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Manning Gymnasium

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Section I – Executive Summary

Manning Recreation Center is the central hub for the City of Manning, IA, providing space for the members to participate in recreational sports leagues, exercise classes, and local programs. The facility has a variety of amenities, such as a racquetball court, one full-size basketball court, a children's mat room, full weight room, and a swimming pool with an outdoor waterpark addition. Throughout the year, the main gymnasium is filled with practices, games, and tournaments of youth volleyball and basketball leagues. In the summer, the pool and locker room areas are utilized to host swimmeets for surrounding towns. The Recreation Center is a vital resource for the community of Manning because of the variety of community programs and regional tournaments that it can host.

The current facility, however, was built in 1938 and lacks space for the occupancy and events that the community has grown to need. The main gymnasium in the Recreation Center is constantly utilized throughout the week with youth practices and exercise classes. On weekends, the courts are booked with volleyball and basketball tournaments. This packed schedule causes issues with minimal open gym times for the community and makes logistically planning court usage difficult. The City of Manning has consulted a student design team from the University of Iowa's College of Engineering to discuss plans for creating additional facilities in or around the current Recreation Center to create more space that will benefit the community.

The City of Manning has multiple needs that could be met in one new building. The most important need is a new gymnasium that provides more space to better host community programs, local youth league tournaments, and open gym times. Additionally, Manning needs more storage space related to its recreation programs, redesign of the local Senior Center, and space for community events.

The design team conducted a site visit to better understand the current use of space and possible areas for construction of this new gymnasium. After discussion, we provided the City of Manning with four design alternatives that meet the needs of the community; these are briefly summarized here: (More details of each of the alternatives are provided in Section V.)

1. Demolition of the existing Senior Center and construction of a 3-story building in that location. This facility will include a gymnasium on the ground floor large enough for one full basketball court and bleachers. The second and third floors would be utilized for a variety of uses, with spaces for exercise classes and event rooms. The existing parking lot would be extended south, into the space of the soon to be relocated natural gas facility, n order to provide additional parking.

2. Construction of a new gymnasium at ground level on the south side of the existing Recreation Center. This design would require the removal of the racquetball court. The new

gymnasium would connect to the existing gym as a point of entry. An additional entrance would be designed alongside the northern sidewalk. This design would require additional parking be created across Main Street in Manning City Park.

3. Placement of the new gymnasium as described in Alternative 2 but additional parking would be created by expanding the current parking lot south, into the area of the current natural gas facility.

4. Construction of a new gymnasium in the location of the existing natural gas facility. This would be relatively same designed as described in Alternate 1, however this building would be slightly smaller because of differences in land plot size. The parking lot would be built in the lot of the current Senior Center.

After we shared these the concepts and answered questions, the City of Manning chose Alternative 1. The design team then created civil, structural, and architectural plans for the project. The civil plans include design of the site of the gymnasium and two parking lots, broken up into the east and west parking lots. In addition, a full grading plan for the site and parking lots is provided. The architectural plan focuses on the aesthetics of the building, which will help garner support from the community for the project. The structural plans show the framing layout and each structural element that has been designed to resist the loads that will act on the building.

This Design Report provides scope of work, an overview of alternatives, and a full construction cost estimate for the project. All the civil, structural, and architectural drawing plans are submitted via the Manning Gymnasium Project Drawing Set. Visuals of the design are submitted in a summary poster and presentation form.

When calculating the cost estimate of the gymnasium, general contractor costs were used to estimate the total material and labor costs. *Gordian, Square Foor Costs with RSMeans Data, 2019* was the primary source for architectural and structural cost and labor prices. All physical aspects of the building were included within the estimate, with exceptions for equipment needed and inflation into the year of when the construction will be completed. For civil site design, cost estimates were determined with comparison of Iowa DOT Tabulation of Construction and Material Bids, which was a database of projects that have been bid on in Iowa, which unit costs for materials specified.

The structural cost estimate for the project is $1.05 million. This includes the total cost of structural steel, concrete slabs and foundations, and masonry. The architectural estimate projected the costs of sporting equipment, wall and floor finishes, restrooms design, the kitchen, and utilities such as the elevator. The approximation for all architectural features was $1.27 million. For the civil side, the price estimated the total cost of the base and subbase material, hot mix asphalt as pavement for the parking lots, concrete removal and sidewalk, and pavement markings. This material and work were determined to cost $890,000.

The subtotal cost estimate for the construction of the new Manning Gymnasium is $3.2 million with a contingency of 20%, which results in a construction cost of $4.08 million. A full breakdown of the structural, architectural, and civil cost estimates is provided in Section VII.

Section II – Organization Qualifications and Experience

Organization and Design Team Description:

We are a group of senior Civil Engineering students enrolled in our department's capstone design course. We are excited to offer our professional services and present a gymnasium design. Our project manager is Kusai Contractor, who oversaw the civil site design portion of the project. Blythe Rients was our technical support chair and led the structural design. Finally, Dalen Acton served as our document editor also headed up the architectural design throughout the project. Complete resumes for each member of the project team are provided in Appendix D.

Description of Experience with Similar Projects:

Our team has a diverse field of knowledge directly applicable to the Manning Gymnasium Project. Among the three engineers leading this project, we have worked with Stanley Consultants, HGA Architects and Engineers, and HR Green.

Kusai interned at Stanley Consultants in Chicago, Illinois, as a Transportation Design Intern. In that role, he worked on highway interchange projects, with experience in highway drainage design, annotating cross sections, and quantity calculations. On another project, he prepared site plans, design computations, and quantity estimates for a water main replacement and pavement repair of a neighborhood in Bloomington, Illinois. Kusai has taken classes focusing on structural design, transportation and traffic design, and construction. Throughout his coursework and work experience, Kusai has gained working knowledge of AutoCAD, MicroStation, Revit, and ArcGIS.

Blythe has experience with civil and structural design, as well as compiling construction cost estimates through her work as an intern at HGA Architects and Engineers, a premier firm that works on projects of various kinds and magnitudes. She has interned with their Construction Estimating and Structural Engineering teams during the summers of 2021 and 2022 in Minneapolis, Minnesota. She assisted in the design of a two-story steel office building, conducted studies comparing prices of structural materials, and estimated the construction cost of their current projects. Blythe is studying Civil Engineering with a focus in structures, mechanics, and materials as well as minoring in Spanish. She has taken many courses relevant to this project including civil materials, foundation design, design of wood, concrete, and steel structures, as well as structural systems for buildings which will allow her to implement her studies into the design of the Manning Gymnasium.

Dalen interned for HR Green during the summers of 2021 and 2022, where he was a construction inspector for the I-80/380 interchange reconstruction in Coralville, Iowa. He conducted bridge, roadway, and underground structure inspections during his time at HR Green. Dalen is studying Civil Engineering and focusing on structures, mechanics, and materials at the University of Iowa. He has taken courses in structural foundations, bridge engineering, steel structure design, concrete Structure design, structural health monitoring, and structural systems for buildings.

Section III – Design Services

Project Scope

After the design alternatives were discussed with the client and the final design was chosen, the design team divided the work into three separate categories: Structural, Architectural, and Civil. Blythe Rients headed the structural work on the project, designing the steel members, foundations, and the open web joists over the gymnasium. Dalen Acton used Revit to model the project, creating a rendering that was used both for visual and structural calculation purposes. Kusai Contractor lead the civil site design by creating the parking lots and sidewalk plan for the project. A summary of the work we completed is shown below. Also, there is a more detailed analysis of each of the final design services provided in Section VI.

Structural:

The structural system was developed to best support the architectural goals and foster a space that is open, safe, and efficiently designed. The system we found to be the best solution was a steel framed building, using open web joists to reduce the number of visible columns in the design. This was especially important when considering the long spans over the gymnasium, which also hosted an event space on the third floor, creating loads that need to be carried down to the foundations. The floor system that was used over the gym is a non-composite acoustical metal deck that allows the rest of the spaces in the building to remain quiet even when the gymnasium is in use. Both the open web joists and the metal decking were specified from Nucor Vulcraft using their design load tables that use basic LRFD load combinations per ASCE 7-16. The open web joists are tied into wide-flange hot-rolled steel girders, that are designed to resist the bending moment and transfer the loads to the steel columns via shear connections. All girders and columns have been designed per AISC Steel Construction Manual 15th Ed. The columns were placed on shallow foundations due to the existing soil conditions in Manning. The lateral system that was used were braced frames that provide excellent stiffness and resistance to heavy wind loads.

Architectural:

For the architectural design, the goal was to convince the community that everyone in the city of Manning can enjoy themselves at the new gymnasium. Our team focused on designing and presenting a project that can be multipurpose, serving athletics, community organizations and meetings, and recreation. We did not want to present a design that stands out amongst the existing buildings, as this structure will be close to the current gymnasium and the downtown area. We accomplished this by matching the brick exterior and large windows that the existing gym offers, using terrazzo flooring to give the building a clean and modern feel, and designing the third floor to be as separate as possible from sports activities going on beneath it by installing a sound proofing system within the floor to minimize disruptions coming from the gym below. The third floor is laid out to suit a more relaxed environment by providing comfortable seating, a fully accessible kitchen, and a rooftop patio that covers more than a quarter of the top floor.

Civil:

The civil site development started with looking through Iowa SUDAS to determine constraints and requirements for the design. Finding the values for total parking spaces required due to occupancy, minimum aisle widths, and number of ADA accessible parking spaces were all a part of the initial design for the parking lots. It was determined that the size of the new structure combined with the existing Recreation Center will necessitate two parking. These were drawn and developed as the west and east Lots. Using AutoCAD Civil 3D, the parking lot geometry was drawn with more details for the curbs, islands, pavement markings, and sidewalk being determined as the site was being drawn. Working with both the structural and architectural leads, the location for the finished building and dimensions were laid out on the map. With all that information, the full site design of the parking lot and gymnasium were designed. This includes a grading plan that shows how the gymnasium and parking lot tie into existing contours.

Work Plan

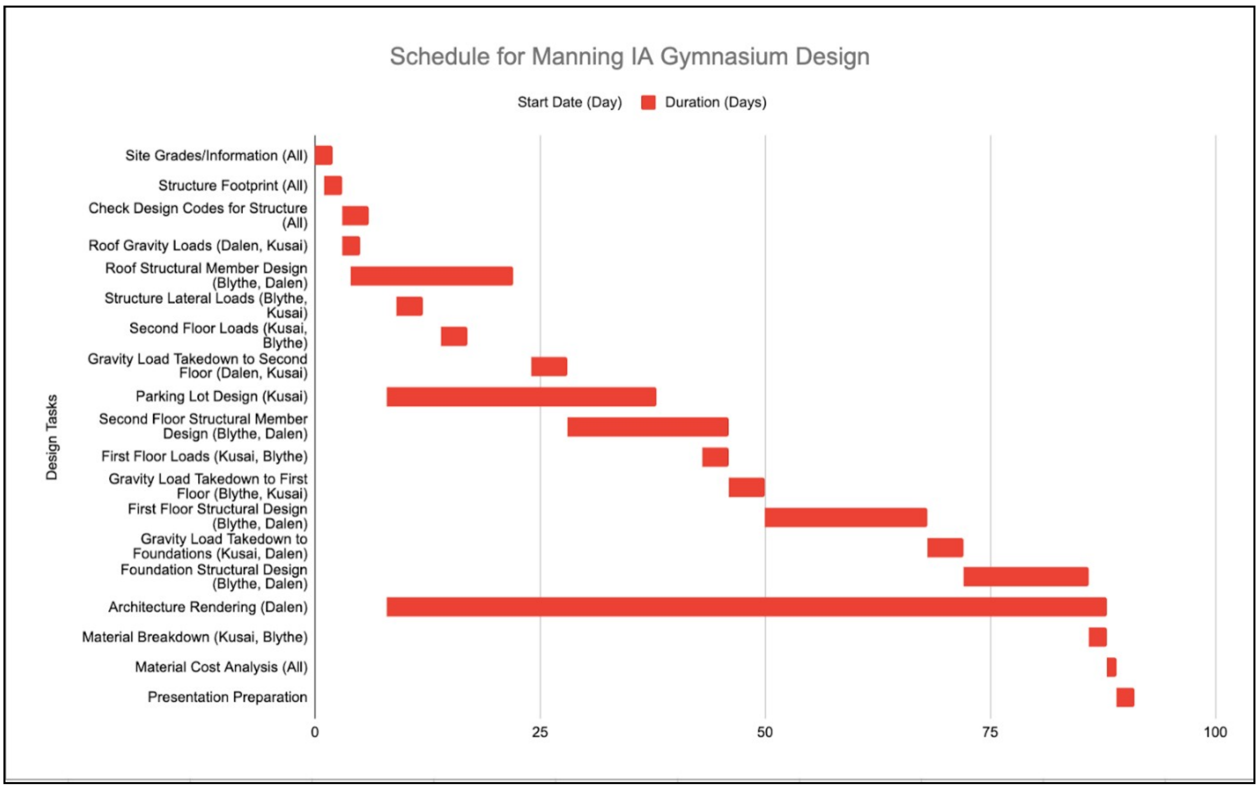


Figure 1: Design Work Plan

Section IV – Constraints, Challenges, and Impacts

Constraints

Space was the largest constraint in the design of the new gymnasium. Regardless of the design chosen by the client, the location of the gymnasium in all four alternatives had a limited space to construct the new building or attachment. The current Recreation Center is located on the south side of Highway 141. The City of Manning did not want any expansion north of the highway, because it would create an unnecessary crossing through the busy highway. In alternatives 2 and 3, the expansion of the gymnasium off the current Recreation Center would have space constraints from the distance to the road and ability to maintain highway site distance that is allowable according to Iowa SUDAS.

To the east, the lot was not deemed feasible for expansion due to the steeply sloped hill that leads to the road. There is no space to the west of the building due to the addition of Hillside Splash, an outdoor waterpark that extends to the southwest corner of the current indoor pool. These space constraints limited construction of the new gymnasium to either to the small lot to the north, or south of the current Recreation Center. All of this factored into the decision to construct the gymnasium in the location of the current Senior Center.

In addition to space constraints, there are certain accessibly issues with the current Recreation Center. There is no ADA ramp or access to the current building from the south. Making changes to the existing Recreation Center, which was built prior to the American with Disabilities Act of 1990, would require extensive work that would not fall into the project scope. Therefore, certain parts of the existing building must remain untouched by the new design to avoid demolition of the existing wall and structure of the Recreation Center.

There is also an aesthetic constraint that the team considered within the design alternatives of the gymnasium. The City of Manning has mostly brick buildings exteriors, including the current Recreation Center. The client requested that the new building match the town's aesthetic, so that must be considered within both the structural and architectural plans.

Challenges

The design team provided the City of Manning with multiple design alternatives, all with a varied scope of work. For example, two alternatives required the removal of the racquetball court within the existing Recreation Center. This is something that must be considered within the designs because it these courts are currently enjoyed by the community.

Another example revolves around alternative 1, which was chosen by the City of Manning for the design of the new gymnasium. The new gymnasium will be located at the site of the current Senior Center. The design will affect those people who utilize the Senior Center since the space is unusable for the duration of the demolition and construction process.

The Manning Recreation Center was built in 1938, consisting of numerous structural materials. The existing gym was designed with wood framing, masonry walls, and structural steel, whereas the indoor and outdoor pool used mainly precast concrete. Without the original structural plans, the design team is forced to make assumptions for the alternatives that involved attaching or making modifications to the current Recreation Center.

The terrain of the site poses a challenge. The current facility is located on a steep hill, which influences both the structural and civil design. Stormwater runoff and drainage is an important consideration within all four design alternatives. Alternative 1 places the new gymnasium at the site of the current Senior Center. This site, as well as all additional parking designed in the civil site design, must be properly graded and account of the hill to ensure proper drainage of the site. The hill also poses challenges to meeting ADA requirements.

Another challenge for the construction of the new gymnasium revolves around the operational logistics for the Recreation Center staff. The existing center has keycard access to allow members 24-hour access to the facility. The City of Manning expressed concerns about staffing both buildings to process non-members and their payments. This challenge required both the City of Manning and the design team to find a solution that allows for accurate access for members and non-members, while reducing staffing.

The City of Manning did not provide the design team with a strict budget, however this does not imply that the client has an unlimited budget. The City may opt to use government funding or raise funds from their community to finance community projects like this. The design team must be able to provide a reasonable construction cost estimate to the client for the project to be considered feasible to community.

Societal Impact within Community

The construction of the new gymnasium will greatly benefit the community of Manning. The current Recreation Center is used for its gymnasium, pool, spin room, children's mat room, and weight room and operates almost at maximum capacity week-to-week. The new gymnasium will allow the Recreation Center to expand the positive impacts the space has on the community.

The design of the new facility includes a full-sized gymnasium with painted lines to accommodate a full-sized basketball or volleyball court. This allows for the community to both host more local recreational play and open gym time, as well as providing space to play larger basketball or volleyball tournaments. In addition, the court is large enough to be split into two spaces, perfect for practices or hosting two different groups entirely. The gymnasium also has bleachers to accommodate parents, friends, and fans watching events.

On the second floor, there will be an additional viewing area of the gymnasium below. There will also be an entirely new studio room constructed. This is a multi-use space that can be used for spin classes, yoga, and as a dance studio. This provides more space and a wider variety of activities for people to participate in.

The third floor provides many benefits as well. The redesigned Senior Center is important to keep those community members active and involved. The new space provides the ability to lay it out similarly to the current old Senior Center, or to devise it into new configurations. The event rooms and patio provide the City of Manning with the ability to rent out rooms to host corporate events, birthday parties, and much more.

This new gymnasium can help the entire community become more connected, from youth to seniors. By expanding the current building, the existing Recreation Center and the new Manning Gymnasium will provide the community with so many programs, classes, and spaces that allow every citizen to access something they're passionate about.

Section V – Alternative Solutions That Were Considered

Alternative 1: New Gymnasium Replacing Senior Center and Parking Lot Extension South

Design Alternative 1 includes construction of a new 3-story gymnasium in the current location of the Senior Center. This facility would include a gymnasium on the main floor, with a large bleacher seating section as well as a lobby area with a concession stand and tables. The second floor includes the viewing area of the gymnasium, as well as a flex space that can be used for spin classes, yoga, dance studio, or other exercise classes. The third floor would include the new Senior Center, as well as event rooms and a patio. These spaces would be available for rent to host events like corporate dinners, birthday parties, or other gatherings. All the spaces would have access to a full commercial kitchen located across the hall. This design shows a parking lot extension southward, essentially doubling the size of the existing parking lot.

The pros to this alternative include its distance to the existing Recreation Center and the south parking lot extension. This proximity would create a seamless transition for both staff and community members to go from one building to the next. Additionally, this alternative will provide the most space in terms of square footage for the client, providing them with flexibility to organize their own events and storage more easily.

A challenge to this design is the fact that the Senior Center will be out of commission for an extended period—from the time of the first demolition until the completion of the entire project. The client did bring up a possible work around, discussing how the Senior Center could either be permanently or temporarily moved to the newly renovated Manning Public Library if this design is chosen.

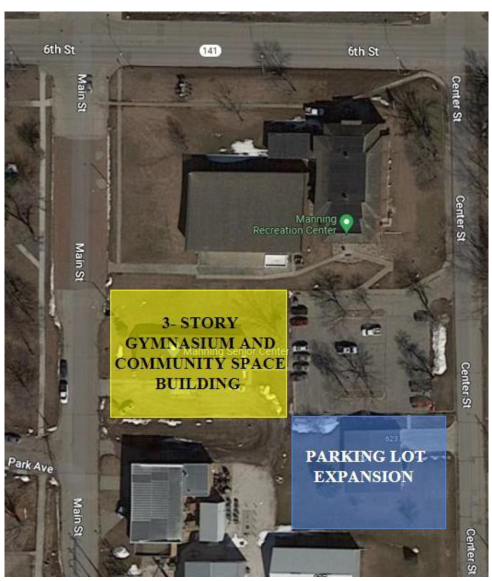


Figure 2: Design Alternative 1

Alternative 2: New Gymnasium South and Parking Lot Extension West

Alternative 2 involves construction of a new gymnasium in the location of the existing Natural Gas Facility. The client confirmed that this facility has been scheduled for relocation and this space is available for construction. The parking lot would be expanded westward to Main Street.
This parking lot extension would provide roughly one and a half times more parking. This alternative also would provide a through lane for bus pickup and drop-off, which would be beneficial during times when the gymnasium is hosting tournaments.

However, in this alternative the new gymnasium would be quite a bit smaller in square footage than described in alternative 1. This is because this lot has less total area, which is one of the major constraints of this design. However, the design team would still propose multi-use spaces on the second and third floors that can be utilized by the community for a variety of purposes.

Another challenge to alternative 2 is that it demolishes the Senior Center completely without providing a similar sized space. The new gymnasium of this design could have a Senior Center, but then it removes the amount of space available for multi-usage. However, if the City of Manning can provide adequate space in the Manning Public Library to host the seniors' programs, then this alternative is a great solution and more cost effective than alternative 1.

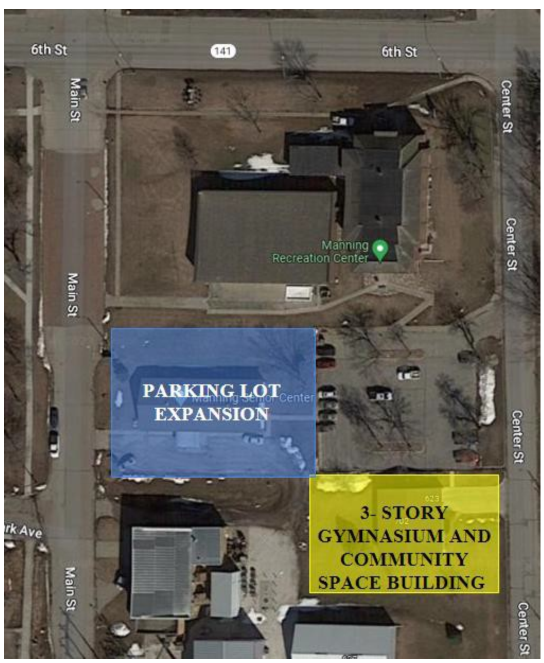


Figure 3: Design Alternative 2

Alternative 3: Gymnasium Expansion and Parking Lot Extension South

Alternative 3 is a gymnasium addition to the current gym. This design would require removal of the existing racquetball court. We propose cutting the building in half so that the top half would meet existing ground and serve as the foundation for the new gymnasium. The bottom half of the racquetball court would stay connected to the existing weight room and be used for storage. The parking lot would be extended south in the same design as described in Alternative 1.

The pro to alternative 3 is that it provides the least invasive construction project of all the alternatives. Other than the removal of the racquetball court, construction of the new court would not affect any of the other spaces of the existing Recreation Center. Also, it would provide a seamless transition between the two courts. This would be a nice project in terms of having the Recreation Center play host to tournaments, as there would be two courts in proximity and no travel between buildings would be necessary.

However, there are some challenges to this design. The ADA concerns mentioned in the Constraints section remain. Since there is no elevator in the current Recreation Center, a person in a wheelchair would need to wrap around the eastern sidewalk of the building to get to the new gymnasium. Additionally, this design doesn't provide any additional space or storage, which is one of the clients' biggest expressed needs.

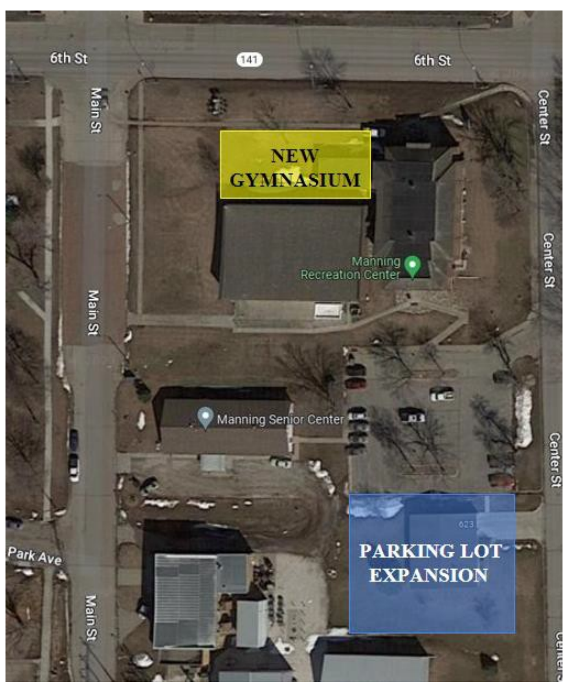


Figure 4: Design Alternative 3

Alternative 4: Gymnasium Expansion and Parking Lot Extension Across Main Street

Alternative 4 attaches the new gymnasium at the same location as described in alternative 3. However, this design relocates the parking lot across Main Street and into the current location of Manning City Park.

A benefit of this design is the ability to completely redesign the parking lot in City Park. With the parking lot across Main Street, we can design ADA compliant parking, crossings, and sidewalks to provide up-to-date feature. A new sidewalk would tie into the already existing sidewalk north of the current Recreation Center.

In addition to solving the ADA compliance issue, this design alternative does not have any implications for the existing Senior Center. Though there isn't additional space for storage, exercise classes, or other events provided, it meets the basic need of the City of Manning by constructing a new gymnasium that allows for more usage for tournaments, practices, and open-gym times.

Figure 5: Design Alternative 4

Section VI – Final Design Details

Structural Details

Design Loads:

After laying out the geometry of the building, the loads acting on the building were calculated per ASCE 7-16. The risk category of the structure was determined to be III, defined as a structure "which the failure of which could pose a substantial risk to human life." The occupancy of the building was determined to be 1272 and needs to be designed accordingly. The dead loads were determined by including all the weight of materials that will be incorporated into the building that will be acting on the structural members. This includes architectural, structural, mechanical, electrical, and plumbing loads that will remain permanently over the building's lifespan. We found the live loads for the respective spaces in our building, the snow loads that will need to be accounted for in Manning, IA, as well as the wind loads that will affect our Lateral Force Resisting System. These loads were implemented in our design by using LRFD Load combinations so the design strength equaled or exceeded the effects of the factored loads which resulted in the most critical case.

Steel System:

Structural steel was used for the framing of the building due to its constructability and its ability to span long distances for the gymnasium framing. This system was also chosen because of the windows our team desired to implement in our new facility. Concrete was also a viable option for this structure, but structural steel would be cheaper.

Open Web Steel Joists:

Due to the span of 85 FT over the gymnasium, long span open when joists needed to be used to limit deflection while simultaneously being able to carry the loads from the event space on the third floor which has a live load of 100 PSF and a dead load of 63 PSF. For consistency in our system, open web joists from Nucor Vulcraft were used for the rest of the joists framing the building. Nucor Vulcraft has LRFD factored load tables that were used to design for strength and serviceability of all the joists in the building.

Wide Flange Steel Girders:

Standard steel ASTM A992 Grade 50 wide-flange hot-rolled shapes were used for the girders that supported the floor and roof open web joists. These were used due to their ability to resist bending moment and their ability to tie into W-shape columns using shear connections. AISC Steel

Construction Manual (15^{th} ed.) was used to design each member, checking its flexural and shear strength as well as its deflection against limits presented in the International Building Code (IBC).

Columns:

The girders transferred the gravity loads into steel columns that brought the load down to the foundation of the structure. Standard steel ASTM A992 Grade 50 W-shapes were also used for our columns which were sized according to AISC (15^{th} ed.). For compression strength using Design Table 4-1a: Available Strength in Axial Compression which already takes buckling into account.

Noncomposite Metal Decking:

Nucor Vulcraft's Noncomposite metal decks with a 3-1/4" concrete slab on top were designed for the second and first flooring system with a 2-hour fire rating per the International Building Code. The metal decking over the gymnasium was specified to be an acoustical cellular deck to help with the sound control from the gym to the floors above. All other floors have the same non-composite decking, but without the acoustical panel and the same concrete slab on top. These metal decks were analyzed as continuous beams with supports at each of the framing elements underneath. The moment was determined from analysis on Robot Structural Analysis Professional 2023 and compared with the capacity of the decking provided by Vulcraft.

Roof System:

The roofing system was designed to be a typical steel building roof with a metal deck, a waterproofing membrane, fiberboard insulation, and felt and gravel which say on top of our roof joists and carried a dead load of 13 PSF and a roof live load of 20 PSF.

Foundations:

According to the Iowa DNR, the soil type at the site is a silty clay, thus the allowable bearing pressure was 1500 PSF for strength and settlement limit states. For this soil, shallow foundations were used to carry the loads from the columns down to the ground. The columns were placed on bearing plates that were on top of concrete pedestals that were connected to the footing. There also is a foundation wall around the exterior of the building that extends 3'-6" below the bottom of the slab on grade which is below the frost line. This will allow the structure to not undergo frost heaving during the changing seasons. All of the foundations will be normal weight concrete that will have rebar tying the pedestal to the footing. These have been designed per the American Concrete Institute.

Lateral System:

The lateral system of the building consists of braced frames and shear walls. The stairwells and elevator shafts act as the shear walls on the northwest and northeast corners of the building and a braced frame were placed on the south face of the building and bracing was placed in the center of the building spanning east-west to prevent twist. The lateral system is placed in both directions to account for wind acting on the building that was calculated using ASCE 7-16. The braced frames and shear walls prevent drift of the building by providing stiffness. The benefit of using braced frames is that they act like a truss and can be configured in many ways. The braces provide shear stiffness through the axial stresses that are developed, and the columns provide flexural stiffness. Shear walls were used as a part of the lateral system because they are necessary components to our architectural layout and requirements per the IBC and their consideration of fireproofing the means of egress. The concrete masonry unit stairwells and elevator shafts are placed on the corners of the building providing lateral resistance in both planes which decreases the number of braced frames needing to be included.

Shear Connections:

The connections from the steel ASTM A992 Grade 50 wide-flange hot-rolled girders to columns were designed to act as a shear connection, not transferring moment. They were typical shear tab connections using A36 steel plates and F3125 Grade A325 bolts to connect the plate to the web of the girder. Those plates were then connected to the column flange using fillet welds on both sides of the plates. These were all designed against failure of the bolt, plate, web of the girder, and weld per AISC design specifications.

Architecture Details

Building Lot Regulations:

Using the Manning City Zoning Ordinances, our building falls into the 4 RM District and we had to abide by these regulations for the light and air quality within the community. This means the side distances from adjacent buildings is six feet, and front and rear regulations were twenty feet. Our maximum building layout turned out to be 146' x 120', but we allotted to decrease these to account for the inconsistent measurements from Google Earth's measurement tool and ended with a final building footprint of 140' x 115'.

Occupancy of Building:

Working from our floor plan, we used the International Building Code (IBC) to determine our occupancy based on square footage of the building and what activities we anticipate would be taking place at one time. Our building's gymnasium is classified as an A-4 (Indoor Sporting Events, IBC 303.5) and the second and third floor gathering area is an A-2 assemble area (IBC 303.3). According to table 1004.5 in the IBC, the values for different room types were used to determine our total occupancy of 1,272. This comes from 880 on the first floor, 120 on the second, and 272 on the third floor. With these values, we determined the number of exits from the building (table 1006.3.3), the capacity of the elevator (KONE Monospace 500), vestibule space (1105.1.1), ADA compliant entrances, hallway and stair egress widths (1005.3.2, 1005.3.1), the number of restrooms needed (2902.1), and the total number of parking spaces.

Means of Egress:

For the means of egress, the multiplier values come from the IBC manual within the sections listed above in 'Occupancy of the Building.' The stair egress widths were calculated by the occupancy per floor level multiplied by 0.3 inches. This provides 0.3 inches per occupant. Also, it is important to note that with more than one exit, the egress width is permitted to be reduced to withhold no less than 50 percent of the required occupancy of each floor. This was utilized for all stair widths, as each stairwell dimension is not large enough to support 100 percent of the occupancy. Using table 1006.3.3, the minimum number of exits for a building with more than 1,000 occupants is four. We opted to place these strategically around the building with one on the east and west side and two in the gymnasium, as this has the most capacity of any of the rooms on the first floor. The elevators come from KONE Elevators and Escalators; we selected a 3000lb capacity elevator with interior dimensions of 7' 6" x 7' 11". This allows emergency personnel to fit a full-size gurney within the elevator.

Building Layout Design:

To adhere to the City of Manning code for the building's footprint , we had to adhere to a 6 ft side and 20 ft back and front offsets from the adjacent buildings. Once we had the 140' x 115' building dimensions, laying out everything that we wanted to include within this relatively small area was challenging, as we also had to abide by the International Building Code (IBC) and fire code. After many iterations and client input, we arrived at the final layout you see now. Our goal was to be able to include an exercise room in which to hold classes such as biking, yoga, and HIIT workouts, as the room currently used was converted from an office and is quite small. We also sought to include a senior center within our design. While our plan provides a room that is slightly smaller from their current space, they gain a commercial kitchen. Finally, we wanted to include a community room that can be rented for any kind of gathering. With the option of a partition wall, this space can be split into two smaller sections, or stay as one large open room with a total area of 4,900 SF. We set a limit of 200 people allowed in this space, as it is directly above the gymnasium and the joists are designed only for this amount of people.

Architectural Design Choices for Viewing Capacity:

We wanted to create an illusion of a larger space. We accomplished this by incorporating glass curtain walls within the building to open up as much space as possible. The vestibule in the front of the building is composed of glass curtain walls, as well as an aesthetic look to the exterior of the entrance. This vestibule would block the view of the gym from the northern side of the first floor, as well as the view of the front of the building from the hallway on the first floor if it were any other material. We thought the best way to fix this and accomplish our goal of an open concept gym would be to design the vestibule as glass. This same ideology is true for the implication of the curtain wall on the east side of the gymnasium. This opens up the lobby and provides more natural light to the gym space while also increasing viewing capacity for fans. We removed the north wall of the gym on the second floor to continue the open concept goals within the second floor and help with viewing capacity. In total, these details bring the viewing capacity of the gymnasium court to an estimated 400 people. By abiding by codes of egress per the International Building Code (IBC), we accomplish our goals while keeping those who will utilize this space safe.

Architectural Design Choices for Material Selection:

After discussing project goals with our client, we understood that they are in need of a new gymnasium and more space for their active community. The best way to accomplish this would be to create a new gymnasium close to their existing recreation center, which is the alternative our client chose. With this alternative comes the issue of how to design a building that will include new engineering ideas but will also not stand out to its adjacent buildings. We accomplished this by matching the brick facade on the exterior of the building while also including natural light within the structure through large windows and glass curtain walls. We feel that this design will complement the existing recreation center and to not draw attention away from it. The interior of the new gymnasium includes modern aesthetic choices such as terracotta flooring, oak wood flooring, and vinal flooring within the exercise room. These modern material selections bring those who utilize the space the pleasure of feeling of being in a new building, and also blending in this new structure into the existing landscape.

Civil Details

Parking Capacity Requirements:

Because of the high occupancy of the new gymnasium, both an extension of the existing parking lot and the creation of a new parking lot across Main Street will be required. These parking lots are named East Parking Lot and West Parking Lot respectively. The total required parking spaces are based on the square footage of the building, which was calculated to be around 40,000 square feet. Using Table 8C-1.01 Parking Ratios in Iowa SUDAS, the design team classified the new gymnasium Land Use as Office and Business Services between 25,000 to 100,00 square feet. Following the prompted Spaces per Unit, it was calculated that the minimum total required parking spaces was 136 spaces. The parking lot design devised by our team provides a total of 79 spaces in the West Lot and 64 spaces in the East Lot, which total 143 spaces created. In addition to those, there are 20 on-street parking spaces located on Main Street. The total parking capacity of the new gymnasium is 163 spaces, well above the minimum specified in Iowa SUDAS.

Minimum Parking Dimensions:

We designed both the East Lot and West Lot with a two-way aisle, providing two lanes of traffic throughout the entirety of both lots. The purpose of this was to keep traffic flowing and minimize the number of backups and delays during high occupancy events hosted by the Manning Recreation Center. Using Table 8B-1.02: Minimum Parking Dimensions, it was determined that the aisle width needed to be a minimum of 24 feet. Both the West and East Lots meet that minimum of 24 feet aisle width, as well as some locations providing extra space with up to 30 feet aisle width to make the parking lot more efficient.

ADA Requirements

From Iowa SUDAS Table 8C-1.02 Minimum Accessible Parking Ratio, the design team was able to determine the number of ADA compliant parking spaces required for the design of the East Lot and West Lot. According to the table, the West Lot, with a capacity of 71 parking spaces, requires 3 accessible spaces at a minimum. For the East lot with a capacity of 58 spaces, the minimum would also be 3 accessible spaces. We considered these minimums, as well as the demographics of the City of Manning and the usage of the new gymnasium space for the Senior Center. After discussion, the final parking lot design provided 8 total ADA compliant parking spaces in the West Lot, and 6 in the East Lot. All handicap parking areas have accessibility for at least one van parking, as well as multiple accessible vehicles parking spaces as well.

Utility Plan

It was important to make sure the new building and parking lots had adequate power to successfully run everything that is needed. We decided that drawing electricity from the power station directly south of the site was the best way to go because this would place junction boxes in both the east and west lot. These boxes would be connected to the new gymnasium via underground wiring. Then wiring would connect the junction boxes to light poles within each lot. Because of the number of children and elderly people that could be present on the site, having adequate lighting is important to make sure everyone is safe.

Section VII – Engineer's Cost Estimate
Structural Construction Cost Estimate

Line Item:		Quantity	Unit	Unit Cost	Cost	Subtotal:
Structural Steel:						
	W and C -Shapes and HSS Members	48.53	TONS	$5,000.00	$ 242,650.00	
	Vulcraft Joists	FROM VULCRAFT QUOTE			$ 475,135.00	
	Vulcraft Metal Decking	FROM VULCRAFT QUOTE			$ 198,265.00	
						$ 916,050.00
Concrete:						
	Floor Slabs	463.3781	CY	$ 130.00	$ 60,239.15	
	Foundations	79.18	CY	$ 130.00	$ 10,293.40	
	Rebar	15%			$ 10,579.88	
						$ 81,112.43
Masonry						
	8" 50% Solid CMU	5358	SF	$ 27.00	$ 144,666.00	
						$ 144,666.00
					Total Cost:	**$ 1,141,828.43**

Table 1: Structural Construction Cost Estimate

The structural materials that were used in this were structural steel for the framing of the building including W-Shapes for girders and structural columns, C-Shapes for the staircase stringers, HSS members for braced frames, open web joists, and metal decking. The price of steel per ton was determined to be $5000 dollars based on current market prices for materials, installation, and inflation. A quote was provided to us from the specified manufacturer of our open web joists and metal decking, Nucor Vulcraft. With our quantities and product type, they were able to determine a total cost of $673,400.00 for the product package. Concrete was used for the floor slabs and foundations of the building, and a unit cost was determined to be $130/CY including the formwork and installation. This did not include the rebar that would be used, and we estimated a 15% increase in price to account for the steel reinforcement. Lastly, masonry was used for our stairwells and the elevator shaft in the building. We used an 8" CMU block that was 50% solid and had a unit price of $27.00/SF for the material and installation from *Gordian, Square Foor Costs with RSMeans Data, 2019.* This resulted in a final structural cost of $1,142,000.00.

Architectural Construction Cost Estimate

Line Item		Quanity	Units	Unit Cost	Cost	Subtotal
Sporting Equitment						
	Basketball Goal Assembly	6	Per.	$ 17,500.00	$ 105,000.00	
	Bleachers	Bussey Seating		$ 78,300.00	$ 78,300.00	
						$ 183,300.00
Walls and Flooring						
	Basketball Court Flooring	9162	SF.	$ 4.50	$ 41,229.00	
	Court Instilation	9162	SF.	$ 6.00	$ 54,972.00	
	Court Painting	1	Per.	$ 75.00	$ 75.00	
	Exercise Room Flooring	2149	SF.	$ 0.72	$ 1,547.28	
	Commercial Gym Exterior Walls	514	LF.	$ 79.95	$ 41,094.30	
	Windows	55	Per.	$ 619.00	$ 34,045.00	
	Interior Partion Walls	12528	SF.	$ 5.06	$ 63,391.68	
	Glass Curtain Walls	Solar Innovations		$131,566.00	$ 131,566.00	
	3rd Floor Carpet+Instilation	7607	SF.	$ 5.22	$ 39,708.54	
	3rd Floor Terrazzo	1129	SF.	$ 25.00	$ 28,225.00	
	2nd Floor Terrazzo	3650.14	SF.	$ 25.00	$ 91,253.50	
	1st Floor Terrazzo	6325	SF.	$ 25.00	$ 158,125.00	
	Terrazzo Instilation	9975.14	SF.	$ 6.05	$ 60,349.60	
	Full Length Mirror (6'x8')	14	Per.	$ 450.00	$ 6,300.00	
	Stairs	4.36	24 Stairs	$ 21,975.00	$ 95,811.00	
	Gymnasium Lighting Fixtures	24	Per	$ 250.00	$ 6,000.00	
	Other Lighting Fixtures	52	Per	$ 100.00	$ 5,200.00	
	Exterior Wall Assembly	20958	Per Sf.	$ 12.00	$ 251,496.00	
						$ 1,110,388.90
Restrooms						
	Toilets	28	Per.	$ 490.00	$ 13,720.00	
	Hand Dryers	24	Per.	$ 470.00	$ 11,280.00	
	Water Fountian	10	Per.	$ 1,612.00	$ 16,120.00	
	Sinks	24	Per.	$ 270.00	$ 6,480.00	
	Stalls	61	Per. Piece	$ 275.00	$ 16,775.00	
						$ 64,375.00
Kitchens						
	Counters and Cabinets	2	Per.	$ 270.00	$ 540.00	
						$ 540.00
Misulaneous						
	Kone Elevator	1	Per.	$ 70,500.00	$ 70,500.00	
	Kone Elevator Instilation	1	Per.	$ 31,833.00	$ 31,833.00	
	Steel Doors	46	Per.	$ 2,800.00	$ 128,800.00	
	Glass Doors	4	Per.	$ 4,800.00	$ 19,200.00	
	Stair Railing	3	Per. 40 FT.	$ 3,400.00	$ 10,200.00	
	Wall Railing	63	Per. 2 FT.	$ 40.00	$ 2,520.00	
	Enterance, Awning, and Lettering	1	Per.	$ 52,400.00	$ 52,400.00	
						$ 315,453.00
					Total Cost:	**$ 1,674,056.90**
	MEP	39900	Per. SF.	$ 55.00	$ 2,194,500.00	
					Total Cost:	**$ 2,194,500.00**

Table 2: Architectural Construction Cost Estimate

The materials used in the architectural design are included in the figure above, where prices were found using general contractors around the area, specific companies whereas their products are being used within the design, and *Gordian, Square Foor Costs with RSMeans Data, 2019.* Hussy Seating is where our bleachers are coming from, and the price obtained for these came directly from a representative of them, where the dimensions and location of these were taken into consideration. The flooring for the gymnasium will be installed by My Backyard Sports, and the price of the flooring materials and installation came from their website. For the terrazzo flooring, all materials and installation will be from Terrazzo.com. The general items such as toilets, urinals, sinks, mirrors, etc, will be coming from commercial stores such as Lowes and Home Depot. Steel Doors are from Securall, and glass doors will be from Comanche-Door USA. Installation costs for these come from general contractor installation prices.

Civil Construction Cost Estimate

West Lot		Quantity	Unit	Unit Cost	Cost	Subtotal:
Soil:						
	4" Graded Base Course	700	TON	$29.75	$20,825.00	
	12" Prepared Subgrade	2100	TON	$29.75	$62,475.00	
	Cut	TBD	SF			
	Fill	TBD	SF			
						$ 83,300.00
Concrete:						
	Concrete Removal	0	SY	$10	$ -	
	6" PCC Curb	1357	LF	$40.00	$ 54,280.00	
	4" PCC Sidewalk Pavement	2681	SF	$6.50	$ 17,426.50	
						$ 71,706.50
Asphalt						
	3" HMA Pavement Base Course	510	TON	$250.00	$ 127,500.00	
	2" HMA Pavement Surface Course	338	TON	$200.00	$ 67,600.00	
						$ 195,100.00
Pavement Marking						
	4" Yellow Pavement Marking	1368	LF	$2.00	$ 2,736.00	
						$ 2,736.00
				West Total Cost:		**$ 352,842.50**
East Lot		Quantity	Unit	Unit Cost	Cost	Subtotal:
Soil:						
	4" Graded Base Course	717	TON	$29.75	$21,330.75	
	12" Prepared Subgrade	2152	TON	$29.75	$64,022.00	
	Cut	TBD	SF			
	Fill	TBD	SF			
						$ 85,352.75
Concrete:						
	Concrete Removal	16115	SY	$10	$ 161,150.00	
	6" PCC Curb	1303	LF	$40.00	$ 52,120.00	
	4" PCC Sidewalk Pavement	5747	SF	$6.50	$ 37,355.50	
						$ 250,625.50
Asphalt						
	3" HMA Pavement Base Course	520	TON	$250.00	$ 130,000.00	
	2" HMA Pavement Surface Course	345	TON	$200.00	$ 69,000.00	
						$ 199,000.00
Pavement Marking						
	4" Yellow Pavement Marking	1216	LF	$2.00	$ 2,432.00	
						$ 2,432.00
				East Total Cost:		**$ 537,410.25**
				Total Cost:		$ 890,252.75

Figure 3: Civil Construction Cost Estimate

The cost estimate for the civil construction and design of the site is shown above. For materials such as 4” Graded Base Course and 12” Prepared Subgrade, the square footage was used with an estimate of the density of the material to convert the quantity into the unit of tons. This same process was followed for the 2” HMA Pavement Base Course and 2” HMA Pavement Surface Course.

The cost per unit price of the materials were primarily determined by looking through Iowa Department of Transportation (IDOT) Bid Tabulations. This database has previous contracts and bids for a variety of projects and was helpful to compare those unit prices as estimates for this design. The total civil design and construction cost is estimated at roughly $890,000. The estimate was broken down into both West Lot and East Lot, as shown in detail in the cost estimate above. The East Lot costs a substantial amount more, due to the cost of concrete removal as shown.

Appendices

For all mathematical solutions and procedures, refer to the attached calculation report.

For all references to the structural, architectural, or civil sheets, refer to the attached sheets.

Design Drawings

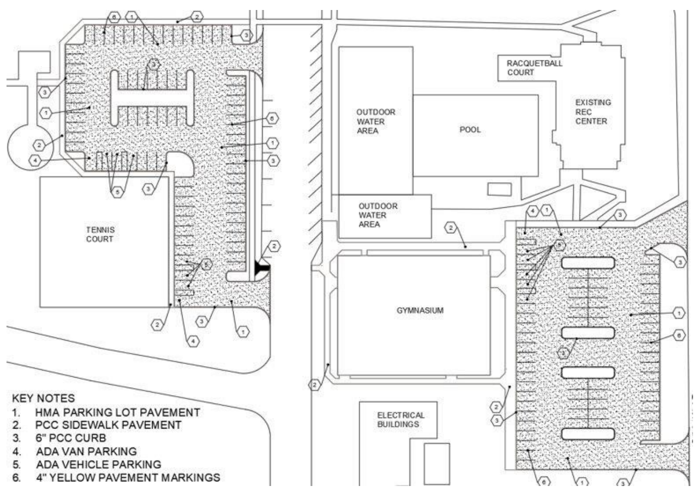


Figure A: Full Site Plan

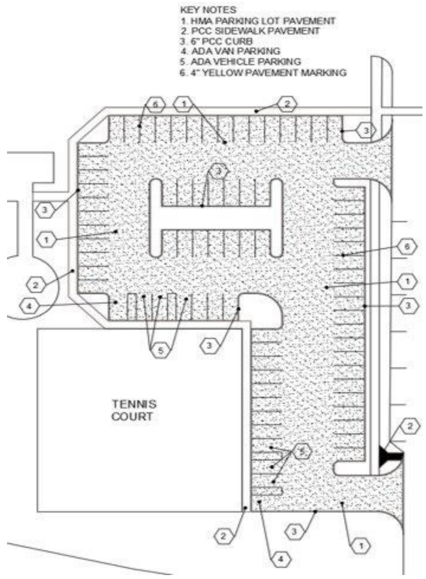


Figure B: West Lot Design

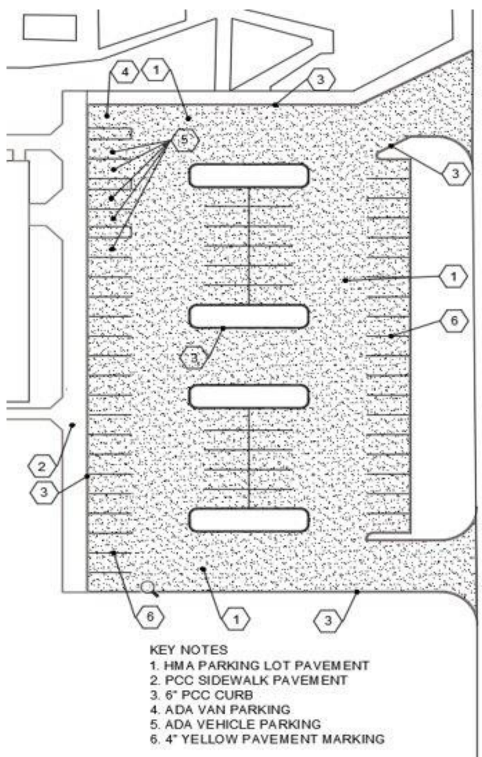


Figure C: East Lost Design

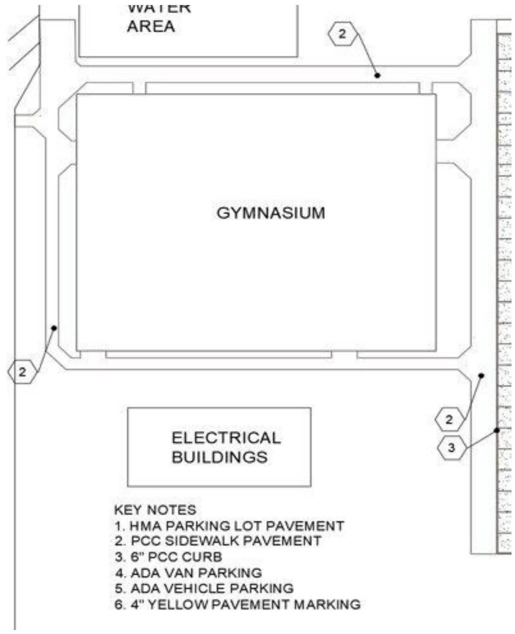


Figure D: Gymnasium Sidewalk Design

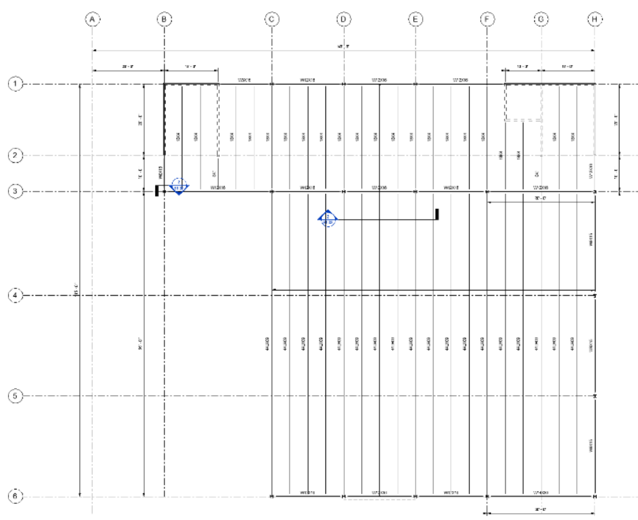


Figure E: Structural Roof Framing Plan

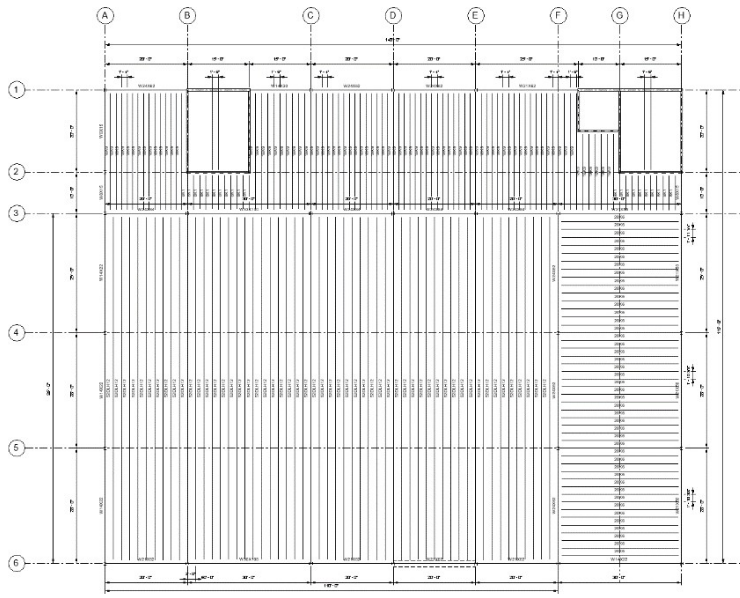


Figure F: Second Floor Roof Framing Plan

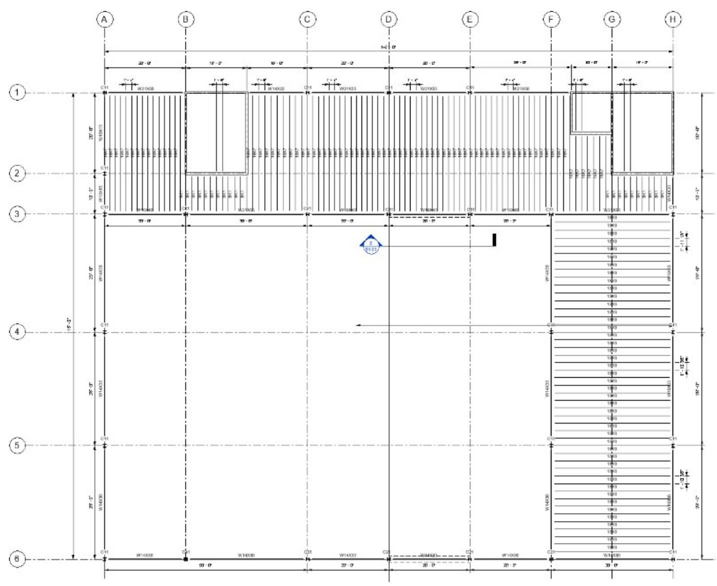


Figure G: First Floor Framing Plan

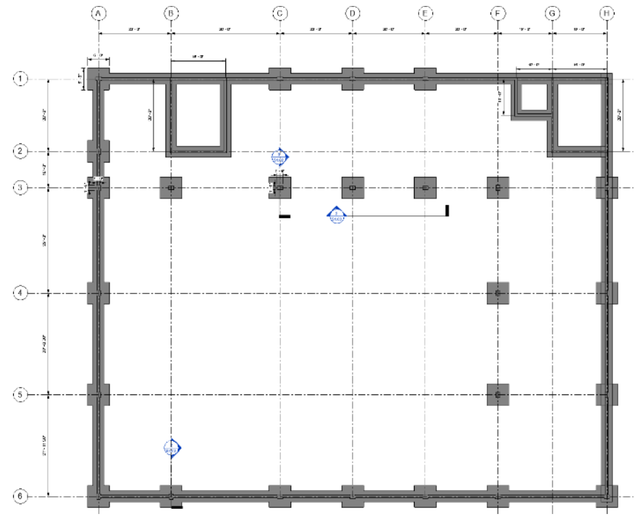


Figure H: Foundation Plan

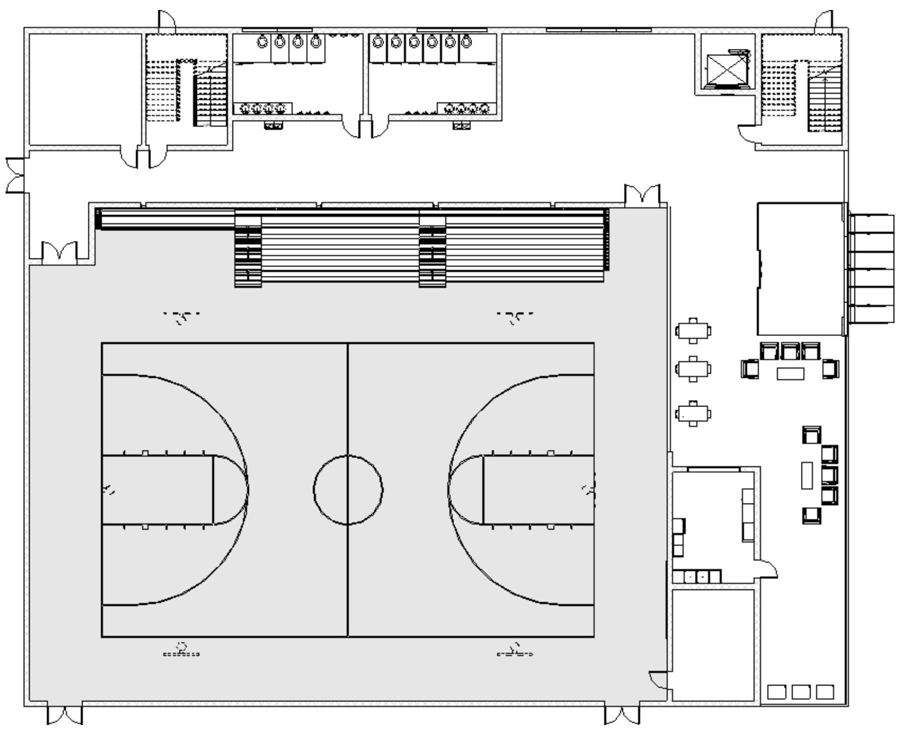


Figure I: First Floor Layout

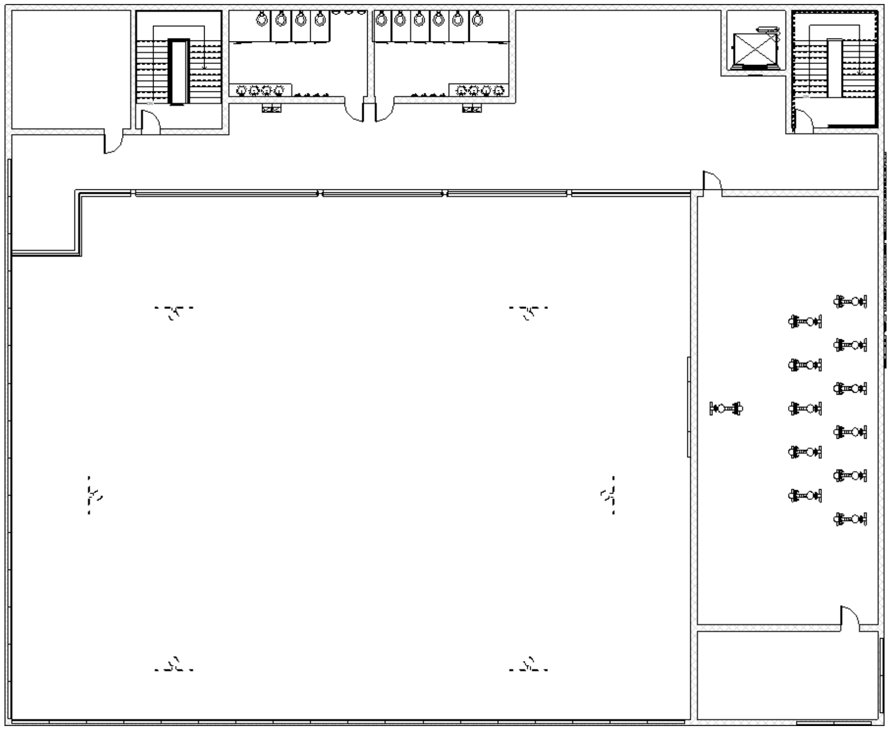


Figure J: Second Floor Layout

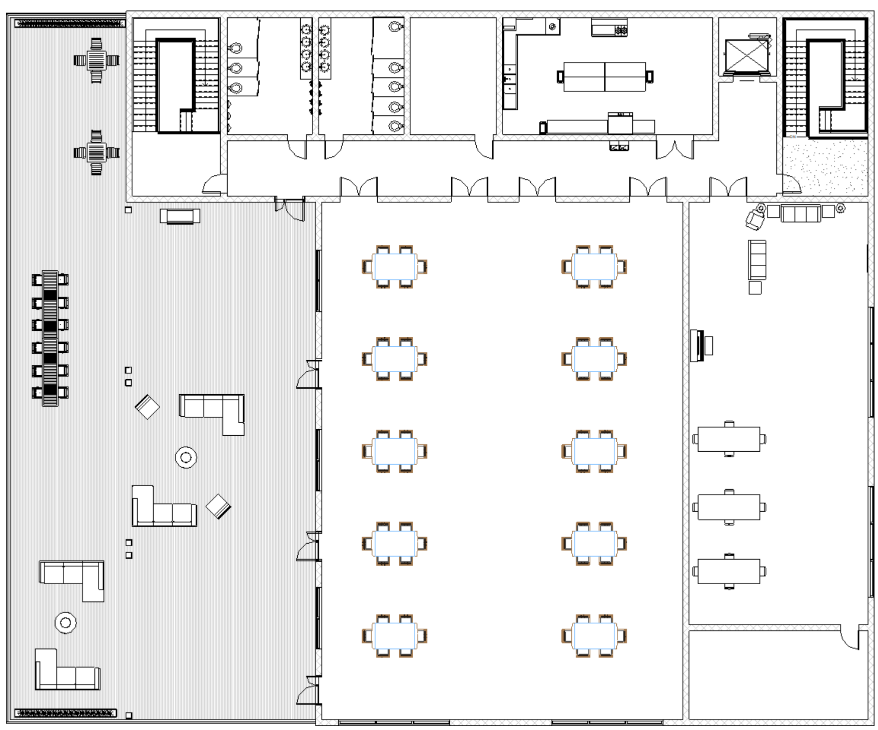


Figure K: Third Floor Layout

Design Renderings and Models

Figure L: Rendering of Gymnasium Floor

Figure M: Rendering of Patio

Figure N: Rendering of Gym from Second Floor

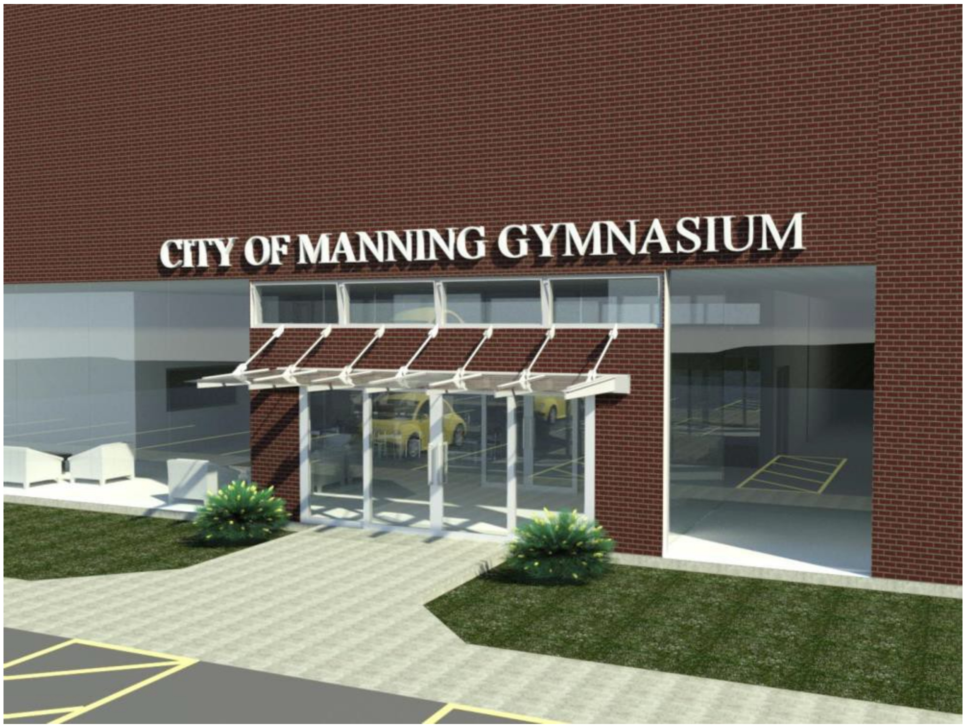


Figure O: Rendering of Gymnasium Entrance

Figure P: Rendering of Gym from Second Floor

Figure Q: Rendering of Lobby

MANNING GYMNASIUM: DESIGN LOAD CALCULATION REPORT

SENIOR DESIGN

Performed for:
Cit of Manning

Performed by:
Blythe Rients

ROOF DEAD LOADS:

UPPER ROOF:

- FOUR-PLY FELT AND GRAVEL: **6 PSF**
- INSULATION- FIBERBOARD INSULATION: **1.5 PSF**
- WATERPROOFING MEMBRANE' LIQUID APPLIED: **3 PSF**
- METAL DECK: DECK METAL 3 N Vulcraft N22: **2.26 PSF**

TOTAL UPPER ROOF DEAD LOAD:
(PROJECTED ONTO HORIZONTAL PLANE): **13 PSF**

$D := 13\ psf$

LOWER ROOF:

$TW_{openjoists} := 10\ ft$

$w_{DSI} := D \cdot TW_{openjoists} = ?\ plf$

- OPEN WEB JOISTS: **XXX PSF**
- MECHANICAL, ELECTRICAL PLUMBING
  - LIGHTING: **1 PSF**
  - MECHANICAL: **4 PSF**
  - PLUMBING: **1 PSF**
- ACOUSTICAL FIBERBOARD: **1 PSF**

TOTAL LOWER ROOF DEAD LOAD: XXX PSF

TOTAL ROOF DEAD LOAD: 20 PSF

THIRD FLOOR DEAD LOADS:

-FLOOR FINISH: VARIES WITH ROOM

-BATHROOMS AND KITCHEN: 3/8" CERAMIC TILE: **4.7 PSF**

3/8" MORTAR BED: **4.5 PSF**

-EVENT ROOM SPACE:

CARPETING: **3 PSF**

WATERPROOF MEMBRANE: **3 PSF**

-SUBFLOOR: 4" CONCRETE: **38.333 PSF**

average between 4 3/4 and 3 1/4 therefore 4"

-METAL DECK: Vulcraft 1.5VLP 20/20 Acoustical: **3.8 PSF**

-MECHANICAL, ELECTRICAL PLUMBING

LIGHTING: **1 PSF**

MECHANICAL: **4 PSF**

PLUMBING: **1 PSF**

-PARTITIONS: **5 PSF**

TOTAL THIRD FLOOR DEAD LOAD IN BATHROOM AND KITCHEN: 60.2 PSF

TOTAL THIRD FLOOR DEAD LOAD ALL OTHER FLOORS: 57 PSF

Metal Deck:

Total Dead Load on Third Floor: 62 PSF

Construction Live Load: 20 PSF

Wet Concrete: 42.2 PSF

$$D := 4.7 + 4.5 + 42.2 + 3.8 + 1 + 4 + 1 + 5$$

$$\cdot psf = 66.2\ psf$$

TOTAL DEAD LOAD: 66 PSF

Superimposed Design Load, ϕW_n, / Deflection at L/360 (psf) LWC (110 pcf), f'_c = 3000 psi

Total Slab Depth	Deck Gage	Span (ft-in.) 4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	12'-0"
3½"	22	1262/1410	797/722	544/417	392/263	293/176	225/123	176/90	113/52
	20	1480/1528	939/782	643/452	464/285	348/191	268/134	212/97	138/56
	19	1480/1634	1071/837	734/484	531/305	399/204	309/143	244/104	160/60
	18	1479/1723	1177/882	814/510	589/321	444/215	344/151	273/110	180/63
	16	1479/1904	1176/975	975/564	712/355	538/238	418/167	332/121	221/70
4"	22	1556/2088	983/1069	671/618	484/389	362/261	279/183	219/133	141/77
	20	1772/2260	1163/1157	796/669	576/421	432/282	334/198	264/144	172/83
	19	1772/2415	1330/1236	913/715	661/450	497/301	385/212	305/154	201/89
	18	1772/2546	1410/1303	1015/754	736/475	555/318	431/223	342/162	226/94
	16	1771/2811	1409/1439	1168/833	894/524	676/351	526/246	419/179	279/104
4¾"	22	2072/3463	1310/1773	896/1026	647/646	485/432	374/304	294/221	191/128
	20	2249/3745	1556/1917	1067/1109	772/698	581/468	450/328	356/239	233/138
	19	2249/3997	1785/2046	1226/1184	889/745	670/499	520/350	413/255	273/148
	18	2249/4213	1790/2157	1367/1248	993/786	749/526	583/369	463/269	308/156
	16	2248/4649	1789/2380	1483/1377	1213/867	918/581	715/408	571/297	382/172

Notes:
1. For high loads long term concrete creep should be considered.
2. Use Composite Deck-Slab Strength Web Based Solutions for alternate slabs or ASD design.

Section Properties

Deck Gage	Deck Weight w_{dd} (psf)	Base Metal Thickness t (in.)	Yield Strength F_y (ksi)	Effective Moment of Inertia at Service Load $I_d = (2I_e+I_g)/3$ I_d+ (in⁴/ft)	I_d- (in⁴/ft)	Effective Section Modulus at F_y = 50 ksi S_e+ (in³/ft)	S_e- (in³/ft)	Design Moment ϕM_n+ (lb-ft/ft)	ϕM_n- (lb-ft/ft)	Ve V S (l
22	1.6	0.0295	50	0.155	0.178	0.169	0.179	634	671	4
20	2.0	0.0358	50	0.197	0.217	0.224	0.229	840	859	4
19	2.3	0.0418	50	0.239	0.257	0.266	0.278	997	1042	5
18	2.6	0.0474	50	0.277	0.290	0.306	0.318	1148	1193	6
16	3.3	0.0598	50	0.364	0.367	0.393	0.402	1474	1508	7

SECOND FLOOR DEAD LOADS:

-FLOOR FINISH: VARIES WITH ROOM

-BATHROOMS: 3/8" CERAMIC TILE: **4.7 PSF**

3/8" MORTAR BED: **4.5 PSF**

-YOGA/SPIN STUDIO: HARD WOOD 7/8": **4 PSF**

-VIEWING AREA COORIDOR: TERRAZZO 1-1/2" (Directly on slab): **19 PSF**

-SUBFLOOR: 4" CONCRETE: **38.3 PSF (dry)**

-WET CONCRETE: **42.2 PSF**

-METAL DECK: DECK METAL 20 GUAGE: **2.5 PSF**

-MECHANICAL, ELECTRICAL PLUMBING

LIGHTING: **1 PSF**

MECHANICAL: **4 PSF**

PLUMBING: **1 PSF**

TOTAL SECOND FLOOR DEAD LOAD IN BATHROOM: 55.2 PSF

TOTAL SECOND FLOOR DEAD LOAD IN WORKOUT ROOM: 50 PSF

TOTAL SECOND FLOOR DEAD LOAD WITH WET CONCRETE: 70 PSF

LIVE LOADS:

ROOF LIVE LOAD: UPPER ROOF LIVE LOAD: 20 PSF ORDINARY FLAT ROOFS

FLOOR LIVE LOAD: 40 PSF

STOREAGE ROOMS 20 PSF
RESTROOMS: 60 PSF
ASSEMBLY AREAS: 100 PSF
BALCONIES AND DECKS: 100 PSF
KITCHEN: 150 PSF

BALANCED SNOW LOAD:

-RISK CATEGORY III: $I_s := 1.10$

-GROUD SNOW LOAD:
MANNING, IA

$P_g := 25 \ \frac{lbf}{ft^2}$

-ROOF SNOW LOAD FACTORS:

Exposure Factor:

$C_e := 0.9$

Thermal Factor:

$C_t := 1.0$

BALANCED SNOW LOAD: 17.325 PSF

$P_f := 0.7 \cdot C_e \cdot C_t \cdot I_s \cdot P_g = \left(\left(1 \cdot 10^3\right)\right) \ psf$

Table 7.3-2 Thermal Factor, C_t

Thermal Condition[a]	C_t
All structures except as indicated below	1.0
Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds 25°F × h × ft²/Btu (4.4 K × m²/W)	1.1
Unheated and open air structures	1.2
Freezer building	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than 2.0°F × h × ft²/Btu (0.4 K × m²/W)	0.85

Table 7.3-1 Exposure

Surface Roughness Category	F Exp
B (see Section 26.7)	(
C (see Section 26.7)	(
D (see Section 26.7)	(
Above the tree line in windswept mountainous areas	(
In Alaska, in areas where trees do not exist within a 2-mi (3-km) radius of the site	(

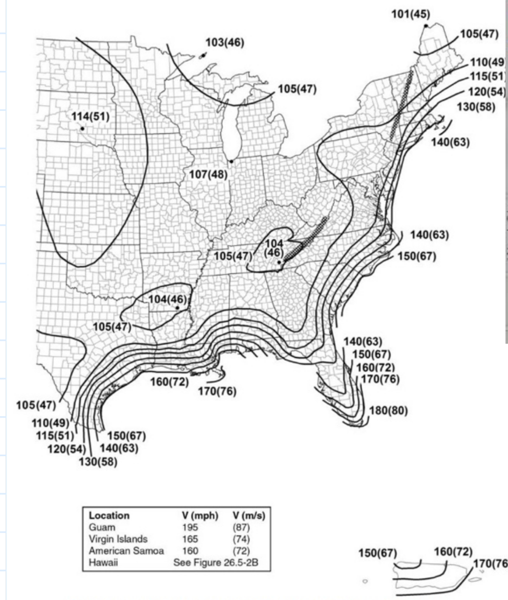
Blythe Rients
Dr. Christopher Stoakes
Senior Design Project: East Wind Loads
Due: April 7th, 2023

Building Classification: ASCE 1.5-1 and Risk Category III

Wind Load Parameters:

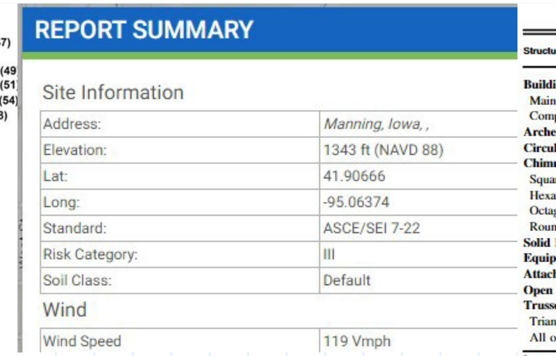
Wind Speed: ASCE 7-16: Fig. 26.5-1B

$V := 119\ mph$



Location	V (mph)	V (m/s)
Guam	195	(87)
Virgin Islands	165	(74)
American Samoa	160	(72)
Hawaii	See Figure 26.5-2B	

FIGURE 26.5-1B (*Continued*). Basic Wind Speeds for Risk Category II Buildings and Other Structures



REPORT SUMMARY

Site Information

Address:	*Manning, Iowa, ,*
Elevation:	1343 ft (NAVD 88)
Lat:	41.90666
Long:	-95.06374
Standard:	ASCE/SEI 7-22
Risk Category:	III
Soil Class:	Default

Wind

Wind Speed	119 Vmph

Topography factor: ASCE 7-16: Section 26.8

$K_{zt} := 1.0$

Directionality factor: ASCE 7-16: Table 26.6-1

$K_d := 0.85$

Building located in suburban area, according to Sec. 26.7.2 and 25.7.3, **Exposure B** is used

Ground Elevation: Google

$z_e := 1355$ ft

ASCE 7-16: Table 26.9-1

Ground Elev. Factor $K_e := e^{-.0000362 \cdot z_e} = 0.952$

Mean Roof Height:

$h_{48} := 48\ ft = 48\ ft$

Velocity Pressure Coefficients:

SELECT Z LOCATION:

z: 15.00 ft, Roof Height: 48 ft. second level: 33 ft

FIND α AND zg: ASCE 7-16: Table 26.11-1

$\alpha := 7$

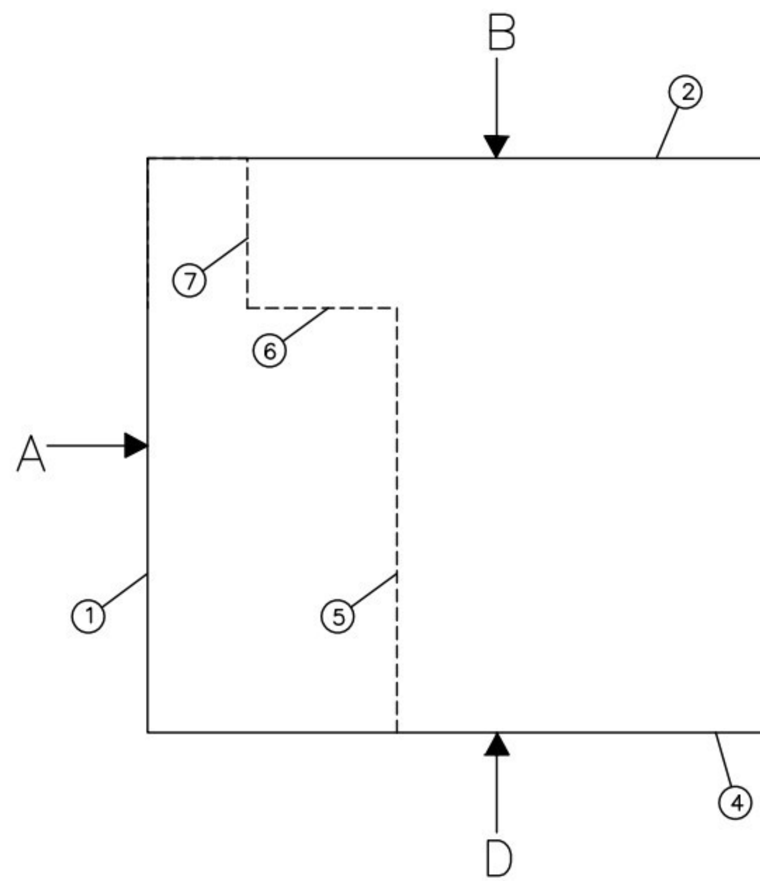
$z_g := 1200\ ft$

Velocity pressure exposure coefficient: ASCE 7-16: Table 26.10-1

$$K_{z15} := 2.01 \cdot \left(\frac{15\ ft}{z_g}\right)^{\frac{2}{\alpha}} = 0.575$$

$$K_{z33} := 2.01 \cdot \left(\frac{33\ ft}{z_g}\right)^{\frac{2}{\alpha}} = 0.72$$

$$K_{zh} := 2.01 \cdot \left(\frac{h_{48}}{z_g}\right)^{\frac{2}{\alpha}} = 0.801$$



Velocity Pressure: (ASCE 7-16: Equation 26.10-1)

$$q_{15} := 0.00256\ \frac{psf}{mph^2} \cdot K_{z15} \cdot K_{zt} \cdot K_e \cdot V^2 = 19.838\ psf$$

$$q_{33} := 0.00256\ \frac{psf}{mph^2} \cdot K_{z33} \cdot K_{zt} \cdot K_e \cdot V^2 = 24.85\ psf$$

$$q_{48} := 0.00256\ \frac{psf}{mph^2} \cdot K_{zh} \cdot K_{zt} \cdot K_e \cdot V^2 = 27.658\ psf$$

Gust Effect Factor: (ASCE 7-16: 26.11.1)

$$G := 0.85$$

Internal Pressures: (ASCE 7-16: Table 26.13-1)

Enclosed Building: Moderate Internal Pressure

Internal Pressure Coefficient:

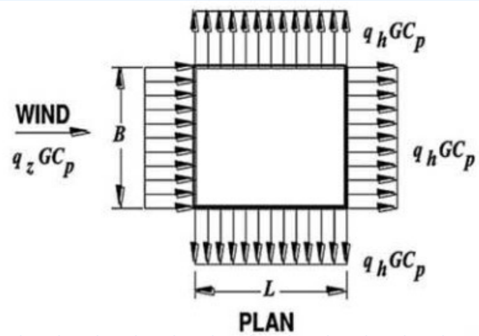
$GC_{pi} := -0.18$ $\qquad$ $GC_{pi} := 0.18$

WIND DIRECTION A: EAST

$\frac{L}{B} = 1.217$

$B := 115\ ft$ $L := 140\ ft$

Wall Pressures:



Wall Pressure Coefficients, C_p

Surface	L/B
Windward wall	All values
Leeward wall	0–1
	2
	≥4
Sidewall	All values

WINDWARD WALLS: Surface 1, 5, 7

ASCE 7-16: 27.3-1

$C_p := 0.8$

Internal Pressures:
POSITIVE:

$p_{15wpos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = 8.431\ psf$

$p_{33wpos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = 10.561\ psf$

$p_{48wpos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = 11.755\ psf$

NEGATIVE:

$p_{15wneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 14$

$-\left(\left(GC_{pi}\right)\right)\right)\right) = 18.165\ psf$ $p_{48wneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(\right.\right.$

LEEWARD WALLS: Surface 3

Linear Interpolation: ASCE 7-16: Fig. 27.3-1 --------->

$C_p := -0.457$

Interpolation: When L/B between table values

$x_1 := 1 \qquad x_2 := 2 \qquad y_1 := -0.5 \qquad y_2 := -0.3$

$x := \left(\dfrac{\left(y_2 - y_1\right)}{\left(x_2 - x_1\right)}\right) \cdot \left(\left(x - x_1\right)\right) + y_1 = -0.45$

Internal Pressures:

POSITIVE:

$p_{15lpos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = -9.585\ psf$

$p_{33lpos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = -12.007\ psf$

NET PRESSURE:

$p_{48lpos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -13.364\ psf$

NEGATIVE:

$p_{15lneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -3.515\ psf$

$p_{33lneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -4.403\ psf$

$p_{48lneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -4.9\ psf$

$\left({}_{2} \quad {}_{1} \right)$

$p_{15w} := p_{15wpos} + |p_{15lpos}| = 18.016 \ psf$

$p_{33w} := p_{33wpos} + |p_{33lpos}| = 22.568 \ psf$

$p_{48w} := p_{48wpos} + |p_{48lpos}| = 25.118 \ psf$

SIDE WALLS: Surfaces 2, 4 and 6

ASCE 7-16: 27.3-1

$C_p := -0.7$

Internal Pressures:

POSITIVE:

$$p_{15spos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = -13.068\ psf$$

$$p_{33spos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = -16.37\ psf$$

$$p_{48spos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -18.22\ psf$$

NEGATIVE:

$$p_{15sneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -6.998\ psf$$

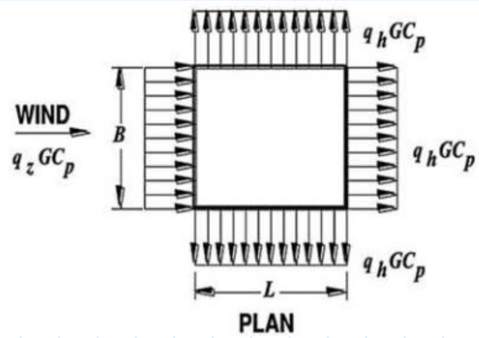
$$p_{33sneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -8.766\ psf$$

$$p_{48sneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -9.756\ psf$$

WIND DIRECTION C: WEST

$B := 115\ ft$ $L := 140\ ft$

$\frac{L}{B} = 1.217$



Wall Pressure Coefficients, C_p

Surface	L/B
Windward wall	All values
	0–1
Leeward wall	2
	≥4
Sidewall	All values

ASCE 7-16: Fig. 27.3-1

Wall Pressures:

WINDWARD WALLS: Surface 3

ASCE 7-16: 27.3-1

$C_p := 0.8$

Internal Pressures:

POSITIVE:

$p_{15wpos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = 8.431\ psf$

$p_{33wpos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = 10.561\ psf$

$$p_{48wpos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = 11.755 \; psf$$

NEGATIVE:

$$p_{15wneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 14.501 \; psf$$

$$p_{33wneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 18.165 \; psf$$

$$p_{48wneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 20.218 \; psf$$

LEEWARD WALLS: Surface 1, 5, AND 7

Interpolation: When L/B between table values

Linear Interpolation: ASCE 7-16: Fig. 27.3-1 ---------- >

$C_p := -0.457$

$x_1 := 1$ $x_2 := 2$ $y_1 := -0.5$ $y_2 := -0.3$

$x := \frac{(y_2 - y_1)}{(x_2 - x_1)} \cdot ((x - x_1)) + y_1 = -0.457$

Internal Pressures:

POSITIVE:

$p_{15lpos} := ((q_{15} \cdot K_d \cdot G \cdot C_p)) - ((q_{15} \cdot K_d \cdot GC_{pi})) = -9.585\ psf$

$p_{33lpos} := ((q_{33} \cdot K_d \cdot G \cdot C_p)) - ((q_{33} \cdot K_d \cdot GC_{pi})) = -12.007\ psf$

NET PRESSURE:

$p_{48lpos} := ((q_{48} \cdot K_d \cdot G \cdot C_p)) - ((q_{48} \cdot K_d \cdot GC_{pi})) = -13.364\ psf$

NEGATIVE:

$p_{15lneg} := ((q_{15} \cdot K_d \cdot G \cdot C_p)) - ((q_{15} \cdot K_d \cdot -((GC_{pi})))) = -3.515\ psf$

$p_{33lneg} := ((q_{33} \cdot K_d \cdot G \cdot C_p)) - ((q_{33} \cdot K_d \cdot -((GC_{pi})))) = -4.403\ psf$

$p_{48lneg} := ((q_{48} \cdot K_d \cdot G \cdot C_p)) - ((q_{48} \cdot K_d \cdot -((GC_{pi})))) = -4.9\ psf$

$\left({}_{2} \qquad {}_{1} \right)$

$$p_{15w} := p_{15wpos} + |p_{15lpos}| = 18.016 \ psf$$

$$p_{33w} := p_{33wpos} + |p_{33lpos}| = 22.568 \ psf$$

$$p_{48w} := p_{48wpos} + |p_{48lpos}| = 25.118 \ psf$$

SIDE WALLS: Surfaces 2, 4 and 6

ASCE 7-16: 27.3-1

$C_p := -0.7$

Internal Pressures:

POSITIVE:

$p_{15spos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = -13.068\ psf$

$p_{33spos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = -16.37\ psf$

$p_{48spos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -18.22\ psf$

NEGATIVE:

$p_{15sneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -6.998\ psf$

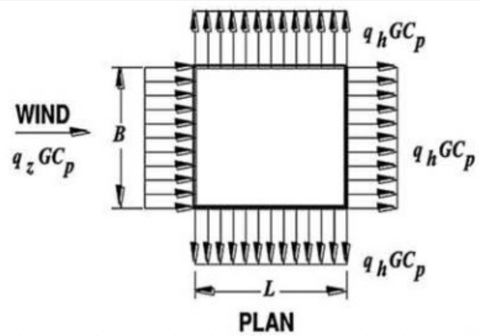
$p_{33sneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -8.766\ psf$

$$p_{48sneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -9.756\ psf$$

WIND DIRECTION B: SOUTH

$L := 115\ ft$ $B := 140\ ft$

$\frac{L}{B} = 0.821$



Wall Pressure Coefficients, C_p

Surface	L/B
Windward wall	All values
Leeward wall	0–1
	2
	≥4
Sidewall	All values

ASCE 7-16: Fig. 27.3-1

Wall Pressures:

WINDWARD WALLS: Surface 2

ASCE 7-16: 27.3-1

$C_p := 0.8$

Internal Pressures:

POSITIVE:

$p_{15wpos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = 8.431\ psf$

$p_{33wpos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = 10.561\ psf$

$$p_{48wpos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = 11.755\ psf$$

NEGATIVE:

$$p_{15wneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 14.501\ psf$$

$$p_{33wneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 18.165\ psf$$

$$p_{48wneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 20.218\ psf$$

LEEWARD WALLS: Surface 4 AND 6

Linear Interpolation: ASCE 7-16: Fig. 27.3-1

$C_p := -0.536$

Internal Pressures:

POSITIVE:

$p_{15lpos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = -10.717\ psf$

$p_{33lpos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = -13.425\ psf$

$p_{48lpos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -14.942\ psf$

NEGATIVE:

$p_{15lneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -4.647\ psf$

$p_{33lneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -5.821\ psf$

$p_{48lneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -6.479\ psf$

Interpolation: When L/B between table values

---------- >

$x_1 := 1$ $x_2 := 2$ $y_1 := -0.5$ $y_2 := -0.3$

$$x := \frac{\left(\left(y_2 - y_1\right)\right)}{\left(x_2 - x_1\right)} \cdot \left(\left(x - x_1\right)\right) + y_1 = -0.536$$

NET PRESSURE:

Non-Commercial Use Only

$\left(\quad _{2} \qquad _{1} \right)$

$$p_{15w} := p_{15wpos} + \left| p_{15lpos} \right| = 19.148\ psf$$

$$p_{33w} := p_{33wpos} + \left| p_{33lpos} \right| = 23.986\ psf$$

$$p_{48w} := p_{48wpos} + \left| p_{48lpos} \right| = 26.697\ psf$$

SIDE WALLS: Surfaces 1, 3, 5 and 7

ASCE 7-16: 27.3-1

$C_p := -0.7$

Internal Pressures:

POSITIVE:

$p_{15spos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = -13.068\ psf$

$p_{33spos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = -16.37\ psf$

$p_{48spos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -18.22\ psf$

NEGATIVE:

$p_{15sneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -6.998\ psf$

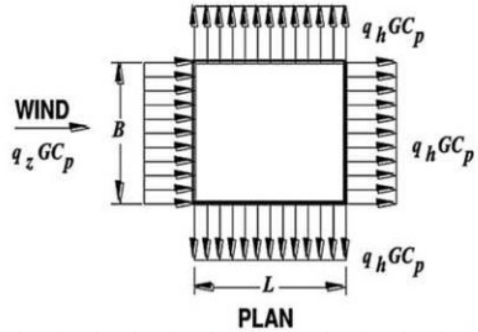
$p_{33sneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -8.766\ psf$

$$p_{48sneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -9.756\ psf$$

WIND DIRECTION D: NORTH

$L := 115\ ft$ $B := 140\ ft$

$\frac{L}{B} = 0.821$



Wall Pressure Coefficients, C_p

Surface	L/B
Windward wall	All values
Leeward wall	0–1
	2
	≥4
Sidewall	All values

ASCE 7-16: Fig. 27.3-1

Wall Pressures:

WINDWARD WALLS: Surface 4 AND 6

ASCE 7-16: 27.3-1

$C_p := 0.8$

Internal Pressures:

POSITIVE:

$p_{15wpos} := ((q_{15} \cdot K_d \cdot G \cdot C_p)) - ((q_{15} \cdot K_d \cdot GC_{pi})) = 8.431\ psf$

$p_{33wpos} := ((q_{33} \cdot K_d \cdot G \cdot C_p)) - ((q_{33} \cdot K_d \cdot GC_{pi})) = 10.561\ psf$

$p_{48wpos} := ((q_{48} \cdot K_d \cdot G \cdot C_p)) - ((q_{48} \cdot K_d \cdot GC_{pi})) = 11.755\ psf$

NEGATIVE:

$$p_{15wneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 14.501\ psf$$

$$p_{33wneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 18.165\ psf$$

$$p_{48wneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 20.218\ psf$$

LEEWARD WALLS: Surface 2

Interpolation: When L/B between table values

Linear Interpolation: ASCE 7-16: Fig. 27.3-1 - ------- >

$C_p := -0.536$

$x_1 := 1$ $x_2 := 2$ $y_1 := -0.5$ $y_2 := -0.3$

$$x := \left(\frac{\left(y_2 - y_1\right)}{\left(x_2 - x_1\right)}\right) \cdot \left(\left(x - x_1\right)\right) + y_1 = -0.536$$

Internal Pressures:

POSITIVE:

$p_{15lpos} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot GC_{pi}\right)\right) = -10.717\ psf$

NET PRESSURE:

$p_{33lpos} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot GC_{pi}\right)\right) = -13.425\ psf$

$p_{48lpos} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -14.942\ psf$

NEGATIVE:

$p_{15lneg} := \left(\left(q_{15} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{15} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -4.647\ psf$

$p_{33lneg} := \left(\left(q_{33} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{33} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -5.821\ psf$

$p_{48lneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -6.479\ psf$

$\left({}_{2} \quad {}_{1} \right)$

$p_{15w} := p_{15wpos} + |p_{15lpos}| = 19.148\ psf$

$p_{33w} := p_{33wpos} + |p_{33lpos}| = 23.986\ psf$

$p_{48w} := p_{48wpos} + |p_{48lpos}| = 26.697\ psf$

SIDE WALLS: Surfaces 1 and 3

ASCE 7-16: 27.3-1

$C_p := -0.7$

Internal Pressures:

POSITIVE:

$p_{15spos} := ((q_{15} \cdot K_d \cdot G \cdot C_p)) - ((q_{15} \cdot K_d \cdot GC_{pi})) = -13.068\ psf$

$p_{33spos} := ((q_{33} \cdot K_d \cdot G \cdot C_p)) - ((q_{33} \cdot K_d \cdot GC_{pi})) = -16.37\ psf$

$p_{48spos} := ((q_{48} \cdot K_d \cdot G \cdot C_p)) - ((q_{48} \cdot K_d \cdot GC_{pi})) = -18.22\ psf$

NEGATIVE:

$p_{15sneg} := ((q_{15} \cdot K_d \cdot G \cdot C_p)) - ((q_{15} \cdot K_d \cdot -((GC_{pi})))) = -6.998\ psf$

$p_{33sneg} := ((q_{33} \cdot K_d \cdot G \cdot C_p)) - ((q_{33} \cdot K_d \cdot -((GC_{pi})))) = -8.766\ psf$

$$p_{48sneg} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_p\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -9.756\ psf$$

Roof Pressures:

Roof Pressure Coefficients:

Angle < 10 degrees:

From 0 to h/2 AND h/2 to h

$C_{p1} := -0.9$

POSITIVE:

$p_{48spos1} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p1}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -22.216\ psf$

NEGATIVE:

$p_{48sneg1} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p1}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -13.753\ psf$

$C_{p2} := -0.18$

POSITIVE:

$p_{48spos2} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p2}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -7.829\ psf$

NEGATIVE:

$p_{48sneg2} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p2}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 0.635\ psf$

From h to 2h

$C_{p1} := -0.5$

POSITIVE:

$p_{48spos1} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p1}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -14.223\ psf$

NEGATIVE:

$p_{48sneg1} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p1}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -5.76\ psf$

$C_{p2} := -0.18$

POSITIVE:

$p_{48spos2} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p2}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -7.829\ psf$

NEGATIVE:

$p_{48sneg2} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p2}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 0.635\ psf$

From >2h

$C_{p1} := -0.3$

POSITIVE:

$p_{48spos1} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p1}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -10.226 \; psf$

NEGATIVE:

$p_{48sneg1} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p1}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = -1.763 \; psf$

$C_{p2} := -0.18$

POSITIVE:

$p_{48spos2} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p2}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot GC_{pi}\right)\right) = -7.829 \; psf$

NEGATIVE:

$p_{48sneg2} := \left(\left(q_{48} \cdot K_d \cdot G \cdot C_{p2}\right)\right) - \left(\left(q_{48} \cdot K_d \cdot -\left(\left(GC_{pi}\right)\right)\right)\right) = 0.635 \; psf$

Roof Framing Joist Sizes:

L Shape (10',20',30'): **18K4**
Event Space (85'): **44LH09**

Roof Framing Girder Sizes:

Girder 1: G1: **W12x16**
Girder 2: G2: **W12x16**
Girder 3: G3: **W8x15**
Girder 4: G4: **W8x15**
Girder 5: G5: **W8x15**
Girder 6: G6: **W14x30**

Third Floor Framing Joist Sizes:

North Floor (30'):**18K9**
North Floor (10'): **8K1**
East Floor (30'): **20K6**
Gym Span (85'): **52DLH12**

Third Floor Framing Girder Sizes:
G31: **W21x62**
G32: **W24x62**
G33: **W14x30**
G34: **W33x130**
G35: **W24x84**
G36: **W30x108**
G37: **W21x62**
G38: **W14x22**
G39: **W21x50**
G310: **W8x15**
G311: **W8x15**
G312: **W21x55**
G313: **W24x62**

Second Floor Framing Joist Sizes:

North Floor (30'):**16K7**
North Floor (10'): **8K1**
East Floor (30'): **18K9**

Second Floor Framing Girder Sizes:
G21: **W21x50**
G22: **W21x55**
G23: **W14x22**
G24: **W21x55**
G25: **W16x40**
G29: **W24x62**
G210: **W10x15**
G211: **W10x15**
G212: **W21x50**
G213: **W24x62**

THIRD FLOOR: (NORTH) 30 FT Span

$D := 66\ psf$

$TW := 1.5\ ft$

$L_{kitchen} := 150\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{kitchen} = 319.2\ psf$

$w_u := TW \cdot q_u = 478.8\ plf$

<- STRENGTH

$w_{userv} := TW \cdot L_{kitchen} = 225\ plf$

<- SERVICEAB

$w_{SW} := 10.1\ plf$

K Series: 18K9
Weight: 10.1 PLF
Capacity:
(serviceability): 229 PLF
(strength): 603 PLF

$w_{maxstrength} := 603\ plf$

$w_{maxserv} := 229\ plf$

$$\text{if } w_u + w_{SW} < w_{maxstrength} \;\Big\|\; \text{"OK"} \;\text{else}\; \text{"REVISE DESIGN"} = \text{"OK"}$$

$$\text{if } w_{userv} < w_{maxserv} \;\Big\|\; \text{"OK"} \;\text{else}\; \text{"REVISE DESIGN"} = \text{"OK"}$$

10 FT SPAN: 8K1
Weight: 5.1 plf
Depth: 8 in

$w_{SW} := 5.1\ plf$

$w_{maxkseries} := 480\ plf$

$$\text{if } w_{userv} + w_{SW} < w_{maxkseries} \;\Big\|\; \text{"OK"} \;\text{else}\; \text{"REVISE DESIGN"} = \text{"OK"}$$

THIRD FLOOR: (EAST) SPAN: 30 FT

$D := 66\ psf$

$TW := 2\ ft$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 239.2\ psf$

$w_u := TW \cdot q_u = 478.4\ plf$

<- STRENGTH

$w_{userv} := TW \cdot L_{assembly} = 200\ plf$

<- SERVICEABILITY

K Series:

20K6
Weight: 8.4 PLF
Capacity:
(serviceability): 218 PLF
(strength): 504 PLF

$w_{SW} := 8.4\ plf$

$w_{maxstrength} := 504\ plf$

if $w_u + w_{SW} < w_{maxstrength}$ = "OK"
"OK"
"REVISE DESIGN"

$w_{maxserv} := 218\ plf$

if $w_{userv} < w_{maxserv}$ = "OK"
"OK"
else
"REVISE DESIGN"

$= 23.2\ in$ $\quad$ $24\ in - 23.2\ in = 0.8\ in$ $\quad$ 29 FT Ba

$29\ ft$

15 $\quad$ $23.2\ in - 12\ in = 11.2\ in$ $\quad$ Spac

$= 22.4\ in$ $\quad$ $24\ in - 22.4\ in = 1.6\ in$ $\quad$ 28 FT Ba

$28\ ft$

15 $\quad$ $22.4\ in - 12\ in = 10.4\ in$ $\quad$ Spac

THIRD FLOOR: (GYM DEEP OPEN WEB JOISTS)

$D_{gym} := 3 + 3 + 42.166 + 3.8 + 6 + 5 = 62.966$

$D := 63\ psf$

$L_{assembly} := 100\ psf$ $TW := 2\ ft$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$w_{userv} := TW \cdot L_{assembly} = 200\ plf$

<- SE

$w_u := TW \cdot q_u = 471.2\ plf$

<- STRENGTH

$w_{umaxstrength} := \dfrac{49230\ lbf}{85\ ft} = 579.176\ plf$

$w_{SW} := 29\ plf$

OPEN WEB JOISTS:

52DLH12

WEIGHT: 29 PLF
DEPTH: 52 IN
CAPACITY: (STRENGTH)
(SERVICEABI

if $w_u + w_{SW} < w_{maxstrength}$ = "OK"
"OK"
"REVISE DESIGN"

$w_{maxstrength} := 504\ plf$

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if $w_{userv} < w_{maxserv}$

$w_{maxserv} := 204\ plf$

THIRD FLOOR GIRDER SIZING:

THIRD FLOOR GIRDER DESIGN

Reaction Forces for joists: **18K9**

K Series: Spaced at 1' - 4"

$w_{SWjoist} := 10.1\ plf$ $TW_{joist} := 1\ ft + 4\ in$

$D := 66\ psf$

$L_{kitchen} := 150\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{kitchen} = 319.2\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 425.6\ plf$

$w_{ujoist} := w_{SWjoist} + w_{SI} = 435.7\ plf$

Reactions:

$L := 30\ ft$

$R_{joist}(L)$

$:= \frac{w_{ujoist}}{2} \cdot L \rightarrow 217.85 \cdot L \cdot plf$

$R_{joist}(L)$

$= 6535.5\ lbf$

$= \left(\left(6.536 \cdot 10^{3}\right)\right)\ lbf$

$R_{joistLH14} := R_{joist}(L)$

Reaction Forces for joists: **18K9**

K Series: Spaced at 1' - 6"

$w_{SWjoist} := 10.1\ plf$ $TW_{joist} := 1\ ft + 6\ in$

$D := 63\ psf$

$L_{kitchen} := 150\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{kitchen} = 315.6\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 473.4\ plf$

Reactions:

$L := \begin{bmatrix} 20\ ft \\ 30\ ft \end{bmatrix}$

$R_{joist}\ L := \dfrac{w_{ujoist}}{2} \cdot L \rightarrow 241.75 \cdot L \cdot plf$

$R_{joist}\ L\ 0$

$R_{joist}\ L\ 1$

$= 4835\ lbf$ $= 7252.5\ lbf$

$$R_{joistLH1620ft} := R_{joist}\ L\ 0 = \left(\left(4.835 \cdot 10^{3}\right)\right)\ lbf$$

$$R_{joistLH1630ft} := R_{joist}\ L\ 1 = \left(\left(7.253 \cdot 10^{3}\right)\right)\ lbf$$

Reaction Forces for joists: **20K6**

K Series: Spaced at 2' - 0"

$w_{SWjoist} := 8.4\ plf$ $TW_{joist} := 2\ ft$

$D := 63\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 471.2\ plf$

Reactions:

$L := 30\ ft$

$$R_{joist}\ L := \frac{w_{ujoist}}{2} \cdot L \rightarrow 239.80000000000004 \cdot L \cdot plf$$

$R_{joist}\ L$

$= 7194\ lbf$

$R_{joistLH2} := R_{joist}\ \ L$

$= \left(\left(7.194 \cdot 10^{3}\right)\right)\ lbf$

Reaction Forces for joists: **8K1**

K Series: Spaced at 1' - 6"

$w_{SWjoist} := 5.1\ plf$ $TW_{joist} := 1\ ft + 6\ in$

$D := 63\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 353.4\ plf$

Reactions:

$L := 10\ ft$

$$R_{joist}\ L := \frac{w_{ujoist}}{2} \cdot L \rightarrow 179.25000000000003 \cdot L \cdot plf$$

$R_{joist}\ L$

$= 1792.5\ lbf$

$R_{joistk} := R_{joist}\ \ L$

$= \left(\left(1.793 \cdot 10^{3}\right)\right)\ lbf$

DLH Series: Spaced at 2' - 0": **52DLH12**

$w_{SWjoist} := 29\ plf$ $TW_{joist} := 2\ ft$

$D := 63\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 471.2\ plf$

Reactions:

$L := 85\ ft$

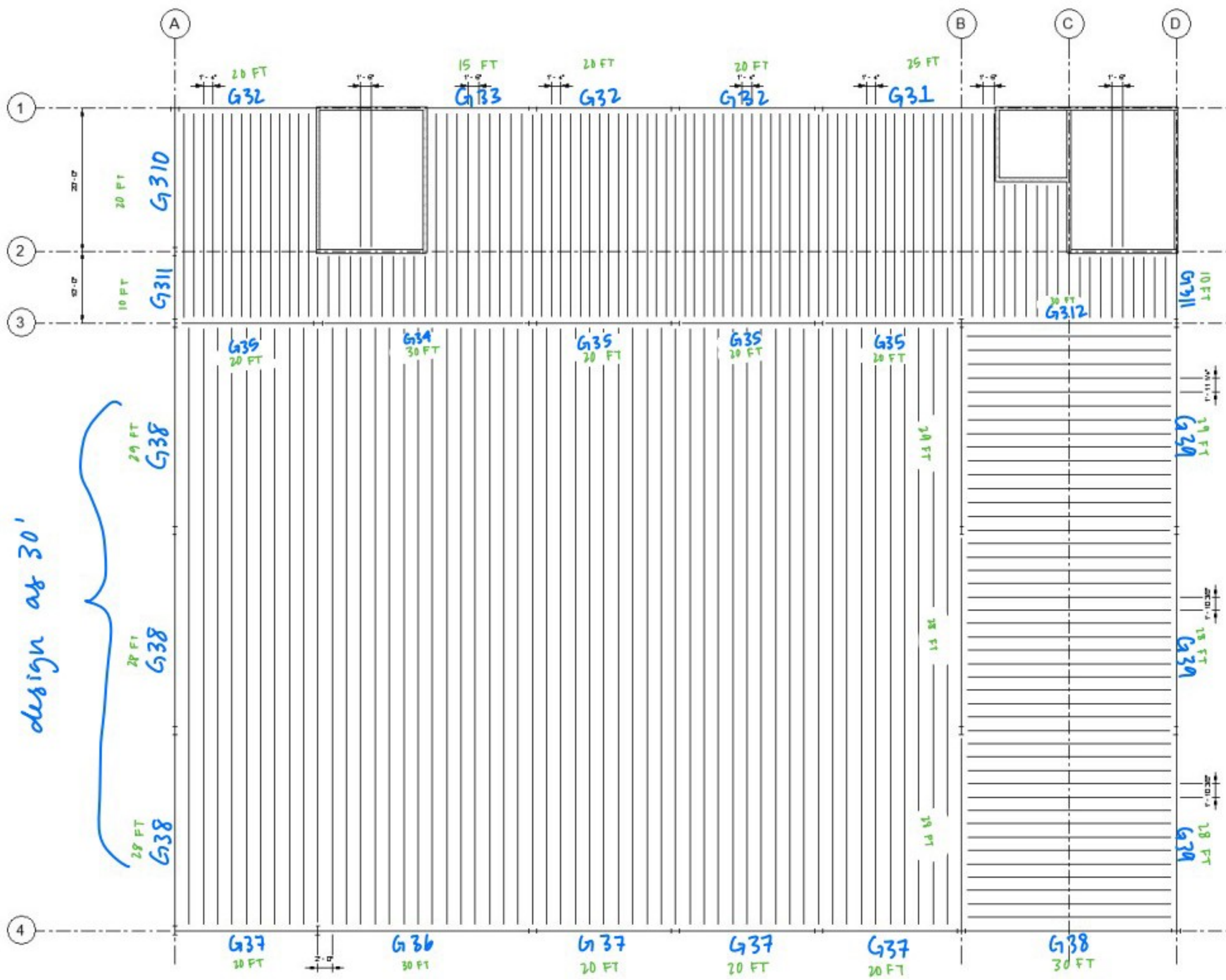
$R_{joist}(L) := \frac{w_{ujoist}}{2} \cdot L \rightarrow 250.100000000000025 \cdot L \cdot plf$

$R_{joist}(L)$

$= 21258.5\ lbf$

$$R_{joistDLH} := R_{joist}\ \ L = \left(\left(2.126 \cdot 10^{4}\right)\right)\ lbf$$

THIRD FLOOR FRAMING PLAN:

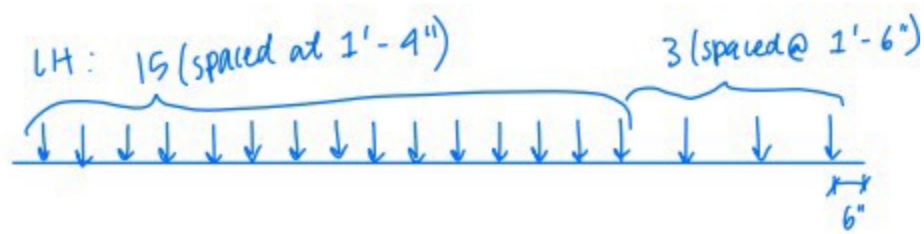


Non-Commercial Use Only

G31: 25' Span

$P_{ijoistLH14} := R_{joistLH14} = 6535.5\ lbf$

G31 → 25'



$P_{ijoistLH16} := R_{joistLH1630ft} = 7252.5\ lbf$

$L_{G1} := 25\ ft$ $\qquad L_b := 1.5\ ft$

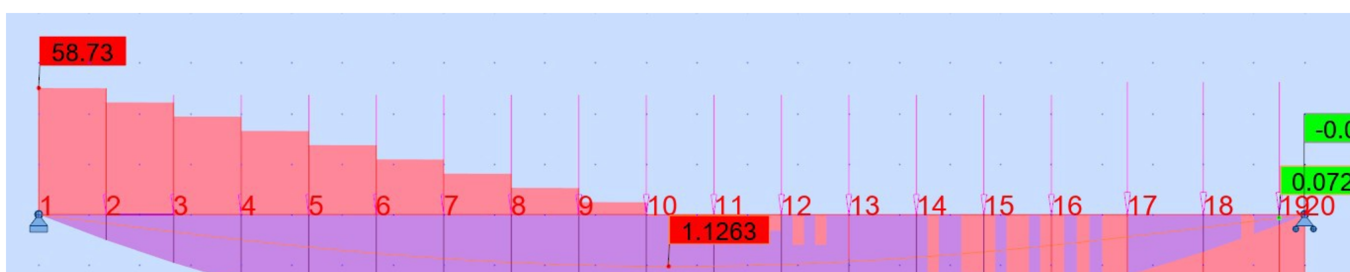
$w_{SWjoist} := 10.1\ plf$

$L_{G31} := 25\ ft$

$1\ ft + 4\ in = 1.33333333\ ft$

$1\ ft + 6\ in = 1.5\ ft$

$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$ $\qquad \begin{bmatrix} 1.333 \\ 2.667 \end{bmatrix}$



$$x := \begin{bmatrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{bmatrix} \qquad 1.33333333 \cdot x = \begin{bmatrix} 4 \\ 5.333 \\ 6.667 \\ 8 \\ 9.333 \\ 10.667 \\ 12 \\ 13.333 \\ 14.667 \\ 16 \\ 17.333 \\ 18.667 \\ 20 \end{bmatrix}$$

Max Shear:

$V_{max} := 62.63 \ kip$

Max Moment:

$M_{max} := 386.53 \ kip \cdot ft$

Max Deformation:

$\delta_{max} := 1.1263 \ in$

Flexure Check:

$L_p := 6.25\ ft$

$\phi M_p := 540\ kip \cdot ft$

A992:

W21x62: Dimensions

$F_y := 50\ ksi$

$Z_x := 144\ in^3$

$E := 29000\ ksi$

$L_r := 18.1\ ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 600\ kip \cdot ft$

$S_x := 127\ in^3$

$F_u := 65\ ksi$

$I_y := 8.54\ in^4$

$\phi := 0.9$

$C_w := 5960\ in^6$

$h_o := 20.4\ in$

$J := 1.83\ in^4$

$c := 1$

```
if Lb ≤ Lp                  = "YIELDING"
  ‖ "YIELDING"
else if Lp < Lb ≤ Lr
  ‖ "INELASTIC"
else
  ‖ "ELASTIC"
```

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.333\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(1.577 \cdot 10^3\right)\ ksi$$

$$M_n := \text{if } L_b \le L_p \;\; \| F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\; \| C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\frac{L_b - L_p}{L_r - L_p} \right) \right) \;\; \text{else} \;\; \| F_{cr} \cdot S_x \; = 600 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 540 \; kip \cdot ft$$

$$\text{if } M_{max} < \phi M_n \;\; \| \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} \; = \text{"OK"}$$

Shear Check:

$$\phi V_n := 252 \; kip$$

$$\text{if } V_{max} < \phi V_n \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} \; = \text{"OK"}$$

Girder 4: G4 = W21x62

Serviceability Check:

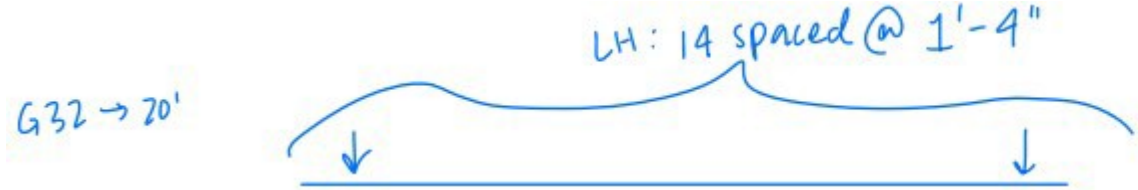
$$\Delta_{DL} := \frac{L_{G31}}{240} = 1.25 \; in$$

$$\delta_{max} := 1.1263 \; in$$

$$\text{if } \delta_{max} < \Delta_{DL} \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} \; = \text{"OK"}$$

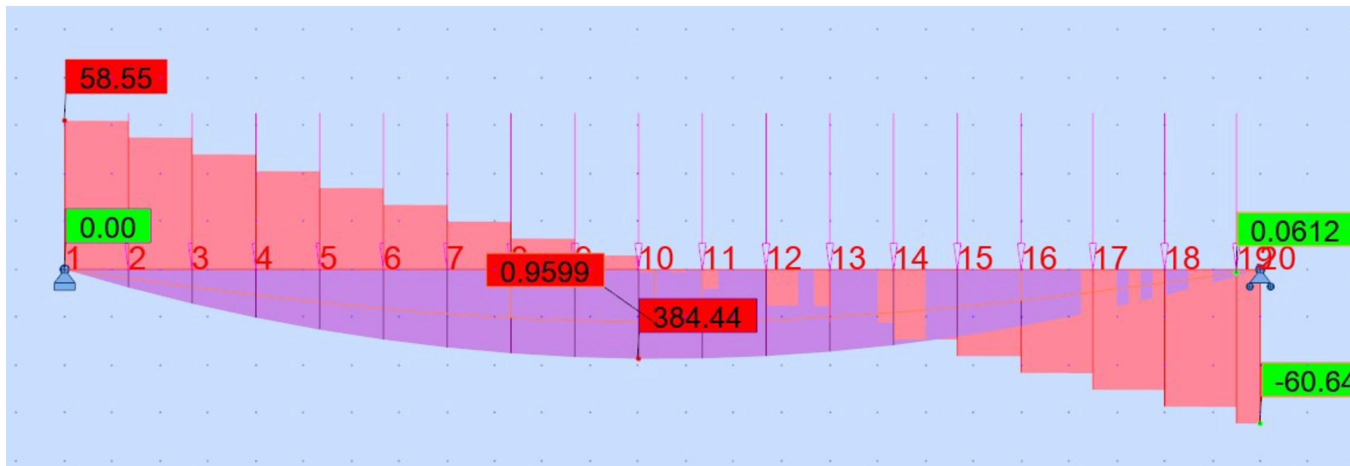
G32: 20' Span

$P_{ijoistLH14} := R_{joistLH14} = 6535.5\ lbf$



$L_{G32} := 20\ ft$ $\qquad L_b := 1\ ft + 4\ in$

$1\ ft + 4\ in = 1.333\ ft$



$$x := \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{bmatrix} \qquad 1.33333333 \cdot x = \begin{bmatrix} 1.333 \\ 2.667 \\ 4 \\ 5.333 \\ 6.667 \\ 8 \\ 9.333 \\ 10.667 \\ 12 \\ 13.333 \\ 14.667 \end{bmatrix}$$

$$\begin{bmatrix} 13 \\ 14 \\ 15 \end{bmatrix} \quad \begin{bmatrix} 16 \\ 17.333 \\ 18.667 \\ 20 \end{bmatrix}$$

Max Shear:

$V_{max} := 60.64\ kip$

Max Moment:

$M_{max} := 384.44\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 0.9599\ in$

Flexure Check:

$L_p := 4.87\ ft$

$\phi M_p := 574\ kip \cdot ft$

A992:

W24x62: Dimensions

$L_r := 14.4\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 153\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 637.5\ kip \cdot ft$

$S_x := 131\ in^3$

$F_u := 65\ ksi$

$I_y := 34.5\ in^4$

$\phi := 0.9$

$C_w := 4620\ in^6$

if $L_b \le L_p$ = "YIELDING"
 "YIELDING"
else if $L_p < L_b \le L_r$
 "INELASTIC"
else
 "ELASTIC"

$h_o := 23.1\ in$

$J := 1.71\ in^4$

$c := 1$

Assume:

$C_b := 1.0$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.746\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(3.414 \cdot 10^3\right)\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p} \right) \right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 637.5\ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 573.75\ kip \cdot ft$$

$$\begin{array}{l} \text{if } M_{max} < \phi M_n \\ \quad \| \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 306\ kip$$

$$\begin{array}{l} \text{if } V_{max} < \phi V_n \\ \quad \| \text{"OK"} \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G32}}{240} = 1\ in$$

$$\begin{array}{l} \text{if } \delta_{max} < \Delta_{DL} \\ \quad \| \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} = \text{"OK"}$$

Girder 4: G4 = W24x62

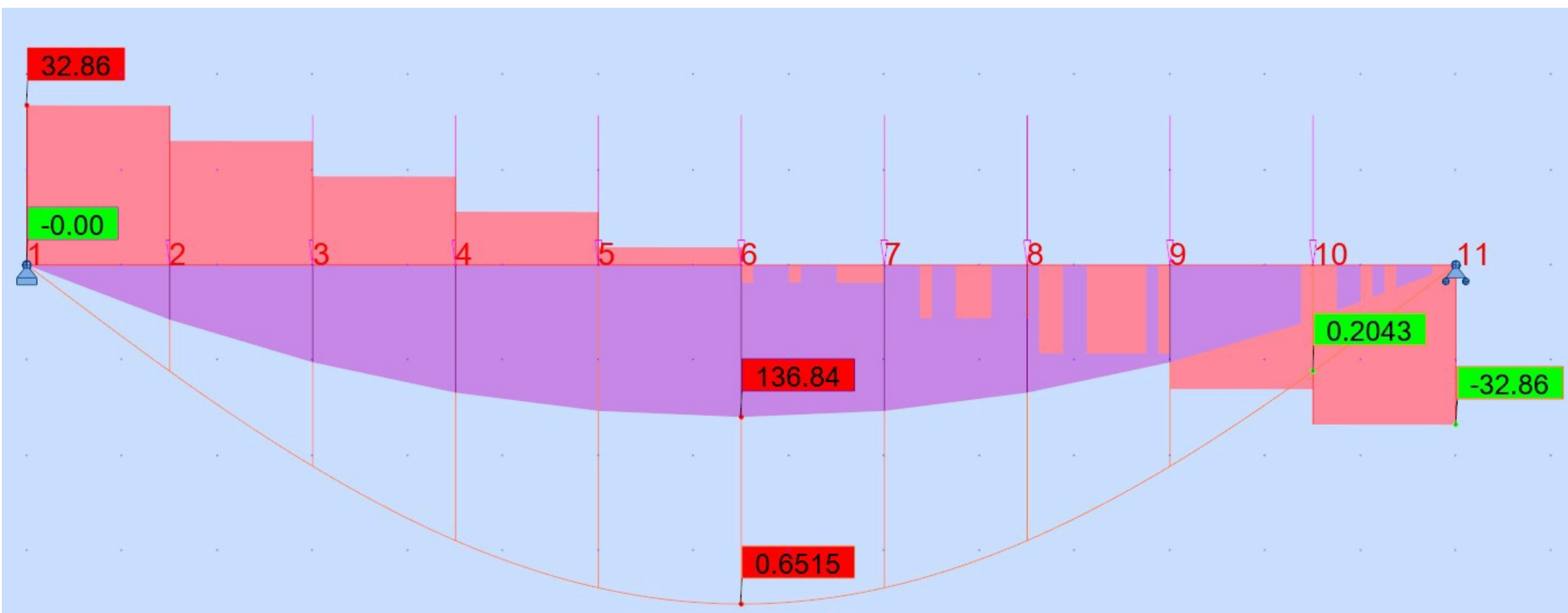
G33: 15' Span

$P_{ijoistLH16} := R_{joistLH1630ft} = 7252.5\ lbf$

G33 → 15'

$L_{G33} := 15\ ft$ $L_b := 1\ ft + 6\ in$

$1\ ft + 6\ in = 1.5\ ft$



Max Shear:

$V_{max} := 32.86\ kip$

Max Moment:

$M_{max} := 136.84\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 0.6515\ in$

Flexure Check:

$L_p := 5.26\ ft$

$L_r := 14.9\ ft$

$\phi M_p := 177\ kip \cdot ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 197.083\ kip \cdot ft$

$\phi := 0.9$

A992:

$F_y := 50\ ksi$

$F_u := 65\ ksi$

W14x30: Dimensions

$Z_x := 47.3\ in^3$

$S_x := 42.0\ in^3$

$E := 29000\ ksi$

$I_y := 19.6\ in^4$

$C_w := 887\ in^6$

$h_o := 13.4\ in$

$J := 0.380\ in^4$

$c := 1$

if $L_b \le L_p$
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

= "YIELDING"

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.772\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(2.781 \cdot 10^3\right)\ ksi$$

$$M_n := \text{if } L_b \le L_p \;\; \| F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\; \| C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\frac{L_b - L_p}{L_r - L_p} \right) \right) \;\; \text{else} \;\; \| F_{cr} \cdot S_x = 197.083 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 177.375 \; kip \cdot ft$$

$$\text{if } M_{max} < \phi M_n \;\; \| \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 306 \; kip$$

$$\text{if } V_{max} < \phi V_n \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G33}}{240} = 0.75 \; in$$

$$\text{if } \delta_{max} < \Delta_{DL} \;\; \| \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} = \text{"OK"}$$

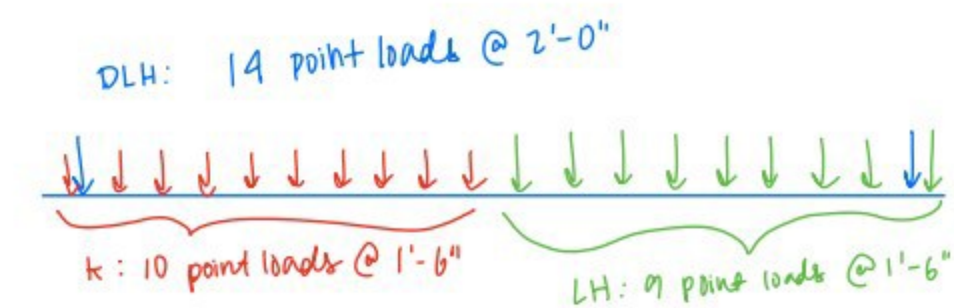
Girder 4: G4 = W14x30

G34: 30' Span

$P_{ijoistLH16} := R_{joistLH1630ft} = 7252.5\ lbf$

G34 → 30'

(draw nodes @ every 6")

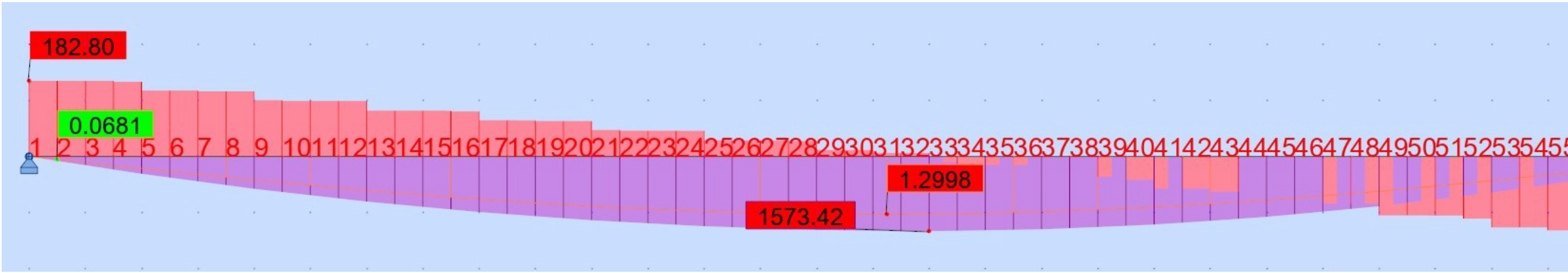


$P_{ijoistk} := R_{joistk} = 1792.5\ lbf$

$P_{ijoistDLH} := R_{joistDLH} = 21258.5\ lbf$

$L_{G34} := 30\ ft$ $L_b := 1\ ft + 6\ in$

$1\ ft + 6\ in = 1.5\ ft$



Max Shear:

$V_{max} := 207.39\ kip$

Max Moment:

$M_{max} := 1573.42\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 1.2998\ in$

Flexure Check:

$L_p := 8.44\ ft$

$\phi M_p := 1750\ kip \cdot ft$

A992:

W33x130: Dimensions

$L_r := 24.2\ ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = \left(\left(1.946 \cdot 10^3\right)\right) kip \cdot ft$

$\phi := 0.9$

$F_y := 50\ ksi$

$F_u := 65\ ksi$

$Z_x := 467\ in^3$

$S_x := 406\ in^3$

$E := 29000\ ksi$

$I_y := 218\ in^4$

$C_w := 56600\ in^6$

$h_o := 32.2\ in$

$J := 7.37\ in^4$

$c := 1$

if $L_b \le L_p$
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

= "YIELDING"

Assume:

$C_b := 1.0$

$r_{ts} := \sqrt{\left(\sqrt{\left(I_y \cdot C_w\right)}\right)} = 2.941\ in$

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(7.649 \cdot 10^{3}\right) ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p} \right) \right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = \left(1.946 \cdot 10^3 \right) \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = \left(1.751 \cdot 10^3 \right) \; kip \cdot ft$$

$$\begin{cases} \text{"OK"} & \text{if } M_{max} < \phi M_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 306 \; kip$$

$$\begin{cases} \text{"OK"} & \text{if } V_{max} < \phi V_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Serviceability Check:

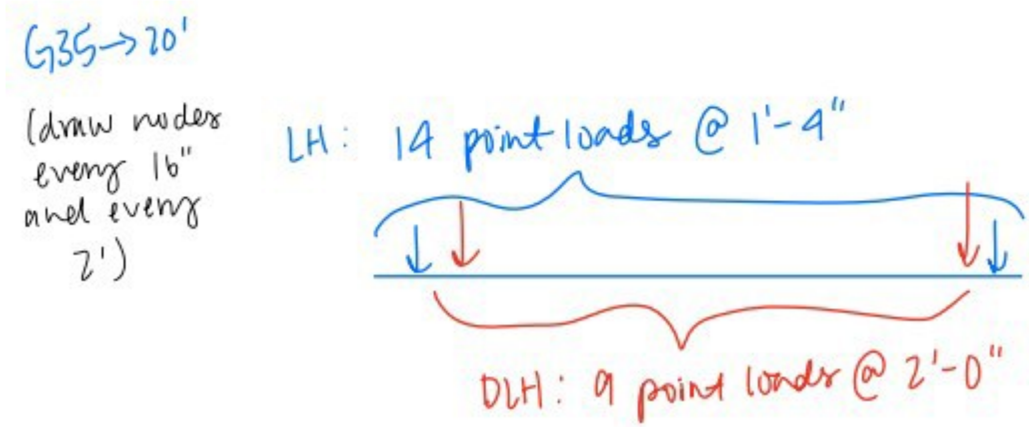
$$\Delta_{DL} := \frac{L_{G34}}{240} = 1.5 \; in$$

$$\begin{cases} \text{"OK"} & \text{if } \delta_{max} < \Delta_{DL} \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Girder 4: G4 = W33x130

G35: 20' Span

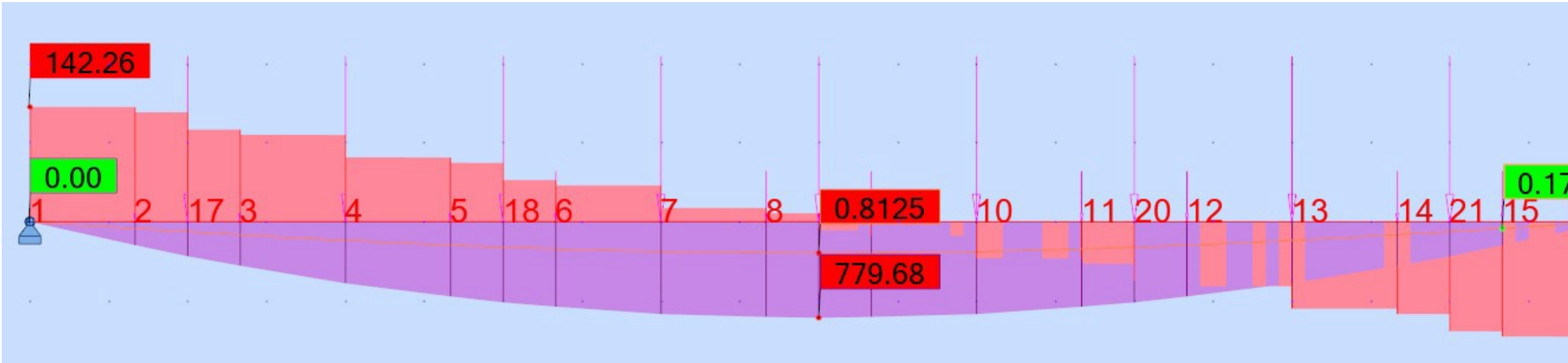
$P_{ijoistLH14} := R_{joistLH14} = 6535.5\ lbf$



$P_{ijoistDLH} := R_{joistDLH} = 21258.5\ lbf$

$L_{G35} := 20\ ft$ $\qquad$ $L_b := 1\ ft + 4\ in$

$1\ ft + 4\ in = 1.333\ ft$



Max Shear:

$V_{max} := 142.26\ kip$

Max Moment:

$M_{max} := 779.28\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 0.8125\ in$

Flexure Check:

$L_p := 6.89\ ft$

$\phi M_p := 840\ kip \cdot ft$

A992:

W24x84: Dimensions

$F_y := 50\ ksi$

$Z_x := 224\ in^3$

$E := 29000\ ksi$

$L_r := 20.3\ ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 933.333\ kip \cdot ft$

$S_x := 196\ in^3$

$F_u := 65\ ksi$

$I_y := 94.4\ in^4$

$\phi := 0.9$

$C_w := 12800\ in^6$

$h_o := 23.3\ in$

$J := 3.70\ in^4$

$c := 1$

if $L_b \le L_p$
 "YIELDING"
else if $L_p < L_b \le L_r$
 "INELASTIC"
else
 "ELASTIC"

= "YIELDING"

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 2.368\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(6.279 \cdot 10^3\right)\ ksi$$

$$M_n := \text{if } L_b \le L_p \;\|\; F_y \cdot Z_x \;\text{else if } L_p < L_b \le L_r \;\|\; C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right) \;\text{else} \;\|\; F_{cr} \cdot S_x = 933.333 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 840 \; kip \cdot ft$$

$$\text{if } M_{max} < \phi M_n \;\|\; \text{else} \;\|\; \text{"REVISE DESIGN"} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 340 \; kip$$

$$\text{if } V_{max} < \phi V_n \;\|\; \text{"OK"} \;\text{else} \;\|\; \text{"REVISE DESIGN"} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G35}}{240} = 1 \; in$$

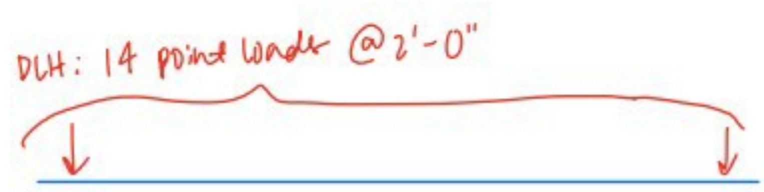
$$\text{if } \delta_{max} < \Delta_{DL} \;\|\; \text{else} \;\|\; \text{"REVISE DESIGN"} = \text{"OK"}$$

Girder 5: G5 = W24x84

G36: 30' Span

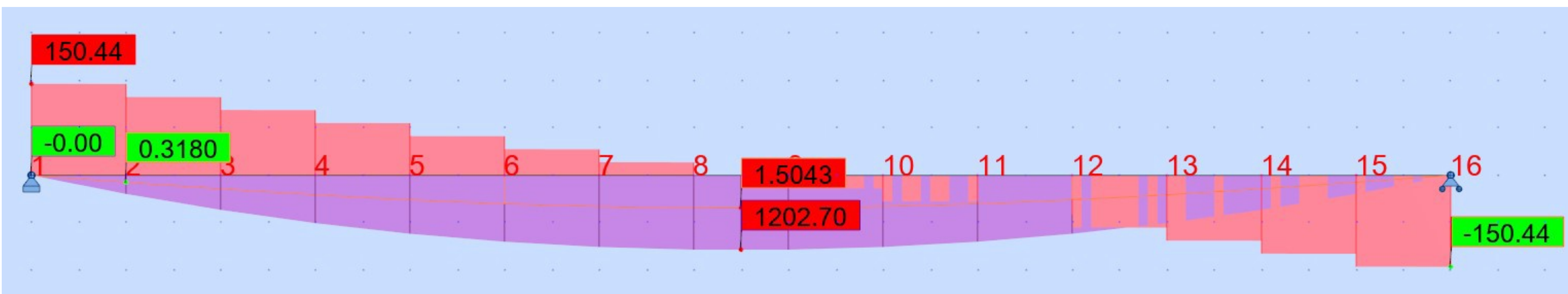
G36→30'

$P_{ijoistDLH16} := R_{joistDLH} = 21258.5\ lbf$



$L_{G36} := 30\ ft$

$L_b := 2\ ft$



Max Shear:

$V_{max} := 150.44\ kip$

Max Moment:

$M_{max} := 1202.70\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 1.50\ in$

Flexure Check:

$L_p := 6.89\ ft$

$\phi M_p := 840\ kip \cdot ft$

A992:

W30x108: Dimensions

$L_r := 20.3\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 224\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 933.333\ kip \cdot ft$

$S_x := 196\ in^3$

$F_u := 65\ ksi$

$I_y := 94.4\ in^4$

$\phi := 0.9$

$C_w := 12800\ in^6$

$h_o := 23.3\ in$

$J := 3.70\ in^4$

$c := 1$

if $L_b \le L_p$
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

= "YIELDING"

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 2.368\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(2.796 \cdot 10^3\right) ksi$$

$$M_n := \text{if } L_b \le L_p \;\; \| F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\; \| C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right) \;\; \text{else} \;\; \| F_{cr} \cdot S_x = 933.333 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 840 \; kip \cdot ft$$

if $M_{max} < \phi M_n$ ‖ else ‖ "REVISE DESIGN" = "REVISE DESIGN"

Shear Check:

$$\phi V_n := 487 \; kip$$

if $V_{max} < \phi V_n$ ‖ "OK" else ‖ "REVISE DESIGN" = "OK"

Serviceability Check:

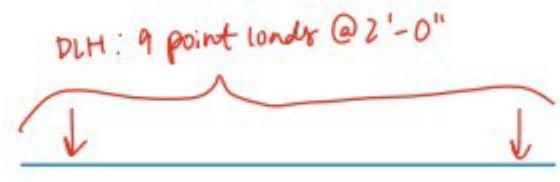
$$\Delta_{DL} := \frac{L_{G36}}{240} = 1.5 \; in$$

if $\delta_{max} < \Delta_{DL}$ ‖ else ‖ "REVISE DESIGN" = "OK"

Girder 6: G6 = W30x108

G37: 20' Span

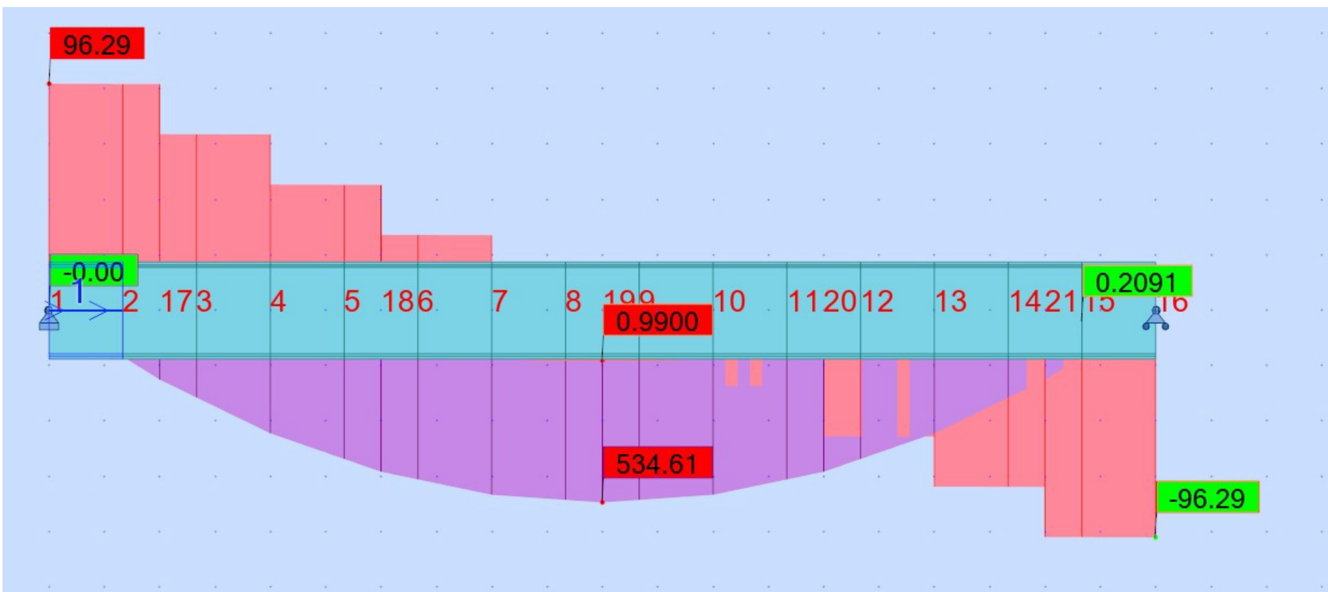
G37 → 20'



$P_{ijoistDLH16} := R_{joistDLH} = 21258.5\ lbf$

$L_{G37} := 20\ ft$ $\qquad L_b := 2\ ft$

W21x62



Max Shear: $V_{max} := 96.29\ kip$

Max Moment: $M_{max} := 534.61\ kip \cdot ft$

Max Deformation: $\delta_{max} := 0.9900\ in$

Flexure Check:

$L_p := 6.25\ ft$

$\phi M_p := 540\ kip \cdot ft$

A992:

W21x62: Dimensions

$L_r := 18.1\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 144\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 600\ kip \cdot ft$

$S_x := 127\ in^3$

$F_u := 65\ ksi$

$I_y := 57.5\ in^4$

$\phi := 0.9$

$C_w := 5960\ in^6$

if $L_b \le L_p$ = "YIELDING"
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

$h_o := 20.4\ in$

$J := 1.83\ in^4$

$c := 1$

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 2.147\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(2.298 \cdot 10^3\right)\ ksi$$

$$M_n := \text{if } L_b \le L_p \;\|\; F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\|\; C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right) \;\; \text{else} \;\|\; F_{cr} \cdot S_x = 600 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 540 \; kip \cdot ft$$

$$\text{if } M_{max} < \phi M_n \;\|\; \text{else} \;\|\; \text{“REVISE DESIGN”} = \text{“OK”}$$

Shear Check:

$$\phi V_n := 252 \; kip$$

$$\text{if } V_{max} < \phi V_n \;\|\; \text{“OK”} \;\; \text{else} \;\|\; \text{“REVISE DESIGN”} = \text{“OK”}$$

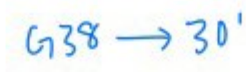
Serviceability Check:

$$\Delta_{DL} := \frac{L_{G37}}{240} = 1 \; in$$

$$\text{if } \delta_{max} < \Delta_{DL} \;\|\; \text{else} \;\|\; \text{“REVISE DESIGN”} = \text{“OK”}$$

Girder 7: G7 = W21x62

G38: 30' Span



$L_{G8} := 20\ ft$ $\quad L_b := 2\ ft$

$D := 63\ psf$ $\quad L_{assembly} := 100\ psf$

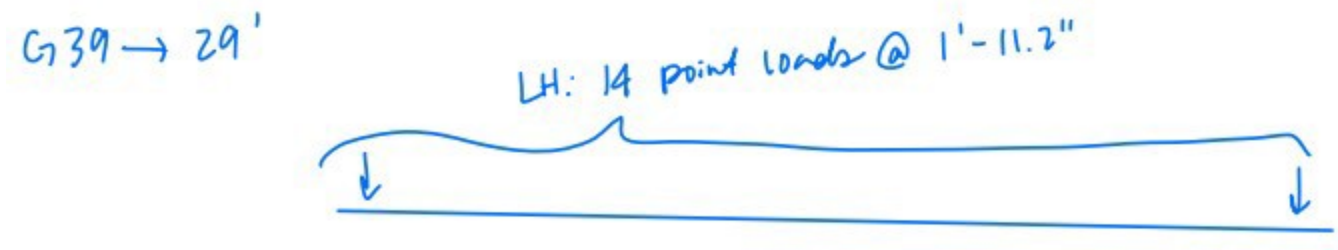
Maximum area load on roof:

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$TW := 1\ ft$

$w_u := q_u \cdot TW = 0.2356\ klf$

G39: 29' Span



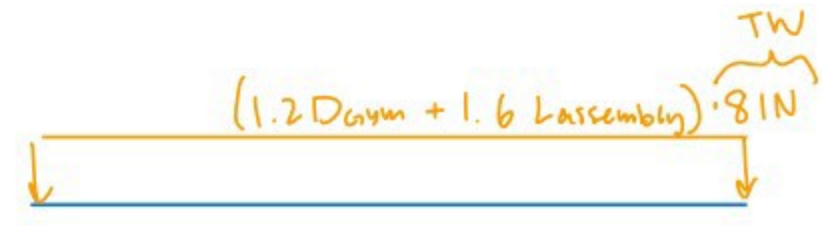
$P_{ijoistLH2} := R_{joistLH2} = 7194\ lbf$

$L_{G9} := 29\ ft$ $L_b := 1\ ft + 11.2\ in$

G310: 20' Span

$L_{G10} := 20\ ft$ $\qquad L_b := 20\ ft$

G310 → 20'



$D := 63\ psf$ $\qquad L_{assembly} := 100\ psf$

Maximum area load on roof:

$$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$$

$$TW := \frac{1\ ft + 4\ in}{2} = 0.667\ ft$$

$$w_u := q_u \cdot TW = 0.15707\ klf$$

G311: 10' Span

G311 → 10'

$L_{G11} := 10\ ft$ $\qquad$ $L_b := 10\ ft$

$D := 63\ psf$ $\qquad$ $L_{assembly} := 100\ psf$

Maximum area load on roof:

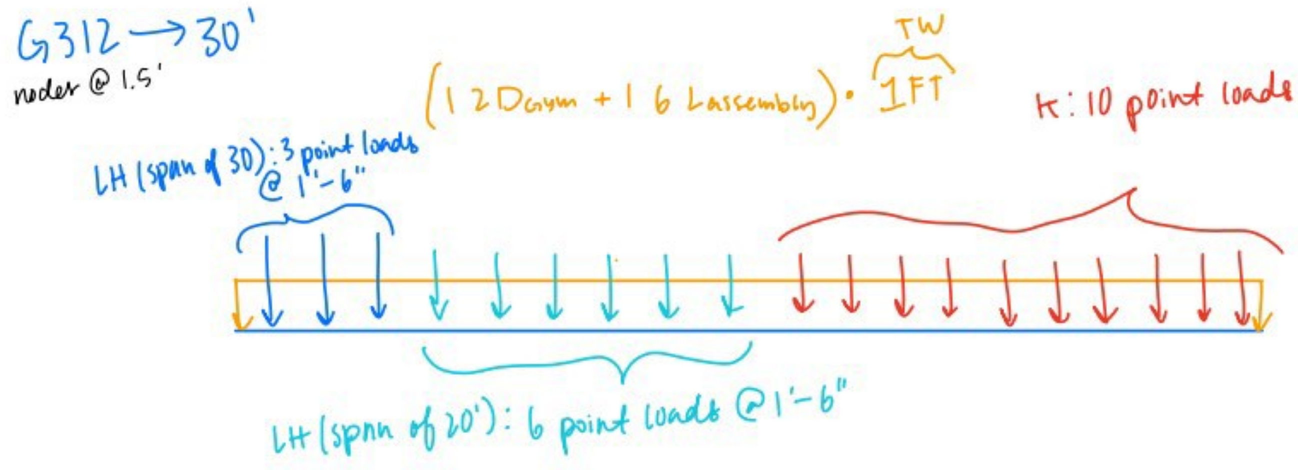
$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$TW := \dfrac{1\ ft + 6\ in}{2} = 9\ in$

$w_u := q_u \cdot TW = 0.1767\ klf$

G312: 30' Span

$L_{G312} := 30\ ft$ $L_b := 1.5\ ft$



$P_{ijoistLH16} := R_{joistLH1630ft} = 7252.5\ lbf$

$P_{ijoistk} := R_{joistk} = \left(\left(1.793 \cdot 10^{3}\right)\right)\ lbf$

$R_{joistLH1620ft} = \left(\left(4.835 \cdot 10^{3}\right)\right)\ lbf$

$L_{G312} := 30\ ft$ $L_b := 1\ ft + 6\ in$

$1\ ft + 6\ in = 1.5\ ft$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$TW := 1\ ft = 12\ in$

$w_u := q_u \cdot TW = 0.2356\ klf$

Max Shear:

$V_{max} := 48.46\ kip$

Max Moment:

$M_{max} := 292.19\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 1.3961\ in$

Flexure Check:

$L_p := 6.11\ ft$

$\phi M_p := 473\ kip \cdot ft$

A992:

W21x55: Dimensions

$F_y := 50\ ksi$

$Z_x := 126\ in^3$

$E := 29000\ ksi$

$L_r := 17.4\ ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 525\ kip \cdot ft$

$S_x := 110\ in^3$

$F_u := 65\ ksi$

$I_y := 48.4\ in^4$

$\phi := 0.9$

$C_w := 4980\ in^6$

if $L_b \le L_p$
"YIELDING"
else if $L_p < L_b \le L_r$
"INELASTIC"
else
"ELASTIC"

= "YIELDING"

$h_o := 20.3\ in$

$J := 1.83\ in^4$

$c := 1$

Assume:

$C_b := 1.0$

$$r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 2.113\ in$$

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(3.952 \cdot 10^3\right)\ ksi$$

(r_{ts})

$$M_n := \text{if } L_b \le L_p \;\; \| F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\; \| C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right) \;\; \text{else} \;\; \| F_{cr} \cdot S_x = 525 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 472.5 \; kip \cdot ft$$

if $M_{max} < \phi M_n$ = "OK"
‖
else
‖"REVISE DESIGN"

Shear Check:

$$\phi V_n := 234 \; kip$$

if $V_{max} < \phi V_n$ = "OK"
‖"OK"
else
‖"REVISE DESIGN"

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G312}}{240} = 1.5 \; in$$

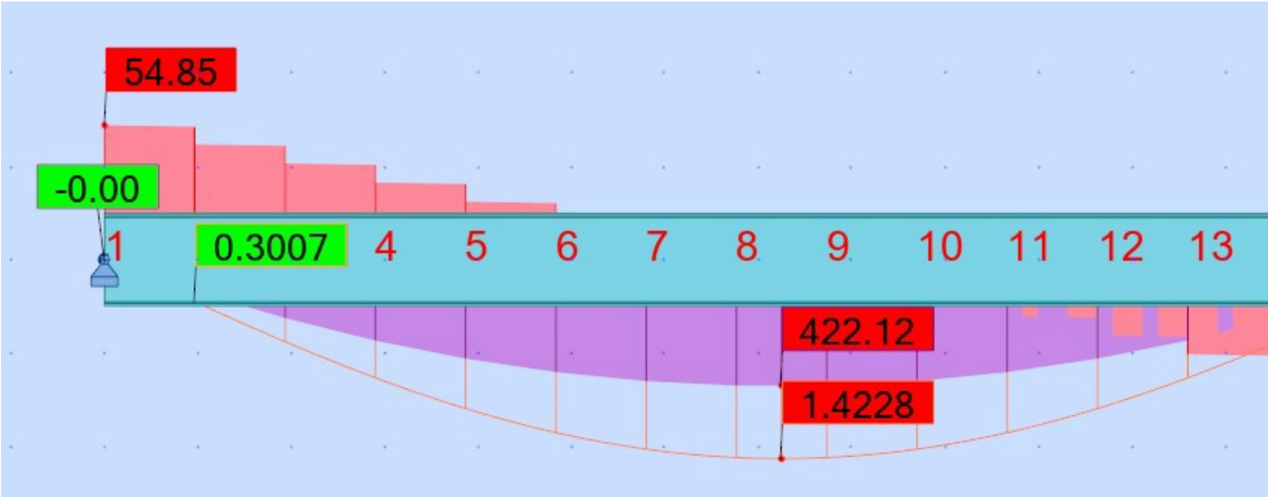
if $\delta_{max} < \Delta_{DL}$ = "OK"
‖
else
‖"REVISE DESIGN"

Girder 12: G12 = W21x55

G313: 29' Span

$L_{G313} := 29\ ft$ $\quad L_b := 1\ ft + 11.2\ in$ $\quad x := 1\ ft + 11.2\ in = 1.933\ ft$

$P_{ijoistLH2} := R_{joistLH2} = 7194\ lbf$



$D := 63\ psf$ $\quad L_{assembly} := 100\ psf$

Maximum area load on roof:

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$TW := 1\ ft = 1\ ft$

$w_u := q_u \cdot TW = 0.2356\ klf$

Max Shear:

$V_{max} := 54.85\ kip$

Max Moment:

$M_{max} := 422.12\ kip \cdot ft$

Max Deformation:

$\delta_{max} := 1.4228\ in$

Flexure Check:

$L_p := 4.87\ ft$

$\phi M_p := 574\ kip \cdot ft$

A992:

W24x62: Dimensions

$F_y := 50\ ksi$

$Z_x := 153\ in^3$

$E := 29000\ ksi$

$L_r := 14.4\ ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 637.5\ kip \cdot ft$

$S_x := 131\ in^3$

$F_u := 65\ ksi$

$I_y := 34.5\ in^4$

$\phi := 0.9$

$C_w := 4620\ in^6$

if $L_b \leq L_p$
  "YIELDING"
else if $L_p < L_b \leq L_r$
  "INELASTIC"
else
  "ELASTIC"

= "YIELDING"

$h_o := 23.1\ in$

$J := 1.71\ in^4$

$c := 1$

Assume:

$C_b := 1.0$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.746\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(1.627 \cdot 10^3\right) ksi$$

$$M_n := \text{if } L_b \le L_p \;\; \| F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\; \| C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\frac{L_b - L_p}{L_r - L_p} \right) \right) \;\; \text{else} \;\; \| F_{cr} \cdot S_x = 637.5 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 573.75 \; kip \cdot ft$$

$$\text{if } M_{max} < \phi M_n \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 306 \; kip$$

$$\text{if } V_{max} < \phi V_n \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G313}}{240} = 1.45 \; in$$

$$\text{if } \delta_{max} < \Delta_{DL} \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} = \text{"OK"}$$

Girder 13: G12 = W24x62

Second Floor Design:

SECOND FLOOR: (NORTH) 30 FT Span

$D := 70 \; psf$

$TW := 1.5 \; ft$

$L_{assembly} := 100 \; psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244 \; psf$

$w_u := TW \cdot q_u = 366 \; plf$ <- STRENGTH

$w_{SW} := 8.6 \; plf$

$w_{userv} := TW \cdot L_{assembly} = 150 \; plf$ <- SERVICEAB

K Series: 16K7
Weight: 8.6 PLF
Capacity:
(serviceability): 151 PLF
(strength): 444 PLF

$w_{maxstrength} := 444 \; plf$

$w_{maxserv} := 151 \; plf$

if $w_u + w_{SW} < w_{maxstrength}$
  "OK"
  "REVISE DESIGN"
= "OK"

if $w_{userv} < w_{maxserv}$
  "OK"
else
  "REVISE DESIGN"
= "OK"

10 FT SPAN: 8K1
Weight: 5.1 plf
Depth: 8 in

$w_{SW} := 5.1\ plf$

$w_{maxkseries} := 480\ plf$

$$\text{if } w_{userv} + w_{SW} < w_{maxkseries} = \text{"OK"}$$
$$\quad \text{"OK"}$$
$$\quad \text{"REVISE DESIGN"}$$

EAST FLOOR: (EAST) SPAN: 30 FT

$D := 70\ psf$

$TW := 2\ ft$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$

$w_u := TW \cdot q_u = 488\ plf$ <- STRENGTH

$w_{userv} := TW \cdot L_{assembly} = 200\ plf$ <- SERVICEABILITY

$w_{SW} := 10.1\ plf$

K Series: 18K9
Weight: 10.1 PLF
Capacity:
(serviceability): 229 PLF
(strength): 603 PLF

$w_{maxstrength} := 603\ plf$

$w_{maxserv} := 229\ plf$

$$\text{if } w_u + w_{SW} < w_{maxstrength} \;\Big\|\; \text{"OK"} \;\; \Big\|\; \text{"REVISE DESIGN"} \quad = \text{"OK"}$$

$$\text{if } w_{userv} < w_{maxserv} \;\Big\|\; \text{"OK"} \;\; \text{else} \;\Big\|\; \text{"REVISE DESIGN"} \quad = \text{"OK"}$$

$= 23.2\ in$ $24\ in - 23.2\ in = 0.8\ in$ 29 FT Ba

$29\ ft$

15

$23.2\ in - 12\ in = 11.2\ in$ Spac

$= 22.4\ in$ $24\ in - 22.4\ in = 1.6\ in$ 28 FT Ba

$28\ ft$

15

$22.4\ in - 12\ in = 10.4\ in$ Spac

SECOND FLOOR GIRDER DESIGN

Reaction Forces for joists: **16K7**

K Series: Spaced at 1' - 4"

$w_{SWjoist} := 8.6\ plf$

$TW_{joist} := 1\ ft + 4\ in$

$D := 70\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 325.333\ plf$

Reactions:

$L := 30\ ft$

$R_{joist}\ L := \frac{w_{ujoist}}{2} \cdot L \rightarrow 166.96666666666667 \cdot L \cdot plf$

$R_{joist}\ L$

$= 5009\ lbf$

$R_{joistLH14} := R_{joist}\ L$ $= \left(\left(5.009 \cdot 10^{3}\right)\right)\ lbf$

Reaction Forces for joists: **16K7**

K Series: Spaced at 1' - 6"

$w_{SWjoist} := 8.6\ plf$

$TW_{joist} := 1\ ft + 6\ in$

$D := 70\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 366\ plf$

Reactions:

$L := \begin{bmatrix} 20\ ft \\ 30\ ft \end{bmatrix}$

$R_{joist}\ L := \frac{w_{ujoist}}{2} \cdot L \rightarrow 187.3 \cdot L \cdot plf$

$R_{joist}\ L\ 0$

$R_{joist}\ L\ 1 = 3746\ lbf$

$= 5619\ lbf$

$$R_{joistLH1620ft} := R_{joist}\ L\ 0 = \left(\left(3.746 \cdot 10^{3}\right)\right)\ lbf$$

$$R_{joistLH1630ft} := R_{joist}\ L\ 1 = \left(\left(5.619 \cdot 10^{3}\right)\right)\ lbf$$

Reaction Forces for joists: **18K9: East**

K Series: Spaced at 2' - 0"

$TW_{joist} := 2\ ft$

$w_{SWjoist} := 10.1\ plf$

$D := 63\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 235.6\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 471.2\ plf$

Reactions: $L := 30\ ft$

$R_{joist}\ L := \frac{w_{ujoist}}{2} \cdot L \rightarrow 240.65 \cdot L \cdot plf$

$R_{joist}\ L$

$= 7219.5\ lbf$

$$R_{joistLH2} := R_{joist\ L} = \left(\left(7.22 \cdot 10^{3}\right)\right) lbf$$

Reaction Forces for joists: **8K1**

K Series: Spaced at 1' - 6"

$w_{SWjoist} := 5.1\ plf$ $TW_{joist} := 1\ ft + 6\ in$

$D := 70\ psf$

$L_{assembly} := 100\ psf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$

$w_{SI} := q_u \cdot TW_{joist} = 366\ plf$

Reactions: $L := 10\ ft$

$R_{joist}\ L := \frac{w_{ujoist}}{2} \cdot L \rightarrow 185.55 \cdot L \cdot plf$

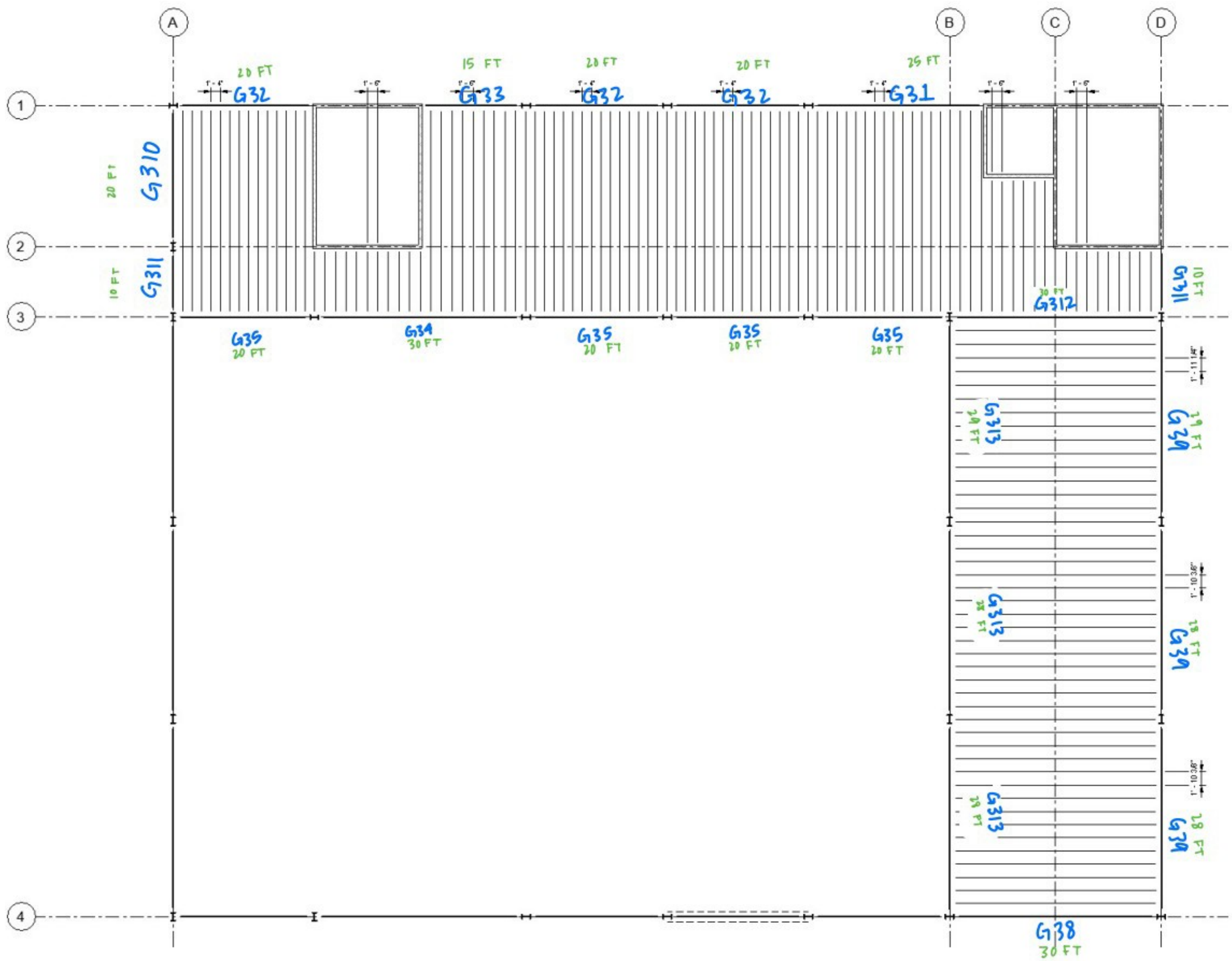
$R_{joist}\ L$

$= 1855.5\ lbf$

$$R_{joistk} := R_{joist} \quad L$$

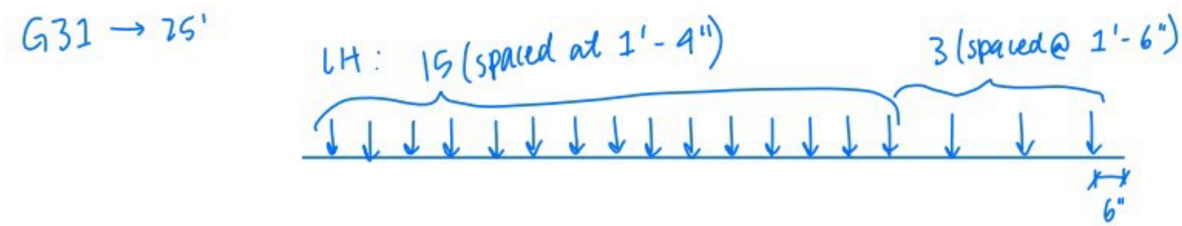
$$= \left(\left(1.856 \cdot 10^{3} \right) \right) \, lbf$$

SECOND FLOOR FRAMING PLAN:



G21: 25' Span

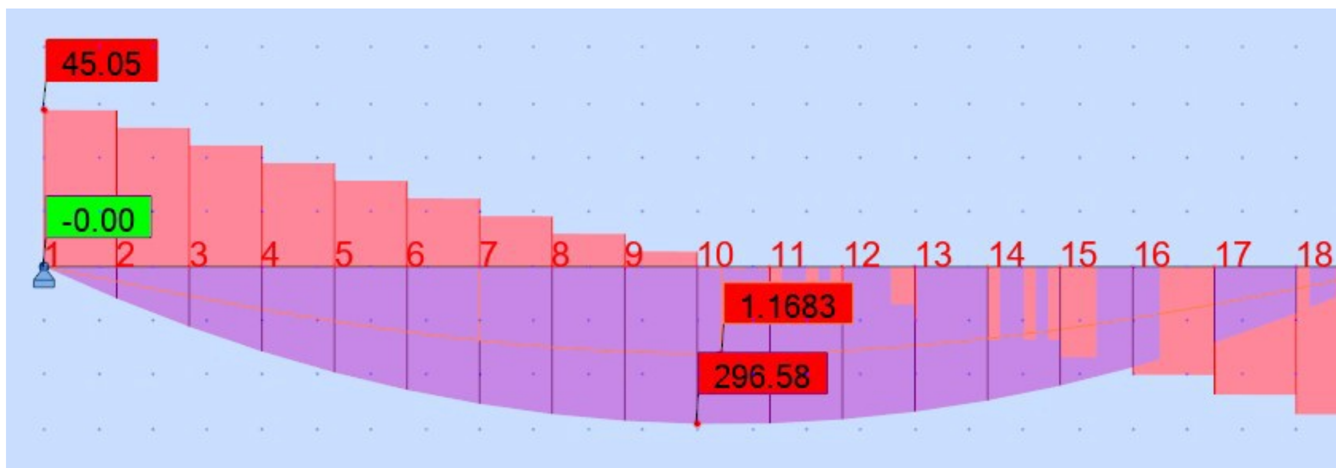
$P_{ijoistLH14} := R_{joistLH14} = 5009\ lbf$



$P_{ijoistLH16} := R_{joistLH1630ft} = 5619\ lbf$

$L_{G21} := 25\ ft$ $L_b := 1.5\ ft$

$w_{SWjoist} := 8.6\ plf$



$1\ ft + 4\ in = 1.33333333\ ft$

$1\ ft + 6\ in = 1.5\ ft$

$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \qquad \begin{bmatrix} 1.333 \\ 2.667 \\ 4 \end{bmatrix}$$

$$x := \begin{bmatrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ \vdots \end{bmatrix} \qquad 1.33333333 \cdot x = \begin{bmatrix} 5.333 \\ 6.667 \\ 8 \\ 9.333 \\ 10.667 \\ 12 \\ 13.333 \\ 14.667 \\ 16 \\ 17.333 \\ 18.667 \\ 20 \end{bmatrix}$$

$V_{max} := 48.19\ kip$

$M_{max} := 296.58\ kip \cdot ft$

$\delta_{max} := 1.1683\ in$

Flexure Check:

$L_p := 4.59\ ft$

$\phi M_p := 413\ kip \cdot ft$

A992:

W21x50: Dimensions

$L_r := 13.6\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 110\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 458.333\ kip \cdot ft$

$S_x := 94.5\ in^3$

$F_u := 65\ ksi$

$I_y := 24.9\ in^4$

$\phi := 0.9$

$C_w := 2570\ in^6$

if $L_b \le L_p$
"YIELDING"
else if $L_p < L_b \le L_r$
"INELASTIC"
else
"ELASTIC"

= "YIELDING"

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(2.371 \cdot 10^3\right)\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p}\right)\right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 458.333 \ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 412.5 \ kip \cdot ft$$

$$\begin{cases} & \text{if } M_{max} < \phi M_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 237 \ kip$$

$$\begin{cases} \text{"OK"} & \text{if } V_{max} < \phi V_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G21}}{240} = 1.25 \ in$$

$$\begin{cases} & \text{if } \delta_{max} < \Delta_{DL} \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Girder 21: G21 = W21x50

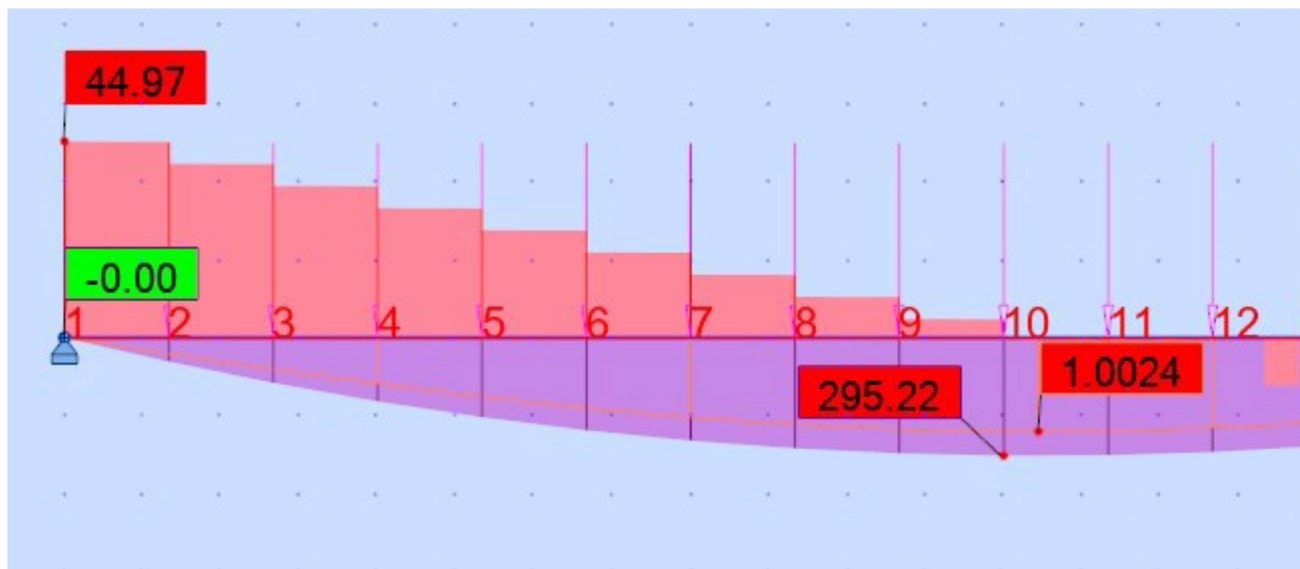
G22: 20' Span

$P_{ijoistLH14} := R_{joistLH14} = 5009\ lbf$

$L_{G22} := 20\ ft$ $\quad L_b := 1\ ft + 4\ in$

$1\ ft + 4\ in = 1.333\ ft$

$$x := \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{bmatrix} \qquad 1.33333333 \cdot x = \begin{bmatrix} 1.333 \\ 2.667 \\ 4 \\ 5.333 \\ 6.667 \\ 8 \\ 9.333 \\ 10.667 \\ 12 \\ 13.333 \\ 14.667 \\ 16 \end{bmatrix}$$



$$\begin{bmatrix} \vdots \end{bmatrix}$$

$$\begin{bmatrix} 17.333 \\ 18.667 \\ 20 \end{bmatrix}$$

$V_{max} := 46.57\ kip$ $M_{max} := 295.22\ kip \cdot ft$ $\delta_{max} := 1.00\ in$

Flexure Check:

$L_p := 6.11\ ft$

$L_r := 17.4\ ft$

$\phi M_p := 473\ kip \cdot ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 525\ kip \cdot ft$

$\phi := 0.9$

A992:

$F_y := 50\ ksi$

$F_u := 65\ ksi$

W21x55: Dimensions

$Z_x := 126\ in^3$

$S_x := 94.5\ in^3$

$E := 29000\ ksi$

$I_y := 24.9\ in^4$

$C_w := 2570\ in^6$

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

if $L_b \le L_p$ = "YIELDING"
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(3 \cdot 10^3\right)\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p}\right)\right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 525\ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 472.5\ kip \cdot ft$$

$$\begin{cases} \text{"OK"} & \text{if } M_{max} < \phi M_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 234\ kip$$

$$\begin{cases} \text{"OK"} & \text{if } V_{max} < \phi V_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G22}}{240} = 1\ in$$

$$\begin{cases} & \text{if } \delta_{max} < \Delta_{DL} \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"REVISE DESIGN"}$$

Girder 22: G22 = W21x55

G23: 15' Span

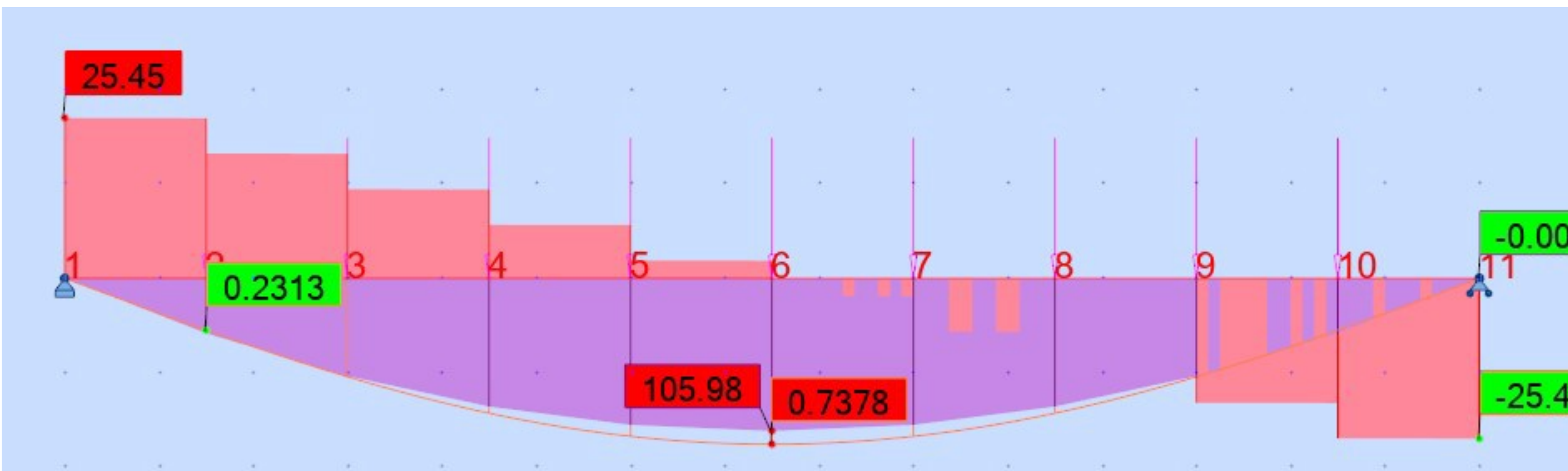
$P_{ijoistLH16} := R_{joistLH1630ft} = 5619\ lbf$

G33 → 15'

$L_{G23} := 15\ ft$

$L_b := 1\ ft + 6\ in$

$1\ ft + 6\ in = 1.5\ ft$



$V_{max} := 25.45\ kip$

$M_{max} := 105.98\ kip \cdot ft$

$\delta_{max} := 0.7378\ in$

Flexure Check:

$L_p := 3.67\ ft$

$L_r := 10.4\ ft$

$\phi M_p := 125\ kip \cdot ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 138.333\ kip \cdot ft$

$\phi := 0.9$

A992:

$F_y := 50\ ksi$

$F_u := 65\ ksi$

W14x22: Dimensions

$Z_x := 33.2\ in^3$

$S_x := 94.5\ in^3$

$E := 29000\ ksi$

$I_y := 24.9\ in^4$

$C_w := 2570\ in^6$

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

if $L_b \le L_p$
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else

= "YIELDING"

"ELASTIC"

Assume:

$C_b := 1.0$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(2.371 \cdot 10^{3}\right)\ ksi$$

$$M_n := \begin{cases} \text{if } L_b \le L_p & F_y \cdot Z_x \\ \text{else if } L_p < L_b \le L_r & C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p}\right)\right) \\ \text{else} & F_{cr} \cdot S_x \end{cases} = 138.333\ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 124.5\ kip \cdot ft$$

$$\begin{array}{l} \text{if } M_{max} < \phi M_n \\ \quad \| \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 94.5\ kip$$

$$\begin{array}{l} \text{if } V_{max} < \phi V_n \\ \quad \| \text{"OK"} \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} = \text{"OK"}$$

Serviceability Check:

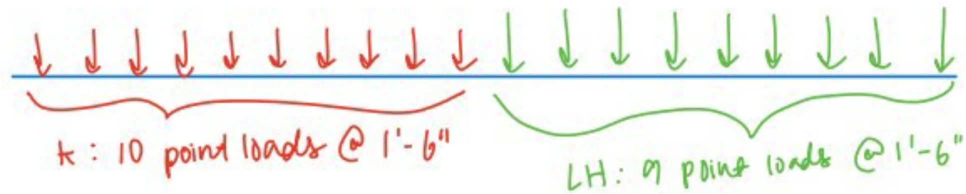
$$\Delta_{DL} := \frac{L_{G23}}{240} = 0.75\ in$$

$$\begin{array}{l} \text{if } \delta_{max} < \Delta_{DL} \\ \quad \| \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} = \text{"OK"}$$

Girder 23: G23 = W14x22

G24: 30' Span

G34 → 30'

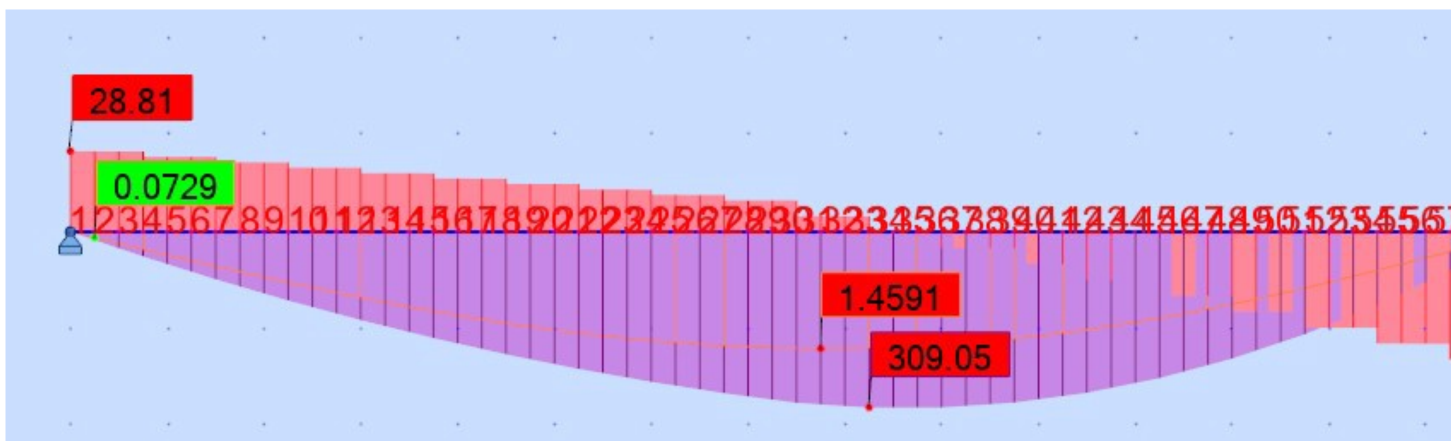


$P_{ijoistLH16} := R_{joistLH1630ft} = 5619\ lbf$

$P_{ijoistk} := R_{joistk} = 1855.5\ lbf$

$L_{G24} := 30\ ft$ $\quad L_b := 1\ ft + 6\ in$

$1\ ft + 6\ in = 1.5\ ft$



$V_{max} := 45.74\ kip$ $M_{max} := 309.05\ kip \cdot ft$ $\delta_{max} := 1.4591\ in$

Flexure Check:

$L_p := 6.11\ ft$

$L_r := 17.4\ ft$

$\phi M_p := 473\ kip \cdot ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 525\ kip \cdot ft$

$\phi := 0.9$

A992:

$F_y := 50\ ksi$

$F_u := 65\ ksi$

W21x55: Dimensions

$Z_x := 126\ in^3$

$S_x := 94.5\ in^3$

$E := 29000\ ksi$

$I_y := 24.9\ in^4$

$C_w := 2570\ in^6$

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

if $L_b \le L_p$
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

= "YIELDING"

Assume:

$C_b := 1.0$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(2.371 \cdot 10^3\right)\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p} \right) \right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 525 \ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 472.5 \ kip \cdot ft$$

$$\begin{cases} \text{"OK"} & \text{if } M_{max} < \phi M_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 234 \ kip$$

$$\begin{cases} \text{"OK"} & \text{if } V_{max} < \phi V_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G24}}{240} = 1.5 \ in$$

$$\begin{cases} \text{"OK"} & \text{if } \delta_{max} < \Delta_{DL} \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Girder 24: G24 = W21x55

G25: 20' Span

$P_{ijoistLH14} := R_{joistLH14} = 5009\ lbf$

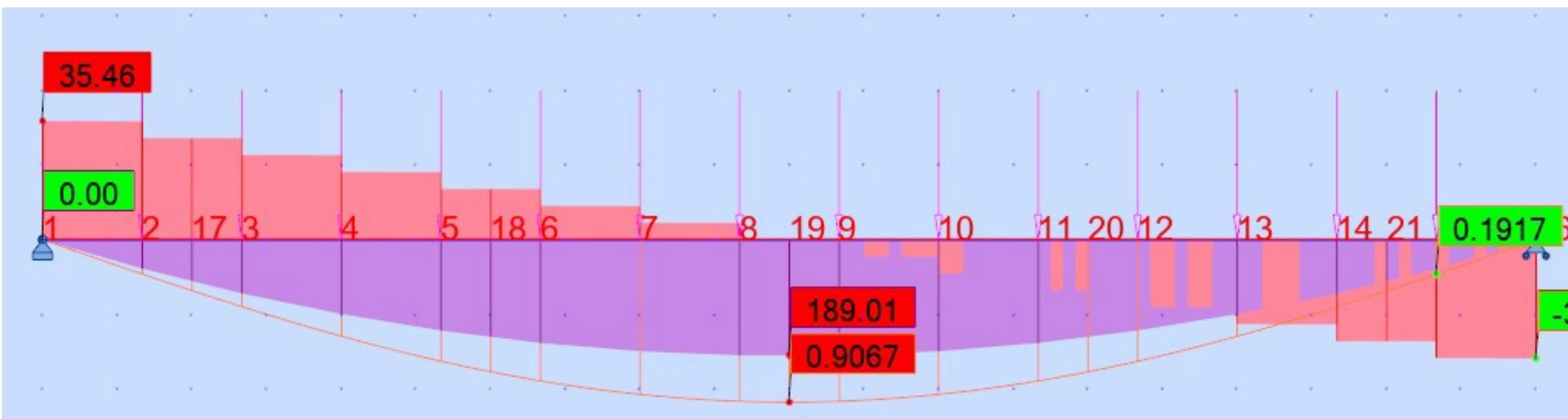
G35 → 20'

(draw nodes every 16" and every 2')

LH: 14 point loads @ 1'-4"

$L_{G25} := 20\ ft$ $\quad L_b := 1\ ft + 4\ in$

$1\ ft + 4\ in = 1.333\ ft$



Non-Commercial Use Only

$V_{max} := 35.46\ kip$

$M_{max} := 189.01\ kip \cdot ft$

$\delta_{max} := 0.9067\ in$

Flexure Check:

$L_p := 5.55\ ft$

$\phi M_p := 274\ kip \cdot ft$

A992:

W16x40: Dimensions

$L_r := 15.9\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 73.0\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 304.167\ kip \cdot ft$

$S_x := 94.5\ in^3$

$F_u := 65\ ksi$

$I_y := 24.9\ in^4$

$\phi := 0.9$

$C_w := 2570\ in^6$

if $L_b \le L_p$ = "YIELDING"
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{\left(L_b\right)}{r_{ts}}\right)^2} = \left(3 \cdot 10^3\right)\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p} \right) \right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 304.167 \ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 273.75 \ kip \cdot ft$$

$$\begin{cases} \text{“OK”} & \text{if } M_{max} < \phi M_n \\ \text{“REVISE DESIGN”} & \text{else} \end{cases} = \text{“OK”}$$

Shear Check:

$$\phi V_n := 146 \ kip$$

$$\begin{cases} \text{“OK”} & \text{if } V_{max} < \phi V_n \\ \text{“REVISE DESIGN”} & \text{else} \end{cases} = \text{“OK”}$$

Serviceability Check:

$$\varDelta_{DL} := \frac{L_{G25}}{240} = 1 \ in$$

$$\begin{cases} \text{“OK”} & \text{if } \delta_{max} < \varDelta_{DL} \\ \text{“REVISE DESIGN”} & \text{else} \end{cases} = \text{“OK”}$$

Girder 25: G25 = W16x40

G28: 29' Span

$L_{G28} := 29\ ft$ $L_b := 29\ ft$ $I_x := 103\ in^4$

$$M_{max} := \frac{\left(\left(16\ plf \cdot 29\ ft^2\right)\right)}{2} = 6.728\ kip \cdot ft$$

$$V_{max} := \frac{16\ plf \cdot 29\ ft}{2} = 232\ lbf$$

$$\delta_{max} := \frac{\left(\left(5 \cdot 16\ plf \cdot 29\ ft^4\right)\right)}{384 \cdot E \cdot I_x} = 0.085\ in$$

Flexure Check:

$L_p := 2.73\ ft$

$L_r := 8.05\ ft$

$\phi M_p := 75.4\ kip \cdot ft$

Plastic Moment:

$M_p := F_y \cdot Z_x = 83.75\ kip \cdot ft$

$\phi := 0.9$

A992:

$F_y := 50\ ksi$

$F_u := 65\ ksi$

W12x16: Dimensions

$Z_x := 20.1\ in^3$

$S_x := 17.1\ in^3$

$E := 29000\ ksi$

$I_y := 2.82\ in^4$

$C_w := 96.9\ in^6$

$h_o := 11.7\ in$

$J := 1.03\ in^4$

$c := 1$

if $L_b \le L_p$ = "ELASTIC"
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 0.983\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = 16.365\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p} \right) \right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 23.32\ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 20.988\ kip \cdot ft$$

$$\begin{cases} \text{“OK”} & \text{if } M_{max} < \phi M_n \\ \text{“REVISE DESIGN”} & \text{else} \end{cases} = \text{“OK”}$$

Shear Check:

$$\phi V_n := 79.2\ kip$$

$$\begin{cases} \text{“OK”} & \text{if } V_{max} < \phi V_n \\ \text{“REVISE DESIGN”} & \text{else} \end{cases} = \text{“OK”}$$

Serviceability Check:

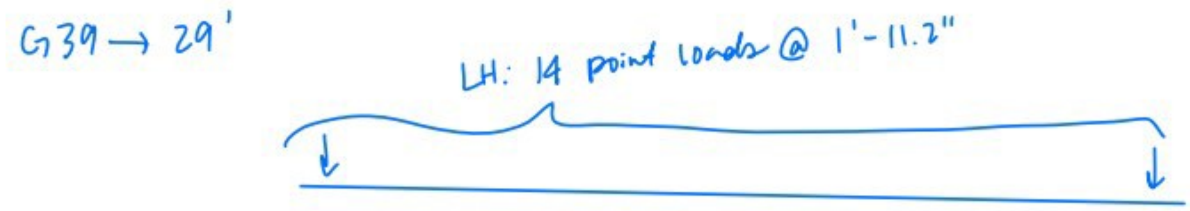
$$\Delta_{DL} := \frac{L_{G28}}{240} = 1.45\ in$$

$$\begin{cases} \text{“OK”} & \text{if } \delta_{max} < \Delta_{DL} \\ \text{“REVISE DESIGN”} & \text{else} \end{cases} = \text{“OK”}$$

Girder 28: G28 = W12x16

G29: 29' Span

$P_{ijoistLH2} := R_{joistLH2} = 7219.5\ lbf$



$L_{G29} := 29\ ft$ $L_b := 1\ ft + 11.2\ in$

$$\frac{29\ ft}{240} = 1.45\ in$$

G210: 20' Span

$L_{G210} := 20\ ft$ $\quad L_b := 20\ ft$

G310 → 20'

$D := 70\ psf$ $\quad L_{assembly} := 100\ psf$

Maximum area load on roof:

$$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$$

$$TW := \frac{1\ ft + 4\ in}{2} = 8\ in$$

$$w_u := q_u \cdot TW = 0.16267\ klf$$

G211: 10' Span

G311 → 10'

$L_{G211} := 10\ ft$ $L_b := 10\ ft$

$D := 70\ psf$ $L_{assembly} := 100\ psf$

Maximum area load on roof:

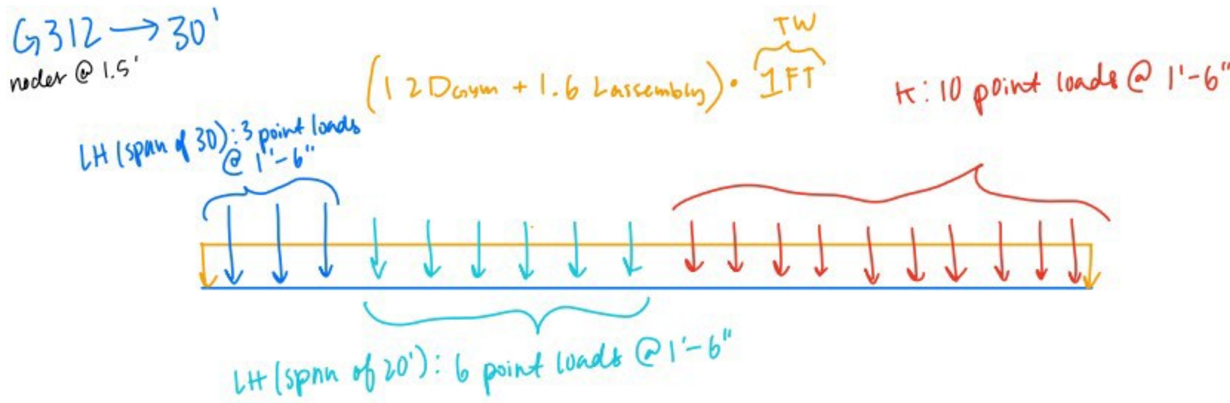
$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$

$TW := \dfrac{1\ ft + 6\ in}{2} = 9\ in$

$w_u := q_u \cdot TW = 0.183\ klf$

G212: 30' Span

$L_{G212} := 30\ ft$ $\quad L_b := 1.5\ ft$



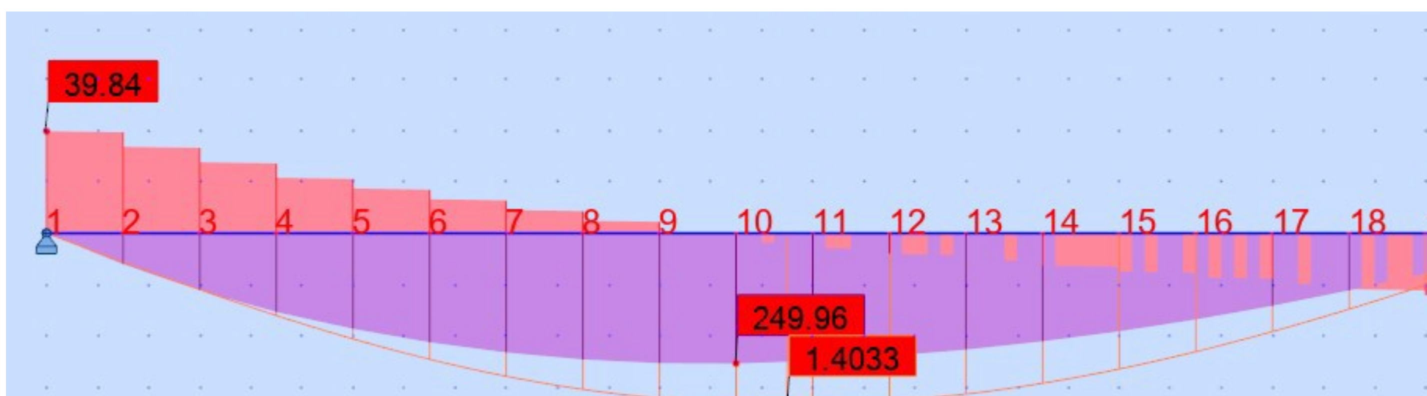
$P_{ijoistLH16} := R_{joistLH1630ft} = 5619\ lbf$

$P_{ijoistk} := R_{joistk} = \left(\left(1.856 \cdot 10^{3}\right)\right)\ lbf$

$R_{joistLH1620ft} = \left(\left(3.746 \cdot 10^{3}\right)\right)\ lbf$

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$

$TW := 1\ ft = 12\ in$



$w_u := q_u \cdot TW = 0.244 \ klf$

$V_{max} := 39.84 \ kip$ $M_{max} := 249.96 \ kip \cdot ft$ $\delta_{max} := 1.4033 \ in$

Flexure Check:

$L_p := 4.59\ ft$

$\phi M_p := 413\ kip \cdot ft$

A992:

W21x50: Dimensions

$L_r := 13.6\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 110\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 458.333\ kip \cdot ft$

$S_x := 94.5\ in^3$

$F_u := 65\ ksi$

$I_y := 24.9\ in^4$

$\phi := 0.9$

$C_w := 2570\ in^6$

if $L_b \le L_p$
"YIELDING"
else if $L_p < L_b \le L_r$
"INELASTIC"
else
"ELASTIC"

= "YIELDING"

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

Assume:

$C_b := 1.0$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(2.371 \cdot 10^3\right)\ ksi$$

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b \le L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\dfrac{L_b - L_p}{L_r - L_p}\right)\right) & \text{else if } L_p < L_b \le L_r \\ F_{cr} \cdot S_x & \text{else} \end{cases} = 458.333\ kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 412.5\ kip \cdot ft$$

$$\begin{cases} \text{"OK"} & \text{if } M_{max} < \phi M_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Shear Check:

$$\phi V_n := 237\ kip$$

$$\begin{cases} \text{"OK"} & \text{if } V_{max} < \phi V_n \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G212}}{240} = 1.5\ in$$

$$\begin{cases} \text{"OK"} & \text{if } \delta_{max} < \Delta_{DL} \\ \text{"REVISE DESIGN"} & \text{else} \end{cases} = \text{"OK"}$$

Girder 212: G212 = W21x50

G213: 29' Span

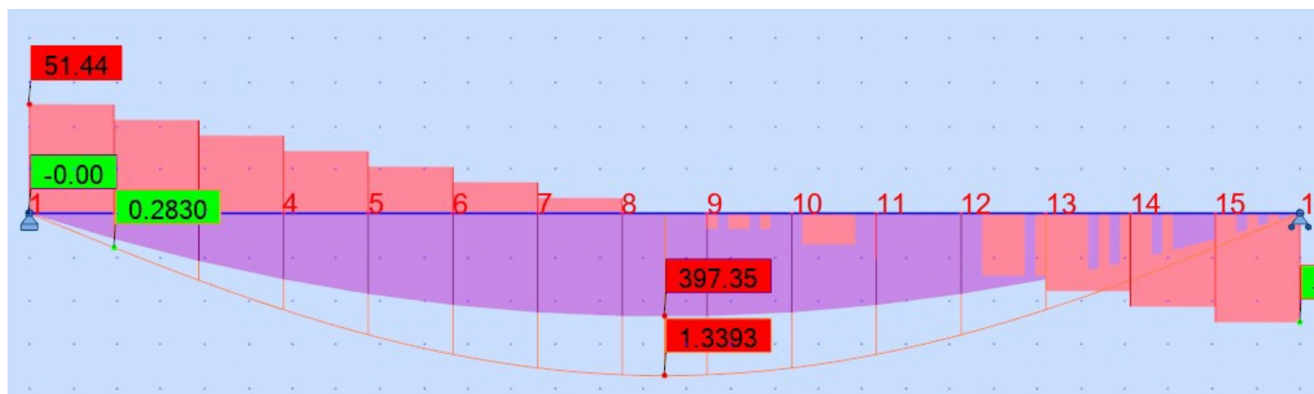
$L_{G213} := 29\ ft$ $\qquad L_b := 1\ ft + 11.2\ in$

$P_{ijoistLH2} := R_{joistLH2} = 7219.5\ lbf$

$D := 70\ psf$ $\qquad L_{assembly} := 100\ psf$

Maximum area load on roof:

$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$



$TW := 1\ ft = 1\ ft$

$w_u := q_u \cdot TW = 0.244\ klf$

$V_{max} := 39.84\ kip$ $M_{max} := 249.96\ kip \cdot ft$ $\delta_{max} := 1.4033\ in$

Flexure Check:

$L_p := 4.87\ ft$

$\phi M_p := 574\ kip \cdot ft$

A992:

W24x62: Dimensions

$L_r := 14.4\ ft$

Plastic Moment:

$F_y := 50\ ksi$

$Z_x := 153\ in^3$

$E := 29000\ ksi$

$M_p := F_y \cdot Z_x = 637.5\ kip \cdot ft$

$S_x := 94.5\ in^3$

$F_u := 65\ ksi$

$I_y := 24.9\ in^4$

$\phi := 0.9$

$C_w := 2570\ in^6$

$h_o := 20.3\ in$

$J := 1.14\ in^4$

$c := 1$

if $L_b \le L_p$
  "YIELDING"
else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

= "YIELDING"

Assume:

$$C_b := 1.0$$

$$r_{ts} := \sqrt{\left(\frac{\sqrt{\left(I_y \cdot C_w\right)}}{S_x}\right)} = 1.636\ in$$

$$F_{cr} := \frac{\left(C_b \cdot \pi^2 \cdot E\right)}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = \left(1.43 \cdot 10^3\right)\ ksi$$

$$M_n := \text{if } L_b \le L_p \;\; \| F_y \cdot Z_x \;\; \text{else if } L_p < L_b \le L_r \;\; \| C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x \right) \cdot \left(\frac{L_b - L_p}{L_r - L_p} \right) \right) \;\; \text{else} \;\; \| F_{cr} \cdot S_x = 637.5 \; kip \cdot ft$$

$$\phi M_n := \phi \cdot M_n = 573.75 \; kip \cdot ft$$

if $M_{max} < \phi M_n$ ‖ … else ‖ "REVISE DESIGN" = "OK"

Shear Check:

$$\phi V_n := 306 \; kip$$

if $V_{max} < \phi V_n$ ‖ "OK" else ‖ "REVISE DESIGN" = "OK"

Serviceability Check:

$$\Delta_{DL} := \frac{L_{G213}}{240} = 1.45 \; in$$

if $\delta_{max} < \Delta_{DL}$ ‖ … else ‖ "REVISE DESIGN" = "OK"

Girder 213: G213 = W24x62

Metal Deck Design: Third Floor

Superimposed Design Load, $øW_n$, / Deflection at L/360 (psf) LWC (110 pcf), f'_c = 3000 psi

Total Slab Depth	Deck Gage	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	12'-0"
3½"	22	1262/1410	797/722	544/417	392/263	293/176	225/123	176/90	113/52
	20	1480/1528	939/782	643/452	464/285	348/191	268/134	212/97	138/56
	19	1480/1634	1071/837	734/484	531/305	399/204	309/143	244/104	160/60
	18	1479/1723	1177/882	814/510	589/321	444/215	344/151	273/110	180/63
	16	1479/1904	1176/975	975/564	712/355	538/238	418/167	332/121	221/70
4"	22	1556/2088	983/1069	671/618	484/389	362/261	279/183	219/133	141/77
	20	1772/2260	1163/1157	796/669	576/421	432/282	334/198	264/144	172/83
	19	1772/2415	1330/1236	913/715	661/450	497/301	385/212	305/154	201/89
	18	1772/2546	1410/1303	1015/754	736/475	555/318	431/223	342/162	226/94
	16	1771/2811	1409/1439	1168/833	894/524	676/351	526/246	419/179	279/104
4¾"	22	2072/3463	1310/1773	896/1026	647/646	485/432	374/304	294/221	191/128
	20	2249/3745	1556/1917	1067/1109	772/698	581/468	450/328	356/239	233/138
	19	2249/3997	1785/2046	1226/1184	889/745	670/499	520/350	413/255	273/148
	18	2249/4213	1790/2157	1367/1248	993/786	749/526	583/369	463/269	308/156
	16	2248/4649	1789/2380	1483/1377	1213/867	918/581	715/408	571/297	382/172

Notes:
1. For high loads long term concrete creep should be considered.
2. Use Composite Deck-Slab Strength Web Based Solutions for alternate slabs or ASD design.

Section Properties

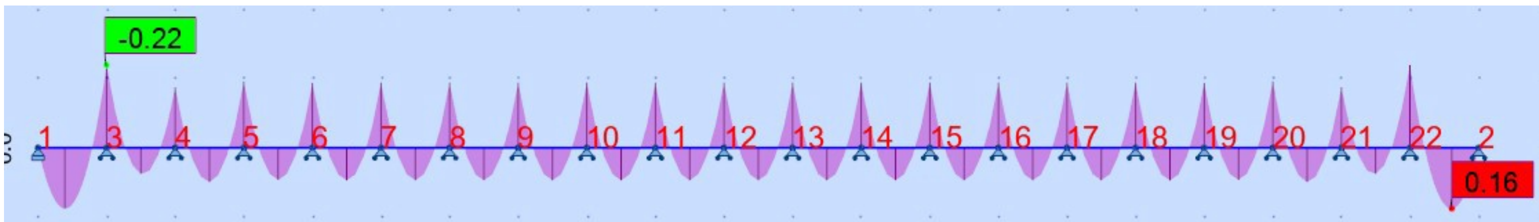
Deck Gage	Deck Weight w_{dd} (psf)	Base Metal Thickness t (in.)	Yield Strength F_y (ksi)	Effective Moment of Inertia at Service Load $I_d = (2I_e+I_g)/3$ I_d+ (in^4/ft)	I_d- (in^4/ft)	Effective Section Modulus at F_y = 50 ksi S_e+ (in^3/ft)	S_e- (in^3/ft)	Design Moment $øM_n+$ (lb-ft/ft)	$øM_n-$ (lb-ft/ft)	Vertical Web Shear $øV_n$ (lb/ft)
22	1.6	0.0295	50	0.155	0.178	0.169	0.179	634	671	4035
20	2.0	0.0358	50	0.197	0.217	0.224	0.229	840	859	4874
19	2.3	0.0418	50	0.239	0.257	0.266	0.278	997	1042	5666
18	2.6	0.0474	50	0.277	0.290	0.306	0.318	1148	1193	6398
16	3.3	0.0598	50	0.364	0.367	0.393	0.402	1474	1508	7996

Optional Features

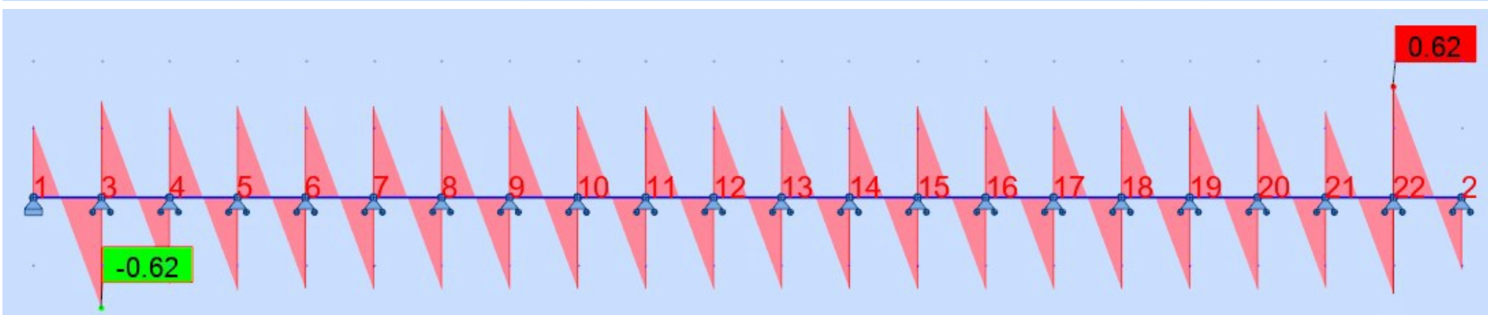
- Inquire regarding cost and lead times for:
  - -Short cuts < 6'-0"
  - -Sheet Lengths > 42'-0"
  - -Alternative metallic and painted finishes
- Factory Hanger Tabs

$$numberofsupports := \frac{42\,ft}{2\,ft} = 21$$

Moment:



Shear:



$M_{maxpos} := 160\ lbf \cdot ft$

$M_{posreq} := 840\ lbf \cdot ft$

Max Load on Third Floor Metal Deck:

$q_u := 1.2 \cdot 66\ psf + 1.6 \cdot 150\ psf = 319.2\ psf$

$M_{maxneg} := -220\ lbf \cdot ft$

$M_{negreq} := 859\ lbf \cdot ft$

$w_u := 1.5\ ft \cdot q_u = 478.8\ plf$

$V_{max} := 620\ lbf$

$V_{req} := 4874\ lbf$

```
if M_maxpos < M_posreq    = "OK"
    "OK"
else
    "REVISE DESIGN"
```

```
if M_maxneg < M_negreq    = "OK"
    "OK"
else
    "REVISE DESIGN"
```

```
if V_max < V_req    = "OK"
    "OK"
else
    "REVISE DESIGN"
```

Column Loads:

Third Floor Column

(Connecting Roof to Third Floor)

Roof Girder Reaction Forces:

$R_{G1} := 3.49\ kip$

$R_{G2} := 8.79\ kip$

$R_{G3} := 4.48\ kip$

$R_{G4} := 0.78\ kip$

$R_{G5} := 2.25\ kip$

$R_{G6} := 11.08\ kip$

3rd Floor Girder Reaction Forces:

$R_{G31} := 62.63\ kip$

$R_{G32} := 60.64\ kip$

$R_{G33} := 32.86\ kip$

$R_{G34} := 45.74\ kip$

$R_{G35} := 142.26\ kip$

$R_{G36} := 150.44\ kip$

2nd Floor Girder Reaction Forces:

$R_{G37} := 96.29\ kip$ $R_{G38} := 3.93\ kip$ R_{G39}

$:= 32.34\ kip$ $R_{G310} := 1.7\ kip$ $R_{G311} :=$

$0.85\ kip$ $R_{G312} := 48.46\ kip$ $R_{G313} :=$

$54.85\ kip$

$R_{G21} := 48.19\ kip$

$R_{G22} := 46.57\ kip$

$R_{G23} := 25.45\ kip$

$R_{G24} := 45.74\ kip$

$R_{G25} := 35.46\ kip$

$R_{G28} := 232\ lbf$

$R_{G29} := 51.06\ kip$

$R_{G210} := 1.78\ kip$

$R_{G211} := 1\ kip$

$R_{G212} := 39.84\ kip$

R $_2$

$_G$ $_1$ $_3 := 51.44\ kip$

Roof Joist Reactions:

$J_{18K4} := 1.5\ kip$

$J_{44LH09} := 4.25\ kip$

3rd Floor Joist Reactions:

$J_{third18K9} := 7.253\ kip$

$J_{20K6} := 7.194\ kip$

$J_{52DLH12} := 21.26\ kip$

2nd Floor Joist Reactions:

$J_{16K7} := 5.62\ kip$

$J_{second18K9} := 6.98\ kip$

Point Loads On Third Story Columns: 15 ft

W8x31
W8x31
W8x31

$A1 := R_{G3} + R_{G2} + J_{18K4} = 14.77\ kip$

$P_{A1} := 31\ plf \cdot 15\ ft = 465\ lbf$

$\phi P_{A1} := 230\ kip$

$A2 := 2 \cdot R_{G2} + J_{18K4} = 19.08\ kip$

$\phi P_{A2} := 230\ kip$

$A3 := R_{G2} + R_{G1} + J_{18K4} = 13.78\ kip$

$\phi P_{A3} := 230\ kip$

W8x31
W8x31
W8x31
W8x31
W8x31
W8x31

$B1 := R_{G4} + R_{G1} = 4.27\ kip$

$\phi P_{B1} := 230\ kip$

$B2 := R_{G1} + R_{G2} + J_{18K4} = 13.78\ kip$

$\phi P_{B2} := 230\ kip$

$B3 := 2 \cdot R_{G2} + J_{18K4} + J_{44LH09} = 23.33\ kip$

$\phi P_{B3} := 230\ kip$

$B4 := B3 = 23.33\ kip$

$\phi P_{B4} := 230\ kip$

$B5 := B4 = 23.33\ kip$

$\phi P_{B5} := 230\ kip$

$B6 := R_{G4} + R_{G5} + R_{G1} = 6.52\ kip$

$\phi P_{B6} := 230\ kip$

W8x31
W8x31

$C1 := 2 \cdot R_{G5} = 4.5\ kip$

$\phi P_{C1} := 230\ kip$

$C2 := C1 = 4.5\ kip$

$\phi P_{C2} := 230\ kip$

$D1 := R_{G2} + J_{44LH09} = 13.04\ kip$

$D2 := 2 \cdot R_{G2} \quad + J_{44LH09} =$

W8x31

$21.83\ kip\ D3 := D2 = 21.83\ kip$ $\phi P_{D1} := 230\ kip$ W8x31

W8x31

W8x31

W8x31

$D4 := R_{G2} + R_{G6} + J_{44LH09} = 24.12\ kip$ $\phi P_{D2} := 230\ kip$

$D5 := R_{G5} + R_{G6} = 13.33\ kip$ $\phi P_{D3} := 230\ kip$

$\phi P_{D4} := 230\ kip$

$\phi P_{D5} := 230\ kip$

Point Loads On Second Story Columns: 19 ft

W8x31
W8x31
W8x31
W8x31

$E1 := R_{G32} + R_{G310} = 62.34\ kip$ | $P_{E1} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{E1} := 162\ kip$

$E2 := P_{A1} + A1 + R_{G33} + R_{G32} = 108.735\ kip$ | $P_{E2} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{E2} := 162\ kip$

$E3 := P_{A1} + A2 + 2 \cdot R_{G32} = 140.825\ kip$ | $P_{E3} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{E3} := 162\ kip$

$E4 := P_{A1} + A3 + R_{G32} + R_{G31} = 137.515\ kip$ | $P_{E4} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{E4} := 162\ kip$

W8x31

$F1 := R_{G310} + R_{G311} = 2.55\ kip$ | $P_{F1} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{F1} := 162\ kip$

W8x31
W8x48
W8x48
W8x67
W8x67
W8x67
W8x31

$G1 := R_{G311} + R_{G35} + R_{G38} = 147.04\ kip$ | $P_{G1} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{G1} := 162\ kip$

$G2 := P_{A1} + B1 + R_{G35} + R_{G34} + J_{52DLH12} + J_{third18K9} = 221.248\ kip$ | $P_{G2} := 48\ plf \cdot 19\ ft = 912\ lbf$ | $\phi P_{G2} := 264\ kip$

$G3 := P_{A1} + B2 + R_{G34} + R_{G35} + J_{52DLH12} + J_{third18K9} = 230.758\ kip$ | $P_{G3} := 48\ plf \cdot 19\ ft = 912\ lbf$ | $\phi P_{G3} := 264\ kip$

$G4 := P_{A1} + B3 + 2 \cdot R_{G35} + J_{52DLH12} + J_{third18K9} = 336.828\ kip$ | $P_{G4} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^{3}\right)\right)\ lbf$ | $\phi P_{G4} := 381\ kip$

$P_{G5} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^{3}\right)\right)\ lbf$

$G5 := P_{A1} + B4 + 2 \cdot R_{G35} + J_{52DLH12} + J_{third18K9} = 336.828\ kip$ | $P_{G6} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^{3}\right)\right)\ lbf$ | $\phi P_{G5} := 381\ kip$

$G6 := P_{A1} + B5 + R_{G35} + R_{G312} + R_{G313} + J_{third18K9} = 276.618\ kip$ | $P_{G7} := 31\ plf \cdot 19\ ft = 589\ lbf$ | $\phi P_{G6} := 381\ kip$

$G7 := P_{A1} + B6 + R_{G311} + R_{G312} + R_{G39} = 88.635\ kip$ | $\phi P_{G7} := 162\ kip$

W8x31
W8x31
W8x31

$H1 := 2 \cdot R_{G38} = 7.86\ kip$ $P_{H1} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{H1} := 162\ kip$

$H2 := 2 \cdot R_{G313} + J_{20K6} = 116.894\ kip$ $P_{H2} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{H2} := 162\ kip$

$H3 := 2 \cdot R_{G39} + J_{20K6} + C1 + P_{A1} = 76.839\ kip$ $P_{H3} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{H3} := 162\ kip$

W8x31
W8x31
W8x31

$I1 := H1 = 7.86\ kip$ $P_{I1} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{I1} := 162\ kip$

$I2 := H2 = 116.894\ kip$ $P_{I2} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{I2} := 162\ kip$

$I3 := 2 \cdot R_{G39} + J_{20K6} + C2 + P_{A1} = 76.839\ kip$ $P_{I3} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{I3} := 162\ kip$

W8x31
W8x58
W8x67
W8x48
W8x48
W8x48
W8x31

$J1 := R_{G38} + R_{G37} = 100.22\ kip$ $P_{J1} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{J1} := 162\ kip$

$J2 := R_{G37} + R_{G36} + J_{52DLH12} = 267.99\ kip$ $P_{J2} := 58\ plf \cdot 19\ ft = \left(\left(1.102 \cdot 10^3\right)\right)\ lbf$ $\phi P_{J2} := 325\ kip$

$J3 := D1 + R_{G36} + R_{G37} + J_{52DLH12} + P_{A1} = 281.495\ kip$ $P_{J3} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^3\right)\right)\ lbf$ $\phi P_{J3} := 381\ kip$

$J4 := D2 + 2 \cdot R_{G37} + J_{52DLH12} + P_{A1} = 236.135\ kip$ $P_{J4} := 48\ plf \cdot 19\ ft = 912\ lbf$ $\phi P_{J4} := 264\ kip$

$J5 := D3 + 2 \cdot R_{G37} + J_{52DLH12} + P_{A1} = 236.135\ kip$ $P_{J5} := 48\ plf \cdot 19\ ft = 912\ lbf$ $\phi P_{J5} := 264\ kip$

$J6 := D4 + R_{G37} + R_{G38} + R_{G313} + P_{A1} = 179.655\ kip$ $P_{J6} := 48\ plf \cdot 19\ ft = 912\ lbf$ $\phi P_{J6} := 264\ kip$

$J7 := D5 + R_{G38} + R_{G39} + P_{A1} = 50.065\ kip$ $P_{J7} := 31\ plf \cdot 19\ ft = 589\ lbf$ $\phi P_{J7} := 162\ kip$

Point Loads On First Story Columns: 14 ft

W8x31
W8x31
W8x31
W8x31

$K1 := P_{E1} + E1 + R_{G22} + R_{G210} = 111.279\ kip$ $\quad P_{K1} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{K1} := 253\ kip$

$K2 := P_{E2} + E2 + R_{G23} + R_{G22} = 181.344\ kip$ $\quad P_{K2} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{K2} := 253\ kip$

$K3 := 2 \cdot R_{G22} + E3 + P_{E3} = 234.554\ kip$ $\quad P_{K3} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{K3} := 253\ kip$

$K4 := P_{E4} + E4 + R_{G22} + R_{G21} = 232.864\ kip$ $\quad P_{K4} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{K4} := 253\ kip$

W8x31

$L1 := P_{F1} + F1 + R_{G210} + R_{G211} = 5.919\ kip$ $\quad P_{L1} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{L1} := 253\ kip$

W8x31
W8x48
W8x48
W8x67
W8x67
W8x67
W8x31

$M1 := P_{G1} + G1 + R_{G211} + R_{G25} + R_{G28} = 184.321\ kip$ $\quad P_{M1} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{M1} := 253\ kip$

$M2 := P_{E1} + G2 + R_{G25} + R_{G24} + J_{16K7} = 308.657\ kip$ $\quad P_{M2} := 48\ plf \cdot 14\ ft = 672\ lbf$ $\quad \phi P_{M2} := 394\ kip$

$M3 := P_{G3} + G3 + R_{G24} + R_{G25} + J_{16K7} = 318.49\ kip$ $\quad P_{M3} := 48\ plf \cdot 14\ ft = 672\ lbf$ $\quad \phi P_{M3} := 394\ kip$

$M4 := P_{G4} + G4 + 2 \cdot R_{G25} + J_{16K7} = 414.641\ kip$ $\quad P_{M4} := 67\ plf \cdot 14\ ft = 938\ lbf$ $\quad \phi P_{M4} := 560\ kip$

$M5 := 2 \cdot R_{G25} + J_{16K7} + G5 + P_{G5} = 414.641\ kip$ $\quad P_{M5} := 67\ plf \cdot 14\ ft = 938\ lbf$ $\quad \phi P_{M5} := 560\ kip$

$M6 := P_{G6} + G6 + R_{G25} + R_{G212} + R_{G213} + J_{16K7} = 410.251\ kip$ $\quad P_{M6} := 67\ plf \cdot 14\ ft = 938\ lbf$ $\quad \phi P_{M6} := 560\ kip$

$M7 := P_{G7} + G7 + R_{G211} + R_{G212} + R_{G29} = 181.124\ kip$ $\quad P_{M7} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\quad \phi P_{M7} := 253\ kip$

W8x31
W8x31
W8x31

$N1 := 2 \cdot R_{G28} + H1 + P_{H1} = 8.913\ kip$ $P_{N1} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{N1} := 253\ kip$

$N2 := 2 \cdot R_{G213} + J_{second18K9} + H2 + P_{H2} = 227.343\ kip$ $P_{N2} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{N2} := 253\ kip$

$N3 := 2 \cdot R_{G29} + J_{second18K9} + H3 + P_{H3} = 186.528\ kip$ $P_{N3} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{N3} := 253\ kip$

W8x31
W8x31
W8x31

$O1 := 2 \cdot R_{G28} + I1 + P_{I1} = 8.913\ kip$ $P_{O1} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{O1} := 253\ kip$

$O2 := 2 \cdot R_{G213} + J_{second18K9} + I2 + P_{I2} = 227.343\ kip$ $P_{O2} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{O2} := 253\ kip$

$O3 := R_{G29} + J_{second18K9} + I3 + P_{I3} = 135.468\ kip$ $P_{O3} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{O3} := 253\ kip$

W8x31
W8x58
W8x67
W8x48
W8x48
W8x48
W8x31

$P1 := P_{J1} + J1 + R_{G28} + R_{G28} = 101.273\ kip$ $P_{P1} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{P1} := 253\ kip$

$P2 := 2 \cdot R_{G28} + J2 + P_{J2} = 269.556\ kip$ $P_{P2} := 58\ plf \cdot 14\ ft = 812\ lbf$ $\phi P_{P2} := 482\ kip$

$P3 := 2 \cdot R_{G28} + J3 + P_{J3} = 283.232\ kip$ $P_{P3} := 67\ plf \cdot 14\ ft = 938\ lbf$ $\phi P_{P3} := 560\ kip$

$P4 := 2 \cdot R_{G28} + J4 + P_{J4} = 237.511\ kip$ $P_{P4} := 48\ plf \cdot 14\ ft = 672\ lbf$ $\phi P_{P4} := 394\ kip$

$P5 := 2 \cdot R_{G28} + J5 + P_{J5} = 237.511\ kip$ $P_{P5} := 48\ plf \cdot 14\ ft = 672\ lbf$ $\phi P_{P5} := 394\ kip$

$P6 := P_{J6} + J6 + R_{G28} + R_{G28} + R_{G213} = 232.471\ kip$ $P_{P6} := 48\ plf \cdot 14\ ft = 672\ lbf$ $\phi P_{P6} := 394\ kip$

$P7 := P_{J7} + J7 + R_{G28} + R_{G29} = 101.946\ kip$ $P_{P7} := 31\ plf \cdot 14\ ft = 434\ lbf$ $\phi P_{P7} := 253\ kip$

Metal Deck Design: Third Floor

Superimposed Design Load, ϕW_n, / Deflection at L/360 (psf) — LWC (110 pcf), f'_c = 3000 psi

Total Slab Depth	Deck Gage	Span (ft-in.) 4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	12'-0"
3½"	22	1262/1410	797/722	544/417	392/263	293/176	225/123	176/90	113/52
	20	1480/1528	939/782	643/452	464/285	348/191	268/134	212/97	138/56
	19	1480/1634	1071/837	734/484	531/305	399/204	309/143	244/104	160/60
	18	1479/1723	1177/882	814/510	589/321	444/215	344/151	273/110	180/63
	16	1479/1904	1176/975	975/564	712/355	538/238	418/167	332/121	221/70
4"	22	1556/2088	983/1069	671/618	484/389	362/261	279/183	219/133	141/77
	20	1772/2260	1163/1157	796/669	576/421	432/282	334/198	264/144	172/83
	19	1772/2415	1330/1236	913/715	661/450	497/301	385/212	305/154	201/89
	18	1772/2546	1410/1303	1015/754	736/475	555/318	431/223	342/162	226/94
	16	1771/2811	1409/1439	1168/833	894/524	676/351	526/246	419/179	279/104
4¾"	22	2072/3463	1310/1773	896/1026	647/646	485/432	374/304	294/221	191/128
	20	2249/3745	1556/1917	1067/1109	772/698	581/468	450/328	356/239	233/138
	19	2249/3997	1785/2046	1226/1184	889/745	670/499	520/350	413/255	273/148
	18	2249/4213	1790/2157	1367/1248	993/786	749/526	583/369	463/269	308/156
	16	2248/4649	1789/2380	1483/1377	1213/867	918/581	715/408	571/297	382/172

Notes:
1. For high loads long term concrete creep should be considered.
2. Use Composite Deck-Slab Strength Web Based Solutions for alternate slabs or ASD design.

Section Properties

Deck Gage	Deck Weight w_{dd} (psf)	Base Metal Thickness t (in.)	Yield Strength F_y (ksi)	Effective Moment of Inertia at Service Load $I_d = (2I_e+I_g)/3$ I_d+ (in⁴/ft)	I_d- (in⁴/ft)	Effective Section Modulus at F_y = 50 ksi S_e+ (in³/ft)	S_e- (in³/ft)	Design Moment ϕM_n+ (lb-ft/ft)	ϕM_n- (lb-ft/ft)	Vertical Web Shear ϕV_n (lb/ft)
22	1.6	0.0295	50	0.155	0.178	0.169	0.179	634	671	4035
20	2.0	0.0358	50	0.197	0.217	0.224	0.229	840	859	4874
19	2.3	0.0418	50	0.239	0.257	0.266	0.278	997	1042	5666
18	2.6	0.0474	50	0.277	0.290	0.306	0.318	1148	1193	6398
16	3.3	0.0598	50	0.364	0.367	0.393	0.402	1474	1508	79[illegible]6

$$numberofsupports := \frac{42\ ft}{2\ ft} = 21$$

Optional Features

- Inquire regarding cost and lead times for:
  - -Short cuts < 6'-0"
  - -Sheet Lengths > 42'-0"
  - -Alternative metallic and painted finishes
- Factory Hanger Tabs

$$D := 66\ psf$$

$$L_{kitchen} := 150\ psf$$

Max Load on Third Floor Metal Deck:

$$q_u := 1.2 \cdot D + 1.6 \cdot L_{kitchen} = 319.2\ psf$$

$$w_u := 1.5\ ft \cdot q_u = 478.8\ plf$$

Moment:

Shear:

$M_{maxpos} := 160\ lbf \cdot ft$

$M_{posreq} := 840\ lbf \cdot ft$

$M_{maxneg} := -220\ lbf \cdot ft$

$M_{negreq} := 859\ lbf \cdot ft$

$V_{max} := 620\ lbf$

$V_{req} := 4874\ lbf$

Moment:

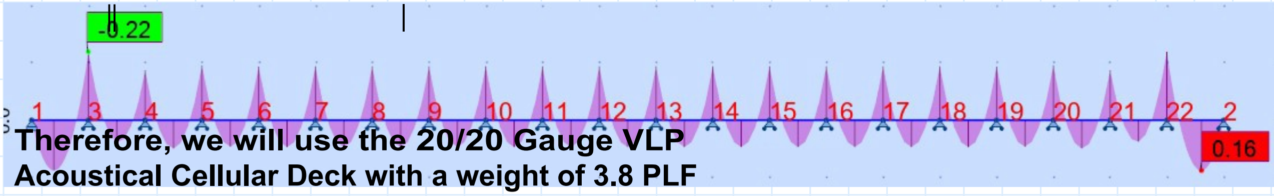
if $M_{maxpos} < M_{posreq}$
  "OK"
else
  "REVISE DESIGN"
= "OK"

if $M_{maxneg} < M_{negreq}$
  "OK"
else
  "REVISE DESIGN"
= "OK"

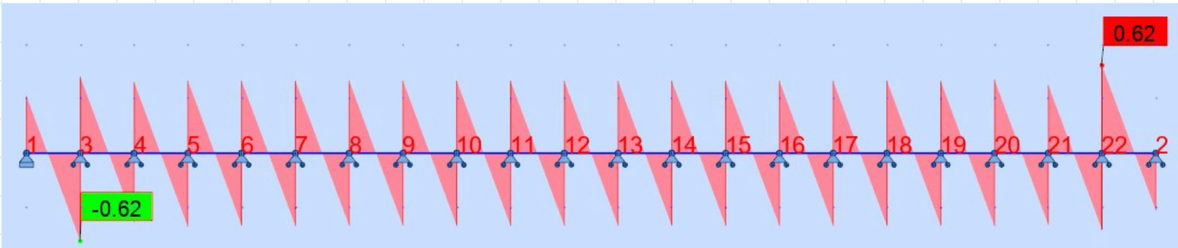
Shear:

if $V_{max} < V_{req}$
  "OK"
else

|= “OK”
“REVISE DESIGN”



Therefore, we will use the 20/20 Gauge VLP Acoustical Cellular Deck with a weight of 3.8 PLF for our third floor deck. We will have 3 1/4 " of Lightweight Concrete on top.



Metal Deck Design: Second Floor

1.5C-36 NON-COMPOSITE DECK
GRADE 50 STEEL
LRFD

Inward Uniform Design Loads, LRFD (psf)

Deck Gage	Spans	Criteria	Span (ft-in.) 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"
24	Single	ϕW_n	295	233	189	156	131	112	96	84	74	58	47
		L/240	141	99	72	54	42	33	26	21	18	12	9
	Double	ϕW_n	260	207	168	140	118	101	87	76	67	53	43
		L/240	291	204	149	112	86	68	54	44	36	26	19
	Triple	ϕW_n	319	255	208	173	146	125	108	94	83	66	53
		L/240	228	160	117	88	68	53	43	35	29	20	15
22	Single	ϕW_n	336	265	215	178	149	127	110	95	84	66	54
		L/240	182	128	93	70	54	42	34	28	23	16	12
	Double	ϕW_n	311	247	200	166	140	119	103	90	79	62	51
		L/240	382	269	196	147	113	89	71	58	48	34	24
	Triple	ϕW_n	385	306	249	206	174	148	128	112	98	78	63
		L/240	300	211	153	115	89	70	56	45	37	26	19
20	Single	ϕW_n	429	339	275	227	191	163	140	122	107	85	69
		L/240	222	156	114	86	66	52	41	34	28	20	14
	Double	ϕW_n	410	326	265	219	185	158	136	119	104	83	67
		L/240	486	341	249	187	144	113	91	74	61	43	31
	Triple	ϕW_n	508	404	329	273	230	196	170	148	130	103	84
		L/240	381	268	195	147	113	89	71	58	48	33	24
18	Single	ϕW_n	596	471	382	315	265	226	195	170	149	118	95
		L/240	297	209	152	114	88	69	55	45	37	26	19
	Double	ϕW_n	560	445	361	300	252	215	186	162	143	113	91
		L/240	683	480	350	263	203	159	128	104	85	60	44
	Triple	ϕW_n	693	551	449	372	314	268	231	202	178	141	114
		L/240	536	376	274	206	159	125	100	81	67	47	34

Note:
1.Table does not account for web crippling. Required bearing should be determined based on specific span conditions.

$$numberofsupports := \frac{30\ ft}{2\ ft} = 15$$

$$D := 70\ psf$$

$$L_{assembly} := 100\ psf$$

Max Load on Second Floor Metal Deck:

$$q_u := 1.2 \cdot D + 1.6 \cdot L_{assembly} = 244\ psf$$

$$w_u := 1.5\ ft \cdot q_u = 366\ plf$$

$$Strength := 300\ psf$$

if $q_u < Strength$
  "OK"
else
  "REVISE DESIGN"

= "OK"

Therefore, we will use the 22 Gauge 1.5C Non-Composite Deck with a weight of 1.6 PLF for our second floor deck. We will have 3 1/4 " of Lightweight Concrete on top.

Senior Design Foundation Design:

Allowable Bearing Pressure:

$q_{allow} := 1500\ psf$

$P := 150\ kip$

$A := \sqrt{\dfrac{P}{q_{allow}}} = 100\ ft^2$

$B := \sqrt{A} = 10\ ft$

$q_{gross} := \dfrac{P}{A} = 0.01\ ksi$

Column Loads:

Third Floor Column

(Connecting Roof to Third Floor)

Roof Girder Reaction Forces:

$R_{G1} := 3.49\ kip$

$R_{G2} := 8.79\ kip$

$R_{G3} := 4.48\ kip$

$R_{G4} := 0.78\ kip$

$R_{G5} := 2.25\ kip$

$R_{G6} := 11.08\ kip$

3rd Floor Girder Reaction Forces:

$R_{G31} := 62.63\ kip$

$R_{G32} := 60.64\ kip$

$R_{G33} := 32.86\ kip$

$R_{G34} := 45.74\ kip$

$R_{G35} := 142.26\ kip$

$R_{G36} := 150.44\ kip$

$R_{G37} := 96.29\ kip$

2nd Floor Girder Reaction Forces:

$R_{G38} := 3.93\ kip$ $R_{G39} := 32.34\ kip$

$R_{G310} := 1.7\ kip$ $R_{G311} := 0.85\ kip$ R_{G312}

$:= 48.46\ kip$ $R_{G313} := 54.85\ kip$

$R_{G21} := 48.19\ kip$ $R_{G22} := 46.57\ kip$ $R_{G23} := 25.45\ kip$ $R_{G24} := 45.74\ kip$ $R_{G25} := 35.46\ kip$ $R_{G28} := 232\ lbf$ $R_{G29} := 51.06\ kip$ $R_{G210} := 1.78\ kip$ $R_{G211} := 1\ kip$ $R_{G212} := 39.84$

k

p

$_{G213} := 51.44\ kip$

i

R

Roof Joist Reactions:

$J_{18K4} := 1.5\ kip$

$J_{44LH09} := 4.25\ kip$

3rd Floor Joist Reactions:

$J_{third18K9} := 7.253\ kip$

$J_{20K6} := 7.194\ kip$

$J_{52DLH12} := 21.26\ kip$

2nd Floor Joist Reactions:

$J_{16K7} := 5.62\ kip$

$J_{second18K9} := 6.98\ kip$

Point Loads On Third Story Columns: 15 ft

$A1 := R_{G3} + R_{G2} + J_{18K4} = 14.77\ \text{kip}$

$P_{A1} := 31\ \text{plf} \cdot 15\ \text{ft} = 465\ \text{lbf}$

$A2 := 2 \cdot R_{G2} + J_{18K4} = 19.08\ \text{kip}$

$A3 := R_{G2} + R_{G1} + J_{18K4} = 13.78\ \text{kip}$

$B1 := R_{G4} + R_{G1} = 4.27\ \text{kip}$

$B2 := R_{G1} + R_{G2} + J_{18K4} = 13.78\ \text{kip}$

$B3 := 2 \cdot R_{G2} + J_{18K4} + J_{44LH09} = 23.33\ \text{kip}$

$B4 := B3 = 23.33\ \text{kip}$

$B5 := B4 = 23.33\ \text{kip}$

$B6 := R_{G4} + R_{G5} + R_{G1} = 6.52\ \text{kip}$

$C1 := 2 \cdot R_{G5} = 4.5\ \text{kip}$

$C2 := C1 = 4.5\ \text{kip}$

$D1 := R_{G2} + J_{44LH09} = 13.04\ \text{kip}$

$D2 := 2 \cdot R_{G2} + J_{44LH09} = 21.83\ \text{kip}$

$D3 := D2 = 21.83\ \text{kip}$

$D4 := R_{G2} + R_{G6} + J_{44LH09} = 24.12\ kip$

$D5 := R_{G5} + R_{G6} = 13.33\ kip$

Point Loads On Second Story Columns: 19 ft

$E1 := R_{G32} + R_{G310} = 62.34\ kip$

$P_{E1} := 31\ plf \cdot 19\ ft = 589\ lbf$

$E2 := P_{A1} + A1 + R_{G33} + R_{G32} = 108.735\ kip$

$P_{E2} := 31\ plf \cdot 19\ ft = 589\ lbf$

$E3 := P_{A1} + A2 + 2 \cdot R_{G32} = 140.825\ kip$

$P_{E3} := 31\ plf \cdot 19\ ft = 589\ lbf$

$E4 := P_{A1} + A3 + R_{G32} + R_{G31} = 137.515\ kip$

$P_{E4} := 31\ plf \cdot 19\ ft = 589\ lbf$

$F1 := R_{G310} + R_{G311} = 2.55\ kip$

$P_{F1} := 31\ plf \cdot 19\ ft = 589\ lbf$

$G1 := R_{G311} + R_{G35} + R_{G38} = 147.04\ kip$

$P_{G1} := 31\ plf \cdot 19\ ft = 589\ lbf$

$G2 := P_{A1} + B1 + R_{G35} + R_{G34} + J_{52DLH12} + J_{third18K9} = 221.248\ kip$

$P_{G2} := 48\ plf \cdot 19\ ft = 912\ lbf$

$G3 := P_{A1} + B2 + R_{G34} + R_{G35} + J_{52DLH12} + J_{third18K9} = 230.758\ kip$

$P_{G3} := 48\ plf \cdot 19\ ft = 912\ lbf$

$G4 := P_{A1} + B3 + 2 \cdot R_{G35} + J_{52DLH12} + J_{third18K9} = 336.828\ kip$

$P_{G4} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^3\right)\right)\ lbf$

$P_{G5} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^3\right)\right)\ lbf$

$G5 := P_{A1} + B4 + 2 \cdot R_{G35} + J_{52DLH12} + J_{third18K9} = 336.828\ kip$

$P_{G6} := 67\ plf \cdot 19\ ft = \left(\left(1.273 \cdot 10^3\right)\right)\ lbf$

$G6 := P_{A1} + B5 + R_{G35} + R_{G312} + R_{G313} + J_{third18K9} = 276.618\ kip$

$P_{G7} := 31\ plf \cdot 19\ ft = 589\ lbf$

$G7 := P_{A1} + B6 + R_{G311} + R_{G312} + R_{G39} = 88.635\ kip$

$H1 := 2 \cdot R_{G38} = 7.86\ kip$

$H3 := 2 \cdot R_{G39} + J_{20K6} + C1 + P_{A1} = 76.839\ kip$

$H2 := 2 \cdot R_{G313} + J_{20K6} = 116.894\ kip$

P

H

1

$:= 31\ plf \cdot 19\ ft = 589\ lbf\ P_{H2}$

$:= 31\ plf \cdot 19\ ft = 589\ lbf\ P_{H3}$

$:= 31\ plf \cdot 19\ ft = 589\ lbf$

$I1 := H1 = 7.86\ kip$

$P_{I1} := 31\ plf \cdot 19\ ft = 589\ lbf$

$I2 := H2 = 116.894\ kip$

$P_{I2} := 31\ plf \cdot 19\ ft = 589\ lbf$

$I3 := 2 \cdot R_{G39} + J_{20K6} + C2 + P_{A1} = 76.839\ kip$

$P_{I3} := 31\ plf \cdot 19\ ft = 589\ lbf$

$J1 := R_{G38} + R_{G37} = 100.22\ kip$

$P_{J1} := 31\ plf \cdot 19\ ft = 589\ lbf$

$J2 := R_{G37} + R_{G36} + J_{52DLH12} = 267.99\ kip$

$P_{J2} := 58\ plf \cdot 19\ ft = \left(1.102 \cdot 10^3\right)\ lbf$

$J3 := D1 + R_{G36} + R_{G37} + J_{52DLH12} + P_{A1} = 281.495\ kip$

$P_{J3} := 67\ plf \cdot 19\ ft = \left(1.273 \cdot 10^3\right)\ lbf$

$J4 := D2 + 2 \cdot R_{G37} + J_{52DLH12} + P_{A1} = 236.135\ kip$

$P_{J4} := 48\ plf \cdot 19\ ft = 912\ lbf$

$J5 := D3 + 2 \cdot R_{G37} + J_{52DLH12} + P_{A1} = 236.135\ kip$

$P_{J5} := 48\ plf \cdot 19\ ft = 912\ lbf$

$J6 := D4 + R_{G37} + R_{G38} + R_{G313} + P_{A1} = 179.655\ kip$

$P_{J6} := 48\ plf \cdot 19\ ft = 912\ lbf$

$J7 := D5 + R_{G38} + R_{G39} + P_{A1} = 50.065\ kip$

$P_{J7} := 31\ plf \cdot 19\ ft = 589\ lbf$

$K1 := P_{E1} + E1 + R^{G22} + R_{G210} = 111.279\ kip$

$A := \frac{K1}{q_{allow}} = 74.186\ ft^2$ $B := \sqrt{A} = 8.613\ ft$ $B - 8\ ft = 7.358\ in$

$K2 := P_{E2} + E2 + R_{G23} + R_{G22} = 181.344\ kip$

$A := \frac{K2}{q_{allow}} = 120.896\ ft^2$ $B := \sqrt{A} = 10.995\ ft$ $B - 10\ ft = 11.943\ in$

$K3 := 2 \cdot R^{G22} + E3 + P_{E3} = 234.554\ kip$

$K4 := P_{E4} + E4 + R_{G22} + R_{G21} = 232.864\ kip$

$A := \frac{K3}{q_{allow}} = 156.369\ ft^2$ $B := \sqrt{A} = 12.505\ ft$ $B - 12\ ft = 6.057\ in$

$B := \sqrt{A} = 12.46\ ft$ $B - 12\ ft = 5.516\ in$

$A := \frac{K4}{q_{allow}} = 155.243\ ft^2$

$L1 := P_{F1} + F1 + R_{G210} + R_{G211} = 5.919\ kip$

$M1 := P_{G1} + G1 + R_{G211} + R_{G25} + R_{G28} = 184.321\ kip$

$M2 := P_{E1} + G2 + R^{G25} + R_{G24} + J_{16K7} = 308.657\ kip$

$A := \frac{L1}{q_{allow}} = 3.946\ ft^2$ $B := \sqrt{A} = 1.986\ ft$ $B - 1\ ft = 11.837\ in$

$M3 := P_{G3} + G3 + R_{G24} + R_{G25} + J_{16K7} = 318.49\ kip$

$M4 := P_{G4} + G4 + 2 \cdot R^{G25} + J_{16K7} = 414.641\ kip$

$A := \frac{M1}{q_{allow}} = 122.881\ ft^2$ $B := \sqrt{A} = 11.085\ ft$ $B - 11\ ft = 1.022\ in$

$M5 := 2 \cdot R_{G25} + J_{16K7} + G5 + P_{G5} = 414.641\ kip$

$M6 := P_{G6} + G6 + R^{G25} + R_{G212} + R_{G213} + J_{16K7} = 410.251\ kip$

$A := \frac{M2}{q_{allow}} = 205.771\ ft^2$ $B := \sqrt{A} = 14.345\ ft$ $B - 14\ ft = 4.137\ in$

$M7 := P_{G7} + G7 + R_{G211} + R_{G212} + R_{G29} = 181.124\ kip$

$A := \frac{M3}{q_{allow}} = 212.327\ ft^2$ $B := \sqrt{A} = 14.571\ ft$ $B - 14\ ft = 6.857\ in$

$N1 := 2 \cdot R^{G28} + H1 + P_{H1} = 8.913\ kip$

$A := \frac{M4}{q_{allow}} = 276.427\ ft^2$ $B := \sqrt{A} = 16.626\ ft$ $B - 16\ ft = 7.513\ in$

$N2 := 2 \cdot R_{G213} + J_{second18K9} + H2 + P_{H2} = 227.343\ kip$

$N3 := 2 \cdot R^{G29} + J_{second18K9} + H3 + P_{H3} = 186.528\ kip$

$A := \frac{M5}{q} = 276.427\ ft^2$ $B := \sqrt{A} = 16.626\ ft$ $B - 16\ ft = 7.513\ in$

$O1 := 2 \cdot R^{G28} + I1 + P_{I1} = 8.913\ kip$

$O2 := 2 \cdot R_{G213} + J_{second18K9} + I2 + P_{I2} = 227.343\ kip$

$O3 := R^{G29} + J_{second18K9} + I3 + P_{I3} = 135.468\ kip$

$P1 := P_{J1} + J1 + R^{G28} + R_{G28} = 101.273\ kip$

$P2 := 2 \cdot R_{G28} + J2 + P_{J2} = 269.556\ kip$

$P3 := 2 \cdot R^{G28} + J3 + P_{J3} = 283.232\ kip$

$P4 := 2 \cdot R_{G28} + J4 + P_{J4} = 237.511\ kip$

$P5 := 2 \cdot R^{G28} + J5 + P_{J5} = 237.511\ kip$

$P6 := P_{J6} + J6 + R_{G28} + R_{G28} + R_{G213} = 232.471\ kip$

$P7 := P_{J7} + J7 + R^{G28} + R_{G29} = 101.946\ kip$

$A := \frac{M6}{q_{allow}} = 273.501\ ft^2$ $\quad B := \sqrt{A} = 16.538\ ft$ $\quad B - 16\ ft = 6.454\ in$

$A := \frac{M7}{q_{allow}} = 120.749\ ft^2$ $\quad B := \sqrt{A} = 10.989\ ft$ $\quad B - 10\ ft = 11.863\ in$

$A := \frac{N1}{q_{allow}} = 5.942\ ft^2$ $\quad B := \sqrt{A} = 2.438\ ft$ $\quad B - 2\ ft = 5.251\ in$

$A := \frac{N2}{q_{allow}} = 151.562\ ft^2$ $\quad B := \sqrt{A} = 12.311\ ft$ $\quad B - 12\ ft = 3.733\ in$

$A := \frac{N3}{q_{allow}} = 124.352\ ft^2$ $\quad B := \sqrt{A} = 11.151\ ft$ $\quad B - 11\ ft = 1.816\ in$

$A := \frac{O1}{q_{allow}} = 5.942\ ft^2$ $\quad B := \sqrt{A} = 2.438\ ft$ $\quad B - 2\ ft = 5.251\ in$

$A := \frac{O2}{q_{allow}} = 151.562\ ft^2$

$A := \frac{O3}{q_{allow}} = 90.312\ ft^2$

$A := \frac{P1}{q_{allow}} = 67.515\ ft^2$

$A := \frac{P2}{q_{allow}} = 179.704\ ft^2$

$A := \frac{P3}{q_{allow}} = 188.821\ ft^2$

$A := \frac{P4}{q_{allow}} = 158.341\ ft^2$

$A := \frac{P5}{q_{allow}} = 158.341\ ft^2$

$A := \frac{P6}{q_{allow}} = 154.981\ ft^2$

$A := \frac{P7}{q_{allow}} = 67.964\ ft^2$

−8 ft =

in B − 12 ft = 7

B ≔ A = 12.311 ft B ≔ A = 9.503 ft B ≔ A = 8.217 ft B ≔

B − 12 ft

= 3.733

in

2.601 in B

in

A = 13.405 ft B ≔ A = 13.741 ft B ≔ A = 12.583 ft B ≔ A =

B

−

−13 ft =

B − 12 ft = 5.389 in

12.583 ft B ≔ A = 12.449 ft B ≔ A = 8.244 ft

9

B − 8 ft = 2.928 in

ft

4.864 in B

=

6.

0

−13 ft =

3

9

i

8.895 in

n

B − 12

B

ft = 7

$A := \frac{K1}{q_{allow}} = 74.186\ ft^2$ $A := \frac{O1}{q_{allow}} = 124.352\ ft^2$

$A := \frac{K2}{q_{allow}} = 120.896\ ft^2$ $A := \frac{O2}{q_{allow}} = 5.942\ ft^2$

$A := \frac{K3}{q_{allow}} = 156.369\ ft^2$ $A := \frac{O3}{q_{allow}} = 151.562\ ft^2$

$A := \frac{K4}{q_{allow}} = 155.243\ ft^2$ $A := \frac{P1}{q_{allow}} = 90.312\ ft^2$

$A := \frac{L1}{q_{allow}} = 3.946\ ft^2$ $A := \frac{P2}{q_{allow}} = 67.515\ ft^2$

$A := \frac{M1}{q_{allow}} = 122.881\ ft^2$ $A := \frac{P3}{q_{allow}} = 179.704\ ft^2$

$A := \frac{M2}{q_{allow}} = 205.771\ ft^2$ $A := \frac{P4}{q_{allow}} = 188.821\ ft^2$

$A := \frac{M3}{q_{allow}} = 212.327\ ft^2$ $A := \frac{P5}{q_{allow}} = 158.341\ ft^2$

$A := \frac{M4}{q_{allow}} = 276.427\ ft^2$ $A := \frac{P6}{q_{allow}} = 158.341\ ft^2$

$A := \frac{M5}{q_{allow}} = 276.427\ ft^2$ $A := \frac{P7}{q_{allow}} = 154.981\ ft^2$

$A := \frac{M6}{q_{allow}} = 273.501\ ft^2$ $= 67.964\ ft^2$

$A := \frac{M7}{q_{allow}} = 120.749\ ft^2$

$A := \frac{N1}{q_{allow}} = 5.942\ ft^2$

$A := \frac{N2}{q_{allow}} = 151.562\ ft^2$

$A := N3$

$B := \sqrt{A} = 8.613\ ft$ $B := \sqrt{A} = 10.995\ ft$ $B := \sqrt{A} = 12.505\ ft$ $B := \sqrt{A} = 12.46\ ft$ $B := \sqrt{A} = 1.986\ ft$ $B := \sqrt{A} = 11.085\ ft$ $B := \sqrt{A} = 14.345\ ft$ $B := \sqrt{A} = 14.571\ ft$ $B := \sqrt{A} = 16.626\ ft$ $B := \sqrt{A} = 16.626\ ft$ $B := \sqrt{A} = 16.538\ ft$ $B := \sqrt{A} = 10.989\ ft$ $B := \sqrt{A} = 2.438\ ft$ $B := \sqrt{A} = 12.311\ ft$ $B := \sqrt{A} = 11.151\ ft$ $B := \sqrt{A} = 2.438\ ft$ $B := \sqrt{A} = 12.311\ ft$

$B := \sqrt{A} = 9.503\ ft$ $B := \sqrt{A} = 8.217\ ft$ $B := \sqrt{A} = 13.405\ ft$ $B := \sqrt{A} = 13.741\ ft$ $B := \sqrt{A} = 12.583\ ft$ $B := \sqrt{A} =$

12.583 ft B - 8 ft = 11.837 in B − 11 ft = 11.863 in B - 13 ft = 4.864 in B - 13 ft = 8.895 in

7.358 in

B ≔ A = B - 10 ft = ft = 1.022 in B − B − 2 ft = 5.251 in B − 12 ft = 7 in B - 12 ft = 7 in

12.449 ft 11.943 in 14 ft = 4.137 in B B - 12 ft = 3.733 in B - 12 ft = 5.389 in

B - 8 ft = 2.928 in

B ≔ A B − 12 ft = − 14 ft = 6.857 in B - 11 ft = 1.816 in

= 8.244

6.057 in B B − 16 ft = 7.513 B − 2 ft = 5.251 in

ft

− 12 ft = in B − 16 ft = B - 12 ft = 3.733 in

5.516 in B 7.513 in B − 16 ft B − 9 ft = 6.039 in

− 1 ft = = 6.454 in B - 10 B − 8 ft = 2.601 in

8'-8"

11'-0"

12'-8"

12'-6"

2'-0"

11'-2"

14'-6"

14'-8"

16'-8"

16'-8"

16'-8"

11'-0"

2'-6"

12'-4"

11'-2"

2'-6"

12'-4"

9'-8"

8'-3"

13'-6"

13'-9"

12'-8"

12'-8"

12'-6"

8'-3"

Footing Width:

Depth of footing:

Column Width:

K1	8'-8"
K2	11'-0"
K3	12'-8"
K4	12'-8"
L1	2'-0"
M1	11'-2"
M2	14'-8"
M3	14'-8"
M4	16'-8"
M5	16'-8"
M6	16'-8"
M7	11'-0"
N1	2'-6"
N2	12'-4"
N3	11'-2"
O1	2'-6"
O2	12'-4"
O3	9'-8"
P1	8'-3"
P2	13'-6"
P3	13'-9"
P4	12'-8"
P5	12'-8"
P6	12'-8"
P7	8'-3"

B:=FIF “8'8”

B:=FIF “11'0”

B:=FIF “12'8”

B:=FIF “12'8”

B:=FIF “2'0”

B:=FIF “11'2”

B:=FIF “14'8”

B:=FIF “14'8”

B:=FIF “16'8”

B:=FIF “16'8”

B:=FIF “16'8”

B:=FIF “11'0”

B:=FIF “2'6”

B:=FIF

“12'4”

B:=FIF

“11'2”

B:=FIF

“2'6”

B:=FIF

“12'4”

B:=FIF

“9'8”

B:=FIF

“8'3”

B:=FIF

“13'6”

B:=FIF

“13'9”

B:=FIF

“12'8”

B:=FIF

“12'8”

B:=FIF

“12'8”

B:=

FIF

“8'3
”

= 8.667 ft

= 11 ft

= 12.667 ft

= 12.667 ft

= 2 ft

= 11.167 ft

= 14.667 ft

= 14.667 ft

= 16.667 ft

= 16.667 ft

= 16.667 ft

= 11 ft

= 2.5 ft

= 12.333 ft

= 11.167 ft

= 2.5 ft

= 12.333 ft

= 9.667 ft

= 8.25 ft

= 13.5 ft

= 13.75 ft

= 12.667 ft

= 12.667 ft

= 12.667 ft

= 8.25 ft

W8x31 W8x31 W8x31
W8x31 W8x31 W8x31
W8x48 W8x48 W8x67
W8x67 W8x67 W8x31
W8x31 W8x31 W8x31
W8x31 W8x31 W8x31
W8x31 W8x58 W8x67
W8x48 W8x48 W8x48
W8x31

K1 = 111.279 kip

K2 = 181.344 kip

K3 = 234.554 kip

K4 = 232.864 kip

L1 = 5

.919 kip M1 =

184.321 kip M2 =

308.657 kip M3

= 318.49 kip M4

= 414.641 kip M5

= 414.641 kip M6

= 410.251 kip M7

= 181.124 kip N1

= 8.913 kip N2

= 227.343 kip N3

= 186.528 kip O1

= 8.913 kip O2

= 227.343 kip O3

= 135.468 kip P1

= 101.273 kip P2

= 269.556 kip

p P3 = 283

.232 kip

P4 = 237.511 kip

kip P5 = 237.511

kip P6 = 232.471

kip P7 = 101.946

kip

Rebar design groups:

K1, P1, P7 Design as 8'-8" with max load: 111.279 kip

K2, M1, M7, N3 Design as 11'-2" with max load: 186.528 kip

K3, K4, N2, O2, P4, P5, P6 Design as 12'-8" with max load: 237.511 kip

M2, M3, M4, M5, M6, P2, P3 Design as 16'-8" with max load: 414.641 kip

20.5.1.3 *Specified concrete cover requirements*

20.5.1.3.1 Nonprestressed cast-in-place concrete members shall have specified concrete cover for reinforcement at least that given in Table 20.5.1.3.1.

Table 20.5.1.3.1—Specified concrete cover for cast-in-place nonprestressed concrete members

Concrete exposure	Member	Reinforcement	Specified cover, in.
Cast against and permanently in contact with ground	All	All	3
Exposed to weather or in contact with ground	All	No. 6 through No. 18 bars	2
		No. 5 bar, W31 or D31 wire, and smaller	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars	1-1/2
		No. 11 bar and smaller	3/4
	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	1-1/2

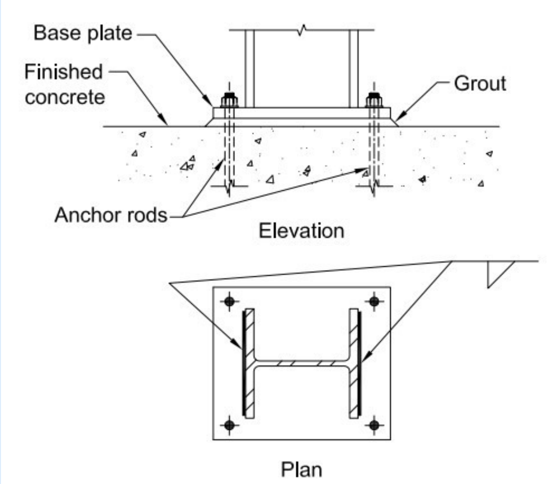


Fig. 14-2. Typical column base for axial compressive loads.

Pedestal:

$f_c' := 3500\ psi$

Column Base Plates: Typically ASTM A36 Steel shop welded to the column on both sides of the web and flanges. Typical thickness of grout underneath a base plate is 3/4 to 1.5 in.

Shorter dimension of the base plate (dimension parallel to the flanges for base plate for W shapes): B

~~Longer d~~imension of the base plate (dimension parallel to the web for base plate for W shapes): N

W8x31:

$d := 8.00\ in$ $\quad b_f := 8.00\ in$ $\quad B := 12\ in$ $\quad N := 12\ in$ $\quad F_y := 36\ ksi$

$m := \frac{N - 0.95 \cdot d}{2} = 2.2\ in$ $\quad n := \frac{(B - 0.8 \cdot b_f)}{2} = 2.8\ in$ $\quad l := \max\left(m, n, \frac{1}{4} \cdot \sqrt{d \cdot b_f}\right) = 2.8\ in$

$inc := \frac{1}{8}\ in = 0.125\ in$ $\quad 7 \cdot inc = 0.875\ in$

Base Plate Thicknesses:

$t_{min} := l \cdot \sqrt{\frac{2 \cdot K1}{0.90 \cdot F_y \cdot B \cdot N}}$ $\quad t_{min} := l \cdot \sqrt{\frac{2 \cdot K2}{0.90 \cdot F_y \cdot B \cdot N}}$ $\quad t_{min} := l \cdot \sqrt{\frac{2 \cdot K3}{0.90 \cdot F_y \cdot B \cdot N}}$ $\quad t_{min} := l \cdot$ $\quad t_{min} := l \cdot$ $\quad t_{min} := l \cdot$ $\quad t_{min} := l \cdot$

$2 \cdot K4$

$0.90 \cdot F_y \cdot$ $= 0.612$ in

$B \cdot N$ $= 0.781$ in

$2 \cdot N2$

$0.90 \cdot F_y \cdot$ $= 0.888$ in

$B \cdot N$

$2 \cdot N3$ $= 0.885$ in

$0.90 \cdot F_y \cdot$

$B \cdot N$ $= 0.874$ in

$2 \cdot O1$

$0.90 \cdot F_y \cdot$ $= 0.792$ in

$B \cdot N$ $= 0.173$ in

$t_{min}K1 := \frac{5}{8}$ in

$t_{min}K2 := \frac{7}{8}$ in

$t_{min}K3 := 1$ in

$t_{min}K4 := 1$ in

$t_{min}N2 := \frac{7}{8}$ in

$t_{min}N3 := \frac{7}{8}$ in

$t_{min}O1 := \frac{1}{4}$ in

$t_{min} := 1 \cdot t_{min} :=$

$1 \cdot t_{min} := 1 \cdot t_{min}$

$:= 1 \cdot t_{min} := 1 \cdot$

$t_{min} := 1 \cdot t_{min} :=$

$1 \cdot t_{min} := 1 \cdot$

$2 \cdot L1$

$0.90 \cdot F_y \cdot$ $B \cdot N$ $= 0.141$ in

$B \cdot N$ $= 0.787$ in

$2 \cdot M1$

$0.90 \cdot F_y \cdot$ $= 0.78$ in

$B \cdot N$

$2 \cdot M7$ $= 0.173$ in

$0.90 \cdot F_y \cdot$

$B \cdot N$ $= 0.874$ in

$2 \cdot N1$

$0.90 \cdot F_y \cdot$ $= 0.675$ in

$B \cdot N$ $= 0.583$ in

$2 \cdot O2$

$0.90 \cdot F_y \cdot$ $= 0.585$ in

$B \cdot N$

$2 \cdot O3$

$0.90 \cdot F_y \cdot$

$B \cdot N$

$2 \cdot P1$

$0.90 \cdot F_y \cdot$

$B \cdot N$

$2 \cdot P7$

$0.90 \cdot F_y \cdot$

$t_{min}L1 := \frac{1}{4}$ in

$t_{min}M1 := \frac{7}{8}$ in

$t_{min}M7 := \frac{7}{8}$ in

$t_{min}N1 := \frac{1}{4}$ in

$t_{min}O2 := \frac{7}{8}$ in

$t_{min}O3 := \frac{3}{4}$ in

$t_{min}P1 := \frac{5}{8}$ in

$t_{min}P7 := \frac{5}{8}$ in

W8x48:

$d := 8.50\ in$ $\quad b_f := 8.11\ in$ $\quad B := 12\ in$ $\quad N := 12\ in$

$m := \frac{N - 0.95 \cdot d}{2} = 1.963\ in$ $\quad n := \frac{(B - 0.8 \cdot b_f)}{2} = 2.756\ in$ $\quad l := max\left(m, n, \frac{1}{4} \cdot d \cdot b_f\right) = 2.756\ in$

Base Plate Thicknesses:

$t_{min} := l \cdot \frac{2 \cdot M2}{0.90 \cdot F_y \cdot B \cdot N} = 1.002\ in$

$t_{min} := l \cdot \frac{2 \cdot M3}{0.90 \cdot F_y \cdot B \cdot N} = 1.018\ in$

$t_{min} := l \cdot \frac{2 \cdot P4}{0.90 \cdot F_y \cdot B \cdot N} = 0.879\ in$

$t_{min} := l \cdot \frac{2 \cdot P5}{0.90 \cdot F_y \cdot B \cdot N} = 0.879\ in$

$t_{min} := l \cdot \frac{2 \cdot P6}{0.90 \cdot F_y \cdot B \cdot N} = 0.87\ in$

$t_{min}M2 := 1\ in + \frac{1}{8}\ in$

$t_{min}M3 := 1\ in + \frac{1}{8}\ in$

$t_{min}P4 := 1\ in$

$t_{min}P5 := 1\ in$

$t_{min}P6 := \frac{7}{8}\ in$

W8x58:

$d := 8.75\ in$ $b_f := 8.22\ in$ $B := 12\ in$ $N := 12\ in$

$m := \frac{N - 0.95 \cdot d}{2} = 1.844\ in$ $n := \frac{(B - 0.8 \cdot b_f)}{2} = 2.712\ in$ $l := max\left(m, n, \frac{1}{4} \cdot \sqrt{d \cdot b_f}\right) = 2.712\ in$

Base Plate Thicknesses:

$t_{min} := l \cdot \sqrt{\frac{2 \cdot P2}{0.90 \cdot F_y \cdot B \cdot N}} = 0.922\ in$ $t_{min}P2 := 1\ in$

W8x67:

$d := 9.00\ in$ $b_f := 8.28\ in$ $B := 12\ in$ $N := 12\ in$

$m := \frac{N - 0.95 \cdot d}{2} = 1.725\ in$ $n := \frac{(B - 0.8 \cdot b_f)}{2} = 2.688\ in$ $l := max\left(m, n, \frac{1}{4} \cdot \sqrt{d \cdot b_f}\right) = 2.688\ in$

Base Plate Thicknesses:

$10 \cdot inc = 1.25\ in$

$t_{min} := l \cdot$ $t_{min} := l \cdot t_{min}$ $\sqrt{\frac{2 \cdot M4}{0.90 \cdot F_y \cdot B \cdot N}}$ $\sqrt{\frac{M6}{0.90 \cdot F_y \cdot B \cdot N}}$ $\sqrt{\frac{2 \cdot P3}{0.90 \cdot F_y \cdot B \cdot N}}$

$t_{min} := l \cdot$ $:= l \cdot$ $\sqrt{\frac{2 \cdot M5}{0.90 \cdot F_y \cdot B \cdot N}}$

2 ·

$t_{min}M4 := 1$

$in + \frac{1}{4}\ in$

$= 1.133\ in$

$t_{min}M5 := 1$

$in + \frac{1}{4}\ in$

$= 1.133\ in$

$t_{min}M6 := 1$

$in + \frac{1}{4}\ in$

$= 1.127\ in$

$t_{min}P3 := 1$

in

$= 0.937\ in$

Check Footings for One-way Shear

K1 8'-8"

Bar has 1/2 in diameter:

$B := FIF\ \text{"8'8"} = 8.667\ ft$

$L_1 := B = 8.667\ ft$ $L_2 := B = 8.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := K1$ $d_f := 18\ in$ $c_2 := 14\ in$ $c_1 := c_2$

$cover1 := c_c + \frac{d_w}{2} = 3.25\ in$ $cover2 := c_c + d_w + \frac{d_w}{2} = 3.75\ in$

$AverageCover := \frac{cover1 + cover2}{2} = 3.5\ in$ $d := d_f - AverageCover = 14.5\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 32.6\ kip$

Punch Out Shear:

$V_{upunchout} := q_u \cdot (L_1 \cdot L_2 - (c_1 + d) \cdot (c_2 + d)) = 102.922\ kip$ $\frac{(B - c_2)}{4} = 22.5\ in$

Shear Resistance of Concrete:

$$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f_c'}{psi}} \cdot psi \cdot L_2 \cdot d\right) = 134\ kip$$

if $V_{uoneWay} \le \phi V_c$
‖ "OK"
else
‖ "REVISE DESIGN"

= "OK"

Check for Two-Way (punching) shear:

Shear force at the critical section at distance d/2 around the column:

$$V_{utwoWay} := q_u \cdot \left(L_1 \cdot L_2 - \left(c_1 + d\right) \cdot \left(c_2 + d\right)\right) = 102.922\ kip$$

Two-Way shear resistance of concrete:

$$\beta := \frac{c_1}{c_2} = 1 \qquad b_o := 2 \cdot \left(c_1 + d\right) + 2 \cdot \left(c_2 + d\right) = 114\ in$$

$d = 14.5\ in$ $\quad d := 14.5$

For Corner Column: (if interior 40, if edge 30)

$b_o := 114$

$\alpha_s := 20$ $\quad f_c' = 3.5\ ksi$

$f_c' := 3.5$

$$\phi V_c := \left(0.75 \cdot \min\left(4, \left(2 + \frac{4}{\beta}\right), \left(2 + \alpha_s \cdot \frac{d}{b_o}\right)\right) \cdot \lambda \cdot \sqrt{f_c'} \cdot b_o \cdot d\right) \cdot kip = 9277.439\ kip$$

$$\text{if } V_{utwoWay} \le \phi V_c \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"REVISE DESIGN"} \quad = \text{"OK"}$$

Check for flexural reinforcement:

$$M_u := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2}\right) \cdot \left(\frac{(L_1 - c_2)}{4}\right) = 90.28\ \text{kip} \cdot \text{ft}$$

$$f_c' := 3500\ \text{psi}$$

$$d := d_f - AverageCover = 1.208\ \text{ft}$$

$$b := L_1$$

Using Rule of Thumb
Preliminary area of Steel:

$$\frac{\frac{M_u}{\text{kip} \cdot \text{ft}}}{4 \cdot \frac{d}{\text{in}}} \cdot \text{in}^2 = 1.557\ \text{in}^2$$

$$A_{steel} := 0.25\ \text{in}^2 \cdot \pi = 0.196\ \text{in}^2 \qquad s := 18\ \text{in} \qquad n := \frac{b}{s} = 5.778 \qquad n := 8$$

$$A_s := n \cdot A_{steel} = 1.571\ \text{in}^2 \qquad f_y := 60\ \text{ksi}$$

$$a := \frac{(A_s \cdot f_y)}{0.85 \cdot f_c' \cdot b} = 0.305\ \text{in} \qquad F_s := 0.85 \cdot f_c' \cdot b \cdot a = \left(9.425 \cdot 10^4\right)\ \text{lbf}$$

$$M_n := F_s \cdot \left(d - \frac{a}{2}\right) = 112.687\ \text{kip} \cdot \text{ft}$$

Maximum bar spacing:

$$MaxBarSpacing := \min\left(2 \cdot d_f, 18\ \text{in}\right) = 18\ \text{in}$$

$$M_r := 0.9 \cdot M_n = 101.4\ \text{kip} \cdot \text{ft} \qquad b \;\; = 13\ \text{in}$$

$$\text{if } M_u \le M_r \;\|\; = \text{"OK"} \;\|\; \text{else} \;\|\; \text{"REVISE DESIGN"}$$

$$\text{if } b < MaxBarSpacing \;\|\; = \text{"OK"} \;\|\; \text{else} \;\|\; \text{"REVISE DESIGN"}$$

Development Length:

To be conservative:

$f_y := 60$ $d_b := d_w = 0.5$ in

$K_{tr} := 0$ $\psi_t := 1$ $\psi_s := 1$ $\psi_e := 1$ $c_b := 3$ $\alpha_{exs} := 1$ $d_b := 0.5$ $f'_c := 3.5$

$$l_d := \max\left(12, \frac{3}{40} \cdot \alpha_{exs} \cdot \frac{\left(\psi_s \cdot \min\left(\left(\psi_t \cdot \psi_e, 1.7\right)\right)\right)}{\min\left(2.5, \frac{\left(c_b + K_{tr}\right)}{d_b}\right)} \cdot \frac{\left(f_y \cdot d_b\right)}{\lambda \cdot \min\left(100, \sqrt{f'_c}\right)}\right) \cdot \text{in} = 12 \text{ in}$$

Length of bars from the critical bending section:

$$\frac{\left(b - c_1\right)}{2} = 45 \text{ in}$$

Footing size is enough to accommodate the full bar development

Bearing Capacity of Column at Base:

$A_1 := c_1 \cdot c_2 = 196\ in^2$

$h := d_f$

$l := \min(L_1, 2 \cdot h + c_1 + 2 \cdot h) = 86\ in$

$f'_c := 3500\ psi$

$A_2 := l^2 = (7.396 \cdot 10^3)\ in^2$

$N_1 := 0.65 \cdot (0.85 \cdot f'_c \cdot A_1) = 379.015\ kip$

$N_2 := 0.65 \cdot \min\left(\left(0.85 \cdot f'_c \cdot A_1 \cdot \sqrt{\frac{A_2}{A_1}}\right), 2 \cdot (0.85 \cdot f'_c \cdot A_1)\right) = 758.03\ kip$

Bearing Capacity of Column Base:

$\phi P_{nb} := \min(N_1, N_2) = 379.015\ kip$

if $K1 < \phi P_{nb}$ = "OK"
  "OK"
else
  "REVISE DESIGN"

Dowel Bars:

$A_6 := 0.44\ in^2$

Due to concrete bearing strength at the column base, we just need minimum area for dowels:

$0.005 \cdot A_1 = 0.98\ in^2$

Provide 3#6 bars:

$d_6 := 0.750\ in$

$f_c' := 3.5$ $\quad d_b := \frac{d_6}{in} = 0.75$ $\quad A_{sdowel} := 3 \cdot A_6 = 1.32\ in^2$

$l_{dc} := \max\left(8, \frac{(0.02 \cdot f_y \cdot d_b)}{\lambda \cdot \min(100, \sqrt{f_c'})}, 0.0003 \cdot f_y \cdot d_b\right) \cdot in = 8\ in$

Therefore, the provided footing thickness of 18in is adequate to fully develop these bars.

For extending into the column, the development length should be based on the larger of the dowel bar or the pedestal rebar. The Pedestal rebars are #6.

Splice Length:

$d_b := d_6 = 0.75\ in$

$f_y := 60000\ psi$

$SpliceLength := \text{if } f_y \le 60000\ psi$
$\quad \max(12\ in, l_{dc}, 0.0005 \cdot 60 \cdot d_b \cdot \alpha_s)$
else
$\quad \max(12\ in, l_{dc}, (0.0009 \cdot 60 - 24) \cdot d_b \cdot \alpha_s)$
$= 12\ in$

Extend dowel bars 1 ft into the pedestal:

Therefore K1 is a 8'-8" x 8'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

Check Footings for One-way Shear

N3 11'-2" W8x31

$B := \mathrm{FIF}(\text{"11'2"}) = 11.167\ ft$ $N3 = 186.528\ kip$

Bar has 1/2 in diameter:

$L_1 := B = 11.167\ ft$ $L_2 := B = 11.167\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := N3$ $d_f := 18\ in$ $c_2 := 14\ in$ $c_1 := c_2$

$cover1 := c_c + \frac{d_w}{2} = 3.25\ in$ $cover2 := c_c + d_w + \frac{d_w}{2} = 3.75\ in$

$AverageCover := \frac{cover1 + cover2}{2} = 3.5\ in$ $d := d_f - AverageCover = 14.5\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.5\ ksf$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 63.3\ kip$

Punch Out Shear:

$V_{upunchout} := q_u \cdot (L_1 \cdot L_2 - (c_1 + d) \cdot (c_2 + d)) = 178.09\ kip$ $\frac{(B - c_2)}{4} = 30\ in$

Shear Resistance of Concrete:

$$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \frac{\sqrt{f'_c}}{psi} \cdot psi \cdot L_2 \cdot d\right) = \left(8 \cdot 10^{-2}\right) ft^{\frac{1}{2}} \cdot s \cdot kip$$

if $V_{uoneWay} \le \phi V_c$ = ? lb
"OK"
else
"REVISE DESIGN"

Check for Two-Way (punching) shear:

Shear force at the critical section at distance d/2 around the column:

$$V_{utwoWay} := q_u \cdot \left(L_1 \cdot L_2 - (c_1 + d) \cdot (c_2 + d)\right) = 178.09\ kip$$

Two-Way shear resistance of concrete:

$$\beta := \frac{c_1}{c_2} = 1 \qquad b_o := 2 \cdot (c_1 + d) + 2 \cdot (c_2 + d) = 114\ in$$

$d = 14.5\ in$ $\qquad d := 14.5$

For Corner Column (if interior 40, if edge 30)

$\alpha_s := 20$

$\sqrt{f'_c} = 0.004 \frac{1}{psi} \cdot ksi$ $\qquad b_o := 114$

$f'_c := 3.5$

$$\phi V_c := \left(0.75 \cdot \min\left(4, \left(2 + \frac{4}{\beta}\right), \left(2 + \alpha_s \cdot \frac{d}{b_o}\right)\right) \cdot \lambda \cdot \sqrt{f'_c} \cdot b_o \cdot d\right) \cdot kip = 9277.439\ kip$$

$$\text{if } V_{utwoWay} \le \phi V_c \; \| \text{"OK"} \; \text{else} \; \| \text{"REVISE DESIGN"} \quad = \text{"OK"}$$

Check for flexural reinforcement:

$$M_u := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2}\right) \cdot \left(\frac{(L_1 - c_2)}{4}\right) = 208.8 \; kip \cdot ft$$

$$f_c' := 3500 \; psi$$

$$d := d_f - AverageCover = 1.208 \; ft$$

$$b := L_1$$

Using Rule of Thumb
Preliminary area of Steel:

$$\frac{\frac{M_u}{kip \cdot ft}}{4 \cdot \frac{d}{in}} \cdot in^2 = 3.6 \; in^2$$

$$A_{steel} := 0.25 \; in^2 \cdot \pi = 0.196 \; in^2 \qquad s := 14 \; in \qquad n := \frac{b}{s} = 9.571 \qquad n := 8$$

$$A_s := n \cdot A_{steel} = 1.571 \; in^2 \qquad f_y := 60 \; ksi$$

$$a := \frac{(A_s \cdot f_y)}{0.85 \cdot f_c' \cdot b} = 0.236 \; in \qquad F_s := 0.85 \cdot f_c' \cdot b \cdot a = (9.425 \cdot 10^4) \; lbf$$

$$M_n := F_s \cdot \left(d - \frac{a}{2}\right) = 112.954 \; kip \cdot ft$$

Maximum bar spacing:

$$MaxBarSpacing := \min(2 \cdot d_f, 18 \; in) = 18 \; in$$

$b = 16.75\ in$

$M_r := 0.9 \cdot M_n = 101.7\ kip \cdot ft$

$\text{if } M_u \le M_r$ "OK" else "REVISE DESIGN" = "REVISE DESIGN"

$\text{if } \frac{b}{n} < MaxBarSpacing$ "OK" else "REVISE DESIGN" = "OK"

Development Length:

To be conservative:

$f_y := 60$ $\quad d_b := d_w = 0.5\ in$

$K_{tr} := 0$ $\quad \psi_t := 1$ $\quad \psi_s := 1$ $\quad \psi_e := 1$ $\quad c_b := 3$ $\quad \alpha_{exs} := 1$ $\quad d_b := 0.5$ $\quad f'_c := 3.5$

$$l_d := \max\left(12, \frac{3}{40} \cdot \alpha_{exs} \cdot \frac{\left(\psi_s \cdot \min\left(\psi_t \cdot \psi_e, 1.7\right)\right)}{\min\left(2.5, \frac{\left(c_b + K_{tr}\right)}{d_b}\right)} \cdot \frac{\left(f_y \cdot d_b\right)}{\lambda \cdot \min\left(100, \sqrt{f'_c}\right)}\right) \cdot in = 12\ in$$

Length of bars from the critical bending section: $\frac{\left(b - c_1\right)}{2} = 60\ in$

Footing size is enough to accommodate the full bar development

Bearing Capacity of Column at Base:

$A_1 := c_1 \cdot c_2 = 196\ in^2$ $\qquad h := d_f$

$l := \min(L_1, 2 \cdot h + c_1 + 2 \cdot h) = 86\ in$

$f_c' := 3500\ psi$

$A_2 := l^2 = (7.396 \cdot 10^3)\ in^2$

$N_1 := 0.65 \cdot (0.85 \cdot f_c' \cdot A_1) = 379.015\ kip$

$N_2 := 0.65 \cdot \min\left(\left(0.85 \cdot f_c' \cdot A_1 \cdot \frac{A_2}{A_1}\right), 2 \cdot (0.85 \cdot f_c' \cdot A_1)\right) = 758.03\ kip$

Bearing Capacity of Column Base:

$\phi P_{nb} := \min(N_1, N_2) = 379.015\ kip$

```
if K1 < ϕP_nb      = "OK"
  ‖ "OK"
else
  ‖ "REVISE DESIGN"
```

Dowel Bars:

Due to concrete bearing strength at the column base, we just need minimum area for dowels:

$A_6 := 0.44\ in^2$

$0.005 \cdot A_1 = 0.98\ in^2$

Provide 3#6 bars:

$d_6 := 0.750\ in$

$d_6 = 0.75$

$A_{sdowel} := 3 \cdot A_6 = 1.32\ in^2$

$f_c' := 3.5$ $d_b :=$ in

$l_{dc} := \max\left(8, \sqrt{(0.02 \cdot f_y \cdot d_b)}, 0.0003 \cdot f_y \cdot d_b\right) \cdot in = 8\ in$

$\lambda \cdot \min(100, f_c')$

Therefore, the provided footing thickness of 18in is adequate to fully develop these bars.

For extending into the column, the development length should be based on the larger of the dowel bar or the pedestal rebar. The Pedestal rebars are #6.

Splice Length:

$d_b := d_6 = 0.75\ in$

$f_y := 60000\ psi$

$l = 12\ in$

$SpliceLength := \text{if } f_y \le 60000\ psi$

$\max(12\ in, l_{dc}, 0.0005 \cdot 60 \cdot d_b \cdot \alpha_s)$

else

$\sqrt{}$

Extend dowel bars 1 ft into the pedestal:

$0.0009 \cdot 60 \quad - 24$

$\max(12\ in, l_{dc}, \quad \cdot d_b \cdot \alpha_s)$

Therefore K1 is a 8'-8" x 8'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

K2 11'-0"

Bar has 1/2 in diameter:

$B := FIF\ \text{"11'0"} = 11\ ft$

$L_1 := B = 11\ ft \qquad L_2 := B = 11\ ft \qquad \lambda := 1 \qquad c_c := 3\ in \qquad d_w := 0.5\ in$

$P_u := K2 \qquad d_f := 10\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.5\ ksf \qquad d := d_f - c_c - d_w = 6.5\ in \qquad c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 72.1\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \left(\frac{f'_c}{psi}\right) \cdot psi \cdot L_2 \cdot d\right) = (4 \cdot 10^{-2})\ ft^2 \cdot s\ lb^2 \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
"OK"
else
"REVISE DESIGN"

Therefore K2 is a 11'-0" x 11'-0" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

K3 12'-8"

Bar has 1/2 in diameter:

$B := FIF\ \text{"12'8"} = 12.667\ ft$

$L_1 := B = 12.667\ ft$ $L_2 := B = 12.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := K3$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.46\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 93.4\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(5 \cdot 10^{-2}\right) \frac{ft^2 \cdot s^{1}}{lb^{2}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
 "OK"
else
 "REVISE DESIGN"

Therefore K3 is a 12'-8" x 12'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

K4 12'-8"

Bar has 1/2 in diameter:

$B := FIF\ \text{"12'8"} = 12.667\ ft$

$L_1 := B = 12.667\ ft$ $P_u := K4$ $L_2 := B = 12.667\ ft$ $\lambda := 1$ $d_f := 12\ in$

$c_c := 3 \text{ in}$ $d_w := 0.5 \text{ in}$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.45 \text{ ksf}$ $d := d_f - c_c - d_w = 8.5 \text{ in}$ $c_2 := 14 \text{ in}$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 92.7 \text{ kip}$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(5 \cdot 10^{-2}\right) \frac{ft^2 \cdot s^1}{lb^2} \cdot kip^1$

if $V_{uoneWay} \le \phi V_c$
“OK”
else
“REVISE DESIGN”
= ?

Therefore K4 is a 12'-8" x 12'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

L1 2'-0"

$B := FIF\ \text{"2'0"} = 2\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 2\ ft$ $L_2 := B = 2\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := L1$ $d_f := 6\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$ $d := d_f - c_c - d_w = 2.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 0.6\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \frac{\sqrt{f_c'}}{psi} \cdot psi \cdot L_2 \cdot d\right) = \left(2 \cdot 10^{-3}\right) ft^{\frac{1}{2}} \cdot s \cdot kip \cdot lb^{\frac{1}{2}}$

if $V_{uoneWay} \le \phi V_c$ | = ?
‖ "OK"
else
‖ "REVISE DESIGN"

Therefore L1 is a 2'-0" x 2'-0" x 0'-6" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M1 11'-2"

$B := FIF\ \text{"11'2"} = 11.167\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 11.167\ ft$ $L_2 := B = 11.167\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := M1$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$

$d := d_f - c_c - d_w = 8.5\ in$

$c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 70.8\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(5 \cdot 10^{-2}\right) \frac{ft^2 \cdot s^2}{lb} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
  "OK"
else
  "REVISE DESIGN"

Therefore M1 is a 11'-2" x 11'-2" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M2 14'-8"

$B := FIF\ "14'8" = 14.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 14.667\ ft$ $L_2 := B = 14.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := M2$ $d_f := 14\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.43\ ksf$ $d := d_f - c_c - d_w = 10.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 123.6\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \left(\frac{f'_c}{psi}\right)^{\frac{1}{2}} \cdot psi \cdot L_2 \cdot d\right) = \left(8 \cdot 10^{-2}\right) \frac{ft^2 \cdot s}{lb^2} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
"OK"
else
"REVISE DESIGN"

Therefore M2 is a 14'-8" x 14'-8" x 1'-2" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M3 14'-8"

$B := FIF\ "14'8" = 14.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 14.667\ ft$ $L_2 := B = 14.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := M3$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ \text{ksf}$ $d := d_f - c_c - d_w = 8.5\ \text{in}$ $c_2 := 14\ \text{in}$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 131.2\ \text{kip}$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(6 \cdot 10^{-2} \right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
‖ "OK"
else
‖ "REVISE DESIGN"

Therefore M3 is a 14'-8" x 14'-8" x 1'-2" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M4 16'-8"

$B := FIF(\text{"16'8"}) = 16.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 16.667\ ft$ $L_2 := B = 16.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := M4$ $d_f := 14\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.49\ ksf$ $d := d_f - c_c - d_w = 10.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 171\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(9 \cdot 10^{-2}\right) \frac{ft^2 \cdot s}{lb^2}^{\frac{1}{2}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ =?
"OK"
else
"REVISE DESIGN"

Therefore M4 is a 16'-8" x 16'-8" x 1'-4" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M5 16'-8"

$B := FIF(\text{"16'8"}) = 16.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 16.667\ ft$ $L_2 := B = 16.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := M5$ $d_f := 14\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.49\ ksf$

$d := d_f - c_c - d_w = 10.5\ in$

$c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 171\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(9 \cdot 10^{-2}\right) \frac{ft^2 \cdot s}{lb^2} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
‖ "OK"
else
‖ "REVISE DESIGN"

Therefore M5 is a 16'-8" x 16'-8" x 1'-4" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M6 16'-8"

$B := FIF\ \text{"16'8"} = 16.667\ ft$

M7 11'-0"

$B := FIF("11'0") = 11\ ft$

M6 16'-8"

$B := FIF("16'8") = 16.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 16.667\ ft$ $L_2 := B = 16.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := M6$ $d_f := 14\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$ $d := d_f - c_c - d_w = 10.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 169.2\ kip$ $\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(9 \cdot 10^{-2}\right) \frac{ft^2 \cdot s^{1}}{lb^{2}} \cdot kip^{1}$

if $V_{uoneWay} \le \phi V_c$
 ‖ "OK"
else
 ‖ "REVISE DESIGN"
$= ?$

Therefore M6 is a 16'-8" x 16'-8" x 1'-4" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

M7 11'-0"

$B := FIF("11'0") = 11\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 11\ ft$ $P_u := M7$ $L_2 := B = 11\ ft$ $\lambda := 1$

$d_f := 12\ in$ $c_c := 3\ in$ $d_w := 0.5$

in

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.5\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 69.3\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = (5 \cdot 10^{-2})\ \frac{ft^2 \cdot s}{lb^2} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ | = ?
‖ "OK"
else
‖ "REVISE DESIGN"

Therefore M7 is a 11'-0" x 11'-0" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

N1	2'-6"
N2	12'-4"
N3	11'-2"
O1	2'-6"
O2	12'-4"
O3	9'-8"
P1	8'-3"
P2	13'-6"
P3	13'-9"
P4	12'-8"
P5	12'-8"
P6	12'-8"

B := FIF "2'6" B := FIF "13'6"

B := FIF "12'4" B := FIF "13'9"

B := FIF "11'2" B := FIF "12'8"

B := FIF "2'6" B := FIF "12'8"

B := FIF "12'4" B := FIF "12'8"

B := FIF "9'8"

B := FIF "8'3"

$= 2.5$ ft

$= 12.333$ ft

$= 11.167$ ft

$= 2.5$ ft

$= 12.333$ ft

$= 9.667$ ft

$= 8.25$ ft

$= 13.5$ ft

$= 13.75$ ft

$= 12.667$ ft

$= 12.667$ ft

$= 12.667$ ft

P7 8'-3"

$B := FIF\ \text{“8'3”} = 8.25\ ft$

N1 2'-6"

$B := FIF\ \text{“2'6”} = 2.5\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 2.5\ ft$ $L_2 := B = 2.5\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := N1$ $d_f := 6\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.43\ ksf$ $d := d_f - c_c - d_w = 2.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\left(\frac{(L_1 - c_2)}{2}\right) - d\right) = 1.6\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \frac{\sqrt{f_c'}}{psi} \cdot psi \cdot L_2 \cdot d\right) = \left(3 \cdot 10^{-3}\right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ | = ?
‖ “OK”
else
‖ “REVISE DESIGN”

Therefore N1 is a 2'-6" x 2'-6" x 0'-6" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

N2 12'-4"

$B := FIF\ \text{“12'4”} = 12.333\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 12.333\ ft$ $P_u := N2$ $L_2 := B = 12.333\ ft$ $\lambda := 1$

$d_f := 12\ in$ $c_c := 3\ in$ $d_w := 0.5\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.49\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 89.9\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(5 \cdot 10^{-2} \right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
  "OK"
else
  "REVISE DESIGN"

Therefore N2 is a 12'-4" x 12'-4" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

N3 11'-2"

$B := FIF\left(\text{"11'2"}\right) = 11.167\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 11.167\ ft$ $L_2 := B = 11.167\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := N3$ $d_f := 12\ in$

$q_u := \dfrac{P_u}{L_1 \cdot L_2} = 1.5\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\dfrac{\left(L_1 - c_2\right)}{2} - d\right) = 71.7\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\dfrac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(5 \cdot 10^{-2}\right) \dfrac{ft^2 \cdot s^{\frac{1}{1}}}{lb^2} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
  "OK"
else
  "REVISE DESIGN"

Therefore N3 is a 11'-2" x 11'-2" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

O1 2'-6"

$B := FIF\left(\text{"2'6"}\right) = 2.5\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 2.5\ ft$ $L_2 := B = 2.5\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := O1$ $d_f := 6\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.43\ ksf$

$d := d_f - c_c - d_w = 2.5\ in$

$c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 1.6\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(3 \cdot 10^{-3}\right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
  "OK"
else
  "REVISE DESIGN"

Therefore O1 is a 2'-6" x 2'-6" x 0'-6" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

O2 12'-4"

$B := FIF("12'4") = 12.333\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 12.333\ ft$ $L_2 := B = 12.333\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := O2$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.49\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 89.9\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d\right) = \left(5 \cdot 10^{-2}\right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
‖ "OK"
else
‖ "REVISE DESIGN"

Therefore O2 is a 12'-4" x 12'-4" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

O3 9'-8"

$B := FIF("9'8") = 9.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 9.667\ ft$ $L_2 := B = 9.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := O3$ $d_f := 10\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.45\ ksf$ $d := d_f - c_c - d_w = 6.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 52\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(3 \cdot 10^{-2} \right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ | = ?
  ‖ "OK"
else
  ‖ "REVISE DESIGN"

Therefore O1 is a 9'-8" x 9'-8" x 0'-10" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

P1 8'-3"

$B := FIF\ \text{"8'3"} = 8.25\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 8.25\ ft$ $L_2 := B = 8.25\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P1$ $d_f := 10\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.49\ ksf$ $d := d_f - c_c - d_w = 6.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 36.8\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \frac{\sqrt{f'_c \cdot psi}}{psi} \cdot psi \cdot L_2 \cdot d\right) = \left(3 \cdot 10^{-2}\right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
  "OK"
else
  "REVISE DESIGN"

Therefore P1 is a 8'-3" x 8'-3" x 0'-10" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

P2 13'-6"

$B := FIF\ \text{"13'6"} = 13.5\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 13.5\ ft$ $L_2 := B = 13.5\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P2$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 109\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(6 \cdot 10^{-2} \right) \frac{ft^2 \cdot s^{1}}{lb^{2}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
  "OK"
else
  "REVISE DESIGN"

Therefore P2 is a 13'-6" x 13'-6" x 1'-2" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

P3 13'-9"

$B := FIF\ "13'9" = 13.75\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 13.75\ ft$ $L_2 := B = 13.75\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P3$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.5\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 115\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \left(\frac{f'_c}{psi} \right)^{\frac{1}{2}} \cdot psi \cdot L_2 \cdot d \right) = \left(6 \cdot 10^{-2} \right) \frac{ft^2 \cdot s}{lb^2}^{1} \cdot kip$

if $V_{uoneWay} \le \phi V_c$
"OK"
else
"REVISE DESIGN"
$= ?$

Therefore P3 is a 13'-9" x 13'-9" x 1'-2" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

P4 12'-8"

$B := FIF\ "12'8" = 12.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 12.667\ ft$ $L_2 := B = 12.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P4$ $d_f := 12\ in$

$$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf \qquad d := d_f - c_c - d_w = 8.5\ in \qquad c_2 := 14\ in$$

$$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 94.5\ kip$$

$$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(5 \cdot 10^{-2} \right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$$

if $V_{uoneWay} \le \phi V_c$
 "OK"
else
 "REVISE DESIGN"
= ?

Therefore P4 is a 12'-8" x 12'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

$\sqrt{}$

P5 12'-8"

$B := FIF\ ``12'8" = 12.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 12.667\ ft$ $L_2 := B = 12.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P5$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$ $d := d_f - c_c - d_w = 8.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\left(\frac{(L_1 - c_2)}{2} \right) - d \right) = 94.5\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \frac{\sqrt{f'_c}}{psi} \cdot psi \cdot L_2 \cdot d \right) = \left(5 \cdot 10^{-2} \right) \frac{ft^{\frac{1}{2}} \cdot s}{lb^{\frac{1}{2}}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
 "OK"
else
 "REVISE DESIGN"

Therefore P5 is a 12'-8" x 12'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

P6 12'-8"

$B := FIF\ ``12'8" = 12.667\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 12.667\ ft$ $L_2 := B = 12.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P6$ $d_f := 12\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.45\ ksf$

$d := d_f - c_c - d_w = 8.5\ in$

$c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 92.5\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(5 \cdot 10^{-2}\right) \frac{ft^{2} \cdot s^{1}}{lb^{2}} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ = ?
 "OK"
else
 "REVISE DESIGN"

Therefore P6 is a 12'-8" x 12'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

P7 8'-3"

$B := FIF\ \text{"8'3"} = 8.25\ ft$

Bar has 1/2 in diameter:

$L_1 := B = 8.25\ ft$ $L_2 := B = 8.25\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$P_u := P7$ $d_f := 10\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.5\ ksf$ $d := d_f - c_c - d_w = 6.5\ in$ $c_2 := 14\ in$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d \right) = 37.1\ kip$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot L_2 \cdot d \right) = \left(3 \cdot 10^{-2}\right) \frac{ft^2 \cdot s}{lb^2} \cdot kip$

if $V_{uoneWay} \le \phi V_c$ $= ?$
"OK"
else
"REVISE DESIGN"

Therefore P6 is a 8'-3" x 8'-3" x 0'-10" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

Pedestal Design:

According to ACI:

10.7.6.1.5 If anchor bolts are placed in the top of a column or pedestal, the bolts shall be enclosed by transverse reinforcement that also surrounds at least four longitudinal bars within the column or pedestal. The transverse reinforcement shall be distributed within 5 in. of the top of the pedestal and shall consist of at least two No. 4 or three No. 3 ties or hoops.

16.3.3.1 Design strengths of connections between pedestals and foundations shall satisfy Eq. 16.3.3.1 for each applicable load combination:

$$\phi S_n \geq U$$

S_n = nominal flexural, shear, axial, torsional, or bearing strength of the connection

ϕ = Table 21.2.1 - Strength reduction factors

Table 21.2.1 — Strength reduction factors ϕ

	Action or structural element	ϕ	Exceptions
(a)	Moment, axial force, or combined moment and axial force	0.65 to 0.90 in accordance with 21.2.2	Near ends of pretensioned members where strands are not fully developed, ϕ shall be in accordance with 21.2.3.
(b)	Shear	0.75	Additional requirements are given in 21.2.4 for structures designed to resist earthquake effects.
(c)	Torsion	0.75	—
(d)	Bearing	0.65	—
(e)	Post-tensioned anchorage zones	0.85	—
(f)	Brackets and corbels	0.75	—
(g)	Struts, ties, nodal zones, and bearing areas designed in accordance with strut-and-tie method in Chapter 23	0.75	—
(h)	Components of connections of precast members controlled by yielding of steel elements in tension	0.90	—
(i)	Plain concrete elements	0.60	—
(j)	Anchors in concrete elements	0.45 to 0.75 in accordance with Chapter 17	—

21.2.2 Strength reduction factor for moment, axial force, or combined moment and axial force shall be in accordance with Table 21.2.2.

16.3.3.4 Contact surface between a supported member and foundation, or between a supported member or foundation and an intermediate bearing element, nominal bearing strength Bn shall be calculated in accordance with 22.8 for concrete surfaces. Bn shall be the lesser of the nominal concrete bearing strengths for the supported member or foundation surface, and shall nor exceed the strength of intermediate bearing elements if present.

16.3.4.1 For connections between a cast-in-place column or pedestal and foundation, As, crossing the interface shall be at least 0.005Ag, where Ag is the gross area of the supported member.

FOOTING REBAR DESIGN

Rebar design groups:

K1, P1, P7 Design as 8'-8" with max load: 111.279 kip

K2, M1, M7, N3 Design as 11'-2" with max load: 186.528 kip

K3, K4, N2, O2, P4, P5, P6 Design as 12'-8" with max load: 237.511 kip

M2, M3, M4, M5, M6, P2, P3 Design as 16'-8" with max load: 414.641 kip

$$P_{u12ft8} := 237.511\ kip$$

$$P_{u16ft8} := 414.641\ kip$$

8'-8" Designed with #4 8x8

12-8" Designed with #6 12x12

11'-2" Designed with #4 8x8

16'-8" Designed with #8 26x26

Check Footings for One-way Shear

$f_c' := 3500\ psi$

K1 8'-8"

$B := FIF\ \text{“8'8”} = 8.667\ ft$ $K1 := 111.279\ kip$ Bar has 1/2 in diameter:

$L_1 := B = 8.667\ ft$ $L_2 := B = 8.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$c_1 := c_2$

$P_u := K1$ $d_f := 18\ in$ $c_2 := 14\ in$

$cover1 := c_c + \frac{d_w}{2} = 3.25\ in$ $cover2 := c_c + d_w + \frac{d_w}{2} = 3.75\ in$

$AverageCover := \frac{cover1 + cover2}{2} = 3.5\ in$ $d := d_f - AverageCover = 14.5\ in$

$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$

$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2} - d\right) = 32.6\ kip$

Punch Out Shear:

$V_{upunchout} := q_u \cdot \left(L_1 \cdot L_2 - (c_1 + d) \cdot (c_2 + d)\right) = 102.922\ kip$ $\frac{(B - c_2)}{4}$

Shear Resistance of Concrete:

$= 22.5\ in$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{\frac{f_c'}{psi}} \cdot psi \cdot L_2 \cdot d \right) = 134\ kip$

if $V_{uoneWay} \le \phi V_c$
  "OK"
else
  "REVISE DESIGN"

$= \text{"OK"}$

Check for Two-Way (punching) shear:

Shear force at the critical section at distance d/2 around the column:

$V_{utwoWay} := q_u \cdot \left(\left(L_1 \cdot L_2 - \left(\left(c_1 + d \right) \right) \cdot \left(\left(c_2 + d \right) \right) \right) \right) = 102.922\ kip$

Two-Way shear resistance of concrete:

$\beta := \frac{c_1}{c_2} = 1$

$b_o := 2 \cdot \left(\left(c_1 + d \right) \right) + 2 \cdot \left(\left(c_2 + d \right) \right) = 114\ in$

$d := 14.5$

$d = 14.5\ in$

For Corner Column: √(if interior 40, if edge 30)

$b_o := 114$

$\alpha_s := 20$

$f_c' = 3.5\ ksi$

$f_c' := 3.5$

$\phi V_c := \left(0.75 \cdot min \left(4 , \left(2 + \frac{4}{\beta} \right) , \left(2 + \alpha_s \cdot \frac{d}{b_o} \right) \right) \cdot \lambda \cdot \sqrt{f_c' \cdot b_o \cdot d} \right) \cdot kip = 9277.439\ kip$

WHAT IS GOING ON HERE?

√

if $V_{utwoWay} \le \phi V_c$ | = "OK"
"OK"
else
"REVISE DESIGN"

Check for flexural reinforcement:

$$M_u := q_u \cdot L_2 \cdot \left(\frac{(L_1 - c_2)}{2}\right) \cdot \left(\frac{(L_1 - c_2)}{4}\right) = 90.28\ kip \cdot ft$$

$f_c' := 3500\ psi$

$b := L_1$

$d := d_f - AverageCover = 1.208\ ft$

Using Rule of Thumb
Preliminary area of Steel:

$$\frac{M_u}{kip \cdot ft} \over 4 \cdot \frac{d}{in} \cdot in^2 = 1.557\ in^2$$

$13\ in \cdot 8 = 8.667\ ft$

$n := \frac{b}{s} = 8$

$A_{steel} := 0.25\ in^2 \cdot \pi = 0.196\ in^2$ $s := 13\ in$ $n := 8$

$A_s := n \cdot A_{steel} = 1.571\ in^2$ $f_y := 60\ ksi$

$$a := \frac{(A_s \cdot f_y)}{0.85 \cdot f_c' \cdot b} = 0.305\ in$$

$F_s := 0.85 \cdot f_c' \cdot b \cdot a = (9.425 \cdot 10^4)\ lbf$

$$M_n := F_s \cdot \left(d - \frac{a}{2}\right) = 112.687\ kip \cdot ft$$

Maximum bar spacing:

$MaxBarSpacing := min(2 \cdot d_f, 18\ in) = 18\ in$

$\frac{b}{n} = 13\ in$

$M_r := 0.9 \cdot M_n = 101.4\ kip \cdot ft$

if $M \le M$ | = "OK"

if b

‖"OK"

‖
else

‖"REVISE DESIGN"

‖

$< MaxBarSpacing$ = "OK"

‖"OK"
else

‖"REVISE DESIGN"

Development Length:

To be conservative:

$f_y := 60$ $d_b := d_w = 0.5\ in$

$\psi_s := 1$ $\psi_e := 1$ $c_b := 3$ $d_b := 0.5$

$K_{tr} := 0$ $\psi_t := 1$ $\alpha_{exs} := 1$ $f_c' := 3.5$

$$l_d := \max\left(12, \frac{3}{40} \cdot \alpha_{exs} \cdot \frac{\left(\psi_s \cdot \min\left(\psi_t \cdot \psi_e, 1.7\right)\right)}{\min\left(2.5, \frac{\left(c_b + K_{tr}\right)}{d_b}\right)} \cdot \lambda \cdot \min\left(100, \sqrt{f_c'}\right) \cdot \left(f_y \cdot d_b\right)\right) \cdot in = 12\ in$$

Length of bars from the critical bending section:

$$\frac{\left(b - c_l\right)}{2} = 45\ in$$

Footing size is enough to accommodate the full bar development

Bearing Capacity of Column at Base:

$$h := d_f$$

$$A_1 := c_1 \cdot c_2 = 196\ in^2$$

$$l := min\left(\left(L_1, 2 \cdot h + c_1 + 2 \cdot h\right)\right) = 86\ in$$

$$f_c' := 3500\ psi$$

$$A_2 := l^2 = \left(\left(7.396 \cdot 10^3\right)\right)\ in^2$$

$$N_1 := 0.65 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right) = 379.015\ kip$$

$$N_2 := 0.65 \cdot min\left(\left(\left(0.85 \cdot f_c' \cdot A_1 \cdot \frac{A_2}{A_1}\right), 2 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right)\right)\right) = 758.03\ kip$$

Bearing Capacity of Column Base:

$$\phi P_{nb} := min\left(\left(N_1, N_2\right)\right) = 379.015\ kip$$

if $K1 < \phi P_{nb}$
  "OK"
else
  "REVISE DESIGN"

= "OK"

Dowel Bars:

Due to concrete bearing strength at the column base, we just need minimum area for dowels:

$$0.005 \cdot A_1 = 0.98\ in^2$$

Provide 4#6 bars:

$$d_6 := 0.750\ in$$

$$A_6 := 0.44\ in^2$$

$d_6 = 0.75\ in$

$A_{sdowel} := 4 \cdot A_6 = 1.76\ in^2$

$f_c' := 3.5$ $d_b :=$

$$l_{dc} := \max\left(8, \left(\frac{0.02 \cdot f_y \cdot d_b}{\lambda \cdot \min\left(\sqrt{f_c'}, 100\right)}\right), 0.0003 \cdot f_y \cdot d_b\right) \cdot in = 8\ in$$

Therefore, the provided footing thickness of 18in is adequate to fully develop these bars.

For extending into the column, the development length should be based on the larger of the dowel bar or the pedestal rebar. The Pedestal rebars are #6.

Splice Length:

$f_y := 60000\ psi$

$d_b := d_6 = 0.75\ in$

$$SpliceLength := \text{if } f_y \le 60000\ psi \; \max\left(12\ in, l_{dc}, 0.0005 \cdot 60 \cdot d_b \cdot \alpha_s\right) \; \text{else} \; \max\left(12\ in, l_{dc}, \left(\left(0.0009 \cdot 60 - 24\right)\right) \cdot d_b \cdot \alpha_s\right) = 12\ in$$

Extend dowel bars 1 ft into the pedestal:

$\sqrt{}$

Therefore K1 is a 8'-8" x 8'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

Check Footings for One-way Shear

N3 11'-2" W8x31

$$B := FIF\ \text{"11'2"} = 11.167\ ft \qquad N3 := 186.528\ kip$$

Bar has 1/2 in diameter:

$L_1 := B = 11.167\ ft$ $L_2 := B = 11.167\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.5\ in$

$c_1 := c_2$

$P_u := N3$ $d_f := 30\ in$ $c_2 := 14\ in$

$$cover1 := c_c + \frac{d_w}{2} = 3.25\ in \qquad cover2 := c_c + d_w + \frac{d_w}{2} = 3.75\ in$$

$$AverageCover := \frac{cover1 + cover2}{2} = 3.5\ in \qquad d := d_f - AverageCover = 26.5\ in$$

$$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.5\ ksf$$

$$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{\left(\left(L_1 - c_2 \right) \right)}{2} - d \right) = 46.6\ kip$$

Punch Out Shear:

$$V_{upunchout} := q_u \cdot \left(\left(L_1 \cdot L_2 - \left(\left(c_1 + d \right) \right) \cdot \left(\left(c_2 + d \right) \right) \right) \right) = 169.489\ kip \qquad \frac{\left(\left(B - c_2 \right) \right)}{4} = 30\ in$$

Shear Resistance of Concrete: $f_c' := 3.5$

$$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{f'_c} \cdot \frac{L_2}{ft} \cdot \frac{d}{ft}\right) \cdot kip = 69\ kip$$

$$\text{if } V_{uoneWay} \le \phi V_c \;\|\; \text{"OK"} \;\text{else}\; \|\; \text{"REVISE DESIGN"} \;= \text{"OK"}$$

Check for Two-Way (punching) shear:

Shear force at the critical section at distance d/2 around the column:

$$V_{utwoWay} := q_u \cdot \left(L_1 \cdot L_2 - \left(c_1 + d\right) \cdot \left(c_2 + d\right)\right) = 169.489\ kip$$

Two-Way shear resistance of concrete:

$$\beta := \frac{c_1}{c_2} = 1 \qquad b_o := 2 \cdot \left(c_1 + d\right) + 2 \cdot \left(c_2 + d\right) = 162\ in$$

$d := 26.5$

$d = 26.5\ in$

For Interior Column: (if interior 40, if edge 30)

$b_o := 162$

$\alpha_s := 40$

$f_c' = 3.5$ $f_c' := 3.5$

$$\phi V_c := \left(0.75 \cdot min\left(4, \left(2 + \frac{4}{\beta}\right), \left(2 + \alpha_s \cdot \frac{d}{b_o}\right)\right) \cdot \lambda \cdot \sqrt{f_c'} \cdot b_o \cdot d\right) \cdot kip = 24094.403\ kip$$

$$\text{if } V_{utwoWay} \le \phi V_c \;\; \| \text{“OK”} \;\; \text{else} \;\; \| \text{“REVISE DESIGN”} \;\; = \text{“OK”}$$

Check for flexural reinforcement:

$$f_c' := 3500\ psi$$

$$M_u := q_u \cdot L_2 \cdot \left(\frac{\left(L_1 - c_2\right)}{2}\right) \cdot \left(\frac{\left(L_1 - c_2\right)}{4}\right) = 208.8\ kip \cdot ft$$

$$b := L_1$$

$$d := d_f - AverageCover = 2.208\ ft$$

Using Rule of Thumb
Preliminary area of Steel:

$$\frac{\dfrac{M_u}{kip \cdot ft}}{4 \cdot \dfrac{d}{in}} \cdot in^2 = 1.97\ in^2$$

$$A_{steel} := 0.25\ in^2 \cdot \pi = 0.196\ in^2 \qquad s := 18\ in \qquad n := \frac{b}{s} = 7.444 \qquad n := 8$$

$$16 \cdot \frac{8}{12} = 10.667$$

$$A_s := n \cdot A_{steel} = 1.571\ in^2 \qquad f_y := 60\ ksi$$

$$a := \frac{\left(A_s \cdot f_y\right)}{0.85 \cdot f_c' \cdot b} = 0.236\ in$$

$$F_s := 0.85 \cdot f_c' \cdot b \cdot a = \left(9.425 \cdot 10^4\right)\ lbf$$

$$M_n := F_s \cdot \left(d - \frac{a}{2}\right) = 207.202\ kip \cdot ft$$

Maximum bar spacing:

$$MaxBarSpacing := min\left(2 \cdot d_f, 18\ in\right) = 18\ in$$

$$M_r := 0.9 \cdot M_n = 186.5\ kip \cdot ft$$

$$\frac{b}{n} = 16.75\ in$$

$$\text{if } M_u \le M_r \;\; \| \text{“OK”} \;\; = \text{“REVISE DESIGN”}$$

$$\text{if } \frac{b}{n} < MaxBarSpacing \;\; = \text{“OK”}$$

else

"REVISE DESIGN"

"OK"

else

"REVISE DESIGN"

Development Length:

To be conservative:

$f_y := 60$ $d_b := d_w = 0.5\ in$

$\psi_s := 1$ $\psi_e := 1$ $c_b := 3$ $d_b := 0.5$

$K_{tr} := 0$ $\psi_t := 1$ $\alpha_{exs} := 1$ $f_c' := 3.5$

$$l_d := \max\left(12,\ \frac{3}{40} \cdot \alpha_{exs} \cdot \frac{\left(\psi_s \cdot \min\left(\psi_t \cdot \psi_e, 1.7\right)\right)}{\min\left(2.5, \frac{\left(c_b + K_{tr}\right)}{d_b}\right)} \cdot \frac{\left(f_y \cdot d_b\right)}{\lambda \cdot \min\left(100, \sqrt{f'_c}\right)}\right) \cdot in = 12\ in$$

Length of bars from the critical bending section:

$$\frac{\left(b - c_l\right)}{2} = 60\ in$$

Footing size is enough to accommodate the full bar development

Bearing Capacity of Column at Base:

$h := d_f$

$A_1 := c_1 \cdot c_2 = 196\ in^2$

$l := min\left(\left(L_1, 2 \cdot h + c_1 + 2 \cdot h\right)\right) = 134\ in$

$f_c' := 3500\ psi$

$A_2 := l^2 = \left(\left(1.796 \cdot 10^4\right)\right)\ in^2$

$N_1 := 0.65 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right) = 379.015\ kip$

$N_2 := 0.65 \cdot min\left(\left(\left(0.85 \cdot f_c' \cdot A_1 \cdot \frac{A_2}{A_1}\right), 2 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right)\right)\right) = 758.03\ kip$

Bearing Capacity of Column Base:

$\phi P_{nb} := min\left(\left(N_1, N_2\right)\right) = 379.015\ kip$

```
if K1 < φPnb        = "OK"
    "OK"
else
    "REVISE DESIGN"
```

Dowel Bars:

Due to concrete bearing strength at the column base, we just need minimum area for dowels:

$0.005 \cdot A_1 = 0.98\ in^2$

Provide 3#6 bars:

$d_6 := 0.750\ in$

$A_6 := 0.44\ in^2$

$d_6 = 0.75\ in$

$A_{sdowel} := 3 \cdot A_6 = 1.32\ in^2$

$f_c' := 3.5$ $d_b :=$

$l_{dc} := \max\left(8, \left(\frac{0.02 \cdot f_y \cdot d_b}{\lambda \cdot \min\left(\sqrt{f_c'}, 100\right)}\right), 0.0003 \cdot f_y \cdot d_b\right) \cdot in = 8\ in$

Therefore, the provided footing thickness of 18in is adequate to fully develop these bars.

For extending into the column, the development length should be based on the larger of the dowel bar or the pedestal rebar. The Pedestal rebars are #6.

Splice Length:

$d_b := d_6 = 0.75\ in$

$f_y := 60000\ psi$

$SpliceLength := \text{if } f_y \le 60000\ psi \ \max\left(12\ in, l_{dc}, 0.0005 \cdot 60 \cdot d_b \cdot \alpha_s\right)$ else $\max\left(12\ in, l_{dc}, \left(\left(0.0009 \cdot 60 - 24\right) \cdot d_b \cdot \alpha_s\right)\right) = 12\ in$

Extend dowel bars 1 ft into the pedestal:

Therefore N3 is a 8'-8" x 8'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

Check Footings for One-way Shear

P5 12'-8" W8x48

$B := FIF\ \text{“12'8”} = 12.667\ ft$ $P_{u12ft8} = 237.511\ kip$

Bar has 3/4 in diameter:

$L_1 := B = 12.667\ ft$ $L_2 := B = 12.667\ ft$ $\lambda := 1$ $c_c := 3\ in$ $d_w := 0.75\ in$

$c_1 := c_2$

$P_u := P_{u12ft8}$ $d_f := 34\ in$ $c_2 := 14\ in$

$$cover1 := c_c + \frac{d_w}{2} = 3.375\ in \qquad cover2 := c_c + d_w + \frac{d_w}{2} = 4.125\ in$$

$$AverageCover := \frac{cover1 + cover2}{2} = 3.75\ in \qquad d := d_f - AverageCover = 30.25\ in$$

$$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.48\ ksf$$

$$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\frac{\left(L_1 - c_2\right)}{2} - d\right) = 60.5\ kip$$

Punch Out Shear:

$$V_{upunchout} := q_u \cdot \left(L_1 \cdot L_2 - \left(c_1 + d\right) \cdot \left(c_2 + d\right)\right) = 217.382\ kip \qquad \frac{\left(B - c_2\right)}{4} = 34.5\ in$$

Shear Resistance of Concrete: $f_c' := 3.5$

$$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \sqrt{f'} \cdot L_2 \cdot \right.$$

$c \quad ft \quad d \Big) \cdot kip = 90$

$kip\Big) \quad ft$

if $V_{uoneWay} \le \phi V_c$ | = "OK"
‖ "OK"
else
‖ "REVISE DESIGN"

Check for Two-Way (punching) shear:

Shear force at the critical section at distance d/2 around the column:

$V_{utwoWay} := q_u \cdot \left(\left(L_1 \cdot L_2 - \left(\left(c_1 + d\right)\right) \cdot \left(\left(c_2 + d\right)\right)\right)\right) = 217.382\ kip$

Two-Way shear resistance of concrete:

$\beta := \frac{c_1}{c_2} = 1 \qquad b_o := 2 \cdot \left(\left(c_1 + d\right)\right) + 2 \cdot \left(\left(c_2 + d\right)\right) = 177\ in$

$d := 30.25$

$d = 30.25\ in$

For Interior Column: (if interior 40, if edge 30)

$b_o := 177$

$\alpha_s := 40$

$f_c' = 3.5 \qquad f_c' := 3.5$

$\phi V_c := \left(0.75 \cdot min\left(4, \left(2 + \frac{4}{\beta}\right), \left(2 + \alpha_s \cdot \frac{d}{b_o}\right)\right) \cdot \lambda \cdot \sqrt{f_c'} \cdot b_o \cdot d\right) \cdot kip = 30050.654\ kip$

$\sqrt{}$

if $V_{utwoWay} \le \phi V_c$ $= \text{“OK”}$
‖ “OK”
else
‖ “REVISE DESIGN”

Check for flexural reinforcement:

$$M_u := q_u \cdot L_2 \cdot \left(\frac{\left(L_1 - c_2\right)}{2}\right) \cdot \left(\frac{\left(L_1 - c_2\right)}{4}\right) = 309.975\ kip \cdot ft$$

$f_c' := 3500\ psi$

$b := L_1$

$d := d_f - AverageCover = 2.521\ ft$

Using Rule of Thumb
Preliminary area of Steel:

$$\frac{\frac{M_u}{kip \cdot ft}}{4 \cdot \frac{d}{in}} \cdot in^2 = 2.562\ in^2$$

$A_{steel} := (0.25\ in)^2 \cdot \pi = 0.196\ in^2$ $\quad s := 12\ in$ $\quad n := \frac{b}{s} = 12.667$ $\quad n := 12$ $\quad 12 \cdot 12\ in = 12\ ft$

$A_s := n \cdot A_{steel} = 2.356\ in^2$ $\quad f_y := 60\ ksi$

$$a := \frac{\left(A_s \cdot f_y\right)}{0.85 \cdot f_c' \cdot b} = 0.313\ in$$

$$F_s := 0.85 \cdot f_c' \cdot b \cdot a = \left(1.414 \cdot 10^5\right)\ lbf$$

$$M_n := F_s \cdot \left(d - \frac{a}{2}\right) = 354.533\ kip \cdot ft$$

Maximum bar spacing:

$$MaxBarSpacing := min\left(2 \cdot d_f, 18\ in\right) = 18\ in$$

$$\frac{b}{n} = 12.667\ in$$

$$M_r := 0.9 \cdot M_n = 319.1\ kip \cdot ft$$

if $M_u \le M_r$ $= \text{“OK”}$

if $\frac{b}{n}$

‖"OK"

‖ else

‖"REVISE DESIGN"

$< MaxBarSpacing$ = "OK"

else "OK"

"REVISE DESIGN"

Development Length:

To be conservative:

$f_y := 60$ $d_b := d_w = 0.75$ in

$\psi_s := 1$ $\psi_e := 1$ $c_b := 3$ $d_b := 0.5$

$K_{tr} := 0$ $\psi_t := 1$ $\alpha_{exs} := 1$ $f_c' := 3.5$

$$l_d := \max\left(12, \frac{3}{40} \cdot \alpha_{exs} \cdot \frac{\left(\psi_s \cdot \min\left(\psi_t \cdot \psi_e, 1.7\right)\right)}{\min\left(2.5, \frac{c_b + K_{tr}}{d_b}\right)} \cdot \frac{\left(f_y \cdot d_b\right)}{\lambda \cdot \min\left(100, \sqrt{f_c'}\right)}\right) \cdot in = 12\ in$$

Length of bars from the critical bending section:

$$\frac{\left(b - c_l\right)}{2} = 5.75\ ft$$

Footing size is enough to accommodate the full bar development

Bearing Capacity of Column at Base:

$$h := d_f$$

$$A_1 := c_1 \cdot c_2 = 196\ in^2$$

$$l := min\left(\left(L_1, 2 \cdot h + c_1 + 2 \cdot h\right)\right) = 150\ in$$

$$f_c' := 3500\ psi$$

$$A_2 := l^2 = \left(\left(2.25 \cdot 10^4\right)\right)\ in^2$$

$$N_1 := 0.65 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right) = 379.015\ kip$$

$$N_2 := 0.65 \cdot min\left(\left(\left(0.85 \cdot f_c' \cdot A_1 \cdot \sqrt{\frac{A_2}{A_1}}\right), 2 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right)\right)\right) = 758.03\ kip$$

Bearing Capacity of Column Base:

$$\phi P_{nb} := min\left(\left(N_1, N_2\right)\right) = 379.015\ kip$$

```
if K1 < ϕP_nb        = "OK"
  ‖ "OK"
else
  ‖ "REVISE DESIGN"
```

Dowel Bars:

Due to concrete bearing strength at the column base, we just need minimum area for dowels:

$$0.005 \cdot A_1 = 0.98\ in^2$$

Provide 3#6 bars:

$$d_6 := 0.750\ in$$

$$A_6 := 0.44\ in^2$$

$d_6 = 0.75\ in$

$A_{sdowel} := 3 \cdot A_6 = 1.32\ in^2$

$f_c' := 3.5$ $d_b :=$

$$l_{dc} := \max\left(8, \left(\frac{0.02 \cdot f_y \cdot d_b}{\lambda \cdot \min\left(\sqrt{f_c'}, 100\right)}\right), 0.0003 \cdot f_y \cdot d_b\right) \cdot in = 8\ in$$

Therefore, the provided footing thickness of 18in is adequate to fully develop these bars.

For extending into the column, the development length should be based on the larger of the dowel bar or the pedestal rebar. The Pedestal rebars are #6.

Splice Length:

$d_b := d_6 = 0.75\ in$

$f_y := 60000\ psi$

$$SpliceLength := \text{if } f_y \le 60000\ psi \ \| \max\left(12\ in, l_{dc}, 0.0005 \cdot 60 \cdot d_b \cdot \alpha_s\right) \ \text{else} \ \| \max\left(12\ in, l_{dc}, \left(0.0009 \cdot 60 - 24\right) \cdot d_b \cdot \alpha_s\right) = 12\ in$$

Extend dowel bars 1 ft into the pedestal:

Therefore N3 is a 8'-8" x 8'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

Check Footings for One-way Shear

16'-8"

$B := FIF\ \text{“16'8”} = 16.667\ ft$

$P_{u16ft8} = 414.641\ kip$

$L_1 := B = 16.667\ ft$

$c_c := 3\ in$

Bar has #8 1 in diameter:

$L_2 := B = 16.667\ ft$ $\lambda := 1$

$d_w := 1\ in$

$c_1 := c_2$

$P_u := P_{u16ft8}$ $d_f := 38\ in$ $c_2 := 14\ in$

$$cover1 := c_c + \frac{d_w}{2} = 3.5\ in \qquad cover2 := c_c + d_w + \frac{d_w}{2} = 4.5\ in$$

$$AverageCover := \frac{cover1 + cover2}{2} = 4\ in$$

$d := d_f - AverageCover = 34\ in$

$$q_u := \frac{P_u}{L_1 \cdot L_2} = 1.49\ ksf$$

$$V_{uoneWay} := q_u \cdot L_2 \cdot \left(\left(\frac{(L_1 - c_2)}{2}\right) - d\right) = 122.3\ kip$$

Punch Out Shear:

$$V_{upunchout} := q_u \cdot \left(\left(L_1 \cdot L_2 - \left(\left(c_1 + d\right)\right) \cdot \left(\left(c_2 + d\right)\right)\right)\right) = 390.758\ kip$$

$$\frac{\left(\left(B - c_2\right)\right)}{4} = 46.5\ in$$

Shear Resistance of Concrete: $f_c' := 3.5$

$\phi V_c := 0.75 \cdot \left(2 \cdot \lambda \cdot \quad f' \cdot L_2 \cdot \right.$

$c \quad d \quad f \cdot kip =$

$t \quad 133\ kip \quad ft$

if $V_{uoneWay} \le \phi V_c$ $\quad$ = "OK"

"OK"

else

"REVISE DESIGN"

Check for Two-Way (punching) shear:

Shear force at the critical section at distance d/2 around the column:

$V_{utwoWay} := q_u \cdot \left(L_1 \cdot L_2 - \left(\left(c_1 + d\right) \cdot \left(c_2 + d\right)\right)\right) = 390.758\ kip$

Two-Way shear resistance of concrete:

$\beta := \frac{c_1}{c_2} = 1$ $\qquad b_o := 2 \cdot \left(\left(c_1 + d\right)\right) + 2 \cdot \left(\left(c_2 + d\right)\right) = 192\ in$

$d := 34$

$d = 34\ in$

For Interior Column: (if interior 40, if edge 30)

$b_o := 192$

$\alpha_s := 40$

$f_c' = 3.5$ $\qquad f_c' := 3.5$

$\phi V_c := \left(0.75 \cdot min\left(4, \left(2 + \frac{4}{\beta}\right), \left(2 + \alpha_s \cdot \frac{d}{b_o}\right)\right) \cdot \lambda \cdot \sqrt{f_c'} \cdot b_o \cdot d\right) \cdot kip = 36638.309\ kip$

$\sqrt{}$

$$\text{if } V_{utwoWay} \le \phi V_c \quad \text{"OK"} \quad \text{else} \quad \text{"REVISE DESIGN"} \quad = \text{"OK"}$$

Check for flexural reinforcement:

$$M_u := q_u \cdot L_2 \cdot \left(\frac{\left(L_1 - c_2\right)}{2}\right) \cdot \left(\frac{\left(L_1 - c_2\right)}{4}\right) = 747.131\ kip \cdot ft$$

$$f_c' := 3500\ psi$$

$$b := L_1$$

$$d := d_f - AverageCover = 2.833\ ft$$

Using Rule of Thumb
Preliminary area of Steel:

$$\frac{M_u}{kip \cdot ft} \over {4 \cdot \frac{d}{in}} \cdot in^2 = 5.494\ in^2$$

$$n := \frac{b}{s} = 20$$

$$A_{steel} := 0.25\ in^2 \cdot \pi = 0.196\ in^2 \qquad s := 10\ in \qquad n := 26$$

$$A_s := n \cdot A_{steel} = 5.105\ in^2 \qquad f_y := 60\ ksi$$

$$a := \frac{\left(A_s \cdot f_y\right)}{0.85 \cdot f_c' \cdot b} = 0.515\ in$$

$$F_s := 0.85 \cdot f_c' \cdot b \cdot a = \left(3.063 \cdot 10^5\right)\ lbf$$

$$M_n := F_s \cdot \left(d - \frac{a}{2}\right) = 861.295\ kip \cdot ft$$

Maximum bar spacing:

$$MaxBarSpacing := min\left(2 \cdot d_f, 18\ in\right) = 18\ in$$

$$\frac{b}{n} = 7.692\ in$$

$$M_r := 0.9 \cdot M_n = 775.2\ kip \cdot ft$$

$$\text{if } M \le M \quad = \text{"OK"}$$

$$\text{if } \frac{b}{}$$

“OK”

else

“REVISE DESIGN”

$< MaxBarSpacing$ = “OK”

n

“OK”

else

“REVISE DESIGN”

Development Length:

To be conservative:

$f_y := 60$ $d_b := d_w = 1\ in$

$\psi_s := 1$ $\psi_e := 1$ $c_b := 3$ $d_b := 0.5$

$K_{tr} := 0$ $\psi_t := 1$ $\alpha_{exs} := 1$ $f_c' := 3.5$

$$l_d := \max\left(12, \frac{3}{40} \cdot \alpha_{exs} \cdot \frac{\left(\psi_s \cdot \min\left(\psi_t \cdot \psi_e, 1.7\right)\right)}{\min\left(2.5, \frac{c_b + K_{tr}}{d_b}\right)} \cdot \frac{\left(f_y \cdot d_b\right)}{\lambda \cdot \min\left(100, \sqrt{f_c'}\right)}\right) \cdot in = 12\ in$$

Length of bars from the critical bending section:

$$\frac{(b - c_l)}{2} = 7.75\ ft$$

Footing size is enough to accommodate the full bar development

Bearing Capacity of Column at Base:

$h := d_f$

$A_1 := c_1 \cdot c_2 = 196\ in^2$

$l := min\left(\left(L_1, 2 \cdot h + c_1 + 2 \cdot h\right)\right) = 166\ in$

$f_c' := 3500\ psi$

$A_2 := l^2 = \left(\left(2.756 \cdot 10^4\right)\right)\ in^2$

$N_1 := 0.65 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right) = 379.015\ kip$

$N_2 := 0.65 \cdot min\left(\left(\left(0.85 \cdot f_c' \cdot A_1 \cdot \sqrt{\frac{A_2}{A_1}}\right), 2 \cdot \left(\left(0.85 \cdot f_c' \cdot A_1\right)\right)\right)\right) = 758.03\ kip$

Bearing Capacity of Column Base:

$\phi P_{nb} := min\left(\left(N_1, N_2\right)\right) = 379.015\ kip$

```
if K1 < φP_nb            | = "OK"
  ‖ "OK"                 |
else                     |
  ‖ "REVISE DESIGN"      |
```

Dowel Bars:

Due to concrete bearing strength at the column base, we just need minimum area for dowels:

$0.005 \cdot A_1 = 0.98\ in^2$

Provide 3#6 bars:

$d_6 := 0.750\ in$

$A_6 := 0.44\ in^2$

$d_6 = 0.75\ in$

$A_{sdowel} := 3 \cdot A_6 = 1.32\ in^2$

$f_c' := 3.5$ $d_b :=$

$$l_{dc} := \max\left(8, \left(\frac{0.02 \cdot f_y \cdot d_b}{\lambda \cdot \min\left(\sqrt{f_c'}, 100\right)}\right), 0.0003 \cdot f_y \cdot d_b\right) \cdot in = 8\ in$$

Therefore, the provided footing thickness of 18in is adequate to fully develop these bars.

For extending into the column, the development length should be based on the larger of the dowel bar or the pedestal rebar. The Pedestal rebars are #6.

Splice Length:

$d_b := d_6 = 0.75\ in$

$f_y := 60000\ psi$

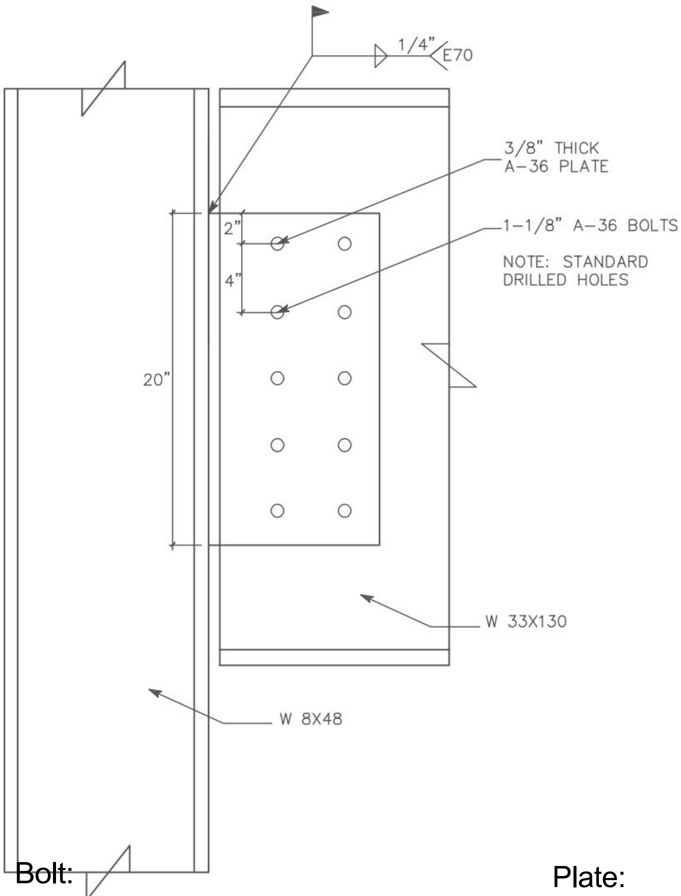
$$SpliceLength := \text{if } f_y \le 60000\ psi \;\; \max\left(12\ in, l_{dc}, 0.0005 \cdot 60 \cdot d_b \cdot \alpha_s\right) \;\; \text{else} \;\; \max\left(12\ in, l_{dc}, \left(0.0009 \cdot 60 - 24\right) \cdot d_b \cdot \alpha_s\right) = 12\ in$$

Extend dowel bars 1 ft into the pedestal:

Therefore N3 is a 8'-8" x 8'-8" x 1'-0" footing with 1/2" diameter reinforcement in both directions with clear cover of 3"

Ch. 9 p. 987 Shear Tab
and p. 1001

W33x130 Girder tp W8x48 Column



Weld:

$w := \frac{1}{4}\ in$

Bolt:
ASTM F3125 Gr. A325

$F_{uBolt} := 120\ ksi$

Plate:
ASTM A36

$F_{yPlate} := 36\ ksi$

$F_{uPlate} := 58\ ksi$

Section:
ASTM A992

$F_{ySection} := 50\ ksi$

$F_{uSection} := 65\ ksi$

Diameter:

$d_b := \frac{9}{8}\ in$

Area:

$A_b := \frac{d_b^{\,2}}{4} \cdot \pi = 0.994\ in^2$

Hole Diameter: Standard Punched

$d_h := d_b + \frac{1}{8}\ in = 1.25\ in$

Based on table J3.3

For W 33x130

$d := 33.1\ in$ $t_w := 0.580\ in$ $b_f := 11.5\ in$ $t_f := 0.855\ in$

Shear Tab Plate Thickness:

$$t_p := \frac{3}{8}\ in$$

Check thickness requirements for simplified design procedure:

$$\frac{d_b}{2} + \frac{1}{16}\ in = 0.625\ in$$

```
if  d_b/2 + 1/16 in > t_p     | = "OK"
  ‖ "OK"
else
  ‖ "REVISE PLATE THICKNESS"
```

```
if  d_b/2 + 1/16 in > t_w     | = "OK"
  ‖ "OK"
else
  ‖ "REVISE PLATE THICKNESS"
```

$L_{ev} := 2\ in$

$L_{eh} := 2\ in$

$s := 4\ in$

$n_{bolts} := 10$

Plate Strength:

Shear Failure Mode of Shear Tab:

Gross length in shear:

$$L_g := 2 \cdot L_{ev} + \left(\left(n_{bolts} - 1\right)\right) \cdot s = 40\ in$$

Gross area in shear:

$$A_{gv} := t_p \cdot L_g = 15\ in^2$$

Strength in shear yielding:

$$\phi R_{nPlateShearYielding} := 1.0 \cdot 0.6 \cdot F_{yPlate} \cdot A_{gv} = 324\ kip$$

Net area in shear:

$$A_{nv} := A_{gv} - n_{bolts} \cdot d_h \cdot t_p = 10.313\ in^2$$

Check to see if this should
be Av instead

Strength in Shear Rupture:

$$\phi R_{nPlateShearRupture} := 0.75 \cdot 0.6 \cdot F_{uPlate} \cdot A_{nv} = 269.156\ kip$$

Block Shear Strength:

Block shear failure mode of shear tab:

Gross area along shear plane:

$$A_{gv} := t_p \cdot \left(L_{ev} + \left(n_{bolts} - 1\right) \cdot s\right) = 14.25\ in^2$$

Net Area in Shear:

$$A_{nv} := A_{gv} - \left(\left(n_{bolts} - 1\right) + 0.5\right) \cdot d_h \cdot t_p = 9.797\ in^2$$

Net Area along tension plane:

$$A_{nt} := \left(L_{eh} - \frac{d_h}{2}\right) \cdot t_p = 0.516\ in^2$$

$U := 1$

$$\phi R_{nBlockShear} := 0.75 \cdot \left(\min\left(0.6 \cdot F_{uPlate} \cdot A_{nv}, 0.6 \cdot F_{yPlate} \cdot A_{gv}\right) + U \cdot F_{uPlate} \cdot A_{nt}\right) = 253.28\ kip$$

Plate Strength:

$$\phi R_{nPlate} := \min\left(\phi R_{nPlateShearYielding}, \phi R_{nPlateShearRupture}, \phi R_{nBlockShear}\right) = 253.28\ kip$$

Bolted Connection:

Bolt shear strength:

$$F_{nv} := 0.4 \cdot F_{uBolt} = 48\ ksi$$

Bolts in single shear:

$$\phi R_{nBoltShear} := 0.75 \cdot F_{nv} \cdot A_b = 35.785\ kip$$

Bolt bearing in plate with thickness tp

Lc based on end bolt

$$L_{c1} := L_{ev} - \frac{d_h}{2} = 1.375\ in$$

$$\phi R_{nEndBoltBearing} := 0.75 \cdot \min\left(1.2 \cdot L_{c1} \cdot t_p \cdot F_{uPlate}, 2.4 \cdot d_b \cdot t_p \cdot F_{uPlate}\right) = 26.916 \text{ kip}$$

Lc based on distance between the bolt holes:

$$L_{c2} := s - d_h = 2.75 \text{ in}$$

$$\phi R_{nIntBoltBearing} := 0.75 \cdot \min\left(1.2 \cdot L_{c2} \cdot t_p \cdot F_{uPlate}, 2.4 \cdot d_b \cdot t_p \cdot F_{uPlate}\right) = 44.044 \text{ kip}$$

The Bolt Strength:

$$\phi R_{nEndBolt} := \min\left(\left(\phi R_{nBoltShear}, \phi R_{nEndBoltBearing}\right)\right) = 26.916\ \text{kip}$$

$$\phi R_{nIntBolt} := \min\left(\left(\phi R_{nBoltShear}, \phi R_{nIntBoltBearing}\right)\right) = 35.785\ \text{kip}$$

Connection strength with four end bolt and eight interior bolt:

$$\phi R_{nBolts} := 4 \cdot \phi R_{nEndBolt} + 6 \cdot \phi R_{nIntBolt} = 322.371\ \text{kip}$$

Bolt bearing in beam web with thickness tw

$$\phi R_{nEndBoltBearing} := 0.75 \cdot \min\left(\left(1.2 \cdot L_{c1} \cdot t_w \cdot F_{uSection}, 2.4 \cdot d_b \cdot t_w \cdot F_{uSection}\right)\right) = 46.654\ \text{kip}$$

$$\phi R_{nIntBoltBearing} := 0.75 \cdot \min\left(\left(1.2 \cdot L_{c1} \cdot t_w \cdot F_{uSection}, 2.4 \cdot d_b \cdot t_w \cdot F_{uSection}\right)\right) = 46.654\ \text{kip}$$

The Bolt Strength:

$$\phi R_{nEndBolt} := \min\left(\left(\phi R_{nBoltShear}, \phi R_{nEndBoltBearing}\right)\right) = 35.785\ \text{kip}$$

$$\phi R_{nIntBolt} := \min\left(\left(\phi R_{nBoltShear}, \phi R_{nIntBoltBearing}\right)\right) = 35.785\ \text{kip}$$

Connection strength with two end bolt and one interior bolt:

$$\phi R_{nBolts} := 4 \cdot \phi R_{nEndBolt} + 6 \cdot \phi R_{nIntBolt} = 357.847\ kip$$

Connection Strength:

Connection strength is minimum of plate and bolts:

$$\phi R_n := \min\left(\left(\phi R_{nBolts}, \phi R_{nPlate}\right)\right) = 253.28\ kip$$

Max Shear:

$$V_{max} := 207.39\ kip$$

$$\left\| \begin{array}{l} \text{if } V_{max} \le \phi R_n \\ \quad \| \text{"OK"} \\ \text{else} \\ \quad \| \text{"REVISE DESIGN"} \end{array} \right| = \text{"OK"}$$

Welded Connection:

Weld size must be greater than 5/8*tp

$$\left\| \begin{array}{l} \text{if } w > \frac{5}{8} \cdot t_p \\ \quad \| \text{"OK"} \\ \text{else} \\ \quad \| \text{"REVISE WELD SIZE"} \end{array} \right| = \text{"OK"}$$

Weld on both sides of the plate. The weld develops full strength of the plate and, therefore, no need to perform calculations to compute the weld strength.

Staircase Design: AISC p. 3-151

Raised Pattern Floor Plate Flexural-Strength Controlled Applications

Span:

$Span := 6\ ft$

Loads:

$L := 100\ psf$

$q_{wetc} := 1.1 \cdot (115\ pcf \cdot 4\ in) = 42.167\ psf$

Bent Plate Capacity:

$q_{bpcapacity} := 46.9\ psf$ <- 3/16 " thick plate

```
if q_wetc < q_bpcapacity   | = "OK"
  ‖ "OK"                   |
else                       |
  ‖ "REVISE DESIGN"        |
```

Design of C- Shape Stringer:

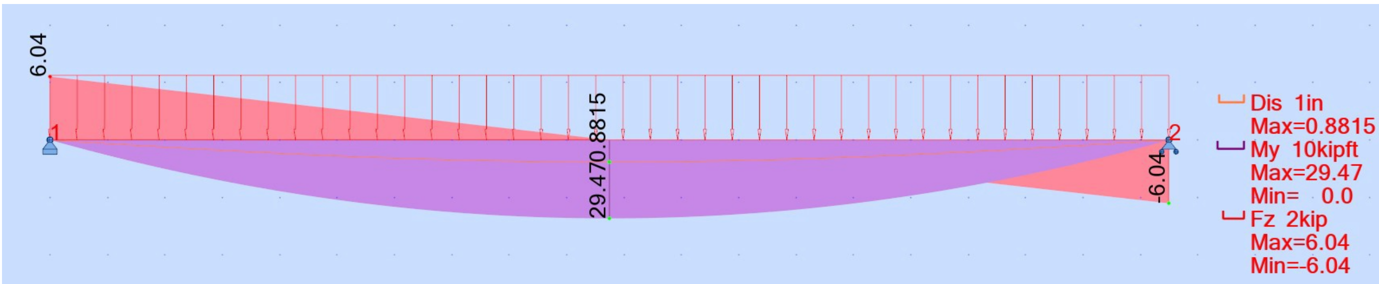
$q_{bentplate} := 3.70\ psf$ $D := q_{bentplate} + q_{wetc} = 0.319\ psi$

$$TW := \frac{5.5\ ft}{2} = 2.75\ ft$$

$w_u := (1.2 \cdot D + 1.6 \cdot L) \cdot TW = 591.36\ plf$

$L_c := 19.5\ ft$ $L_b := 0\ in$

Beam Analysis: 10x20



$V_{max} := 2\ kip$ $M_{max} := 29.47\ kip \cdot ft$ $\delta_{max} := 0.8815\ in$

Flexure Check:

$L_p := 2.87\ ft$

$\phi M_p := 52.4\ kip \cdot ft$

A36:

C10x20: Dimensions

$L_r := 13.0\ ft$

Plastic Moment:

$F_y := 36\ ksi$

$Z_x := 419\ in^3$

$M_p := F_y \cdot Z_x = \left(\left(1.257 \cdot 10^3\right)\right)\ kip \cdot ft$

$S_x := 16.5\ in^3$

$\phi := 0.9$

$E := 29000\ ksi$

$I_y := 2.8\ in^4$

$C_w := 56.9\ in^6$

$h_o := 9.56\ in$

$J := 0.368\ in^4$

$c := 1$

if $L_b \le L_p$ | = "YIELDING"

‖ "YIELDING"

else if $L_p < L_b \le L_r$
  "INELASTIC"
else
  "ELASTIC"

$M_n := F_y \cdot Z_x$

$\phi M_n := \phi \cdot M_n = (1.131 \cdot 10^3)$ kip · ft

if $M_{max} < \phi M_n$ = "OK"
  "OK"
else
  "REVISE DESIGN"

Shear Check:

$\phi V_n := 73.9$ kip

if $V_{max} < \phi V_n$ = "OK"
  "OK"
else
  "REVISE DESIGN"

Serviceability Check:

$\Delta_{DL} := \frac{L_c}{240} = 0.975$ in

if $\delta_{max} < \Delta_{DL}$ = "OK"
  "OK"
else
  "REVISE DESIGN"

Stringer : C 10x20

Length:

Landing:

4'-5" by 13'-10"
4ft x 4ft

Stairs:
1st Set of Stairs:
  Hyp: 14 ft
  Width: 5.5 ft

2nd:
  Width 5.5 ft
  Hyp: 11'-1"

3rd:
  Width: 4ft
  Hyp: 2'-2"

4th:
  Width: 4ft
  Hyp: 14ft

5th
  Wrdth: 4ft
  Hyp: 17'-2"

Multiply all by 2:

One step: Concrete:

11in*4in
Hyp: 1'-1"

$t_c := 4\ \text{in}$

$$Hyp := (14\ \text{ft} + 11\ \text{ft} + 1\ \text{in} + 2\ \text{ft} + 2\ \text{in} + 14\ \text{ft} + 17\ \text{ft} + 2\ \text{in} + 1\ \text{ft} + 1\ \text{in}) \cdot 2 = 119\ \text{ft}$$

$$stairs := \frac{Hyp}{1\ \text{ft} + 1\ \text{in}} = 109.846$$

$$stairs \cdot 11\ \text{in} \cdot t_c = 33.564\ \text{ft}^2$$

Means of Egress Calculations

upancy:

$A_{floor1} := 141\ ft \cdot 116\ ft = 16356\ ft^2$

$A_{gym} := 9250\ ft^2$

$A_{floor2} := 141\ ft \cdot 116\ ft - A_{gym} = 7106\ ft^2$

$A_{exerciseroom} := 28\ ft \cdot 70\ ft = 1960\ ft^2$

$A_{floor3} := 141\ ft \cdot 116\ ft = 16356\ ft^2$

$A_{storage1} := 20\ ft \cdot 25\ ft + 14\ ft \cdot 20\ ft = 780\ ft^2$

$A_{total} := A_{floor1} + A_{floor2} + A_{floor3} = 39818\ ft^2$

$A_{storage2} := 20\ ft \cdot 25\ ft + 14\ ft \cdot 23\ ft + \left(532\ ft^2\right) = 1354\ f$

$$Occupancy_{floor1int} := \frac{A_{gym}}{15\ ft^2} + \frac{\left(A_{floor1} - A_{gym} - A_{storage1}\right)}{25\ ft^2} + \frac{A_{storage1}}{300\ ft^2} = 872.3067$$

$Occupancy_{floor1} := 880$

$$Occupancy_{floor2int} := \frac{A_{exerciseroom}}{50\ ft^2} + \frac{\left(A_{floor2} - A_{exerciseroom} - A_{storage2}\right)}{25\ ft^2} + \frac{A_{storage2}}{300\ ft^2} = 195.3933$$

$Occupancy_{floor2} := 190$

$A_{communityroom} := \left(59\ ft + 29\ ft\right) \cdot 85\ ft = 7480\ ft^2$

$A_{stairs} := 14\ ft \cdot 19\ ft \cdot 2 = 532\ ft^2$

$A_{patio} := 4725\ ft^2$

$W_{project12} := 5.5\ ft$

$W_{f2tof3} := Occupancy_{floor3} \cdot 0.3\ in = 5.5\ ft$

$W_{project12} > 2.375\ ft = 1$

$W_{f2tof3} \cdot 50\% = 2.75\ ft$

$W_{project23} := 4.0\ ft$

$W_{project23} > 2.75\ ft = 1$

Stair widths are in compliance

way Egress:

$= Occupancy_{floor1} \cdot 0.15\ in = 11\ ft$

$W_{f2} := Occupancy_{floor2} \cdot 0.15\ in = 2.375\ ft$

$W_{f3} := Occupancy_{floor3} \cdot 0.15\ i$

trooms Needed:

Needing 1 toilet stall per 200 occupants

$\frac{upancy_{floor1}}{200} = 4.4$

$\frac{Occupancy_{floor2}}{200} = 0.95$

$\frac{Occupancy_{floor3}}{200} = 1.1$

ooms in final design: 10

Restrooms in final design: 10

Restrooms in final design: 8

king Stalls:

$= 132.7267$

Total stalls in final design: 152 including 14 ADA spaces.

ARCHITECTURAL

	ITEM DISCRIPTION	MANUFACTURE	COST PER. ITEM ($)	# ITEMS	TOTAL COST PER ITEM	NOTES	GRAND TOTAL:	#VALUE!
SPORTING EQUIPMENT								
	BASKETBALL GOAL	GERED SPORTS	$ 17,500.00	6	$ 105,000.00			
	BLEACHERS	HUSSEY SEATING	78300	1	$ 78,300.00			
					$ -			
WALLS AND FLOORS	BB COURT FLOORING	MY BACKYARD SPORTS	$ 1.00	9162	$ 9,162.00	ITEM COST IS /SQ FOOT OF MATERIAL (LAMINATE FLOORING)		RECCOMEND THIS OPTION AS IT IS A RECREATIONAL GYM
	COURT INSTILATION	MY BACKYARD SPORTS	$ 4.00	9162	$ 36,648.00	ITEM COST IS /SQ FOOT OF MATERIAL		
	BB COURT FLOORING	MY BACKYARD SPORTS	$ 4.50	9162	$ 41,229.00	ITEM COST IS /SQ FOOT OF MATERIAL (HARDWOOD FLOORING)		EXPENSIVE OPTION, BUT BETTER LONGEVITY
	COURT INSTILATION	MY BACKYARD SPORTS	$ 6.00	9162	$ 54,972.00	ITEM COST IS /SQ FOOT OF MATERIAL		ALSO A BETTER FEEL FOR THE PLAYERS
	COURT PAINTING	BY BACKYARD SPORTS	$ 75.00	1	$ 75.00			
	EXERCISE ROOM FLOORING	Nexus Self Adhesive 12-Inch Vinyl Floor T	$ 0.72	2149	$ 1,547.28	AMAZON, ITEM IS /SQ FOOT		
	COMMERCIAL GYM EXTERIOR WALLS	Face Brick, rigid steel	$ 79.95	514	$ 41,094.30	514 ft linier dimension of walls, $26.65*3 storys, Instilation included		
	WINDOWS	ALUMINUM, DOUBLE HANG, INSUL. GLAS	$ 619.00	55	$ 34,045.00			
	INTERIOR PARTION WALLS	2"x8" METAL STUD, DOUBLE DRYWALL	$ 5.06	12528	$ 63,391.68	PRICE PER S.F. OF SURFACE		
	GLASS CURTAIN WALLS	GENERAL CONTRACTOR	Solar Innovation s	129566	#VALUE!	Non-tinted, 1/2" thick, 1/8" float, clear, price per S.F. of surface		
	3RD FLOOR CARPET+INSTILATION	GENERAL CONTRACTOR	$ 5.22	7607	$ 39,708.54			
	3RD FLOOR TERRAZZO	EPOXY TERRAZZO	$ 25.00	1129	$ 28,225.00	TERRAZZO.COM		
	2ND FLOOR TERRAZZO	EPOXY TERRAZZO	$ 25.00	3650.14	$ 91,253.50	TERRAZZO.COM		
	1ST FLOOR TERRAZZO	EPOXY TERRAZZO	$ 25.00	6325	$ 158,125.00	TERRAZZO.COM		
	TERRAZZO INSTILATION	GENERAL CONTRACTOR	$ 6.05	9975.14	$ 60,349.60			
	FULL LENGTH MIRROR (6'x8')	THE MIRROR COMPANY	$ 450.00	14	$ 6,300.00	6 IN BATHROOMS, 8 IN EXERCISE ROOM		
	STAIRS	GENERAL CONTRACTOR	$ 21,975.00	4.36	$ 95,811.00	COST PER 24 STAIR RISERS		
	Gym lights	Pro lighting	$ 126.00	$ 24.00	$ 3,024.00	LED lighting - has lots of benifits (see gymnasium lighting design, sports revenue calculator)		
					$ -			
BATHROOM	TOILETS	ZERN ONE (HOMEDEPOT)	$ 490.00	28	$ 13,720.00			
	HAND DRYERS	XLERATOR (PRO-DRYERS)	$ 470.00	24	$ 11,280.00			
	WATER FOUNTIAN	ELKAY	$ 1,612.00	10	$ 16,120.00			
	SINKS	MONA (HOMEDEPOT)	$ 270.00	24	$ 6,480.00	MONA WALL MOUNTED SINK IN WHITE		
	STALLS	ONE POINT PARTITIONS	$ 275.00	61	$ 16,775.00	POWDER COATED STEEL TOILET		
					$ -			
					$ -			
					$ -			
COMMERCIAL KITCHEN	COUNTER TOP	HAMPTON BAY WILSONART 8' STRAIGHT	$ 270.00	1	$ 270.00	HOME DEPOT		
FIRST FLOOR KITCHEN	COUNTER TOP	HAMPTON BAY WILSONART 8' STRAIGHT	$ 270.00	1	$ 270.00	HOME DEPOT		
MISULANEOUS	KONE ELEVATOR	KONE	$ 70,500.00	1	$ 70,500.00	HYDRAULIC ELEVATOR, 3 STORIES, 3000 LB RAITING		
	KONE ELEVATOR INSTILATION	KONE	$ 31,833.00	1	$ 31,833.00			
	STEEL DOORS	SECURALL Steel Door	$ 2,800.00	46	$ 128,800.00			
	GLASS DOORS	COMANCHE-DOOR CLOSES USA	$ 4,800.00	4	$ 19,200.00			
	STAIR RAILING	CABLE RAILING	$ 3,400.00	3	$ 10,200.00	ITEM COST IS /40FT, HOME DEPOT		
	WALL RAILING	HAND RAIL	$ 40.00	63	$ 2,520.00	ITEM COST IS /2FT, HOME DEPOT		

Line Item		Quanity	Units	Unit Cost	Cost	Subtotal
Sporting Equitment						
	Basketball Goal Assembly	6	Per.	$ 17,500.00	$ 105,000.00	
	Bleachers	Bussey Seating		$ 78,300.00	$ 78,300.00	
						$ 183,300.00
Walls and Flooring						
	Basketball Court Flooring	9162	SF.	$ 4.50	$ 41,229.00	
	Court Instilation	9162	SF.	$ 6.00	$ 54,972.00	
	Court Painting	1	Per.	$ 75.00	$ 75.00	
	Exercise Room Flooring	2149	SF.	$ 0.72	$ 1,547.28	
	Commercial Gym Exterior Walls	514	LF.	$ 79.95	$ 41,094.30	
	Windows	55	Per.	$ 619.00	$ 34,045.00	
	Interior Partion Walls	12528	SF.	$ 5.06	$ 63,391.68	
	Glass Curtain Walls	Solar Innovations		$ 131,566.00	$ 131,566.00	
	3rd Floor Carpet+Instilation	7607	SF.	$ 5.22	$ 39,708.54	
	3rd Floor Terrazzo	1129	SF.	$ 25.00	$ 28,225.00	
	2nd Floor Terrazzo	3650.14	SF.	$ 25.00	$ 91,253.50	
	1st Floor Terrazzo	6325	SF.	$ 25.00	$ 158,125.00	
	Terrazzo Instilation	9975.14	SF.	$ 6.05	$ 60,349.60	
	Full Length Mirror (6'x8')	14	Per.	$ 450.00	$ 6,300.00	
	Stairs	4.36	24 Stairs	$ 21,975.00	$ 95,811.00	
	Gymnasium Lighting Fixtures	24	Per	$ 250.00	$ 6,000.00	
	Other Lighting Fixtures	52	Per	$ 100.00	$ 5,200.00	
	Exterior Wall Assembly	20958	Per Sf.	$ 12.00	$ 251,496.00	
						$ 1,110,388.90
Restrooms						
	Toilets	28	Per.	$ 490.00	$ 13,720.00	
	Hand Dryers	24	Per.	$ 470.00	$ 11,280.00	
	Water Fountian	10	Per.	$ 1,612.00	$ 16,120.00	
	Sinks	24	Per.	$ 270.00	$ 6,480.00	
	Stalls	61	Per. Piece	$ 275.00	$ 16,775.00	
						$ 64,375.00
Kitchens						
	Counters and Cabinets	2	Per.	$ 270.00	$ 540.00	
						$ 540.00
Misulaneous						
	Kone Elevator	1	Per.	$ 70,500.00	$ 70,500.00	
	Kone Elevator Instilation	1	Per.	$ 31,833.00	$ 31,833.00	
	Steel Doors	46	Per.	$ 2,800.00	$ 128,800.00	
	Glass Doors	4	Per.	$ 4,800.00	$ 19,200.00	
	Stair Railing	3	Per. 40 FT.	$ 3,400.00	$ 10,200.00	
	Wall Railing	63	Per. 2 FT.	$ 40.00	$ 2,520.00	
	Enterance, Awning, and Lettering	1	Per.	$ 52,400.00	$ 52,400.00	
						$ 315,453.00
					Total Cost:	**$ 1,674,056.90**
	MEP	39900	Per. SF.	$ 55.00	$ 2,194,500.00	
					Total Cost:	**$ 2,194,500.00**

Line Item:		Quantity	Unit	Unit Cost	Cost	Subtotal:
Structural Steel:						
	W and C -Shapes and HSS Members	48.53	TONS	$ 5,000.00	$ 242,650.00	
	Vulcraft Joists	FROM VULCRAFT QUOTE			$ 475,135.00	
	Vulcraft Metal Decking	FROM VULCRAFT QUOTE			$ 198,265.00	
	Connections	117	PER	$ 1,500.00	$ 175,500.00	
						$ 1,091,550.00
Concrete:						
	Floor Slabs	463.37809	CY	$ 130.00	$ 60,239.15	
	Foundations	79.18	CY	$ 130.00	$ 10,293.40	
	Rebar	15%			$ 10,579.88	
						$ 81,112.43
Masonry						
	8" 50% Solid CMU	5358	SF	$ 27.00	$ 144,666.00	
	Rebar	15%			$ 21,699.90	
						$ 166,365.90
					Total Cost:	**$ 1,339,028.33**

CIVIL SITE DESIGN COST ESTIMATE

West Lot Construction		Quantity	Unit	Unit Cost	Cost	Subtotal:
Soil:						
	4" Graded Base Course	700	TON	$29.75	$20,825.00	
	12" Prepared Subgrade	2100	TON	$29.75	$62,475.00	
						$ 83,300.00
Concrete:						
	Concrete Removal	0	SY	$10	$ -	
	6" PCC Curb	1357	LF	$40.00	$ 54,280.00	
	4" PCC Sidewalk Pavement	2681	SF	$6.50	$ 17,426.50	
						$ 71,706.50
Asphalt						
	3" HMA Pavement Base Course	510	TON	$250.00	$ 127,500.00	
	2" HMA Pavement Surface Course	338	TON	$200.00	$ 67,600.00	
						$ 195,100.00
Pavement Marking						
	4" Yellow Pavement Marking	1368	LF	$2.00	$ 2,736.00	
						$ 2,736.00
Utilities						
	Junction Box	1	UNIT	$6,000.00	$ 6,000.00	
	Light Poles	19	UNIT	$3,500.00	$ 66,500.00	
	Electrical Circuit	1158	LF	$360	$ 416,880.00	
						$ 489,380.00
Drainage						
	Double Grate Intake	3	UNIT	$13,500	$40,500.00	
	48" Manhole	1	UNIT	$6,000	$6,000.00	
	36" Storm Sewer	314	LF	$125	$39,250.00	
						$ 85,750.00
Landscaping						
	Black Walnut Tree (Juglans nigra)	3	UNIT	$75	$225.00	
	Hoptree (Ptelea trifoliata)	5	UNIT	$6	$30.00	
	Meadow Willow (Salix petiolaris)	9	UNIT	$2	$18.00	
						$ 273.00
				West Total Cost:		**$ 928,245.50**
East Lot Construction		Quantity	Unit	Unit Cost	Cost	Subtotal:
Soil:						
	4" Graded Base Course	717	TON	$29.75	$21,330.75	
	12" Prepared Subgrade	2152	TON	$29.75	$64,022.00	
						$ 85,352.75
Concrete:						
	Concrete Removal	16115	SY	$10	$ 161,150.00	
	6" PCC Curb	1303	LF	$40.00	$ 52,120.00	
	4" PCC Sidewalk Pavement	5747	SF	$6.50	$ 37,355.50	
						$ 250,625.50
Asphalt						
	3" HMA Pavement Base Course	520	TON	$250.00	$ 130,000.00	
	2" HMA Pavement Surface Course	345	TON	$200.00	$ 69,000.00	
						$ 199,000.00
Pavement Marking						
	4" Yellow Pavement Marking	1216	LF	$2.00	$ 2,432.00	
						$ 2,432.00
Utilities						
	Junction Box	1	UNIT	$6,000.00	$ 6,000.00	
	Light Poles	16	UNIT	$3,500.00	$ 56,000.00	
	Electrical Circuit	946	LF	$360	$ 340,560.00	
						$ 402,560.00
Drainage						
	Double Grate Intake	0	UNIT	$13,500	$0.00	
	48" Manhole	0	UNIT	$6,000	$0.00	
	36" Storm Sewer	0	LF	$125	$0.00	
						$ -
Landscaping						
	Black Walnut Tree (Juglans nigra)	3	UNIT	$75	$225.00	
	Hoptree (Ptelea trifoliata)	4	UNIT	$6	$24.00	
	Meadow Willow (Salix petiolaris)	6	UNIT	$2	$12.00	
						$ 261.00
				East Total Cost:		**$ 940,231.25**
Senior Center Demolition				**Demoltion Cost:**		**$ 40,000.00**
Construction Cost				**Construction Cost:**		**$ 812,250.00**
				Total Cost:		$ 2,720,726.75

https://www.powellstone.com/graded-base/

https://iowadot.gov/contracts/lettings/230118BidTabsPrimary.pdf

sq sf

https://calculator.academy/square-feet-to-tons-calculator/#f1p1|f2p0

27986	SF	WITH	150 LB/FT^3	AND	4" THICK	IS	700	TONS	4" GRADED BASE COURSE
27986	SF	WITH	150 LB/FT^3	AND	12" THICK	IS	2100	TONS	12" PREPARED SUBGRADE
27986	SF	WITH	145 LB/FT^3	AND	3" THICK	IS	510	TONS	HMA PAVEMENT BASE COURSE
27986	SF	WITH	145 LB/FT^3	AND	3" THICK	IS	338	TONS	HMA PAVEMENT SURFACE COURSE
28696	SF	WITH	150 LB/FT^3	AND	4" THICK	IS	717	TONS	4" GRADED BASE COURSE
28696	SF	WITH	150 LB/FT^3	AND	12" THICK	IS	2152	TONS	12" PREPARED SUBGRADE
28696	SF	WITH	145 LB/FT^3	AND	3" THICK	IS	520	TONS	HMA PAVEMENT BASE COURSE
28696	SF	WITH	145 LB/FT^3	AND	3" THICK	IS	345	TONS	HMA PAVEMENT SURFACE COURSE

4IN PCC SIDEWALK IS $60/SY SO 60/9= 6.667 =$6.4/SF

WEST LOT PARKING + ADA	71	8	79			
WEST LOT AREA	27986 SF					
WEST LOT CURB	724	316	317	1357 LF		
WEST LOT PAVEMENT MARK	76	18	1368 LF			
WEST LOT SIDEWALK	2681 SF					
GYMNASIUM SIDEWALK	5747 SF					
EAST LOT PARKING + ADA	58	6	64			
EAST LOT AREA	28696 SF					
EAST LOT CURB	554	309	110	1303 LF		
EAST LOT PAVEMENT MARK	62	18	1116	54	46	1216 LF
EAST LOT CONCRETE REMOVE	16115 SF					
TOTAL LOT PARKING + ADA	129	14	143			
TOTAL LOT AREA	56682 SF					
TOTAL LOT CURB	2660 LF					
TOTAL PAVEMENT MARKING	2584 LF					
TOTAL SIDEWALK	8428 SF					
					$ 5,733,811.98	
SENIOR CENTER	5000 SF					