STRUCTURAL DESIGN OF A RESIDENCE HALL

A Major Qualifying Project Report

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By

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Abstract

A design of two structural systems for the New Residence Hall at WPI. One design was completed in steel, in accordance with AISC/ANSI 360-05. The other design was of reinforced concrete, in accordance with ACI 318-02. These designs were compared on the basis of cost, constructability, and available points toward LEED certification.

Acknowledgements

We would like to thank Professors El-Korchi and Jayachandran for all the help they have given us as project advisors.

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1. Introduction

1.1 Capstone Design Experience Statement

This project met the Capstone Design Experience requirement through the design of two load-resisting systems for the New Residence Hall currently under construction. Throughout this project, we applied the relevant building codes and specifications (780 Code of Massachusetts Regulations, AISC/ANSI 360-05, ACI 318-02, ASCE 7) and the loads that would be supported by a building of this type and occupancy, determined the layout of the bays in concurrence with the spatial vision of the architect, calculated the forces that would be developed in these members, and merged all these aspects to present a final deliverable of 2 completed structural designs. One design was completed using reinforced cast-in-place -concrete members, and the other, steel members. These designs were compared in order to select the design that best fits the needs of the university, and to explore the eight constraints listed in the ASCE commentary: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political constraints. The constraints found to be most relevant to this project were economic, manufacturability, and environmental concerns.

1.2 Project Goals

The scope of this project included the structural design of WPI's new proposed residence hall, located at 30 Dean St. Two designs were developed and compared. A foundation design was also developed to support the selected superstructure design. While the as-built structure is supported by a slab on grade foundation, this project assumed that a basement level is required, and foundations were designed accordingly. Finally a cost estimate made with regard to both steel and concrete designs was evaluated as a factor in the selection of which design was most appropriate.

2. Background

2.1 The Need for a New Residence Hall

WPI has several reasons for constructing a New Residence Hall. Over the past few decades, WPI has been under a period of continued growth both in academic facilities and student body. To accommodate that growth, WPI has taken steps to increase their undergraduate housing. Most WPI Freshmen live in on-campus housing; however, many upperclassmen choose to live off campus, or cannot be accommodated with existing housing capacity. The purpose of this New Residence Hall is two-fold: to bring upperclass students back to the campus, and to revitalize the lower campus of WPI. (Worcester Polytechnic Institute, 2007). To bring upperclass students back on campus, the building is configured as approximately 60 4-person apartments each with a full kitchen, living room, bathroom, and either single-occupancy or double occupancy bedrooms. Scheduled to be open at the beginning of the 08-09 academic year, the building will also include amenities such as wireless internet access, air conditioning, space for students to work in project groups, as well as recreation and fitness spaces (WPI, 2007). While not studied in this MQP, the construction project also includes a parking garage with a capacity of 189 vehicles and renovation of the existing Founders Hall to include a restaurant serving appetizers, sandwiches, tea, coffee, soda, beer and wine. (WPI, 2007).

2.1.1 Goals for the Structure

WPI wants to encourage sustainable design. Therefore, a priority for WPI is that this New Residence Hall be Eco-Friendly. Out of concern for the new hall's impact on the environment, WPI has decided to earn a LEED accreditation for the New Residence Hall. Standing for Leadership in Energy and Environmental Design, LEED provides project owners with guidelines for best practices in sustainable, energy-efficient, and environmentally responsible design (USGBC 2007).

Another major concern for WPI and something that is a concern for any urban university is the severe lack of parking. WPI is attempting to address this with the construction of the 189 space parking garage adjoining the residence hall. This parking garage is the first on WPI's campus and should help to alleviate the lack of parking on WPI's campus (WPI 2007).

Another benefit of the New Residence Hall is to revitalize WPI's lower campus. The New Residence Hall features a number of community spaces including fitness areas, conference rooms, and tech suites. Combined with the new dining facilities at the Goat's Head Restaurant, WPI hopes this will provide a place for more upperclassmen to interact and become more of a community (WPI 2007).

The goals and priorities of the project owner are addressed in the architectural plan developed by Cannon Design. While developing our structural systems, any layout changes made were made keeping these priorities in mind. Additionally, when evaluating our structures, these considerations were also relevant to the selection of the better design.

2.1.2 Applicable Loads

The structural frame of the building must be designed to resist all loads that can be expected to be applied to it over the course of the structure's predicted lifecycle. These loads include self-weight of structural elements, other dead loads such as equipment and the weight of the green roof, occupancy live loads, construction loads, wind load, earthquake load, and snow load. Values for live load and snow load were obtained from the Massachusetts building code, 780 CMR 1600. Wind load was calculated using the simplified design procedure of ASCE 7-02.

Dead loads for structural systems were calculated on a unit weight of materials basis. Other dead load, such as non-structural partitions, MEP elements, and finishes were included based on a weight per square foot consistent with values used in design exercises in previous coursework (CE3010, CE3008, CE3006). The dead weight of the curtain wall was estimated parametrically. Knowing that the building was to have a brick veneer, the thickness of available brick veneer systems was researched. We were unable to find a reliable source for the unit weight of brick materials, so this value was calculated by purchasing 10 bricks from a home improvement store and measuring their volume and weight. The green roof was also a unique load that the project team had not worked with before. The weight of this system was calculated based on the unit weight of saturated topsoil and an assumption of a 6” thick layer.

2.2 LEED Sustainable Design Certification and Design Impact

For the reasons discussed above, WPI chose to design this New Residence Hall to meet the criteria of the Green Building Council and earn a LEED certification. In summary, LEED stands for The Leadership in Energy and Environmental Design, and is run by the U.S. Green Building Council. This system is the Green Building Rating System and is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED advocates a whole-building approach, focusing on five key areas of environmental and individual health: site development, water saving, energy efficiency, material selection, and indoor environmental quality (USGBC 2007). LEED provides a roadmap for measuring and documenting success for every building type and phase of a building lifecycle. LEED was developed to provide the building industry with a single creditable standard for green construction process, and is constantly refined by an open consensus-based process. A project is eligible for a LEED certification if it can meet a set of prerequisites, and achieve number of points to earn the certificate. Multiple levels of LEED project certification can be achieved based on the number of points earned. Projects are awarded Certified, Silver, Gold, or Platinum certification depending on the number of credits they earn. These credits have multiple values and are distributed among the five categories mentioned. Each category must receive a minimum score to obtain the certification. These guidelines are how LEED plans to help the building industry become more energy efficient and environmentally responsible (United States Green Building Council, 2007).

This Project falls under the LEED-NC category of the program that is designed for multiple buildings and on Campus Buildings. The Application and ways the building can earn points towards a LEED certification are included in the Appendix.

The largest impact of LEED compliant design on the structural design comes from the green roof. The extra weight significantly increases the requirements for the design of the roof structural members, as discussed in section 2.1.2.

2.3 Steel Superstructures

There are many different types of steel with yield points varying from 24 to 100 ksi. This range in strength is largely due to the variety of component metals which can be used in the manufacturing process and even changes in the manufacturing process itself can play a significant role in the strength and other properties of steel. By far the most common type of steel used in the United States is A992 steel, which was established by the ASTM (American Society for Testing and Materials) as the standard steel of construction and possesses a yield strength of 50 ksi and an ultimate strength of 65 ksi. A992 is also readily available in many shapes and sizes, from sheet steel to wide-flange-beams, again making it ideal for common use and design. A992 is the preferred material for wide-flange sections, and is recommended for other shapes when available (AISC 2005).

Steel design is commonly conducted with regard to two different methods. These design methods are.

1. Allowable Strength Design (ASD)
2. Load and Resistance Factor Design (LRFD)

Each have their own advantage and are more conservative in some cases than the other.

2.3.1 Allowable Strength Design

Allowable Strength Design (ASD) is the method in which the allowable strength of the structure must be more then the strength of the structure determined through ASD loading. It is based off the idea that the structure not exceeds the elastic limit that is the limit at which any further deformation becomes permanent. Typically this limit is established through the use of a factor of safety this factor of safety is the same across the board for both Live and Dead loads of the structure.

2.3.2 Load and Resistance Factor Design

Load and Resistance Factor Design (LRFD) is a method used nearly universally outside of the United States and to some extent within the United States. In this method the structure must be designed for two states, ultimate limit state and serviceability limit state. Ultimate limit state involves the building and its ability to not collapse under peak design loads. In order for this to be true factored resistance to bending, shear and tensile and compressive stresses must be found. Serviceability limit state has to do with the comfort of the occupants inside such as deflection, swaying. Often this value is greater than the value calculated for the Ultimate Limit state so it is unnecessary to make design changes.

The way which LRFD most varies from ASD is in the way that loads are factored. Equations exist regarding the probability of failure. Some factors which are factored into these equations are variability in construction quality, and consistency of materials. Loads which are attributed as more important such as dead loads are given a lower factor then other loads which may be highly variable such as wind, earthquake or service loads. Typically this type of structure is much more lean and efficient than those designed through ASD.

2.3.3 ASD vs. LRFD

Both of these methods are used to design steel structures and are perfectly safe and legitimate. ASD on occasion can give a more conservative value then LRFD but in order for this to be true live load must exceed dead load by a ratio of 3 or lower. With a higher live to dead load ratio LRFD will give a more conservative result. Both can be related to one another through common factors. Finally for some reason the United States has been slow to adopt LRFD while the rest of the world has. There is no particular reason for this except for the experience in ASD already exists.

2.3.4 Limit States

To analyze a structural system, there are several limit states that can be investigated: the elastic capacity and the plastic capacity of a flexural member, or the limit states of local and general buckling. Buckling limit states are evaluated for all members, while the difference between elastic and plastic capacity primarily applies to flexural members. Compression members usually fail by Euler buckling, plastic failure, or some combination of the two. The failure mode is predicted by the column slenderness, KL/r. Flexural members are usually selected with member geometries such that the limit states of local buckling are greater than that of cross-section plastification, and structural systems are usually designed so that the compression flange of the beam is braced to prevent lateral-torsional buckling (McCormac, 2008). Elastic capacity is the limit state in which failure is predicted to occur as soon as the extreme fibers reach their yield stress. This is expressed in the equation for ultimate moment $M_u=F_yS_x$ where S_x is the section modulus and F_y is the yield stress of the material. Comparatively, plastic capacity allows for the entire cross-section to reach yielding before failure occurs by the formation of a plastic hinge (Fitzgerald, 1982). In this case, the section modulus is replaced by the plastic section modulus. The use of plastic capacity design allows for greater capacities. ASD has provisions for the use of both elastic and plastic design, while LRFD exclusively uses plastic design.

Additionally, for statically indeterminate structures, such as rigid frames or other moment resisting structures, additional capacity can be calculated through the evaluation of moment redistribution. In a statically determinate system, the formation of one plastic hinge makes the system unstable and causes collapse. When the structure is indeterminate, more than one plastic hinge will be required to cause collapse. In this case, the structure will have additional capacity beyond that predicted by plastic design.

2.4 Concrete Superstructures

Reinforced concrete is a widely used building material all over the world. In many places, concrete can provide advantages over steel construction: the local availability of its constituent parts (cement, aggregates, water, and reinforcing steel), the comparatively simple skills required to install it compared to steel, the required lead time for shop fabrication of steel, and in some regions, economy of cost mean that it is widely used as a building material (Macgregor & Wight, 2005).

As a construction material, concrete is isotropic, but is much stronger in compression than in tension. This makes concrete alone ill-suited for applications where it will be subjected to applied tension or flexure. However, steel is very strong in tension. By including steel in regions of concrete members subject to tension and ensuring composite action of the two materials, concrete becomes an effective material in construction (MacGregor & Wight, 2005).

As a construction material, concrete has many advantages: economy, fire resistance, rigidity, low maintenance, and material availability. Because concrete materials are available locally, the direct costs of concrete may be lower than steel. Additionally, because concrete does not require the fabrication lead time of steel, a project owner may realize cost savings through the earlier project completion. The comparison of the direct cost of the use of steel or concrete will be discussed in this project. In terms of fire resistance, concrete inherently provides a fire-rating between one and three hours. Comparatively, steel and timber construction both require special fireproofing treatments to attain required fire resistance rating. Because concrete is a much more rigid material than steel, the effects of wind sway and vibration are reduced, increasing occupant comfort. These advantages all affect the decision of project owners, architects, and engineers to use steel or concrete (MacCormac & Wight, 2005).

2.5 Foundation Background

Foundations are an essential part of a building. The function of a foundation is to transfer all the loads from the structure to the ground. The primary considerations which a designer must deal with are the bearing stress of the building caused by the building and the ability for the soil to support said load. Other then soil conditions there are any number of special environmental conditions which must be taken into account. These include frost heave, Damage caused by freeze-thaw cycling, the effects of chlorates used for ice removal on surrounding areas, or even areas prone to natural hazards such as hurricanes. A well documented and studied example of a building with an inadequate foundation can be seen in the "Leaning" Tower of Pisa (Coduto 2001).

There are Primarily Two types of Foundations. These are:

1. Shallow Foundations
2. Deep Foundations

2.5.1 Shallow Foundations

This type of foundation only extends typically a meter below the ground. Modern shallow foundations are almost completely made of reinforced concrete. This type of foundation transfers force into the soil almost entirely vertically. Advantages of a shallow foundation are it is often much easier to build then deep foundations due to all the work going on at comparatively easy to reach to depths (Coduto 2001). Shallow foundations are simpler to construct and therefore cost much less money than deep foundations often do. Unfortunately these foundations are only feasible in an area in which ground level soil is sufficiently compacted (Coduto 2001).

Shallow Foundations can be divided up into the following subtypes

- Slab-on-Grade Foundation
- Mat Slab Foundation
- Spread Footing Foundation

Slab-on Grade Foundation

Slab on Grade type foundation is a foundation which in which a mold for the foundation is set directly into the ground. The concrete is then poured leaving no space between the concrete and soil. This type of foundation is used largely in warmer environments where there is no risk of freezing and there is no need for floor insulation (Coduto 2001).

Advantages of this foundation include it being incredibly cheap and easy to produce as well as sturdy and resilient to termites as there are limited spaces for termites to hide. Disadvantages include poor access to utilities, lack of insulation so loss of heat and thereby money through the ground. Another disadvantage is caused by the low profile and closeness to ground which increases vulnerability to flood damage. Furthermore it is often difficult to renovate or expand a structure with a Slab-on-Grade foundation. Finally soil settling can present serious trouble with these foundations as it is much more difficult to jack up the whole slab then it would be simply to perform work on a single footing.

In spite of all these drawbacks efforts can be made to minimize them. Settling can be minimized by compaction of the soil before construction is undertaken; it is still taken into account during the design procedure. Insulation can be put down before the concrete is poured helping with heat loss issues, though these solutions do add considerable expense to the process. Also special care must be taken with the utilities as copper can react negatively with concrete causing premature determination and all electrical conduits must remain watertight due to the high likelihood of them encountering moisture in the slab. Despite these drawbacks and limitations slab on grade provides the best cost versus value ratio of any other foundation type (Coduto 2001).

Mat Slab Foundation

Mat Slab Foundations are similar to Slab-on-Grade in that they encompass the whole footing of a building but are different in that they are often but at the bottom of basements and are often not on grade with the ground. They are typically used when the loads would result in spread footings which would encompass more than half of the overall footing (Coduto 2001).

Mat-Slab footings are advantageous in situations which requires great heavy loading in a small area. They make load transfer between one area of the foundation to the other as they often have complicated internal reinforcement which balances and distributes loads. These foundations can be expensive as they often require more material to be used in their construction then is needed. These foundation types are often used in High-rise buildings in which support extremely heavy loads in a small area. In those examples loads can be high requiring a slab depth of several meters (Coduto 2001).

Spread Footing Foundation

Spread Footing Foundations are pads of typically concrete (others can be used) which are placed directly under columns to support the loads transferring them to soil or bedrock. These footings are embedded which controls lateral capacity, penetration of soft near-surface layers and layers likely to change volume due to frost heave. These pads may either be rectangular or circular. Also these foundations may be continuous typically if they support the foundation wall. It is most often used for small to medium structures which may not have great loads but may also be used for larger structures (coduto 2001). The current Foundation design of the New Residence Hall utilizes square footings.

Deep Foundations

Deep Foundations are typically used when suitable soil cannot be found near the surface. Therefore it is necessary for the foundations to be deep enough to reach either bedrock (at a considerable distance) or to create enough shear stress with the surrounding soil. Piles are typically placed under various columns and other sources of loads. There are many different types of deep foundations but most consist of various forms of caissons or piles which are driven or sunk to a certain depth. Deep foundations tend to run more expensive then shallow foundations but are necessary in certain situations (Coduto 2001).

2.5.2 Foundation Walls

Foundation walls typically consist of concrete, masonry, or steel retaining wall which holds back rock or soil from the building's basement. It also resists groundwater preventing flooding of the lower levels of the structure. The soil and rock which the retaining wall holds back places a horizontal pressure upon the wall which must be countered using a variety of systems furthermore if the foundation wall is below the water table pore water pressure also exerts a force on the wall. The systems which prevent retaining walls from being overturned are divided up into 4 types.

- Gravity Wall
- Piling Wall
- Cantilever Wall
- Anchored Wall

Gravity Wall

Gravity walls are dependent on their mass to resist lateral earth pressure. They often have a slight setback and are wider towards the bottom to resist overturning moments. Though in the past these were commonly used for large foundation walls, currently large walls are often built as composite gravity walls with some other mechanism to prevent their overturning and failure (Coduto 2001).

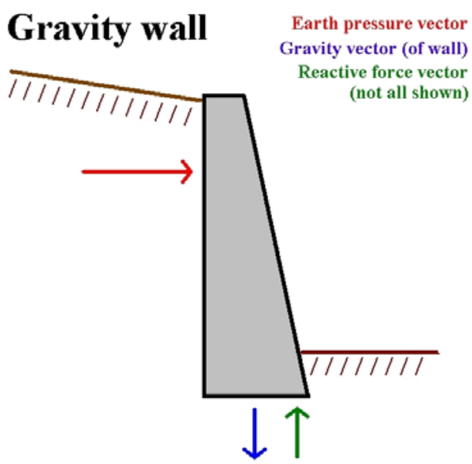

Figure 2-1: Gravity Wall Schematic

Piling Wall

Often used in soil conditions which are soft or in space restricted areas, Pile walls are typically of driven steel, timber, or plastic. Design for this type of wall can get extremely complex but as a rule of thumb 1/3 of the pile is above ground and the other 2/3 is below ground level. Drainage is extremely important with this type of wall far more important than with other designs as excessive hydrostatic pressure will compromise the piles (Coduto 2001).

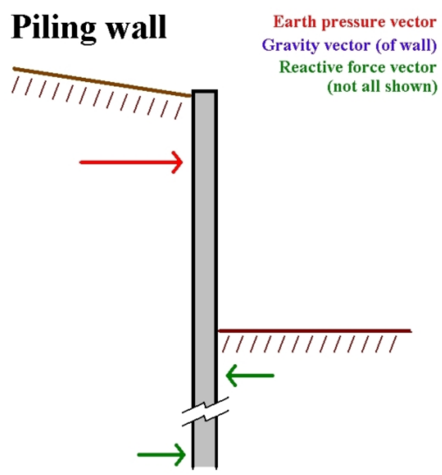

Figure 2-2: Sheet Piling Wall Schematic

Cantilevered Wall

Once the most common type of wall for taller applications, cantilever walls are typically made of thin steel sheeting, cast-in-place concrete, or mortar masonry. They are typically placed in an inverted T shape. Using a cantilever action caused by their large footing they convert horizontal pressure on the wall into vertical pressure to the ground. They also sometimes feature buttresses to the right angle of the wall in order to improve stability. It is important that these walls have rigid concrete footings below the frost line to prevent frost heave (Coduto 2001).

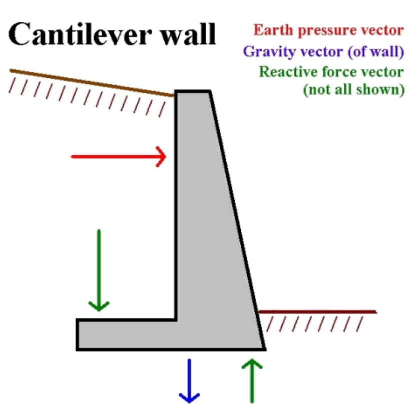

Figure 2-3: Cantilever Wall Schematic

Anchored Wall

Anchored foundation walls utilize an anchored support or tieback to connect one of the sides of the wall to rock or some other solid material via a cable. Highly mechanically complex this method is best employed with very high loads or when constraints would cause the walls area to be to slender (Coduto 2001).

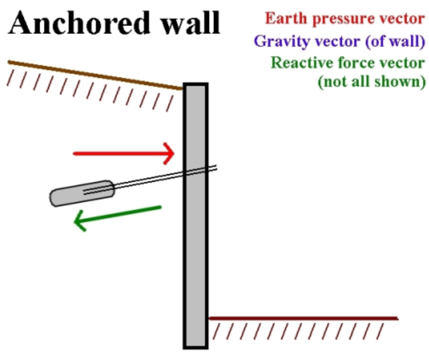

Figure 2-4: Anchored Wall Schematic

3. Methodology

3.1 Project Schedule

This project was completed over the course of the 2007-2008 Academic year. In A term, we began with background research. This included identifying any special concerns to be addressed due to the sustainability features of the New Residence Hall, as well as the applicable loads to be used for the gravity and lateral-force resisting systems. Lateral loads were calculated using the ASCE 7-02 simplified wind design procedure. Occupancy loads were taken from the Massachusetts Building Code (780 CMR 1600). During B term, the steel superstructure was designed. In C term, the concrete structure and foundations were designed. D term was devoted to developing a cost estimate and to writing the report.

3.2 Determination of Loads

Dead loads were determined based on the weight of materials used in construction. Live loads were taken from the Massachusetts Building Code, 780 CMR 1600. These gave a live load of 100 psf, and a dead load of 50 psf. Based on these square-foot weights, the load combination $W=1.2D_L+1.6L_L$ was the governing combination for the floor slab, beams, and columns. This gave a factored load of 220 psf, not including the self-weight of beams, girders, and columns. The weight of the exterior wall was calculated based on the density and thickness of commercially available veneer brick systems: this gave a weight of 51 pounds per lineal foot of wall at each story. The imposed moments, shears, and deflections were calculated using techniques of structural analysis and beam tables from MacGregor and Wight and from the AISC Steel Construction Manual. For beams with both distributed and point loads applied to them, the principle of superposition was used to calculate these values. Steel beams and girders were designed as pin-ended members, while the concrete structure was analyzed as partially fixed-ended, using a typical positive moment of $\omega l^2/10$.

3.3 Steel Design

The steel superstructure was designed using the design procedure from the 13th edition of the AISC Steel Construction Manual. Beams and girders were given an initial size, based on superimposed moment. This moment was calculated using the beam equations from table 3-23 of the Steel Construction Manual. Only wide-flange compact sections were considered. If this moment capacity was sufficient, the additional moment due to the self-weight of the beam was added, and moment was checked again. The beam was also checked for its shear capacity and its service deflection is checked. Allowable deflection was limited to L/300. Beams were designed to resist applied loads without any composite action with the concrete slab above.

Columns were designed using the same resources as beams. Column size was selected based on the minimum dimension required to accommodate connections with the specified beam sizes and axial load. Only wide-flange sections with an acceptable width to depth ratio (b/d) were considered.

3.3.1. Beam Design Procedure

Except for very short steel sections, moment capacity will generally be the limiting capacity of a beam (MacCormac 2005). Therefore, using plastic design, the governing equations are:

$$\Phi * M_p \geq M_u$$

And

$$M_p = Z_x * F_y$$

Where Φ is the resistance factor, M_p is the nominal moment capacity of the beam, M_u is the applied moment, Z_x is the plastic section modulus of the selected section, and F_y is the yield stress of the steel. For A992 steel, F_y is 50 ksi. For flexure, Φ=0.90. Based on these equations, we calculated a required plastic section modulus, Z_x, for each beam. An appropriate beam size was selected from the Steel

Construction Manual table 3-2: W Shapes, selection by Z_x. After selecting a trial size, the additional moment caused by the self-weight of the beam was added to the superimposed moment value, and compared to the moment capacity of the beam.

After checking moment capacity, the beam's shear capacity was checked. The governing equations are:

Φ*0.$V_p \geq V_u$

and

V_p=0.6*A_w*F_y

Where V_p is the nominal shear capacity, V_u is the applied shear, and A_w is the area of the web of the beam. This is also the limit state of beam yielding that is evaluated in the connection design.

The beam must also not exhibit deflections greater than allowable during service conditions. Except in special cases involving precision machinery or other special requirements, allowable deflection is limited to L/300 (MacCormac 2005). The measured deflection is calculated based on the unfactored live load. For example, the deflection of a beam subjected only to a distributed load would have a maximum deflection at its midpoint equal to $\frac{5\omega l^4}{384EI}$. If the predicted deflection was less than the allowable, the trial beam size was selected. If at any point in the design procedure the trial size was insufficient, a new size was selected and its shear and moment capacities and deflection are checked again.

3.3.2. Column Design Procedure

Column Design is slightly more complicated than the beam design procedure. While in practice, column sizes were selected using table 4-1 from the AISC Steel Construction manual, this section will discuss the mathematical basis for this table. For doubly symmetric members, including W-shape sections used in this design, the critical limit state is flexural buckling. Φ for compression is equal to 0.90. The governing equations are:

$\Phi P_n \geq P_u$

And

$P_u = F_{cr} * A_g$

Where A_g is the gross cross sectional area of the member, and F_{cr} is the flexural buckling stress. F_{cr} was calculated based on the slenderness ratio of the column, and the elastic critical buckling stress, or Euler buckling stress. Euler buckling is a function of the slenderness ratio, KL/r. For this building, the braced frames prevented any sidesway: this means that a K value of 1.0 is conservative. L is the unbraced length, and r is the minimum radius of gyration. The Euler buckling stress is defined by the following equation:

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

Where E is the elastic modulus of steel. The value of F_{cr} is dependent on the ratio of the Euler stress to the yield stress:

$$F_{cr} = \left\{ \begin{array}{c|c} \left[0.658^{\frac{F_y}{F_e}}\right] F_y & F_e \geq 0.44 F_y \\ 0.877 F_e & F_e < 0.44 F_y \end{array} \right\}$$

In no case does the AISC specification allow a column with a slenderness ratio over 200.

3.3.3. Connection Design Procedure

All connections in this project were designed to be bolted connections. Connections were designed with sufficient strength to resist applied shear in 5 limit states: shear yielding, shear rupture, block shear failure, bolt shear, and bolt bearing. The available strength under each limit state multiplied by the appropriate limit factor must be greater than the applied shear. Additionally, other minimum dimensional requirements are imposed by the AISC standard (2005).

Shear yielding is yielding in the overall cross section of the connected members. For shear yielding, the available strength of a connection is given by $R_n = 0.6F_yA_g$, where A_g is the gross area subject to shear. Φ=1.00 for shear yielding. Both connected members, as well as the connecting angle, must be evaluated for this limit state. Shear rupture is a limit state characterized by sudden brittle failure in the local region of the connection. For the shear rupture limit state, the available strength is given by $R_n = 0.6F_uA_n$, where A_n is the net area subject to shear, and F_u is the ultimate strength of the material. Φ=0.75 for shear rupture. All components must be evaluated for shear rupture capacity. Block Shear failure is a limit state that occurs when a connection ruptures along one shear plane, and yields along a perpendicular plane, causing the tearing out of a block of material in the connection, causing a failure. The available strength is given by $R_n = 0.6F_uA_{nv} + F_uA_{nt} \leq 0.6F_yA_{gv} + F_uA_{nt}$, where A_{nv} and A_{gv} are the net and gross areas subject to shear, respectively. Φ=0.75 for block shear failure.

The last two limit states of connection design deal with the bolts and bolt holes. For bolt shear, available strength is given by $R_n = F_nA_b$, where F_n is the nominal shear stress, taken from table J3.2 of the AISC specification (2005), and A_b is the nominal cross-sectional area of the bolt. The nominal area is calculated without consideration of the removal of material for thread forming. Instead, depending if threads are included or excluded from the shear planes of a connection, the allowable shear stress is adjusted by table J3.2. For bolt shear, Φ=0.75. This limit state applies to the bolts. For bolt bearing strength, assuming that connection deflection is a design concern, the available strength is given by $R_n = 1.2L_ctF_u \leq 2.4dtF_u$, where *t* is the thickness of the connected material, L_c is the clear distance between the edge of the hole and the next hole or edge of the plate, and d is the nominal bolt diameter. The bearing strength capacity of the connection is given by the sum of the bearing capacities of the individual bolts. For bearing strength, Φ=0.75.

3.4 Concrete Design

Concrete members were designed in accordance with ACI 381-02: *Building Code Requirements for Structural Concrete*, as expressed in the textbook used in the reinforced concrete course: *Reinforced Concrete: Mechanics and Design* (MacGregor & Wight, 2005). Calculations were done with a custom spreadsheet designed to calculate the required size of the beam, as well as tensile reinforcement for positive moment and negative moment, and shear reinforcement required. These values were then used as inputs for a second spreadsheet used to calculate required properties of columns. Both of these spreadsheets can be found in the appendix. All beams are designed with 4000 psi concrete. Columns use 3000 psi concrete, because the design interaction diagrams included in MacGregor & Wight are only applicable to 3000 psi concrete.

3.4.1. Beam Design Procedure

Like the steel structure, beam design for concrete is also carried out primarily on the basis of applied moment. As described in section 3.2, maximum positive moment, negative moment, and shear are determined using the techniques of structural analysis. For beams with only distributed loading, a minimum shear value is also calculated for later use when designing the shear reinforcement. Calculation began with an estimate of the dead weight of the beam. This was added to the applied moments used to calculate M_u. Based on the applied moment and value of ΦK_n, a value of bd^2 was calculated. This gave initial values for the width and depth of the beam, using the following equation:

$$\frac{M_u}{\Phi K_n} = \frac{bd^2}{12{,}000}$$

Based on the selected beam width, our spreadsheet calculated d, and corrects the original estimate of beam weight. The spreadsheet will then iteratively adjust beam weight and depth to convergence.

To calculate the required reinforcement, further iterative calculation was required. The equation used to calculate the required area of steel is

$$A_s = \frac{M_u}{\Phi F_y jd}$$

Where $jd = \left(d - \frac{a}{2}\right)$ is initialized with a value of 0.875*d*. Based on the required area of steel A_s, positive reinforcing steel was selected to provide more steel than the required A_s. At this point, the depth of the Whitney stress block is calculated. This was used to check if the section is tension controlled, and eventually to check moment capacity. If the section was not tension controlled, $\Phi = 0.75$ was used instead of $\Phi = 0.90$. At this point, positive moment capacity was calculated using the following equation:

$$M_n = A_s F_y \left(d - \frac{a}{2}\right)$$

This was multiplied by the resistance factor Φ and checked against the applied moment. The design process for flexural steel was repeated to determine a reinforcement configuration for the regions of the beam subjected to negative moment.

After selecting all flexural steel, shear reinforcement was selected. For this project, all shear stirrups are #4 Gr. 40 double leg ties. The spreadsheet determined the spacing required for stirrups at the point of maximum moment based on the required shear strength and the available shear capacity of the concrete without stirrups. For economy, the spreadsheet also calculated the point (if any) at which the shear stresses are low enough to permit an increase in stirrup spacing to 12", and determined the point where stirrups are not needed.

3.4.2. Column Design Procedure

Concrete column design was completed through the use of interaction diagrams from MacGregor & Wight. Because these diagrams are all calculated based on concrete with f_c' = 3000 psi, this is the concrete specified for use in the columns. All columns were designed as square, non-slender columns, with reinforcement in either 2 or 4 faces, based on the e/h ratio, where e is an eccentricity found from the ratio of applied moment to the applied axial load, and h being the height of the column. For eccentricity ratios less than 0.2, columns with reinforcement in 4 faces were used. For columns with eccentricity ratios greater than this, columns with reinforcement in two faces were used. To calculate the required dimensions, a reinforcement ratio ρ_t of 1.5% was used as a trial value. Based on this, the required area was found using this equation:

$$A_{g\ (trial)} = \frac{P_u}{0.40(f'_c + F_y \rho_t)}$$

Where f'_c and F_y are the concrete and steel yield strengths, respectively. The square root of this value was taken and rounded up to give the required size of the column in inches. If this yielded a slender column, the size was increased until an acceptable slenderness ratio was reached. Based on table C-C2.2 from the AISC manual (Approximate values of Effective Length Factor), a design value of K of 1.2 was used. For concrete design, a slenderness ratio greater than 28 is a slender column (MacGregor & Wight, 2005). Column sizes are selected to be below this minimum threshold.

The actual required steel ratio was calculated using the interaction diagrams from MacGregor and Wight. These diagrams are calculated for particular values of γ. γ is calculated based on the size of the column compared to the amount of cover over the bars. Assuming #8 reinforcing bars (a median size for this application) and #3 ties (typical),

$$\gamma = \frac{d - 2(2.375)}{d}$$

Based on the ratios of P_u/A_g and M_u/A_gh, values of ρ_t were selected from the interaction diagrams with γ greater and less than the calculated γ for the column. Using linear interpolation, an appropriate value of ρ_t is selected. In no case is a ρ_t less than 0.01 used (ACI 10.9.1). Using this value, the required area of steel was calculated:

$$A_{st} = \rho_t A_g$$

An arrangement of reinforcing bars that met the required area and allowed an equal number of bars in all faces with reinforcement was selected.

Between each floor, lap splices are required. The length of these splices was calculated using the following equation:

$$Splice\ Length = 1.3\left(\frac{F_y \alpha \beta \lambda}{20\sqrt{f'_c}}\right) d_b$$

Where in all cases used here, α, β, and λ equal 1.0, and d_b is the diameter of one reinforcing bar.

The final element in specifying the column is the spacing of ties. From ACI 7.10.5.2, The spacing used was the minimum of:

- 16 longitudinal bar diameters
- 48 tie diameters
- Least dimension of the column.

3.5 Foundation Design

The foundation design for the New Residence Hall foundation can be broken down into a series of steps. These steps are as follows.

1. Soil Analysis
2. Develop Approximate Footing Size
3. Design Footing Reinforcements
4. Develop Foundation Wall Designs

These four steps are general and encompass many other smaller tasks, but present a relatively accurate picture of the work which was conducted in order to analyze the forces and develop an adequate design to deal with said forces. Because of the importance of intermediate values to the significance of our foundation results, calculation procedure is discussed in section 4.3: Foundation Results.

3.6 Cost Estimating

One of the primary criteria for comparing the steel and concrete designs is cost. After designing both superstructures, quantities of all materials used in the construction of each were taken off. Once quantities were determined, price data from the RS Means Building Construction Cost Data 2007 were used to determine trade costs for the construction of each system. Construction began on the project in March 2007, and will be completed in August 2008. Prices were escalated to the midpoint of construction. The pricing from RSMeans is a national average. These values were adjusted to construction using the City Cost Indexes from the same source. Adjustment factors were applied individually to CSI MasterFormat 2004 Divisions.

For the steel structure, the RS Means book had two available pricing structures: one provided pricing based on lineal feet of particular sections, with an adjustment based on total project weight, and a second based on building function and total weight. The cost of the steel was based on the pricing listed for the first option, as this seemed more accurate. However, the cost predicted based on the second method was also calculated as a check.

For the concrete structure, the takeoff was slightly more complicated. Based on the beams specified in the design, the total volume of concrete was taken off in cubic yards. Rebar was taken off in lineal feet for each bar size, multiplied by the unit weight per foot of that size, and a total weight of reinforcement calculated. Formwork was taken off in square feet of contact area based on reuse of formwork three times. RS Means had cost data for formwork based on 1-5 uses; without actual construction techniques to compare to, a median value was selected.

4. Results

4.1 Steel Structure

As described in the background, floors 2-5 have identical beam and column arrangements, while the first floor has a slightly different layout. Following the design procedure described in 3.2, the beam sizes of floors 2-5 are shown in Table 4.1, and Table 4.2 shows the specified column sizes for floors 2-5. The beam sizes of the first floor are shown in tables 4.3, and Table 4.4 shows column sizes for floors 1 and 2. Beam names are defined by the names of the columns at their endpoints. For beams with girders at one or both ends, that girder's name is enclosed in brackets and used instead of a column. The spreadsheets used to calculate beam and column sizes, as well as floor plans showing column names and locations can be found in the appendix. Figure 4.1 shows an example of a part of the second floor plan.

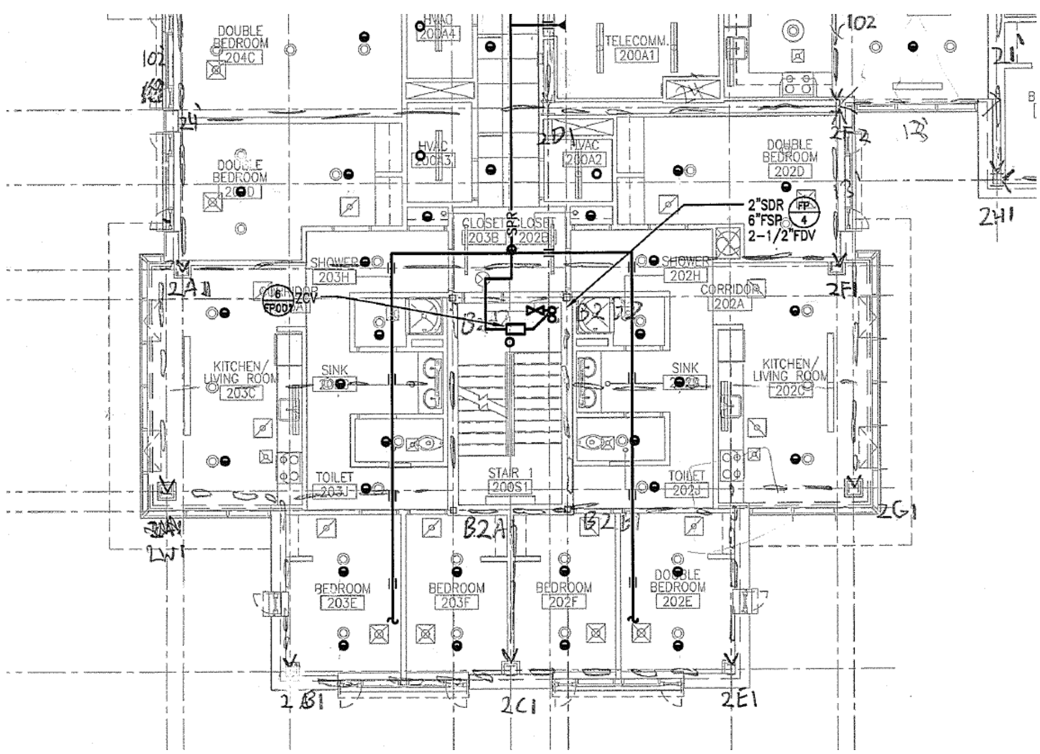

Figure 4-1: Sample Floor Plan

Table 4-1: Specified Steel Beam Sizes, Floors 2-5

Beam	Beam Size	Girder	Beam Size
	Floors 2-5		
Beam	Beam Size	Girder	Beam Size
2V1-B2H1	**W8x10**	2U1-2U2	**W21x48**
2V2-B2H2	**W8x10**	2U2-2U3	**W12x13**
2T1(-)	**W12x14**	2U3-2U4	**W18x35**
B2H1(-)	**W18x35**	2T1-B2H1	**W12x14**
B2H2(-)	**W18x35**	B2H2-2T2	**W12x14**
2T2(-)	**W12x14**	B2G1-B2G2	**W18x35**
2U1(-)	**W18x35**	B2G3-B2G4	**W18x35**
(-)2Q1	**W12x14**	B2F1-B2F2	**W18x35**
(-)B2E1	**W18x35**	B2F3-B2F4	**W18x35**
(-)B2E2	**W18x35**	2R1-2R2	**W18x35**
(-)2Q2	**W12x14**	2R2-2R3	**W21x48**
(-)2R1	**W21x48**	2Q1-B2E1	**W12x14**
2U2(-)	**W21x48**	B2E2-2Q2	**W12x14**
2U3(-)	**W21x48**	2P1-2P2	**W12x14**
(-)2R3	**W21x48**	2P2-2P3	**W12x14**
(-)2S1	**W8x10**	2P3-2P4	**W8x10**
B2G1-B2F1	**W12x14**	2P4-2P5	**W8x10**
B2G2-B2F2	**W8x10**	2O1(-)	**W12x14**
B2G3-B2F3	**W8x10**	(-)2O2	**W12x14**
B2G4-B2F4	**W12x14**	2V1(-)	**W12x14**
(-)2S2	**W8x10**	(-)2V2	**W12x14**
2S1(-)	**W8x10**		
2S2(-)	**W8x10**		
(-)(-)3	**W8x10**		
(-)(-)4	**W8x10**		
2R1-2P2	**W21x48**		
2R2-2P3	**W21x48**		
2R3-2P4	**W21x48**		
(-)2P1	**W18x35**		
(-)2P5	**W18x35**		
B2E1-3O1	**W8x10**		
B2E2-3O2	**W8x10**		

Floors 2-5	
Beam	Beam Size
2V1-B2H1	**W8x10**
2V2-B2H2	**W8x10**
2T1(-)	**W12x14**
B2H1(-)	**W18x35**
B2H2(-)	**W18x35**
2T2(-)	**W12x14**
2U1(-)	**W18x35**
(-)2Q1	**W12x14**
(-)B2E1	**W18x35**
(-)B2E2	**W18x35**
(-)2Q2	**W12x14**
(-)2R1	**W21x48**
2U2(-)	**W21x48**
2U3(-)	**W21x48**
(-)2R3	**W21x48**
(-)2S1	**W8x10**
B2G1-B2F1	**W12x14**
B2G2-B2F2	**W8x10**
B2G3-B2F3	**W8x10**
B2G4-B2F4	**W12x14**
(-)2S2	**W8x10**
2S1(-)	**W8x10**
2S2(-)	**W8x10**
(-)(-)3	**W8x10**
(-)(-)4	**W8x10**
2R1-2P2	**W21x48**
2R2-2P3	**W21x48**
2R3-2P4	**W21x48**
(-)2P1	**W18x35**
(-)2P5	**W18x35**
B2E1-3O1	**W8x10**
B2E2-3O2	**W8x10**

Table 4-2: Specified Steel Column Sizes, Floors 1-2

Floor 1-2	
Columns	Beam Size
1A1	**W10x30**
1A2	**W10x30**
1A3	**W10x30**
1A4	**W10x30**
1B1	**W8x13**
1B2	**W8x13**
B1A1	**W10x30**
B1A2	**W10x30**
B1A3	**W10x30**
B1A4	**W10x30**
B1B1	**W10x30**
B1B2	**W10x30**
B1B3	**W10x30**
B1B4	**W10x30**
1C1	**W8x13**
1C2	**W8x13**
1D1	**W10x33**
1D2	**W10x33**
1D3	**W10x33**
(1E1	**W8x13**
(1E2	**W8x13**
1F1	**W10x30**
1F2	**W10x30**
1F3	**W10x30**
1F4	**W10x30**
1F5	**W10x30**
1G1	**W8x13**
1G2	**W8x13**
1W1	**W8x13**
1W2	**W8x13**

Table 4-3: Specified Steel Beam Sizes, Floor 1

Floor 1			
Beam	Beam Size	Girder	Beam Size
1X1-1V1	**W8x10**	1X2-1X3	**W21x48**
1X7-B1H1	**W8x10**	1X3-1X4	**W12x14**
1V1(-)	**W12x14**	1X4-1X5	**W18x35**
1X2(-)	**W18x35**	1X6-1X7	**W12x14**
B1H1(-)	**W18x35**	B1H2-1W1	**W12x14**
1W1(-)	**W12x14**	B1F1-B1F2	**W18x35**
1X3(-)	**W18x35**	B1F3-B1F4	**W18x35**
(-)1S1	**W12x14**	B1G1-B1G2	**W18x35**
(-)B1E1	**W18x35**	B1G3-B1G4	**W18x35**
(-)B1E2	**W18x35**	1T1-1T2	**W18x35**
(-)1E2	**W12x14**	1T2-1T3	**W21x48**
(-)1T1	**W21x48**	1S1-B1E1	**W12x14**
1X4(-)	**W21x48**	B1E2-1S2	**W12x14**
1X5(-)	**W21x48**	1R1-1R2	**W12x14**
(-)1T3	**W21x48**	1R2-1R3	**W12x14**
(-)1U1	**W8x10**	1R3-1R4	**W8x10**
B1F1-B1G1	**W12x14**	1R4-1R5	**W8x10**
B1F2-B1G2	**W8x10**	1R5-1R6	**W12x14**
B1F3-B1G3	**W8x10**	1R6-1R7	**W12x14**
B1F4-B1G4	**W12x14**	1X1-1X2	**W12x14**
(-)1U2	**W8x10**	1X5-1X6	**W12x14**
1U1(-)	**W8x10**		
1U2(-)	**W8x10**		
(-)(-)1	**W8x10**		
(-)(-)2	**W8x10**		
1T1-1R3	**W21x48**		
1T2-1R4	**W21x48**		
1T3-1R5	**W21x48**		
(-)1R2	**W18x35**		
(-)1R6	**W18x35**		
B1E1-1R1	**W8x10**		
B1E2-1R7	**W8x10**		
1X6(-)	**W18x35**		

Floor 1	
Beam	Beam Size
1X1-1V1	**W8x10**
1X7-B1H1	**W8x10**
1V1(-)	**W12x14**
1X2(-)	**W18x35**
B1H1(-)	**W18x35**
1W1(-)	**W12x14**
1X3(-)	**W18x35**
(-)1S1	**W12x14**
(-)B1E1	**W18x35**
(-)B1E2	**W18x35**
(-)1E2	**W12x14**
(-)1T1	**W21x48**
1X4(-)	**W21x48**
1X5(-)	**W21x48**
(-)1T3	**W21x48**
(-)1U1	**W8x10**
B1F1-B1G1	**W12x14**
B1F2-B1G2	**W8x10**
B1F3-B1G3	**W8x10**
B1F4-B1G4	**W12x14**
(-)1U2	**W8x10**
1U1(-)	**W8x10**
1U2(-)	**W8x10**
(-)(-)1	**W8x10**
(-)(-)2	**W8x10**
1T1-1R3	**W21x48**
1T2-1R4	**W21x48**
1T3-1R5	**W21x48**
(-)1R2	**W18x35**
(-)1R6	**W18x35**
B1E1-1R1	**W8x10**
B1E2-1R7	**W8x10**
1X6(-)	**W18x35**

Table 4-4: Specified Steel Column Sizes, Floors 3-5

	Floor 3-5
Columns	Beam Size
3A1	**W10x19**
3A2	**W10x19**
3A3	**W10x19**
3A4	**W10x19**
3B1	**W8x13**
3B2	**W8x13**
B3A1	**W10x19**
B3A2	**W10x19**
B3A3	**W10x19**
B3A4	**W10x19**
B3B1	**W10x19**
B3B2	**W10x19**
B3B3	**W10x19**
B3B4	**W10x19**
3C1	**W8x13**
3C2	**W8x13**
3D1	**W10x30**
3D2	**W10x30**
3D3	**W10x30**
(3E1	**W8x13**
(3E2	**W8x13**
3F1	**W10x19**
3F2	**W10x19**
3F3	**W10x19**
3F4	**W10x19**
3F5	**W10x19**
3G1	**W8x13**
3G2	**W8x13**
3W1	**W8x13**
3W2	**W8x13**

As a sample, the column base plates and beam connection subject to the most extreme loading were designed as well. The specified connection is a bolted double-angle connection that connects beam 3F1-3G1 with Column G1, is fabricated from an A36 4 ½ X 4 ½ X $^{5}/_{16}$ single angle, and can be seen in Figure 4.2. The connection is made with 4 ¾" A325 bolts. We also determined that a column on a large footing would require a base plate 40" square and 1.5" thick, fabricated from A992 steel.

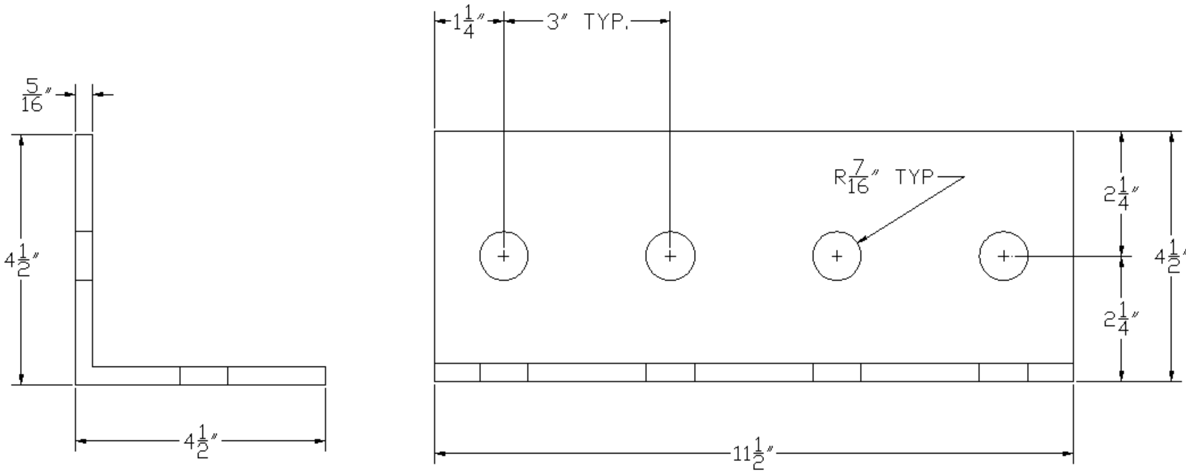

Figure 4-2: Steel Connection Angle

4.2 Concrete Structure

After an initial evaluation of beam A1-F1 we found that due to the long length of this beam, an unacceptably large cross-section would be required to support the loads of this beam. To address this issue, in the concrete design, additional columns were added at the midpoints of beams A1-F1 and A4-F5. These columns were named C3 and C4, respectively. This reduced the required sizes of all beams to acceptable levels. Beams and columns follow the same naming conventions as our steel design. Using the spreadsheets described in the methodology, and included in the appendix of this report, the specified sizes and reinforcement of the beams on floors 2-5 can be found in Table 4.5. The beams specified for use on the first floor can be found in Table 4.6. As described in the methodology, Different column sizes were specified for the first floor, second and third floors, and fifth and sixth floors. The specified column sizes for each of these conditions can be found in Tables 4.7, 4.8, and 4.9, respectively.

Table 4-5: Specified Concrete Beams, Floors 2-5

Floors 2-5									
Beam Name	Length	Width	Depth	Positive Steel	Negative Steel	length of negative steel	Initial Spacing	Change to 12" spacing	change to no stirrups
Units	feet	inches	inches			feet	inches	feet	feet
B1-C1	16	10	15	3 #6 bars	3 #5 bars	9.3	6.0	5.0	6.0
C1-E1	16	10	15	3 #6 bars	3 #5 bars	9.3	6.0	5.0	6.0
B1-[A0-BA1]	14	8	14	3 #6 bars	3 #5 bars	8.2	6.0	4.0	5.0
C1-[BA1-BB1]	12	8	16	3 #6 bars	2 #7 bars	7.0	7.0	4.0	5.0
E1-[3G1-BB1]	14	8	14	3 #6 bars	3 #5 bars	8.2	6.0	4.0	5.0
A0-BA1	18	9	12	2 #6 bars	2 #6 bars	5.3	3.0	N/A	N/A
G1-BB1	23	8	13	2 #6 bars	2 #7 bars	13.4	4.0	N/A	N/A
BA1-BA2	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3.0	N/A	N/A
BB1-BB2	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3.0	N/A	N/A
BA1-BB1	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2.0	N/A	N/A
BA2-BB2	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2.0	N/A	N/A
A0-A1	17	12	17	3 #7 bars	4 #7 bars	9.9	7.0	N/A	N/A
G1-F1	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7.0	N/A	N/A
[A0-A1]-[BA1-BA2]	22	12	17	3 #7 bars	2 #8 bars	12.8	7.0	8.0	N/A
[G1-F1]-[BB1-BB2]	22	12	17	3 #7 bars	2 #8 bars	12.8	7.0	8.0	N/A
A1-C3	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6.0	11.0	N/A
C3-F1	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6.0	11.0	N/A
A1-A2	26	13	17.5	3 #8 bars	3 #9 bars	15.2	4.0	N/A	N/A
F1-F2	13	9	14	2 #7 bars	2 #6 bars	7.6	6.0	4.0	5.0
D1-F2	22	14	20	6 #6 bars	5 #6 bars	12.8	7.0	10.0	N/A
D1-[A1-A2]	29	16	20	4 #8 bars	4 #7 bars	16.9	6.0	12.0	N/A
D1-D2	16	9	15	2 #7 bars	2 #9 bars	9.3	3.0	N/A	N/A
A2-[D1-D2]	29	16	20	4 #8 bars	4 #7 bars	16.9	6.0	12.0	N/A
D2-F3	22.5	20	20	5 #8 bars	3 #9 bars	13.1	5.0	11.0	N/A
F2-F3	13	9	14	3 #6 bars	4 #7 bars	7.6	6.0	5.0	N/A
D2-F3	23	12	19	4 #7 bars	3 #7 bars	13.4	8.0	9.0	N/A
F3-F4	23	11	19	3 #8 bars	2 #8 bars	13.4	8.0	8.0	10.0
[A2-A3]-[D2-D3]	29	16	20	4 #8 bars	4 #7 bars	16.9	6.0	12.0	N/A
A3-[D2-D3]	29	16	20	4 #8 bars	4 #7 bars	16.9	6.0	12.0	N/A
D3-[A3-A4]	29	16	20	4 #8 bars	4 #7 bars	16.9	6.0	12.0	N/A
D3-F4	22	14	20	6 #6 bars	5 #6 bars	12.8	7.0	10.0	N/A
A3-A4	26	13	17.5	3 #8 bars	3 #9 bars	15.2	4	N/A	N/A
F4-F5	13	9	14	2 #7 bars	2 #6 bars	7.6	6	4	5
A4-C4	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6.0	11.0	N/A
C4-F5	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6.0	11.0	N/A
BA3-BB3	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3	N/A	N/A
BA3-BA4	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3	N/A	N/A
BB3-BB4	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2	N/A	N/A
BA4-BB4	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2	N/A	N/A
F5-G2	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7.0	N/A	N/A
A4-A5	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7.0	N/A	N/A
A5-BA4	18	9	14.5	2 #6 bars	2 #6 bars	10.5	3.0	N/A	N/A
G2-BB4	23	8	13	2 #6 bars	2 #7 bars	13.4	4.0	N/A	N/A
E2-[G2-BB4]	14	8	14	3 #6 bars	3 #5 bars	8.2	6.0	4.0	5.0
C2-[BA4-BB4]	12	8	16	3 #6 bars	2 #7 bars	7.0	7.0	4.0	5.0
B2-[A5-BA4]	14	8	14	3 #6 bars	3 #5 bars	8.2	6.0	4.0	5.0
B2-C2	16	10	15	3 #6 bars	3 #5 bars	9.3	6.0	5.0	6.0
C2-E2	16	10	15	3 #6 bars	3 #5 bars	9.3	6.0	5.0	6.0
F2-[H1-H2]	13	8	14.5	4 #5 bars	2 #6 bars	7.6	6.0	4.0	5.0
F3-H2	13	12	16	4 #6 bars	5 #5 bars	7.6	7.0	5.0	6.0
F4-[H2-H3]	13	8	14.5	4 #5 bars	2 #6 bars	7.6	6.0	4.0	5.0
H1-H2	24	12	18	3 #8 bars	3 #7 bars	14.0	8.0	9.0	11.0
H2-H3	28	14	19.5	4 #7 bars	2 #9 bars	16.3	7.0	11.0	12.0
I1-I2	24	12	17.5	3 #7 bars	2 #8 bars	14.0	8.0	8.0	8.0
I2-I3	28	14	19	4 #7 bars	2 #9 bars	16.3	7.0	11.0	12.0
J1-J2	24	11	18	4 #6 bars	2 #8 bars	14.0	8.0	8.0	9.0
J2-J3	28	12	20	5 #6 bars	3 #7 bars	16.3	8.0	10.0	11.0
K1-K2	24	13	18	5 #6 bars	3 #7 bars	14.0	7.0	9.0	9.0
K2-K3	28	15	20	3 #9 bars	5 #6 bars	16.3	6.0	12.0	14.0
H1-I1	18	9	14	2 #7 bars	2 #6 bars	10.5	6.0	4.0	6.0
I1-J1	11.5	8	10.5	2 #6 bars	2 #5 bars	6.7	4.0	2.0	3.0
J1-K1	17	10	13	2 #7 bars	2 #6 bars	9.9	5.0	4.0	5.0
H2-I2	18	12	17	3 #7 bars	3 #7 bars	10.5	7.0	7.0	8.0
I2-J2	11.5	8	13.5	2 #7 bars	2 #6 bars	6.7	6.0	3.0	4.0
J2-K2	17	12	16.5	4 #6 bars	2 #8 bars	9.9	7.0	6.0	7.0
H3-I3	18	10	15	2 #7 bars	2 #7 bars	10.5	6.0	5.0	6.0

Table 4-6: Specified Concrete Beams, Floor 1

Floor 1									
Beam Name	Length	Width	Depth	Positive Steel	Negative Steel	length of negative steel	Initial Spacing	Change to 12" spacing	to no stirrups
Units	feet	inches	inches			feet	inches	feet	feet
B1-C1	16	10	15	3 #6 bars	3 #5 bars	9.3	6	5	6
C1-E1	16	10	15	3 #6 bars	3 #5 bars	9.3	6	5	6
B1-[A0-BA1]	14	8	14	3 #6 bars	3 #5 bars	8.2	6	4	5
C1-[BA1-BB1]	12	8	16	3 #6 bars	2 #7 bars	7.0	7	4	5
E1-[3G1-BB1]	14	8	14	3 #6 bars	3 #5 bars	8.2	6	4	5
A0-BA1	18	9	12	2 #6 bars	2 #6 bars	10.5	3	N/A	N/A
G1-BB1	23	8	13	2 #6 bars	2 #7 bars	13.4	4	N/A	N/A
BA1-BA2	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3	N/A	N/A
BB1-BB2	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3	N/A	N/A
BA1-BB1	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2	N/A	N/A
BA2-BB2	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2	N/A	N/A
A0-A1	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7	N/A	N/A
G1-F1	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7	N/A	N/A
[A0-A1]-[BA1-BA2]	22	12	17	3 #7 bars	2 #8 bars	12.8	7	8	N/A
[G1-F1]-[BB1-BB2]	22	12	17	3 #7 bars	2 #8 bars	12.8	7	8	N/A
A1-C3	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6	11	N/A
C3-F1	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6	11	N/A
A1-A2	26	13	17.5	3 #8 bars	3 #9 bars	15.2	4	N/A	N/A
F1-F2	13	9	14	2 #7 bars	2 #6 bars	7.6	6	4	5
D1-F2	22	14	20	6 #6 bars	5 #6 bars	12.8	7	10	N/A
D1-[A1-A2]	29	16	20	4 #8 bars	4 #7 bars	16.9	6	12	N/A
D1-D2	16	9	15	2 #7 bars	2 #9 bars	9.3	3	N/A	N/A
A2-[D1-D2]	29	16	20	4 #8 bars	4 #7 bars	16.9	6	12	N/A
D2-F3	22.5	20	20	5 #8 bars	3 #9 bars	13.1	5	11	N/A
F2-F3	13	9	14	3 #6 bars	4 #7 bars	7.6	6	5	N/A
D2-F3	23	12	19	4 #7 bars	3 #7 bars	13.4	8	9	N/A
F3-F4	23	11	19	3 #8 bars	2 #8 bars	13.4	8	8	10
[A2-A3]-[D2-D3]	29	16	20	4 #8 bars	4 #7 bars	16.9	6	12	N/A
A3-[D2-D3]	29	16	20	4 #8 bars	4 #7 bars	16.9	6	12	N/A
D3-[A3-A4]	29	16	20	4 #8 bars	4 #7 bars	16.9	6	12	N/A
D3-F4	22	14	20	6 #6 bars	5 #6 bars	12.8	7	10	N/A
A3-A4	26	13	17.5	3 #8 bars	3 #9 bars	15.2	4	N/A	N/A
F4-F5	13	9	14	2 #7 bars	2 #6 bars	7.6	6	4	5
A4-C4	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6	11	N/A
C4-F5	24	16	20.5	7 #6 bars	8 #5 bars	14.0	6	11	N/A
BA3-BB3	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3	N/A	N/A
BA3-BA4	17	7	12.5	2 #6 bars	3 #6 bars	9.9	3	N/A	N/A
BB3-BB4	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2	N/A	N/A
BA4-BB4	10	7	12.5	2 #6 bars	2 #6 bars	5.8	2	N/A	N/A
F5-G2	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7	N/A	N/A
A4-A5	17	12	16.5	3 #8 bars	2 #5 bars	9.9	7	N/A	N/A
A5-BA4	18	9	14.5	2 #6 bars	2 #6 bars	10.5	3	N/A	N/A
G2-BB4	23	8	13	2 #6 bars	2 #7 bars	13.4	4	N/A	N/A
E2-[G2-BB4]	14	8	14	3 #6 bars	3 #5 bars	8.2	6	4	5
C2-[BA4-BB4]	12	8	16	3 #6 bars	2 #7 bars	7.0	7	4	5
B2-[A5-BA4]	14	8	14	3 #6 bars	3 #5 bars	8.2	6	4	5
B2-C2	16	10	15	3 #6 bars	3 #5 bars	9.3	6	5	6
C2-E2	16	10	15	3 #6 bars	3 #5 bars	9.3	6	5	6
F2-[H1-H2]	13	8	14.5	4 #5 bars	2 #6 bars	7.6	6	4	5
F3-H2	13	12	16	4 #6 bars	5 #5 bars	7.6	7	5	6
F4-[H2-H3]	13	8	14.5	4 #5 bars	2 #6 bars	7.6	6	4	5
1H1-1I1	18	11	17	4 #6 bars	2 #8 bars	10.5	8	9	11
1I1-1J1	11.5	8	13	2 #6 bars	2 #6 bars	6.7	7	11	12
1J1-1K1	8	8	10	2 #5 bars	2 #5 bars	4.7	8	8	8
1K1-1N1	18.00	10	17.5	3 #7 bars	3 #6 bars	10.5	7	11	12
1H2-1I2	18	15	20.5	4 #8 bars	3 #8 bars	10.5	8	8	9
1I2-1J2	11.5	9	17.5	3 #6 bars	2 #7 bars	6.7	8	10	11
1J2-1K2	8	8	13.5	2 #6 bars	2 #6 bars	4.7	7	9	9
1K2-1N2	18	15	20.5	4 #8 bars	3 #8 bars	10.5	6	12	14
1H3-1I3	18	11	18.5	3 #7 bars	3 #7 bars	10.5	6	4	6
1I3-1J3	11.5	9	14	2 #7 bars	2 #6 bars	6.7	4	2	3
1J3-1L1	12	11	18	3 #7 bars	3 #8 bars	7.0	5	4	5
1L1-1M1	12	9	14.5	2 #7 bars	2 #6 bars	7.0	7	7	8
1H1-1H2	23	11	16.5	4 #6 bars	4 #7 bars	13.4	6	3	4
1H2-1H3	29	11	21.5	4 #7 bars	3 #10 bars	16.9	7	6	7
1I1-1I2	23	15	20.5	4 #8 bars	3 #8 bars	13.4	6	5	6
1I2-1I3	29	18	23.5	5 #8 bars	5 #8 bars	16.9	4	2	4
1J1-1J2	23	12	19	2 #9 bars	3 #7 bars	13.4	6	5	6

Table 4-7: Specified Concrete Columns, Floor 1

							Floor 1								
Column	B1	C1	E1	A0	BA1	BA2	BB1	BB2	G1	A1	C3	F1	D1	F2	A2
Specified Size	21	21	21	21	21	21	21	21	21	21	21	21	31	31	51
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
Selected Reinforcement	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	10 #9 Bars	10 #9 Bars	
Tie Spacing (#3) (in.)	18	18	18	18	18	18	18	18	18	18	18	18	18	18	0
Column	D2	F3	A3	D3	F4	F5	BA3	BA4	BB13	BB4	A4	B2	C2	E2	G2
Specified Size	31	31	51	21	31	21	21	21	21	21	21	21	21	21	21
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
Selected Reinforcement	10 #9 Bars	10 #9 Bars		15 #5 Bars	10 #9 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
Tie Spacing (#3) (in.)	18	18	0	18	18	18	18	18	18	18	18	18	18	18	18
Column	A5	H1	I1	J1	K1	H2	I2	J2	K2	H3	I3	J3	L1		
Specified Size	21	21	21	21	21	31	21	21	21	21	21	21	21		
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces		
Selected Reinforcement	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	10 #9 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	16 #14 Bars		15 #5 Bars	15 #5 Bars		
Tie Spacing (#3) (in.)	18	18	18	18	18	18	18	18	18	18	0	18	18		

Table 4-8: Specified Concrete Columns: Floors 2-3

							Floors 2-4								
Column	B1	C1	E1	A0	BA1	BA2	BB1	BB2	G1	A1	C3	F1	D1	F2	
Specified Size	14	21	14	14	21	21	21	21	14	21	21	21	31	21	
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	
Selected Reinforcement	6 #5 Bars	15 #5 Bars	6 #5 Bars	9 #6 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	9 #6 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	10 #9 Bars	15 #5 Bars	
Tie Spacing (#3) (in.)	14	18	14	14	18	18	18	18	14	18	18	18	18	18	
Column	A2	D2	F3	A3	D3	F4	F5	BA3	BA4	BB13	BB4	A4	B2	C2	
Specified Size	41	31	21	41	21	21	21	21	21	21	21	21	14	21	
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	
Selected Reinforcement	17 #9 Bars	10 #9 Bars	15 #5 Bars	17 #9 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	6 #5 Bars	15 #5 Bars	
Tie Spacing (#3) (in.)	18	18	18	18	18	18	18	18	18	18	18	18	14	18	
Column	E2	G2	A5	H2	I2	J2	K2	H1	I1	J1	K1	H3	I3	J3	K3
Specified Size	14	14	14	21	21	21	21	21	21	21	21	21	21	21	21
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
Selected Reinforcement	6 #5 Bars	9 #6 Bars	9 #6 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
Tie Spacing (#3) (in.)	14	14	14	18	18	18	18	18	18	18	18	18	18	18	18

Table 4-9: Specified Concrete Columns: Floors 4-5

Floors 4-5															
Column	B1	C1	E1	A0	BA1	BA2	BB1	BB2	G1	A1	C3	F1	D1	F2	
Specified Size	14	14	14	14	14	14	14	14	14	14	21	14	21	21	
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	
Selected Reinforcement	4 #7 Bars	7 #5 Bars	4 #7 Bars	10 #8 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars	10 #8 Bars	10 #9 Bars	15 #5 Bars	10 #9 Bars	15 #5 Bars	15 #5 Bars	
Tie Spacing (#3) (in.)	14	14	14	14	14	14	14	14	14	14	18	14	18	18	
Column	A2	D2	F3	A3	D3	F4	F5	BA3	BA4	BB13	BB4	A4	B2	C2	
Specified Size	31	21	21	31	14	21	14	14	14	14	14	14	14	14	
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	
Selected Reinforcement	10 #9 Bars	20 #9 Bars	15 #5 Bars	10 #9 Bars	10 #9 Bars	15 #5 Bars	10 #9 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars	10 #9 Bars	4 #7 Bars	7 #5 Bars	
Tie Spacing (#3) (in.)	18	18	18	18	14	18	14	14	14	14	14	14	14	14	
Column	E2	G2	A5	H2	I2	J2	K2	H1	I1	J1	K1	H3	I3	J3	K3
Specified Size	14	14	14	21	21	21	21	14	14	14	14	14	14	14	14
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
Selected Reinforcement	4 #7 Bars	10 #8 Bars	10 #8 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	10 # 8 Bars	13 #7 Bars	13 #7 Bars	15 #5 Bars	10 # 8 Bars	13 #7 Bars	13 #7 Bars	10 # 8 Bars

4.3 Foundation

As discussed in the methodology section the process of designing the New Residence Halls foundation was broken down into 4 distinct parts. These were

1. Soil Analysis
2. Develop Approximate Footing Size
3. Design Footing Reinforcements
4. Develop Foundation Wall Designs

Each of these steps contains a series of complex calculations and the description to follow is severely truncated, containing only general examples and equations. More extensive calculations can be seen in attachments.

4.3.1 Soil Analysis Results

Conducting proper soil analysis of the site was the first step in designing a foundation adequate enough to support the loads of the building. Through various borings much was learned about the soil composition and properties. In general there is an initial layer of fill and sometimes asphalt which was the result of the previous buildings which had been placed on the site. Below this is a layer Glaciofluvial Deposits which is mostly poorly graded sand. Under this is a layer Glaciolucustrine Deposits within which the water table lies for most of the site. Under this is a layer of Glacial Till which is assumed to go down some great depth to bedrock, but this is of little consequence as it is far beyond the depth of the purposed project. A more thorough description of each of the layers can be found below. The soil analysis was performed by Sea Board Drilling, and a copy obtained through the construction site office of Gilbane Building Company. Their report is included in the appendix.

- **Fill** (SP) This fill consisted of rubble which has been placed in the area over the last few decades from the various constructions which have been done within the site. It can be equated with poorly graded sand and has a density of approximately 115 pcf.
- **Glaciofluvial Deposits** (SW) This layer is the deposits that came from a glacial river which disappeared millennia ago. It consists largely of well-graded sand which has a density of 115 pcf.
- **Glaciolucustrine Deposits**(SM) This layer was largely the result of deposits from a glacial lake. It consists of silty sand and has a unit weight of approximately 125pcf. It is also important to note that the water table begins in this layer.
- **Glacial Till** (GM) Silty Gravel is the main component of this layer, and was the deposit of a glacier scraping across New England Many Millennia ago. It possesses a density of about 132.5 pcf.

Exploring the site was done by Sea Board Drilling Services and New Hampshire Boring. Unfortunately the New Hampshire Boring explorations only penetrated to a depth of 6 feet, due to high blow counts. Therefore those borings were not taken into account in the soil analysis as the depth of most of our design work was 10 ft down or greater. Instead we only used the 4 boring explorations which were conducted within the building's footprint for our analysis.

Sea Board Drilling used a Winch Safety Hammer to a depth between 25 and 30 feet. The principal depth of design was 10 to 15 feet and the average number of blows per 6 inches at that depth was 6.

Conducting analysis using these 4 borings was a simple process. The depths of each soil type layer was compared and averaged among the explorations. The elevation was varied between 502.5 and 500 feet. It was decided that the ground would be leveled to the Elevation of 500 feet. The average groundwater depth was found to be 10 feet below ground level.

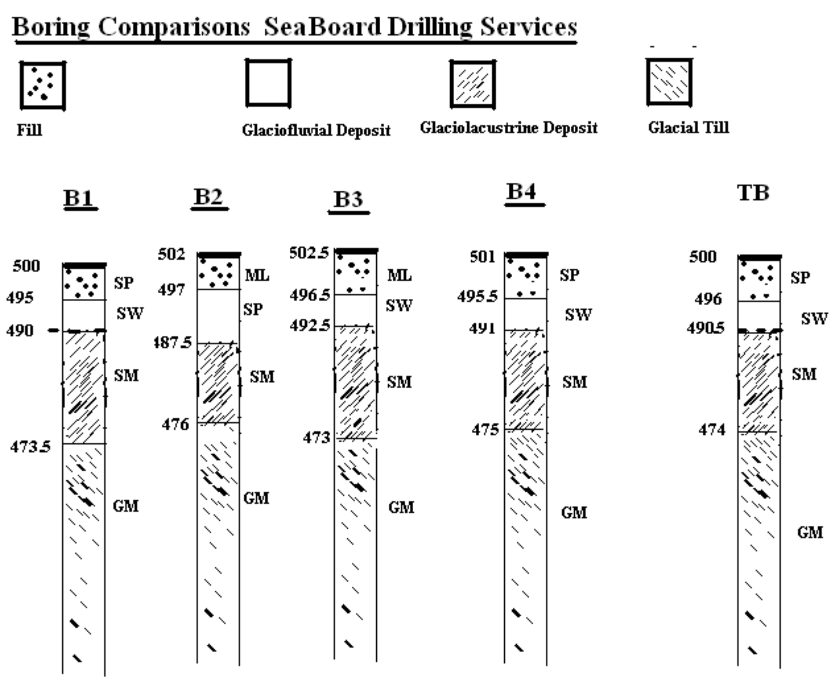

Figure 4-3: Boring Comparisons

4.3.2 Footing Size Results

Due to the wide range of vertical column loads, it was decided that in the construction of the building one size would not be prudent for every footing. Therefore, footing sizes were broken up into three groups, each designed to carry a load equal to or less than a predetermined amount. Footing sizes were based on the following three axial force parameters and column sizes. All Equations and were obtained from *Foundation Design* by Coduto.

Column Size	Design Value
• Small Column:W8x13	67 Kips
• Medium Column: W10 x 30	383 Kips
• Large Column: W10 x 33	714 Kips

By looking at previous designs an approximate footing size was developed. For the small footing for instance a footing size of 2.5' square was approximated.

Bearing pressure is the first equation used to develop a footing size in our method. The decision was made to attempt to design the footings to be simple square spread footings. Though many factors are involved in this development most have no effect on the final bearing pressure that they are largely ignored for spread footings. Therefore they are reduced to the equation

$$q = \frac{P + W_f}{A} - u_D$$

Values are below

q = bearing pressure

P = vertical column load

Wf = weight of the foundation and soil above the foundation

A = area of the base of the foundation

ud = pore water pressure at the bottom of the foundation

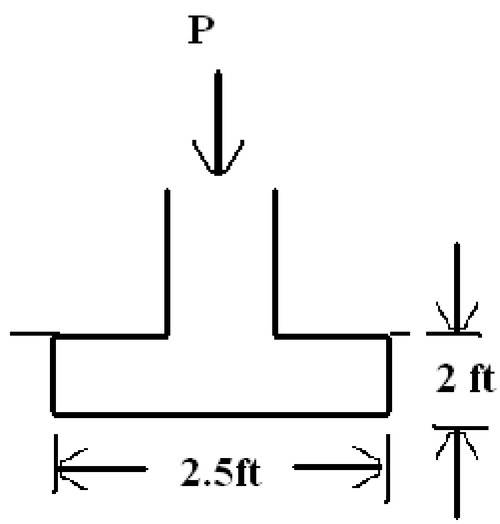

Figure 4-4: Sample Footing Schematic

The Bearing pressure figures were calculated for each of the spread footing sizes and pressures were determined as follows.

Table 4-10: Bearing Pressures

Footing Size	P (ksf)
Small	10.9
Medium	12.8

Large	12.9

Bearing pressure must be less than the bearing capacity of the soil. Bearing capacity is a measure the geotechnical strength of the soil. Though there are three types of bearing capacity failure, likely failure for the New Residence Hall was the intermediate case. The intermediate case is known as Local Shear where shear surfaces are found under the foundation but vague near the surface. This was because of the medium dense soil which the foundations rest upon. Despite this, in the design process only checks for the general shear case followed by settlement analysis were performed. The settlement analysis implicitly protected against the other two cases.

There are many equations for bearing capacity of a soil. Some of these equations are more useful than others depending on knowledge of soil conditions and types of loading. Some of the equations which were discussed in the methodology included a simplified equation, the Terezagi equation and the Vesic Equation.

The Terezagi equation is based on number of assumptions for shallow foundations. The most significant of these are a foundation bottom to prevent sliding, the soil is homogeneous and extends for a semi infinite depth, general shear governs and no consolidation occurs. This approach is conservative, but is only valid for foundation that the depth is less than the base.

While Terezagi's equation only considers vertical loads with a level ground surface Vesic's allows for these to be varied. Shape factors allow Vesic's equations to consider a variety of shapes more accurately. Depth factors allows for spread footings to be any depth. Load inclination factors consider that do not act in a straight vertical fashion to the centroid of the footing. Base inclination factors deal with footings that are placed at an angle to better receive loads. Finally the ground inclination factors deal with the prospect of a foundation being close to or on the soil surface.

Vesic's equation has its advantages when one of these factors significantly alters the results of the calculations but for simplicity Terezaghi's equation was for use in this project. Despite its lack of details we expect both equations to produce similar results. For square foundations the Terezagi equation is

$$q_{ult} = 1.3c'N_c + \sigma'_{zD}N_q + 0.4\gamma'BN_\gamma$$

Values are below

q_{ult} = ultimate bearing capacity

c' = effective cohesion for soil beneath foundation

ϕ' = effective friction angle for soil beneath foundation

σ'_{zD} = vertical effective stress at depth D below the foundation

γ' = effective unit weight of soil

D= depth of foundation below ground surface

B= width of foundation

N_c, N_q, N_γ = Terezaghi's bearing capacity factors

The Terezaghi equation and its factors are overly dependent on the effective friction angle. Stress of the soil is at depth D must be calculated as part of the function. In our case it was approximately 250 lb/ft^2. Using this and the STP N60 value from the hammer determining the angle of friction is possible. The equation for N60 is.

$$N_{60} = \frac{E_m C_B C_S C_R N}{0.60}$$

Values are below.

N_{60} = SPT N value corrected for field procedures

E_m= Hammer Efficiency

C_B= Borehole Diameter Correction

C_S= Sampler Correction

C_R = rod length correction

N= measured SPT N value

All these values can be determined either by the equipment used or by the results of the test borings. It was determined that using a Safety hammer as they did for the boring samples that the value for N60 is 5.225. Using N60 and the known value for soil stress the angle of friction can be determined as 30 degrees. Using the Terezaghi equation, the ultimate bearing capacity can be found for each footing size. The results are as follows.

Table 4-11: Footing Bearing Capacities

Footing Size	Bearing Capacity (Ksf)

Small	14.14
Medium	17.00
Large	19.43

From these results we can determine that all the footings are sufficiently resistant to general shear failure.

Pore water pressure is an important characteristic that must be taken into account. A high groundwater table will saturate soil leaving it with a different shear friction angle. Field tests are often unreliable and even a small mistake in a shear angle can result in a drastic drop in bearing capacity so it is important to be conservative with soil calculations. The groundwater table is at the same level as the footing therefore this was taken into account while calculating the results: consideration of groundwater is implicitly included in the general shear case solutions. It is also very important to consider a factor of safety when dealing with bearing capacity equations. While there are no formal regulations of factors of safety for foundations, it is left to the engineer to use proper engineering judgment in determining what the factor of safety should be. All these footings were designed to have a factor of safety between 1.25 and 1.5, which was sufficient.

Next, settlement analysis was conducted on the slab. This was done doing a simplified version of Boussinesq's equation. This equation presents results which are within 5 % of Boussinesq's, which is sufficient in nearly all cases, including the New Residence Hall.

$$\Delta\sigma_z = \left[1 - \left(\frac{1}{1 + \frac{B}{2z_f}^2} \right)^{1.76} \right] . \left(q - \sigma_{zD} \right).$$

After determining the change in stress, known values for stress were used to determine actual settlement.

After determining that the chosen footing size and depth were adequate to support the building a final check must be preformed. The total area of all the footings must be divided by the total area of the building's footprint. If this value is greater than 50% then there is no need for individual footings and a mat footing of solid concrete would be a more efficient solution. In the case of the New Residence Hall the total area of the footings was much less area of the footprint. Therefore the decision was made to use individual spread footings and not one large mat.

4.3.3 Footing Reinforcement Results

Designing the structural reinforcement was the next step. It was divided up into the following:

1. calculate effective depth of each footing
2. calculate factored two way shear force of each footing
3. calculate nominal two way shear capacity of each footing
4. calculate area of reinforcement required to resist flexural forces
5. determine how many beams are sufficient to meet flexural capacity and footing dimension constraints

A square footing like the ones which are being used in the New Residence Hall are governed by two way shear. The equation for this shear is

$$V_{uc} = \left(\frac{P_u}{4} + \frac{M_u}{c + d}\right)\left(\frac{B^2 - (c + d)^2}{B^2}\right)$$

V_{uc} = factored shear force on most critical face

P_u = applied normal force

B = footing width

c = base plate width

d = effective depth

The results of the equation yielded an extremely minor shear force within the smaller footing size but the shear forces became very large as the axial load increased in the larger footings. The factored shear force was as follows

Table 4-12: Footing Shear Forces

Footing Size	Factored Shear Force on critical face (K)
Small	1.622
Medium	75.3
Large	158

After determining the shear force placed upon each footing, the nominal capacity of each footing was determined. This is determined with the equation.

$$V_{nc} = 4\, b_0\, d \sqrt{f_c'}$$

Values are.

V_{nc} = nominal two-way shear capacity on the critical section

b_0 = length of the critical shear surface (c + d)

d = effective depth

f_c' = 28 day compressive strength of concrete

This equation addressed the structural strength of the footing with regard to the concrete compressive strength on the shear surface. By placing the footing values into this equation we were able to determine shear capacities of each footing. These can be found in table 4-13.

Table 4-13: Footing Shear Capacities

Footing Size	Shear Capacity (K)
Small	108.8
Medium	116.45

Large	164.6

Once the footing size was checked for two way shear, the area required for reinforcing steel was calculated. The first step was to determine the cantilever distance to be considered in the reinforcement placement. This was determined with the equation

$$I = \frac{B - c}{2}$$

After the cantilever distance was calculated, all required data to determine the flexural stress were identified. The equation for this is

$$M_{uc} = \frac{P_u I^2}{2B}$$

The results for this equation are as follows:

Table 4-14: Footing Flexural Stress

Footing Size	Cantilever Distance (in)	Moment force (lb-in)
Small	11	135,000
Medium	23	1,809,000
Large	40	6,347,000

It is clear that the forces flexural forces are much greater upon the larger of the footings as they are required to withstand far more axial force. With this moment force in hand the required area of the flexural reinforcement was calculated using the equation

$$A = \left(\frac{f'_c\, b}{1.176\, f_y}\right) \cdot \left(d - \sqrt{d^2 - \frac{2.353\, M_{uc}}{\phi\, f'_c\, b}}\right)$$

This equation takes into account the stress at the area which is under most critical flexure.

Also to be considered is the minimum steel within the footing and the maximum steel within the footing. These values are governed by ACI 10.5.4 and 7.12.2, because footings are treated as structural slabs of uniform thickness. The minimum steel must be grade 60 steel, which is what was used in the footings, greater than .0018 the gross cross sectional area of the footing. The max amount of steel used is intended to maintain the ductility of the footing. It never governs the design of a simple footing there for in the case of the New Residence Hall we need not deal with it.

Also the steel must meet several spacing requirements. These ensure there is ample strength within the concrete as well as room for the aggregate to properly be distributed around the reinforcement.

- The clear space between the bars must be at least 2d, 1 in. or 4/3 times the nominal maximum aggregate size whichever is greater, where d is the diameter of a reinforcing bar.
- The center to center spacing of the reinforcement must not exceed 3T or 18 inches whichever is less, where t is the slab thickness.

Neither of these requirements was of great concern to us as our reinforcement fit easily within the footings. The final results of our analysis were as follows:

Table 4-15: Specified footing Reinforcement

Footing Size	Required Area (in^2)	Reinforcement
Small	1.96	2 #8 Bars at 10in.
Medium	2.42	4 #8 Bars at 11.2in.
Large	3.88	6 #8 Bars at 12.9in.

Figures 4-5, 4-6, and 4-7 show drawings of small, medium, and large footings, respectively.

- Small Footing.

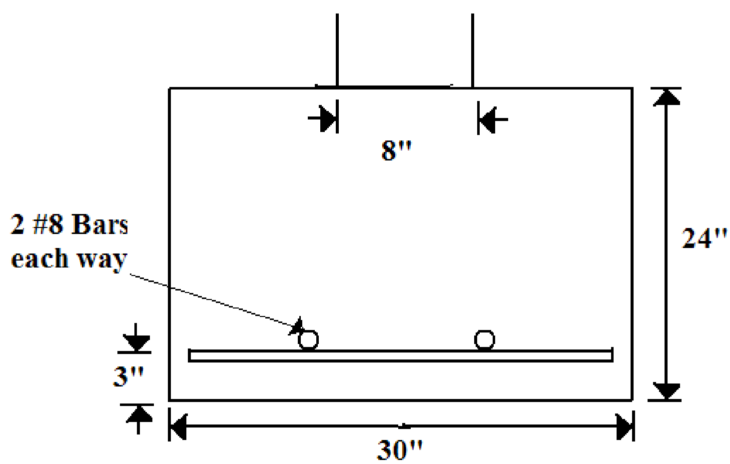

Figure 4-5: Small Footing Design

- Medium Footing.

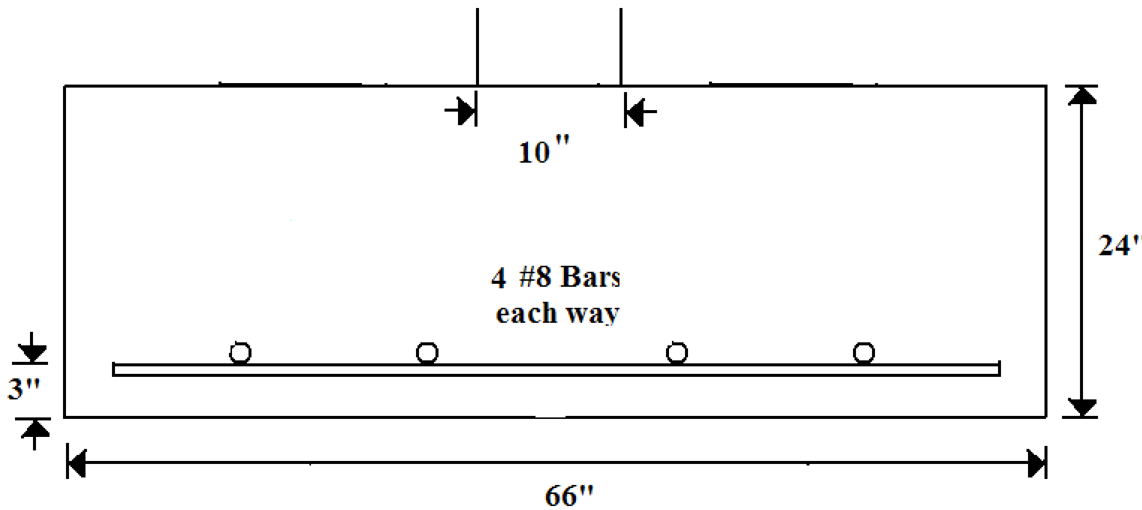

Figure 4-6: Medium Footing Design

- Large footing

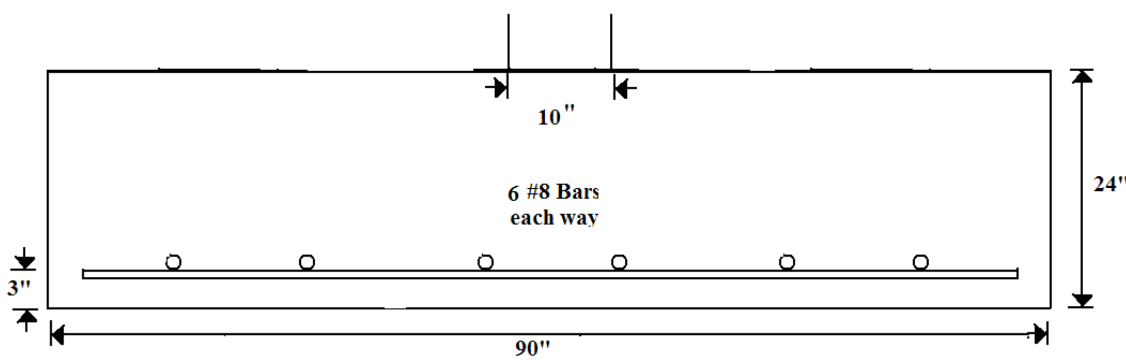

Figure 4-7: Large Footing Design

The Location of these footings in the structure is shown in Figure 4-8.

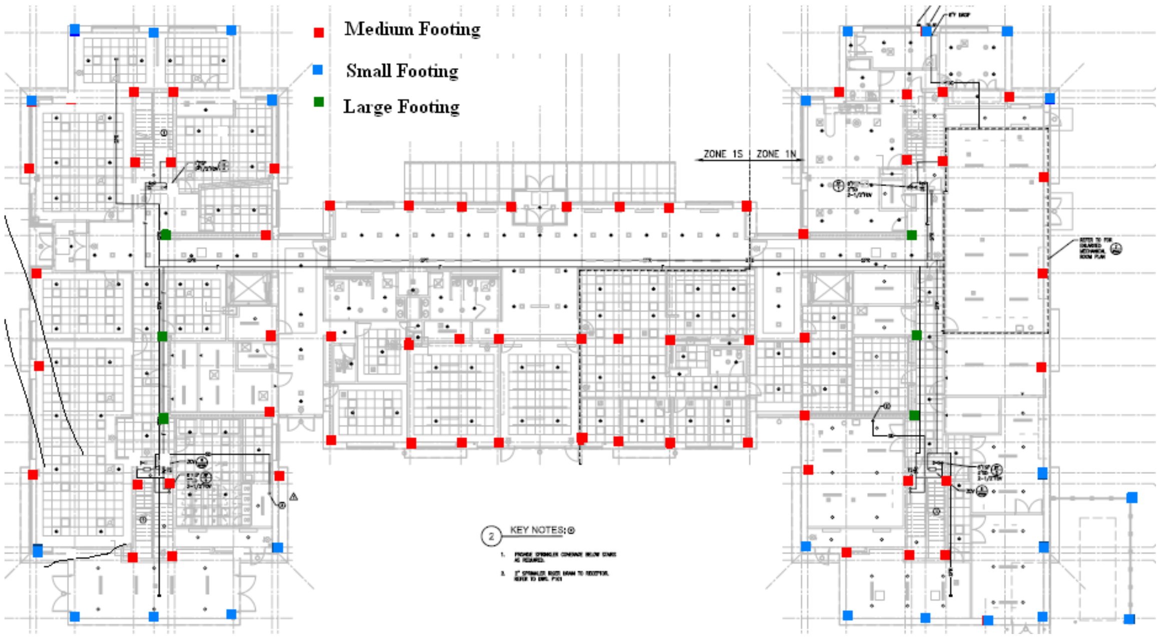

Figure 4-8: Footing Locations and Sizes

4.3.4. Foundation Wall Design

A final part of our design process enacted was to develop a design for the retaining wall which will support the newly designed basement. This wall was not designed to resist any imposed gravity load, but it must retain the full lateral pressure of the soil. The process was broken down into a series of steps.

- Determine lateral earth pressures which must be restrained
- Determine the external stability

Lateral earth pressure is the direct horizontal stresses of the soil. In its simplest form it is equated in terms of K where

$$K = \frac{\sigma_x'}{\sigma_z'}$$

Several Conditions were considered in order to effectively gage the resisting condition of the wall. This condition takes into account whether the wall is to be At-Rest (both rigid and unyielding), Active (allowed to move inward and rotate a small amount), or Passive (allowed to rotate and move out into the resisting soil). To ensure this the structure must be rigid, cannot have significant flexural movement, or unyielding meaning it cannot translate or rotate.

In these ideal conditions soil must be empirically formulated based on correlations created in lab testing by Mayne and Kulhawy. The equation which is used is

$$K_0 = (1 - \sin\phi)\ OCR^{\sin\phi'}$$

where:

K_0 = coefficient of effective friction angle

ϕ' = effective friction angle of soil

OCR = over consolidation ratio of soil

In homogeneous soil K is constant and vertical effective stress varies with depth then the horizontal stress varies with depth forming a triangular pressure distribution thus if at rest then the horizontal force per unit length of wall is equal to.

$$P_0/b = \frac{\gamma H^2 K_0}{2}$$

where:

P_0 = nominal force between soil and wall per unit length of wall

b = unit length of wall

γ = unit weight of soil

H = height of wall

Again this situation is only suitable for homogeneous soil composition which unfortunately is not in occurrence on the site.

In order to ensure the safety of the design the foundation wall was assumed to be passive. This means the wall is exerting force on the soil. The equation which is to be used in our foundation wall was developed by Rankine. Rankine's equations were used despite their simplicity because of the level ground which is assumed to exist beyond the wall as well as the lack of surcharge load.

To design a cantilever wall it must be externally stable in order to adequately perform its role.

- This indicates it must not slide horizontally
- It must not overturn
- The resultant of the normal force must act on the middle third of the footing
- the foundation must not resist deep seated shear failure
- It must not settle excessively

Evaluating for sliding was performed using the limit equilibrium approach as if the force exerted on it was causing it to fail. Then the factor of safety was the ratio of the force which causes it to fail to those actually acting on the wall. Forces causing sliding are driving forces. They consist of the horizontal component of the lateral earth pressures acting on the back of the wall, the hydrostatic forces acting on the wall soil unit. These forces are countered by the resisting forces. These forces are the lateral earth pressure acting on the area in front of the wall-soil footing, the sliding friction along the bottom of the footing and the hydrostatic pressure acting on the front of the foundation. Factor of safety must be at least 1.5, but a true factor of safety typically ends up being between 2.5 -3.5 due to built in conservatism within the equations.

Using Rankine's method, we first used the following equation to solve for K which is the active coefficient of lateral earth pressure.

$$K = \frac{\cos^2(\phi - \alpha)}{\cos^2\alpha \ \cos(\phi_\omega + \alpha)\left[1 + \sqrt{\frac{\sin(\phi + \phi_\omega)\ \sin(\phi - \beta)}{\cos(\phi_\omega + \alpha)\ \cos(\alpha + \beta)}}\right]^2}$$

Using this, the unit weight of the soil and the inclination of the ground surface above the wall the horizontal and vertical equivalent pressures were determined.

$$G_h = \gamma K_a \cos\phi_\omega$$
$$G_v = \gamma K_a \sin\phi_\omega$$

$$V_a / b = \frac{H^2 G_h}{2}$$

$$P_a / b = \frac{H^2 G_h}{2}$$

The next step was to develop a trial design and to calculate its sliding stability. The height of the design including wall, and foundation were calculated. From this, the normal force acting on the wall per foot and the shear force per foot was found. Using these values and adding them to the weight at the bottom of the footing we determined the trial design is adequate for sliding. If the design was inadequate then this can be solved by extending the heel of the footing, adding a key beneath the footing, installing tieback anchors, installing tie-down anchors or using stronger backfill.

After designing for sliding is complete it was necessary to design the wall for overturning. Forces that might cause the wall to overturn include the horizontal component of the lateral earth pressure, and hydrostatic forces from the backfill. Resisting moments are the vertical components of lateral earth pressure, the weight of the wall unit, surcharge loads acting on the wall unit, and finally hydrostatic pressures acting on the front footing.

$$\Sigma M_R / b$$

$$\Sigma M_D / b$$

The foundation wall like footing may be subject to bearing capacity failure and excessive settlement. Bearing capacity failure is determined by using the footings eccentricity that is the distance from the center of the footing to the resultant force. Equivalent bearing pressure must be less than the allowable bearing pressure.

Finally a cantilever wall is checked for deep seated shear failure. Unfortunately in this case deep seated shear failure is a catastrophic failure and much larger in scope than any other failure modes dealt with. Due to the presence of glacial till underneath the retaining wall in this project, it was ahighly unlikely failure mode.

The last step of designing the foundation and basement system was in the design of the development of a basement retaining wall which prevented the sight soil from coming in. For the new residence hall the retaining wall was chosen to be of the cantilever variety. This is because cantilever walls are relatively inexpensive and the geotechnical pressures of the soil are not so overwhelming that they would require additional supports.

A retaining wall design was created and then tested using the equations outlined in the methodology. Our design had a wall height of 10 feet, a toe height of 1 foot, a toe length of 7 feet and a wall thickness of 8 inches, constructed of reinforced concrete. The design was tested for sliding and overturning; both of which it was found adequate for. It was then tested for settlement and bearing capacity which were sufficient due to the light weight and expansive bottom area of the design.

There were two concerns in regards to the soil where most important. The first was the water table which was just below the retaining wall structure. Therefore the wall did not have to deal with this soil variation. Unfortunately the soil composition is not homogeneous along the foundation wall so two different soil densities did have to be taken into account during calculations.

4.4 *Cost Estimate*

Based on the takeoffs discussed in section 3.6, tables 4-16 and 4-17 show the cost summaries for steel and concrete superstructures, respectively. A complete price breakdown and takeoff quantities can be found in the appendix. It should be noted that these costs are trade costs, and included no profit or general conditions concerns.

Table 4-16: Steel Cost Summary

Sections Selected	Total ft. of Steel	Cost per Selection	
W21x48	1353	$	77,973.39
W18x35	1930	$	86,135.90
W14x43	2528	$	134,489.60
W12x14	432	$	8,696.16
W10x33	322	$	20,099.24
W10x30	1438	$	58,181.48
W10x19	1440	$	40,147.20
W8x31	640	$	26,828.80
W8x13	1260	$	26,472.60
W8x10	1826	$	32,228.90
Total Price		**$**	**562,378.60**

Table 4-17: Concrete Cost Summary

Item		Cost	
Rebar		$	349,034.61
Concrete		$	269,855.04
Placing		$	62,116.46
Formwork		$	82,529.60
Stirrups		$	77,985.74
Total Price		**$**	**841,521.46**

5. Conclusions

The goal of this project was to present two design alternatives for the structural system of the New Residence Hall at WPI, and select one as a superior design. Based on our evaluation of the relevant criteria from the ASCE commentary, we have come to the conclusion that our steel design is more appropriate in this application than our concrete design. This is in agreement with the decision of the A-

E team hired by WPI to design the New Residence Hall to use a steel structure. The advantages and disadvantages of each design in relation to each criterion are discussed below.

Our economic comparison of our designs is based on the results of our cost estimate. As seen in the results section of this report, our steel structure was a significantly cheaper alternative.

As expressed in the background research on LEED certification and the goals of WPI relating to the New Residence Hall, achieving an energy-efficient and sustainable design was a major goal of the project. Both steel and concrete structural systems are eligible for points towards LEED certification. For example, most steel includes recycled content, earning a point in the Materials & Resources Category, credit C.4. However, steel is usually purchased from one of a few specialist producers usually not local. This makes steel projects usually ineligible for credit 5, use of regional materials. Concrete construction is eligible for credit 5, as most concrete is produced in batching plants widely distributed throughout the country. Based on these available credits, the environmental and sustainability benefits of steel and concrete offset each other. However, steel could have an advantage depending on the location of the rolling mill and fabrication shop.

Several manufacturability concerns are relevant to our selection of a steel structure as superior to concrete in this application: beam depths, speed of construction, column sizes, and MEP coordination.

Based on the building code in the city of Worcester, the New Residence Hall was limited in overall project height. In order to obtain the most available space and highest ceilings possible, minimizing the depths of beams was a goal of this project. Here, steel has the advantage. As our results show, most steel beams range between 8 and 12 inches in depth, with a small number deeper. In comparison, many of the concrete beams sized have depths in the 18”-20” range. This depth advantage is also related to the MEP systems of the building. Since both the structural frame and MEP systems will need to be concealed in a plenum space, any way to create overlap between these systems in vertical space will reduce the required size of this plenum space. With a steel structure, it is a simple matter to create penetrations in the web of a beam for MEP items to pass through, allowing them to be mounted in the same vertical space as the beams.

In addition to larger beams, the column sizes we calculated for our concrete design were much larger than our steel columns. This loss of space is critical, especially on the first floor, which is designed with open space and clear sight lines. The minimization of column size matches with the architect's plan for the space.

Additionally, because WPI is on a tight schedule with a hard deadline in August of 2008, speed of construction is of the utmost importance. While overall speed of construction is faster with concrete than steel due to the lead time required for offsite fabrication of steel members, the speed of erection is faster with steel. Through careful project management and the use of a fast track schedule, the structure would be erected faster with steel than would be required for formwork, pouring, and curing of concrete.

Beyond the deliverables produced for this project, this MQP group gained practical experience in structural design. In our coursework, we learned the design procedure for structures of steel and concrete. Through this Major Qualifying Project, we extended that knowledge to apply to a large-scale, real-world problem. As we all plan to have careers in structural engineering and related disciplines, this was a valuable exercise. Additionally, we learned from each other: coming into this project, we had a variety of strengths. Some members of the group had more experience with the design processes we used, some had better writing skills, and some had a better understanding of the overall construction process and how buildings go together. As we conclude this project, we find that we have all become more proficient in the areas we were initially weak in.

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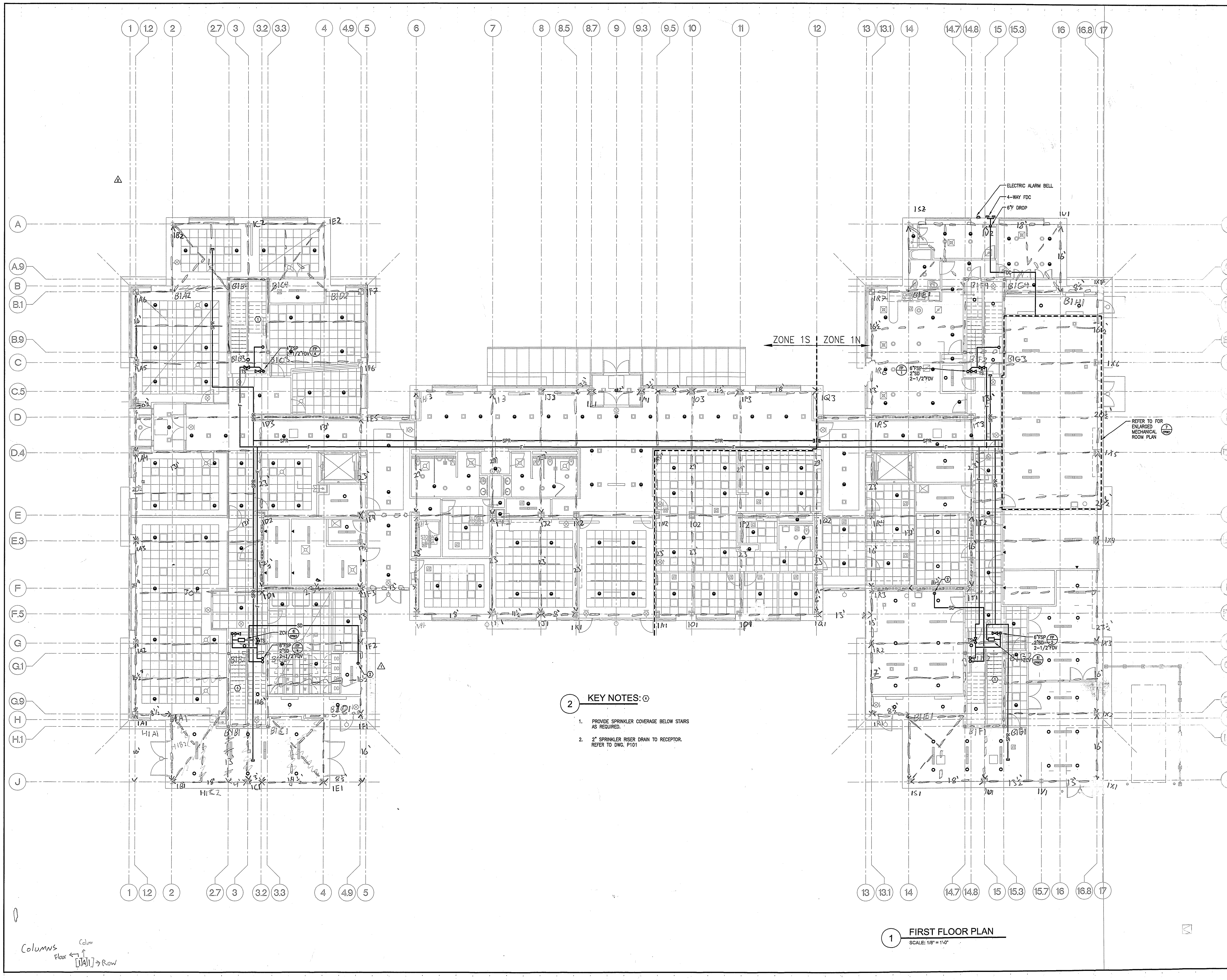
Appendix

Text



2 KEY NOTES:

1. PROVIDE SPRINKLER COVERAGE BELOW STAIRS AS REQUIRED.
2. 2" SPRINKLER RISER DRAIN TO RECEPTOR. REFER TO DWG. P101

1 FIRST FLOOR PLAN

SCALE: 1/8" = 1'-0"

WPI

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Key Plan

Project North

PROGRESS ONLY

ELECTRICAL BUYOUT

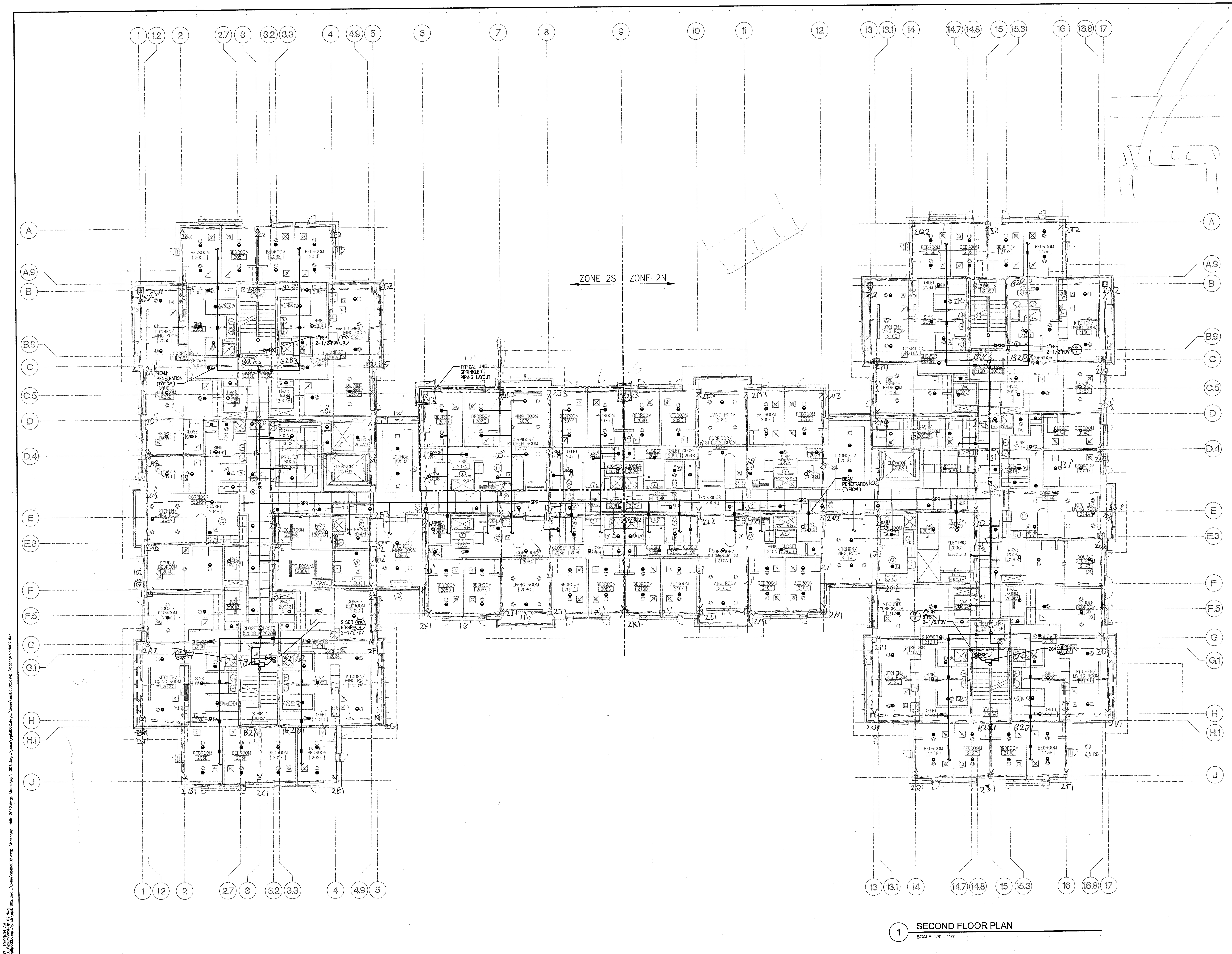
No.	Revisions	Date
	CONSTRUCTION DOCUMENTS	6/22/07
	ADDENDUM #1	5/31/07

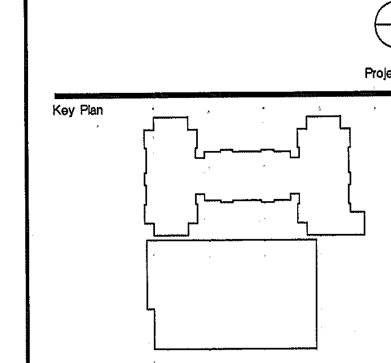
Drawing Title:

FIRST FLOOR
FIRE PROTECTION PLAN

Issue Date: JUNE 12, 2007
Drawn by: JPM
Checked by: RF
Project No: 02757.00
Scale: 1/8" = 1'-0"
Drawing No:

FP101





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Drawing Title:

SECOND FLOOR
FIRE PROTECTION PLAN

Issue Date: JUNE 12, 2007
Drawn by: JPM Checked by: RF
Project No: 02757.00 Scale: 1/8" = 1'-0"
Drawing No:

FP102

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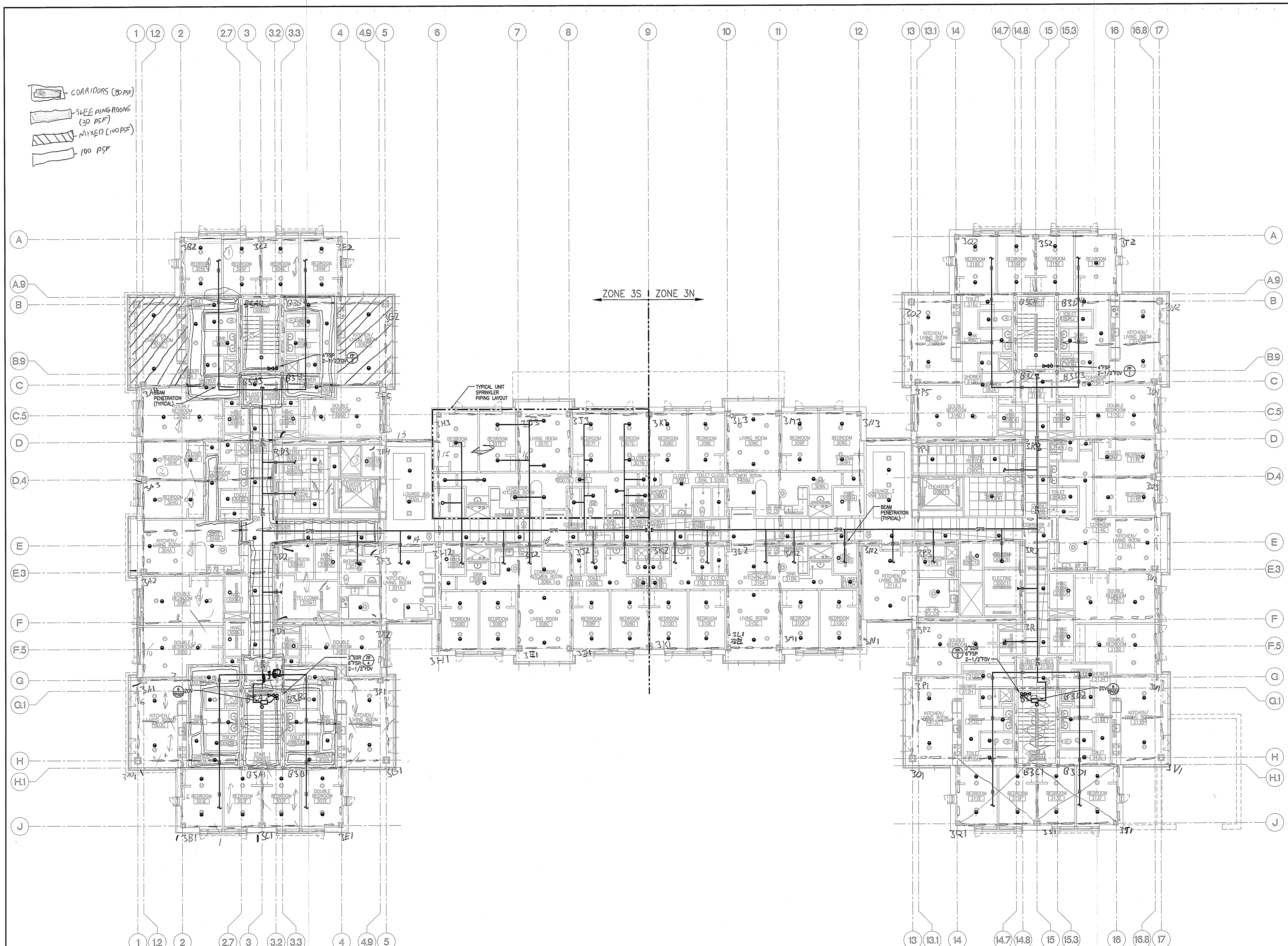

1 THIRD FLOOR PLAN
SCALE: 1/8" = 1'-0"

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No.	Revisions	Date

Drawing Title:

THIRD FLOOR
FIRE PROTECTION PLAN

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Scale: 1/8" = 1'-0"
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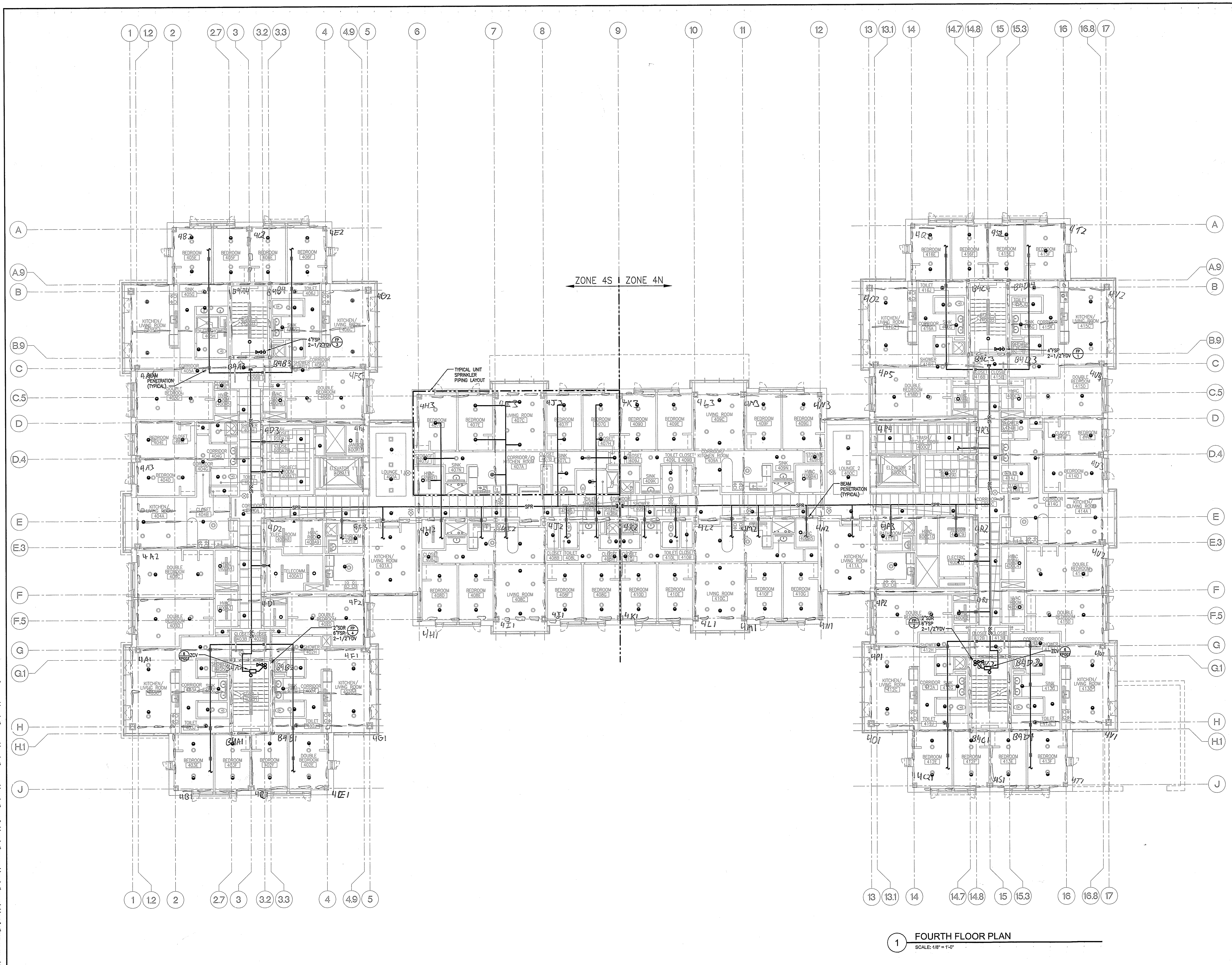
FP103



1 FOURTH FLOOR PLAN
SCALE: 1/8" = 1'-0"

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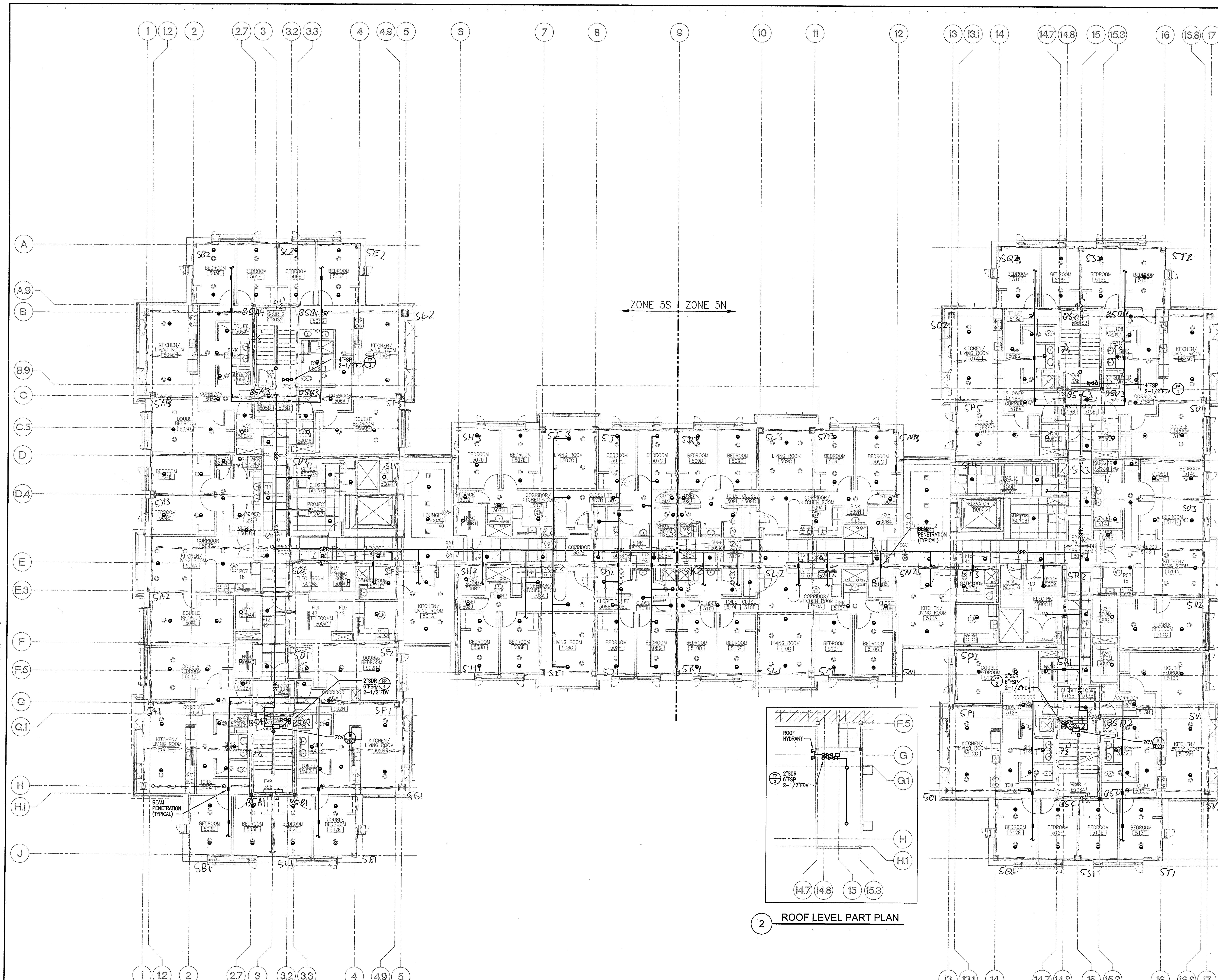
No.	Revisions	Date

Drawing Title:
FOURTH FLOOR
FIRE PROTECTION PLAN

Issue Date: JUNE 12, 2007
Drawn by: JPM Checked by: RF
Project No.: 02757.00 Scale: 1/8" = 1'-0"
Drawing No.:

FP104



2 ROOF LEVEL PART PLAN

1 FIFTH FLOOR AND PARTIAL ROOF PLAN
SCALE: 1/8" = 1'-0"

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Key Plan

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ELECTRICAL BUYOUT

No. Revisions Date

Drawing Title:

FIFTH FLOOR
AND PARTIAL ROOF PLAN
FIRE PROTECTION

Issue Date
Drawn By
Project No.
Drawing No.

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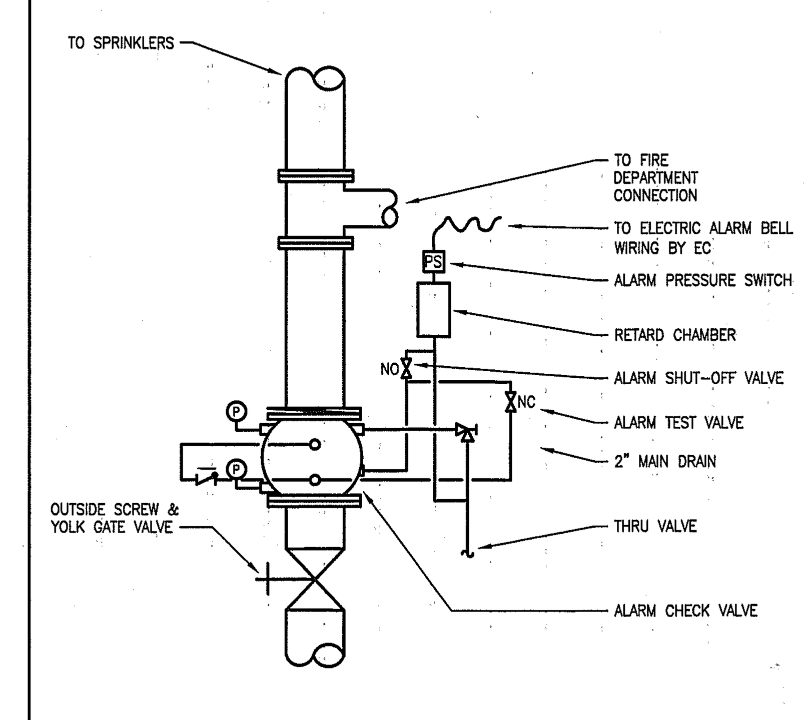


4 SPRINKLER ALARM CHECK VALVE

3 SYMBOLS

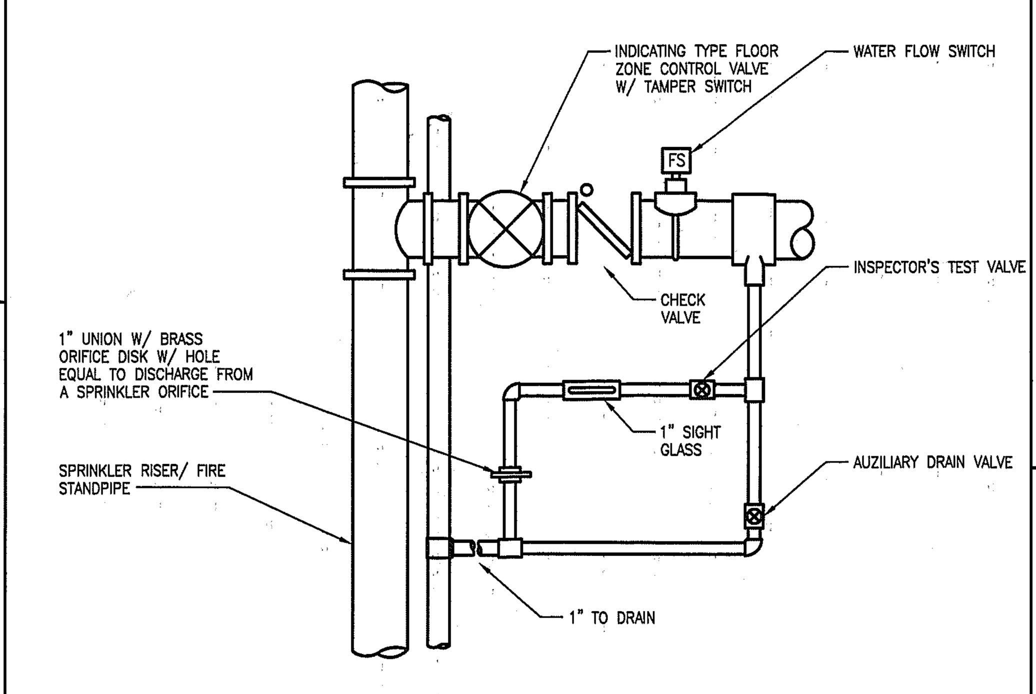
SPR	SPRINKLER PIPING (SPR)
F	FIRE PROTECTION PIPING (F)
DF	DRY FIRE PROTECTION PIPING (DF)
	DIRECTION OF FLOW
	PIPE ANCHOR
	UNION
	VALVE
	OS&Y VALVE
	CHECK VALVE (SHOWN W/FLOW)
	CONCEALED SPRINKLER HEAD
	UPRIGHT SPRINKLER HEAD
	PENDENT SPRINKLER HEAD
	SEMI RECESSED SPRINKLER HEAD
	SIDEWALL SPRINKLER HEAD
	BACKFLOW PREVENTER (BFP)
	FLOW SWITCH
	RISER INDICATOR – TOP INDICATES TYPE OF RISER, BOTTOM INDICATES RISER NUMBER
	RISER INDICATOR – TOP INDICATES TYPE OF RISER, BOTTOM INDICATES RISER NUMBER

2 ABBREVIATIONS

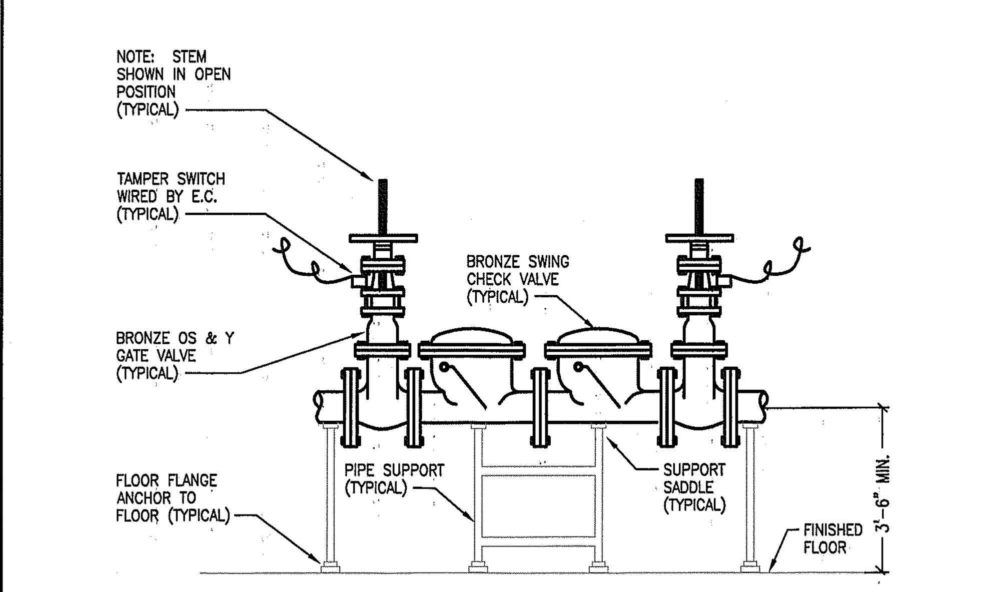
AC	AIR COMPRESSOR
CA	COMPRESSED AIR
CONN	CONNECTION
DCVA	DOUBLE CHECK VALVE ASSEMBLY
DWG	DRAWING
DFP	DRY FIRE PROTECTION (PIPING)
EC	ELECTRICAL CONTRACTOR
FACP	FIRE ALARM CONTROL PANEL
FDC	FIRE DEPARTMENT CONNECTION
FDV	FIRE DEPARTMENT VALVE
FHC	FIRE HOSE CABINET
FLR	FLOOR
FP	FIRE PROTECTION
FS	FLOW SWITCH
FSP	FIRE STANDPIPE
GPM	GALLONS PER MINUTE
IN	INCHES
MC	MECHANICAL CONTRACTOR
N.C.	NORMALLY CLOSED
NIC	NOT IN CONTRACT
NO.	NUMBER
N.O.	NORMALLY OPEN
OSW	OPEN SITE WASTE
OS & Y	OUTSIDE SCREW & YOKE
P	PUMP
SPR	SPRINKLER
TS	TAMPER SWITCH
TYP	TYPICAL
VIF	VERIFY IN FIELD
W/	WITH
ZCV	ZONE CONTROL VALVE

1 DRAWING LIST

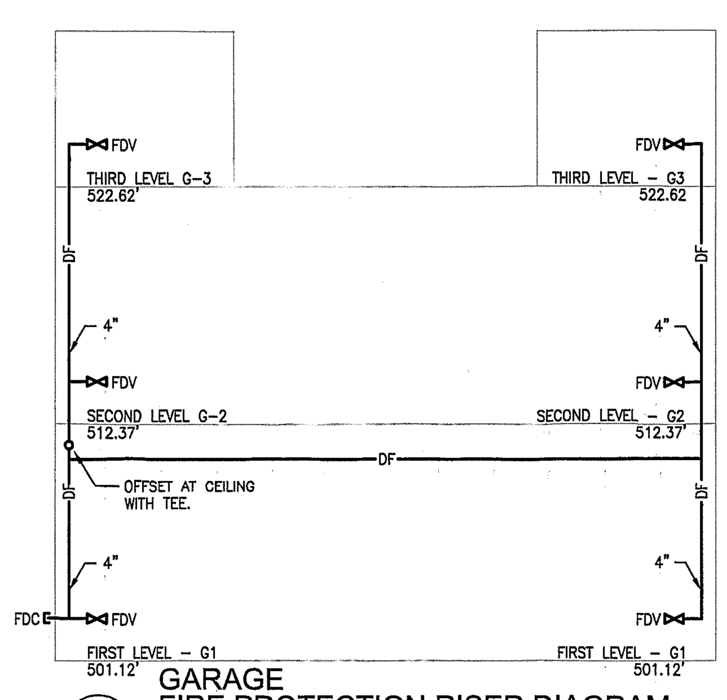
FP001	FIRE PROTECTION LEGEND, DETAILS, RISER DIAGRAM AND ENLARGED PLAN
FP101	FIRST FLOOR FIRE PROTECTION PLAN
FP102	SECOND FLOOR FIRE PROTECTION PLAN
FP103	THIRD FLOOR FIRE PROTECTION PLAN
FP104	FOURTH FLOOR FIRE PROTECTION PLAN
FP105	FIFTH FLOOR AND PARTIAL ROOF FIRE PROTECTION PLAN
GFP101	GARAGE TYPICAL LEVEL FIRE PROTECTION PLAN



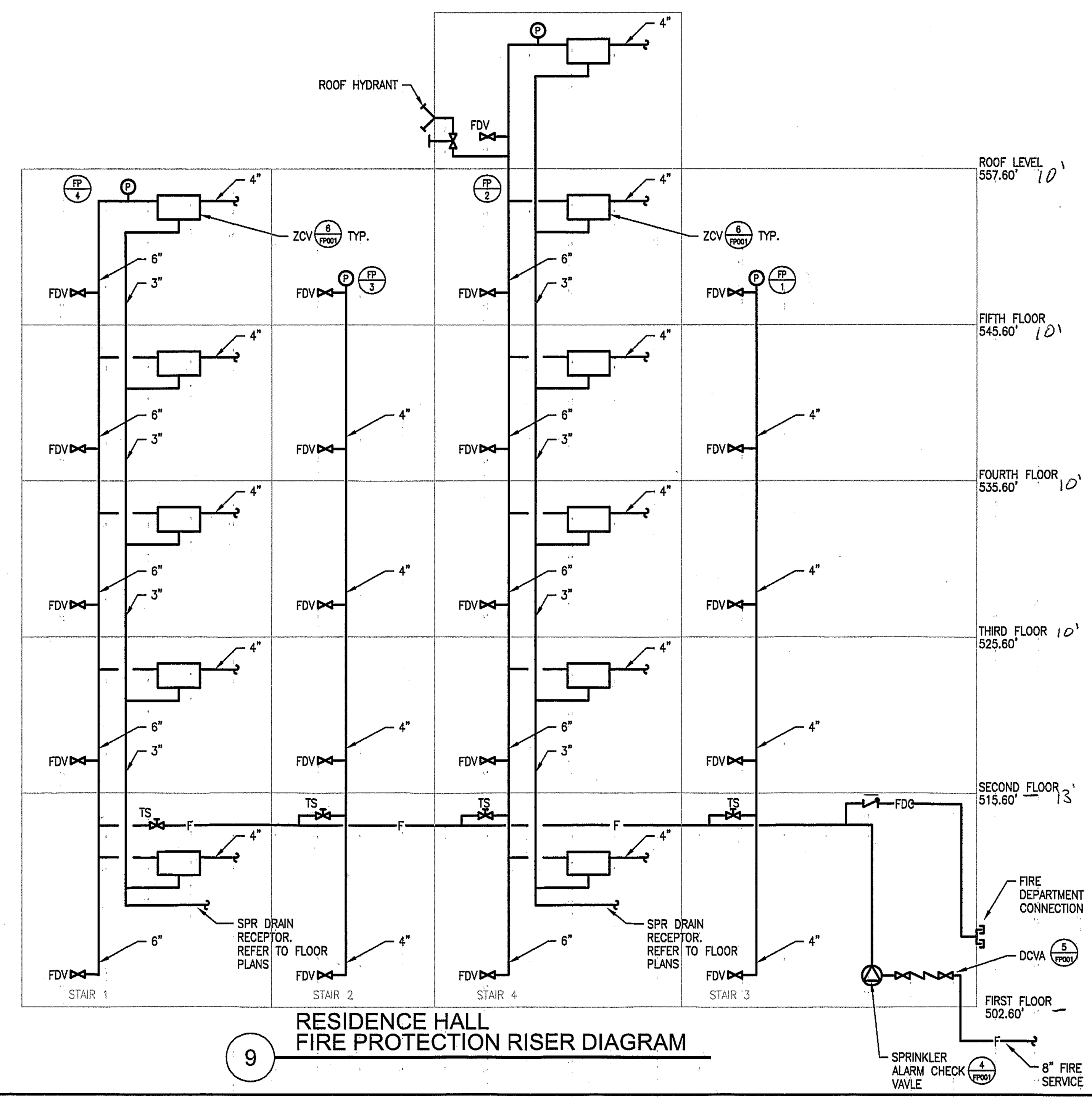
6 SPRINKLER ZONE CONTROL VALVE (ZCV)



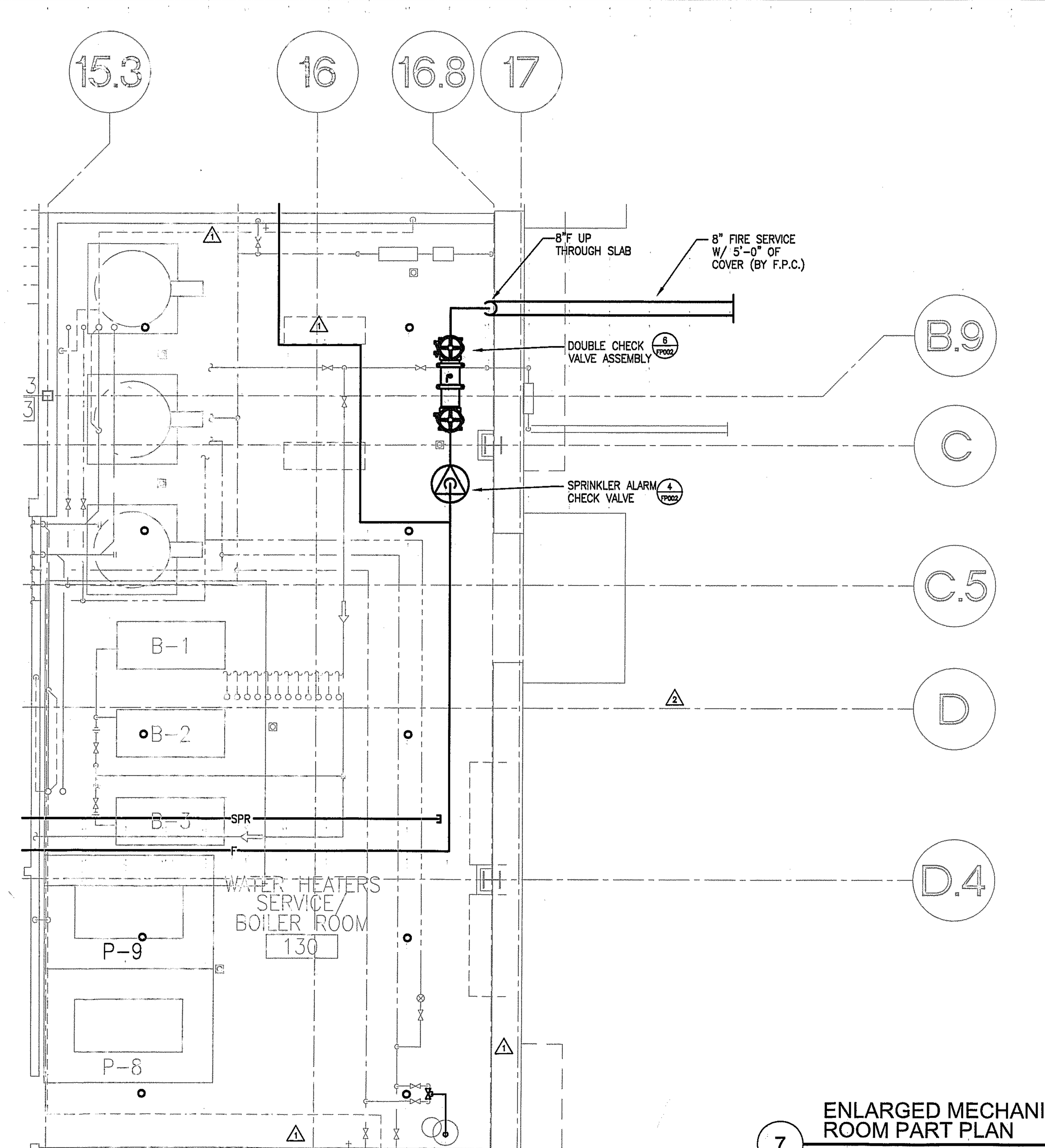
5 DOUBLE CHECK VALVE ASSEMBLY



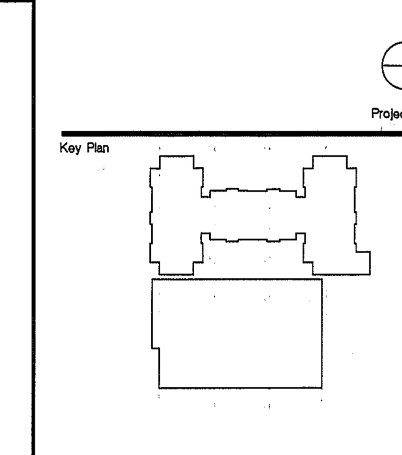
8 GARAGE FIRE PROTECTION RISER DIAGRAM



9 RESIDENCE HALL FIRE PROTECTION RISER DIAGRAM



7 ENLARGED MECHANICAL ROOM PART PLAN
1/4" = 1'-0"



PROGRESS ONLY

ELECTRICAL BUYOUT

No.	Revisions	Date
1	FOUNDATION PERMIT SUBMITTAL	4/10/07

Drawing Title:

FIRE PROTECTION LEGEND, DETAILS, RISER DIAGRAM AND ENLARGED PLAN

Issue Date: JUNE 12, 2007
Drawn by: JPM
Checked by: RF
Project No: 02757.00
Scale: AS NOTED
Drawing No:

FP001

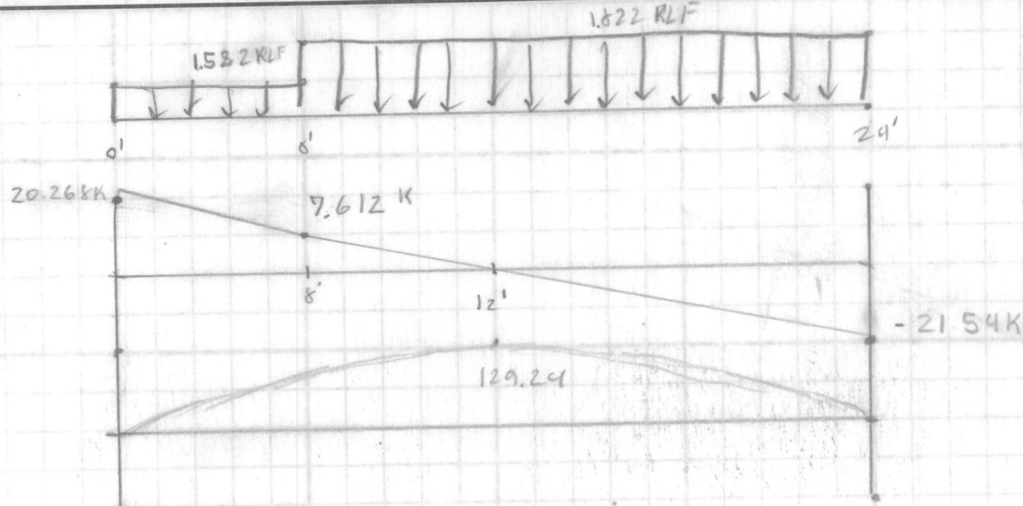
CUSTOMER/PROJECT ____ FILE ____

DATE ____ INITIALS ____ SHEET ____ OF ____

SUBJECT Moment & Sher with Beam Weight

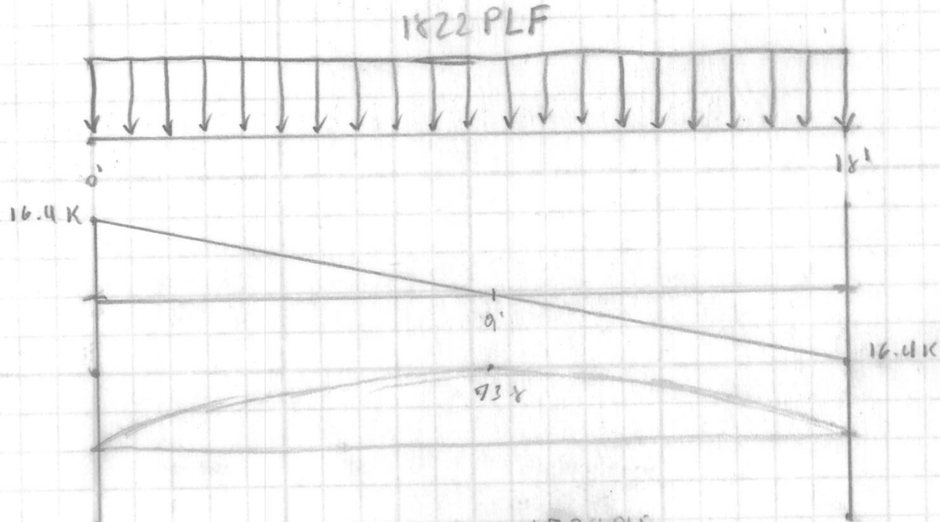
Beam 2F4 - 2F3

24' Long



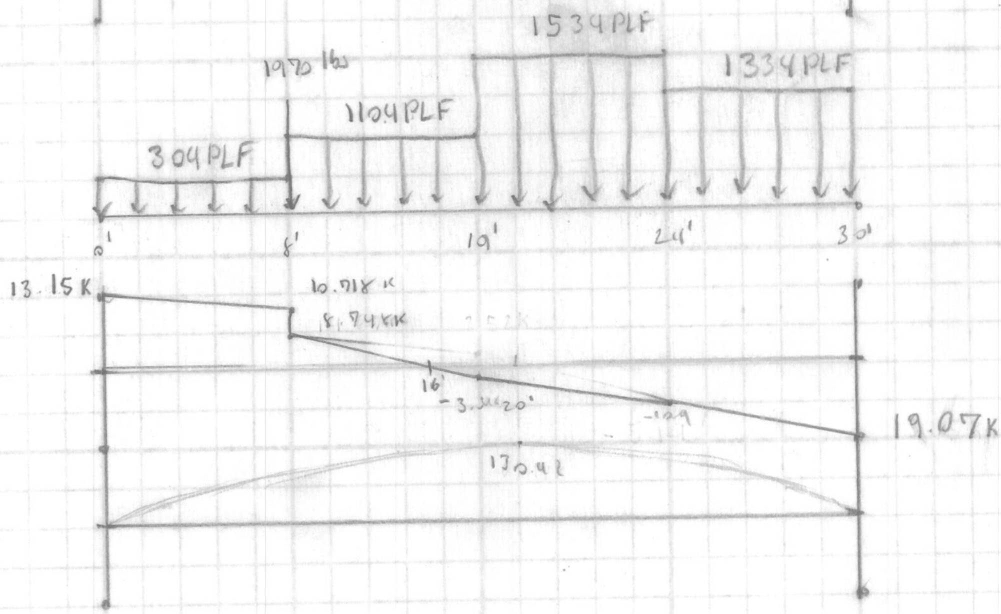
Beam 2F3 - 2F2

18' Long



Beam 2H3 - 2H2

30' Long



31.616 +

14. 143.736 + 70.68

34.96
25.84

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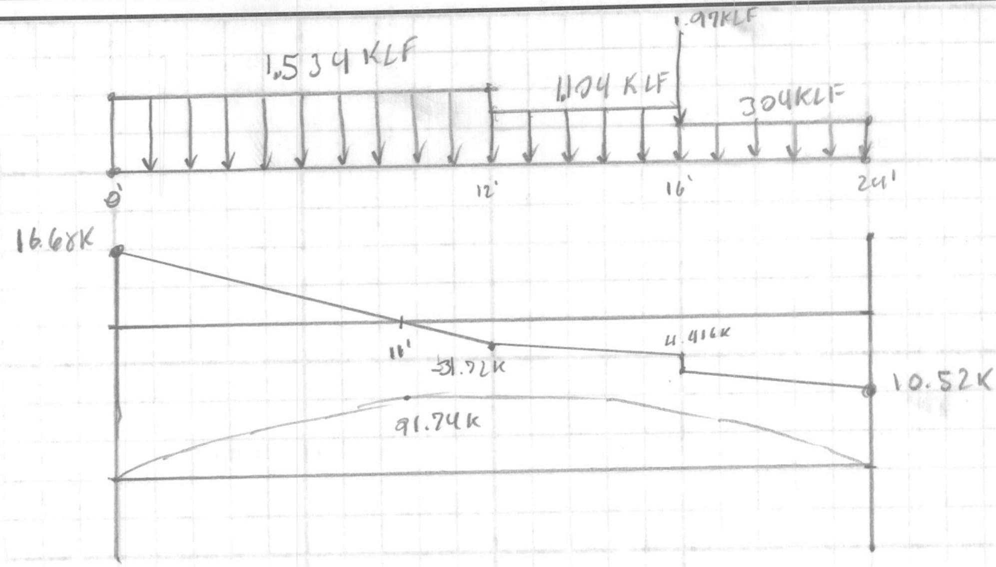
CUSTOMER/PROJECT ______________________ FILE ______________________
DATE ______________ INITIALS ______________ SHEET ____________ OF ____________
SUBJECT ____

Beam 2H2 - 2H1
24'



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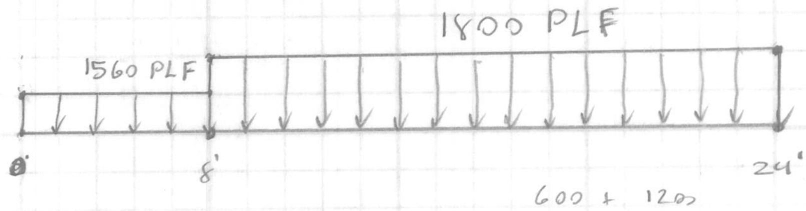
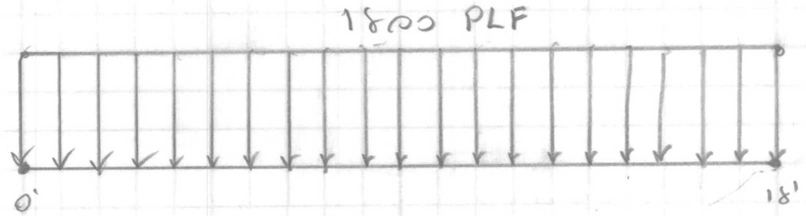
CUSTOMER/PROJECT Kyle Kappmeyer FILE
DATE INITIALS SHEET OF
SUBJECT Moment & Shear w/o Beam weight

30.14
141.52
69.536

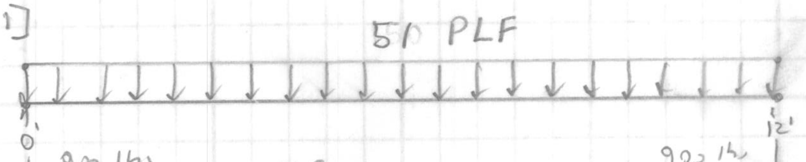
Beam 2F4 - 2F3
24' Long
← 24' 12' →



Beam 2F3 - 2F2
18' Long
← 24' 12' →

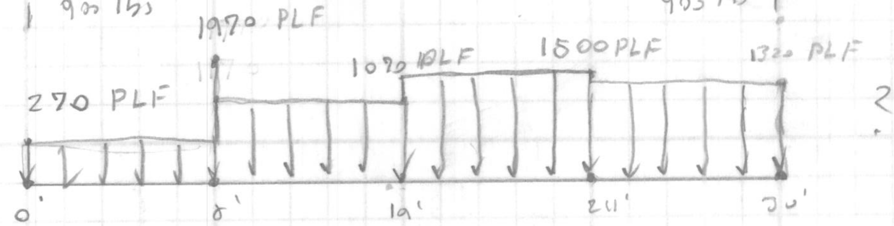


Girder 2F4 → [2H3 - 2H12]
Girder 2F2 → [2H2 - 2H1]
12' Long

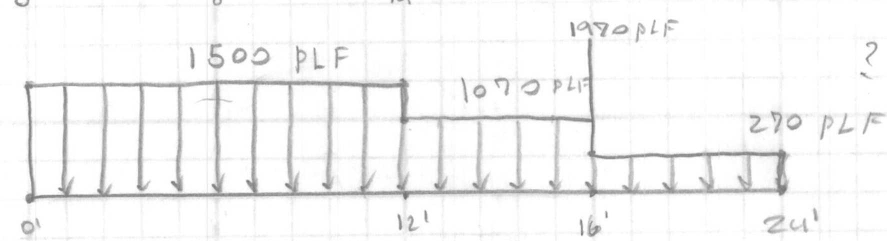


1125

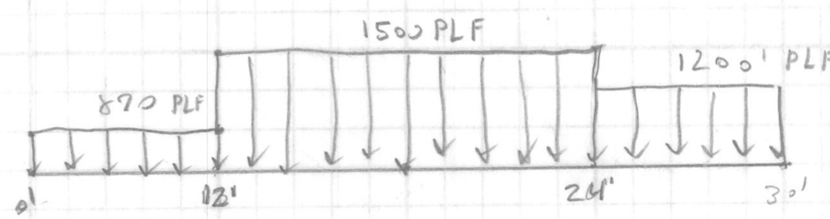
Beam 2H3 - 2H2
30' Long
← 12' 18' →



Beam 2H2 - 2H1
24'
← 12' 18' →

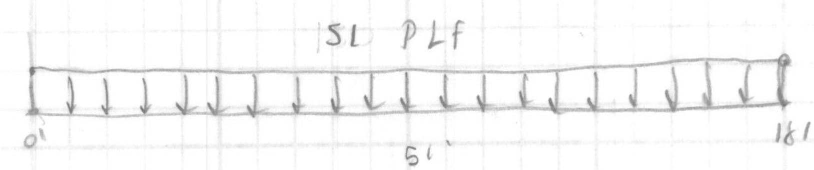


Beam 2I3 - 2I2
30' Long
← 18' 12' →

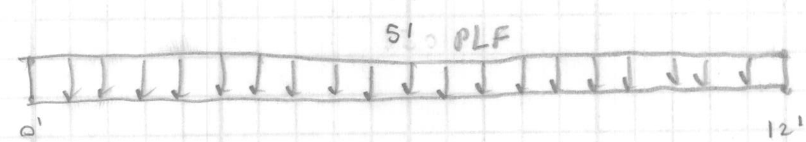


Beam 2J2 - 2J3

Girder 2H1 - 2J1
2J1 - 2K1, 2H3 - 2J3
2J3 - 2K3
18' Long



Girder 2I1 - 2J1
2I3 - 2J3
12'



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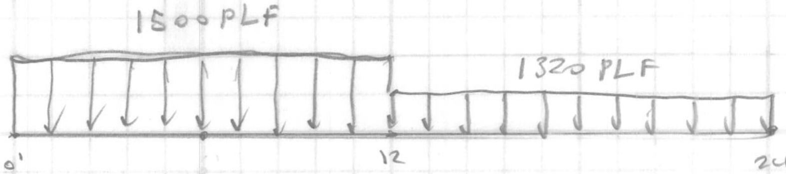
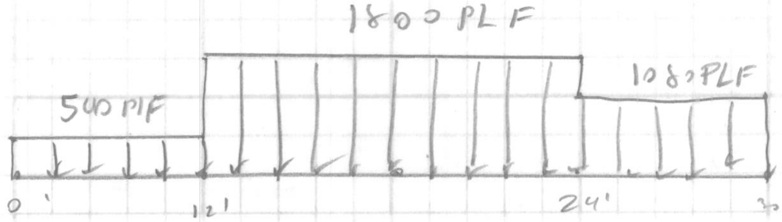
SUBJECT ______

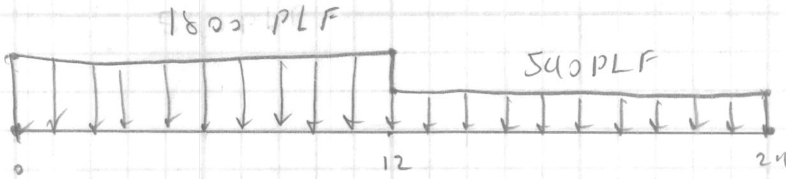
Beam 2I2 - 2I1
2J1 - 2J2
24'
← 18' 12' →



Beam 2K3 - 2K2
30' Ln
← 18' 18' →



Beam 2K2 - 2K1
24'
← 18 18 →



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CUSTOMER/PROJECT ______________ FILE ______________

DATE ______________ INITIALS ______________ SHEET ______ OF ______

SUBJECT Moment : She W/o Beam Weight

Beam 2F4-2F3

24' Long

Beam 2F3-2F2

18' Long

Guide 2F4- [2H3-2H12]

Guid 2F2- [2H2-2H1]

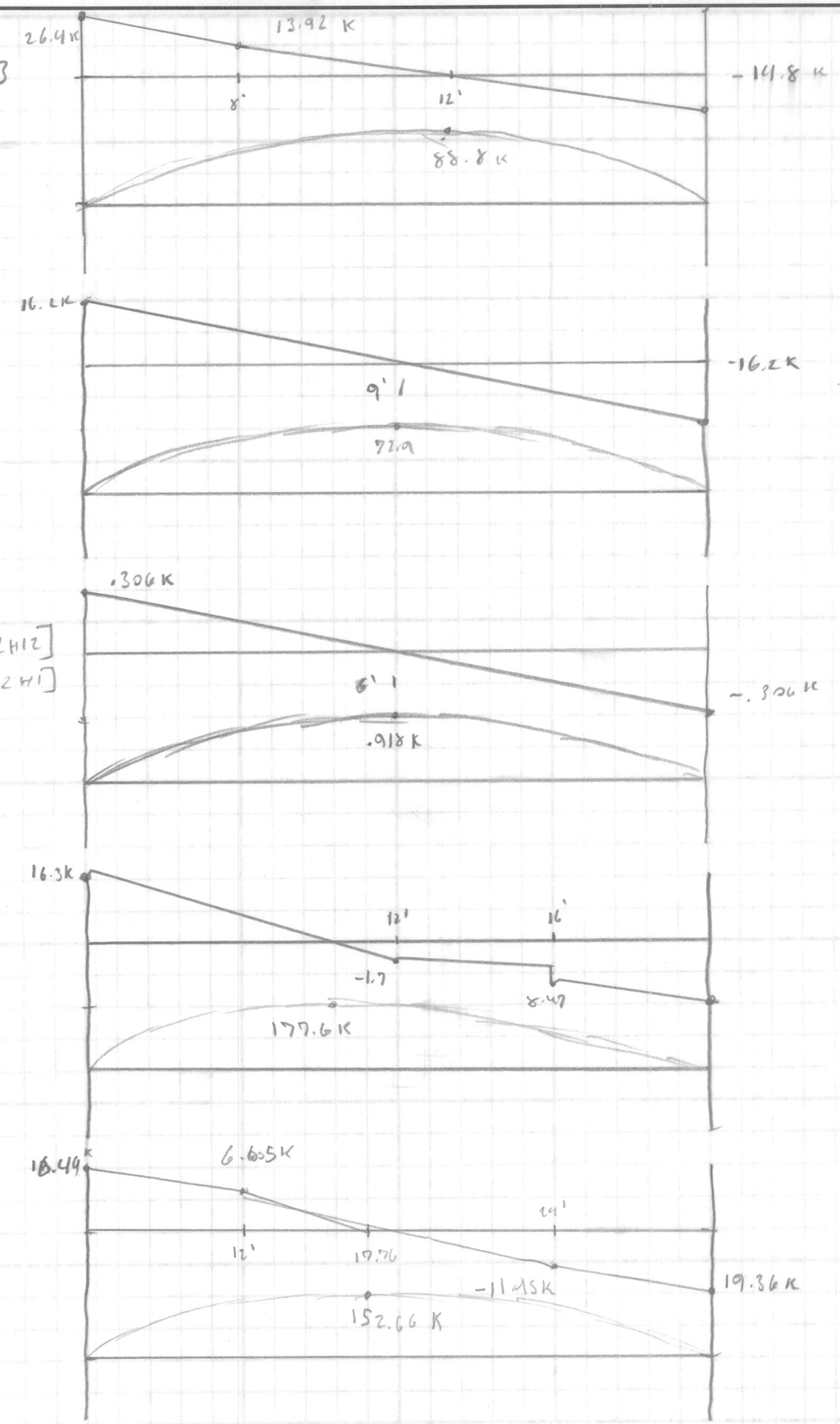
12' Lg

Beam 2H2-2H1

24'

Beam 2J3-2J2

30'



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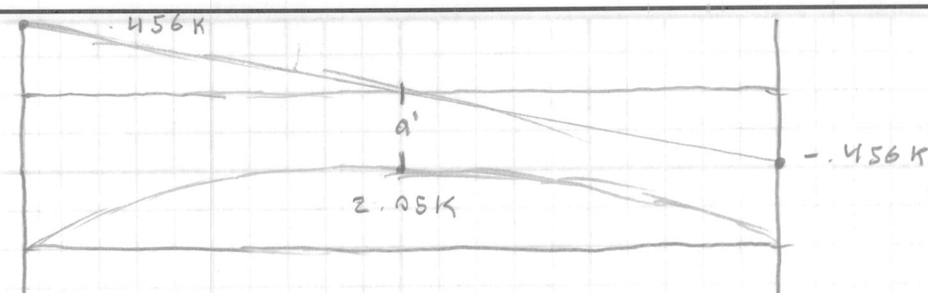
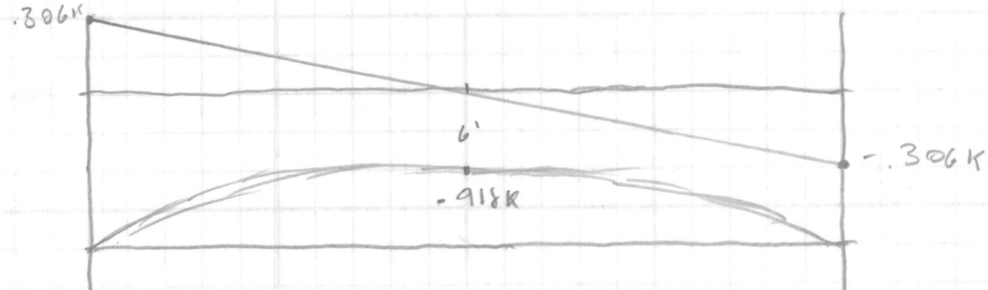
DATE ______ INITIALS ______ SHEET ______ OF ______
SUBJECT ______

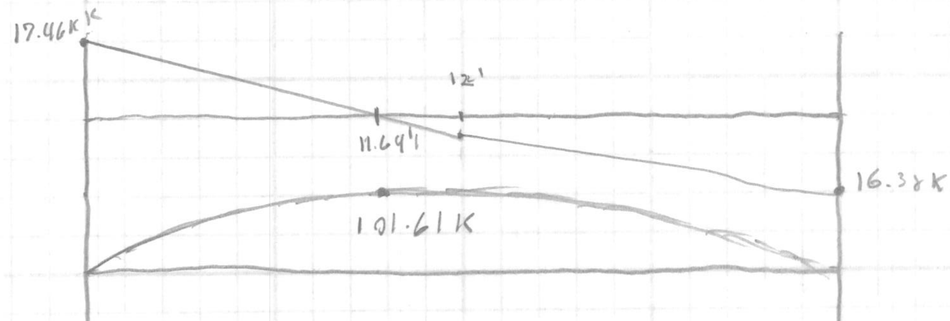
Girder 2H1-2I1,
2J1-2K1, 2H3-2I3
2J3-2K3
18' Long



Girder 2I1-2J1
2I2-2J2
12' Long

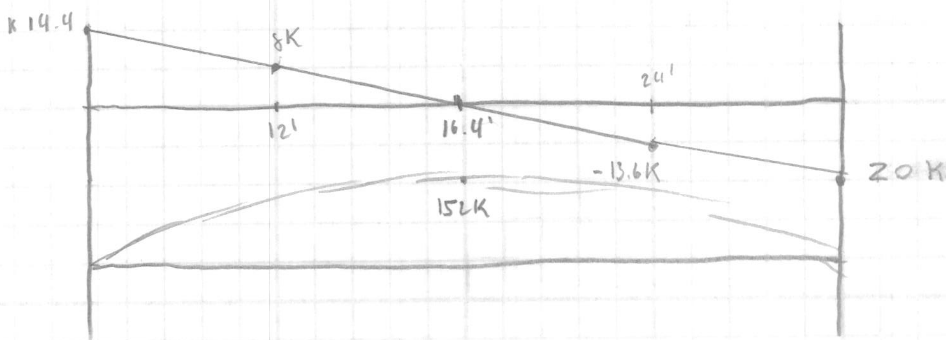


Beam 2I2-2I1
2J1-2J2
24' Long

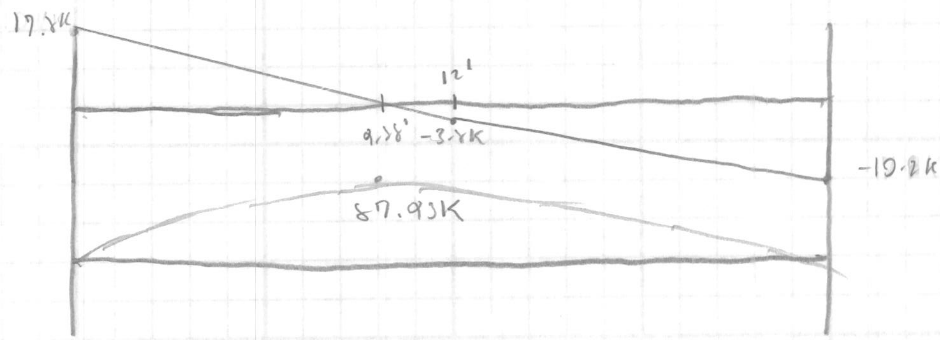


Beam 2K3-2K2
30' Long

17.6
96
38.4



Beam 2K2-2K1
24' Long



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CUSTOMER/PROJECT Beam Design for 2H3 FILE
DATE INITIALS SHEET OF
SUBJECT For Roof

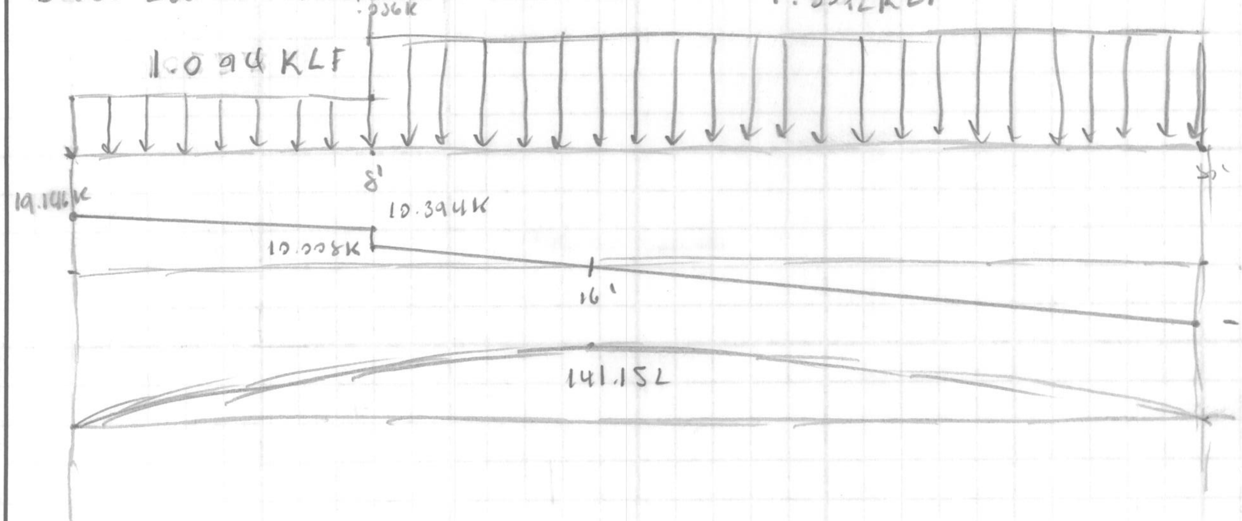
Beam Design 2H3 - 2H2 (Roof)

Wt Beam W14x43

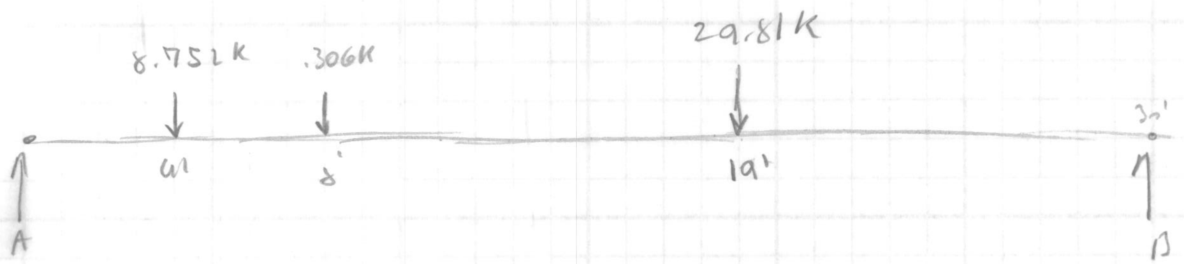
length - 30'

(Dead Load)

Dead Load - 1.292KLF + .043 PIF 1.3332KLF



Reactions



$\Sigma M_A = 8.75(4) + .306(8') + 29.81(19') - B(30') = 0$

$\Sigma M_A = \frac{35 + 2.448 + 554.42}{30'} = B$

A = 19.146
B = 19.72

A = 38.866 - 19.72

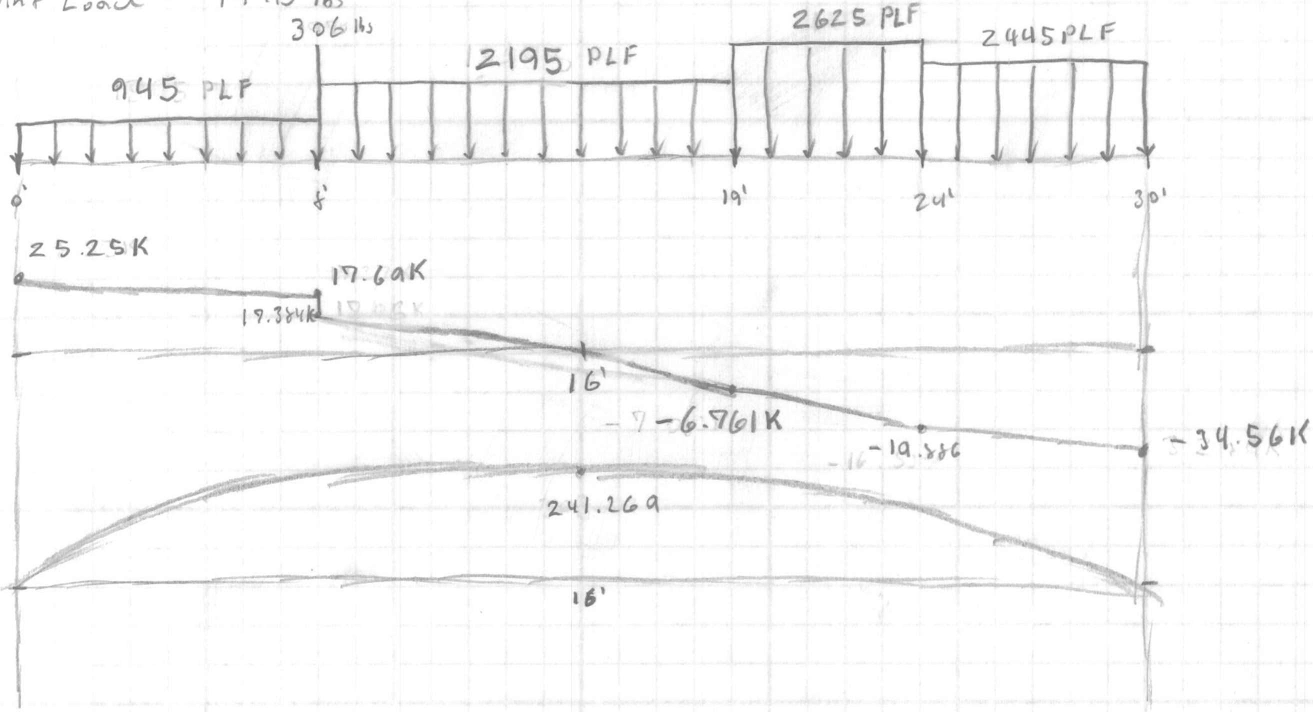
CUSTOMER/PROJECT Beam Design f. 2H3 FILE
DATE INITIALS SHEET OF
SUBJECT

Beam Design 2H3 - 2H2

Length - 30'

Dead Load - Varies 75 PSF + Live load PSF (operat. live)

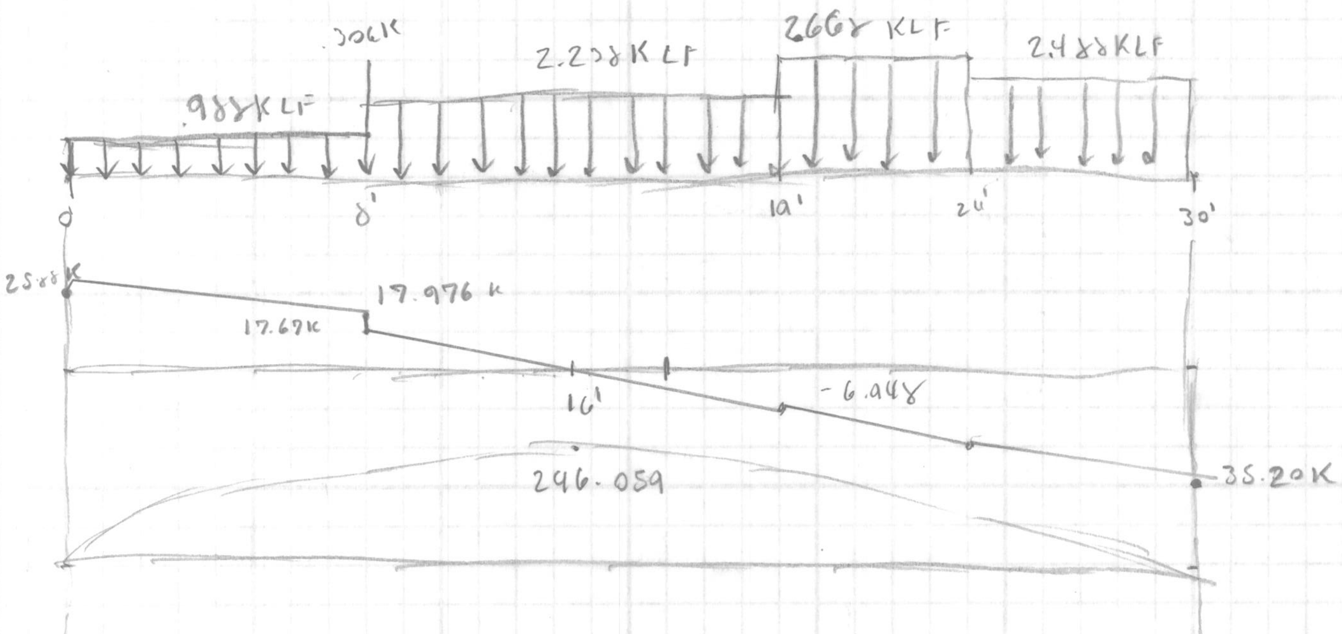
Point Load - 1970 lbs



Beam with Beam Weight

length - 30'

Dead Load - Varies 75 PSF + live load PSF



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CUSTOMER/PROJECT ______ FILE ______
DATE ______ INITIALS ______ SHEET ______ OF ______
SUBJECT ______

Moment Around A for 2H3 - 2H2

length 30'

$\Sigma M_A = 7.560(4') + .306(8') + 24.145(13.5') + 13.125(21.5')$
$14.670(27') - B(30')$

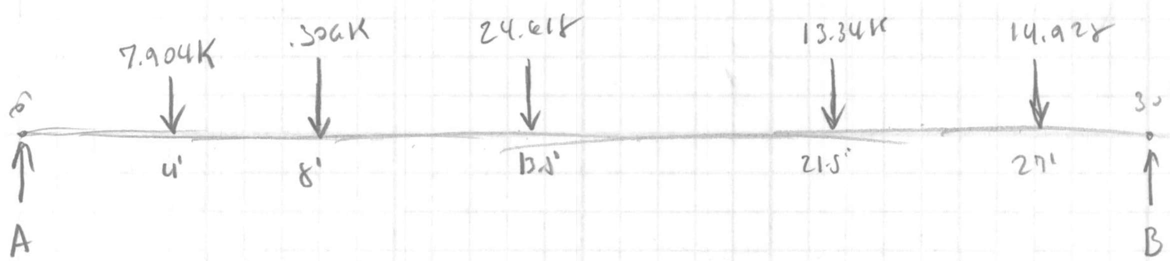
$\Sigma M_A = 30.24 + 2.448 + 325.95 + 282.187 + 396.09 = B(30')$

$B = 34.56K$

$A = 59.815 - 34.56 = 25.25$

A = 25.25 K
B = 34.56 K

Moment Around A for 2H3 - 2H2 w/ Beam weight



$\Sigma M_A = 7.904(4') + .306(8) + 24.618(13.5) + 13.34(21.5')$
$+ 14.928(27) + B(30') = 0$

$\Sigma M_A = \frac{31.616 + 2.448 + 332.343 + 286.81 + 403.056}{30} = B$

$B = 35.2091$

$A = 25.8789$

A = 25.8789K
B = 35.2091K

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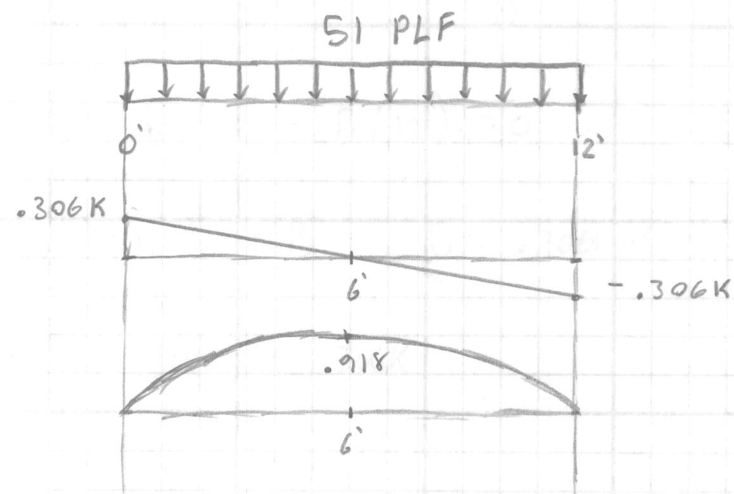
CUSTOMER/PROJECT Beam Design for 2H3 FILE
DATE INITIALS SHEET OF
SUBJECT

Beam Design 2F4 - [2H3 - 2H2]

Length - 12'

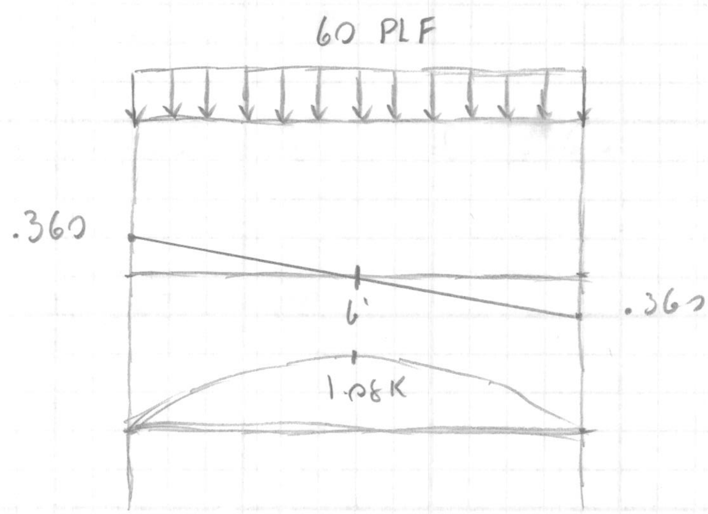
Dead Load - 51plf (Brick facade)



Beam with Beam Weight

Length - 12'

Dead Load - 51plf (Brick facade) + 9 plf (Beam weight)



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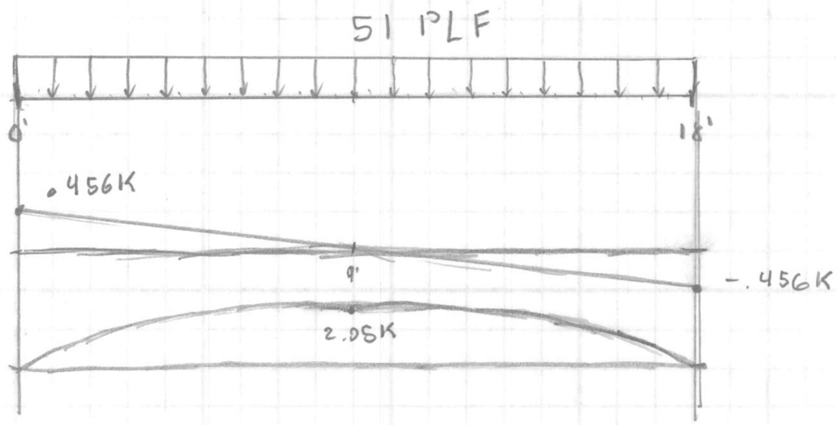
CUSTOMER/PROJECT Beam Design for 2H3 FILE
DATE INITIALS SHEET OF
SUBJECT

Beam Design 2H3 - 2I3

Length - 18'

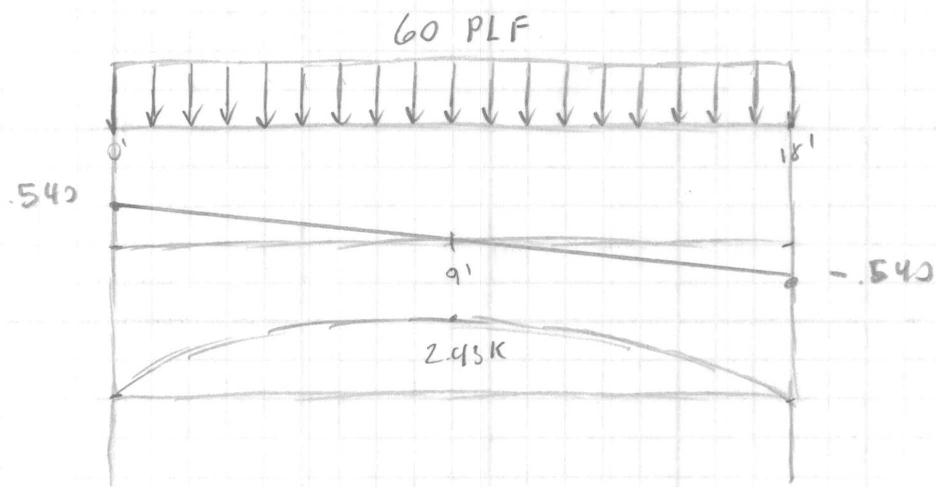
Dead Load - 51 plf (curtin wall, Brick Facade)



Beam with Beam Weight

Length - 18'

Dead Load - 51 plf + 9 plf
(Brick facad) (Beam weght)



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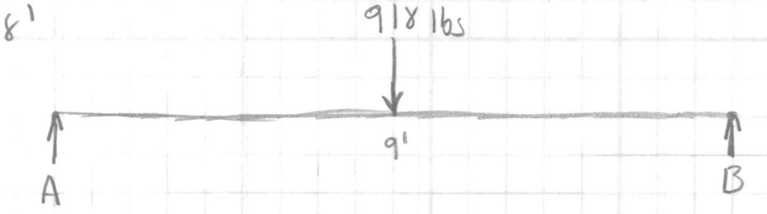
Moment Around A for 2H3 - 2I2

length 18'



$\Sigma M_A = 918 \text{ lbs } (9') - B(18') = 0$

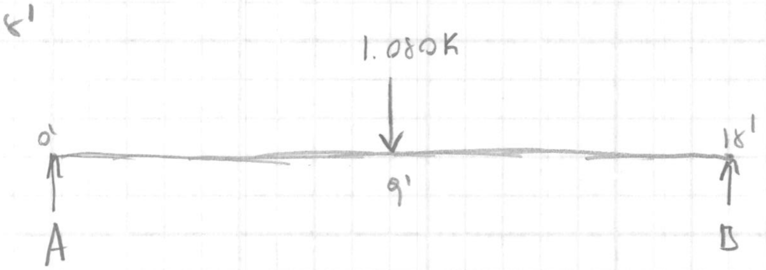
$\Sigma M_A = \dfrac{8.262 \text{ KLF}}{18'} = B \qquad B = .459 \text{ K}$

$A = .918\text{K} - .459\text{K} = .459\text{K}$

A = .459K
B = .459K

Moment Around A for 2H3 - 2I2

length 18'



$\Sigma M_A = 1.080(9') + B(18') = 0$

$\Sigma M_A = \dfrac{9.720}{18'} = B \qquad B = .540\text{K}$

$A = 1.080 - .540 = .540$

A = .540K
B = .540K

CUSTOMER/PROJECT Column 2H3 FILE
DATE INITIALS SHEET OF
SUBJECT

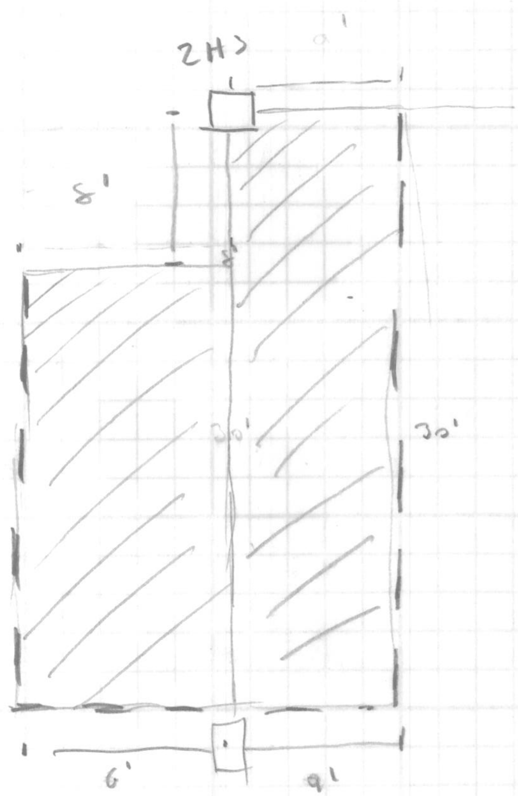
Column Design 2H3

(EACH FLOOR)

$P_u = P_{2H3-2H2} + P_{2H3-PI3} = 25.878K + .540K = 26.418K$

(ROOF)

$P_u = 19.146K$



Tributary width

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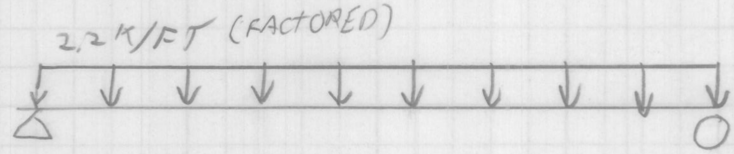
BEAM 3B1-3C1

$L = 16'$ $L_s = 15'$



ESTIMATE D as $0.4^{K/FT}$

$W = 2.2 + 1.2(0.4) = 2.68^{K/FT}$

$M_U(+) = \frac{WL^2}{10}$

$= \frac{2.68(16)^2}{10} = 68.6^{'K}$

$\frac{bd^2}{12} = \frac{M_U}{\phi k_n}$

$\phi k_n = f'_c w(1 - 0.59w)$ $w = \rho f_y / f'_c$

$w = .01 \frac{60}{4} = 0.15$

$\phi k_n = 0.9(4)(0.15)(1 - 0.59(.15)) = 0.492$

$bd^2 = \frac{68.6(12)}{.492} = 1672.5''^3$

B	d	
8	14.5''	← THIS ONE $h = 17''$
10	13''	
12	12''	$D = 0.67(1.417)(0.15) = 0.24^{K/FT}$
14	11''	
16	10.5''	$2.4 < 0.4$ ✓ OK
18	10''	

ASSUME $jd = 0.875d = 12.69''$

$A_s = \frac{M_U}{\phi F_y jd}$ $A_{smin} = \frac{3\sqrt{f'_c}\, b_w d}{F_y} \leq \frac{200 b_w d}{F_y}$

$= \frac{68.6(12)}{0.9(60)(12.69)} = 1.2''^2$ $= 0.360,$ 0.387

USE 1.2

TRY 3 #7 BARS $(A_s = 1.70 \text{ in}^2)$

$$a = \frac{A_s F_y}{0.85 f'_c b}$$

$$= \frac{1.7(60)}{0.85(4)(8)} = 3.75''$$

$a/d_t = 0.258 < 0.319$ ✓ TENSION CONTROLLED

$\phi = 0.9, \quad F_y = F_s$

$$\phi M_n = \phi\left[A_s F_y \left(d - \frac{a}{2}\right)\right]$$

$$= 0.9\left[1.7(60)\left(14.5 - \frac{3.75}{2}\right)\right]/12 = 96.58'^{K}$$

$96.58'^{K} > 68.6'^{K}$ ✓ OK

BEAM 3B1-3C1)

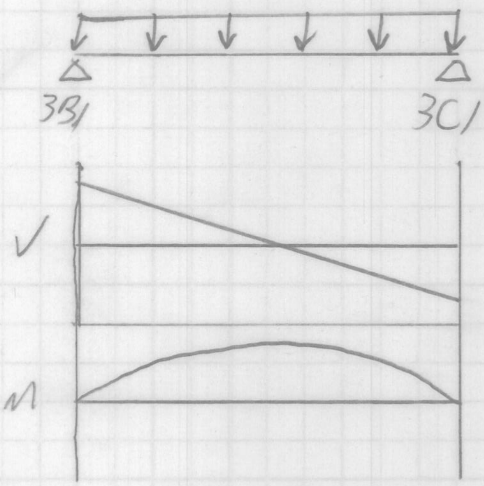
LOAD: SLEEPING (30PSF)

$W_t = 13/2 = 6.5'$

$L = 6.5(30)/2 = 97.5$ PLF

$D = 51$ PLF (CURTAIN WALL)

$W = 148.5$ PLF $\quad \ell = 16.25'$



$V_{max} = W\ell/2 = 1206.6$ #

$M_{max} = \frac{W\ell^2}{8} = 4902$ '-#

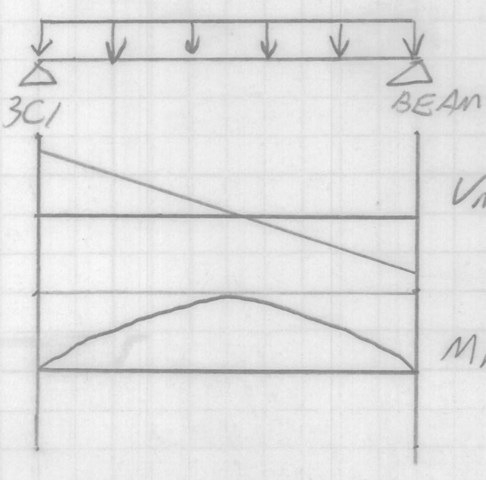
BEAM 3C1-3E1 IS IDENTICAL TO 3B1-3C1

BEAM 3C1-(B3A1-B3B1)

LOADS: CORRIDOR + SLEEPING

$\ell = 9'$

$L = 18(30) = 540$ PLF



$V_{max} = W\ell/2 = 2430$ #

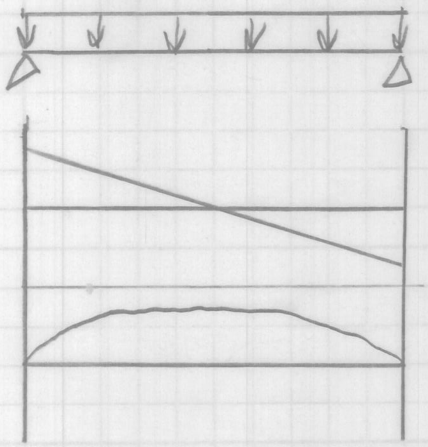
$M_{max} = W\ell^2/8 = 5468$ #'

BEAM 3B1-[3A0-(B3A1-B3A2)]

LOADS; CURTAIN WALL, BEDROOM @ 17.75'

$\ell = 9'$

$L = 9(30)/2 = 135$ PLF $+51 = 186$ PLF



$V_{max} = \frac{wL}{2} = 837\#$

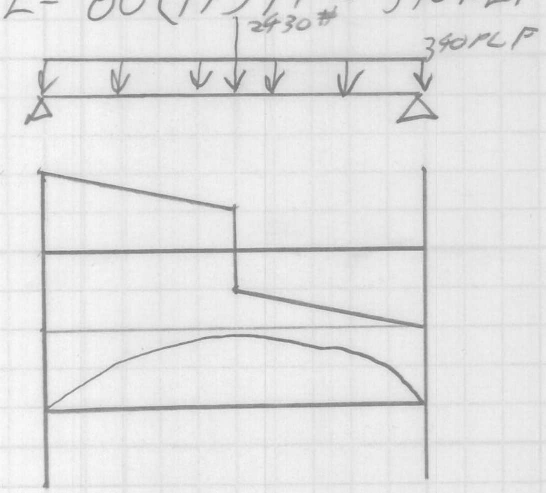
$M_{max} = \frac{wL^2}{8} = 1883'\#$

BEAM 3E1-[3G1-(B3B1-B3B2)] IS IDENTICAL TO ABOVE.

BEAM B3A1 - B3B1 $\ell = 8.5'$

L = POINT + CORRIDOR

$L = 80(17)/4 = 340$ PLF



$V_{max} = \frac{wL}{2} + \frac{P}{2} = 2{,}660\#$

$M_{max} = \frac{wL^2}{8} + \frac{PL}{2} = 13398'\#$

BEAM 3G1 – (B3B1 – B3B2) $\ell = 22.5'$

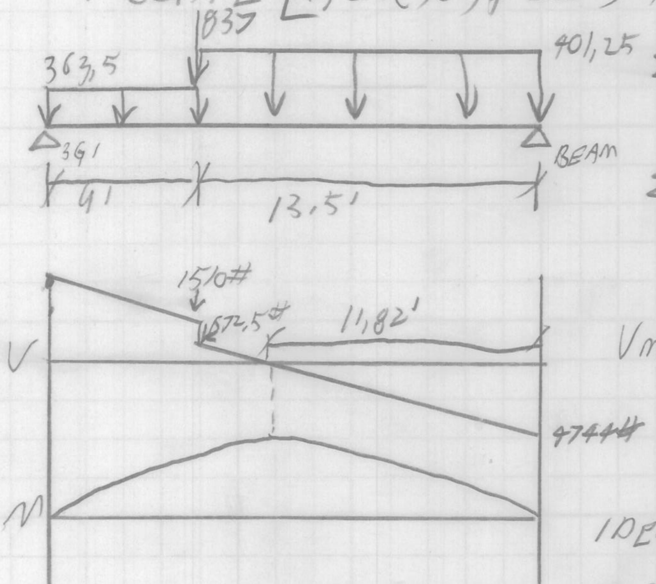
FROM COLUMN TO 9': 2' OF 100PSF, CURTAIN WALL, 4.25' OF 100PSF

FROM 9' TO END: 7.25' OF 30PSF, 2' OF 80PSF, 4.25' OF 100PSF

@9': 837# POINT LOAD

$0\text{-}9;\ L = 51 + [(4.25 \cdot 100) + 2(100)]/2 = 363.5\ PLF$

$9\text{-}22.5;\ L = [7.25(30) + 2(80) + 4.25(100)]/2 = 401.25\ PLF$



$\Sigma F_y = 0 = 3G1 + B - 363.5(9) - 837 - 401.25(13.5)$

$3G1 + B = 9525\#$

$\Sigma M_{3G1} = 0 = B(22.5) - 837(9) - 363.5(9)(4.5)$
$- 401.25(13.5)(9 + 6.75)$

$B = 4781 \quad A = 4744$

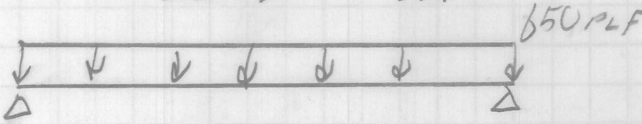
$V_{max} = 4781\#$

$M_{max} = \frac{1}{2}(4744)(11.82) = 28{,}044'\#$

IDENTICAL TO 3A0 – (B3A1 – B3A2)

BEAM (B3B1 – B3B2) – (3G1 – 3F1) $\ell = 22.5'$

FROM 0 TO 8.5: 6.5' OF 100PSF,
FROM 8.5 TO 12: 6.5' OF 80
FROM 12 TO 22.5 6.5' OF 100PSF
REPLACE WITH UNIFORM LOAD OF 650 PLF, SIMPLIFICATION IS CONSERVATIVE.



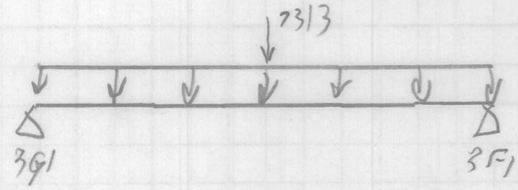
$V_{max} = w\ell/2 = 7313\#$

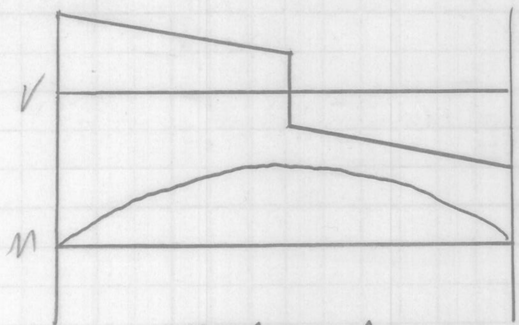
$M_{max} = w\ell^2/8 = 41{,}133\#'$

BEAM (B3A1 – B3A2) – (3A1 – 3A0) IS IDENTICAL

BEAM 3G1-3F1) $l = 18'$

LOADS; 51 PLF 2' OF 100 PSF = 251 PLF
@ 9', 7313#





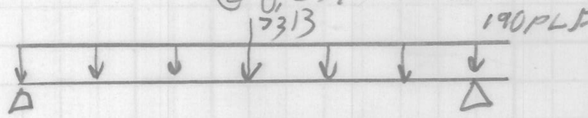
$V_{max} = wl/2 + P/2 = 5916\#$

$M_{max} = \frac{wl^2}{8} + \frac{PL}{2} = 75,983'\#$

BEAM 3A0-3A1 IS IDENTICAL

BEAM B3B1-B3B2 $l = 16.5'$

LOADS: 4.75' OF 80 PSF
@ 8.25: 7313#



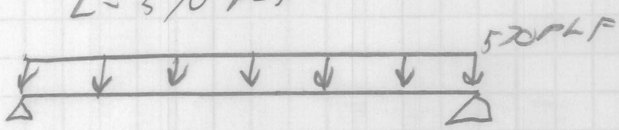
$V_{max} = \frac{wl + P}{2} = 5224\#$

$M_{max} = \frac{wl^2}{8} + \frac{Pl}{2} = 66,798'\#$

SEE ABOVE FOR SHEAR AND MOMENT DIAGRAMS.

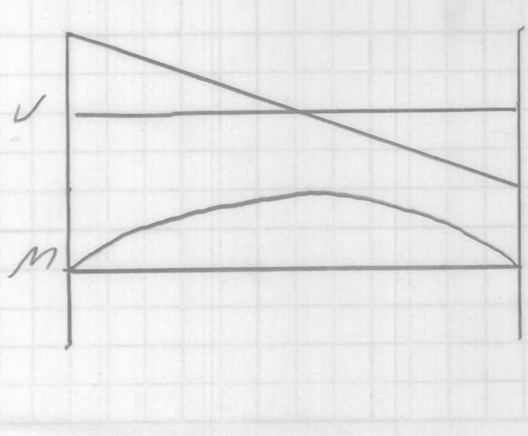
BEAM B3A1-B3A2 IS IDENTICAL.

BEAM B3A2-B3B2 $l = 8.5'$
LOADS: 3' OF 80 PSF, 8.25' OF 80 PSF
L = 570 PLF



$V_{max} = wl/2 = 2423\#$

$M_{max} = \frac{wl^2}{8} = 5148'\#$



5)

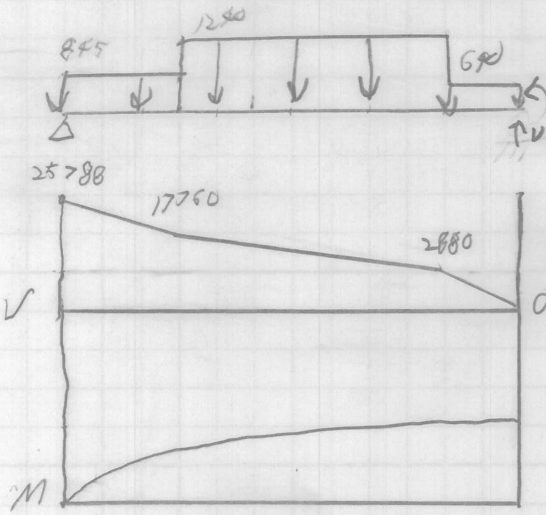
BEAM 3A1-3F1 $\ell = 52'$

LOADS: 0 TO 9.5: 6.5' OF 100PSF, 6.5' OF 30PSF Z1
9.5 TO 17.5: 6.5' OF 100PSF, 3' OF 80PSF 3.5' OF 100PSF Z2
17.5 TO 21.5: 5' OF 80 PSF 4.5' OF 100PSF, 3.5' OF 100PSF Z3
21.5 TO 26: 1.5' OF 80PSF 6.5' OF 80PSF Z4
BEAM IS SYMMETRIC

Z1: 845 PLF Z2: 1240 PLF Z3: 1200 PLF Z4: 640 PLF

COMBINE Z2 + Z3 @ 1240 PLF

LEFT HALF OF BEAM:



$V_{max} = 845(9.5) + 1240(12) + 640(4.5)$

$= 25,788^{\#}$

$M_{max} = 9.5\frac{(25788+17760)}{2} + 12\left(\frac{17760+2880}{2}\right) + \frac{2880(4.5)}{2} = 337,171'^{\#}$

BEAM 3F1-3F2 $\ell = 12.5'$

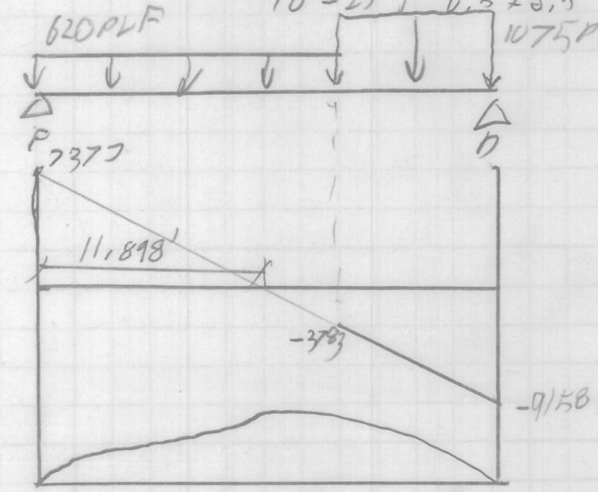
LOADS: 51 PLF

$V_{max} = w\ell/2 = 318^{\#}$

$M_{max} = w\ell^2/8 = 996'^{\#}$

BEAM 3F2-3D1 $\ell = 23'$

LOADS; 0 TO 18': 6.5' OF 30 PSF, 8.5' OF 50 PSF = 620 PLF
18'-23'; 6.5 + 3.5' OF 100 PSF 1075 PLF



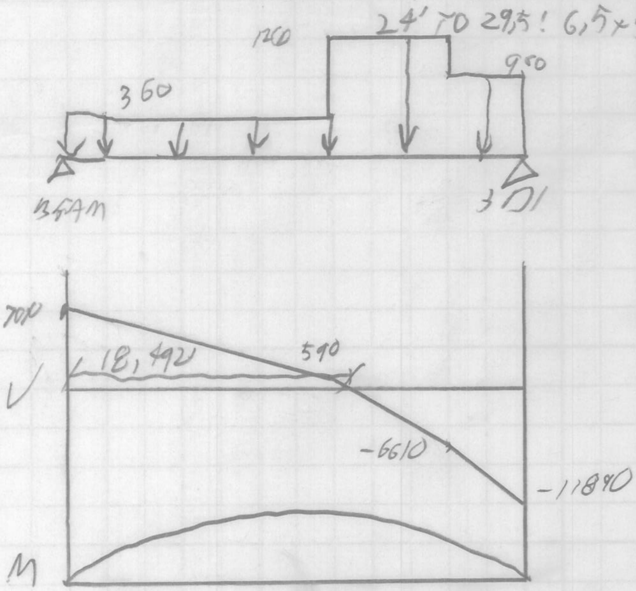
$\Sigma F_y = 0 = F + D - 620(18) - 1075(5)$
$F + D = 16535$

$\Sigma M_F = 0 = D(23) - 620(18)(9) - 1075(5)(11.5)$
$D = 9158\#$
$F = 7377\#$

$M_{max} = 7377(11.898)/2 = 43887'\#$

BEAM (3A1-3A2)-3D1 $\ell = 29.5'$

LOADS; FROM 0 TO 18': 6.5' OF 30 PSF, 5.5' OF 30 PSF ⇒ 360 PLF
FROM 18 TO 24': 6.5 + 5.5' OF 100 PSF 1200 PLF
24' TO 29.5': 6.5 + 5.5' OF 80 PSF 960 PLF



$B + 3D1 = 360(18) + 1200(6) + 960(5.5)$
$= 18960$
$D(29.5) = 360(18)(9) + 1200(6)(21) + 960(5.5)(26.75)$
$D = 11890\#$
$B = 7070\#$

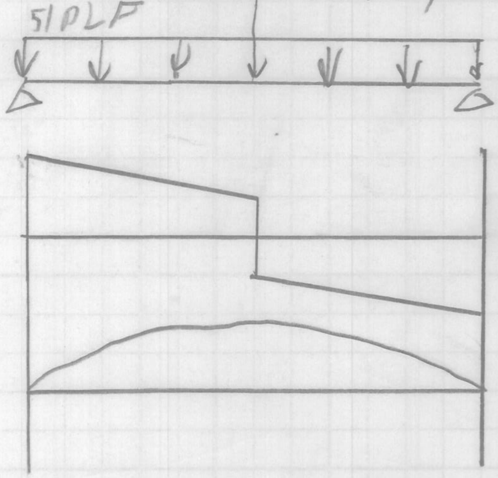
$M_{max} = 18(7070 + 590)/2 + 590(0.491)/2$
$= 69085'\#$

BEAM 3A3-(3D2-3D3) IS IDENTICAL

7/

BEAM 3A1-3A2 $l = 24'$

LOADS: 51PLF, 7070#@ 12'



$V_{max} = \frac{WL+P}{2} = 4147\#$

$M_{max} = \frac{wl^2}{8} + \frac{Pl}{2} = 88512\#'$

BEAM 3A2-(3D1-3D2) $l = 29.5'$

LOADS; 6 TO 18': 6.5' OF 30PSF, 5' OF 100PSF
18 TO 29.5: 6.5+5 OF 100PSF

LOAD IMPOSED BY CURTAIN WALL

BRICK VENEER, 1/2"

DENSITY = 1922 KG/m³

CONVERSION FACTORS: 1 KG => 2.21 LB
1 m => 3.28' ($1 m^3 => 35.29'^3$)

$$1922\ KG/m^3 = \left(\frac{1922\ KG}{m^3}\right)\left(\frac{2.21\ LB}{KG}\right)\left(\frac{m^3}{35.29'^3}\right) = 120.4\ LB/FT^3$$

$\gamma = 120.4\ LB/CF$ $T = 0.5" = 0.0417'$

$D = 120.4(0.0417) = 5.015\ PSF$

ASSUME 10' STORIES, EACH FLOOR OF CURTAIN WALL HANGS FROM BEAMS ABOVE

$D = 5.015(10') = 50.15\ PLF$

USE 51 PLF

W21 X 55

$A = 16.2''^2$ $I_x = 1140$ $S_x = 110$ $r_x = 8.4$ $Z_x = 126$

$I_y = 48.4$ $S_y = 11.8$ $r_y = 1.73''$ $Z_y = 18.4''^3$

$r_{ts} = 2.11''$ $h_o = 20.3''$ $J = 1.24''^4$ $C_w = 4980''^6$

$M_p = F_y Z_x = 50(126) = 6300'^k$

$$L_p = 1.76\, r_y \sqrt{\frac{E}{F_y}}$$

$= ~~1.76~~\ 73.3''$

$$L_r = 1.95\, r_{ts} \frac{E}{0.7F_y} \sqrt{\frac{J_c}{S_x h_o}} \sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7F_y}{E} \quad \frac{S_x h_o}{J_c}\right)^2}}$$

$= 208.5''$

IF RADICAL FROM F 2.4 ≐ 0, THEN

$$L_r = \pi r_{ts} \sqrt{\frac{E}{0.7F_y}}$$

$= 190.8''$

M_n / $L_b = L_r$

$= 0.7 F_y S_x$

$= 3850''^k \Rightarrow 320.8'^k$

3Ei – 3A1 $L = 29'$ $L_{s1} = 9'$ $L_{s2} = 13'$

FACTORED SUPERIMPOSED LOAD = $0.147^{K/LS/FT}$

$w = 3.22^{K/FT}$

ESTIMATE BEAM WT @ $0.5^{K/FT}$

$w = 1.2(0.5) + 3.22 = 3.82^{K/FT}$

$$M_U = \frac{wL^2}{10}$$

$$= \frac{3.82(24^2)}{10} = 220.0'^K$$

$$\frac{M_U}{\phi k_n} = \frac{bd^2}{12{,}000}$$

$\phi k_n = 0.9(f'_c w(1-0.59w))$

$w = 0.15$

$\phi k_n = 0.9(4000)(1-0.59(.15))(0.15) = 492$

$$bd^2 = \frac{220.0(12{,}000)}{492}$$

$= 5366''^3$

b	d
10	23.5"
12	21.5" ←
14	20" ← THIS ONE (h = 21.5")
16	18.5"
18	17.5"
20	16.5"

$D = 14/12(21.5/12)(.15) = 0.3^K < 0.5$ ✓ OK

$$A_s = \frac{M_U}{\phi f_y jd}$$ $jd = 0.875d = 17.5''$

$$= \frac{220(12)}{0.9(50)(17.5)} = 3.35^{\#}$$

ROOF LOADS;

SOIL
SNOW
ROOF LIVE LOAD

SOIL: WCS => SATURATED SOIL. MUST BE TOP SOIL (TO GROW GRASS)

$\gamma = 135$ PCF (USACE)

ASSUME 4" 135/3 = **45 psF**

SNOW LOAD

FROM MASS B.C.

WORCESTER IS ZONE 3, USE **35 psF**

L_R = 20PSF FOR $T_a < 200'^2$
16PSF FOR $200 < T_a < 600$
12PSF FOR $T_A > 600$

LOAD COMBINATION:

$1.2D + 1.6S$ ($S > L_R$ ALWAYS)

$1.2(45) + 1.6(35) =$ **110 PSF**

$A = P/S$

$S =$ ~~5 K/□~~ 5 K/□

$P = 370 + 410 + 35 + 120 = 935$ K

$A = 935/5 = 187'^2$

$A = L^2$

$L = \sqrt{187} = 14' \times 14'$

1B1-1C1

$L=18'$ $A_t=8'$ G?: N

IDENTICALS: 1C1-1E1, 1B2-1C2, 1C2-1E2

WING SAME AS UPPER FLOORS

BEAM 1F3-[1G1-1G2]

L: 13' $A_t=8.5'$ G: N W: Y

IDENTICALS: 1F5-[1G3-1G2]

1F4-1G2

L: 13' $A_t=17'$ G: N W: N

NO IDENTICALS

1G1-1H1

L: 18' $A_t=$ ~~11.25~~ 5' G: N W: Y

IDENTICAL! 1G3-1H3

1H1-1J1

L: 11.5' $A_t=$ ~~11.25~~ 5' G: N W: Y

IDENTICAL 1H3-1J3

1J1-1K1:

$L=8'$ $A_t=$ ~~11.25~~ 5' G: N W: Y

~~IDENTICAL~~

1K1-1N1

$L=19'$ $A_t=$ ~~11.25~~ 5' G: N W: Y

1G2-1H2:

L=18' A_t=25.25' G:N W:N

1H2-1J2:

L=11.5' A_t=25.25' G:N W:N

1J2-1K2:

L=8' A_t=25.25' G:N W:N

1K2-1N2:

L=19' A_t=25.25' G:N W:N

1G3-1H3

L=18' A_t=~~14~~ 15' G:N W:Y

1H3-1J3

L=11.5' A_t=~~14~~ 15' G:N W:Y

1J3-1L1

L=12' A_t=~~14~~ 15' G:Y W:Y ←

1L1-1M1

L=12' A_t=~~14~~ 15' G:N W:Y

1G1-1G2

L=22' A_t=9' G:Y W:N ←

1H1-1H2

L=22' A_t=14.5 G:N W:N

1J1-1J2

L=22' A_t=10' G:N W:N

1K1-1K2

L=22' A_t=13.5' G:N W:N

1G2-1G3

L:28' A_t=9' G:Y W:N ⟸

1H2-1H3

L=28' A_t=14.5' G:N W:N

1J2-1J3

L=28' A_t=10' G:N W:N

1K2-[1J3-1L1]

L=29' A_t=13.5' G:N W:N

SLAB DESIGN:

ASSUME BEAM SPACING OF 7.5'

L = 100 PSF

ESTIMATE THICKNESS:

$\ell = 7.5'$

MIN $h = \ell/24 = 3.75''$

TRY 4" SLAB

ASSUMING #4 REINF, 3/4" COVER,

$d = 4 - (0.75 + 0.5/2) = 3''$

$W_d = 150 \#/ft^3 (4''/12''/1') = 50 \#/ft^2$

$W_L = 100$ PSF

ASSUME TRIB WIDTH = 1.0'

$W = 1.2D + 1.6L = 1.2(50) + 1.6(100) = 220$ PLF

$\phi_b = 0.9$

CHECK SLAB THICKNESS:

$$\frac{bd^2}{12{,}000} = \frac{M_U}{\phi K_n}$$

$\phi K_n = \phi [f'_c w(1 - 0.59w)$

$w = \rho f_y / f'_c$

$$w = \frac{0.01(60{,}000)}{4000} = 0.15$$

$\phi K_n = 0.9[4 \cdot 0.15(1 - 0.59(0.15))] = 492.2$

$$M_U = \frac{WL^2}{10} = \frac{220(7.5)^2}{10} = \quad 1.24'^K$$

$$\frac{bd^2}{12000} = \frac{M_u}{\phi k_n}$$

$$d = \sqrt{\frac{M_u(12000)}{\phi k_n b}}$$

$$= \sqrt{\frac{1.24(12{,}000)}{492.2(12)}} = 1.59'' < 4'' \quad \checkmark \text{ OK FLEX}$$

CHECK SHEAR:

$$V_u = \frac{220(7.5)(1.15)}{2} = 948.8^{\#}$$

$$\phi_v = 0.75$$

$$\phi V_c = 0.75(2\sqrt{f'_c}\, b_w d)$$

$$= 0.75(2\sqrt{4000})(12)(4)$$

$$= 4.55^{k} > 0.95^{k} \quad \checkmark \text{ OK SHEAR}$$

DESIGN REINFORCING STEEL:

ASSUME $jd = 0.925d$

$$A_s = \frac{M_u}{\phi F_y jd}$$

$$= \frac{1.24(12)}{0.9(60)(0.925)(4)} = 0.075 \text{ in}^2/'$$

$$a = \frac{A_s F_y}{.85 f'_c b}$$

$$= \frac{0.075(60)}{0.85(4)(12)} = 0.110''$$

$$jd = d - \frac{a}{2} = 3 - 0.05 = 2.95'' \qquad j = 0.983$$

$$A_s = \frac{M_u}{\phi f_y j d}$$

$$= \frac{1.23(12)}{0.9(60)(2.95)} = 0.093''^2/'$$

$$A_{s\,min} = 0.0018\,bh$$

$$= 0.0018(12)(4) = 0.086$$

0.093 > 0.086 USE 0.093

USING #4 BARS, $s = 0.2''/0.093''/' = 2.16'$

FOR CRACK CONTROL,

$$s_{min} = \frac{540}{f_s} - 2.5\,c_c$$

$$= \frac{540}{36} - 2.5(0.75) = 13.1''$$

USE 13'' SPACING FOR TENSION STEEL.

FOR TEMP STEEL:

$A_s = 0.0018\,bh = 0.086''^2/'$

PROVIDE #4 BARS @ 18'' O.C

INFILL BEAM DESIGN:

$W = V_{SLAB} = 950\ PLF(2) < 1{,}9\ KLF$

CALC EFFECTIVE FLANGEWIDTH

MIN OF:

$l/4 = 23(12)/4 = 69''$

$8h = 8(4'') = 32(2) = 64''$

$SLAB/2 = 7.5(12)/2 = 45''$ ← GOVERNS

ASSUME $b_w = 12''$, $h = 18''$

$d = h - 3.5'' = 14.5''$

AREA OF ⊕ MOMENT STEEL

$$A_s = \frac{M_U}{\phi f_y j d}$$

$$M_U = \frac{wL^2}{10} \qquad V_U = \frac{1.15\,wL}{2} = 1.1^K/1\ SPAN$$

$$= \frac{1.9(23')}{10} = 100.5'^K$$

$j = 0.95$

$$A_s = \frac{100.5(12)}{0.9(60)(0.85)(14.5)} = 1.81''^2$$

TRY 4 #7 BARS ($A_s = 2.4''^2$)

$$a = \frac{A_s f_y}{0.85 f'_c b}$$

$$= \frac{2.4''(60)}{0.85(4)(12)} = 3.53'' < 4''$$ RECTANGULAR ACTION

$d_t = 18'' - (1.5 + 0.375) = 16.125''$

$a/d_t = 3.53''/16.125'' = 0.218 < 0.319$ ✓ TENSION CONTROLLED

$f_s = F_y,\ \phi_b = 0.9$

$\phi M_n = \phi[A_s F_y (d - a/2)]$

$= 0.9[2.4(60)(14.5 - 3.53/2)/(12)$

$= 137.5'^k > 100.5$ ✓ OK

(1) MOMENT STEEL

$M_u = \frac{wL^2}{12}$

$= \frac{1.9(24)^2}{12} = 91.2'^k$

$b = 12''$

$d = h - 2.5'' = 15.5''$

$d_t = h - 2.25 = 15.75''$

$A_s = \frac{M_u}{\phi F_y \, j d}$

$= \frac{91.2(12)}{0.9(60)(0.95)(15.5)} = 1.38''^2$

TRY 6 #5 BARS ($A_s = 1.86''$)

$a = \frac{A_s F_y}{0.85 f'_c b}$

$= \frac{1.86(60)}{0.85(4)(12)} = 2.73''$

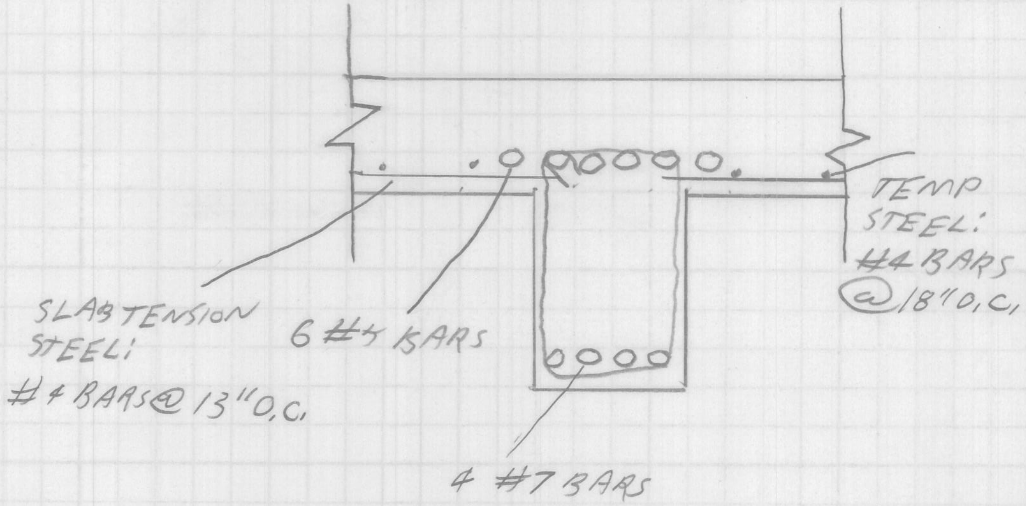
$a/d_t = 2.73/15.75 = 0.173 < 0.319$ ✓ TENSION CONTROLLED

$\phi = 0.9,\ F_y = F_s$

$$\phi M_n = \phi[A_s F_y (d - a/2)]/12$$

$$= 0.9(1.86)(60)(15.5 - 2.73/2)/12$$

$$= 118.3'^{k} > 91.2'^{k} \checkmark OK$$



Large Column

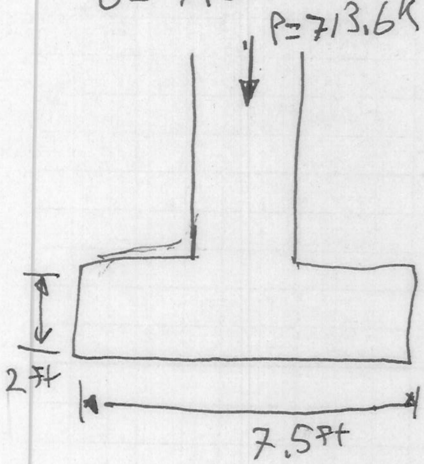
P for ~~Large~~ large Column = 713.6^k

$W_f = 2 \cdot 7.5^2 \cdot .15^k/ft^3$

$u_D = 0$

$B = 7.5$

$q = \frac{P + W_f}{A} - u_D$



$q = \frac{713.6^k + 7.5^2 \cdot 2 \cdot .15}{7.5^2} = \frac{730.275^k}{56.25}$

$q = 12.98266$

$\sigma'_{zD} = \Sigma \gamma H - u$

$q_{ult} = 1.3 c' N_c + \sigma'_{zD} N_q + .3 \gamma' B N_\gamma$

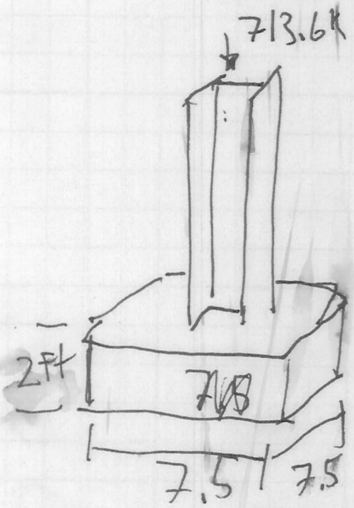
$q_{ult} = 1.3 \; 150 \frac{lb}{ft^2} (37.2) + 270 \frac{lb}{ft^3} \cdot 22.5 + .3 \left(135 \frac{lb}{ft^3}\right) 7.5 ft \; 20.1$

$q_{ult} = 7254 \quad + 6075 \quad + 6105.37$

$q_{ult} = 19434.375 \; lb/ft^2$

$q < q_{ult}$

$12.98 \; k/ft^2 < 19.43 \; lb/ft^2$ ~~ok~~ ✓



Find the required Area for steel

$I = \frac{B-c}{2} = \frac{30-8}{2} = 11 in$

135116

$M_{uc} = \frac{P_u I^2}{2B} + 0 = \frac{67,000 \; 11^2}{2(30)} =$ ~~[illegible]~~ 10^6

$A_s = \left(\frac{3000(28.5)}{1.176(60,000)}\right)\left(20.5 - \sqrt{20.5^2 - \frac{2.353(8.107 \cdot 10^6)}{.9(3000)28.5}}\right)$

1.21

$\left(\frac{85,500}{70560}\right)\left(20.5 - \sqrt{420.25 - \frac{19,075,771}{76950}}\right)$

$1.21 \cdot (20.5 - 13.128)$

$A_{s_3} = 8.92 in^2$

$I = \frac{B-c}{2} = 23 in$

$M_{uc} = \frac{P_u I^2}{2B} + 0 = \frac{383(23^2)}{112} = 1808991.071$

$A_s = \left(\frac{4000 \; 30.5}{1.176(60,000)}\right)\left(20.5 - \sqrt{420.25 - \frac{2.353(1.809)}{.9(3000)30.5}}\right)$

$A_s = (1.73)\left(20.5 - \sqrt{420.25 - \frac{4.256 \cdot 10^6}{82350}}\right)$

$A_{s_M} = 1.68 in^2$

$I = \frac{B-c}{2} = \frac{90-10}{2} = 40 in$

$M_{uc} = \frac{714 \; 40^2}{2(90)} = 6.347 \cdot 10^6$

$A_s = \left(\frac{6000 \cdot 30.5}{1.776(60,000)}\right)\left(20.5 - \sqrt{420.25 - \frac{2.353(6.347)}{.9 \, 6000 \; 30.5}}\right)$

1.71 $\cdot$ 2.35

$A_s = 4.02$

Case 1 $D_w \le D$ is present so

$$\gamma' = \gamma_b = \gamma - \gamma_w$$

$$q_a = \frac{q_{ult}}{F}$$

$$q \le q_a$$

Settlement It must be ensured that no foundations settle excessively

$$\Delta\sigma_z = I_\sigma (q - \sigma'_{zD})$$

if $I_\sigma = \frac{1}{4\pi}$ = stress influence factor using Boussinesq's method (found in Appendix) or Simplified method

Square Foundation

$$\Delta\sigma_z = \left[1 - \left(\frac{1}{1 + \left(\frac{B}{2z_f}\right)^2}\right)^{1.76}\right](q - \sigma'_{zD})$$

min D of 30in

$$\text{Area} = \frac{P + W_f}{q_A + u_D}$$

B depends of Bearing capacity and δ settlement

Shear Loads
Wind and Earthquake Loads

Footings on Frozen soil below 60"-50"

σ_{ult}

126394.5 81637.05374

68091.25 42634.8

3287.75 8250.75

Foundation Design

1. Foundation design is calculated using soil composition w/ bearing pressure

Bearing Pressure is calced using

$$q = \frac{P + W_f}{A} - u_D$$

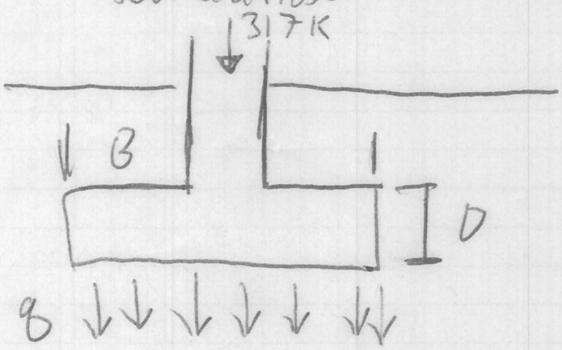
where the Foundation is a shallow individual footing using reinforced concrete as construction material

P in this case for Column H3 is **317 k** and is the vertical column load

A is base of the foundation B^2 for square footing

W_f is weight of the foundation including weight of the soil above

u_D is the pore water pressure at the bottom of the foundation



Of course Bearing pressure must be compared to the Bearing Capacity of the soil for the given Foundation Size. This Capacity is Approx using Vesics equation to account for a below ground footing at different angles to the soil

$$q_{ult} = c' N_c s_c d_c i_c b_c g_c + \sigma'_{zD} N_q s_q d_q i_q b_q g_q + 0.5\gamma' B N_\gamma s_\gamma d_\gamma i_\gamma b_\gamma g_\gamma$$

this includes equations for load factors, s

Depth Factors d

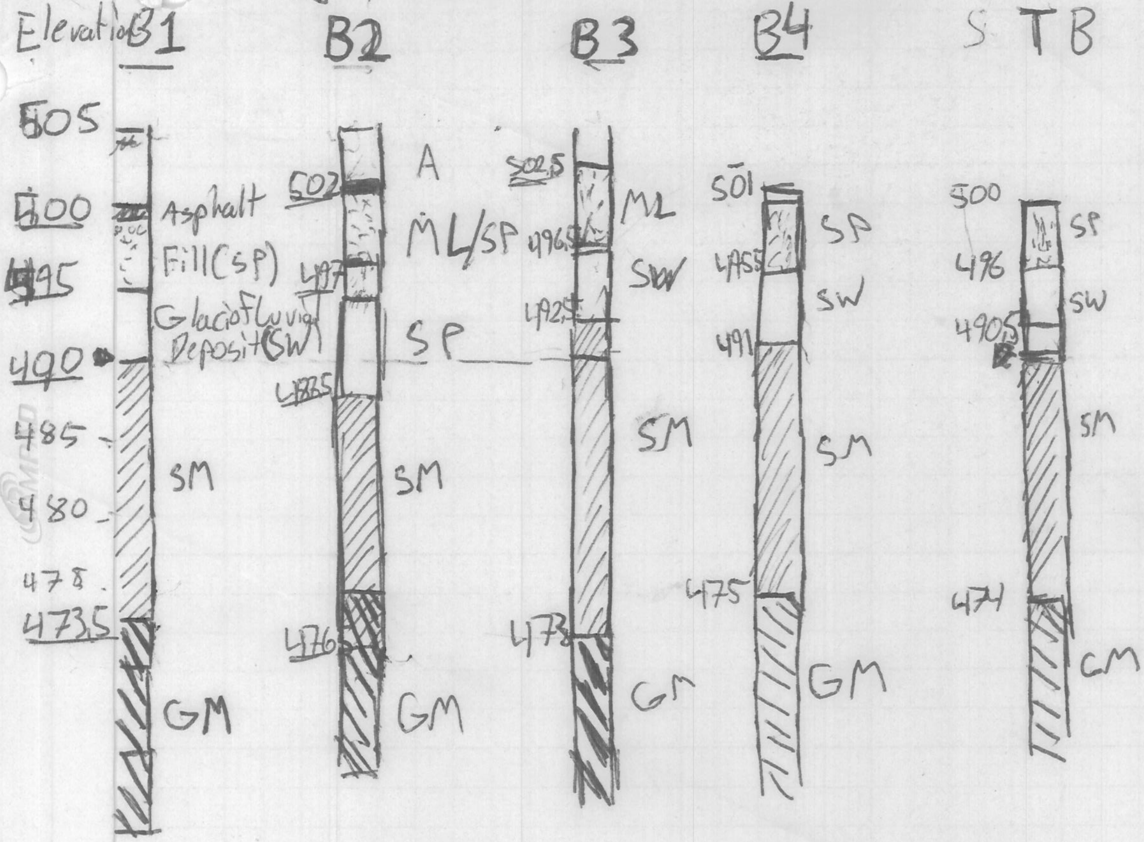
Load inclination Factors i

Base inclination Factors b

Bearing Capacity Factors g

Pore water Pressure must be considered

Boring Comparrisons SeaBoard Drilling Services



~~Hammer~~ Winch Safty Hammer

Design Depth 490

SPT Avg. 6

SP = Poorly-graded sand $\gamma = 115\ lb/ft^3$

SW - Well graded sand $\gamma = 115\ lb/ft^3$

SM - Silty sand $\gamma = 125\ lb/ft^3$ K

GM - Silty gravel $\gamma = 132.5\ lb/ft^3$

$A_s \geq .0018(24)\cdot 30 = 12.96\,in^2$

$A_s \geq .0018(24)(56) = 2.42\,in^2$

$A_s \geq .0018(24)(90) = 3.88\,in^3$

$A_{s_L} = 4.02\,in^2 \geq 3.88\,in^2$

$A_{ss} > 2$ #8

$A_{sm} = 4$ #8

A_{sL} 6 #8

Clear space between Bars$_{small}$ = 30/3 = 10 in

medium = 56/5 = 11.2

Large = 90/7 = 12.85

Check development Length

$I_{d_s} = I - 3 = 11 - 3 = 8\,in$

$I_{d_m} = I - 3 = 23 - 3 = 20\,in$

$I_d = I - 3 = 40 - 3 = 37\,in$

$$\frac{C + K_b}{d_b} = \frac{3.5 + 0}{1} = 3.5 > 2.5$$

$$\frac{I_d}{d_b} = \frac{3}{40}\,\frac{60{,}000}{\sqrt{3000}}\,\frac{(1)(1)(1)(1)}{2.5} = 32.86$$

$$\frac{I_d}{d_b} = \frac{3}{40}\,\frac{60{,}000}{\sqrt{3000}}\,\frac{(1)(.8)(1)(1)}{2.5} = 23.79$$

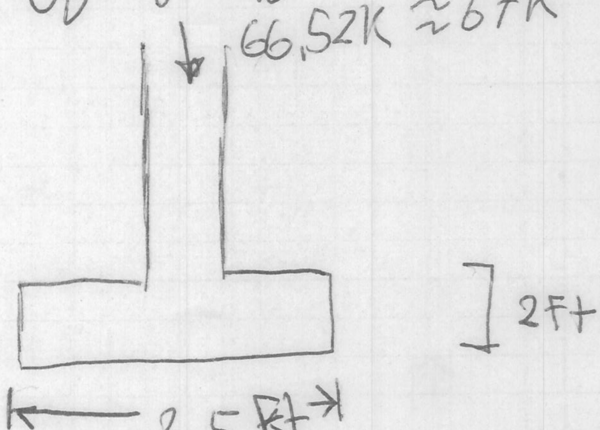
Connections to super structure

Light Column Design   Foundation assumed square

P for light Column = 66.52K ≈ 67K

W_f = weight of Foundation and soil above

$U_D = \gamma \, Z_w$



$$q = \frac{P + W_f}{A} - u_D$$

$$q = \frac{67K + (2.5^2 \cdot 2 \cdot .15K)}{2.5^2} - 2Ft\,(62.4\ lb/Ft^3)$$

$$q = \frac{68.875K}{6.25Ft^2} - \frac{62.4lb}{Ft^2}$$

$$11.02\ K/Ft - .062\ K/Ft$$

$\sigma_z'D = \gamma D$

$\sigma_z'D = 125\ lb/Ft^3 \cdot 2Ft = 250\ lb/Ft^2$

$q_{ult} = 1.3\,c\,N_c + \sigma'_D N_q + .4\gamma' B N_\gamma$ $q = 10.96\ K/Ft^2$

$d = T - 3in - d_b$ $d_b = .5in$

$20.5 \approx 24in - 3in - .5in$ $T = 24in$

$V_{uc} \leq \phi V_{nc}$ $V_{uc} \leq .85 V_{nc}$

Critical Shear $d/2 = 10.25in$

$V_{nc} = V_c + V_s$

$$V_{uc} = \left(\frac{P_u}{4} + \frac{M_u}{c+d}\right)\left(\frac{B^2 - (c+d)^2}{B^2}\right)$$

Small $\left(\frac{67K}{4} + \frac{0}{8+20.5}\right)\left(\frac{2.5ft^2 - (8+20.5in)^2}{2.5ft^2}\right)$

Med $\left(\frac{383}{4} + \frac{0}{10+20.5}\right)\left(\frac{5.5ft^2 - (10+20.5)^2}{5.5ft^2}\right)$

Large $\left(\frac{714}{4} + \frac{0}{10+20.5}\right)\left(\frac{7.5ft^2 - (10+30.5)^2}{(7.5ft^2)}\right)$

$V_{uc_s} =$ ~~16.75K~~ $1.633K$

$b_o = c + d$

$V_{ucm} = 95.75k \approx 75.3K$

$V_{ucL} = 178.5k \approx 158.$~~00~~$K$

$V_{nc_s} = 4 b_o \cdot d \sqrt{f'c} = 4(28.5) \cdot 20.5 \sqrt{3000}$

$128K$

$V_{ncM} = 4 b_o d \sqrt{f'c} = 4(30.5)(20.5)\sqrt{3000} = 137K$

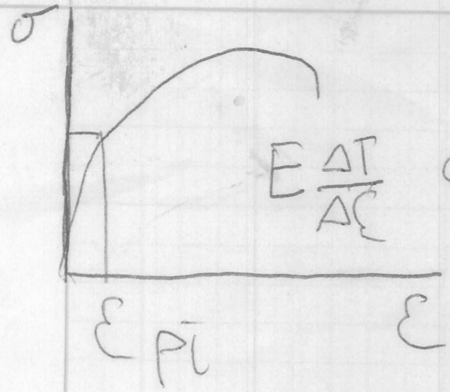
$V_{ncL} = 4 b_o d \sqrt{f'c} = 4(30.5)(20.5) \cdot \sqrt{6000} = 198K$

$V_{uc} \leq \phi V_{un}$

S $1.633 \leq 108.8K$

M $75.3K \leq 116.45K$

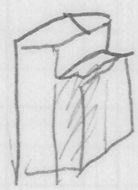
L $158K \leq 164.6K$



$E\frac{\Delta\sigma}{\Delta\varepsilon}$ $\sigma = E\varepsilon$, $\varepsilon = \frac{\sigma}{E}$

$A = \frac{1}{2}\varepsilon_p \sigma_p - \frac{1}{2}\frac{\sigma_{pl}}{E} \cdot \sigma_{pl} = \frac{1\sigma_{pl}^2}{2E}$

Wood Properties
Yellow Pine



moisture
green → Dry
40%-80%

$K_o = (1 - \sin\phi')\,OCR$

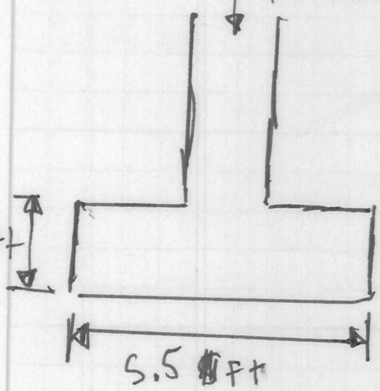
Medium Column

P for med column = 382.841 K

$W_f = 2ft \cdot 5.5ft^2 \cdot .15 \,k/ft^3$

$U_D = 0$

$B = 5.5ft$



$q = \dfrac{P + W_f}{A} - U_D$

$q = \dfrac{382.841 + 5^2 \cdot 2 \cdot .15}{[illegible]}$

$q = 12.775$

$\sigma'_{zD} = \Sigma \gamma H + u$

$\sigma'_{zD} \; 135 \,lb/ft^3 \cdot 2ft = 270 \,lb/ft^2$

$\phi' = 30°$

$q_{ult} = 1.3 c' N_c + \sigma'_{zD} N_q + .3 \gamma' B N_\gamma$

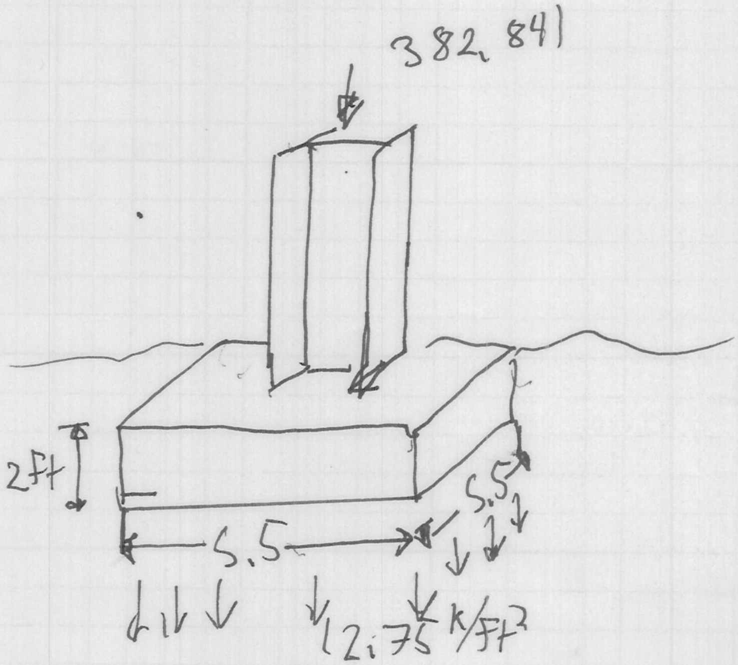
$q_{ult} = 1.3(150 \,lb/ft^3)(37.2) + 270 \cdot 22.5 + .3(135 \,lb/ft^3) 5.5 \cdot 20.1$

$q_{ult} = 7254 + 6075 + 4477.275$

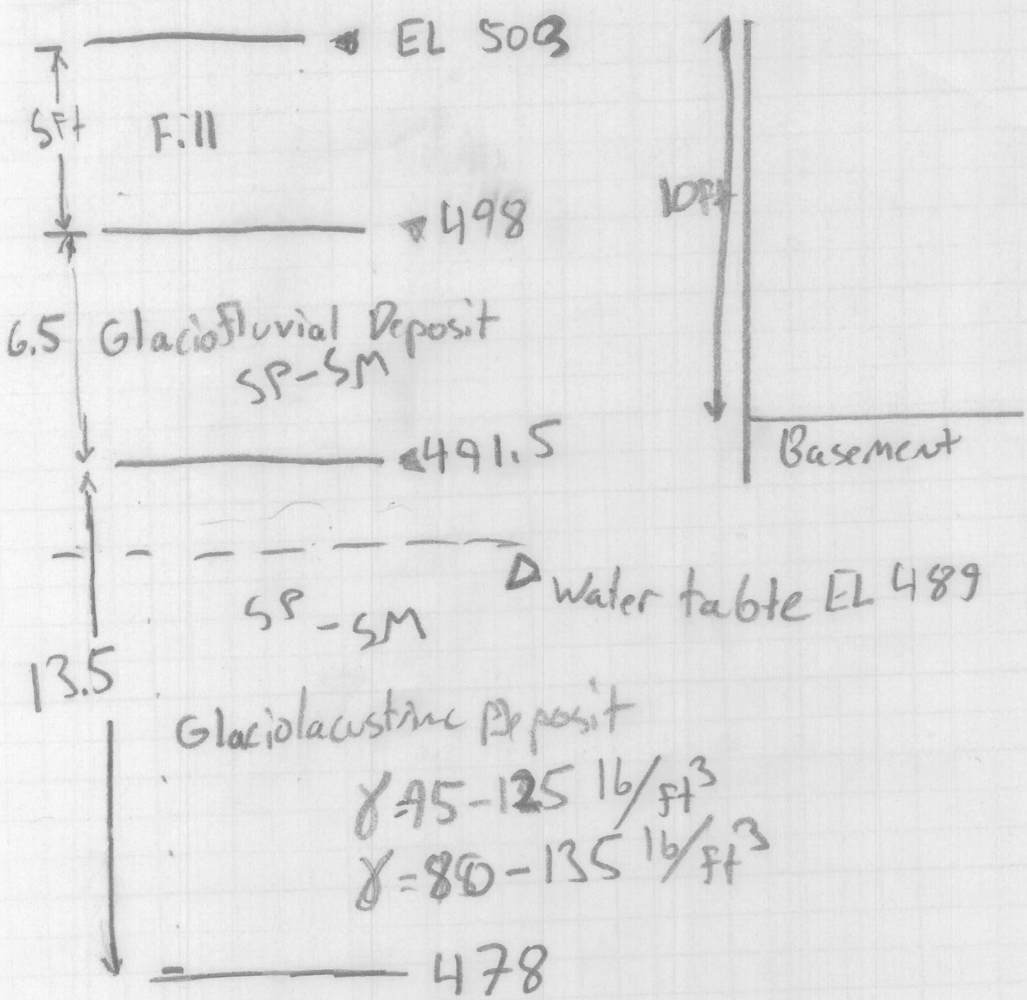
$q_{ult} = 17.006 \,k/ft^2$

$q < q_{ult}$

$12.75 \,k/ft^2 < 17.00 \,k/ft^2$



Typical Soil profile



Glacial Till ML

$\gamma = 75\text{-}110\ \text{lb/ft}^3$

$$N_{60} = \frac{E_m C_B C_S C_R N}{.6}$$

Safety $E_m = .55$

Diameter 4.25 in $C_B = 1$

Sampler Standard $C_S = 1$

Rod Length 23.5ft $C_R = .95$

SPT value = 6

$$N_{60} = \frac{.55 \cdot 1 \cdot 1 \cdot .95 \cdot 6}{.6} = 5.225$$

$\phi' = 30°$

$C' = 150\ \text{lb/ft}$

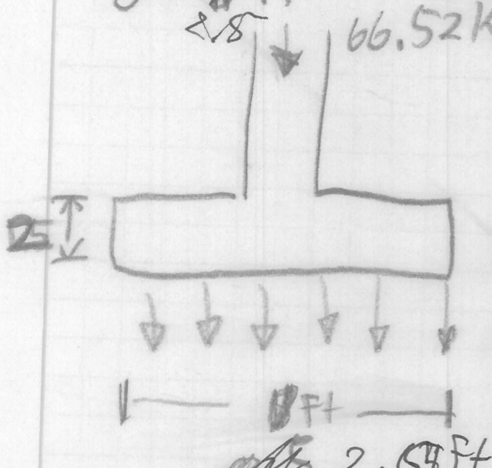
Light column

P for light Column = 66.52K

W_F = ~~0t foundation reaches~~

U_D = 0 (foundation is sig above water table

B = ~~8~~ 2.5 ft



$$q = \frac{P + W_F}{A} - U_D$$

$$q = \frac{66.52 + 5.5 \cdot 2 \cdot .15}{2.5} = \frac{69.52}{2.5}$$

q = ~~2.788~~ k/ft^2 11.1232

$\sigma'_{zD} = \Sigma \gamma H + u$

σ_{zD} $135\ lb/ft^3 \cdot 2ft = 270\ lb/ft^2$

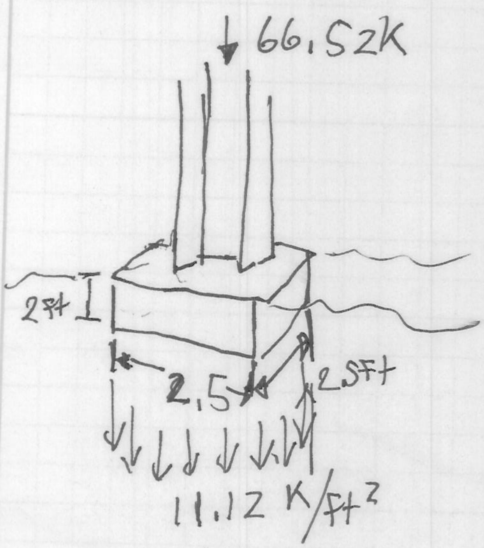
$q_{ult} = 1.3c'N_c + \sigma'_{zD} N_q + .3\gamma' B N_\gamma$

$q_{ult} = (1.3)(150\ lb/ft^2)(37.2) + 270\ lb/ft^2 \cdot 22.5 + .3\ 135\ lb/ft^3 \cdot 20.1$

$q_{ult} = 7254 + 6075 + 814.05 = 14143.03\ lb/ft^2$

$11.1232\ k/ft^2 < 14.14\ k/ft^2$ column ok

Small Column



Moment

Girder	Length	Shear	Moment (ft-K)	Exterior(plf)	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Moment (ft	Zreq'd (ci) W	Final Beam Size
1A2-1A3	24	21498.75	247.235625	61.2	50	0.9	65.9295	**W18x35**	48	251.3828	67.03542	**W21x48**
1A3-1A4	21	Force is on Columns	3.37365	61.2	50	0.9	N/A	**W8x10**	10	4.03515	1.07604	**W8x10**
1A4-1A5	21	22058.83929	187.5001339	61.2	50	0.9	50.00003571	**W18x35**	35	189.8154	50.61743571	**W18x35**
1B1-B1A1	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
B1A2-1B2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
B1B1-B1B2	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B1B3-B1B4	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B1C1-B1C2	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B1C3-B1C4	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
1D1-1D2	18	33990.825	237.935775	0	50	0.9	63.44954	**W18x35**	35	239.6368	63.90314	**W18x35**
1D2-1D3	23	30774.95217	276.9745696	0	50	0.9	73.85988522	**W18x35**	48	280.7834	74.87556522	**W21x48**
1E1-B1D1	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
B1D2-1E2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1F1-1F2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1F2-1F3	13	Force is on Columns	0	0	50	0.9		**W8x10**	10	0.2535	0.0676	**W8x10**
1F3-1F4	17	Force is on Columns	0	0	50	0.9		**W8x10**	10	0.4335	0.1156	**W8x10**
1F4-1F5	23	Force is on Columns	4.04685	61.2	50	0.9	N/A	**W8x10**	10	4.84035	1.29076	**W8x10**
1F5-1F6	13	Force is on Columns	1.29285	61.2	50	0.9	N/A	**W8x10**	10	1.54635	0.41236	**W8x10**
1F6-1F7	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1A1-1A2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1A5-1A6	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**

Beam	Length	Dead Load W/o(psf)	Trib. Area (f)	Exterior(plf)	Live Load(	Snow Load	Factored Load(p	Distributed	Moment (ft	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Distributed	Moment (ft-K) W	Zreq'd (ci) W	Beam Size
1A1-B1A1	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
1A6-B1A2	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
1B1(-)	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178125	11.864475	**W12x14**
B1A1(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
B1A2(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
1B2(-)	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178125	11.864475	**W12x14**
1A2(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**
(-)1E1	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178125	11.864475	**W12x14**
(-)B1D1	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
(-)B1D2	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
(-)1E2	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178125	11.864475	**W12x14**
(-)1D1	27	75	12	0	100	0	250	3000	273.375	50	0.9	72.9	**W21x48**	48	3057.6	278.6238	74.29968	**W21x48**
1A3(-)	27	75	16.25	0	100	0	250	4062.5	370.1953	50	0.9	98.71875	**W21x48**	48	4120.1	375.4441125	100.11843	**W21x48**
1A4(-)	27	75	14.75	0	100	0	250	3687.5	336.0234	50	0.9	89.60625	**W21x48**	48	3745.1	341.2722375	91.00593	**W21x48**
(-)1D3	27	75	10.75	0	100	0	250	2687.5	244.8984	50	0.9	65.30625	**W21x48**	48	2745.1	250.1472375	66.70593	**W21x48**
(-)1C1	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	35	1728.2	4.37450625	1.166535	**W8x10**
B1B1-B1C1	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.7716625	10.33911	**W12x14**
B1B2-B1C2	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.8011875	6.61365	**W8x10**
B1B3-B1C3	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.8011875	6.61365	**W8x10**
B1B4-B1C4	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.7716625	10.33911	**W12x14**
(-)1C2	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.29856875	1.146285	**W8x10**
1C1(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.29856875	1.146285	**W8x10**
1C2(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.29856875	1.146285	**W8x10**
(-)(-)1	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.105875	5.0949	**W8x10**
(-)(-)2	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.105875	5.0949	**W8x10**
1D1-1F3	23.5	75	16	0	100	0	250	4000	276.125	50	0.9	73.63333	**W21x48**	48	4057.6	280.1012	74.69365333	**W21x48**
1D2-1F4	23.5	75	20.75	0	100	0	250	5187.5	358.0996	50	0.9	95.49323	**W21x48**	48	5245.1	362.0758094	96.55354917	**W21x48**
1D3-1F5	23.5	75	18	0	100	0	250	4500	310.6406	50	0.9	82.8375	**W21x48**	48	4557.6	314.616825	83.89782	**W21x48**
(-)1F2	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**
(-)1F6	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**
B1D1-1F1	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
B1D2-1F7	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
1A5(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**

Shear

Girder	Length	Beam Size	h/wt	Web Yielding	Shear (lb)	Vn (k)	Vn*phib (k)	Shear	New Beam	New Vn (k)	NewVn*phib (k	New Shear
1A2-1A3	24	**W21x48**	53.5	ok	21498.75	216.3	194.67	ok				
1A3-1A4	21	**W8x10**	40.5	ok	54843.75	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1A4-1A5	21	**W18x35**	53.5	ok	22058.84	159.3	143.37	ok				
1B1-B1A1	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B1A2-1B2	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B1B1-B1B2	33	**W18x35**	40.5	ok	17003.7	159.3	143.37	ok				
B1B3-B1B4	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B1C1-B1C2	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B1C3-B1C4	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
1D1-1D2	18	**W18x35**	53.5	ok	33990.83	159.3	143.37	ok				
1D2-1D3	23	**W21x48**	53.5	ok	30774.95	216.3	194.67	ok				
1E1-B1D1	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B1D2-1E2	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1F1-1F2	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1F2-1F3	13	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1F3-1F4	17	**W8x10**	40.5	ok		40.239	36.2151	ok				
1F4-1F5	23	**W8x10**	40.5	ok		40.239	36.2151	ok				
1F5-1F6	13	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1F6-1F7	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1A1-1A2	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1A5-1A6	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
Beam	Length	Beam Size	h/wt	Web Yielding	Shear (lb)	Vn (k)	Vn*phib (k)	Shear				
1A1-B1A1	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
1A6-B1A2	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
1B1(-)	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
B1A1(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
B1A2(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
1B2(-)	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
1A2(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)1E1	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)B1D1	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)B1D2	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)1E2	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)1D1	27	**W21x48**	53.6	ok	40500	159.3	143.37	ok				
1A3(-)	27	**W21x48**	53.6	ok	54843.75	159.3	143.37	ok				
1A4(-)	27	**W21x48**	53.6	ok	49781.25	159.3	143.37	ok				
(-)1D3	27	**W21x48**	53.6	ok	36281.25	159.3	143.37	ok				
(-)1C1	4.5	**W8x10**	40.5	ok	3793.95	159.3	143.37	ok				
B1B1-B1C1	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
B1B2-B1C2	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B1B3-B1C3	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B1B4-B1C4	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
(-)1C2	4.5	**W8x10**	40.5	ok	3793.95	71.4	64.26	ok				
1C1(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
1C2(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
(-)(-)1	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
(-)(-)2	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
1D1-1F3	23.5	**W21x48**	53.6	ok	47000	159.3	143.37	ok				
1D2-1F4	23.5	**W21x48**	53.6	ok	60953.13	159.3	143.37	ok				
1D3-1F5	23.5	**W21x48**	53.6	ok	52875	159.3	143.37	ok				
(-)1F2	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)1F6	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
B1D1-1F1	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
B1D2-1F7	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
1A5(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				

Moment

Girder	Length	Shear	Moment (ft-K)	Exterior(plf)	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Moment (ft	Zreq'd (ci) W	Final Beam Size
1X2-1X3	16	32248.125	370.8534375	61.2	50	0.9	98.89425	**W18x35**	48	372.6966	99.38577	**W21x48**
1X3-1X4	23	Force is on Columns	4.04685	61.2	50	0.9	N/A	**W8x10**	10	4.84035	1.29076	**W8x10**
1X4-1X5	21	22058.83929	187.5001339	61.2	50	0.9	50.00003571	**W18x35**	35	189.8154	50.61743571	**W18x35**
1X6-1X7	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
B1H2-1W1	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
B1F1-B1F2	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B1F3-B1F4	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B1G1-B1G2	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B1G3-B1G4	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
1T1-1T2	18	33990.825	237.935775	0	50	0.9	63.44954	**W18x35**	35	239.6368	63.90314	**W18x35**
1T2-1T3	23	30774.95217	276.9745696	0	50	0.9	73.85988522	**W18x35**	48	280.7834	74.87556522	**W21x48**
1S1-B1E1	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
B1E2-1S2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1R1-1R2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1R2-1R3	13	Force is on Columns	0	0	50	0.9		**W8x10**	10	0.2535	0.0676	**W8x10**
1R3-1R4	17	Force is on Columns	0	0	50	0.9		**W8x10**	10	0.4335	0.1156	**W8x10**
1R4-1R5	23	Force is on Columns	4.04685	61.2	50	0.9	N/A	**W8x10**	10	4.84035	1.29076	**W8x10**
1R5-1R6	13	Force is on Columns	1.29285	61.2	50	0.9	N/A	**W8x10**	10	1.54635	0.41236	**W8x10**
1R6-1R7	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1X1-1X2	16	Force is on Columns	1.9584	61.2	50	0.9	N/A	**W8x10**	10	2.3424	0.62464	**W8x10**
1X5-1X6	21	Force is on Columns	3.37365	61.2	50	0.9	N/A	**W8x10**	10	4.03515	1.07604	**W8x10**

Beam	Length	Dead Load W/o(psf)	Trib. Area (f)	Exterior(plf)	Live Load(	Snow Loac	Factored Load(p	Distributed	Moment (ft	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Distributed	Moment (ft-K) W	Zreq'd (ci) W	Beam Size
1X1-1V1	13	75	9	61.2	100	0	250	2311.2	48.8241	50	0.9	13.01976	**W8x10**	10	2323.2	49.0776	13.08736	**W8x10**
1X7-B1H1	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
1V1(-)	8	75	7.5	61.2	100	0	250	1936.2	15.4896	50	0.9	4.13056	**W12x14**	14	1953	15.624	4.1664	**W12x14**
1X2(-)	8	75	16.5	0	100	0	250	4125	33	50	0.9	8.8	**W18x35**	35	4167	33.336	8.8896	**W18x35**
B1H1(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
1W1(-)	11	75	7.5	61.2	100	0	250	1936.2	29.28503	50	0.9	7.80934	**W12x14**	14	1953	29.539125	7.8771	**W12x14**
1X3(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**
(-)1S1	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178125	11.864475	**W12x14**
(-)B1E1	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
(-)B1E2	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92946875	25.314525	**W18x35**
(-)1E2	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178125	11.864475	**W12x14**
(-)1T1	27	75	12	0	100	0	250	3000	273.375	50	0.9	72.9	**W21x48**	48	3057.6	278.6238	74.29968	**W21x48**
1X4(-)	27	75	16.25	0	100	0	250	4062.5	370.1953	50	0.9	98.71875	**W21x48**	48	4120.1	375.4441125	100.11843	**W21x48**
1X5(-)	27	75	14.75	0	100	0	250	3687.5	336.0234	50	0.9	89.60625	**W21x48**	48	3745.1	341.2722375	91.00593	**W21x48**
(-)1T3	27	75	10.75	0	100	0	250	2687.5	244.8984	50	0.9	65.30625	**W21x48**	48	2745.1	250.1472375	66.70593	**W21x48**
(-)1U1	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	35	1728.2	4.37450625	1.166535	**W8x10**
B1F1-B1G1	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.7716625	10.33911	**W12x14**
B1F2-B1G2	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.8011875	6.61365	**W8x10**
B1F3-B1G3	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.8011875	6.61365	**W8x10**
B1F4-B1G4	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.7716625	10.33911	**W12x14**
(-)1U2	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.29856875	1.146285	**W8x10**
1U1(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.29856875	1.146285	**W8x10**
1U2(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.29856875	1.146285	**W8x10**
(-)(-)1	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.105875	5.0949	**W8x10**
(-)(-)2	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.105875	5.0949	**W8x10**
1T1-1R3	23.5	75	16	0	100	0	250	4000	276.125	50	0.9	73.63333	**W21x48**	48	4057.6	280.1012	74.69365333	**W21x48**
1T2-1R4	23.5	75	20.75	0	100	0	250	5187.5	358.0996	50	0.9	95.49323	**W21x48**	48	5245.1	362.0758094	96.55354917	**W21x48**
1T3-1R5	23.5	75	18	0	100	0	250	4500	310.6406	50	0.9	82.8375	**W21x48**	48	4557.6	314.616825	83.89782	**W21x48**
(-)1R2	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**
(-)1R6	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**
B1E1-1R1	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
B1E2-1R7	8.5	75	9	61.2	100	0	250	2311.2	20.87303	50	0.9	5.56614	**W8x10**	10	2323.2	20.9814	5.59504	**W8x10**
1X6(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.19725	62.18593333	**W18x35**

Shear

Girder	Length	Beam Size	h/wt	Web Yielding	Shear (lb)	Vn (k)	Vn*phib (k)	Shear	New Beam	New Vn (k)	NewVn*phib (k	New Shear
1X2-1X3	16	**W21x48**	53.5	ok	32248.13	216.3	194.67	ok				
1X3-1X4	23	**W8x10**	40.5	ok	54843.75	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1X4-1X5	21	**W18x35**	53.5	ok	22058.84	159.3	143.37	ok				
1X6-1X7	16	**W8x10**	40.5	ok	31522.8	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B1H2-1W1	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B1F1-B1F2	33	**W18x35**	40.5	ok	17003.7	159.3	143.37	ok				
B1F3-B1F4	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B1G1-B1G2	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B1G3-B1G4	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
1T1-1T2	18	**W18x35**	53.5	ok	33990.83	159.3	143.37	ok				
1T2-1T3	23	**W21x48**	53.5	ok	30774.95	216.3	194.67	ok				
1S1-B1E1	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B1E2-1S2	16	**W8x10**	40.5	ok	37666.35	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1R1-1R2	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1R2-1R3	13	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1R3-1R4	17	**W8x10**	40.5	ok		40.239	36.2151	ok				
1R4-1R5	23	**W8x10**	40.5	ok		40.239	36.2151	ok				
1R5-1R6	13	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1R6-1R7	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1X1-1X2	16	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
1X5-1X6	21	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
Beam	Length	Beam Size	h/wt	Web Yielding	Shear (lb)	Vn (k)	Vn*phib (k)	Shear				
1X1-1V1	8.5	**W8x10**	40.5	ok	15022.8	40.239	36.2151	ok				
1X7-B1H1	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
1V1(-)	13.5	**W12x14**	54.3	ok	7744.8	71.4	64.26	ok				
1X2(-)	13.5	**W18x35**	53.5	ok	16500	71.4	64.26	ok				
B1H1(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
1W1(-)	13.5	**W12x14**	54.3	ok	10649.1	71.4	64.26	ok				
1X3(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)1S1	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)B1E1	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)B1E2	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)1E2	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)1T1	27	**W21x48**	53.6	ok	40500	159.3	143.37	ok				
1X4(-)	27	**W21x48**	53.6	ok	54843.75	159.3	143.37	ok				
1X5(-)	27	**W21x48**	53.6	ok	49781.25	159.3	143.37	ok				
(-)1T3	27	**W21x48**	53.6	ok	36281.25	159.3	143.37	ok				
(-)1U1	4.5	**W8x10**	40.5	ok	3793.95	159.3	143.37	ok				
B1F1-B1G1	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
B1F2-B1G2	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B1F3-B1G3	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B1F4-B1G4	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
(-)1U2	4.5	**W8x10**	40.5	ok	3793.95	71.4	64.26	ok				
1U1(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
1U2(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
(-)(-)1	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
(-)(-)2	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
1T1-1R3	23.5	**W21x48**	53.6	ok	47000	159.3	143.37	ok				
1T2-1R4	23.5	**W21x48**	53.6	ok	60953.13	159.3	143.37	ok				
1T3-1R5	23.5	**W21x48**	53.6	ok	52875	159.3	143.37	ok				
(-)1R2	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)1R6	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
B1E1-1R1	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
B1E2-1R7	8.5	**W8x10**	40.5	ok	9822.6	40.239	36.2151	ok				
1X6(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				

Moment

Girder	Length	Shear	Moment (ft	Exterior(plf	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Moment (ft	Zreq'd (ci) '	Final Beam Size
2A1-2A2	24	21498.75	247.2356	61.2	50	0.9	65.9295	**W18x35**	48	251.3828	67.03542	**W21x48**
2A2-2A3	21	Force is on	3.37365	61.2	50	0.9	N/A	**W8x10**	10	4.03515	1.07604	**W8x10**
2A3-2A4	21	22058.84	187.5001	61.2	50	0.9	50.00004	**W18x35**	35	189.8154	50.61744	**W18x35**
2B1-B2A1	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
B2A2-2B2	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
B2B1-B2B:	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B2B3-B2B	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B2C1-B2C	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B2C3-B2C	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
2D1-2D2	18	33990.83	237.9358	0	50	0.9	63.44954	**W18x35**	35	239.6368	63.90314	**W18x35**
2D2-2D3	23	30774.95	276.9746	0	50	0.9	73.85989	**W18x35**	48	280.7834	74.87557	**W21x48**
2E1-B2D1	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
B2D2-2E2	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
2F1-2F2	13	Force is on	1.29285	61.2	50	0.9	N/A	**W8x10**	10	1.54635	0.41236	**W8x10**
2F2-2F3	18	Force is on	0	0	50	0.9		**W8x10**	10	0.486	0.1296	**W8x10**
2F3-2F4	20	Force is on	0	0	50	0.9		**W8x10**	10	0.6	0.16	**W8x10**
2F4-2F5	13	Force is on	1.29285	61.2	50	0.9	N/A	**W8x10**	10	1.54635	0.41236	**W8x10**
2G1(-)	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**
(-)2G2	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**
2W1(-)	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**
(-)2W2	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**

Beam	Length	Dead Load	Trib. Area (	Exterior(plf	Live Load(	Snow Loac	Factored L	Distributed	Moment (ft	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Distributed	Moment (ft	Zreq'd (ci) W
2W1-B2A1	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
2W2-B2A2	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
2B1(-)	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
B2A1(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
B2A2(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
2B2(-)	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
2A1(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593
(-)2E1	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
(-)B2D1	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
(-)B2D2	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
(-)2E2	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
(-)2D1	27	75	12	0	100	0	250	3000	273.375	50	0.9	72.9	**W21x48**	48	3057.6	278.6238	74.29968
2A2(-)	27	75	16.25	0	100	0	250	4062.5	370.1953	50	0.9	98.71875	**W21x48**	48	4120.1	375.4441	100.1184
2A3(-)	27	75	14.75	0	100	0	250	3687.5	336.0234	50	0.9	89.60625	**W21x48**	48	3745.1	341.2722	91.00593
(-)2D3	27	75	10.75	0	100	0	250	2687.5	244.8984	50	0.9	65.30625	**W21x48**	48	2745.1	250.1472	66.70593
(-)2C1	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	35	1728.2	4.374506	1.166535
B2B1-B2C	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.77166	10.33911
B2B2-B2C:	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.80119	6.61365
B2B3-B2C:	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.80119	6.61365
B2B4-B2C	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.77166	10.33911
(-)2C2	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.298569	1.146285
2C1(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.298569	1.146285
2C2(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.298569	1.146285
(-)(-)1	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.10588	5.0949
(-)(-)2	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.10588	5.0949
2D1-2F2	23.5	75	16	0	100	0	250	4000	276.125	50	0.9	73.63333	**W21x48**	48	4057.6	280.1012	74.69365
2D2-2F3	23.5	75	20.75	0	100	0	250	5187.5	358.0996	50	0.9	95.49323	**W21x48**	48	5245.1	362.0758	96.55355
2D3-2F4	23.5	75	18	0	100	0	250	4500	310.6406	50	0.9	82.8375	**W21x48**	48	4557.6	314.6168	83.89782
(-)2F1	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593
(-)2F5	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593
B2D1-2G1	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
B2D2-2G2	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
2A4(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593

Shear

Girder	Length	Beam Size	h/wt	Web Yieldi	Shear (lb)	Vn (k)	Vn*phib (k	Shear	New Beam	New Vn (k)	NewVn*phi	New Shear
2A1-2A2	24	**W21x48**	53.5	ok	21498.75	216.3	194.67	ok				
2A2-2A3	21	**W8x10**	40.5	ok	54843.75	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2A3-2A4	21	**W18x35**	53.5	ok	22058.84	159.3	143.37	ok				
2B1-B2A1	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B2A2-2B2	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B2B1-B2B	33	**W18x35**	40.5	ok	17003.7	159.3	143.37	ok				
B2B3-B2B	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B2C1-B2C	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B2C3-B2C	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
2D1-2D2	18	**W18x35**	53.5	ok	33990.83	159.3	143.37	ok				
2D2-2D3	20	**W21x48**	53.5	ok	30774.95	216.3	194.67	ok				
2E1-B2D1	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B2D2-2E2	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2F1-2F2	13	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2F2-2F3	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2F3-2F4	20	**W8x10**	40.5	ok		40.239	36.2151	ok				
2F4-2F5	13	**W8x10**	40.5	ok		40.239	36.2151	ok				
2G1(-)	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
(-)2G2	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2W1(-)	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
(-)2W2	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
Beam	Length	Beam Size	h/wt	Web Yieldi	Shear (lb)	Vn (k)	Vn*phib (k	Shear				
2W1-B2A1	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
2W2-B2A2	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
2B1(-)	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
B2A1(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
B2A2(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
2B2(-)	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
2A1(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)2E1	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)B2D1	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)B2D2	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)2E2	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)2D1	27	**W21x48**	53.6	ok	40500	159.3	143.37	ok				
2A2(-)	27	**W21x48**	53.6	ok	54843.75	159.3	143.37	ok				
2A3(-)	27	**W21x48**	53.6	ok	49781.25	159.3	143.37	ok				
(-)2D3	27	**W21x48**	53.6	ok	36281.25	159.3	143.37	ok				
(-)2C1	4.5	**W8x10**	40.5	ok	3793.95	159.3	143.37	ok				
B2B1-B2C	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
B2B2-B2C	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B2B3-B2C	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B2B4-B2C	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
(-)2C2	4.5	**W8x10**	40.5	ok	3793.95	71.4	64.26	ok				
2C1(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
2C2(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
(-)(-)1	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
(-)(-)2	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
2D1-2F2	23.5	**W21x48**	53.6	ok	47000	159.3	143.37	ok				
2D2-2F3	23.5	**W21x48**	53.6	ok	60953.13	159.3	143.37	ok				
2D3-2F4	23.5	**W21x48**	53.6	ok	52875	159.3	143.37	ok				
(-)2F1	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)2F5	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
B2D1-2G1	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
B2D2-2G2	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
2A4(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				

Moment

Girder	Length		Moment (ft	Exterior(plf	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Moment (ft	Zreq'd (ci) '	Final Beam Size
2U1-2U2	24	21498.75	247.2356	61.2	50	0.9	65.9295	**W18x35**	48	251.3828	67.03542	**W21x48**
2U2-2U3	21	Force is on	3.37365	61.2	50	0.9	N/A	**W8x10**	10	4.03515	1.07604	**W8x10**
2U3-2U4	21	22058.84	187.5001	61.2	50	0.9	50.00004	**W18x35**	35	189.8154	50.61744	**W18x35**
2T1-B2H1	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
B2H2-2T2	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
B2G1-B2G	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B2G3-B2G	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B2F1-B2F2	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
B2F3-B2F4	33	17003.7	221.0481	0	50	0.9	58.94616	**W18x35**	35	226.7654	60.47076	**W18x35**
2R1-2R2	18	33990.83	237.9358	0	50	0.9	63.44954	**W18x35**	35	239.6368	63.90314	**W18x35**
2R2-2R3	23	30774.95	276.9746	0	50	0.9	73.85989	**W18x35**	48	280.7834	74.87557	**W21x48**
2Q1-B2E1	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
B2E2-2Q2	15	Force is on	1.72125	61.2	50	0.9	N/A	**W8x10**	10	2.05875	0.549	**W8x10**
2P1-2P2	13	Force is on	1.29285	61.2	50	0.9	N/A	**W8x10**	10	1.54635	0.41236	**W8x10**
2P2-2P3	18	Force is on	0	0	50	0.9		**W8x10**	10	0.486	0.1296	**W8x10**
2P3-2P4	20	Force is on	0	0	50	0.9		**W8x10**	10	0.6	0.16	**W8x10**
2P4-2P5	13	Force is on	1.29285	61.2	50	0.9	N/A	**W8x10**	10	1.54635	0.41236	**W8x10**
2O1(-)	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**
(-)2O2	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**
2V1(-)	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**
(-)2V2	18	Force is on	2.4786	61.2	50	0.9	N/A	**W8x10**	10	2.9646	0.79056	**W8x10**

Beam	Length	Dead Load	Trib. Area (	Exterior(plf	Live Load(	Snow Loac	Factored L	Distributed	Moment (ft	Fy	Phib	Zreq'd (ci)	Beam Size	Beam Dea	Distributed	Moment (ft	Zreq'd (ci) W
2V1-B2H1	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
2V2-B2H2	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
2T1(-)	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
B2H1(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
B2H2(-)	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
2T2(-)	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
2U1(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593
(-)2Q1	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
(-)B2E1	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
(-)B2E2	13.5	75	16.5	0	100	0	250	4125	93.97266	50	0.9	25.05938	**W18x35**	35	4167	94.92947	25.31453
(-)2Q2	13.5	75	7.5	61.2	100	0	250	1936.2	44.10906	50	0.9	11.76242	**W12x14**	14	1953	44.49178	11.86448
(-)2R1	27	75	12	0	100	0	250	3000	273.375	50	0.9	72.9	**W21x48**	48	3057.6	278.6238	74.29968
2U2(-)	27	75	16.25	0	100	0	250	4062.5	370.1953	50	0.9	98.71875	**W21x48**	48	4120.1	375.4441	100.1184
2U3(-)	27	75	14.75	0	100	0	250	3687.5	336.0234	50	0.9	89.60625	**W21x48**	48	3745.1	341.2722	91.00593
(-)2R3	27	75	10.75	0	100	0	250	2687.5	244.8984	50	0.9	65.30625	**W21x48**	48	2745.1	250.1472	66.70593
(-)2S1	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	35	1728.2	4.374506	1.166535
B2G1-B2F	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.77166	10.33911
B2G2-B2F:	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.80119	6.61365
B2G3-B2F:	9	75	9.75	0	100	0	250	2437.5	24.67969	50	0.9	6.58125	**W8x10**	10	2449.5	24.80119	6.61365
B2G4-B2F4	9	75	15.25	0	100	0	250	3812.5	38.60156	50	0.9	10.29375	**W12x14**	14	3829.3	38.77166	10.33911
(-)2S2	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.298569	1.146285
2S1(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.298569	1.146285
2S2(-)	4.5	75	6.5	61.2	100	0	250	1686.2	4.268194	50	0.9	1.138185	**W8x10**	10	1698.2	4.298569	1.146285
(-)(-)3	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.10588	5.0949
(-)(-)4	9	75	7.5	0	100	0	250	1875	18.98438	50	0.9	5.0625	**W8x10**	10	1887	19.10588	5.0949
2R1-2P2	23.5	75	16	0	100	0	250	4000	276.125	50	0.9	73.63333	**W21x48**	48	4057.6	280.1012	74.69365
2R2-2P3	23.5	75	20.75	0	100	0	250	5187.5	358.0996	50	0.9	95.49323	**W21x48**	48	5245.1	362.0758	96.55355
2R3-2P4	23.5	75	18	0	100	0	250	4500	310.6406	50	0.9	82.8375	**W21x48**	48	4557.6	314.6168	83.89782
(-)2P1	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593
(-)2P5	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593
B2E1-3O1	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
B2E2-3O2	9	75	9	61.2	100	0	250	2311.2	23.4009	50	0.9	6.24024	**W8x10**	10	2323.2	23.5224	6.27264
2U4(-)	22	75	15.25	0	100	0	250	3812.5	230.6563	50	0.9	61.50833	**W18x35**	35	3854.5	233.1973	62.18593

Shear

Girder	Length	Beam Size	h/wt	Web Yieldi	Shear (lb)	Vn (k)	Vn*phib (k	Shear	New Beam	New Vn (k	NewVn*phi	New Shear
2U1-2U2	24	**W21x48**	53.5	ok	21498.75	216.3	194.67	ok				
2U2-2U3	21	**W8x10**	40.5	ok	54843.75	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2U3-2U4	21	**W18x35**	53.5	ok	22058.84	159.3	143.37	ok				
2T1-B2H1	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B2H2-2T2	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B2G1-B2G	33	**W18x35**	40.5	ok	17003.7	159.3	143.37	ok				
B2G3-B2G	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B2F1-B2F2	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
B2F3-B2F4	33	**W18x35**	53.5	ok	17003.7	159.3	143.37	ok				
2R1-2R2	18	**W18x35**	53.5	ok	33990.83	159.3	143.37	ok				
2R2-2R3	20	**W21x48**	53.5	ok	30774.95	216.3	194.67	ok				
2Q1-B2E1	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
B2E2-2Q2	15	**W8x10**	40.5	ok	38244.15	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2P1-2P2	13	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2P2-2P3	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2P3-2P4	20	**W8x10**	40.5	ok		40.239	36.2151	ok				
2P4-2P5	13	**W8x10**	40.5	ok		40.239	36.2151	ok				
2O1(-)	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
(-)2O2	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
2V1(-)	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
(-)2V2	18	**W8x10**	40.5	ok	42399.5	40.239	36.2151	fail	**W12x14**	71.4	64.26	ok
Beam	Length	Beam Size	h/wt	Web Yieldi	Shear (lb)	Vn (k)	Vn*phib (k	Shear				
2V1-B2H1	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
2V2-B2H2	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
2T1(-)	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
B2H1(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
B2H2(-)	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
2T2(-)	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
2U1(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)2Q1	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)B2E1	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)B2E2	13.5	**W18x35**	53.5	ok	27843.75	71.4	64.26	ok				
(-)2Q2	13.5	**W12x14**	54.3	ok	13069.35	71.4	64.26	ok				
(-)2R1	27	**W21x48**	53.6	ok	40500	159.3	143.37	ok				
2U2(-)	27	**W21x48**	53.6	ok	54843.75	159.3	143.37	ok				
2U3(-)	27	**W21x48**	53.6	ok	49781.25	159.3	143.37	ok				
(-)2R3	27	**W21x48**	53.6	ok	36281.25	159.3	143.37	ok				
(-)2S1	4.5	**W8x10**	40.5	ok	3793.95	159.3	143.37	ok				
B2G1-B2F	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
B2G2-B2F	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B2G3-B2F	9	**W8x10**	40.5	ok	10968.75	40.239	36.2151	ok				
B2G4-B2F	9	**W12x14**	54.3	ok	17156.25	71.4	64.26	ok				
(-)2S2	4.5	**W8x10**	40.5	ok	3793.95	71.4	64.26	ok				
2S1(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
2S2(-)	4.5	**W8x10**	40.5	ok	3793.95	40.239	36.2151	ok				
(-)(-)3	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
(-)(-)4	9	**W8x10**	40.5	ok	8437.5	40.239	36.2151	ok				
2R1-2P2	23.5	**W21x48**	53.6	ok	47000	159.3	143.37	ok				
2R2-2P3	23.5	**W21x48**	53.6	ok	60953.13	159.3	143.37	ok				
2R3-2P4	23.5	**W21x48**	53.6	ok	52875	159.3	143.37	ok				
(-)2P1	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
(-)2P5	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				
B2E1-3O1	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
B2E2-3O2	9	**W8x10**	40.5	ok	10400.4	40.239	36.2151	ok				
2U4(-)	22	**W18x35**	53.5	ok	41937.5	159.3	143.37	ok				

Basement Columns

Columns	Hieght	Axial Load lb (cur)	Axial Load (Prev)	Axial Load (Total)	Beam Size	E Modulus	K value	Columns	Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (K	Compact fl	.56(E/Fsqrt	Web Comp	1.49(E/Fsq	Pass/Fail
BA1	10	64024.25	297604.8625	361629.1125	**W10x30**	29000	0.65	BA1	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BA2	10	62923.35	301639.4625	364562.8125	**W10x30**	29000	0.65	BA2	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BA3	10	59263.85	275405.1393	334668.9893	**W10x30**	29000	0.65	BA3	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BA4	10	64583.5	299745.8893	364329.3893	**W10x30**	29000	0.65	BA4	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BB1	10	13287.75	61401.75	74689.5	**W8x13**	29000	0.65	BB1	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BB2	10	13287.75	61401.75	74689.5	**W8x13**	29000	0.65	BB2	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BBA1	10	68014.8	314694	382708.8	**W10x30**	29000	0.65	BBA1	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BBA2	10	51011.1	236020.5	287031.6	**W10x30**	29000	0.65	BBA2	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BBA3	10	68014.8	314694	382708.8	**W10x30**	29000	0.65	BBA3	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BBA4	10	51011.1	236020.5	287031.6	**W10x30**	29000	0.65	BBA4	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BBB1	10	51011.1	236020.5	287031.6	**W10x30**	29000	0.65	BBB1	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
B5B2	10	68014.8	314694	382708.8	**W10x30**	29000	0.65	B5B2	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
B5B3	10	51011.1	236020.5	287031.6	**W10x30**	29000	0.65	B5B3	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
B5B4	10	68014.8	314694	382708.8	**W10x30**	29000	0.65	B5B4	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BC1	10	7641.9	35282.7	42924.6	**W8x13**	29000	0.65	BC1	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BC2	10	7641.9	35282.7	42924.6	**W8x13**	29000	0.65	BC2	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BD1	10	122945.225	571218.757	694163.982	**W10x33**	29000	0.65	BD1	1.94	40.20619	3.14	176.8771	9.71	1717.476	9.14	13.48659	27.1	35.88395	Pass
BD2	10	126394.5272	587215.1624	713609.6896	**W10x33**	29000	0.65	BD2	1.94	40.20619	3.14	176.8771	9.71	1717.476	9.14	13.48659	27.1	35.88395	Pass
BD3	10	121385.6022	563974.4804	685360.0826	**W10x33**	29000	0.65	BD3	1.94	40.20619	3.14	176.8771	9.71	1717.476	9.14	13.48659	27.1	35.88395	Pass
(BE1	10	13287.75	61401.75	74689.5	**W8x13**	29000	0.65	(BE1	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
(BE2	10	13287.75	61401.75	74689.5	**W8x13**	29000	0.65	(BE2	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BF1	10	42587.95	198017.1	240605.05	**W10x30**	29000	0.65	BF1	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BF2	10		0	0	**W10x30**	29000	0.65	BF2	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BF3	10		0	0	**W10x30**	29000	0.65	BF3	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BF4	10		0	0	**W10x30**	29000	0.65	BF4	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BF5	10	42587.95	198017.1	240605.05	**W10x30**	29000	0.65	BF5	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
BG1	10	10580.4	49012.2	59592.6	**W8x13**	29000	0.65	BG1	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BG2	10	10580.4	49012.2	59592.6	**W8x13**	29000	0.65	BG2	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BW1	10	10580.4	49012.2	59592.6	**W8x13**	29000	0.65	BW1	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
BW2	10	10580.4	49012.2	59592.6	**W8x13**	29000	0.65	BW2	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass

First Floor Columns

Columns	Hieght	Axial Load lb (cur)	Axial Load lb	Axial Load (Pre	Beam Size	E Modulus	K value	Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (K)	Compact fl	.56(E/Fsqrt)	Web Compact	1.49(E/Fsqrt)	Pass/Fail
1A1	13	64024.25	233580.613	297604.8625	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1A2	13	62923.35	238716.113	301639.4625	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1A3	13	59263.85	216141.289	275405.1393	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1A4	13	64583.5	235162.389	299745.8893	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1B1	13	13287.75	48114	61401.75	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1B2	13	13287.75	48114	61401.75	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
B1A1	13	68014.8	246679.2	314694	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1A2	13	51011.1	185009.4	236020.5	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1A3	13	68014.8	246679.2	314694	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1A4	13	51011.1	185009.4	236020.5	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1B1	13	51011.1	185009.4	236020.5	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1B2	13	68014.8	246679.2	314694	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1B3	13	51011.1	185009.4	236020.5	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
B1B4	13	68014.8	246679.2	314694	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1C1	13	7641.9	27640.8	35282.7	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1C2	13	7641.9	27640.8	35282.7	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1D1	13	122945.225	448273.532	571218.757	**W10x33**	29000	0.65	1.94	52.26804	3.14	104.661	9.71	1016.258226	9.14	13.48658593	27.1	35.88395184	Pass
1D2	13	126394.5272	460820.635	587215.1624	**W10x33**	29000	0.65	1.94	52.26804	3.14	104.661	9.71	1016.258226	9.14	13.48658593	27.1	35.88395184	Pass
1D3	13	121385.6022	442588.878	563974.4804	**W10x33**	29000	0.65	1.94	52.26804	3.14	104.661	9.71	1016.258226	9.14	13.48658593	27.1	35.88395184	Pass
(1E1	13	13287.75	48114	61401.75	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
(1E2	13	13287.75	48114	61401.75	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1F1	13	42587.95	155429.15	198017.1	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1F2	13		0	0	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1F3	13		0	0	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1F4	13		0	0	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1F5	13	42587.95	155429.15	198017.1	**W10x30**	29000	0.65	1.37	74.0146	3.14	52.19423	8.84	461.397018	5.7	13.48658593	29.5	35.88395184	Pass
1G1	13	10580.4	38431.8	49012.2	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1G2	13	10580.4	38431.8	49012.2	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1W1	13	10580.4	38431.8	49012.2	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass
1W2	13	10580.4	38431.8	49012.2	**W8x13**	29000	0.65	0.843	120.2847	3.14	19.76226	3.84	75.88706522	7.84	13.48658593	29.9	35.88395184	Pass

Second Floor Columns

Columns	Hieght	Axial Load lb(cur)	Axial Load lb (Prev)	Axial Load lb (Total)	Beam Size	E Modulus	K value	Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (K)	Compact flange	.56(E/Fsqrt)	Web Comp	1.49(E/Fsqrt)	Pass or Fail
2A1	10	64024.25	169556.3625	233580.6125	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2A2	10	62923.35	175792.7625	238716.1125	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2A3	10	59263.85	156877.4393	216141.2893	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2A4	10	64583.5	170578.8893	235162.3893	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2B1	10	13287.75	34826.25	48114	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2B2	10	13287.75	34826.25	48114	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
B2A1	10	68014.8	178664.4	246679.2	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
B2A2	10	51011.1	133998.3	185009.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	7.7	13.48658593	33.6	35.88395184	Pass
B2A3	10	68014.8	178664.4	246679.2	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
B2A4	10	51011.1	133998.3	185009.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	7.7	13.48658593	33.6	35.88395184	Pass
B2B1	10	51011.1	133998.3	185009.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	7.7	13.48658593	33.6	35.88395184	Pass
B2B2	10	68014.8	178664.4	246679.2	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
B2B3	10	51011.1	133998.3	185009.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	7.7	13.48658593	33.6	35.88395184	Pass
B2B4	10	68014.8	178664.4	246679.2	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2C1	10	7641.9	19998.9	27640.8	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2C2	10	7641.9	19998.9	27640.8	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2D1	10	122945.225	325328.307	448273.532	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2D2	10	126394.5272	334426.1081	460820.6353	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2D3	10	121385.6022	321203.2761	442588.8783	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
(2E1	10	13287.75	34826.25	48114	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
(2E2	10	13287.75	34826.25	48114	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2F1	10	42587.95	112841.2	155429.15	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	7.7	13.48658593	33.6	35.88395184	Pass
2F2	10		0	0	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2F3	10		0	0	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2F4	10		0	0	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
2F5	10	42587.95	112841.2	155429.15	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	7.7	13.48658593	33.6	35.88395184	Pass
2G1	10	10580.4	27851.4	38431.8	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2G2	10	10580.4	27851.4	38431.8	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2W1	10	10580.4	27851.4	38431.8	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
2W2	10	10580.4	27851.4	38431.8	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass

Third Floor Columns

Columns	Hieght	Axial Load lb(cur)	Axial Load lb (Prev)	Axial Load lb (Total)	Beam Size	E Modulus	K value	Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (k	Compact fl	.56(E/Fsqr	Web Comp	1.49(E/Fsq	Pass/Fail
3A1	10	64024.25	105532.1125	169556.3625	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3A2	10	62923.35	112869.4125	175792.7625	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3A3	10	59263.85	97613.58929	156877.4393	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3A4	10	64583.5	105995.3893	170578.8893	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3B1	10	13287.75	21538.5	34826.25	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3B2	10	13287.75	21538.5	34826.25	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
B3A1	10	68014.8	110649.6	178664.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3A2	10	51011.1	82987.2	133998.3	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3A3	10	68014.8	110649.6	178664.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3A4	10	51011.1	82987.2	133998.3	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3B1	10	51011.1	82987.2	133998.3	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3B2	10	68014.8	110649.6	178664.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3B3	10	51011.1	82987.2	133998.3	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
B3B4	10	68014.8	110649.6	178664.4	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3C1	10	7641.9	12357	19998.9	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3C2	10	7641.9	12357	19998.9	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3D1	10	122945.225	202383.082	325328.307	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
3D2	10	126394.5272	208031.5809	334426.1081	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
3D3	10	121385.6022	199817.6739	321203.2761	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.761	5.7	13.48659	29.5	35.88395	Pass
(3E1	10	13287.75	21538.5	34826.25	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
(3E2	10	13287.75	21538.5	34826.25	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3F1	10	42587.95	70253.25	112841.2	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3F2	10		0	0	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3F3	10		0	0	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3F4	10		0	0	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3F5	10	42587.95	70253.25	112841.2	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7564	5.09	13.48659	35.4	35.88395	Pass
3G1	10	10580.4	17271	27851.4	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3G2	10	10580.4	17271	27851.4	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3W1	10	10580.4	17271	27851.4	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass
3W2	10	10580.4	17271	27851.4	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491	7.84	13.48659	29.9	35.88395	Pass

Fourth Floor Columns

Columns	Hieght	Axial Load lb (Prev)	Axial Load lb (cur)	Axial Load lb (total)	Beam Size	E Modulus	K value	Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (K)	Compact flange	.56(E/Fsqrt)	Web Compact	1.49(E/Fsqrt)	Pass/Fail
4A1	10	41507.8625	64024.25	105532.1125	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4A2	10	49946.0625	62923.35	112869.4125	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4A3	10	38349.73929	59263.85	97613.58929	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4A4	10	41411.88929	64583.5	105995.3893	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4B1	10	8250.75	13287.75	21538.5	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4B2	10	8250.75	13287.75	21538.5	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
B4A1	10	42634.8	68014.8	110649.6	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4A2	10	31976.1	51011.1	82987.2	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4A3	10	42634.8	68014.8	110649.6	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4A4	10	31976.1	51011.1	82987.2	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4B1	10	31976.1	51011.1	82987.2	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4B2	10	42634.8	68014.8	110649.6	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4B3	10	31976.1	51011.1	82987.2	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
B4B4	10	42634.8	68014.8	110649.6	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4C1	10	4715.1	7641.9	12357	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4C2	10	4715.1	7641.9	12357	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4D1	10	79437.857	122945.225	202383.082	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
4D2	10	81637.05374	126394.5272	208031.5809	**W10x30**	29000	0.65	1.37	56.93431	3.14	88.20825	8.84	779.7609605	5.7	13.48658593	29.5	35.88395184	Pass
4D3	10	78432.07174	121385.6022	199817.6739	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
(4E1	10	8250.75	13287.75	21538.5	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
(4E2	10	8250.75	13287.75	21538.5	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4F1	10	27665.3	42587.95	70253.25	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4F2	10			0	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4F3	10			0	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4F4	10			0	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4F5	10	27665.3	42587.95	70253.25	**W10x19**	29000	0.65	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48658593	35.4	35.88395184	Pass
4G1	10	6690.6	10580.4	17271	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4G2	10	6690.6	10580.4	17271	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4W1	10	6690.6	10580.4	17271	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass
4W2	10	6690.6	10580.4	17271	**W8x13**	29000	0.65	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48658593	29.9	35.88395184	Pass

Fifth Floor Columns, 1/2

Columns	Hieght	Axial Load lb	K value	Beam	E Modulus	Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (K)	Flange Hieght	Flange thickness	Compact flange	.56(E/Fsqrt)	Web Compact	1.49(E/Fsqrt)	Fail or Pass
5A1	10	41507.8625	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5A2	10	49946.0625	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5A3	10	38349.73929	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5A4	10	41411.88929	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5B1	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5B2	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
B5A1	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5A2	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5A3	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5A4	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5B1	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5B2	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5B3	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5B4	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5C1	10	4715.1	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5C2	10	4715.1	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5D1	10	79437.857	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5D2	10	81637.05374	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5D3	10	78432.07174	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
(5E1	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
(5E2	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5F1	10	27665.3	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F2	10		0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F3	10		0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F4	10		0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F5	10	27665.3	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5G1	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5G2	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5W1	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5W2	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5V1	10	41507.8625	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5V2	10	49946.0625	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5V3	10	38349.73929	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5V4	10	41411.88929	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5U1	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5U2	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
B5D1	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5D2	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5D3	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5D4	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5C1	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5C2	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5C3	10	31976.1	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
B5C4	10	42634.8	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5J1	10	4715.1	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5J2	10	4715.1	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5J1	10	79437.857	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5J2	10	81637.05374	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5J3	10	78432.07174	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
(5K1	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
(5K2	10	8250.75	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5L1	10	27665.3	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5L2	10		0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F3	10		0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F4	10		0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5F5	10	27665.3	0.65	**W12x14**	29000	0.753	103.5857	3.14	26.64759634	4.16	110.8540008	3.97	0.225	8.822222222	13.48658593	54.3	35.88395184	Fail
5G1	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5G2	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5W1	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail
5W2	10	6690.6	0.65	**W8x10**	29000	0.841	92.74673	3.14	33.23992845	2.96	98.39018821	3.94	0.205	9.609756098	13.48658593	40.5	35.88395184	Fail

Fifth Floor Columns, 2/2

Columns		Min r	K*L/r	Pi	Fe Ksi	Area si	Buckling (K)	Compact flange	.56(E/Fsqr	Web Comp	1.49(E/Fsqrt)	Pass or Fail
5A1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5A2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5A3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5A4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5B1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5B2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
B5A1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5A2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5A3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5A4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5B1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5B2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5B3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5B4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5C1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5C2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5D1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5D2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5D3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
(5E1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
(5E2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5F1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F5	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5G1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5G2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5W1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5W2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5V1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5V2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5V3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5V4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5U1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5U2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
B5D1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5D2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5D3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5D4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5C1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5C2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5C3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
B5C4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5J1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5J2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5J1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5J2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5J3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
(5K1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
(5K2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5L1	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5L2	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F3	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F4	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5F5	**W10x19**	0.874	89.24485	3.14	35.89971	5.62	201.7563765	5.09	13.48659	35.4	35.88395184	Pass
5G1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5G2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5W1	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass
5W2	**W8x13**	0.843	92.52669	3.14	33.39821	3.84	128.2491402	7.84	13.48659	29.9	35.88395184	Pass

Beam Name	1F3-[1H1-1H2]	1F4-1H2	1F5-[1H2-1H3]	1H1-1I1	1I1-1J1
Tributary Width	8.75	20.25	11.5	11.5	11.5
Factored Load (PLF)	1976	4455	2530	2581	2581
Estimated Beam Weight*factor	130	206.25	157.5	233.75	130
Beam Length (ft)	13	13	13	18	11.5
Moment (+) ('-lb)	35591.4	78775.13	45418.75	91197.9	35852.98
Moment (-) ('-lb)	29660	65646	37849	75998	29877
Max Shear (k)/Φ	12.6	28.0	16.1	26.3	13.6
Min Shear (k)/Φ	4.56	10.10	5.82	8.44	5.20
f'c (psi)	4000	4000	4000	4000	4000
fy (psi)	60000	60000	60000	60000	60000
ω	0.15	0.15	0.15	0.15	0.15
ΦKn (psi)	492.21	492.21	492.21	492.21	492.21
bd^2 (in^3)	868	1921	1107	2223	874
b (in)	8	10	9	11	8
d (in)	10.5	14	11.5	14.5	10.5
h (in)	13	16.5	14	17	13
jd (in)	9.1875	12.25	10.0625	12.6875	9.1875
As Req'd (+) (in^2)	0.86	1.43	1.00	1.60	0.87
Specified Positive Steel	2 #6 bars	3 #7 bars	3 #6 bars	4 #6 bars	2 #6 bars
As+ (in^2)	0.88	1.80	1.32	1.76	0.88
As Req'd (-) (in^2)	0.72	1.19	0.84	1.33	0.72
Specified Negative Steel	2 #6 bars	2 #7 bars	2 #6 bars	2 #8 bars	2 #6 bars
AS- (in^2)	0.88	1.20	0.88	1.58	0.88
a	1.94	3.18	2.59	2.82	1.94
a/dt	0.18	0.23	0.23	0.19	0.18
a/dt < .319?	YES	YES	YES	YES	YES
Moment Capacity OK?	YES	YES	YES	YES	YES
a (-)	1.94	2.12	1.73	2.53	1.94
a/dt (-)	0.18	0.15	0.15	0.17	0.18
a/dt < .319? (-)	YES	YES	YES	YES	YES
Moment Capacity OK? (-)	YES	YES	YES	YES	YES
Vc (k)	10.63	17.71	13.09	20.18	10.63
Stirrups Required?	YES	YES	YES	YES	YES
Smax (in)	5	7	5.5	7	5
Sreq/d	45.5	12.0	33.0	20.5	31.5
Initial Spacing	5	7	6	7	5
v @12" spacing	8	10	8	11	8
distance where 12" OK (')	3	5	4	7	3
Distance where no Stirrups (')	5	5	5	7	4

1J1-1K1	1K1-1N1	1H2-1I2	1I2-1J2	1J2-1K2	1K2-1N2	1H3-1I3	1I3-1J3	1J3-1L1
11.5	11.5	26	26	26	26	14.5	14.5	14.5
2581	2581	5720	5720	5720	5720	3241	3241	3241
100	218.75	384.375	196.875	135	384.375	254.375	157.5	247.5
8	18	18	11.5	8	18	18	11.5	12
17158.4	90711.9	197781.8	78250.67	37472	197781.8	113250.2	44945.16	104614
14299	75593	164818	65209	31227	164818	94375	37454	138090
7.1	26.1	57.0	29.6	15.6	57.0	32.6	17.0	64.3
3.57	8.40	18.31	11.34	7.81	18.31	10.49	6.51	44.88
4000	4000	4000	4000	4000	4000	4000	4000	4000
60000	60000	60000	60000	60000	60000	60000	60000	60000
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21
418	2212	4822	1908	914	4822	2761	1096	2550
8	10	15	9	8	15	11	9	11
7.5	15	18	15	11	18	16	11.5	15.5
10	17.5	20.5	17.5	13.5	20.5	18.5	14	18
6.5625	13.125	15.75	13.125	9.625	15.75	14	10.0625	13.5625
0.58	1.54	2.79	1.32	0.87	2.79	1.80	0.99	1.71
2 #5 bars	3 #7 bars	4 #8 bars	3 #6 bars	2 #6 bars	4 #8 bars	3 #7 bars	2 #7 bars	3 #7 bars
0.62	1.80	3.16	1.32	0.88	3.16	1.80	1.20	1.80
0.48	1.28	2.33	1.10	0.72	2.33	1.50	0.83	2.26
2 #5 bars	3 #6 bars	3 #8 bars	2 #7 bars	2 #6 bars	3 #8 bars	3 #7 bars	2 #6 bars	3 #8 bars
0.62	1.32	2.37	1.20	0.88	2.37	1.80	0.88	2.37
1.37	3.18	3.72	2.59	1.94	3.72	2.89	2.35	2.89
0.18	0.21	0.21	0.17	0.18	0.21	0.18	0.20	0.19
YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES
1.37	2.33	2.79	2.35	1.94	2.79	2.89	1.73	3.80
0.18	0.16	0.15	0.16	0.18	0.15	0.18	0.15	0.25
YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES
7.59	18.97	34.15	17.08	11.13	34.15	22.26	13.09	21.57
YES	YES	YES	YES	YES	YES	YES	YES	YES
3.5	7.5	6	7.5	5.5	6	8	5.5	3.5
-149.5	18.0	6.5	10.5	21.5	6.5	13.5	25.5	3.0
-150	8	6	8	6	6	8	6	3
6	11	13	11	8	13	12	8	11
1	6	8	4	2	8	7	4	11
2	7	8	5	3	8	7	4	12

1L1-1M1	1H1-1H2	1H2-1H3	1I1-1I2	1I2-1I3	1J1-1J2	1J2-1J3	1K1-1K2	1K2-[1J3-1L1]
14.5	15.5	15.5	14.75	14.75	9.75	9.75	13.25	13.25
3241	3410	3410	3245	3245	2145	2145	2915	2915
163.125	226.875	295.625	384.375	528.75	285	403.125	322.5	470
12	23	29	23	29	23	29	23	29
49019.4	85023	129452	191993.9	317372.4	128547	214297.3	171263.8	284678.5
40850	112743	240000	159995	264477	107123	178581	142720	237232
18.2	49.7	63.8	46.0	62.9	30.8	42.5	41.0	56.4
6.81	2.13	14.32	13.91	18.24	9.32	12.32	12.41	16.36
4000	4000	4000	4000	4000	4000	4000	4000	4000
60000	60000	60000	60000	60000	60000	60000	60000	60000
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
492.21	492.21	410.175	492.21	492.21	492.21	492.21	492.21	492.21
1195	2073	3787	4681	7737	3134	5225	4175	6940
9	11	11	15	18	12	15	12	16
12	14	19	18	21	16.5	19	19	21
14.5	16.5	21.5	20.5	23.5	19	21.5	21.5	23.5
10.5	12.25	16.625	15.75	18.375	14.4375	16.625	16.625	18.375
1.04	1.54	1.73	2.71	3.84	1.98	2.86	2.29	3.44
2 #7 bars	4 #6 bars	4 #7 bars	4 #8 bars	5 #8 bars	2 #9 bars	3 #9 bars	4 #7 bars	5 #8 bars
1.20	1.76	2.40	3.16	3.95	2.00	3.00	2.40	3.95
0.86	2.05	3.21	2.26	3.20	1.65	2.39	1.91	2.87
2 #6 bars	4 #7 bars	3 #10 bars	3 #8 bars	5 #8 bars	3 #7 bars	4 #7 bars	3 #8 bars	4 #8 bars
0.88	2.40	3.81	2.37	3.95	1.80	2.40	2.37	3.16
2.35	2.82	3.85	3.72	3.87	2.94	3.53	3.53	4.36
0.20	0.20	0.20	0.21	0.18	0.18	0.19	0.19	0.21
YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES
1.73	3.85	6.11	2.79	3.87	2.65	2.82	3.49	3.49
0.14	0.28	0.32	0.15	0.18	0.16	0.15	0.18	0.17
YES	YES	NO!	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES
13.66	19.48	26.44	34.15	47.81	25.05	36.05	28.84	42.50
YES	YES	YES	YES	YES	YES	YES	YES	YES
6	3.5	4.5	6	5	7.5	6	7.5	5.5
23.0	4.0	4.0	13.0	12.0	25.0	26.0	13.5	13.0
6	4	4	6	5	8	6	8	6
9	10	14	13	15	12	14	14	15
4	8	13	10	14	9	12	9	13
4	8	13	9	11	9	11	9	11

Beam Name	3B1-3C1	3C3-3A1	3B1-[3A0-B3A1]	3C1-[B3A1-B3B1]	3A1-B3A1
Factored Load (PLF)	2200	3220	1980	3960	2530
Estimated Beam Weight*factor	187.5	410	140	160	323.75
Beam Length (ft)	16	24	14	12	22
Moment (+) ('-lb)	61120	209088	41552	59328	138121.5
Moment (-) ('-lb)	50933	174240	34627	49440	115101
Max Shear (k)/Φ	19.1	48.4	14.1	22.0	34.2
Min Shear (k)/Φ	6.37	14.52	4.95	8.24	10.46
f'c (psi)	4000	4000	4000	4000	4000
fy (psi)	60000	60000	60000	60000	60000
ω	0.15	0.15	0.15	0.15	0.15
ΦKn (psi)	492.21	492.21	492.21	492.21	492.21
bd^2 (in^3)	1490	5098	1013	1446	3367
b (in)	10	16	8	8	14
d (in)	12.5	18	11.5	13.5	16
h (in)	15	20.5	14	16	18.5
jd (in)	10.9375	15.75	10.0625	11.8125	14
As Req'd (+) (in^2)	1.24	2.95	0.92	1.12	2.19
Specified Positive Steel	3 #6 bars	7 #6 bars	3 #6 Bars	3 #6 bars	6 #6 bars
As+ (in^2)	1.32	3.08	1.32	1.32	2.64
As Req'd (-) (in^2)	1.03	2.46	0.76	0.93	1.83
Specified Negative Steel	3 #5 bars	8 #5 bars	3 #5 bars	2 #7 bars	6 #5 bars
AS- (in^2)	0.93	2.48	0.93	1.20	1.86
a	1.64	2.74	2.05	2.65	2.34
a/dt	0.13	0.15	0.18	0.20	0.15
a/dt < .319?	YES	YES	YES	YES	YES
Moment Capacity OK?	YES	YES	YES	YES	YES
a (-)	1.64	2.74	2.05	2.65	2.34
a/dt (-)	0.13	0.15	0.18	0.20	0.15
a/dt < .319? (-)	YES	YES	YES	YES	YES
Moment Capacity OK? (-)	YES	YES	YES	YES	YES
Vc (k)	15.81	36.43	11.64	13.66	28.33
Stirrups Required?	YES	YES	YES	YES	YES
Smax (in)	6	5.5	5.5	6.5	6.5
Sreq/d	33.0	13.0	40.5	14.0	23.5
Initial Spacing	6	6	6	7	7
v @12" spacing	9	13	8	10	12
distance where 12" OK (')	5	11	4	4	9
Distance where no Stirrups (')	6	9	5	5	8

[3A01-3A1]-[B3A1-B3A2]	3A01-3A1	[3A1-3A2]-3D1	3D1-3F2	3D2-3F3	3F4-[3H2-3H3]	3F3-3H2	3I2-3I3
1870	N/A	1870	3245	4400	2591	5060	3251
255	247.5	400	350	500	145	240	262.5
22	17	29	22	22.5	13	13	17.5
102850	95326.65	190907	173998	248062.5	46238.4	89570	107600.9
85708	28864	159089	144998	206719	38532	74642	89667
25.5	12.8	37.8	43.1	60.4	16.4	31.8	31.6
7.79	12.75	10.97	13.18	18.38	5.93	11.48	10.25
4000	4000	4000	4000	4000	4000	4000	4000
60000	60000	60000	60000	60000	60000	60000	60000
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21
2507	2324	4654	4242	6048	1127	2184	2623
12	12	16	14	20	8	12	12
14.5	14	17.5	17.5	17.5	12	13.5	15
17	16.5	20	20	20	14.5	16	17.5
12.6875	12.25	15.3125	15.3125	15.3125	10.5	11.8125	13.125
1.80	1.73	2.77	2.53	3.60	0.98	1.69	1.82
3 #7 bars	3 #8 bars	4 #8 bars	6 #6 bars	5 #8 bars	4 #5 bars	4 #6 bars	6 #5 bars
1.80	1.80	3.16	2.64	3.95	1.24	1.76	1.86
1.50	0.56	2.31	2.10	3.00	0.82	1.40	1.52
2 #8 bars	2 #5 bars	4 #7 bars	5 #6 bars	3 #9 bars	2 #6 bars	5 #5 bars	5 #5 bars
1.58	0.62	2.40	2.20	3.00	0.88	1.55	1.55
2.32	0.91	2.65	2.77	2.65	1.94	2.28	2.28
0.16	0.07	0.15	0.16	0.15	0.16	0.17	0.15
YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES
2.32	0.91	2.65	2.77	2.65	1.94	2.28	2.28
0.16	0.07	0.15	0.16	0.15	0.16	0.17	0.15
YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES
[redacted]							
22.01	21.25	35.42	30.99	44.27	12.14	20.49	22.77
YES	YES	YES	YES	YES	YES	YES	YES
7	7	5.5	6.5	4.5	6	6.5	7.5
36.5	-14.0	63.5	12.5	9.5	24.5	10.5	14.5
7	7	6	7	5	6	7	8
11	N/A	13	13	13	9	10	11
8	N/A	12	10	11	4	5	7
8	N/A	10	9	9	5	5	7

F1-F2	F2-F3	D2-F3	F3-F4	H1-H2	H2-H3	I1-I2	I2-I3	J1-J2	J2-J3	K1-K2
2581	3960	2200	1980	1705	1705	1595	1595	1595	1595	1925
157.5	277.5	285	261.25	270	341.25	262.5	332.5	247.5	300	292.5
13	17	23	23	24	28	24	28	24	28	24
46280.65	122463.8	131456.5	118562.1	113760	160426	106992	151116	106128	148568	127728
38567	102053	109547	98802	94800	133688	89160	125930	88440	123807	106440
16.4	36.7	31.5	28.4	26.3	32.7	24.8	30.8	24.6	30.3	29.6
5.93	12.01	9.53	8.59	7.90	9.55	7.43	9.00	7.37	8.84	8.87
4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21
1128	2986	3205	2891	2773	3911	2608	3684	2587	3622	3114
9	12	12	11	12	14	12	14	11	12	13
11.5	16	16.5	16.5	15.5	17	15	16.5	15.5	17.5	15.5
14	18.5	19	19	18	19.5	17.5	19	18	20	18
10.0625	14	14.4375	14.4375	13.5625	14.875	13.125	14.4375	13.5625	15.3125	13.5625
1.02	1.94	2.02	1.82	1.86	2.40	1.81	2.33	1.74	2.16	2.09
2 #7 bars	2 #9 bars	4 #7 bars	3 #8 bars	3 #8 bars	4 #7 bars	3 #7 bars	4 #7 bars	4 #6 bars	5 #6 bars	5 #6 bars
1.20	2.00	2.40	2.37	2.37	2.40	1.80	2.40	1.76	2.20	2.20
0.85	1.62	1.69	1.52	1.55	2.00	1.51	1.94	1.45	1.80	1.74
2 #6 bars	3 #7 bars	3 #7 bars	2 #8 bars	3 #7 bars	2 #9 bars	2 #8 bars	2 #9 bars	2 #8 bars	3 #7 bars	3 #7 bars
0.88	1.80	1.80	1.58	1.80	2.00	1.58	2.00	1.58	1.80	1.80
1.73	2.65	2.65	2.53	2.65	2.52	2.32	2.52	2.53	2.65	2.44
0.15	0.17	0.16	0.15	0.17	0.15	0.15	0.15	0.16	0.15	0.16
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
1.73	2.65	2.65	2.53	2.65	2.52	2.32	2.52	2.53	2.65	2.44
0.15	0.17	0.16	0.15	0.17	0.15	0.15	0.15	0.16	0.15	0.16
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
13.09	24.29	25.05	22.96	23.53	30.10	22.77	29.22	21.57	26.56	25.49
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
5.5	7.5	7.5	8	7.5	6.5	7.5	6.5	7.5	7.5	7
30.0	11.0	22.5	26.5	48.5	56.5	66.0	89.5	45.0	40.5	33.0
6	8	8	8	8	7	8	7	8	8	7
8	12	12	12	11	12	11	12	11	13	11
4	7	9	8	9	11	8	11	8	10	9
5	7	9	9	8	10	8	9	9	10	9

K2-K3	H1-I1	I1-J1	J1-K1	H2-I2	I2-J2	J2-K2	H3-I3	I3-J3	J3-K3
1925	1316	1316	1316	2860	2860	2860	1646	1646	1646
375	157.5	105	162.5	255	135	247.5	187.5	110	175
28	18	11.5	17	18	11.5	17	18	11.5	17
180320	47741.4	18792.73	42728.65	100926	39608.88	89806.75	59405.4	23223.1	52626.9
150267	39785	15661	35607	84105	33007	74839	49505	19353	43856
36.8	13.8	7.1	12.8	29.1	15.0	26.9	17.1	8.8	15.8
10.73	4.42	2.72	4.19	9.35	5.74	8.80	5.50	3.37	5.16
4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21	492.21
4396	1164	458	1042	2461	966	2189	1448	566	1283
15	9	8	10	12	8	12	10	8	10
17.5	11.5	8	10.5	14.5	11	14	12.5	8.5	11.5
20	14	10.5	13	17	13.5	16.5	15	11	14
15.3125	10.0625	7	9.1875	12.6875	9.625	12.25	10.9375	7.4375	10.0625
2.62	1.05	0.60	1.03	1.77	0.91	1.63	1.21	0.69	1.16
3 #9 bars	2 #7 bars	2 #6 bars	2 #7 bars	3 #7 bars	2 #7 bars	4 #6 bars	2 #7 bars	2 #6 bars	3 #6 bars
3.00	1.20	0.88	1.20	1.80	1.20	1.76	1.20	0.88	1.32
2.18	0.88	0.50	0.86	1.47	0.76	1.36	1.01	0.58	0.97
5 #6 bars	2 #6 bars	2 #5 bars	2 #6 bars	3 #7 bars	2 #6 bars	2 #8 bars	2 #7 bars	2 #5 bars	2 #7 bars
2.20	0.88	0.62	0.88	1.80	0.88	1.58	1.20	0.62	1.20
2.59	1.73	1.37	1.55	2.65	1.94	2.32	2.12	1.37	2.12
0.15	0.15	0.17	0.15	0.18	0.18	0.17	0.17	0.16	0.18
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
2.59	1.73	1.37	1.55	2.65	1.94	2.32	2.12	1.37	2.12
0.15	0.15	0.17	0.15	0.18	0.18	0.17	0.17	0.16	0.18
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
33.20	13.09	8.10	13.28	22.01	11.13	21.25	15.81	8.60	14.55
YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
6	5.5	4	5	7	5.5	7	6	4	5.5
42.5	153.0	-71.0	-197.0	18.0	25.0	21.5	84.5	418.5	81.5
6	6	-71	-197	7	6	7	6	4	6
13	8	6	8	11	8	10	9	6	8
12	4	2	4	7	3	6	5	2	5
10	6	3	5	7	4	6	6	4	6

Beam Name	A0-BA1	G1-BB1	BA1-BB1	BA1-BA2	A1-A2	D1-D2
Trib Width (ft)	23	23	17	7	0	0
Point Ld Magnitude (k)	14.1	14.1	22	25.5	37.8	37.8
distance from support a (ft)	9	13	5	10	15	10.5
Factored Load (PLF)	5111	5111	3740	1540	51	0
Estimated Beam Weight*factor	135	130	109.375	131.25	255	168.75
Beam Length (ft)	18	23	10	17	26	16
R1 (k)	46.00	58.78	18.70	13.09	0.66	0.00
R2a (k)	7.05	5.68	11.00	9.41	14.57	10.33
R2b (k)	63.45	64.78	55.00	78.84	187.37	79.14
Moment (+) ('-lb)	31597	34476	27431	43128	101287	46795
Moment (-) ('-lb)	31867	45276	27532	61805	138412	89539
Max Shear (k)/Φ	148	167	99	124	255	107
Min Shear (k)/Φ	85	86	73	105	250	106
Φ	0.90	0.90	0.90	0.90	0.90	0.75
f'c (psi)	4000	4000	4000	4000	4000	4000
fy (psi)	60000	60000	60000	60000	60000	60000
ω	0.15	0.15	0.15	0.15	0.15	0.15
ΦKn (psi)	492.21	492.21	492.21	492.21	492.21	410.175
bd^2 (in^3)	770	841	669	1051	2469	1369
b (in)	9	8	7	7	12	9
d (in)	9.5	10.5	10	12.5	14.5	12.5
h (in)	12	13	12.5	15	17	15
jd (in)	8.3125	9.1875	8.75	10.9375	12.6875	10.9375
As Req'd (+) (in^2)	0.84	0.83	0.70	0.88	1.77	1.14
Specified Positive Steel	2 #6 bars	2 #6 bars	2 #6 bars	2 #6 bars	3 #7 bars	2 #7 bars
As+ (in^2)	0.88	0.88	0.88	0.88	1.80	1.20
As Req'd (-) (in^2)	0.85	1.10	0.70	1.26	2.42	2.18
Specified Negative Steel	2 #6 bars	2 #7 bars	2 #6 bars	3 #6 bars	4 #7 bars	2 #9 bars
AS- (in^2)	0.88	1.20	0.88	1.32	2.40	2.00
a	1.73	1.94	2.22	2.22	2.65	2.35
a/dt	0.182	0.185	0.222	0.177	0.183	0.188
a/dt < .319?	YES	YES	YES	YES	YES	YES
Moment Capacity OK?	YES	YES	YES	YES	YES	YES
a (-)	1.73	2.65	2.22	3.33	3.53	3.92
a/dt (-)	0.182	0.252	0.222	0.266	0.243	0.314
a/dt < .319? (-)	YES	YES	YES	YES	YES	YES
Moment Capacity OK? (-)	YES	YES	YES	YES	YES	YES
Vc (k)	10.81	10.63	8.85	11.07	22.01	14.23
Stirrups Required?	YES	YES	YES	YES	YES	YES
Smax (in)	2	2.5	2.5	3	3.5	3
Sreq/d	3.0	3.5	1.5	2.5	3.5	2.5
Initial Spacing	2	3	2	3	4	3
v @12" spacing	7	8	7	9	11	9
distance where 12" OK (')	N/A	N/A	N/A	N/A	N/A	N/A
Distance where no Stirrups (')	N/A	N/A	N/A	N/A	N/A	N/A

Column	B1	C1	E1	A0	BA1	BA2	BB1	BB2	G1	A1
Pu (k)	166	315.5	166	191.5	222.5	222.5	222.5	222.5	191.5	336.3
Mu ('-k)	61.546486	49.44	61.546486	118.665	117.7763	117.7763	117.7763	117.7763	118.665	205.8101
Length (')	13	13	13	13	13	13	13	13	13	13
Fy (ksi)	60	60	60	60	60	60	60	60	60	60
F'c (ksi)	3	3	3	3	3	3	3	3	3	3
ρt trial	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Ag (in^2)	106.41	202.24	106.41026	122.76	142.63	142.6282	142.6282	142.6282	122.7564	215.58
Required Size (in)	21	21	21	21	21	21	21	21	21	21
Specified Size	21	21	21	21	21	21	21	21	21	21
e (in.)	4.4	1.9	4.4491436	7.4	6.4	6.351979	6.351979	6.351979	7.435924	7.3
e/h	0.029	0.012	0.0285202	0.048	0.041	0.040718	0.040718	0.040718	0.047666	0.047
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
KL/r	29.714286	29.71429	29.714286	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429
Slenderness check	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
γ	0.774	0.774	0.7738095	0.774	0.774	0.77381	0.77381	0.77381	0.77381	0.774
Pu/Ag	0.376	0.715	0.3764172	0.434	0.505	0.504535	0.504535	0.504535	0.43424	0.763
Mu/Ag	0.140	0.112	0.1395612	0.269	0.267	0.267066	0.267066	0.267066	0.269082	0.467
Lower ρt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper ρt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ρt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As Req'd (in^2)	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
Selected Reinforcement	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
Bar #	5	5	5	5	5	5	5	5	5	5
As Provided (in^2)	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65
Tie Spacing (#3) (in.)	18	18	18	18	18	18	18	18	18	18
Splice Lengths (in.)	71.2	71.2	71.203932	71.2	71.2	71.20393	71.20393	71.20393	71.20393	71.2

C3	F1	D1	F2	A2	D2	F3	A3	D3	F4	F5	BA3	BA4
484	306	939.5	681.5	2739	837	642	2739	373	681.5	306	222.5	222.5
0	176.5647	90.60386	123.9428	159.1	225.2446	35.05567	159.1	181.701	123.9428	176.5647	117.7763	117.7763
13	13	13	13	13	13	13	13	13	13	13	13	13
60	60	60	60	60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
310.26	196.15	602.24	436.86	1755.77	536.54	411.54	1755.77	239.10	436.859	196.1538	142.6282	142.6282
21	21	31	31	51	31	31	51	21	31	21	21	21
21	21	31	31	51	31	31	51	21	31	21	21	21
0.0	6.9	1.2	2.2	0.7	3.2	0.7	0.7	5.8	2.182411	6.924104	6.351979	6.351979
0.000	0.044	0.007	0.014	0.004	0.021	0.004	0.004	0.037	0.01399	0.044385	0.040718	0.040718
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
29.71429	29.71429	20.12903	20.12903	12.23529	20.12903	20.12903	12.23529	29.71429	20.12903	29.71429	29.71429	29.71429
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.774	0.774	0.847	0.847	0.907	0.847	0.847	0.907	0.774	0.846774	0.77381	0.77381	0.77381
1.098	0.694	0.978	0.709	1.053	0.871	0.668	1.053	0.846	0.709157	0.693878	0.504535	0.504535
0.000	0.400	0.094	0.129	0.061	0.234	0.036	0.061	0.412	0.128973	0.400373	0.267066	0.267066
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.41	4.41	9.61	9.61	26.01	9.61	9.61	26.01	4.41	9.61	4.41	4.41	4.41
15 #5 Bars	15 #5 Bars	10 #9 Bars	10 #9 Bars		10 #9 Bars	10 #9 Bars		15 #5 Bars	10 #9 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
5	5	9	9		9	9		5	9	5	5	5
4.65	4.65	10	10		10	10		4.65	10	4.65	4.65	4.65
18	18	18	18	0	18	18	0	18	18	18	18	18
71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.20393	71.20393	71.20393	71.20393

BB13	BB4	A4	B2	C2	E2	G2	A5	H1	I1	J1	K1	H2
222.5	222.5	336.3	166	315.5	166	191.5	191.5	236.4	268.7	229.5	184.6	676.6
117.7763	117.7763	205.8101	61.54649	49.44	61.54649	118.665	118.665	135.9312	166.4128	108.2302	155.3093	161.3875
13	13	13	13	13	13	13	13	13	13	13	13	13
60	60	60	60	60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
142.6282	142.6282	215.5769	106.4103	202.2436	106.4103	122.7564	122.7564	151.54	172.24	147.12	118.33	433.72
21	21	21	21	21	21	21	21	21	21	21	21	31
21	21	21	21	21	21	21	21	21	21	21	21	31
6.351979	6.351979	7.343804	4.449144	1.880444	4.449144	7.435924	7.435924	6.9	7.4	5.7	10.1	2.9
0.040718	0.040718	0.047076	0.02852	0.012054	0.02852	0.047666	0.047666	0.044	0.048	0.036	0.065	0.018
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	29.71429	20.12903
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.77381	0.77381	0.77381	0.77381	0.77381	0.77381	0.77381	0.77381	0.774	0.774	0.774	0.774	0.847
0.504535	0.504535	0.762585	0.376417	0.71542	0.376417	0.43424	0.43424	0.536	0.609	0.520	0.419	0.704
0.267066	0.267066	0.46669	0.139561	0.112109	0.139561	0.269082	0.269082	0.308	0.377	0.245	0.352	0.168
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	9.61
15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	10 #9 Bars
5	5	5	5	5	5	5	5	5	5	5	5	9
4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	10
18	18	18	18	18	18	18	18	18	18	18	18	18
71.20393	71.20393	71.20393	71.20393	71.20393	71.20393	71.20393	71.20393	71.2	71.2	71.2	71.2	71.2

I2	J2	K2	H3	I3	J3	L1
592.8	505.7	410.4	256.8	295.3	301.8	192.9
144.3621	79.17228	163.6435	257.8979643	270.53	204.9837	97.2
13	13	13	13	13	13	13
60	60	60	60	60	60	60
3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015
380.00	324.17	263.08	164.62	189.29	193.46	123.65
21	21	21	21	21	21	21
21	21	21	21	21	21	21
2.9	1.9	4.8	12.1	11.0	8.2	6.0
0.019	0.012	0.031	0.077	0.070	0.052	0.039
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
29.71429	29.71429	29.71429	29.71428571	29.71429	29.71429	29.71429
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.774	0.774	0.774	0.774	0.774	0.774	0.774
1.344	1.147	0.931	0.582	0.670	0.684	0.437
0.327	0.180	0.371	0.585	0.613	0.465	0.220
0.01	0.01	0.01	0.02	0.025	0.01	0.01
0.01	0.01	0.01	0.015	0.02	0.01	0.01
0.01	0.01	0.01	0.0565	0.0615	0.01	0.01
4.41	4.41	4.41	24.9165	27.1215	4.41	4.41
15 #5 Bars	15 #5 Bars	15 #5 Bars	16 #14 Bars		15 #5 Bars	15 #5 Bars
5	5	5	14		5	5
4.65	4.65	4.65	24.96		4.65	4.65
18	18	18	18	0	18	18
71.2	71.2	71.2	71.2	71.2	71.2	71.2

Column	B1	C1	E1	A0	BA1	BA2	BB1	BB2	G1	A1
Pu (k)	132.8	252.4	132.8	153.2	178	178	178	178	153.2	269.04
Mu ('-k)	61.54649	49.44	61.54649	118.665	117.77627	117.7763	117.7763	117.7763	118.665	205.8101
Length (')	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Fy (ksi)	60	60	60	60	60	60	60	60	60	60
F'c (ksi)	3	3	3	3	3	3	3	3	3	3
ρt trial	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Ag (in^2)	85.13	161.79	85.12821	98.21	114.10	114.1026	114.1026	114.1026	98.20513	172.46
Required Size (in)	11	21	11	11	21	21	21	21	11	21
Specified Size	14	21	14	14	21	21	21	21	14	21
e (in.)	5.6	2.4	5.56143	9.3	7.9	7.939973	7.939973	7.939973	9.294905	9.2
e/h	0.044	0.019	0.044138	0.074	0.063	0.063016	0.063016	0.063016	0.073769	0.073
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
KL/r	36	24	36	36	24	24	24	24	36	24
Slenderness check	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
γ	0.661	0.774	0.660714	0.661	0.774	0.77381	0.77381	0.77381	0.660714	0.774
Pu/Ag	0.678	0.572	0.677551	0.782	0.404	0.403628	0.403628	0.403628	0.781633	0.610
Mu/Ag	0.314	0.112	0.314013	0.605	0.267	0.267066	0.267066	0.267066	0.605433	0.467
Lower ρt	0.0133	0.01	0.0133	0.018	0.01	0.01	0.01	0.01	0.018	0.01
Upper ρt	0.007	0.01	0.007	0.02	0.01	0.01	0.01	0.01	0.02	0.01
ρt	0.009016	0.01	0.009016	0.01936	0.01	0.01	0.01	0.01	0.01936	0.01
As Req'd (in^2)	1.767136	4.41	1.767136	3.79456	4.41	4.41	4.41	4.41	3.79456	4.41
Selected Reinforcement	6 #5 Bars	15 #5 Bars	6 #5 Bars	9 #6 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	9 #6 Bars	15 #5 Bars
Bar #	5	5	5	6	5	5	5	5	6	5
As Provided (in^2)	1.86	4.65	1.86	3.96	4.65	4.65	4.65	4.65	3.96	4.65
Tie Spacing (#3) (in.)	14	18	14	14	18	18	18	18	14	18
Splice Lengths (in.)	71.2	71.2	71.20393	71.2	71.2	71.20393	71.20393	71.20393	71.20393	71.2

C3	F1	D1	F2	A2	D2	F3	A3	D3	F4	F5	BA3	BA4
387.2	244.8	751.6	545.2	2191.2	669.6	513.6	2191.2	298.4	545.2	244.8	178	178
0	176.5647	90.60386	123.9428	159.1	225.2446	35.05567	159.1	181.701	123.9428	176.5647	117.7763	117.7763
10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
248.21	156.92	481.79	349.49	1404.62	429.23	329.23	1404.62	191.28	349.4872	156.9231	114.1026	114.1026
21	21	31	21	41	31	21	41	21	21	21	21	21
21	21	31	21	41	31	21	41	21	21	21	21	21
0.0	8.7	1.4	2.7	0.9	4.0	0.8	0.9	7.3	2.728014	8.655131	7.939973	7.939973
0.000	0.069	0.011	0.022	0.007	0.032	0.007	0.007	0.058	0.021651	0.068692	0.063016	0.063016
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
24	24	16.25806	24	12.29268	16.25806	24	12.29268	24	24	24	24	24
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.774	0.774	0.847	0.774	0.884	0.847	0.774	0.884	0.774	0.77381	0.77381	0.77381	0.77381
0.878	0.555	0.782	1.236	1.304	0.697	1.165	1.304	0.677	1.236281	0.555102	0.403628	0.403628
0.000	0.400	0.094	0.281	0.095	0.234	0.079	0.095	0.412	0.281049	0.400373	0.267066	0.267066
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.41	4.41	9.61	4.41	16.81	9.61	4.41	16.81	4.41	4.41	4.41	4.41	4.41
15 #5 Bars	15 #5 Bars	10 #9 Bars	15 #5 Bars	17 #9 Bars	10 #9 Bars	15 #5 Bars	17 #9 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
5	5	9	5	9	9	5	9	5	5	5	5	5
4.65	4.65	10	4.65	17	10	4.65	17	4.65	4.65	4.65	4.65	4.65
18	18	18	18	18	18	18	18	18	18	18	18	18
71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.20393	71.20393	71.20393	71.20393

BB13	BB4	A4	B2	C2	E2	G2	A5	H2	I2	J2	K2	H1
178	178	269.04	132.8	252.4	132.8	153.2	153.2	479.6	398.8	387.2	480.8	160.4
117.7763	117.7763	205.8101	61.54649	49.44	61.54649	118.665	118.665	40.04323	43.9892	54.77591	43.8	102.7771
10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
114.1026	114.1026	172.4615	85.12821	161.7949	85.12821	98.20513	98.20513	307.44	255.64	248.21	308.21	102.82
21	21	21	11	21	11	11	11	21	21	21	21	21
21	21	21	14	21	14	14	14	21	21	21	21	21
7.939973	7.939973	9.179755	5.56143	2.350555	5.56143	9.294905	9.294905	1.0	1.3	1.7	1.1	7.7
0.063016	0.063016	0.072855	0.044138	0.018655	0.044138	0.073769	0.073769	0.008	0.011	0.013	0.009	0.061
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
24	24	24	36	24	36	36	36	24	24	24	24	24
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.77381	0.77381	0.77381	0.660714	0.77381	0.660714	0.660714	0.660714	0.774	0.774	0.774	0.774	0.774
0.403628	0.403628	0.610068	0.677551	0.572336	0.677551	0.781633	0.781633	1.088	0.904	0.878	1.090	0.364
0.267066	0.267066	0.46669	0.314013	0.112109	0.314013	0.605433	0.605433	0.091	0.100	0.124	0.099	0.233
0.01	0.01	0.01	0.0133	0.01	0.0133	0.018	0.018	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.007	0.01	0.007	0.02	0.02	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.009016	0.01	0.009016	0.01936	0.01936	0.01	0.01	0.01	0.01	0.01
4.41	4.41	4.41	1.767136	4.41	1.767136	3.79456	3.79456	4.41	4.41	4.41	4.41	4.41
15 #5 Bars	15 #5 Bars	15 #5 Bars	6 #5 Bars	15 #5 Bars	6 #5 Bars	9 #6 Bars	9 #6 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
5	5	5	5	5	5	6	6	5	5	5	5	5
4.65	4.65	4.65	1.86	4.65	1.86	3.96	3.96	4.65	4.65	4.65	4.65	4.65
18	18	18	14	18	14	14	14	18	18	18	18	18
71.20393	71.20393	71.20393	71.20393	71.20393	71.20393	71.20393	71.20393	71.2	71.2	71.2	71.2	71.2

I1	J1	K1	H3	I3	J3	K3
182.8	178	220.8	160.4	182.8	178	220.8
92.27573	90.6122	106.4	102.7771	92.27573	90.6122	106.4
10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60
3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015
117.18	114.10	141.54	102.8205	117.1795	114.1026	141.5385
21	21	21	21	21	21	21
21	21	21	21	21	21	21
6.1	6.1	5.8	7.689059	6.057488	6.108687	5.782609
0.048	0.048	0.046	0.061024	0.048075	0.048482	0.045894
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
24	24	24	24	24	24	24
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.774	0.774	0.774	0.77381	0.77381	0.77381	0.77381
0.415	0.404	0.501	0.363719	0.414512	0.403628	0.50068
0.209	0.205	0.241	0.233055	0.209242	0.20547	0.24127
0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.41	4.41	4.41	4.41	4.41	4.41	4.41
15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
5	5	5	5	5	5	5
4.65	4.65	4.65	4.65	4.65	4.65	4.65
18	18	18	18	18	18	18
71.2	71.2	71.2	71.20393	71.20393	71.20393	71.20393

Column	B1	C1	E1	A0	BA1	BA2	BB1
Pu (k)	66.4	126.2	66.4	76.6	89	89	89
Mu ('-k)	61.5	49.44	61.5464865	118.7	117.8	117.776271	117.776271
Length (')	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Fy (ksi)	60	60	60	60	60	60	60
F'c (ksi)	3	3	3	3	3	3	3
ρt trial	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Ag (in^2)	42.56	80.90	42.56410256	49.10	57.05	57.05128205	57.05128205
Required Size (in)	11	11	11	11	11	11	11
Specified Size	14	14	14	14	14	14	14
e (in.)	11.1	4.7	11.12285901	18.6	15.9	15.87994665	15.87994665
e/h	0.088	0.037	0.088276659	0.148	0.126	0.126031323	0.126031323
Configuration: Bars in	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
KL/r	36	36	36	36	36	36	36
Slenderness check	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
γ	0.661	0.661	0.660714286	0.661	0.661	0.660714286	0.660714286
Pu/Ag	0.339	0.644	0.33877551	0.391	0.454	0.454081633	0.454081633
Mu/Ag	0.314	0.252	0.314012686	0.605	0.601	0.600899342	0.600899342
Lower ρt	0.0133	0.01	0.0133	0.05	0.05	0.05	0.05
Upper ρt	0.007	0.01	0.007	0.035	0.03	0.03	0.03
ρt	0.009016	0.01	0.009016	0.0398	0.0364	0.0364	0.0364
As Req'd (in^2)	1.767136	1.96	1.767136	7.8008	7.1344	7.1344	7.1344
Selected Reinforcement	4 #7 Bars	7 #5 Bars	4 #7 Bars	10 #8 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars
Bar #	7	5	7	8	7	7	7
As Provided (in^2)	2.4	2.17	2.4	7.9	7.2	7.2	7.2
Tie Spacing (#3) (in.)	14	14	14	14	14	14	14
Splice Lengths (in.)	71.2	71.2	71.2	71.2	71.2	71.2	71.2

BB2	G1	A1	C3	F1	D1	F2	A2	D2
89	76.6	134.52	193.6	122.4	375.8	272.6	1095.6	334.8
117.776271	118.6649514	205.8	0.0	176.6	90.6	123.9	159.1	225.2
10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
57.05128205	49.1025641	86.23	124.10	78.46	240.90	174.74	702.31	214.62
11	11	11	21	11	21	21	31	21
14	14	14	21	14	21	21	31	21
15.87994665	18.58980962	18.4	0.0	17.3	2.9	5.5	1.7	8.1
0.126031323	0.147538172	0.146	0.000	0.137	0.023	0.043	0.014	0.064
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
36	36	36	24	36	24	24	16.25806452	24
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.660714286	0.660714286	0.661	0.774	0.661	0.774	0.774	0.847	0.774
0.454081633	0.390816327	0.686	0.439	0.624	0.852	0.618	1.140	0.759
0.600899342	0.605433426	1.050	0.000	0.901	0.205	0.281	0.166	0.511
0.05	0.05	0.05	0.01	0.05	0.01	0.01	0.01	0.03
0.03	0.035	0.05	0.01	0.05	0.01	0.01	0.01	0.028
0.0364	0.0398	0.05	0.01	0.05	0.01	0.01	0.01	0.0446
7.1344	7.8008	9.8	4.41	9.8	4.41	4.41	9.61	19.6686
12 #7 Bars	10 #8 Bars	10 #9 Bars	15 #5 Bars	10 #9 Bars	15 #5 Bars	15 #5 Bars	10 #9 Bars	20 #9 Bars
7	8	9	5	9	5	5	9	9
7.2	7.9	10	4.65	10	4.65	4.65	10	20
14	14	14	18	14	18	18	18	18
71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2

F3	A3	D3	F4	F5	BA3	BA4	BB13	BB4
256.8	1095.6	149.2	272.6	122.4	89	89	89	89
35.1	159.1	181.7	123.9427691	176.5646624	117.776271	117.776271	117.776271	117.776271
10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
164.62	702.31	95.64	174.7435897	78.46153846	57.05128205	57.05128205	57.05128205	57.05128205
21	31	11	21	11	11	11	11	11
21	31	14	21	14	14	14	14	14
1.6	1.7	14.6	5.456027985	17.31026102	15.87994665	15.87994665	15.87994665	15.87994665
0.013	0.014	0.116	0.043301809	0.137383024	0.126031323	0.126031323	0.126031323	0.126031323
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
24	16.25806452	36	24	36	36	36	36	36
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.774	0.847	0.661	0.773809524	0.660714286	0.660714286	0.660714286	0.660714286	0.660714286
0.582	1.140	0.761	0.61814059	0.624489796	0.454081633	0.454081633	0.454081633	0.454081633
0.079	0.166	0.927	0.281049363	0.900840114	0.600899342	0.600899342	0.600899342	0.600899342
0.01	0.01	0.05	0.01	0.05	0.05	0.05	0.05	0.05
0.01	0.01	0.05	0.01	0.05	0.03	0.03	0.03	0.03
0.01	0.01	0.05	0.01	0.05	0.0364	0.0364	0.0364	0.0364
4.41	9.61	9.8	4.41	9.8	7.1344	7.1344	7.1344	7.1344
15 #5 Bars	10 #9 Bars	10 #9 Bars	15 #5 Bars	10 #9 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars	12 #7 Bars
5	9	9	5	9	7	7	7	7
4.65	10	10	4.65	10	7.2	7.2	7.2	7.2
18	18	14	18	14	14	14	14	14
71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2

A4	B2	C2	E2	G2	A5	H2	I2	J2
134.52	66.4	126.2	66.4	76.6	76.6	239.8	199.4	193.6
205.8101067	61.5464865	49.44	61.5464865	118.6649514	118.6649514	40.0	44.0	54.8
10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
86.23076923	42.56410256	80.8974359	42.56410256	49.1025641	49.1025641	153.72	127.82	124.10
11	11	11	11	11	11	21	21	21
14	14	14	14	14	14	21	21	21
18.35950996	11.12285901	4.70110935	11.12285901	18.58980962	18.58980962	2.0	2.6	3.4
0.145710397	0.088276659	0.037310392	0.088276659	0.147538172	0.147538172	0.016	0.021	0.027
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
36	36	36	36	36	36	24	24	24
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.660714286	0.660714286	0.660714286	0.660714286	0.660714286	0.660714286	0.774	0.774	0.774
0.686326531	0.33877551	0.643877551	0.33877551	0.390816327	0.390816327	0.544	0.452	0.439
1.050051565	0.314012686	0.252244898	0.314012686	0.605433426	0.605433426	0.091	0.100	0.124
0.05	0.0133	0.01	0.0133	0.05	0.05	0.01	0.01	0.01
0.05	0.007	0.01	0.007	0.035	0.035	0.01	0.01	0.01
0.05	0.009016	0.01	0.009016	0.0398	0.0398	0.01	0.01	0.01
9.8	1.767136	1.96	1.767136	7.8008	7.8008	4.41	4.41	4.41
10 #9 Bars	4 #7 Bars	7 #5 Bars	4 #7 Bars	10 #8 Bars	10 #8 Bars	15 #5 Bars	15 #5 Bars	15 #5 Bars
9	7	5	7	8	8	5	5	5
10	2.4	2.17	2.4	7.9	7.9	4.65	4.65	4.65
14	14	14	14	14	14	18	18	18
71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2

K2	H1	I1	J1	K1	H3	I3	J3	K3
240.4	80.2	91.4	89	110.4	80.2	91.4	89	110.4
43.8	102.8	92.3	90.6	106.4	102.7770889	92.27572812	90.61219565	106.4
10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
60	60	60	60	60	60	60	60	60
3	3	3	3	3	3	3	3	3
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
154.10	51.41	58.59	57.05	70.77	51.41025641	58.58974359	57.05128205	70.76923077
21	11	11	11	11	11	11	11	11
21	14	14	14	14	14	14	14	14
2.2	15.4	12.1	12.2	11.6	15.37811804	12.11497525	12.21737469	11.56521739
0.017	0.122	0.096	0.097	0.092	0.122048556	0.096150597	0.096963291	0.09178744
4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces	4 faces
24	36	36	36	36	36	36	36	36
SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT	SHORT
0.774	0.661	0.661	0.661	0.661	0.660714286	0.660714286	0.660714286	0.660714286
0.545	0.409	0.466	0.454	0.563	0.409183673	0.466326531	0.454081633	0.563265306
0.099	0.524	0.471	0.462	0.543	0.524372902	0.470794531	0.462307121	0.542857143
0.01	0.04	0.035	0.035	0.04	0.04	0.035	0.035	0.04
0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.01	0.04	0.0384	0.0384	0.04	0.04	0.0384	0.0384	0.04
4.41	7.84	7.5264	7.5264	7.84	7.84	7.5264	7.5264	7.84
15 #5 Bars	10 # 8 Bars	13 #7 Bars	13 #7 Bars	15 #5 Bars	10 # 8 Bars	13 #7 Bars	13 #7 Bars	10 # 8 Bars
5	8	7	7	8	8	7	7	8
4.65	7.9	7.8	1.8	7.9	7.9	7.8	1.8	7.9
18	14	14	14	14	14	14	14	14
71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2	71.2

Sections Selected	Total ft. of Steel	Cost per Selection	
W21x48	1353	$	77,973.39
W18x35	1930	$	86,135.90
W14x43	2528	$	134,489.60
W12x14	432	$	8,696.16
W10x33	322	$	20,099.24
W10x30	1438	$	58,181.48
W10x19	1440	$	40,147.20
W8x31	640	$	26,828.80
W8x13	1260	$	26,472.60
W8x10	1826	$	32,228.90
Total Price		**$**	**562,378.60**

Item	Cost	
Rebar	$	349,034.61
Concrete	$	269,855.04
Placeing	$	62,116.46
Framework	$	82,529.60
Stirrups	$	77,985.74
Total Price	**$**	**841,521.46**

Columns

5th Floor	Length:10'
Type	#
W10x19	45
W8x31	16
W8x13	20
4th Floor	Length:10'
Type	#
W10x30	4
W10x19	41
W8x31	16
W8x13	20
3rd Floor	Length:10'
Type	#
W10x30	6
W10x19	41
W8x31	16
W8x13	20
2nd Floor	Length:10'
Type	#
W10x30	28
W10x19	17
W8x31	16
W8x13	20
1st Floor	Length:13'
Type	#
W18x35	4
W10x33	14
W10x30	46
W8x13	20
Basement	Length:10'
Type	#
W18x35	4
W10x33	14
W10x30	46
W8x13	20

Total	Length:10'		
Type	#	Total Length of Column	
W10x33	14	140	ft
W10x30	84	840	ft
W10x19	144	1440	ft
W8x31	64	640	ft
W8x13	100	1000	ft
Total	Length:13'		
Type	#		
W18x35	4	52	ft
W10x33	14	182	ft
W10x30	46	598	ft
W8x13	20	260	ft

W18x35	52	ft
W10x33	322	ft
W10x30	1438	ft
W10x19	1440	ft
W8x31	640	ft
W8x13	1260	ft

Girders

5th Floor

Type	#
W18x35	16
W14x43	18
W8x10	26

4th Floor

Type	#
W21x48	4
W18x35	12
W14x43	18
W8x10	26

3rd Floor

Type	#
W21x48	4
W18x35	12
W14x43	18
W8x10	26

2nd Floor

Type	#
W21x48	4
W18x35	12
W14x43	18
W8x10	26

1st Floor

Type	#
W21x48	4
W18x35	12
W14x43	18
W8x10	26

Basement

Type	#
W21x48	4
W18x35	12
W14x43	18
W8x10	26

Total

Type	#	Total Length of Girder	
W21x48	20	282	ft
W18x35	60	1026	ft
W14x43	108	2400	ft
W8x10	156	1298	ft

Beams

5th Floor			Total			
Type	#		Type	#	Total Length of Beams	
W12x14	20		**W21x48**	66	1071	ft
W18x35	22		**W12x14**	60	432	ft
W14x43	16		**W18x35**	74	852	ft
W8x10	24		**W14x43**	96	128	ft
4th Floor			**W8x10**	120	528	ft
Type	#					
W21x48	14					
W12x14	12					
W18x35	14					
W14x43	16					
W8x10	24					
3rd Floor						
Type	#					
W21x48	14					
W12x14	12					
W18x35	14					
W14x43	16					
W8x10	24					
2nd Floor						
Type	#					
W21x48	14					
W12x14	12					
W18x35	14					
W14x43	16					
W8x10	24					
1st Floor						
Type	#					
W21x48	12					
W12x14	12					
W18x35	16					
W14x43	16					
W8x10	24					
Basement						
Type	#					
W21x48	12					
W12x14	12					
W18x35	16					
W14x43	16					
W8x10	24					

W18x35		52	ft
W10x33		322	ft
W10x30		1438	ft
W10x19		1440	ft
W8x31		640	ft
W8x13		1260	ft

Total Type	#	Total Length of Girder	
W21x48	20	282	ft
W18x35	60	1026	ft
W14x43	108	2400	ft
W8x10	156	1298	ft

Total Type	#	Total Length of Beams	
W21x48	66	1071	ft
W12x14	60	432	ft
W18x35	74	852	ft
W14x43	96	128	ft
W8x10	120	528	ft

	ft					
W21x48	1353	57.63	$/L.F.	Interpolated between 21 x44 & x50	$	77,973.39
W18x35	1930	44.63	$/L.F.		$	86,135.90
W14x43	2528	53.2	$/L.F.		$	134,489.60
W12x14	432	20.13	$/L.F.		$	8,696.16
W10x33	322	62.42	$/L.F.		$	20,099.24
W10x30	1438	40.46	$/L.F.	Interpolated between 10 x26 & x33	$	58,181.48
W10x19	1440	27.88	$/L.F.	Interpolated between 10 x15 & x22	$	40,147.20
W8x31	640	41.92	$/L.F.		$	26,828.80
W8x13	1260	21.01	$/L.F.	Interpolated between 8 x10 & x15	$	26,472.60
W8x10	1826	17.65	$/L.F.		$	32,228.90
					$	562,378.60

Includes Labor, Equipment, Materials, Fabrication, and suffecent Bolted connections

ft	lbs/ft	lbs	tons	
48	1353	64944		
35	1930	67550		
43	2528	108704		
14	432	6048		
33	322	10626		
30	1438	43140		
19	1440	27360		
31	640	19840		
13	1260	16380		
10	1826	18260		
		382852	191.43	+10%

Bar	lbs/ft	Length		Total	Weight			
		Columns	Beams	Length	lbs	Tons	$/ton	$
5	1.04	13914.00	1832.30	15746.30	16376.15	8.19	1775	$ 14,533.83
6	1.50	283.50	4447.37	4730.87	7096.30	3.55	1775	$ 6,297.97
7	2.04	1722.00	2624.85	4346.85	8867.57	4.43	1775	$ 7,869.97
8	2.67	892.50	2632.83	3525.33	9412.64	4.71	1470	$ 6,918.29
9	3.40	2162.00	510.87	2672.87	9087.75	4.54	1470	$ 6,679.49
10	4.30	0.00	50.70	50.70	218.01	0.11	1470	$ 160.24
14	7.65	208.00	0.00	208.00	1591.20	0.80	1470	$ 1,169.53
								$ 43,629.33

Concrete					$/C.Y	$
Yrds ^ 3						
	Columns		Beams	Beams		
1st	88.282	All		141.680	$ 108.00	$ 15,301.45
2-3	55.425			Columns		
4-5	33.509			177.216	$ 104.00	$ 18,430.43

Placeing	$/C.Y	$
Beams		
141.680	$ 30.35	$ 4,299.99
Columns		
177.216	$ 19.55	$ 3,464.57

FrameWork			Total
Beams		$ 3,810.76	
Columns	1st	$ 2,340.60	
	2-3	$ 2,397.96	
	4-5	$ 1,766.88	
			$ 10,316.20

Total Price	$ 841,521.46

Stirrups

Bar	lbs/ft	Length			$/ton	$	
		ft.	lbs	ton.	$/ton	$	
4	0.67	2368.89	1587.16	0.794			
		1979.67	1326.38	0.663			
		1694.67	1135.43	0.568			
		6043.22	4048.96	2.024	1775	$ 3,593.45	-columns

		Length					
		ft.	lbs	ton.	$/ton	$	
4	0.67	5175.33	3467.47	1.73			
		5175.33	3467.47	1.73			
		10350.67	6934.95	3.47	1775	$ 6,154.77	-Beams