THE UNIVERSITY OF IOWA
IOWA INITIATIVE FOR SUSTAINABLE COMMUNITIES

FINAL DELIVERABLE

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Completed By	Scott Blondin, Mohammed Omer, Cole Taylor, and Trevor Weise
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Course Name	Project Design and Management CEE:4850
Instructor	Christopher Stoakes
Community Partners	Joy Padgent, Hotel Manning

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Iowa Initiative for Sustainable Communities
The University of Iowa
347 Jessup Hall
Iowa City, IA, 52241
Phone: 319.335.0032
Email: iisc@uiowa.edu
Website: http://iisc.uiowa.edu/

Keosauqua Building Rehabilitation
705 1st Street
Keosauqua, Iowa 52565

IOWA

ENGINEERING

PREPARED FOR: JOY PADGENT, MANAGER HOTEL MANNING

DATE SUBMITTED: MAY 7, 2023

SUBMITTED BY:

COLE TAYLOR, PROJECT MANAGER
SCOTT BLONDIN, TECHNICAL SUPPORT
TREVOR WEISE, REPORT PRODUCTION
MOHAMMED OMER, REPORT PRODUCTION

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Executive Summary

The following report contains the investigation, engineering design, and cost estimation for the rehabilitation of an abandoned two-story building at 705 1st Street in downtown Keosauqua, Iowa. The goal of this project is to renovate the abandoned building to have large apartments on the second floor and a restaurant space on the ground floor. The building has been abandoned for many years and thus the space will need to be completely renovated including the exterior of the building with updates to the building facade and both the main street and the side street entrances. The interior of the building will need to be renovated as well due to poor conditions in the basement, such as deteriorating floors and ceilings, as well as the walls and ceilings of both the ground and second stories. The ground floor is a large open space with a small mezzanine that will need to be renovated, including the demolition and installation of new partition walls to accommodate a new restaurant. The second story has partition walls and a kitchenette that will need to be removed to make room for what will be three large apartments that will be separated by a shared main landing.

Proposed additions to the structural systems of the building include joists that span in the short direction and beams that span in the long direction. There will be new steel columns connecting the first floor to the second floor, as well as space for a garage door that will allow for garbage to be disposed of from the kitchen of the restaurant. Part of the existing building south wall will be removed to allow for the garage space. In addition to this are changes to the layout of all three floors of the building. The floor plans include newly placed staircases that will require the removal and demolition of parts of the existing building's exterior and some of the interior elements, such as the old freight elevator. Further improvements to the interior of the building will be a small mail room on the landing of the new staircase on the northernmost wall that will service the three apartments on the floor above. New bathrooms will also be placed on the first floor to service restaurant clients. An improvement to the exterior of the building is an ADA accessible ramp on the southern part of the building to allow for handicap access to the restaurant.

Cost estimates have been conducted for both the demolition and construction of the new building elements, as well as updates to the building facade. The facade of the exterior of the second story of the building will be restored to its previous condition at the request of the client. The exterior of the first floor will have new windows and brick facade to allow for a better experience when inside the restaurant. During the removal and replacement of the current floors on all three levels, an inspection should be conducted to ensure that the current structural floor systems meet or exceed the design outlined later in this report. If they do not, they will need to be removed and replaced to meet the required loads outlined in ASCE 7-16.

Team Qualifications and Experience:

Our team is composed of four civil engineering students at the University of Iowa. The students were assigned to the project as part of their capstone design course required for graduation. The team is focused on bringing innovative and creative solutions to meet the needs of our clients. The qualifications and expertise of each team member is discussed below:

Cole Taylor, Project Manager: Cole is a senior civil engineering major focusing in CEE practice. Cole's role as the project manager is to coordinate communications with the client (Joy Padgent), provide oversight and coordination for the team throughout the project, as well as helping with design. Cole has improved his knowledge in project management skills by taking courses at the University of Iowa such as Project Management Skills and Transportation Infrastructure and Construction Management. Cole has also worked as a project manager intern for Gleeson Constructors and Engineers for the past two years, where he had a major role in managing several 100+ million dollar projects for global meat processors such as Hormel Foods and Tyson Foods.

Mohammed Omer, Editor: Mohammed is a senior in civil engineering at the University of Iowa with a structural engineering focus. Mohammed's role is to help with any design aspects concerning structural and interior design scopes. The structural focus has taught Mohammed numerous structural design skills. Over the past few semesters, classes like Principles of Structures, Design of Wood Structures, and Foundation of Structures have all been loaded with structural design aspects and have taught Mohammed how to use programs such as Revit, Robot, and even Civil 3-D. Past internship experiences at Walter P Moore engineering have also shown Mohammed structural design techniques on "real world" projects.

Trevor Weise, Editor: Trevor is a senior at the University of Iowa studying Civil Engineering with a focus in structural engineering. Trevor's role as an editor will be to aid in the drafting of report documents, project proposals, and presentations as needed. Trevor will also use his background in structural engineering to assist in the design of structural elements throughout the project. Trevor has acquired several useful skills over the past few years from his coursework and internship experiences. Trevor has learned modeling and analysis techniques using softwares such as Robot, Revit, and Ansys. Trevor's role in his past internship experience as a construction engineer was to oversee numerous construction projects and to ensure the safe and successful completion of projects under the estimated budget.

Scott Blondin, Tech Support: Scott is a senior civil engineering major with a focus area in architecture. Scott's role as tech support will be to aid in the use of different softwares as they are needed to complete different aspects of the project such as the use of Revit to create renderings of the designed space, Robot to aid in structural analysis and design, and Civil 3D to site layout and construction plans. Scott has learned how to successfully use these programs through courses he has taken at the University of Iowa such as Transportation Design, Concrete Structures Design, and Steel Structures Design. He also has been working as a civil engineering intern at Shive-hattery a local architectural engineering company, where he has assisted in the civil engineering of large commercial projects such as student housing developments.

Proposed Services

The scope of this project is the complete rehabilitation of an abandoned downtown building located at 705 1st Street in Keosauqua. The total rehabilitation will include the basement, ground story, second story, and exterior of the building. The basement and foundation will be inspected to see if improvements are needed to meet the requirements of the renovated building. The ground floor rehabilitation will include turning the space into a modern restaurant. The two entries to the building will be renovated and updated to meet current building entryway codes. The facade of the building as well as interior updates will be accomplished with consideration of the overall aesthetic of the town. The second story will be residential space with the creation of two or three large apartments that will be separated by a shared landing. These spaces will be modern with influence of the surrounding town and will be able to accommodate families.

Current and proposed floor plans have been drafted for all three levels of the building as well as a demolition plan for all three floors. A new proposed site layout for the exterior of the building and a demolition plan for the exterior of the building have been drawn. Elevation views from the exterior of the building will be provided from both the eastern part of the building as well as the southern part of the building. Section views will be provided to aid in the construction of architectural and structural elements. Finally, structural framing plans will be included for the construction of new structural elements that should be implemented as needed if the current structural design will not meet the needs of the new floor plans.

Gantt Charts:

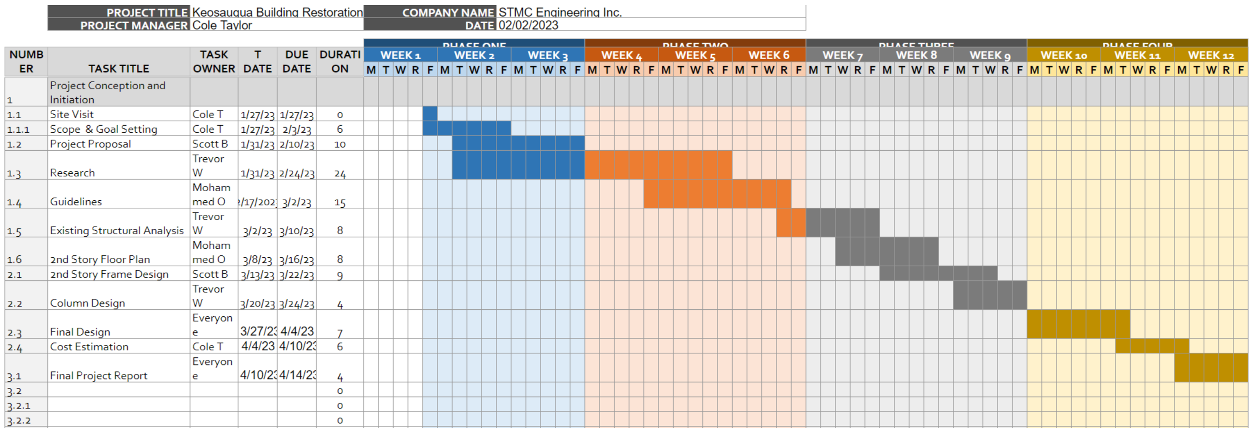


Figure 1: Gantt Chart

Methods and Design Guides:

This project will contain many moving parts including redesign of apartment space, adding a restaurant, and moving a stairwell on the interior of the building. This would entail the use of many design guides including SUDAS, Keosauqua City Code, and the IBC. SUDAS and City code is used to regulate utilities, sanitary sewer, and stormwater. The IBC (International Building Code) is the most essential design guide to the project. The main sections of the IBC are Chapter 8 (Interior Finish, Decorative Materials, and Furnishings), Chapter 10 (Means of Egress), Chapter 27 (Standby and Emergency Power), and Section 3103 (Temporary Structures).

Constraints, Challenges, and Impacts

Constraints:

Some of the major constraints of the project are time and the condition of the existing building. In addition, there were no previous drawings for the layout and dimensions of the building, so measurements had to be conducted during the site visit. A tape measure was used to conduct most of the measurements, allowing for a slight margin of error from the existing building layout. Despite no provided budget, the team understood that all designs were to be cost effective to the purpose of the project.

Challenges:

The challenges of this project include the run down and abandoned state of the existing building, and the debris on the ground floor and basement. Other challenges were the condition of the foundation and structural stability of the basement and ground floors. These were hard to determine and needed to be estimated due to a lack of a floor plan of the existing structure and the clutter of objects on the site that prevented intense inspection of structural elements.

Another challenge was updating and modernizing both the commercial and residential spaces while maintaining the influence of the surrounding town.

Societal Impact:

The main impact to societal life in Keosauqua from the project is the addition of new housing to the area. These apartments will help provide an updated space for families or young professionals to live in downtown Keosauqua. The modernization of living spaces in the downtown area could ignite growth in the small town.

Another impact is restoration of the facade and exterior of the abandoned building to both modernize and restore the streetscape. The facade and exterior will be updated to expose brick of historic Iowa towns and display the culture and historic aspects of downtown Keosauqua.

The project also provides economic impact from the businesses on the ground floor, including a restaurant.

Final Design Details

It should be noted that due to current conditions on the site some structural elements of the existing building were not able to be properly examined by the team. As a result, the team designed a new complete structural system for the building to meet the needs of the new layouts. An inspection should take place prior to construction starting of the current structural systems to make sure they are at the standard or exceeding the standard of the design included in this report.

Load calculations were performed using ASCE 7-16 chapter 4 for live loads and chapter 7 for snow loads. The dead loads and live loads were found in pounds per square foot (PSF) and converted to pounds per linear foot to analyze the structural members as a simplified two dimensional system. A structural hierarchy system was made in order to properly analyze the floor plan of two separate levels. First, the floor joists were analyzed to make sure that they could take on all the live and dead loads. It should be noted that all our beams and girders are W-shaped steel as they have a high compressive strength that allows for large loads to be taken on. In addition, all members were tested against shear force, bending moment, and deflection with deflection being the governing factor. The dead loads taken into account were the floor deck, 5 inch normal weight concrete, Lighting & conduit, and then MEP. For our connections of the beams to girders, we designed shear connections. A shear connection is one that has a shear tab plate with a number of bolts going through the plate. The shear plate as well as the bolts were tested for shear and tensile strength in order to determine the sizing and number of bolts as well as the dimensions for our shear plate. In addition, we designed the first-floor system incorporating the newly modeled stair that leads down to the basement. Columns were designed as square hollow steel sections (HSS) to resist any axial compressive loading that is induced by subjected loadings on the structure. Axial compressive forces cause buckling so the columns were designed to not buckle. Square sections were used to making connections easier.For our first-floor system, all dimensions needed were taken down during the site visits. The floor interior and exterior beams are supported by their respective interior or exterior beams.

The beams on the first floor were designed to carry any live and dead loads that are probable for a restaurant.

Second Floor Layout

The second-floor layout has been altered to allow for the creation of three apartment units. The units are a one-bedroom, two-bedroom, and three-bedroom apartment, each of which has kitchen units and one bathroom. The new floor plan also includes a stairway from the outside of the building on 1st Street to a landing that all three units will share. The new layout for the second floor is shown in the figure below.

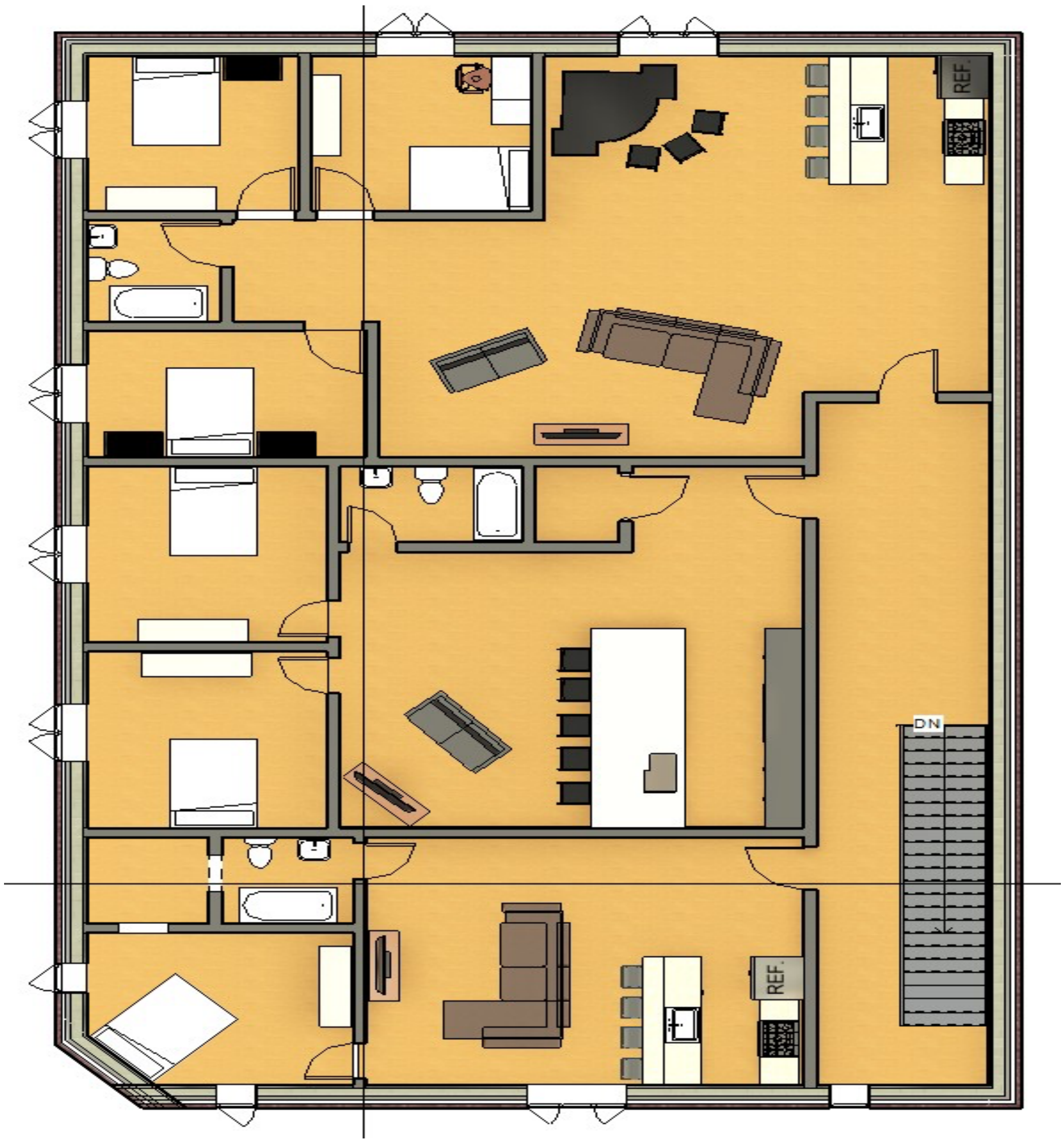


Figure 2: Second Story Layout

Restaurant Layout

The first-floor layout was changed to implement a new restaurant in the space. The partition walls of the existing office space were removed to open the space for tables and booths to service the restaurant's patrons. The existing mezzanine and freight elevator were removed to allow space for an industrial sized kitchen and a stairwell to the basement. The improvements to the ground floor layout also include two new bathrooms as well as a mail room that will service the apartment units on the floor above. The new layout can be seen in the figure below.

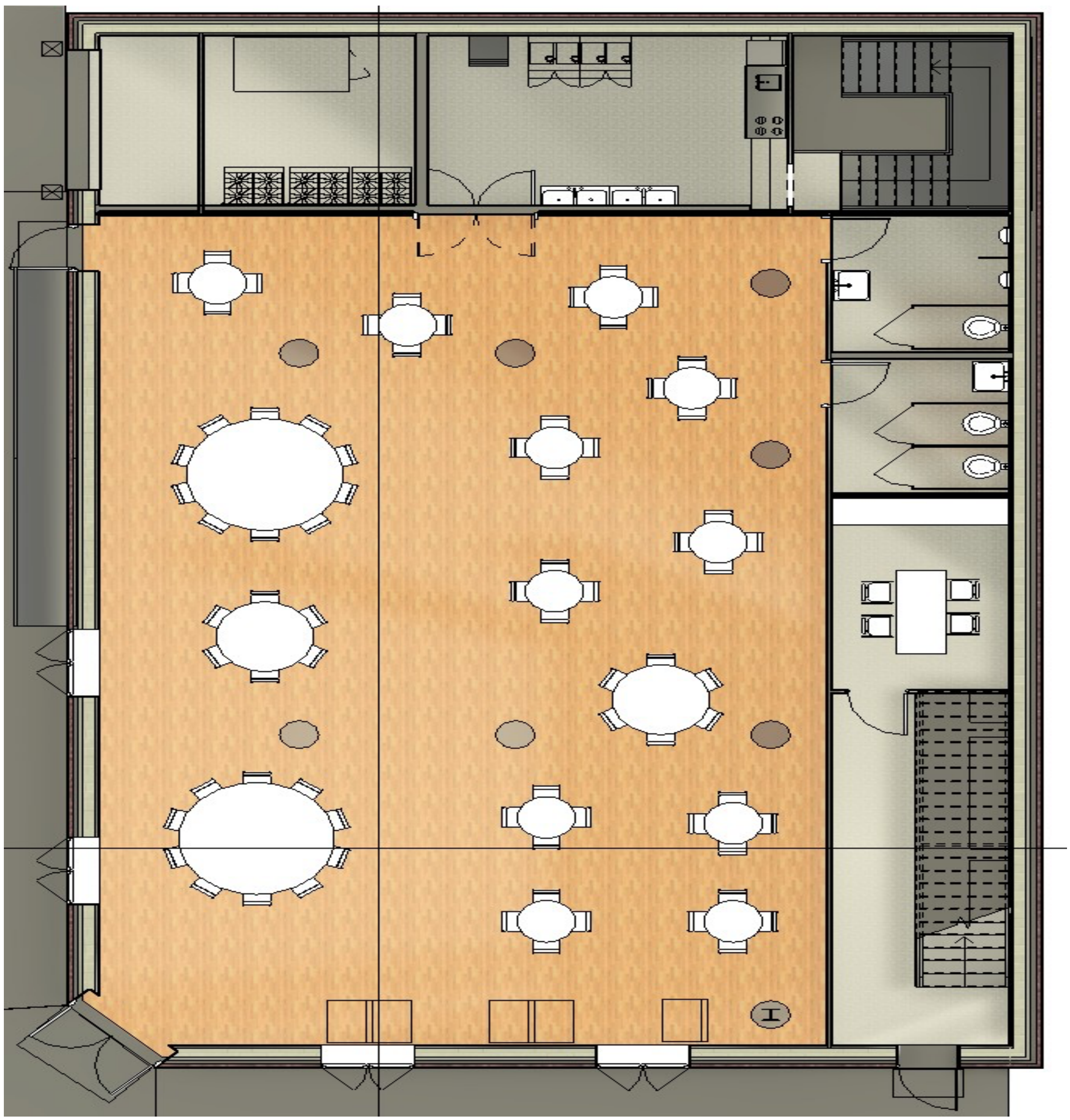


Figure 3: First Floor Layout

Basement Layout

The new basement layout has been changed to allow for the implementation of two large walk-in refrigerator units for use by the restaurant on the floor above. A new staircase from the ground floor to the basement will go where the existing freight elevator is. The southwest corner of the basement will house all the HVAC and MEP equipment, which should be designed separately by a licensed engineer in those fields. The rest of the basement space will be shelving for the restaurant to use as needed. The new layout of the basement is shown in the figure below.

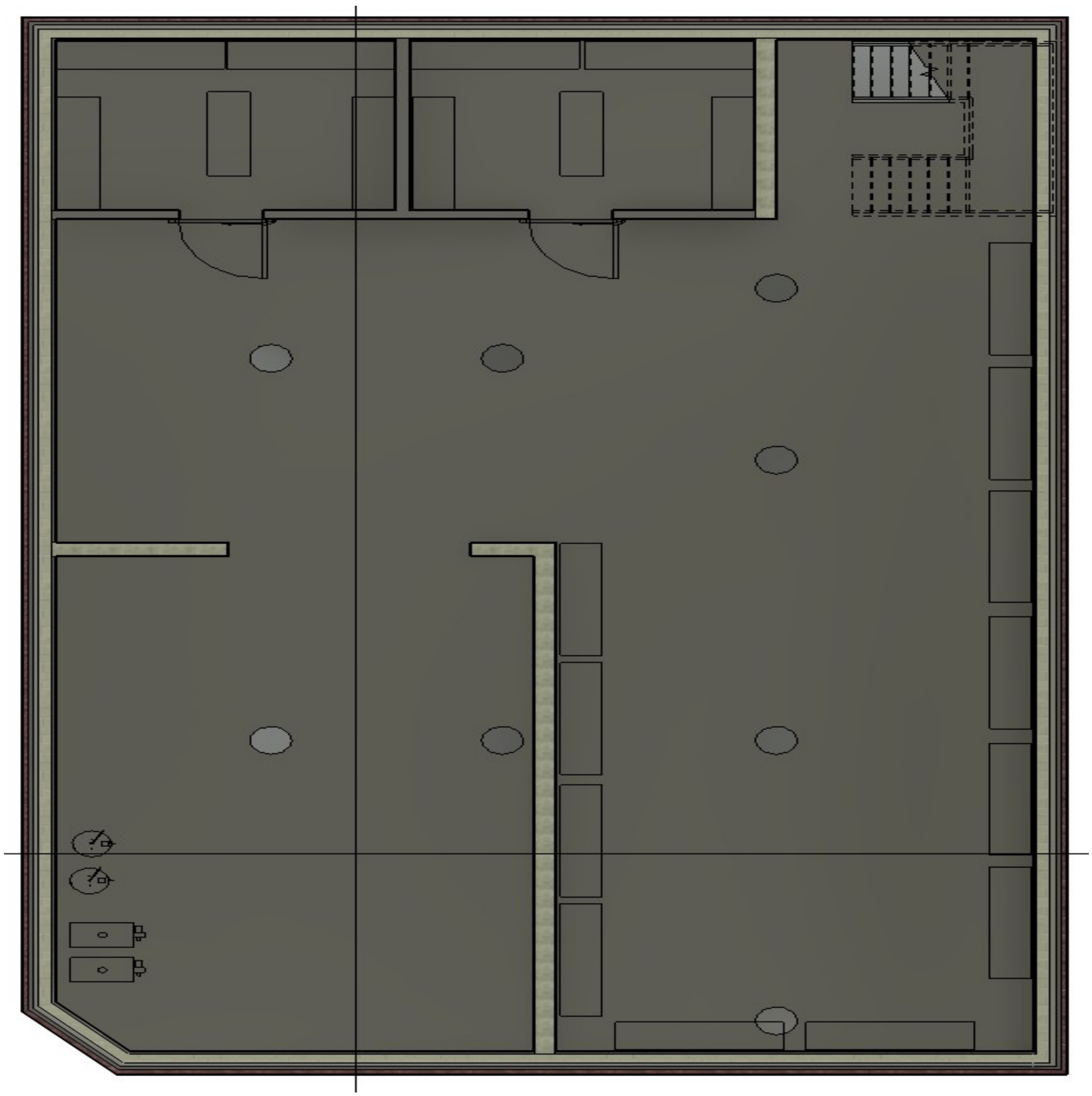


Figure 4: Basement Layout

Site Plan Design

The exterior site plan of the building was reworked including changes to the facade of the building, parking layout, and a garage door on the northwest corner that houses garbage enclosures for the restaurant. The new site plan also includes an ADA ramp on the southwest wall of the building that makes the restaurant handicap accessible. The site is located on the corner of 1st Street and Van Buren Street, and those streets will go untouched. The largest change comes outside of the newly implemented garage door where there will be a driveway with a 1.0% grade down slope to go up to the finished floor elevation of the building while also tying into the existing elevation of Van Buren street. The existing drainage of the streets and sidewalks was outside the scope of this project and should be examined by an engineer to see if the current design is up to the specifications of Iowa Statewide Urban Design and Specifications (SUDAS). The demolition of the existing site elements are located on Design Sheet C1.0 and the new site plan complete with grading details is located on Design sheet C2.0.

Alternative Design Options

Alternative 1: Alternative one is the lowest cost alternative and represents the minimal amount of work to make the building functional. This option includes moving the 2nd floor access door and stairwell in the middle of the building to the north side interior along the wall. This will give separate access to the second floor without disturbing the aesthetic of the first-floor commercial space. It also includes the redesign of the second floor into two modern apartments. This will entail a demo of the current second floor including all existing walls and flooring.

Alternative 2: Alternative two is the intermediate cost alternative, and this option will require a considerable amount of work and costs to be completed successfully. This alternative includes three two-bedroom apartments with a single bathroom in each unit. It requires the entire second floor to be renovated. In addition, the existing stairwell that leads to these apartments will be relocated for the accessibility of the residents. This alternative also provides for remodeling of the first floor in order to create a restaurant.

Alternative 3: Alternative three is the most expensive cost alternative, and this option will require the most extensive amount of work to be completed successfully. In addition to the remodeling and refinishing of the first and second floor to establish the restaurant and the apartments mentioned in Alternative two, the basement will be thoroughly cleaned in order for it to be used as restaurant storage. This alternative requires more work to the façade, including removal of an overhang on the left side of the building.

Design Services Cost Proposal

Autodesk Revit was used to generate material quantities and prices were assigned according to Construction Costs. The cost estimate is divided into separate sections which include: building demolition, site demolition, site renovation, and building renovation. The figures below include the detailed cost estimate. It should be noted MEP costs are estimated as a lump sum.

Table 1: Construction Cost Estimate

Discipline	Cost (USD)
Demolition	$85,000.00
Site	$36,500.00
Structural	$805,000.00
Architectural	$345,000.00
MEP	$233,500.00
Materials and Labor Subtotal	$1,505,000.00
Construction and Administration (20%)	$301,000.00
Contingency (15%)	$226,000.00
Total Construction	$2,032,000

References:

International Code Council. International Building Code. Falls Church, Va. :International Code Council, 2000. *https://codes.iccsafe.org/content/IBC2018P6*

Iowa Statewide Urban Design and Specifications. Ames, IA. :SUDAS Board or Directors, 2023. *https://iowasudas.org/manuals/design-manual/*

Keosauqua Iowa City Documents & Codes, Keosauqua, IA. :Keosauqua Chamber, 2023. *https://keosauqua.com/city-resources.html*

Appendix A - Design Calculations

LENGTH OF MEMBERS: $L_{b1} := 24\ ft$ $L_{b2} := L_{b1}$ $L_{b3} := 24\ ft - 7\ ft$ $L_{b4} := 16\ ft$

$L_y := 8.25\ ft$ $L_{b5} := \sqrt{(L_{b4} - 8\ ft)^2 + (L_y)^2} = 11.492\ ft$ $L_{b6} := L_{b1}$ $L_{b7} := L_{b1}$

$L_{g1} := 33\ ft$ $L_{g2} := L_{g1}$ $L_{g3} := 41.25\ ft$ $L_{g4} := L_{g3}$

$L_{tb1} := 41.25\ ft$

LENGTH DUE TO TRIBUTARY AREA FOR JOIST 4: $L_x := \dfrac{L_{b1} + (L_{b4})}{2} = 20\ ft$

WEIGHT OF 5INCH CONCRETE SLAB: $h_s := 5\ in$ $w_c := 150\ pcf$ $w_{slab} := h_s \cdot w_c = 62.5\ psf$

ELASTIC MODULUS OF ALL STEEL CHOICES: $E := 29000\ ksi$

ALLOWABLE DEFFLECTIONS FOR HORIZONTAL MEMBERS: $\Delta_{allowb1} := \dfrac{L_{b1}}{360} = 0.8\ in$ $\Delta_{allowb2} := \Delta_{allowb1} = 0.8\ in$

$\Delta_{allowb3} := \dfrac{L_{b3}}{360} = 0.567\ in$ $\Delta_{allowb4} := \dfrac{L_{b4}}{360} = 0.533\ in$ $\Delta_{allowb5} := \dfrac{L_{b5}}{360} = 0.383\ in$

$\Delta_{allowb6} := \dfrac{L_{b1}}{360} = 0.8\ in$ $\Delta_{allowb7} := \Delta_{allowb1} = 0.8\ in$ $\Delta_{allowg1} := \dfrac{L_y \cdot 4}{360} = 1.1\ in$

$\Delta_{allowg2} := \Delta_{allowg1} = 1.1\ in$ $\Delta_{allowg3} := \dfrac{L_y \cdot 5}{} = 1.375\ in$ $\Delta_{allowg4} := \Delta_{allowg3} = 1.375\ in$

$\Delta_{allowtb1} := \Delta_{allowg3} = 1.375\ in$

TRIBUTARY WIDTHS: $t_{bb2} := L_y = 8.25\ ft$ $t_{bb1} := \frac{t_{bb2}}{2} = 4.125\ ft$ $t_{bb3} := t_{bb2} = 8.25\ ft$

$t_{bb4} := t_{bb1} = 4.125\ ft$ $t_{bb5} := .25 \cdot t_{bb4} = 1.031\ ft$ $t_{bb6} := t_{bb2} = 8.25\ ft$

$t_{bb7} := t_{bb1} = 4.125\ ft$

Uniformly Distributed LLs on 2nd Floor: $LL_{PrivRooms} := 40\ psf$

Uniformly Distributed DLs on 2nd Floor: $DL_{MetalDeck18} := 3\ psf$ $DL_{MDA} := 4\ psf$

$DL_{slab} := w_{slab} = 62.5\ psf$ $DL := DL_{MetalDeck18} + DL_{MDA} + DL_{slab} = 69.5\ psf$

LIVE LOADS ACTING ON EACH BEAM:

$LL_{PrivRoomsb1} := LL_{PrivRooms} \cdot t_{bb1} = 165\ plf$

$LL_{PrivRoomsb2} := LL_{PrivRooms} \cdot t_{bb2} = 330\ plf$

$LL_{PrivRoomsb3} := LL_{PrivRooms} \cdot t_{bb3} = 330\ plf$

$LL_{PrivRoomsb4} := LL_{PrivRooms} \cdot t_{bb4} = 165\ plf$

$LL_{PrivRoomsb5} := LL_{PrivRooms} \cdot t_{bb5} = 41.25\ plf$

$LL_{PrivRoomsb6} := LL_{PrivRooms} \cdot t_{bb6} = 330\ plf$

$LL_{PrivRoomsb7} := LL_{PrivRooms} \cdot t_{bb7} = 165\ plf$

BEAM 1: (Designed against moment, shear, and deflection)

Assume exterior beams 1 to be W12x16

$Weight_{w12x16} := 16\ plf$

$I_{xb1} := 103\ in^4$

$DL = 69.5\ psf$ $\quad LL_{PrivRoomsb1} = 165\ plf$

$w_{llb1} := LL_{PrivRoomsb1} = 165\ plf$ $\quad w_{dlb1} := DL \cdot t_{bb1} + Weight_{w12x16} = 302.688\ plf$

$w_{b1} := 1.2 \cdot w_{dlb1} + 1.6 \cdot w_{llb1} = 0.627\ klf$

$\Delta_{maxb1} := \dfrac{5 \cdot w_{dlb1} \cdot L_{b1}^{\ 4}}{384 \cdot E \cdot I_{xb1}} = 0.756\ in$ $\quad \Delta_{allowb1} = 0.8\ in$

$ANSb1D :=$ if $\Delta_{maxb1} \le \Delta_{allowb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb1D =$ "Sizing is okay!"

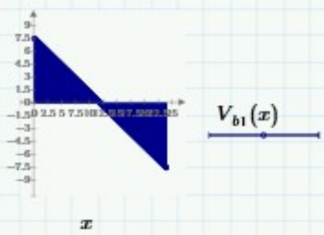
$R_{Lb1} := \dfrac{w_{b1} \cdot L_{b1}}{2} = 7.527\ kip$ $\quad R_{Rb1} := (w_{b1} \cdot L_{b1}) - R_{Lb1} = 7.527\ kip$

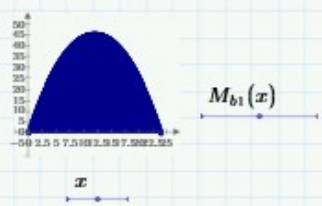
$V_{b1}(x) :=$ if $0 < \dfrac{L_{b1}}{in}$
  $7.527 - .627 \cdot x$
else
  0

$M_{b1}(x) :=$ if $0 < \dfrac{L_{b1}}{in}$
  $7.527 \cdot x - \dfrac{.628 \cdot x^2}{2}$
else
  0

$V_{maxb1} := V_{b1}(0)\ kip = 7.527\ kip$ $\quad M_{maxb1} := M_{b1}\left(\dfrac{L_{b1}}{2\ ft}\right) kip \cdot ft = 45.108\ kip \cdot ft$

$\phi_v V_{nxb1} := 79.2\ kip$ $\quad \phi_b M_{pxb1} := 75.4\ kip \cdot ft$





$ANSb1S :=$ if $V_{maxb1} \le \phi_v V_{nxb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb1M :=$ if $M_{maxb1} \le \phi_b M_{pxb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb1S =$ "Sizing is okay!" $\quad ANSb1M =$ "Sizing is okay!"

BEAM 3: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W12x14

$Weight_{w12x14} := 14\ plf$

$I_{xb3} := 88.6\ in^4$

$DL = 69.5\ psf$ $\quad LL_{PrivRoomsb3} = 330\ plf$

$w_{llb3} := LL_{PrivRoomsb3} = 330\ plf$ $\quad w_{dlb3} := DL \cdot t_{bb3} + Weight_{w12x14} = 587.375\ plf$

$w_{b3} := 1.2 \cdot w_{dlb3} + 1.6 \cdot w_{llb3} = 1.233\ klf$

$$\Delta_{maxb3} := \frac{5 \cdot w_{dlb3} \cdot L_{b3}^{4}}{384 \cdot E \cdot I_{xb3}} = 0.43\ in \qquad \Delta_{allowb3} = 0.567\ in$$

$ANSb3D :=$ if $\Delta_{maxb3} \le \Delta_{allowb3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb3D =$ "Sizing is okay!"

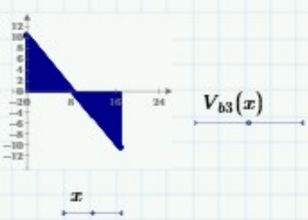
$$R_{Lb3} := \frac{w_{b3} \cdot L_{b3}}{2} = 10.479\ kip \qquad R_{Rb3} := \left(w_{b3} \cdot L_{b3}\right) - R_{Lb3} = 10.479\ kip$$

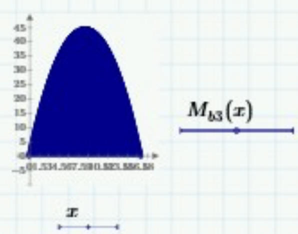
$V_{b3}(x) :=$ if $0 \le \frac{L_{b3}}{in}$
  $10.479 - 1.233 \cdot x$
else
  0

$M_{b3}(x) :=$ if $0 \le \frac{L_{b3}}{ft}$
  $10.479 \cdot x - \frac{1.233 \cdot x^2}{2}$
else
  0

$V_{maxb3} := V_{b3}(0)\ kip = 10.479\ kip$ $\quad M_{maxb3} := M_{b3}\left(\frac{L_{b3}}{2\ ft}\right) kip \cdot ft = 44.529\ kip \cdot ft$

$\phi_v V_{nxb3} := 64.3\ kip$ $\quad \phi_b M_{pxb3} := 65.3\ kip \cdot ft$





$ANSb3S :=$ if $V_{maxb3} \le \phi_v V_{nxb3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb3M :=$ if $M_{maxb3} \le \phi_b M_{pxb3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb3S =$ "Sizing is okay!" $\quad ANSb3M =$ "Sizing is okay!"

BEAM 4: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W8x10

$Weight_{w8x10} := 14\ plf$

$I_{xb4} := 30.8\ in^4$

$DL = 69.5\ psf$ $\quad LL_{PrivRoomsb4} = 165\ plf$

$w_{llb4} := LL_{PrivRoomsb4} = 165\ plf$ $\quad w_{dlb4} := DL \cdot t_{bb4} + Weight_{w8x10} = 300.688\ plf$

$w_{b4} := 1.2 \cdot w_{dlb4} + 1.6 \cdot w_{llb4} = 0.625\ klf$

$\Delta_{maxb4} := \dfrac{5 \cdot w_{dlb4} \cdot L_{b4}^4}{384 \cdot E \cdot I_{xb4}} = 0.496\ in$ $\quad \Delta_{allowb4} = 0.533\ in$

$ANSb4D :=$ if $\Delta_{maxb4} \le \Delta_{allowb4}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb4D =$ "Sizing is okay!"

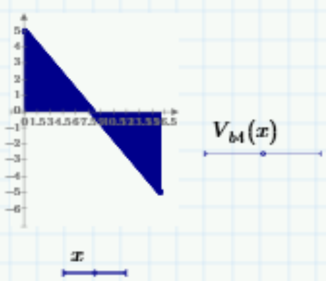
$R_{Lb4} := \dfrac{w_{b4} \cdot L_{b4}}{2} = 4.999\ kip$ $\quad R_{Rb4} := (w_{b4} \cdot L_{b4}) - R_{Lb4} = 4.999\ kip$

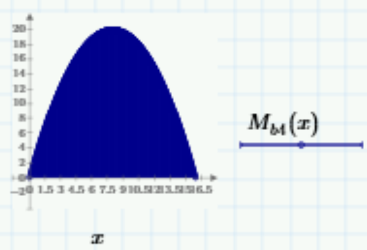
$V_{b4}(x) :=$ if $0 \le \dfrac{L_{b4}}{in}$
  $4.999 - .625 \cdot x$
else
  0

$M_{b4}(x) :=$ if $0 \le \dfrac{L_{b4}}{ft}$
  $4.999 \cdot x - \dfrac{.625 \cdot x^2}{2}$
else
  0

$V_{maxb4} := V_{b4}(0)\ kip = 4.999\ kip$ $\quad M_{maxb4} := M_{b4}\left(\dfrac{L_{b4}}{2\ ft}\right) kip \cdot ft = 19.992\ kip \cdot ft$

$\phi_v V_{nxb4} := 40.2\ kip$ $\quad \phi_b M_{pxb4} := 32.9\ kip \cdot ft$





$ANSb4S :=$ if $V_{maxb4} \le \phi_v V_{nxb4}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb4M :=$ if $M_{maxb4} \le \phi_b M_{pxb4}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb4S =$ "Sizing is okay!" $ANSb4M =$ "Sizing is okay!"

BEAM 5: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be C4x4.5

$Weight_{c4x4.5} := 4.5\ plf$

$I_{xb5} := 3.53\ in^4$

$DL = 69.5\ psf$ $LL_{PrivRoomsb5} = 41.25\ plf$

$w_{llb5} := LL_{PrivRoomsb5} = 41.25\ plf$ $w_{dlb5} := DL \cdot t_{bb5} + Weight_{c4x4.5} = 76.172\ plf$

$w_{b5} := 1.2 \cdot w_{dlb5} + 1.6 \cdot w_{llb5} = 0.157\ klf$

$\Delta_{maxb5} := \dfrac{5 \cdot w_{dlb5} \cdot L_{b5}^4}{384 \cdot E \cdot I_{xb5}} = 0.292\ in$ $\Delta_{allowb4} = 0.533\ in$

$ANSb5D :=$ if $\Delta_{maxb5} \le \Delta_{allowb5}$
‖ "Sizing is okay!"
else
‖ "Sizing is NOT okay!"

$ANSb5D =$ "Sizing is okay!"

$R_{Lb5} := \dfrac{w_{b5} \cdot L_{b5}}{2} = 0.904\ kip$ $R_{Rb5} := (w_{b5} \cdot L_{b5}) - R_{Lb5} = 0.904\ kip$

$V_{b5}(x) :=$ if $0 \le \dfrac{L_{b5}}{in}$
‖ $.904 - .157 \cdot x$
else
‖ 0

$M_{b5}(x) :=$ if $0 \le \dfrac{L_{b5}}{ft}$
‖ $.904 \cdot x - \dfrac{.157 \cdot x^2}{2}$
else
‖ 0

$V_{maxb5} := V_{b5}(0)\ kip = 0.904\ kip$ $M_{maxb5} := M_{b5}\left(\dfrac{L_{b5}}{2\ ft}\right) kip \cdot ft = 2.603\ kip \cdot ft$

$\phi_v V_{nxb5} := 9.72\ kip$ $\phi_b M_{pxb5} := 5.54\ kip \cdot ft$

$ANSb5S :=$ if $V_{maxb5} \le \phi_v V_{nxb5}$
‖ "Sizing is okay!"
else
‖ "Sizing is NOT okay!"

$ANSb5M :=$ if $M_{maxb5} \le \phi_b M_{pxb5}$
‖ "Sizing is okay!"
else
‖ "Sizing is NOT okay!"

$ANSb5S =$ "Sizing is okay!"

$ANSb5M =$ "Sizing is okay!"

TRANSFER BEAM 1: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W21x101

$Weight_{w24x84} := 101\ plf$

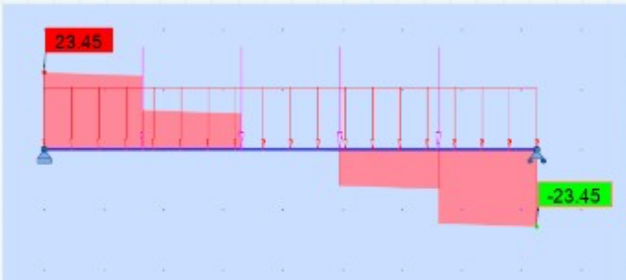
$I_{xtb1} := 2850\ in^4$

$DL = 69.5\ psf$ $w_{dltb1} := Weight_{w24x84} = 0.101\ klf$ $B3 := R_{Rb3} = 10.479\ kip$

$w_{tb1} := 1.2 \cdot w_{dltb1} = 0.121\ klf$ $\qquad$ $P_{wtb1} := w_{tb1} \cdot 5 \cdot L_y = 5\ kip$

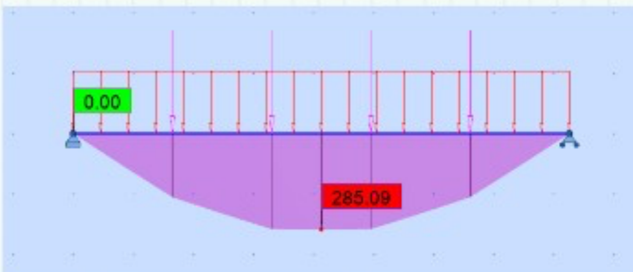
$$R_{Rtb1} := R_{Rtb1} \cdot (5 \cdot L_y) - B3 \cdot (4 \cdot L_y) - B3 \cdot (3 \cdot L_y) - P_{wtb1} \cdot (2.5 \cdot L_y) - B3 \cdot (2 \cdot L_y) - B3 \cdot (L_y) \xrightarrow{solve,\ R_{Rtb1}} 23.4582000000000097 \cdot kip$$

$R_{Ltb1} := ((B3 \cdot 4) + P_{wtb1}) - R_{Rtb1} = 23.458\ kip$



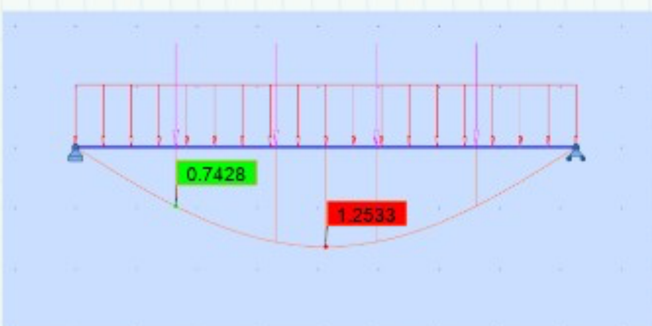
$V_{maxtb1} := 23.04\ kip$

$\phi_v V_{nxtb1} := 340\ kip$



$M_{maxtb1} := 280.84\ kip \cdot ft$

$\phi_b M_{pxtb1} := 840\ kip \cdot ft$



$\Delta_{maxtb1} := 1.2533\ in$

$\Delta_{allowtb1} = 1.375\ in$

$ANStb1D :=$ if $\Delta_{maxtb1} \le \Delta_{allowtb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANStb1D =$ "Sizing is okay!"

$ANStb1S :=$ if $V_{maxtb1} \le \phi_v V_{nxtb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANStb1M :=$ if $M_{maxtb1} \le \phi_b M_{pxtb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANStb1S =$ "Sizing is okay!" $\qquad$ $ANStb1M =$ "Sizing is okay!"

BEAM 6: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W21x93

$Weight_{w24x94} := 93\ plf$ $\quad x := 7\ ft$

$I_{xb6} := 843\ in^4$

$LL_{PrivRoomsb6} = 0.33\ klf$

$DL = 69.5\ psf$ $\quad w_{dlb6} := Weight_{w24x94} = 0.093\ klf$ $\quad P_{tb1} := R_{Ltb1} = 23.458\ kip$

$w_{b6} := (1.2 \cdot (DL \cdot t_{bb6}) + w_{dlb6}) + 1.6 \cdot LL_{PrivRoomsb6} = 1.309\ klf$

$R_{Rb6} := R_{Rb6} \cdot L_{b6} - P_{tb1} \cdot (L_{b6} - x) - w_{b6} \cdot L_{b6} \cdot \frac{L_{b6}}{2} \xrightarrow{solve,\ R_{Rb6}} 15.7086 \cdot ft \cdot klf + 16.616225000000011333 \cdot kip$

$R_{Rb6} := 15.7086\ kip + 16.616225\ kip = 32.325\ kip$

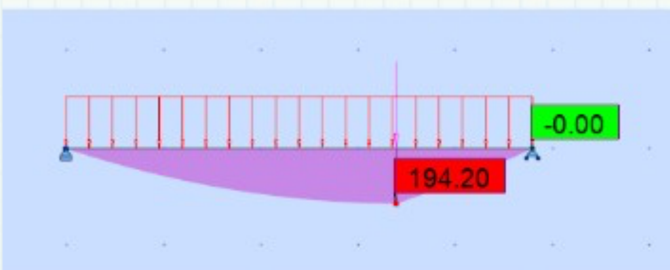
$R_{Lb6} := (P_{tb1} + (w_{b6} \cdot L_{b6})) - R_{Rb6} = 22.551\ kip$

$V_{maxb6} := 32.32\ kip$

$\phi_v V_{nxb6} := 376\ kip$

$ANSb6S :=$ if $V_{maxb6} \le \phi_v V_{nxb6}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb6S =$ "Sizing is okay!"



$M_{maxb6} := 194.2\ kip \cdot ft$

$\phi_b M_{pxb6} := 829\ kip \cdot ft$

$ANSb6M :=$ if $M_{maxb6} \le \phi_b M_{pxb6}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb6M =$ "Sizing is okay!"

$\Delta_{maxb6} := .3146\ in$

$\Delta_{allowb6} = 0.8\ in$

$ANSb6D :=$ if $\Delta_{maxtb1} \le \Delta_{allowtb1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb6D =$ "Sizing is okay!"

BEAM 7: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W21x93

$Weight_{w24x93} := 93\ plf$ $\qquad x := 7\ ft$

$I_{xb7} := 843\ in^4$

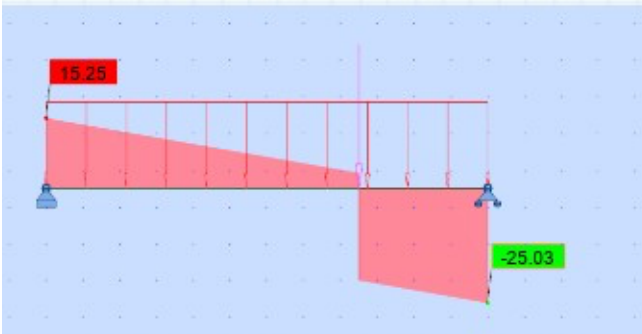
$DL = 69.5\ psf$ $\qquad w_{dlb7} := Weight_{w24x93} = 0.093\ klf$ $\qquad P_{tb7} := R_{Rtb1} = 23.458\ kip$

$w_{b7} := \left(1.2 \cdot \left(DL \cdot t_{bb7}\right) + w_{dlb7}\right) + 1.6 \cdot LL_{PrivRoomsb7} = 0.701\ klf$

$$R_{Rb7} := R_{Rb7} \cdot L_{b7} - P_{tb7} \cdot \left(L_{b7} - x\right) - w_{b7} \cdot L_{b7} \cdot \frac{L_{b7}}{2} \xrightarrow{solve, R_{Rb7}} 8.41230000000000144 \cdot ft \cdot klf + 16.616225000000006375 \cdot kip$$

$R_{Rb7} := 8.4123\ kip + 16.616225\ kip = 25.029\ kip$

$R_{Lb7} := \left(P_{tb7} + \left(w_{b7} \cdot L_{b7}\right)\right) - R_{Rb7} = 15.254\ kip$

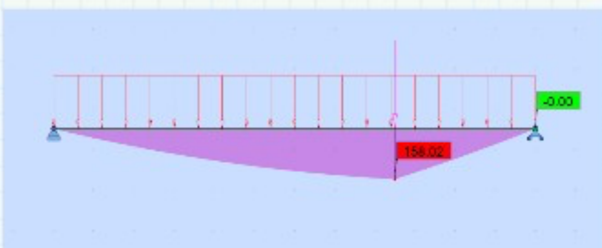


$V_{maxb7} := 25.03\ kip$

$\phi_v V_{nxb7} := 376\ kip$

$ANSb7S :=$ if $V_{maxb7} \le \phi_v V_{nxb7}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb7S =$ "Sizing is okay!"

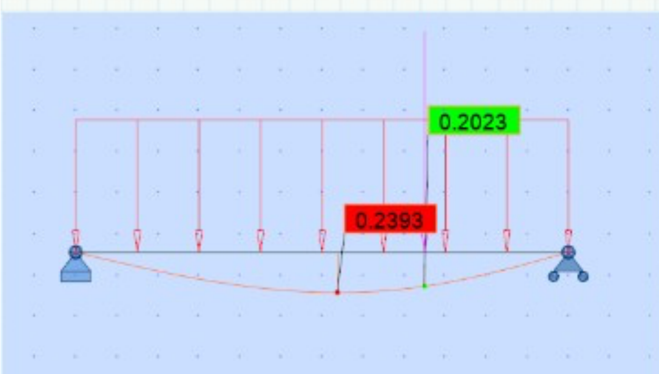


$M_{maxb7} := 158.02\ kip \cdot ft$

$\phi_b M_{pxb7} := 829\ kip \cdot ft$

$ANSb7M :=$ if $M_{maxb7} \le \phi_b M_{pxb7}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb7M =$ "Sizing is okay!"



$\Delta_{maxb7} := .2393\ in$

$\Delta_{allowb7} = 0.8\ in$

$ANSb7D :=$ if $\Delta_{maxb7} \le \Delta_{allowb7}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSb7D =$ "Sizing is okay!"

GIRDER 1: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W24x68

$Weight_{w24x68} := 68\ plf$

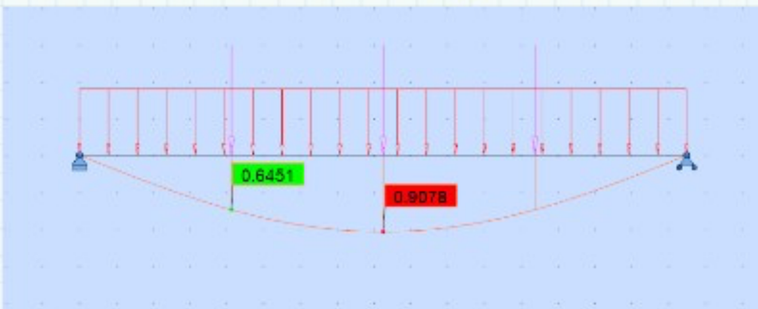
$L_y := 8.25\ ft$

$P_{g1} := R_{Lb2} = 14.967\ kip$

$w_{dlg1} := Weight_{w24x68} = 68\ plf$ $\quad w_{g1} := 1.2 \cdot w_{dlg1} = 0.082\ klf$ $\quad P_{wg1} := w_{g1} \cdot L_{g1} = 2.693\ kip$

$$R_{Rg1} := R_{Rg1} \cdot (4 \cdot L_y) - P_{g1} \cdot (3 \cdot L_y) - ((P_{wg1} + P_{g1}) \cdot (2 \cdot L_y)) - P_{g1} \cdot (L_y) \xrightarrow{solve,\ R_{Rg1}} 23.7969000000000088 \cdot kip$$

$R_{Lg1} := ((3 \cdot P_{g1}) + P_{wg1}) - R_{Rg1} = 23.797\ kip$

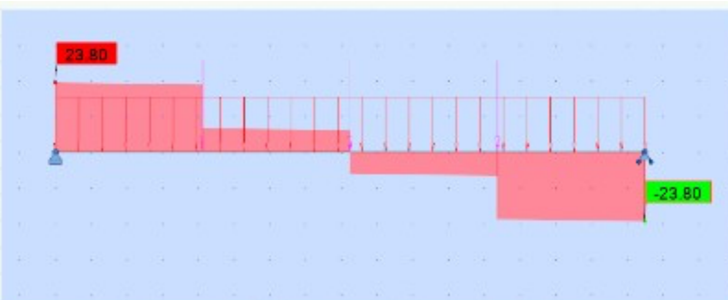


$\Delta_{allowg1} = 1.1\ in$

$\Delta_{maxg1} := .9078 \cdot in$

$ANSg1D :=$ if $\Delta_{maxg1} \le \Delta_{allowg1}$
‖ "Sizing is okay!"
else
‖ "Sizing is NOT okay!"

$ANSg1D =$ "Sizing is okay!"

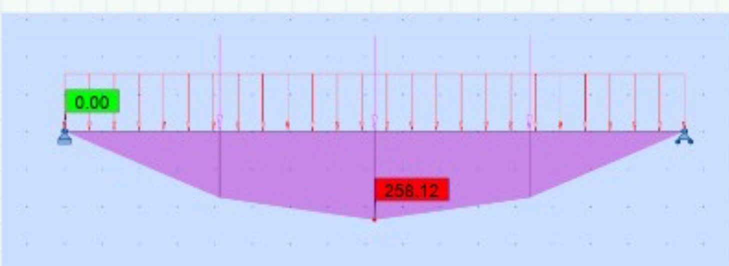


$V_{maxg1} := 23.8\ kip$

$\phi_v V_{nxg1} := 295\ kip$

$ANSg1S :=$ if $V_{maxg1} \le \phi_v V_{nxg1}$
‖ "Sizing is okay!"
else
‖ "Sizing is NOT okay!"

$ANSg1S =$ "Sizing is okay!"



$M_{maxg1} := 258.12\ kip \cdot ft$

$\phi_b M_{pxg1} := 664\ kip \cdot ft$

$ANSg1M :=$ if $M_{maxg1} \le \phi_b M_{pxg1}$
‖ "Sizing is okay!"
else
‖ "Sizing is NOT okay!"

$ANSg1M =$ "Sizing is okay!"

GIRDER 2: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W24x104

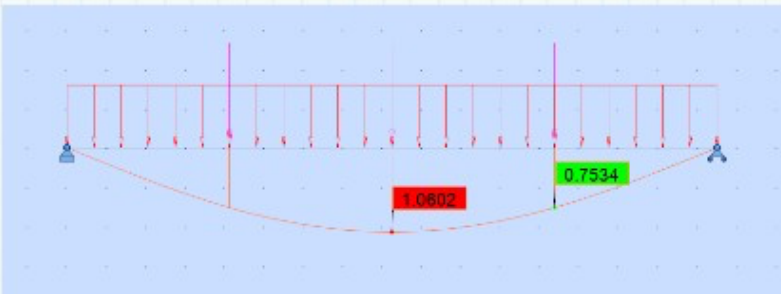
$Weight_{w24x104} := 104\ plf$

$P_{g2} := R_{Lb2} + R_{Rb2} = 29.934\ kip$

$w_{dlg2} := Weight_{w24x104} = 104\ plf$ $w_{g2} := 1.2 \cdot w_{dlg2} = 0.125\ klf$ $P_{wg2} := w_{g2} \cdot L_{g2} = 4.118\ kip$

$R_{Rg2} := R_{Rg2} \cdot (4 \cdot L_y) - P_{g2} \cdot (3 \cdot L_y) - ((P_{wg2} + P_{g2}) \cdot (2 \cdot L_y)) - P_{g2} \cdot (L_y) \xrightarrow{solve,\ R_{Rg2}} 46.9602000000000177 \cdot kip$

$R_{Lg2} := ((3 \cdot P_{g2}) + P_{wg2}) - R_{Rg2} = 46.96\ kip$

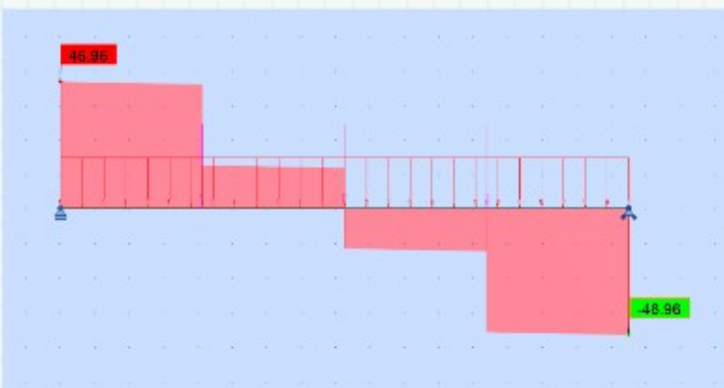


$\Delta_{allowg2} = 1.1\ in$

$\Delta_{maxg2} := 1.0602 \cdot in$

ANSg2D := if $\Delta_{maxg2} \le \Delta_{allowg2}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

ANSg2D = "Sizing is okay!"



$V_{maxg2} := 46.96\ kip$

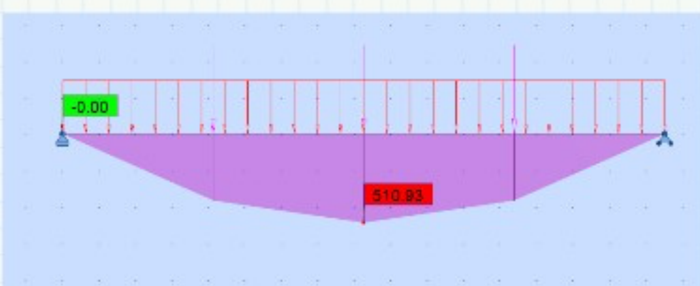
$\phi_v V_{nxg2} := 362\ kip$

ANSg2S := if $V_{maxg2} \le \phi_v V_{nxg2}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

ANSg2S = "Sizing is okay!"

$M_{maxg2} := 510.93\ kip \cdot ft$

$\phi_b M_{pxg2} := 1080\ kip \cdot ft$



ANSg2M := if $M_{maxg2} \le \phi_b M_{pxg2}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

ANSg2M = "Sizing is okay!"

GIRDER 3: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W24x207

$Weight_{w24x207} := 207\ plf$

$P_{g3} := R_{Rb2} + R_{Lb3} = 25.446\ kip$

$w_{dlg3} := Weight_{w24x207} = 207\ plf$ $\quad w_{g3} := 1.2 \cdot w_{dlg3} = 0.248\ klf$ $\quad P_{wg3} := w_{g3} \cdot L_{g3} = 10.247\ kip$

$$R_{Rg3} := R_{Rg3} \cdot (5 \cdot L_y) - P_{g3} \cdot (4 \cdot L_y) - P_{g3} \cdot (3 \cdot L_y) - P_{wg3} \cdot (2.5 \cdot L_y) - P_{g3} \cdot (2 \cdot L_y) - P_{g3} \cdot (L_y) \xrightarrow{solve, R_{Rg3}} 56.0157000000000185 \cdot kip$$

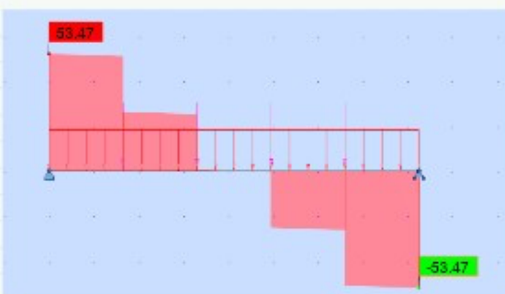
$R_{Lg3} := ((4 \cdot P_{g3}) + P_{wg3}) - R_{Rg3} = 56.016\ kip$

$\Delta_{allowg3} = 1.375\ in$

$\Delta_{maxg3} := 1.0243 \cdot in$

$ANSg3D :=$ if $\Delta_{maxg3} \le \Delta_{allowg3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSg3D =$ "Sizing is okay!"

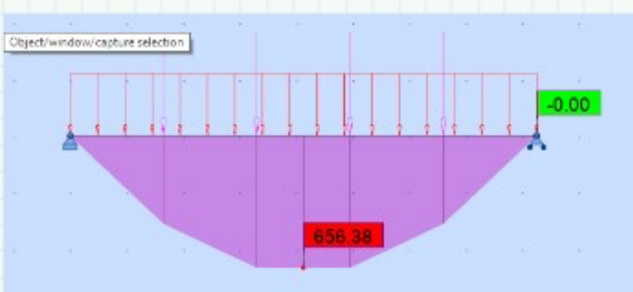


$V_{maxg3} := 53.47\ kip$

$\phi_v V_{nxg3} := 671\ kip$

$ANSg3S :=$ if $V_{maxg3} \le \phi_v V_{nxg3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSg3S =$ "Sizing is okay!"



$M_{maxg3} := 656.38\ kip \cdot ft$

$\phi_b M_{pxg3} := 2270\ kip \cdot ft$

$ANSg3M :=$ if $M_{maxg3} \le \phi_b M_{pxg3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSg3M =$ "Sizing is okay!"

GIRDER 4: (Designed against moment, shear, and deflection)

Assume interior beams 2 to be W12x19

$Weight_{w12x19} := 19\ plf$

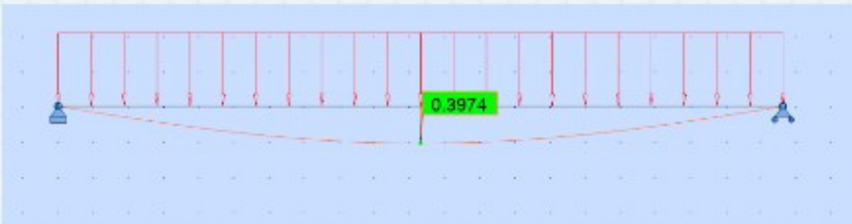
$w_{dlg4} := Weight_{w12x19} = 19\ plf$

$w_{g4} := 1.2 \cdot w_{dlg4} = 0.023\ klf$

$P_{wg4} := w_{g4} \cdot L_{g4} = 0.941\ kip$

$R_{Rg4} := \dfrac{w_{g4} \cdot L_{g4}}{2} = 0.47\ kip$

$R_{Lg4} := w_{g4} \cdot L_{g4} - R_{Rg4} = 0.47\ kip$

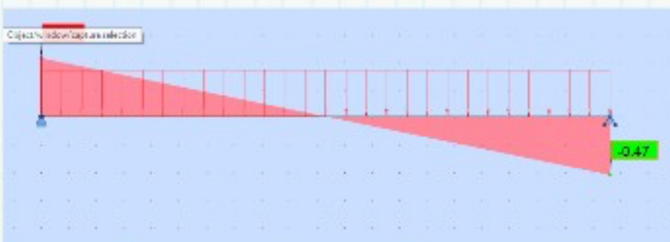


$\Delta_{allowg4} = 1.375\ in$

$\Delta_{maxg4} := .3974 \cdot in$

$ANSg4D :=$ if $\Delta_{maxg4} \le \Delta_{allowg4}$
"Sizing is okay!"
else
"Sizing is NOT okay!"

$ANSg3D =$ "Sizing is okay!"

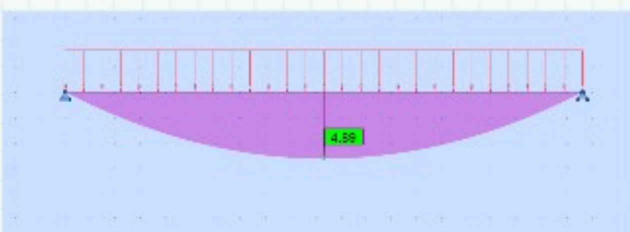


$V_{maxg4} := .47\ kip$

$\phi_v V_{nxg4} := 86\ kip$

$ANSg4S :=$ if $V_{maxg4} \le \phi_v V_{nxg4}$
"Sizing is okay!"
else
"Sizing is NOT okay!"

$ANSg4S =$ "Sizing is okay!"



$M_{maxg4} := 4.89\ kip \cdot ft$

$\phi_b M_{pxg4} := 92.6\ kip \cdot ft$

$ANSg4M :=$ if $M_{maxg4} \le \phi_b M_{pxg4}$
"Sizing is okay!"
else
"Sizing is NOT okay!"

$ANSg4M =$ "Sizing is okay!"

COLUMN AXIAL
COMPRESSIVE FORCES
FROM BEAM AND GIRDER
REACTION FORCES:

COLUMN A1: $P_{nA1} := (R_{Lb1} + R_{Lg1}) \cdot 2 = 62.647\ kip$

COLUMN A3: $P_{nA3} := (R_{Rb1} + R_{Lb1} + R_{Lg2}) \cdot 2 = 124.027\ kip$

COLUMN A5: $P_{nA5} := (R_{Rb1} + R_{Rg1}) \cdot 2 = 62.647\ kip$

COLUMN E1: $P_{nE1} := (R_{Rg1} + R_{Lg1} + R_{Lb2}) \cdot 2 = 125.122\ kip$

COLUMN E3: $P_{nE3} := (R_{Lg3} + R_{Rg2} + R_{Lb6} + R_{Rb2}) \cdot 2 = 280.987\ kip$

COLUMN E5: $P_{nE5} := (R_{Rb6} + R_{Lg4} + R_{Rg1}) \cdot 2 = 113.184\ kip$

COLUMN I1: $P_{nI1} := (R_{Lb2} + R_{Rg1} + R_{Lb5}) \cdot 2 = 79.337\ kip$

COLUMN J2: $P_{nJ2} := (R_{Rb5} + R_{Lb4}) \cdot 14 = 82.643\ kip$ Upsized column due to how small it would look!

COLUMN J3: $P_{nJ3} := (R_{Rb4} + R_{Rg3} + R_{Lb7}) \cdot 2 = 152.537\ kip$

COLUMN J5: $P_{nJ5} := (R_{Rg4} + R_{Rb7}) \cdot 2 = 50.998\ kip$

SELECTING COLUMN SIZES: $L := 14\ ft$

COLUMN A1: ASSUME HSS 6x6x1/8: $\phi_n P_{nA1} := 75.1\ kip$

$P_{nA1} = 62.647\ kip$

$ANSCA1 :=$ if $P_{nA1} \le \phi_n P_{nA1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCA1 =$ "Sizing is okay!"

COLUMN A3: ASSUME HSS 6x6x1/4: $\phi_n P_{nA3} := 162\ kip$

$P_{nA3} = 124.027\ kip$

$ANSCA3 :=$ if $P_{nA3} \le \phi_n P_{nA3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCA3 =$ "Sizing is okay!"

COLUMN A5: ASSUME HSS 6x6x1/8: $\phi_n P_{nA5} := 75.1\ kip$

$P_{nA5} = 62.647\ kip$

$ANSCA5 := \text{if } P_{nA5} \le \phi_n P_{nA5}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCA5 =$ "Sizing is okay!"

COLUMN E1: ASSUME HSS 6x6x1/4: $\phi_n P_{nE1} := 161\ kip$

$P_{nE1} = 125.122\ kip$

$ANSCE1 := \text{if } P_{nE1} \le \phi_n P_{nE1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCE1 =$ "Sizing is okay!"

COLUMN E3: ASSUME HSS 7x7x3/8: $\phi_n P_{nE3} := 303\ kip$

$P_{nE3} = 280.987\ kip$

$ANSCE3 := \text{if } P_{nE3} \le \phi_n P_{nE3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCE3 =$ "Sizing is okay!"

COLUMN E5: ASSUME HSS 6x6x3/16: $\phi_n P_{nE5} := 124\ kip$

$P_{nE5} = 113.184\ kip$

$ANSCE5 := \text{if } P_{nE5} \le \phi_n P_{nE5}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCE5 =$ "Sizing is okay!"

COLUMN I1: ASSUME HSS 5.5x5.5x3/16: $\phi_n P_{nI1} := 105$ ***kip***

$P_{nI1} = 79.337$ ***kip***

$ANSCI1 :=$ if $P_{nI1} \le \phi_n P_{nI1}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCI1 =$ "Sizing is okay!"

COLUMN J2: ASSUME HSS 5.5x5.5x3/16: $\phi_n P_{nJ2} := 105$ ***kip***

$P_{nJ2} = 82.643$ ***kip***

$ANSCJ2 :=$ if $P_{nJ2} \le \phi_n P_{nJ2}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCJ2 =$ "Sizing is okay!"

COLUMN J3: ASSUME HSS 6x6x1/4: $\phi_n P_{nJ3} := 162$ ***kip***

$P_{nJ3} = 152.537$ ***kip***

$ANSCJ3 :=$ if $P_{nJ3} \le \phi_n P_{nJ3}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCJ2 =$ "Sizing is okay!"

COLUMN J5: ASSUME HSS 5.5x5.5x3/16: $\phi_n P_{nJ5} := 105$ ***kip***

$P_{nJ5} = 50.998$ ***kip***

$ANSCJ5 :=$ if $P_{nJ5} \le \phi_n P_{nJ5}$
  "Sizing is okay!"
else
  "Sizing is NOT okay!"

$ANSCJ5 =$ "Sizing is okay!"

COLUMN TO BEAM CONNECTIONS:

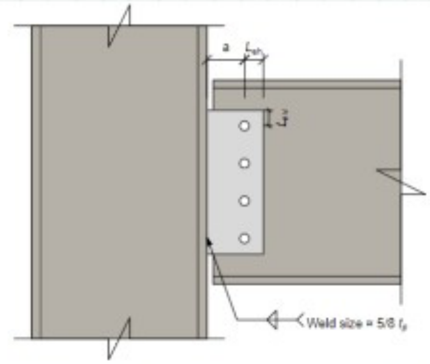
ASSUMPTIONS: $F_{uBolt} := 120\ ksi$ $F_{yPlate} := 36\ ksi$ $F_{ySection} := 50\ ksi$

$F_{uPlate} := 58\ ksi$ $F_{uSection} := 65\ ksi$

$d_b := 1 \cdot in$ $A_b := \frac{\pi}{4} \cdot d_b^{\,2} = 0.785\ in^2$

ASSUMING STANDARD PUNCHED HOLES: $d_h := d_b + \frac{1}{16} \cdot in + \frac{1}{16} \cdot in = 1.125\ in$

Girder: W24x207: $\begin{bmatrix} d & t_w & b_f & t_f \end{bmatrix} := \begin{bmatrix} 25.7\ in & .870 \cdot in & 13\ in & 1.57 \cdot in \end{bmatrix}$



$t_p := \frac{1}{4} \cdot in$ $\frac{d_b}{2} + \frac{1}{16} \cdot in = 0.563\ in$ $L_{ev} := 4\ in$

$2 \cdot d_b = 2\ in$ $d - 2 \cdot t_f = 22.56\ in$

$L_{eh} := 3\ in$ $s := 3\ in$ $numBolts := 3$

$a := 3.5\ in$ $L_g := 2 \cdot L_{ev} + (numBolts - 1) \cdot s = 14\ in$

$A_{gv} := t_p \cdot L_g = 3.5\ in^2$ A32

$\phi R_{nPlateShearYielding} := 1 \cdot .6 \cdot F_{yPlate} \cdot A_{gv} = 75.6\ kip$

BOTH SIDES OF PLATE ARE WELDED TO COLUMN FLANGE USING FILLET WLEDS

$2 \cdot d_b = 2\ in$

$A_v := (a + L_{eh}) \cdot (L_{ev} \cdot 2 \cdot 3) = 156\ in^2$

$A_{nv} := A_{gv} - numBolts \cdot d_h \cdot t_p = 2.656\ in^2$ $\phi R_{nPlateShearRupture} := .75 \cdot F_{uPlate} \cdot A_{nv} = 115.547\ kip$

$A_{gv} := t_p \cdot (L_{ev} + (numBolts - 1) \cdot s) = 2.5\ in^2$ $A_{nv} := A_{gv} - ((numBolts - 1) + .5) \cdot d_h \cdot t_p = 1.797\ in^2$

$A_{nt} := \left(L_{eh} - \frac{d_h}{2}\right) \cdot t_p = 0.609\ in^2$ $U := 1$

$\phi R_{nBlockShear} := .75 \cdot (\min(.6 \cdot F_{uPlate} \cdot A_{nv}, .6 \cdot F_{yPlate} \cdot A_{gv}) + U \cdot F_{uPlate} \cdot A_{nt}) = 67.008\ kip$

$\phi R_{nPlate} := \min(\phi R_{nPlateShearYielding}, \phi R_{nPlateShearRupture}, \phi R_{nBlockShear}) = 67.008\ kip$

$F_{uBolt} = 120\ ksi$ $\phi R_{nBoltShear} := \frac{.75 \cdot F_{uBolt} \cdot A_b}{numBolts} = 23.562\ kip$

$L_{c1} := L_{ev} - \frac{d_h}{2} = 3.438\ in$ $\phi R_{nEndBoltBearing} := .75 \cdot \min(1.2 \cdot L_{c1} \cdot t_p \cdot F_{uPlate}, 2.4 \cdot d_b \cdot t_p \cdot (F_{uPlate})) = 26.1\ kip$

$\phi R_{nEndBolt} := \min(\phi R_{nBoltShear}, \phi R_{nEndBoltBearing}) = 23.562\ kip$ $L_{c2} := s - d_h = 1.875\ in$

$\phi R_{nIntBearing} := .75 \cdot \min(1.2 \cdot L_{c2} \cdot t_p \cdot F_{uPlate}, 2.4 \cdot d_b \cdot t_p \cdot F_{uPlate}) = 24.469\ kip$

$\phi R_{nIntBolt} := \min(\phi R_{nBoltShear}, \phi R_{nIntBearing}) = 23.562\ kip$

$\phi R_{nBolts1} := 2 \cdot \phi R_{nIntBolt} + 2 \cdot \phi R_{nEndBolt} = 94.248\ kip$

$\phi R_{nEndBoltBearing} := .75 \cdot min(1.2 \cdot L_{c1} \cdot t_w \cdot F_{uSection}, 2.4 \cdot d_b \cdot t_w \cdot F_{uSection}) = 101.79\ kip$

$\phi R_{nEndBolt} := min(\phi R_{nBoltShear}, \phi R_{nEndBoltBearing}) = 23.562\ kip$

$\phi R_{nIntBearing} := .75 \cdot min(1.2 \cdot L_{c2} \cdot t_w \cdot F_{uSection}, 2.4 \cdot d_b \cdot t_w \cdot F_{uSection}) = 95.428\ kip$

$\phi R_{nIntBolt} := min(\phi R_{nBoltShear}, \phi R_{nIntBearing}) = 23.562\ kip$

$\phi R_{nBolts2} := 2 \cdot \phi R_{nEndBolt} + 2 \cdot \phi R_{nIntBolt} = 94.248\ kip$

$\phi R_{nBolts} := min(\phi R_{nBolts1}, \phi R_{nBolts2}) = 94.248\ kip$

$\phi R_n := min(\phi R_{nBolts}, \phi R_{nPlate}) = 67.008\ kip$ MUST RESIST: $R_{Lg3} := 53.47\ kip$

$\frac{5}{8} \cdot t_p = 0.156\ in$ USE 3/16 in weld on both sides of plate!

$h_{plate} := 2 \cdot L_{ev} + (numBolts - 1) \cdot s = 14\ in$

First floor Plan

DEAD LOADS:
- 5in Lightweight Conc: 62.5psf
- Lighting-lights & conduit: 1psf
-mechanical-duct allowance: 4psf
-plumbing-piping allowance: 1psf

Live loads
- Public bathroom
- Stairs
- Restaurant
- Kitchen

$L_x := 24\ ft$

$LL_{stairs} := 100\ psf$

$L_{x2} := 16\ ft$ $L_y := 8.25\ ft$

$LL_R := 100\ psf$

$LL_{kitchen} := 150\ psf$

$$L_{x3} := \frac{L_x + (L_x - 8\ ft)}{2} = 20\ ft$$

$L_{J5} := \sqrt{(24\ ft - 16\ ft)^2 + (8.25\ ft)^2}$

$L_{J7} := 17\ ft$

$E := 29000\ ksi$

$t_{bIntJoists} := 8.25\ ft$ $t_{bExtJoists1} := \frac{t_{bIntJoists}}{2} = 4.125\ ft$ $t_{bExtJoists2} := t_{bExtJoists1}$

$t_{bExtJoists4} := 4.125\ ft$ $t_{bExtJoists5} := .25 \cdot t_{bExtJoists4} = 1.031\ ft$

$t_{bExtJoists7} := 4.125\ ft$

Interior Joists

Live Load Element Factor: $K_{LLIntJoists} := 2$ $A_{TIntJoists} := L_x \cdot t_{bIntJoists} = (2.851 \cdot 10^4)\ in^2$

Uniformly Dist LL on 1st Floor:

$LL_{stairs} := 100\ psf$

$LL_{Kitchen} := 150\ psf$ $LL_{restaurant} := 100\ psf$

Reduction In Uniform LL (bathroom):

$$LL_{restaurantINT} := LL_{restaurant} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLIntJoists} \cdot A_{TIntJoists}}}\right) = 31.281\ psf$$

Reduction in Uniform LL (Stairs):

$$LL_{Stairs} := LL_{stairs} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLIntJoists} \cdot A_{TIntJoists}}}\right) = 31.281\ psf$$

Exterior Joist 1:

Live Load Element Factor: $K_{LLExtJoists} := 1$ $A_{TExtJoists1} := L_x \cdot t_{bExtJoists1} = (1.426 \cdot 10^4)\ in^2$

$$LL_{restaurantEXT1} := LL_{restaurant} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLExtJoists} \cdot A_{TExtJoists1}}}\right) = 37.563\ psf$$

Exterior Joist (3):

$$A_{TExtJoists2} := L_{x3} \cdot t_{bExtJoists2} = (1.188 \cdot 10^4)\ in^2$$

Exterior Joist (4):

$$A_{TExtJoists4} := L_{x2} \cdot t_{bExtJoists4} = (9.504 \cdot 10^3)\ in^2$$

Exterior Joist (5):

$$A_{TExtJoists5} := L_{J5} \cdot t_{bExtJoists5} = (1.707 \cdot 10^3)\ in^2$$

Interior joists(2):

ASSUME W18x86 for Interior Joists:

$$w_{llInt} := (LL_{restaurantINT} + LL_{kitchen}) \cdot L_x = (4.351 \cdot 10^3)\ plf \qquad Weight_{w18x86} := 86\ plf$$

$$DL := 62.5\ psf + 4\ psf + 1\ psf + 1\ psf = 68.5\ psf \qquad x := 1\ klf$$

$$w_{dlInt} := DL \cdot L_x + Weight_{w18x86} = (1.73 \cdot 10^3)\ plf$$

$$E := 29000\ ksi$$

$$w_{Int} := 1.2 \cdot w_{dlInt} + 1.6 \cdot w_{llInt} = 9.037\ klf$$

$$I_x := 1530\ in^4$$

$$\Delta_{allow} := \frac{L_x}{360} = 0.8\ in \qquad \Delta_{max} := \frac{5 \cdot w_{llInt} \cdot L_x^4}{384 \cdot E \cdot I_x} = 0.732\ in$$

$ANS :=$ if $\Delta_{max} \le \Delta_{allow}$
  "Sizing is OKAY!"
else
  "Sizing is NOT OKAY!"

$ANS =$ "Sizing is OKAY!"

W18X86 IS A SUFFICIENT MEMBER

$$R_{LJ2} := \frac{w_{Int} \cdot L_x}{2} = 108.447\ kip \qquad R_{RJ2} := (w_{Int} \cdot L_x) - R_{LJ2} = 108.447\ kip$$

$V(x) :=$ if $0 \le \frac{L_x}{in}$
  $105.898 - 8.825 \cdot x$
else
  0

$M(x) :=$ if $0 \le \frac{L_x}{in}$
  $105.898 \cdot x - \frac{8.825 \cdot x^2}{2}$
else
  0

$LL_{tot} := LL_{kitchen} + LL_{restaurantINT}$

Exterior Joist (1) design:

Assume exterior joists 1 to be W14x61

$Weight_{w14x61} := 61\ plf$

$$LL_{totEXT1} := LL_{tot} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLExtJoists} \cdot A_{TExtJoists1}}} \right) = 68.095\ psf$$

$DL = 68.5\ psf$ $\qquad w_{dlExt1} := DL \cdot L_x + Weight_{w14x61} = \left(1.705 \cdot 10^3\right)\ plf$

$w_{llExt1} := LL_{totEXT1} \cdot L_x = \left(1.634 \cdot 10^3\right)\ plf$

$w_{Ext1} := 1.2 \cdot w_{dlExt1} + 1.6 \cdot w_{llExt1} = 4.661\ klf$ $\qquad I_x := 640\ in^4$

$$\Delta_{max2} := \frac{5 \cdot w_{llExt1} \cdot L_x^4}{384 \cdot E \cdot I_x} = 0.657\ in \qquad \Delta_{allow} := \frac{L_x}{360} = 0.8\ in$$

$ANS :=$ if $\Delta_{max2} \le \Delta_{allow}$
  "Sizing is OKAY!"
else
  "Sizing is NOT OKAY!"

$ANS =$ "Sizing is OKAY!"

$$R_{LJ1} := \frac{w_{Ext1} \cdot L_x}{2} = 55.93\ kip \qquad R_{RJ1} := \left(w_{Ext1} \cdot L_x\right) - R_{LJ1} = 55.93\ kip$$

$V(x) :=$ if $0 \le \frac{L_x}{in}$
  $55.93 - 4.661 \cdot x$
else
  0

$M(x) :=$ if $0 \le \frac{L_x}{in}$
  $55.93 \cdot x - \frac{4.661 \cdot x^2}{2}$
else
  0

$V_{max} := V(0) \cdot kip = 55.93\ kip$

$$M_{max} := M\left(\frac{L_x}{2\ in}\right) \cdot kip \cdot ft = -4.027 \cdot 10^4\ kip \cdot ft$$

$\phi_v V_{nx} := 236\ kip$

$\phi_b M_{px} := 383\ kip \cdot ft$

W14X61 IS A SUFFICIENT MEMBER

STAIR JOISTS (3): Assume W8x48 $Weight_{w8x48} := 48\ plf$

$$LL_{totEXT2} := LL_{tot} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLExtJoists} \cdot A_{TExtJoists2}}} \right) = 70.268\ psf$$

$L_{xJ3} := 24\ ft - 7\ ft$

$L_{x2} = 16\ ft$

$DL = 68.5\ psf$ $w_{dlExt2} := DL \cdot L_{x3} + Weight_{w8x48} = (1.418 \cdot 10^{3})\ plf$

$w_{llExt2} := LL_{totEXT2} \cdot L_{x3} = (1.405 \cdot 10^{3})\ plf$

$w_{Ext2} := 1.2 \cdot w_{dlExt2} + 1.6 \cdot w_{llExt2} = 3.95\ klf$ $I_x := 184\ in^4$

$$\Delta_{max3} := \frac{5 \cdot w_{llExt2} \cdot L_{xJ3}{}^4}{384 \cdot E \cdot I_x} = 0.495\ in$$ $$\Delta_{allow} := \frac{L_{xJ3}}{360} = 0.567\ in$$

CHECK IBC FOR ALLOW DEFLECTION!!

$ANS :=$ if $\Delta_{max3} \le \Delta_{allow}$
  "Sizing is OKAY!"
else
  "Sizing is NOT OKAY!"

$ANS =$ "Sizing is OKAY!"

$$R_{LJ3} := \frac{w_{Ext2} \cdot L_{x3}}{2} = 39.502\ kip$$ $R_{RJ3} := w_{Ext2} \cdot L_{x3} - R_{LJ3} = 39.502\ kip$

$L_{x3} = 240\ in$

$V(x) :=$ if $0 \le x \le \frac{L_{x3}}{in}$
  $39.502 - 3.95 \cdot x$
else
  0

$M(x) :=$ if $0 \le x \le \frac{L_{x3}}{in}$
  $39.502 \cdot x - \frac{3.95 \cdot x^2}{2}$
else
  0

$V_{max} := V(0) \cdot kip = 39.502\ kip$ $M_{max} := M(120) \cdot kip \cdot ft = -2.37 \cdot 10^4\ kip \cdot ft$

$\phi_v V_{nx} := 102\ kip$ $\phi_b M_{px} := 184\ kip \cdot ft$

W8X48 IS A SUFFICIENT MEMBER

EXTERIOR JOISTS (4): Assume W10x30 $Weight_{w10x30} := 30\ plf$

$$LL_{totEXT4} := LL_{tot} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLExtJoists} \cdot A_{TExtJoists4}}} \right) = 73.213\ psf$$

$L_{x2} = 16\ ft$

$DL = 68.5\ psf$ $w_{dlExt4} := DL \cdot L_{x2} + Weight_{w10x30} = \left(1.126 \cdot 10^3\right)\ plf$

$w_{llExt4} := LL_{totEXT4} \cdot L_{x2} = \left(1.171 \cdot 10^3\right)\ plf$

$w_{Ext4} := 1.2 \cdot w_{dlExt4} + 1.6 \cdot w_{llExt4} = 3.225\ klf$ $I_x := 170\ in^4$

$$\Delta_{max3} := \frac{5 \cdot w_{llExt4} \cdot L_{x2}^{\ 4}}{384 \cdot E \cdot I_x} = 0.35\ in$$

$$\Delta_{allow} := \frac{L_{x2}}{360} = 0.533\ in$$

CHECK IBC FOR ALLOW DEFLECTION!!

ANS := if $\Delta_{max3} \le \Delta_{allow}$
‖ "Sizing is OKAY!"
else
‖ "Sizing is NOT OKAY!"

ANS = "Sizing is OKAY!"

$$R_{LJ4} := \frac{w_{Ext4} \cdot L_{x2}}{2} = 25.804\ kip$$

$R_{RJ4} := w_{Ext4} \cdot L_{x2} - R_{LJ4} = 25.804\ kip$

$V(x) :=$ if $0 \le x \le \frac{L_{x2}}{in}$
‖ $25.804 - 3.225 \cdot x$
else
‖ 0

$M(x) :=$ if $0 \le x \le \frac{L_{x2}}{in}$
‖ $25.804 \cdot x - \frac{3.225 \cdot x^2}{2}$
else
‖ 0

$V_{max} := V(0) \cdot kip = 25.804\ kip$ $M_{max} := M(8) \cdot kip \cdot ft = 103.232\ kip \cdot ft$

$\phi_v V_{nx} := 94.5\ kip$ $\phi_b M_{px} := 137\ kip \cdot ft$

W10X30 IS A SUFFICIENT MEMBER

EXTERIOR JOISTS (5): Assume C5X6.7 $Weight_{c5x6.7} := 6.7\ plf$

$t_{bJ5} := 1.031\ ft$

$$LL_{totEXT5} := LL_{tot} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLExtJoists} \cdot A_{TExtJoists5}}}\right) = 111.145\ psf$$

$L_{x2} = 16\ ft$

$L_{J5} := 11.492\ ft$

$DL = 68.5\ psf$ $w_{dlExt5} := DL \cdot t_{bJ5} + Weight_{c5x6.7} = 77.324\ plf$

$w_{llExt5} := LL_{totEXT5} \cdot t_{bJ5} = 114.59\ plf$

$w_{Ext5} := 1.2 \cdot w_{dlExt5} + 1.6 \cdot w_{llExt5} = 0.276\ klf$ $I_x := 7.48\ in^4$

$$\Delta_{max3} := \frac{5 \cdot w_{llExt5} \cdot L_{J5}^{\ 4}}{384 \cdot E \cdot I_x} = 0.207\ in$$

$$\Delta_{allow} := \frac{L_{J5}}{360} = 0.383\ in$$

CHECK IBC FOR ALLOW DEFLECTION!!

$ANS :=$ if $\Delta_{max3} \le \Delta_{allow}$
  "Sizing is OKAY!"
else
  "Sizing is NOT OKAY!"

$ANS =$ "Sizing is OKAY!"

$$R_{LJ5} := \frac{w_{Ext5} \cdot L_{J5}}{2} = 1.587\ kip$$

$$R_{RJ5} := w_{Ext5} \cdot L_{J5} - R_{LJ5} = 1.587\ kip$$

$V(x) :=$ if $0 \le x \le \frac{L_{J5}}{in}$
  $1.587 - 0.276 \cdot x$
else
  0

$M(x) :=$ if $0 \le x \le \frac{L_{J5}}{in}$
  $1.587 \cdot x - \frac{0.276 \cdot x^2}{2}$
else
  0

$V_{max} := V(0) \cdot kip = 1.587\ kip$

$$M_{max} := M\left(\frac{L_{J5}}{2\ in}\right) \cdot kip \cdot ft = -546.677\ kip \cdot ft$$

$\phi_v V_{nx} := 9.72\ kip$

$\phi_b M_{px} := 5.54\ kip \cdot ft$

C5X6.7 IS A SUFFICIENT MEMBER

$K_{LLIntJoists} := 2$ $A_{TIntJoists} := L_x \cdot t_{bIntJoists} = \left(2.851 \cdot 10^4\right)\ in^2$

Exterior Joist (7):

$A_{TExtJoists7} := L_{J7} \cdot t_{bExtJoists7} = \left(1.01 \cdot 10^4\right)\ in^2$

TRANSFER BEAM 1: (Designed against moment, shear, and deflection)

Assume transfer beam 1 to be W18x60

$Weight_{w18x60} := 60\ plf$

$L_{tb} := 16.5\ ft$

$J3 := R_{RJ3} = 39.502\ kip$ $\quad w_{dlTB1} := Weight_{w18x60} = 0.06\ klf$ $\quad w_{TB1} := 1.2 \cdot Weight_{w18x60} = 0.072\ klf$

$P_{wTB1} := w_{TB1} \cdot 5 \cdot L_y = 2.97\ kip$

$R_{RTB1} := R_{RTB1} \cdot (5 \cdot L_y) - J3 \cdot (4 \cdot L_y) - J3 \cdot (3 \cdot L_y) - P_{wTB1} \cdot (2.5 \cdot L_y) - J3 \cdot (2 \cdot L_y) - J3 \cdot (L_y) \xrightarrow{solve, R_{RTB1}} 80.4$

$R_{LTB1} := (4 \cdot J3 + P_{wTB1}) - R_{RTB1} = 80.489\ kip$

$\Delta_{allow} := \dfrac{L_{tb}}{360} = 0.55\ in$

$$V(x) := \text{if } 0 \le x \le \frac{L_y}{ft}$$
$$\quad 81.33 - 0.113 \cdot x$$
$$\text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft}$$
$$\quad 80.398 - 39.502 - 0.113 \cdot \left(x - \frac{L_y}{ft}\right)$$
$$\text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft}$$
$$\quad 39.964 - 39.502 - 0.113 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right)$$
$$\text{else if } \frac{3 \cdot L_y}{ft} \le x \le \frac{4 \cdot L_y}{ft}$$
$$\quad -0.47 - 39.502 - 0.113 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right)$$
$$\text{else}$$
$$\quad -40.904 - 39.502 - 0.113 \cdot \left(x - \left(4 \cdot \frac{L_y}{ft}\right)\right)$$

$V\left(\dfrac{L_y}{ft}\right) = 80.398$

$V\left(2 \cdot \dfrac{L_y}{ft}\right) = 39.964$

$V\left(3 \cdot \dfrac{L_y}{ft}\right) = -0.47$

$V\left(4 \cdot \dfrac{L_y}{ft}\right) = -40.904$

$V\left(5 \cdot \dfrac{L_y}{ft}\right) = -81.338$

$$M(x) := \text{if } 0 \le x \le \frac{L_y}{ft}$$

$$\quad 81.338 \cdot x - \frac{0.113 \cdot x^2}{2}$$

$$\text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft}$$

$$\quad 667.193 + 80.398 \cdot \left(x - \frac{L_y}{ft}\right) - 39.502 \cdot \left(x - \frac{L_y}{ft}\right) - \frac{0.113 \cdot \left(x - \frac{L_y}{ft}\right)^2}{2}$$

$$\text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft}$$

$$\quad 1000.739 + 39.964 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - 39.502 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - \frac{0.113 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right)^2}{2}$$

$$\text{else if } \frac{3 \cdot L_y}{ft} \le x \le \frac{4 \cdot L_y}{ft}$$

$$\quad 1.001 \cdot 10 - 0.47 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - 39.502 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - \frac{0.113 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right)^2}{2}$$

$$\text{else}$$

$$\quad -323.605 - 40.904 \cdot \left(x - \left(\frac{4 \cdot L_y}{ft}\right)\right) - 39.502 \cdot \left(x - \left(\frac{4 \cdot L_y}{ft}\right)\right) - 0.113 \cdot \frac{\left(x - \left(\frac{4 \cdot L_y}{ft}\right)\right)^2}{2}$$

$M\left(\frac{L_y}{ft}\right) = 667.193$ $\qquad$ $M\left(3 \cdot \frac{L_y}{ft}\right) = 1.001 \cdot 10^3$

$M\left(\frac{5 \cdot L_y}{ft}\right) = -990.8$

$M\left(2 \cdot \frac{L_y}{ft}\right) = 1000.739$ $\qquad$ $M\left(4 \cdot \frac{L_y}{ft}\right) = -323.605$

$V_{max} := V(0)\ kip = 81.33\ kip$ $\qquad$ $M_{max} := M\left(\frac{L_y}{ft} \cdot 2\right) = 1.001 \cdot 10^3$

$\phi_v V_{nx} := 375\ kip$ $\qquad$ $\phi_b M_{px} := 953\ kip \cdot ft$

W18X60 IS A SUFFICIENT MEMBER

EXTERIOR JOISTS (6): **Assume W14x74** $Weight_{w14x74} := 74\ plf$

$t_{bJ6} := 8.25\ ft$

$$LL_{totEXT6} := LL_{tot} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLIntJoists} \cdot A_{TIntJoists}}} \right) = 56.708\ psf$$

$L_x = 24\ ft$

$L_{x2} = 16\ ft$

$DL = 68.5\ psf$ $\quad w_{dlExt6} := DL \cdot t_{bJ6} + Weight_{w14x74} = 639.125\ plf$

$L_{J6} := L_x$

$w_{llExt6} := LL_{totEXT6} \cdot t_{bJ6} = 467.837\ plf$

$P_{TB1} := R_{LTB1} = 80.489\ kip$

$w_{Ext6} := 1.2 \cdot w_{dlExt6} + 1.6 \cdot w_{llExt6} = 1.515\ klf$ $\quad I_x := 171\ in^4$

mber/Case	UX (in)	UZ (in)
1/ 2	0.0	-0.6701

$\Delta_{allow} := \frac{L_{J6}}{360} = 0.8\ in$

CHECK IBC FOR ALLOW DEFLECTION!!

W14X74 IS A SUFFICIENT MEMBER

XTERIOR JOISTS (7): **Assume W14x90** $Weight_{w14x90} := 90\ plf$

$t_{bJ7} := 4.125\ ft$

$$L_{totEXT7} := LL_{tot} \cdot \left(.25 + \frac{15\ in}{\sqrt{K_{LLExtJoists} \cdot A_{TExtJoists7}}} \right) = 72.38\ psf$$

$L_x = 24\ ft$

$L_{x2} = 16\ ft$

$L = 68.5\ (psf)$ $\quad w_{dlExt7} := DL \cdot t_{bJ7} + Weight_{w14x90} = 372.563\ plf$

$L_{J7} := L_{xJ3}$

$_{llExt7} := LL_{totEXT7} \cdot t_{bJ7} = 298.569\ plf$

$P_{TB1} := R_{LTB1} = 80.489\ kip$

$_{Ext7} := 1.2 \cdot w_{dlExt7} + 1.6 \cdot w_{llExt7} = 0.925\ klf$ $\quad I_x := 455\ in^4$

ember/Case	UX (in)	UZ (in)
1/ 1	0.0	-0.5012

$\Delta_{allow} := \frac{L_{J7}}{360} = 0.567\ in$

CHECK IBC FOR ALLOW DEFLECTION!!

W14X90 IS A SUFFICIENT MEMBER

EXTERIOR BEAM (1) ANALYSIS

$J2 := R_{LJ2} = 108.447\ kip$

ASSUME W24x176:

$I_x := 5680\ in^4$

$Weight_{w24x176} := 176\ plf$

$w_{dl} := Weight_{w24x176} = 0.176\ klf$

$P_{wdl} := w_{dl} \cdot 4 \cdot L_y = 5.808\ kip$

$$C_{E1} = C_{E1} \cdot (L_y \cdot 4) - J2 \cdot (L_y \cdot 3) - (J2 + P_{wdl}) \cdot (L_y \cdot 2) - J2 \cdot (L_y) \xrightarrow{solve,\ C_{E1}} 165.573763361919855 \cdot kip$$

$C_{A1} := ((J2 \cdot 3) + P_{wdl}) - C_{E1} = 165.574\ kip$

$w_{dl} := 1.2\ Weight_{w24x176} = 0.211\ klf$

$$V(x) := \begin{cases} 165.574 - .176 \cdot x & \text{if } 0 \le x \le \frac{L_y}{ft} \\ 164.122 - 108.447 - .176 \cdot \left(x - \frac{L_y}{ft}\right) & \text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft} \\ 54.223 - 108.447 - .176 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) & \text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft} \\ -55.676 - 108.447 - .176 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) & \text{else} \end{cases}$$

$V\left(\frac{L_y}{ft}\right) = 164.122$

$V\left(2 \cdot \frac{L_y}{ft}\right) = 54.223$

$V\left(3 \cdot \frac{L_y}{ft}\right) = -55.676$

$V\left(4 \cdot \frac{L_y}{ft}\right) = -165.575$

$A_{w18x143} := 42\ in^2$

$\Delta_{allow} := \frac{4 \cdot L_y}{360} = 1.1\ in$

Member/Case	UX (in)	UZ (in)
1/ 1	0.0	-0.9819

$$M(x) := \text{if } 0 \le x \le \frac{L_y}{ft}$$

$$\quad 165.575 \cdot x - \frac{.176 \cdot x^2}{2}$$

$$\text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft}$$

$$\quad 1360 + 164.122 \cdot \left(x - \frac{L_y}{ft}\right) - 108.447 \cdot \left(x - \frac{L_y}{ft}\right) - \frac{.176 \cdot \left(x - \frac{L_y}{ft}\right)^2}{2}$$

$$\text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft}$$

$$\quad 1813.329 + 54.223 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - 108.447 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - .176 \cdot \frac{\left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right)^2}{2}$$

$$\text{else}$$

$$\quad 1359.992 - 55.676 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - 108.447 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - \frac{.176 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right)^2}{2}$$

$M\left(\frac{L_y}{ft}\right) = 1360$

$M\left(3 \cdot \frac{L_y}{ft}\right) = 1359.992$

$M\left(2 \cdot \frac{L_y}{ft}\right) = 1813.329$

$M\left(4 \cdot \frac{L_y}{ft}\right) = -0.012$

$V_{max} := V(0)\ kip = 165.574\ kip$

$M_{max} := M\left(\frac{L_y}{ft} \cdot 2\right) = 1.813 \cdot 10^3$

$\phi_v V_{nx} := 567\ kip$

$\phi_b M_{px} := 1920\ kip \cdot ft$

W24X335 IS A SUFFICIENT MEMBER

INTERIOR BEAM (2) ANALYSIS

$J2_2 := R_{RJ2} + R_{LJ2} = 216.893\ kip$

ASSUME W36x247:

$Weight_{w36x247} := 0.247\ klf$

$I_x := 15600\ in^4$

$w_{dl} := Weight_{w36x247} = 0.247\ klf$

$P_{wdl} := w_{dl} \cdot 4 \cdot L_y = 8.151\ kip$

$C_{E2} = C_{E2} \cdot (L_y \cdot 4) - J2_2 \cdot (L_y \cdot 3) - (J2_2 + P_{wdl}) \cdot (L_y \cdot 2) - J2_2 \cdot (L_y) \xrightarrow{solve, C_{E2}} 329.415026723839695 \cdot kip$

$w_{B2} := 1.2 \cdot w_{dl} = 0.296\ klf$

$C_{A2} := (P_{wdl} + (J2_2 \cdot 3)) - C_{E2} = 329.415\ kip$

$V(x) :=$ if $0 \le x \le \frac{L_y}{ft}$

$\quad 329.415 - .247 \cdot x$

else if $\frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft}$

$\quad 327.377 - 216.893 - .247 \cdot \left(x - \frac{L_y}{ft}\right)$

else if $2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft}$

$\quad 108.446 - 216.893 - .247 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right)$

else

$\quad -110.485 - 216.893 - .247 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right)$

$V\left(\frac{L_y}{ft}\right) = 327.377$

$V\left(2 \cdot \frac{L_y}{ft}\right) = 108.446$

$V\left(3 \cdot \frac{L_y}{ft}\right) = -110.485$

$V\left(4 \cdot \frac{L_y}{ft}\right) = -329.416$

$L_{b3} := 33\ ft$

$\Delta_{allow} := \frac{L_{b3}}{360} = 1.1\ in$

Member/Case	UX (in)	UZ (in)
1/ 1	0.0	-0.9980

$$M(x) := \text{if } 0 \le x \le \frac{L_y}{ft}$$
$$\quad 329.415 \cdot x - \frac{.247 \cdot x^2}{2}$$
$$\text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft}$$
$$\quad 2709 + 327.377 \cdot \left(x - \frac{L_y}{ft}\right) - 216.893 \cdot \left(x - \frac{L_y}{ft}\right) - \frac{.247 \cdot \left(x - \frac{L_y}{ft}\right)^2}{2}$$
$$\text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft}$$
$$\quad 3612.087 + 108.446 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - 216.893 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - \frac{.247 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right)^2}{2}$$
$$\text{else}$$
$$\quad 2709 - 110.485 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - 216.893 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - \frac{.247 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right)^2}{2}$$

$M\left(\frac{L_y}{ft}\right) = 2.709 \cdot 10^3$

$M\left(3 \cdot \frac{L_y}{ft}\right) = 2.709 \cdot 10^3$

$M\left(2 \cdot \frac{L_y}{ft}\right) = 3612.087$

$M\left(4 \cdot \frac{L_y}{ft}\right) = -0.274$

$V_{max} := V(0)\ kip = 329.415\ kip$

$M_{max} := M\left(\frac{L_y}{ft} \cdot 2\right) = 3.612 \cdot 10^3$

$\phi_v V_{nx} := 881\ kip$

$\phi_b M_{px} := 3860\ kip \cdot ft$

W36X330 IS A SUFFICIENT MEMBER

INTERIOR BEAM (3) ANALYSIS

$R_{RJ22} := 147.948\ kip$

$J2_2 = 216.893\ kip$

$J23 := R_{LJ2} + R_{RJ3} = 147.948\ kip$

ASSUME W30x191:

$Weight_{w30x191} := 0.191\ klf$

$I_x := 9200\ in^4$

$w_{dlB3} := Weight_{w30x191} = 0.191\ klf$

$w_{B3} := 1.2 \cdot w_{dlB3} = 0.229\ klf$

$P_{wB3} := w_{B3} \cdot 5 \cdot L_y = 9.455\ kip$

$$C_{J2} := C_{J2} \cdot (5 \cdot L_y) - J23 \cdot (4 \cdot L_y) - J2_2 \cdot (3 \cdot L_y) - P_{wB3} \cdot (2.5 \cdot L_y) - J2_2 \cdot (2 \cdot L_y) - J2_2 \cdot (L_y) \xrightarrow{solve, C_{J2}} 383.3575$$

$C_{E2B3} := (P_{wB3} + (J2_2 \cdot 3) + J23) - C_{J2} = 424.72\ kip$

$L_{b3} := 41.25\ ft$

Member/Case	UX (in)	UZ (in)
1/ 1	0.0	-1.1271

$\Delta_{allow} := \dfrac{L_{b3}}{360} = 1.375\ in$

EXTERIOR BEAM (4) ANALYSIS

$J2_2 := R_{RJ2} = 108.447\ kip$

ASSUME W33x201:

$Weight_{w33x201} := 0.201\ klf$

$I_x := 11600\ in^4$

$w_{dlB4} := Weight_{w33x201} = 0.201\ klf$

$P_{wdlB4} := w_{dlB4} \cdot 5 \cdot L_y = 8.291\ kip$

$$C_{J3} := C_{J3} \cdot (L_y \cdot 5) - J2 \cdot (L_y \cdot 4) - J2 \cdot (L_y \cdot 3) - P_{wdlB4} \cdot \left(\frac{L_y \cdot 5}{2}\right) - J2 \cdot (L_y \cdot 2) - J2 \cdot (L_y) \xrightarrow{solve, C_{J3}} 221.0386428$$

$C_{E3} := ((4 \cdot J2) + (P_{wdlB4})) - C_{J3} = 221.039\ kip$

$w_{dlB4} := Weight_{w33x201} = 0.201\ klf$

$$V(x) := \begin{array}{l} \text{if } 0 \le x \le \frac{L_y}{ft} \\ \quad \| 215.941 - .201 \cdot x \\ \text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft} \\ \quad \| 214.283 - 105.898 - .201 \cdot \left(x - \frac{L_y}{ft}\right) \\ \text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft} \\ \quad \| 106.727 - 105.898 - .201 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) \\ \text{else if } \frac{3 \cdot L_y}{ft} \le x \le \frac{4 \cdot L_y}{ft} \\ \quad \| -0.829 - 105.898 - .201 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) \\ \text{else} \\ \quad \| -108.385 - 105.898 - 0.201 \cdot \left(x - \left(4 \cdot \frac{L_y}{ft}\right)\right) \end{array}$$

$V\left(\frac{L_y}{ft}\right) = 214.283$

$V\left(2 \cdot \frac{L_y}{ft}\right) = 106.727$

$V\left(3 \cdot \frac{L_y}{ft}\right) = -0.829$

$V\left(4 \cdot \frac{L_y}{ft}\right) = -108.385$

$V\left(5 \cdot \frac{L_y}{ft}\right) = -215.941$

$$M(x) := \text{if } 0 \le x \le \frac{L_y}{ft}$$

$$\left\| 215.941 \cdot x - \frac{.201 \cdot x^2}{2} \right.$$

$$\text{else if } \frac{L_y}{ft} \le x \le 2 \cdot \frac{L_y}{ft}$$

$$\left\| 1775 + 214.283 \cdot \left(x - \frac{L_y}{ft}\right) - 105.898 \cdot \left(x - \frac{L_y}{ft}\right) - \frac{.201 \cdot \left(x - \frac{L_y}{ft}\right)^2}{2} \right.$$

$$\text{else if } 2 \cdot \frac{L_y}{ft} \le x \le 3 \cdot \frac{L_y}{ft}$$

$$\left\| 2662.336 + 106.727 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - 105.898 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right) - \frac{.201 \cdot \left(x - \left(2 \cdot \frac{L_y}{ft}\right)\right)^2}{2} \right.$$

$$\text{else if } \frac{3 \cdot L_y}{ft} \le x \le \frac{4 \cdot L_y}{ft}$$

$$\left\| 2662 - 0.829 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - 105.898 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right) - \frac{.201 \cdot \left(x - \left(3 \cdot \frac{L_y}{ft}\right)\right)^2}{2} \right.$$

$$\text{else}$$

$$\left\| 1775 - 108.385 \cdot \left(x - \left(\frac{4 \cdot L_y}{ft}\right)\right) - 105.898 \cdot \left(x - \left(\frac{4 \cdot L_y}{ft}\right)\right) - .201 \cdot \frac{\left(x - \left(\frac{4 \cdot L_y}{ft}\right)\right)^2}{2} \right.$$

$M\left(\frac{L_y}{ft}\right) = 1.775 \cdot 10^3$ $\quad$ $M\left(3 \cdot \frac{L_y}{ft}\right) = 2.662 \cdot 10^3$

$M\left(\frac{5 \cdot L_y}{ft}\right) = 0.325$

$M\left(2 \cdot \frac{L_y}{ft}\right) = 2662.336$ $\quad$ $M\left(4 \cdot \frac{L_y}{ft}\right) = 1.775 \cdot 10^3$

$V_{max} := V(0)\ kip = 215.941\ kip$ $\quad$ $M_{max} := M\left(\frac{L_y}{ft} \cdot 2\right) = 2.662 \cdot 10^3$

$\phi_v V_{nx} := 723\ kip$ $\quad$ $\phi_b M_{px} := 2900\ kip \cdot ft$

W33X201 IS A SUFFICIENT MEMBER