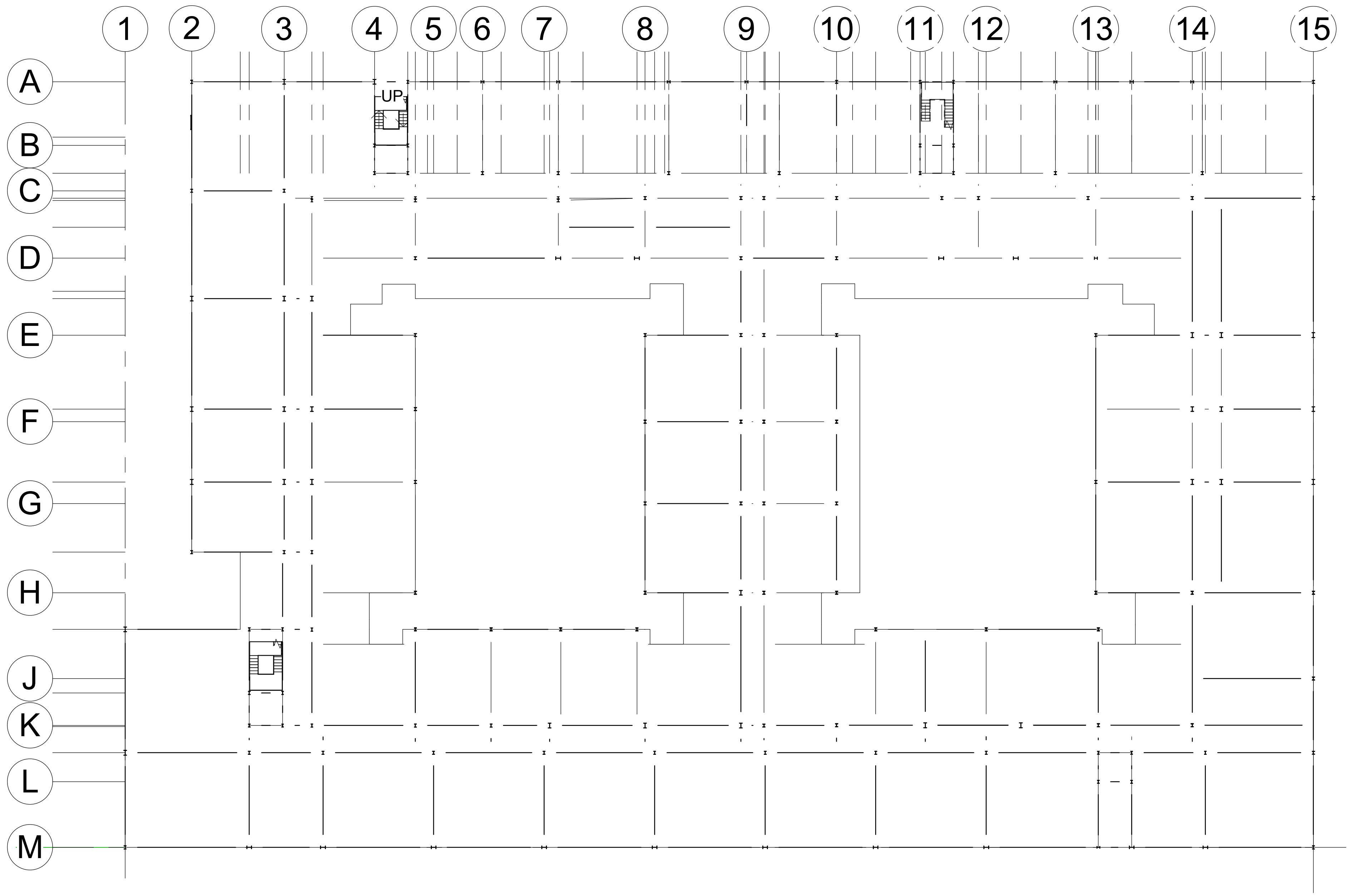

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STUDIO
T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

STRUCTURAL PLAN - LEVEL 6

Project number	20352	S.7
Date	April 25, 2020	
Drawn by	SAS/AO	
Checked by	RS	Scale 1" - 40'-0"

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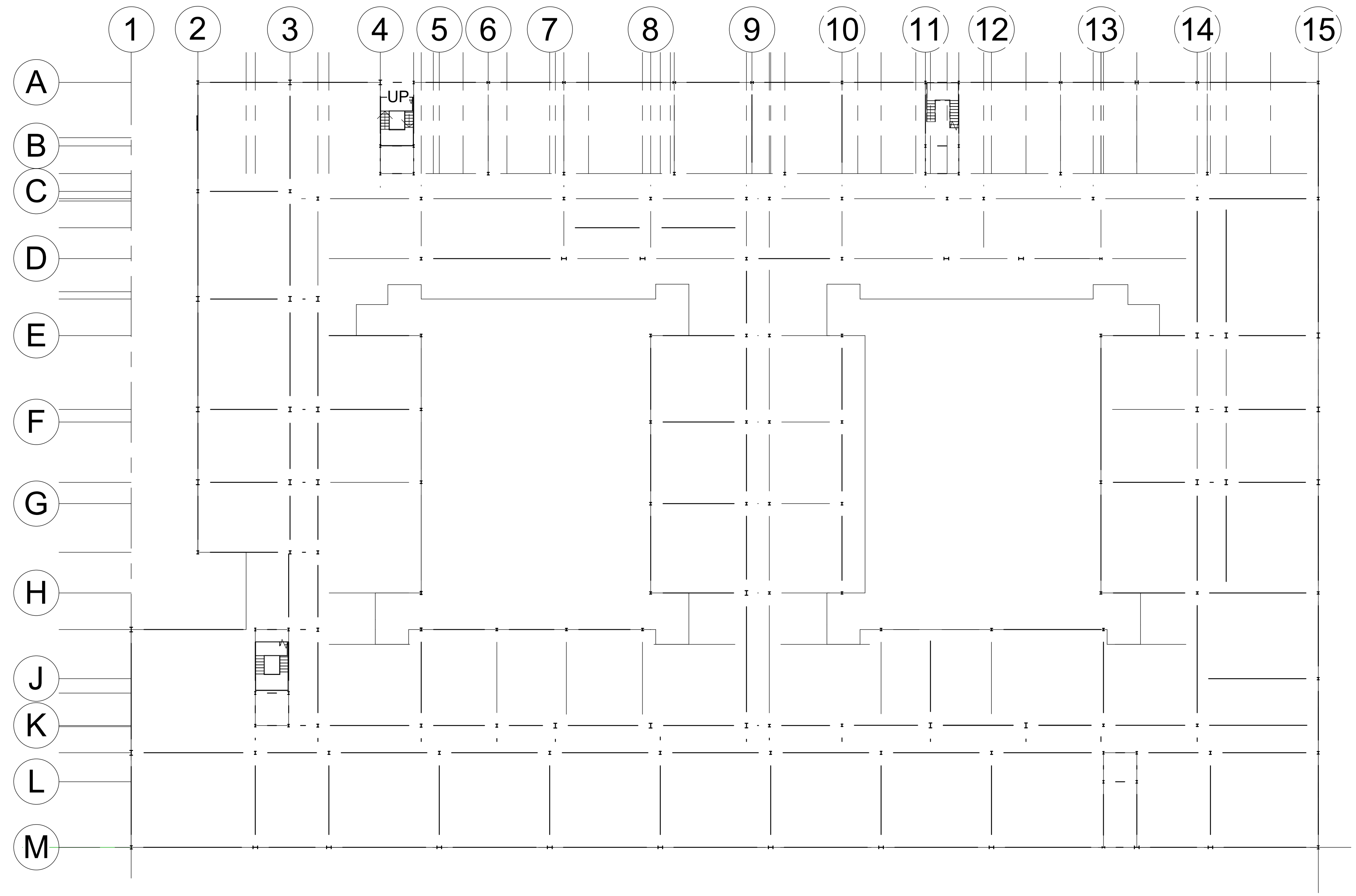

RADS CONSTRUCTION, LLC

STUDIO
T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

STRUCTURAL PLAN - LEVEL 7

Project number	20352	S.8
Date	April 25, 2020	
Drawn by	SAS/AO	
Checked by	RS	Scale 1" - 40'-0"

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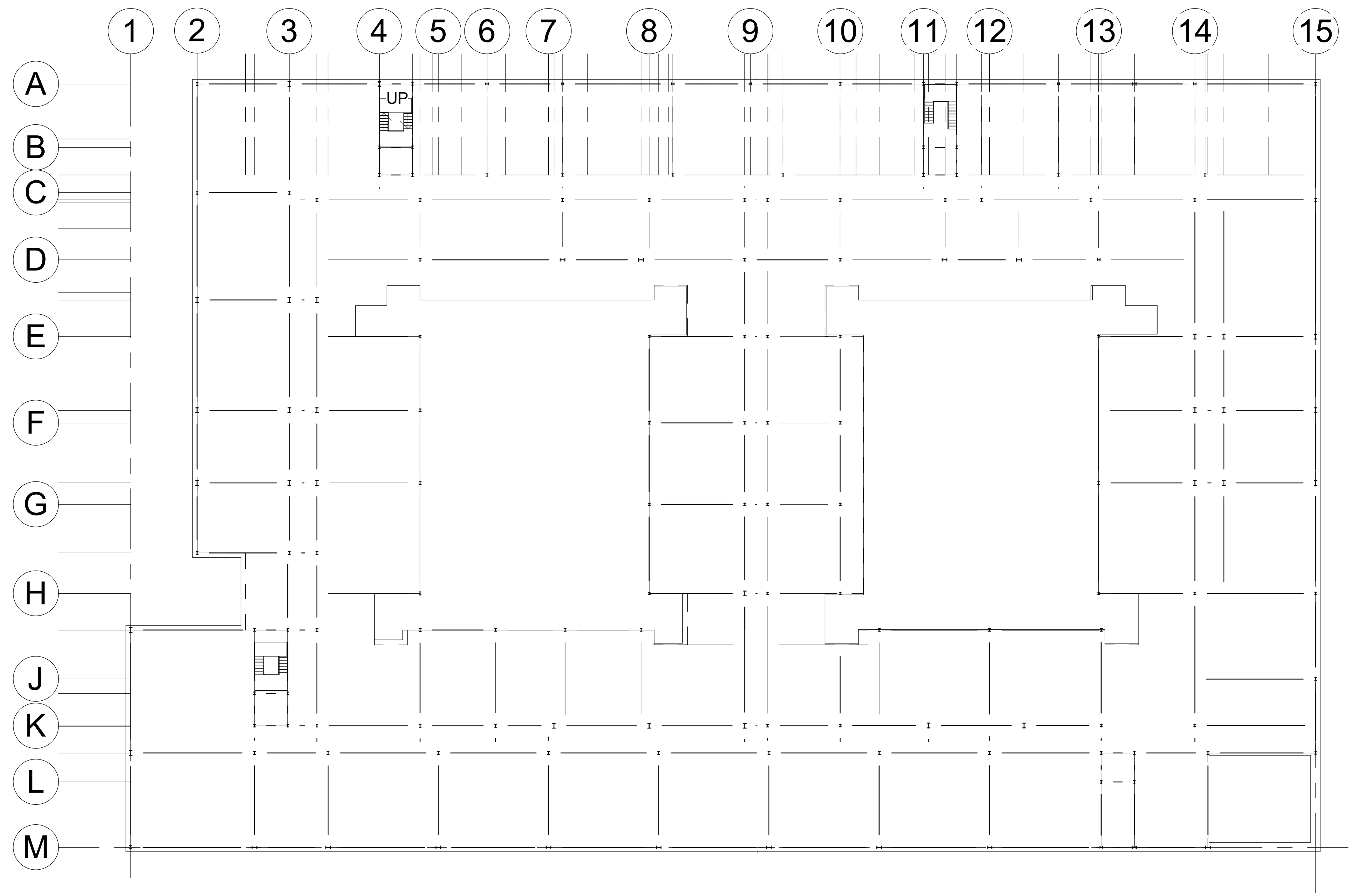

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

STRUCTURAL PLAN - ROOF

Project number	20352	S.9
Date	April 25, 2020	
Drawn by	SAS/AO	
Checked by	RS	Scale 1" - 40'-0"

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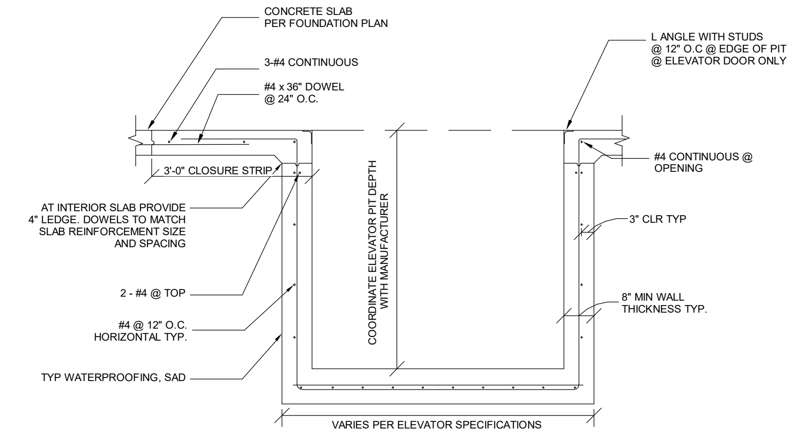


NOTE: VERIFY ALL DEPTH ELEVATIONS AND DIMENSIONS WITH ELEVATOR MANUFACTURER

1 TYPICAL ELEVATOR PIT DETAIL

SPLICE LENGTH FOR GRADE 60, UNCOATED REINFORCEMENT IN NORMAL WEIGHT CONCRETE

LOCATION	F'c (Psi)	No. 6 & SMALLER BARS & DEFORMED WIRES	No. 7 & LARGER BARS
TOP	3000	75db	93db
OTHER	3000	58db	72db
TOP	4000	65db	80db
OTHER	4000	50db	61db
TOP	5000	58db	71db

DEVELOPMENT LENGTH (Ld) FOR GRADE 60, UNCOATED REINFORCEMENT IN NORMAL WEIGHT CONCRETE

LOCATION	F'c (Psi)	No. 6 & SMALLER BARS & DEFORMED WIRES	No. 7 & LARGER BARS
TOP	3000	58db	72db
OTHER	3000	44db	55db
TOP	4000	50db	61db
OTHER	4000	38db	47db
TOP	5000	45db	55db

NOTES:
1) CLEAR SPACING OF BARS BEING DEVELOPED OR SPLICED MUST BE GREATER THAN 2db & THE MIN. CONCRETE COVER MUST BE GREATER THAN db WHERE db IS THE NORMAL BAR DIAMETER.
2) TOP BARS ARE HORIZONTAL BARS SO PLACED THAT MORE THAN 12" OF FRESH CONCRETE IS CAST IN THE MEMBER BELOW THE DEVELOPMENT LENGTH OR SPLICE.
3) USE A MULTIPLIER OF 1.3 X LENGTH SHALL BE USED FOR LIGHTWEIGHT CONCRETE.

2 ELEVATOR PIT REBAR SPECIFICATIONS

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

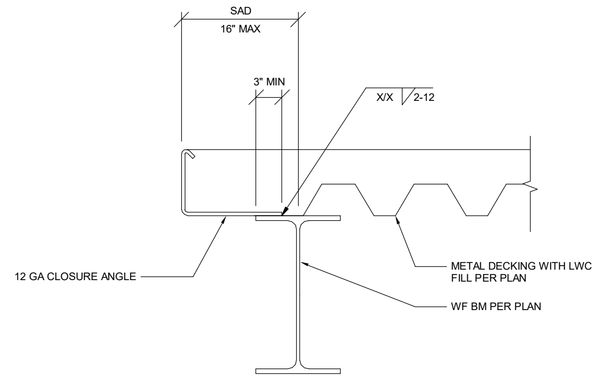
No.	Description	Date

TYPICAL DETAILS

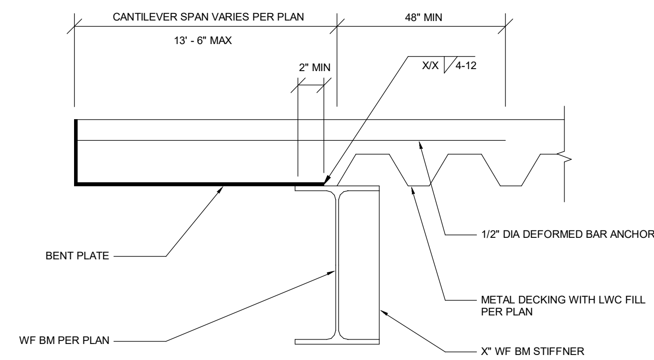
Project number	20352
Date	April 25, 2020
Drawn by	SAS
Checked by	RS

S.10

5/20/20 4:31:10 PM

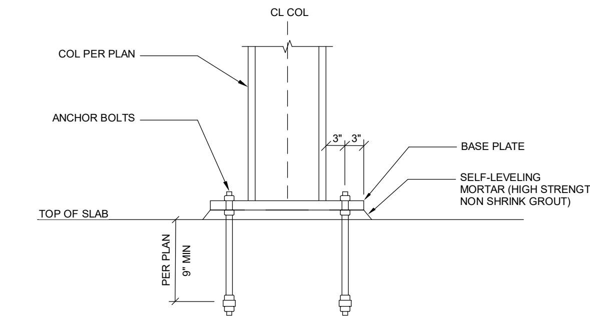


TOPPED DECK AT OPENING

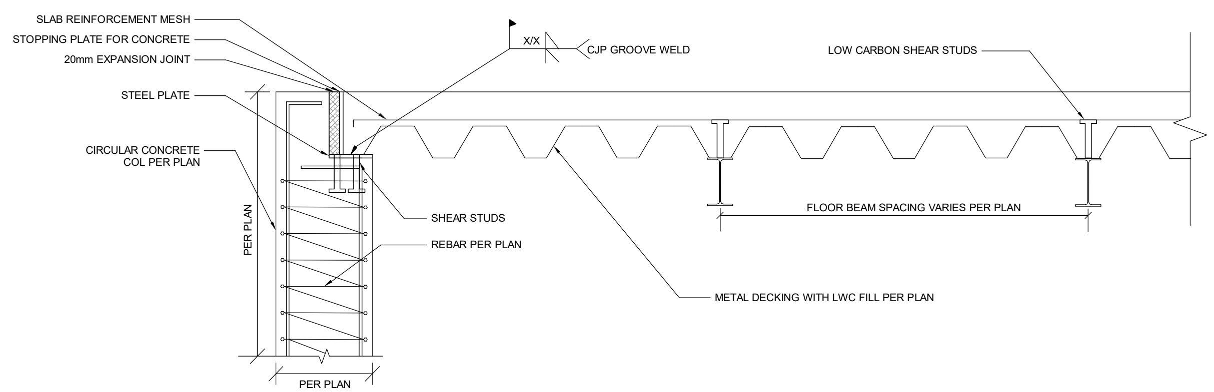


TOPPED DECK WITH CANTILEVERED OVERHANG

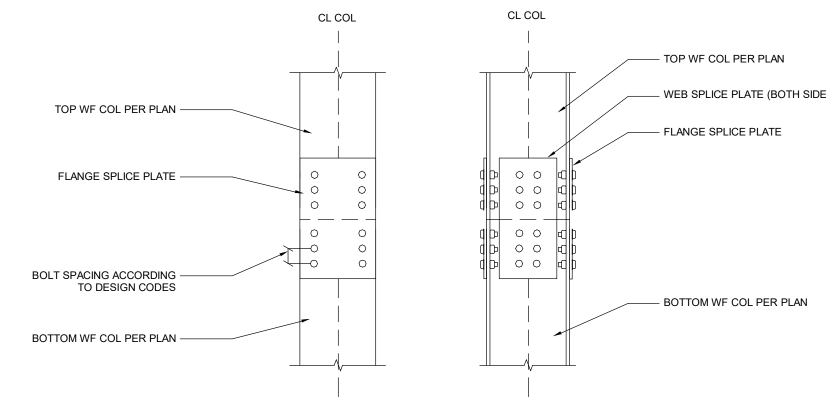
4 TYPICAL EDGE OF METAL DECK



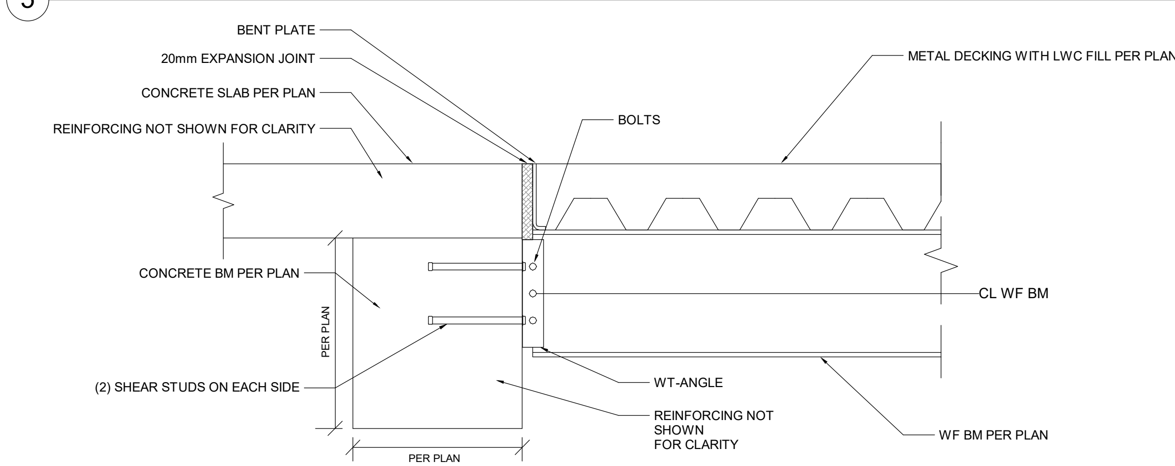
1 WF COL TO FOUNDATION CONNECTION



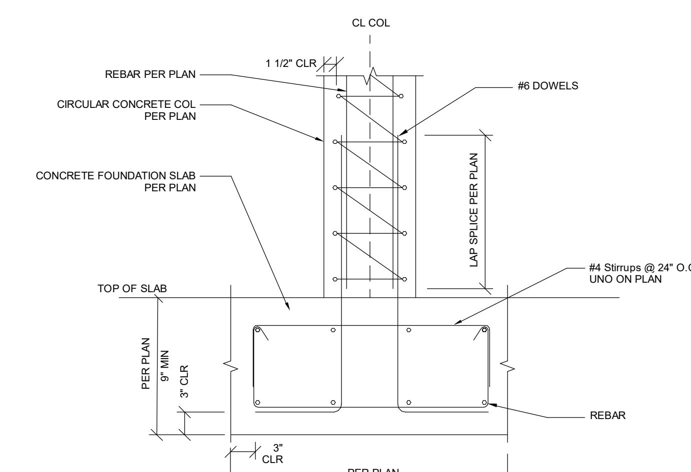
5 TYPICAL STL DECKING CONCRETE FLR TO RC COL CONNECTION



2 TYPICAL WF COL BOLTED SPLICE CONNECTION



6 TYPICAL STL DECKING CONCRETE FLOOR TO RCC BM CONNECTION



3 TYPICAL FOUNDATION TO CONCRETE COL CONNECTION

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

GRAVITY FORCE RESISTING SYSTEM DETAILS

Project number	20352
Date	April 25, 2020
Drawn by	SAS
Checked by	RS

S.11.1

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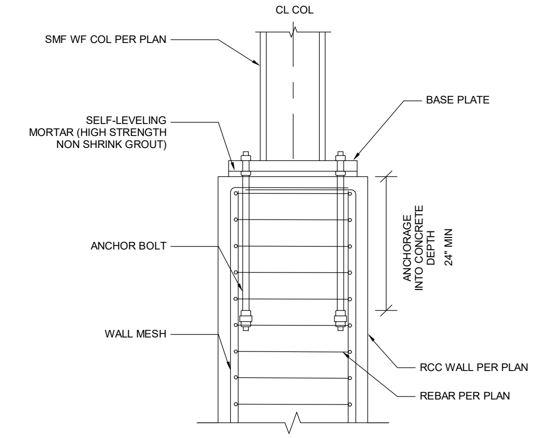

1 STL COL ON TOP OF REINF. CONCRETE COL CONNECTION

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

GRAVITY FORCE RESISTING SYSTEM DETAILS

Project number	20352	S.11.2
Date	April 25, 2020	
Drawn by	SAS	
Checked by	RS	

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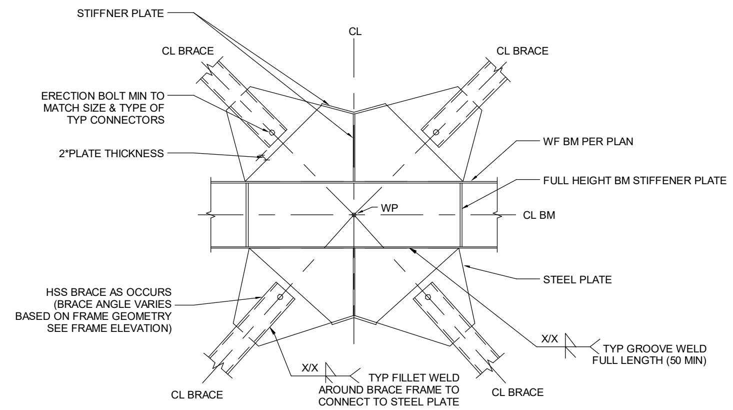
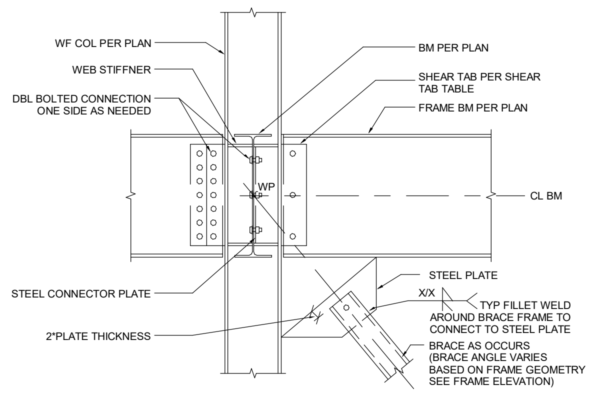


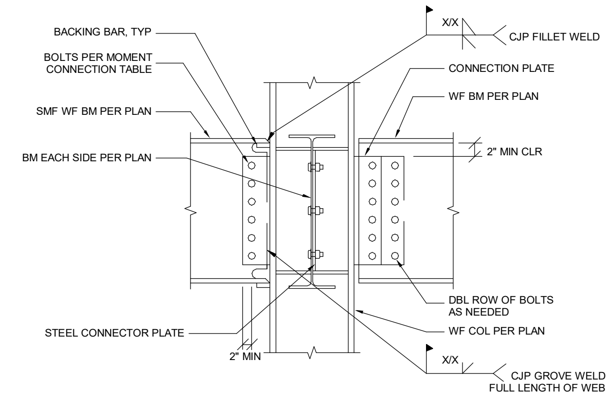
6 4-WAY SCBF TO WF BM CONNECTION

TO BE DEVELOPED

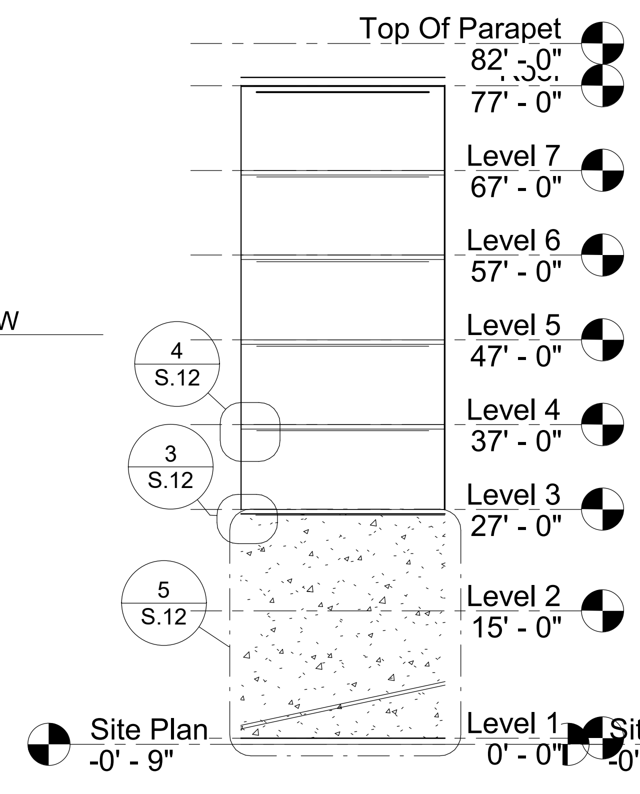
3 STL COL ON TOP OF SPECIAL REINF. CONCRETE SW



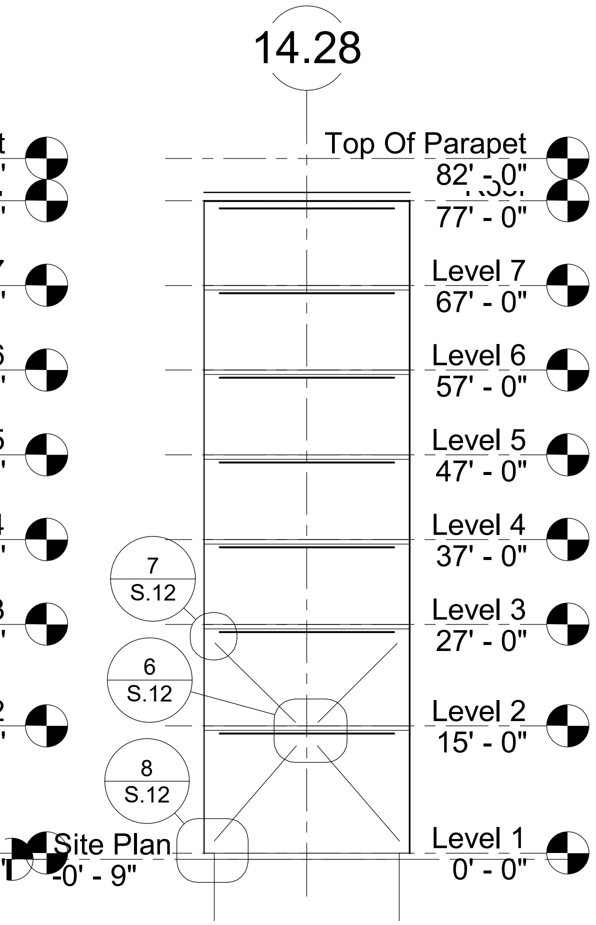
7 SCBF TO WF COL AND BM CONNECTION



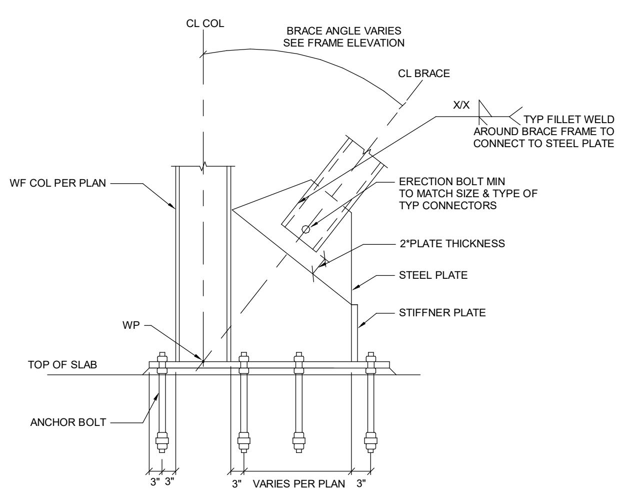
4 SMF TO WF COL AND BM CONNECTION



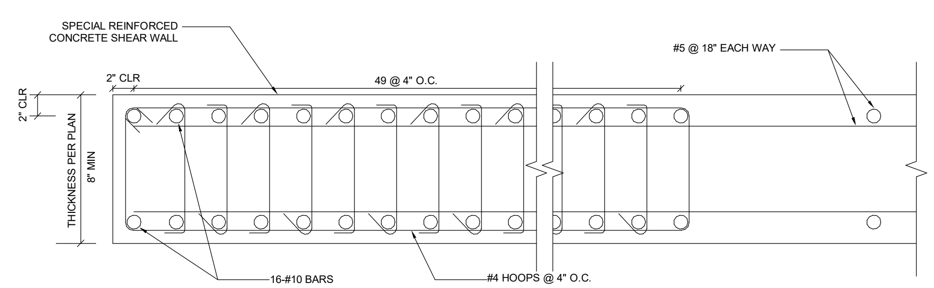
2 SRCW - SMF ELEVATION VIEW



1 SCBF - SMF ELEVATION VIEW



8 SCBF TO FOUNDATION CONNECTION



5 SPECIAL REINFORCED CONCRETE SHEAR WALL SECTION

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

LATERAL FORCE RESISTING SYSTEM DETAILS

Project number	20352
Date	April 25, 2020
Drawn by	SAS
Checked by	RS

S.12

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Appendix C:

Structural Calculations Package

SCU Faculty and Staff Housing Development
Structural Calculations

San Jose, CA

Structural Design Package

April 16, 2020

Prepared For:
Santa Clara University
500 El Camino Real, Santa Clara, CA 95053

Prepared By:
Spencer A. Saito, Designer
Santa Clara, California

General Nomenclature

Symbol	Name	Units
A	Cross-sectional area	in2
A_c	Area of concrete	in2
A_e	Effective net area	in2
A_f	Flange area	in2
A_g	Gross cross-sectional area of the shear plate	in2
A_{gt}	Gross area subject to tension	in2
A_{gv}	Gross area subject to shear	in2
A_{nt}	Net area subject to tension	in2
A_{nv}	Net area subject to shear	in2
A_w	Area of web	in2
A_{wei}	Effective weld area	in2
C_b	Lateral-torsional buckling modification factor for nonuniform moment diagrams when both ends of the segment are braced	
C_w	Warping constant	in6
F_c	Available stress in main member	ksi
F_{cr}	Critical stress	ksi
F_{EXX}	Filler metal classification strength	ksi
F_{nt}	Nominal Tensile Strength from AISC Specification Table J3.2	ksi
F_{nv}	Nominal Shear Strength from AISC Specification Table J3.2	ksi
F_u	Specified minimum tensile strength	ksi
F_y	Specified minimum yield strength	ksi
G	Ratio of the total column stiffess framing into a joint to that of the stiffening members framing into the same joint	
I_x	Moment of inertia about the x-axis	in4
I_y	Moment of inertia about the y-axis	in4
J	Torsional constant	in4
K	Effective length factor	
K_{dep}	Fillet depth	in
L_b	Length between points that are either braced against lateral displacement of compression flange or braced against twist of the cross section	in
L_c	Effective length of member	in
L_{cx}	Effective length of member for buckling about x-axis	in
L_{cy}	Effective length of member for buckling about y-axis	in
L_{cz}	Effective length of member for buckling about longitudinal axis	in
L_p	Limiting laterally unbraced length for the limit state of yielding	in
M_{px}	Plastic bending moment about the x-axis	kip-ft
M_r	Required flexural strength	kip-in
M_{rx}	Required flexural strength about x-axis	kip-in
M_{ry}	Required flexural strength about y-axis	kip-in
M_u	Required flexural strength using LRDF load combinations	kip-in or kip-ft, as indicated
M_y	Flexural yield moment	kip-in
S_x	Mimimum elastic section modulus taken about the x-axis	in3
S_y	Mimimum elastic section modulus taken about the y-axis	in3
T	Distance between web toes of fillets at top and at bottom of web	in
T	Tension force due to service loads	kip
T	Required strength	kip
T	Thickness of flat circular washer or mean thickness of square or rectangular beveled washer	in
T	Width of element	in
U	Shear lag coefficient	
V	Maximum vertical shear for any condition of symmetrical loading	kip

V	Shear force	kip
V	Vertical component of the required force	kip
V	Vertical shear	kip
V'	Horizontal shear strength at the steel-concrete interface	kip
V_c	Required shear force on the gusset-to-column connection	kip
V_c	Available shear strength	kip
V_{nx}	Nominal strong-axis shear strength	kip
V_r	Required shear strength	kip
V_u	Required shear strength using LRFD load combinations	kip
Z_x	Plastic section modulus about the x-axis	in3
Z_y	Plastic section modulus about the y-axis	in3
b_{eff}	Effective width	in
b_f	Width of flange	in
b_f	Connection element width	in
d_b	Nominal bolt diameter	in
d_h	Hole diameter	in
h_o	Distance between flange centroids	in
k	Plate buckling coefficient for beams coped at top flange only	
k	Distance from outer face of flane to the web toe of fillet	in
r_{ts}	Effective radius of gyration	in
r_x	Radius of gyration about x-axis	in
r_y	Radius of gyration about y-axis	in
t_f	Thickness of flange	in
t_w	Web thickness	in
Δ	Deformation	in
β	Distance from the face of the beam flange to the centroid of the gusset-to-column connection for uniform force method	in
Φ	Resistance factor given by the AISC Specification for a particular limit state	

Table of Contents:

Structural Narrative:

The following support calculations are for a new seven (7) story mixed-use building, consisting of two floors of above ground parking & commerical space and five floors of residential units. This project is located at 1200 Campbell Avenue, San Jose California. The first two (2) floors are approximately 91,320 square feet and the upper five (5) floors are approximately 68,880 square feet, with a total of about 606,685 square feet. A 9-inch thick foundation slab was assumed to be adequate enough to counteract the pressure along with the dead load from the structural steel, concrete, and metal decking. The gravity system is concrete diaphragm supported by circular concrete columns and concrete over metal deck supported by steel framing, and the lateral system is composed of steel special concentric brace frames, special reinforced concrete shear walls, and special steel moment frames with moment frame connections.

Due to constraints resulting from the university's transition to no face-to-face meetings and online classes, the project scope was modified to omit the following design items:

- Foundation
- Parking garage ramps
- Connection details
- Non load bearing structural components
- Elevated concrete slab gravity load for the parking garage
- Steel Braced Frames

Flat Weights (psf)

PARKING GARAGE

CBC Live Load Category: Garages: Passenger vehicles only (Table 4.3-1)

Slope :12

Is there a Balcony? No

Material	Sloped?	Weight
Cement Finish	Yes	30.0
Topping (Concrete)	Yes	0.0
5" Lightweight Concrete Floor Fill (Slabs)	Yes	40.0
Lighting	No	0.8
Insulation	No	0.0
M.E.P.		4.0
Ceiling		0.0
Sprinklers		1.5
Concrete Beams		10.0
Concrete Girders		10.0
Columns		10.0
Miscellaneous		1.5
Dead Load		108.0
Dead Load - Horizontal Projection		108.0
Partitions	No	0.0
Live Load		60.0
Live Load - Reduced R_2 =	1.00	60.0
Total Load (psf)		**168.0**

COMMERCIAL SPACE

CBC Live Load Category: Stores: Retail 1st FLR (Table 4.3-1)

Slope :12

Is there a Balcony? No

Material	Sloped?	Weight
Cement Finish	Yes	30.0
Topping (Concrete)	Yes	0.0
4" Lightweight Concrete Floor Fill (Slabs)	Yes	32.0
Lighting	No	0.8
Insulation	No	0.0
M.E.P.		4.0
Ceiling		0.0
Sprinklers		1.5
Concrete Beams		10.0
Concrete Girders		10.0
Columns		10.0
Miscellaneous (5% of Total)		4.9
Dead Load		104.0
Dead Load - Horizontal Projection		104.0
Partitions	No	0.0
Live Load		100.0
Live Load - Reduced R_2 =	1.00	100.0
Total Load (psf)		**204.0**

TYPICAL RESIDENTIAL FLOOR

CBC Live Load Category Residential: Other (Table 4.3-1)

Slope :12

Is there a Balcony? No

Material	Sloped?	Weight
3" Concrete Over Metal Deck	No	24.0
Carpet/Linoleum	No	2.0
Metal Decking, 18 Gauge	No	3.0
Solar/Other	Yes	0.0
Insulation	Yes	0.0
M.E.P. + Sprinklers		5.5
Ceiling (Drywall)		2.0
Beams (Assumption)		10.0
Girders (Assumption)		10.0
Columns		10.0
Miscellaneous (5% of Total)		3.3
Dead Load		70.0
Dead Load - Horizontal Projection		70.0
Partitions	No	0.0
Live Load		40.0
Live Load - Reduced R_2 =	1.00	40.0
Total Load (psf)		**110.0**

TYPICAL RESIDENTIAL FLOOR - CORRIDOR

CBC Live Load Category Walkways (Table 4.3-1)

Slope :12

Is there a Balcony? No

Material	Sloped?	Weight
3" Concrete Over Metal Deck	No	24.0
Carpet/Linoleum	No	2.0
Metal Decking, 18 Gauge	No	3.0
Solar/Other	Yes	0.0
Insulation	Yes	0.0
M.E.P. + Sprinklers		5.5
Ceiling (Drywall)		2.0
Beams (Assumption)		10.0
Girders (Assumption)		10.0
Columns		10.0
Miscellaneous (5% of Total)		3.3
Dead Load		70.0
Dead Load - Horizontal Projection		70.0
Partitions	No	0.0
Live Load		60.0
Live Load - Reduced R_2 =	1.00	60.0
Total Load (psf)		**130.0**

ROOF - SLOPED

CBC Live Load Category: Roof: Ordinary flat, pitched, and curved roofs (Table 4.3-1)

Slope: 3:12

Is there a Balcony? No

Material	Sloped?	Weight
Solar/Other	Yes	3.0
Waterproofing Bituminous, Smooth Surfac	Yes	1.5
Sheathing/Decking	Yes	3.0
Metal Deck	Yes	2.8
Rigid Insulation	Yes	1.5
M.E.P.		5.0
Ceiling		0.0
Sprinklers		1.5
Beams (20 plf @ 8'-0" oc)		10.0
Girders (30 plf @ 20'-0" oc)		10.0
Columns		10.0
Miscellaneous (5% of Total)		2.4
Dead Load		51.0
Dead Load - Horizontal Projection		51.0
Partitions	No	0.0
Live Load		20.0
Live Load - Reduced R_2 =	1.00	20.0
Total Load (psf)		**71.0**

TOTAL GRAVITY LOADS:

	Intended Use	Area (ft^2)	Dead Loads (psf)	Dead Loads (kips)	Live Load (psf)	Live Load (kips)
Ground Floor	Parking Garage/Open Space	91318.94	-	-	-	-
2nd Floor	Parking Garage	66404.75	108.0	7172	60.0	3984
2nd Floor	Residential Units	24914.19	70.0	1744	40.0	997
3rd Floor	Residential units (~65 units)	68882.61	70.0	4822	40.0	2755
4th Floor	Residential units	68882.61	70.0	4822	40.0	2755
5th Floor	Residential units	68882.61	70.0	4822	40.0	2755
6th Floor	Residential units	68882.61	70.0	4822	40.0	2755
7th Floor	Residential units	74815.6	70.0	5237	40.0	2993
Roof	-	73701.02	51.0	3759	40.0	2948
	Total:	606685	579	37199	340	21943

OSHPD

SCU Faculty & Staff Housing Development

1200 Campbell Ave, San Jose, CA 95126, USA

Latitude, Longitude: 37.3488651, -121.93011160000003

Date	1/4/2020, 6:56:49 PM
Design Code Reference Document	ASCE7-16
Risk Category	III
Site Class	D - Stiff Soil

Type	Value	Description
S_S	1.5	MCE_R ground motion. (for 0.2 second period)
S_1	0.6	MCE_R ground motion. (for 1.0s period)
S_{MS}	1.5	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	1	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	null -See Section 11.4.8	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	null -See Section 11.4.8	Site amplification factor at 1.0 second
PGA	0.518	MCE_G peak ground acceleration
F_{PGA}	1.1	Site amplification factor at PGA
PGA_M	0.57	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	2.054	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	2.142	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.763	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.817	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.518	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.959	Mapped value of the risk coefficient at short periods

Type	Value	Description
C_{R1}	0.935	Mapped value of the risk coefficient at a period of 1 s

Wind Load Analysis - Main Wind-Force Resisting System

Design Per ASCE 7-16 Code for Enclosed Buildings

Input Data:

Wind Speed, V =	99	mph (ATC Hazards by Location)
Bldg. Classification =	III	
Exposure Category =	C	
Ridge Height, hr =	95	ft.
Eave Height, he =	83	ft.
Building Width =	309	ft.
Building Length =	463	ft.
Roof Type =	Monoslope	(Gable or Monoslope)
Topographic Factor, Kzt =	1	
Directionality Factor, Kd =	0.85	
Enclosed? (Y/N)	Y	
Hurrican Region?	N	
Component Name =	Wall	
Effective Area, Ae =	900	ft^2 (Area Tributary to C&C)

Parameters and Coefficients:

Roof Angle, q =	2.22	deg.
Mean Roof Ht., h =	83	ft. (h = (hr+he)/2, for roof angle >10 deg.)

Wall External Pressure Coefficients, GCp:

GCp Zone 4 Pos. =	0.60	
GCp Zone 5 Pos. =	0.60	
GCp Zone 4 Neg. =	-0.70	
GCp Zone 5 Neg. =	-1.00	

Positive & Negative Internal Pressure Coefficients, GCpi:

+GCpi Coef. =	0.18	(positive internal pressure)
-GCpi Coef. =	-0.18	(negative internal pressure)

If z <= 15 then: Kz = 2.01*(15/zg)^(2/a) ,If z > 15 then: Kz = 2.01*(z/zg)^(2/a) (Table 30.3-1)

Wind Shear Exponent, α =	9.5	
Terrain Exposure Constant, zg =	900	
Velocity Pressure Coeff., Kz =	1.217	(Kh = Kz)

Velocity Pressure: qz = 0.00256*Kz*Kzt*Kd*V^2(Sect. 30.3.2, Eq. 30.3-1)

qz = 26.0 psf   qh = 0.00256*Kh*Kzt*Kd*V^2(qz evaluated at z = h)

Design Net External Wind Pressures (Sect. 30.4 & 30.6):

For h <= 60 ft.:p = qh*((GCp) - (+/-GCpi))(psf)

For h >60 ft.:p = q*(GCp) - qi*(+/-GCpi)(psf)

where: q = qz for windward walls,q = qh for leeward walls and side walls

qi = qh for all walls (conservatively assumed per Sect. 30.6)

Wind Load Tabulation for Wall Components & Cladding							
Component	z	Kz	qh	p = Net Design Pressures (psf)			
	(ft.)		(psf)	Zone 4 (+)	Zone 4 (-)	Zone 5 (+)	Zone 5 (-)
Wall	0	0.85	18.128	15.55	-4.80	15.55	-4.85
	15	0.85	18.128	15.55	-4.80	15.55	-4.85
	20	0.902	19.234	16.21	-4.80	16.21	-4.85
	25	0.945	20.160	16.77	-4.80	16.77	-4.85
	30	0.982	20.948	17.24	-4.80	17.24	-4.85
	35	1.015	21.639	17.66	-4.80	17.66	-4.85
	40	1.044	22.256	18.03	-4.80	18.03	-4.85
	45	1.070	22.815	18.36	-4.80	18.36	-4.85
	50	1.094	23.327	18.67	-4.80	18.67	-4.85
	55	1.116	23.800	18.95	-4.80	18.95	-4.85
	60	1.137	24.240	19.22	-4.80	19.22	-4.85
	65	1.156	24.652	19.46	-4.80	19.46	-4.85
	70	1.174	25.039	19.70	-4.80	19.70	-4.85
	75	1.191	25.406	19.91	-4.80	19.91	-4.85
	80	1.208	25.753	20.12	-4.80	20.12	-4.85
	85	1.223	26.084	20.32	-4.80	20.32	-4.85
	90	1.238	26.400	20.51	-4.80	20.51	-4.85
For z=hr:	95	1.252	26.702	20.69	-4.80	20.69	-4.85
For z = he:	83	1.217	25.954	20.24	-4.67	20.24	-30.63
For z = h:	83	1.217	25.954	20.24	-4.67	20.24	-30.63

Notes: 1. (+) and (-) signs signify wind pressures acting toward & away from respective surfaces.

2. Width of Zone 5 (end zones), 'α' = 30.9 ft.

3. Per Code Section 30.2.2, the minimum wind load for C&C shall not be less than 16 psf.

LATERAL DESIGN

Equivalent Lateral Force - Special Reinforced Concrete Shear Wall

Design Per ASCE 7-16 Code

Building Classification

Structure Type =	All other structures		
Soil Site Class =	D	(Assumption)	
Building Risk Category =	III		
Response Spectral Acc. (0.2 sec) S_s =	1.5	g	
Response Spectral Acc. (1.0 sec) S_1 =	0.6	g	
Site Coefficient, F_a =	1.0		
Site Coefficient, F_v =	1.5		
S_{DS} =	1.0		
S_{D1} =	0.6		
Long Period = T_L =	12	sec	
Importance Factor = I_e =	1.25		(ASCE 7 Table 1.5-2)
Response Modification Coefficient = R =	5	for Special Reinforced Concrete Shear Wall	
Deflection Amplification Factor = C_d =	5		(ASCE 7 Table 12.2-1)
Story Heigh Below Level x = h_{sx} =	15	ft	

Approximate Period

C_t =	0.03		(ASCE 7 Table 12.8-2, "Steel eccentrically braced frames")
x =	0.75		(ASCE 7 Table 12.8-2, "Steel eccentrically braced frames")
Height to the Top of the Structure = h_n =	77	ft	
Approximate Period = T_a =	0.78	secs	(ASCE 7 12.8-7)

Seismic Response Coeffecient

C_s =	0.250		
C_{s_max} =	0.192	for T < T_L	(ASCE 7 12.8-3) **Governs**
C_{s_min1} =	0.055		(ASCE 7 12.8-5)
C_{s_min2} =	0.075		(ASCE 7 12.8-6)
$C_{s\_governs}$ =	**0.192**		

Base Shear

Total Weight = W =	37199	kips
Base Shear = V =	7155	kips

Lateral Force at Each Level

Level	Weight (kips)	Height (ft)	$W_x h_x$^k	C_{vx}	Fx
Roof	6707	77	948279	0.225	1610
6	8230	67	992973	0.236	1686
5	7577	57	760385	0.180	1291
4	7577	47	610289	0.145	1036
3	7577	37	464626	0.110	789
2	7577	27	324430	0.077	551
1	5159	15	113028	0.027	192
			4214011	1.0	7155

where: k = 1.14

Overturning Moment

OTM =	406189	kft

Story Shears

V_1 =	7155	kip
V_2 =	6963	kip
V_3 =	6413	kip
V_4 =	5624	kip
V_5 =	4587	kip
V_6 =	3296	kip
V_{Roof} =	1610	kip

Allowable Story Drift

Allowable Story Drift = Δ_a =	0.27	in	(ASCE 7 Table 12.12-1)
Design Story Drift = Δ_s =	0.068	in	

Shear Modulus

Weight of Material = W =	145	pcf
Compressive Strength = f'c =	4000	psi
Poisson's Ratio = v =	0.3	
Modulus of Elasticity of the Material = E =	3.64E+06	psi
Shear Modulus = G =	1.40E+06	psi

Required Wall Thickness

Total Length of Shear Walls in x-direction	242.9	ft	
Total Length of Shear Walls in y-direction	125.6	ft	
Lateral Force in x-direction = L_x =	0.034	klf	
Lateral Force in y-direction = L_y =	0.0176	klf	
Thickness of Walls in x-direction =	**0.0054**	**in**	
Thickness of Walls in y-direction =	**0.00278**	**in**	
Therefore by ACI 318, Use:	**8**	**in**	(ACI 318, Table 11.3.1.1, p.164)

Special Reinforced Concrete Shear Wall Design

Design Per ASCE 7-16 Code, ACI 318, & SEAOC Bluebook

Building Geometry

Soil Site Class =	D		
Risk Category =	III		
Response Spectral Acc. (0.2 sec) Ss =	1.5		
Response Spectral Acc. (1.0 sec) S1 =	0.6		
Redundancy Factor = ρ =	1.0	(ASCE 7 12.3.4.2)	
Seismic Importance Factor = I_e =	1.0		
Concrete Strength = f'c =	4000	psi	
Steel Yield Strength = fy =	60	ksi	
Number of Stories = n =	7	stories	

Load Combinations for Design

1.2D + 1.0E + L =	8046	psf	**Governs**
0.9D + 1.0E =	7613	psf	

Actions at Base of Wall

Governing Axial Force at Base of Wall =	3593	kips
Governing Moment at Base of Wall =	37357	kip-ft
Governing Shear at Base of Wall =	870	kips

Preliminary Sizing of Wall

Wall Length = l_w =	343	in
Wall Thickness = b =	**14**	**in**

Minimum Thickness to Prevent Wall Buckling (SEAOC Blue Book)

Clear Height at First Story = l_n =	15	ft	
Recommended Thickness =	11.3	in	**OK**

Layout of Vertical Reinforcement

Bar Size =	**#8**		
Area of Steel = A_s =	0.79	in^2	For ease of construction
Longitudinal Vertical Bar Spacing =	10	in o.c.	**OK**
Minimum Reinforcement Ratio = ρ_p =	0.0056		**OK**

Flexural Strength at Base of Wall (ACI 318 Section 21.2)

Strength Reduction Factor = Φ =	0.65	(0.002<Steel Stress<0.005 - Compression-Controlled)	
Nominal Axial Force = P_n =	5527	kips	
Nominal Moment Strength = ΦM_n =	61986	kip-ft	**OK**

Lab Splice Length (ACI 318 Section 25.5)

Ψ_t =	1.0	(Vertical Bars)	
Ψ_e =	1.0	(Uncoated Reinforcement)	
Ψ_s =	1.0	(#7 Bars or Larger)	
λ =	1.0	(Normal Weight Concrete)	
Diameter of Rebar = d_b =	1.0	in	
K_{tr} =	0	(No transverse reinforcement that "croses the potential plane of splitting")	
Cover Measured From Center of Bar = c_b =	2.00	in	(With 1.5" Cover)
Length of Splice = l_d =	35.6	in	
Required Length for Class B Lap Splice =	3.85	ft	

Splices in Plastic-Hinge Regions

Equivalent Plastic-Hinge Length = l_p =	8.7	ft	

Shear Strength of Wall (SEAOC Blue Book)

α_c =	1.0		
Shear Demand = V_u = V_E =	870	kips	
Shear Amplification Factor = ω_v =	1.53	for buildings over 6 stories (Recommendation)	
Magnified Shear Demand = V_u^* =	2215	kips	at the base of the wall
A_{cv} =	4802	in^2	
Required Horizontal Reinforcement = ρ_t =	0.000009		
Try Bar Size =	#7	@ 10 in o.c. each face	
Required Horizontal Reinforcement = ρ_t =	00857142857		**OK**
Shear Capacity = ΦV_n =	1664	kips	

Shear Friction (Sliding Shear) Strength of Wall

Shear-Transfer Reinforcement = A_{vf} =	34.8	in^2	
Coefficient of Friction = μ =	1.0	(Construction joint at the 1st story with the surface roughened)	
Permanent Net Compression = V_n =	5397	kips	**No Good** (ACI 318 Eq 22.9..4.2)

Requirement for Special Boundary Elements

Design Displacement = δ_u =	1.89	in	(Assumption Based on ASCE 7 Requirements)
δ_u/h_w =	0.0105		**Does Not Govern**
Special Boundary Elements Check "c" =	36.3	in	**Special Boundary Elements are NOT REQUIRED**

Concrete Diaphragm Design

Design Per ASCE 7-16 Code & ACI 318

Building Classification

Seismic Design Category =	D	
Soil Site Class =	D	(Assumption)
Building Risk Category =	III	
Response Spectral Acc. (0.2 sec) S_s =	1.5	g
Response Spectral Acc. (1.0 sec) S_1 =	0.6	g
Site Coefficient, F_a =	1.0	
Site Coefficient, F_v =	1.5	
S_{DS} =	1.0	
S_{D1} =	0.6	
Redundancy Factor = ρ =	1.0	(ASCE 7 12.3.4.2)
Concrete Strength = f'c =	4000	psi
Steel Yield Strength = fy =	60	ksi
Modulus of Elasticity of Concrete = E =	3605	ksi

Diaphragm Design Forces

Level	Wpx (kip)	Sum Wpx (kip)	Fx (kip)	Sum Fx (kip)	Sum Fx/Sum Wpx	Fpx (kip)	Fpx/Fx
Roof	6707	6707	1610	1610	0.240	1610	1.00
6	8230	14937	1686	3296	0.221	1816	1.08
5	7577	22514	1291	4587	0.204	1544	1.20
4	7577	30091	1036	5624	0.200	1515	1.46
3	7577	37668	789	6413	0.200	1515	1.92
2	7577	45245	551	6963	0.200	1515	2.75
	45245		6963				

Height of First Floor = floor1 =	15	
Height of First 2 Floors = floor2 =	27	

N-S Direction

Wall	Length (in)	Width (in)	Moment of Inertia (ft^3)	Stiffness (k1) for First Floor	Stiffness (k2) for First 2 Floors	2nd Floor Force (kips)	3rd Floor Force (kips)
E - F	343	14	27245	14.27	4.40	1326	1221
E - F.8_14.3	582	14	133098	24.21	7.47	2250	2072
E - F.8_15	582	14	133098	24.21	7.47	2250	2072
J - K.5	294	14	17157	12.23	3.77	1137	1047
				74.9	23.1	6963	6413

E-W Direction

Wall	Length (in)	Width (in)	Moment of Inertia (ft^3)	Stiffness (k1) for First Floor	Stiffness (k2) for First 2 Floors	2nd Floor Force (kips)	3rd Floor Force (kips)
6 - 7.4	398	14	42565	16.6	5.11	951	876
8 - 9.1	324	14	22964	13.5	4.16	774	713
12.3 - 14	679	14	211355	28.2	8.72	1623	1495
7.1 - 8_D	378	14	36465	15.7	4.85	904	832
11.1 - 12.3_D	378	14	36465	15.7	4.85	904	832
7.1 - 8_K	378	14	36465	15.7	4.85	904	832
11.1 - 12.3_K	378	14	36465	15.7	4.85	904	832
				121	37.4	6963	6413

Slab Shear

Max. Shear =	2250	kip
Width of Slab =	331	ft
Shear Demand = Vud =	6.81	k/ft
Strength Reduction Factor = Φ =	0.75	(ACI 318, Section 9.3.2)
Thickness of Slab =	6.25	in

Note: Ignore Steel (Concrete Only)

Shear Capacity = ΦVn =	7.12	k/ft	**OK**	(ACI 318, Section 21.11.9)
Max. Shear Capacity = ΦVnmax =	0.4	k/ft	**OK**	

Chords

Moment = Mu =	33755	k-ft	
Depth = D =	202	ft	
Tension Demand = Tu =	167	kip	

Chord Reinforcing

Strength Reduction Factor = Φ =	0.9		
Area of Steel Required = Asreq'd =	3.10	in^2	
Use Rebar =	#7	bars	
# of Bars =	6	bars	
Total Area of Steel = As =	3.6	in^2	**OK**

Collectors

Max Diaphragm Load Transferred to Wall =	490	kip
Diaphragm Width =	331	ft
Load Along Diaphragm =	1.48	k/ft
Load Collected Before Wall =	39.2	kip
Rho =	2.5	
Rho*Fpx =	83.4	kip

Tension Collector Reinforcing

Strength Reduction Factor = Φ =	0.9		
Area of Steel Required = Asreq'd =	1.54	in^2	
Use:	#5		
	5	bars	
Total Area of Steel = As =	1.6	in^2	**OK**

Table 12.2-1 Design Coefficients and Factors for Seismic Force-Resisting Systems

Seismic Force-Resisting System	ASCE 7 Section Where Detailing Requirements Are Specified	Response Modification Coefficient, R[a]	Overstrength Factor, Ω_0[b]	Deflection Amplification Factor, C_d[c]	Structural System Limitations Including Structural Height, h_n (ft) Limits[d] — Seismic Design Category: B	C	D[e]	E[e]	F[f]
A. BEARING WALL SYSTEMS									
1. Special reinforced concrete shear walls[g,h]	14.2	5	2½	5	NL	NL	160	160	100
2. Ordinary reinforced concrete shear walls[g]	14.2	4	2½	4	NL	NL	NP	NP	NP
3. Detailed plain concrete shear walls[g]	14.2	2	2½	2	NL	NP	NP	NP	NP
4. Ordinary plain concrete shear walls[g]	14.2	1½	2½	1½	NL	NP	NP	NP	NP
5. Intermediate precast shear walls[g]	14.2	4	2½	4	NL	NL	40[i]	40[i]	40[i]
6. Ordinary precast shear walls[g]	14.2	3	2½	3	NL	NP	NP	NP	NP
7. Special reinforced masonry shear walls	14.4	5	2½	3½	NL	NL	160	160	100
8. Intermediate reinforced masonry shear walls	14.4	3½	2½	2¼	NL	NL	NP	NP	NP
9. Ordinary reinforced masonry shear walls	14.4	2	2½	1¾	NL	160	NP	NP	NP
10. Detailed plain masonry shear walls	14.4	2	2½	1¾	NL	NP	NP	NP	NP
11. Ordinary plain masonry shear walls	14.4	1½	2½	1¼	NL	NP	NP	NP	NP
12. Prestressed masonry shear walls	14.4	1½	2½	1¾	NL	NP	NP	NP	NP
13. Ordinary reinforced AAC masonry shear walls	14.4	2	2½	2	NL	35	NP	NP	NP
14. Ordinary plain AAC masonry shear walls	14.4	1½	2½	1½	NL	NP	NP	NP	NP
15. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance	14.5	6½	3	4	NL	NL	65	65	65
16. Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets	14.1	6½	3	4	NL	NL	65	65	65
17. Light-frame walls with shear panels of all other materials	14.1 and 14.5	2	2½	2	NL	NL	35	NP	NP
18. Light-frame (cold-formed steel) wall systems using flat strap bracing	14.1	4	2	3½	NL	NL	65	65	65
B. BUILDING FRAME SYSTEMS									
1. Steel eccentrically braced frames	14.1	8	2	4	NL	NL	160	160	100
2. Steel special concentrically braced frames	14.1	6	2	5	NL	NL	160	160	100
3. Steel ordinary concentrically braced frames	14.1	3¼	2	3¼	NL	NL	35[j]	35[j]	NP[j]
4. Special reinforced concrete shear walls[g,h]	14.2	6	2½	5	NL	NL	160	160	100
5. Ordinary reinforced concrete shear walls[g]	14.2	5	2½	4½	NL	NL	NP	NP	NP
6. Detailed plain concrete shear walls[g]	14.2 and 14.2.2.7	2	2½	2	NL	NP	NP	NP	NP
7. Ordinary plain concrete shear walls[g]	14.2	1½	2½	1½	NL	NP	NP	NP	NP
8. Intermediate precast shear walls[g]	14.2	5	2½	4½	NL	NL	40[i]	40[i]	40[i]
9. Ordinary precast shear walls[g]	14.2	4	2½	4	NL	NP	NP	NP	NP
10. Steel and concrete composite eccentrically braced frames	14.3	8	2½	4	NL	NL	160	160	100
11. Steel and concrete composite special concentrically braced frames	14.3	5	2	4½	NL	NL	160	160	100
12. Steel and concrete composite ordinary braced frames	14.3	3	2	3	NL	NL	NP	NP	NP
13. Steel and concrete composite plate shear walls	14.3	6½	2½	5½	NL	NL	160	160	100
14. Steel and concrete composite special shear walls	14.3	6	2½	5	NL	NL	160	160	100
15. Steel and concrete composite ordinary shear walls	14.3	5	2½	4½	NL	NL	NP	NP	NP
16. Special reinforced masonry shear walls	14.4	5½	2½	4	NL	NL	160	160	100
17. Intermediate reinforced masonry shear walls	14.4	4	2½	4	NL	NL	NP	NP	NP

Equivalent Lateral Force - Steel Special Moment Frame

Design Per ASCE 7-16 Code

Building Classification

Structure Type =	All other structures		
Soil Site Class =	D	(Assumption)	
Building Risk Category =	III		
Response Spectral Acc. (0.2 sec) S_s =	1.5	g	
Response Spectral Acc. (1.0 sec) S_1 =	0.6	g	
Site Coefficient, F_a =	1.0		
Site Coefficient, F_v =	1.5		
S_{DS} =	1.0		
S_{D1} =	0.6		
Long Period = T_L =	12	sec	
Importance Factor = I_e =	1.25		(ASCE 7 Table 1.5-2)
Response Modification Coefficient = R =	8	for Steel Special Moment Frame	
Deflection Amplification Factor = C_d =	5.5		(ASCE 7 Table 12.2-1)

Approximate Period

C_t =	0.028		(ASCE 7 Table 12.8-2, "Steel eccentrically braced frames")
x =	0.8		(ASCE 7 Table 12.8-2, "Steel eccentrically braced frames")
Height to the Top of the Structure = h_n =	77	ft	
Approximate Period = T_a =	0.90	secs	(ASCE 7 12.8-7)

Seismic Response Coeffecient

C_s =	0.156		
C_{s_max} =	0.104	for $T < T_L$	(ASCE 7 12.8-3) **Governs**
C_{s_min1} =	0.055		(ASCE 7 12.8-5)
C_{s_min2} =	0.047		(ASCE 7 12.8-6)
$C_{s\_governs}$ =	**0.104**		

Base Shear

Total Weight = W =	28283	kips
Base Shear = V =	2932	kips

Lateral Force at Each Level

Level	Weight (kips)	Height (ft)	$W_x h_x$^k	C_{vx}	Fx
Roof	6707	77	1242895	0.230	675
6	8230	67	1290248	0.239	700
5	7577	57	978131	0.181	531
4	7577	47	775677	0.144	421
3	7577	37	581806	0.108	316
2	7577	27	398357	0.074	216
1	5159	15	133794	0.025	73
			5400908	1.0	2932

where: k = 1.20

Overturning Moment

OTM = 167550 kft

Story Shears

V_1 =	2932	kip
V_2 =	2859	kip
V_3 =	2643	kip
V_4 =	2327	kip
V_5 =	1906	kip
V_6 =	1375	kip
V_{Roof} =	675	kip

Steel Special Moment Frame Design

Design Per ASCE 7-16 Code

Building Classification

Risk Category =	III		
Importance Factor = I_e =	1.25		(Table 1.5-2)
Structure Type =	All other structures		
Response Modification Coefficient = R =	8		(Table 12.2-1)
Deflection Amplification Factor = C_d =	5.5		(Table 12.2-1)
Story Heigh Below Level x = h_{sx} =	12	ft	
Modulus of Elasticity = E =	29000	ksi	

Allowable Story Drift

Allowable Story Drift = Δ_a =	2.16	in
Design Story Drift = Δ_s =	0.49	in

Column Design (E-W direction) - Along Gridline A

Number of Moment Frames =	15		
Number of Lines =	3		
Number of Frames Per Line =	5		
Force in y-direction = Fy =	117	kips	
Required Moment of Inertia = Ix =	1537	in^4	
Use Column =	**W18X97**		
Moment of Intertia of Column =	1750	in^4	**OK**

Beam Design (E-W direction) - Along Grideline A

Span Length = L =	29.8	ft	
Tributary width =	29.1	ft	
Load = w =	4.0	klf	
Required Moment = M =	448	k-ft	
Use Beam =	**W18X60**		
Moment =	461	k-ft	**OK**

Column Design (E-W direction) - Along Gridline D & K

Number of Moment Frames =	15		
Number of Lines =	3		
Number of Frames Per Line =	4		
Force in y-direction = Fy =	147	kips	
Required Moment of Inertia = Ix =	1922	in^4	
Use Column =	**W18X119**		
Moment of Intertia =	2190	in^4	**OK**

Beam Design (E-W direction) - Along Gridline D & K

Span Length = L =	31.5	ft	
Tributary width =	30	ft	
Load = w =	4.9	klf	
Required Moment = M =	606	k-ft	
Use Beam =	**W18X76**		
Moment =	611	k-ft	**OK**

Column Design (E-W direction) - Along Gridline M

Number of Moment Frames =	15		
Number of Lines =	3		
Number of Frames Per Line =	6		
Force in y-direction = Fy =	98	kips	
Required Moment of Inertia = Ix =	1281	in^4	
Use Column =	**W18X76**		
Moment of Intertia =	1330	in^4	**OK**

Beam Design (E-W direction) - Along Gridline M

Span Length = L =	36.5	ft	
Tributary width =	20.1	ft	
Load = w =	4.9	klf	
Required Moment = M =	809	k-ft	
Use Beam =	**W21X93**		
Moment =	829	k-ft	**OK**

Column Design (N-S direction) - Along Gridline 1, 2.2 & 2.9

Number of Moment Frames in y-direction =	15		
Number of Lines =	3		
Number of Frames Per Line =	5		
Force in x-direction = Fx =	117	kips	
Required Moment of Inertia = Ix =	1537	in^4	
Use Column =	**W18X97**		
Moment of Intertia =	1750	in^4	**OK**

Beam Design (N-S direction) - Along Gridline 1, 2.2 & 2.9

Span Length = L =	40.8	ft	
Tributary width =	26.0	ft	
Load = w =	4.5	klf	
Required Moment = M =	936	k-ft	
Use Beam =	**W21X101**		
Moment =	949	k-ft	**OK**

Column Design (N-S direction) - Along Gridline 3.3, 8.9 & 14

Number of Moment Frames in y-direction =	15		
Number of Lines =	3		
Number of Frames Per Line =	5		
Force in x-direction = Fx =	117	kips	
Required Moment of Inertia = Ix =	1537	in^4	
Use Column =	**W18X97**		
Moment of Intertia =	1750	in^4	**OK**

Beam Design (N-S direction) - Along Gridline 3.3, 8.9 & 14

Span Length = L =	29.5	ft	
Tributary width =	20.4	ft	
Load = w =	5.7	klf	
Required Moment = M =	625	k-ft	
Use Beam =	**W21X73**		
Moment =	645	k-ft	**OK**

Column Design (N-S direction) - Along Gridline 14.3 & 15

Number of Moment Frames in y-direction =	15		
Number of Lines =	3		
Number of Frames Per Line =	5		
Force in x-direction = Fx =	117	kips	
Required Moment of Inertia = Ix =	1537	in^4	
Use Column =	**W18X97**		
Moment of Intertia =	1750	in^4	**OK**

Beam Design (N-S direction) - Along Gridline 14.3 & 15

Span Length = L =	24.5	ft	
Tributary width =	20.0	ft	
Load = w =	5.9	klf	
Required Moment = M =	440	k-ft	
Use Beam =	**W18X60**		
Moment =	461	k-ft	**OK**

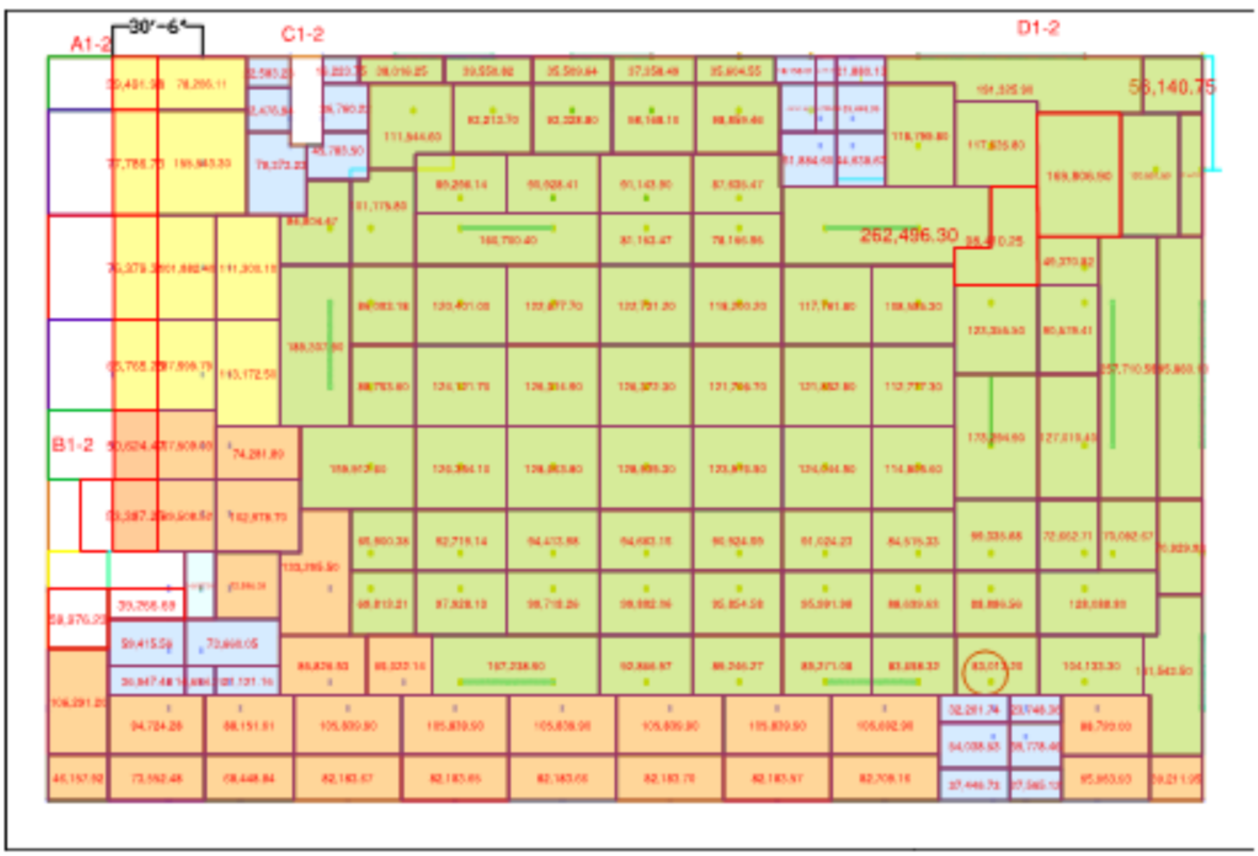
18. Ordinary reinforced masonry shear walls	14.4	2	2½	2	NL	160	NP	NP	NP
19. Detailed plain masonry shear walls	14.4	2	2½	2	NL	NP	NP	NP	NP
20. Ordinary plain masonry shear walls	14.4	1½	2½	1¼	NL	NP	NP	NP	NP
21. Prestressed masonry shear walls	14.4	1½	2½	1¾	NL	NP	NP	NP	NP
22. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance	14.5	7	2½	4½	NL	NL	65	65	65
23. Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets	14.1	7	2½	4½	NL	NL	65	65	65
24. Light-frame walls with shear panels of all other materials	14.1 and 14.5	2½	2½	2½	NL	NL	35	NP	NP
25. Steel buckling-restrained braced frames	14.1	8	2½	5	NL	NL	160	160	100
26. Steel special plate shear walls	14.1	7	2	6	NL	NL	160	160	100
C. MOMENT-RESISTING FRAME SYSTEMS									
1. Steel special moment frames	14.1 and 12.2.5.5	8	3	5½	NL	NL	NL	NL	NL
2. Steel special truss moment frames	14.1	7	3	5½	NL	NL	160	100	NP
3. Steel intermediate moment frames	12.2.5.7 and 14.1	4½	3	4	NL	NL	35[k]	NP[k]	NP[k]
4. Steel ordinary moment frames	12.2.5.6 and 14.1	3½	3	3	NL	NL	NP[l]	NP[l]	NP[l]
5. Special reinforced concrete moment frames[m]	12.2.5.5 and 14.2	8	3	5½	NL	NL	NL	NL	NL
6. Intermediate reinforced concrete moment frames	14.2	5	3	4½	NL	NL	NP	NP	NP
7. Ordinary reinforced concrete moment frames	14.2	3	3	2½	NL	NP	NP	NP	NP
8. Steel and concrete composite special moment frames	12.2.5.5 and 14.3	8	3	5½	NL	NL	NL	NL	NL
9. Steel and concrete composite intermediate moment frames	14.3	5	3	4½	NL	NL	NP	NP	NP
10. Steel and concrete composite partially restrained moment frames	14.3	6	3	5½	160	160	100	NP	NP
11. Steel and concrete composite ordinary moment frames	14.3	3	3	2½	NL	NP	NP	NP	NP
12. Cold-formed steel—special bolted moment frame[n]	14.1	3½	3[o]	3½	35	35	35	35	35
D. DUAL SYSTEMS WITH SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1. Steel eccentrically braced frames	14.1	8	2½	4	NL	NL	NL	NL	NL
2. Steel special concentrically braced frames	14.1	7	2½	5½	NL	NL	NL	NL	NL
3. Special reinforced concrete shear walls[g,h]	14.2	7	2½	5½	NL	NL	NL	NL	NL
4. Ordinary reinforced concrete shear walls[g]	14.2	6	2½	5	NL	NL	NP	NP	NP
5. Steel and concrete composite eccentrically braced frames	14.3	8	2½	4	NL	NL	NL	NL	NL
6. Steel and concrete composite special concentrically braced frames	14.3	6	2½	5	NL	NL	NL	NL	NL
7. Steel and concrete composite plate shear walls	14.3	7½	2½	6	NL	NL	NL	NL	NL
8. Steel and concrete composite special shear walls	14.3	7	2½	6	NL	NL	NL	NL	NL
9. Steel and concrete composite ordinary shear walls	14.3	6	2½	5	NL	NL	NP	NP	NP
10. Special reinforced masonry shear walls	14.4	5½	3	5	NL	NL	NL	NL	NL
11. Intermediate reinforced masonry shear walls	14.4	4	3	3½	NL	NL	NP	NP	NP
12. Steel buckling-restrained braced frames	14.1	8	2½	5	NL	NL	NL	NL	NL
13. Steel special plate shear walls	14.1	8	2½	6½	NL	NL	NL	NL	NL
E. DUAL SYSTEMS WITH INTERMEDIATE MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1. Steel special concentrically braced frames[p]	14.1	6	2½	5	NL	NL	35	NP	NP
2. Special reinforced concrete shear walls[g,h]	14.2	6½	2½	5	NL	NL	160	100	100
3. Ordinary reinforced masonry shear walls	14.4	3	3	2½	NL	160	NP	NP	NP
4. Intermediate reinforced masonry shear walls	14.4	3½	3	3	NL	NL	NP	NP	NP

continues

GRAVITY DESIGN

Gravity Column Schedule

Gravity Columns	Largest Trib. Area (in^2)	Largest Trib. Area (ft^2)	Dead (psf)	Live (psf)	Roof Live (psf)	Dead (kips)	Live (kips)	Roof Live (kips)	Sizes
A1-2	155543	1080	471	240	20	509	260	22	W12X106
B1-2	133296	926	471	240	20	436	223	19	W12X96
C1-2	79373	551	471	240	20	260	133	12	W12X65
D1-2	169807	1179	509	260	20	601	307	24	Conc. COL
A3-4	155543	1080	331	160	20	358	173	22	W12X72
B3-4	133296	926	331	160	20	307	149	19	W12X65
C3-4	79373	551	331	160	20	183	89	12	W12X45
D3-4	169807	1179	331	160	20	391	189	24	W12X79
D3-4 (Corridor))	169807	1179	331	240	20	391	284	24	W12X96
A5-6	155543	1080	191	80	20	207	87	22	W12X50
B5-6	133296	926	191	80	20	177	75	19	W12X45
C5-6	79373	551	191	80	20	106	45	12	W12X40
D5-6	169807	1179	191	80	20	226	95	24	W12X53
D5-6 (Corridor)	169807	1179	191	120	20	226	142	24	W12X58
A7-Roof	155543	1080	121	40	20	131	44	22	W12X40
B7-Roof	133296	926	121	40	20	113	38	19	W12X40
C7-Roof	79373	551	121	40	20	67	23	12	W10X22
D7-Roof	169807	1179	121	40	20	143	48	24	W10X33
D7-Roof (Corrrdior)	169807	1179	121	60	20	143	71	24	W10X39



Steel Column

Description : A1-2 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x106**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 15.0 ft
Top & Bottom Fixity Top Pinned, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for X-X Axis buckling = 15.0 ft, K = 0.80
Y-Y (depth) axis :
Unbraced Length for Y-Y Axis buckling = 15.0 ft, K = 0.80

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 1,590.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Up: Axial Load at 15.0 ft, D = 509.0, LR = 22.0, L = 260.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = 0.8662 : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 1,039.71 k
0.9 * Pn 1,200.30 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 591.28 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 281.625 k-ft

PASS Maximum Shear Stress Ratio = 0.0 : 1
Load Combination
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0 ft above base
for load combination :
Along X-X 0.0 in at 0.0 ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.596	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.866	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D+1.60L	0.857	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.756	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.540	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D+L	0.727	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D	0.510	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.736	PASS	0.00 ft	0.000	PASS	0.00 ft
+0.90D	0.383	PASS	0.00 ft	0.000	PASS	0.00 ft
+1.40D+L	0.812	PASS	0.00 ft	0.000	PASS	0.00 ft
+0.70D	0.298	PASS	0.00 ft	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X @ Top	Y-Y Axis Reaction @ Base	Y-Y @ Top	Mx - End Moments (k-ft) @ Base	Mx @ Top	My - End Moments @ Base	My @ Top
D Only	510.590								
+D+L	770.590								
+D+Lr	532.590								

Steel Column

Description : A1-2 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction @ Base	k @ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	k-ft @ Top	My - End Moments @ Base	@ Top
+D+0.750Lr+0.750L	722.090								
+D+0.750L	705.590								
+0.60D	306.354								
Lr Only	22.000								
L Only	260.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction @ Base	k @ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	k-ft @ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	770.590								
"	Minimum	22.000								
Reaction, X-X Axis Base	Maximum	510.590								
"	Minimum	510.590								
Reaction, Y-Y Axis Base	Maximum	510.590								
"	Minimum	510.590								
Reaction, X-X Axis Top	Maximum	510.590								
"	Minimum	510.590								
Reaction, Y-Y Axis Top	Maximum	510.590								
"	Minimum	510.590								
Moment, X-X Axis Base	Maximum	510.590								
"	Minimum	510.590								
Moment, Y-Y Axis Base	Maximum	510.590								
"	Minimum	510.590								
Moment, X-X Axis Top	Maximum	510.590								
"	Minimum	510.590								
Moment, Y-Y Axis Top	Maximum	510.590								
"	Minimum	510.590								

Maximum Deflections for Load Combinations

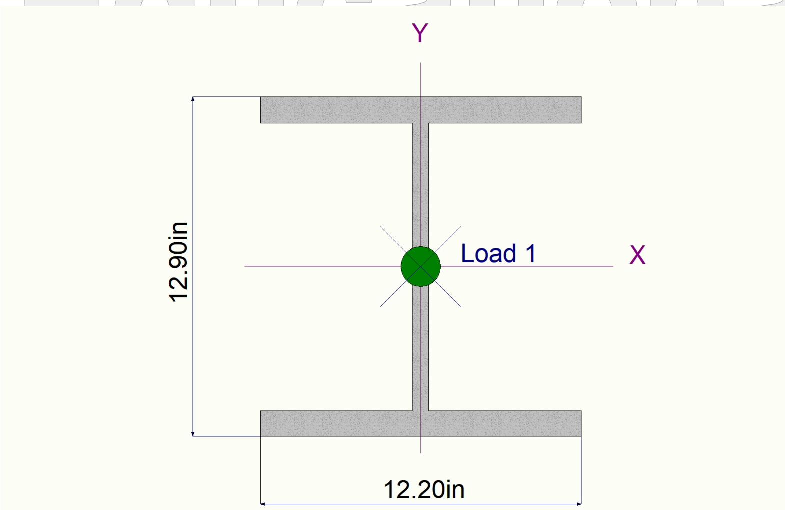
Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

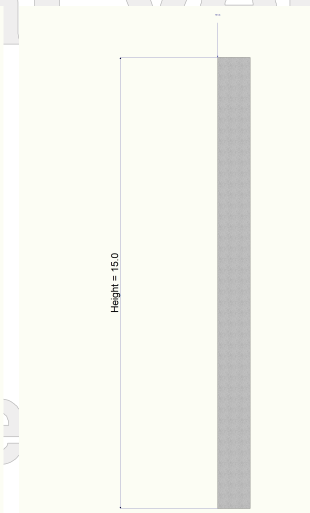
Steel Section Properties : W12x106

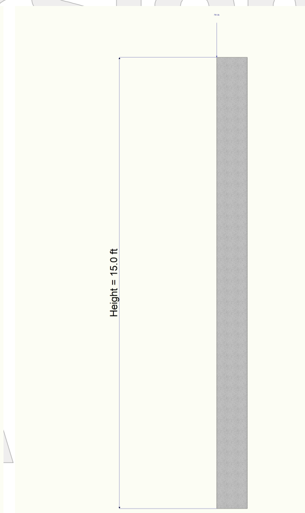
Depth	=	12.900	in	I xx	=	933.00	in^4	J	=	9.130	in^4
Web Thick	=	0.610	in	S xx	=	145.00	in^3	Cw	=	10700.00	in^6
Flange Width	=	12.200	in	R xx	=	5.470	in				
Flange Thick	=	0.990	in	Zx	=	164.000	in^3				
Area	=	31.200	in^2	I yy	=	301.000	in^4				
Weight	=	106.000	plf	S yy	=	49.300	in^3	Wno	=	36.300	in^2
Kdesign	=	1.590	in	R yy	=	3.110	in	Sw	=	110.000	in^4
K1	=	1.125	in	Zy	=	75.100	in^3	Qf	=	34.200	in^3
rts	=	3.520	in	rT	=	0.000	in	Qw	=	81.000	in^3
Ycg	=	0.000	in								

Description : A1-2 STL COLS

Sketches







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Title Block Line 6

Project Title:
Engineer:
Project ID:
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Steel Column

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DESCRIPTION: A3-4 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x72**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 720.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Up: Axial Load at 10.0 ft, D = 358.0, LR = 22.0, L = 173.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.8478** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 718.26 k
0.9 * Pn 847.26 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 405.0 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 184.50 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0 ft above base
for load combination :
Along X-X 0.0 in at 0.0 ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.593	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.848	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D+1.60L	0.835	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.754	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.550	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D+L	0.712	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D	0.508	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.725	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+0.90D	0.381	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+1.40D+L	0.797	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft
+0.70D	0.296	PASS	0.00 ft	1.00	1.00	39.47	22.60	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	358.720								
+D+L	531.720								
+D+Lr	380.720								
+D+0.750Lr+0.750L	504.970								

Steel Column

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DESCRIPTION: A3-4 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	488.470								
+0.60D	215.232								
Lr Only	22.000								
L Only	173.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	531.720								
"	Minimum	22.000								
Reaction, X-X Axis Base	Maximum	358.720								
"	Minimum	358.720								
Reaction, Y-Y Axis Base	Maximum	358.720								
"	Minimum	358.720								
Reaction, X-X Axis Top	Maximum	358.720								
"	Minimum	358.720								
Reaction, Y-Y Axis Top	Maximum	358.720								
"	Minimum	358.720								
Moment, X-X Axis Base	Maximum	358.720								
"	Minimum	358.720								
Moment, Y-Y Axis Base	Maximum	358.720								
"	Minimum	358.720								
Moment, X-X Axis Top	Maximum	358.720								
"	Minimum	358.720								
Moment, Y-Y Axis Top	Maximum	358.720								
"	Minimum	358.720								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

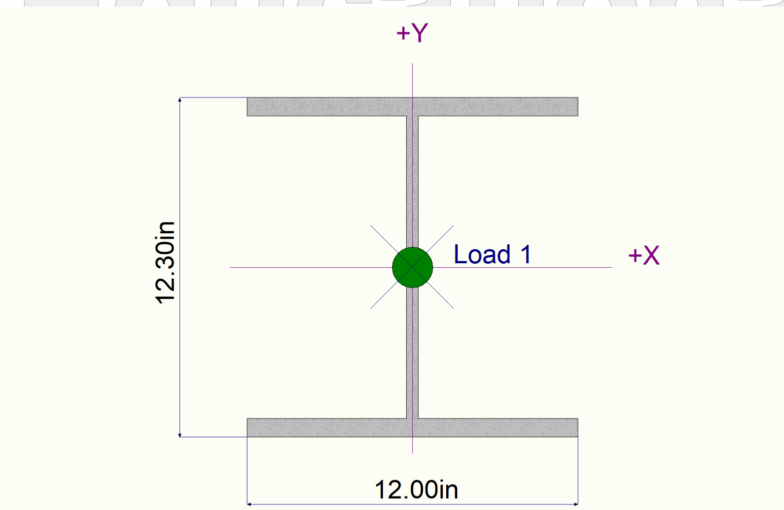
Steel Section Properties : W12x72

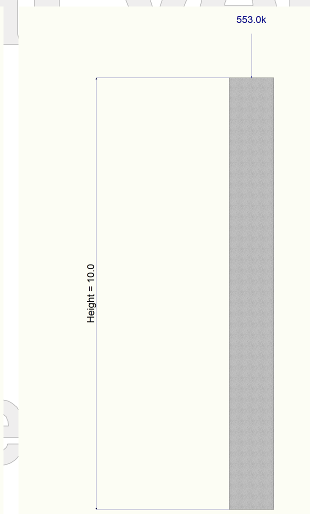
Depth	=	12.300	in	I xx	=	597.00	in^4	J	=	2.930	in^4
Web Thick	=	0.430	in	S xx	=	97.40	in^3	Cw	=	6,540.00	in^6
Flange Width	=	12.000	in	R xx	=	5.310	in				
Flange Thick	=	0.670	in	Zx	=	108.000	in^3				
Area	=	21.100	in^2	I yy	=	195.000	in^4				
Weight	=	72.000	plf	S yy	=	32.400	in^3	Wno	=	34.900	in^2
Kdesign	=	1.270	in	R yy	=	3.040	in	Sw	=	70.100	in^4
K1	=	1.063	in	Zy	=	49.200	in^3	Qf	=	22.500	in^3
rts	=	3.410	in					Qw	=	53.200	in^3
Ycg	=	0.000	in								

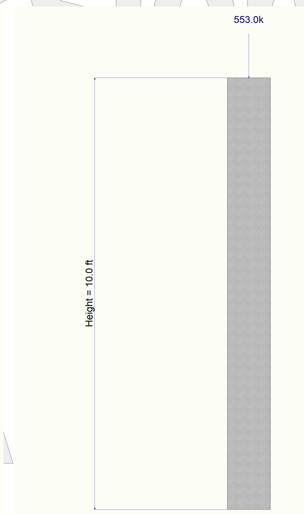
Steel Column

DESCRIPTION: A3-4 STL COLS

Sketches







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Steel Column

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: A5-6 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x50**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 500.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Up: Axial Load at 10.0 ft, D = 207.0, LR = 22.0, L = 87.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7992** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 399.20 k
0.9 * Pn 499.50 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 251.259 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 79.875 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.582	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.799	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D+1.60L	0.777	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.743	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.569	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D+L	0.673	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D	0.498	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.695	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+0.90D	0.374	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+1.40D+L	0.756	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft
+0.70D	0.291	PASS	0.00 ft	1.00	1.00	61.22	23.17	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	207.500								
+D+L	294.500								
+D+Lr	229.500								
+D+0.750Lr+0.750L	289.250								

Steel Column

DESCRIPTION: A5-6 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction @ Base	@ Top	k	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	@ Top	k-ft	My - End Moments @ Base	@ Top
+D+0.750L	272.750										
+0.60D	124.500										
Lr Only	22.000										
L Only	87.000										

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction @ Base	@ Top	k	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	@ Top	k-ft	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	294.500										
"	Minimum	22.000										
Reaction, X-X Axis Base	Maximum	207.500										
"	Minimum	207.500										
Reaction, Y-Y Axis Base	Maximum	207.500										
"	Minimum	207.500										
Reaction, X-X Axis Top	Maximum	207.500										
"	Minimum	207.500										
Reaction, Y-Y Axis Top	Maximum	207.500										
"	Minimum	207.500										
Moment, X-X Axis Base	Maximum	207.500										
"	Minimum	207.500										
Moment, Y-Y Axis Base	Maximum	207.500										
"	Minimum	207.500										
Moment, X-X Axis Top	Maximum	207.500										
"	Minimum	207.500										
Moment, Y-Y Axis Top	Maximum	207.500										
"	Minimum	207.500										

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

Steel Section Properties : W12x50

Depth	=	12.200	in	I xx	=	391.00	in^4	J	=	1.710	in^4
Web Thick	=	0.370	in	S xx	=	64.20	in^3	Cw	=	1,880.00	in^6
Flange Width	=	8.080	in	R xx	=	5.180	in				
Flange Thick	=	0.640	in	Zx	=	71.900	in^3				
Area	=	14.600	in^2	I yy	=	56.300	in^4				
Weight	=	50.000	plf	S yy	=	13.900	in^3	Wno	=	23.400	in^2
Kdesign	=	1.140	in	R yy	=	1.960	in	Sw	=	30.200	in^4
K1	=	0.938	in	Zy	=	21.300	in^3	Qf	=	14.300	in^3
rts	=	2.250	in					Qw	=	35.400	in^3
Ycg	=	0.000	in								

Title Block Line 1
You can change this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 31 MAR 2020, 1:56PM

Steel Column

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6
Software copyright ENERCALC, INC. 1983-2020, Build:12.20.2.24

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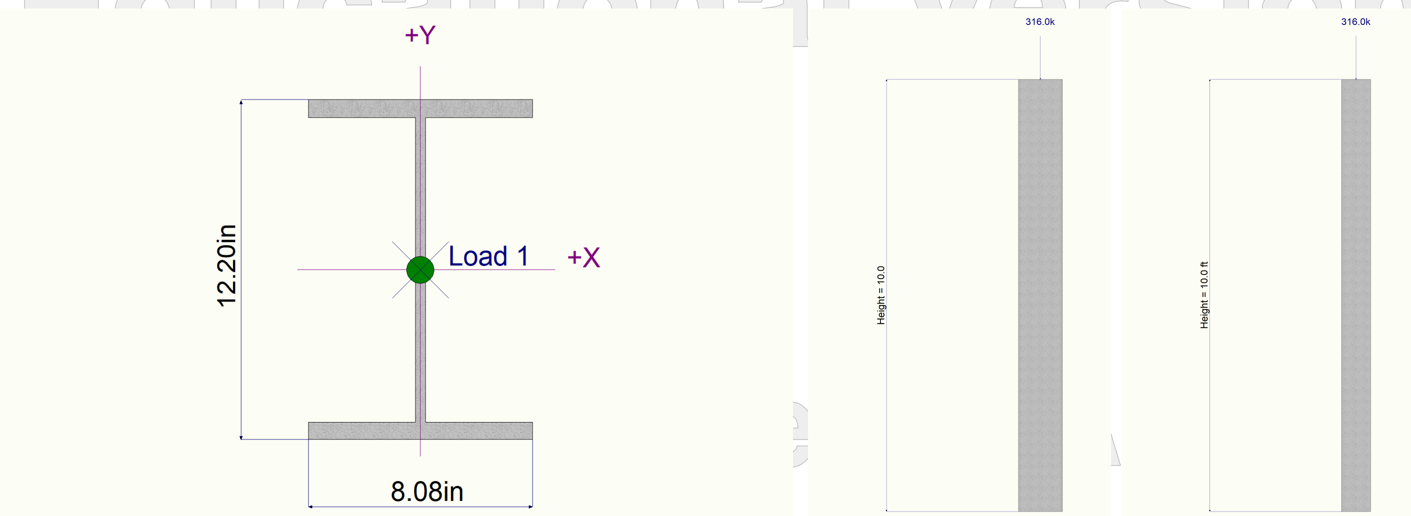
DESCRIPTION: A5-6 STL COLS

Sketches



Steel Column

DESCRIPTION: A7-Roof STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x40**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 400.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Up: Axial Load at 10.0 ft, D = 131.0, LR = 22.0, L = 44.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.6007** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 239.080 k
0.9 * Pn 398.017 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 196.456 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 63.0 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0 ft above base
for load combination :
Along X-X 0.0 in at 0.0 ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.462	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.601	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60L	0.573	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.595	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.485	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+L	0.507	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D	0.396	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.534	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+0.90D	0.297	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.40D+L	0.573	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+0.70D	0.231	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	131.400								
+D+L	175.400								
+D+Lr	153.400								
+D+0.750Lr+0.750L	180.900								

Steel Column

DESCRIPTION: A7-Roof STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	164.400								
+0.60D	78.840								
Lr Only	22.000								
L Only	44.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	180.900								
"	Minimum	22.000								
Reaction, X-X Axis Base	Maximum	131.400								
"	Minimum	131.400								
Reaction, Y-Y Axis Base	Maximum	131.400								
"	Minimum	131.400								
Reaction, X-X Axis Top	Maximum	131.400								
"	Minimum	131.400								
Reaction, Y-Y Axis Top	Maximum	131.400								
"	Minimum	131.400								
Moment, X-X Axis Base	Maximum	131.400								
"	Minimum	131.400								
Moment, Y-Y Axis Base	Maximum	131.400								
"	Minimum	131.400								
Moment, X-X Axis Top	Maximum	131.400								
"	Minimum	131.400								
Moment, Y-Y Axis Top	Maximum	131.400								
"	Minimum	131.400								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

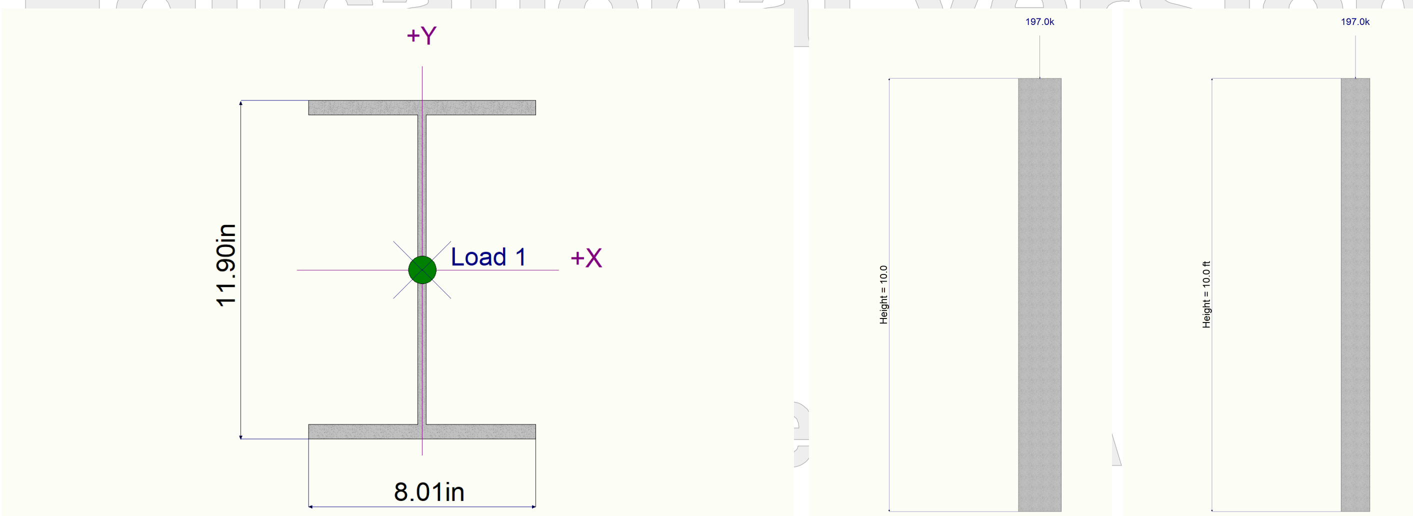
Steel Section Properties : W12x40

Depth	=	11.900	in	I xx	=	307.00	in^4	J	=	0.906	in^4
Web Thick	=	0.295	in	S xx	=	51.50	in^3	Cw	=	1,440.00	in^6
Flange Width	=	8.010	in	R xx	=	5.130	in				
Flange Thick	=	0.515	in	Zx	=	57.000	in^3				
Area	=	11.700	in^2	I yy	=	44.100	in^4				
Weight	=	40.000	plf	S yy	=	11.000	in^3	Wno	=	22.800	in^2
Kdesign	=	1.020	in	R yy	=	1.940	in	Sw	=	23.500	in^4
K1	=	0.875	in	Zy	=	16.800	in^3	Qf	=	11.300	in^3
rts	=	2.210	in					Qw	=	27.800	in^3
Ycg	=	0.000	in								

Steel Column

DESCRIPTION: A7-Roof STL COLS

Sketches



Steel Column

DESCRIPTION: B1-2 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x96**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 15.0 ft
Top & Bottom Fixity Top Pinned, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 15.0 ft, K = 0.80
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 15.0 ft, K = 0.80

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 1,440.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 15.0 ft, D = 437.0, LR = 19.0, L = 223.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.8243** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 892.43 k
0.9 * Pn 1,082.68 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 527.53 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 253.125 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.567	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.824	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D+1.60L	0.816	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.720	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.514	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D+L	0.692	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D	0.486	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.701	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+0.90D	0.364	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+1.40D+L	0.773	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft
+0.70D	0.283	PASS	0.00 ft	1.00	1.00	46.60	26.47	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	438.440								
+D+L	661.440								
+D+Lr	457.440								

Steel Column

DESCRIPTION: B1-2 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750Lr+0.750L	619.940								
+D+0.750L	605.690								
+0.60D	263.064								
Lr Only	19.000								
L Only	223.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	661.440								
"	Minimum	19.000								
Reaction, X-X Axis Base	Maximum	438.440								
"	Minimum	438.440								
Reaction, Y-Y Axis Base	Maximum	438.440								
"	Minimum	438.440								
Reaction, X-X Axis Top	Maximum	438.440								
"	Minimum	438.440								
Reaction, Y-Y Axis Top	Maximum	438.440								
"	Minimum	438.440								
Moment, X-X Axis Base	Maximum	438.440								
"	Minimum	438.440								
Moment, Y-Y Axis Base	Maximum	438.440								
"	Minimum	438.440								
Moment, X-X Axis Top	Maximum	438.440								
"	Minimum	438.440								
Moment, Y-Y Axis Top	Maximum	438.440								
"	Minimum	438.440								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

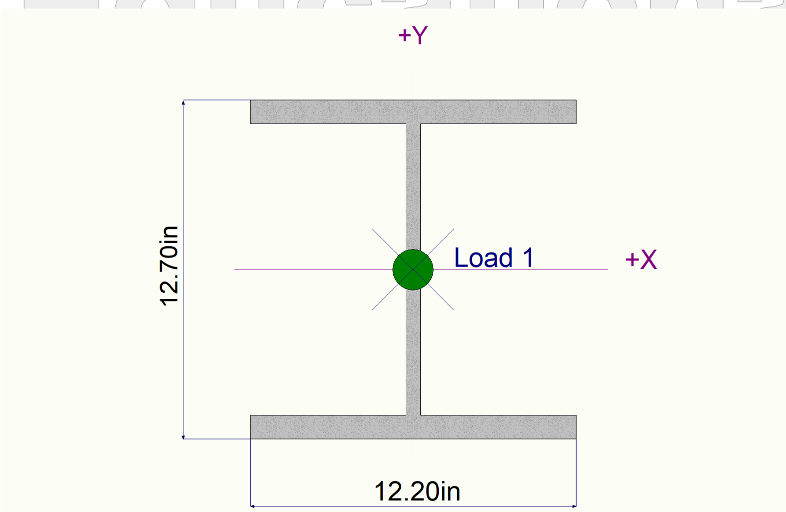
Steel Section Properties : W12x96

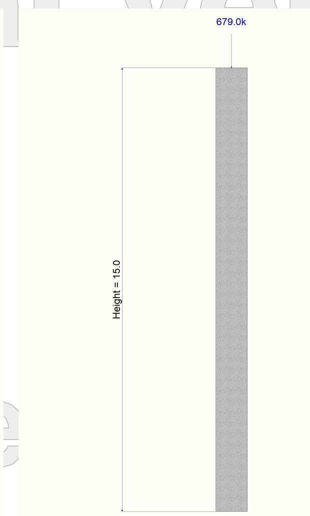
Depth	=	12.700	in	I xx	=	833.00	in^4	J	=	6.850	in^4
Web Thick	=	0.550	in	S xx	=	131.00	in^3	Cw	=	9,410.00	in^6
Flange Width	=	12.200	in	R xx	=	5.440	in				
Flange Thick	=	0.900	in	Zx	=	147.000	in^3				
Area	=	28.200	in^2	I yy	=	270.000	in^4				
Weight	=	96.000	plf	S yy	=	44.400	in^3	Wno	=	36.000	in^2
Kdesign	=	1.500	in	R yy	=	3.090	in	Sw	=	98.800	in^4
K1	=	1.125	in	Zy	=	67.500	in^3	Qf	=	30.900	in^3
rts	=	3.490	in					Qw	=	73.000	in^3
Ycg	=	0.000	in								

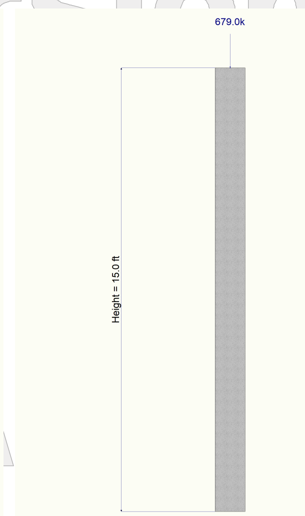
Steel Column

DESCRIPTION: B1-2 STL COLS

Sketches







Steel Column

DESCRIPTION: B3-4 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x65**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 650.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 307.0, LR = 19.0, L = 149.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.8058** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 617.08 k
0.9 * Pn 765.79 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 356.217 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 160.811 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.562	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.806	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D+1.60L	0.793	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.716	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.522	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D+L	0.677	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D	0.482	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.689	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+0.90D	0.362	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+1.40D+L	0.757	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft
+0.70D	0.281	PASS	0.00 ft	1.00	1.00	39.74	22.73	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	307.650								
+D+L	456.650								
+D+Lr	326.650								
+D+0.750Lr+0.750L	433.650								

Steel Column

DESCRIPTION: B3-4 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	419.400								
+0.60D	184.590								
Lr Only	19.000								
L Only	149.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	456.650								
"	Minimum	19.000								
Reaction, X-X Axis Base	Maximum	307.650								
"	Minimum	307.650								
Reaction, Y-Y Axis Base	Maximum	307.650								
"	Minimum	307.650								
Reaction, X-X Axis Top	Maximum	307.650								
"	Minimum	307.650								
Reaction, Y-Y Axis Top	Maximum	307.650								
"	Minimum	307.650								
Moment, X-X Axis Base	Maximum	307.650								
"	Minimum	307.650								
Moment, Y-Y Axis Base	Maximum	307.650								
"	Minimum	307.650								
Moment, X-X Axis Top	Maximum	307.650								
"	Minimum	307.650								
Moment, Y-Y Axis Top	Maximum	307.650								
"	Minimum	307.650								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

Steel Section Properties : W12x65

Depth	=	12.100	in	I xx	=	533.00	in^4	J	=	2.180	in^4
Web Thick	=	0.390	in	S xx	=	87.90	in^3	Cw	=	5,780.00	in^6
Flange Width	=	12.000	in	R xx	=	5.280	in				
Flange Thick	=	0.605	in	Zx	=	96.800	in^3				
Area	=	19.100	in^2	I yy	=	174.000	in^4				
Weight	=	65.000	plf	S yy	=	29.100	in^3	Wno	=	34.500	in^2
Kdesign	=	1.200	in	R yy	=	3.020	in	Sw	=	62.600	in^4
K1	=	1.000	in	Zy	=	44.100	in^3	Qf	=	20.200	in^3
rts	=	3.380	in					Qw	=	47.500	in^3
Ycg	=	0.000	in								

Title Block Line 1
You can change this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

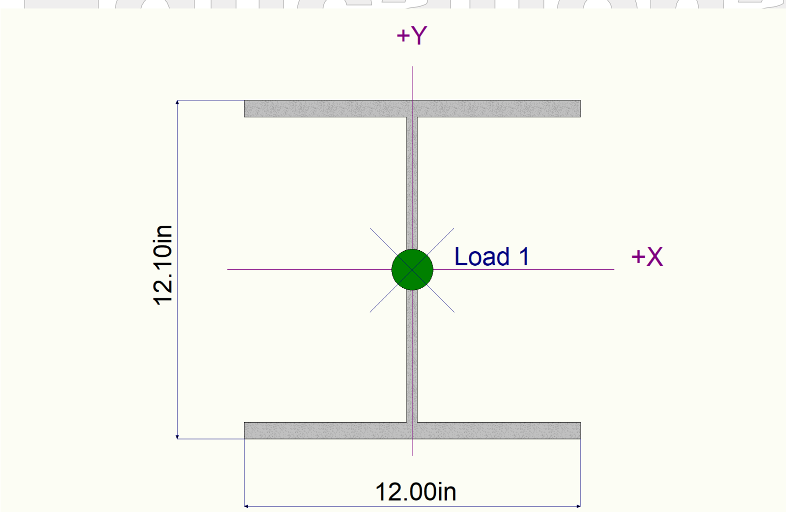
Printed: 31 MAR 2020, 1:58PM

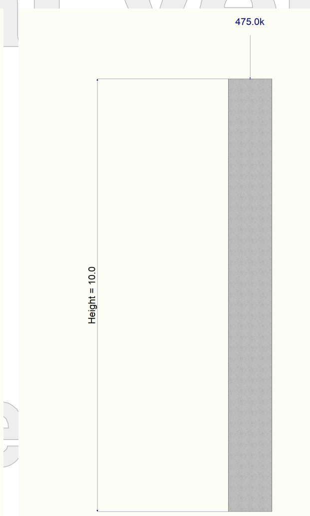
Steel Column

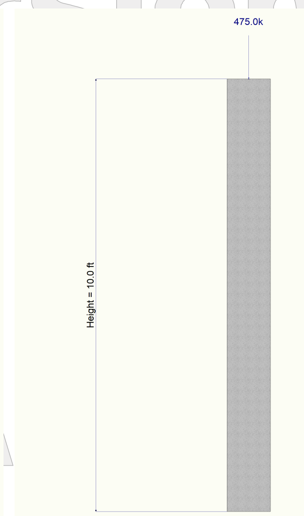
File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: B3-4 STL COLS

Sketches







Steel Column

DESCRIPTION: B5-6 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x45**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 450.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 177.0, LR = 19.0, L = 75.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7662** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 342.440 k
0.9 * Pn 446.921 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 222.837 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 71.250 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.556	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.766	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+1.60L	0.745	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.712	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.544	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+L	0.644	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D	0.476	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.666	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+0.90D	0.357	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.40D+L	0.724	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+0.70D	0.278	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	177.450								
+D+L	252.450								
+D+Lr	196.450								
+D+0.750Lr+0.750L	247.950								

Steel Column

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6
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DESCRIPTION: B5-6 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction @ Base	k @ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	k-ft @ Top	My - End Moments @ Base	@ Top
+D+0.750L	233.700								
+0.60D	106.470								
Lr Only	19.000								
L Only	75.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction @ Base	k @ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	k-ft @ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	252.450								
"	Minimum	19.000								
Reaction, X-X Axis Base	Maximum	177.450								
"	Minimum	177.450								
Reaction, Y-Y Axis Base	Maximum	177.450								
"	Minimum	177.450								
Reaction, X-X Axis Top	Maximum	177.450								
"	Minimum	177.450								
Reaction, Y-Y Axis Top	Maximum	177.450								
"	Minimum	177.450								
Moment, X-X Axis Base	Maximum	177.450								
"	Minimum	177.450								
Moment, Y-Y Axis Base	Maximum	177.450								
"	Minimum	177.450								
Moment, X-X Axis Top	Maximum	177.450								
"	Minimum	177.450								
Moment, Y-Y Axis Top	Maximum	177.450								
"	Minimum	177.450								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

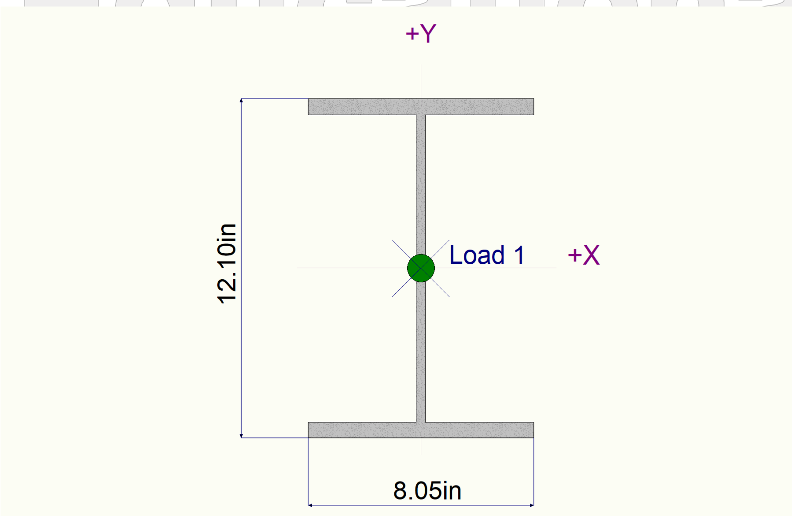
Steel Section Properties : W12x45

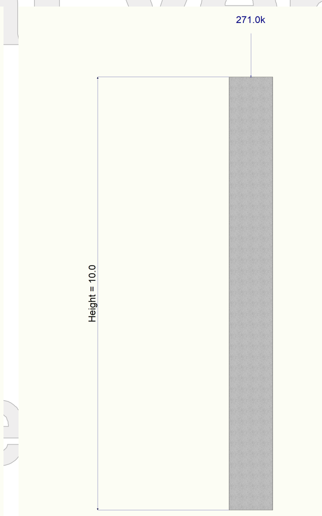
Depth	=	12.100	in	I xx	=	348.00	in^4	J	=	1.260	in^4
Web Thick	=	0.335	in	S xx	=	57.70	in^3	Cw	=	1,650.00	in^6
Flange Width	=	8.050	in	R xx	=	5.150	in				
Flange Thick	=	0.575	in	Zx	=	64.200	in^3				
Area	=	13.100	in^2	I yy	=	50.000	in^4				
Weight	=	45.000	plf	S yy	=	12.400	in^3	Wno	=	23.200	in^2
Kdesign	=	1.080	in	R yy	=	1.950	in	Sw	=	26.800	in^4
K1	=	0.938	in	Zy	=	19.000	in^3	Qf	=	12.800	in^3
rts	=	2.230	in					Qw	=	31.700	in^3
Ycg	=	0.000	in								

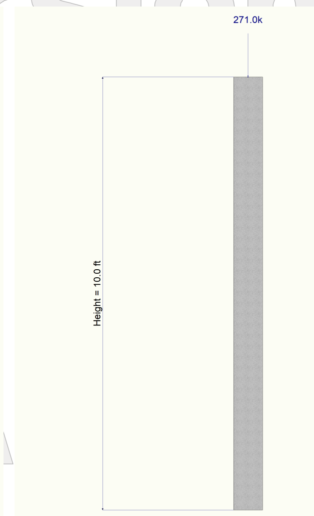
Steel Column

DESCRIPTION: B5-6 STL COLS

Sketches







Steel Column

DESCRIPTION: B7-Roof STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x40**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 400.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 113.0, LR = 19.0, L = 38.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.5185** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 206.380 k
0.9 * Pn 398.017 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 196.456 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 63.0 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0 ft above base
for load combination :
Along X-X 0.0 in at 0.0 ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.399	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.519	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60L	0.495	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.514	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.418	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+L	0.437	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D	0.342	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.461	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+0.90D	0.256	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.40D+L	0.494	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+0.70D	0.199	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	113.400								
+D+L	151.400								
+D+Lr	132.400								
+D+0.750Lr+0.750L	156.150								

Steel Column

DESCRIPTION: B7-Roof STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	141.900								
+0.60D	68.040								
Lr Only	19.000								
L Only	38.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	156.150								
"	Minimum	19.000								
Reaction, X-X Axis Base	Maximum	113.400								
"	Minimum	113.400								
Reaction, Y-Y Axis Base	Maximum	113.400								
"	Minimum	113.400								
Reaction, X-X Axis Top	Maximum	113.400								
"	Minimum	113.400								
Reaction, Y-Y Axis Top	Maximum	113.400								
"	Minimum	113.400								
Moment, X-X Axis Base	Maximum	113.400								
"	Minimum	113.400								
Moment, Y-Y Axis Base	Maximum	113.400								
"	Minimum	113.400								
Moment, X-X Axis Top	Maximum	113.400								
"	Minimum	113.400								
Moment, Y-Y Axis Top	Maximum	113.400								
"	Minimum	113.400								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

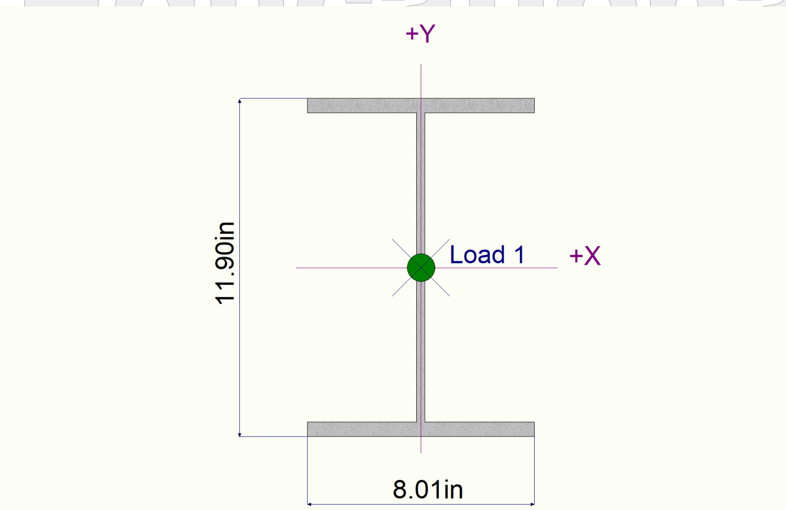
Steel Section Properties : W12x40

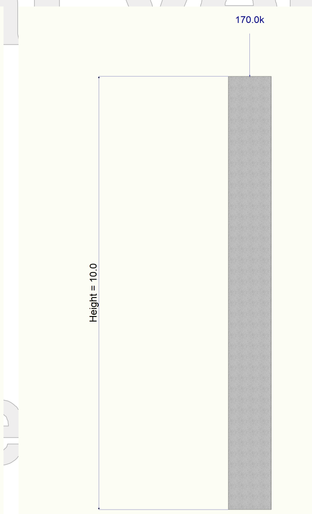
Depth	=	11.900	in	I xx	=	307.00	in^4	J	=	0.906	in^4
Web Thick	=	0.295	in	S xx	=	51.50	in^3	Cw	=	1,440.00	in^6
Flange Width	=	8.010	in	R xx	=	5.130	in				
Flange Thick	=	0.515	in	Zx	=	57.000	in^3				
Area	=	11.700	in^2	I yy	=	44.100	in^4				
Weight	=	40.000	plf	S yy	=	11.000	in^3	Wno	=	22.800	in^2
Kdesign	=	1.020	in	R yy	=	1.940	in	Sw	=	23.500	in^4
K1	=	0.875	in	Zy	=	16.800	in^3	Qf	=	11.300	in^3
rts	=	2.210	in					Qw	=	27.800	in^3
Ycg	=	0.000	in								

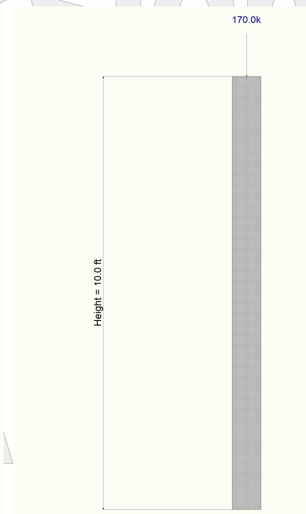
Steel Column

DESCRIPTION: B7-Roof STL COLS

Sketches







Steel Column

DESCRIPTION: C1-2 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x65**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 15.0 ft
Top & Bottom Fixity Top Pinned, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 15.0 ft, K = 0.80
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 15.0 ft, K = 0.80

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 975.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 15.0 ft, D = 260.0, LR = 29.0, L = 133.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7425** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 540.47 k
0.9 * Pn 727.86 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 339.571 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 160.811 k-ft

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.502	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.743	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D+1.60L	0.723	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.677	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.494	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D+L	0.613	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D	0.430	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.633	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+0.90D	0.323	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+1.40D+L	0.685	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft
+0.70D	0.251	PASS	0.00 ft	1.00	1.00	47.68	27.27	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	260.975								
+D+L	393.975								
+D+Lr	289.975								

Steel Column

DESCRIPTION: C1-2 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750Lr+0.750L	382.475								
+D+0.750L	360.725								
+0.60D	156.585								
Lr Only	29.000								
L Only	133.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	393.975								
"	Minimum	29.000								
Reaction, X-X Axis Base	Maximum	260.975								
"	Minimum	260.975								
Reaction, Y-Y Axis Base	Maximum	260.975								
"	Minimum	260.975								
Reaction, X-X Axis Top	Maximum	260.975								
"	Minimum	260.975								
Reaction, Y-Y Axis Top	Maximum	260.975								
"	Minimum	260.975								
Moment, X-X Axis Base	Maximum	260.975								
"	Minimum	260.975								
Moment, Y-Y Axis Base	Maximum	260.975								
"	Minimum	260.975								
Moment, X-X Axis Top	Maximum	260.975								
"	Minimum	260.975								
Moment, Y-Y Axis Top	Maximum	260.975								
"	Minimum	260.975								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

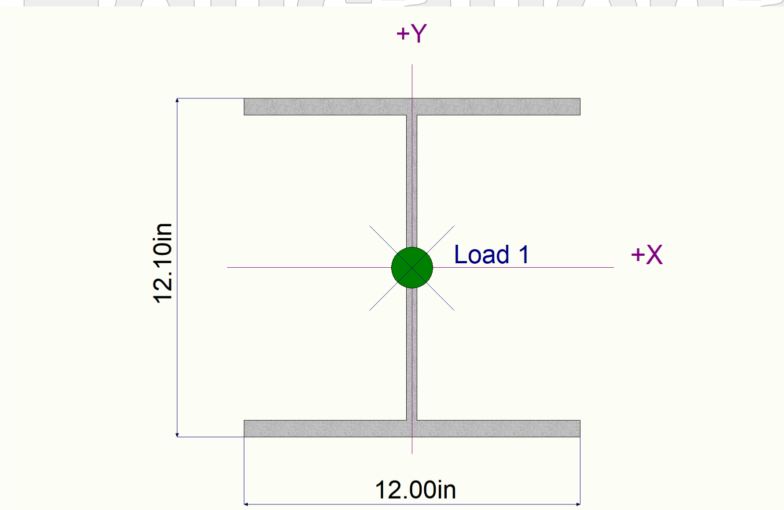
Steel Section Properties : W12x65

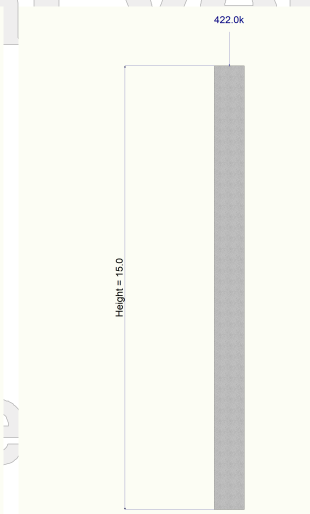
Depth	=	12.100	in	I xx	=	533.00	in^4	J	=	2.180	in^4
Web Thick	=	0.390	in	S xx	=	87.90	in^3	Cw	=	5,780.00	in^6
Flange Width	=	12.000	in	R xx	=	5.280	in				
Flange Thick	=	0.605	in	Zx	=	96.800	in^3				
Area	=	19.100	in^2	I yy	=	174.000	in^4				
Weight	=	65.000	plf	S yy	=	29.100	in^3	Wno	=	34.500	in^2
Kdesign	=	1.200	in	R yy	=	3.020	in	Sw	=	62.600	in^4
K1	=	1.000	in	Zy	=	44.100	in^3	Qf	=	20.200	in^3
rts	=	3.380	in					Qw	=	47.500	in^3
Ycg	=	0.000	in								

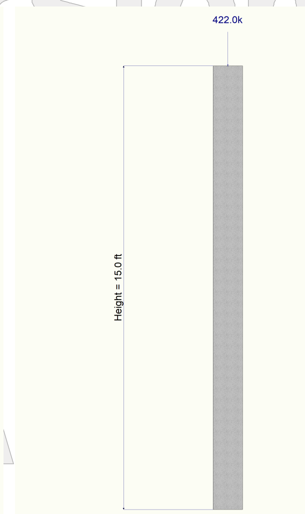
Steel Column

DESCRIPTION: C1-2 STL COLS

Sketches







Steel Column

DESCRIPTION: C3-4 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : W12x45
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 450.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 183.0, LR = 12.0, L = 89.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio =	**0.8246**	: 1
Load Combination	+1.20D+0.50Lr+1.60L	
Location of max.above base	0.0	ft
At maximum location values are . . .		
Pu	368.540	k
0.9 * Pn	446.921	k
Mu-x	0.0	k-ft
0.9 * Mn-x :	222.837	k-ft
Mu-y	0.0	k-ft
0.9 * Mn-y :	71.250	k-ft
PASS Maximum Shear Stress Ratio =	**0.0**	: 1
Load Combination	0.0	
Location of max.above base	0.0	ft
At maximum location values are . . .		
Vu : Applied	0.0	k
Vn * Phi : Allowable	0.0	k

Maximum Load Reactions . .

Top along X-X	0.0 k
Bottom along X-X	0.0 k
Top along Y-Y	0.0 k
Bottom along Y-Y	0.0 k

Maximum Load Deflections . . .

Along Y-Y 0.0 in at 0.0ft above base
for load combination :

Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.575	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.825	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+1.60L	0.811	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.735	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.536	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+L	0.692	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D	0.493	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.705	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+0.90D	0.369	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+1.40D+L	0.774	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft
+0.70D	0.287	PASS	0.00 ft	1.00	1.00	61.54	23.30	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	183.450								
+D+L	272.450								
+D+Lr	195.450								
+D+0.750Lr+0.750L	259.200								

Steel Column

DESCRIPTION: C3-4 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	250.200								
+0.60D	110.070								
Lr Only	12.000								
L Only	89.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	272.450								
"	Minimum	12.000								
Reaction, X-X Axis Base	Maximum	183.450								
"	Minimum	183.450								
Reaction, Y-Y Axis Base	Maximum	183.450								
"	Minimum	183.450								
Reaction, X-X Axis Top	Maximum	183.450								
"	Minimum	183.450								
Reaction, Y-Y Axis Top	Maximum	183.450								
"	Minimum	183.450								
Moment, X-X Axis Base	Maximum	183.450								
"	Minimum	183.450								
Moment, Y-Y Axis Base	Maximum	183.450								
"	Minimum	183.450								
Moment, X-X Axis Top	Maximum	183.450								
"	Minimum	183.450								
Moment, Y-Y Axis Top	Maximum	183.450								
"	Minimum	183.450								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

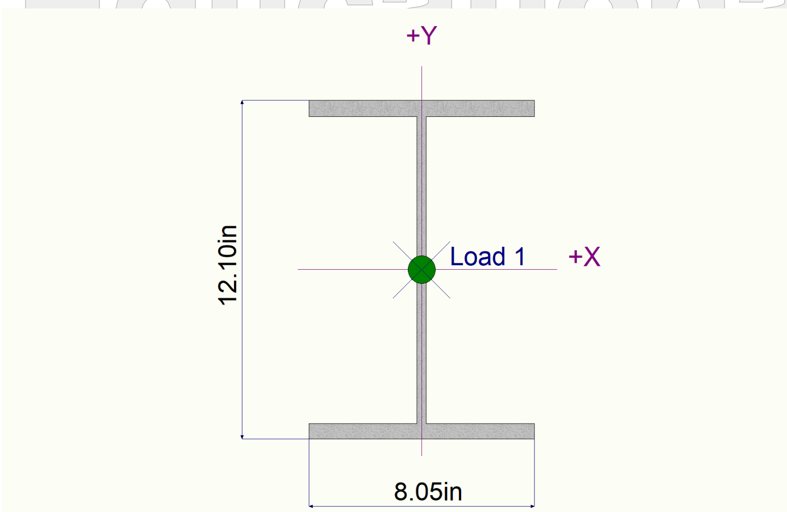
Steel Section Properties : W12x45

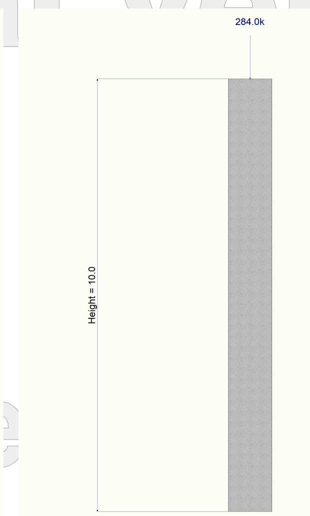
Depth	=	12.100	in	I xx	=	348.00	in^4	J	=	1.260	in^4
Web Thick	=	0.335	in	S xx	=	57.70	in^3	Cw	=	1,650.00	in^6
Flange Width	=	8.050	in	R xx	=	5.150	in				
Flange Thick	=	0.575	in	Zx	=	64.200	in^3				
Area	=	13.100	in^2	I yy	=	50.000	in^4				
Weight	=	45.000	plf	S yy	=	12.400	in^3	Wno	=	23.200	in^2
Kdesign	=	1.080	in	R yy	=	1.950	in	Sw	=	26.800	in^4
K1	=	0.938	in	Zy	=	19.000	in^3	Qf	=	12.800	in^3
rts	=	2.230	in					Qw	=	31.700	in^3
Ycg	=	0.000	in								

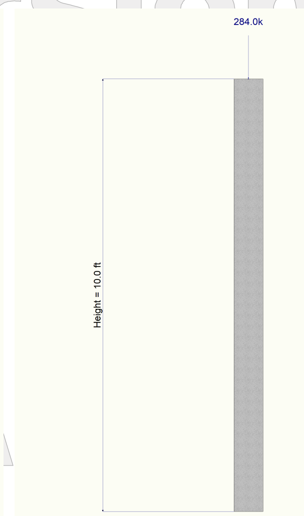
Steel Column

DESCRIPTION: C3-4 STL COLS

Sketches







Title Block Line 1
You can change this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 31 MAR 2020, 11:26PM

Steel Column

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: C5-6 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x40**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 400.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 106.0, LR = 12.0, L = 45.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.5168** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 205.680 k
0.9 * Pn 398.017 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 196.456 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 63.0 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.374	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.517	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60L	0.502	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.482	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.369	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+L	0.434	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D	0.321	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.449	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+0.90D	0.241	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+1.40D+L	0.487	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft
+0.70D	0.187	PASS	0.00 ft	1.00	1.00	61.86	23.39	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	106.400								
+D+L	151.400								
+D+Lr	118.400								
+D+0.750Lr+0.750L	149.150								

Steel Column

DESCRIPTION: C5-6 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	140.150								
+0.60D	63.840								
Lr Only	12.000								
L Only	45.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	151.400								
"	Minimum	12.000								
Reaction, X-X Axis Base	Maximum	106.400								
"	Minimum	106.400								
Reaction, Y-Y Axis Base	Maximum	106.400								
"	Minimum	106.400								
Reaction, X-X Axis Top	Maximum	106.400								
"	Minimum	106.400								
Reaction, Y-Y Axis Top	Maximum	106.400								
"	Minimum	106.400								
Moment, X-X Axis Base	Maximum	106.400								
"	Minimum	106.400								
Moment, Y-Y Axis Base	Maximum	106.400								
"	Minimum	106.400								
Moment, X-X Axis Top	Maximum	106.400								
"	Minimum	106.400								
Moment, Y-Y Axis Top	Maximum	106.400								
"	Minimum	106.400								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

Steel Section Properties : W12x40

Depth	=	11.900	in	I xx	=	307.00	in^4	J	=	0.906	in^4
Web Thick	=	0.295	in	S xx	=	51.50	in^3	Cw	=	1,440.00	in^6
Flange Width	=	8.010	in	R xx	=	5.130	in				
Flange Thick	=	0.515	in	Zx	=	57.000	in^3				
Area	=	11.700	in^2	I yy	=	44.100	in^4				
Weight	=	40.000	plf	S yy	=	11.000	in^3	Wno	=	22.800	in^2
Kdesign	=	1.020	in	R yy	=	1.940	in	Sw	=	23.500	in^4
K1	=	0.875	in	Zy	=	16.800	in^3	Qf	=	11.300	in^3
rts	=	2.210	in					Qw	=	27.800	in^3
Ycg	=	0.000	in								

Title Block Line 1
You can change this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 31 MAR 2020, 11:26PM

Steel Column

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6
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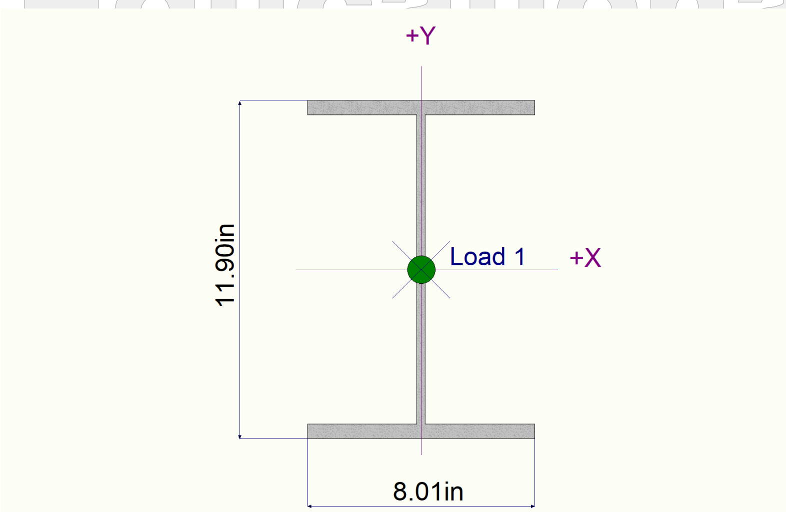
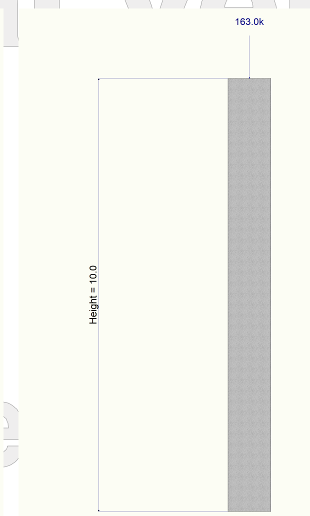
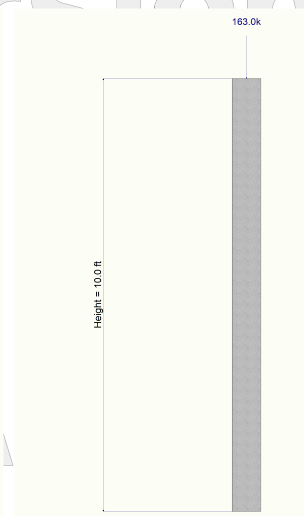
Lic. # : KW-06090157 - Educational Version
Licensed User : SANTA CLARA UNIVERSITY, CIVIL ENGINEERING

DESCRIPTION: C5-6 STL COLS

Sketches







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Project ID:
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Steel Column

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Lic. # : KW-06090157 - Educational Version

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DESCRIPTION: C7-Roof STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W10x22**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 220.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 67.0, LR = 12.0, L = 23.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7666** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 123.464 k
0.9 * Pn 161.048 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 76.188 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 22.875 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0 ft above base
for load combination :
Along X-X 0.0 in at 0.0 ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.584	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.767	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D+1.60L	0.729	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.763	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.620	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D+L	0.644	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D	0.501	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.681	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+0.90D	0.376	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+1.40D+L	0.727	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft
+0.70D	0.292	PASS	0.00 ft	1.00	1.00	90.23	28.10	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	67.220								
+D+L	90.220								
+D+Lr	79.220								
+D+0.750Lr+0.750L	93.470								

Steel Column

DESCRIPTION: C7-Roof STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	84.470								
+0.60D	40.332								
Lr Only	12.000								
L Only	23.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	93.470								
"	Minimum	12.000								
Reaction, X-X Axis Base	Maximum	67.220								
"	Minimum	67.220								
Reaction, Y-Y Axis Base	Maximum	67.220								
"	Minimum	67.220								
Reaction, X-X Axis Top	Maximum	67.220								
"	Minimum	67.220								
Reaction, Y-Y Axis Top	Maximum	67.220								
"	Minimum	67.220								
Moment, X-X Axis Base	Maximum	67.220								
"	Minimum	67.220								
Moment, Y-Y Axis Base	Maximum	67.220								
"	Minimum	67.220								
Moment, X-X Axis Top	Maximum	67.220								
"	Minimum	67.220								
Moment, Y-Y Axis Top	Maximum	67.220								
"	Minimum	67.220								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

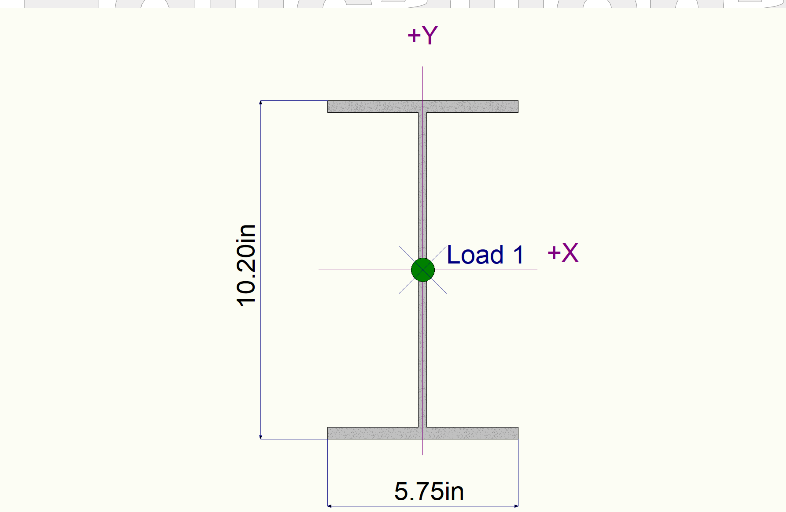
Steel Section Properties : W10x22

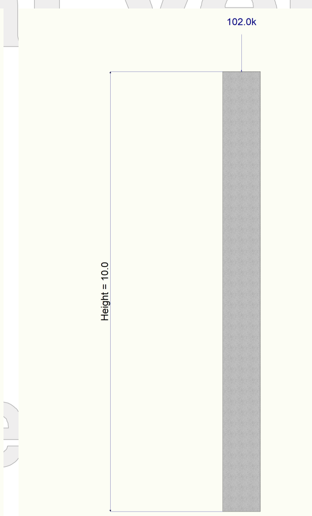
Depth	=	10.200	in	I xx	=	118.00	in^4	J	=	0.239	in^4
Web Thick	=	0.240	in	S xx	=	23.20	in^3	Cw	=	275.00	in^6
Flange Width	=	5.750	in	R xx	=	4.270	in				
Flange Thick	=	0.360	in	Zx	=	26.000	in^3				
Area	=	6.490	in^2	I yy	=	11.400	in^4				
Weight	=	22.000	plf	S yy	=	3.970	in^3	Wno	=	14.100	in^2
Kdesign	=	0.660	in	R yy	=	1.330	in	Sw	=	7.320	in^4
K1	=	0.625	in	Zy	=	6.100	in^3	Qf	=	4.880	in^3
rts	=	1.550	in					Qw	=	12.900	in^3
Ycg	=	0.000	in								

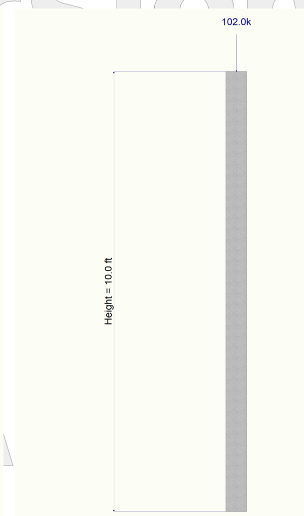
Steel Column

DESCRIPTION: C7-Roof STL COLS

Sketches







Concrete Column

DESCRIPTION: D1-2 CONC COLS

Code References

Calculations per ACI 318-14, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

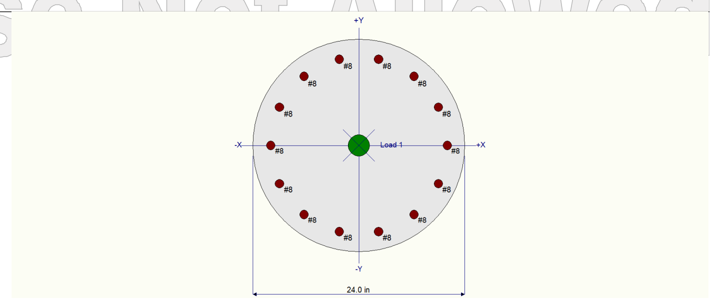
f'c : Concrete 28 day strength = 4.0 ksi
E = = 3,644.15 ksi
Density = 145.0 pcf
β = 0.850
fy - Main Rebar = 60.0 ksi
E - Main Rebar = 29,000.0 ksi
Allow. Reinforcing Limits *ASTM A615 Bars Used*
Min. Reinf. = 1.0 %
Max. Reinf. = 8.0 %

Overall Column Height = 15.0 ft
End Fixity Top Fixed, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 15.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 15.0 ft, K = 1.0

Column Cross Section

Column Dimensions : 24.0in Diameter, Column Edge to Rebar Edge Cover = 1.50in

Column Reinforcing : 14 - #8 bars



Applied Loads

Entered loads are factored per load combinations specified by use

Column self weight included : 6,832.96 lbs * Dead Load Factor
AXIAL LOADS . . .
Parking Garage Flat Weights & Above: Axial Load at 15.0 ft above base, D = 601.0, LR = 24.0, L = 307.0 k

DESIGN SUMMARY

Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 14.899 ft

Maximum Stress Ratio **0.893 : 1**
Ratio = (Pu^2+Mu^2)^.5 / (PhiPn^2+PhiMn^2)^.5
Pu = 1,232.60 k φ * Pn = 1,379.63 k
Mu-x = 0.0 k-ft φ * Mn-x = 0.0 k-ft
Mu-y = 0.0 k-ft φ * Mn-y = 0.0 k-ft
Mu Angle = 0.0 deg
Mu at Angle = 0.0 k-ft φMn at Angle = 0.0 k-ft
Pn & Mn values located at Pu-Mu vector intersection with capacity curve

Column Capacities . . .
Pnmax : Nominal Max. Compressive Axial Capacity 2,164.12 k
Pnmin : Nominal Min. Tension Axial Capacity k
φ Pn, max : Usable Compressive Axial Capacity 1,379.63 k
φ Pn, min : Usable Tension Axial Capacity k

Maximum SERVICE Load Reactions . .
Top along Y-Y 0.0 k Bottom along Y-Y 0.0 k
Top along X-X 0.0 k Bottom along X-X 0.0 k

Maximum SERVICE Load Deflections . . .
Along Y-Y 0.0 in at 0.0 ft above base
for load combination :
Along X-X 0.0 in at 0.0 ft above base
for load combination :

General Section Information φ = 0.750 β = 0.850 θ = 0.850
ρ : % Reinforcing 2.445 % Rebar % Ok
Reinforcing Area 11.060 in^2
Concrete Area 452.389 in^2

Governing Load Combination Results

Governing Factored Load Combination	Moment X-X	Moment Y-Y	Dist. from base ft	Axial Load k Pu	Axial Load k φ * Pn	δx	δx * Mux	δy	δy * Muy	Alpha (deg)	δ Mu	φ Mn	Utilization Ratio
+1.40D			14.90	850.97	1,379.63					0.000			**0.617**
+1.20D+0.50Lr+1.60L			14.90	1,232.60	1,379.63					0.000			**0.893**
+1.20D+1.60L			14.90	1,220.60	1,379.63					0.000			**0.885**

Concrete Column

DESCRIPTION: D1-2 CONC COLS

Governing Load Combination Results

Governing Factored Load Combination	Moment X-X	Moment Y-Y	Dist. from base ft	Axial Load k Pu	Axial Load k φ * Pn	Bending Analysis k-ft δx	δx * Mux	δy	δy * Muy	Alpha (deg)	δ Mu	φ Mn	Utilization Ratio
+1.20D+1.60Lr+L			14.90	1,074.80	1,379.63					0.000			**0.779**
+1.20D+1.60Lr			14.90	767.80	1,379.63					0.000			**0.557**
+1.20D+L			14.90	1,036.40	1,379.63					0.000			**0.751**
+1.20D			14.90	729.40	1,379.63					0.000			**0.529**
+1.20D+0.50Lr+L			14.90	1,048.40	1,379.63					0.000			**0.760**
+0.70D			14.90	425.48	1,379.63					0.000			**0.308**
+1.40D+L			14.90	1,157.97	1,379.63					0.000			**0.839**

Maximum Reactions

Note: Only non-zero reactions are listed

Load Combination	X-X Axis Reaction k @ Base	X-X Axis Reaction @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Axial Reaction @ Base	My - End Moments k-ft @ Base	My - End Moments @ Top	Mx - End Moments @ Base	Mx - End Moments @ Top
D Only					607.833				
+D+L					914.833				
+D+Lr					631.833				
+D+0.750Lr+0.750L					856.083				
+D+0.750L					838.083				
+D+0.750Lr					625.833				
+0.60D					364.700				
Lr Only					24.000				
L Only					307.000				

Maximum Moment Reactions

Note: Only non-zero reactions are listed

Load Combination	Moment About X-X Axis @ Base	Moment About X-X Axis @ Top		Moment About Y-Y Axis @ Base	Moment About Y-Y Axis @ Top	
D Only			k-ft			k-ft
+D+L			k-ft			k-ft
+D+Lr			k-ft			k-ft
+D+0.750Lr+0.750L			k-ft			k-ft
+D+0.750L			k-ft			k-ft
+D+0.750Lr			k-ft			k-ft
+0.60D			k-ft			k-ft
Lr Only			k-ft			k-ft
L Only			k-ft			k-ft

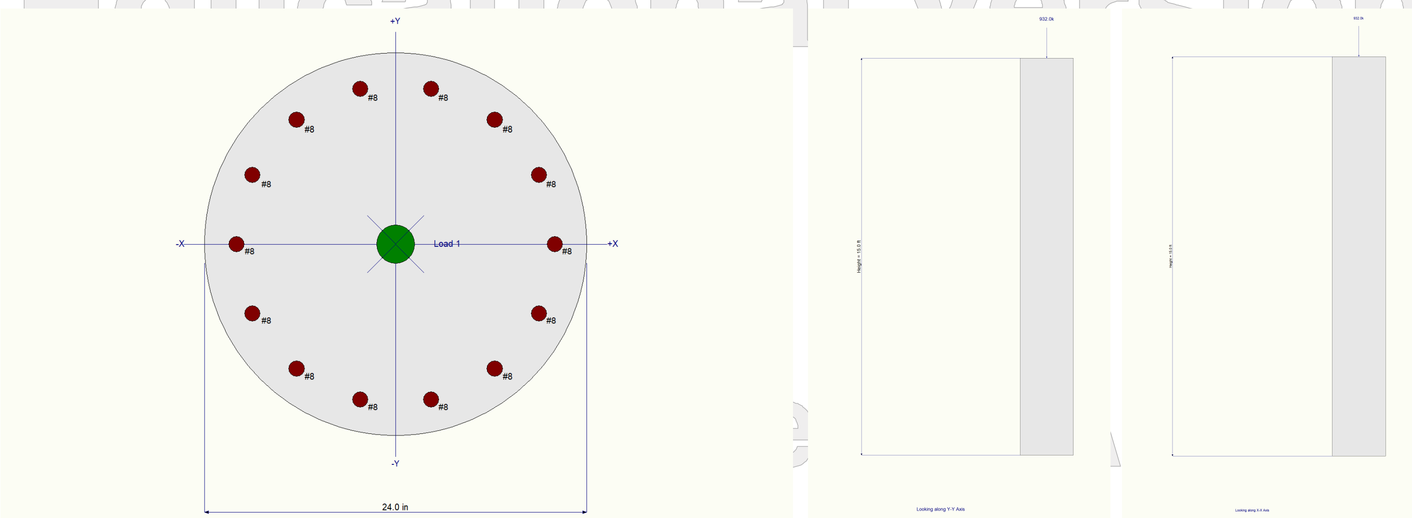
Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

Concrete Column

DESCRIPTION: D1-2 CONC COLS

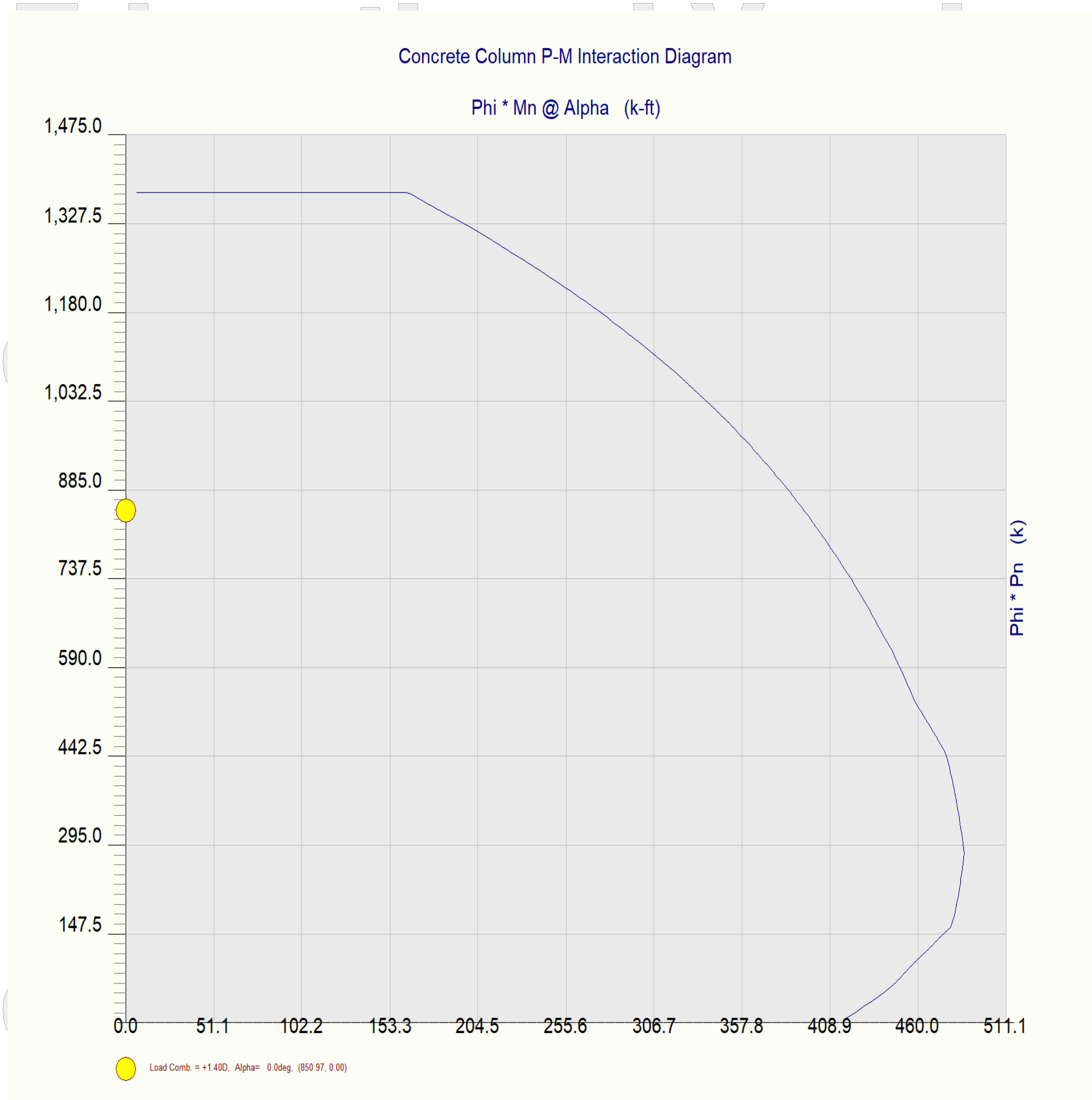
Sketches



Interaction Diagrams

Concrete Column

DESCRIPTION: D1-2 CONC COLS



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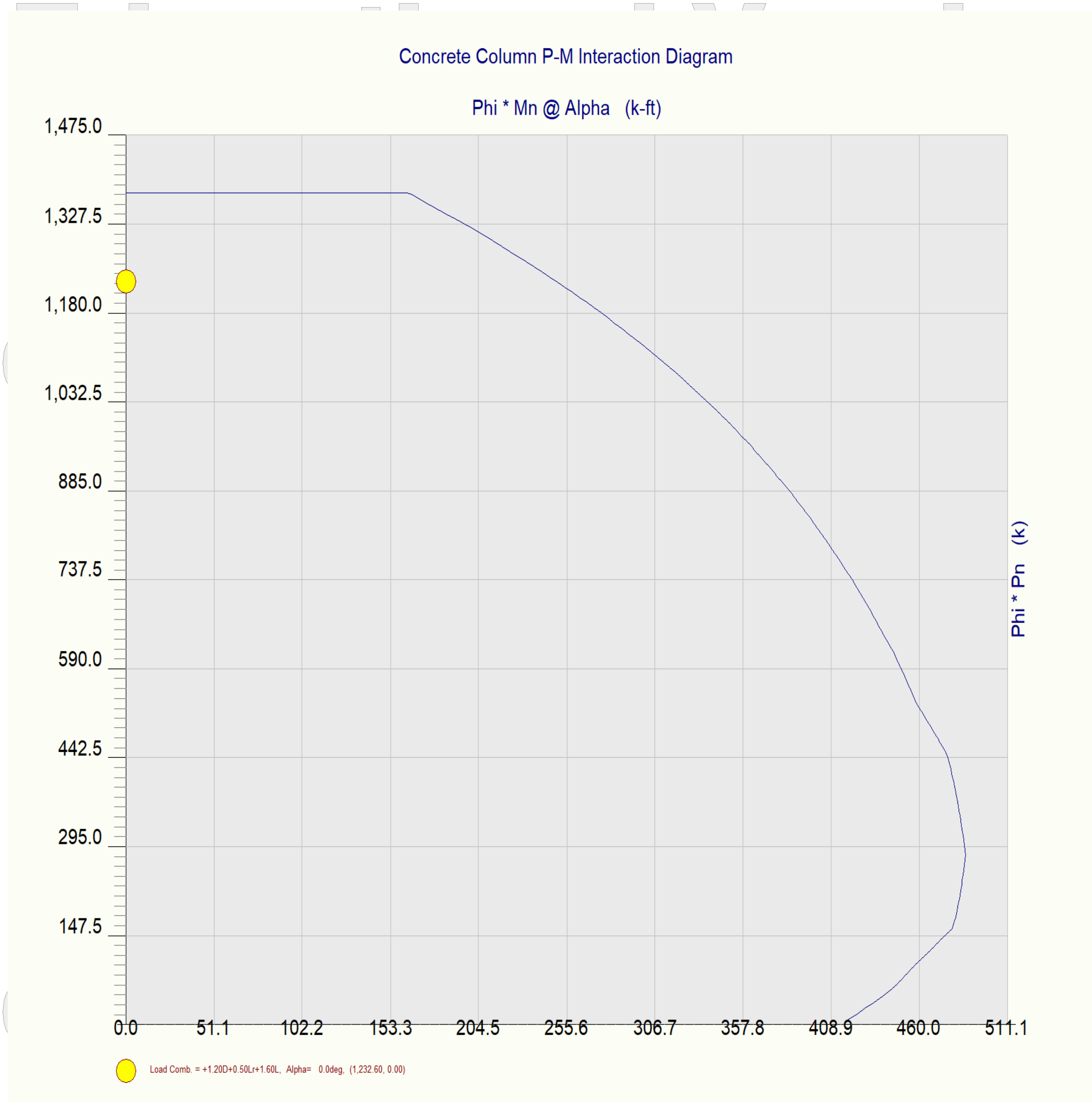

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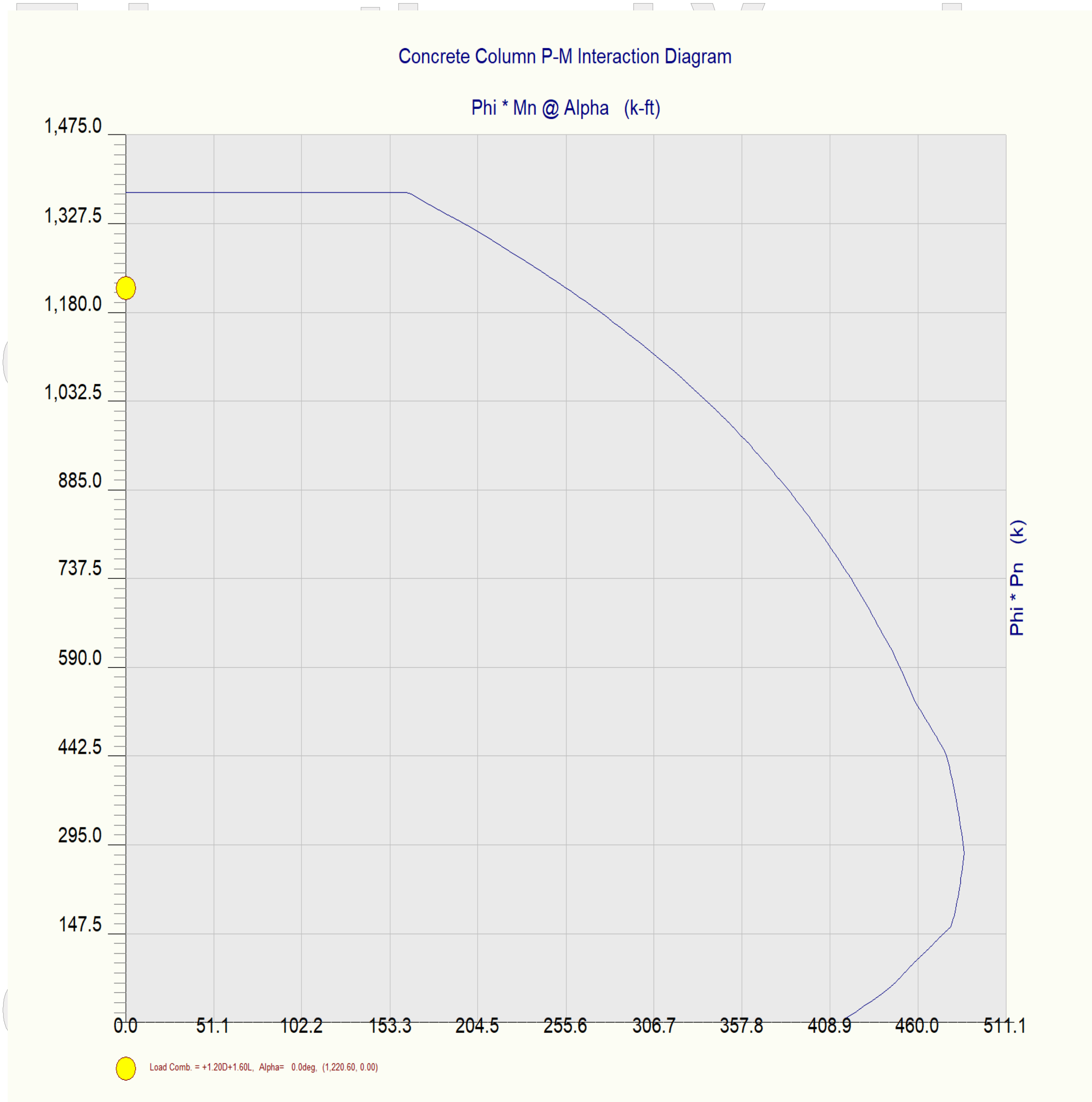
DESCRIPTION: D1-2 CONC COLS



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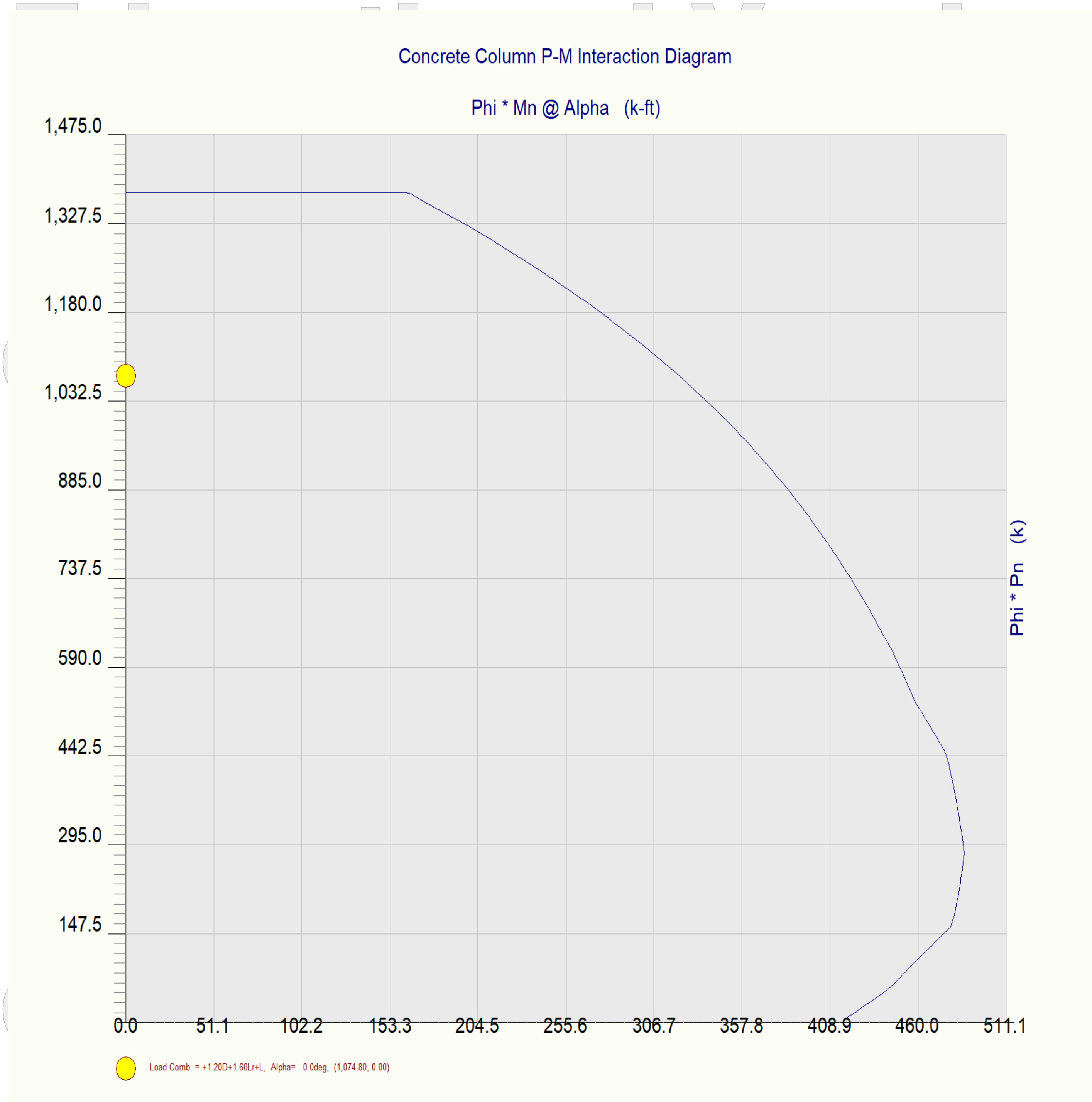

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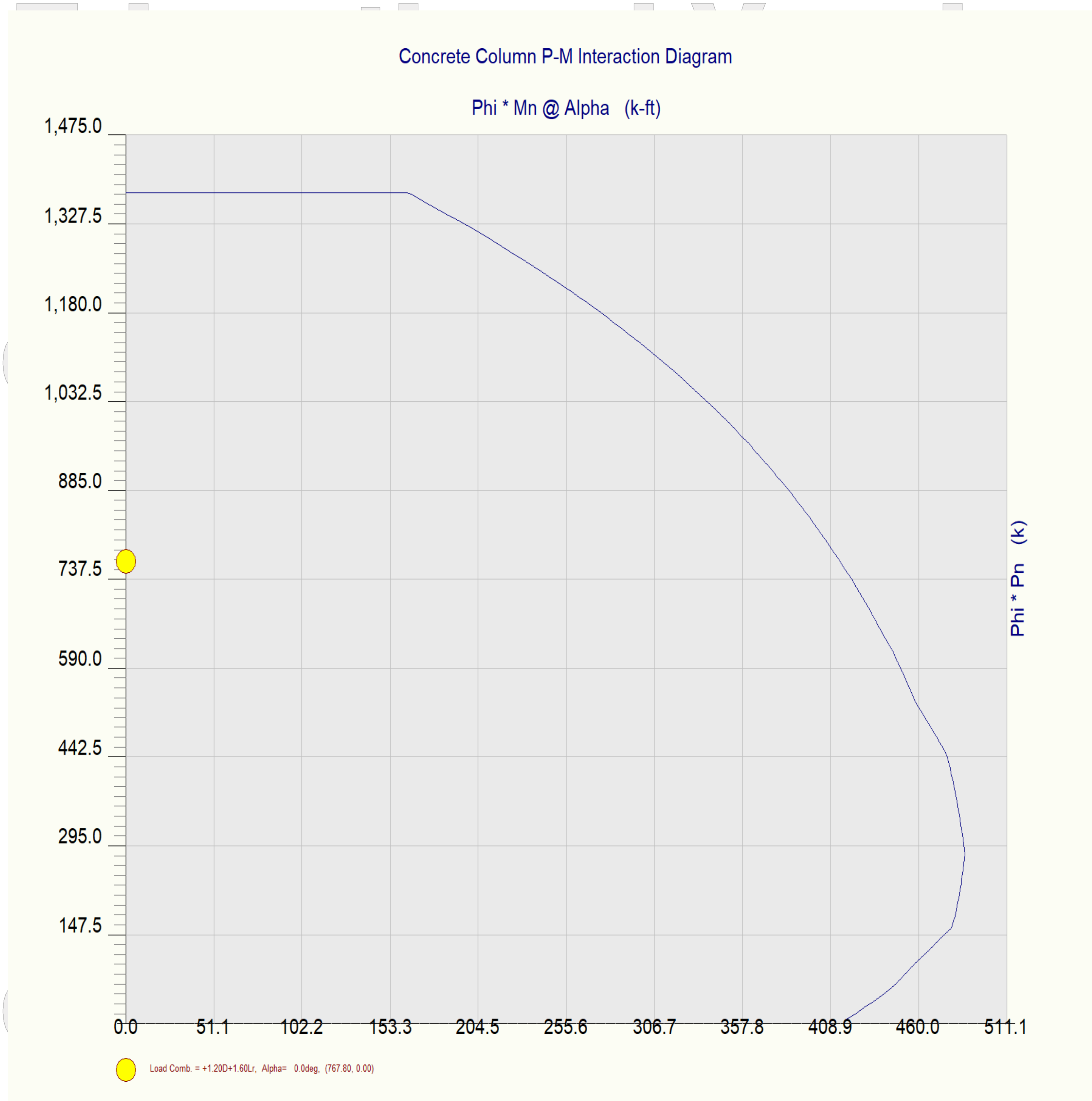

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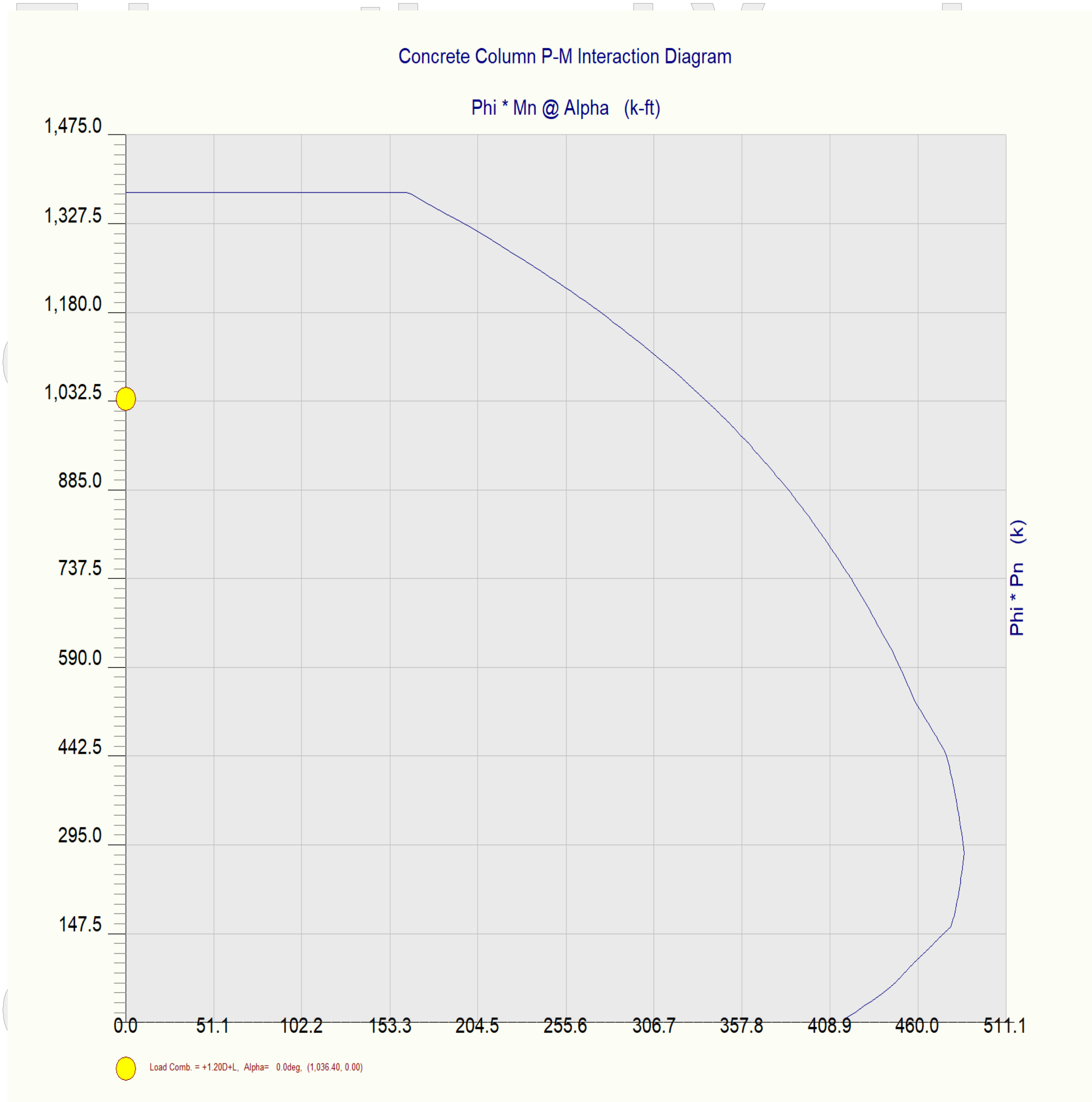

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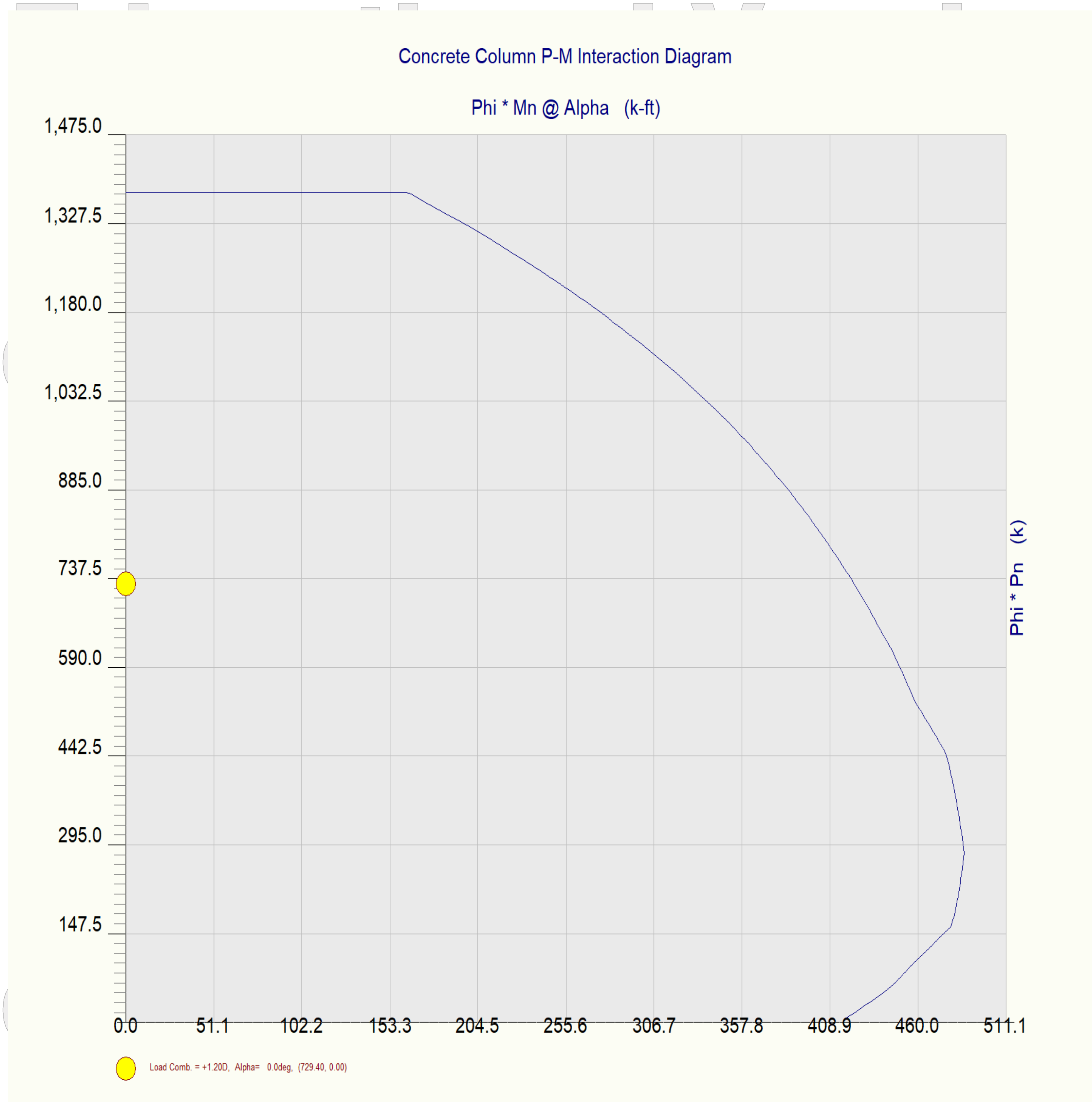

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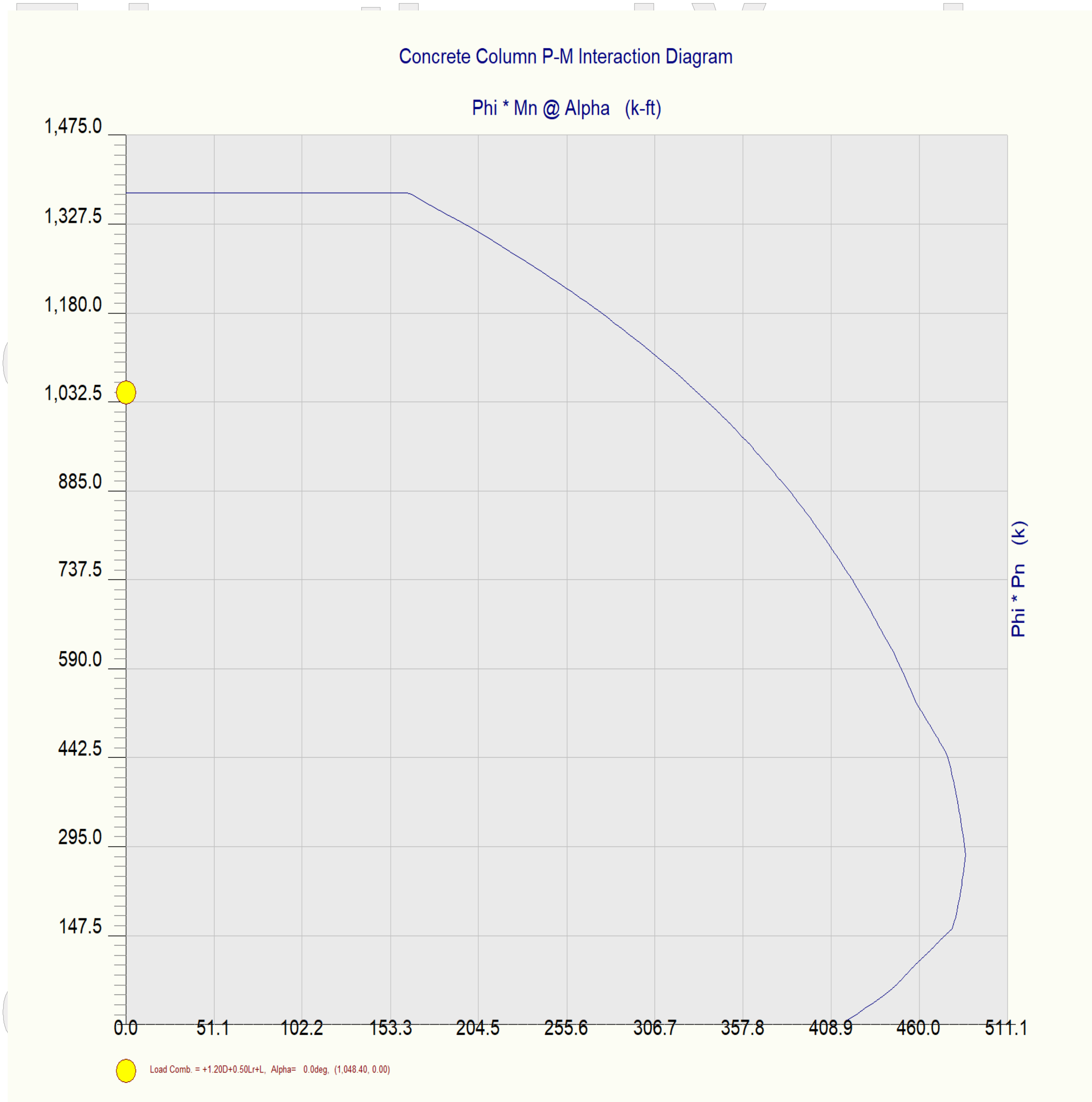

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Concrete Column

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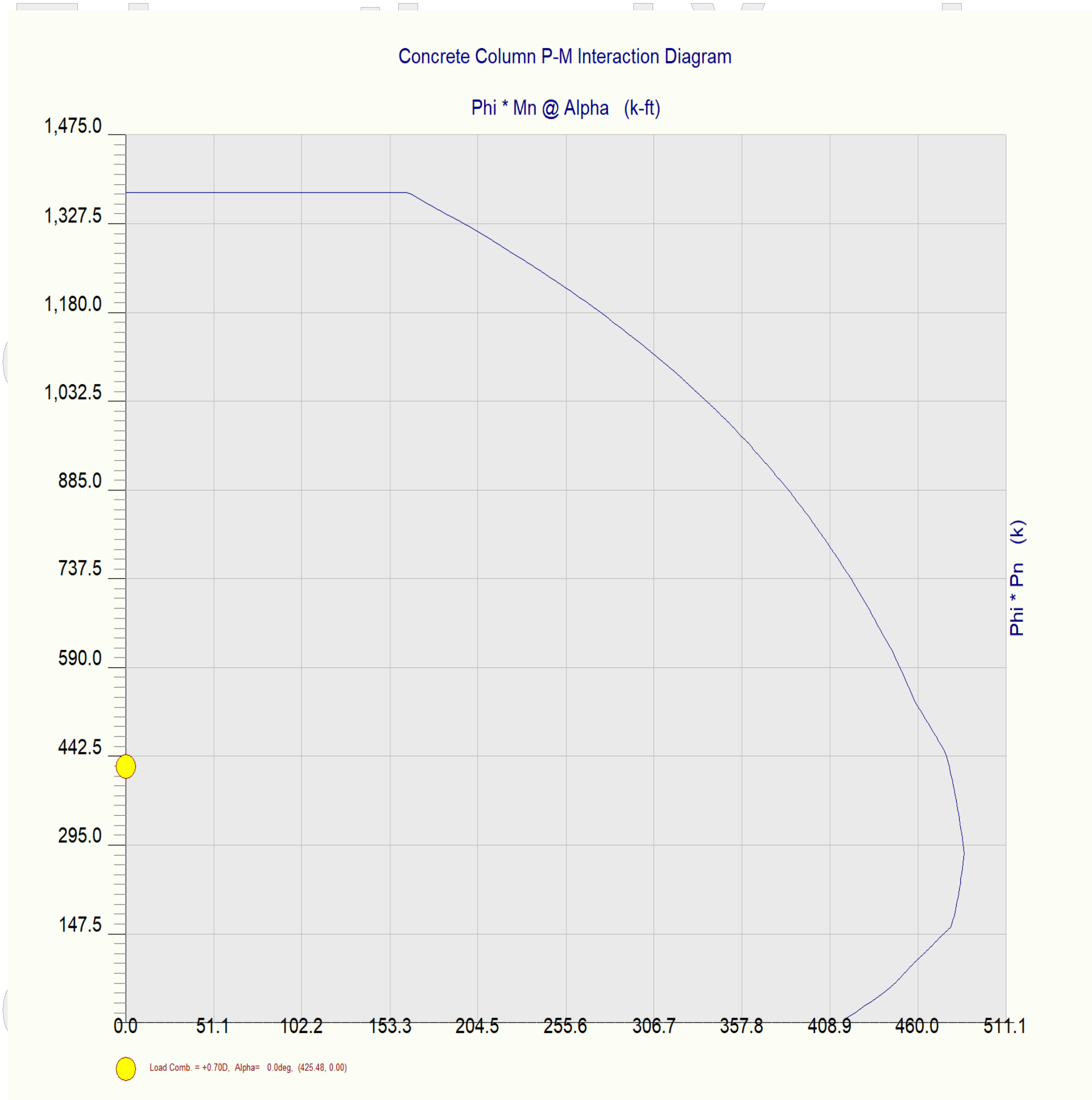
DESCRIPTION: D1-2 CONC COLS



Concrete Column

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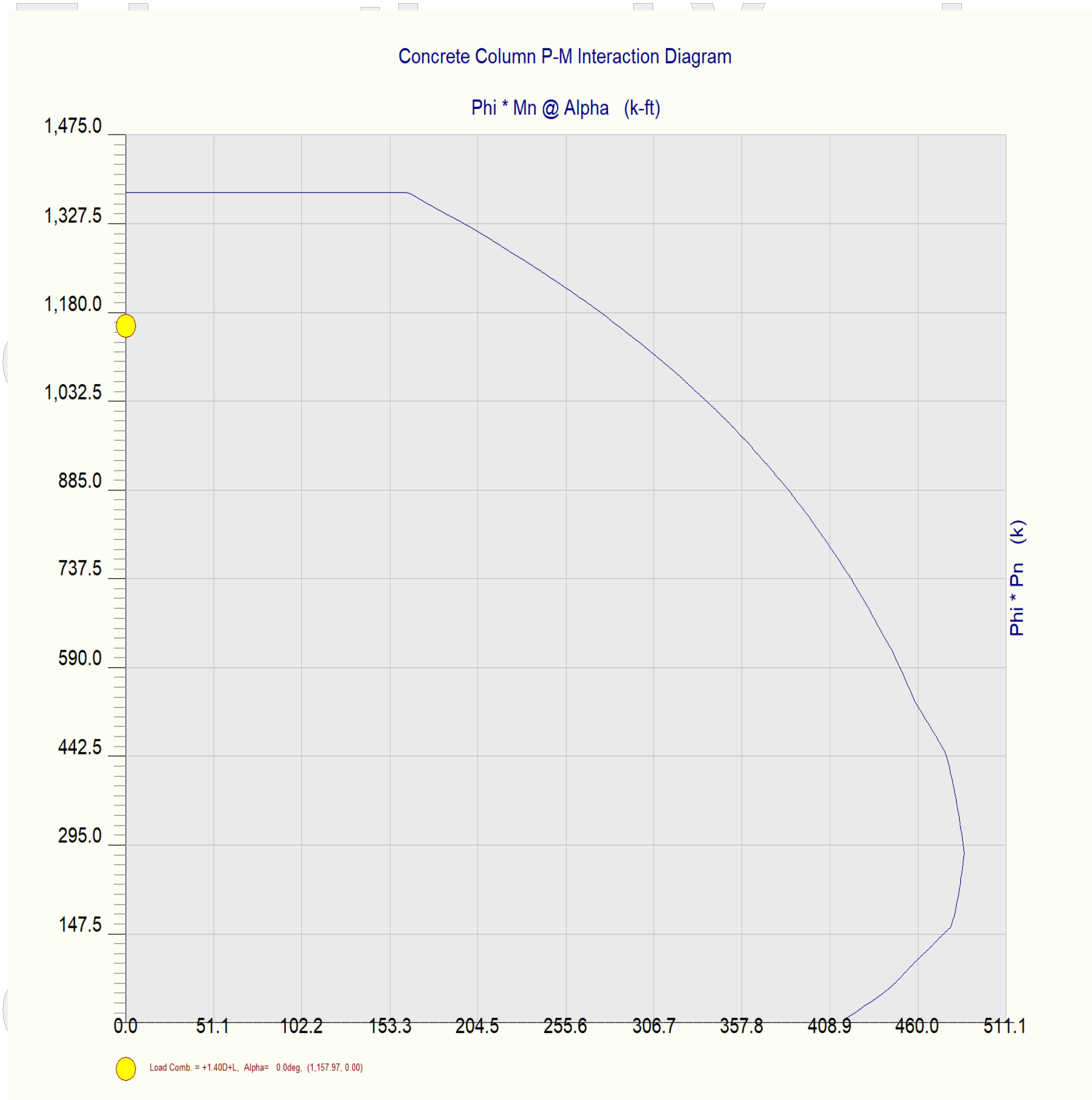

Steel Column

DESCRIPTION: D3-4 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x79**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top Pinned, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 0.80
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 0.80

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 790.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 391.0, LR = 24.0, L = 189.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.8079** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 784.55 k
0.9 * Pn 971.05 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 446.250 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 203.625 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.565	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.808	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D+1.60L	0.796	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.718	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.524	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D+L	0.679	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D	0.484	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.691	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+0.90D	0.363	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+1.40D+L	0.759	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft
+0.70D	0.282	PASS	0.00 ft	1.00	1.00	31.48	17.98	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	391.790								
+D+L	580.790								
+D+Lr	415.790								
+D+0.750Lr+0.750L	551.540								

Title Block Line 1
You can change this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 31 MAR 2020, 2:02PM

Steel Column

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6
Software copyright ENERCALC, INC. 1983-2020, Build:12.20.2.24

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DESCRIPTION: D3-4 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	533.540								
+0.60D	235.074								
Lr Only	24.000								
L Only	189.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	580.790								
"	Minimum	24.000								
Reaction, X-X Axis Base	Maximum	391.790								
"	Minimum	391.790								
Reaction, Y-Y Axis Base	Maximum	391.790								
"	Minimum	391.790								
Reaction, X-X Axis Top	Maximum	391.790								
"	Minimum	391.790								
Reaction, Y-Y Axis Top	Maximum	391.790								
"	Minimum	391.790								
Moment, X-X Axis Base	Maximum	391.790								
"	Minimum	391.790								
Moment, Y-Y Axis Base	Maximum	391.790								
"	Minimum	391.790								
Moment, X-X Axis Top	Maximum	391.790								
"	Minimum	391.790								
Moment, Y-Y Axis Top	Maximum	391.790								
"	Minimum	391.790								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

Educational Version

Steel Section Properties : W12x79

Depth	=	12.400	in	I xx	=	662.00	in^4	J	=	3.840	in^4
Web Thick	=	0.470	in	S xx	=	107.00	in^3	Cw	=	7,330.00	in^6
Flange Width	=	12.100	in	R xx	=	5.340	in				
Flange Thick	=	0.735	in	Zx	=	119.000	in^3				
Area	=	23.200	in^2	I yy	=	216.000	in^4				
Weight	=	79.000	plf	S yy	=	35.800	in^3	Wno	=	35.300	in^2
Kdesign	=	1.330	in	R yy	=	3.050	in	Sw	=	78.500	in^4
K1	=	1.063	in	Zy	=	54.300	in^3	Qf	=	24.900	in^3
rts	=	3.430	in					Qw	=	58.900	in^3
Ycg	=	0.000	in								

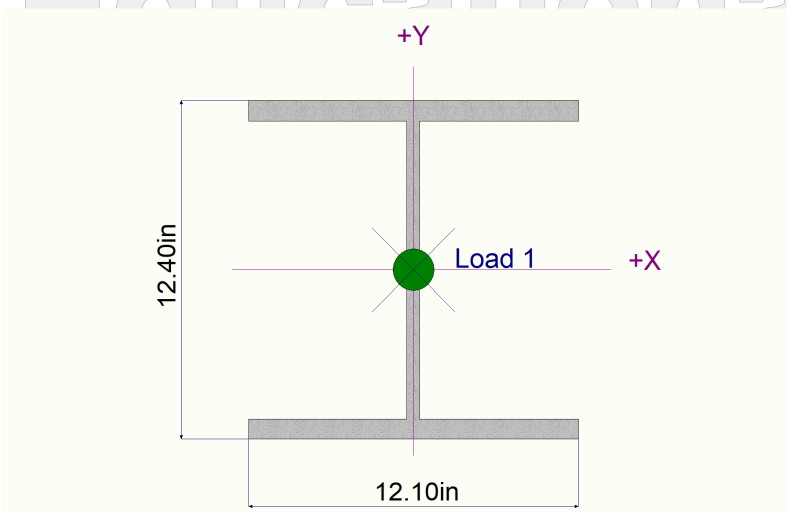
Commercial Use Not Allowed

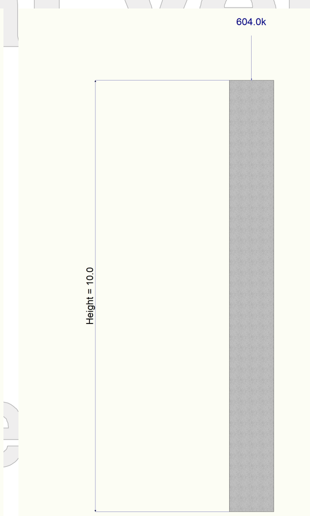
Educational Version

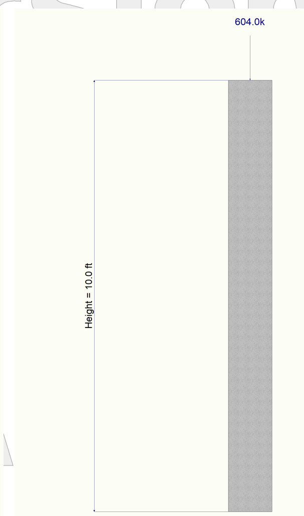
Steel Column

DESCRIPTION: D3-4 STL COLS

Sketches







Steel Column

DESCRIPTION: D5-6 STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x53**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 530.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 226.0, LR = 24.0, L = 95.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7368** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 435.836 k
0.9 * Pn 591.55 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 285.315 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 109.125 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

	Maximum Axial + Bending Stress Ratios							Maximum Shear Ratios		
Load Combination	Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Stress Ratio	Status	Location
+1.40D	0.536	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.737	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D+1.60L	0.716	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.685	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.524	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D+L	0.620	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D	0.460	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.640	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+0.90D	0.345	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+1.40D+L	0.697	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft
+0.70D	0.268	PASS	0.00 ft	1.00	1.00	48.39	22.94	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	226.530								
+D+L	321.530								
+D+Lr	250.530								
+D+0.750Lr+0.750L	315.780								

Steel Column

DESCRIPTION: D5-6 STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	297.780								
+0.60D	135.918								
Lr Only	24.000								
L Only	95.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	321.530								
"	Minimum	24.000								
Reaction, X-X Axis Base	Maximum	226.530								
"	Minimum	226.530								
Reaction, Y-Y Axis Base	Maximum	226.530								
"	Minimum	226.530								
Reaction, X-X Axis Top	Maximum	226.530								
"	Minimum	226.530								
Reaction, Y-Y Axis Top	Maximum	226.530								
"	Minimum	226.530								
Moment, X-X Axis Base	Maximum	226.530								
"	Minimum	226.530								
Moment, Y-Y Axis Base	Maximum	226.530								
"	Minimum	226.530								
Moment, X-X Axis Top	Maximum	226.530								
"	Minimum	226.530								
Moment, Y-Y Axis Top	Maximum	226.530								
"	Minimum	226.530								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

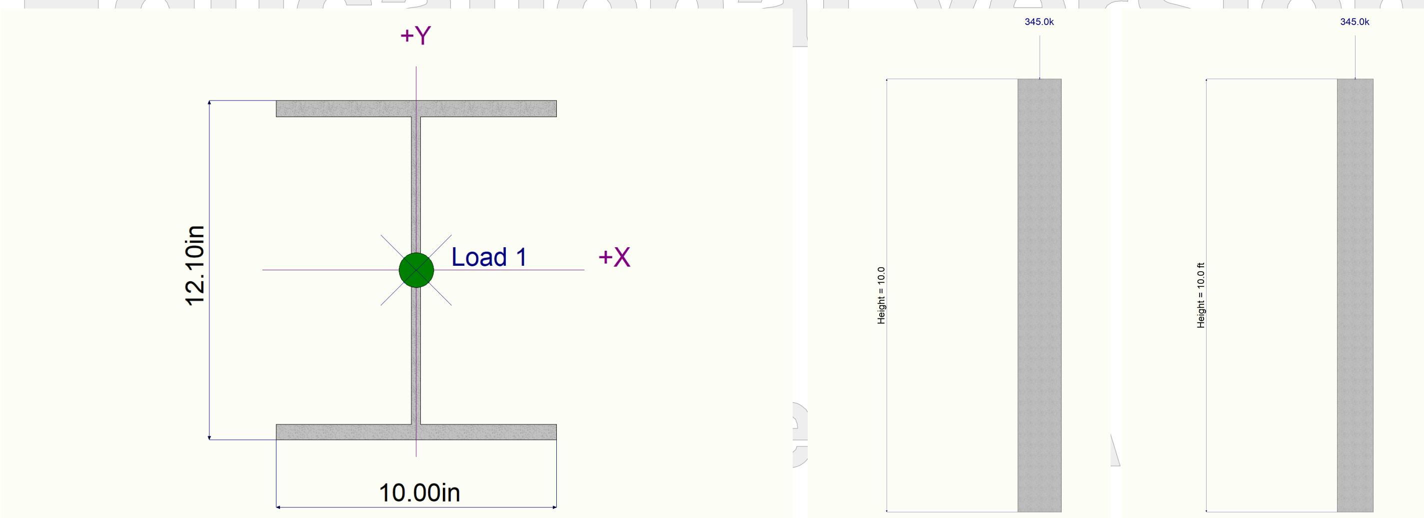
Steel Section Properties : W12x53

Depth	=	12.100	in	I xx	=	425.00	in^4	J	=	1.580	in^4
Web Thick	=	0.345	in	S xx	=	70.60	in^3	Cw	=	3,160.00	in^6
Flange Width	=	10.000	in	R xx	=	5.230	in				
Flange Thick	=	0.575	in	Zx	=	77.900	in^3				
Area	=	15.600	in^2	I yy	=	95.800	in^4				
Weight	=	53.000	plf	S yy	=	19.200	in^3	Wno	=	28.800	in^2
Kdesign	=	1.180	in	R yy	=	2.480	in	Sw	=	41.400	in^4
K1	=	0.938	in	Zy	=	29.100	in^3	Qf	=	16.000	in^3
rts	=	2.790	in					Qw	=	38.300	in^3
Ycg	=	0.000	in								

Steel Column

DESCRIPTION: D5-6 STL COLS

Sketches



Steel Column

DESCRIPTION: D7-Roof STL COLS

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W10x33**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 330.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 143.0, LR = 24.0, L = 48.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7895** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 260.796 k
0.9 * Pn 330.320 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 134.228 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 52.50 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.607	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.790	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D+1.60L	0.753	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.782	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.637	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D+L	0.666	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D	0.521	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.702	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+0.90D	0.391	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+1.40D+L	0.753	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft
+0.70D	0.304	PASS	0.00 ft	1.00	1.00	61.86	28.64	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	143.330								
+D+L	191.330								
+D+Lr	167.330								
+D+0.750Lr+0.750L	197.330								

Steel Column

DESCRIPTION: D7-Roof STL COLS

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	179.330								
+0.60D	85.998								
Lr Only	24.000								
L Only	48.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	197.330								
"	Minimum	24.000								
Reaction, X-X Axis Base	Maximum	143.330								
"	Minimum	143.330								
Reaction, Y-Y Axis Base	Maximum	143.330								
"	Minimum	143.330								
Reaction, X-X Axis Top	Maximum	143.330								
"	Minimum	143.330								
Reaction, Y-Y Axis Top	Maximum	143.330								
"	Minimum	143.330								
Moment, X-X Axis Base	Maximum	143.330								
"	Minimum	143.330								
Moment, Y-Y Axis Base	Maximum	143.330								
"	Minimum	143.330								
Moment, X-X Axis Top	Maximum	143.330								
"	Minimum	143.330								
Moment, Y-Y Axis Top	Maximum	143.330								
"	Minimum	143.330								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

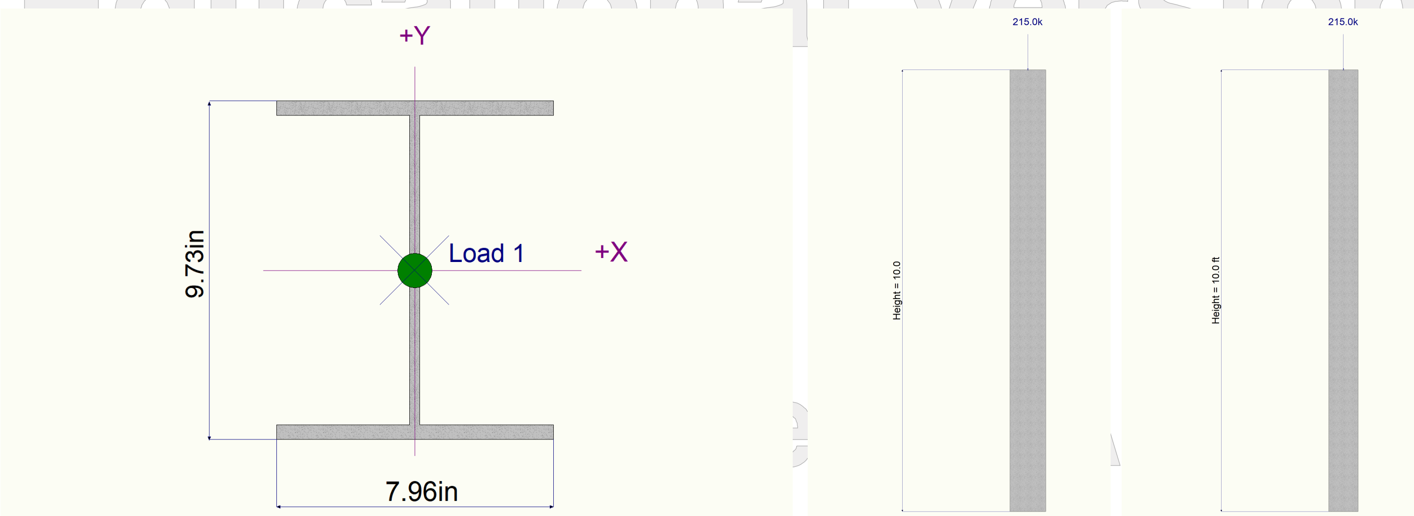
Steel Section Properties : W10x33

Depth	=	9.730	in	I xx	=	171.00	in^4	J	=	0.583	in^4
Web Thick	=	0.290	in	S xx	=	35.00	in^3	Cw	=	791.00	in^6
Flange Width	=	7.960	in	R xx	=	4.190	in				
Flange Thick	=	0.435	in	Zx	=	38.800	in^3				
Area	=	9.710	in^2	I yy	=	36.600	in^4				
Weight	=	33.000	plf	S yy	=	9.200	in^3	Wno	=	18.500	in^2
Kdesign	=	0.935	in	R yy	=	1.940	in	Sw	=	16.000	in^4
K1	=	0.750	in	Zy	=	14.000	in^3	Qf	=	7.750	in^3
rts	=	2.200	in					Qw	=	18.900	in^3
Ycg	=	0.000	in								

Steel Column

DESCRIPTION: D7-Roof STL COLS

Sketches



Steel Column

DESCRIPTION: D3-4 STL COLS (Corridor)

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x96**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top Pinned, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 0.80
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 0.80

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 960.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 391.0, LR = 24.0, L = 284.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = 0.7922 : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 936.75 k
0.9 * Pn 1,182.53 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 551.25 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 253.125 k-ft

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

PASS Maximum Shear Stress Ratio = 0.0 : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.464	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.792	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D+1.60L	0.782	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.670	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.430	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D+L	0.638	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D	0.398	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.648	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+0.90D	0.298	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+1.40D+L	0.704	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft
+0.70D	0.232	PASS	0.00 ft	1.00	1.00	31.07	17.65	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments (k-ft) @ Base	@ Top	My - End Moments @ Base	@ Top
D Only	391.960								
+D+L	675.960								
+D+Lr	415.960								
+D+0.750Lr+0.750L	622.960								

Steel Column

DESCRIPTION: D3-4 STL COLS (Corridor)

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
+D+0.750L	604.960								
+0.60D	235.176								
Lr Only	24.000								
L Only	284.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments k-ft @ Base	@ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	675.960								
"	Minimum	24.000								
Reaction, X-X Axis Base	Maximum	391.960								
"	Minimum	391.960								
Reaction, Y-Y Axis Base	Maximum	391.960								
"	Minimum	391.960								
Reaction, X-X Axis Top	Maximum	391.960								
"	Minimum	391.960								
Reaction, Y-Y Axis Top	Maximum	391.960								
"	Minimum	391.960								
Moment, X-X Axis Base	Maximum	391.960								
"	Minimum	391.960								
Moment, Y-Y Axis Base	Maximum	391.960								
"	Minimum	391.960								
Moment, X-X Axis Top	Maximum	391.960								
"	Minimum	391.960								
Moment, Y-Y Axis Top	Maximum	391.960								
"	Minimum	391.960								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

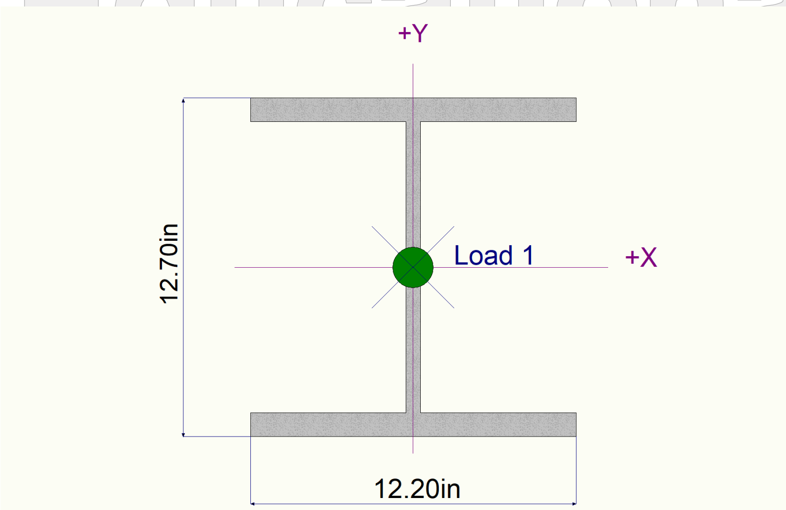
Steel Section Properties : W12x96

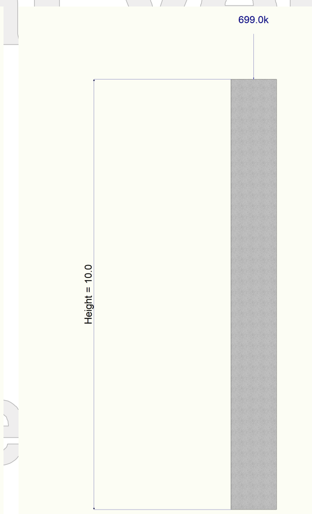
Depth	=	12.700	in	I xx	=	833.00	in^4	J	=	6.850	in^4
Web Thick	=	0.550	in	S xx	=	131.00	in^3	Cw	=	9,410.00	in^6
Flange Width	=	12.200	in	R xx	=	5.440	in				
Flange Thick	=	0.900	in	Zx	=	147.000	in^3				
Area	=	28.200	in^2	I yy	=	270.000	in^4				
Weight	=	96.000	plf	S yy	=	44.400	in^3	Wno	=	36.000	in^2
Kdesign	=	1.500	in	R yy	=	3.090	in	Sw	=	98.800	in^4
K1	=	1.125	in	Zy	=	67.500	in^3	Qf	=	30.900	in^3
rts	=	3.490	in					Qw	=	73.000	in^3
Ycg	=	0.000	in								

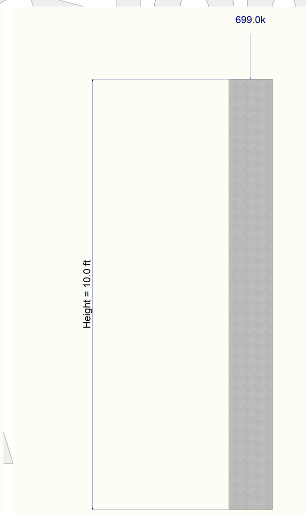
Steel Column

DESCRIPTION: D3-4 STL COLS (Corridor)

Sketches







Steel Column

DESCRIPTION: D5-6 STL COLS (Corridor)

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W12x58**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 580.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 226.0, LR = 24.0, L = 142.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7896** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 511.10 k
0.9 * Pn 647.26 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 317.580 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 121.875 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.490	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.790	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D+1.60L	0.771	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.699	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.479	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D+L	0.639	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D	0.420	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.658	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+0.90D	0.315	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+1.40D+L	0.709	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft
+0.70D	0.245	PASS	0.00 ft	1.00	1.00	47.81	22.73	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	226.580								
+D+L	368.580								
+D+Lr	250.580								
+D+0.750Lr+0.750L	351.080								

Steel Column

DESCRIPTION: D5-6 STL COLS (Corridor)

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction @ Base	k @ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	k-ft @ Top	My - End Moments @ Base	@ Top
+D+0.750L	333.080								
+0.60D	135.948								
Lr Only	24.000								
L Only	142.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction @ Base	k @ Top	Y-Y Axis Reaction @ Base	@ Top	Mx - End Moments @ Base	k-ft @ Top	My - End Moments @ Base	@ Top
Axial @ Base	Maximum	368.580								
"	Minimum	24.000								
Reaction, X-X Axis Base	Maximum	226.580								
"	Minimum	226.580								
Reaction, Y-Y Axis Base	Maximum	226.580								
"	Minimum	226.580								
Reaction, X-X Axis Top	Maximum	226.580								
"	Minimum	226.580								
Reaction, Y-Y Axis Top	Maximum	226.580								
"	Minimum	226.580								
Moment, X-X Axis Base	Maximum	226.580								
"	Minimum	226.580								
Moment, Y-Y Axis Base	Maximum	226.580								
"	Minimum	226.580								
Moment, X-X Axis Top	Maximum	226.580								
"	Minimum	226.580								
Moment, Y-Y Axis Top	Maximum	226.580								
"	Minimum	226.580								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

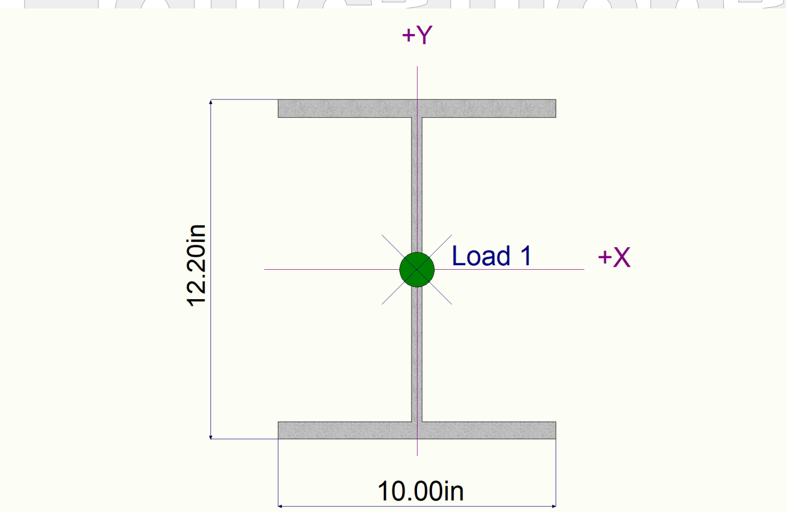
Steel Section Properties : W12x58

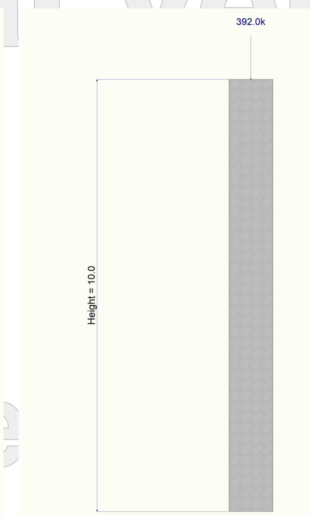
Depth	=	12.200	in	I xx	=	475.00	in^4	J	=	2.100	in^4
Web Thick	=	0.360	in	S xx	=	78.00	in^3	Cw	=	3,570.00	in^6
Flange Width	=	10.000	in	R xx	=	5.280	in				
Flange Thick	=	0.640	in	Zx	=	86.400	in^3				
Area	=	17.000	in^2	I yy	=	107.000	in^4				
Weight	=	58.000	plf	S yy	=	21.400	in^3	Wno	=	28.900	in^2
Kdesign	=	1.240	in	R yy	=	2.510	in	Sw	=	46.200	in^4
K1	=	0.938	in	Zy	=	32.500	in^3	Qf	=	17.800	in^3
rts	=	2.810	in					Qw	=	42.400	in^3
Ycg	=	0.000	in								

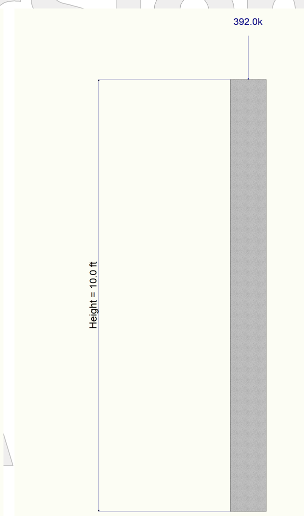
Steel Column

DESCRIPTION: D5-6 STL COLS (Corridor)

Sketches







Steel Column

DESCRIPTION: D7-Roof STL COLS (Corridor)

Code References

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **W10x39**
Analysis Method : Load Resistance Factor
Steel Stress Grade
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 10.0 ft
Top & Bottom Fixity Top & Bottom Pinned
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 10.0 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 10.0 ft, K = 1.0

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 390.0 lbs * Dead Load Factor
AXIAL LOADS . . .
Residential & Above: Axial Load at 10.0 ft, D = 143.0, LR = 24.0, L = 71.0 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.7524** : 1
Load Combination +1.20D+0.50Lr+1.60L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pu 297.668 k
0.9 * Pn 395.616 k
Mu-x 0.0 k-ft
0.9 * Mn-x : 164.176 k-ft
Mu-y 0.0 k-ft
0.9 * Mn-y : 64.50 k-ft

PASS Maximum Shear Stress Ratio = **0.0** : 1
Load Combination 0.0
Location of max.above base 0.0 ft
At maximum location values are . . .
Vu : Applied 0.0 k
Vn * Phi : Allowable 0.0 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.0 k

Maximum Load Deflections . . .
Along Y-Y 0.0 in at 0.0ft above base
for load combination :
Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Maximum Shear Ratios: Stress Ratio	Status	Location
+1.40D	0.507	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D+0.50Lr+1.60L	0.752	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D+1.60L	0.722	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D+1.60Lr+L	0.711	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D+1.60Lr	0.532	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D+L	0.614	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D	0.435	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.20D+0.50Lr+L	0.645	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+0.90D	0.326	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+1.40D+L	0.687	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft
+0.70D	0.254	PASS	0.00 ft	1.00	1.00	60.61	28.10	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	143.390								
+D+L	214.390								
+D+Lr	167.390								
+D+0.750Lr+0.750L	214.640								

Steel Column

DESCRIPTION: D7-Roof STL COLS (Corridor)

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	X-X Axis Reaction k @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments k-ft @ Base	Mx - End Moments k-ft @ Top	My - End Moments @ Base	My - End Moments @ Top
+D+0.750L	196.640								
+0.60D	86.034								
Lr Only	24.000								
L Only	71.000								

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	X-X Axis Reaction k @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments k-ft @ Base	Mx - End Moments k-ft @ Top	My - End Moments @ Base	My - End Moments @ Top
Axial @ Base	Maximum	214.640								
"	Minimum	24.000								
Reaction, X-X Axis Base	Maximum	143.390								
"	Minimum	143.390								
Reaction, Y-Y Axis Base	Maximum	143.390								
"	Minimum	143.390								
Reaction, X-X Axis Top	Maximum	143.390								
"	Minimum	143.390								
Reaction, Y-Y Axis Top	Maximum	143.390								
"	Minimum	143.390								
Moment, X-X Axis Base	Maximum	143.390								
"	Minimum	143.390								
Moment, Y-Y Axis Base	Maximum	143.390								
"	Minimum	143.390								
Moment, X-X Axis Top	Maximum	143.390								
"	Minimum	143.390								
Moment, Y-Y Axis Top	Maximum	143.390								
"	Minimum	143.390								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+Lr	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750Lr+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+0.750L	0.0000	in	0.000	ft	0.000	in	0.000	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

Steel Section Properties : W10x39

Depth	=	9.920	in	I xx	=	209.00	in^4	J	=	0.976	in^4
Web Thick	=	0.315	in	S xx	=	42.10	in^3	Cw	=	992.00	in^6
Flange Width	=	7.990	in	R xx	=	4.270	in				
Flange Thick	=	0.530	in	Zx	=	46.800	in^3				
Area	=	11.500	in^2	I yy	=	45.000	in^4				
Weight	=	39.000	plf	S yy	=	11.300	in^3	Wno	=	18.800	in^2
Kdesign	=	1.030	in	R yy	=	1.980	in	Sw	=	19.900	in^4
K1	=	0.813	in	Zy	=	17.200	in^3	Qf	=	9.550	in^3
rts	=	2.240	in					Qw	=	23.000	in^3
Ycg	=	0.000	in								

Title Block Line 1
You can change this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 31 MAR 2020, 2:05PM

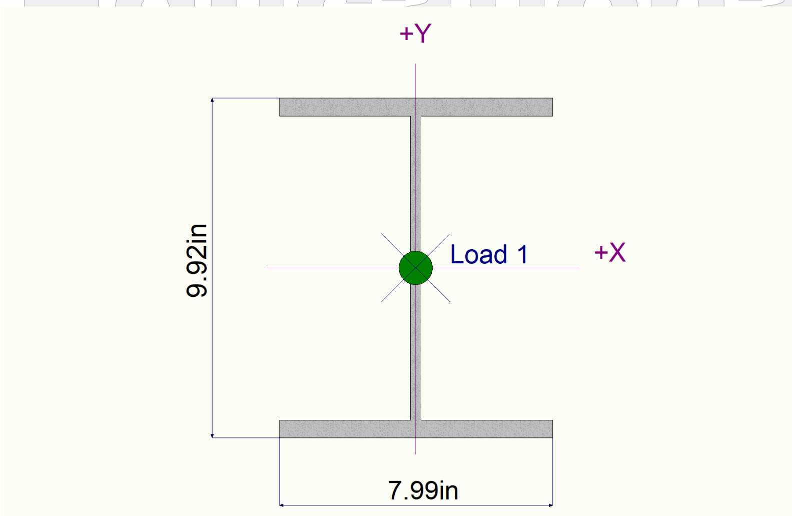
Steel Column

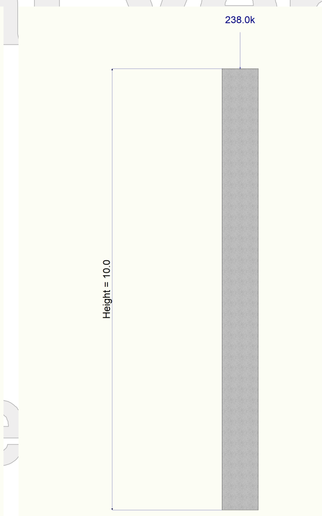
File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6
Software copyright ENERCALC, INC. 1983-2020, Build:12.20.2.24

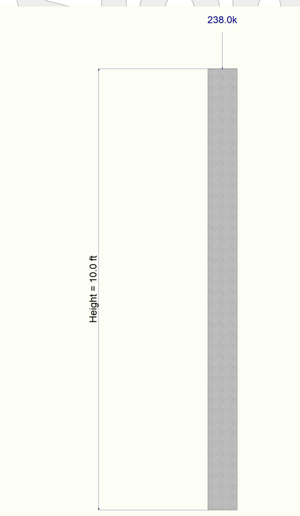
Lic. # : KW-06090157 - Educational Version
Licensed User : SANTA CLARA UNIVERSITY, CIVIL ENGINEERING

DESCRIPTION: D7-Roof STL COLS (Corridor)

Sketches







Gravity Beam Schedule

Steel Gravity Beams	Largest Trib. Width (ft)	Dead (ksf)	Live (ksf)	Dead (klf)	Live (klf)	Sizes	Camber (in)
Residential - 11 ft and below	15.1	0.07	0.04	1.06	0.604	W8X13	
Residential - 20 ft to 30 ft spans	30.2	0.07	0.04	2.11	1.00	W16X100	
Residential - 30 to 37 ft spans	30.2	0.07	0.04	2.11	1.00	W18X97	3.25
Residential - 40 to 45 ft spans	18.0	0.07	0.04	1.26	0.720	W18X130	3.25
Residential (corridor) - 25.5 ft & below spans	20.0	0.07	0.06	1.40	1.20	W14X68	
Residential (corridor) - 30 to 37 ft spans	20.0	0.07	0.06	1.40	1.20	W18X119	
Residential (corridor) - 40 to 48 ft spans	20.8	0.07	0.06	1.45	1.245	W21X122	4.0
Residential (Roof) - 11 ft and below	15.1	0.051	0.02	0.77	0.302	W6X16	
Residential (Roof) - 20 ft to 30 ft spans	30.2	0.051	0.02	1.54	1.00	W16X67	
Residential (Roof) - 30 to 37 ft spans	30.2	0.051	0.02	1.54	1.00	W18X106	
Residential (Roof) - 40 to 45 ft spans	18.0	0.051	0.02	0.918	0.360	W18X119	

Concrete Gravity Beams	Largest Trib. Width (ft)	Dead (ksf)	Live (ksf)	Dead (klf)	Live (klf)	Total Height (in)	Width (in)	Layer 1		Layer 2		Layer 3	
								# of Bars	Bar Size #	# of Bars	Bar Size #	# of Bars	Bar Size #
Parking Garage - 18'3" and below spans	24.0	0.108	0.06	2.59	1.44	16.0	18.0	7	9				
Parking Garage - 19 to 29.5 ft spans	31.0	0.108	0.06	3.35	1.86	22.0	24.0	8	10	8	10		
Parking Garage - 30' to 45'3" spans	28.3	0.108	0.06	3.06	1.698	26.0	28.0	10	10	10	10	10	9

Steel Beam

DESCRIPTION: Residential - 11 ft and below spans

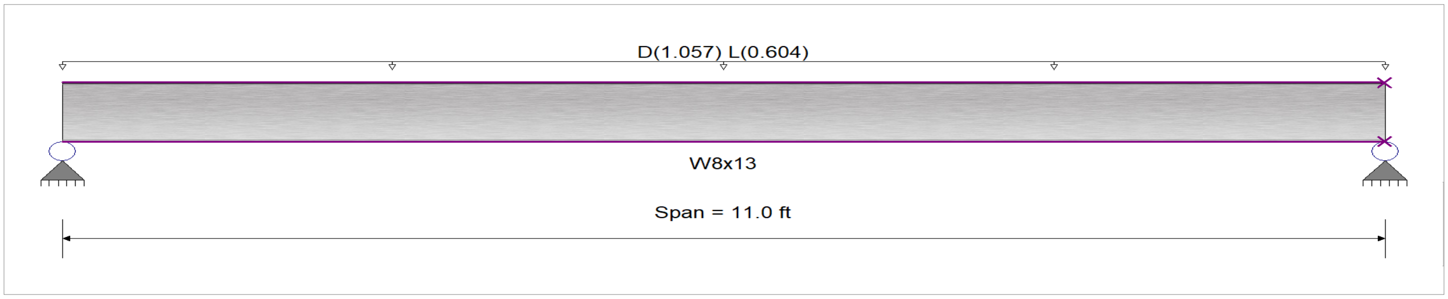
CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam is Fully Braced against lateral-torsional buckling
Bending Axis : Major Axis Bending

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.040 ksf, Tributary Width = 15.10 ft, (Typical Residential Floor)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.796** : 1	Maximum Shear Stress Ratio =	**0.225** : 1
Section used for this span	**W8x13**	Section used for this span	**W8x13**
Mu : Applied	34.037 k-ft	Vu : Applied	12.377 k
Mn * Phi : Allowable	42.750 k-ft	Vn * Phi : Allowable	55.131 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	5.500 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.174 in	Ratio =	758 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.482 in	Ratio =	274 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 11.00 ft	1	0.530	0.149	22.66		22.66	47.50	42.75	1.00	1.00	8.24	55.13	55.13
+1.20D+1.60L													
Dsgn. L = 11.00 ft	1	0.796	0.225	34.04		34.04	47.50	42.75	1.00	1.00	12.38	55.13	55.13
+1.20D+L													
Dsgn. L = 11.00 ft	1	0.668	0.188	28.56		28.56	47.50	42.75	1.00	1.00	10.38	55.13	55.13
+1.20D													
Dsgn. L = 11.00 ft	1	0.454	0.128	19.42		19.42	47.50	42.75	1.00	1.00	7.06	55.13	55.13
+0.90D													
Dsgn. L = 11.00 ft	1	0.341	0.096	14.57		14.57	47.50	42.75	1.00	1.00	5.30	55.13	55.13
+1.40D+L													
Dsgn. L = 11.00 ft	1	0.744	0.210	31.79		31.79	47.50	42.75	1.00	1.00	11.56	55.13	55.13
+0.70D													
Dsgn. L = 11.00 ft	1	0.265	0.075	11.33		11.33	47.50	42.75	1.00	1.00	4.12	55.13	55.13

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	0.4824	5.531		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	9.207	9.207
Overall MINimum	3.322	3.322

Steel Beam

DESCRIPTION: Residential - 11 ft and below spans

Vertical Reactions

Support notation : Far left is #1 — Values in KIPS

Load Combination	Support 1	Support 2
D Only	5.885	5.885
+D+L	9.207	9.207
+D+0.750L	8.377	8.377
+0.60D	3.531	3.531
L Only	3.322	3.322

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Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

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Steel Beam

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DESCRIPTION: Residential - 20 to 30 ft spans

CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

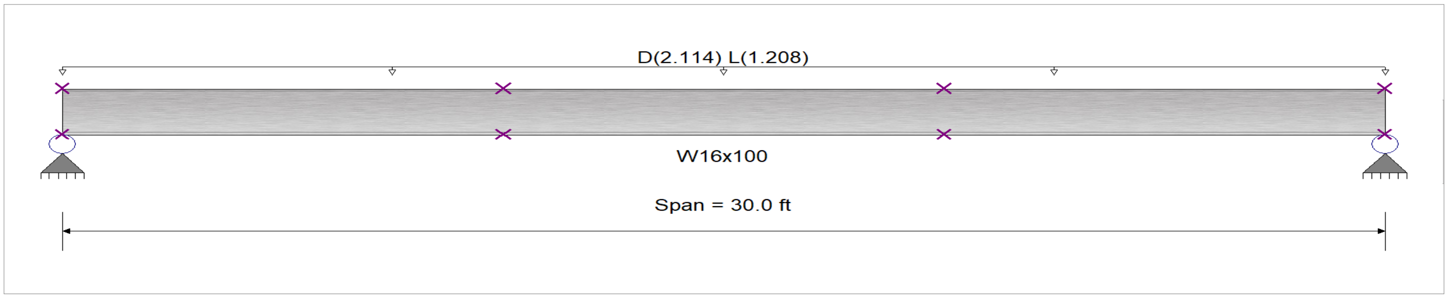
Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam bracing is defined as a set spacing over all spans
Bending Axis : Major Axis Bending

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.040 ksf, Tributary Width = 30.20 ft, (Typical Residential Floor)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.699 : 1	Maximum Shear Stress Ratio =	0.231 : 1
Section used for this span	W16x100	Section used for this span	W16x100
Mu : Applied	516.330 k-ft	Vu : Applied	68.844 k
Mn * Phi : Allowable	738.158 k-ft	Vn * Phi : Allowable	298.350 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.511 in	Ratio =	703 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	1.450 in	Ratio =	248 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.416	0.156	309.07		309.07	825.00	742.50	1.46	1.00	46.49	298.35	298.35
Dsgn. L = 10.03 ft	1	0.472	0.053	348.71	309.07	348.71	820.18	738.16	1.01	1.00	15.68	298.35	298.35
Dsgn. L = 10.03 ft	1	0.418	0.156	310.40		310.40	825.00	742.50	1.45	1.00	46.49	298.35	298.35
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.616	0.231	457.64		457.64	825.00	742.50	1.46	1.00	68.84	298.35	298.35
Dsgn. L = 10.03 ft	1	0.699	0.078	516.33	457.64	516.33	820.18	738.16	1.01	1.00	23.21	298.35	298.35
Dsgn. L = 10.03 ft	1	0.619	0.231	459.61		459.61	825.00	742.50	1.45	1.00	68.84	298.35	298.35
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.519	0.194	385.37		385.37	825.00	742.50	1.46	1.00	57.97	298.35	298.35
Dsgn. L = 10.03 ft	1	0.589	0.066	434.79	385.37	434.79	820.18	738.16	1.01	1.00	19.54	298.35	298.35
Dsgn. L = 10.03 ft	1	0.521	0.194	387.03		387.03	825.00	742.50	1.45	1.00	57.97	298.35	298.35
+1.20D													
Dsgn. L = 9.94 ft	1	0.357	0.134	264.92		264.92	825.00	742.50	1.46	1.00	39.85	298.35	298.35
Dsgn. L = 10.03 ft	1	0.405	0.045	298.89	264.92	298.89	820.18	738.16	1.01	1.00	13.44	298.35	298.35
Dsgn. L = 10.03 ft	1	0.358	0.134	266.06		266.06	825.00	742.50	1.45	1.00	39.85	298.35	298.35
+0.90D													
Dsgn. L = 9.94 ft	1	0.268	0.100	198.69		198.69	825.00	742.50	1.46	1.00	29.89	298.35	298.35
Dsgn. L = 10.03 ft	1	0.304	0.034	224.17	198.69	224.17	820.18	738.16	1.01	1.00	10.08	298.35	298.35
Dsgn. L = 10.03 ft	1	0.269	0.100	199.54		199.54	825.00	742.50	1.45	1.00	29.89	298.35	298.35

Steel Beam

DESCRIPTION: Residential - 20 to 30 ft spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D+L													
Dsgn. L = 9.94 ft	1	0.578	0.217	429.52		429.52	825.00	742.50	1.46	1.00	64.61	298.35	298.35
Dsgn. L = 10.03 ft	1	0.657	0.073	484.61	429.52	484.61	820.18	738.16	1.01	1.00	21.78	298.35	298.35
Dsgn. L = 10.03 ft	1	0.581	0.217	431.37		431.37	825.00	742.50	1.45	1.00	64.61	298.35	298.35
+0.70D													
Dsgn. L = 9.94 ft	1	0.208	0.078	154.53		154.53	825.00	742.50	1.46	1.00	23.25	298.35	298.35
Dsgn. L = 10.03 ft	1	0.236	0.026	174.35	154.53	174.35	820.18	738.16	1.01	1.00	7.84	298.35	298.35
Dsgn. L = 10.03 ft	1	0.209	0.078	155.20		155.20	825.00	742.50	1.45	1.00	23.25	298.35	298.35

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	1.4499	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	51.330	51.330
Overall MINimum	18.120	18.120
D Only	33.210	33.210
+D+L	51.330	51.330
+D+0.750L	46.800	46.800
+0.60D	19.926	19.926
L Only	18.120	18.120

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Steel Beam

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DESCRIPTION: Residential - 30 to 37 ft spans

CODE REFERENCES

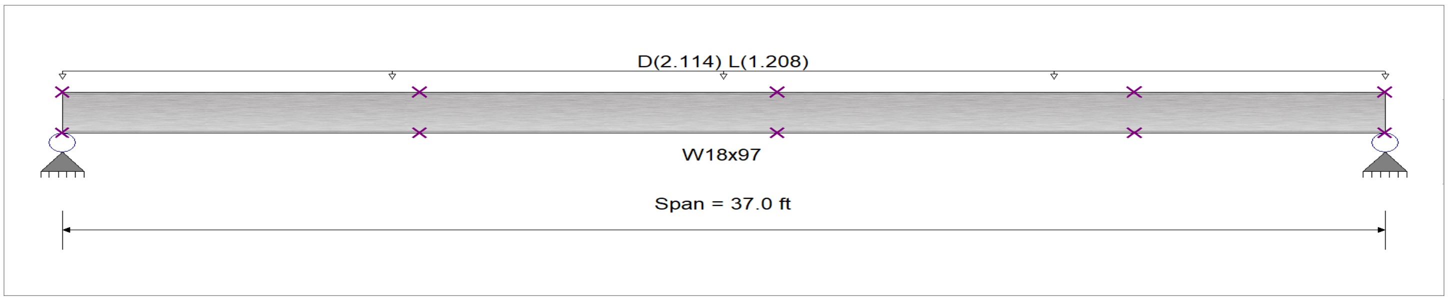
Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Beam bracing is defined as a set spacing over all spans	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.040 ksf, Tributary Width = 30.20 ft, (Typical Residential Floor)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	0.992 : 1	Maximum Shear Stress Ratio =	0.284 : 1
Section used for this span	W18x97	Section used for this span	W18x97
Mu : Applied	784.779 k-ft	Vu : Applied	84.841 k
Mn * Phi : Allowable	791.250 k-ft	Vn * Phi : Allowable	298.530 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	18.500ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	1.007 in	Ratio =	440 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	2.854 in	Ratio =	156 <240.0
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.526	0.192	416.22		416.22	879.17	791.25	1.52	1.00	57.26	298.53	298.53
Dsgn. L = 10.04 ft	1	0.669	0.089	529.70	416.22	529.70	879.17	791.25	1.04	1.00	26.51	298.53	298.53
Dsgn. L = 9.94 ft	1	0.665	0.118	526.31	327.96	526.31	879.17	791.25	1.11	1.00	35.34	298.53	298.53
Dsgn. L = 7.08 ft	1	0.414	0.192	327.96		327.96	879.17	791.25	1.55	1.00	57.26	298.53	298.53
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.779	0.284	616.65		616.65	879.17	791.25	1.52	1.00	84.84	298.53	298.53
Dsgn. L = 10.04 ft	1	0.992	0.132	784.78	616.65	784.78	879.17	791.25	1.04	1.00	39.27	298.53	298.53
Dsgn. L = 9.94 ft	1	0.985	0.175	779.76	485.88	779.76	879.17	791.25	1.11	1.00	52.36	298.53	298.53
Dsgn. L = 7.08 ft	1	0.614	0.284	485.88		485.88	879.17	791.25	1.55	1.00	84.84	298.53	298.53
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.656	0.239	519.19		519.19	879.17	791.25	1.52	1.00	71.43	298.53	298.53
Dsgn. L = 10.04 ft	1	0.835	0.111	660.75	519.19	660.75	879.17	791.25	1.04	1.00	33.06	298.53	298.53
Dsgn. L = 9.94 ft	1	0.830	0.148	656.52	409.09	656.52	879.17	791.25	1.11	1.00	44.08	298.53	298.53
Dsgn. L = 7.08 ft	1	0.517	0.239	409.09		409.09	879.17	791.25	1.55	1.00	71.43	298.53	298.53
+1.20D													
Dsgn. L = 9.94 ft	1	0.451	0.164	356.76		356.76	879.17	791.25	1.52	1.00	49.08	298.53	298.53
Dsgn. L = 10.04 ft	1	0.574	0.076	454.03	356.76	454.03	879.17	791.25	1.04	1.00	22.72	298.53	298.53
Dsgn. L = 9.94 ft	1	0.570	0.101	451.12	281.11	451.12	879.17	791.25	1.11	1.00	30.29	298.53	298.53
Dsgn. L = 7.08 ft	1	0.355	0.164	281.11		281.11	879.17	791.25	1.55	1.00	49.08	298.53	298.53

Steel Beam

DESCRIPTION: Residential - 30 to 37 ft spans

Load Combination			Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length		Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+0.90D														
Dsgn. L =	9.94 ft	1	0.338	0.123	267.57		267.57	879.17	791.25	1.52	1.00	36.81	298.53	298.53
Dsgn. L =	10.04 ft	1	0.430	0.057	340.52	267.57	340.52	879.17	791.25	1.04	1.00	17.04	298.53	298.53
Dsgn. L =	9.94 ft	1	0.428	0.076	338.34	210.83	338.34	879.17	791.25	1.11	1.00	22.72	298.53	298.53
Dsgn. L =	7.08 ft	1	0.266	0.123	210.83		210.83	879.17	791.25	1.55	1.00	36.81	298.53	298.53
+1.40D+L														
Dsgn. L =	9.94 ft	1	0.731	0.267	578.65		578.65	879.17	791.25	1.52	1.00	79.61	298.53	298.53
Dsgn. L =	10.04 ft	1	0.931	0.123	736.42	578.65	736.42	879.17	791.25	1.04	1.00	36.85	298.53	298.53
Dsgn. L =	9.94 ft	1	0.925	0.165	731.71	455.94	731.71	879.17	791.25	1.11	1.00	49.13	298.53	298.53
Dsgn. L =	7.08 ft	1	0.576	0.267	455.94		455.94	879.17	791.25	1.55	1.00	79.61	298.53	298.53
+0.70D														
Dsgn. L =	9.94 ft	1	0.263	0.096	208.11		208.11	879.17	791.25	1.52	1.00	28.63	298.53	298.53
Dsgn. L =	10.04 ft	1	0.335	0.044	264.85	208.11	264.85	879.17	791.25	1.04	1.00	13.25	298.53	298.53
Dsgn. L =	9.94 ft	1	0.333	0.059	263.16	163.98	263.16	879.17	791.25	1.11	1.00	17.67	298.53	298.53
Dsgn. L =	7.08 ft	1	0.207	0.096	163.98		163.98	879.17	791.25	1.55	1.00	28.63	298.53	298.53

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	2.8539	18.606		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	63.252	63.252
Overall MINimum	22.348	22.348
D Only	40.904	40.904
+D+L	63.252	63.252
+D+0.750L	57.665	57.665
+0.60D	24.542	24.542
L Only	22.348	22.348

Pre-Composite Camber Beam Design (Residential - 30 to 37 ft spans)

Design Per AISC 360-16

Material Properties

G =	11200	ksi
E =	29000	ksi
Fy =	50	ksi
φb =	0.9	
φv =	0.9	
Cb =	1	
C =	1	

Stud Properties

Fu =	60	ksi

Type of Construction

Type =	IIIA	(Assumption: Ordinary)
Fire Rating =	1	hour
Type of Concrete =	NWC	

Beam Data

Trib. Width =	30.2	ft
Beam Length =	37	ft
Unbraced Length =	10	ft
Fcr =	207	ksi

Total Dead Load

Typical Residential Floor =	70.0	psf
Concrete & Metal Deck Gage 20 =	62.5	psf
Beam Self-Weight =	3.2	psf
	135.7	psf

Total Live Load

Typical Residential Floor =	40.0	psf
	40.0	psf

Deflection

ΔD =	3.41	in

Round Camber Down to Nearest 1/4"

Use: **3.25** **in** (Req'd Pre-Camber)

Section Properties

Designation =	**W18X97**	
$Beam_{weight}$ =	97	plf
Area =	28.5	in^2
Depth =	18.6	in
bf =	11.1	in
tw =	0.535	in
tw/2=	5/16	in
tf =	0.87	in
k =	1.27	in
bf/2tf=	6.41	
h/tw=	30	
Ix =	1750	in^4
Zx =	211	in^3
Sx =	188	in^3
rx =	7.82	in
Iy =	201	in^4
Zy =	55.3	in^3
Sy =	36.1	in^3
ry =	2.65	in
J =	5.86	in^4
Cw =	15800	in^6
rts =	3.08	in
ho =	17.7	in

Return to TABLE OF CONTENTS

2.4 3WxH-36 Composite Deck

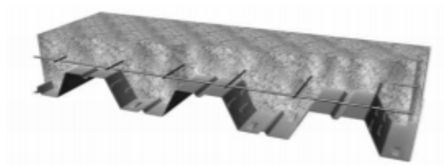
6 ½" Total Slab Depth

Normal Weight Concrete (145 pcf)

Concrete Volume 1.543yd³/100ft²

1 Hour Fire Rating

ASC STEEL DECK



3WxH-36 6 1/2 " Slab Depth, 145 pcf NWC

	Gage	Single	Double	Triple	Gage	Single	Double	Triple
Maximum Unshored Span	22	8' - 11"	9' - 9"	10' - 1"	19	11' - 3"	12' - 4"	12' - 9"
	21	9' - 8"	10' - 5"	10' - 9"	18	11' - 8"	13' - 5"	13' - 8"
	20	10' - 5"	11' - 1"	11' - 5"	16	12' - 3"	15' - 0"	14' - 5"

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
22	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	516	452	398	352	313	280	251	226	203	184	166	151	137	125	113
	LRFD, ϕW	691	603	530	468	415	370	330	296	265	239	215	194	175	158	143
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3839	3813	3790	3781	3762	3745	3729	3715	3702	3698	3687	3677	3667	3658	3649
	PAF Base Steel ≥ .25"	3649	3635	3622	3621	3610	3600	3592	3583	3576	3577	3571	3564	3559	3553	3548
	PAF Base Steel ≥ 0.125"	3634	3621	3609	3609	3598	3589	3581	3573	3566	3568	3561	3556	3550	3545	3541
	#12 Screw Base Steel ≥ .0385"	3621	3608	3597	3597	3587	3579	3571	3564	3557	3559	3553	3548	3542	3538	3533
	Concrete + Deck =	62.2 psf			I_{cr} = 78.7 in^4/ft			ASD		M_{no}/Ω= 48.0 kip-in/ft				V_n/Ω = 4.14 kip/ft		
	$(I_{cr}+I_u)/2$ =	154.9 in^4/ft			I_u = 231.1 in^4/ft			LRFD		ϕM_{no}= 73.5 kip-in/ft				ϕV_n = 6.01 kip/ft		

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
21	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	569	498	439	390	347	310	279	251	227	205	186	169	154	140	128
	LRFD, ϕW	762	666	586	519	461	411	368	330	297	268	242	219	198	180	163
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3902	3872	3846	3836	3815	3795	3777	3761	3746	3742	3729	3717	3706	3695	3685
	PAF Base Steel ≥ .25"	3684	3667	3652	3653	3640	3629	3619	3609	3600	3603	3595	3588	3581	3575	3569
	PAF Base Steel ≥ 0.125"	3667	3651	3638	3639	3627	3616	3606	3597	3589	3592	3585	3578	3572	3566	3560
	#12 Screw Base Steel ≥ .0385"	3652	3638	3624	3626	3615	3605	3596	3587	3579	3583	3576	3569	3563	3558	3552
	Concrete + Deck =	62.4 psf			I_{cr} = 84.9 in^4/ft			ASD		M_{no}/Ω= 52.5 kip-in/ft				V_n/Ω = 4.80 kip/ft		
	$(I_{cr}+I_u)/2$ =	159.4 in^4/ft			I_u = 233.8 in^4/ft			LRFD		ϕM_{no}= 80.3 kip-in/ft				ϕV_n = 6.91 kip/ft		

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
20	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	618	542	478	424	378	339	305	275	249	225	205	187	170	155	142
	LRFD, ϕW	829	726	639	566	504	450	403	362	327	295	267	242	220	200	182
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3949	3916	3887	3878	3854	3832	3812	3794	3778	3775	3760	3747	3735	3723	3712
	PAF Base Steel ≥ .25"	3710	3691	3675	3677	3663	3650	3639	3628	3619	3622	3614	3606	3598	3591	3585
	PAF Base Steel ≥ 0.125"	3692	3674	3659	3662	3648	3636	3626	3616	3607	3611	3602	3595	3588	3581	3575
	#12 Screw Base Steel ≥ .0385"	3676	3660	3645	3649	3636	3625	3614	3605	3596	3601	3593	3586	3579	3573	3567
	Concrete + Deck =	62.5 psf			I_{cr} = 90.6 in^4/ft			ASD		M_{no}/Ω= 56.7 kip-in/ft				V_n/Ω = 5.38 kip/ft		
	$(I_{cr}+I_u)/2$ =	163.5 in^4/ft			I_u = 236.4 in^4/ft			LRFD		ϕM_{no}= 86.8 kip-in/ft				ϕV_n = 7.71 kip/ft		

All Gages	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) for all vertical load spans, WWF Size or Area of Steel per foot width					
	3/4" Welded Shear Studs	6x6 W1.4xW1.4 A_s = 0.028 in^2/ft	6x6 W2.9xW2.9 A_s = 0.058 in^2/ft	6x6 W4.0xW4.0 A_s = 0.080 in^2/ft	4x4 W4xW4 A_s = 0.120 in^2/ft	4x4 W6xW6 A_s = 0.180 in^2/ft
	12 in o.c.	n/a	6030	7020	8820	11520
	24 in o.c.	n/a	6030	7020	7750	7750
	36 in o.c.	n/a	5170	5170	5170	5170

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Project Descr:

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Steel Beam

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: Residential - 40 to 45 ft spans

CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

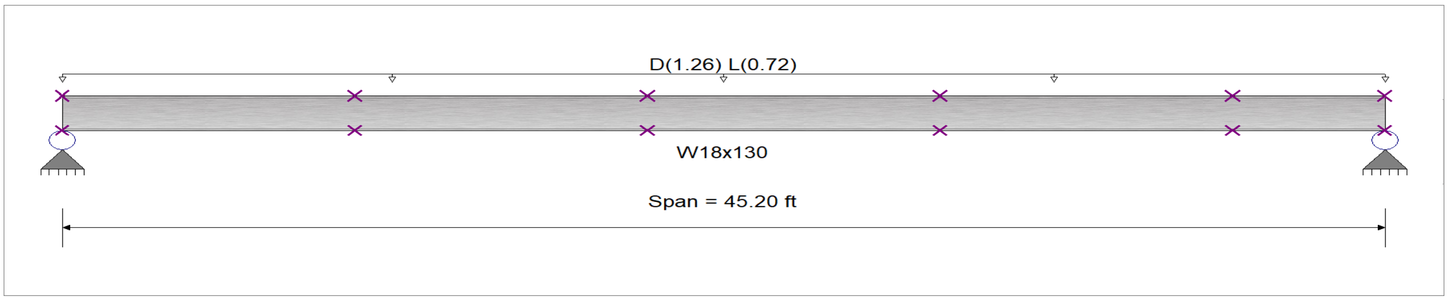
Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam bracing is defined as a set spacing over all spans
Bending Axis : Major Axis Bending

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.040 ksf, Tributary Width = 18.0 ft, (Typical Residential Floor)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	0.662 : 1	Maximum Shear Stress Ratio =	0.164 : 1
Section used for this span	W18x130	Section used for this span	W18x130
Mu : Applied	720.172 k-ft	Vu : Applied	63.732 k
Mn * Phi : Allowable	1,087.500 k-ft	Vn * Phi : Allowable	387.930 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	22.600ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.952 in	Ratio =	569 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	2.790 in	Ratio =	194 <240.0
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.314	0.113	341.12		341.12	1,208.33	1,087.50	1.56	1.00	43.98	387.93	387.93
Dsgn. L = 9.94 ft	1	0.450	0.063	489.81	341.12	489.81	1,208.33	1,087.50	1.10	1.00	24.63	387.93	387.93
Dsgn. L = 10.07 ft	1	0.457	0.037	496.97	444.25	496.97	1,208.33	1,087.50	1.01	1.00	14.32	387.93	387.93
Dsgn. L = 9.94 ft	1	0.409	0.087	444.25	205.59	444.25	1,208.33	1,087.50	1.21	1.00	33.68	387.93	387.93
Dsgn. L = 5.29 ft	1	0.189	0.113	205.59		205.59	1,208.33	1,087.50	1.58	1.00	43.98	387.93	387.93
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.455	0.164	494.33		494.33	1,208.33	1,087.50	1.56	1.00	63.73	387.93	387.93
Dsgn. L = 9.94 ft	1	0.653	0.092	709.80	494.33	709.80	1,208.33	1,087.50	1.10	1.00	35.69	387.93	387.93
Dsgn. L = 10.07 ft	1	0.662	0.054	720.17	643.77	720.17	1,208.33	1,087.50	1.01	1.00	20.76	387.93	387.93
Dsgn. L = 9.94 ft	1	0.592	0.126	643.77	297.92	643.77	1,208.33	1,087.50	1.21	1.00	48.80	387.93	387.93
Dsgn. L = 5.29 ft	1	0.274	0.164	297.92		297.92	1,208.33	1,087.50	1.58	1.00	63.73	387.93	387.93
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.385	0.139	418.60		418.60	1,208.33	1,087.50	1.56	1.00	53.97	387.93	387.93
Dsgn. L = 9.94 ft	1	0.553	0.078	601.07	418.60	601.07	1,208.33	1,087.50	1.10	1.00	30.22	387.93	387.93
Dsgn. L = 10.07 ft	1	0.561	0.045	609.85	545.15	609.85	1,208.33	1,087.50	1.01	1.00	17.58	387.93	387.93
Dsgn. L = 9.94 ft	1	0.501	0.107	545.15	252.28	545.15	1,208.33	1,087.50	1.21	1.00	41.32	387.93	387.93
Dsgn. L = 5.29 ft	1	0.232	0.139	252.28		252.28	1,208.33	1,087.50	1.58	1.00	53.97	387.93	387.93
+1.20D													
Dsgn. L = 9.94 ft	1	0.269	0.097	292.39		292.39	1,208.33	1,087.50	1.56	1.00	37.70	387.93	387.93

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Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 2 APR 2020, 8:41PM

Steel Beam

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

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DESCRIPTION: Residential - 40 to 45 ft spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
Dsgn. L = 9.94 ft	1	0.386	0.054	419.84	292.39	419.84	1,208.33	1,087.50	1.10	1.00	21.11	387.93	387.93
Dsgn. L = 10.07 ft	1	0.392	0.032	425.97	380.78	425.97	1,208.33	1,087.50	1.01	1.00	12.28	387.93	387.93
Dsgn. L = 9.94 ft	1	0.350	0.074	380.78	176.22	380.78	1,208.33	1,087.50	1.21	1.00	28.86	387.93	387.93
Dsgn. L = 5.29 ft	1	0.162	0.097	176.22		176.22	1,208.33	1,087.50	1.58	1.00	37.70	387.93	387.93
+0.90D													
Dsgn. L = 9.94 ft	1	0.202	0.073	219.29		219.29	1,208.33	1,087.50	1.56	1.00	28.27	387.93	387.93
Dsgn. L = 9.94 ft	1	0.290	0.041	314.88	219.29	314.88	1,208.33	1,087.50	1.10	1.00	15.83	387.93	387.93
Dsgn. L = 10.07 ft	1	0.294	0.024	319.48	285.59	319.48	1,208.33	1,087.50	1.01	1.00	9.21	387.93	387.93
Dsgn. L = 9.94 ft	1	0.263	0.056	285.59	132.16	285.59	1,208.33	1,087.50	1.21	1.00	21.65	387.93	387.93
Dsgn. L = 5.29 ft	1	0.122	0.073	132.16		132.16	1,208.33	1,087.50	1.58	1.00	28.27	387.93	387.93
+1.40D+L													
Dsgn. L = 9.94 ft	1	0.430	0.155	467.33		467.33	1,208.33	1,087.50	1.56	1.00	60.25	387.93	387.93
Dsgn. L = 9.94 ft	1	0.617	0.087	671.04	467.33	671.04	1,208.33	1,087.50	1.10	1.00	33.74	387.93	387.93
Dsgn. L = 10.07 ft	1	0.626	0.051	680.84	608.61	680.84	1,208.33	1,087.50	1.01	1.00	19.62	387.93	387.93
Dsgn. L = 9.94 ft	1	0.560	0.119	608.61	281.65	608.61	1,208.33	1,087.50	1.21	1.00	46.14	387.93	387.93
Dsgn. L = 5.29 ft	1	0.259	0.155	281.65		281.65	1,208.33	1,087.50	1.58	1.00	60.25	387.93	387.93
+0.70D													
Dsgn. L = 9.94 ft	1	0.157	0.057	170.56		170.56	1,208.33	1,087.50	1.56	1.00	21.99	387.93	387.93
Dsgn. L = 9.94 ft	1	0.225	0.032	244.91	170.56	244.91	1,208.33	1,087.50	1.10	1.00	12.31	387.93	387.93
Dsgn. L = 10.07 ft	1	0.228	0.018	248.48	222.12	248.48	1,208.33	1,087.50	1.01	1.00	7.16	387.93	387.93
Dsgn. L = 9.94 ft	1	0.204	0.043	222.12	102.79	222.12	1,208.33	1,087.50	1.21	1.00	16.84	387.93	387.93
Dsgn. L = 5.29 ft	1	0.095	0.057	102.79		102.79	1,208.33	1,087.50	1.58	1.00	21.99	387.93	387.93

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	2.7904	22.729		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 — Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	47.686	47.686
Overall MINimum	16.272	16.272
D Only	31.414	31.414
+D+L	47.686	47.686
+D+0.750L	43.618	43.618
+0.60D	18.848	18.848
L Only	16.272	16.272

Pre-Composite Camber Beam Design (Residential - 40 to 45.2 ft spans)

Design Per AISC 360-16

Material Properties

G =	11200	ksi
E =	29000	ksi
Fy =	50	ksi
φb =	0.9	
φv =	0.9	
Cb =	1	
C =	1	

Stud Properties

Fu =	60	ksi

Type of Construction

Type =	IIIA	(Assumption: Ordinary)
Fire Rating =	1	hour
Type of Concrete =	NWC	

Beam Data

Trib. Width =	18.0	ft
Beam Length =	45.2	ft
Unbraced Length =	10.0	ft
Fcr =	227	ksi

Total Dead Load

Typical Residential Floor =	70.0	psf
Concrete & Metal Deck Gage 20 =	62.5	psf
Beam Self-Weight =	7.2	psf
	139.7	psf

Total Live Load

Typical Residential Floor =	40.0	psf
	40.0	psf

Deflection

ΔD =	3.31	in

Round Camber Down to Nearest 1/4"

Use: **3.25** **in** (Req'd Pre-Camber)

Section Properties

Designation =	**W18X130**	
$Beam_{weight}$ =	130	plf
Area =	38.3	in^2
Depth =	19.3	in
bf =	11.2	in
tw =	0.67	in
tw/2=	3/8	in
tf =	1.2	in
k =	1.6	in
bf/2tf=	4.65	
h/tw=	23.9	
Ix =	2460	in^4
Zx =	290	in^3
Sx =	256	in^3
rx =	8.03	in
Iy =	278	in^4
Zy =	76.7	in^3
Sy =	49.9	in^3
ry =	2.7	in
J =	14.5	in^4
Cw =	22700	in^6
rts =	3.13	in
ho =	18.1	in

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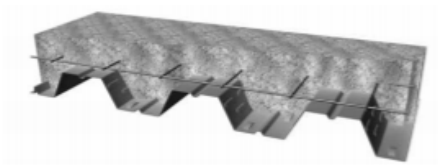
2.4 3WxH-36 Composite Deck

6 ½" Total Slab Depth

Normal Weight Concrete (145 pcf)

Concrete Volume 1.543yd³/100ft²

1 Hour Fire Rating



3WxH-36 6 1/2 " Slab Depth, 145 pcf NWC

Maximum Unshored Span	Gage	Single	Double	Triple	Gage	Single	Double	Triple
	22	8' - 11"	9' - 9"	10' - 1"	19	11' - 3"	12' - 4"	12' - 9"
	21	9' - 8"	10' - 5"	10' - 9"	18	11' - 8"	13' - 5"	13' - 8"
	20	10' - 5"	11' - 1"	11' - 5"	16	12' - 3"	15' - 0"	14' - 5"

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
22	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	516	452	398	352	313	280	251	226	203	184	166	151	137	125	113
	LRFD, φW	691	603	530	468	415	370	330	296	265	239	215	194	175	158	143
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3839	3813	3790	3781	3762	3745	3729	3715	3702	3698	3687	3677	3667	3658	3649
	PAF Base Steel ≥ .25"	3649	3635	3622	3621	3610	3600	3592	3583	3576	3577	3571	3564	3559	3553	3548
	PAF Base Steel ≥ 0.125"	3634	3621	3609	3609	3598	3589	3581	3573	3566	3568	3561	3556	3550	3545	3541
	#12 Screw Base Steel ≥ .0385"	3621	3608	3597	3597	3587	3579	3571	3564	3557	3559	3553	3548	3542	3538	3533
	Concrete + Deck = 62.2 psf	I_{cr} = 78.7 in⁴/ft	ASD	M_{no}/Ω = 48.0 kip-in/ft	V_n/Ω = 4.14 kip/ft											
	$(I_{cr}+I_u)/2$ = 154.9 in⁴/ft	I_u = 231.1 in⁴/ft	LRFD	ϕM_{no} = 73.5 kip-in/ft	ϕV_n = 6.01 kip/ft											

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
21	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	569	498	439	390	347	310	279	251	227	205	186	169	154	140	128
	LRFD, φW	762	666	586	519	461	411	368	330	297	268	242	219	198	180	163
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3902	3872	3846	3836	3815	3795	3777	3761	3746	3742	3729	3717	3706	3695	3685
	PAF Base Steel ≥ .25"	3684	3667	3652	3653	3640	3629	3619	3609	3600	3603	3595	3588	3581	3575	3569
	PAF Base Steel ≥ 0.125"	3667	3651	3638	3639	3627	3616	3606	3597	3589	3592	3585	3578	3572	3566	3560
	#12 Screw Base Steel ≥ .0385"	3652	3638	3624	3626	3615	3605	3596	3587	3579	3583	3576	3569	3563	3558	3552
	Concrete + Deck = 62.4 psf	I_{cr} = 84.9 in⁴/ft	ASD	M_{no}/Ω = 52.5 kip-in/ft	V_n/Ω = 4.80 kip/ft											
	$(I_{cr}+I_u)/2$ = 159.4 in⁴/ft	I_u = 233.8 in⁴/ft	LRFD	ϕM_{no} = 80.3 kip-in/ft	ϕV_n = 6.91 kip/ft											

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
20	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	618	542	478	424	378	339	305	275	249	225	205	187	170	155	142
	LRFD, φW	829	726	639	566	504	450	403	362	327	295	267	242	220	200	182
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3949	3916	3887	3878	3854	3832	3812	3794	3778	3775	3760	3747	3735	3723	3712
	PAF Base Steel ≥ .25"	3710	3691	3675	3677	3663	3650	3639	3628	3619	3622	3614	3606	3598	3591	3585
	PAF Base Steel ≥ 0.125"	3692	3674	3659	3662	3648	3636	3626	3616	3607	3611	3602	3595	3588	3581	3575
	#12 Screw Base Steel ≥ .0385"	3676	3660	3645	3649	3636	3625	3614	3605	3596	3601	3593	3586	3579	3573	3567
	Concrete + Deck = 62.5 psf	I_{cr} = 90.6 in⁴/ft	ASD	M_{no}/Ω = 56.7 kip-in/ft	V_n/Ω = 5.38 kip/ft											
	$(I_{cr}+I_u)/2$ = 163.5 in⁴/ft	I_u = 236.4 in⁴/ft	LRFD	ϕM_{no} = 86.8 kip-in/ft	ϕV_n = 7.71 kip/ft											

All Gages	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) for all vertical load spans, WWF Size or Area of Steel per foot width					
	3/4" Welded Shear Studs	6x6 W1.4xW1.4 A_s = 0.028 in²/ft	6x6 W2.9xW2.9 A_s = 0.058 in²/ft	6x6 W4.0xW4.0 A_s = 0.080 in²/ft	4x4 W4xW4 A_s = 0.120 in²/ft	4x4 W6xW6 A_s = 0.180 in²/ft
	12 in o.c.	n/a	6030	7020	8820	11520
	24 in o.c.	n/a	6030	7020	7750	7750
	36 in o.c.	n/a	5170	5170	5170	5170

Steel Beam

DESCRIPTION: Residential (corridor) - 25.5 ft & below spans

CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

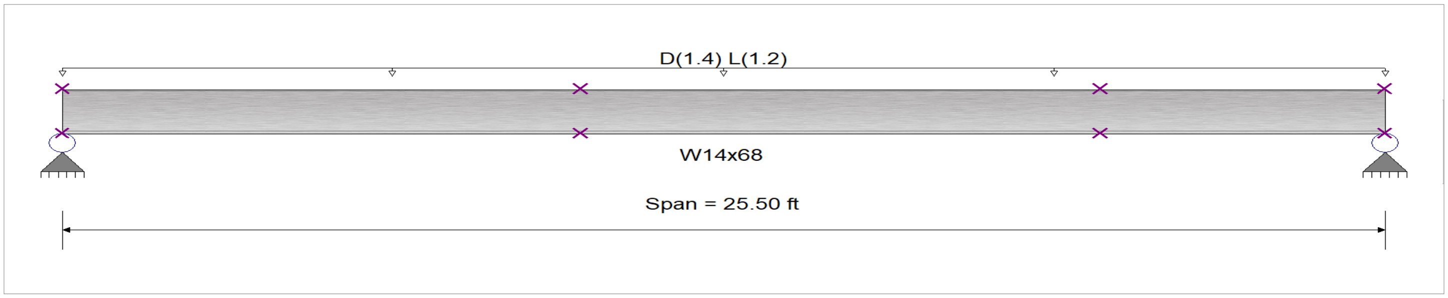
Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam bracing is defined as a set spacing over all spans
Bending Axis : Major Axis Bending

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.060 ksf, Tributary Width = 20.0 ft, (Typical Residential Floor (Corridor))

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.694 : 1	Maximum Shear Stress Ratio =	0.269 : 1
Section used for this span	W14x68	Section used for this span	W14x68
Mu : Applied	299.245 k-ft	Vu : Applied	46.940 k
Mn * Phi : Allowable	431.250 k-ft	Vn * Phi : Allowable	174.30 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	12.750ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.547 in	Ratio =	558 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	1.218 in	Ratio =	251 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.98 ft	1	0.369	0.150	159.17		159.17	479.17	431.25	1.42	1.00	26.20	174.30	174.30
Dsgn. L = 9.98 ft	1	0.387	0.085	167.05	113.59	167.05	479.17	431.25	1.04	1.00	14.82	174.30	174.30
Dsgn. L = 5.54 ft	1	0.263	0.150	113.59		113.59	479.17	431.25	1.55	1.00	26.20	174.30	174.30
+1.20D+1.60L													
Dsgn. L = 9.98 ft	1	0.661	0.269	285.14		285.14	479.17	431.25	1.42	1.00	46.94	174.30	174.30
Dsgn. L = 9.98 ft	1	0.694	0.152	299.25	203.48	299.25	479.17	431.25	1.04	1.00	26.55	174.30	174.30
Dsgn. L = 5.54 ft	1	0.472	0.269	203.48		203.48	479.17	431.25	1.55	1.00	46.94	174.30	174.30
+1.20D+L													
Dsgn. L = 9.98 ft	1	0.532	0.217	229.37		229.37	479.17	431.25	1.42	1.00	37.76	174.30	174.30
Dsgn. L = 9.98 ft	1	0.558	0.123	240.72	163.68	240.72	479.17	431.25	1.04	1.00	21.36	174.30	174.30
Dsgn. L = 5.54 ft	1	0.380	0.217	163.68		163.68	479.17	431.25	1.55	1.00	37.76	174.30	174.30
+1.20D													
Dsgn. L = 9.98 ft	1	0.316	0.129	136.43		136.43	479.17	431.25	1.42	1.00	22.46	174.30	174.30
Dsgn. L = 9.98 ft	1	0.332	0.073	143.19	97.36	143.19	479.17	431.25	1.04	1.00	12.71	174.30	174.30
Dsgn. L = 5.54 ft	1	0.226	0.129	97.36		97.36	479.17	431.25	1.55	1.00	22.46	174.30	174.30
+0.90D													
Dsgn. L = 9.98 ft	1	0.237	0.097	102.33		102.33	479.17	431.25	1.42	1.00	16.85	174.30	174.30
Dsgn. L = 9.98 ft	1	0.249	0.055	107.39	73.02	107.39	479.17	431.25	1.04	1.00	9.53	174.30	174.30
Dsgn. L = 5.54 ft	1	0.169	0.097	73.02		73.02	479.17	431.25	1.55	1.00	16.85	174.30	174.30

Steel Beam

DESCRIPTION: Residential (corridor) - 25.5 ft & below spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D+L													
Dsgn. L = 9.98 ft	1	0.585	0.238	252.11		252.11	479.17	431.25	1.42	1.00	41.50	174.30	174.30
Dsgn. L = 9.98 ft	1	0.614	0.135	264.59	179.91	264.59	479.17	431.25	1.04	1.00	23.48	174.30	174.30
Dsgn. L = 5.54 ft	1	0.417	0.238	179.91		179.91	479.17	431.25	1.55	1.00	41.50	174.30	174.30
+0.70D													
Dsgn. L = 9.98 ft	1	0.185	0.075	79.59		79.59	479.17	431.25	1.42	1.00	13.10	174.30	174.30
Dsgn. L = 9.98 ft	1	0.194	0.043	83.52	56.79	83.52	479.17	431.25	1.04	1.00	7.41	174.30	174.30
Dsgn. L = 5.54 ft	1	0.132	0.075	56.79		56.79	479.17	431.25	1.55	1.00	13.10	174.30	174.30

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	1.2178	12.823		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	34.017	34.017
Overall MINimum	11.230	11.230
D Only	18.717	18.717
+D+L	34.017	34.017
+D+0.750L	30.192	30.192
+0.60D	11.230	11.230
L Only	15.300	15.300

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Steel Beam

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: Residential (corridor) - 30 to 37 ft spans

CODE REFERENCES

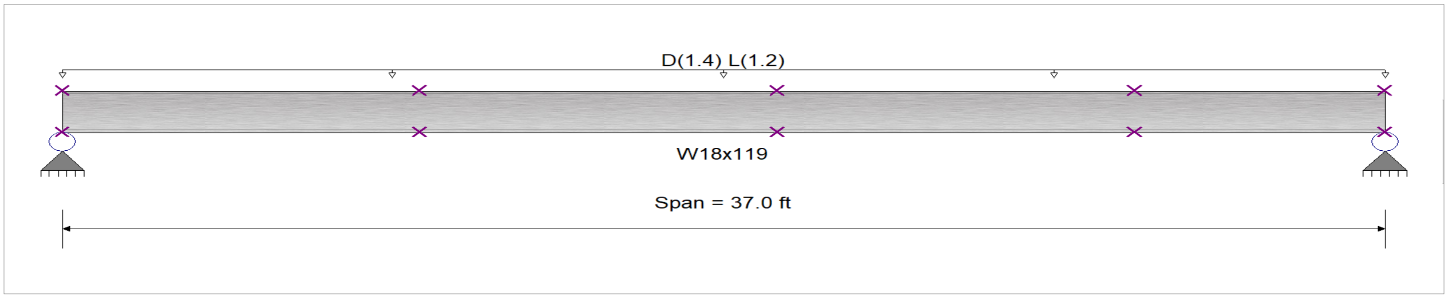
Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Beam bracing is defined as a set spacing over all spans	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.060 ksf, Tributary Width = 20.0 ft, (Typical Residential Floor (Corridor))

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.652 : 1	Maximum Shear Stress Ratio =	0.185 : 1
Section used for this span	W18x119	Section used for this span	W18x119
Mu : Applied	640.487 k-ft	Vu : Applied	69.242 k
Mn * Phi : Allowable	982.500 k-ft	Vn * Phi : Allowable	373.350 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	18.500ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.800 in	Ratio =	554 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	1.814 in	Ratio =	245 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment Length	Span #	Max Stress Ratios M	Max Stress Ratios V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.291	0.105	285.95		285.95	1,091.67	982.50	1.52	1.00	39.34	373.35	373.35
Dsgn. L = 10.04 ft	1	0.370	0.049	363.91	285.95	363.91	1,091.67	982.50	1.04	1.00	18.21	373.35	373.35
Dsgn. L = 9.94 ft	1	0.368	0.065	361.59	225.31	361.59	1,091.67	982.50	1.11	1.00	24.28	373.35	373.35
Dsgn. L = 7.08 ft	1	0.229	0.105	225.31		225.31	1,091.67	982.50	1.55	1.00	39.34	373.35	373.35
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.512	0.185	503.27		503.27	1,091.67	982.50	1.52	1.00	69.24	373.35	373.35
Dsgn. L = 10.04 ft	1	0.652	0.086	640.49	503.27	640.49	1,091.67	982.50	1.04	1.00	32.05	373.35	373.35
Dsgn. L = 9.94 ft	1	0.648	0.114	636.39	396.55	636.39	1,091.67	982.50	1.11	1.00	42.73	373.35	373.35
Dsgn. L = 7.08 ft	1	0.404	0.185	396.55		396.55	1,091.67	982.50	1.55	1.00	69.24	373.35	373.35
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.414	0.150	406.46		406.46	1,091.67	982.50	1.52	1.00	55.92	373.35	373.35
Dsgn. L = 10.04 ft	1	0.526	0.069	517.28	406.46	517.28	1,091.67	982.50	1.04	1.00	25.88	373.35	373.35
Dsgn. L = 9.94 ft	1	0.523	0.092	513.97	320.26	513.97	1,091.67	982.50	1.11	1.00	34.51	373.35	373.35
Dsgn. L = 7.08 ft	1	0.326	0.150	320.26		320.26	1,091.67	982.50	1.55	1.00	55.92	373.35	373.35
+1.20D													
Dsgn. L = 9.94 ft	1	0.249	0.090	245.10		245.10	1,091.67	982.50	1.52	1.00	33.72	373.35	373.35
Dsgn. L = 10.04 ft	1	0.317	0.042	311.93	245.10	311.93	1,091.67	982.50	1.04	1.00	15.61	373.35	373.35
Dsgn. L = 9.94 ft	1	0.315	0.056	309.93	193.12	309.93	1,091.67	982.50	1.11	1.00	20.81	373.35	373.35
Dsgn. L = 7.08 ft	1	0.197	0.090	193.12		193.12	1,091.67	982.50	1.55	1.00	33.72	373.35	373.35

Steel Beam

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DESCRIPTION: Residential (corridor) - 30 to 37 ft spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+0.90D													
Dsgn. L = 9.94 ft	1	0.187	0.068	183.83		183.83	1,091.67	982.50	1.52	1.00	25.29	373.35	373.35
Dsgn. L = 10.04 ft	1	0.238	0.031	233.94	183.83	233.94	1,091.67	982.50	1.04	1.00	11.71	373.35	373.35
Dsgn. L = 9.94 ft	1	0.237	0.042	232.45	144.84	232.45	1,091.67	982.50	1.11	1.00	15.61	373.35	373.35
Dsgn. L = 7.08 ft	1	0.147	0.068	144.84		144.84	1,091.67	982.50	1.55	1.00	25.29	373.35	373.35
+1.40D+L													
Dsgn. L = 9.94 ft	1	0.455	0.165	447.31		447.31	1,091.67	982.50	1.52	1.00	61.54	373.35	373.35
Dsgn. L = 10.04 ft	1	0.579	0.076	569.26	447.31	569.26	1,091.67	982.50	1.04	1.00	28.49	373.35	373.35
Dsgn. L = 9.94 ft	1	0.576	0.102	565.62	352.45	565.62	1,091.67	982.50	1.11	1.00	37.98	373.35	373.35
Dsgn. L = 7.08 ft	1	0.359	0.165	352.45		352.45	1,091.67	982.50	1.55	1.00	61.54	373.35	373.35
+0.70D													
Dsgn. L = 9.94 ft	1	0.146	0.053	142.98		142.98	1,091.67	982.50	1.52	1.00	19.67	373.35	373.35
Dsgn. L = 10.04 ft	1	0.185	0.024	181.96	142.98	181.96	1,091.67	982.50	1.04	1.00	9.10	373.35	373.35
Dsgn. L = 9.94 ft	1	0.184	0.033	180.79	112.66	180.79	1,091.67	982.50	1.11	1.00	12.14	373.35	373.35
Dsgn. L = 7.08 ft	1	0.115	0.053	112.66		112.66	1,091.67	982.50	1.55	1.00	19.67	373.35	373.35

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	1.8136	18.606		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	50.302	50.302
Overall MINimum	16.861	16.861
D Only	28.102	28.102
+D+L	50.302	50.302
+D+0.750L	44.752	44.752
+0.60D	16.861	16.861
L Only	22.200	22.200

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Steel Beam

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DESCRIPTION: Residential (corridor)- 40 to 48 ft spans

CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

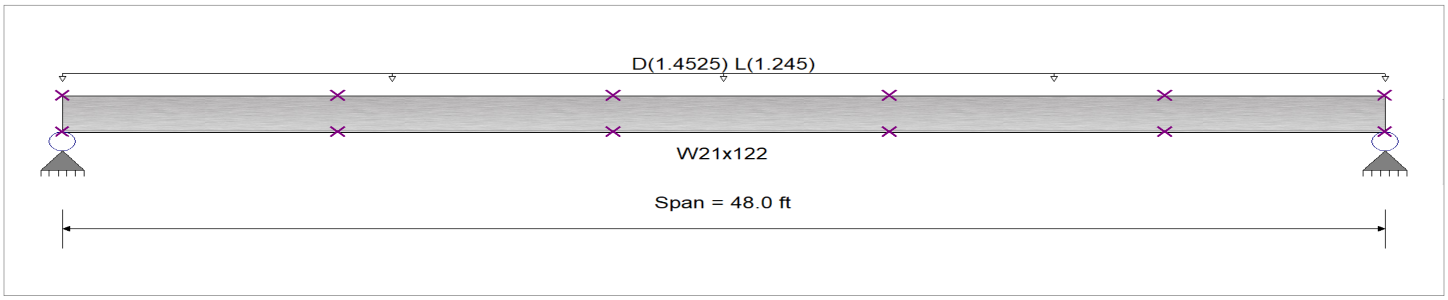
Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam bracing is defined as a set spacing over all spans
Bending Axis : Major Axis Bending

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculatior

Beam self weight calculated and added to loading
Uniform Load : D = 0.070, L = 0.060 ksf, Tributary Width = 20.750 ft, (Typical Residential Floor (Corridor))

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	0.971 : 1	Maximum Shear Stress Ratio =	0.238 : 1
Section used for this span	W21x122	Section used for this span	W21x122
Mu : Applied	1,117.843 k-ft	Vu : Applied	93.154 k
Mn * Phi : Allowable	1,151.250 k-ft	Vn * Phi : Allowable	390.60 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	24.000ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	1.740 in	Ratio =	330 <360.0
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	3.941 in	Ratio =	146 <240.0
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.87 ft	1	0.360	0.135	414.92		414.92	1,279.17	1,151.25	1.55	1.00	52.90	390.60	390.60
Dsgn. L = 10.01 ft	1	0.535	0.080	616.18	414.92	616.18	1,279.17	1,151.25	1.11	1.00	31.14	390.60	390.60
Dsgn. L = 10.01 ft	1	0.551	0.033	634.84	596.51	634.84	1,279.17	1,151.25	1.01	1.00	13.00	390.60	390.60
Dsgn. L = 10.01 ft	1	0.518	0.090	596.51	355.90	596.51	1,279.17	1,151.25	1.15	1.00	35.07	390.60	390.60
Dsgn. L = 8.09 ft	1	0.309	0.135	355.90		355.90	1,279.17	1,151.25	1.56	1.00	52.90	390.60	390.60
+1.20D+1.60L													
Dsgn. L = 9.87 ft	1	0.635	0.238	730.60		730.60	1,279.17	1,151.25	1.55	1.00	93.15	390.60	390.60
Dsgn. L = 10.01 ft	1	0.942	0.140	1,084.99	730.60	1,084.99	1,279.17	1,151.25	1.11	1.00	54.83	390.60	390.60
Dsgn. L = 10.01 ft	1	0.971	0.059	1,117.84	1,050.35	1,117.84	1,279.17	1,151.25	1.01	1.00	22.89	390.60	390.60
Dsgn. L = 10.01 ft	1	0.912	0.158	1,050.35	626.69	1,050.35	1,279.17	1,151.25	1.15	1.00	61.75	390.60	390.60
Dsgn. L = 8.09 ft	1	0.544	0.238	626.69		626.69	1,279.17	1,151.25	1.56	1.00	93.15	390.60	390.60
+1.20D+L													
Dsgn. L = 9.87 ft	1	0.512	0.193	589.99		589.99	1,279.17	1,151.25	1.55	1.00	75.23	390.60	390.60
Dsgn. L = 10.01 ft	1	0.761	0.113	876.18	589.99	876.18	1,279.17	1,151.25	1.11	1.00	44.28	390.60	390.60
Dsgn. L = 10.01 ft	1	0.784	0.047	902.71	848.21	902.71	1,279.17	1,151.25	1.01	1.00	18.48	390.60	390.60
Dsgn. L = 10.01 ft	1	0.737	0.128	848.21	506.08	848.21	1,279.17	1,151.25	1.15	1.00	49.86	390.60	390.60
Dsgn. L = 8.09 ft	1	0.440	0.193	506.08		506.08	1,279.17	1,151.25	1.56	1.00	75.23	390.60	390.60
+1.20D													
Dsgn. L = 9.87 ft	1	0.309	0.116	355.65		355.65	1,279.17	1,151.25	1.55	1.00	45.35	390.60	390.60

Steel Beam

DESCRIPTION: Residential (corridor)- 40 to 48 ft spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
Dsgn. L = 10.01 ft	1	0.459	0.068	528.16	355.65	528.16	1,279.17	1,151.25	1.11	1.00	26.69	390.60	390.60
Dsgn. L = 10.01 ft	1	0.473	0.029	544.15	511.29	544.15	1,279.17	1,151.25	1.01	1.00	11.14	390.60	390.60
Dsgn. L = 10.01 ft	1	0.444	0.077	511.29	305.06	511.29	1,279.17	1,151.25	1.15	1.00	30.06	390.60	390.60
Dsgn. L = 8.09 ft	1	0.265	0.116	305.06		305.06	1,279.17	1,151.25	1.56	1.00	45.35	390.60	390.60
+0.90D													
Dsgn. L = 9.87 ft	1	0.232	0.087	266.73		266.73	1,279.17	1,151.25	1.55	1.00	34.01	390.60	390.60
Dsgn. L = 10.01 ft	1	0.344	0.051	396.12	266.73	396.12	1,279.17	1,151.25	1.11	1.00	20.02	390.60	390.60
Dsgn. L = 10.01 ft	1	0.354	0.021	408.11	383.47	408.11	1,279.17	1,151.25	1.01	1.00	8.36	390.60	390.60
Dsgn. L = 10.01 ft	1	0.333	0.058	383.47	228.80	383.47	1,279.17	1,151.25	1.15	1.00	22.54	390.60	390.60
Dsgn. L = 8.09 ft	1	0.199	0.087	228.80		228.80	1,279.17	1,151.25	1.56	1.00	34.01	390.60	390.60
+1.40D+L													
Dsgn. L = 9.87 ft	1	0.564	0.212	649.27		649.27	1,279.17	1,151.25	1.55	1.00	82.78	390.60	390.60
Dsgn. L = 10.01 ft	1	0.838	0.125	964.20	649.27	964.20	1,279.17	1,151.25	1.11	1.00	48.72	390.60	390.60
Dsgn. L = 10.01 ft	1	0.863	0.052	993.40	933.42	993.40	1,279.17	1,151.25	1.01	1.00	20.34	390.60	390.60
Dsgn. L = 10.01 ft	1	0.811	0.140	933.42	556.92	933.42	1,279.17	1,151.25	1.15	1.00	54.87	390.60	390.60
Dsgn. L = 8.09 ft	1	0.484	0.212	556.92		556.92	1,279.17	1,151.25	1.56	1.00	82.78	390.60	390.60
+0.70D													
Dsgn. L = 9.87 ft	1	0.180	0.068	207.46		207.46	1,279.17	1,151.25	1.55	1.00	26.45	390.60	390.60
Dsgn. L = 10.01 ft	1	0.268	0.040	308.09	207.46	308.09	1,279.17	1,151.25	1.11	1.00	15.57	390.60	390.60
Dsgn. L = 10.01 ft	1	0.276	0.017	317.42	298.25	317.42	1,279.17	1,151.25	1.01	1.00	6.50	390.60	390.60
Dsgn. L = 10.01 ft	1	0.259	0.045	298.25	177.95	298.25	1,279.17	1,151.25	1.15	1.00	17.53	390.60	390.60
Dsgn. L = 8.09 ft	1	0.155	0.068	177.95		177.95	1,279.17	1,151.25	1.56	1.00	26.45	390.60	390.60

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	3.9410	24.137		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1   Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	67.668	67.668
Overall MINimum	22.673	22.673
D Only	37.788	37.788
+D+L	67.668	67.668
+D+0.750L	60.198	60.198
+0.60D	22.673	22.673
L Only	29.880	29.880

Pre-Composite Camber Beam Design (Residential (corridor) - 40 to 48 ft spans)

Design Per AISC 360-16

Material Properties

G =	11200	ksi
E =	29000	ksi
Fy =	50	ksi
φb =	0.9	
φv =	0.9	
Cb =	1	
C =	1	

Stud Properties

Fu =	60	ksi

Type of Construction

Type =	IIIA	(Assumption: Ordinary)
Fire Rating =	1	hour
Type of Concrete =	NWC	

Beam Data

Trib. Width =	20.8	ft
Beam Length =	48.0	ft
Unbraced Length =	10.0	ft
Fcr =	247	ksi

Total Dead Load

Typical Residential Floor =	70.0	psf
Concrete & Metal Deck Gage 20 =	62.5	psf
Beam Self-Weight =	5.9	psf
	138.4	psf

Total Live Load

Typical Residential Floor =	40.0	psf
	40.0	psf

Deflection

ΔD =	4.00	in

Round Camber Down to Nearest 1/4"

Use: **4.0** **in** (Req'd Pre-Camber)

Section Properties

Designation =	**W21X122**	
$Beam_{weight}$ =	122	plf
Area =	35.9	in^2
Depth =	21.7	in
bf =	12.4	in
tw =	0.6	in
tw/2=	5/16	in
tf =	0.96	in
k =	1.46	in
bf/2tf=	6.45	
h/tw=	31.3	
Ix =	2960	in^4
Zx =	307	in^3
Sx =	273	in^3
rx =	9.09	in
Iy =	305	in^4
Zy =	75.6	in^3
Sy =	49.2	in^3
ry =	2.92	in
J =	8.98	in^4
Cw =	32700	in^6
rts =	3.4	in
ho =	20.7	in

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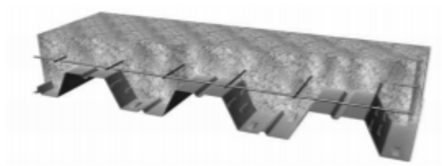
2.4 3WxH-36 Composite Deck

6 ½" Total Slab Depth
Normal Weight Concrete (145 pcf)

Concrete Volume 1.543yd³/100ft²

1 Hour Fire Rating



3WxH-36 6 1/2 " Slab Depth, 145 pcf NWC

Maximum Unshored Span	Gage	Single	Double	Triple	Gage	Single	Double	Triple
	22	8' - 11"	9' - 9"	10' - 1"	19	11' - 3"	12' - 4"	12' - 9"
	21	9' - 8"	10' - 5"	10' - 9"	18	11' - 8"	13' - 5"	13' - 8"
	20	10' - 5"	11' - 1"	11' - 5"	16	12' - 3"	15' - 0"	14' - 5"

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
22	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	516	452	398	352	313	280	251	226	203	184	166	151	137	125	113
	LRFD, ϕW	691	603	530	468	415	370	330	296	265	239	215	194	175	158	143
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3839	3813	3790	3781	3762	3745	3729	3715	3702	3698	3687	3677	3667	3658	3649
	PAF Base Steel ≥ .25"	3649	3635	3622	3621	3610	3600	3592	3583	3576	3577	3571	3564	3559	3553	3548
	PAF Base Steel ≥ 0.125"	3634	3621	3609	3609	3598	3589	3581	3573	3566	3568	3561	3556	3550	3545	3541
	#12 Screw Base Steel ≥ .0385"	3621	3608	3597	3597	3587	3579	3571	3564	3557	3559	3553	3548	3542	3538	3533
	Concrete + Deck = 62.2 psf	I_{cr} = 78.7 in^4/ft	ASD	M_{no}/Ω = 48.0 kip-in/ft	V_n/Ω = 4.14 kip/ft											
	$(I_{cr}+I_u)/2$ = 154.9 in^4/ft	I_u = 231.1 in^4/ft	LRFD	ϕM_{no} = 73.5 kip-in/ft	ϕV_n = 6.01 kip/ft											

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
21	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	569	498	439	390	347	310	279	251	227	205	186	169	154	140	128
	LRFD, ϕW	762	666	586	519	461	411	368	330	297	268	242	219	198	180	163
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3902	3872	3846	3836	3815	3795	3777	3761	3746	3742	3729	3717	3706	3695	3685
	PAF Base Steel ≥ .25"	3684	3667	3652	3653	3640	3629	3619	3609	3600	3603	3595	3588	3581	3575	3569
	PAF Base Steel ≥ 0.125"	3667	3651	3638	3639	3627	3616	3606	3597	3589	3592	3585	3578	3572	3566	3560
	#12 Screw Base Steel ≥ .0385"	3652	3638	3624	3626	3615	3605	3596	3587	3579	3583	3576	3569	3563	3558	3552
	Concrete + Deck = 62.4 psf	I_{cr} = 84.9 in^4/ft	ASD	M_{no}/Ω = 52.5 kip-in/ft	V_n/Ω = 4.80 kip/ft											
	$(I_{cr}+I_u)/2$ = 159.4 in^4/ft	I_u = 233.8 in^4/ft	LRFD	ϕM_{no} = 80.3 kip-in/ft	ϕV_n = 6.91 kip/ft											

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
20	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	618	542	478	424	378	339	305	275	249	225	205	187	170	155	142
	LRFD, ϕW	829	726	639	566	504	450	403	362	327	295	267	242	220	200	182
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3949	3916	3887	3878	3854	3832	3812	3794	3778	3775	3760	3747	3735	3723	3712
	PAF Base Steel ≥ .25"	3710	3691	3675	3677	3663	3650	3639	3628	3619	3622	3614	3606	3598	3591	3585
	PAF Base Steel ≥ 0.125"	3692	3674	3659	3662	3648	3636	3626	3616	3607	3611	3602	3595	3588	3581	3575
	#12 Screw Base Steel ≥ .0385"	3676	3660	3645	3649	3636	3625	3614	3605	3596	3601	3593	3586	3579	3573	3567
	Concrete + Deck = 62.5 psf	I_{cr} = 90.6 in^4/ft	ASD	M_{no}/Ω = 56.7 kip-in/ft	V_n/Ω = 5.38 kip/ft											
	$(I_{cr}+I_u)/2$ = 163.5 in^4/ft	I_u = 236.4 in^4/ft	LRFD	ϕM_{no} = 86.8 kip-in/ft	ϕV_n = 7.71 kip/ft											

All Gages	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) for all vertical load spans, WWF Size or Area of Steel per foot width					
	3/4" Welded Shear Studs	6x6 W1.4xW1.4 A_s = 0.028 in^2/ft	6x6 W2.9xW2.9 A_s = 0.058 in^2/ft	6x6 W4.0xW4.0 A_s = 0.080 in^2/ft	4x4 W4xW4 A_s = 0.120 in^2/ft	4x4 W6xW6 A_s = 0.180 in^2/ft
	12 in o.c.	n/a	6030	7020	8820	11520
	24 in o.c.	n/a	6030	7020	7750	7750
	36 in o.c.	n/a	5170	5170	5170	5170

Steel Beam

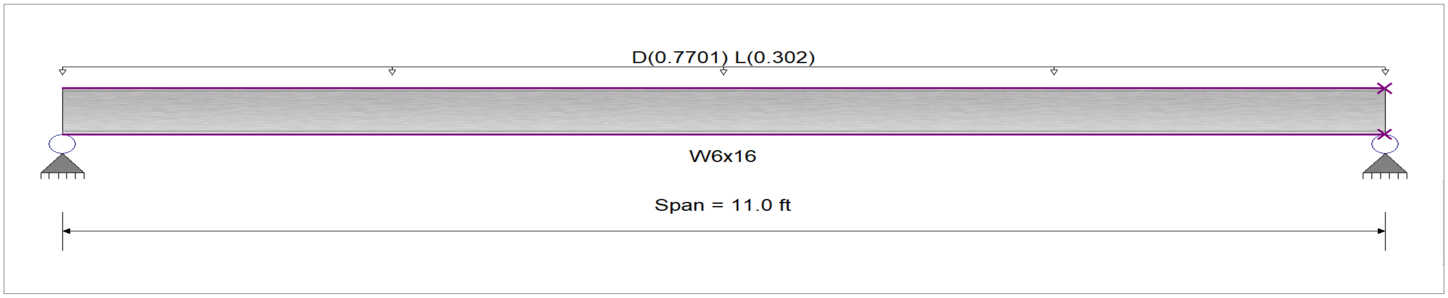
DESCRIPTION: Residential (Roof) - 11 ft and below spans

CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Beam is Fully Braced against lateral-torsional buckling	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.0510, L = 0.020 ksf, Tributary Width = 15.10 ft, (Typical Roof)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.492** : 1	Maximum Shear Stress Ratio =	**0.160** : 1
Section used for this span	**W6x16**	Section used for this span	**W6x16**
Mu : Applied	21.576 k-ft	Vu : Applied	7.846 k
Mn * Phi : Allowable	43.875 k-ft	Vn * Phi : Allowable	48.984 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	5.500ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.107 in	Ratio =	1,229 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.387 in	Ratio =	341 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 11.00 ft	1	0.379	0.124	16.65		16.65	48.75	43.88	1.00	1.00	6.05	48.98	48.98
+1.20D+1.60L													
Dsgn. L = 11.00 ft	1	0.492	0.160	21.58		21.58	48.75	43.88	1.00	1.00	7.85	48.98	48.98
+1.20D+L													
Dsgn. L = 11.00 ft	1	0.429	0.140	18.84		18.84	48.75	43.88	1.00	1.00	6.85	48.98	48.98
+1.20D													
Dsgn. L = 11.00 ft	1	0.325	0.106	14.27		14.27	48.75	43.88	1.00	1.00	5.19	48.98	48.98
+0.90D													
Dsgn. L = 11.00 ft	1	0.244	0.079	10.70		10.70	48.75	43.88	1.00	1.00	3.89	48.98	48.98
+1.40D+L													
Dsgn. L = 11.00 ft	1	0.483	0.157	21.21		21.21	48.75	43.88	1.00	1.00	7.71	48.98	48.98
+0.70D													
Dsgn. L = 11.00 ft	1	0.190	0.062	8.32		8.32	48.75	43.88	1.00	1.00	3.03	48.98	48.98

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	0.3868	5.531		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	5.985	5.985
Overall MINimum	1.661	1.661

Steel Beam

DESCRIPTION: Residential (Roof) - 11 ft and below spans

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
D Only	4.324	4.324
+D+L	5.985	5.985
+D+0.750L	5.569	5.569
+0.60D	2.594	2.594
L Only	1.661	1.661

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Engineer:
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Steel Beam

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DESCRIPTION: Residential (Roof) - 20 to 30 ft spans

CODE REFERENCES

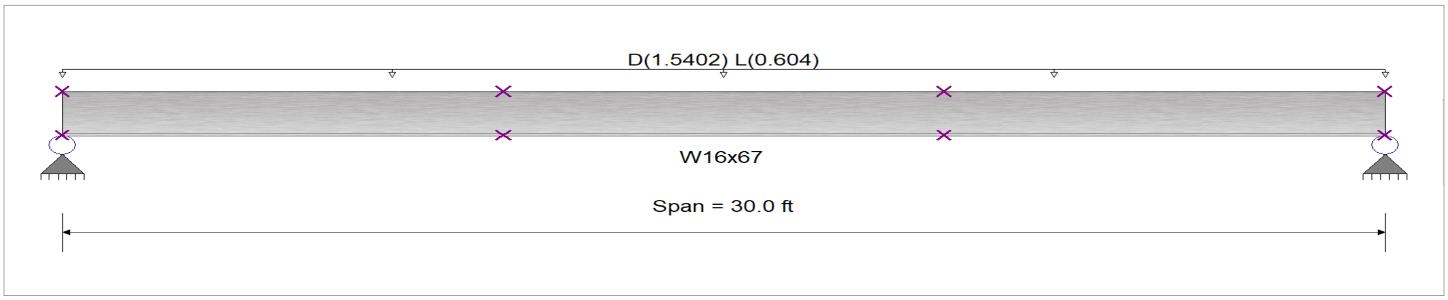
Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Beam bracing is defined as a set spacing over all spans	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.0510, L = 0.020 ksf, Tributary Width = 30.20 ft, (Typical Roof)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.679** : 1	Maximum Shear Stress Ratio =	**0.225** : 1
Section used for this span	**W16x67**	Section used for this span	**W16x67**
Mu : Applied	325.692 k-ft	Vu : Applied	43.426 k
Mn * Phi : Allowable	479.756 k-ft	Vn * Phi : Allowable	193.155 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.400 in	Ratio =	900 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	1.463 in	Ratio =	246 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.460	0.175	224.36		224.36	541.67	487.50	1.46	1.00	33.75	193.16	193.16
Dsgn. L = 10.03 ft	1	0.528	0.059	253.13	224.36	253.13	533.06	479.76	1.01	1.00	11.38	193.16	193.16
Dsgn. L = 10.03 ft	1	0.462	0.175	225.33		225.33	541.67	487.50	1.45	1.00	33.75	193.16	193.16
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.592	0.225	288.67		288.67	541.67	487.50	1.46	1.00	43.43	193.16	193.16
Dsgn. L = 10.03 ft	1	0.679	0.076	325.69	288.67	325.69	533.06	479.76	1.01	1.00	14.64	193.16	193.16
Dsgn. L = 10.03 ft	1	0.595	0.225	289.92		289.92	541.67	487.50	1.45	1.00	43.43	193.16	193.16
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.518	0.197	252.54		252.54	541.67	487.50	1.46	1.00	37.99	193.16	193.16
Dsgn. L = 10.03 ft	1	0.594	0.066	284.92	252.54	284.92	533.06	479.76	1.01	1.00	12.81	193.16	193.16
Dsgn. L = 10.03 ft	1	0.520	0.197	253.62		253.62	541.67	487.50	1.45	1.00	37.99	193.16	193.16
+1.20D													
Dsgn. L = 9.94 ft	1	0.394	0.150	192.31		192.31	541.67	487.50	1.46	1.00	28.93	193.16	193.16
Dsgn. L = 10.03 ft	1	0.452	0.050	216.97	192.31	216.97	533.06	479.76	1.01	1.00	9.75	193.16	193.16
Dsgn. L = 10.03 ft	1	0.396	0.150	193.14		193.14	541.67	487.50	1.45	1.00	28.93	193.16	193.16
+0.90D													
Dsgn. L = 9.94 ft	1	0.296	0.112	144.23		144.23	541.67	487.50	1.46	1.00	21.70	193.16	193.16
Dsgn. L = 10.03 ft	1	0.339	0.038	162.73	144.23	162.73	533.06	479.76	1.01	1.00	7.32	193.16	193.16
Dsgn. L = 10.03 ft	1	0.297	0.112	144.85		144.85	541.67	487.50	1.45	1.00	21.70	193.16	193.16

Steel Beam

DESCRIPTION: Residential (Roof) - 20 to 30 ft spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D+L													
Dsgn. L = 9.94 ft	1	0.584	0.222	284.59		284.59	541.67	487.50	1.46	1.00	42.81	193.16	193.16
Dsgn. L = 10.03 ft	1	0.669	0.075	321.08	284.59	321.08	533.06	479.76	1.01	1.00	14.43	193.16	193.16
Dsgn. L = 10.03 ft	1	0.586	0.222	285.81		285.81	541.67	487.50	1.45	1.00	42.81	193.16	193.16
+0.70D													
Dsgn. L = 9.94 ft	1	0.230	0.087	112.18		112.18	541.67	487.50	1.46	1.00	16.88	193.16	193.16
Dsgn. L = 10.03 ft	1	0.264	0.029	126.57	112.18	126.57	533.06	479.76	1.01	1.00	5.69	193.16	193.16
Dsgn. L = 10.03 ft	1	0.231	0.087	112.66		112.66	541.67	487.50	1.45	1.00	16.88	193.16	193.16

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	1.4633	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	33.168	33.168
Overall MINimum	9.060	9.060
D Only	24.108	24.108
+D+L	33.168	33.168
+D+0.750L	30.903	30.903
+0.60D	14.465	14.465
L Only	9.060	9.060

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Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 2 APR 2020, 3:34PM

Steel Beam

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

Lic. # : KW-06090157 - Educational Version **Licensed User : SANTA CLARA UNIVERSITY, CIVIL ENGINEERING**

DESCRIPTION: Residential (Roof) - 30 to 37 ft spans

CODE REFERENCES

Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

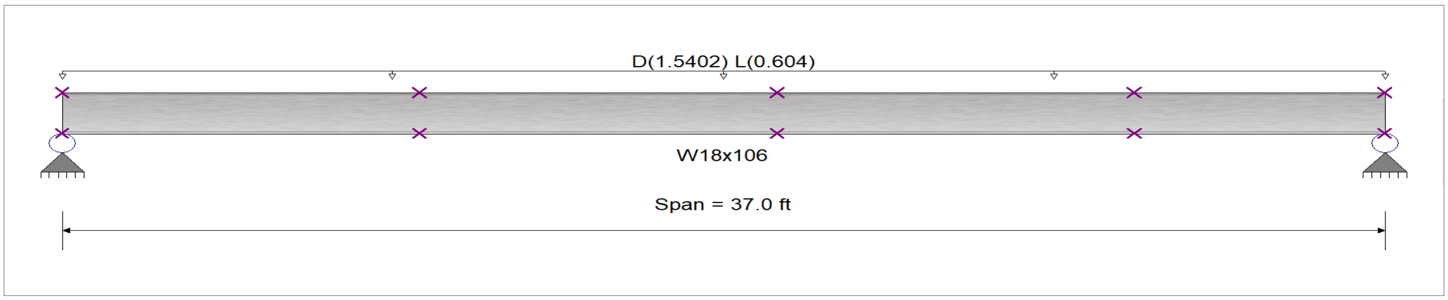
Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam bracing is defined as a set spacing over all spans
Bending Axis : Major Axis Bending

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.0510, L = 0.020 ksf, Tributary Width = 30.20 ft, (Typical Roof)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.584 : 1	Maximum Shear Stress Ratio =	0.164 : 1
Section used for this span	W18x106	Section used for this span	W18x106
Mu : Applied	503.422 k-ft	Vu : Applied	54.424 k
Mn * Phi : Allowable	862.500 k-ft	Vn * Phi : Allowable	330.990 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	18.500ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.462 in Ratio =	961 >=360.
Max Upward Transient Deflection	0.000 in Ratio =	0 <360.0
Max Downward Total Deflection	1.721 in Ratio =	258 >=240.
Max Upward Total Deflection	0.000 in Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.359	0.129	309.90		309.90	958.33	862.50	1.52	1.00	42.64	330.99	330.99
Dsgn. L = 10.04 ft	1	0.457	0.060	394.39	309.90	394.39	958.33	862.50	1.04	1.00	19.73	330.99	330.99
Dsgn. L = 9.94 ft	1	0.454	0.079	391.86	244.18	391.86	958.33	862.50	1.11	1.00	26.31	330.99	330.99
Dsgn. L = 7.08 ft	1	0.283	0.129	244.18		244.18	958.33	862.50	1.55	1.00	42.64	330.99	330.99
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.459	0.164	395.57		395.57	958.33	862.50	1.52	1.00	54.42	330.99	330.99
Dsgn. L = 10.04 ft	1	0.584	0.076	503.42	395.57	503.42	958.33	862.50	1.04	1.00	25.19	330.99	330.99
Dsgn. L = 9.94 ft	1	0.580	0.101	500.20	311.69	500.20	958.33	862.50	1.11	1.00	33.59	330.99	330.99
Dsgn. L = 7.08 ft	1	0.361	0.164	311.69		311.69	958.33	862.50	1.55	1.00	54.42	330.99	330.99
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.402	0.144	346.84		346.84	958.33	862.50	1.52	1.00	47.72	330.99	330.99
Dsgn. L = 10.04 ft	1	0.512	0.067	441.41	346.84	441.41	958.33	862.50	1.04	1.00	22.09	330.99	330.99
Dsgn. L = 9.94 ft	1	0.509	0.089	438.58	273.29	438.58	958.33	862.50	1.11	1.00	29.45	330.99	330.99
Dsgn. L = 7.08 ft	1	0.317	0.144	273.29		273.29	958.33	862.50	1.55	1.00	47.72	330.99	330.99
+1.20D													
Dsgn. L = 9.94 ft	1	0.308	0.110	265.63		265.63	958.33	862.50	1.52	1.00	36.55	330.99	330.99
Dsgn. L = 10.04 ft	1	0.392	0.051	338.05	265.63	338.05	958.33	862.50	1.04	1.00	16.92	330.99	330.99
Dsgn. L = 9.94 ft	1	0.389	0.068	335.88	209.30	335.88	958.33	862.50	1.11	1.00	22.55	330.99	330.99
Dsgn. L = 7.08 ft	1	0.243	0.110	209.30		209.30	958.33	862.50	1.55	1.00	36.55	330.99	330.99

Steel Beam

DESCRIPTION: Residential (Roof) - 30 to 37 ft spans

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+0.90D													
Dsgn. L = 9.94 ft	1	0.231	0.083	199.22		199.22	958.33	862.50	1.52	1.00	27.41	330.99	330.99
Dsgn. L = 10.04 ft	1	0.294	0.038	253.54	199.22	253.54	958.33	862.50	1.04	1.00	12.69	330.99	330.99
Dsgn. L = 9.94 ft	1	0.292	0.051	251.91	156.97	251.91	958.33	862.50	1.11	1.00	16.92	330.99	330.99
Dsgn. L = 7.08 ft	1	0.182	0.083	156.97		156.97	958.33	862.50	1.55	1.00	27.41	330.99	330.99
+1.40D+L													
Dsgn. L = 9.94 ft	1	0.453	0.163	391.11		391.11	958.33	862.50	1.52	1.00	53.81	330.99	330.99
Dsgn. L = 10.04 ft	1	0.577	0.075	497.75	391.11	497.75	958.33	862.50	1.04	1.00	24.91	330.99	330.99
Dsgn. L = 9.94 ft	1	0.573	0.100	494.56	308.17	494.56	958.33	862.50	1.11	1.00	33.21	330.99	330.99
Dsgn. L = 7.08 ft	1	0.357	0.163	308.17		308.17	958.33	862.50	1.55	1.00	53.81	330.99	330.99
+0.70D													
Dsgn. L = 9.94 ft	1	0.180	0.064	154.95		154.95	958.33	862.50	1.52	1.00	21.32	330.99	330.99
Dsgn. L = 10.04 ft	1	0.229	0.030	197.19	154.95	197.19	958.33	862.50	1.04	1.00	9.87	330.99	330.99
Dsgn. L = 9.94 ft	1	0.227	0.040	195.93	122.09	195.93	958.33	862.50	1.11	1.00	13.16	330.99	330.99
Dsgn. L = 7.08 ft	1	0.142	0.064	122.09		122.09	958.33	862.50	1.55	1.00	21.32	330.99	330.99

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	1.7209	18.606		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	41.629	41.629
Overall MINimum	11.174	11.174
D Only	30.455	30.455
+D+L	41.629	41.629
+D+0.750L	38.835	38.835
+0.60D	18.273	18.273
L Only	11.174	11.174

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Steel Beam

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: Residential (Roof) - 40 to 45 ft spans

CODE REFERENCES

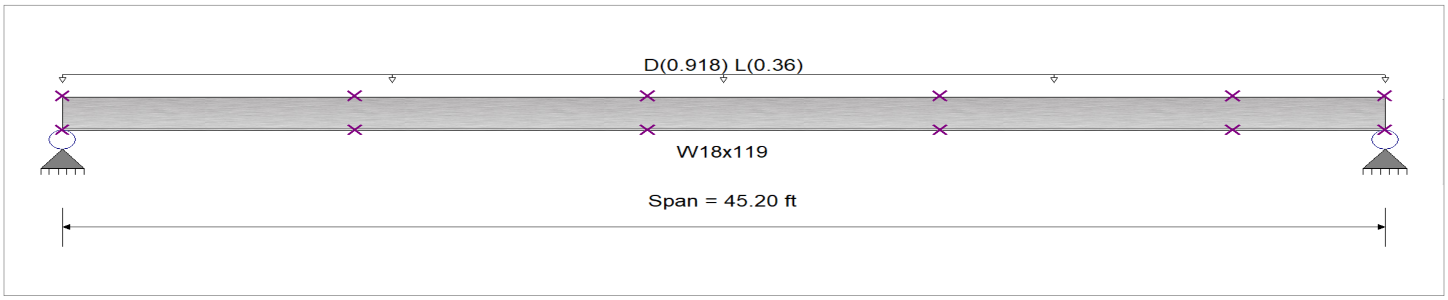
Calculations per AISC 360-10, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Beam bracing is defined as a set spacing over all spans	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		

Unbraced Lengths

First Brace starts at 10.0 ft from Left-Most support
Regular spacing of lateral supports on length of beam = 10.0 ft



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.0510, L = 0.020 ksf, Tributary Width = 18.0 ft, (Typical Roof)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.473 : 1	Maximum Shear Stress Ratio =	0.110 : 1
Section used for this span	W18x119	Section used for this span	W18x119
Mu : Applied	464.894 k-ft	Vu : Applied	41.141 k
Mn * Phi : Allowable	982.500 k-ft	Vn * Phi : Allowable	373.350 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	22.600ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.535 in	Ratio =	1,014 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	2.075 in	Ratio =	261 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 9.94 ft	1	0.259	0.088	254.49		254.49	1,091.67	982.50	1.56	1.00	32.81	373.35	373.35
Dsgn. L = 9.94 ft	1	0.372	0.049	365.42	254.49	365.42	1,091.67	982.50	1.10	1.00	18.37	373.35	373.35
Dsgn. L = 10.07 ft	1	0.377	0.029	370.76	331.43	370.76	1,091.67	982.50	1.01	1.00	10.69	373.35	373.35
Dsgn. L = 9.94 ft	1	0.337	0.067	331.43	153.38	331.43	1,091.67	982.50	1.21	1.00	25.12	373.35	373.35
Dsgn. L = 5.29 ft	1	0.156	0.088	153.38		153.38	1,091.67	982.50	1.58	1.00	32.81	373.35	373.35
+1.20D+1.60L													
Dsgn. L = 9.94 ft	1	0.325	0.110	319.10		319.10	1,091.67	982.50	1.56	1.00	41.14	373.35	373.35
Dsgn. L = 9.94 ft	1	0.466	0.062	458.20	319.10	458.20	1,091.67	982.50	1.10	1.00	23.04	373.35	373.35
Dsgn. L = 10.07 ft	1	0.473	0.036	464.89	415.57	464.89	1,091.67	982.50	1.01	1.00	13.40	373.35	373.35
Dsgn. L = 9.94 ft	1	0.423	0.084	415.57	192.32	415.57	1,091.67	982.50	1.21	1.00	31.50	373.35	373.35
Dsgn. L = 5.29 ft	1	0.196	0.110	192.32		192.32	1,091.67	982.50	1.58	1.00	41.14	373.35	373.35
+1.20D+L													
Dsgn. L = 9.94 ft	1	0.286	0.097	281.24		281.24	1,091.67	982.50	1.56	1.00	36.26	373.35	373.35
Dsgn. L = 9.94 ft	1	0.411	0.054	403.83	281.24	403.83	1,091.67	982.50	1.10	1.00	20.31	373.35	373.35
Dsgn. L = 10.07 ft	1	0.417	0.032	409.73	366.26	409.73	1,091.67	982.50	1.01	1.00	11.81	373.35	373.35
Dsgn. L = 9.94 ft	1	0.373	0.074	366.26	169.50	366.26	1,091.67	982.50	1.21	1.00	27.76	373.35	373.35
Dsgn. L = 5.29 ft	1	0.173	0.097	169.50		169.50	1,091.67	982.50	1.58	1.00	36.26	373.35	373.35
+1.20D													
Dsgn. L = 9.94 ft	1	0.222	0.075	218.13		218.13	1,091.67	982.50	1.56	1.00	28.12	373.35	373.35

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Project Title:
Engineer:
Project ID:
Project Descr:

Printed: 2 APR 2020, 3:39PM

Steel Beam

File = C:\Users\Owner\Desktop\SCU Faculty Staff Housing Development.ec6

DESCRIPTION: Residential (Roof) - 40 to 45 ft spans

Load Combination / Segment Length	Span #	Max Stress Ratios M	Max Stress Ratios V	Summary of Moment Values max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	Summary of Shear Values VuMax	Vnx	Phi*Vnx
Dsgn. L = 9.94 ft	1	0.319	0.042	313.22	218.13	313.22	1,091.67	982.50	1.10	1.00	15.75	373.35	373.35
Dsgn. L = 10.07 ft	1	0.323	0.025	317.79	284.08	317.79	1,091.67	982.50	1.01	1.00	9.16	373.35	373.35
Dsgn. L = 9.94 ft	1	0.289	0.058	284.08	131.47	284.08	1,091.67	982.50	1.21	1.00	21.53	373.35	373.35
Dsgn. L = 5.29 ft	1	0.134	0.075	131.47		131.47	1,091.67	982.50	1.58	1.00	28.12	373.35	373.35
+0.90D													
Dsgn. L = 9.94 ft	1	0.167	0.056	163.60		163.60	1,091.67	982.50	1.56	1.00	21.09	373.35	373.35
Dsgn. L = 9.94 ft	1	0.239	0.032	234.91	163.60	234.91	1,091.67	982.50	1.10	1.00	11.81	373.35	373.35
Dsgn. L = 10.07 ft	1	0.243	0.018	238.35	213.06	238.35	1,091.67	982.50	1.01	1.00	6.87	373.35	373.35
Dsgn. L = 9.94 ft	1	0.217	0.043	213.06	98.60	213.06	1,091.67	982.50	1.21	1.00	16.15	373.35	373.35
Dsgn. L = 5.29 ft	1	0.100	0.056	98.60		98.60	1,091.67	982.50	1.58	1.00	21.09	373.35	373.35
+1.40D+L													
Dsgn. L = 9.94 ft	1	0.323	0.110	317.60		317.60	1,091.67	982.50	1.56	1.00	40.95	373.35	373.35
Dsgn. L = 9.94 ft	1	0.464	0.061	456.03	317.60	456.03	1,091.67	982.50	1.10	1.00	22.93	373.35	373.35
Dsgn. L = 10.07 ft	1	0.471	0.036	462.70	413.61	462.70	1,091.67	982.50	1.01	1.00	13.34	373.35	373.35
Dsgn. L = 9.94 ft	1	0.421	0.084	413.61	191.41	413.61	1,091.67	982.50	1.21	1.00	31.35	373.35	373.35
Dsgn. L = 5.29 ft	1	0.195	0.110	191.41		191.41	1,091.67	982.50	1.58	1.00	40.95	373.35	373.35
+0.70D													
Dsgn. L = 9.94 ft	1	0.130	0.044	127.25		127.25	1,091.67	982.50	1.56	1.00	16.41	373.35	373.35
Dsgn. L = 9.94 ft	1	0.186	0.025	182.71	127.25	182.71	1,091.67	982.50	1.10	1.00	9.19	373.35	373.35
Dsgn. L = 10.07 ft	1	0.189	0.014	185.38	165.71	185.38	1,091.67	982.50	1.01	1.00	5.34	373.35	373.35
Dsgn. L = 9.94 ft	1	0.169	0.034	165.71	76.69	165.71	1,091.67	982.50	1.21	1.00	12.56	373.35	373.35
Dsgn. L = 5.29 ft	1	0.078	0.044	76.69		76.69	1,091.67	982.50	1.58	1.00	16.41	373.35	373.35

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	2.0753	22.729		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1

Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	31.572	31.572
Overall MINimum	8.136	8.136
D Only	23.436	23.436
+D+L	31.572	31.572
+D+0.750L	29.538	29.538
+0.60D	14.062	14.062
L Only	8.136	8.136

Concrete Beam

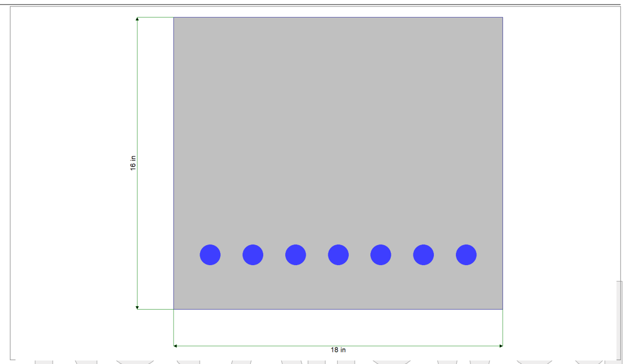
DESCRIPTION: Parking Garage - 18'3" and below spans

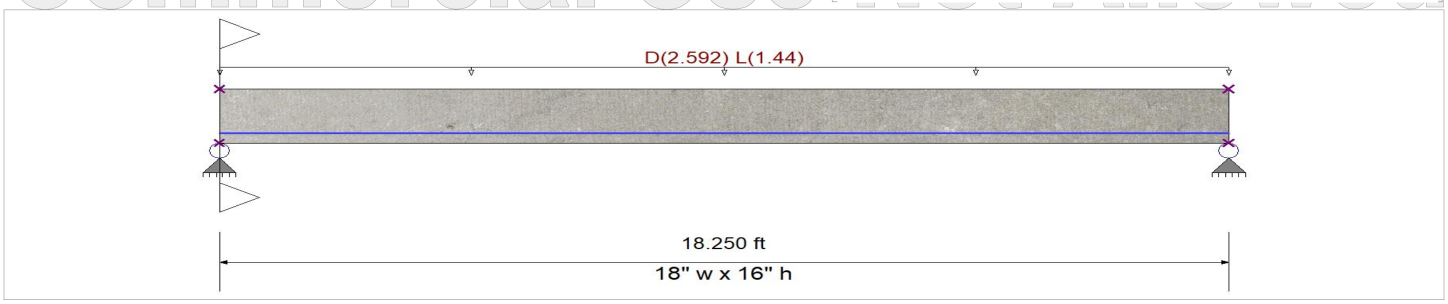
CODE REFERENCES

Calculations per ACI 318-14, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

f'c	= 4.0 ksi	ϕ Phi Values Flexure :	0.90
$fr = f'c^{1/2} * 7.50$	= 474.342 psi	Shear :	0.750
ψ Density	= 145.0 pcf	β_1 =	0.850
λ LtWt Factor	= 1.0		
Elastic Modulus	= 3,644.15 ksi	Fy - Stirrups	40.0 ksi
fy - Main Rebar	= 60.0 ksi	E - Stirrups =	29,000.0 ksi
E - Main Rebar	= 29,000.0 ksi	Stirrup Bar Size #	3
		Number of Resisting Legs Per Stirrup =	2





Cross Section & Reinforcing Details

Rectangular Section, Width = 18.0 in, Height = 16.0 in
Span #1 Reinforcing....
7-#9 at 3.0 in from Bottom, from 0.0 to 18.250 ft in this span

Beam self weight calculated and added to loads
Load for Span Number 1
Uniform Load : D = 0.1080, L = 0.060 ksf, Tributary Width = 24.0 ft, (Parking Garage)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.814** : 1	
Section used for this span	**Typical Section**	
Mu : Applied	239.904	k-ft
Mn * Phi : Allowable	294.764	k-ft
Location of maximum on span	9.108	ft
Span # where maximum occurs	Span # 1	

Maximum Deflection				
Max Downward Transient Deflection	0.228 in	Ratio =	959	>=360
Max Upward Transient Deflection	0.000 in	Ratio =	0	<360.0
Max Downward Total Deflection	0.738 in	Ratio =	296	>=240
Max Upward Total Deflection	0.000 in	Ratio =	0	<240.0

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	39.438	39.438
Overall MINimum	13.140	13.140
+D+H	26.298	26.298
+D+L+H	39.438	39.438
+D+Lr+H	26.298	26.298
+D+S+H	26.298	26.298
+D+0.750Lr+0.750L+H	36.153	36.153
+D+0.750L+0.750S+H	36.153	36.153
+D+0.60W+H	26.298	26.298
+D+0.750Lr+0.750L+0.450W+H	36.153	36.153
+D+0.750L+0.750S+0.450W+H	36.153	36.153
+0.60D+0.60W+0.60H	15.779	15.779
+D+0.70E+0.60H	26.298	26.298

Concrete Beam

DESCRIPTION: Parking Garage - 18'3" and below spans

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
+D+0.750L+0.750S+0.5250E+H	36.153	36.153
+0.60D+0.70E+H	15.779	15.779
D Only	26.298	26.298
Lr Only		
L Only	13.140	13.140
S Only		
W Only		
E Only		
H Only		

Detailed Shear Information

Load Combination	Span Number	Distance (ft)	'd' (in)	Vu (k) Actual	Vu (k) Design	Mu (k-ft)	d*Vu/Mu	Phi*Vc (k)	Comment	Phi*Vs (k)	Phi*Vn (k)	Spacing (in) Req'd	Spacing (in) Suggest
+1.20D+1.60L+0.50S+1.60H	1	0.00	13.00	52.58	52.58	0.00	1.00	34.21	PhiVc < Vu	18.368	55.7	4.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.20	13.00	51.43	51.43	10.37	1.00	34.21	PhiVc < Vu	17.218	55.7	5.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.40	13.00	50.28	50.28	20.52	1.00	34.21	PhiVc < Vu	16.069	55.7	5.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.60	13.00	49.13	49.13	30.43	1.00	34.21	PhiVc < Vu	14.920	55.7	5.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.80	13.00	47.98	47.98	40.12	1.00	34.21	PhiVc < Vu	13.770	55.7	6.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.00	13.00	46.84	46.84	49.57	1.00	34.21	PhiVc < Vu	12.621	55.7	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.20	13.00	45.69	45.69	58.80	0.84	32.14	PhiVc < Vu	13.549	53.6	6.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.40	13.00	44.54	44.54	67.80	0.71	30.43	PhiVc < Vu	14.107	51.9	6.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.60	13.00	43.39	43.39	76.57	0.61	29.15	PhiVc < Vu	14.241	50.6	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.80	13.00	42.24	42.24	85.10	0.54	28.15	PhiVc < Vu	14.092	49.6	6.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.99	13.00	41.09	41.09	93.41	0.48	27.34	PhiVc < Vu	13.745	48.8	6.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.19	13.00	39.94	39.94	101.50	0.43	26.68	PhiVc < Vu	13.255	48.1	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.39	13.00	38.79	38.79	109.35	0.38	26.13	PhiVc < Vu	12.657	47.6	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.59	13.00	37.64	37.64	116.97	0.35	25.66	PhiVc < Vu	11.976	47.1	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.79	13.00	36.49	36.49	124.36	0.32	25.26	PhiVc < Vu	11.230	46.7	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.99	13.00	35.34	35.34	131.53	0.29	24.91	PhiVc < Vu	10.432	46.4	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.19	13.00	34.19	34.19	138.46	0.27	24.60	PhiVc < Vu	9.592	46.1	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.39	13.00	33.04	33.04	145.17	0.25	24.33	PhiVc < Vu	8.717	45.8	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.59	13.00	31.89	31.89	151.64	0.23	24.08	PhiVc < Vu	7.814	45.5	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.79	13.00	30.74	30.74	157.89	0.21	23.86	PhiVc < Vu	6.887	45.3	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.99	13.00	29.60	29.60	163.91	0.20	23.66	PhiVc < Vu	5.939	45.1	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.19	13.00	28.45	28.45	169.69	0.18	23.47	PhiVc < Vu	4.973	44.9	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.39	13.00	27.30	27.30	175.25	0.17	23.30	PhiVc < Vu	3.993	44.8	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.59	13.00	26.15	26.15	180.58	0.16	23.15	PhiVc < Vu	2.999	44.6	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.79	13.00	25.00	25.00	185.68	0.15	23.00	PhiVc < Vu	1.994	44.5	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.99	13.00	23.85	23.85	190.55	0.14	22.87	PhiVc < Vu	0.9799	44.3	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	5.19	13.00	22.70	22.70	195.20	0.13	22.74	PhiVc/2 < Vu <=	Min 9.6.3.1	37.0	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	5.39	13.00	21.55	21.55	199.61	0.12	22.62	PhiVc/2 < Vu <=	Min 9.6.3.1	36.9	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	5.58	13.00	20.40	20.40	203.79	0.11	22.51	PhiVc/2 < Vu <=	Min 9.6.3.1	36.8	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	5.78	13.00	19.25	19.25	207.75	0.10	22.41	PhiVc/2 < Vu <=	Min 9.6.3.1	36.7	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	5.98	13.00	18.10	18.10	211.47	0.09	22.31	PhiVc/2 < Vu <=	Min 9.6.3.1	36.6	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	6.18	13.00	16.95	16.95	214.97	0.09	22.21	PhiVc/2 < Vu <=	Min 9.6.3.1	36.5	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	6.38	13.00	15.80	15.80	218.23	0.08	22.12	PhiVc/2 < Vu <=	Min 9.6.3.1	36.4	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	6.58	13.00	14.65	14.65	221.27	0.07	22.03	PhiVc/2 < Vu <=	Min 9.6.3.1	36.3	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	6.78	13.00	13.50	13.50	224.08	0.07	21.95	PhiVc/2 < Vu <=	Min 9.6.3.1	36.2	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	6.98	13.00	12.36	12.36	226.66	0.06	21.86	PhiVc/2 < Vu <=	Min 9.6.3.1	36.2	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	7.18	13.00	11.21	11.21	229.01	0.05	21.78	PhiVc/2 < Vu <=	Min 9.6.3.1	36.1	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	7.38	13.00	10.06	10.06	231.13	0.05	21.71	Vu < PhiVc/2	lot Reqd 9.6.	21.7	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	7.58	13.00	8.91	8.91	233.02	0.04	21.63	Vu < PhiVc/2	lot Reqd 9.6.	21.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	7.78	13.00	7.76	7.76	234.68	0.04	21.56	Vu < PhiVc/2	lot Reqd 9.6.	21.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	7.98	13.00	6.61	6.61	236.12	0.03	21.49	Vu < PhiVc/2	lot Reqd 9.6.	21.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	8.18	13.00	5.46	5.46	237.32	0.02	21.42	Vu < PhiVc/2	lot Reqd 9.6.	21.4	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	8.38	13.00	4.31	4.31	238.29	0.02	21.35	Vu < PhiVc/2	lot Reqd 9.6.	21.3	0.0	0.0

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Concrete Beam

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DESCRIPTION: Parking Garage - 18'3" and below spans

Detailed Shear Information

Load Combination	Span Number	Distance (ft)	'd' (in)	Vu (k) Actual	Vu (k) Design	Mu (k-ft)	d*Vu/Mu	Phi*Vc (k)	Comment	Phi*Vs (k)	Phi*Vn (k)	Spacing (in) Req'd	Spacing (in) Suggest
+1.20D+1.60L+0.50S+1.60H	1	8.58	13.00	3.16	3.16	239.04	0.01	21.28	Vu < PhiVc/2	lot Reqd 9.6.	21.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	8.78	13.00	2.01	2.01	239.55	0.01	21.21	Vu < PhiVc/2	lot Reqd 9.6.	21.2	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	8.98	13.00	0.86	0.86	239.84	0.00	21.14	Vu < PhiVc/2	lot Reqd 9.6.	21.1	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	9.17	13.00	-0.29	0.29	239.90	0.00	21.11	Vu < PhiVc/2	lot Reqd 9.6.	21.1	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	9.37	13.00	-1.44	1.44	239.73	0.01	21.17	Vu < PhiVc/2	lot Reqd 9.6.	21.2	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	9.57	13.00	-2.59	2.59	239.32	0.01	21.24	Vu < PhiVc/2	lot Reqd 9.6.	21.2	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	9.77	13.00	-3.74	3.74	238.69	0.02	21.31	Vu < PhiVc/2	lot Reqd 9.6.	21.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	9.97	13.00	-4.88	4.88	237.83	0.02	21.38	Vu < PhiVc/2	lot Reqd 9.6.	21.4	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	10.17	13.00	-6.03	6.03	236.75	0.03	21.45	Vu < PhiVc/2	lot Reqd 9.6.	21.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	10.37	13.00	-7.18	7.18	235.43	0.03	21.52	Vu < PhiVc/2	lot Reqd 9.6.	21.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	10.57	13.00	-8.33	8.33	233.88	0.04	21.60	Vu < PhiVc/2	lot Reqd 9.6.	21.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	10.77	13.00	-9.48	9.48	232.10	0.04	21.67	Vu < PhiVc/2	lot Reqd 9.6.	21.7	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	10.97	13.00	-10.63	10.63	230.10	0.05	21.75	Vu < PhiVc/2	lot Reqd 9.6.	21.7	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	11.17	13.00	-11.78	11.78	227.86	0.06	21.82	PhiVc/2 < Vu <=	Min 9.6.3.1	36.1	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	11.37	13.00	-12.93	12.93	225.40	0.06	21.90	PhiVc/2 < Vu <=	Min 9.6.3.1	36.2	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	11.57	13.00	-14.08	14.08	222.70	0.07	21.99	PhiVc/2 < Vu <=	Min 9.6.3.1	36.3	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	11.77	13.00	-15.23	15.23	219.78	0.08	22.07	PhiVc/2 < Vu <=	Min 9.6.3.1	36.4	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	11.97	13.00	-16.38	16.38	216.63	0.08	22.16	PhiVc/2 < Vu <=	Min 9.6.3.1	36.5	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.17	13.00	-17.53	17.53	213.25	0.09	22.26	PhiVc/2 < Vu <=	Min 9.6.3.1	36.6	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.37	13.00	-18.68	18.68	209.64	0.10	22.36	PhiVc/2 < Vu <=	Min 9.6.3.1	36.7	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.57	13.00	-19.83	19.83	205.80	0.10	22.46	PhiVc/2 < Vu <=	Min 9.6.3.1	36.8	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.77	13.00	-20.98	20.98	201.73	0.11	22.57	PhiVc/2 < Vu <=	Min 9.6.3.1	36.9	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.96	13.00	-22.12	22.12	197.43	0.12	22.68	PhiVc/2 < Vu <=	Min 9.6.3.1	37.0	6.5	6.0
+1.20D+1.60L+0.50S+1.60H	1	13.16	13.00	-23.27	23.27	192.90	0.13	22.80	PhiVc < Vu	0.4692	44.3	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	13.36	13.00	-24.42	24.42	188.15	0.14	22.93	PhiVc < Vu	1.488	44.4	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	13.56	13.00	-25.57	25.57	183.16	0.15	23.07	PhiVc < Vu	2.498	44.5	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	13.76	13.00	-26.72	26.72	177.95	0.16	23.22	PhiVc < Vu	3.498	44.7	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	13.96	13.00	-27.87	27.87	172.50	0.18	23.39	PhiVc < Vu	4.485	44.8	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	14.16	13.00	-29.02	29.02	166.83	0.19	23.56	PhiVc < Vu	5.458	45.0	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	14.36	13.00	-30.17	30.17	160.93	0.20	23.75	PhiVc < Vu	6.415	45.2	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	14.56	13.00	-31.32	31.32	154.79	0.22	23.97	PhiVc < Vu	7.353	45.4	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	14.76	13.00	-32.47	32.47	148.43	0.24	24.20	PhiVc < Vu	8.269	45.6	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	14.96	13.00	-33.62	33.62	141.84	0.26	24.46	PhiVc < Vu	9.159	45.9	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	15.16	13.00	-34.77	34.77	135.02	0.28	24.75	PhiVc < Vu	10.017	46.2	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	15.36	13.00	-35.92	35.92	127.97	0.30	25.08	PhiVc < Vu	10.837	46.5	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	15.56	13.00	-37.07	37.07	120.69	0.33	25.46	PhiVc < Vu	11.610	46.9	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	15.76	13.00	-38.22	38.22	113.19	0.37	25.89	PhiVc < Vu	12.325	47.3	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	15.96	13.00	-39.36	39.36	105.45	0.40	26.40	PhiVc < Vu	12.967	47.8	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	16.16	13.00	-40.51	40.51	97.48	0.45	27.00	PhiVc < Vu	13.515	48.4	6.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	16.36	13.00	-41.66	41.66	89.29	0.51	27.72	PhiVc < Vu	13.939	49.2	6.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	16.55	13.00	-42.81	42.81	80.86	0.57	28.62	PhiVc < Vu	14.195	50.1	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	16.75	13.00	-43.96	43.96	72.21	0.66	29.75	PhiVc < Vu	14.216	51.2	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	16.95	13.00	-45.11	45.11	63.33	0.77	31.22	PhiVc < Vu	13.893	52.7	6.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	17.15	13.00	-46.26	46.26	54.21	0.92	33.22	PhiVc < Vu	13.039	54.7	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	17.35	13.00	-47.41	47.41	44.87	1.00	34.21	PhiVc < Vu	13.196	55.7	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	17.55	13.00	-48.56	48.56	35.30	1.00	34.21	PhiVc < Vu	14.345	55.7	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	17.75	13.00	-49.71	49.71	25.50	1.00	34.21	PhiVc < Vu	15.494	55.7	5.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	17.95	13.00	-50.86	50.86	15.47	1.00	34.21	PhiVc < Vu	16.644	55.7	5.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	18.15	13.00	-52.01	52.01	5.22	1.00	34.21	PhiVc < Vu	17.793	55.7	4.8	4.0

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	18.250	239.90	294.76	0.81

Concrete Beam

DESCRIPTION: Parking Garage - 18'3" and below spans

Load Combination / Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
+1.40D+1.60H					
Span # 1	1	18.250	167.98	294.76	0.57
+1.20D+0.50Lr+1.60L+1.60H					
Span # 1	1	18.250	239.90	294.76	0.81
+1.20D+1.60L+0.50S+1.60H					
Span # 1	1	18.250	239.90	294.76	0.81
+1.20D+1.60Lr+L+1.60H					
Span # 1	1	18.250	203.93	294.76	0.69
+1.20D+1.60Lr+0.50W+1.60H					
Span # 1	1	18.250	143.98	294.76	0.49
+1.20D+1.60Lr-0.50W+1.60H					
Span # 1	1	18.250	143.98	294.76	0.49
+1.20D+L+1.60S+1.60H					
Span # 1	1	18.250	203.93	294.76	0.69
+1.20D+1.60S+0.50W+1.60H					
Span # 1	1	18.250	143.98	294.76	0.49
+1.20D+1.60S-0.50W+1.60H					
Span # 1	1	18.250	143.98	294.76	0.49
+1.20D+0.50Lr+L+W+1.60H					
Span # 1	1	18.250	203.93	294.76	0.69
+1.20D+0.50Lr+L-W+1.60H					
Span # 1	1	18.250	203.93	294.76	0.69
+1.20D+L+0.50S+W+1.60H					
Span # 1	1	18.250	203.93	294.76	0.69
+1.20D+L+0.50S-W+1.60H					
Span # 1	1	18.250	203.93	294.76	0.69
+0.90D+W+1.60H					
Span # 1	1	18.250	107.99	294.76	0.37
+0.90D-W+1.60H					
Span # 1	1	18.250	107.99	294.76	0.37
+1.40D+L+0.20S+E+1.60H					
Span # 1	1	18.250	227.93	294.76	0.77
+1.40D+L+0.20S-E+1.60H					
Span # 1	1	18.250	227.93	294.76	0.77
+0.70D+E+0.90H					
Span # 1	1	18.250	83.99	294.76	0.28
+0.70D-E+0.90H					
Span # 1	1	18.250	83.99	294.76	0.28

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl (in)	Location in Span (ft)	Load Combination	Max. "+" Defl (in)	Location in Span (ft)
+D+L+H	1	0.7381	9.125		0.0000	0.000

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Engineer:
Project ID:
Project Descr:

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Concrete Beam

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Lic. # : KW-06090157 - Educational Version
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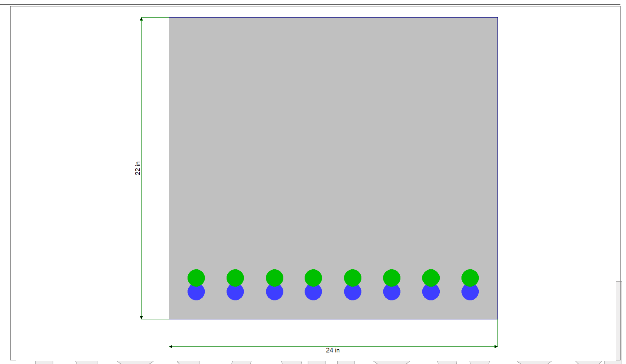
DESCRIPTION: Parking Garage - 19 to 29.5 ft spans

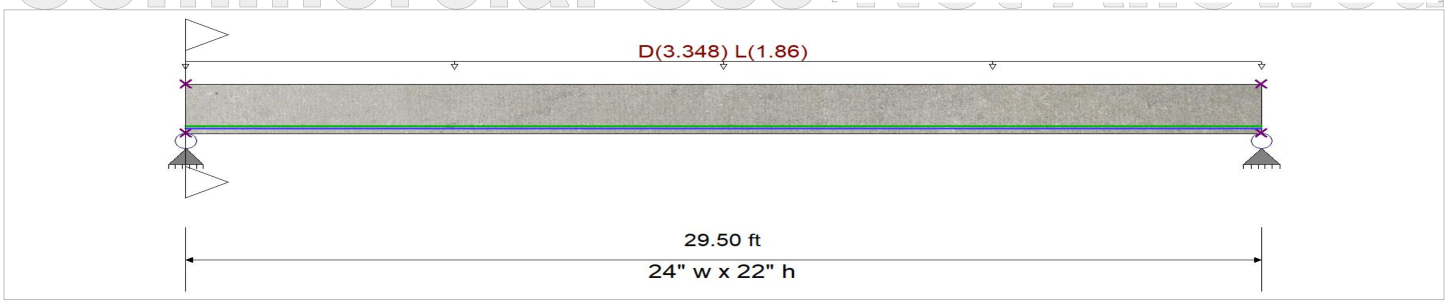
CODE REFERENCES

Calculations per ACI 318-14, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

f'c	=	4.0 ksi	φ Phi Values	Flexure :	0.90
fr = f'c$^{1/2}$ * 7.50	=	474.342 psi		Shear :	0.750
ψ Density	=	145.0 pcf	β_1	=	0.850
λ LtWt Factor	=	1.0			
Elastic Modulus	=	3,644.15 ksi	Fy - Stirrups		40.0 ksi
fy - Main Rebar	=	60.0 ksi	E - Stirrups	=	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #		3
			Number of Resisting Legs Per Stirrup	=	2.0





Cross Section & Reinforcing Details

Rectangular Section, Width = 24.0 in, Height = 22.0 in
Span #1 Reinforcing....
8-#10 at 2.0 in from Bottom, from 0.0 to 29.50 ft in this span
8-#10 at 3.0 in from Bottom, from 0.0 to 29.50 ft in this span

Beam self weight calculated and added to loads
Load for Span Number 1
Uniform Load : D = 0.1080, L = 0.060 ksf, Tributary Width = 31.0 ft, (Parking Garage)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.879** : 1	
Section used for this span	**Typical Section**	
Mu : Applied	830.17	k-ft
Mn * Phi : Allowable	944.78	k-ft
Location of maximum on span	14.723	ft
Span # where maximum occurs	Span # 1	

Maximum Deflection			
Max Downward Transient Deflection	0.390 in	Ratio =	907 >=360
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	1.200 in	Ratio =	294 >=240
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	84.660	84.660
Overall MINimum	27.435	27.435
+D+H	57.225	57.225
+D+L+H	84.660	84.660
+D+Lr+H	57.225	57.225
+D+S+H	57.225	57.225
+D+0.750Lr+0.750L+H	77.801	77.801
+D+0.750L+0.750S+H	77.801	77.801
+D+0.60W+H	57.225	57.225
+D+0.750Lr+0.750L+0.450W+H	77.801	77.801
+D+0.750L+0.750S+0.450W+H	77.801	77.801
+0.60D+0.60W+0.60H	34.335	34.335
+D+0.70E+0.60H	57.225	57.225

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Lic. # : KW-06090157 - Educational Version — **Licensed User : SANTA CLARA UNIVERSITY, CIVIL ENGINEERING**

DESCRIPTION: Parking Garage - 19 to 29.5 ft spans

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
+D+0.750L+0.750S+0.5250E+H	77.801	77.801
+0.60D+0.70E+H	34.335	34.335
D Only	57.225	57.225
Lr Only		
L Only	27.435	27.435
S Only		
W Only		
E Only		
H Only		

Detailed Shear Information

Load Combination	Span Number	Distance (ft)	'd' (in)	Vu Actual	(k) Design	Mu (k-ft)	d*Vu/Mu	Phi*Vc (k)	Comment	Phi*Vs (k)	Phi*Vn (k)	Spacing (in) Req'd	Suggest
+1.20D+1.60L+0.50S+1.60H	1	0.00	20.00	112.57	112.57	0.00	1.00	79.69	PhiVc < Vu	32.877	112.7	4.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.32	20.00	110.11	110.11	35.90	1.00	79.69	PhiVc < Vu	30.416	112.7	4.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.64	20.00	107.65	107.65	71.00	1.00	79.69	PhiVc < Vu	27.956	112.7	4.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.97	20.00	105.18	105.18	105.31	1.00	79.69	PhiVc < Vu	25.495	112.7	5.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.29	20.00	102.72	102.72	138.82	1.00	79.69	PhiVc < Vu	23.035	112.7	5.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.61	20.00	100.26	100.26	171.54	0.97	79.69	PhiVc < Vu	20.574	112.7	6.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.93	20.00	97.80	97.80	203.47	0.80	73.78	PhiVc < Vu	24.021	106.8	5.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.26	20.00	95.34	95.34	234.61	0.68	69.07	PhiVc < Vu	26.277	102.1	5.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.58	20.00	92.88	92.88	264.95	0.58	65.52	PhiVc < Vu	27.362	98.5	4.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.90	20.00	90.42	90.42	294.50	0.51	62.76	PhiVc < Vu	27.665	95.8	4.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.22	20.00	87.96	87.96	323.25	0.45	60.54	PhiVc < Vu	27.422	93.5	4.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.55	20.00	85.50	85.50	351.22	0.41	58.72	PhiVc < Vu	26.783	91.7	4.9	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.87	20.00	83.04	83.04	378.39	0.37	57.20	PhiVc < Vu	25.845	90.2	5.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.19	20.00	80.58	80.58	404.76	0.33	55.90	PhiVc < Vu	24.679	88.9	5.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.51	20.00	78.12	78.12	430.35	0.30	54.79	PhiVc < Vu	23.333	87.8	5.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.84	20.00	75.66	75.66	455.13	0.28	53.82	PhiVc < Vu	21.843	86.8	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	5.16	20.00	73.20	73.20	479.13	0.25	52.96	PhiVc < Vu	20.238	86.0	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	5.48	20.00	70.74	70.74	502.33	0.23	52.20	PhiVc < Vu	18.536	85.2	7.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	5.80	20.00	68.28	68.28	524.74	0.22	51.52	PhiVc < Vu	16.755	84.5	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	6.13	20.00	65.82	65.82	546.36	0.20	50.91	PhiVc < Vu	14.908	83.9	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	6.45	20.00	63.36	63.36	567.18	0.19	50.35	PhiVc < Vu	13.004	83.4	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	6.77	20.00	60.90	60.90	587.21	0.17	49.85	PhiVc < Vu	11.051	82.8	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	7.09	20.00	58.44	58.44	606.45	0.16	49.38	PhiVc < Vu	9.057	82.4	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	7.42	20.00	55.98	55.98	624.89	0.15	48.95	PhiVc < Vu	7.027	81.9	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	7.74	20.00	53.52	53.52	642.54	0.14	48.55	PhiVc < Vu	4.966	81.5	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	8.06	20.00	51.05	51.05	659.40	0.13	48.18	PhiVc < Vu	2.878	81.2	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	8.38	20.00	48.59	48.59	675.46	0.12	47.83	PhiVc < Vu	0.7658	80.8	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	8.70	20.00	46.13	46.13	690.73	0.11	47.50	PhiVc/2 < Vu <=	Min 11.5.6.3	66.4	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	9.03	20.00	43.67	43.67	705.21	0.10	47.19	PhiVc/2 < Vu <=	Min 11.5.6.3	66.0	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	9.35	20.00	41.21	41.21	718.89	0.10	46.90	PhiVc/2 < Vu <=	Min 11.5.6.3	65.8	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	9.67	20.00	38.75	38.75	731.79	0.09	46.62	PhiVc/2 < Vu <=	Min 11.5.6.3	65.5	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	9.99	20.00	36.29	36.29	743.88	0.08	46.36	PhiVc/2 < Vu <=	Min 11.5.6.3	65.2	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	10.32	20.00	33.83	33.83	755.19	0.07	46.10	PhiVc/2 < Vu <=	Min 11.5.6.3	65.0	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	10.64	20.00	31.37	31.37	765.70	0.07	45.86	PhiVc/2 < Vu <=	Min 11.5.6.3	64.7	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	10.96	20.00	28.91	28.91	775.42	0.06	45.63	PhiVc/2 < Vu <=	Min 11.5.6.3	64.5	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	11.28	20.00	26.45	26.45	784.34	0.06	45.40	PhiVc/2 < Vu <=	Min 11.5.6.3	64.3	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	11.61	20.00	23.99	23.99	792.47	0.05	45.18	PhiVc/2 < Vu <=	Min 11.5.6.3	64.0	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	11.93	20.00	21.53	21.53	799.81	0.04	44.97	Vu < PhiVc/2	lot Reqd 9.6.	45.0	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	12.25	20.00	19.07	19.07	806.35	0.04	44.76	Vu < PhiVc/2	lot Reqd 9.6.	44.8	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	12.57	20.00	16.61	16.61	812.10	0.03	44.56	Vu < PhiVc/2	lot Reqd 9.6.	44.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	12.90	20.00	14.15	14.15	817.06	0.03	44.36	Vu < PhiVc/2	lot Reqd 9.6.	44.4	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	13.22	20.00	11.69	11.69	821.23	0.02	44.16	Vu < PhiVc/2	lot Reqd 9.6.	44.2	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	13.54	20.00	9.23	9.23	824.60	0.02	43.97	Vu < PhiVc/2	lot Reqd 9.6.	44.0	0.0	0.0

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DESCRIPTION: Parking Garage - 19 to 29.5 ft spans

Detailed Shear Information

Load Combination	Span Number	Distance (ft)	'd' (in)	Vu (k) Actual	Vu (k) Design	Mu (k-ft)	d*Vu/Mu	Phi*Vc (k)	Comment	Phi*Vs (k)	Phi*Vn (k)	Spacing (in) Req'd	Spacing (in) Suggest
+1.20D+1.60L+0.50S+1.60H	1	13.86	20.00	6.77	6.77	827.18	0.01	43.78	Vu < PhiVc/2	lot Reqd 9.6.	43.8	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	14.19	20.00	4.31	4.31	828.96	0.01	43.59	Vu < PhiVc/2	lot Reqd 9.6.	43.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	14.51	20.00	1.85	1.85	829.95	0.00	43.40	Vu < PhiVc/2	lot Reqd 9.6.	43.4	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	14.83	20.00	-0.62	0.62	830.15	0.00	43.31	Vu < PhiVc/2	lot Reqd 9.6.	43.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	15.15	20.00	-3.08	3.08	829.56	0.01	43.50	Vu < PhiVc/2	lot Reqd 9.6.	43.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	15.48	20.00	-5.54	5.54	828.17	0.01	43.68	Vu < PhiVc/2	lot Reqd 9.6.	43.7	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	15.80	20.00	-8.00	8.00	825.99	0.02	43.87	Vu < PhiVc/2	lot Reqd 9.6.	43.9	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	16.12	20.00	-10.46	10.46	823.01	0.02	44.07	Vu < PhiVc/2	lot Reqd 9.6.	44.1	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	16.44	20.00	-12.92	12.92	819.24	0.03	44.26	Vu < PhiVc/2	lot Reqd 9.6.	44.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	16.77	20.00	-15.38	15.38	814.68	0.03	44.46	Vu < PhiVc/2	lot Reqd 9.6.	44.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	17.09	20.00	-17.84	17.84	809.33	0.04	44.66	Vu < PhiVc/2	lot Reqd 9.6.	44.7	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	17.41	20.00	-20.30	20.30	803.18	0.04	44.86	Vu < PhiVc/2	lot Reqd 9.6.	44.9	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	17.73	20.00	-22.76	22.76	796.24	0.05	45.08	PhiVc/2 < Vu <=	Min 11.5.6.3	63.9	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	18.05	20.00	-25.22	25.22	788.50	0.05	45.29	PhiVc/2 < Vu <=	Min 11.5.6.3	64.1	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	18.38	20.00	-27.68	27.68	779.98	0.06	45.51	PhiVc/2 < Vu <=	Min 11.5.6.3	64.4	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	18.70	20.00	-30.14	30.14	770.66	0.07	45.74	PhiVc/2 < Vu <=	Min 11.5.6.3	64.6	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	19.02	20.00	-32.60	32.60	760.54	0.07	45.98	PhiVc/2 < Vu <=	Min 11.5.6.3	64.8	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	19.34	20.00	-35.06	35.06	749.63	0.08	46.23	PhiVc/2 < Vu <=	Min 11.5.6.3	65.1	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	19.67	20.00	-37.52	37.52	737.93	0.08	46.49	PhiVc/2 < Vu <=	Min 11.5.6.3	65.3	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	19.99	20.00	-39.98	39.98	725.44	0.09	46.76	PhiVc/2 < Vu <=	Min 11.5.6.3	65.6	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	20.31	20.00	-42.44	42.44	712.15	0.10	47.04	PhiVc/2 < Vu <=	Min 11.5.6.3	65.9	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	20.63	20.00	-44.90	44.90	698.07	0.11	47.34	PhiVc/2 < Vu <=	Min 11.5.6.3	66.2	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	20.96	20.00	-47.36	47.36	683.20	0.12	47.66	PhiVc/2 < Vu <=	Min 11.5.6.3	66.5	7.3	7.0
+1.20D+1.60L+0.50S+1.60H	1	21.28	20.00	-49.82	49.82	667.53	0.12	48.00	PhiVc < Vu	1.825	81.0	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	21.60	20.00	-52.28	52.28	651.07	0.13	48.36	PhiVc < Vu	3.925	81.4	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	21.92	20.00	-54.75	54.75	633.82	0.14	48.74	PhiVc < Vu	6.001	81.7	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	22.25	20.00	-57.21	57.21	615.77	0.15	49.16	PhiVc < Vu	8.047	82.2	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	22.57	20.00	-59.67	59.67	596.93	0.17	49.61	PhiVc < Vu	10.059	82.6	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	22.89	20.00	-62.13	62.13	577.30	0.18	50.09	PhiVc < Vu	12.033	83.1	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	23.21	20.00	-64.59	64.59	556.87	0.19	50.62	PhiVc < Vu	13.962	83.6	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	23.54	20.00	-67.05	67.05	535.65	0.21	51.21	PhiVc < Vu	15.839	84.2	7.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	23.86	20.00	-69.51	69.51	513.64	0.23	51.85	PhiVc < Vu	17.655	84.9	7.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	24.18	20.00	-71.97	71.97	490.83	0.24	52.57	PhiVc < Vu	19.398	85.6	6.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	24.50	20.00	-74.43	74.43	467.23	0.27	53.38	PhiVc < Vu	21.054	86.4	6.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	24.83	20.00	-76.89	76.89	442.84	0.29	54.29	PhiVc < Vu	22.604	87.3	5.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	25.15	20.00	-79.35	79.35	417.65	0.32	55.32	PhiVc < Vu	24.026	88.3	5.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	25.47	20.00	-81.81	81.81	391.67	0.35	56.52	PhiVc < Vu	25.287	89.5	5.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	25.79	20.00	-84.27	84.27	364.90	0.38	57.92	PhiVc < Vu	26.346	90.9	5.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	26.11	20.00	-86.73	86.73	337.34	0.43	59.59	PhiVc < Vu	27.145	92.6	4.9	4.0
+1.20D+1.60L+0.50S+1.60H	1	26.44	20.00	-89.19	89.19	308.98	0.48	61.59	PhiVc < Vu	27.601	94.6	4.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	26.76	20.00	-91.65	91.65	279.82	0.55	64.06	PhiVc < Vu	27.594	97.1	4.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	27.08	20.00	-94.11	94.11	249.88	0.63	67.18	PhiVc < Vu	26.936	100.2	4.9	4.0
+1.20D+1.60L+0.50S+1.60H	1	27.40	20.00	-96.57	96.57	219.14	0.73	71.24	PhiVc < Vu	25.329	104.2	5.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	27.73	20.00	-99.03	99.03	187.61	0.88	76.78	PhiVc < Vu	22.253	109.8	5.9	4.0
+1.20D+1.60L+0.50S+1.60H	1	28.05	20.00	-101.49	101.49	155.28	1.00	79.69	PhiVc < Vu	21.805	112.7	6.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	28.37	20.00	-103.95	103.95	122.16	1.00	79.69	PhiVc < Vu	24.265	112.7	5.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	28.69	20.00	-106.41	106.41	88.25	1.00	79.69	PhiVc < Vu	26.726	112.7	4.9	4.0
+1.20D+1.60L+0.50S+1.60H	1	29.02	20.00	-108.88	108.88	53.55	1.00	79.69	PhiVc < Vu	29.186	112.7	4.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	29.34	20.00	-111.34	111.34	18.05	1.00	79.69	PhiVc < Vu	31.646	112.7	4.2	4.0

Maximum Forces & Stresses for Load Combinations

Load Combination Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	29.500	830.17	944.78	0.88

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DESCRIPTION: Parking Garage - 19 to 29.5 ft spans

Load Combination Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
+1.40D+1.60H					
Span # 1	1	29.500	590.85	944.78	0.63
+1.20D+0.50Lr+1.60L+1.60H					
Span # 1	1	29.500	830.17	944.78	0.88
+1.20D+1.60L+0.50S+1.60H					
Span # 1	1	29.500	830.17	944.78	0.88
+1.20D+1.60Lr+L+1.60H					
Span # 1	1	29.500	708.77	944.78	0.75
+1.20D+1.60Lr+0.50W+1.60H					
Span # 1	1	29.500	506.44	944.78	0.54
+1.20D+1.60Lr-0.50W+1.60H					
Span # 1	1	29.500	506.44	944.78	0.54
+1.20D+L+1.60S+1.60H					
Span # 1	1	29.500	708.77	944.78	0.75
+1.20D+1.60S+0.50W+1.60H					
Span # 1	1	29.500	506.44	944.78	0.54
+1.20D+1.60S-0.50W+1.60H					
Span # 1	1	29.500	506.44	944.78	0.54
+1.20D+0.50Lr+L+W+1.60H					
Span # 1	1	29.500	708.77	944.78	0.75
+1.20D+0.50Lr+L-W+1.60H					
Span # 1	1	29.500	708.77	944.78	0.75
+1.20D+L+0.50S+W+1.60H					
Span # 1	1	29.500	708.77	944.78	0.75
+1.20D+L+0.50S-W+1.60H					
Span # 1	1	29.500	708.77	944.78	0.75
+0.90D+W+1.60H					
Span # 1	1	29.500	379.83	944.78	0.40
+0.90D-W+1.60H					
Span # 1	1	29.500	379.83	944.78	0.40
+1.40D+L+0.20S+E+1.60H					
Span # 1	1	29.500	793.18	944.78	0.84
+1.40D+L+0.20S-E+1.60H					
Span # 1	1	29.500	793.18	944.78	0.84
+0.70D+E+0.90H					
Span # 1	1	29.500	295.42	944.78	0.31
+0.70D-E+0.90H					
Span # 1	1	29.500	295.42	944.78	0.31

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl (in)	Location in Span (ft)	Load Combination	Max. "+" Defl (in)	Location in Span (ft)
+D+L+H	1	1.2002	14.750		0.0000	0.000

Concrete Beam

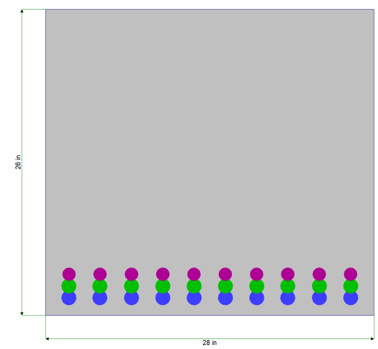
DESCRIPTION: Parking Garage - 30' to 45'3" spans

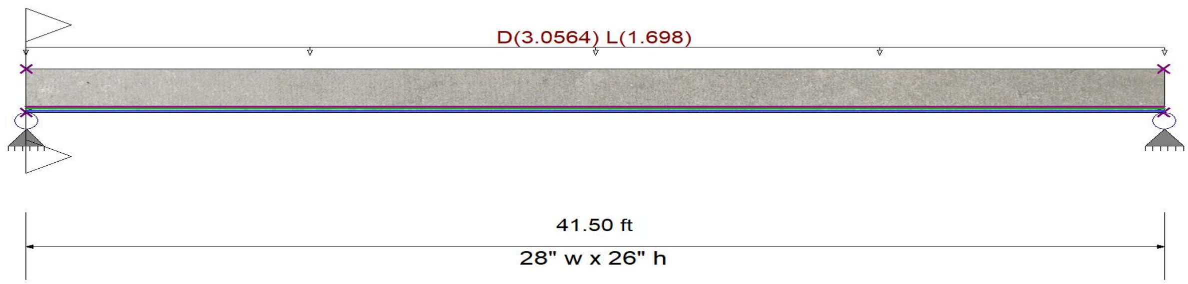
CODE REFERENCES

Calculations per ACI 318-14, IBC 2015, CBC 2016, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

f'c	=	4.0 ksi	ϕ Phi Values Flexure :	0.90
$fr = f'c^{1/2} * 7.50$	=	474.342 psi	Shear :	0.750
ψ Density	=	145.0 pcf	β_1 =	0.850
λ LtWt Factor	=	1.0		
Elastic Modulus	=	3,644.15 ksi	Fy - Stirrups	40.0 ksi
fy - Main Rebar	=	60.0 ksi	E - Stirrups =	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #	3
			Number of Resisting Legs Per Stirrup =	2.0





Cross Section & Reinforcing Details

Rectangular Section, Width = 28.0 in, Height = 26.0 in
Span #1 Reinforcing....
10-#10 at 1.50 in from Bottom, from 0.0 to 41.50 ft in this span
10-#10 at 2.50 in from Bottom, from 0.0 to 41.50 ft in this span
10-#9 at 3.50 in from Bottom, from 0.0 to 41.50 ft in this span

Beam self weight calculated and added to loads
Load for Span Number 1
Uniform Load : D = 0.1080, L = 0.060 ksf, Tributary Width = 28.30 ft, (Parking Garage)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.939** : 1	
Section used for this span	**Typical Section**	
Mu : Applied	1,563.83	k-ft
Mn * Phi : Allowable	1,665.19	k-ft
Location of maximum on span	20.712	ft
Span # where maximum occurs	Span # 1	

Maximum Deflection			
Max Downward Transient Deflection	0.609 in	Ratio =	818 >=360
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	1.947 in	Ratio =	255 >=240
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	113.865	113.865
Overall MINimum	35.233	35.233
+D+H	78.631	78.631
+D+L+H	113.865	113.865
+D+Lr+H	78.631	78.631
+D+S+H	78.631	78.631
+D+0.750Lr+0.750L+H	105.056	105.056
+D+0.750L+0.750S+H	105.056	105.056
+D+0.60W+H	78.631	78.631
+D+0.750Lr+0.750L+0.450W+H	105.056	105.056
+D+0.750L+0.750S+0.450W+H	105.056	105.056
+0.60D+0.60W+0.60H	47.179	47.179

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Concrete Beam

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Lic. # : KW-06090157 - Educational Version **Licensed User : SANTA CLARA UNIVERSITY, CIVIL ENGINEERING**

DESCRIPTION: Parking Garage - 30' to 45'3" spans

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
+D+0.70E+0.60H	78.631	78.631
+D+0.750L+0.750S+0.5250E+H	105.056	105.056
+0.60D+0.70E+H	47.179	47.179
D Only	78.631	78.631
Lr Only		
L Only	35.233	35.233
S Only		
W Only		
E Only		
H Only		

Detailed Shear Information

Load Combination	Span Number	Distance (ft)	'd' (in)	Vu (k) Actual	Design	Mu (k-ft)	d*Vu/Mu	Phi*Vc (k)	Comment	Phi*Vs (k)	Phi*Vn (k)	Spacing (in) Req'd	Suggest
+1.20D+1.60L+0.50S+1.60H	1	0.00	24.50	150.73	150.73	0.00	1.00	113.89	PhiVc < Vu	36.842	154.3	4.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.45	24.50	147.44	147.44	67.62	1.00	113.89	PhiVc < Vu	33.547	154.3	4.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	0.91	24.50	144.14	144.14	133.74	1.00	113.89	PhiVc < Vu	30.252	154.3	5.3	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.36	24.50	140.85	140.85	198.37	1.00	113.89	PhiVc < Vu	26.958	154.3	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	1.81	24.50	137.55	137.55	261.50	1.00	113.89	PhiVc < Vu	23.663	154.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.27	24.50	134.26	134.26	323.14	0.85	113.89	PhiVc < Vu	20.368	154.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	2.72	24.50	130.96	130.96	383.29	0.70	108.13	PhiVc < Vu	22.834	148.6	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.17	24.50	127.67	127.67	441.94	0.59	100.97	PhiVc < Vu	26.695	141.4	6.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	3.63	24.50	124.37	124.37	499.10	0.51	95.60	PhiVc < Vu	28.778	136.0	5.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.08	24.50	121.08	121.08	554.76	0.45	91.40	PhiVc < Vu	29.676	131.8	5.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.54	24.50	117.78	117.78	608.93	0.39	88.04	PhiVc < Vu	29.746	128.5	5.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	4.99	24.50	114.49	114.49	661.60	0.35	85.28	PhiVc < Vu	29.213	125.7	5.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	5.44	24.50	111.20	111.20	712.78	0.32	82.97	PhiVc < Vu	28.229	123.4	5.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	5.90	24.50	107.90	107.90	762.47	0.29	81.00	PhiVc < Vu	26.897	121.4	6.0	4.0
+1.20D+1.60L+0.50S+1.60H	1	6.35	24.50	104.61	104.61	810.66	0.26	79.31	PhiVc < Vu	25.293	119.7	6.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	6.80	24.50	101.31	101.31	857.36	0.24	77.84	PhiVc < Vu	23.472	118.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	7.26	24.50	98.02	98.02	902.56	0.22	76.54	PhiVc < Vu	21.474	117.0	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	7.71	24.50	94.72	94.72	946.27	0.20	75.39	PhiVc < Vu	19.331	115.8	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	8.16	24.50	91.43	91.43	988.48	0.19	74.36	PhiVc < Vu	17.067	114.8	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	8.62	24.50	88.13	88.13	1,029.20	0.17	73.43	PhiVc < Vu	14.702	113.9	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	9.07	24.50	84.84	84.84	1,068.43	0.16	72.59	PhiVc < Vu	12.251	113.0	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	9.52	24.50	81.54	81.54	1,106.16	0.15	71.82	PhiVc < Vu	9.727	112.2	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	9.98	24.50	78.25	78.25	1,142.39	0.14	71.11	PhiVc < Vu	7.141	111.5	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	10.43	24.50	74.95	74.95	1,177.14	0.13	70.45	PhiVc < Vu	4.499	110.9	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	10.89	24.50	71.66	71.66	1,210.39	0.12	69.85	PhiVc < Vu	1.810	110.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	11.34	24.50	68.36	68.36	1,242.14	0.11	69.28	PhiVc/2 < Vu <=	Min 11.5.6.3	96.2	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	11.79	24.50	65.07	65.07	1,272.40	0.10	68.76	PhiVc/2 < Vu <=	Min 11.5.6.3	95.7	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.25	24.50	61.78	61.78	1,301.16	0.10	68.26	PhiVc/2 < Vu <=	Min 11.5.6.3	95.2	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	12.70	24.50	58.48	58.48	1,328.44	0.09	67.79	PhiVc/2 < Vu <=	Min 11.5.6.3	94.7	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	13.15	24.50	55.19	55.19	1,354.21	0.08	67.35	PhiVc/2 < Vu <=	Min 11.5.6.3	94.3	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	13.61	24.50	51.89	51.89	1,378.49	0.08	66.93	PhiVc/2 < Vu <=	Min 11.5.6.3	93.9	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	14.06	24.50	48.60	48.60	1,401.28	0.07	66.53	PhiVc/2 < Vu <=	Min 11.5.6.3	93.5	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	14.51	24.50	45.30	45.30	1,422.58	0.07	66.14	PhiVc/2 < Vu <=	Min 11.5.6.3	93.1	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	14.97	24.50	42.01	42.01	1,442.38	0.06	65.77	PhiVc/2 < Vu <=	Min 11.5.6.3	92.7	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	15.42	24.50	38.71	38.71	1,460.68	0.05	65.42	PhiVc/2 < Vu <=	Min 11.5.6.3	92.4	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	15.87	24.50	35.42	35.42	1,477.49	0.05	65.07	PhiVc/2 < Vu <=	Min 11.5.6.3	92.0	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	16.33	24.50	32.12	32.12	1,492.81	0.04	64.74	Vu < PhiVc/2	lot Reqd 9.6.	64.7	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	16.78	24.50	28.83	28.83	1,506.63	0.04	64.42	Vu < PhiVc/2	lot Reqd 9.6.	64.4	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	17.23	24.50	25.53	25.53	1,518.96	0.03	64.10	Vu < PhiVc/2	lot Reqd 9.6.	64.1	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	17.69	24.50	22.24	22.24	1,529.79	0.03	63.80	Vu < PhiVc/2	lot Reqd 9.6.	63.8	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	18.14	24.50	18.94	18.94	1,539.13	0.03	63.49	Vu < PhiVc/2	lot Reqd 9.6.	63.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	18.60	24.50	15.65	15.65	1,546.98	0.02	63.20	Vu < PhiVc/2	lot Reqd 9.6.	63.2	0.0	0.0

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DESCRIPTION: Parking Garage - 30' to 45'3" spans

Detailed Shear Information

Load Combination	Span Number	Distance (ft)	'd' (in)	Vu (k) Actual	Vu (k) Design	Mu (k-ft)	d*Vu/Mu	Phi*Vc (k)	Comment	Phi*Vs (k)	Phi*Vn (k)	Spacing (in) Req'd	Spacing (in) Suggest
+1.20D+1.60L+0.50S+1.60H	1	19.05	24.50	12.36	12.36	1,553.33	0.02	62.90	Vu < PhiVc/2	lot Reqd 9.6.	62.9	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	19.50	24.50	9.06	9.06	1,558.18	0.01	62.61	Vu < PhiVc/2	lot Reqd 9.6.	62.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	19.96	24.50	5.77	5.77	1,561.55	0.01	62.33	Vu < PhiVc/2	lot Reqd 9.6.	62.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	20.41	24.50	2.47	2.47	1,563.41	0.00	62.04	Vu < PhiVc/2	lot Reqd 9.6.	62.0	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	20.86	24.50	-0.82	0.82	1,563.79	0.00	61.90	Vu < PhiVc/2	lot Reqd 9.6.	61.9	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	21.32	24.50	-4.12	4.12	1,562.67	0.01	62.18	Vu < PhiVc/2	lot Reqd 9.6.	62.2	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	21.77	24.50	-7.41	7.41	1,560.05	0.01	62.47	Vu < PhiVc/2	lot Reqd 9.6.	62.5	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	22.22	24.50	-10.71	10.71	1,555.94	0.01	62.76	Vu < PhiVc/2	lot Reqd 9.6.	62.8	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	22.68	24.50	-14.00	14.00	1,550.34	0.02	63.05	Vu < PhiVc/2	lot Reqd 9.6.	63.0	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	23.13	24.50	-17.30	17.30	1,543.24	0.02	63.34	Vu < PhiVc/2	lot Reqd 9.6.	63.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	23.58	24.50	-20.59	20.59	1,534.65	0.03	63.64	Vu < PhiVc/2	lot Reqd 9.6.	63.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	24.04	24.50	-23.89	23.89	1,524.56	0.03	63.95	Vu < PhiVc/2	lot Reqd 9.6.	63.9	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	24.49	24.50	-27.18	27.18	1,512.98	0.04	64.26	Vu < PhiVc/2	lot Reqd 9.6.	64.3	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	24.95	24.50	-30.48	30.48	1,499.91	0.04	64.58	Vu < PhiVc/2	lot Reqd 9.6.	64.6	0.0	0.0
+1.20D+1.60L+0.50S+1.60H	1	25.40	24.50	-33.77	33.77	1,485.34	0.05	64.91	PhiVc/2 < Vu <=	Min 11.5.6.3	91.9	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	25.85	24.50	-37.07	37.07	1,469.27	0.05	65.24	PhiVc/2 < Vu <=	Min 11.5.6.3	92.2	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	26.31	24.50	-40.36	40.36	1,451.72	0.06	65.59	PhiVc/2 < Vu <=	Min 11.5.6.3	92.5	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	26.76	24.50	-43.65	43.65	1,432.66	0.06	65.95	PhiVc/2 < Vu <=	Min 11.5.6.3	92.9	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	27.21	24.50	-46.95	46.95	1,412.12	0.07	66.33	PhiVc/2 < Vu <=	Min 11.5.6.3	93.3	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	27.67	24.50	-50.24	50.24	1,390.08	0.07	66.72	PhiVc/2 < Vu <=	Min 11.5.6.3	93.7	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	28.12	24.50	-53.54	53.54	1,366.54	0.08	67.13	PhiVc/2 < Vu <=	Min 11.5.6.3	94.1	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	28.57	24.50	-56.83	56.83	1,341.51	0.09	67.57	PhiVc/2 < Vu <=	Min 11.5.6.3	94.5	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	29.03	24.50	-60.13	60.13	1,314.99	0.09	68.02	PhiVc/2 < Vu <=	Min 11.5.6.3	95.0	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	29.48	24.50	-63.42	63.42	1,286.97	0.10	68.50	PhiVc/2 < Vu <=	Min 11.5.6.3	95.5	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	29.93	24.50	-66.72	66.72	1,257.46	0.11	69.02	PhiVc/2 < Vu <=	Min 11.5.6.3	96.0	6.3	6.0
+1.20D+1.60L+0.50S+1.60H	1	30.39	24.50	-70.01	70.01	1,226.45	0.12	69.56	PhiVc < Vu	0.4501	110.0	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	30.84	24.50	-73.31	73.31	1,193.95	0.13	70.15	PhiVc < Vu	3.160	110.6	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	31.30	24.50	-76.60	76.60	1,159.95	0.13	70.77	PhiVc < Vu	5.826	111.2	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	31.75	24.50	-79.90	79.90	1,124.46	0.15	71.45	PhiVc < Vu	8.441	111.9	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	32.20	24.50	-83.19	83.19	1,087.48	0.16	72.19	PhiVc < Vu	10.998	112.6	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	32.66	24.50	-86.49	86.49	1,049.00	0.17	73.00	PhiVc < Vu	13.487	113.4	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	33.11	24.50	-89.78	89.78	1,009.03	0.18	73.88	PhiVc < Vu	15.896	114.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	33.56	24.50	-93.07	93.07	967.56	0.20	74.86	PhiVc < Vu	18.213	115.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	34.02	24.50	-96.37	96.37	924.60	0.21	75.95	PhiVc < Vu	20.419	116.4	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	34.47	24.50	-99.66	99.66	880.14	0.23	77.17	PhiVc < Vu	22.493	117.6	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	34.92	24.50	-102.96	102.96	834.19	0.25	78.55	PhiVc < Vu	24.407	119.0	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	35.38	24.50	-106.25	106.25	786.75	0.28	80.13	PhiVc < Vu	26.126	120.6	6.2	4.0
+1.20D+1.60L+0.50S+1.60H	1	35.83	24.50	-109.55	109.55	737.81	0.30	81.95	PhiVc < Vu	27.601	122.4	5.9	4.0
+1.20D+1.60L+0.50S+1.60H	1	36.28	24.50	-112.84	112.84	687.38	0.34	84.07	PhiVc < Vu	28.770	124.5	5.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	36.74	24.50	-116.14	116.14	635.45	0.37	86.59	PhiVc < Vu	29.544	127.0	5.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	37.19	24.50	-119.43	119.43	582.03	0.42	89.63	PhiVc < Vu	29.798	130.1	5.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	37.64	24.50	-122.73	122.73	527.12	0.48	93.38	PhiVc < Vu	29.349	133.8	5.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	38.10	24.50	-126.02	126.02	470.71	0.55	98.11	PhiVc < Vu	27.914	138.5	5.8	4.0
+1.20D+1.60L+0.50S+1.60H	1	38.55	24.50	-129.32	129.32	412.80	0.64	104.28	PhiVc < Vu	25.038	144.7	6.5	4.0
+1.20D+1.60L+0.50S+1.60H	1	39.01	24.50	-132.61	132.61	353.40	0.77	112.68	PhiVc < Vu	19.934	153.1	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	39.46	24.50	-135.91	135.91	292.51	0.95	113.89	PhiVc < Vu	22.016	154.3	6.6	4.0
+1.20D+1.60L+0.50S+1.60H	1	39.91	24.50	-139.20	139.20	230.12	1.00	113.89	PhiVc < Vu	25.310	154.3	6.4	4.0
+1.20D+1.60L+0.50S+1.60H	1	40.37	24.50	-142.49	142.49	166.24	1.00	113.89	PhiVc < Vu	28.605	154.3	5.7	4.0
+1.20D+1.60L+0.50S+1.60H	1	40.82	24.50	-145.79	145.79	100.87	1.00	113.89	PhiVc < Vu	31.90	154.3	5.1	4.0
+1.20D+1.60L+0.50S+1.60H	1	41.27	24.50	-149.08	149.08	34.00	1.00	113.89	PhiVc < Vu	35.194	154.3	4.6	4.0

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					

Title Block Line 1
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Title Block Line 6

Project Title:
Engineer:
Project ID:
Project Descr:

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Concrete Beam

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DESCRIPTION: Parking Garage - 30' to 45'3" spans

Load Combination / Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
Span # 1	1	41.500	1,563.83	1,665.19	0.94
+1.40D+1.60H					
Span # 1	1	41.500	1,142.11	1,665.19	0.69
+1.20D+0.50Lr+1.60L+1.60H					
Span # 1	1	41.500	1,563.83	1,665.19	0.94
+1.20D+1.60L+0.50S+1.60H					
Span # 1	1	41.500	1,563.83	1,665.19	0.94
+1.20D+1.60Lr+L+1.60H					
Span # 1	1	41.500	1,344.50	1,665.19	0.81
+1.20D+1.60Lr+0.50W+1.60H					
Span # 1	1	41.500	978.96	1,665.19	0.59
+1.20D+1.60Lr-0.50W+1.60H					
Span # 1	1	41.500	978.96	1,665.19	0.59
+1.20D+L+1.60S+1.60H					
Span # 1	1	41.500	1,344.50	1,665.19	0.81
+1.20D+1.60S+0.50W+1.60H					
Span # 1	1	41.500	978.96	1,665.19	0.59
+1.20D+1.60S-0.50W+1.60H					
Span # 1	1	41.500	978.96	1,665.19	0.59
+1.20D+0.50Lr+L+W+1.60H					
Span # 1	1	41.500	1,344.50	1,665.19	0.81
+1.20D+0.50Lr+L-W+1.60H					
Span # 1	1	41.500	1,344.50	1,665.19	0.81
+1.20D+L+0.50S+W+1.60H					
Span # 1	1	41.500	1,344.50	1,665.19	0.81
+1.20D+L+0.50S-W+1.60H					
Span # 1	1	41.500	1,344.50	1,665.19	0.81
+0.90D+W+1.60H					
Span # 1	1	41.500	734.22	1,665.19	0.44
+0.90D-W+1.60H					
Span # 1	1	41.500	734.22	1,665.19	0.44
+1.40D+L+0.20S+E+1.60H					
Span # 1	1	41.500	1,507.66	1,665.19	0.91
+1.40D+L+0.20S-E+1.60H					
Span # 1	1	41.500	1,507.66	1,665.19	0.91
+0.70D+E+0.90H					
Span # 1	1	41.500	571.06	1,665.19	0.34
+0.70D-E+0.90H					
Span # 1	1	41.500	571.06	1,665.19	0.34

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl (in)	Location in Span (ft)	Load Combination	Max. "+" Defl (in)	Location in Span (ft)
+D+L+H	1	1.9467	20.750		0.0000	0.000

Metal Decking

From ASC Steel Deck Catalog: www.ascsd.com

[Residential Units](#)

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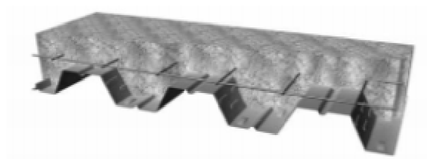
2.4 3WxH-36 Composite Deck

6 ¼" Total Slab Depth

Light Weight Concrete (110 pcf)

Concrete Volume 1.466yd³/100ft²

2 Hour Fire Rating



3WxH-36 6 1/4 " Slab Depth, 110 pcf LWC

Maximum Unshored Span	Gage	Single	Double	Triple	Gage	Single	Double	Triple
	22	10' - 1"	10' - 11"	11' - 4"	19	12' - 2"	13' - 10"	14' - 3"
	21	11' - 0"	11' - 9"	12' - 1"	18	12' - 7"	15' - 1"	14' - 9"
	20	11' - 9"	12' - 5"	12' - 10"	16	13' - 3"	16' - 6"	15' - 7"

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	474	416	368	327	291	261	235	212	192	174	159	145	132	121	111
	LRFD, ϕW	637	558	492	436	388	347	311	280	253	229	208	188	171	156	142
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
22	Arc Spot Weld 1/2" Effective Dia	2522	2496	2473	2464	2445	2428	2412	2398	2385	2381	2370	2360	2350	2341	2332
	PAF Base Steel ≥ .25"	2332	2318	2305	2304	2293	2283	2275	2266	2259	2260	2254	2247	2242	2236	2231
	PAF Base Steel ≥ 0.125"	2317	2304	2292	2292	2281	2272	2264	2256	2249	2251	2244	2239	2233	2228	2224
	#12 Screw Base Steel ≥ .0385"	2304	2291	2280	2280	2270	2262	2254	2247	2240	2242	2236	2231	2225	2221	2216
	Concrete + Deck =	45.3 psf			I_{cr} = 97.0 in⁴/ft		ASD		M_{no}/Ω= 43.4 kip-in/ft			V_n/Ω = 3.34 kip/ft				
	$(I_{cr}+I_u)/2$ =	157.6 in⁴/ft			I_u = 218.1 in⁴/ft		LRFD		ϕM_{no}= 66.4 kip-in/ft			ϕV_n = 4.82 kip/ft				

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	521	458	404	359	321	288	259	234	213	193	176	161	147	135	124
	LRFD, ϕW	700	614	542	481	428	384	345	311	281	255	231	210	192	175	160
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
21	Arc Spot Weld 1/2" Effective Dia	2586	2557	2530	2521	2499	2479	2461	2445	2430	2427	2413	2401	2390	2379	2370
	PAF Base Steel ≥ .25"	2368	2352	2337	2337	2325	2313	2303	2293	2285	2287	2279	2272	2265	2259	2253
	PAF Base Steel ≥ 0.125"	2351	2336	2322	2323	2311	2300	2291	2282	2274	2276	2269	2262	2256	2250	2245
	#12 Screw Base Steel ≥ .0385"	2337	2322	2309	2311	2299	2289	2280	2271	2264	2267	2260	2254	2247	2242	2237
	Concrete + Deck =	45.6 psf			I_{cr} = 104.2 in⁴/ft		ASD		M_{no}/Ω= 47.4 kip-in/ft			V_n/Ω = 3.89 kip/ft				
	$(I_{cr}+I_u)/2$ =	163 in⁴/ft			I_u = 221.7 in⁴/ft		LRFD		ϕM_{no}= 72.5 kip-in/ft			ϕV_n = 5.71 kip/ft				

Gage	Vertical Load Span (ft-in)	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"
	ASD & LRFD - Available Superimposed Load Capacity, W (psf)															
	ASD, W/Ω	564	496	439	390	349	313	282	255	232	211	192	176	161	148	136
	LRFD, ϕW	759	666	588	522	466	418	376	339	307	279	254	231	211	193	177
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) 36/4 Attachment Pattern															
20	Arc Spot Weld 1/2" Effective Dia	2634	2601	2573	2563	2539	2517	2498	2480	2463	2460	2446	2432	2420	2408	2397
	PAF Base Steel ≥ .25"	2395	2377	2360	2362	2348	2336	2324	2314	2304	2308	2299	2291	2283	2277	2270
	PAF Base Steel ≥ 0.125"	2377	2360	2344	2347	2334	2322	2311	2301	2292	2296	2288	2280	2273	2267	2260
	#12 Screw Base Steel ≥ .0385"	2362	2345	2331	2334	2321	2310	2300	2290	2282	2286	2278	2271	2264	2258	2252
	Concrete + Deck =	45.6 psf			I_{cr} = 110.8 in⁴/ft		ASD		M_{no}/Ω= 51.1 kip-in/ft			V_n/Ω = 3.89 kip/ft				
	$(I_{cr}+I_u)/2$ =	167.9 in⁴/ft			I_u = 225.1 in⁴/ft		LRFD		ϕM_{no}= 78.1 kip-in/ft			ϕV_n = 6.51 kip/ft				

All Gages	LRFD - Available Diaphragm Shear Capacity, ϕS_n (plf / ft) for all vertical load spans, WWF Size or Area of Steel per foot width				
3/4" Welded Shear Studs	6x6 W1.4xW1.4 A_s = 0.028 in²/ft	6x6 W2.9xW2.9 A_s = 0.058 in²/ft	6x6 W4.0xW4.0 A_s = 0.080 in²/ft	4x4 W4xW4 A_s = 0.120 in²/ft	4x4 W6xW6 A_s = 0.180 in²/ft
12 in o.c.	n/a	4990	5980	7780	10480
24 in o.c.	n/a	4990	5980	7750	7750
36 in o.c.	n/a	4990	5170	5170	5170

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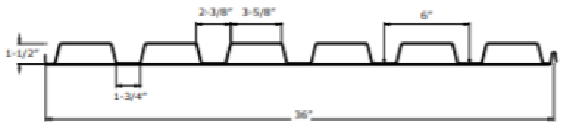
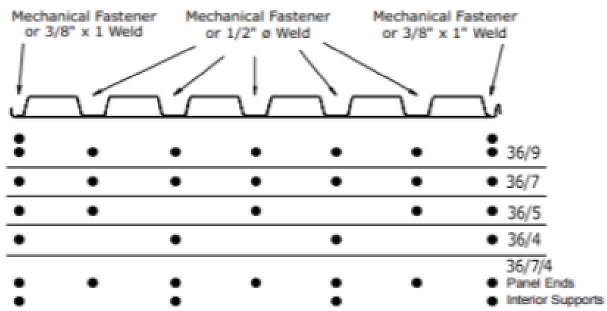
2.2 **DGBF-36 & BF-36**

BF-36



Attachment Patterns



Note: Weld sizes are effective not visible. Refer to AISI S100-2016 or AWS D1.3 for additional welding requirements.

Panel Properties

Gage	Weight	Base Metal Thickness	Yield Strength	Tensile Strength	Gross Section Properties: Area	Moment of Inertia	Distance to N.A. from Bottom	Section Modulus	Radius of Gyration
	w psf	t in	F_y ksi	F_u ksi	A_g in²/ft	I_g in⁴/ft	y_b in	S_g in³/ft	r in
20/20	3.54	0.0359/0.036	40	55	1.047	0.460	0.58	0.462	0.663
20/18	4.01	0.0359/0.047	40	55	1.190	0.503	0.52	0.472	0.650
20/16	4.68	0.0359/0.059	40	55	1.330	0.535	0.48	0.479	0.634
18/20	4.35	0.0478/0.036	40	55	1.231	0.564	0.65	0.601	0.677
18/18	4.83	0.0478/0.047	40	55	1.370	0.614	0.59	0.613	0.670
18/16	5.35	0.0478/0.059	40	55	1.521	0.661	0.55	0.624	0.659
16/20	5.03	0.0598/0.036	40	55	1.423	0.661	0.70	0.736	0.682
16/18	5.51	0.0598/0.047	40	55	1.562	0.721	0.65	0.752	0.679
16/16	6.03	0.0598/0.059	40	55	1.713	0.777	0.60	0.767	0.674

Gage	Effective Section Modulus for Bending at F_y: Area	Section Modulus	Distance to N.A. from Bottom	Section Modulus	Distance to N.A. from Bottom	Effective Moment of Inertia for Deflection at Service Load: Moment of Inertia	Moment of Inertia	Uniform Load Only $I_d = (2I_e+I_g)/3$	
	A_e+ in²/ft	S_e+ in³/ft	y_b in	S_e- in³/ft	y_b in	I_e+ in⁴/ft	I_e- in⁴/ft	I+ in⁴/ft	I- in⁴/ft
20/20	0.691	0.288	0.44	0.442	0.71	0.370	0.402	0.401	0.421
20/18	0.797	0.294	0.39	0.456	0.63	0.401	0.462	0.435	0.475
20/16	0.914	0.299	0.36	0.468	0.55	0.423	0.517	0.461	0.523
18/20	0.906	0.433	0.54	0.573	0.76	0.508	0.496	0.526	0.519
18/18	1.016	0.443	0.50	0.590	0.70	0.550	0.560	0.572	0.578
18/16	1.141	0.451	0.46	0.608	0.63	0.590	0.632	0.613	0.642
16/20	1.141	0.596	0.63	0.701	0.80	0.639	0.592	0.646	0.615
16/18	1.252	0.610	0.58	0.723	0.74	0.695	0.660	0.704	0.681
16/16	1.377	0.622	0.54	0.744	0.68	0.749	0.741	0.758	0.753

Reactions at Supports (plf) Based on Web Crippling

Gage	Condition	Bearing Length of Webs — Allowable (R_n/Ω): 1"	1.5"	2"	3"	Factored (ΦR_n): 1"	1.5"	2"	3"
22	End	586	664	730	840	897	1016	1117	1285
	Interior	934	1038	1126	1273	1390	1544	1675	1894
20	End	822	927	1016	1164	1258	1418	1554	1781
	Interior	1320	1461	1579	1778	1964	2173	2349	2644
18	End	1393	1561	1701	1938	2132	2388	2603	2965
	Interior	2268	2491	2679	2994	3374	3705	3985	4454
16	End	2106	2345	2547	2885	3222	3588	3897	4415
	Interior	3462	3781	4050	4501	5150	5624	6065	6696

Web Crippling Constraints h=1.32" r=0.125" θ=78.3°

Appendix D:

Water Resources Calculations Package

Table D-1: Baseline potable water demand in the residential space using GBI's Green Globes consumption calculator.

BASELINE WATER USE ANALYSIS FOR MULTI-FAMILY RESIDENTIAL			TOTAL BLDG SQUARE FOOTAGE	
			292,563	
Avg. size of residential units	1000		290	No. of units
Occupancy (persons/unit)		2	580	No. of persons/unit
Flush fixtures	(flushes per day/person)	(gallons per flush)	WATER USE (GAL PER YEAR)	
Toilets-Males & Females	5	1.6	1,693,600	
Flow fittings	(uses per day/person)	(gallons per use)		
Residential lavatory faucets	8	1.25	2,117,000	
Residential showerheads	1	15	3,175,500	
Resid. kitchen sink faucets	4	7.5	6,351,000	
Residential Appliances	(U.S. EPA cycles per yr)	(gallons/yr per unit)		
Clothes Washer	392	11760	3,410,400	
Dishwasher	215	1720	498,800	
SUB-TOTAL-PLUMBING & APPLIANCES		Gallons/yr	17,246,300	
		Acre-feet/yr	52.92	
		Acre-feet/yr/unit	0.18	
Other Systems				
Comfort systems (HVAC)				
Landscape irrigation				
		TOTAL WATER USE - BASELINE	17,246,300	
ASSUMPTIONS (from "input" tab)				
Shower use (minutes)	6			
Baseline shower flow rate (gpm)	2.5			
Baseline water factor (clothes washer)	10			
Cubic ft (clothes washer)	3			
Baseline water factor (dishwasher)	8			
Kitchen faucet use (min)	3			
Baseline kitchen faucet flow rate (gpm)	2.5			
Baseline lav faucet flow rate (gpm)	2.5			
Lavatory faucet use (min)	0.5			

Table D-2: Reduced potable water demand in the residential space using GBI's Green Globes consumption calculator.

WATER USE ANALYSIS FOR MULTI-FAMILY RESIDENTIAL PROJECT			TOTAL BUILDING SQUARE FOOTAGE		
			292,563		
Avg size of residential units (sf)	1000		293	No. of units	
Occupancy (persons/unit)		2	585	No. of persons	
Flush fixtures	(flushes per day/person)	(WATERSENSE max gallons per flush)	WATER USE (GAL PER YEAR)		
Toilets-Males & Females	5	0.8	854,284		
Flow fittings	(uses per day/person)	(gallons per use)			
Residential lavatory faucets	8	0.9	1,537,711		
Residential showerheads	1	10.8	2,306,567		
Resid. kitchen sink faucets	4	5.25	4,484,991		
Residential Appliances	cycles per yr)	(gallons/yr per unit)			**COMPARISON WITH BASELINE**
Clothes Washer	392	7056	2,064,325		
Dishwasher	215	1247	364,826		(gallons per year)
				Baseline Water Use	17,246,300
SUB-TOTAL-PLUMBING & APPLIANC		Gallons/yr	11,612,703	Project Water Use	11,612,703
		Acre-feet/yr	35.63	Percent Reduction	**32.7%**
		Acre-feet/yr/unit	0.12		
Other Systems					
Comfort systems (HVAC)					
Landscape irrigation					
		TOTAL WATER USE - PROJECT	11,612,703		
OTHER ASSUMPTIONS:					
Shower use (minutes)	6				
Shower flow rate (gpm)	1.8				
Water factor (clothes washer)	6				
Cubic ft (clothes washer)	3				
Water use (dishwasher)	5.8				
Kitchen faucet use (min)	3				
Kitchen faucet flow rate (gpm)	1.75				
Lavatory faucet flow rate (gpm)	1.8				
Lavatory faucet use (min)	0.5				

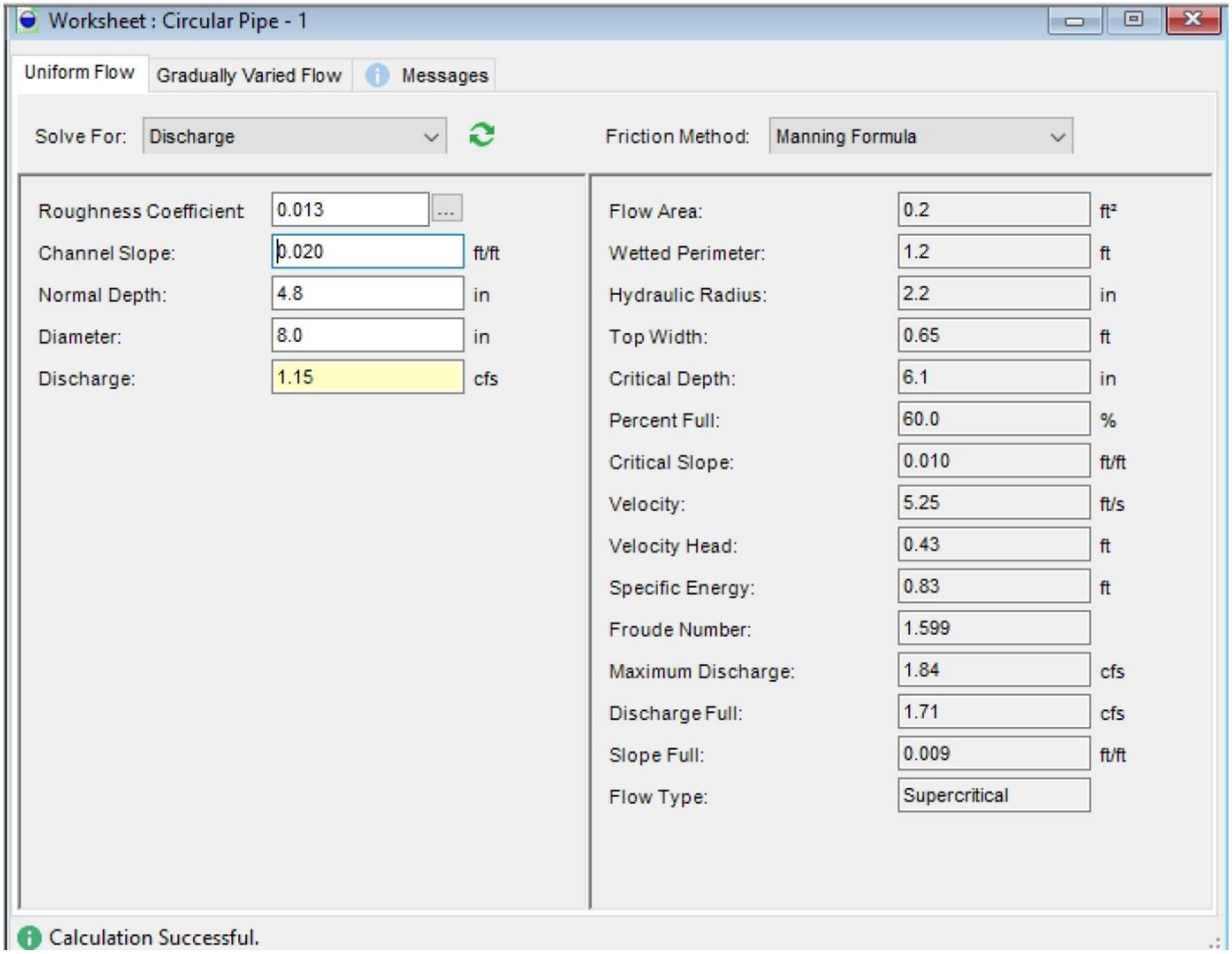


Figure D-1: Screen capture of the calculations performed in Bentley FlowMaster for the sanitary sewer pipes.

Appendix E:

Stormwater Management Calculations Package

Inlet A
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Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	6.0 in
Discharge	0.21 cfs

Results

Normal Depth	2.6 in
Flow Area	0.1 ft²
Wetted Perimeter	0.7 ft
Hydraulic Radius	1.3 in
Top Width	0.49 ft
Critical Depth	2.8 in
Percent Full	42.6 %
Critical Slope	0.008 ft/ft
Velocity	2.66 ft/s
Velocity Head	0.11 ft
Specific Energy	0.32 ft
Froude Number	1.167
Maximum Discharge	0.60 cfs
Discharge Full	0.56 cfs
Slope Full	0.001 ft/ft
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	42.6 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.6 in
Critical Depth	2.8 in
Channel Slope	0.010 ft/ft
Critical Slope	0.008 ft/ft

Inlet B
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Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	24.0 in
Discharge	10.23 cfs

Results

Normal Depth	11.3 in
Flow Area	1.5 ft²
Wetted Perimeter	3.0 ft
Hydraulic Radius	5.8 in
Top Width	2.00 ft
Critical Depth	13.7 in
Percent Full	47.1 %
Critical Slope	0.005 ft/ft
Velocity	7.02 ft/s
Velocity Head	0.77 ft
Specific Energy	1.71 ft
Froude Number	1.449
Maximum Discharge	24.33 cfs
Discharge Full	22.62 cfs
Slope Full	0.002 ft/ft
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	47.1 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	11.3 in
Critical Depth	13.7 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft

Inlet C

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Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	24.0 in
Discharge	9.65 cfs

Results	
Normal Depth	10.9 in
Flow Area	1.4 ft²
Wetted Perimeter	3.0 ft
Hydraulic Radius	5.6 in
Top Width	1.99 ft
Critical Depth	13.3 in
Percent Full	45.6 %
Critical Slope	0.005 ft/ft
Velocity	6.91 ft/s
Velocity Head	0.74 ft
Specific Energy	1.66 ft
Froude Number	1.456
Maximum Discharge	24.33 cfs
Discharge Full	22.62 cfs
Slope Full	0.002 ft/ft
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	45.6 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	10.9 in
Critical Depth	13.3 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft

Inlet E
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Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	8.0 in
Discharge	0.46 cfs

Results

Normal Depth	3.4 in
Flow Area	0.1 ft²
Wetted Perimeter	1.0 ft
Hydraulic Radius	1.8 in
Top Width	0.66 ft
Critical Depth	3.8 in
Percent Full	42.9 %
Critical Slope	0.007 ft/ft
Velocity	3.23 ft/s
Velocity Head	0.16 ft
Specific Energy	0.45 ft
Froude Number	1.224
Maximum Discharge	1.30 cfs
Discharge Full	1.21 cfs
Slope Full	0.001 ft/ft
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	42.9 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	3.4 in
Critical Depth	3.8 in
Channel Slope	0.010 ft/ft
Critical Slope	0.007 ft/ft

Inlet G
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Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	24.0 in
Discharge	11.88 cfs

Results

Normal Depth	12.4 in
Flow Area	1.6 ft²
Wetted Perimeter	3.2 ft
Hydraulic Radius	6.1 in
Top Width	2.00 ft
Critical Depth	14.9 in
Percent Full	51.5 %
Critical Slope	0.006 ft/ft
Velocity	7.29 ft/s
Velocity Head	0.83 ft
Specific Energy	1.85 ft
Froude Number	1.423
Maximum Discharge	24.33 cfs
Discharge Full	22.62 cfs
Slope Full	0.003 ft/ft
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	51.5 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	12.4 in
Critical Depth	14.9 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

Inlet I
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Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	8.0 in
Discharge	0.66 cfs

Results	
Normal Depth	4.2 in
Flow Area	0.2 ft²
Wetted Perimeter	1.1 ft
Hydraulic Radius	2.1 in
Top Width	0.67 ft
Critical Depth	4.6 in
Percent Full	52.6 %
Critical Slope	0.008 ft/ft
Velocity	3.54 ft/s
Velocity Head	0.19 ft
Specific Energy	0.54 ft
Froude Number	1.179
Maximum Discharge	1.30 cfs
Discharge Full	1.21 cfs
Slope Full	0.003 ft/ft
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	52.6 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	4.2 in
Critical Depth	4.6 in
Channel Slope	0.010 ft/ft
Critical Slope	0.008 ft/ft

Inlet J
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Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	5.0 in
Discharge	0.16 cfs

Results	
Normal Depth	2.4 in
Flow Area	0.1 ft²
Wetted Perimeter	0.6 ft
Hydraulic Radius	1.2 in
Top Width	0.42 ft
Critical Depth	2.5 in
Percent Full	47.2 %
Critical Slope	0.008 ft/ft
Velocity	2.47 ft/s
Velocity Head	0.09 ft
Specific Energy	0.29 ft
Froude Number	1.116
Maximum Discharge	0.37 cfs
Discharge Full	0.35 cfs
Slope Full	0.002 ft/ft
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	47.2 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.4 in
Critical Depth	2.5 in
Channel Slope	0.010 ft/ft
Critical Slope	0.008 ft/ft

Inlet L
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Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	20.0 in
Discharge	8.52 cfs

Results	
Normal Depth	11.3 in
Flow Area	1.3 ft²
Wetted Perimeter	2.8 ft
Hydraulic Radius	5.4 in
Top Width	1.65 ft
Critical Depth	13.2 in
Percent Full	56.6 %
Critical Slope	0.006 ft/ft
Velocity	6.70 ft/s
Velocity Head	0.70 ft
Specific Energy	1.64 ft
Froude Number	1.345
Maximum Discharge	14.96 cfs
Discharge Full	13.91 cfs
Slope Full	0.004 ft/ft
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	56.6 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	11.3 in
Critical Depth	13.2 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

Inlet K
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Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Diameter	20.0 in
Discharge	8.42 cfs

Results	
Normal Depth	11.2 in
Flow Area	1.3 ft²
Wetted Perimeter	2.8 ft
Hydraulic Radius	5.4 in
Top Width	1.65 ft
Critical Depth	13.1 in
Percent Full	56.1 %
Critical Slope	0.006 ft/ft
Velocity	6.68 ft/s
Velocity Head	0.69 ft
Specific Energy	1.63 ft
Froude Number	1.348
Maximum Discharge	14.96 cfs
Discharge Full	13.91 cfs
Slope Full	0.004 ft/ft
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	56.1 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	11.2 in
Critical Depth	13.1 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

North Underdrain

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Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013
Channel Slope	0.005 ft/ft
Diameter	6.0 in
Discharge	0.37 cfs

Results

Normal Depth	4.5 in
Flow Area	0.2 ft²
Wetted Perimeter	1.1 ft
Hydraulic Radius	1.8 in
Top Width	0.43 ft
Critical Depth	3.7 in
Percent Full	75.6 %
Critical Slope	0.009 ft/ft
Velocity	2.29 ft/s
Velocity Head	0.08 ft
Specific Energy	0.46 ft
Froude Number	0.663
Maximum Discharge	0.43 cfs
Discharge Full	0.40 cfs
Slope Full	0.004 ft/ft
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	56.1 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	4.5 in
Critical Depth	3.7 in
Channel Slope	0.005 ft/ft
Critical Slope	0.009 ft/ft

West Underdrain
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Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013
Channel Slope	0.005 ft/ft
Diameter	4.0 in
Discharge	0.07 cfs

Results

Normal Depth	2.0 in
Flow Area	0.0 ft²
Wetted Perimeter	0.5 ft
Hydraulic Radius	1.0 in
Top Width	0.33 ft
Critical Depth	1.7 in
Percent Full	49.4 %
Critical Slope	0.008 ft/ft
Velocity	1.54 ft/s
Velocity Head	0.04 ft
Specific Energy	0.20 ft
Froude Number	0.754
Maximum Discharge	0.14 cfs
Discharge Full	0.13 cfs
Slope Full	0.001 ft/ft
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	56.1 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.0 in
Critical Depth	1.7 in
Channel Slope	0.005 ft/ft
Critical Slope	0.008 ft/ft

North Bioretention Outflow Pipe
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Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.005 ft/ft
Diameter	8.0 in
Discharge	0.50 cfs

Results	
Normal Depth	4.4 in
Flow Area	0.2 ft²
Wetted Perimeter	1.1 ft
Hydraulic Radius	2.1 in
Top Width	0.66 ft
Critical Depth	4.0 in
Percent Full	54.7 %
Critical Slope	0.007 ft/ft
Velocity	2.54 ft/s
Velocity Head	0.10 ft
Specific Energy	0.46 ft
Froude Number	0.825
Maximum Discharge	0.92 cfs
Discharge Full	0.85 cfs
Slope Full	0.002 ft/ft
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	45.6 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	4.4 in
Critical Depth	4.0 in
Channel Slope	0.005 ft/ft
Critical Slope	0.007 ft/ft

West Bioretention Outflow Pipe
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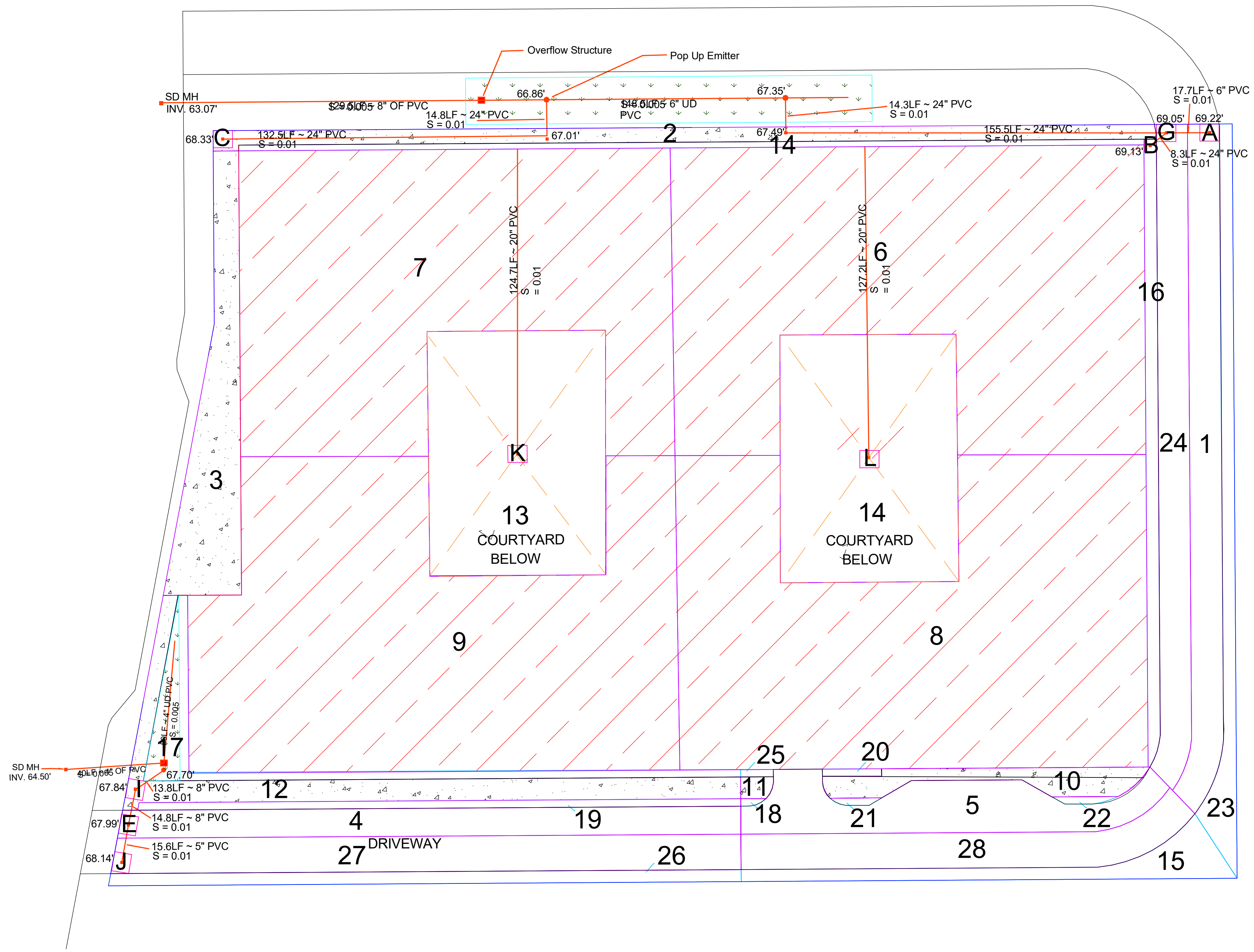
Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.005 ft/ft
Diameter	4.0 in
Discharge	0.09 cfs

Results	
Normal Depth	2.3 in
Flow Area	0.1 ft^2
Wetted Perimeter	0.6 ft
Hydraulic Radius	1.1 in
Top Width	0.33 ft
Critical Depth	2.0 in
Percent Full	58.5 %
Critical Slope	0.009 ft/ft
Velocity	1.64 ft/s
Velocity Head	0.04 ft
Specific Energy	0.24 ft
Froude Number	0.719
Maximum Discharge	0.14 cfs
Discharge Full	0.13 cfs
Slope Full	0.002 ft/ft
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	45.6 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.3 in
Critical Depth	2.0 in
Channel Slope	0.005 ft/ft
Critical Slope	0.009 ft/ft



RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

FINAL BIORETENTION LAYOUT

Project number	20352
Date	April 25, 2020
Drawn by	RH
Checked by	LD

E.14

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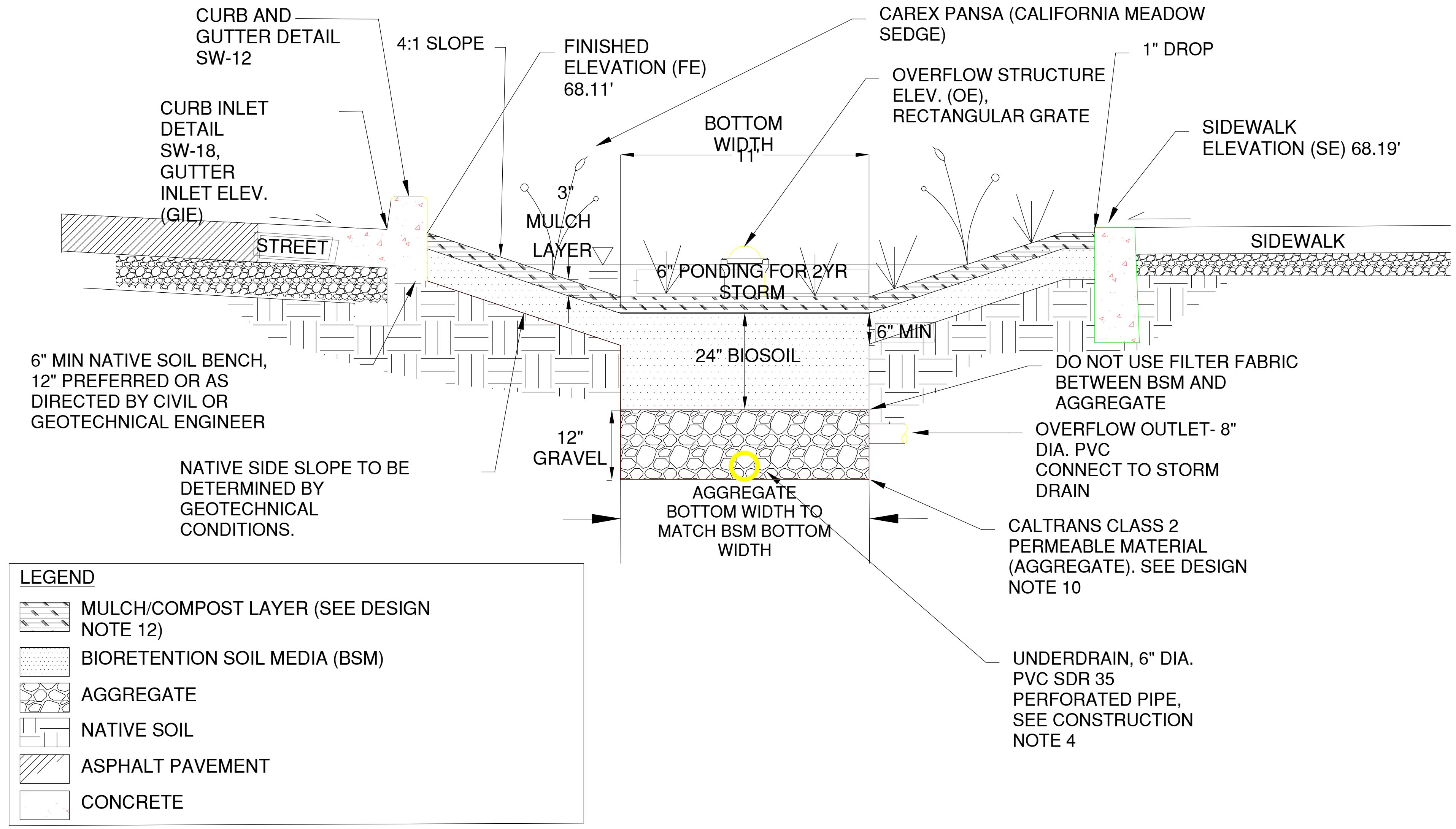

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

NORTH BIORETENTION CROSS-SECTION

Project number	20352
Date	April 25, 2020
Drawn by	RH
Checked by	LD

E.15

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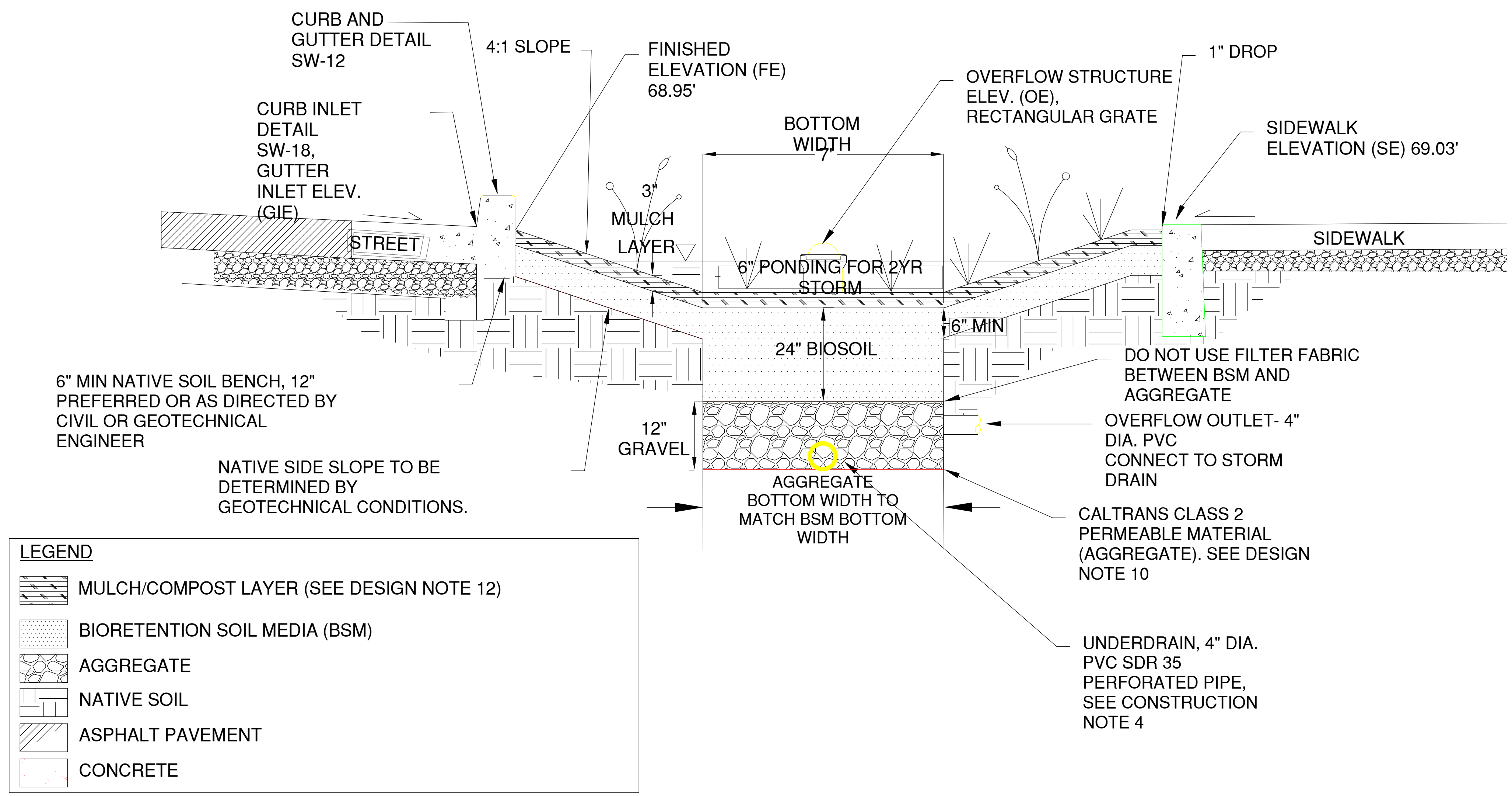

RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

WEST BIORETENTION CROSS-SECTION

Project number	20352	E.16
Date	April 25, 2020	
Drawn by	RH	
Checked by	LD	

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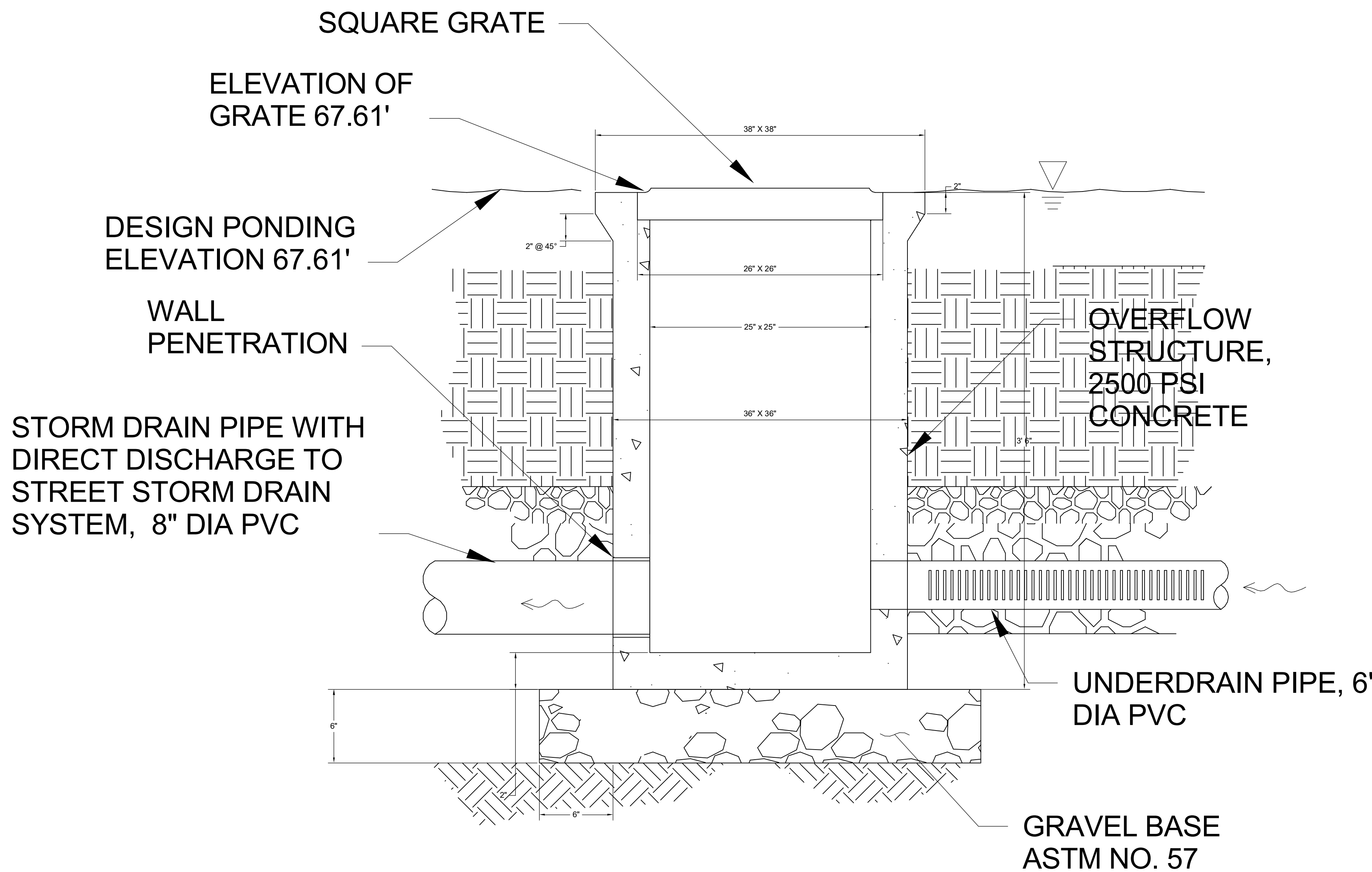


RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

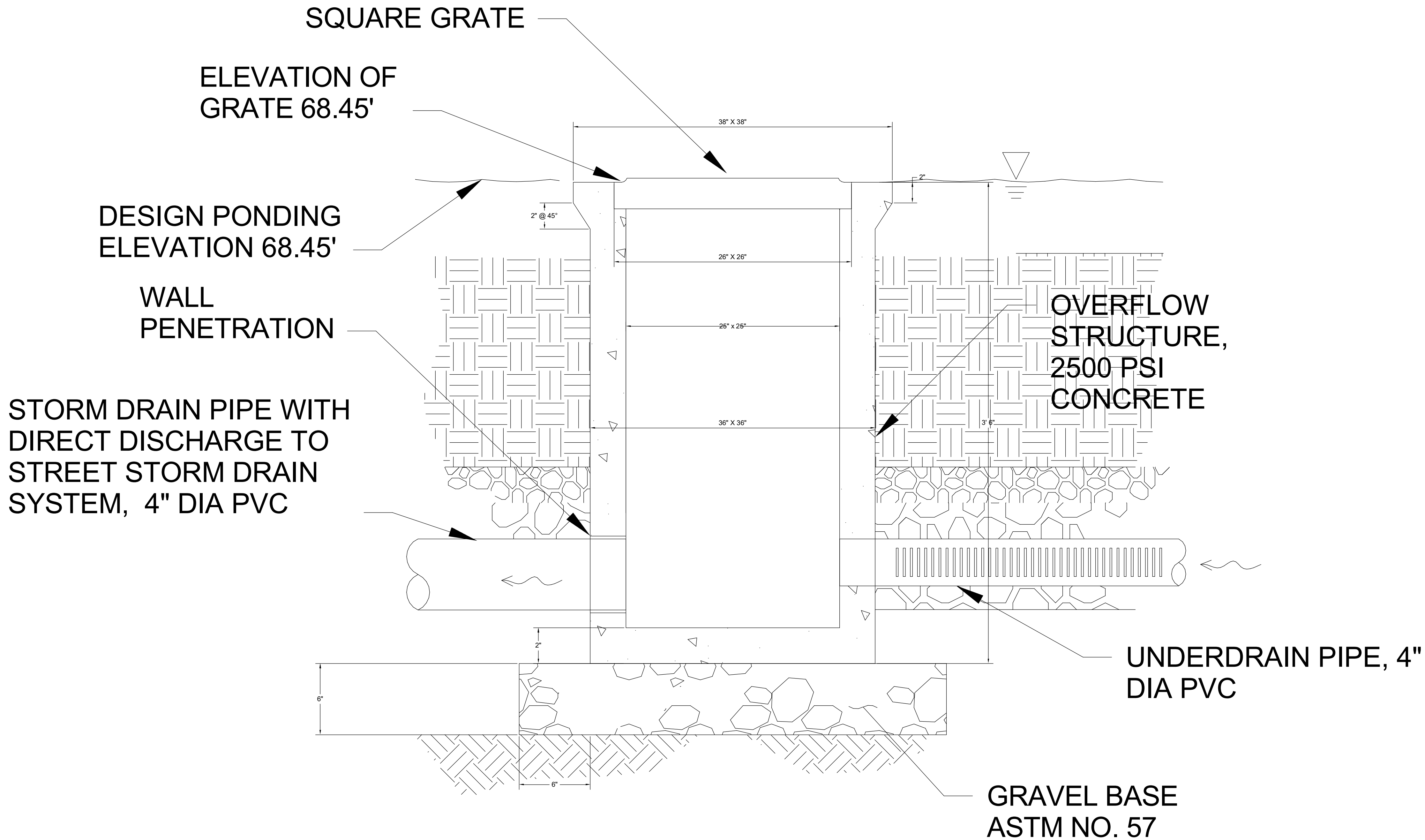
No.	Description	Date

NORTH OVERFLOW STRUCTURE

Project number	20352
Date	April 25, 2020
Drawn by	RH
Checked by	Checker

E.17

6/9/20 1:58:27 PM



RADS CONSTRUCTION, LLC.

STUDIO T SQUARE

Santa Clara University

SCU's Faculty & Staff Housing Development
1200 Campbell Avenue
San Jose, CA 95126

No.	Description	Date

WEST OVERFLOW STRUCTURE

Project number	20352
Date	April 25, 2020
Drawn by	RH
Checked by	LD

E.18

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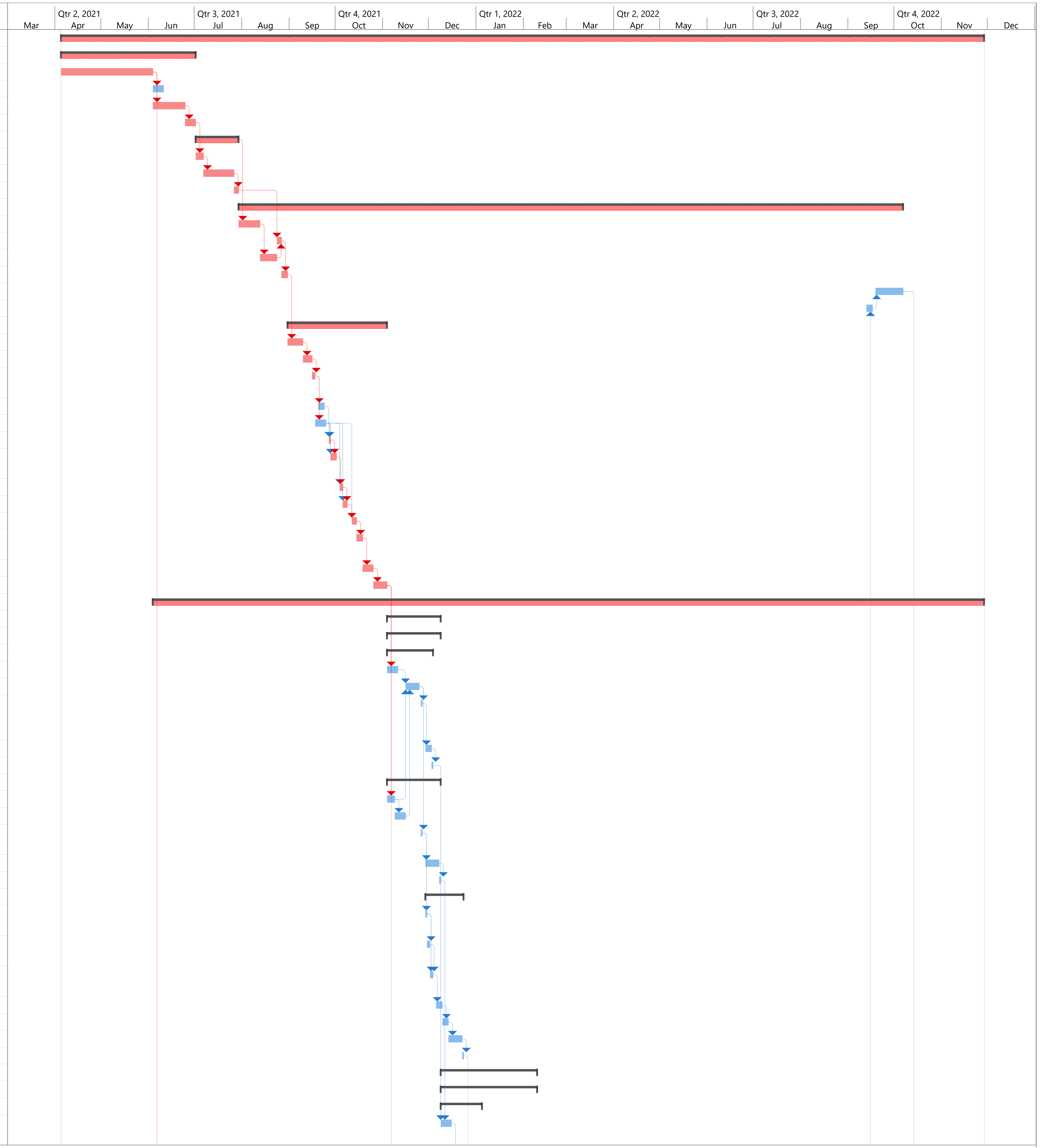
Appendix F:

Construction Management Package

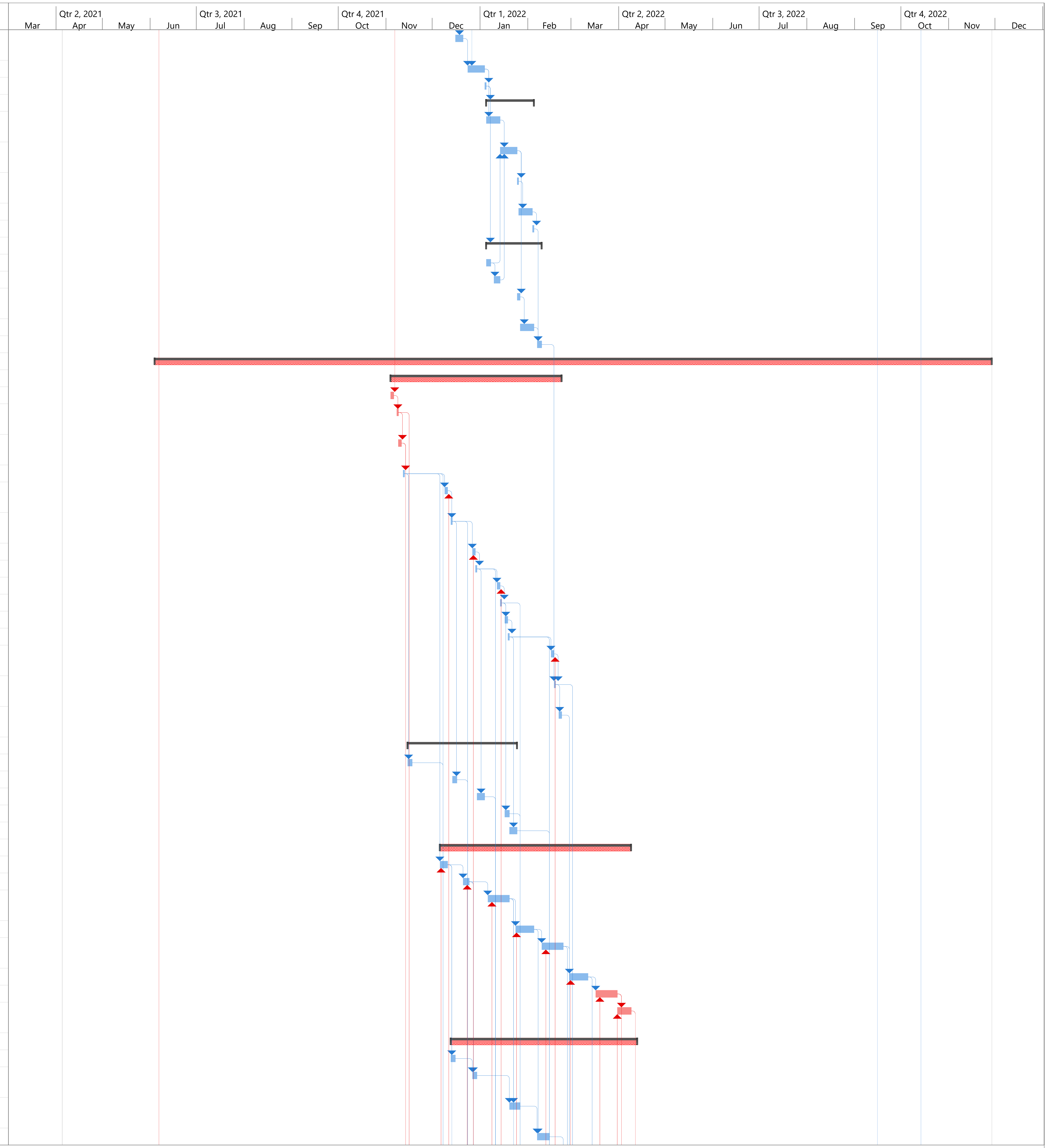
ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**1200 Campbell**	**426 days**	**Mon 4/5/21**	**Mon 11/28/2**	
2		**Preconstruction Activity**	**63 days**	**Mon 4/5/21**	**Thu 7/1/21**	
3		Detailed Design	60 edays	Mon 4/5/21	Fri 6/4/21	
4		Archaeology Dig	5 days	Fri 6/4/21	Thu 6/10/21	3
5		Permitting	21 edays	Fri 6/4/21	Fri 6/25/21	3
6		Site Mobilization	5 days	Fri 6/25/21	Thu 7/1/21	5
7		**Site Utlities**	**20 days**	**Fri 7/2/21**	**Thu 7/29/21**	
8		Exisitng Site Markings	3 days	Fri 7/2/21	Tue 7/6/21	6
9		Install Utility Lines	14 days	Wed 7/7/21	Mon 7/26/21	8
10		Tie In to Main	3 days	Tue 7/27/21	Thu 7/29/21	9
11		**Site Work**	**306 days**	**Fri 7/30/21**	**Thu 10/6/22**	
12		Demolition	10 days	Fri 7/30/21	Thu 8/12/21	7
13		Rough Grading	3 days	Tue 8/24/21	Thu 8/26/21	14,10
14		Excavation	7 days	Fri 8/13/21	Mon 8/23/21	12
15		Backfill	2 days	Fri 8/27/21	Mon 8/30/21	13
16		Landscaping	14 days	Mon 9/19/22	Thu 10/6/22	17
17		Paving	4 days	Tue 9/13/22	Fri 9/16/22	208
18		**Foundation**	**45 days**	**Tue 8/31/21**	**Wed 11/3/21**	
19		Rebar Placement	7 days	Tue 8/31/21	Thu 9/9/21	15
20		Foundation Formwork Install	4 days	Fri 9/10/21	Wed 9/15/21	19
21		4' Mat Foundation concrete placement	2 days	Thu 9/16/21	Fri 9/17/21	20
22		Structural Footings	4 days	Mon 9/20/21	Thu 9/23/21	21
23		Structural Cure	7 edays	Fri 9/17/21	Fri 9/24/21	21
24		Foundation Formwork Remove	1 day	Mon 9/27/21	Mon 9/27/21	23,22
25		Waterproof Membrane	4 days	Tue 9/28/21	Fri 10/1/21	23,24
26		Protection Board	2 days	Mon 10/4/21	Tue 10/5/21	23,25
27		Insulation	3 days	Wed 10/6/21	Fri 10/8/21	23,26
28		Drainage Layer	3 days	Tue 10/12/21	Thu 10/14/21	23,27
29		Steel Embeds for Steel Columns	2 days	Fri 10/15/21	Mon 10/18/21	28
30		Topping Slab	5 days	Tue 10/19/21	Mon 10/25/21	29
31		Topping Slab Cure	7 days	Tue 10/26/21	Wed 11/3/21	30
32		**Shell**	**383 days**	**Fri 6/4/21**	**Mon 11/28/2**	
33		**Level 1**	**23 days**	**Thu 11/4/21**	**Wed 12/8/21**	
34		**Concrete Garage**	**23 days**	**Thu 11/4/21**	**Wed 12/8/21**	
35		**Concrete Columns**	**20 days**	**Thu 11/4/21**	**Fri 12/3/21**	
36		Column Rebar	5 days	Thu 11/4/21	Wed 11/10/21	31
37		Column Forms	7 days	Tue 11/16/21	Wed 11/24/21	36,42,43
38		Pour Columns and Finsh Columns	1 day	Fri 11/26/21	Fri 11/26/21	37
39		Cure Time	4 days	Mon 11/29/21	Thu 12/2/21	38
40		Remove Column Formwork	1 day	Fri 12/3/21	Fri 12/3/21	39
41		**Concrete Shear Walls**	**23 days**	**Thu 11/4/21**	**Wed 12/8/21**	
42		Wall Rebar	3 days	Thu 11/4/21	Mon 11/8/21	31
43		Wall Forms	4 days	Tue 11/9/21	Mon 11/15/21	42
44		Pour Columns and Finsh Walls	1 day	Fri 11/26/21	Fri 11/26/21	37
45		Cure Time	7 days	Mon 11/29/21	Tue 12/7/21	44
46		Remove Wall Formwork	1 day	Wed 12/8/21	Wed 12/8/21	45
47		**Open Space Mixed Use**	**19 days**	**Mon 11/29/21**	**Thu 12/23/21**	
48		Erect Steel in Steel Embeds	1 day	Mon 11/29/21	Mon 11/29/21	44
49		Erect Metal Decking	2 days	Tue 11/30/21	Wed 12/1/21	48
50		Place Deck Rebar	2 days	Thu 12/2/21	Fri 12/3/21	48,49
51		Deck Framework	4 days	Mon 12/6/21	Thu 12/9/21	50
52		Pour Concrete Deck	2 days	Fri 12/10/21	Mon 12/13/21	51
53		Concrete Cure	7 days	Tue 12/14/21	Wed 12/22/21	52
54		Remove Deck Formwork	1 day	Thu 12/23/21	Thu 12/23/21	53
55		**Level 2**	**45 days**	**Thu 12/9/21**	**Wed 2/9/22**	
56		**Concrete Garage**	**45 days**	**Thu 12/9/21**	**Wed 2/9/22**	
57		**Concrete Deck**	**19 days**	**Thu 12/9/21**	**Tue 1/4/22**	
58		Concrete Deck Forms	5 days	Thu 12/9/21	Wed 12/15/21	40,46



Project: 050720r1Construction
Date: Wed 6/3/20

Critical Activity	Summary	Inactive Summary	Manual Summary	External Milestone	Progress
Task	Project Summary	Manual Task	Start-only	Deadline	Manual Progress
Split	Inactive Task	Duration-only	Finish-only	Critical	
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Critical Split	

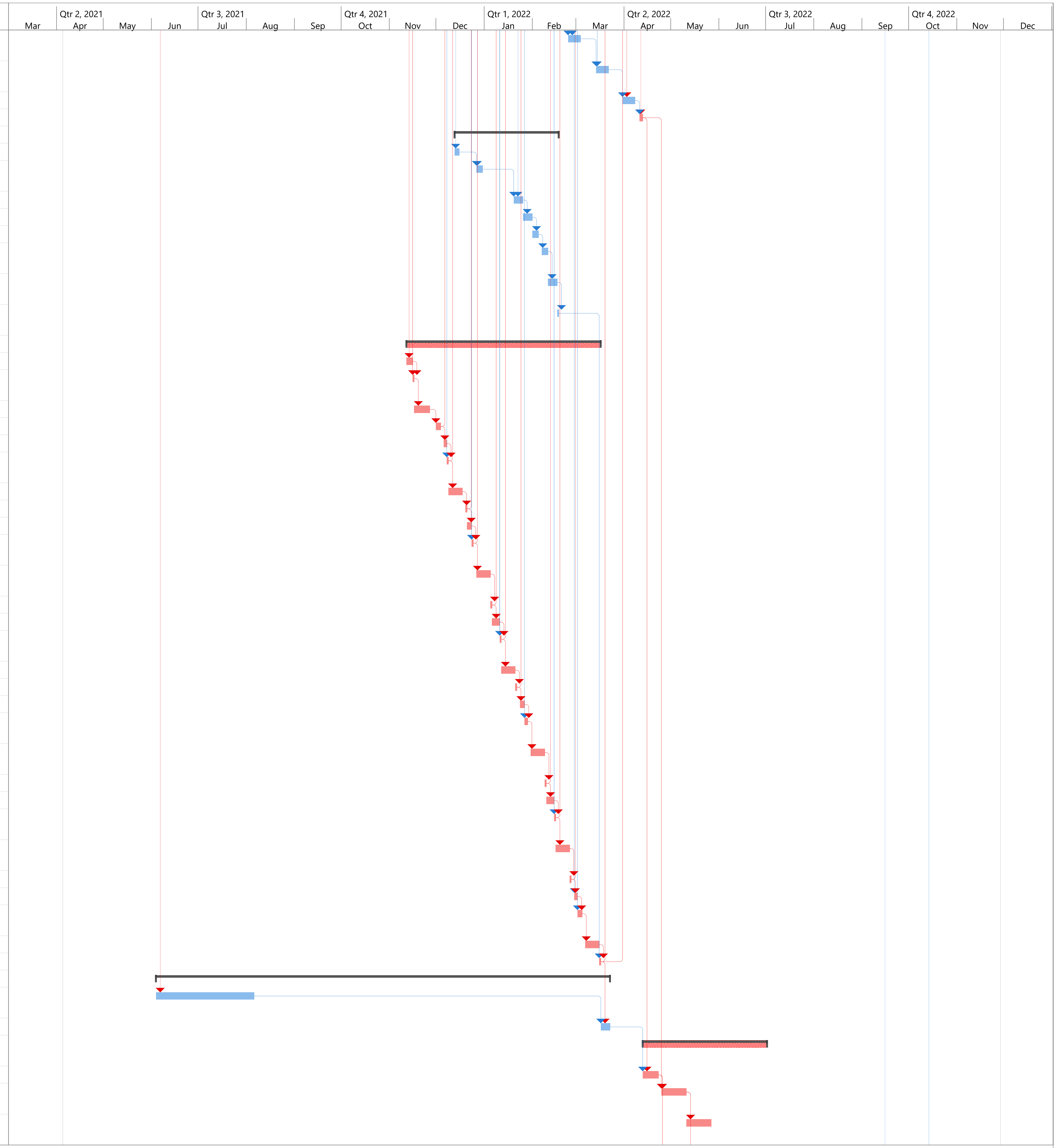
ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
59		Concrete Pour	3 days	Thu 12/16/21	Mon 12/20/21	58
60		Concrete Cure	7 days	Fri 12/24/21	Mon 1/3/22	59,54
61		Remove Formwork	1 day	Tue 1/4/22	Tue 1/4/22	60
62		**Concrete Columns**	**23 days**	**Wed 1/5/22**	**Fri 2/4/22**	**61**
63		Column Rebar	7 days	Wed 1/5/22	Thu 1/13/22	60
64		Column Forms	7 days	Fri 1/14/22	Mon 1/24/22	63,69,70
65		Pour Columns and Finsh Columns	1 day	Tue 1/25/22	Tue 1/25/22	64
66		Cure Time	7 days	Wed 1/26/22	Thu 2/3/22	65
67		Remove Formwork	1 day	Fri 2/4/22	Fri 2/4/22	66
68		**Concrete Shear Walls**	**26 days**	**Wed 1/5/22**	**Wed 2/9/22**	**61**
69		Wall Rebar	3 days	Wed 1/5/22	Fri 1/7/22	
70		Wall Forms	4 days	Mon 1/10/22	Thu 1/13/22	69
71		Pour Columns and Finsh Walls	2 days	Tue 1/25/22	Wed 1/26/22	64
72		Cure Time	7 days	Thu 1/27/22	Fri 2/4/22	71
73		Install L2 Stair	3 days	Mon 2/7/22	Wed 2/9/22	72,67
74		**Residential**	**383 days**	**Fri 6/4/21**	**Mon 11/28/2**	
75		**Steel Erect**	**77 days**	**Thu 11/4/21**	**Tue 2/22/22**	
76		Level 1	2 days	Thu 11/4/21	Fri 11/5/21	31
77		L2 Deck	1 day	Mon 11/8/21	Mon 11/8/21	76
78		Level 2	2 days	Tue 11/9/21	Wed 11/10/21	77
79		L3 Deck	1 day	Fri 11/12/21	Fri 11/12/21	78
80		Level 3	2 days	Thu 12/9/21	Fri 12/10/21	79,130
81		L4 Deck	1 day	Mon 12/13/21	Mon 12/13/21	80
82		Level 4	2 days	Mon 12/27/2	Tue 12/28/21	81,134
83		L5 Deck	1 day	Wed 12/29/2	Wed 12/29/2	82
84		Level 5	2 days	Wed 1/12/22	Thu 1/13/22	83,138
85		L6 Deck	1 day	Fri 1/14/22	Fri 1/14/22	84
86		Level 6	2 days	Mon 1/17/22	Tue 1/18/22	85
87		L7 Deck	1 day	Wed 1/19/22	Wed 1/19/22	86
88		Level 7	2 days	Wed 2/16/22	Thu 2/17/22	87,146
89		Roof Deck	1 day	Fri 2/18/22	Fri 2/18/22	88,73
90		Top of Parapet steel	2 days	Mon 2/21/22	Tue 2/22/22	89
91		**Stairs**	**50 days**	**Mon 11/15/2**	**Mon 1/24/22**	
92		Level 3 Stairs	3 days	Mon 11/15/2	Wed 11/17/2	79
93		Level 4 Stairs	3 days	Tue 12/14/21	Thu 12/16/21	81
94		Level 5 Stairs	3 days	Thu 12/30/21	Mon 1/3/22	83
95		Level 6 Stairs	3 days	Mon 1/17/22	Wed 1/19/22	85
96		Level 7 Stairs	3 days	Thu 1/20/22	Mon 1/24/22	87
97		**MEP Rough In**	**90 days**	**Mon 12/6/21**	**Fri 4/8/22**	
98		Level 1	5 days	Mon 12/6/21	Fri 12/10/21	79,128
99		Level 2	4 days	Tue 12/21/21	Fri 12/24/21	98,132
100		Level 3	10 days	Thu 1/6/22	Wed 1/19/22	99,136
101		Level 4	10 days	Mon 1/24/22	Fri 2/4/22	100,140
102		Level 5	10 days	Thu 2/10/22	Wed 2/23/22	101,144
103		Level 6	10 days	Mon 2/28/22	Fri 3/11/22	102,148
104		Level 7	10 days	Thu 3/17/22	Wed 3/30/22	103,152
105		Roof	7 days	Thu 3/31/22	Fri 4/8/22	104,152
106		**Exterior Walls**	**87 days**	**Mon 12/13/2**	**Tue 4/12/22**	
107		Level 1	3 days	Mon 12/13/2	Wed 12/15/2	98
108		Level 2	3 days	Mon 12/27/21	Wed 12/29/21	107,99
109		Level 3	5 days	Thu 1/20/22	Wed 1/26/22	108,100
110		Level 4	6 days	Mon 2/7/22	Mon 2/14/22	109,101



Project: 050720r1Construction
Date: Wed 6/3/20

Critical Activity	Summary	Inactive Summary	Manual Summary	External Milestone	Progress
Task	Project Summary	Manual Task	Start-only	Deadline	Manual Progress
Split	Inactive Task	Duration-only	Finish-only	Critical	
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Critical Split	

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
111		Level 5	6 days	Thu 2/24/22	Thu 3/3/22	110,102
112		Level 6	6 days	Mon 3/14/22	Mon 3/21/22	111,103
113		Level 7	6 days	Thu 3/31/22	Thu 4/7/22	112,104
114		Roof	2 days	Mon 4/11/22	Tue 4/12/22	113,105
115		**Electrical Branch In**	**49 days**	**Mon 12/13/2**	**Thu 2/17/22**	
116		Level 1	3 days	Mon 12/13/2	Wed 12/15/2	98
117		Level 2	4 days	Mon 12/27/21	Thu 12/30/21	116,99
118		Level 3	4 days	Thu 1/20/22	Tue 1/25/22	117,100
119		Level 4	4 days	Wed 1/26/22	Mon 1/31/22	118
120		Level 5	4 days	Tue 2/1/22	Fri 2/4/22	119
121		Level 6	4 days	Mon 2/7/22	Thu 2/10/22	120
122		Level 7	4 days	Fri 2/11/22	Wed 2/16/22	121
123		Roof	1 day	Thu 2/17/22	Thu 2/17/22	122
124		**Concrete over Metal Deck**	**88 days**	**Fri 11/12/21**	**Wed 3/16/2**	
125		L2 Formwork	2 days	Fri 11/12/21	Mon 11/15/2	78
126		L2 Concrete Pour	1 day	Tue 11/16/21	Tue 11/16/21	77,125
127		L2 Cure Time	7 days	Wed 11/17/2	Fri 11/26/21	126
128		Remove Formwork	3 days	Wed 12/1/21	Fri 12/3/21	127FS+4 edays
129		L3 Formwork	2 days	Mon 12/6/21	Tue 12/7/21	128
130		L3 Concrete Pour	1 day	Wed 12/8/21	Wed 12/8/21	79,129,92
131		L3 Cure Time	7 days	Thu 12/9/21	Fri 12/17/21	130
132		Remove Formwork	1 day	Mon 12/20/2	Mon 12/20/2	131
133		L4 Formwork	3 days	Tue 12/21/2	Thu 12/23/2	132
134		L4 Concrete Pour	1 day	Fri 12/24/21	Fri 12/24/21	81,133,93
135		Cure Time	7 days	Mon 12/27/21	Tue 1/4/22	134
136		Remove Formwork	1 day	Wed 1/5/22	Wed 1/5/22	135
137		L5 Formwork	3 days	Thu 1/6/22	Mon 1/10/22	136
138		L5 Concrete Pour	1 day	Tue 1/11/22	Tue 1/11/22	83,137,94
139		Cure Time	7 days	Wed 1/12/22	Thu 1/20/22	138
140		Remove Formwork	1 day	Fri 1/21/22	Fri 1/21/22	139
141		L6 Formwork	3 days	Mon 1/24/22	Wed 1/26/22	140
142		L6 Concrete Pour	2 days	Thu 1/27/22	Fri 1/28/22	85,141,95
143		Cure Time	7 days	Mon 1/31/22	Tue 2/8/22	142
144		Remove Formwork	1 day	Wed 2/9/22	Wed 2/9/22	143
145		L7 Formwork	3 days	Thu 2/10/22	Mon 2/14/22	144
146		L7 Concrete Pour	1 day	Tue 2/15/22	Tue 2/15/22	87,145,96
147		Cure Time	7 days	Wed 2/16/22	Thu 2/24/22	146
148		Remove Formwork	1 day	Fri 2/25/22	Fri 2/25/22	147
149		Roof Formwork	2 days	Mon 2/28/22	Tue 3/1/22	148,90
150		Roof Concrete Pour	3 days	Wed 3/2/22	Fri 3/4/22	89,149
151		Cure Time	7 days	Mon 3/7/22	Tue 3/15/22	150
152		Remove Formwork	1 day	Wed 3/16/22	Wed 3/16/22	151,123
153		**Elevators**	**204 days**	**Fri 6/4/21**	**Tue 3/22/22**	
154		Shop Drawings and Fabrication	45 days	Fri 6/4/21	Thu 8/5/21	3
155		Install Elevators	4 days	Thu 3/17/22	Tue 3/22/22	152,154
156		**Interior Partitions - Opening Frames**	**58 days**	**Wed 4/13/22**	**Fri 7/1/22**	
157		Level 2	8 days	Wed 4/13/22	Fri 4/22/22	114,155
158		Level 3	12 days	Mon 4/25/22	Tue 5/10/22	114,157
159		Level 4	12 days	Wed 5/11/22	Thu 5/26/22	158



Project: 050720r1Construction
Date: Wed 6/3/20

Critical Activity | Summary | Inactive Summary | Manual Summary | External Milestone | Progress
Task | Project Summary | Manual Task | Start-only | Deadline | Manual Progress
Split | Inactive Task | Duration-only | Finish-only | Critical
Milestone | Inactive Milestone | Manual Summary Rollup | External Tasks | Critical Split

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
160			Level 5	12 days	Wed 5/11/22	Thu 5/26/22	158
161			Level 6	12 days	Fri 5/27/22	Mon 6/13/22	160
162			Level 7	12 days	Fri 5/27/22	Mon 6/13/22	160
163			Roof	4 days	Fri 5/27/22	Wed 6/1/22	160
164			**Doors and Windows**	**50 days**	**Mon 4/25/2**	**Fri 7/1/22**	**157**
173			**Electrical Branch In**	**66 days**	**Wed 5/4/22**	**Wed 8/3/22**	**165**
174			Level 1	4 days	Wed 5/4/22	Mon 5/9/22	165
175			Level 2	7 days	Tue 5/10/22	Wed 5/18/22	166,174
176			Level 3	7 days	Tue 5/31/22	Wed 6/8/22	167,175
177			Level 4	7 days	Thu 6/16/22	Fri 6/24/22	168,176
178			Level 5	7 days	Mon 6/27/22	Tue 7/5/22	169,177
179			Level 6	7 days	Wed 7/6/22	Thu 7/14/22	170,178
180			Level 7	7 days	Fri 7/15/22	Mon 7/25/22	171,179
181			Roof	7 days	Tue 7/26/22	Wed 8/3/22	172,180
182			**MEP Finishes**	**58 days**	**Tue 5/10/22**	**Thu 7/28/22**	
183			Level 1	14 days	Tue 5/10/22	Fri 5/27/22	174
184			Level 2	14 days	Mon 5/30/22	Thu 6/16/22	183
185			Level 3	14 days	Mon 5/30/22	Thu 6/16/22	183
186			Level 4	14 days	Fri 6/17/22	Wed 7/6/22	185
187			Level 5	14 days	Fri 6/17/22	Wed 7/6/22	185
188			Level 6	14 days	Thu 7/7/22	Tue 7/26/22	187
189			Level 7	14 days	Thu 7/7/22	Tue 7/26/22	187
190			Roof	2 days	Wed 7/27/22	Thu 7/28/22	189
191			**Interior Finishes**	**83 days**	**Thu 8/4/22**	**Mon 11/28/2**	
192			**Interior Flooring - Carpeting and Tiling**	**32 days**	**Thu 8/4/22**	**Fri 9/16/22**	
193			Level 1 Storefront	2 days	Thu 8/4/22	Fri 8/5/22	183,181,190
194			Level 2	5 days	Mon 8/8/22	Fri 8/12/22	193,184
195			Level 3	5 days	Mon 8/15/22	Fri 8/19/22	194,185
196			Level 4	5 days	Mon 8/22/22	Fri 8/26/22	195,186
197			Level 5	5 days	Mon 8/29/22	Fri 9/2/22	196,187
198			Level 6	5 days	Mon 9/5/22	Fri 9/9/22	197,188
199			Level 7	5 days	Mon 9/12/22	Fri 9/16/22	198,189
200			**Interior Paint - First Coat**	**35 days**	**Mon 8/8/22**	**Fri 9/23/22**	
201			Level 1 Storefront	5 days	Mon 8/8/22	Fri 8/12/22	193
202			Level 2	5 days	Mon 8/15/22	Fri 8/19/22	201,194
203			Level 3	5 days	Mon 8/22/22	Fri 8/26/22	202,195
204			Level 4	5 days	Mon 8/29/22	Fri 9/2/22	203,196
205			Level 5	5 days	Mon 9/5/22	Fri 9/9/22	204,197
206			Level 6	5 days	Mon 9/12/22	Fri 9/16/22	205,198
207			Level 7	5 days	Mon 9/19/22	Fri 9/23/22	206,199
208			Façade Finishes	21 days	Mon 8/15/22	Mon 9/12/22	201
209			MEP Commissioning	14 days	Mon 9/26/22	Thu 10/13/2	207
210			Punchlist Items	32 days	Fri 10/14/22	Mon 11/28/2	209,16

Project: 050720r1Construction
Date: Wed 6/3/20

Critical Activity, Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Critical, Critical Split, Progress, Manual Progress

Project Estimate Sheet

Project:						
Location:						
Construction Start Year		2021				
RSMeans Cost Data Year		2019				
Division	**Scope**	**Amount**	**City Index**	**Adjusted Amount [1]**		
1	General Requirements	$19,205,605.77	1	$19,205,605.77		0.199
2	Existing Conditions	$92,750.00	1.219	$113,062.25		0.001
3	Concrete	$3,977,645.71	1.219	$5,044,639.62		0.052
5	Metals	$8,102,951.86	1.219	$9,877,498.32		0.103
7	Thermal & Moisture Protection	$16,054.19	1.219	$19,570.06		0.0002
8	Openings	$5,195,182.63	1.219	$6,332,927.62		0.066
9	Finishes	$9,644,781.95	1.219	$11,756,989.20		0.122
11	Equipment	$863,209.88	1.219	$1,052,252.84		0.011
12	Furnishings	$6,656,940.54	1.219	$8,114,810.52		0.084
14	Conveying Equipment	$1,266,000.00	1.219	$1,543,254.00		0.016
21	Fire Suppression	$2,770,463.40	1.219	$3,377,194.88		0.035
22	Plumbing	$3,862,469.92	1.219	$4,708,350.84		0.049
23	Heating, Ventilation, and Air Conditioning	$12,560,056.68	1.219	$15,310,709.09		0.159
26	Electrical	$5,550,701.08	1.219	$6,766,304.61		0.070
27	Communications	$925,988.78	1.219	$1,128,780.32		0.012
31	Earthwork	$404,215.55	1.219	$492,738.76		0.005
32	Exterior Improvements	$1,095,145.59	1.219	$1,334,982.47		0.014
33	Utilities	$93,709.96	1.219	$114,232.44		0.001
	TOTAL Project Value			**$96,293,903.60**		1.000

													19205605.77
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [2]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	**General Contractor Fee**												**0**
2	10% Overhead		0.1									76822423.1	**7682242.31**
3	5% Profit		0.05									76822423.1	**3841121.155**
4	Design Fee 10%		0.1									76822423.1	**7682242.31**
5													**0**
6													**0**
7													**0**
8													**0**
9													**0**
10													**0**
11													**0**
12													**0**
13													**0**
14													**0**
15													**0**
16													**0**
17													**0**
18													**0**
19													**0**
20													**0**
21													**0**
22													**0**
23													**0**
24													**0**
25													**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													19205605.77
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [2]	Total Bare Cost	Total Incl O&P	Total Item Cost
41													0
42													0
43													0
44													0
45													0
46													0
47													0
48													0
49													0
50													0

													92750
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [3]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	Demolition												**0**
2	Site Preparation (36000 SF)		2	SF	G.2040-1100						37100	46375	**92750**
3												0	**0**
4												0	**0**
5												0	**0**
6												0	**0**
7												0	**0**
8												0	**0**
9												0	**0**
10												0	**0**
11												0	**0**
12												0	**0**
13												0	**0**
14												0	**0**
15												0	**0**
16													**0**
17													**0**
18													**0**
19													**0**
20													**0**
21													**0**
22													**0**
23													**0**
24													**0**
25													**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													92750
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [3]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

											$3,977,645.71		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans page	Crew	Daily Output	Total Bare Cost	Total Incl O&P	**Total Item Cost**		
	Concrete Mat Slab 4 ft	Yes	14751	CY	03-31-13-2950	81	C-20	400	9.29	13.05			
1	**Slab on Grade 9.25 in**	Yes	2756	CY	03-31-13-4650	81	C-20	185	20.1	28.5	**$55,395.60**		14.8972973
2	**Level 2 Concrete/Metal Deck**	Yes	24914	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$59,046.18**		9.278957169
3	**Level 2 6.25in Concrete Slab**	Yes	66405	SF	03-30-53-3200	77	C-8	2585	3.82	4.59	**$253,667.10**		25.68858801
	Parking Ramp	Yes	2180	SF	03-30-53-3200	77	C-8	2585	3.82	4.59	**$8,327.60**		0.8433268859
	Level 3 Concrete/Metal Deck		24489	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$73,711.89**		9.120670391
4	**Level 3 Concrete**	Yes	68350	SF	03-30-53-3200	77	C-8	2585	3.82	4.59	**$261,097.00**		26.4410058
5	**Level 4 Concrete**	Yes	74816	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$177,313.92**		27.86443203
6	**Level 5 Concrete**	Yes	74816	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$177,313.92**		27.86443203
7	**Level 6 Concrete**	Yes	74816	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$177,313.92**		27.86443203
8	**Level 7 Concrete**	Yes	74816	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$177,313.92**		27.86443203
9	**Roof Concrete**	Yes	73701	SF	03-30-53-3250	77	C-8	2685	2.37	3.01	**$174,671.37**		27.44916201
10	Top of Parapet Concrete	Yes									**$0.00**		#DIV/0!
11											**$0.00**		#DIV/0!
	Concrete Beams												#DIV/0!
12	Level 2 16 x 18	Yes	17.77	CY	03-31-13.70-0600	80	C-20	90	41.45	58	**$736.57**		0.1974444444
13	Level 3 16 x 18	Yes	16.75		03-31-13-0601	80	C-21	90	41.45	58	**$694.29**		0.1861111111
14	Level 2 22 x 24	Yes	157.54		03-31-13-0800	80	C-20	92	40.25	57	**$6,340.99**		1.712391304
15	Level 3 22 x 24	Yes	157.54		03-31-13-0801	80	C-21	92	40.25	57	**$6,340.99**		1.712391304
16	Level 2 26 x 28	Yes	314.48		03-31-13-1000	80	C-20	140	26.4	37.5	**$8,302.27**		2.246285714
17	Level 2 26 x 28	Yes	314.48		03-31-13-1001	80	C-21	140	26.4	37.5	**$8,302.27**		2.246285714
18											**$0.00**		#DIV/0!
19	**Concrete Columns**										**$0.00**		#DIV/0!
	Level 0												#DIV/0!
	30" Concrete Columns	Yes	252										#DIV/0!
20	**Level 1**										**$0.00**		#DIV/0!
21	12X18	Yes	24	CY	03-31-13.70-0800			92	40.25	57	**$966.00**		0.2608695652
22	24"	Yes	222	CY	03-31-13.70-0800			92	40.25	57	**$8,935.50**		2.413043478
23											**$0.00**		#DIV/0!
24	**Level 2**										**$0.00**		#DIV/0!
25	12x18	Yes	32	CY	03-31-13.70-0600	80	C-20	90	41.45	58	**$1,326.40**		0.3555555556
26											**$0.00**		#DIV/0!
27	**Concrete Slab Formwork (4 Uses)**										**$0.00**		#DIV/0!
28	Level 2 Elevated Slab (SF*1.10)		73045.5	SF	03-11-13.35-7000	55		500	3.37	5	**$365,227.50**		146.091
29	Level 3 Elevated Slab (SF*1.10)		75185	SF	03-11-13.35-7000	55		500	3.37	5	**$375,925.00**		150.37
30											**$0.00**		#DIV/0!
31	**Concrete Beam Formwork**										**$0.00**		#DIV/0!
32	Accounted for in Concrete Slab Formwork										**$0.00**		#DIV/0!
33											**$0.00**		#DIV/0!
34	**Concrete Column Formwork**										**$0.00**		#DIV/0!

											$3,977,645.71		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans page	Crew	Daily Output	Total Bare Cost	Total Incl O&P	Total Item Cost		
35	**Level1**										$0.00		#DIV/0!
36	12X18	Yes	2970	SFCA	03-11-13.25-6000			180	11.13	15.7	$33,056.10		16.5
37	24"		3942	SFCA	03-11-13.25-1800		C-1	130	22.2	29.5	$116,289.00		30.32307692
38											$0.00		#DIV/0!
39	**Level 2**										$0.00		#DIV/0!
40	12x18		135	SFCA	03-11-13.25-6000			2.63	11.13	15.7	$2,119.50		51.33079848
											$0.00		#DIV/0!
	Concrete Shear Walls										$0.00		#DIV/0!
	Concrete Shear Walls 14"		227	CY	03-30-53.40-4300	78	C-140	80.02	302.85	385	$87,395.00		2.836790802
											$0.00		#DIV/0!
	Concrete Shear Walls Formwork										$0.00		#DIV/0!
	Level 1 to Level 2		10470	SF	03-11-19-0150			992	6.54	7.85	$82,189.50		10.55443548
41											$0.00		#DIV/0!
42	**Concrete Slab Rebar**										$0.00		#DIV/0!
43	9" Concrete Slab		104	TON	03-21-11.60-0600			2.3	1790	2275	$236,600.00		45.2173913
44											$0.00		#DIV/0!
46											$0.00		#DIV/0!
47	**Shear Walls Rebar**										$0.00		#DIV/0!
48	Tension Reinforcing		5.676	Ton				95	64.1	84	$476.78		0.05974736842
49	Shear Reinforcing		9.9	Ton				130	22.95	30.5	$301.95		0.07615384615
50											$0.00		#DIV/0!
50	**Roof Construction**										$0.00		#DIV/0!
50	Roof Structure	No	73701	SF	M.020 Apt,4-7	81			1.76	2.2	$162,142.20		#DIV/0!
50	Roof Covering	No	73701	SF	M.020 Apt,4-7	81			1.39	1.7375	$128,055.49		#DIV/0!
50											$0.00		#DIV/0!
50	**Stair Construction**	No	56	Flights	C2010 Stair Const	414					$0.00		#DIV/0!
50	NW Stair		14		C2010 Stair Const	414			10725	13406.25	$187,687.50		#DIV/0!
50	NE Stair		14		C2010 Stair Const	414			10725	13406.25	$187,687.50		#DIV/0!
50	SW Stair		14		C2010 Stair Const	414			10725	13406.25	$187,687.50		#DIV/0!
50	SE Stair		14		C2010 Stair Const	414			10725	13406.25	$187,687.50		#DIV/0!
50											$0.00		#DIV/0!
50											$0.00		#DIV/0!
50											$0.00		#DIV/0!
50											$0.00		#DIV/0!
50											$0.00		
50											$0.00		
50											$0.00		
50											$0.00		
50											$0.00		
50											$0.00		

											$3,977,645.71		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans page	Crew	Daily Output	Total Bare Cost	Total Incl O&P	**Total Item Cost**		
50											**$0.00**		
50											**$0.00**		

760													8102951.86
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [4]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	**L1 2" Deep Metal Deck**		24914	SF	05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**75738.56**
2	**L2 2" Deep Metal Deck**		24489		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**74446.56**
3	**L3 2" Deep Metal Deck**		74816		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**227440.64**
4	**L4 2" Deep Metal Deck**		74816		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**227440.64**
5	**L5 2" Deep Metal Deck**		74816		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**227440.64**
6	**L6 2" Deep Metal Deck**		74816		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**227440.64**
7	**L7 2" Deep Metal Deck**		74816		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**227440.64**
8	**ROOF 2" Deep Metal Deck**		73701		05-31-13-5200	2019	141	E-4	3860		2.54	3.04	**224051.04**
9													**0**
10	**Level 1**												**0**
11	W10X33		1	LF	05-12-23.75-0740		131	E-2	550	LF	56.74	65.5	**65.5**
12	W12X65		330	LF	05-12-23.75-1580		132	E-2	750	LF	90.91	102	**33660**
13	W12X72		81	LF	05-12-23.75-1700		132	E-2	640	LF	112.51	126	**10206**
14	12X106		345	LF	05-12-23.75-1740		132	E-2	640	LF	133.51	150	**51750**
15	W18X76		90	LF	3940		132	E-2	900	LF	116.96	132	**11880**
16	W18X97		195	LF	3960		132	E-2	900	LF	131.96	148	**28860**
19													**0**
20	**Level 2**												**0**
21	W16x26		129	LF	05-12-23-2700		133	E-2	1000	LF	42.81	48.5	**6256.5**
22	W8X13		269	LF	300		131	E-2	600	LF	22.58	27.5	**7397.5**
23	W16X100		254	LF	3140		132	E-2	760	LF	103.82	116	**29464**
24	W18X60		46	LF	3920		132		900	LF	101.46	114	**5244**
25	W18X97		1529	LF	3960			E-2	900	LF	131.96	148	**226292**
26	W21X73		58	LF	4700				1036	LF	105.04	118	**6844**
27	W21X93		187	LF	4740		132		1000	LF	141.26	158	**29546**
28	W21X101		126	LF	4760				1000	LF	153.26	171	**21546**
29	W21X132		120	LF	4780		132		1000	LF	183.26	204	**24480**
30				LF						LF			**0**
31	**Level 3**			LF						LF			**0**
32	W8X13		315	LF	300		131	E-2	600	LF	22.58	27.5	**8662.5**
33	W14x68		271	LF	2360		132		760	LF	114.32	127	**34417**
34	W16X100		417	LF	3140		132	E-2	760	LF	103.82	116	**48372**
35	W18X60		29	LF	3920		132		900	LF	101.46	114	**3306**
36	W18X97		1413	LF	3960			E-2	900	LF	131.96	148	**209124**
37	W18x119		164	LF	3960				900	LF	131.96	148	**24272**
38	W18x130		79	LF	3960				900	LF	131.96	148	**11692**
39	W18X143		64	LF	3960				900	LF	131.96	148	**9472**
40	W21X73		58	LF	4700				1036	LF	105.04	118	**6844**
41	W21X93		186	LF	4740		132		1000	LF	141.26	158	**29388**
42	W21X101		132	LF	4760				1000	LF	153.26	171	**22572**

760													**8102951.86**
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [4]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
43	W21X122		39	LF	4780				1000	LF	183.26	204	**7956**
44				LF						LF			**0**
45	**Level 4**												**0**
46	W8X13		332	LF	300		131	E-2	600	LF	22.58	27.5	**9130**
47	W14x68		547	LF	2360		132		760	LF	114.32	127	**69469**
48	W16X67		106	LF	3140				760	LF	103.82	116	**12296**
49	W16X100		1114	LF	3140		132	E-2	760	LF	103.82	116	**129224**
50	W18X60		75	LF	3920		132		900	LF	101.46	114	**8550**
51	W18X76		109		3940				900		116.96	132	**14388**
52	W18X97		2753	LF	3960			E-2	900	LF	131.96	148	**407444**
53	W18x119		817	LF	3960				900	LF	131.96	148	**120916**
54	W18x130		171	LF	3960				900	LF	131.96	148	**25308**
55	W18X143		64	LF	3960				900	LF	131.96	148	**9472**
56	W21X73		145	LF	4700				1036	LF	105.04	118	**17110**
57	W21X93		186	LF	4740		132		1000	LF	141.26	158	**29388**
58	W21X101		132	LF	4760				1000	LF	153.26	171	**22572**
59	W21X122		352	LF	4780				1000	LF	183.26	204	**71808**
60													**0**
61	**Level 5**												**0**
62	W8X13		309	LF	300		131	E-2	600	LF	22.58	27.5	**8497.5**
63	W14x68		531	LF	2360		132		760	LF	114.32	127	**67437**
64	W16X67		132	LF	3140				760	LF	103.82	116	**15312**
65	W16X100		1013	LF	3140		132	E-2	760	LF	103.82	116	**117508**
66	W18X60		120	LF	3920		132		900	LF	101.46	114	**13680**
67	W18x76		109		3940				900		116.96	132	**14388**
68	W18X97		2647	LF	3960			E-2	900	LF	131.96	148	**391756**
69	W18x119		912	LF	3960				900	LF	131.96	148	**134976**
70	W18x130		171	LF	3960				900	LF	131.96	148	**25308**
71	W18X143		64	LF	3960				900	LF	131.96	148	**9472**
72	W21X73		145	LF	4700				1036	LF	105.04	118	**17110**
73	W21X93		186	LF	4740		132		1000	LF	141.26	158	**29388**
74	W21X101		132	LF	4760				1000	LF	153.26	171	**22572**
75	W21X122		477	LF	4780				1000	LF	183.26	204	**97308**
76													**0**
77	**Level 6**												**0**
78	W8X13		324	LF	300		131	E-2	600	LF	22.58	27.5	**8910**
79	W14x68		540	LF	2360		132		760	LF	114.32	127	**68580**
80	W16X67		132	LF	3140				760	LF	103.82	116	**15312**
81	W16X100		1048	LF	3140		132	E-2	760	LF	103.82	116	**121568**
82	W18X60		120	LF	3920		132		900	LF	101.46	114	**13680**

No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [4]	Total Bare Cost	Total Incl O&P	Total Item Cost
760													**8102951.86**
83	W18x76		109		3940				900		116.96	132	**14388**
84	W18X97		2618	LF	3960			E-2	900	LF	131.96	148	**387464**
85	W18x119		946	LF	3960				900	LF	131.96	148	**140008**
86	W18x130		171	LF	3960				900	LF	131.96	148	**25308**
87	W18X143		65	LF	3960				900	LF	131.96	148	**9620**
88	W21X73		145	LF	4700				1036	LF	105.04	118	**17110**
89	W21X93		186	LF	4740		132		1000	LF	141.26	158	**29388**
90	W21X101		132	LF	4760				1000	LF	153.26	171	**22572**
91	W21X122		385	LF	4780				1000	LF	183.26	204	**78540**
92													**0**
93	**Level 7**												**0**
94	W8X13		324	LF	300		131	E-2	600	LF	22.58	27.5	**8910**
95	W14x68		564	LF	2360		132		760	LF	114.32	127	**71628**
96	W16X67		132	LF	3140				760	LF	103.82	116	**15312**
97	W16X100		1008	LF	3140		132	E-2	760	LF	103.82	116	**116928**
98	W18X60		120	LF	3920		132		900	LF	101.46	114	**13680**
99	W18x76		109		3940				900		116.96	132	**14388**
100	W18X97		2535	LF	3960			E-2	900	LF	131.96	148	**375180**
101	W18x119		935	LF	3960				900	LF	131.96	148	**138380**
102	W18x130		259	LF	3960				900	LF	131.96	148	**38332**
103	W18X143		65	LF	3960				900	LF	131.96	148	**9620**
104	W21X73		145	LF	4700				1036	LF	105.04	118	**17110**
105	W21X93		186	LF	4740		132		1000	LF	141.26	158	**29388**
106	W21X101		132	LF	4760				1000	LF	153.26	171	**22572**
107	W21X122		432	LF	4780				1000	LF	183.26	204	**88128**
108													**0**
109	**Roof**												**0**
110	W16x26		23	LF	05-12-23-2700		133	E-2	1000	LF	42.81	48.5	**1115.5**
111	W6X16		363		120		131		600		30.03	35.5	**12886.5**
112	W8X13		145	LF	300		131	E-2	600	LF	22.58	27.5	**3987.5**
113	W14x68		58	LF	2360		132		760	LF	114.32	127	**7366**
114	W16X67		1448	LF	3140				760	LF	103.82	116	**167968**
115	W16X100		192	LF	3140		132	E-2	760	LF	103.82	116	**22272**
116	W18X60		120	LF	3920		132		900	LF	101.46	114	**13680**
117	W18x76		109		3940				900		116.96	132	**14388**
118	W18X97		234	LF	3960			E-2	900	LF	131.96	148	**34632**
119	W18x106		2353						900		160.96	180	**423540**
120	W18x119		902	LF	3960				900	LF	131.96	148	**133496**
121	W18x130		45	LF	3960				900	LF	131.96	148	**6660**
123	W21X73		100	LF	4700				1036	LF	105.04	118	**11800**

760													**8102951.86**
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [4]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
124	W21X93		186	LF	4740		132		1000	LF	141.26	158	**29388**
125	W21X101		132	LF	4760				1000	LF	153.26	171	**22572**
126	W21X122		128	LF	4780				1000	LF	183.26	204	**26112**
127													**0**
128	**Level Parapet**												**0**
129	W6X16		99		120		131		600		30.03	35.5	**3514.5**
130	W8X13		97	LF	300		131	E-2	600	LF	22.58	27.5	**2667.5**
131	W16X67		163	LF	3140				760	LF	103.82	116	**18908**
132													**0**
133	**Level 1 Columns**												**0**
134	W 16 x 26		419	LF	05-12-23-2700		133	E-2	1000	LF	42.81	48.5	**20321.5**
135	W 18X97		77	LF	3960			E-2	900	LF	131.96	148	**11396**
136													**0**
137	**Level 2 Columns**												**0**
138	W12x45	No	264	LF	05-12-23.75-1560	2019	132	E-2	750	LF	78.91	89	**23496**
139	W12X65	No	108	LF	05-12-23.75-1580	2019	132	E-2	750	LF	90.91	102	**11016**
140	12X106	No	144	LF	05-12-23.75-1740	2019	132	E-2	640	LF	133.51	150	**21600**
141	W18X76	No	108	LF	05-12-23.75-3940	2019	132	E-2	900	LF	116.96	132	**14256**
142	W18X97	No	156	LF	05-12-23.75-3960	2019	132	E-2	900	LF	131.96	148	**23088**
143													**0**
144	**Level 3 Columns**												**0**
145	W12X45	No	250	LF	1560				750	LF	78.91	89	**22250**
146	W12X65	No	160	LF	05-12-23.75-1580				750	LF	90.91	102	**16320**
147	W12X72	No	40		05-12-23.75-1700				640	LF	112.51	126	**5040**
148	W12X79	No	660	LF	05-12-23.75-1700				640	LF	112.51	126	**83160**
149	W18X76	No	100	LF	3940				900	LF	116.96	132	**13200**
150	W18X97	No	230	LF	3960			E-2	900	LF	131.96	148	**34040**
151	W18x119	No	80	LF	3960				900	LF	131.96	148	**11840**
152													**0**
153	**Level 4 Columns**												**0**
154	W12X40		220	LF	1560				750	LF	78.91	89	**19580**
155	W12X45		170	LF	1560				750	LF	78.91	89	**15130**
156	W12X50		30	LF	1560				750	LF	78.91	89	**2670**
157	W12X53		640	LF	1560				750	LF	78.91	89	**56960**
158	W12X65		20	LF	05-12-23.75-1580				750	LF	90.91	102	**2040**
159	W12X79		10	LF	05-12-23.75-1700				640	LF	112.51	126	**1260**
160	W18X76		100	LF	3940				900	LF	116.96	132	**13200**
161	W18X97		240	LF	3960			E-2	900	LF	131.96	148	**35520**
162	W18x119		80	LF	3960				900	LF	131.96	148	**11840**
163													**0**

760													**8102951.86**
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [4]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
164	**Level 5 Columns**												**0**
165	W12X40		230	LF	1560				750	LF	78.91	89	**20470**
166	W12X45		180	LF	1560				750	LF	78.91	89	**16020**
167	W12X50		40	LF	1560				750	LF	78.91	89	**3560**
168	W12X53		640	LF	1560				750	LF	78.91	89	**56960**
169	W12X79		10	LF	05-12-23.75-1700				640	LF	112.51	126	**1260**
170	W18X76		100	LF	3940				900	LF	116.96	132	**13200**
171	W18X97		240	LF	3960			E-2	900	LF	131.96	148	**35520**
172	W18x119		80	LF	3960				900	LF	131.96	148	**11840**
173													**0**
174	**Level 6 Columns**												**0**
175	W10X22		220	LF	05-12-23.75-0700				600	LF	40.03	46.5	**10230**
176	W10X33		650	LF	05-12-23.75-0740				550	LF	56.74	65.5	**42575**
177	W12X40		190	LF	1560				750	LF	78.91	89	**16910**
178	W12X45		30	LF	1560				750	LF	78.91	89	**2670**
179	W12X79		10	LF	05-12-23.75-1700				640	LF	112.51	126	**1260**
180	W18X76		100	LF	3940				900	LF	116.96	132	**13200**
181	W18X97		240	LF	3960			E-2	900	LF	131.96	148	**35520**
182	W18x119		80	LF	3960				900	LF	131.96	148	**11840**
183													**0**
184	**Level 7 Columns**												**0**
185	W10X22		230	LF	05-12-23.75-0700				600	LF	40.03	46.5	**10695**
186	W10X33		630	LF	05-12-23.75-0740				550	LF	56.74	65.5	**41265**
187	W12X40		220	LF	1560				750	LF	78.91	89	**19580**
188	W12X79		10	LF	05-12-23.75-1700				640	LF	112.51	126	**1260**
189	W18X76		100	LF	3940				900	LF	116.96	132	**13200**
190	W18X97		240	LF	3960			E-2	900	LF	131.96	148	**35520**
191	W18x119		80	LF	3960				900	LF	131.96	148	**11840**
192													**0**
193	**Roof Columns**												**0**
194	W10X22		120	LF	05-12-23.75-0700				600	LF	40.03	46.5	**5580**
195													**0**
196													**0**
197													**0**
198													**0**
199													**0**
200													**0**
201													**0**
202													**0**
203													**0**

760													**8102951.86**
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [4]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
204													**0**
205													**0**
206													**0**
207													**0**
208													**0**

No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [5]	Total Bare Cost	Total Incl O&P	Total Item Cost
													16054.189
1	**Bioretention**												**0**
2	EPDM 45 mil Thick		4338.97	SF	07-13-53-10.0090		225		580		2.72	3.7	**16054.189**
3													**0**
4													**0**
5													**0**
6													**0**
7													**0**
8													**0**
9													**0**
10													**0**
11													**0**
12													**0**
13													**0**
14													**0**
15													**0**
16													**0**
17													**0**
18													**0**
19													**0**
20													**0**
21													**0**
22													**0**
23													**0**
24													**0**
25													**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													16054.189
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [5]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													5195182.625		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [6]	Total Bare Cost	Total Incl O&P	**Total Item Cost**		
1	**Exterior Walls (Curtain Wall)**	No		SF			81				20.82		**0**		#DIV/0!
2	North Wall 3-7	No	20405	SF	M.020-2020					SF	20.82	26.025	**531040.125**		#DIV/0!
3	East Wall 3-7		13970	SF	M.020-2020					SF	20.82	26.025	**363569.25**		#DIV/0!
4	South Wall 3-7	No	21615	SF	M.020-2020					SF	20.82	26.025	**562530.375**		#DIV/0!
5	West Wall 3-7	No	13915	SF	M.020-2020					SF	20.82	26.025	**362137.875**		#DIV/0!
6												0	**0**		#DIV/0!
7	**Interior Doors**											0	**0**		#DIV/0!
8	Level 1		1	Each	M.020-1020				12	Each	1244	1555	**1555**		0.08333333333
9	Level 2		106		M.020-1020				12		1244	1555	**164830**		8.833333333
10	Level 3		395		M.020-1020				12		1244	1555	**614225**		32.91666667
11	Level 4		410		M.020-1020				12		1244	1555	**637550**		34.16666667
12	Level 5		410		M.020-1020				12		1244	1555	**637550**		34.16666667
13	Level 6		429		M.020-1020				12		1244	1555	**667095**		35.75
14	Level 7		420		M.020-1020				12		1244	1555	**653100**		35
15												0	**0**		#DIV/0!
16												0	**0**		#DIV/0!
17												0	**0**		#DIV/0!
18												0	**0**		#DIV/0!
19												0	**0**		#DIV/0!
20												0	**0**		#DIV/0!
21												0	**0**		#DIV/0!
22													**0**		#DIV/0!
23													**0**		#DIV/0!
24													**0**		#DIV/0!
25													**0**		#DIV/0!
26													**0**		#DIV/0!
27													**0**		
28													**0**		
29													**0**		
30													**0**		
31													**0**		
32													**0**		
33													**0**		
34													**0**		
35													**0**		
36													**0**		
37													**0**		
38													**0**		
39													**0**		
40													**0**		

												5195182.625		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [6]	Total Bare Cost	Total Incl O&P	**Total Item Cost**		
41													**0**		
42													**0**		
43													**0**		
44													**0**		
45													**0**		
46													**0**		
47													**0**		
48													**0**		
49													**0**		
50													**0**		

													9644781.95
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [7]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	Glazed/Prefab Metal Panels											0	**0**
2	Level 1		15480	SF	M0.20-2020		81				20.82	26.025	**402867**
3	Level 2		7979								20.82	26.025	**207653.475**
4	Level 3		25815								20.82	26.025	**671835.375**
5	Level 4		25989								20.82	26.025	**676363.725**
6	Level 5		25120								20.82	26.025	**653748**
7	Level 6		26923								20.82	26.025	**700671.075**
8	Level 7		2692								20.82	26.025	**70059.3**
9			26929								20.82	26.025	**700827.225**
10	Interior Walls				M.020-1010		81					0	**0**
11	Level 1										9.17	11.4625	**0**
12	Level 2		24515								9.17	11.4625	**281003.1875**
13	Level 3		88532								9.17	11.4625	**1014798.05**
14	Level 4		94355								9.17	11.4625	**1081544.188**
15	Level 5		90544								9.17	11.4625	**1037860.6**
16	Level 6		94293								9.17	11.4625	**1080833.513**
17	Level 7		92887	81							9.17	11.4625	**1064717.238**
18												0	**0**
19	Parapet Wall		12219									0	**0**
20												0	**0**
21												0	**0**
22												0	**0**
23												0	**0**
24												0	**0**
25												0	**0**
26												0	**0**
27												0	**0**
28												0	**0**
29												0	**0**
30												0	**0**
31												0	**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

														9644781.95
No.	Item Description	Self-Performed?	Quantity	Unit		RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [7]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41														**0**
42														**0**
43														**0**
44														**0**
45														**0**
46														**0**
47														**0**
48														**0**
49														**0**
50														**0**

													863209.875		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [8]	Total Bare Cost	Total Incl O&P	**Total Item Cost**		
1	**Residential Gas Ranges, Dis**										1.65	2.0625	**0**		
2	Level 1 Mixed Use		24914								1.65	2.0625	**51385.125**		
3	L2 Res		24914								1.65	2.0625	**51385.125**		#DIV/0!
4	L3 Res		69434								1.65	2.0625	**143207.625**		
5	L4 Res		74816								1.65	2.0625	**154308**		
6	L5 Res		74816								1.65	2.0625	**154308**		
7	L6 Res		74816								1.65	2.0625	**154308**		
8	L7 Res		74816								1.65	2.0625	**154308**		
9													**0**		
10													**0**		
11													**0**		
12													**0**		
13													**0**		
14													**0**		
15													**0**		
16													**0**		
17													**0**		
18													**0**		
19													**0**		
20													**0**		
21													**0**		
22													**0**		
23													**0**		
24													**0**		
25													**0**		
26													**0**		
27													**0**		
28													**0**		
29													**0**		
30													**0**		
31													**0**		
32													**0**		
33													**0**		
34													**0**		
35													**0**		
36													**0**		
37													**0**		
38													**0**		
39													**0**		
40													**0**		

													863209.875
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [8]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													6656940.54
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [9]	Total Bare Cost	Total Incl O&P	Total Item Cost
1	**Residential Fittings**	No		SF									**0**
2	Level 2 Residential	No	24914	SF	M.020-1030						4.98	6.225	**155089.65**
3	Level 3 Residential	No	69434		M.020-1030						4.98	6.225	**432226.65**
4	Level 4 Residential		74816		M.020-1030						4.98	6.225	**465729.6**
5	Level 5 Residential		74816		M.020-1030						4.98	6.225	**465729.6**
6	Level 6 Residential		74816		M.020-1030						4.98	6.225	**465729.6**
7	Level 7 Residential		74816		M.020-1030						4.98	6.225	**465729.6**
8												0	**0**
9	**Floor Finishes**											0	**0**
10	Level 1 Mixed Use		24914		M.020-3020						5.32	6.65	**165678.1**
11	L2 Res		24914		M.020-3020						5.32	6.65	**165678.1**
12	L3 Res		69434		M.020-3020						5.32	6.65	**461736.1**
13	L4 Res		74816		M.020-3020						5.32	6.65	**497526.4**
14	L5 Res		74816		M.020-3020						5.32	6.65	**497526.4**
15	L6 Res		74816		M.020-3020						5.32	6.65	**497526.4**
16	L7 Res		74816		M.020-3020							0	**0**
17													**0**
18	**Ceiling Finishes**												**0**
19	Level 1 Mixed Use		24914		M.020-3030						4.59	4.59	**114355.26**
20	L2 Res		24914		M.020-3030						4.59	4.59	**114355.26**
21	L3 Res		69434		M.020-3030						4.59	4.59	**318702.06**
22	L4 Res		74816		M.020-3030						4.59	4.59	**343405.44**
23	L5 Res		74816		M.020-3030						4.59	4.59	**343405.44**
24	L6 Res		74816		M.020-3030						4.59	4.59	**343405.44**
25	L7 Res		74816		M.020-3030						4.59	4.59	**343405.44**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													6656940.54
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [9]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													1266000
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [10]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	**Elevators**											0	**0**
2	NW Elevators											0	**0**
3	NE Elevator		2	Each	M.020-1010		81			Each	253200	316500	**633000**
4	SW Elevator											0	**0**
5	SE Elevator		2				811			Each	253200	316500	**633000**
6												0	**0**
7												0	**0**
8												0	**0**
9												0	**0**
10												0	**0**
11												0	**0**
12												0	**0**
13												0	**0**
14												0	**0**
15												0	**0**
16												0	**0**
17												0	**0**
18												0	**0**
19												0	**0**
20												0	**0**
21												0	**0**
22												0	**0**
23												0	**0**
24												0	**0**
25												0	**0**
26												0	**0**
27												0	**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													1266000
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [10]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													2770463.4
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [11]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	**Sprinkler Residential**	No					81					0	**0**
2	L2 Res		24914				81				3.03	3.7875	**94361.775**
3	L3 Res		69434								3.03	3.7875	**262981.275**
4	L4 Res		74816								3.03	3.7875	**283365.6**
5	L5 Res		74816								3.03	3.7875	**283365.6**
6	L6 Res		74816								3.03	3.7875	**283365.6**
7	L7 Res		74816								3.03	3.7875	**283365.6**
8												0	**0**
9	**Standpipes Residential**											0	**0**
10	L2 Res		24914								0.99	1.2375	**30831.075**
11	L3 Res		69434								0.99	1.2375	**85924.575**
12	L4 Res		74816								0.99	1.2375	**92584.8**
13	L5 Res		74816								0.99	1.2375	**92584.8**
14	L6 Res		74816								0.99	1.2375	**92584.8**
15	L7 Res		74816								0.99	1.2375	**92584.8**
16												0	**0**
17	**Sprinkler Garage**											0	**0**
18	Level 1		66405								3.03	3.7875	**251508.9375**
19	Level 2		66405								3.03	3.7875	**251508.9375**
20												0	**0**
21	**Standpipes Garage**											0	**0**
22	Level 1		66405								0.99	1.2375	**82176.1875**
23	Level 2		66405								0.99	1.2375	**82176.1875**
24												0	**0**
25	**Sprinkler for Offices**											0	**0**
26	Level 1 Mixed Use		24914								3.03	3.7875	**94361.775**
27												0	**0**
28	**Standpipes Offices**											0	**0**
29	Level 1 Mixed Use		24914								0.99	1.2375	**30831.075**
30												0	**0**
31												0	**0**
32												0	**0**
33												0	**0**
34												0	**0**
35												0	**0**
36												0	**0**
37													**0**
38													**0**
39													**0**
40													**0**

													2770463.4
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [11]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													3862469.924
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [12]	Total Bare Cost	Total Incl O&P	Total Item Cost
1	**Plumbing Fixtures (1 fixture/**											0	0
2	Level 1 Mixed Use		87.41754386	each	M.020-2010		81			each	1942	2427.5	212206.0877
3	Level 2 Residential		87.41754386	each	M.020-2010					each	1942	2427.5	212206.0877
4	Level 3 Residential		243.6280702	each	M.020-2010					each	1942	2427.5	591407.1404
5	Level 4 Residential		262.5122807	each	M.020-2010					each	1942	2427.5	637248.5614
6	Level 5 Residential		262.5122807	each	M.020-2010					each	1942	2427.5	637248.5614
7	Level 6 Residential		262.5122807	each	M.020-2010					each	1942	2427.5	637248.5614
8	Level 7 Residential		262.5122807	each	M.020-2010					each	1942	2427.5	637248.5614
9												0	0
10	**Domestic Water Distribution**											0	0
11	Level 1 Mixed Use		24914	SF	M.020-2020					SF	8.7	10.875	270939.75
12	Level 2 Residential		24914	SF	M.020-2020					SF		0	0
13	Level 3 Residential		69434	SF	M.020-2020					SF		0	0
14	Level 4 Residential		74816	SF	M.020-2020					SF		0	0
15	Level 5 Residential		74816	SF	M.020-2020					SF		0	0
16	Level 6 Residential		74816	SF	M.020-2020					SF		0	0
17	Level 7 Residential		74816	SF	M.020-2020					SF		0	0
18												0	0
19	**Roof Drains**											0	0
20	Roof Drain		73701	SF						SF	0.29	0.3625	26716.6125
21												0	0
22												0	0
23													0
24													0
25													0
26													0
27													0
28													0
29													0
30													0
31													0
32													0
33													0
34													0
35													0
36													0
37													0
38													0
39													0
40													0

													3862469.924
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [12]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													12560056.68
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [13]	Total Bare Cost	Total Incl O&P	Total Item Cost
												0	
1	**Energy Supply for residential area**	No		S.F. Floor	M.020-3010							0	**0**
2	L2 Res		24914	SF/floor							8.42	10.525	**262219.85**
3	L3 Res		69434								9.65	12.0625	**837547.625**
4	L4 Res		74816								8.42	10.525	**787438.4**
5	L5 Res		74816								8.42	10.525	**787438.4**
6	L6 Res		74816								8.42	10.525	**787438.4**
7	L7 Res		74816								8.42	10.525	**787438.4**
8												0	**0**
9	**Cooling Generating Systems for resid**				M.020-3030							0	**0**
10	L2 Res		24914								9.65	12.0625	**300525.125**
11	L3 Res		69434								9.65	12.0625	**837547.625**
12	L4 Res		74816								9.65	12.0625	**902468**
13	L5 Res		74816								9.65	12.0625	**902468**
14	L6 Res		74816								9.65	12.0625	**902468**
15	L7 Res		74816								9.65	12.0625	**902468**
16												0	**0**
17	**Energy Supply for garage**				M.020-3010							0	**0**
18	Level 1		66405								8.42	10.525	**698912.625**
19	Level 2		66405								8.42	10.525	**698912.625**
20												0	**0**
21	**Cooling for garage**				M.020-3030							0	**0**
22	Level 1		66405								9.65	12.0625	**801010.3125**
23	Level 2		66405								9.65	12.0625	**801010.3125**
24												0	**0**
25	**Energy supply for offices**				M.020-3010							0	**0**
26	Level 1 Mixed Use		24914								8.42	10.525	**262219.85**
27												0	**0**
28	**Cooling supply for offices**				M.020-3030							0	**0**
29	Level 1 Mixed Use		24914								9.65	12.0625	**300525.125**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**

													12560056.68
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [13]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
40													**0**
41													**0**
42													**0**
43													**0**
44													**0**
45	Cooling Generating Systems for residen												**0**
46	Energy Supply for garage												**0**
47	Cooling for garage												**0**
48	Energy supply for offices												**0**
49	Cooling supply for offices												**0**
50													**0**

													5550701.075
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [14]	Total Bare Cost	Total Incl O&P	Total Item Cost
1	**Electrical Service Distributio**											0	**0**
2	Level 1 Mixed Use		24914				81				2.82	3.525	**87821.85**
3	L2 Res		24914				81				2.82	3.525	**87821.85**
4	L3 Res		69434				81				2.82	3.525	**244754.85**
5	L4 Res		74816				81				2.82	3.525	**263726.4**
6	L5 Res		74816				81				2.82	3.525	**263726.4**
7	L6 Res		74816				81				2.82	3.525	**263726.4**
8	L7 Res		74816				81				2.82	3.525	**263726.4**
9												0	**0**
10	**Lighting/Branch Wiring**											0	**0**
11	Level 1 Mixed Use		24914				81				7.79	9.7375	**242600.075**
12	L2 Res		24914				81				7.79	9.7375	**242600.075**
13	L3 Res		69434				81				7.79	9.7375	**676113.575**
14	L4 Res		74816				81				7.79	9.7375	**728520.8**
15	L5 Res		74816				81				7.79	9.7375	**728520.8**
16	L6 Res		74816				81				7.79	9.7375	**728520.8**
17	L7 Res		74816				81				7.79	9.7375	**728520.8**
18												0	**0**
19												0	**0**
20												0	**0**
21												0	**0**
22												0	**0**
23												0	**0**
24												0	**0**
25												0	**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													5550701.075
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [14]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													925988.775
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [15]	Total Bare Cost	Total Incl O&P	Total Item Cost
1	**Communications and Securit**										1.77	2.2125	**0**
2	Level 1 Mixed Use		24914				81				1.77	2.2125	**55122.225**
3	L2 Res		24914								1.77	2.2125	**55122.225**
4	L3 Res		69434								1.77	2.2125	**153622.725**
5	L4 Res		74816								1.77	2.2125	**165530.4**
6	L5 Res		74816								1.77	2.2125	**165530.4**
7	L6 Res		74816								1.77	2.2125	**165530.4**
8	L7 Res		74816								1.77	2.2125	**165530.4**
9												0	**0**
10												0	**0**
11												0	**0**
12												0	**0**
13												0	**0**
14												0	**0**
15												0	**0**
16												0	**0**
17												0	**0**
18												0	**0**
19												0	**0**
20												0	**0**
21												0	**0**
22												0	**0**
23												0	**0**
24													**0**
25													**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													925988.775
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [15]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													404215.55
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [16]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
1	Building Excavation and Backfi		99194	SF	A2010.6940	2019	309				3.26	4.075	**404215.55**
2													**0**
3													**0**
4													**0**
5													**0**
6													**0**
7													**0**
8													**0**
9													**0**
10													**0**
11													**0**
12													**0**
13													**0**
14													**0**
15													**0**
16													**0**
17													**0**
18													**0**
19													**0**
20													**0**
21													**0**
22													**0**
23													**0**
24													**0**
25													**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													404215.55
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [16]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													1095145.59
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [17]	Total Bare Cost	Total Incl O&P	Total Item Cost
1	**Bioretention**												**0**
2	Biorentention Package		1								78855.84	91645.59	**91645.59**
3													**0**
4													**0**
5	Pavement (36000 SF)		2	SF	G.2040-1104						239000	298750	**597500**
6	Sidewalks (36000 SF)		2	SF	G.2040-1108						23800	29750	**59500**
7	Lighting (36000 SF)		2	SF	G.2040-1110						55800	69750	**139500**
8	Landscaping (36000 SF)		2	SF	G.2040-1112						82800	103500	**207000**
9												0	**0**
10													**0**
11													**0**
12													**0**
13													**0**
14													**0**
15													**0**
16													**0**
17													**0**
18													**0**
19													**0**
20													**0**
21													**0**
22													**0**
23													**0**
24													**0**
25													**0**
26													**0**
27													**0**
28													**0**
29													**0**
30													**0**
31													**0**
32													**0**
33													**0**
34													**0**
35													**0**
36													**0**
37													**0**
38													**0**
39													**0**
40													**0**

													1095145.59
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [17]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

													93709.955		
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [18]	Total Bare Cost	Total Incl O&P	**Total Item Cost**		
1	**Utility Connection Identificat**			Each	33-05-97.05		677	B-14	1	Each	5445	6825	**0**		
2	Water Utility		1		33-05-97.05-0020						5445	6825	**6825**		
3	Sanitary Utility		1		33-05-97.05						5445	6825	**6825**		
4	Stormwater Utility		1		33-05-97.05						5445	6825	**6825**		
5	Gas Utility		1		33-05-97.05						5445	6825	**6825**		
6	Telecommunication		1		33-05-97.05-0030								**0**		
7													**0**		
8	Potable Water Main Piping 14"		839	LF	33-14-13.25-3010		679	B-20A	213	LF	21.3	26.5	**22233.5**		
	Hydrant Lateral 8"		187	LF	33-14-13.15-2060		678	B-21A	133.33	LF	71.59	84.5	**15801.5**		
	Hydrant Lateral 4"		52	LF	33-14-13.25-2160		679	B-20	430	LF	4.18	5.65	**293.8**		
9	Sanitary Sewage Piping 8"		364	LF	33-31-11-2080		682	B-21	335	LF	21.19	25.5	**9282**		
10	Stormwater Gravity Piping 8"		956.7	LF	33-42-11.40-2040`		684	B-14	330	LF	15.52	19.65	**18799.155**		148
11													**0**		14.3
12													**0**		155.5
13													**0**		17.7
14													**0**		8.3
15													**0**		132.5
16													**0**		129.5
17													**0**		14.8
18													**0**		124.7
19													**0**		127.2
20													**0**		40
21													**0**		13.8
22													**0**		14.8
23													**0**		15.6
24													**0**		
25													**0**		
26													**0**		
27													**0**		
28													**0**		
29													**0**		
30													**0**		
31													**0**		
32													**0**		
33													**0**		
34													**0**		
35													**0**		
36													**0**		
37													**0**		
38													**0**		

													93709.955
No.	Item Description	Self-Performed?	Quantity	Unit	RSMeans Code	RSMeans Year	RSMeans page	Crew	Daily Output	Unit [18]	Total Bare Cost	Total Incl O&P	**Total Item Cost**
39													**0**
40													**0**
41													**0**
42													**0**
43													**0**
44													**0**
45													**0**
46													**0**
47													**0**
48													**0**
49													**0**
50													**0**

[1] Adjusting for location and inflation

[2] Make sure this unit matches your quantity take off unit

[3] Make sure this unit matches your quantity take off unit

[4] Make sure this unit matches your quantity take off unit

[5] Make sure this unit matches your quantity take off unit

[6] Make sure this unit matches your quantity take off unit

[7] Make sure this unit matches your quantity take off unit

[8] Make sure this unit matches your quantity take off unit

[9] Make sure this unit matches your quantity take off unit

[10] Make sure this unit matches your quantity take off unit

[11] Make sure this unit matches your quantity take off unit

[12] Make sure this unit matches your quantity take off unit

[13] Make sure this unit matches your quantity take off unit

[14] Make sure this unit matches your quantity take off unit

[15] Make sure this unit matches your quantity take off unit

[16] Make sure this unit matches your quantity take off unit

[17] Make sure this unit matches your quantity take off unit

[18] Make sure this unit matches your quantity take off unit

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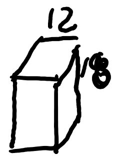
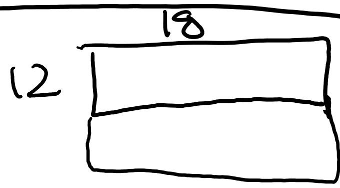
SFCA of Columns





1' × 27' × 2
+
1.5ft × 27' × 2

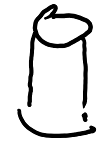
54ft
+
81

135ft²/per column

22 total columns
×
135 ft²/per column

24" 

$\pi r^2 \times l = \pi (12)^2 \cdot$



2' × 27' = 54ft²/per colm

73 total columns
×
54ft²/column

Link to Synchro Pro Animation

https://drive.google.com/file/d/1F3Gc96dHH3lYk9YWuuKRWl8Lg-jLWda4/view?usp=sharing