Evaluation of Structural Retrofit of a Hillside Home

ARCE 453-01: Independent Senior Project
Fall Quarter, 2023

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Design Evaluation and Research Commentary

Owner Story

On November 24, 2021 after months of initial planning, the project owner received approval from the San Luis Obispo Planning and Building Department for initial work on a residential remodeling submission. This approval including a grading permit and other initial site work to begin renovation of the owner’s hillside residential property.

The owner was looking to retrofit their current residence, remodeling the house to create new rooms and enlarge the living space, adding significantly to the existing square footage. The overall plan focused on extending the existing concrete slab foundation on grade out over an adjacent downhill slope. This would open a new garage space underneath the existing patio and residential structure. In early December of 2022 the owner desired that the design and calculation packages be submitted to the County Planning Department, and subsequently determined that should be done no later than December 22nd. In the owner’s view that allowed a few days for processing and review before new 2022 California Building Codes would become effective on January 01, 2023.

This December 22, 2022 date was not to be extended since all structural projects, including existing structure retrofits and remodels, submitted for plan review before January 01, 2023 would only be required to satisfy design codes utilizing 2018 California Building Code requirements. If the project was not submitted for plan review before January 01, 2023, all design calculation package specifications and subsequent design factors would be required to meet the new 2022 California Building Code standards.

Even if design changes were minimal or there were no changes to the initial retrofit design, design plans and engineering calculations would need to meet the new code standard if submitted after January 1st. This would result in extra time and added costs to account for the additional hours for engineers to ensure all new code standards were reflected in both overall structural plans and the calculation package.

For the owner in this case, time was in fact money. If the structural design process was set back for any reason in late 2022, the subsequent late submission of a structural package for review by the County of San Luis Obispo Planning & Building Department would have resulted in additional delays, and exceeding the owner’s original project timeline. The original project schedule had included some extra time for structural design revisions as requested from engineering assessment, design changes requested by the owners due to changing their mind on the final structure, or focused points-of-interest from plan reviewers. Not all potential delays could however have been anticipated.

Typically project timeframes plan and scheduled to account for design changes from engineering evaluations and/or post-plan submission reviews. Yet the owner could not them self have predicted the remodeling being delayed due to an in-development design needing a comprehensive rework at the eleventh hour because of new building codes. An unaccounted delay in the development phase just before submitting plans adds expenses for the owner as well. It was simply chance timing for the owner that the remodeling project was moving forward in the same period of time the architectural engineering industry was to be subject to new code standards. Updates to standards occur approximately every three years, but timing can vary.
The owner, not wanting to overly delay the project and pay unplanned expenses, called upon the head engineer, head contractor, architect, head mechanical contractor, and civil engineer to a quick succession of coordinated, last minute meetings. Within these last-minute, cramped design sessions they collaborated on a finalized submission package in time for December 22 submission date. Afterwards adjustments and revisions could occur after the Planning & Building Department began reviewing the plans. Follow-up with major design revisions that would legally be satisfied utilizing the 2018 California Codes, and not be required to revise the overall structural pack to reflect the new codes.

From conceptual-rough drafts to the finalized design, different depictions were communicated within the engineering team. The earliest rough-draft sketches depicted a singular concrete slab supported underneath by wooden joists and large glue laminated beams [GLB’s]. The design was rapidly altered, refined till the finalized calculation package was formed. The engineers found this retrofit to be quite difficult, impacted by the limited time available. The final designing showed signs of the “on the spot” compromises generated in those rapid design sessions. In particular, the garage space overhead framing.

Thought Process of Engineer Team as Starting Point

**Original Design Timeline in Summary:**

During this retrofit in the Central Coast, the owner and architect wanted a patio with concrete. This encouraged structural engineers to consider making the entire floor addition all concrete at the patio and residence addition as it then match the existing concrete slab on grade. However, a monolithic concrete slab and formwork would be expensive, so metal deck was then considered. To use concrete on metal decking an initial 3.5” of concrete over the top of the residential decking would be necessary for fire separation (1 hour minimum). The originally rough draft sketches depicted this system would be supported on engineered lumber, such as glue-laminated beams. Another approach considered was the system could have been changed to framing entirely using all concrete over metal deck over steel framing. This design was a more robust option though too much for typical residential design.

These early designs of structural steel or engineered lumber beams were eventually found to be problematic to both design and draft details for within the limited time frame. Thus, these designs were quickly abandoned. For the owner and contractor, these ideas were further dismissed due to the metal deck with structural concrete fill adding a new subcontractor to the mix. Other concerns included the attaching metal deck to wood framing, or how the concrete was to have a stamped pattern and compromise the concrete’s structural integrity. On the other hand, the idea of using steel structural members within wood framing was investigated for potential applications in the framing design. All these designs were seen as being ineffective to account for all the structural challenges being experienced within such a limited time frame. Therefore, a new decision was made to finalize a design with concrete finish (1.5” to 6.5” thick) on plywood sheathing. Supported by engineered wood joist and beams, with the inclusion of a custom steel girder in wood design. To account for fire separation between the garage and the
residential space framing, selected an addition of 5/8” Type X gypsum wallboard to be applied. To account for concrete on the plywood sheathing the engineers detailed that moisture barrier is required to prevent rotting.

To evaluate the finalized “rush-job”, two alternative designs will be based on some of the rough draft concepts that were discussed. Developing them to show solutions to the structural challenges that made this project unique in its structural system. Looking at the pros and cons that each design has, such as concerns about creep over time causing permanent deflection. Determine if the existing design or the alternative designs, even if radically different, satisfy the conditions of being structurally efficiency, economic efficiency, factoring in constructability, and satisfying architectural aesthetics.

**Architectural Influence on the Structural Design**

A starting point for structural engineers on a project is referencing the architectural plans of a given project. Presenting a picture to the engineer(s) of the style, dimensions, and important building characteristics that will factor into how structural members are designed. For this retrofit, the owner wants to expand the existing residence both on what currently exist on grade and expand onto a newly constructed garage space. As examined by Arthur H. Levin in his publication of “*Hillside Building: Design and Construction*”, the architect will assign design priorities to the project differently than the structural engineer will. For example, former structural engineer and architect Arthur Levin explains how the architect and engineer look at designing a residential structure along a hillside.

For Downhill sites, where the lot is on downhill side of a street, (Levin, pg. 7):

- **Advantages:**
  Buildings being easier to construct than uphill lots as building materials are carried down rather than up, view is generally better and not blocked by other buildings, less need for grading - shoring - and retaining walls.

- **Disadvantage:**
  Foundation system if more complicated than that used for uphill lots.

For Uphill sites, where the lot is on uphill side of a street, (Levin, pg. 7-8):

- **Advantages:**
  Easy to provide patio facilities in the clear space generally required behind the building.

- **Disadvantages:**
  - Earth slides (particularly after a fire has denuded the hill above) and rockslides can damage or destroy buildings,
  - High retaining walls and shoring are frequently required, and cost can increase dramatically,
- Some authorities require regarding a steep slope adjacent to a street to a maximum angle of 45 degrees - this can be an unexpected cost, if the required grading is high above the street level,
- The authorities may also require you to install many drainage devices - another unexpected cost.

Garage Access, Decking, & Underfloor

"On a sloping street, the garage or carport should be placed at the highest elevation of the lot next to the street (fig. 18). It is generally best to have the garage floor and the dwelling floor leading to it at the same elevation; if you were instead to put the garage at the lower elevation along the street (fig. 19), a portion of the house would be below street level and would require retaining walls. This could also cause drainage problems in the area between the dwelling and the street. If the street is so narrow that a 90-degree turn from it into the driveaway is not possible, then the garage must be turned at an angle to the street, be set back from the street, or have a wide driveway. When possible, to avoid water from the street running into the garage, make the garage floor at least 12 inches above the street at the high side of the driveway.” (Levin, pg. 48-49).

Under flooring within architectural terms as Arthur entails, “Another necessary decision is whether to leave open or enclose the area under the building. If the area is to be open, the structural system could involve: Wood poles, tapered steel or standard steel beams, glue-laminated beams, trusses, an arch. Two disadvantages of the open design are the need for special fire-proofing in some jurisdictions and its reduced salability. Many people think (erroneously) that a cantilevered building is less safe than buildings that are enclosed with stud walls.” (pg. 73)

Except for building failures, deflection is the item that brings the most criticism to engineers. Since, “Sagging cantilever beams and floors that feel “bouncy” are not acceptable even though their design may meet the minimum requirements of the applicable building code” (Levin, pg. 123). The garage space within this retrofit design for the owner was wanting to accommodate as much occupation space below concrete decking. For the engineer, whether a concrete slab or 4" average finish is applied, concrete dead and live loads over time behave and loading can be more significant to wood member design when compared to steel. A concern for the structural engineer is to account for creep. For example, if major creep occurs within long clear span structural members it translates not only to deflection but also cracks in the concrete. Thus, as the engineer designed a wood framed design it’s reasonable that engineered lumber, such as TJI joist, will be selected as they are less susceptible to long-term deflection.
Little Things that Started to Create Structural Challenges

The structural engineer for this renovation has a clear set of goals to achieve. Working in new vertical and lateral structural members into the existing architectural plans that were provided. Balancing the efficiency in both structural stability and the construction cost for the structure to be built within budget. Finally, when finished with designing the structural framing to be effectively communicating the “Lego-set” instructions to contractors. Yet on this project, little things that structural engineers do not upfront think about started to create structural challenges. Two of the most influential variables being drainage and fire.

1. Drainage: A Framing Challenge Reveals Itself

Why do structural engineers need to think about drainage when designing a house? An up-front answer would state that the California Building Code requires a $\frac{1}{4}''/\text{ft}$ slope minimum to prevent water built up. Yet when narrowing down on the details, structural challenges begin to appear. What makes this project unique is how the little things in drainage started to create structural challenges. For instance, to account for exterior drainage the building plans present the exterior patio over an occupied space to be lower than the interior flooring. From there the structural engineer looks at how much slope the exterior concrete will have to be, and the concrete’s total thickness? How is the slope going to being accounted for? The interaction of bearing loads from the exterior wall and two floor frames. How are structural members and hardware interacting? Communicating the design to the contractor?

1.1. Accounting Finished Floor Framing Gap

The owner and architect wanted a finished floor to drop between the interior residential floor and the top of the exterior patio to account for the slope needed for drainage. As shown in Figure 1, the architect reflects in their elevations that each floor was separately: (a) Interior floor based on Slab on Grade (S.O.G) and (b) Exterior patio based on new garage foundation (FND). The engineers had to self-check and measure the actual drop of 6” and that the drop accounted for minimum slope over entire patio span, since it was not directly stated on architect plans.

![Fig. 1: Section Elevation via Architectural Plans](image)
1.2. Where to determine patio slope for drainage?

The first place to check was to see if the architects’ plans had any notations or references list that would include notes on the slope. In the list of provided plans it referred to the Civil Engineer - Grading & Drainage Plan [Fig. 2] as best place to look. Yet when the engineers found the plans too much being communicated in one plan. They found the slope noted slopes of 1.7-2.0% grade yet was not simple to find due to the issues like the existing, removed, and infill soils all represented by same line type.
1.3. How to Account for Slope?

To account for the slope the structural engineers have to possible forms of wood framing the can be selected. Both coming with pros and cons that factor into selecting how the structural system will occur:

A. Dropped Framing

- **Pros:** Flat Framing with Concrete Accounting for Slope, Repetitive Installation & Hardware
- **Cons:** More Concrete Thickness = More Weight

B. Ripped Framing

- **Pros:** Constant Concrete Thickness, Joist can Account for Extra Weight
- **Cons:** More Cost from oversizing members, Installation & Hardware Differs at each Joist End

1.4. Where Does the Gutter Go?

Additionally, the placement of the gutter is a factor to consider when expectations differs between the architect, civil engineer, owner, and the structural engineer. Issues such as gutter placement are where cooperate, discussion, and effectively communication to resolve. In particular, the structural engineer compromising when large mechanical, electricity, and plumbing are predicted to cut through structural members. As shown in Fig. 3, the patio gutter would cut into the joist supporting the exterior patio.

![Dropped Frame Visual](image1)

![Ripped Frame Visual](image2)

![Ripped Frame Visual](image3)

![Dropped Frame Visual](image4)

Fig. 3: Architect, Civil Eng., & Owner vs Structural Eng. Expectation
1.5. Drainage Causing Structural Issues

As these little things have built up to become the structural challenges this retrofit they influential to how the structural engineer will address these issues. Addressing the drainage with two levels of framing interacting at an exterior wall over the garage space and selecting a style of framing. The framing design will need to account for loads beyond the columns with large spans. Other factors for the engineer to account also include the exterior wall sheathing needing to have at least 2” gap from bottom of sheathing to the top of patio finish. Applying a 2” gap between the plywood sheathing from a wet surface to avoid rotting.

2. Fire: Effects on Adjacent Interior, Residential Framing

Buildings within a High Fire-Zone by the Building Code (Fig. 5) requirement to meet a residential flooring criteria, having occupied space barriers meet a 1-hour fire rating minimum. For this project, this requirement effects the structural engineers choices in how to address the floor design. Depending on the selected floor framing, the fire rating is accounting for by:

- If monolithic concrete slab → 3.5” minimum thickness
- If concrete on metal deck → 3.5” min. of concrete + thickness of deck
  - Manufacturer can directly state their products rating (Fig. 4)
- For all wood framing, including concrete finished → Ceiling needing 5/8” Gyp. Board installed

![Fire-Rated Composite Slabs](image)

Table 1: Unprotected Fire Resistance Rating

<table>
<thead>
<tr>
<th>Material</th>
<th>Normal Weight (lb.)</th>
<th>Light Weight (lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hour</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>2 Hour</td>
<td>15%</td>
<td>5%</td>
</tr>
<tr>
<td>3 Hour</td>
<td>30%</td>
<td>10%</td>
</tr>
</tbody>
</table>

![Fig. 4: Verco Decking Catalog; VF5-Catalog-080818-1 Fire Rating Chart](image)

![Fig. 5: International Code Council. “2021 International Building Codes (IBC) - Chapter 6, Table 601](image)
2.1. High Fire Zone Effects on Lateral

Under the owners’ request, fiberglass-wood side paneling is to be installed on as many of the exterior walls. The paneling company had tested their product and provided the report to structural engineers for reference. On the other hand, a new framing challenge revealed itself. (Fig. 6)

Since the testing did not account for structural plywood shear wall sheathing behind fiberglass composite it causes the head engineer to have a lack in confidence. Therefore, the head engineer made the call to use strong walls wherever possible since it fits between exterior and interior sheathings. This decision also accounted for the limited wall lengths to utilize plywood sheathing for interior walls in given cases.

Evaluation of Three Possible Designs

As an evaluation of the structural design that was submitted in the calculation package, will examine three possible flooring designs over the garage space. Ranging from the current design, original rough sketches, to a radically different steel alternative. Looking at how they address the challenges of drainage and fire previously presented:

- Concrete finish on wood framing with plywood sheathing
- Non-Structural concrete on engineered lumber framing with shallow Vercor deck
- Structural concrete on steel framing with Verco deck

An area of key point of interest that can be examined for how challenging it influenced the overall design. Looking at how the beam(s) underneath the exterior wall (Fig. 7) presents a visual summary for how each framing tackles the structural challenges and subsequent solutions.

Challenges for this Structural Member

- Main structural member governed by surrounding beams & joist
- Supports exterior wall from above
- Two levels of floor framing
- Large span over garage space, limiting number of columns

Fig. 6: Delta Millworks Testing Reports

Fig. 7: Point of Interest to Focus Evaluation of all 3 Designs
Design: Concrete Finish on Wood w/ Plywood Sheathing

In general, this design reflects the most up-to-date version of the project originally designed in December of 2022. The owner rather than having a wooden porch decided to have a concrete finish porch. Some of the existing slab on grade foundation and retaining walls were being reused in retrofit as the back wall to the new garage. Therefore, the owner requested a concrete finish for the interior flooring instead of exposed wood flooring to match the existing house flooring. In terms of framing, underneath the moisture barrier and plywood sheathing would be TJI joist that attached to the concrete retaining walls via metal hangers.

While different thicknesses of concrete finish are occurring above, flush framing was used so the ceiling can mostly be flat underneath the residential space. This allows easy installation of continual 5/8” Gyp. Board for fire barrier separation between residential space and the garage. Structural members supporting the exterior patio in most current designs were left exposed but left flush if the owner later wanted them hidden.

How it Addresses the Structural Challenges?

As shown in Fig. 8, the main structural member selected was a W16x67. While an inefficient W-Shape beam in selection, it matches the ceiling height and able to clear span from one column to the exterior wall. Along with being flush framed to exterior patio sheathing.

To accounting for the interior floor and hardware from above, a ripped nailer and ledgers are bolted to the W16x67 to minimize face hanger. These ledgers help save cost in hardware selection.

Communicating Design via Isometric

Below are isometric views of the corner ends of the exterior wall above the garage (can also reference Framing Plan & Section Detail Sheets). While isometric drawings are atypical to structural engineers drafting on projects, they are helpful within design teams to help communicate and visualize what is occurring. Especially when isometrics can present what two or more section details in the two-dimensional perspectives are all communicating.
Pros & Cons to this Design?

Pro:
- Most Economical design in material cost
  - Specifics like one steel beam are acceptable to owner
- Flexible design to account for revisions
  - Such as converting to ripped framing
- W-Shape beam just needing one column within Garage space

Cons:
- Overtime wood is susceptible to creep
- If openings moisture barrier → Rotting
- Ripped Nailer needs start as 8x member minimum
- W16x67 is not a efficient member based on carrying capacity to cost
- W-Shape for floor and exterior member connections need:
  - ledgers, web nailers, and top ripped nailer
- Section Details can easily get too cluttered
- Due the "rush job" adjacent members possible don’t account for elements such as ridge beam
Design: Non-Structural Concrete on Engineered Timber w/ Shallow Vercor Deck

How it Addresses the Structural Challenges?

Much of the design is similar to the previous one, the key differences are that it continues the rough draft design of using a glue laminated beam with non-structural concrete on metal decking. Utilizing Engineered Wood. (Fig. 9) The structural members are girders sized to account for both floor framings and perpendicular beams interacting at the corners. The sizing of the girder and TJI joist together helps minimize face hangers wherever possible, saving cost in hardware selection. To account for the adjacent exterior patio framing, beams attached to the girders with hardware act like cantilever beams. There are two columns that fit within the garage supporting the girder; one underneath the corner of the exterior wall, while the other is offset from the corner to fit in between parking spots.

For the Shallow Verco Deck or equivalent, the total thickness = 3.5″ concrete + deck thickness. From there the type and gauge is governed by both the total thickness and the clear span without shoring. Without shoring is a notable factor as shore framing adds extra cost and materials to the construction phase.

Communicating Design via Isometric
Pros & Cons to this Design?

Pro:
- By using Shallow Vercor:
  - Easy Instillation for contractor
  - Steel acts in tensile well with concrete in compression if bending loads occur
  - Acts as the moisture barrier
- Engineered TJL joist
  - Provides high resistance to deflection
  - Repetitive hardware and installation for contractor

Cons:
- At Ext. Corners with Girder Ends
  - Can be communicating a lot in small area
  - Intricate hardware installation
- 4.5” Conc → Satisfies Residential Fire Resistance Rating on top
  - What about the Framing? → need fire barrier on underside
- GLB Beams and Girders having large 18’ maximum span
  - Large sized due to bending load, bearing load, & deflection

Design: Structural Conc. on Steel Beams w/ Verco Deck

How it Addresses the Structural Challenges?

This design as shown in Fig. 10, selected W-Shape beams & girders that are sized to be optimized for efficiency of loading capacity vs cost. To account for the drop patio decking, a welded L-Shape member acts as a ledger for decking to rest on and transfer gravity loads to the structural beams. The steel girder carries the cantilever beam ends, to account for flush, adjacent decking beams. Perpendicular beams duplicate the selected girder size to provide adequate surface area for prefabricated weld-bolt connections. This is done so the total strength of the connectors, for shear or lateral loadings, is optimized to be stronger than the steel beams themselves. Two columns are fit within the garage as well; one underneath the corner of the exterior wall, while the other is offset from the corner to fit in between parking spots.

For the Verco Deck or equivalent, total thickness = 3.5” concrete + deck thickness. From there the type and gauge are governed by total thickness and clear span without shoring. Without shoring is a notable factor as shore framing adds extra cost and materials to the construction phase. A benefit of using structural concrete on metal deck is that it self-supporting. So less structural members are needed to carry floor loads. Furthermore, it allows the concrete and steel when experiencing loading forces to behave in their most efficient behaviors of each material. For instance, concrete best works when in compression (the floor slab), while both the steel deck and mesh are best suited for tensile forces.
Communicating Design via Isometric

Pros & Cons to this Design?

Pros:
- Most robust design
- Structural Concrete can self support over clear span
  - Less Structural Members needed
- Prefabrication \(\rightarrow\) Less Time and Cost for Installation for Contractor
- For Residential Space, framing doesn’t need gyp. Board ceiling
- Exterior Structural Slab can transfer lateral forces
  - Can utilize Retaining Wall FND with a shear wall \(\rightarrow\) Less Strong Walls needed

Cons:
- Most Expensive
- Most steel and concrete used between all three designs
- Anchor Points into the Concrete Retaining Wall FND have small error tolerance
- Each In-Field Weld add cost rapidly
- For architect not as aesthetically pleasing for a residence without hanging ceiling

Evaluation Closure

Is there a correct answer or is this a trick question? There is no “correct” answer because it involves the right balancing of different priorities within a given project. Structural Engineer tailors building designs based on factors such as: Robustness, Cost, Aesthetics, Building within constraints, Resistance to Rot, Stiffness, Constructability, and others. An owner, architect, structural engineer, and contractor each assign different relative, important factors to what governs a design. Thus, compromises are where discussions with effective communication between everyone to produce a satisfactory, finalized calculation package. As structural engineers, we tailor the structural systems based on the conditions of each design project.
Big Picture Discussion

Influence by Global Issues

As structural engineers, we are entrusted with the fulfillment of our professional duties. Carefully considering the safety, health, and welfare of the general public. Through technical knowledge and sharing ever developing techniques, engineers can lead to improving residential and commercial efficiency. On the other hand, little factors like greenhouse gas over recent years continue to become a growing concern to owners of future developments. Being mindful in the design phase to address these special requests, we adapt structural systems to account for the special needs of owners, such as solar panel installation. On the other hand, we strive to decrease the carbon footprint that a structure produces when it is being constructed, operations and maintenance across its life expectancy, and as much can be recycled when demolition occurs.

Influence by Cultural

The culture of structural engineers is that we directly affect those we serve. Using our creativity, technical knowledge, and engineering practices to improve the quality of life of the owners of residential retrofits or commercial developments. Providing structural systems with a focus on ensuring the safety of the occupants who will reside within the projects we work on. Our contributions enable society, which entrust us as engineers, is to helps address the needs of the general public with housing developments and critical infrastructure to keep daily lifestyles thriving. Furthermore, with this project being built in a high-fire zone, we are expected to account for the fire-resistance of the structure, providing safety to the local residence. Especially when public investment into fire-resistance develops due to recent events like the Maui wildfires in August 2023, Camp Fire in November 2018, or I-10 roadway fire in November 2023.

Meeting Social Needs

Residential projects are more personal investments than a commercial or infrastructure project. Structural engineers are interacting with the owners of the house, whether it is a new house being built or a retrofit. In discussion between the engineer and owner, we are expected to behave professionally but leave room to be interactive and social with the client. To them this is an investment in where they will be living, so we want to create a friendly environment. Entrusting our client to be open for discussion in cooperation to delivering a project that satisfies their need with neighborly attitudes.

Influenced by Environmental Issues

When thinking about the materials invested into residential housing such as lumber, steel, and concrete we should be mindful to what is required to erect structure and what is excess waste. Using our structural knowledge and creativity, we are motivated to not only calculate the most economical designs but using as minimum raw materials. For all materials on a project have a production and transportation system that produces greenhouse gases to produce a usable structural member at the construction site. As engineers we participate in decreasing the waste of resources and greenhouse gases with implementation of integrating environmentally friendly solutions into our project designs.
Meeting Needs of Economic

In the selection of connectors and hardware for a given project design, cost is a key factor to continually account for. The owner and contractor are the most invested into the cost out of all the members of the project team. As structural engineers, we strive to balance the structural stability of the framing while being as cost effective as possible. With the general economy effecting prices of structural members, such as plywood, hangers, or holdowns, we are expected to be selective in what our design requires to function. Minimizing excessive cost whenever possible so the owner receives a cost-efficient structural system that is tailored to their needs.

Lifelong Learning Experience

The biggest take away from work on this project is learning that design options for even a residential remodeling project are difficult to consider if a schedule crunch occurs. This project evaluated alternative designs that could have been considered by the home owner and collaborative engineering team if sufficient time had been available prior to the owner’s December 2022 deadline for package submittal to the County Planning Department. Final building difficulty and costs may have been reduced and overall owner satisfaction with the remodeling enhanced, if the alternative designs could have been considered and evaluated.

Additionally, from experience working on this project I have learned that residential remodeling is not repetitive or mundane, each case is unique. Essentially no two projects in residential design are directly comparable in many respects. Currently, I am planning to continue working with Wethington Engineering, Inc. that was a key participant in the collaborative team that completed and submitted the design package for the residential remodel that was subject of this project. The alternative designs developed and evaluated were compared to that original design. I am looking forward to working on similar projects in the future that I anticipate will be both challenging and unique experiences as a structural engineer.
Reference Citations:


ASCE Board of Directors. (2014). *ASCESEI 7-16 Minimum Design Loads for Buildings and Other Structures* (7th–16th ed.). American Society of Civil Engineers. Summer 2023,


Vertical Design
Concrete Finish on Wood w/ Ply. Sheathing
[Original Design]
Current Design: Key Structural Plan

Vertical Key Plan

Floor

[Diagram of a structural floor plan with various dimensions and annotations]
(FB-1) Type Floor Joist

**FLOOR**

**TriB = 1'**

*spacing determined in analysis program*

![Diagram of floor joist with dimensions and notes.]

(FB-2) Floor beam & dumbwaiter opening

**FLOOR**

**TriB = 2'**

**RB-14 (P1)**

**TriB = P1**

**RB-14 (P2)**

**TriB = P2**

![Diagram of floor beam with dimensions and notes.]

2 - 13/4" x 16" LVL w/ IUS 3.5" Hanger

16" TJI 930 C 16" OC

W/ IUS 2.37 Hanger
Summary

Member

- Moment Utilization
  \[ \frac{M}{M'} = \frac{3270 \text{ lb*ft}}{5710 \text{ lb*ft}} \]

- Shear Utilization
  \[ \frac{V}{V'} = \frac{727 \text{ lb}}{2190 \text{ lb}} \]

- Governing Live / Short-Term Deflection
  \[ \delta_{ST} = 0.219 \text{ in (L/989)} \]

- Governing Long-Term Deflection
  \[ \delta_{LT} = 0.266 \text{ in (L/814)} \]

Load

- Beam Plan Length
  \[ L_X = 18 \text{ ft} \]

Design Conditions

- Design Code for Load Combinations
  - International Building Code (IBC) 2018

Member Properties

- Base Allowable Moment
  \[ M_r = 5710 \text{ lb*ft} \]

- Base Allowable Shear
  \[ V_r = 2190 \text{ lb} \]

- Base Perpendicular Compression Allowable Stress
  \[ F_{c\perp} = 0 \text{ psi} \]

Section Bending (NDS 2018 2.3)

- Governing Duration Factor in Bending
  \[ C_{D,B} = 1 \]

- Beam Stability Factor
  \[ C_L = 1 \]

- Adjusted Allowable Moment
  \[ M_r' = 5710 \text{ lb*ft} \]

Shear Design (NDS 2018 3.4)

- Governing Duration Factor
  \[ C_D = 1 \]

- Adjusted Allowable Shear
  \[ V_r' = 2190 \text{ lb} \]

Bearing (NDS 2018 3.10)

- Base Bearing Strength
  \[ F_{c\perp} / C_b = 0 \text{ psi} \]

Comments

\[
\begin{align*}
\text{Reactions:} & \\
\text{Distance from Left of Beam (ft)} & \\
\text{Bearing: 3 in FactMax: 727 lb} & \\
\text{D: 247 lb} & \\
\text{L: 480 lb} & \\
\text{D: 29 pf} & \\
\text{L: 50.3 pf} & \\
\text{5.5 ft} & \\
\text{10 ft} & \\
\text{15 ft} & \\
\text{Self-weight} & \\
\text{Floor Load} & \\
\text{LW: 1.33 ft} & \\
\text{D: 18 pf} & \\
\text{L: 40 pf} & \\
\text{D: 35 pf} & \\
\text{L: 10.5} & \\
\text{0} & \\
\text{5} & \\
\text{10} & \\
\text{15} & \\
\text{0} & \\
\text{5} & \\
\text{10} & \\
\text{15} & \\
\end{align*}
\]
**Summary**

2 plies - 1 3/4x16 Microlam LVL 2.0E-26000 lb/ft² / 32400 lb/ft²

*Member*

- **Moment Utilization**
  \[
  \frac{M}{M'} = \frac{\text{22%}}{\text{35%}}
  \]

- **Shear Utilization**
  \[
  \frac{V/V'} = \frac{\text{4590 lb}}{13300 lb} = \frac{\text{22%}}{\text{35%}}
  \]

- **Bearing Utilization**
  \[
  \frac{R/R'} = \frac{\text{4590 lb}}{7870 lb} = \frac{\text{58%}}{\text{35%}}
  \]

**Minimum Bearing Length (End Supports)**

\[
\ell_{b,\text{min,end}} = \frac{1.75 \text{ in}}{L/1810}
\]

**Governing Live / Short-Term Deflection**

\[
\delta_{LT} = -0.181 \text{ in} (L/1200)
\]

**Governing Long-Term Deflection**

\[
\delta_{LT} = -0.181 \text{ in}
\]

---

**Key Properties**

- **Beam Plan Length**
  \[
  L_X = 18 \text{ ft}
  \]

- **Continuous Bracing for Lateral Torsional Buckling**
  \[
  \text{Top Braced}
  \]

**Loads**

- **Floor Load**
  \[
  \begin{align*}
  \text{LW} & : 1.33 \text{ k} \quad \text{D} : 18 \text{ psf} \quad \text{L} : 40 \text{ psf} \\
  \text{Self-weight} & : 0.2 \text{ k} \quad \text{D} : 12.9 \text{ psf} \quad \text{L} : 17.5 \text{ psf}
  \end{align*}
  \]

---

**Design Conditions**

**Design Code for Load Combinations**

- **International Building Code (IBC) 2018**

**Member Properties**

- **Cross-Sectional Area**
  \[
  A = \frac{56 \text{ in}^2}{6250 \text{ lb/in}}
  \]

- **Section Modulus**
  \[
  S = \frac{1190 \text{ in}^3}{6250 \text{ lb/in}}
  \]

- **Base Allowable Bending Stress**
  \[
  F_b = \frac{2600 \text{ psi}}{6250 \text{ lb/in}}
  \]

- **Base Allowable Shear Stress**
  \[
  F_s = \frac{285 \text{ psi}}{6250 \text{ lb/in}}
  \]

- **Base Perpendicular Compression Allowable Stress**
  \[
  F_{cL} = \frac{750 \text{ psi}}{6250 \text{ lb/in}}
  \]

**Elastic Modulus (NDS 2018 2.3)**

- **Adjusted Modulus of Elasticity**
  \[
  E' = \frac{2000000 \text{ psi}}{6250 \text{ lb/in}}
  \]

- **Adjusted Shear Modulus**
  \[
  G' = \frac{125000 \text{ psi}}{6250 \text{ lb/in}}
  \]

**Section Bending (NDS 2018 2.3)**

- **Volume Factor**
  \[
  C_v = \frac{0.962}{6250 \text{ lb/in}}
  \]

**Positive Bending (NDS 2018 2.3)**

- **Governing Duration Factor - Positive Bending**
  \[
  C_{D,b} = 1
  \]

- **Governing Beam Stability Factor - Positive Bending**
  \[
  C_{L,b} = 1
  \]

- **Adjusted Bending Strength - Positive Bending**
  \[
  F_{b+} = \frac{2600 \text{ psi}}{6250 \text{ lb/in}}
  \]

**Negative Bending (NDS 2018 2.3)**

- **Governing Duration Factor - Negative Bending**
  \[
  C_{D,b} = 0.9
  \]

- **Governing Beam Stability Factor - Negative Bending**
  \[
  C_{L,b} = 0.83
  \]

- **Adjusted Bending Strength - Negative Bending**
  \[
  F_{b-} = \frac{2020 \text{ psi}}{6250 \text{ lb/in}}
  \]

**Shear Design (NDS 2018 3.4)**

- **Governing Duration Factor**
  \[
  C_D = 1.25
  \]

- **Adjusted Shear Stress**
  \[
  F_s = \frac{356 \text{ psi}}{6250 \text{ lb/in}}
  \]

**Bearing (NDS 2018 3.10)**

- **Base Bearing Strength**
  \[
  F_{cL} / C_b = 750 \text{ psi}
  \]
(FB-3) Typ Deck Joist
Deck (Wmax/Wmin)
TRIB = 1' / 1.33'

(FB-4) Floor Beam @ Grid 4
TRUSS + EXT WALL + FLOOR + DECK (w)
TRIB = 2'
PORCH (p)
TRIB = 27, 180 SF

(FB-5) Floor Beam @ Grid 5
TRUSS + STICK + INT WALL + FLOOR + DECK (w)
TRIB = 2'

805.203.3037 | 916 Larable Court, Paso Robles, CA 93446 | hello@wethingtonengineering.com
Summary

Primary Loading

Member Properties

- 35% Moment Utilization
- 42% Shear Utilization
- 23% Bearing Utilization
- 30% Minimum Bearing Length (End Supports)
- 24% Governing Long-Term Deflection
- 24% Governing Long-Term Deflection

Reactions:

- FactMax: 842 lb
- FactMin: 260 lb
- Bearing: 3 in
- L: 409 lb
- D: 81.1

Key Properties

- Beam Plan Length: \( L_X = 9.25 \text{ ft} \)
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

Loads

- Deck Load: 1.33 x 1.76 ft | D: 61 psf, L: 60 psf
- Self-weight: 3.73 psf

Design Conditions


Member Properties

- Cross-Sectional Area: \( A = 16.2 \text{ in}^2 \)
- Strong Axis Moment of Inertia: \( I_{xx} = 115 \text{ in}^4 \)
- Elastic Modulus: \( E = 2,000,000 \text{ psi} \)
- Positive Bending - Governing Stability Factor: \( C_D = 1.04 \)
- Positive Bending - Adjusted Shear Modulus: \( G' = 125,000 \text{ psi} \)
- Negative Bending - Governing Stability Factor: \( C_L = 0.67 \)
- Negative Bending - Adjusted Bending Strength: \( F_{b}^N = 1690 \text{ psi} \)
- Shear Design (NDS 2018 3.4)
- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Shear Strength: \( F_{v}^a = 285 \text{ psi} \)
- Bearing (NDS 2018 3.10)
- Base Bearing Strength: \( F_{c,b}^N / C_b = 750 \text{ psi} \)

Shear Design (NDS 2018 3.4)

- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Shear Strength: \( F_{v}^a = 285 \text{ psi} \)

Bearing (NDS 2018 3.10)

- Base Bearing Strength: \( F_{c,b}^N / C_b = 750 \text{ psi} \)

Comments
Summary

Member

- Moment Utilization: $M / M' = 7.600$ lb*ft / 72700 lb*ft
- Shear Utilization: $V / V' = 8360$ lb / 21700 lb
- Bearing Utilization: $R / R' = 8360$ lb / 13100 lb
- Minimum Bearing Length (End Supports): $l_{b,min,end} = 1.91$ in

Governing Long-Term Deflection

- $\delta_{LT} = -0.345$ in (L/627)

Key Properties

- PSL is Treated / Wolmanized?: No
- Beam Plan Length: $L_X = 18$ ft
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

Reactions:

- Bearing: 3 in
  - FactMax: 200 lb
  - FactMin: 13500 lb
  - L: 1000 lb
- Bearing: 3 in
  - FactMax: 3500 lb
  - FactMin: 13500 lb
  - L: 2500 lb

Design Conditions

Member Properties

- Cross-Sectional Area: $A = 112$ in$^2$
- Strong Axis Moment of Inertia: $I_{xx} = 2390$ in$^4$
- Section Modulus: $S = 299$ in$^3$
- Base Allowable Bending Stress: $F_b = 2900$ psi
- Base Allowable Shear Stress: $F_c = 290$ psi
- Base Perpendicular Compression Allowable Stress: $F_{c⊥} = 625$ psi
- True Modulus of Elasticity: $E_{true} = 2000000$ psi
- Apparent Modulus of Elasticity: $E_{app} = N_a N$ psi
- Modulus of Elasticity for Deflections: $E = 2000000$ psi

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity: $E' = 2000000$ psi
- Adjusted Shear Modulus: $G' = 125000$ psi

Section Bending (NDS 2018 2.3)

- Volume Factor: $C_V = 0.969$

Positive Bending (NDS 2018 2.3)

- Governing Duration Factor - Positive Bending: $C_D^{+} = 1$
- Governing Beam Stability Factor - Positive Bending: $C_L^{+} = 1$
- Adjusted Bending Strength - Positive Bending: $F_b^{+} = 2920$ psi

Negative Bending (NDS 2018 2.3)

- Governing Duration Factor - Negative Bending: $C_D^{-} = 0.9$
- Governing Beam Stability Factor - Negative Bending: $C_L^{-} = 0.98$
- $F_b^{-} = 2630$ psi
### Adjusted Bending Strength - Negative Bending

**Shear Design (NDS 2018 3.4)**

| Governing Duration Factor | $C_D = 1$ |

### Adjusted Shear Strength

| $F_v' = 290$ psi |

**Bearing (NDS 2018 3.10)**

| Base Bearing Strength | $F_v' / C_b = 625$ psi |

### Comments
Summary

Member Properties

- Cross-Sectional Area: \( A = 84\ \text{in}^2 \)
- Strong Axis Moment of Inertia: \( I_{xx} = 1790\ \text{in}^4 \)
- Section Modulus: \( S = 224\ \text{in}^3 \)
- Base Allowable Bending Stress: \( F_b = 2900\ \text{psi} \)
- Base Allowable Shear Stress: \( F_v = 290\ \text{psi} \)
- Base Perpendicular Compression Allowable Stress: \( F_{c\perp} = 625\ \text{psi} \)
- True Modulus of Elasticity: \( E_{true} = 2,000,000\ \text{psi} \)
- Apparent Modulus of Elasticity: \( E_{app} = N_a N\ \text{psi} \)
- Modulus of Elasticity for Deflections: \( E = 2,000,000\ \text{psi} \)

Elastic Modulus (NDS 2018.2.3)

- Adjusted Modulus of Elasticity: \( E' = 2,000,000\ \text{psi} \)
- Adjusted Shear Modulus: \( G' = 125,000\ \text{psi} \)

Section Bending (NDS 2018.2.3)

- Volume Factor: \( C_V = 0.969 \)

Positive Bending (NDS 2018.2.3)

- Governing Duration Factor - Positive Bending: \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending: \( C_L = 1 \)
- Adjusted Bending Strength - Positive Bending: \( F_b^+ = 2920\ \text{psi} \)

Negative Bending (NDS 2018.2.3)

- Governing Duration Factor - Negative Bending: \( C_{D,b} = 0.9 \)
- Governing Beam Stability Factor - Negative Bending: \( C_L = 0.973 \)
- Adjusted Bending Strength - Negative Bending: \( F_b^- = 2630\ \text{psi} \)

Shear Design (NDS 2018.3.4)

- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Shear Strength: \( F_v = 290\ \text{psi} \)

Bearing (NDS 2018.3.10)

- Base Bearing Strength: \( F_{c\perp} / C_b = 625\ \text{psi} \)

Comments

Design Conditions

Design Code for Load Combinations

International Building Code (IBC) 2018

Key Properties

- PSL is Treated / Wolmanized?: No
- Beam Plan Length: \( L_X = 11\ \text{ft} \)
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

Loads

- Truss Roof: LW: 4.5 ft | D: 30 psf, Lr: 15 psf
- Int. Wall: LW: 1 ft | D: 18 psf, L: 40 psf
- Deck: LW: 1 ft | D: 18 psf
- Floor Load: LW: 1 ft | D: 18 psf, L: 40 psf
- Self-weight

Reactions:

\[
\begin{align*}
\delta_{b,min, end} &= 0.954\ \text{in} \\
\delta_{LT} &= 0.046\ \text{in} \quad \text{(L/2870)} \\
\delta_{ST} &= 0.046\ \text{in} \\
\delta_{LT}^- &= 0.046\ \text{in} \quad \text{(L/2870)}
\end{align*}
\]
(FB-2) Floor Beam & Grid H

Stick + Ext Wall + Floor + Deck

TRIB = 2' 14 1/2' 4 1/2'

w

18.75'

7" x 18" (PSL)

increased trib to account for trucker, core & deck

(FB-7) Floor Beam on Grid I bet. 5 1/2'

Deck

TRIB = 10'

w

18.75'

7" x 18" (PSL)

(FB-6) Garage Header

Deck

TRIB = 4 7/16'

w

11 5/8'

3-1 3/4" x 9 1/4" LVL
Summary

Member
- Moment Utilization: \( M/M' = 52000 \text{ lb*ft} / 90800 \text{ lb*ft} \)
- Shear Utilization: \( V/V' = 11100 \text{ lb} / 24400 \text{ lb} \)
- Bearing Utilization: \( R/R' = 11100 \text{ lb} / 13100 \text{ lb} \)
- Minimum Bearing Length (End Supports): \( \delta_{b, min,end} = 2.53 \text{ in} \)
- Governing Live / Short-Term Deflection: \( \delta_{LT} = -0.258 \text{ in} \)
- Governing Long-Term Deflection: \( \delta_{LT} = -0.395 \text{ in} \)

Key Properties
- PSL is Treated / Wolmanized? No
- Beam Plan Length: \( L_X = 18.8 \text{ ft} \)
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

Loads
- Stick Roof
- Ext. Wall
- Deck
- Floor Load
- Self-weight

Design Conditions

Design Code for Load Combinations
- International Building Code (IBC) 2018

Member Properties
- Cross-Sectional Area: \( A = 126 \text{ in}^2 \)
- Strong Axis Moment of Inertia: \( I_{xy} = 3400 \text{ in}^4 \)
- Section Modulus: \( S = 378 \text{ in}^3 \)
- Base Allowable Bending Stress: \( F_b = 2900 \text{ psi} \)
- Base Allowable Shear Stress: \( F_v = 290 \text{ psi} \)
- Base Perpendicular Compression Allowable Stress: \( F_c\perp = 625 \text{ psi} \)
- True Modulus of Elasticity: \( E_{true} = 2000000 \text{ psi} \)
- Apparent Modulus of Elasticity: \( E_{app} = N_aN \text{ psi} \)
- Modulus of Elasticity for Deflections: \( E = 2000000 \text{ psi} \)

Elastic Modulus (NDS 2018 2.3)
- Adjusted Shear Strength: \( E' = 2000000 \text{ psi} \)
- Adjusted Shear Modulus: \( G' = 1250000 \text{ psi} \)

Section Bending (NDS 2018 2.3)
- Volume Factor: \( C_V = 0.956 \)

Positive Bending (NDS 2018 2.3)
- Governing Duration Factor - Positive Bending: \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending: \( C_L^+ = 1 \)
- Adjusted Bending Strength - Positive Bending: \( F_b^+ = 2880 \text{ psi} \)

Negative Bending (NDS 2018 2.3)
- Governing Duration Factor - Negative Bending: \( C_{D,b} = 0.9 \)
- Governing Beam Stability Factor - Negative Bending: \( C_L^- = 0.974 \)
- Adjusted Bending Strength - Negative Bending: \( F_b^- = 2590 \text{ psi} \)

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Shear Strength: \( F_v = 290 \text{ psi} \)

Bearing (NDS 2018 3.10)
- Base Bearing Strength: \( F_{c\perp,b} / C_b = 625 \text{ psi} \)

Comments
Summary

Primary Loading

Member
- Moment Utilization: 60%
- Shear Utilization: 48%
- Minimum Bearing Length (End Supports): 75%
- Governing Long-Term Deflection: 44%

Reactions:
- FactMax: 11,600 lb
- FactMin: 3,590 lb
- Bearing: 3 in
- D: 5,990 lb
- L: 5,620 lb

Key Properties
- PSL is Treated / Wolmanized?: No
- Beam Plan Length: L_X = 18.8 ft
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

Design Conditions

Design Code for Load Combinations

Member Properties
- Cross-Sectional Area: A = 126 in^2
- Strong Axis Moment of Inertia: I_{xx} = 3,400 in^4
- Section Modulus: S = 378 in^3
- Base Allowable Bending Stress: F_b = 2,900 psi
- Base Allowable Shear Stress: F_v = 290 psi
- Base Perpendicular Compression Allowable Stress: F_{c⊥} = 625 psi
- True Modulus of Elasticity: E_{true} = 2,000,000 psi
- Apparent Modulus of Elasticity: E_{app} = N_a N_{psl} psi
- Modulus of Elasticity for Deflections: E = 2,000,000 psi

Positive Bending (NDS 2018 2.3)
- Governing Duration Factor: C_D = 0.9
- Governing Beam Stability Factor - Positive Bending: C_L = 0.974
- Adjusted Bending Strength - Positive Bending: F_{b+} = 2,880 psi

Negative Bending (NDS 2018 2.3)
- Governing Duration Factor - Negative Bending: C_D = 1
- Governing Beam Stability Factor - Negative Bending: C_L = 1
- Adjusted Bending Strength - Negative Bending: F_{b-} = 2,590 psi

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: C_D = 1
- Adjusted Shear Strength: F_v = 290 psi

Bearing (NDS 2018 3.10)
- Base Bearing Strength: F_{C⊥}/C_b = 625 psi

Comments
Summary

Key Properties

Beam Plan Length

Continuous Bracing for Lateral Torsional Buckling

Loads

Reactions:

Member

3 plies - 1-3/4x9-1/4
MicroLam LVL
2.0E-2600

Moment Utilization

56%

M / M' = 9500 lb*ft / 17 300 lb*ft

Shear Utilization

3330 lb / 9230 lb

Bearing Utilization

3330 lb / 13 800 lb

Minimum Bearing Length (End Supports)

0.847 in

Governing Long-Term Deflection

δLT = -0.262 in

Governing Long-Term Deflection

Governing Live / Short-Term Supports

δLT = -0.177 in (L/527)

Design Conditions

Design Code for Load Combinations

International Building Code (IBC) 2018

Member Properties

Cross-Sectional Area

A = 48.6 in²

Strong Axis Moment of Inertia

Ixx = 346 in⁴

Section Modulus

S = 74.9 in³

Base Allowable Bending Stress

Fb = 2600 psi

Base Allowable Shear Stress

Fv = 285 psi

Base Perpendicular Compression Allowable Stress

Fcc = 750 psi

True Modulus of Elasticity

Etrue = 2 000 000 psi

Apparent Modulus of Elasticity

Eapp = N/11 N psi

Volume Factor

CV = 1.04

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity

E' = 2 000 000 psi

Adjusted Shear Modulus

G' = 125 000 psi

Section Bending (NDS 2018 2.3)

Volume Factor

CV = 1.04

Positive Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending

CD,b+ = C_D,b

Governing Beam Stability Factor - Positive Bending

CV+ = C_V+

Adjusted Bending Strength - Positive Bending

Fb+ = 2770 psi

Negative Bending (NDS 2018 2.3)

Governing Duration Factor - Negative Bending

CD,b− = C_D,b

Governing Beam Stability Factor - Negative Bending

CV− = C_V−

Adjusted Bending Strength - Negative Bending

Fb− = 2490 psi

Shear Design (NDS 2018 3.4)

Governing Duration Factor

CD = 1

Adjusted Shear Strength

Fv = 285 psi

Bearing (NDS 2018 3.10)

Base Bearing Strength

Fb/Cb = 750 psi

Comments
Date: 11/22  By: HW  Project: 2022-024 Knappel

(FB-9) Floor Beam on Gird I bet. 4 & 5

<table>
<thead>
<tr>
<th>DECK (w1)</th>
<th>TRIB = 4.6'</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECK (w2)</td>
<td>TRIB = 1.33'</td>
</tr>
<tr>
<td>TRUSS Roof + Ext Wall + Floor (w3)</td>
<td>TRIB = 90'</td>
</tr>
<tr>
<td>FBD-4 (P1)</td>
<td>TRIB = P1</td>
</tr>
<tr>
<td>FBD-2 (P2)</td>
<td>TRIB = P1</td>
</tr>
</tbody>
</table>

W. W. C. E. T
### Summary

- **Allowable Bending Moment Strength**
  \[ M_{\text{allow}} / \Omega = 231,000 \text{ lb-ft} \]
- **Allowable Shear Strength**
  \[ V_{\text{allow}} / \Omega = 129,000 \text{ lb} \]
- **Critical Deflection**
  \[ \delta_{\text{crit}} = -0.335 \text{ in} \]
- **Critical Deflection Ratio**
  \[ L / L_{\text{p}} = 948 \]
- **Dead Load Deflection**
  \[ \delta_{D} = -0.423 \text{ in} \]

### Reactions:
- **FactMax**: 20,500 lb
- **FactMin**: 7,350 lb
- **D**: 12,200 lb
- **L**: 8,280 lb
- **No Bearing**
- **Torsional Buckling**
- **Continuous Bracing for Lateral Beam Plan Length**

### Key Properties

- **Designation**: W16X67
- **Yield Strength**: \( F_{y} = 50,000 \text{ psi} \)
- **Beam Plan Length**: \( L_{X} = 26.5 \text{ ft} \)
- **Continuous Bracing for Lateral Torsional Buckling**: No continuous bracing

### Member Properties

- **Gross Area**: \( A_{p} = 19.6 \text{ in}^{2} \)
- **Moment of Inertia**: \( I = 954 \text{ in}^{4} \)
- **Section Modulus**: \( S = 117 \text{ in}^{3} \)
- **Fully Plastic Length**: \( L_{p} = 8 \text{ ft}, 8.3 \text{ in} \)
- **Elastic Global Buckling Length**: \( L_{e} = 26 \text{ ft}, 1 \text{ in} \)

### Section Classification (AISC 360-16 B4)

- **Section Classification - Flanges**: Compact
- **Section Classification - Web**: Compact

### Section Flexural Capacity (AISC 360-16, Chapter F)

- **Plastic Moment Resistance**: \( M_{p} = 542,000 \text{ lb-ft} \)
- **Nominal Cross-Section Bending Resistance**: \( M_{\text{nom}} = 542,000 \text{ lb-ft} \)

### Flexural Capacity - Positive Bending (AISC 360-16, Chapter F)

- **Longest Unbraced Segment**: \( L_{u}^{+} = 26 \text{ ft}, 6 \text{ in} \)
- **Lateral-Torsional Buckling Governs?**: Yes

### Flexural Capacity - Negative Bending (AISC 360-16, Chapter F)

- **Lateral-Torsional Buckling Governs?**: No

### Shear Capacity (AISC 360-16, Chapter G)

- **Shear Strenghness**: \( h / t_{w} = 35.9 \)
- **Web Shear Strength Coefficient**: \( C_{\alpha} = 1 \)
<table>
<thead>
<tr>
<th>Nominal Shear Capacity</th>
<th>$V_n = 193,000$ lb</th>
</tr>
</thead>
</table>

Comments
Non-Structural Concrete on Wood w/
Shallow Vercor
Prior Consideration:
Structural, Verco decking with Wood/GLB Framing

Key Plan

1. A
2. B
3. C
4. D
5. E

Nref
Prior Consideration:
Structural, Verco decking with Wood/GLB Framing

Note: to help with constructibility, oversize specific beams to as many connection points are flush. along grid-lines, size most loaded-largest beam, reuse size for continuing members. Primarily do separate calc's to account for differing loading cases.

Design Key Plan

Refer to Clear Calc. Reports for design member choices

Being conservative with using maximum of height of 9’ for all columns for worst cases
<table>
<thead>
<tr>
<th>Calculation</th>
<th>Member</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-1</td>
<td>14&quot; TJI 230</td>
<td>7 ft</td>
<td></td>
</tr>
<tr>
<td>J-2</td>
<td>1-3/4x14 Microllam LVL 2.0E-2600Fb</td>
<td>2.33 ft</td>
<td></td>
</tr>
<tr>
<td>J-3</td>
<td>2 - 1-3/4x14 Microllam LVL 2.0E-2600Fb</td>
<td>11.3 ft</td>
<td></td>
</tr>
<tr>
<td>J-4</td>
<td>14&quot; TJI 230</td>
<td>11.3 ft</td>
<td></td>
</tr>
<tr>
<td>J-5</td>
<td>9-1/2&quot; TJI 230</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>L-1</td>
<td>1-3/4x5-1/2 Microllam LVL 2.0E-2600Fb</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>B-1</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-2</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-3</td>
<td>5-1/2x14 24F-1.8E</td>
<td>18.5 ft</td>
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<tr>
<td>B-4</td>
<td>5-1/2x9-1/2 24F-1.8E</td>
<td>8.5 ft</td>
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<tr>
<td>B-5</td>
<td>5-1/2x14 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-6</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18.8 ft</td>
<td></td>
</tr>
<tr>
<td>B-7</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-8</td>
<td>5-1/2x16 24F-1.8E</td>
<td>18.8 ft</td>
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</tr>
<tr>
<td>B-9</td>
<td>5-1/2x16 24F-1.8E</td>
<td>18.8 ft</td>
<td></td>
</tr>
<tr>
<td>B-10</td>
<td>3 - 1-3/4x9-1/2 Microllam LVL 2.0E-2600Fb</td>
<td>11.5 ft</td>
<td></td>
</tr>
<tr>
<td>C1-1</td>
<td>8x8 D.Fir-L No. 1</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C1-2</td>
<td>8x8 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C2-1</td>
<td>8x8 D.Fir-L No. 1</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C2-2</td>
<td>8x8 D.Fir-L No. 1</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>6x6 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>6x6 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>4x6 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>Typ. Ext. Bearing Wall</td>
<td>2x6 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>HDR-1</td>
<td>4x6 D.Fir-L No. 2</td>
<td>3.75 ft</td>
<td></td>
</tr>
</tbody>
</table>
Summary

Member
- 14" TJI 230

Moment Utilization
- $M / M' = 806 \text{ lb}\cdot\text{ft} / 4990 \text{ lb}\cdot\text{ft}$

Shear Utilization
- $V / V' = 461 \text{ lb} / 1950 \text{ lb}$

Bearing Utilization
- $R / R' = 461 \text{ lb} / 1360 \text{ lb}$

Governing Deflection
- $\delta_{ST} = -0.0143 \text{ in} (L/5880)$
- $\delta_{LT} = -0.0184 \text{ in} (L/4550)$

Key Properties
- Beam Plan Length $L_X = 7 \text{ ft}$

Design Conditions


Member Properties
- Base Allowable Moment $M_r = 4990 \text{ lb}\cdot\text{ft}$
- Base Perpendicular Compression Allowable Stress $F_{c\perp} = 0 \text{ psi}$

Section Bending (NDS 2018 2.3)
- Governing Duration Factor in Bending $C_{D,b} = 1$
- Beam Stability Factor $C_L = 1$
- Adjusted Allowable Moment $M'_r = 4990 \text{ lb}\cdot\text{ft}$

Shear Design (NDS 2018 3.4)
- Governing Duration Factor $C_D = 1$
- Adjusted Allowable Shear $V'_r = 1950 \text{ lb}$

Bearing (NDS 2018 3.10)
- Base Bearing Strength $F_{c\perp} / C_b = 0 \text{ psi}$

Comments

PASS
Summary

Cross-Sectional Area $A = 24.5 \text{ in}^2$
Strong Axis Moment of Inertia $I_{xx} = 400 \text{ in}^4$
Section Modulus $S = 57.2 \text{ in}^3$
Base Allowable Bending Stress $F_b = 2600 \text{ psi}$
Base Allowable Shear Stress $F_v = 285 \text{ psi}$
Base Perpendicular Compression Allowable Stress $F_{c\perp} = 750 \text{ psi}$
True Modulus of Elasticity $E_{true} = 2000000 \text{ psi}$
Apparent Modulus of Elasticity $E_{app} = N_a N \text{ psi}$
Modulus of Elasticity for Deflections $E = 2000000 \text{ psi}$

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity $E' = 2000000 \text{ psi}$
Adjusted Shear Modulus $G' = 125000 \text{ psi}$

Volume Factor $C_V = 0.979$

Section Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending $C_{D,b} = 1$
Governing Beam Stability Factor - Positive Bending $C_L^+ = 1$
Adjusted Bending Strength - Positive Bending $F_b^+ = 2650 \text{ psi}$

Governing Duration Factor - Negative Bending $C_{D,b} = 0.9$
Governing Beam Stability Factor - Negative Bending $C_L^- = 0.782$
Adjusted Bending Strength - Negative Bending $F_b^- = 1900 \text{ psi}$

Shear Design (NDS 2018 3.4)

Governing Duration Factor $C_D = 1$

Bearing (NDS 2018 3.10)

Base Bearing Strength $F_{c\perp}/C_b = 750 \text{ psi}$

Comments

Key Properties

Beam Plan Length $L_X = 2.33 \text{ ft}$
Continuous Bracing for Lateral Torsional Buckling

Reactions:

Bearing: 3 in. Fact:Max: 375 lb Fact: Min: 104 lb D: 174 lb L: 214 lb

Member Properties

<table>
<thead>
<tr>
<th>Moment Utilization</th>
<th>Shear Utilization</th>
<th>Bearing Utilization</th>
<th>Minimum Bearing Length (End Supports)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>8%</td>
<td>10%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Governing Live / Short-Term Deflection

$\delta_{LT} = -0.00104 \text{ in / L (27000)}$

Governing Long-Term Deflection

$\delta_{LT} = -0.00104 \text{ in}$

Design Conditions

Design Code for Load Combinations - International Building Code (IBC) 2018

Member Properties

<table>
<thead>
<tr>
<th>Design Code</th>
<th>Floor Joist</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S.P. - Prior Consideration Design</td>
<td>J-2</td>
</tr>
</tbody>
</table>
**Summary**

**Member**

- Moment Utilization: \( M/M' = 3770 \text{ lb}\cdot\text{ft} / 29 700 \text{ lb}\cdot\text{ft} \)
- Shear Utilization: \( V/V' = 2990 \text{ lb} / 11 600 \text{ lb} \)
- Bearing Utilization: \( R/R' = 2990 \text{ lb} / 7870 \text{ lb} \)

- Minimum Bearing Length (End Supports): \( \ell_{b,\text{min,end}} = 1.14 \text{ in} \)
- Minimum Bearing Length (Int Supports): \( \ell_{b,\text{min,int}} = 1.26 \text{ in} \)

**Reactions:**

- Bearing: 3.9 in
  - FactMin: 344 lb
  - FactMax: 546 lb
  - D: 130 lb
  - L: 1950 lb
- Bearing: 5 in
  - FactMin: 2990 lb
  - FactMax: 1560 lb
  - D: 1340 lb
  - L: 1340 lb
- Bearing: 3.9 in
  - FactMin: 2990 lb
  - FactMax: 1560 lb
  - D: 1340 lb
  - L: 1340 lb

**Reactions: No Continuous Bracing**

**Design Conditions**


**Member Properties**

- Cross-Sectional Area: \( A = 49 \text{ in}^2 \)
- Strong Axis Moment of Inertia: \( I_{xx} = 800 \text{ in}^4 \)
- Section Modulus: \( S = 114 \text{ in}^3 \)
- Base Allowable Bending Stress: \( F_b = 2600 \text{ psi} \)
- Base Allowable Shear Stress: \( F_c = 285 \text{ psi} \)
- Base Perpendicular Compression Allowable Stress: \( F_{cp} = 750 \text{ psi} \)
- True Modulus of Elasticity: \( E_{true} = 2000000 \text{ psi} \)
- Apparent Modulus of Elasticity: \( E_{app} = N \text{ psi} \)
- Modulus of Elasticity for Deflections: \( E = 2000000 \text{ psi} \)

**Elastic Modulus (NDS 2018 2.3)**

- Adjusted Modulus of Elasticity: \( E' = 2000000 \text{ psi} \)
- Adjusted Shear Modulus: \( G' = 125000 \text{ psi} \)

**Section Bending (NDS 2018 2.3)**

- Volume Factor: \( C_V = 0.979 \)

**Positive Bending (NDS 2018 2.3)**

- Governing Duration Factor - Positive Bending: \( C^*_{D,b} = 1.25 \)
- Governing Beam Stability Factor - Positive Bending: \( C^*_{L} = 0.96 \)
- Adjusted Bending Strength - Positive Bending: \( F_b'^* = 3120 \text{ psi} \)

**Negative Bending (NDS 2018 2.3)**

- Governing Duration Factor - Negative Bending: \( C^*_{D,b} = 1 \)
- Governing Beam Stability Factor - Negative Bending: \( C^*_{L} = 0.972 \)
- Adjusted Bending Strength - Negative Bending: \( F_b'^* = 2530 \text{ psi} \)
<table>
<thead>
<tr>
<th>Shear Design (NDS 2018 3.4)</th>
<th>Governing Duration Factor ( C_D = 1.25 )</th>
<th>Adjusted Shear Strength ( F'_v = 356 \text{ psi} )</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bearing (NDS 2018 3.10)</th>
<th>Base Bearing Strength ( F'_{c_b} / C_b = 750 \text{ psi} )</th>
</tr>
</thead>
</table>

Comments
Summary

Member 14" TJI 230

Moment Utilization

\( M / M' = \frac{526 \text{ lb} \cdot \text{ft}}{4990 \text{ lb} \cdot \text{ft}} \)

Shear Utilization

\( V / V' = \frac{472 \text{ lb}}{1950 \text{ lb}} \)

Bearing Utilization

\( R / R' = \frac{930 \text{ lb}}{2790 \text{ lb}} \)

Deflection

- Governing Live / Short-Term: \( \delta_{ST} = -0.00682 \text{ in} \)
- Governing Long-Term: \( \delta_{LT} = -0.00769 \text{ in} \)

Design Conditions

- Base Allowable Moment: \( M_r = 4990 \text{ lb} \cdot \text{ft} \)
- Base Allowable Shear: \( V_r = 1950 \text{ lb} \)
- Base Perpendicular Compression Allowable Stress: \( F_{c\perp} = 0 \text{ psi} \)

Section Bending (NDS 2018 2.3)

- Governing Duration Factor in Bending: \( C_{D,b} = 1 \)
- Beam Stability Factor: \( C_L = 1 \)
- Adjusted Allowable Moment: \( M'_a = 4990 \text{ lb} \cdot \text{ft} \)

Shear Design (NDS 2018 3.4)

- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Allowable Shear: \( V'_a = 1950 \text{ lb} \)

Bearing (NDS 2018 3.10)

- Base Bearing Strength: \( F'_{c\perp} / C_b = 0 \text{ psi} \)

Key Properties

- Beam Plan Length: \( L_X = 11.3 \text{ ft} \)

Reactions:

- Bearing: 3 in
  - FactMax: 226 lb
  - FactMin: 95 lb
  - D: 158 lb
  - L: 188 lb

- Bearing: 3.5 in
  - FactMax: 300 lb
  - FactMin: 128 lb
  - D: 203 lb
  - L: 237 lb

- Bearing: 3 in
  - FactMax: 251 lb
  - FactMin: 104 lb
  - D: 172 lb
  - L: 118 lb

Comments

PASS
Summary

Member

- Moment Utilization: 9-1/2" TJ 230
  \[ M / M' = 1430 \text{ lb}\cdot\text{ft} / 3330 \text{ lb}\cdot\text{ft} \]
- Shear Utilization: 635 lb / 1330 lb
  \[ V / V' = 635 \text{ lb} / 1330 \text{ lb} \]
- Governing Utilization: Bearing Utilization
  \[ R / R' = 635 \text{ lb} / 1250 \text{ lb} \]
  \[ \delta_{ST} = -0.0825 \text{ in} \]
  \[ \delta_{LT} = -0.104 \text{ in} \]

Key Properties

- Beam Plan Length: \( L_X = 9 \text{ ft} \)

Design Conditions


Member Properties

- Base Allowable Moment: \( M_e = 3330 \text{ lb}\cdot\text{ft} \)
- Base Allowable Shear: \( V_e = 1330 \text{ lb} \)
- Base Perpendicular Compression Allowable Stress: \( F_{c\perp} = 0 \text{ psi} \)

Section Bending (NDS 2018 2.3)

- Governing Duration Factor in Bending: \( C_{DB} = 1 \)
- Beam Stability Factor: \( C_L = 1 \)
- Adjusted Allowable Moment: \( M'_e = 3330 \text{ lb}\cdot\text{ft} \)

Shear Design (NDS 2018 3.4)

- Governing Duration Factor: \( C_D = 1 \)

Bearing (NDS 2018 3.10)

- Base Bearing Strength: \( F'_{c\perp} / C_b = 0 \text{ psi} \)

Comments

PASS
**Summary**

- **Primary Loading**
  - $d=5$ in
  - $b=1.75$ in

**Member Properties**

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Deformation</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>2%</td>
<td>-0.00278 in</td>
<td>L/13,000</td>
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<tr>
<td>3%</td>
<td>-0.00378 in</td>
<td>L/10,600</td>
</tr>
</tbody>
</table>

**Design Conditions**

- **Design Code for Load Combinations**
  - International Building Code (IBC) 2018

- **Member Properties**
  - Cross-Sectional Area
    - $A = 9.62 \text{ in}^2$
  - Strong Axis Moment of Inertia
    - $I_{xx} = 24.3 \text{ in}^4$
  - Section Modulus
    - $S = 8.82 \text{ in}^3$
  - Base Allowable Bending Stress
    - $F_{b} = 2600 \text{ psi}$
  - Base Allowable Shear Stress
    - $F_{v} = 285 \text{ psi}$
  - Base Perpendicular Compression Allowable Stress
    - $F_{cc} = 750 \text{ psi}$
  - True Modulus of Elasticity
    - $E_{true} = 2000000 \text{ psi}$
  - Apparent Modulus of Elasticity
    - $E_{app} = NaN \text{ psi}$
  - Modulus of Elasticity for Deflections
    - $E = 2000000 \text{ psi}$

**Positive Bending (NDS 2018 2.3)**

- Adjusted Modulus of Elasticity
  - $E' = 2000000 \text{ psi}$
- Adjusted Shear Modulus
  - $G' = 125000 \text{ psi}$

**Negative Bending (NDS 2018 2.3)**

- Governing Duration Factor - Negative Bending
  - $C_{D,b} = 1$

**Volume Factor**

- $C_{V} = 1.11$

**Shear Design (NDS 2018 3.4)**

- Governing Duration Factor
  - $C_{D} = 1$

**Bearing (NDS 2018 3.10)**

- Base Bearing Strength
  - $F'_{cb} / C_{b} = 750 \text{ psi}$

**Comments**

- Self-weight
  - $D:2.8 \text{ plf}$

- Continuous Bracing for Lateral Torsional Buckling

**Client:** John Lawson  
**Date:** Oct 14, 2023

**Author:** Cameron Cunningham  
**Job #:** ARCE 453-01

**Project:** C.S.P. - Prior Consideration Design  
**Subject:** L-1

**References:** NDS 2018 (ASD)
### Design Conditions

**Design Code for Load Combinations**

**International Building Code (IBC) 2018**

### Member Properties

- **Cross-Sectional Area** \( A = 184 \text{ in}^2 \)
- **Strong Axis Moment of Inertia** \( I_{xx} = 6750 \text{ in}^4 \)
- **Section Modulus** \( S = 643 \text{ in}^3 \)
- **Base Allowable Bending Stress** \( F_b = 2400 \text{ psi} \)
- **Base Allowable Shear Stress** \( F_v = 265 \text{ psi} \)
- **Base Perpendicular Compression Allowable Stress** \( F_c' = 650 \text{ psi} \)
- **True Modulus of Elasticity** \( E_{true} = 1900000 \text{ psi} \)
- **Apparent Modulus of Elasticity** \( E_{app} = 1800000 \text{ psi} \)
- **Modulus of Elasticity for Deflections** \( E = 1800000 \text{ psi} \)
- **Elastic Modulus (NDS 2018 2.3)**
  - **Adjusted Modulus of Elasticity** \( E' = 1800000 \text{ psi} \)

### Section Bending (NDS 2018 2.3)

- **Volume Factor** \( C_V = 0.962 \)

### Positive Bending (NDS 2018 2.3)

- **Governing Duration Factor - Positive Bending** \( C_{D,b} = 1 \)
- **Governing Beam Stability Factor - Positive Bending** \( C_L = 1 \)
- **Adjusted Bending Strength - Positive Bending** \( F_{b}' = 2310 \text{ psi} \)

### Negative Bending (NDS 2018 2.3)

- **Governing Duration Factor - Negative Bending** \( C_{D,b} = 1 \)
- **Governing Beam Stability Factor - Negative Bending** \( C_L = 0.995 \)
- **Adjusted Bending Strength - Negative Bending** \( F_{b}' = 1390 \text{ psi} \)
<table>
<thead>
<tr>
<th>Shear Design (NDS 2018 3.4)</th>
<th>Adjusted Shear Strength</th>
<th>( F'_c = 265 , \text{psi} )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjusted Bending Strength</strong></td>
<td><strong>Negative Bending</strong></td>
<td>( F'_v = F'_v ) = ( F_v' ) = ( \psi_v )</td>
</tr>
<tr>
<td>Governing Duration Factor ( C_D = 1 )</td>
<td><strong>Shear Design (NDS 2018 3.10)</strong></td>
<td>( F'_c \perp / C_b ) = ( 650 , \text{psi} )</td>
</tr>
<tr>
<td><strong>Base Bearing Strength</strong></td>
<td></td>
<td><strong>Comments</strong></td>
</tr>
</tbody>
</table>
**Summary**

**Member**

- **Percentage Utilization**
  - Moment Utilization: 35%
  - Shear Utilization: 88%
  - Bearing Utilization: 32%

**Moment and Shear Stresses**

- Positive Moment (Factored): 27,700 lb
- Positive Shear (Factored): 10,300 lb
- Negative Moment (Factored): -17,000 lb
- Negative Shear (Factored): -3,200 lb

**Bearing**

- Minimum Bearing (Int Sup): 19 in
- Minimum Bearing (End Sup): 22 in

**Governing Live / Short-Term Deflection**

- \( \delta_{LT} = -0.0376 \text{ in} \)

**Governing Long-Term Deflection**

- \( \delta_{LT} = -0.0376 \text{ in} \)

**Design Conditions**

- Cross-Sectional Area: \( A = 184 \text{ in}^2 \)
- Strong Axis Moment of Inertia: \( I_{xx} = 6750 \text{ in}^4 \)
- Section Modulus: \( S = 643 \text{ in}^3 \)
- Base Allowable Bending Stress: \( F_b = 2400 \text{ psi} \)
- Base Allowable Shear Stress: \( F_s = 265 \text{ psi} \)
- Base Perpendicular Compression Allowable Stress: \( F_{pc} = 650 \text{ psi} \)
- True Modulus of Elasticity: \( E_{true} = 1900000 \text{ psi} \)
- Apparent Modulus of Elasticity: \( E_{app} = 1800000 \text{ psi} \)
- Modulus of Elasticity for Deflections: \( E = 1800000 \text{ psi} \)

**Elastic Modulus (NDS 2018 2.3)**

- Adjusted Modulus of Elasticity: \( E^* = 1800000 \text{ psi} \)

**Section Bending (NDS 2018 2.3)**

- Volume Factor: \( C_V = 0.962 \)

**Positive Bending (NDS 2018 2.3)**

- Governing Duration Factor - Positive Bending: \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending: \( C_{L} = 1 \)
- Adjusted Bending Strength - Positive Bending: \( F_b^* = 2310 \text{ psi} \)

**Negative Bending (NDS 2018 2.3)**

- **Member Properties**
  - Cross-Sectional Area: \( A = 184 \text{ in}^2 \)
  - Strong Axis Moment of Inertia: \( I_{xx} = 6750 \text{ in}^4 \)
  - Section Modulus: \( S = 643 \text{ in}^3 \)
  - Base Allowable Bending Stress: \( F_b = 2400 \text{ psi} \)
  - Base Allowable Shear Stress: \( F_s = 265 \text{ psi} \)
  - Base Perpendicular Compression Allowable Stress: \( F_{pc} = 650 \text{ psi} \)
  - True Modulus of Elasticity: \( E_{true} = 1900000 \text{ psi} \)
  - Apparent Modulus of Elasticity: \( E_{app} = 1800000 \text{ psi} \)
  - Modulus of Elasticity for Deflections: \( E = 1800000 \text{ psi} \)

**Elastic Modulus (NDS 2018 2.3)**

- Adjusted Modulus of Elasticity: \( E^* = 1800000 \text{ psi} \)

**Section Bending (NDS 2018 2.3)**

- Volume Factor: \( C_V = 0.962 \)

**Positive Bending (NDS 2018 2.3)**

- Governing Duration Factor - Positive Bending: \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending: \( C_{L} = 1 \)
- Adjusted Bending Strength - Positive Bending: \( F_b^* = 2310 \text{ psi} \)

**Negative Bending (NDS 2018 2.3)**

- **Member Properties**
  - Cross-Sectional Area: \( A = 184 \text{ in}^2 \)
  - Strong Axis Moment of Inertia: \( I_{xx} = 6750 \text{ in}^4 \)
  - Section Modulus: \( S = 643 \text{ in}^3 \)
  - Base Allowable Bending Stress: \( F_b = 2400 \text{ psi} \)
  - Base Allowable Shear Stress: \( F_s = 265 \text{ psi} \)
  - Base Perpendicular Compression Allowable Stress: \( F_{pc} = 650 \text{ psi} \)
  - True Modulus of Elasticity: \( E_{true} = 1900000 \text{ psi} \)
  - Apparent Modulus of Elasticity: \( E_{app} = 1800000 \text{ psi} \)
  - Modulus of Elasticity for Deflections: \( E = 1800000 \text{ psi} \)

**Elastic Modulus (NDS 2018 2.3)**

- Adjusted Modulus of Elasticity: \( E^* = 1800000 \text{ psi} \)

**Section Bending (NDS 2018 2.3)**

- Volume Factor: \( C_V = 0.962 \)

**Positive Bending (NDS 2018 2.3)**

- Governing Duration Factor - Positive Bending: \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending: \( C_{L} = 1 \)
- Adjusted Bending Strength - Positive Bending: \( F_b^* = 2310 \text{ psi} \)

**Negative Bending (NDS 2018 2.3)**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governing Duration Factor - Negative Bending</td>
<td>$C_{D,b} = 1$</td>
</tr>
<tr>
<td>Governing Beam Stability Factor - Negative Bending</td>
<td>$C_L = 0.995$</td>
</tr>
<tr>
<td>Adjusted Bending Strength - Negative Bending</td>
<td>$F_b' = 1390$ psi</td>
</tr>
<tr>
<td>Governing Duration Factor</td>
<td>$C_D = 1$</td>
</tr>
<tr>
<td>Adjusted Shear Strength</td>
<td>$F_v' = 265$ psi</td>
</tr>
<tr>
<td>Bearing (NDS 2018 3.10)</td>
<td></td>
</tr>
<tr>
<td>Base Bearing Strength</td>
<td>$F_v' / C_b = 650$ psi</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
</tr>
</tbody>
</table>
Summary

- **Moment Utilization**: 62%
- **Shear Utilization**: 35%
- **Bearing Utilization**: 44%

Member

- **Minimum Bearing Length (End Supports)**: \( \delta_{b, \text{min,end}} = 1.32 \text{ in} \)
- **Deflection**:
  - Governing Live / Short-Term: \( \delta_{LT} = -0.447 \text{ in (L/496)} \)
  - Governing Long-Term: \( \delta_{LT} = -0.447 \text{ in} \)

Reactions:

```
0 5 10 15
Distance from Left of Beam (ft)
```

Key Properties

- **Beam Plan Length**: \( L_X = 18.5 \text{ ft} \)
- **Continuous Bracing for Lateral Torsional Buckling**: No Continuous Bracing

Loads

- **Self-weight**

Design Conditions

**International Building Code (IBC) 2018**

**Member Properties**

- **Cross-Sectional Area**: \( A = 77 \text{ in}^2 \)
- **Strong Axis Moment of Inertia**: \( I_{xx} = 1260 \text{ in}^4 \)
- **Section Modulus**: \( S = 180 \text{ in}^3 \)
- **Base Allowable Bending Stress**: \( F_b = 2400 \text{ psi} \)
- **Base Allowable Shear Stress**: \( F_v = 265 \text{ psi} \)
- **Base Perpendicular Compression Allowable Stress**: \( F_{p,c} = 650 \text{ psi} \)
- **True Modulus of Elasticity**: \( E_{true} = 1900000 \text{ psi} \)
- **Apparent Modulus of Elasticity**: \( E_{app} = 1800000 \text{ psi} \)
- **Modulus of Elasticity for Deflections**: \( E = 1800000 \text{ psi} \)

**Elastic Modulus (NDS 2018 2.3)**

- **Adjusted Modulus of Elasticity**: \( E' = 1800000 \text{ psi} \)

**Volume Factor**

- **C_V**: 0.991

**Positive Bending (NDS 2018 2.3)**

- **Governing Duration Factor - Positive Bending**: \( C_{D,b} = 1 \)
- **Governing Beam Stability Factor - Positive Bending**: \( C_L^+ = 0.969 \)
- **Adjusted Bending Strength - Positive Bending**: \( F_b^+ = 2330 \text{ psi} \)

**Negative Bending (NDS 2018 2.3)**

- **Governing Duration Factor - Negative Bending**: \( C_{D,b} = 0.9 \)
- **Governing Beam Stability Factor - Negative Bending**: \( C_L^- = 0.986 \)
- **Adjusted Bending Strength - Negative Bending**: \( F_b^- = 1290 \text{ psi} \)

**Shear Design (NDS 2018 3.4)**

- **Governing Duration Factor**: \( C_D = 1 \)
- **Adjusted Shear Strength**: \( F_s = 265 \text{ psi} \)

**Bearing (NDS 2018 3.10)**

- **Base Bearing Strength**: \( F_{c,b} / F_b = 650 \text{ psi} \)

Comments

- **Pasadeo – Prior Consideration Design**
- **Author**: Cameron Cunningham
- **C.S.P. - Prior Consideration Design**
- **References**: NDS 2018 (ASD)
Summary

Client: John Lawson
Author: Cameron Cunningham
Project: C.S.P. - Prior Consideration Design
References: NDS 2018 (ASD)

Design Conditions

- Design Code for Load Combinations
- International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area: $A = 52.2\, \text{in}^2$
- Strong Axis Moment of Inertia: $I_{xx} = 393\, \text{in}^4$
- Section Modulus: $S = 82.7\, \text{in}^3$
- Base Allowable Bending Stress: $F_b = 2400\, \text{psi}$
- Base Allowable Shear Stress: $F_v = 265\, \text{psi}$
- Base Perpendicular Compression Allowable Stress: $F_{c\perp} = 650\, \text{psi}$
- True Modulus of Elasticity: $E_{true} = 1,900,000\, \text{psi}$
- Apparent Modulus of Elasticity: $E_{app} = 1,800,000\, \text{psi}$
- Modulus of Elasticity for Deflections: $E = 1,800,000\, \text{psi}$

Elastic Modulus (NDS 2018 2.3)
- Adjusted Modulus of Elasticity: $E' = 1,800,000\, \text{psi}$

Section Bending (NDS 2018 2.3)
- Volume Factor: $C_V = 1$

Positive Bending (NDS 2018 2.3)
- Governing Duration Factor - Positive Bending: $C_{D,b}^+ = 1$
- Governing Beam Stability Factor - Positive Bending: $C_L^+ = 1$
- Adjusted Bending Strength - Positive Bending: $F_b'^+ = 2400\, \text{psi}$

Negative Bending (NDS 2018 2.3)
- Governing Duration Factor - Negative Bending: $C_{D,b}^- = 0.9$
- Governing Beam Stability Factor - Negative Bending: $C_L^- = 0.996$
- Adjusted Bending Strength - Negative Bending: $F_b'^- = 1300\, \text{psi}$

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: $C_D = 1$
- Adjusted Shear Strength: $F_v' = 265\, \text{psi}$

Bearing (NDS 2018 3.10)
- Base Bearing Strength: $F_{c\perp}' / C_b = 650\, \text{psi}$

Comments

Shear Utilization

Moment Utilization

Shear Utilization

Minimum Bearing Length (End Supports)

Governing Long-Term Deflection

Governing Long-Term Deflection

Reactions:

- FactMax: 4100 lb
- Bearing: 3 in
- D: 1800 lb
- L: 2290 lb

Key Properties

Beam Plan Length: $L_X = 8.5\, \text{ft}$

Continuous Bracing for Lateral Torsional Buckling: Top Braced

Loads

- Distance from Left of Beam (ft)
- Shear: 3 in
- FactMax: 4100 lb
- D: 1800 lb
- L: 2290 lb

- Distance from Left of Beam (ft)
- Self-weight: 4 in
- J5-1
- FactMin: 1200 lb
- D: 1200 lb
- L: 2250 lb

- Distance from Left of Beam (ft)
- J5-2
- FactMax: 4100 lb
- D: 1800 lb
- L: 2290 lb

- Distance from Left of Beam (ft)
- Self-weight: 4 in
- J5-1
- FactMin: 1200 lb
- D: 1200 lb
- L: 2250 lb

- Distance from Left of Beam (ft)
- J5-2
- FactMax: 4100 lb
- D: 1800 lb
- L: 2290 lb
Summary

**Member**
- **Moment Utilization**: 61%  
- **Shear Utilization**: 52%  
- **Bearing Utilization**: 52%

- **Governing Live / Short-Term Deflection**: 0.314 in (L/689)
- **Governing Long-Term Deflection**: 0.551 in (L/392)

**Reactions:**
- **Beam Plan Length**: 18 ft
- **Continuous Bracing for Lateral Torsional Buckling**: Top Braced

**Key Properties**
- **Shear Design (NDS 2018 3.4)**
- **Moment Utilization (ASD)**
- **Positive Bending (NDS 2018 2.3)**
- **Cross-Sectional Area**: $A = 77 \text{ in}^2$
- **Section Modulus**: $S = 180 \text{ in}^4$
- **Base Allowable Shear Stress**: $F_{sb} = 2400 \text{ psi}$
- **Base Allowable Bending Stress**: $F_{b} = 265 \text{ psi}$
- **Base Perpendicular Compression Allowable Stress**: $F_{cl} = 650 \text{ psi}$
- **True Modulus of Elasticity**: $E_{true}$
- **Apparent Modulus of Elasticity**: $E_{app}$
- **Modulus of Elasticity for Deflections**: $E$
- **Volume Factor**: $C_V = 0.993$
- **Adjusted Bending Strength - Positive Bending**: $F_b^+ = 2380 \text{ psi}$
- **Adjusted Bending Strength - Negative Bending**: $F_b^- = 1290 \text{ psi}$
- **Adjusted Shear Strength**: $F_v'$
- **Adjusted Bending Strength - Positive Bending**: $F_b^+ = 2380 \text{ psi}$
- **Adjusted Bending Strength - Negative Bending**: $F_b^- = 1290 \text{ psi}$
- **Adjusted Shear Strength**: $F_v'$
- **Elastic Modulus (NDS 2018 2.3)**

**Design Conditions**

- **Load Combinations**
- **International Building Code (IBC) 2018**
- **Volume Factor**: $C_V = 0.993$
- **Adjusted Bending Strength - Positive Bending**: $F_b^+ = 2380 \text{ psi}$
- **Adjusted Bending Strength - Negative Bending**: $F_b^- = 1290 \text{ psi}$
- **Adjusted Shear Strength**: $F_v'$
- **Adjusted Bending Strength - Positive Bending**: $F_b^+ = 2380 \text{ psi}$
- **Adjusted Bending Strength - Negative Bending**: $F_b^- = 1290 \text{ psi}$
- **Adjusted Shear Strength**: $F_v'$
- **Elastic Modulus (NDS 2018 2.3)**

**Comments**

**References**

- **NDS 2018 (ASD)**
- **Project**: C.S.P. - Prior Consideration Design
- **Author**: Cameron Cunningham
- **Client**: John Lawson
- **Job #:**: ARCE 453-01
- **Subject**: B-5

**Creating with ClearCalcs.com**
Summary

Member
- 42% Moment Utilization
- 32% Shear Utilization
- 61% Bearing Utilization

Minimum Bearing Length (End Supports)
- 16% Governing Live / Short-Term Deflection
- 19% Governing Long-Term Deflection

Design Conditions

Client: John Lawson  Date: Oct 14, 2023
Author: Cameron Cunningham  Job #: ARCE 453-01
Project: C.S.P. - Prior Consideration Design  Subject: B-6

References: NDS 2018 (ASD)

Design Code for Load Combinations

International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area  \( A = 184 \, \text{in}^2 \)
- Strong Axis Moment of Inertia  \( I_{xx} = 6750 \, \text{in}^4 \)
- Elastic Modulus  \( E = 1180 \, \text{psi} \)

Positive Bending (NDS 2018 2.3)
- Governing Duration Factor - Positive Bending  \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending  \( C_L^+ = 1 \)
- Adjusted Bending Strength - Positive Bending  \( F_b^+ = 2180 \, \text{psi} \)

Negative Bending (NDS 2018 2.3)
- Governing Duration Factor - Negative Bending  \( C_{D,b} = 0.9 \)
- Governing Beam Stability Factor - Negative Bending  \( C_L^- = 0.992 \)
- Adjusted Bending Strength - Negative Bending  \( F_b^- = 1180 \, \text{psi} \)

Shear Design (NDS 2018 3.4)
- Governing Duration Factor  \( C_D = 1 \)
- Adjusted Shear Strength  \( F_v' = 265 \, \text{psi} \)

Bearing (NDS 2018 3.10)
- Base Bearing Strength  \( F_{cb}'/C_b = 650 \, \text{psi} \)

Key Properties

- Beam Plan Length  \( L_X = 18.8 \, \text{ft} \)
- Continuous Bracing for Lateral Torsional Buckling
- Top Braced

Reactions:

Shear: 3.8 in
Fact Max: 400 lb
Fact Min: 1060 lb
L: 8.75 in

Distances from Left of Beam (ft)

Distance from Left of Beam (ft)

Volume Factor  \( C_V = 0.907 \)

Comments
Summary

Member

Moment Utilization

\[ M' = \frac{-45900 \text{ lb*ft}}{73700 \text{ lb*ft}} \]

Shear Utilization

\[ V' = \frac{12800 \text{ lb}}{32500 \text{ lb}} \]

Bearing Utilization

Minimum Bearing Length (End Supports)

\[ \ell_{b,\text{min,end}} = 0.836 \text{ in} \]

Minimum Bearing Length (Int Supports)

\[ \ell_{b,\text{min,int}} = 4 \text{ in} \]

Governing Live / Short-Term Deflection

\[ \delta_{\text{LT}} = -0.049 \text{ in} (L/1100) \]

Governing Long-Term Deflection

\[ \delta_{LT} = -0.0709 \text{ in} (L/762) \]

Design Conditions

Design Code for Load Combinations

International Building Code (IBC) 2018

Member Properties

Cross-Sectional Area

\[ A = 184 \text{ in}^2 \]

Strong Axis Moment of Inertia

\[ I_{xx} = 6750 \text{ in}^4 \]

Section Modulus

\[ S = 643 \text{ in}^3 \]

Base Allowable Bending Stress

\[ F_b = 2400 \text{ psi} \]

Base Allowable Shear Stress

\[ F_c = 265 \text{ psi} \]

Base Perpendicular Compression Allowable Stress

\[ F_{c\perp} = 650 \text{ psi} \]

True Modulus of Elasticity

\[ E_{\text{true}} = 1900000 \text{ psi} \]

Apparent Modulus of Elasticity

\[ E_{\text{app}} = 1800000 \text{ psi} \]

Modulus of Elasticity for Deflections

\[ E' = 1800000 \text{ psi} \]

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity

\[ E' = 1800000 \text{ psi} \]

Section Bending (NDS 2018 2.3)

Volume Factor

\[ C_V = 0.949 \]

Positive Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending

\[ C_{D,b} = 1 \]

Governing Beam Stability Factor - Positive Bending

\[ C_L^+ = 0.996 \]

Adjusted Bending Strength - Positive Bending

\[ F_b^+ = 2280 \text{ psi} \]

Negative Bending (NDS 2018 2.3)

Governing Duration Factor - Negative Bending

\[ C_{D,b} = 1 \]

Governing Beam Stability Factor - Negative Bending

\[ C_L^- = 0.997 \]

Adjusted Bending Strength - Negative Bending

\[ F_b^- = 1380 \text{ psi} \]
### Shear Design (NDS 2018 3.4)

<table>
<thead>
<tr>
<th>Description</th>
<th>Equation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governing Duration Factor</td>
<td>$C_D = 1$</td>
<td></td>
</tr>
<tr>
<td>Adjusted Shear Strength</td>
<td>$F'_v = 265 \text{ psi}$</td>
<td></td>
</tr>
</tbody>
</table>

### Bearing (NDS 2018 3.10)

<table>
<thead>
<tr>
<th>Description</th>
<th>Equation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Bearing Strength</td>
<td>$F'_{c\perp}/C_b = 650 \text{ psi}$</td>
<td></td>
</tr>
</tbody>
</table>

**Comments**
Wood Beam (ASD) (version 176) — Generic Beam

Key Properties

Reactions:

Member

- 5-1/2x16 24F-1.8E
- Moment Utilization: 66%
- Shear Utilization: 71%
- Bearing Utilization: 85%
- Governing Live / Short-Term Deflection: 66%
- Governing Long-Term Deflection: 59%
- Governing Long-Term Deflection Without Continuous Bracing: 55%
- Minimum Bearing Length (End Supports): 2.55 in
- Governing Duration Factors:
  - Negative Bending: 0.983
  - Positive Bending: 1
- Governing Beam Stability Factors:
  - Negative Bending: 0.959
  - Positive Bending: 1

Loads

- Self-weight
- Primary Loading

Design Conditions

- Design Code for Load Combinations
- International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area: A = 88 in²
- Strong Axis Moment of Inertia: Iₓ = 1880 in⁴
- Section Modulus: S = 235 in³
- Base Allowable Bending Stress: F₀ = 2400 psi
- Base Allowable Shear Stress: Fₐ = 265 psi
- Base Perpendicular Compression Allowable Stress: Fₚₚₚₚₚ = 650 psi
- True Modulus of Elasticity: Etrue = 1,900,000 psi
- Apparent Modulus of Elasticity: Eapp = 1,800,000 psi
- Modulus of Elasticity for Deflections: E = 1,800,000 psi

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity: E' = 1,800,000 psi

Section Bending (NDS 2018 2.3)

- Volume Factor: CV = 0.976

Positive Bending (NDS 2018 2.3)

- Governing Duration Factor - Positive Bending: CᵥD,b⁻ = 1
- Governing Beam Stability Factor - Positive Bending: CᵥL⁺ = 0.959
- Adjusted Bending Strength - Positive Bending: Fₛ⁺ = 2300 psi

Negative Bending (NDS 2018 2.3)

- Governing Duration Factor - Negative Bending: CᵥD,b⁺ = 0.9
- Governing Beam Stability Factor - Negative Bending: CᵥL⁻ = 0.983
- Adjusted Bending Strength - Negative Bending: Fₛ⁻ = 1270 psi

Shear Design (NDS 2018 3.4)

- Governing Duration Factor: CᵥD = 1
- Adjusted Shear Strength: Fₛ = 265 psi

Bearing (NDS 2018 3.10)

- Base Bearing Strength: Fₛ₀/C₀ = 650 psi

Comments

References: NDS 2018 (ASD)
Summary

Member

- Moment Utilization: 95%
- Shear Utilization: 59%
- Bearing Utilization: 64%

Minimum Bearing Length (End Supports)

\[ L \text{, min, end} = 2.55 \text{ in} \]

Governing Live / Short-Term Deflection

\[ \delta_{LT} = -0.622 \text{ in (L/362)} \]

Governing Long-Term Deflection

\[ \delta_{LT} = -0.622 \text{ in (L/362)} \]

Design Conditions

Design Code for Load Combinations

- International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area
  \[ A = 88 \text{ in}^2 \]
- Strong Axis Moment of Inertia
  \[ I_{xx} = 1880 \text{ in}^4 \]
- Section Modulus
  \[ S = 235 \text{ in}^3 \]
- Base Allowable Bending Stress
  \[ F_{b1} = 2400 \text{ psi} \]
- Base Perpendicular Compression Allowable Stress
  \[ F_{cc} = 650 \text{ psi} \]
- True Modulus of Elasticity
  \[ E_{true} = 1900000 \text{ psi} \]
- Apparent Modulus of Elasticity
  \[ E_{app} = 1800000 \text{ psi} \]
- Deflections
  \[ \delta_{LT} = \delta_{LT} \text{ (L/362)} \]

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity
  \[ E' = 1800000 \text{ psi} \]

Section Bending (NDS 2018 2.3)

- Volume Factor
  \[ C_V = 0.976 \]

Positive Bending (NDS 2018 2.3)

- Governing Duration Factor - Positive Bending
  \[ C_{D,b} = 1 \]
- Governing Beam Stability Factor - Positive Bending
  \[ C_{L,b} = 0.959 \]
- Adjusted Bending Strength - Positive Bending
  \[ F_{b1}^+ = 2300 \text{ psi} \]

Negative Bending (NDS 2018 2.3)

- Governing Duration Factor - Negative Bending
  \[ C_{D,b} = 0.9 \]
- Governing Beam Stability Factor - Negative Bending
  \[ C_{L,b} = 0.983 \]
- Adjusted Bending Strength - Negative Bending
  \[ F_{b1}^- = 1270 \text{ psi} \]

Shear Design (NDS 2018 3.4)

- Governing Duration Factor
  \[ C_D = 1 \]

Bearing (NDS 2018 3.10)

- Base Bearing Strength
  \[ F_{Cc}/F_b = 650 \text{ psi} \]

Comments

Key Properties

- Beam Plan Length
  \[ L_X = 18.8 \text{ ft} \]
- Continuous Bracing for Lateral Torsional Buckling
  \[ \text{No Continuous Bracing} \]

Loads

- Self-weight

Reactions:

- FactMin: 2430 lb
- Bearing: 6 in
- D: 4050 lb
- L: 5060 lb

Continuous Bracing for Lateral Beam Plan Length

- Governing Long-Term Deflection
  \[ \delta_{LT} = -0.622 \text{ in (L/362)} \]

Deflections

- Governing Duration Factor
  \[ C_D = 1 \]
Client: John Lawson
Author: Cameron Cunningham
Project: C.S.P. - Prior Consideration Design

### Member Properties

#### Key Properties
- **Beam Plan Length**: $L_X = 11.5$ ft
- **Continuous Bracing for Lateral Torsional Buckling**: No Continuous Bracing

#### Loads

- **Self-weight**: [Diagram]
- **Project**: [Diagram]

#### Design Conditions
- **Design Code for Load Combinations**: International Building Code (IBC) 2018

#### Member Properties
- **Cross-Sectional Area**: $A = 49.9$ in$^2$

### Summary

#### Member

- **Moment Utilization**: $M / M' = 8110$ lb*ft / 18 100 lb*ft
- **Shear Utilization**: $V / V' = 2820$ lb / 9480 lb
- **Bearing Utilization**: $R / R' = 2820$ lb / 13 800 lb
- **Minimum Bearing Length (End Supports)**: $\ell_{b,min,end} = 0.716$ in

#### Reactions:

- **FactMax**: 2820 lb
- **Bearing**: 3.5 in
- **D**: 1270 lb
- **L**: 1550 lb

#### Design

1. Strong Axis Moment of Inertia: $I_x = 375$ in$^4$
2. Section Modulus: $S = 79$ in$^3$
3. Base Allowable Bending Stress: $F_b = 2600$ psi
4. Base Allowable Shear Stress: $F_v = 285$ psi
5. Base Perpendicular Compression Allowable Stress: $F_{cc} = 750$ psi
6. True Modulus of Elasticity: $E_{true} = 2 000 000$ psi
7. Apparent Modulus of Elasticity: $E_{app} = NaN$ psi
8. Modulus of Elasticity for Deflections: $E = 2 000 000$ psi

#### Elastic Modulus (NDS 2018.2.3)

- **Adjusted Modulus of Elasticity**: $E' = 2 000 000$ psi
- **Adjusted Shear Modulus**: $G' = 125 000$ psi

#### Section Bending (NDS 2018.2.3)

- **Volume Factor**: $C_V = 1.03$

#### Positive Bending (NDS 2018.2.3)

- **Governing Duration Factor - Positive Bending**: $C_{D,b} = 1$

#### Negative Bending (NDS 2018.2.3)

- **Governing Duration Factor - Negative Bending**: $C_{D,b} = 0.9$

#### Shear Design (NDS 2018.3.4)

- **Governing Duration Factor**: $C_D = 1$

#### Bearing (NDS 2018.3.10)

- **Base Bearing Strength**: $F_{cb} / C_b = 750$ psi

#### Comments

- \[ \text{Moment Utilization} = \frac{M}{M'} = \frac{8110 \text{ lb*ft}}{18 100 \text{ lb*ft}} \]
- \[ \text{Shear Utilization} = \frac{V}{V'} = \frac{2820 \text{ lb}}{9480 \text{ lb}} \]
- \[ \text{Bearing Utilization} = \frac{R}{R'} = \frac{2820 \text{ lb}}{13 800 \text{ lb}} \]
- \[ \text{Minimum Bearing Length (End Supports)} = \ell_{b,min,end} = 0.716 \text{ in} \]
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 50,000 \text{ lb}$ |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 50,000 \text{ lb}$ |

Key Properties

- **Member**: 8x8 D.Fir-L No. 1
- **Column Height**: $L = 9 \text{ ft}$
- **Continuous Bracing for Strong Axis Buckling**: No
- **Continuous Bracing for Weak Axis Buckling**: No
- **Continuous Bracing for Lateral Torsional Buckling**: No

Loads

Design Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression - Pure Axial Loading</td>
<td>$F_c^* = 1000 \text{ psi}$</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(l_e/d) = 14.4$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(l_e/b) = 14.4$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{c,x} = 888 \text{ psi}$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F'_{c,y} = 888 \text{ psi}$</td>
</tr>
</tbody>
</table>

Comments

- PASS

- $P_x' = P'_x = 50,000 \text{ lb}$
- $P_y' = P'_y = 50,000 \text{ lb}$

- $L = 9 \text{ ft}$

- $F_c^* = 1000 \text{ psi}$
- $(l_e/d) = 14.4$
- $(l_e/b) = 14.4$
- $F'_{c,x} = 888 \text{ psi}$
- $F'_{c,y} = 888 \text{ psi}$
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 35,700$ lb |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 35,700$ lb |

Key Properties

| Member | 8x8 D.Fir-L No. 2 |
| Column Height | $L = 9$ ft |
| Continuous Bracing for Strong Axis Buckling | No |
| Continuous Bracing for Weak Axis Buckling | No |
| Continuous Bracing for Lateral Torsional Buckling | No |

Design Conditions

| Capacity in Pure Axial Loading (NDS 2018 Section 3.7) | |
| Fully Braced Compression Strength - Pure Axial Loading | $F_{c,x} = 700$ psi |
| Governing Slenderness - X-axis | $(l_e/d) = 14.4$ |
| Governing Slenderness - Y-axis | $(l_e/b) = 14.4$ |
| Adjusted Compression Strength (X-axis) | $F'_{c,x} = 634$ psi |
| Adjusted Compression Strength (Y-axis) | $F'_{c,y} = 634$ psi |

Comments
Summary

Allowable Compressive Load (X-Axis Buckling) \( P'_x = 50,000 \text{ lb} \)
Allowable Compressive Load (Y-Axis Buckling) \( P'_y = 50,000 \text{ lb} \)

Key Properties

<table>
<thead>
<tr>
<th>Member</th>
<th>8x8 D.Fir-L No. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Height</td>
<td>( L = 9 \text{ ft} )</td>
</tr>
<tr>
<td>Continuous Bracing for Strong Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Weak Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Lateral Torsional Buckling</td>
<td>No</td>
</tr>
</tbody>
</table>

Loads

Design Conditions

Design Code for Load Combinations

International Building Code (IBC 2018)

Capacity in Pure Axial Loading (NDS 2018 Section 3.7)

- Fully Braced Compression
  - Fully Braced Compression Strength - Pure Axial Loading \( F'_c = 1000 \text{ psi} \)
  - \( (L_e/d) = 14.4 \)
  - \( (L_e/b) = 14.4 \)
  - Adjusted Compression Strength (X-axis) \( F'_{c,x} = 888 \text{ psi} \)
  - Adjusted Compression Strength (Y-axis) \( F'_{c,y} = 888 \text{ psi} \)

Comments

PASS

44% \( P'_x = P'_x = 50,000 \text{ lb} \)

44% \( P'_y = P'_y = 50,000 \text{ lb} \)
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 50,000$ lb |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 50,000$ lb |

Key Properties

| Member | 8x8 D.Fir-L No. 1 |
| Column Height | $L = 9$ ft |
| Continuous Bracing for Strong Axis Buckling | No |
| Continuous Bracing for Weak Axis Buckling | No |
| Continuous Bracing for Lateral Torsional Buckling | No |

Loads

![Distance from Bottom of Column (ft)]

Self-weight

<table>
<thead>
<tr>
<th>Distance from Bottom of Column (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
</tbody>
</table>

Design Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
<td>$F'_c = 1000$ psi</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(\ell_e/d) = 14.4$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(\ell_e/b) = 14.4$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{c,x} = 888$ psi</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F'_{c,y} = 888$ psi</td>
</tr>
</tbody>
</table>

Comments
Summary

- Allowable Compressive Load (X-Axis Buckling) \( P'_x = 16,900 \text{ lb} \)
- Allowable Compressive Load (Y-Axis Buckling) \( P'_y = 16,900 \text{ lb} \)

Key Properties

<table>
<thead>
<tr>
<th>Member</th>
<th>6x6 D.Fir-L No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Height</td>
<td>( L = 9 \text{ ft} )</td>
</tr>
<tr>
<td>Continuous Bracing for Strong Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Weak Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Lateral Torsional Buckling</td>
<td>No</td>
</tr>
</tbody>
</table>

Design Conditions

- Design Code for Load Combinations
  - Capacity in Pure Axial Loading (NDS 2018 Section 3.7)
    - Fully Braced Compression Strength - Pure Axial Loading \( F'_c = 700 \text{ psi} \)
    - Governing Slenderness - X-axis \( (l_e / d) = 19.6 \)
    - Governing Slenderness - Y-axis \( (l_e / b) = 19.6 \)
    - Adjusted Compression Strength (X-axis) \( F'_{e,x} = 559 \text{ psi} \)
    - Adjusted Compression Strength (Y-axis) \( F'_{e,y} = 559 \text{ psi} \)

Comments

\[ 25\% \quad P'_x = P'_x = 16,900 \text{ lb} \]
\[ 25\% \quad P'_y = P'_y = 16,900 \text{ lb} \]
\[ L = 9 \text{ ft} \]
\[ F'_c = 700 \text{ psi} \]
\[ (l_e / d) = 19.6 \]
\[ F'_{e,x} = 559 \text{ psi} \]
\[ F'_{e,y} = 559 \text{ psi} \]
Summary

- **Allowable Compressive Load (X-Axis Buckling)**: \( P'_x = 16,900 \, \text{lb} \)
- **Allowable Compressive Load (Y-Axis Buckling)**: \( P'_y = 16,900 \, \text{lb} \)

Key Properties

- **Member**: 6x6 D.Fir-L No. 2
- **Column Height**: \( L = 9 \, \text{ft} \)
- **Continuous Bracing for Strong Axis Buckling**: No
- **Continuous Bracing for Weak Axis Buckling**: No
- **Continuous Bracing for Lateral Torsional Buckling**: No

Loads

- **B-9-1**
  - **D**: 4050 lb
  - **L**: 5060 lb

Design Conditions

- **Design Code for Load Combinations**
- **International Building Code (IBC) 2018**

**Capacity in Pure Axial Loading (NDS 2018 Section 3.7)**

- **Fully Braced Compression Strength - Pure Axial Loading**: \( F'_c = 700 \, \text{psi} \)
- **Governing Slenderness - X-axis**: \( (\ell_e/d) = 19.6 \)
- **Governing Slenderness - Y-axis**: \( (\ell_e/b) = 19.6 \)
- **Adjusted Compression Strength (X-axis)**: \( F'_{c,x} = 559 \, \text{psi} \)
- **Adjusted Compression Strength (Y-axis)**: \( F'_{c,y} = 559 \, \text{psi} \)

Comments
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 28,600$ lb |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 8,850$ lb |

Key Properties

- **Member**: 4x6 D.Fir-L No. 2
- **Column Height**: $L = 9$ ft
- **Continuous Bracing for Strong Axis Buckling**: Yes
- **Continuous Bracing for Weak Axis Buckling**: No
- **Continuous Bracing for Lateral Torsional Buckling**: No

Design Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
<td>$F'_c = 1490$ psi</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(\ell_e/d) = 0$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(\ell_e/b) = 30.9$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{c,x} = 1480$ psi</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F'_{c,y} = 460$ psi</td>
</tr>
</tbody>
</table>

Comments
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 7650 \text{ lb}$ |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 12300 \text{ lb}$ |
| Allowable X-Axis Moment | $M'_x = 1360 \text{ lb-ft}$ |
| Combined Compression / Bending | $Int_C = 0.194$ |
| Governing Live / Short-Term X-Axis Deflection | $\delta_{x,ST} = 0.0745 \text{ in}$ |
| Critical Live / Short-Term X-Axis Deflection Ratio | $(L/)_x,ST = 1450$ |
| Governing Long-Term X-Axis Deflection | $\delta_{x,LT} = 0.018 \text{ in}$ |
| Critical Long-Term X-Axis Deflection Ratio | $(L/)_x,LT = 6000$ |

Key Properties

- Member: 2x6 D.Fir-L No. 2
- Column Height: $L = 9 \text{ ft}$
- Continuous Bracing for Strong Axis Buckling: No
- Continuous Bracing for Weak Axis Buckling: Yes
- Continuous Bracing for Lateral Torsional Buckling: Yes

Loads

Design Conditions

Design Code for Load Combinations

<table>
<thead>
<tr>
<th>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
</tr>
</tbody>
</table>

Shear Design (NDS 2018 3.4)

| Shear Capacity (X-axis) | $V'_{nx} = 1580 \text{ lb}$ |

Comments
Summary

Design Conditions

- **Design Code for Load Combinations**
- **International Building Code (IBC) 2018**

Member Properties

- **Cross-Sectional Area** \( A = 19.2 \, \text{in}^2 \)
- **Strong Axis Moment of Inertia** \( I_{xx} = 48.5 \, \text{in}^4 \)
- **Section Modulus** \( S = 17.6 \, \text{in}^3 \)
- **Base Allowable Bending Stress** \( F_b^0 = 900 \, \text{psi} \)
- **Base Allowable Shear Stress** \( F_v^0 = 180 \, \text{psi} \)
- **Base Perpendicular Compression Allowable Stress** \( F_{c\perp}^0 = 625 \, \text{psi} \)
- **True Modulus of Elasticity** \( E_{true} = 1 \, 600,000 \, \text{psi} \)
- **Apparent Modulus of Elasticity** \( E_{app} = 1 \, 600,000 \, \text{psi} \)
- **Modulus of Elasticity for Deflections** \( E = 1 \, 600,000 \, \text{psi} \)

**Elastic Modulus (NDS 2018 2.3)**

- **Adjusted Modulus of Elasticity** \( E' = 1 \, 600,000 \, \text{psi} \)

**Section Bending (NDS 2018 2.3)**

- **Size Factor** \( C_{F,b} = 1.3 \)
- **Incising Factor** \( C_{i,b} = 1 \)

**Positive Bending (NDS 2018 2.3)**

- **Governing Duration Factor** \( C_{D,b}^+ = 1 \)
- **Governing Beam Stability Factor** \( C_{L}^+ = 0.996 \)
- **Adjusted Bending Strength** \( F_{b}^+ = 1170 \, \text{psi} \)

**Negative Bending (NDS 2018 2.3)**

- **Governing Duration Factor** \( C_{D,b}^- = 0.9 \)
- **Governing Beam Stability Factor** \( C_{L}^- = 0.997 \)
- **Adjusted Bending Strength** \( F_{b}^- = 1050 \, \text{psi} \)

**Shear Design (NDS 2018 3.4)**

- **Governing Duration Factor** \( C_D = 1 \)
- **Adjusted Shear Strength** \( F_v^0 = 180 \, \text{psi} \)

**Bearing (NDS 2018 3.10)**

- **Base Bearing Strength** \( F_{c\perp}^0 / C_b = 625 \, \text{psi} \)

Comments

Key Properties

- **Beam Plan Length** \( L_X = 3.75 \, \text{ft} \)
- **Continuous Bracing for Lateral Torsional Buckling** No Continuous Bracing

Loads

- **3.5” Max Tap, Shallow Vercor**
  - L.W. 8 ft: D. 43.7 psf, L. 60 psf
  - W. 3 R: D. 1.35 psf
  - D. 3.7 psf
  - D. 44.4 psf
- **Self-weight**
  - 0.0
  - 1.0
  - 2.0
  - 3.0
  - Distance from Left of Beam(f)

Bearing

- **Bearing** 3 in
  - FactMin: 640 lb
  - FactMax: 1040 lb
  - D: 238 lb
  - L: 360 lb

Moment Utilization

- 4x6 D.Fir-L No. 2
- \( M / M' = 1540 \, \text{lb}\cdot\text{ft} / 1710 \, \text{lb}\cdot\text{ft} \)

Shear Utilization

- \( V / \bar{V}' = 1640 \, \text{lb} / 2310 \, \text{lb} \)

Minimum Bearing Length (End Supports)

- \( \delta_{b,\text{min,end}} = 0.749 \, \text{in} \)

Governing Live / Short-Term Deflection

- \( \delta_{ST} = -0.0275 \, \text{in} / (L/1640) \)

Governing Long-Term Deflection

- \( \delta_{LT} = -0.0388 \, \text{in} / (L/1160) \)

Reactions:

- **Bearing** 3 in
  - FactMin: 640 lb
  - FactMax: 1040 lb
  - D: 238 lb
  - L: 360 lb

- **Wall Load**
  - 3.5’ Max Tap: 43.7 psf; 60 psf
  - 3 W. 3 R: 13 psf
  - 1.35 psf
  - 4.44 psf

- **Self-weight**
  - 0.0
  - 1.0
  - 2.0
  - 3.0
  - Distance from Left of Beam(f)

Design Conditions

- **Subject:** HDR-1
- **Client:** Cameron Cunningham
- **Project:** C.S.P. - Prior Consideration Design
- **Author:** John Lawson
- **Date:** Oct 14, 2023
- **Job #:** ARCE 453-01
### Dimensions

[Diagram of Shallow VERCOR™ 9/16" Deep Deck with 36" Span, 9/8" Depth, and Standard Overlapping Sidelap]

### Deck Weight and Section Properties

<table>
<thead>
<tr>
<th>Gage</th>
<th>Weight (psf)</th>
<th>I_d for Deflection</th>
<th>Moment</th>
<th>Allowable Reactions per ft of Width (lb) due to Web Crippling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Galv Single Span (in. 4/ft)</td>
<td>Multi Span (in. 4/ft)</td>
<td>+S_eff</td>
<td>-S_eff</td>
</tr>
<tr>
<td>26</td>
<td>1.0</td>
<td>0.013</td>
<td>0.013</td>
<td>0.041</td>
</tr>
<tr>
<td>24</td>
<td>1.3</td>
<td>0.018</td>
<td>0.018</td>
<td>0.059</td>
</tr>
<tr>
<td>22</td>
<td>1.6</td>
<td>0.022</td>
<td>0.022</td>
<td>0.073</td>
</tr>
</tbody>
</table>

Notes:
1. Section properties are based on F_y = 60,000 psi (specified minimum F_y = 80,000 psi).
2. I_d is for deflection due to uniform loads.
3. S_eff (+ or -) is the effective section modulus.
4. Allowable (ASD) reactions are based on web crippling, per AISI S100 Section C3.4, where Ω_w = 1.70 for end bearing and 1.75 for interior bearing. Nominal reactions may be determined by multiplying the table values by Ω_w. LRFD reactions may be determined by multiplying nominal reactions by ϕ_w = 0.9 for end reactions and 0.85 for interior reactions.

### Attachment Patterns to Supports

- 36/3
- 36/4
- 36/5
- 36/6
### Allowable Interior Diaphragm Shear Strengths, q (plf) and Flexibility Factors, F (in./lb. x 10^6)

<table>
<thead>
<tr>
<th>Deck Gage</th>
<th>Total Slab Thickness</th>
<th>Attachment Pattern</th>
<th>Span (ft-in.)</th>
<th>2'-0&quot;</th>
<th>2'-6&quot;</th>
<th>3'-0&quot;</th>
<th>3'-6&quot;</th>
<th>4'-0&quot;</th>
<th>4'-6&quot;</th>
<th>5'-0&quot;</th>
<th>5'-6&quot;</th>
<th>6'-0&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ext. Patio</td>
<td>3.0&quot;</td>
<td>q - 3 screws</td>
<td>1629</td>
<td>1600</td>
<td>1582</td>
<td>1566</td>
<td>1559</td>
<td>1549</td>
<td>1541</td>
<td>1535</td>
<td>1529</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 4 screws</td>
<td>1642</td>
<td>1611</td>
<td>1591</td>
<td>1574</td>
<td>1566</td>
<td>1555</td>
<td>1547</td>
<td>1540</td>
<td>1534</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 5 screws</td>
<td>1658</td>
<td>1624</td>
<td>1603</td>
<td>1584</td>
<td>1575</td>
<td>1564</td>
<td>1554</td>
<td>1547</td>
<td>1541</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 6 screws</td>
<td>1694</td>
<td>1653</td>
<td>1628</td>
<td>1606</td>
<td>1595</td>
<td>1582</td>
<td>1571</td>
<td>1562</td>
<td>1554</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness ≥ 3.5&quot;</td>
<td>q - 3 screws</td>
<td>1931</td>
<td>1902</td>
<td>1884</td>
<td>1868</td>
<td>1860</td>
<td>1851</td>
<td>1843</td>
<td>1837</td>
<td>1831</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 4 screws</td>
<td>1642</td>
<td>1611</td>
<td>1591</td>
<td>1574</td>
<td>1566</td>
<td>1555</td>
<td>1547</td>
<td>1540</td>
<td>1534</td>
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<tr>
<td></td>
<td></td>
<td>q - 5 screws</td>
<td>1658</td>
<td>1624</td>
<td>1603</td>
<td>1584</td>
<td>1575</td>
<td>1564</td>
<td>1554</td>
<td>1547</td>
<td>1541</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 6 screws</td>
<td>1694</td>
<td>1653</td>
<td>1628</td>
<td>1606</td>
<td>1595</td>
<td>1582</td>
<td>1571</td>
<td>1562</td>
<td>1554</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>3.0&quot;</td>
<td>q - 3 screws</td>
<td>1691</td>
<td>1651</td>
<td>1625</td>
<td>1603</td>
<td>1592</td>
<td>1579</td>
<td>1568</td>
<td>1559</td>
<td>1552</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 4 screws</td>
<td>1708</td>
<td>1665</td>
<td>1637</td>
<td>1614</td>
<td>1602</td>
<td>1588</td>
<td>1576</td>
<td>1566</td>
<td>1558</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 5 screws</td>
<td>1730</td>
<td>1682</td>
<td>1653</td>
<td>1627</td>
<td>1614</td>
<td>1598</td>
<td>1586</td>
<td>1575</td>
<td>1567</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 6 screws</td>
<td>1777</td>
<td>1721</td>
<td>1687</td>
<td>1656</td>
<td>1641</td>
<td>1623</td>
<td>1607</td>
<td>1595</td>
<td>1585</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness ≥ 3.5&quot;</td>
<td>q - 3 screws</td>
<td>1993</td>
<td>1952</td>
<td>1927</td>
<td>1905</td>
<td>1894</td>
<td>1881</td>
<td>1870</td>
<td>1861</td>
<td>1854</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 4 screws</td>
<td>2010</td>
<td>1967</td>
<td>1939</td>
<td>1915</td>
<td>1904</td>
<td>1889</td>
<td>1878</td>
<td>1868</td>
<td>1860</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 5 screws</td>
<td>2032</td>
<td>1984</td>
<td>1955</td>
<td>1929</td>
<td>1916</td>
<td>1900</td>
<td>1888</td>
<td>1877</td>
<td>1868</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 6 screws</td>
<td>2079</td>
<td>2023</td>
<td>1988</td>
<td>1958</td>
<td>1943</td>
<td>1924</td>
<td>1909</td>
<td>1897</td>
<td>1887</td>
<td></td>
</tr>
<tr>
<td>Int. Flooring</td>
<td>Thickness ≥ 4.0&quot;</td>
<td>q - 3 screws</td>
<td>2295</td>
<td>2254</td>
<td>2229</td>
<td>2207</td>
<td>2196</td>
<td>2182</td>
<td>2172</td>
<td>2163</td>
<td>2155</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 3 screws</td>
<td>1756</td>
<td>1703</td>
<td>1650</td>
<td>1602</td>
<td>1592</td>
<td>1579</td>
<td>1568</td>
<td>1559</td>
<td>1552</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 4 screws</td>
<td>1777</td>
<td>1721</td>
<td>1685</td>
<td>1655</td>
<td>1640</td>
<td>1621</td>
<td>1606</td>
<td>1594</td>
<td>1584</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 5 screws</td>
<td>1804</td>
<td>1743</td>
<td>1705</td>
<td>1671</td>
<td>1655</td>
<td>1635</td>
<td>1618</td>
<td>1605</td>
<td>1594</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>q - 6 screws</td>
<td>1863</td>
<td>1792</td>
<td>1747</td>
<td>1708</td>
<td>1689</td>
<td>1665</td>
<td>1645</td>
<td>1630</td>
<td>1616</td>
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</tr>
<tr>
<td></td>
<td>Thickness ≥ 4.5&quot;</td>
<td>q - 3 screws</td>
<td>2857</td>
<td>2805</td>
<td>2752</td>
<td>2700</td>
<td>2648</td>
<td>2636</td>
<td>2626</td>
<td>2617</td>
<td>2609</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>q - 4 screws</td>
<td>2879</td>
<td>2823</td>
<td>2769</td>
<td>2725</td>
<td>2673</td>
<td>2661</td>
<td>2652</td>
<td>2642</td>
<td>2633</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>q - 5 screws</td>
<td>2904</td>
<td>2845</td>
<td>2797</td>
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<td>2690</td>
<td>2680</td>
<td>2671</td>
<td>2662</td>
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<tr>
<td></td>
<td></td>
<td>q - 6 screws</td>
<td>2979</td>
<td>2923</td>
<td>2875</td>
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<td>2768</td>
<td>2758</td>
<td>2749</td>
<td>2740</td>
<td></td>
</tr>
</tbody>
</table>

See footnotes on page 135. See page 131 for vertical loads footnotes.
Concrete Properties

<table>
<thead>
<tr>
<th>Density (pcf)</th>
<th>Uniform Weight (psf)</th>
<th>Uniform Volume (yd³/100 ft²)</th>
<th>Compressive Strength, f' c (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>145</td>
<td>32.9 to 69.1</td>
<td>0.839 to 1.852</td>
<td>3000</td>
</tr>
</tbody>
</table>

Notes:
1. Volumes and weights do not include allowance for deflection.
2. Weights are for concrete only and do not include weight of steel deck.
3. Total slab depth is nominal depth from top of concrete to bottom of steel deck.

Footnotes for Maximum Unshored Clear Span and Allowable Diaphragm Shear Strength Tables

1. Interior connections may be #12, #14 or Shearflex® screws.
2. Connections at diaphragm perimeter or other collector elements are to be based on the actual shear to be transferred and the capacity of the connections used.
3. If higher shear values than those shown are required, please contact Verco Engineering Dept.
4. SV decks with structural concrete fill have a Flexibility Factor of F <1.
5. Sidelap connections - minimum 1 - #10 screw per span, maximum 36" oc spacing.
6. A continuous 3 span condition is assumed for all span lengths 4 ft and greater. For span lengths less than 4 ft, a 12 ft long sheet is assumed, with a maximum of 7 continuous spans.

Maximum Unshored Clear Span (ft-in.)

<table>
<thead>
<tr>
<th>Gage</th>
<th>Span</th>
<th>3.0&quot; NW</th>
<th>3.5&quot; NW</th>
<th>4.0&quot; NW</th>
<th>4.5&quot; NW</th>
<th>5.0&quot; NW</th>
<th>5.5&quot; NW</th>
<th>6.0&quot; NW</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>1</td>
<td>2'-3&quot;</td>
<td>2'-5&quot;</td>
<td>2'-4&quot;</td>
<td>2'-3&quot;</td>
<td>2'-2&quot;</td>
<td>2'-2&quot;</td>
<td>2'-1&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2'-11&quot;</td>
<td>2'-10&quot;</td>
<td>2'-9&quot;</td>
<td>2'-8&quot;</td>
<td>2'-7&quot;</td>
<td>2'-7&quot;</td>
<td>2'-6&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3'-0&quot;</td>
<td>2'-11&quot;</td>
<td>2'-9&quot;</td>
<td>2'-8&quot;</td>
<td>2'-8&quot;</td>
<td>2'-7&quot;</td>
<td>2'-6&quot;</td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td>3'-3&quot;</td>
<td>3'-2&quot;</td>
<td>3'-1&quot;</td>
<td>3'-0&quot;</td>
<td>2'-11&quot;</td>
<td>2'-10&quot;</td>
<td>2'-9&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3'-11&quot;</td>
<td>3'-9&quot;</td>
<td>3'-8&quot;</td>
<td>3'-6&quot;</td>
<td>3'-5&quot;</td>
<td>3'-4&quot;</td>
<td>3'-3&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3'-11&quot;</td>
<td>3'-10&quot;</td>
<td>3'-8&quot;</td>
<td>3'-7&quot;</td>
<td>3'-6&quot;</td>
<td>3'-4&quot;</td>
<td>3'-3&quot;</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>3'-8&quot;</td>
<td>3'-6&quot;</td>
<td>3'-4&quot;</td>
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<td>2</td>
<td>4'-7&quot;</td>
<td>4'-5&quot;</td>
<td>4'-3&quot;</td>
<td>4'-1&quot;</td>
<td>4'-0&quot;</td>
<td>3'-10&quot;</td>
<td>3'-9&quot;</td>
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<tr>
<td></td>
<td>3</td>
<td>4'-6&quot;</td>
<td>4'-3&quot;</td>
<td>4'-1&quot;</td>
<td>3'-11&quot;</td>
<td>3'-10&quot;</td>
<td>3'-8&quot;</td>
<td>3'-7&quot;</td>
</tr>
</tbody>
</table>

1. Shoring calculations based on the following:
   • Deck supporting dead load of concrete plus 20 psf uniform construction load or 150 pound concentrated construction live load for flexure.
   • Dead load deflection limited to L/180 of span length, not to exceed 3/4".
   • Allowable reactions based on maximum bearing length permitted by AISI S100. Support reactions for unshored spans due to dead loads and uniform construction live loads must be evaluated based on the allowable reactions set forth on page 128.
2. Shoring is required at midspan for spans greater than those shown.

for 4.5" - will use Avg. of 56.25 psf for design

for 5.5" - will use 69.1 psf for design
Structural Concrete on Steel w/ Verco
Alternative Steel Design:
Structural, Verco Decking with all Steel Framing

Key Plan
Alternative Steel Design:  
Structural, Verco Decking with all Steel Framing

Note: to help with constructibility, oversize specific beams to as many connection points are flush. along grid lines, size most loaded largest beam, reuse size for continuing members. Primarily do separate calc’s to account for differing loading cases.

Design Key Plan

Refer to Clear Calc. Reports for design member choices

Being conservative with using maximum of height of 9’ for all columns for worst cases
<table>
<thead>
<tr>
<th>Calculation</th>
<th>Member</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-1</td>
<td>14&quot; TJI 230</td>
<td>7 ft</td>
<td></td>
</tr>
<tr>
<td>J-2</td>
<td>1-3/4x14 Microllam LVL 2.0E-2600Fb</td>
<td>2.33 ft</td>
<td></td>
</tr>
<tr>
<td>J-3</td>
<td>2 - 1-3/4x14 Microllam LVL 2.0E-2600Fb</td>
<td>11.3 ft</td>
<td></td>
</tr>
<tr>
<td>J-4</td>
<td>14&quot; TJI 230</td>
<td>11.3 ft</td>
<td></td>
</tr>
<tr>
<td>J-5</td>
<td>9-1/2&quot; TJI 230</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>L-1</td>
<td>1-3/4x5-1/2 Microllam LVL 2.0E-2600Fb</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>B-1</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-2</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-3</td>
<td>5-1/2x14 24F-1.8E</td>
<td>18.5 ft</td>
<td></td>
</tr>
<tr>
<td>B-4</td>
<td>5-1/2x9-1/2 24F-1.8E</td>
<td>8.5 ft</td>
<td></td>
</tr>
<tr>
<td>B-5</td>
<td>5-1/2x14 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-6</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18.8 ft</td>
<td></td>
</tr>
<tr>
<td>B-7</td>
<td>8-3/4x21 24F-1.8E</td>
<td>18 ft</td>
<td></td>
</tr>
<tr>
<td>B-8</td>
<td>5-1/2x16 24F-1.8E</td>
<td>18.8 ft</td>
<td></td>
</tr>
<tr>
<td>B-9</td>
<td>5-1/2x16 24F-1.8E</td>
<td>18.8 ft</td>
<td></td>
</tr>
<tr>
<td>B-10</td>
<td>3 - 1-3/4x9-1/2 Microllam LVL 2.0E-2600Fb</td>
<td>11.5 ft</td>
<td></td>
</tr>
<tr>
<td>C1-1</td>
<td>8x8 D.Fir-L No. 1</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C1-2</td>
<td>8x8 D.Fir-L No. 2</td>
<td>9 ft</td>
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</tr>
<tr>
<td>C2-1</td>
<td>8x8 D.Fir-L No. 1</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C2-2</td>
<td>8x8 D.Fir-L No. 1</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>6x6 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>6x6 D.Fir-L No. 2</td>
<td>9 ft</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>4x6 D.Fir-L No. 2</td>
<td>9 ft</td>
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<tr>
<td>HDR-1</td>
<td>4x6 D.Fir-L No. 2</td>
<td>3.75 ft</td>
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</tbody>
</table>

**Typ. Ext. Bearing Wall**

2x6 D.Fir-L No. 2 | 9 ft
Summary

Member
- 14" TJI 230
  - Moment Utilization: $M / M' = \frac{806 \text{ lb}\cdot\text{ft}}{4990 \text{ lb}\cdot\text{ft}}$
  - Shear Utilization: $V / V' = \frac{461 \text{ lb}}{1950 \text{ lb}}$
  - Governing Live / Short-Term Deflection: $\delta_{ST} = -0.0143$ in (L/5880)
  - Governing Long-Term Deflection: $\delta_{LT} = -0.0184$ in (L/4550)

Reactions:
- Bearing: 3 in
- FactMax: 461 lb
- FactMin: 164 lb
- D: 274 lb
- L: 187 lb

Key Properties
- Beam Plan Length: $L_X = 7$ ft

Design Conditions
- Base Allowable Moment: $M_r = 4990 \text{ lb}\cdot\text{ft}$
- Base Allowable Shear: $V_r = 1950 \text{ lb}$
- Base Perpendicular Compression Allowable Stress: $F_{c\perp} = 0 \text{ psi}$

Section Bending (NDS 2018 2.3)
- Governing Duration Factor in Bending: $C_{DB} = 1$
- Beam Stability Factor: $C_L = 1$
- Adjusted Allowable Moment: $M'_r = 4990 \text{ lb}\cdot\text{ft}$

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: $C_{D'} = 1$
- Adjusted Allowable Shear: $V'_r = 1950 \text{ lb}$

Bearing (NDS 2018 3.10)
- Base Bearing Strength: $F_{c\perp}/C_b = 0 \text{ psi}$

Comments
Summary

Member

- Moment Utilization: \( \frac{M}{M'} = 225 \text{ lb\cdotft} / 12600 \text{ lb\cdotft} \)
- Shear Utilization: \( \frac{V}{V'} = 387 \text{ lb} / 4650 \text{ lb} \)
- Bearing Utilization: \( \frac{R}{R'} = 387 \text{ lb} / 3940 \text{ lb} \)
- Minimum Bearing Length (End Supports): \( b_{b, min,end} = 0.295 \text{ in} \)
- Governing Live / Short-Term Deflection: \( \delta_{ST} = -0.000975 \text{ in} / (L/28700) \)
- Governing Long-Term Deflection: \( \delta_{LT} = -0.00104 \text{ in} / (L/27000) \)
- Governing Long-Term Deflection: \( \delta_{LT} = -0.00104 \text{ in} / (L/27000) \)

Reactions:

- Bearing: 3 in
- FactMax: 387 lb
- FactMin: 104 lb
- D: 174 lb
- L: 214 lb

Key Properties

- Beam Plan Length: \( L_X = 2.33 \text{ ft} \)
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

Loads

- J-1.5 [for J-2 Design]: 1
- 4.5\" Shallow Vercor: LW: 11.33 lb | D: 56.2 psf | L: 40 psf
- Self Weight: 3.7 in

Design Conditions


Member Properties

- Cross-Sectional Area: \( A = 24.5 \text{ in}^2 \)
- Strong Axis Moment of Inertia: \( I_{xx} = 400 \text{ in}^4 \)
- Section Modulus: \( S = 57.2 \text{ in}^3 \)
- Base Allowable Bending Stress: \( F_b = 2600 \text{ psi} \)
- Base Allowable Shear Stress: \( F_c = 285 \text{ psi} \)
- Base Perpendicular Compression Allowable Stress: \( F_{b,c} = 750 \text{ psi} \)
- True Modulus of Elasticity: \( E = 2000000 \text{ psi} \)
- Apparent Modulus of Elasticity: \( E_{app} = N_a N \text{ psi} \)
- Modulus of Elasticity for Deflections: \( E = 2000000 \text{ psi} \)

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity: \( E' = 2000000 \text{ psi} \)
- Adjusted Shear Modulus: \( G' = 125000 \text{ psi} \)

Section Bending (NDS 2018 2.3)

- Volume Factor: \( C_V = 0.979 \)
- Governing Duration Factor - Positive Bending: \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending: \( C_L^+ = 1 \)
- Adjusted Bending Strength - Positive Bending: \( F_b^+ = 2650 \text{ psi} \)

Negative Bending (NDS 2018 2.3)

- Governing Duration Factor - Negative Bending: \( C_{D,b} = 0.9 \)
- Governing Beam Stability Factor - Negative Bending: \( C_L^- = 0.782 \)
- Adjusted Bending Strength - Negative Bending: \( F_b^- = 1900 \text{ psi} \)

Shear Design (NDS 2018 3.4)

- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Shear Strength: \( F_c = 285 \text{ psi} \)

Bearing (NDS 2018 3.10)

- Base Bearing Strength: \( F_{b,c} / C_b = 750 \text{ psi} \)

Comments
Summary

Member

- 13% Moment Utilization
- 26% Shear Utilization
- 38% Bearing Utilization

- Minimum Bearing Length (End Supports) \( \ell_{b,\text{min,end}} = 1.14 \) in
- Minimum Bearing Length (Int Supports) \( \ell_{b,\text{min,int}} = 1.26 \) in

Reactions:

- Positive Bending
- Negative Bending

Key Properties

- Beam Plan Length \( L_X = 11.3 \) ft
- Continuous Bracing for Lateral Torsional Buckling

No Continuous Bracing

Loads

Design Conditions

- Design Code for Load Combinations
- International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area \( A = 49 \) in²
- Strong Axis Moment of Inertia \( I_{xx} = 800 \) in⁴
- Section Modulus \( S = 114 \) in³
- Base Allowable Bending Stress \( F_b = 2600 \) psi
- Base Allowable Shear Stress \( F_c = 285 \) psi
- Base Perpendicular Compression Allowable Stress \( F_p = 750 \) psi
- True Modulus of Elasticity \( E_{true} = 2,000,000 \) psi
- Apparent Modulus of Elasticity \( E_{app} = N_a N \) psi
- Modulus of Elasticity for Deflections \( E = 2,000,000 \) psi

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity \( E' = 2,000,000 \) psi
- Adjusted Shear Modulus \( G' = 125,000 \) psi

Section Bending (NDS 2018 2.3)

- Volume Factor \( C_V = 0.979 \)

Positive Bending (NDS 2018 2.3)

- Governing Duration Factor - Positive Bending \( C_{D,b} = 1.25 \)
- Governing Beam Stability Factor - Positive Bending \( C_L = 0.96 \)
- Adjusted Bending Strength - Positive Bending \( F_b' = 3120 \) psi

Negative Bending (NDS 2018 2.3)

- Governing Duration Factor - Negative Bending \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Negative Bending \( C_L = 0.972 \)
- Adjusted Bending Strength - Negative Bending \( F_b' = 2530 \) psi

References:

NDS 2018 (ASD)
<table>
<thead>
<tr>
<th>Shear Design (NDS 2018 3.4)</th>
<th>Bearing (NDS 2018 3.10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governing Duration Factor</td>
<td>Base Bearing Strength</td>
</tr>
<tr>
<td>$C_D = 1.25$</td>
<td>$F'_c / C_b = 750 \text{ psi}$</td>
</tr>
<tr>
<td>Adjusted Shear Strength</td>
<td></td>
</tr>
<tr>
<td>$F'_v = 356 \text{ psi}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comments</td>
</tr>
</tbody>
</table>
Summary

Member 14" TJI 230
Moment Utilization: \( M/M' = \frac{526 \text{ lb}\cdot\text{ft}}{4990 \text{ lb}\cdot\text{ft}} \)
Shear Utilization: \( V/V' = \frac{472 \text{ lb}}{1950 \text{ lb}} \)
Bearing Utilization: \( R/R' = \frac{930 \text{ lb}}{2790 \text{ lb}} \)

Deflection:
- Long-Term: \(-0.00769\) in \(\text{L}/9060\)
- Long-Term: \(-0.00769\) in \(\text{L}/10200\)

Design Conditions

- Member Properties:
  - Base Allowable Moment: \( M_b = 4990 \text{ lb}\cdot\text{ft} \)
  - Base Allowable Shear: \( V_b = 1950 \text{ lb} \)
  - Base Perpendicular Compression Allowable Stress: \( F_{c\perp} = 0 \text{ psi} \)

Section Bending (NDS 2018 2.3)
- Governing Duration Factor in Bending: \( C_{D,b} = 1 \)
- Beam Stability Factor: \( C_L = 1 \)
- Adjusted Allowable Moment: \( M_b' = 4990 \text{ lb}\cdot\text{ft} \)

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Allowable Shear: \( V_b' = 1950 \text{ lb} \)

Bearing (NDS 2018 3.10)
- Base Bearing Strength: \( F_{c\perp}/C_b = 0 \) psi

Comments

Key Properties
- Beam Plan Length: \( L_X = 11.3 \text{ ft} \)

Reactions:
- Bearing: 3 in
  - FactMax: 266 lb
  - FactMin: 95 lb
  - D: 158 lb
  - L: 108 lb
- Bearing: 5.5 in
  - FactMax: 291 lb
  - FactMin: 104 lb
  - D: 173 lb
  - L: 118 lb

Loads
- Self-weight
  - Distance from Left of Beam (ft)
  - 0
  - 2
  - 4
  - 6
  - 8
  - 10
- 4.5" Shallow Vercor
  - LW: 1.33 ft | D: 56.2 psf | L: 40 psf
- D: 75 psf
  - C: 5.5 ft
  - L: 17.3 ft
- D: 3.3 psf
  - C: 7.7 ft

Pass
Summary

Member
- 9-1/2" TJI 230
- Moment Utilization: \( M/M' = \frac{1430 \text{ lb}\cdot\text{ft}}{3330 \text{ lb}\cdot\text{ft}} \)
- Shear Utilization: \( V/V' = \frac{635 \text{ lb}}{1330 \text{ lb}} \)
- Governing Live / Short-Term Deflection: \( \delta_{ST} = -0.0825 \text{ in} \) (L/1310)
- Governing Long-Term Deflection: \( \delta_{LT} = -0.104 \text{ in} \) (L/1040)

Design Conditions

Member Properties
- Base Allowable Moment: \( M_r = 3330 \text{ lb}\cdot\text{ft} \)
- Base Perpendicular Compression Allowable Stress: \( F_{c\perp} = 0 \text{ psi} \)

Section Bending (NDS 2018 2.3)
- Governing Duration Factor in Bending: \( C_D,b = 1 \)
- Beam Stability Factor: \( C_L = 1 \)
- Adjusted Allowable Moment: \( M_r' = 3330 \text{ lb}\cdot\text{ft} \)

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: \( C_D = 1 \)
- Adjusted Allowable Shear: \( V_r' = 1330 \text{ lb} \)

Bearing (NDS 2018 3.10)
- Base Bearing Strength: \( F_{c\perp} C_b = 0 \text{ psi} \)

Key Properties
- Beam Plan Length: \( L_X = 9 \text{ ft} \)
- Self-weight: \( D: 2.7 \text{ plf}, L: 80 \text{ plf} \)

Reactions:
- Beam 3 in
  - FactMax: 685 lb
  - FactMac: 160 lb
  - D: 275 lb
  - L: 360 lb

- Bearing 3 in
  - FactMax: 535 lb
  - FactMac: 160 lb
  - D: 275 lb
  - L: 360 lb

Comments

PASS
Summary

Client: John Lawson  
Date: Oct 14, 2023

Author: Cameron Cunningham  
Job #: ARCE 453-01

Project: C.S.P. - Prior Consideration Design  
Subject: L-1

References: NDS 2018 (ASD)

Design Conditions

Design Code for Load Combinations  
International Building Code (IBC) 2018

Member Properties

Cross-Sectional Area  
Strong Axis Moment of Inertia  
Section Modulus  
Base Allowable Bending Stress  
Base Allowable Shear Stress  
Base Perpendicular Compression Allowable Stress  
True Modulus of Elasticity  
Apparent Modulus of Elasticity  
Modulus of Elasticity for Deflections

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity  
Adjusted Shear Modulus

Section Bending (NDS 2018 2.3)

Volume Factor  
Positive Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending  
Governing Beam Stability Factor - Positive Bending  
Adjusted Bending Strength - Positive Bending

Negative Bending (NDS 2018 2.3)

Governing Duration Factor - Negative Bending  
Governing Beam Stability Factor - Negative Bending  
Adjusted Bending Strength - Negative Bending

Shear Design (NDS 2018 3.4)

Governing Duration Factor  
Adjusted Shear Strength

Bearing (NDS 2018 3.10)

Base Bearing Strength  
Comments

References:

- NDS 2018 (ASD)
Client: John Lawson  
Author: Cameron Cunningham  
Project: C.S.P. - Prior Consideration Design  
References: NDS 2018 (ASD)

Summary

Member

Moment Utilization

\[ M / M' = 60\% \]

Shear Utilization

\[ V / V' = 19\% \]

Bearing Utilization

\[ R / R' = 20\% \]

Minimum Bearing Length (End Supports)

\[ \ell_{b,\text{min,end}} = 0.75 \text{ in} \]

Minimum Bearing Length (Int Supports)

\[ \ell_{b,\text{min,int}} = 0.21 \text{ in} \]

Governing Live / Short-Term Deflection

\[ \delta_{ST} = 0.0124 \text{ in} (L/12\,600) \]

Governing Long-Term Deflection

\[ \delta_{LT} = -0.0213 \text{ in} (L/7320) \]

Governing Long-Term Deflection

\[ \delta_{LT} = 0.0124 \text{ in} (L/12\,600) \]

Design Conditions

Design Code for Load Combinations

International Building Code (IBC) 2018

Member Properties

Cross-Sectional Area

\[ A = 184 \text{ in}^2 \]

Strong Axis Moment of Inertia

\[ I_{xx} = 675 \text{ in}^4 \]

Section Modulus

\[ S = 643 \text{ in}^3 \]

Base Allowable Bending Stress

\[ F_b = 2400 \text{ psi} \]

Base Allowable Shear Stress

\[ F_v = 265 \text{ psi} \]

Base Perpendicular Compression Allowable Stress

\[ F_{c⊥} = 650 \text{ psi} \]

True Modulus of Elasticity

\[ E_{\text{true}} = 1\,900 \text{ ksi} \]

Apparent Modulus of Elasticity

\[ E_{\text{app}} = 1\,800 \text{ ksi} \]

Modulus of Elasticity for Deflections

\[ E = 1\,800 \text{ ksi} \]

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity

\[ E' = 1\,800 \text{ ksi} \]

Section Bending (NDS 2018 2.3)

Volume Factor

\[ C_V = 0.962 \]

Positive Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending

\[ C_{D,b} = 1 \]

Governing Beam Stability Factor - Positive Bending

\[ C_L = 1 \]

Adjusted Bending Strength - Positive Bending

\[ F_b^* = 2310 \text{ psi} \]

Negative Bending (NDS 2018 2.3)

Governing Duration Factor - Negative Bending

\[ C_{D,b} = 1 \]

Governing Beam Stability Factor - Negative Bending

\[ C_L = 0.995 \]

\[ F_b^* = 1390 \text{ psi} \]
### Adjusted Bending Strength - Negative Bending

**Shear Design (NDS 2018 3.4)**

<table>
<thead>
<tr>
<th>Governing Duration Factor</th>
<th>$C_D = 1$</th>
</tr>
</thead>
</table>

### Adjusted Shear Strength

$F_v' = 265$ psi

**Bearing (NDS 2018 3.10)**

<table>
<thead>
<tr>
<th>Base Bearing Strength</th>
<th>$F_{c\perp}'/C_b = 650$ psi</th>
</tr>
</thead>
</table>

**Comments**
Summary

Member

- Moment Utilization: $M / M' = \frac{-26100 \text{ lb*ft}}{74700 \text{ lb*ft}}$
- Shear Utilization: $V / V' = \frac{10300 \text{ lb}}{32500 \text{ lb}}$
- Minimum Bearing Length (End Supports): $\ell_{b, \min, \text{end}} = 3.51 \text{ in}$
- Minimum Bearing Length (Int Supports): $\ell_{b, \min, \text{int}} = 4.87 \text{ in}$
- Governing Live / Short-Term Deflection: $\delta_{ST} = -0.0194 \text{ in} (L/8030)$
- Governing Long-Term Deflection: $\delta_{LT} = -0.0376 \text{ in} (L/4150)$

Reactions:

- Bearing: 8 in
  - FactMax: 19900 lb
  - FactMin: 7060 lb
- Bearing: 8 in
  - FactMax: 17700 lb
  - FactMin: 5030 lb
- Bearing: 8 in
  - FactMax: -650 lb
  - FactMin: -2050 lb

Long-Term Deflection

- Governing Long-Term Deflection -0.0376 in (L/4150)
- Deflection -0.0194 in (L/8030)

Design Conditions

- Design Code for Load Combinations
- International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area: $A = 184 \text{ in}^2$
- Strong Axis Moment of Inertia: $I_{xx} = 6750 \text{ in}^4$
- Section Modulus: $S = 643 \text{ in}^3$
- Base Allowable Bending Stress: $F_b = 2400 \text{ psi}$
- Base Allowable Shear Stress: $F_v = 265 \text{ psi}$
- Base Perpendicular Compression Allowable Stress: $F_{pc} = 650 \text{ psi}$
- True Modulus of Elasticity: $E_{true} = 19000000 \text{ psi}$
- Apparent Modulus of Elasticity: $E_{app} = 1800000 \text{ psi}$
- Modulus of Elasticity for Deflections: $E = 1800000 \text{ psi}$

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity: $E' = 1800000 \text{ psi}$

Section Bending (NDS 2018 2.3)

- Volume Factor: $C_V = 0.962$

Positive Bending (NDS 2018 2.3)

- Governing Duration Factor - Positive Bending: $C_{D,b} = 1$
- Governing Beam Stability Factor - Positive Bending: $C_{L,b} = 1$
- Adjusted Bending Strength - Positive Bending: $F_a'^+ = 2310 \text{ psi}$

Negative Bending (NDS 2018 2.3)

Key Properties

- Beam Plan Length: $L_X = 18 \text{ ft}$
- Continuous Bracing for Lateral Torsional Buckling: Top Braced

References: NDS 2018 (ASD)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governing Duration Factor</td>
<td>$C_{D,b} = 1$</td>
</tr>
<tr>
<td>Governing Beam Stability Factor</td>
<td>$C_L = 0.995$</td>
</tr>
<tr>
<td>Adjusted Bending Strength</td>
<td>$F_b = 1390 \text{ psi}$</td>
</tr>
<tr>
<td>Adjusted Shear Strength</td>
<td>$F_v = 265 \text{ psi}$</td>
</tr>
<tr>
<td>Base Bearing Strength</td>
<td>$F_{c:\perp}/C_b = 650 \text{ psi}$</td>
</tr>
</tbody>
</table>

**Comments**
Summary

Primary Loading

Member
- Moment Utilization: 62%
- Shear Utilization: 35%
- Bearing Utilization: 44%

Minimum Bearing Length (End Supports): 4710 lb / 10,700 lb

Reactions:
- FactMax: 4710 lb
- FactMin: 1380 lb
- Bearing: 3 in
- D: 2300 lb
- L: 2400 lb

Key Properties
- Beam Plan Length: 18.5 ft
- Continuous Bracing for Lateral Torsional Buckling: No Continuous Bracing

Loads
- Self-weight

Design Conditions

Design Code for Load Combinations

International Building Code (IBC) 2018

Member Properties
- Cross-Sectional Area: A = 77 in²
- Strong Axis Moment of Inertia: I_{xx} = 1260 in⁴
- Section Modulus: S = 180 in³
- Base Allowable Bending Stress: F_b = 2400 psi
- Base Allowable Shear Stress: F_t = 265 psi
- Base Perpendicular Compression Allowable Stress: F_{c⊥} = 650 psi
- True Modulus of Elasticity: E_{true} = 1900,000 psi
- Apparent Modulus of Elasticity: E_{app} = 1800,000 psi
- Modulus of Elasticity for Deflections: E = 1800,000 psi

Elastic Modulus (NDS 2018 2.3)
- Adjusted Modulus of Elasticity: E' = 1800,000 psi

Section Bending (NDS 2018 2.3)
- Volume Factor: C_V = 0.991

Positive Bending (NDS 2018 2.3)
- Governing Duration Factor - Positive Bending: C_{D,b} = 1
- Governing Beam Stability Factor - Positive Bending: C_{L,b} = 1
- Adjusted Bending Strength - Positive Bending: F_{b}^+ = 2330 psi

Negative Bending (NDS 2018 2.3)
- Governing Duration Factor - Negative Bending: C_{D,b} = 0.9
- Governing Beam Stability Factor - Negative Bending: C_{L,b} = 0.986
- Adjusted Bending Strength - Negative Bending: F_{b}^+ = 1290 psi

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: C_D = 1
- Adjusted Shear Strength: F_s = 265 psi

Bearing (NDS 2018 3.10)
- Base Bearing Strength: F_{b}^+ / C_b = 650 psi

Comments
**Summary**

**Beam Plan Length**
- \( L_X = 8.5 \text{ ft} \)

**Continuous Bracing for Lateral Torsional Buckling**
- Top Braced

**Design Conditions**
- **Design Code for Load Combinations**
- **International Building Code (IBC) 2018**

**Member Properties**
- **Cross-Sectional Area**
  \( A = 52.2 \text{ in}^2 \)
- **Strong Axis Moment of Inertia**
  \( I_{xx} = 393 \text{ in}^4 \)
- **Section Modulus**
  \( S = 82.7 \text{ in}^3 \)
- **Base Allowable Bending Stress**
  \( F_{b} = 2400 \text{ psi} \)
- **Base Allowable Shear Stress**
  \( F_{v} = 265 \text{ psi} \)
- **Base Perpendicular Compression Allowable Stress**
  \( F_{c⊥} = 650 \text{ psi} \)
- **True Modulus of Elasticity**
  \( E_{true} = 1900000 \text{ psi} \)
- **Apparent Modulus of Elasticity**
  \( E_{app} = 1800000 \text{ psi} \)
- **Modulus of Elasticity for Deflections**
  \( E = 1800000 \text{ psi} \)

**Elastic Modulus (NDS 2018 2.3)**
- **Adjusted Modulus of Elasticity**
  \( E' = 1800000 \text{ psi} \)

**Volume Factor**
- \( C_V = 1 \)

**Positive Bending (NDS 2018 2.3)**
- **Governing Duration Factor - Positive Bending**
  \( C_{D,b} = 1 \)
- **Governing Beam Stability Factor - Positive Bending**
  \( C_{L,b} = 1 \)
- **Adjusted Bending Strength - Positive Bending**
  \( F_{b}^{+} = 2400 \text{ psi} \)

**Negative Bending (NDS 2018 2.3)**
- **Governing Duration Factor - Negative Bending**
  \( C_{D,b} = 0.9 \)
- **Governing Beam Stability Factor - Negative Bending**
  \( C_{L,b} = 0.996 \)
- **Adjusted Bending Strength - Negative Bending**
  \( F_{b}^{-} = 1300 \text{ psi} \)

**Shear Design (NDS 2018 3.4)**
- **Governing Duration Factor**
  \( C_{D} = 1 \)
- **Adjusted Shear Strength**
  \( F_{v} = 265 \text{ psi} \)

**Bearing (NDS 2018 3.10)**
- **Base Bearing Strength**
  \( F_{c⊥} / C_{b} = 650 \text{ psi} \)

**Comments**
Summary

Key Properties

Beam Plan Length

Continuous Bracing for Lateral Torsional Buckling

Loads

Design Conditions

Design Code for Load Combinations

International Building Code (IBC) 2018

Member Properties

Cross-Sectional Area

Strong Axis Moment of Inertia

Section Modulus

Base Allowable Bending Stress

Base Allowable Shear Stress

Base Perpendicular Compression Allowable Stress

True Modulus of Elasticity

Apparent Modulus of Elasticity

Modulus of Elasticity for Deflections

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity

Section Bending (NDS 2018 2.3)

Volume Factor

Positive Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending

Governing Beam Stability Factor - Positive Bending

Adjusted Bending Strength - Positive Bending

Negative Bending (NDS 2018 2.3)

Governing Duration Factor - Negative Bending

Governing Beam Stability Factor - Negative Bending

Adjusted Bending Strength - Negative Bending

Shear Design (NDS 2018 3.4)

Governing Duration Factor

Adjusted Shear Strength

Bearing (NDS 2018 3.10)

Base Bearing Strength

Comments
Summary

19% Reaction: FactMax: 10,400 lb / 17,100 lb
Bearing: 3 in
Torsional Buckling
Continuous Bracing for Lateral Beam Plan Length
Governing Long-Term Deflection
Governing Long-Term Deflection
Minimum Bearing Length (End Supports)
Governing Live / Short-Term Deflection
Governing Long-Term Deflection

Key Properties

Distance from Left of Beam (ft)
0-2.1
2.1-5
5-8.75
8.75-

Member
8-3/4x21 24F-1.8E
B/4 3/4 in
FactMax: 900 lb / 117,000 lb

Moment Utilization
M/M' = 48,900 lb•ft / 117,000 lb•ft

Shear Utilization
V/V' = 10,400 lb / 32,500 lb

Bearing Utilization
R/R' = 10,400 lb / 17,100 lb

Minimum Bearing Length (End Supports)
8-3/4 in
FactMax: 900 lb / 117,000 lb

Distance from Left of Beam (ft)
0 5 10 15

Reactions:

Load: Stick Roof
LW: 2.8 lb / 33 psf, Lr: 15 psf
Ext. Wall
LW: 14.1 lb / 13 psf
Self-Weight

Design Conditions

Design Code for Load Combinations
International Building Code (IBC 2018)

Member Properties

Cross-Sectional Area
A = 184 in²

Strong Axis Moment of Inertia
Ixx = 6750 in⁴

Section Modulus
S = 643 in³

Base Allowable Bending Stress
Fb = 2400 psi

Base Allowable Shear Stress
Fv = 265 psi

Base Perpendicular Compression Allowable Stress
Fc⊥ = 650 psi

True Modulus of Elasticity
Etrue = 1900,000 psi

Apparent Modulus of Elasticity
Eapp = 1800,000 psi

Modulus of Elasticity for Deflections
E = 1800,000 psi

Elastic Modulus (NDS 2018 2.3)

Adjusted Modulus of Elasticity
E' = 1800,000 psi

Section Bending (NDS 2018 2.3)

Volume Factor
CV = 0.907

Positive Bending (NDS 2018 2.3)

Governing Duration Factor - Positive Bending
CD, b⁺ = 1

Governing Beam Stability Factor - Positive Bending
CL⁺ = 1

Adjusted Bending Strength - Positive Bending
Fb⁺ = 2180 psi

Negative Bending (NDS 2018 2.3)

Governing Duration Factor - Negative Bending
CD, b⁻ = 0.9

Governing Beam Stability Factor - Negative Bending
CL⁻ = 0.992

Adjusted Bending Strength - Negative Bending
Fb⁻ = 1180 psi

Shear Design (NDS 2018 3.4)

Governing Duration Factor
CD = 1

Adjusted Shear Strength
Fv = 265 psi

Bearing (NDS 2018 3.10)

Base Bearing Strength
Fc⊥/Cb = 650 psi

Comments

Beam Plan Length
Lx = 18.8 ft

Continuous Bracing for Lateral Torsional Buckling
Top Braced
Summary

Member

- B-3/4x21 24F-1.8E
- \( M' = -45,900 \text{ lb} \cdot \text{ft} / 73,700 \text{ lb} \cdot \text{ft} \)
- \( V' = 12,800 \text{ lb} / 32,500 \text{ lb} \)
- \( R' = 24,100 \text{ lb} / 36,300 \text{ lb} \)
- \( \ell_{b,\min,\text{end}} = 0.836 \text{ in} \)
- \( \ell_{b,\min,\text{int}} = 4 \text{ in} \)
- Reactions:
  - Bearing: 5 in
  - Factile: 13,000 lb
  - Factile: 19,800 lb
  - Distance from Left of Beam (ft): 0, 5, 10, 15

Key Properties

Beam Plan Length
- \( L_X = 18 \text{ ft} \)
- Continuous Bracing for Lateral Torsional Buckling

Loads

- Primary Loading
  - Distance from Left of Beam (ft): 0.21 in
  - Load: 8.25 in

Design Conditions

- Design Code for Load Combinations
  - International Building Code (IBC) 2018

Member Properties

- Cross-Sectional Area
  - \( A = 184 \text{ in}^2 \)
- Strong Axis Moment of Inertia
  - \( I_X = 6750 \text{ in}^4 \)
- Section Modulus
  - \( S = 643 \text{ in}^3 \)
- Base Allowable Bending Stress
  - \( F_b = 2400 \text{ psi} \)
- Base Allowable Shear Stress
  - \( F_c = 265 \text{ psi} \)
- Base Perpendicular Compression Allowable Stress
  - \( F_{v,c} = 650 \text{ psi} \)
- True Modulus of Elasticity
  - \( E_{\text{true}} = 1900000 \text{ psi} \)
- Apparent Modulus of Elasticity
  - \( E_{\text{app}} = 1800000 \text{ psi} \)
- Modulus of Elasticity for Deflections
  - \( E' = 1800000 \text{ psi} \)

Elastic Modulus (NDS 2018 2.3)

- Adjusted Modulus of Elasticity
  - \( E' = 1800000 \text{ psi} \)

Section Bending (NDS 2018 2.3)

- Volume Factor
  - \( C_V = 0.949 \)

Positive Bending (NDS 2018 2.3)

- Governing Duration Factor - Positive Bending
  - \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Positive Bending
  - \( C_{L,b} = 0.996 \)
- Adjusted Bending Strength - Positive Bending
  - \( F_b^+ = 2280 \text{ psi} \)

Negative Bending (NDS 2018 2.3)

- Governing Duration Factor - Negative Bending
  - \( C_{D,b} = 1 \)
- Governing Beam Stability Factor - Negative Bending
  - \( C_{L} = 0.997 \)
- Adjusted Bending Strength - Negative Bending
  - \( F_b^- = 1380 \text{ psi} \)
<table>
<thead>
<tr>
<th>Shear Design (NDS 2018 3.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governing Duration Factor</td>
</tr>
<tr>
<td>Adjusted Shear Strength</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bearing (NDS 2018 3.10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Bearing Strength</td>
</tr>
</tbody>
</table>

| Comments |
Summary

Member
- Moment Utilization: 95%
- Shear Utilization: 59%
- Bearing Utilization: 85%
- Minimum Bearing Length (End Supports): 71%

Key Properties
- Beam Plan Length: 18.8 ft
- Continuous Bracing for Lateral Torsional Buckling: No Continuous Bracing

Reactions:
- FactMin: 2430 lb
- FactMax: 9110 lb
- Bearing: 3 in
- D: 4050 lb
- L: 5060 lb

Design Conditions
- Cross-Sectional Area: A = 88 in²
- Strong Axis Moment of Inertia: Iₓ = 1880 in⁴
- Section Modulus: S = 235 in³
- Base Allowable Bending Stress: F₀ = 2400 psi
- Base Allowable Shear Stress: Fₛ = 265 psi
- Base Perpendicular Compression Allowable Stress: Fₛₚ = 650 psi
- True Modulus of Elasticity: Eₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑἐₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑ#error: invalid character 'e' in position 92
- Governing Long-Term Deflection: δ₈₇ = -0.622 in

Loads
- Negative Bending (NDS 2018 2.3)
- Positive Bending (NDS 2018 2.3)

Shear Design (NDS 2018 3.4)
- Governing Duration Factor: Cᵤ₀ = 1
- Adjusted Shear Stress: Fₛ = 265 psi

Bearing (NDS 2018 3.10)
- Base Bearing Strength: Fₛₚ/Cₛ = 650 psi

References:
- NDS 2018 (ASD)
Summary

**Member**
- Moment Utilization: 59%
- Shear Utilization: 64%
- Bearing Utilization: 71%
- Governing Long-Term Deflection: 66%

**Reactions:**
- FactMax: 9110 lb
- FactMin: 2430 lb
- Bearing: 4 in
- D: 4050 lb
- L: 5060 lb

**Key Properties**

- **Load Plan Length**: 18.8 ft
- **Continuous Bracing for Lateral Torsional Buckling**: No Continuous Bracing

**Design Conditions**

### Design Code for Load Combinations

- **Cross-Sectional Area**: \( A = 88 \text{ in}^2 \)
- **Strong Axis Moment of Inertia**: \( I_{xx} = 1880 \text{ in}^4 \)
- **Section Modulus**: \( S = 235 \text{ in}^3 \)
- **Base Allowable Bending Stress**: \( F_b = 2400 \text{ psi} \)
- **Base Allowable Shear Stress**: \( F_c = 265 \text{ psi} \)
- **Base Perpendicular Compression Allowable Stress**: \( F_{cc} = 650 \text{ psi} \)
- **True Modulus of Elasticity**: \( E_{true} = 1900000 \text{ psi} \)
- **Apparent Modulus of Elasticity**: \( E_{app} = 1800000 \text{ psi} \)
- **Deflections**
  - **Elastic Modulus (NDS 2018 2.3)**: \( E' = 1800000 \text{ psi} \)

### Section Bending (NDS 2018 2.3)

- **Volume Factor**: \( C_V = 0.976 \)

### Positive Bending (NDS 2018 2.3)

- **Governing Duration Factor - Positive Bending**: \( C_{D,b}^+ = 1 \)
- **Governing Beam Stability Factor - Positive Bending**: \( C_{L,b}^+ = 0.959 \)
- **Adjusted Bending Strength - Positive Bending**: \( F_{b}^+ = 2300 \text{ psi} \)

### Negative Bending (NDS 2018 2.3)

- **Governing Duration Factor - Negative Bending**: \( C_{D,b}^- = 0.9 \)
- **Governing Beam Stability Factor - Negative Bending**: \( C_{L,b}^- = 0.983 \)
- **Adjusted Bending Strength - Negative Bending**: \( F_{b}^- = 1270 \text{ psi} \)

### Shear Design (NDS 2018 3.4)

- **Governing Duration Factor**: \( C_D = 1 \)

### Bearing (NDS 2018 3.10)

- **Base Bearing Strength**: \( F_{c,b} / C_b = 650 \text{ psi} \)

**Comments**
**Summary**

**Member**

- Moment Utilization: $M / M' = 8110 \text{ lb*ft} / 18100 \text{ lb*ft}$
- Shear Utilization: $V / V' = 2820 \text{ lb} / 9480 \text{ lb}$
- Bearing Utilization: $R_l / R'_l = 2820 \text{ lb} / 13800 \text{ lb}$
- Minimum Bearing Length (End Supports): $\ell_{b,min,end,} = 0.716 \text{ in}$
- Governing Live / Short-Term Deflection: $\delta_{LT} = -0.156 \text{ in (L/884)}$
- Governing Long-Term Deflection: $\delta_{LT} = -0.214 \text{ in (L/645)}$

**Reactions:**

- FactMax: 2820 lb
- FactMin: 760 lb
- Bearing: 3.5 in
- $D = 1270 \text{ lb}$
- $L = 1550 \text{ lb}$

**Key Properties**

- Beam Plan Length: $L_X = 11.5 \text{ ft}$
- Continuous Bracing for Lateral Torsional Buckling: No Continuous Bracing

**Loads**

- Self-weight
- Design Conditions

**Member Properties**

- Cross-Sectional Area: $A = 49.9 \text{ in}^2$

**Design Conditions**

**Member Properties**

- Cross-Sectional Area: $A = 49.9 \text{ in}^2$

**References:**

- NDS 2018 (ASD)

**Comments**

- Strong Axis Moment of Inertia: $I_{xx} = 375 \text{ in}^4$
- Section Modulus: $S = 79 \text{ in}^3$
- Base Allowable Bending Stress: $F_b = 2600 \text{ psi}$
- Base Allowable Shear Stress: $F_s = 285 \text{ psi}$
- Base Perpendicular Compression Allowable Stress: $F_{c\perp} = 750 \text{ psi}$
- True Modulus of Elasticity: $E_{true} = 2000000 \text{ psi}$
- Apparent Modulus of Elasticity: $E_{app} = N_a N \text{ psi}$
- Modulus of Elasticity for Deflections: $E = 2000000 \text{ psi}$

**Elastic Modulus (NDS 2018 2.3)**

- Adjusted Modulus of Elasticity: $E' = 2000000 \text{ psi}$
- Adjusted Shear Modulus: $G' = 125000 \text{ psi}$

**Positive Bending (NDS 2018 2.3)**

- Governing Duration Factor - Positive Bending: $C_{D,b} = 1$
- Governing Beam Stability Factor - Positive Bending: $C_{L,b} = 0.987$
- Adjusted Bending Strength - Positive Bending: $F_{b}^{++} = 2760 \text{ psi}$

**Negative Bending (NDS 2018 2.3)**

- Governing Duration Factor - Negative Bending: $C_{D,b} = 0.9$
- Governing Beam Stability Factor - Negative Bending: $C_{L,b} = 0.989$
- Adjusted Bending Strength - Negative Bending: $F_{b}^{-} = 2480 \text{ psi}$

**Shear Design (NDS 2018 3.4)**

- Governing Duration Factor: $C_D = 1$
- Adjusted Shear Strength: $F_s = 285 \text{ psi}$

**Bearing (NDS 2018 3.10)**

- Base Bearing Strength: $F_{c\perp} / C_b = 750 \text{ psi}$
Summary

- Allowable Compressive Load (X-Axis Buckling) \( P'_{x} = 50,000 \text{ lb} \)
- Allowable Compressive Load (Y-Axis Buckling) \( P'_{y} = 50,000 \text{ lb} \)

Key Properties

<table>
<thead>
<tr>
<th>Member</th>
<th>8x8 D.Fir-L No. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Height</td>
<td>( L = 9 \text{ ft} )</td>
</tr>
<tr>
<td>Continuous Bracing for Strong Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Weak Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Lateral Torsional Buckling</td>
<td>No</td>
</tr>
</tbody>
</table>

Loads

- Self-weight
- Distance from Bottom of Column (ft) 0, 2, 4, 6, 8
- D:13 plf
- B-7-1
- L:9900 lb
- Lr:1440 lb

Design Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
<td>( F_{c}^{*} = 1000 \text{ psi} )</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>( (l_e/d) = 14.4 )</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>( (l_e/b) = 14.4 )</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>( F_{c,x}^{*} = 888 \text{ psi} )</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>( F_{c,y}^{*} = 888 \text{ psi} )</td>
</tr>
</tbody>
</table>

Comments

PASS
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 35,700\text{ lb}$ |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 35,700\text{ lb}$ |

Key Properties

| Member | 8x8 D.Fir-L No. 2 |
| Column Height | $L = 9\text{ ft}$ |
| Continuous Bracing for Strong Axis Buckling | No |
| Continuous Bracing for Weak Axis Buckling | No |
| Continuous Bracing for Lateral Torsional Buckling | No |

Loads

Design Conditions

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<td>Fully Braced Compression</td>
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<td>Strength - Pure Axial Loading</td>
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<td>Governing Slenderness - X-axis</td>
<td>$(l_e/d) = 14.4$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(l_e/b) = 14.4$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{c,x} = 634\text{ psi}$</td>
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<tr>
<td>(Y-axis)</td>
<td></td>
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<tr>
<td>Adjusted Compression Strength</td>
<td>$F'_{c,y} = 634\text{ psi}$</td>
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Comments
Summary

| Allowable Compressive Load (X-Axis Buckling) | $P'_x = 50,000 \text{ lb}$ |
| Allowable Compressive Load (Y-Axis Buckling) | $P'_y = 50,000 \text{ lb}$ |

Key Properties

| Member          | 8x8 D.Fir-L No. 1 |
| Column Height   | $L = 9 \text{ ft}$ |
| Continuous Bracing for Strong Axis Buckling | No |
| Continuous Bracing for Weak Axis Buckling  | No |
| Continuous Bracing for Lateral Torsional Buckling | No |

Design Conditions

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<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
<td>$F'_c = 1000 \text{ psi}$</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(l_e/d) = 14.4$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(l_e/b) = 14.4$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{e,x} = 888 \text{ psi}$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F'_{e,y} = 888 \text{ psi}$</td>
</tr>
</tbody>
</table>

Comments
Summary

- Allowable Compressive Load (X-Axis Buckling) \( P'_x = 50000 \text{ lb} \)
- Allowable Compressive Load (Y-Axis Buckling) \( P'_y = 50000 \text{ lb} \)

Key Properties

- Member: 8x8 D.Fir-L No. 1
- Column Height: \( L = 9 \text{ ft} \)
- Continuous Bracing for Strong Axis Buckling: No
- Continuous Bracing for Weak Axis Buckling: No
- Continuous Bracing for Lateral Torsional Buckling: No

Design Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
<td>( F'_c = 1000 \text{ psi} )</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis ( (l_e/d) )</td>
<td>14.4</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis ( (l_e/b) )</td>
<td>14.4</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis) ( F'_{e,x} )</td>
<td>888 psi</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis) ( F'_{e,y} )</td>
<td>888 psi</td>
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Comments
### Summary

<table>
<thead>
<tr>
<th>Condition</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% Allowable Compressive Load (X-Axis Buckling)</td>
<td>$P'_x = 16,900 \text{ lb}$</td>
</tr>
<tr>
<td>25% Allowable Compressive Load (Y-Axis Buckling)</td>
<td>$P'_y = 16,900 \text{ lb}$</td>
</tr>
</tbody>
</table>

### Key Properties

- **Member**: 6x6 D.Fir-L No. 2
- **Column Height**: $L = 9 \text{ ft}$
- **Continuous Bracing for Strong Axis Buckling**: No
- **Continuous Bracing for Weak Axis Buckling**: No
- **Continuous Bracing for Lateral Torsional Buckling**: No

### Loads

- **Self-weight**: 0 ft
- **Distance from Bottom of Column (ft)**: 0, 2, 4, 6, 8

### Design Conditions

#### Capacity in Pure Axial Loading (NDS 2018 Section 3.7)

<table>
<thead>
<tr>
<th>Component</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Braced Compression Strength - Pure Axial Loading</td>
<td>$F^c_x = 700 \text{ psi}$</td>
<td></td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(L_e/d) = 19.6$</td>
<td></td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(L_e/b) = 19.6$</td>
<td></td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{c,x} = 559 \text{ psi}$</td>
<td></td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F'_{c,y} = 559 \text{ psi}$</td>
<td></td>
</tr>
</tbody>
</table>

### Comments

PASS
Summary

- Allowable Compressive Load (X-Axis Buckling): $P'_x = 16,900$ lb
- Allowable Compressive Load (Y-Axis Buckling): $P'_y = 16,900$ lb

Key Properties

<table>
<thead>
<tr>
<th>Member</th>
<th>6x6 D.Fir-L No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Height</td>
<td>$L = 9$ ft</td>
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<tr>
<td>Continuous Bracing for Strong Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Weak Axis Buckling</td>
<td>No</td>
</tr>
<tr>
<td>Continuous Bracing for Lateral Torsional Buckling</td>
<td>No</td>
</tr>
</tbody>
</table>

Loads

- B-9-1: D:4050 lb, L:5060 lb

Design Conditions

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression - Pure Axial Loading</td>
<td>$F'_c = 700$ psi</td>
</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(l_e/d) = 19.6$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(l_e/b) = 19.6$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F'_{c,x} = 559$ psi</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F'_{c,y} = 559$ psi</td>
</tr>
</tbody>
</table>

Comments

- PASS
Summary

| 10% | Allowable Compressive Load (X-Axis Buckling) | $P_x' = 28,600$ lb |
| 32% | Allowable Compressive Load (Y-Axis Buckling) | $P_y' = 8850$ lb |

Key Properties

- Member: 4x6 D.Fir-L No. 2
- Column Height: $L = 9$ ft
- Continuous Bracing for Strong Axis Buckling: Yes
- Continuous Bracing for Weak Axis Buckling: No
- Continuous Bracing for Lateral Torsional Buckling: No

Loads

Design Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Pure Axial Loading (NDS 2018 Section 3.7)</td>
<td></td>
</tr>
<tr>
<td>Fully Braced Compression</td>
<td>$F_{c,x}' = 1490$ psi</td>
</tr>
<tr>
<td>Strength - Pure Axial Loading</td>
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</tr>
<tr>
<td>Governing Slenderness - X-axis</td>
<td>$(t_e/d) = 0$</td>
</tr>
<tr>
<td>Governing Slenderness - Y-axis</td>
<td>$(t_e/b) = 30.9$</td>
</tr>
<tr>
<td>Adjusted Compression Strength (X-axis)</td>
<td>$F_{c,x} = 1480$ psi</td>
</tr>
<tr>
<td>Adjusted Compression Strength (Y-axis)</td>
<td>$F_{c,y} = 460$ psi</td>
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</tbody>
</table>

Comments
Summary

**15%**
- Allowable Compressive Load (X-Axis Buckling) $P'_x = 7650 \text{ lb}$
- Allowable Compressive Load (Y-Axis Buckling) $P'_y = 12300 \text{ lb}$
- Allowable X-Axis Moment $M'_x = 1360 \text{ lb-ft}$
- Combined Compression / Bending $Int_C = 0.194$

**19%**
- Governing Live / Short-Term X-Axis Deflection $\delta_{x,ST} = 0.0745 \text{ in}$
- Critical Live / Short-Term X-Axis Deflection Ratio $(L/e)_{x,ST} = 1450$
- Governing Long-Term X-Axis Deflection $\delta_{x,LT} = 0.018 \text{ in}$
- Critical Long-Term X-Axis Deflection Ratio $(L/e)_{x,LT} = 6000$

**Key Properties**
- Member: 2x6 D.Fir-L No. 2
- Column Height: $L = 9 \text{ ft}$
- Continuous Bracing for Strong Axis Buckling: No
- Continuous Bracing for Weak Axis Buckling: Yes
- Continuous Bracing for Lateral Torsional Buckling: Yes

**Design Conditions**

**Capacity in Pure Axial Loading (NDS 2018 Section 3.7)**

- Fully Braced Compression Strength - Pure Axial Loading $F'_c = 1490 \text{ psi}$
- Governing Slenderness - X-axis $\left(\frac{L}{d}\right)_x = 19.6$
- Governing Slenderness - Y-axis $\left(\frac{L}{b}\right)_y = 0$
- Adjusted Compression Strength (X-axis) $F'_{c,x} = 928 \text{ psi}$
- Adjusted Compression Strength (Y-axis) $F'_{c,y} = 1480 \text{ psi}$

**Shear Design (NDS 2018 3.4)**

- Shear Capacity (X-axis) $V'_{nx} = 1580 \text{ lb}$

**Comments**
Summary

Key Properties

Beam Plan Length

Continuous Bracing for Lateral Torsional Buckling

Loads

Design Conditions

Member Properties

Cross-Sectional Area

Strong Axis Moment of Inertia

Section Modulus

Base Allowable Bending Stress

Base Allowable Shear Stress

Base Perpendicular Compression Allowable Stress

True Modulus of Elasticity

Apparent Modulus of Elasticity

Modulus of Elasticity for Deflections

Elastic Modulus (NDS 2018.2.3)

Adjusted Modulus of Elasticity

Section Bending (NDS 2018.2.3)

Size Factor

Incising Factor

Positive Bending (NDS 2018.2.3)

Governing Duration Factor - Positive Bending

Governing Beam Stability Factor - Positive Bending

Adjusted Bending Strength - Positive Bending

Negative Bending (NDS 2018.2.3)

Governing Duration Factor - Negative Bending

Governing Beam Stability Factor - Negative Bending

Adjusted Bending Strength - Negative Bending

Shear Design (NDS 2018.3.4)

Governing Duration Factor

Adjusted Shear Strength

Bearing (NDS 2018.3.10)

Base Bearing Strength

Comments
### Table 3-2 (continued)

#### W-Shapes

Selection by $Z_x$

<table>
<thead>
<tr>
<th>Shape</th>
<th>$Z_x$</th>
<th>$M_{pdx}/\Omega_b$</th>
<th>$\phi_b M_{pdx}$</th>
<th>$M_{dx}/\Omega_b$</th>
<th>$\phi_b M_{dx}$</th>
<th>$BF/\Omega_b$</th>
<th>$\phi_b BF$</th>
<th>$L_p$</th>
<th>$L_I$</th>
<th>$L_x$</th>
<th>$V_{bx}/\Omega_v$</th>
<th>$\phi_v V_{bx}$</th>
<th>kips</th>
<th>ft</th>
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</thead>
<tbody>
<tr>
<td>ASD</td>
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<td>358</td>
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<td>214</td>
<td>11.1</td>
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<td>843</td>
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<td>W16×50</td>
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<td>186</td>
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![Red Border](image)

**Note:** Shape does not meet the $h/t_w$ limit for shear in AISC Specification Section G2.1(a) with $F_y = 50$ ksi; therefore, $\phi_v = 0.90$ and $\Omega_v = 1.67$.

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* $\phi_0 = 0.90$, $\phi_v = 1.00$
### Table 3-2 (continued)

#### W-Shapes

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**ASD**

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| $\phi_b = 0.90$ |
| $\phi_y = 1.00$ |

1. Shape exceeds compact limit for flexure with $F_y = 50$ ksi; tabulated values have been adjusted accordingly.

2. Shape does not meet the $h/t_y$ limit for shear in AISC Specification Section G2.1(a) with $F_y = 50$ ksi; therefore, $\phi_v = 0.90$ and $\Omega_v = 1.67$. 

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**AMERICAN INSTITUTE OF STEEL CONSTRUCTION**

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PLB™ or B FORMLOK™
- 1½ in. Deep FORMLOK Deck
- Phosphatized/Painted or Galvanized
- PLB FORMLOK used with PunchLok II System
- B FORMLOK used with TSWs or BPs
- B FORMLOK-SS used with Screws

Dimensions

Deck Weight and Section Properties

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<th>Multi Span (in.4/ft)</th>
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<th>-S_eff</th>
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<th>Interior Bearing Length</th>
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Notes:
1. Section properties are based on $F_y = 50,000$ psi.
2. $I_d$ is for deflection due to uniform loads.
3. $S_{eff}$ (+ or -) is the effective section modulus.
4. Allowable (ASD) reactions are based on web crippling, per AISI S100 Section C3.4, where $\Omega_w = 1.70$ for end bearing and 1.75 for interior bearing. Nominal reactions may be determined by multiplying the table values by $\Omega_w$. LRFD reactions may be determined by multiplying nominal reactions by $\phi_w = 0.9$ for end reactions and 0.85 for interior reactions.

Attachment Patterns to Supports

Note: ○ indicates location of arc spot weld, power actuated fastener, or screw as indicated in the load tables.
□ indicates location of arc seam weld, power actuated fastener, or screw as indicated in the load tables.
Footnotes for Maximum Unshored Clear Span, Allowable Superimposed Loads, and Allowable Diaphragm Shear Strength Tables

1. Shoring calculations are based on the following:
   • Deck supporting dead load of concrete plus 20 psf uniform construction load or 150 pound concentrated construction live load for flexure. 4 psf is added for normal weight concrete and 3 psf is added for light weight concrete to account for ponding due to deck deflection between support members.
   • Dead load deflection limited to L/180 of span length, not to exceed 3/4”.
   • Minimum end and interior bearing of 2”.
2. Concrete fill to have minimum 28-day compressive strength $f'_{c} = 3,000$ psi.
3. Total slab depth is nominal depth from top of concrete to bottom of steel deck.
4. Shoring is required at midspan for allowable superimposed loads in the shaded area to the right of the heavy line.
5. Nominal diaphragm shear strengths may be determined by multiplying the tabulated strengths by $\Omega = 3.0$. LRFD diaphragm shear strength may be determined by multiplying nominal diaphragm shear strength by $\phi = 0.55$.
6. To obtain allowable diaphragm shear strengths using mechanical fasteners, multiply the tabulated strengths by the appropriate adjustment factor, $A_q$, listed in the following table.

<table>
<thead>
<tr>
<th>Attachment Pattern</th>
<th>Adjustment Factor</th>
<th>Normal Weight Concrete</th>
<th>Light Weight Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3 1/2</td>
<td>4</td>
</tr>
<tr>
<td>36/4</td>
<td>$A_{q4}$</td>
<td>0.60</td>
<td>0.66</td>
</tr>
<tr>
<td>36/7</td>
<td>$A_{q7}$</td>
<td>0.49</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Notes:

a. Mechanical fastener attachment patterns are to match the listed attachment patterns for welds.
b. Applicable mechanical fasteners are limited to the following: Hilti Fasteners, Pneutek Fasteners and SDI Recognized #12 or #14 Screws produced by Buildex, Elco, Hilti or Simpson Strong-Tie. Comply with minimum and maximum substrate thickness requirements for applicable mechanical fasteners. Note that these adjustment factors are based on the most conservative value for all listed connectors.
c. Nominal diaphragm shear strengths for mechanically fastened FORMLOK slabs may be determined by multiplying the adjusted tabulated strengths by $\Omega = 3.25$. LRFD diaphragm shear strengths for mechanically fastened FORMLOK slabs may be determined by multiplying the adjusted nominal strengths by $\phi = 0.50$.
d. Consult fastener manufacturer for applicable fire-resistance assembly ratings where mechanical fasteners are required.
### Maximum Unshored Clear Span (ft-in.)

<table>
<thead>
<tr>
<th>Deck Gage</th>
<th>Number of Deck Spans</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>6'-6&quot; 7'-8&quot; 7'-9&quot;</td>
<td>180</td>
<td>115</td>
<td>90</td>
</tr>
<tr>
<td>20</td>
<td>7'-9&quot; 9'-1&quot; 9'-3&quot;</td>
<td>202</td>
<td>130</td>
<td>101</td>
</tr>
<tr>
<td>18</td>
<td>8'-10&quot; 10'-8&quot; 11'-0&quot;</td>
<td>202</td>
<td>130</td>
<td>101</td>
</tr>
<tr>
<td>16</td>
<td>9'-6&quot; 11'-10&quot; 11'-7&quot;</td>
<td>202</td>
<td>130</td>
<td>101</td>
</tr>
</tbody>
</table>

Shoring is required for spans greater than those shown above. See Footnote 1 on page 39 for required bearing.

### Concrete Properties

<table>
<thead>
<tr>
<th>Density (pcf)</th>
<th>Uniform Weight (psf)</th>
<th>Uniform Volume (yd³/100 ft²)</th>
<th>Compressive Strength, f'c (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>145</td>
<td>30.6</td>
<td>0.781</td>
<td>3000</td>
</tr>
</tbody>
</table>

Notes:
1. Volumes and weights do not include allowance for deflection.
2. Weights are for concrete only and do not include weight of steel deck.
3. Total slab depth is nominal depth from top of concrete to bottom of steel deck.

### Allowable Superimposed Loads (psf)

| Deck Gage | Number of Deck Spans | 4'-0" 5'-0" 6'-0" 6'-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 10'-6" 11'-0" 11'-6" 12'-0" |
|-----------|----------------------|-----------------------------|-------------------------------|
| 22        | 1                    | 400 353 261 228 170 148 130 115 101 | 90 80 71 64 57 51           |
| 20        | 1                    | 400 353 261 228 170 148 130 115 101 | 90 80 71 64 57 51           |
| 18        | 1                    | 400 372 274 240 212 189 170 153 140 | 96 85 76 68 61 55           |
| 16        | 1                    | 400 400 297 260 230 205 184 166 151 | 138 127 117 76 68 61         |
| 22        | 2                    | 400 353 261 228 170 148 130 115 101 | 90 80 71 64 57 51           |
| 20        | 2                    | 400 353 261 228 170 148 130 115 101 | 90 80 71 64 57 51           |
| 18        | 2                    | 400 372 274 240 212 189 170 153 140 | 96 85 76 68 61 55           |
| 16        | 2                    | 400 400 297 260 230 205 184 166 151 | 138 127 117 76 68 61         |
| 22        | 3                    | 400 353 261 228 170 148 130 115 101 | 90 80 71 64 57 51           |
| 20        | 3                    | 400 353 261 228 170 148 130 115 101 | 90 80 71 64 57 51           |
| 18        | 3                    | 400 372 274 240 212 189 170 153 140 | 96 85 76 68 61 55           |
| 16        | 3                    | 400 400 297 260 230 205 184 166 151 | 138 127 117 76 68 61         |

See footnotes on page 39.

### Allowable Diaphragm Shear Strengths, q (plf) and Flexibility Factors, F (in./lb. x 10⁶)

| Attachment Pattern | Deck Gage | 4'-0" 5'-0" 6'-0" 6'-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 10'-6" 11'-0" 11'-6" 12'-0" |
|--------------------|-----------|-----------------------------|-------------------------------|
| 36/4               | 22        | q 2074 1925 1825 1754 1726 1701 1679 1659 | 1642 1626 1612 1599 1587 1576 |
|                    |           | F 0.40 0.43 0.45 0.47 0.48 0.49 0.49 0.50 | 0.50 0.51 0.51 0.52 0.52 0.52 |
| 20                 | q 2192 2013 1893 1793 1743 1717 1694 | 1673 1654 1637 1621 1607 1594 |
|                    | F 0.34 0.37 0.40 0.41 0.42 0.43 0.43 0.44 0.44 0.45 0.45 0.46 0.46 0.47 0.47 |
| 18                 | q 2444 2205 2067 1985 1932 1887 1847 1812 1781 | 1753 1728 1705 1684 1665 1648 |
|                    | F 0.27 0.30 0.32 0.33 0.34 0.35 0.35 0.36 0.37 0.37 0.38 0.38 0.39 0.39 0.40 |
| 16                 | q 2713 2414 2215 2138 2073 2016 1966 1922 1883 | 1848 1816 1788 1762 1738 1717 |
|                    | F 0.21 0.24 0.26 0.27 0.28 0.29 0.30 0.30 0.31 0.32 0.32 0.33 0.33 0.34 0.34 |

See footnotes on page 39.
# Maximum Unshored Clear Span (ft-in.)

<table>
<thead>
<tr>
<th>Deck Gage</th>
<th>Number of Deck Spans</th>
<th>Clear Span (ft-in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>1</td>
<td>5'-8&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6'-8&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6'-9&quot;</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>6'-9&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7'-11&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8'-0&quot;</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>7'-9&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9'-4&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<tr>
<td>16</td>
<td>1</td>
<td>8'-4&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10'-4&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10'-4&quot;</td>
</tr>
</tbody>
</table>

Shoring is required for spans greater than those shown above. See Footnote 1 on page 39 for required bearing.

# Concrete Properties

<table>
<thead>
<tr>
<th>Density (pcf)</th>
<th>Uniform Weight (psf)</th>
<th>Uniform Volume (yd³/100 ft²)</th>
<th>Compressive Strength, f'c (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>145</td>
<td>48.7</td>
<td>1,244</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3000</td>
</tr>
</tbody>
</table>

Notes:
1. Volumes and weights do not include allowance for deflection.
2. Weights are for concrete only and do not include weight of steel deck.
3. Total slab depth is nominal depth from top of concrete to bottom of steel deck.

# Allowable Superimposed Loads (psf)

<table>
<thead>
<tr>
<th>Deck Gage</th>
<th>Number of Deck Spans</th>
<th>Span (4'-0&quot; - 12'-0&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>1</td>
<td>400 400 347 297 257 224 197 173 153 136 121 108 96 86 77</td>
</tr>
<tr>
<td></td>
<td>2</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>400 400 393 344 257 224 197 173 153 136 121 108 96 86 77</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>400 400 400 361 272 237 208 184 163 145 129 115 103 92 83</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>400 400 400 361 272 237 208 184 163 145 129 115 103 92 83</td>
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<tr>
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<td>3</td>
<td>400 400 400 361 272 237 208 184 163 145 129 115 103 92 83</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
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<td>400 400 400 369 344 306 227 201 176 159 142 127 114 103 92</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>400 400 400 369 344 306 227 201 176 159 142 127 114 103 92</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>400 400 400 386 341 304 273 198 176 157 140 125 112 101 91</td>
</tr>
<tr>
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<td>2</td>
<td>400 400 400 386 341 304 273 198 176 157 140 125 112 101 91</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>400 400 400 386 341 304 273 198 176 157 140 125 112 101 91</td>
</tr>
</tbody>
</table>

See footnotes on page 39.

# Allowable Diaphragm Shear Strengths, q (plf) and Flexibility Factors, F (in./lb. x 10⁶)

<table>
<thead>
<tr>
<th>Attachment Pattern</th>
<th>Deck Gage</th>
<th>Span (4'-0&quot; - 12'-0&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36/4</td>
<td>22</td>
<td>q 2792 2642 2543 2504</td>
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<tr>
<td></td>
<td></td>
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<td>2377 2359 2343 2329</td>
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<tr>
<td></td>
<td></td>
<td>2316 2304 2294</td>
</tr>
<tr>
<td></td>
<td>F 0.30</td>
<td>0.31 0.32 0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.34 0.34 0.34</td>
</tr>
<tr>
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<td>2525 2491 2461 2434</td>
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<tr>
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<td>0.29 0.30 0.30</td>
</tr>
<tr>
<td></td>
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<tr>
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<tr>
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<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>16</td>
<td>q 3430 3131 2932 2656</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2790 2733 2683 2639</td>
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<tr>
<td></td>
<td></td>
<td>2600 2565 2534</td>
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<td></td>
<td>2505 2479 2456</td>
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<tr>
<td></td>
<td>F 0.17</td>
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<tr>
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<td>0.21 0.21 0.22</td>
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<tr>
<td></td>
<td></td>
<td>0.22 0.22 0.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.23 0.23 0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.24 0.24 0.24</td>
</tr>
</tbody>
</table>

See footnotes on page 39.
### Maximum Unshored Clear Span (ft-in.)

<table>
<thead>
<tr>
<th>Deck Gage</th>
<th>Number of Deck Spans</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>5'-4&quot; 6'-2&quot; 6'-3&quot;</td>
<td>39</td>
<td>320</td>
<td>279</td>
</tr>
<tr>
<td>20</td>
<td>6'-3&quot; 7'-4&quot; 7'-5&quot;</td>
<td>39</td>
<td>320</td>
<td>279</td>
</tr>
<tr>
<td>18</td>
<td>7'-3&quot; 8'-8&quot; 8'-11&quot;</td>
<td>39</td>
<td>320</td>
<td>279</td>
</tr>
<tr>
<td>16</td>
<td>7'-10&quot; 9'-7&quot; 9'-8&quot;</td>
<td>39</td>
<td>320</td>
<td>279</td>
</tr>
</tbody>
</table>

Notes:
1. Volumes and weights do not include allowance for deflection.
2. Weights are for concrete only and do not include weight of steel deck.
3. Total slab depth is nominal depth from top of concrete to bottom of steel deck.

### Concrete Properties

To be used for Tamp. Deck in Clear Calc Report

<table>
<thead>
<tr>
<th>Density (pcf)</th>
<th>Uniform Weight (psf)</th>
<th>Uniform Volume (yd³/100 ft²)</th>
<th>Compressive Strength, f'c (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>145</td>
<td>60.8</td>
<td>1.553</td>
<td>3000</td>
</tr>
</tbody>
</table>

Notes:
1. Volumes and weights do not include allowance for deflection.
2. Weights are for concrete only and do not include weight of steel deck.
3. Total slab depth is nominal depth from top of concrete to bottom of steel deck.

### Allowable Superimposed Loads (psf)

<table>
<thead>
<tr>
<th>Deck Gage</th>
<th>Number of Deck Spans</th>
<th>4'-0&quot;</th>
<th>5'-0&quot;</th>
<th>6'-0&quot;</th>
<th>6'-6&quot;</th>
<th>7'-0&quot;</th>
<th>7'-6&quot;</th>
<th>8'-0&quot;</th>
<th>8'-6&quot;</th>
<th>9'-0&quot;</th>
<th>9'-6&quot;</th>
<th>10'-0&quot;</th>
<th>10'-6&quot;</th>
<th>11'-0&quot;</th>
<th>11'-6&quot;</th>
<th>12'-0&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>1</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>369</td>
<td>320</td>
<td>279</td>
<td>244</td>
<td>215</td>
<td>191</td>
<td>169</td>
<td>151</td>
<td>134</td>
<td>120</td>
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<td>169</td>
<td>151</td>
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<td>120</td>
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<td>96</td>
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<td>18</td>
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<td>16</td>
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<td>400</td>
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<td>151</td>
<td>134</td>
<td>120</td>
<td>107</td>
<td>96</td>
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</table>

### Allowable Diaphragm Shear Strengths, q (plf) and Flexibility Factors, F (in./lb. x 10⁶)

<table>
<thead>
<tr>
<th>Attachment Pattern</th>
<th>Deck Gage</th>
<th>4'-0&quot;</th>
<th>5'-0&quot;</th>
<th>6'-0&quot;</th>
<th>6'-6&quot;</th>
<th>7'-0&quot;</th>
<th>7'-6&quot;</th>
<th>8'-0&quot;</th>
<th>8'-6&quot;</th>
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<th>11'-0&quot;</th>
<th>11'-6&quot;</th>
<th>12'-0&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>36/4</td>
<td>22</td>
<td>q</td>
<td>3270</td>
<td>3120</td>
<td>3021</td>
<td>2983</td>
<td>2950</td>
<td>2921</td>
<td>2896</td>
<td>2874</td>
<td>2855</td>
<td>2837</td>
<td>2822</td>
<td>2807</td>
<td>2794</td>
<td>2783</td>
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<tr>
<td></td>
<td>20</td>
<td>F</td>
<td>0.25</td>
<td>0.26</td>
<td>0.27</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
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</tr>
<tr>
<td></td>
<td>16</td>
<td>F</td>
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<td>0.20</td>
<td>0.21</td>
<td>0.21</td>
<td>0.21</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.23</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Shoring required in shaded areas to right of heavy line.

See footnotes on page 39.
OPENINGS IN FORMLOK DECKS

The following suggestions for openings in FORMLOK deck are intended to address support of construction loads by the deck before the concrete has fully cured and to address distribution of the reactions from superimposed loads to the adjacent composite slab. These suggestions should be evaluated based on specific project conditions by the responsible design professional.

It is suggested in all cases that the openings should be blocked out and the FORMLOK deck left intact whenever possible. After the concrete has cured, the FORMLOK deck in the area of the opening can be removed. If the deck is left intact until after the concrete has fully cured, alternative methods of reinforcing to those illustrated, such as rebar, may be used to distribute superimposed loads around the opening.

**Note:** Typically, individual holes less than 6 in. in diameter and cutting no more than one web need no reinforcing.

(continued on page 31)

**Notes:**
1. Angles shall be placed on top of the FORMLOK deck.
2. Angles shall extend 3 webs past the deck opening (typical).
3. If Dimension A is >4D₁, 4D₂, or 32” whichever is larger, there is no restriction on Dimension B.
4. If Dimension B is >4D₁, 4D₂, or 32” whichever is larger, there is no restriction on Dimension A.
5. If Dimensions A and B are <4D₁, 4D₂, or 32” whichever is larger, the opening group shall be considered as a single large hole, and shall be reinforced as required for the larger opening as shown in Figure 19.
• The diagonal bars shown at larger openings are intended to address cracking at corners and are in addition to the reinforcing required for load distribution.
• Figure 18 illustrates recommendations for holes 6 to 12 in. in diameter, those cutting more than one web, or groups of small holes.
• Figure 19 illustrates recommendations for larger openings, up to 24".
• Provide alternate means of support around openings or groups of openings larger than 24 in.

The critical dimension for an opening or groups of openings is the width measured perpendicular to the deck span as shown in Figures 18 and 19. The length of an opening or hole measured parallel to the direction of the deck span is not limited.

**Notes:**
1. Tubes shall be placed on top of the deck. Note: Availability may suggest the use of alternate members such as channels or angles with comparable strength.
2. Add rebars at corners of opening above the tubes. Rebar size and clear cover to be determined by responsible design professional.
3. If the opening or group of openings occurs in one FORMLOK deck unit, the opening or opening group may be cut before pouring concrete, but it may be preferable to form opening with pour stops and cut the deck after concrete has cured.
4. If the opening or group of openings cuts through two FORMLOK deck units, the deck shall not be cut until concrete has been placed and cured. At the time of pouring, suitable sleeves or bulkheads shall be placed around the opening.
5. When the maximum dimension of an opening or opening group exceeds 24", provide alternate means of support.
Lateral Design

Concrete Finish on Wood w/ Ply. Sheathing
[Original Design]
Lateral Key Plan
Floor
Date: 11/22 By: HW Project: 2022-024 Knaggel

**DIAPHRAGM:**

N/S - ROOF/FLOOR  

9.5 (13, 4.3) = 130 ft

WIND

6.26 (26) = 17 ft

SEISMIC

1.5

WIND

5.03

SEISMIC

3  

WIND

5.53

SEISMIC

CHORD

D  

5.03

9.52 + 475 + 190 = 1417 ft

WIND

742 + 529 + 211 = 1482 ft

SEISMIC

RET wall ok by insp.

12 ft ok by insp.

9.52 + 11u + 40l = 1419 ft

WIND

742 + 129 + 447 = 1318 ft

SEISMIC

CHORD
DIAPHRAGM: III
N/S - ROOF (FLOOR)

5 (13,43) = 600 #

1971

6012

219 #

SEISMIC

WIND

277 #

DIAPHRAGM: III
E/W - ROOF (FLOOR)

H: 2592

N/A

w: 497

I

SEISMIC

VEIW

110 #

12' 32'

D

K

SEISMIC

WIND

3110 #

1854 + 1607 + 198 = 3661 #

(ref. wall ok, lay instp.)
Lateral Member Design

Concrete Finish on Wood w/ Ply. Sheathing
[Original Design]

&
Non-Structural Concrete on Wood w/
Shallow Vercor
Current Design: Key Structural Plan

Lateral Key Plan

Floor
Prior Consideration:
Structural, Verco decking with Wood/GLB Framing

Design Key Plan

N/A, By inspection, Retaining wall satisfies lateral support

N/A, By inspection, Retaining wall satisfies lateral support

Retaining Wall okay by inspection

N/A, By inspection, Retaining wall satisfies lateral support

WSWH 18x9

WSWH 18x9

WSWH 18x9

Page 124 of 144
# Strong-Wall® High-Strength Wood Shearwalls

## Standard and Balloon Framing on Concrete Foundations

<table>
<thead>
<tr>
<th>Strong-Wall® High-Strength Wood Shearwall Model No.</th>
<th>Panel Evaluation Height, $H_a$ (ft.)</th>
<th>Allowable ASD Shear Load, $V$ (lb.)</th>
<th>Allowable ASD Shear Load, $V$ (lb.)</th>
<th>Anchor Tension at Allowable Shear, $T$ (lb.)</th>
<th>Anchor Tension at Allowable Shear, $T$ (lb.)</th>
<th>Drift at Allowable Shear, $\Delta$ (in.)</th>
<th>Drift at Allowable Shear, $\Delta$ (in.)</th>
<th>Drift at Allowable Shear, $\Delta$ (in.)</th>
<th>Seismic$^3$</th>
<th>Seismic$^3$</th>
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</table>

See footnotes on p. 15.
WSWH-AB Anchor Bolts

WSWH-AB anchor bolts in 1" diameters offer flexibility to meet specific project demands. Inspection is easy; the head is stamped with a No-Equal® symbol for identification, bolt length, bolt diameter, and optional "HS" for "High-Strength" if specified.

**Material:** ASTM F1554 Grade 36;
High-Strength (HS) ASTM A193 Grade B7

An additional nut for template installation is provided with each WSWH-AB.

<table>
<thead>
<tr>
<th>Strong-Wall® High-Strength Wood Shearwall Model No.</th>
<th>Model No.</th>
<th>Dia. (in.)</th>
<th>Total Length (in.)</th>
<th>( I_e ) (in.)</th>
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<tbody>
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<td>WSWH12 WSWH18 WSWH24</td>
<td>WSWH-AB1x24</td>
<td>1</td>
<td>24</td>
<td>15( \frac{1}{2} )</td>
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<tr>
<td>WSWH-AB1x24HS</td>
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<td>24</td>
<td>15( \frac{1}{2} )</td>
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<td>27( \frac{1}{2} )</td>
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WSWH-HSR Extension Kit

WSWH-HSR allows for anchorage in tall shearwall applications where full embedment of a WSWH-AB into the footing is required. The head is stamped for identification like a WSWH-AB. Kit includes ASTM A193 Grade B7 high-strength rod with heavy hex nut fixed in place and high-strength coupler nut.

<table>
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<tr>
<th>Strong-Wall® High-Strength Wood Shearwall Model No.</th>
<th>Model No.</th>
<th>Dia. (in.)</th>
<th>Total Length (in.)</th>
<th>( I_e ) (in.)</th>
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</thead>
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<td>29( \frac{1}{2} )</td>
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</tbody>
</table>

**Note:** Do not use in place of WSWH-AB.

Total \( I_e = WSWH-HSR I_e + WSWH-AB I_e + 6\frac{1}{2}'' \)
### Tension Anchorage Solutions — 2,500 psi Concrete\(^1,5,6\)

<table>
<thead>
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<th>Design Criteria</th>
<th>Concrete Condition</th>
<th>Anchor Strength(^2)</th>
<th>ASD Allowable Tension (lb.)</th>
<th>W (in.)</th>
<th>d_s (in.)</th>
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<tbody>
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See footnotes on p. 23.

### Tension Anchorage Solutions — 3,000 psi Concrete\(^1,5,6\)

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<th>d_s (in.)</th>
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<td>20,000</td>
<td>33</td>
<td>11</td>
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<td>26,500</td>
<td>39</td>
<td>13</td>
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<td></td>
<td>33,600</td>
<td>45</td>
<td>15</td>
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<td></td>
<td>36,800</td>
<td>48</td>
<td>16</td>
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<tr>
<td></td>
<td>Uncracked</td>
<td>Standard</td>
<td>6,200</td>
<td>13</td>
<td>6</td>
</tr>
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<td></td>
<td></td>
<td>12,800</td>
<td>21</td>
<td>7</td>
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<td>17,100</td>
<td>26</td>
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<td>High-Strength</td>
<td>21,800</td>
<td>30</td>
<td>10</td>
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<td></td>
<td></td>
<td></td>
<td>28,900</td>
<td>36</td>
<td>12</td>
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<td></td>
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<td>33,100</td>
<td>39</td>
<td>13</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>36,800</td>
<td>42</td>
<td>14</td>
</tr>
</tbody>
</table>

See footnotes on p. 23.
High-Strength Wood Shearwall Anchorage Solutions

Foundation shear reinforcement to resist shear forces from Strong-Wall® high-strength wood shearwalls located at the edge of concrete is shown in the table below. The WSWH12 used in wind applications does not require shear reinforcement when the panel design shear force is less than the anchorage allowable shear load shown in the table below.

Shear Anchorage Solutions

<table>
<thead>
<tr>
<th>Strong-Wall High-Strength Wood Shearwall Model No.</th>
<th>Lₜ or Lₚ (in.)</th>
<th>Seismic</th>
<th>Wind¹</th>
<th>ASD Allowable Shear Load, V (lb)²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shear Reinforcement</td>
<td>Minimum Curb/ Stemwall Width (in.)</td>
<td>Shear Reinforcement</td>
</tr>
<tr>
<td>WSWH12</td>
<td>10½</td>
<td>(1) #3 Tie</td>
<td>6</td>
<td>See Note 7</td>
</tr>
<tr>
<td>WSWH18</td>
<td>15</td>
<td>(2) #3 hairpins³</td>
<td>6</td>
<td>(1) #3 hairpin</td>
</tr>
<tr>
<td>WSWH24</td>
<td>19</td>
<td>(2) #3 hairpins⁵</td>
<td>6</td>
<td>(2) #3 hairpins⁵</td>
</tr>
</tbody>
</table>

1. Shear anchorage designs conform to ACI 318-14 Chapter 17 and ACI 318-11 and assume minimum 2,500 psi concrete. See pp. 22-23 for tension anchorage.
2. Shear reinforcement is not required for interior foundation applications (panel installed away from edge of concrete), or braced wall panel applications.
3. Seismic indicates seismic design category C through F. Detached one- and two-family dwellings in SDC C may use wind anchorage solutions. Seismic shear reinforcement designs conform to ACI 318-14, section 17.2.3.5.3 and ACI 318-11 section D.3.3.5.
4. Wind includes seismic design category A and B and detached one- and two-family dwellings in SDC C.
5. Additional ties may be required at garage curb or stemwall installations below anchor reinforcement per designer.
6. Use (1) #3 hairpin for WSWH18 when standard strength anchor is used.
7. Use (1) #3 tie for WSWH12 when panel design shear force exceeds tabulated anchorage allowable shear load.
8. No. 4 grade 60 shear reinforcement may be substituted for WSWH shear anchorage solutions.
9. Concrete edge distance for anchors must comply with ACI 318-14 section 17.7.2 and ACI 318-11 section D.8.2.
10. The designer may specify alternate shear anchorage.

![Hairpin Reinforcement Diagram](Image)

Hairpin Shear Reinforcement

Field tie and secure during concrete placement. Overlap varies with bolt spacing.

![Tie Reinforcement Diagram](Image)

Tie Shear Reinforcement

Field tie and secure during concrete placement.

![Hairpin Installation Diagram](Image)

Hairpin Installation

Garage curb shown, other footing types similar.
High-Strength Wood Shearwall Anchorage Solutions

**Curb or Stemwall Installation**

Minimum curb/stemwall width per p. 24
Shear reinforcement per p. 24 when required

6' min. $\frac{1}{2} W - \frac{1}{2} W - W$

Perspective View

(Slab not shown for clarity)

Footing Plan

**Slab-on-Grade Installation**

Shear reinforcement per p. 24 when required

6' min. $\frac{1}{2} W - \frac{1}{2} W - W$

Perspective View

Footing Plan

**Brick Ledge Installation**

Minimum curb/stemwall width per p. 24
Shear reinforcement per p. 24 when required

6' min. $\frac{1}{2} W - \frac{1}{2} W - W$

Perspective View

Footing Plan

**Anchorage Solutions General Notes**

1. The designer may specify alternate embedment, footling size or bolt grade.
2. Footing dimensions and rebar requirements are for anchorage only.
Anchorage Solutions General Notes
1. The designer may specify alternate embedment, footing size or bolt grade.
2. Footing dimensions and rebar requirements are for anchorage only.

Anchor Bolt Layout

<table>
<thead>
<tr>
<th>Strong-Wall High-Strength Wood Shearwall Model No.</th>
<th>Distance from Center-to-Center of WSWH-AB, B (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSWH12</td>
<td>8(\frac{1}{8})</td>
</tr>
<tr>
<td>WSWH18</td>
<td>14</td>
</tr>
<tr>
<td>WSWH24</td>
<td>20</td>
</tr>
</tbody>
</table>

WSWH Plan View
Anchorage Layout
Lateral Member Design

Structural Concrete on Steel w/ Verco
Alternative Steel Design:
Structural, Verco Decking with all Steel Framing

Design Key Plan
Special Case Core S.W. Design

Key Plan:

→ Loading:
  * Via irregular diaphragm, load transfer will consider shear wall on line AB, G loaded from guidelines E & F through structural core on Vero deck
  * For vertical design, by inspection, retaining wall satisfies gravity design

→ For Lateral Forces
\[
F_E = F_{sv(ave)} = \frac{0.6 \text{(Wind)}}{3,495^*} = \frac{0.7 \text{(Seismic)}}{3,022^*}
\]
\[
F_F = F_{st.w.} = \frac{3,362^*}{3,403^*}
\]
Total \[
6,857^* \quad 6,425^*
\]  → wind controls

→ For Shear-Friction Check (T.11.7.1)

\[ V_e = 6,857^* \]
\[ v_n = \left(\frac{6,857^*}{1000^*} \right) / 20' = 0.343 \, \text{ft/ft} \]

(Table 22.4.2) \[ V_n = A_v * \delta \times \mu \]
  * For \( \mu \), will consider \( \mu = 1.4 \), where \( \lambda = 1.0 \)
  * For normal weight concrete

\[ A_v = \frac{V_n}{(\delta * \mu)} = \frac{0.343^*}{(0.044^* \text{ft})(140^* \text{ft})} \]

\[ A_v = 0.004 \, \text{in}^2 \]

\[ V_n \geq V_e \]
\[ 0.005 \, \text{in}^2 (60^* \text{ft}) (1.4(1.0)) \geq V_e \]

\[ 4.2 \, \text{ft/ft} \geq 0.343 \, \text{ft/ft} \]

For preliminary core design:

use Horiz: #4 @ 48" o.c.
Vert: #4 @ 48" o.c.

Page 133 of 144
Framing Plan & Section Detail Sheets

Concrete Finish on Wood w/ Ply. Sheathing [Original Design]
Floor Framing Reference Notes:

1. Typical Floor/Deck Sheathing:
   ¾" APA-Rated CDX T&G Plywood
   A. Panel Index 48/24
   B. Glue and Fasten with 10d @ 6:6:10" o.c.

2. Typical Floor Joist:
   16" T.J 230 @ 16" o.c.
   A. Provide IUS2.37/16 hanger at suspended conditions

3. Typical Deck Joist:
   1½" x 9 ½" LVL @ 16" o.c.
   A. Provide MIU1.81/9 hanger at suspended conditions.
   B. Joist to remain level - slope to drain provided at concrete topping

4. HSS5x5x91" steel column

5. Trimmer post - Double 2x wall width
   (Typical, U.N.O.)
   A. Provide LCE4 post cap.

6. Header: 3-1½" x 9 ½" LVL

7. Floor beam: 2-1½" x 16" LVL
   A. Provide IUS3.56/16 hanger at suspended conditions

8. Floor Beam: 7" x 16" PSL
   A. Provide HGU7.25-SDS hanger at suspended conditions

9. Floor Beam: 5½" x 16" PSL
   A. Provide MGU5.50-SDS hanger at suspended conditions

10. Floor Beam: 7" x 18" PSL

11. Floor Beam: W16x47

12. ST624 strap centered about break in beam

13. Concrete Slab on Grade: 5" slab w/ #4 bars @ 16" o.c. each way.
   A. For slab section and underlayment, see detail 23/S2.10

14. Flatwork by others

15. HDU2 holdown to face of wood post with SSTB anchor at footing per details 41/S2.10 and 42/S2.10

16. Site retaining wall shown for reference only - see Grading Permit Plans (GRAD2022-00106)
Structure Plan and Reference Notes:

1. Typical Floor/Deck Sheathing:
   - ½" APA-Rated CDX T&G Plywood
     A. Panel index 48/24
     B. Glue and Fasten with 10d @ 6/6:10" o.c.

2. Typical Floor Joist:
   - 16" TJI 230 @ 16" o.c.
     A. Provide IUS2.37/16 hanger at suspended conditions

3. Typical Deck Joist:
   - 1½" x 9 ½" LVL @ 16" o.c.
     A. Provide MIU1.81/9 hanger at suspended conditions.
     B. Joist to remain level - slope to drain provided at concrete topping

4. HSS5x5x3/8" steel column

5. Trimmer post - Double 2x wall width (Typical, U.N.O.)
   A. Provide LCE4 post cap.

6. Header: 3-1 ½" x 9 ½" LVL

7. Floor beam: 2-1 ½" x 16" LVL
   A. Provide IUS3.56/16 hanger at suspended conditions

8. Floor Beam: 7" x 16" PSL
   A. Provide HSL17.5-60 hanger at suspended conditions

9. Floor Beam: 5½" x 16" PSL
   A. Provide MGU5.50-60 hanger at suspended conditions

10. Floor Beam: 7" x 18" PSL

11. Floor Beam: W16x67

12. ST6224 strap centered about break in beam

13. Concrete Slab on Grade: 5" slab w/ #4 bars @ 16" o.c. each way.
   A. For slab section and underlayment, see detail 23/52.10

14. Flatwork by others

15. HDU2 holdown to face of wood post with SSTB anchor at footing per details 41/52.10 and 42/52.10

16. Site retaining wall shown for reference only - see Grading Permit Plans (GRAZ2022-00106)
MULTI-LAM. BEAM - TOP LOADED

DATE: Fall Q. 2023

INSTALL SDWS SCREWS PER IAPMO-UES ESR-192.

1. ENGINEER OF RECORD IMMEDIATELY IF LOAD CAN NOT BE APPLIED EVENLY

NOTES: (#)

LOAD MUST BE APPLIED EVENLY ACROSS ENTIRE BEAM WIDTH. CONTACT

MEMBERS TYP. SHEATHING NAILING

NOT USED

MIN. SCREW DIAMETER TO BE 0.22".

MIN. SCREW LENGTH TO BE: 3 4

STUD, MIN. OF (3) ROWS OF SDWS SCREWS AT 12" o.c. FOR 14" OR DEEPER.

2. SEE SHEAR WALL SCHEDULE AND NOTES

NOTES: (#)

3. EDGE NAIL ARE TO BE STAGGERED.

4. SHEAR WALL SHTG TO CONTINUE UNBROKEN

5. SHEAR WALL SHTG W/ EDGE NAIL

6. JOIST BEARING ON INT WALL

7. NOT USED

8. JUST AT FLOOR BEAM - PARALLEL

9. NOT USED

10. NOT USED

11. NOT USED

12. NOT USED

13. NOTUSED

14. NOT USED

15. TYP. SHEATHING NAILING

16. NOT USED

17. NOT USED

18. NOT USED

19. NOT USED

20. NOT USED
Framing Plan & Section Detail Sheets

Non-Structural Concrete on Wood w/ Shallow Vercor
Floor Framing Plan

Scale: 1/4"=1'-0"

Floor Framing Reference Notes:

1. Typical Floor/Deck Sheathing: 4.5" Normal Concrete Decking on Metal Decking
   A. Shallow Viceror - 22 Gage
   B. Fasteners with screws 12" o.c.

2. Typical Floor/Deck Sheathing: 3" Tapered Normal Concrete on Metal Decking
   A. Shallow Viceror - 26 Gage
   B. Fasteners with screws 12" o.c.

3. Typical Floor Joist: 14" TJI 230 @ 16" o.c.
   A. Provide IUS2.06/14 hanger at suspended conditions
   B. Equivalent ITS, BA, or HB hangers are acceptable

4. Typical Floor Joist: 9-1/2" TJI 230 @ 16" o.c.
   A. Provide IUS2.06/9.5 hanger at suspended conditions
   B. Equivalent ITS, BA, or HB hangers are acceptable
   C. For Face-Mount conditions, use HU2.1/9 hangers

5. 1-3/4"x14" Microllam LVL 2.0E-2600F
6. 2 - 1-3/4"x14" Microllam LVL 2.0E-2600F
7. 1-3/4"x5-1/2" Microllam LVL 2.0E-2600F
8. 5-1/2x14 24F-1.8E
9. 5-1/2x9-1/2 24F-1.8E
10. 5-1/2x16 24F-1.8E
11. 6-3/4x21 24F-1.8E
12. 3 - 1-3/4"x9-1/4" LVL
13. 8x8 DF-L No.1 Column
   A. Use ECCQ or CCQ94SDS2.5 Column Cap
14. 6x6 DF-L No.2 Column
   A. Use BC6 Post Cap
15. 4x6 DF-L No.2 Column
   A. Use LCE4 Post Cap
16. Trimmer Post - Double 2x wall width (Typical, U.N.O.)
   A. Provide LCE4 post cap
17. ST6224 strap centered about break in beam
18. WWSH 18x9 Strong Wall

---

Scale: 1/4"=1'-0"
Framing Plan & Section Detail Sheets

Structural Concrete on Steel w/ Verco
Floor Framing Reference Notes:

1. Typical Floor/Deck Sheathing: 5" Normal Concrete on Metal Decking
   A. Verco PLW or B Formlok - Gage 16

2. Typical Floor/Deck Sheathing: 5.5" max. to 3.5" min. Tapered Normal Concrete on Metal Decking
   A. Verco PLB or B Formlok - Gage 16
   B. Typ. 1.7-2.0% or 1/4"/ft min slope

3. W18x35
4. W16x26
5. W14x22
6. W10x19
7. W10x12
8. W8x10
9. L2x2x3/8

10. HSS 3x3x4 Column
11. HSS 2x2x4 Column

12. Special-Case Concrete Shear Wall
   A. Horiz.: #4 at 48" o.c.
   B. Vert.: #4 at 48" o.c.

13. Address opening in deck as per pg. 30-31 of VF5_Catalog_080818-1