

Cross-Laminated Timber and Structural Resilience A Major Qualifying Project

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Submitted to:

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Abstract

The goal of this project was to design a Class A office building using mass timber, present the client with a fire analysis, design an alternative building for advanced structural resilience, and include a repair scope with cost estimate evaluation for each option.

Three options for design were analyzed. The first option was rated Type IV-A, but would require extensive structural repair after a time-equivalent fire. The second option was rated at Type IV-A and had the ability to host Class B office space after a time-equivalent fire with only non-structural repair. The third option was rated at Type IV-A and had the ability to host a Class A office space after a time-equivalent fire with only non-structural repair.

Acknowledgements

The team would like to acknowledge and thank Professor Leonard Albano for his continued guidance and support of this project and the team members. His expertise of wood design, structural systems, the construction industry, and numerous resources provided immense support to this project.

The team would also like to thank Michael Richard of Simpson Gumpertz & Heger for sponsoring this project and his support throughout this process. He provided the building plans and shared his expertise to the team regarding mass timber, CLT, and the building layout.

Both Professor Albano and Michael Richard made themselves easily available for any questions that arose and provided guidance that empowered the team toward project completion.

Authorship

This project is the first submittal of an ongoing Major Qualifying Project (MQP). This submittal was submitted by Peyton Graham, with collaboration from Stephanie Bishop and Isabelle Mellor. This project was a collaborative team effort, with each team member contributing equally to the project.

Below details areas of the report each member took leadership of:

Stephanie Bishop: Introduction, Background, Methodology, Material Inventory, Design
Process, Post Fire Structural Damage, Repair Methods, Cost Comparison and Constructability
Peyton Graham: Introduction, Background, Methodology, Design Process, Post Fire Structural
Damage, Repair Methods, Appendices
Isabelle Mellor: Introduction, Background, Methodology, Option 2 Design, Post Fire Structural
Damage, Graphics

Capstone Design Statement

Worcester Polytechnic Institute requires all capstone design projects to meet ABET (Accreditation Board for Engineering and Technology) standards. At WPI, the Major Qualifying Project (MQP) is a high-level research project that addresses a problem found in a student's professional discipline. This MQP designed a four-story office building constructed of Cross-Laminated Timber (CLT) and glue-laminated timber (Glulam). This design addressed a fire analysis of CLT and a more structural resilient design of the building will be completed. A costbenefits analysis was provided for the two designs. The following constraints were identified based on the following categories: Economic, Social, Political, Health & Safety, Manufacturability, Sustainability, and Ethics.

Economic

To address the economic constraint of our capstone design the team compared the cost of our building designed to the current code standard, the cost of our fire repairs, and the cost of the structural resilient building design. We looked at the cost of the materials, manufacturing, transportation, labor, and construction time. In addition, we considered the market flux of CLT.

Social

To address the social constraints of our capstone design we demystified the public stigma that wood and timber materials are less fire resistant than other common construction materials.

Health & Safety

To address the health and safety constraints of our capstone design, we utilized current building codes and requirements during our design. We ensured that fire protection materials and the building height and area are sufficient for a Type IV-A office building.

Manufacturability

To address manufacturability constraints of our capstone design, we considered the location and accessibility of CLT manufacturers in North America, including analyzing which regions have better access to CLT than others with the few current manufacturer locations. We used standard

sections of CLT with section cutouts that are easily prefabricated with CNC machines. We also took into account availability of wood in the current climate, as the COVID-19 pandemic has created various material shortages.

Sustainability

To address the sustainability constraints of our capstone design, we used CLT as our main design material. CLT produces less greenhouse gasses, less waste, significantly lighter when compared to concrete, and has faster construction times than both concrete and steel.

Ethics

To maintain an ethical approach, we conducted ourselves with integrity and professionalism and use our project to advance the health, safety, and welfare of the public. We considered both the socioeconomic and health impacts of the growth of CLT on society. We also utilized the principles of sustainable development in our designs, act professionally to clients, communicate potential issues, and adequately credit the previous extensive research on CLT.

Professional Licensure Statement

The National Council of Examiners for Engineering and Surveying (NCEES) is an organization that provides professional licensure for engineers and surveyors. Only a certified Professional Engineer (PE) can approve and sign off on final engineering plans for a project, ensuring it meets the required safety standards.

To become a licensed Professional Engineer the following requirements must be meet:

- 1. Earn a four-year degree from an ABET accredited university
- Pass the Fundamentals of Engineering (FE) exam to become an Engineer in Training (EIT)
- 3. Work under another PE for a minimum of four years
- 4. Pass the Principles and Practice of Engineering (PE) exam

In this project, a Professional Engineer would work with a team to design, plan, and stamp plans. The professional engineer can size members, run the fire analysis, do lateral design, and work with other parties to make sure the design satisfies all needs.

Table of Contents

Abstract	1
Acknowledgements	2
Authorship	3
Capstone Design Statement	4
Professional Licensure Statement	6
Chapter 1: Introduction	9
2.3: Design of Cross-Laminated Timber	
2.4: Building Codes	14
2.5: CLT and Fire	15
Chapter 3: Methodology	
3.2 Objective 2: Evaluate Fire Resilience and Repair Options of Building	
3.4 Objective 4: Cost Analysis of Building Options	20
Chapter 4: Design for a Type IV-A Office Building	21
4.1: Floor Layouts	21
4.2: Gravitational Loads	22
4.2.1: CLT Paneling for the Roof and Floor Systems	22
4.2.3: GLT Girders	
4.2.4: GLT Columns	29
4.3: Lateral Loading	
4.3.1: Shear Walls	
Chapter 5: Fire Analysis	
5.1: Post-Fire Structural Damage	
5.2: Repair Methods	
6.1: Structural Design Change Overview	40
6.2: Option 1: Designed for Class A	41
6.3: Option 2: Designed for Class B post fire	41
6.4: Option 3: Designed for Class A, with ability to remain Class A after a fire event	51
Chapter 7: Evaluation	52
7.1: Cost Considerations in Design and Construction	52
7.2: Constructability of a Mass Timber Building	53
Chapter 8: Conclusion	54

Works Cited	55
Appendix A: Project Proposal	57
Capstone Design Statement	59
Chapter 1: Introduction	61
Chapter 2: Background	61
2.1: The Growth of CLT	61
2.2: Design of Cross-Laminated Timber	63
2.3: Building Codes	65
2.4: CLT and Fire	66
Chapter 3: Methodology	70
Objective 1: Design a Type IV-B CLT Office Building	70
Objective 2: Evaluate Fire Resilience and Repair Options of Building	71
Objective 3: Design a CLT Office Building for Advanced Structural Resilience	71
Objective 4: Cost Analysis of Building Options	72
Works Cited	73
Appendix B: Mass Timber Calculations	74
Appendix C: Fire Analysis Option 1	154
Appendix D: Fire Analysis Option 2	169
Appendix E: Inventory and Cost Estimate	

Chapter 1: Introduction

Cross-Laminated Timber (CLT) is a type of prefabricated solid wood panel that consists of crosswise layers of kiln-dried lumber board. The engineered wood product was first developed in Germany and Austria during the early 1990s. Gerhard Schickhofer, an Austria-born researcher, completed his PhD thesis on CLT in 1994. After refining press technology between 1995 and 1996, the first multi-story building was constructed in Austria by 1998. The combined growth in CLT structures throughout Europe and research from Schickhofer sparked the first national CLT design guideline for Austria in 2002. By 2013, CLT started to make an appearance within North America and was soon featured in the National Design Specification (NDS) for wood construction by 2015 (American Wood Council, 2017). Since then, CLT has grown rapidly throughout the United States. However, there is still hesitation to construct multi-story buildings with CLT due to the flammability of wood structures that resulted in catastrophic fire damage.

The goal of this project was to design a Class A office building using mass timber, present the client with a fire analysis, design alternative designs for advanced structural resilience, and include a repair scope with cost estimate evaluation for each option. The project was defined into four objectives:

Objective 1: Design a Type IV-A Class A CLT Office Building
Objective 2: Evaluate Fire Resilience and Repair Options of Building
Objective 3: Design a CLT Office Building for Advanced Structural Resilience
Objective 4: Cost Analysis of Building Options

The first phase of the project was the design of a Type IV-A Class A CLT office building. The fire analysis of the original design considered fire exposure and damage, charring, repairs, and post-fire capacity. The second post-fire design was calculated to support a Type IV-A Class B CLT office building. The last building option was to carry a Class A occupancy load post-fire. To conclude, a cost estimate including repairs was presented as financial comparison between the alternative structural designs.

Chapter 2: Background

2.1: Mass Timber

Mass timber is a category of wood product used for columns, beams, flooring, walls, and roofing. Mass timber has a high strength rating due to compressed layers, panelized or single components, and adhesives. In addition to its strength rating, mass timber is significantly lighter than concrete and steel, and less carbon intensive. Products of mass timber include cross-laminated timber (CLT), glue-laminated timber (Glulam), dowel-laminated timber (DLT), nail-laminated timber (NLT), laminated strand lumber (LSL), laminated veneer lumber (LVL), and parallel strand lumber (PSL) (Mass Timber -Think Wood, 2022). Each product varies depending on number of panels, orientation, and how they are held together. For example, DLT uses wood dowels to join laminations together, while glulam components are positioned according to their stress-rated performance and bonded with a durable, moisture-resistant adhesive (Mass Timber – Naturally: Wood, 2022)

2.2: The Growth of CLT

During the early 2000s, CLT production and usage increased significantly in Europe due to its energy efficiency as a part of the Green Movement. This led to the construction of over 500 CLT buildings within England alone. One notable project was the first "timber tower", Murray Grove, which was constructed in Hackney, London in 2009. This nine-story residential building was completely constructed with mass timber and featured a tight honeycomb design using CLT structural panels. This building paved the way for the potential of CLT as an environmentally sustainable and financially viable solution within construction, especially in urban areas. The use of CLT for Murray Grove allowed a faster project schedule by 30% (total of 49 weeks), saved 300 metric tons of CO2, and provided 29 fully insulated and soundproof apartment units simply by avoiding the use of precast concrete and other standard construction materials (Waughthistleton.com, 2021; American Wood Council, 2017). As of June 2021, there have been 1,169 mass timber projects in the United States, 249 of which are in construction or built and 365 in design (see Figure 1) (WoodWorks - Wood Products Council, 2021).



Mass Timber Projects In Design and Constructed in the US (June 2021)

Figure 1: Mass Timber Projects in Design and Constructed in the US (June 2021)

CLT has many benefits compared to standard construction materials such as steel, concrete, and masonry. The carbon emissions from the production of CLT is 50% of what is required for concrete and a shocking 1% of what is required for steel production. Since CLT does not have an abundance of production facilities in the United States, the carbon emissions for travel are far more. However, they still do not reach the emission level of concrete or steel (The B1M, 2017). Another advantage of CLT is the minimal waste during production, due to the ability to reuse sawdust, timber cutouts, and other byproducts. CLT is very energy efficient in performance, with an R-value of 1.25 per inch of thickness. For seismic performance, it is more forgiving due to its ability to flex without losing structural stability. It also provides high performing acoustics, especially with an added acoustic mat layer, which is beneficial for urban construction. Besides the performance and environmental benefits, CLT is 75% lighter than concrete which can reduce groundwork costs for buildings. It also has a significantly lower construction time because panels are prefabricated, so they can be installed immediately on site.

This is especially beneficial for urban areas with minimal on-site storage of materials, because the panels can be produced and transported the day they are needed (Landreman, Archie, and WoodWorks - Wood Products Council, 2017). CLT has grown significantly and has many benefits, but the common misconception of all wood as unsafe for fire conditions causes hesitation.

2.3: Design of Cross-Laminated Timber

Cross-Laminated Timber, or "CLT' is made up of layers, or laminations, that are generally stacked crosswise with the direction of fiber 90 degrees to the previous. An illustration of a sample CLT panel is shown at right in Figure 2. Pairs of parallel layers can be included at the core or the outer layer for special applications. Layers are glued with structural adhesive. To

create CLT panels, individual boards are finger jointed and glued. Odd numbers of layers are used so that both outer layers of wall panels can be oriented parallel to the vertical load path axis to maximize vertical load capacity in wall panels. For floor and roof panel systems, outer



Figure 2: Sample CLT Panel Illustration

layers are oriented parallel to the span axis. Most commonly, CLT panels are composed of three, five, and seven layers (FPInnovations, 2013). Three and five layer panels are the most accessible to produce and are the most readily available from manufacturers.

When designing CLT structures, one important factor is the material constraint. For Nordic X-Lam Cross-Laminated Timber, the maximum dimensions of panels are 106.25"(8.854') x 64' (Nordic Structures, 2020). Standard layup combinations for Nordic X-Lam are listed in Table 1 seen below.

Nordic X-Lam Panel	Longitudinal Layer Thickness	Transverse Layer Thickness	Layup Combination	Total Thickness
89-3s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ¾ in	L-T-L	89 mm = 3 ¹ / ₂ in
105-3s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	L-T-L	105 mm = 4 1/8 in
143-5s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ¾ in	L-T-L-T-L	143 mm = 5 5% in
175-5s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	L-T-L-T-L	175 mm = 6 ⁷ / ₈ in

197-7s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = $\frac{3}{4}$ in	L-T-L-T-L-T-L	197 mm = 7 ³ ⁄ ₄ in
213-71	35 mm = $1-\frac{3}{8}$ in	19 mm = ³ / ₄ in	L-L-T-L-T-L-L	213 mm = 8 3/8 in
244-7s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	L-T-L-T-L-T-L	244 mm = 9 5/8 in
244-71	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	L-L-T-L-T-L-L	244 mm = 9 5/8 in
267-91	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = $\frac{3}{4}$ in	L-L-T-L-T-L-T-L-L	267 mm = 10 ½ in

 Table 1: Nordic X-Lam Standard Panel Layup Combinations (Nordic Structures, 2020)

CLT has a light unit-weight, so vibration and deflection often determine allowable spans, rather than bending or shear. Much of CLT design includes balancing panel capacity with desired interior clear height, as a larger required number of laminations lowers clear height (McLain, Ricky, and Greg Kingsley, 2020).

Another important factor in CLT design is grid efficiency. The most efficient grid designs of CLT often differ from that of steel or concrete. On average, CLT square floor grids are sized between 20' x 20' and 30'x 30', and rectangular grids are sized between 10'x 20' and 20'x 32'. Grids are generally made with glulam girders supporting CLT panels. When designing a larger square grid, intermediate glulam purlins can be utilized, but these usually are not needed in rectangular grids. There are also alternative grid solutions that account for challenges such as MEP placement and unusual required spans. One alternative that has been previously utilized included 2 layers of CLT panels running perpendicular to each other, providing room for MEP structures and negating the need for glulam girders. For larger spans, a composite system of mass timber with a concrete topping or a combination system of CLT floor panels and parallel glulam beams could be utilized (McLain, Ricky, and Greg Kingsley, 2020).

The final important factor for CLT building design is the type of member connections. There are many types of CLT connections, and different options may offer different advantages. Factors to consider in CLT connection designs are load transfer, cost-effectiveness, aesthetic impact, height impact, and crushing or shrinkage leading to differential material movement. Additionally, the connection must have the same fire resistance as the members (McLain, Ricky, and Greg Kingsley, 2020).

2.4: Building Codes

According to the 2021 IBC, there are five construction types. The construction types include I, II, III, IV, and V. Of these, there are further specification categories (see Figure 3 below - eg: A, B, C, HT). The purpose of these classification types is to evaluate and define the severity of building material combustibility and the fire resistance rating (FRR) of its building elements. Each construction type has a different FRR requirement per structural element. Different elements such as bearing walls and floors are not required to have equivalent FRRs (Codes.iccsafe.org, Oct. 2020).

	т	YPE I	TYF	EII	TYP	E III				TYPE IV	TYP	ΈV
BUILDING ELEMENT	Α	в	Α	в	Α	в	Α	в	С	нт	Α	в
Primary structural frame ^f (see Section 202)	3 ^{a, b}	2 ^{a, b,} c	1 ^{b,} c	0 ^c	1 ^{b,} c	0	3 ^a	2 ^a	2 ^a	HT	1 ^{b,} c	0
Bearing walls										1		
Exterior ^{e, f}	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	3	2	2	1/HT ⁹	1	0
Nonbearing walls and partitions Exterior						5	See Ta	ble 70	05.5			
Nonbearing walls and partitions Interior ^d	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ¹ /2 ^b	1 ^{b,c}	1 ^{b,c}	0°	1 ^{b,c}	0	1 ¹ / ₂	1	1	НТ	1 ^{b,c}	0

TABLE 601 FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

For SI: 1 foot = 304.8 mm.

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only

b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber complying with Sector 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.

d. Not less than the fire-resistance rating required by other sections of this code.

e. Not less than the fire-resistance rating based on fire separation distance (see Table 705.5).

f. Not less than the fire-resistance rating as referenced in Section 704.10.

g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

Figure 3: Fire-Resistance Rating Requirements for Building Elements (Table 601 IBC, 2021)

The initial building was designed for a Class A occupancy load of 100 psf and a Type IV-A Classification. A Type IV-A building is considered more appealing for an advertised Class A building due to the higher FRR standard. However, this type does not allow exposed mass timber elements, which can be considered architecturally appealing. The height and square footage for the four-story building is 64 feet high and is just under 83,160 total square feet. The building features an atrium from the first floor to the second floor and a rooftop penthouse with stair and elevator access. The rooftop penthouse is 6,790 square feet with a height of 19 feet. According to the 2021 IBC, rooftop penthouses cannot exceed a third of the square area of the supporting roof deck and cannot exceed a height of 18 feet. However, there is an exception for penthouses that include an elevator to have a maximum height of 28 feet, hence the building is code compliant. The building is also within the 2021 IBC limit for Type IV-A buildings by a significant margin because it includes an automatic sprinkler system. By including an automatic sprinkler system, the building is limited to 18 stories with a total height of 270 feet and a 324,000 total square footage (WoodWorks - Wood Products Council, et al., 2019).

2.5: CLT and Fire

For this case study, we analyzed a fire that occurs in a 4-story office building. The number one cause of office fires is cooking equipment, which accounts for 29% of all office fires. Other causes of office fires include electrical distribution and lighting equipment, heating equipment, intentional, smoking materials, exposure, and electronic or entertainment equipment. The peak times of days for office fires were between noon and 2:00 PM. This is the time of day where the greatest number of people are in the office. However, fires that occur between 7:00 PM and 7:00 AM cause the greatest amount of property damage. Improving automatic detection systems, extinguishing equipment, and the fire resistance rating prevent further damage to be caused to the building ("NFPA Report").

Fire resistance rating (FRR) is the ability of a material to confine fire, continue to provide a structural function during fire, or both (International Code Council, 2021). The FRR is measured from the start of the fire until the material fails to function. Fire resistance of CLT depends upon the number of layers, thickness, adhesive, and panel assembly. Often, noncombustible materials are applied to mass timber to increase the FRR. Wall and floor assemblies that are made of CLT and exposed and covered with non-combustible material can provide up to a 3 hour FRR (Pogue, 2021). CLT's fire resistance is provided through charring. The charring of CLT is different from other timber panels due to the number of layers, glue composition, and joints. Charring is when a timber panel is exposed to a fire greater than 400 degrees C and causes the timber to ignite and burn at a steady rate. As the timber continues to burn, the char becomes an insulating layer. This layer protects the unburnt core of the panel and prevents an excess rise in temperature ("GreenSpec: Cross-Laminated"). Fire Dynamics Simulator (FDS) and Consolidated Model of Fire and Smoke Transport (CFAST) are the two main fire simulation software in use today. FDS is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flows. It is most appropriate for simulations of low-speed, thermally-driven flow, with an emphasis on smoke and heat transfer from fires. CFAST is a two-zone fire model. It is best used to calculate the evolving distribution of smoke, fire gases and temperature throughout compartments of a building during a fire. From both softwares, a heat transfer model can be developed. This can be used to determine thermal gradients of the wood elements, and the impacts on the structural capacity. For the sake of our project, we will not be using fire simulation software. Instead we will borrow parametric models and equations from literature, such as Figure 4, 5, and 6 shown below, to analyze various fire scenarios. This alternative is best suited for our short time frame to complete this project (NIST, 2011).

Table 16.2.1B Effective Char Depths (for CLT

Required Fire Resistance	Effective Char Depths, a _{eff} (in.) lamination thicknesses, h _{lam} (in.)								
(hr.)	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1 ¹ / ₂ -Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

with $\beta_n = 1.5 \text{in./hr.}$)

Figure 4: Effective Char Depths for CLT

Step	Floor Design
Lamination fall-off time	$t_{fo} = \left(rac{h_{lam}}{eta_n} ight)^{1.23}$
Calculation of the effective char depth	$a_{char} = 1.2 \Big[n_{lam} \cdot h_{lam} + eta_n ig(t - (n_{lam} \cdot t_{fo}) ig)^{0.813} \Big]$
Determination of effective residual cross- section	$h_{fire}\ =\ h\ -a_{char}$
Determination of location of neutral axis and section properties of the effective residual cross-section	$y = rac{\Sigma y_i h_i}{\Sigma h_i} \qquad I_{eff} = \Sigma rac{b_i {h_i}^3}{12} + \Sigma b_i {h_i} {d_i}^2$
Calculation of design resisting moment	$S_{eff} = rac{I_{eff}}{h_{fire} - y}$ $M' = KF_bS_{eff}$

Figure 5: Char Equations for Floor Design

Step	Wall Design
Lamination fall-off time	$t_{fo} = \left(rac{h_{lam}}{eta_n} ight)^{1.23}$
Calculation of the effective char depth	$a_{char}=1.2eta_nt^{0.813}$
Determination of effective residual cross- section	$h_{fire}\ =\ h\ -a_{char}$
Determination of location of neutral axis and section properties of the effective residual cross-section	$egin{aligned} & \underline{y} = rac{\Sigma y_i h_i}{\Sigma h_i} & I_{eff} = \Sigma rac{b_i {h_i}^3}{12} + \Sigma b_i {h_i} {d_i}^2 \ & A_{eff} = \Sigma b_i h_i \end{aligned}$
Calculation of resisting axial compression capacity	$S_{eff} = rac{I_{eff}}{h_{fire} - y}$ $M' = KF_bS_{eff}$

Figure 5: Char Equations for Wall Design

When CLT is damaged in a fire, there are multiple ways of fixing or replacing it. When charring is localized it can be removed with sanding, scraping, or abrasive blasting. This is done for minor fire damage and if the structural integrity can remain intact. If small areas are damaged, they can be repaired with equivalent wood sections, such as sections around doors or windows (Ranger, Lindsay, et al, 2019). If the char or fire damage impacts multiple layers of the CLT it is best to replace all layers affected. One solution is to remove and clean the damaged portions and replace it with new laminations attached with adhesive. This solution does not restore full structural capacity of the CLT panel, but it does restore the FRR. Another option is to remove the damaged portions and replace them with new laminations attached with adhered and screwed scarf joints or adhered only. This option reestablishes pre-fire structural capacity, maintains exposed CLT, and restores FRR ("*Post-Fire Restoration*," 2018). Our case study building will have some form of automatic sprinklers. Sprinklers are used as a means of active fire suppression but can be a balance between fire damage and damage from excess water discharge. Accidental or excess water discharge from sprinklers can result in frozen pipes, mechanical damage, installation defects, or corrosion of sprinkler elements. This water can adversely affect the wood structure and cause moisture damage. A high moisture content can affect the strength and stiffness, and lead to decay or mold. CLT does not absorb water very quickly and would only be an issue for prolonged water exposure. This exposure can be limited by concrete toppings which protect the wood from direct water contact (Ranger, Lindsay, et al,

2019).

18

Chapter 3: Methodology

Goal: Design a CLT office building, present the client with a fire resistance evaluation, design an option for advanced structural resilience, and provide a repair scope and cost-benefit analysis for each option.

3.1 Objective 1: Design a Type IV-A Class A CLT Office Building

The goal of this objective was to determine the mass timber members and CLT elements for our four-story office building. Each level of the floor plan was separated to determine the calculations and design of each component. The fourth-floor ceiling and atrium was often analyzed separately due to the weight of the penthouse above, and the exposure to the second floor. Within each level, members were separated into flooring, shear walls, joist, girders, and columns. CLT was used for the flooring and shear walls, while glulam and gypsum were used for the joist, girders, and columns. Spreadsheets were utilized to combine calculations of gravitational loads, lateral loads, fire adjustment factors, and design and allowable moment for every member.

References including the *IBC 2021*, *CLT Handbook*, *Nordic Technical Guides*, *AWC NDS 2018*, and *ASCE 7-10* were used during the design and calculation process. Spreadsheets for each member were created to assist with repetitive design calculations.

3.2 Objective 2: Evaluate Fire Resilience and Repair Options of Building

After the completion of the design of a Class A office building, the fire assessment was completed. Each member of the Option 1 building was designed according to the FRR or induced moment post fire. Similar to objective one, each level was separated to asset with identification and calculations. The char depth of the CLT and glulam members were determined by using the char rating and exposure time that corresponds to a Type IV-A building. Spreadsheets were created to assess the post fire members moment compared to the ultimate moment. Based off these calculations and char depth, it was determined if the member needed to be replaced or repaired.

References including the *IBC 2021*, *CLT Handbook*, *Nordic Technical Guides*, *AWC NDS 2018*, and *FDS 2021* were used during the design and calculation process. Spreadsheets for each member were created to assist with repetitive design calculations.

3.3 Objective 3: Design a CLT Office Building for Advanced Structural Resilience

Objective 3 was the completion of our redesign from a Class A building to a Class B building post fire. After the fire analysis was completed, every member was evaluated to support a reduction of the live load from 100 psf to 50 psf post fire. If the members could not support the reduction, they were resized. A new fire analysis was completed for the new resized members to determine if they could support the reduced live load post fire.

References including the *IBC 2021*, *CLT Handbook*, *Nordic Technical Guides*, *AWC NDS 2018*, and *FDS 2021* were used during the design and calculation process. Spreadsheets for each member were created to assist with repetitive design calculations.

3.4 Objective 4: Cost Analysis of Building Options

Once the fire analyses were completed, an inventory of alternative building elements designs were calculated. This inventory was directly transferred into a cost estimate for the alternative designs as a numerical comparison between structural decisions. This estimate also included the estimated cost of repairs for each design.

References including the 2022 National Construction Estimator and Building Construction Costs with RSMeans Data 2021 were used during the estimation process. A spreadsheet was created to assist with repetitive calculations.

Chapter 4: Design for a Type IV-A Office Building

4.1: Floor Layouts

At the beginning of the design process, the functionality of the office building was determined for later analysis. Each story was distinguished by its purpose. The first floor main entrance has an atrium which is welcoming and open. The entrance could be used as an open cafe/dining space for employees to visit on lunch breaks or host clients to a meal. On the back side of the building core, there is open space with the possibility for use as a mixed lounge and private conference rooms to host clients. On the second floor there is room for a potential conference room overlooking the atrium. The rest of the floor can be used as open workspace to encourage collaborative work. The second floor could promote teamwork and group work with large tables and moving white boards. On the third and fourth floors, areas can be designated to be quieter with private offices and cubicles. There are two kitchenettes, one on each side of the central core, for the ease of breaks and water or coffee refills.



Figure 7: Potential Layout of Floor One and Two



Figure 8: Potential Layout of Floor Three and Four

4.2: Gravitational Loads

The building site was assumed to be located in Worcester, MA. After the functionality of each story was determined, the gravitational loading design began. Starting on the roof, it was assumed there was proper drainage for the ponding effects of rain. This provided a governing load of snow instead of rain. ASCE 7-10 was utilized for all local information regarding live roof loading effects. Stacked framing was assumed for the design to promote room for mechanical, electrical, plumbing, and fire protection equipment throughout the building. This also allowed the design to be slightly more conservative than flushed framing. The official load path was as follows: roof into joists, joists into girders, girders into columns, and columns into foundation.

4.2.1: CLT Paneling for the Roof and Floor Systems

For the ease of constructability, the CLT panels were designed consistently with minor variations between purposes. In the case of the CLT roof, 3-ply panels were able to withhold the roof dead and live loads while the 5-ply panels had to be used throughout the rest of the building

floor systems to hold the 100 psf occupancy live load. These panels alternated between five and six foot widths throughout each level to remain in transportation limit for semi-truck beds.

The process of determining a CLT panel size began with selecting a panel from Nordic Technical Guide for X-Lam. This guide provided panel sizing based on length, loading, and FRR. According to the IBC 2021, a Type IV-A building requires a 2 hour FRR for all flooring members and an 1 ½ hour FRR for roof members. Nordic provides CLT panels that support up to a 2 hour FRR. Due to loads of the penthouse and members in the core, panels of gypsum board were added to the CLT, providing additional time for the FRR. Gypsum was also added to prevent multiple laminations falling off due to charring.

After a panel was selected, spreadsheets were created to simplify the process of calculating the allowable moment, shear, and deflection. The gravitational loads on the corresponding floor were run through the eight ASD load combination equations, and the combination that provided the largest load governed. The actual moment, shear, and deflection were calculated. If any of these calculations were larger than the allowable values, a new panel size was selected. This process was repeated for all CLT panels. All members had acceptable shear, moment, and deflection values.

As shown in the figures below, the highlighted areas include the sections of paneling. An inventory of CLT and spreadsheets can be found in Appendix E and Appendix B

4.2.2: GLT Joists

Glue-Laminated Timber joists were stacked on top of the girders and utilized to support the CLT floors or roof. The determination of a joist member began with gravitational loads on the corresponding floor. The gravitational loads were inputted into the eight load combinations, and what combination provided the largest load governed. A joist was selected from Nordic Technical Guide Lam+. According to the IBC 2021 a Type IV-A building requires a 3 hour FRR for all structural members, except members only supporting the roof, which only require a 2 hour rating. Nordic provides glulam members that support up to a 2 hour FRR. As a result of this, the members were designed to withhold a 2-hour FRR on three sides of the beam where it would be exposed to fire, and 2 additional panels of gypsum board were added. The two panels of gypsum provide an additional hour FRR, bringing the glulam joist up to the require 3 hour FRR. Spreadsheets were created to simplify the process of calculating the allowable moment and shear. A fire resistance adjustment factor, provided by Nordic, was applied to the adjusted bending moment. If the moment of the member was greater than the allowable moment, a new size and fire resistance adjustment factor was selected. This process was repeated for all glulam joists. All members had acceptable shear, moment, and deflection values.

As shown in the figures below, the highlighted vertical members include the typical and specially designed joists. An inventory of glulam members and spreadsheets for typical and special case joist can be found in Appendix E and Appendix B.



Figure 9: Typical Joist First and Second Floor Ceiling



Figure 10: Typical Joist Floor Third and Fourth Floor Ceiling



Figure 11: Special Case Joist First and Second Floor Ceiling



Figure 12: Special Case Joist Floor Third and Fourth Floor Ceiling

4.2.3: GLT Girders

The determination of a glulam girder member began with gravitational loads on the corresponding floor and joist. The gravitational loads were broken down into three-point loads from the joist stacked on the girders. The loads from each individual joist were inputted into the eight load combinations equations, and whatever combination provided the largest load governed. The self-weight of the glulam girder was also considered. A girder was selected from Nordic Technical Guide Lam+. According to the IBC 2021, for a Type IV-A building, it requires a 3-hour FRR for all structural members. Nordic provides glulam members that support up to a 2-hour FRR. As a result of this, the members were designed to withhold a 2-hour FRR on four sides of the beam where it would be exposed to fire, and 2 additional panels of gypsum board were added. The two panels of gypsum provide an additional hour FRR, bringing the glulam girder up to the require 3-hour FRR.

Spreadsheets were created to simplify the process of calculating the allowable moment and shear. A fire resistance adjustment factor, provided by Nordic, was applied to the adjusted bending moment. If the moment of the member was greater than the allowable moment, a new size and fire resistance adjustment factor was selected. This process was repeated for all glulam girders. All members had acceptable shear, moment, and deflection values.

27

The girders can be seen as the horizontal beams within the plan views shown below. An inventory of glulam members and spreadsheets for typical and special case girders can be found in Appendix E and Appendix B.



Figure 14: Typical Girders Third and Fourth Floor Ceiling



Figure 15: Special Case Girders Floor First and Second Floor Ceiling



Figure 16: Special Case Girders Third and Fourth Floor Ceiling

4.2.4: GLT Columns

The last calculation for the gravity loads were within the columns. Columns were selected from Nordic's Technical Guide Lam+. Due to a Type IV-A building having a required 3-hour FRR, all columns were initially selected based on their allowable concentric end load and corresponding FRR. The largest FRR Nordic provides is for 2 hours. As a result of this, the columns were covered with two gypsum wall boards, allowing for an additional 1-hour FRR. In addition, the columns were kept square to assist with the fire analysis and evenly char on all four sides.

Once this criterion was met, calculations were completed to ensure the column could support the axial loading. The first step was to determine the loading from the girders on either side of the column and the self-weight of the column. The adjusted compression parallel to the grain and the minimum modulus of elasticity were calculated. The ratio of effective length to depth was checked to be less than 50. If it was less than 50, the critical buckling design value and column stability factor could be computed. The axial buckling capacity was used to determine the allowable load and compared to the Nordic allowable concentric end load for a 3-hour FRR. Spreadsheets were created to repeat this process for the corresponding columns on floors 1-3.

The figures below show the typical and special case column sizes per floor. The column sizes increased with each floor from top to bottom, due to the additional weight from the floor above. The columns around the core are the largest because the need to withhold the weight of the penthouse. An inventory of glulam members and spreadsheets for typical and special case joist can be found in Appendix E and Appendix B.







Figure 18: Typical Columns Floor Three and Four







Figure 20: Special Case Columns Floor Three and Four

4.3: Lateral Loading

4.3.1: Seismic Loading

Seismic loading was determined with the use of *ASCE 7-10* Seismic Analysis Program. This program provided a spreadsheet that combined geographic location, soil classification, risk category, and weight of the building per floor to determine seismic loading. It was assumed the building was located in Worcester, Massachusetts, but a specific site was not selected. Based off this assumption, the unknown soil was classified as Site Class D. The building was determined to be in risk category II, as this category is assigned to most structures. The weight of the structural members and height per floor were inputted into the spreadsheets. The inventory of all the members was used to calculate the average weight per floor and converted into kips. Initially, it was thought wind loads were significantly greater. However, due to the weight of the penthouse and mechanical systems, seismic loading was quite similar to wind loading. The Seismic Analysis Program spreadsheet can be found in Figures 21 and 22.

	SEISMIC	BASE SHE	AR AND V	ERTICAL	SHEAR D	ISTRIBU	ITION
Lising E	auivalant L	Per IBC	2012 and AS	CE 7-10 Sp Bogular Mu	ecifications) uldina/Stri	uctural Systems
Job Name:		aleral Force P	locedure for	Regular wu	Subject:	inung/stri	uctural Systems
Job Number:					Originator:		Checker:
					e nginaren		
Input Data:			1				
Risk	Category =	II	IBC 2012, Ta	able 1604.5,	page 336	LTT.	
Importance	e Factor, I =	1.00	ASCE 7-10 1	able 1.5-2,	bage 5		F10
Soll	Site Class =	D	ASCE 7-10 I	able 20.3-1,	page 204		F9
Elocation		0 180		iguros 22.1	to 22 11		
Spectral		0.160	ASCE 7-10 F	igures 22-1	to 22-11		
Long Trans	Period TI =	6,000	Sec ASCE 7	Fia's 22-12	to 22-18		← F5
Structure	Height, hn =	83.000	ft.	193. 22-12	lo 22-10 hi	n	← F4
Actual Calc.	Period. Tc =	0.000	sec. from ind	ependent ar	alvsis		← F3
Seismic Resis	st. System =	B24	Light-framed	walls with s	hear		← F2 ↑
			panels of all	other materi	als (ASCE		← F1 hx
			7-10 Table 1	2.2-1)		┵┌└──	
Structure Weig	ht Distribut	ion:	_			V = Cs*V	$V = \Sigma(Fi) = 427.74$ kips
No. of Seisr	mic Levels =	5				<u>Seismic</u>	Base Shear
					(Re	egular Bidg. (Configurations Only)
	Seismic	Height, hx	Weight, Wx				
	Level x	(ft.)	(kips)				
	5	83.000	262.30				
	4	64.000	2657.98				
	3	46.000	003.02				
	<u> </u>	16,000	866 50				
	-	10.000	000.09				
			5500.40	(1005		10 7 0	
Desultas	lotal Weig	ght, W = ΣW_X =	5569.49	kips (ASCE	7-10 Sectio	n 12.7.2)	
Results:							
Site Coefficien	te:						
Site Coefficient	<u>Ea =</u>	1 600		able 11 4-1	nage 66		
	Fv =	2 400	ASCE Table	11 4-2 page	66		
		2.100		11.1 <u>2</u> , page	00		
Maximum Spec	ctral Respor	nse Acceleratio	ons for Short	and 1-Seco	ond Periods		
	SMS =	0.288	SMS = Fa*SS	, ASCE Egr	. 11.4-1, pa	ge 65	
	SM1 =	0.158	SM1 = Fv*S1,	ASCE Eqn	. 11.4-2, pa	ge 65	
Design Spectra	al Response	e Acceleration	s for Short a	nd 1-Secon	d Periods :		
	SDS =	0.192	SDS = 2*SMS	/3, ASCE 7	-10 Eqn. 11	.4-3, page	65
	SD1 =	0.106	SD1 = 2*SM1	3, ASCE E	qn. 11.4-4, p	bage 65	
1							(continued:)

Figure	21:	Seismic	Analy	vsis Pro	ogram	Spread	lsheet
- ngai v		NOIDHIN				opr cat	

Salamia Dagian Catagon						
Seismic Design Category			Tabla 11 6 1	page 67		
Category(for SDS)		ASCE 7-10	Table 11.0-1,	page 67		
		ASCE 7-10	of oithor opt	page 07	abovo contr	
Use Calegory	- D	WOSt Childan		egory case		UIS
Fundamental Period:		-				
Period Coefficient, CT	= 0.020	ASCE 7-10	Table 12.8-2,	page 90		
Period Exponent, x	= 0.75	ASCE 7-10	Table 12.8-2,	page 90		
Approx. Period, Ta	= 0.550	sec., Ta = C	т*hո^(х), АS	CE 7-10 Se	ction 12.8.2	.1, Eqn. 12.8-7
Upper Limit Coef., Cu	= 1.689	ASCE 7-10	Table 12.8-1,	page 90		
Period max., T(max)	= 0.929	sec., T(max) =	= Cu*Ta, AS0	CE 7-10 Se	ction 12.8.2	, page 90
Fundamental Period, T	= 0.550	sec., T = Ta	a <= Cu*Ta, ∖	ASCE 7-10	Section 12.	8.2, page 90
Seismic Design Coefficie	nts and Factors	:				
Response Mod. Coef., R	= 2.5	ASCE 7-10	Table 12.2-1,	pages 73-	75	
Overstrength Factor, Ωo	= 2.5	ASCE 7-10	Table 12.2-1,	pages 73-	75	
Defl. Amplif. Factor, Cd	= 2.5	ASCE 7-10	Table 12.2-1,	pages 73-	75	
Cs	= 0.077	Cs = SDS/(R	/I), ASCE 7-	10 Section	12.8.1.1, Eq	n. 12.8-2
CS(max)	= 0.077	For T<=TL,	CS(max) = S	D1/(T*(R/I)), ASCE 7-1	0 Eqn. 12.8-3
CS(min)	= 0.010	CS(min) = 0	.044*SDS*I >	>= 0.01, AS	CE 7-10 Eq	n. 12.8-5
Use: Cs	= 0.077	CS(min) <= C	S <= CS(max)			
Delemia Dece Ober						
Seismic Base Shear:	- 407.74			10 Contine	1001 5	10.0.1
V	- 421.14	$kips, \mathbf{V} = \mathbf{CS}^*$	W, ASCE 7-	IN SECTION	ı∠.ö.1, Eqn.	12.8-1
Seismic Shear Vertical D	istribution:					
Distributio	on Exponent, k =	1.02	k = 1 for T<	=0.5 sec. k	= 2 for T>=2	2.5 sec
	,		$k = (2-1)^{*}(T)^{*}$	-0.5)/(2.5-0	5)+1. for 0.	5 sec. < T < 2.5
Lateral Fo	ce at Any Level:	$F_x = C_{vx} V$.	ASCE 7-10 \$	Section 12.	3.3. Ean. 12	.8-11. page 91
Vertical Dis	stribution Factor:	$C_{vx} = W_x h_x$	$k/(\Sigma Wi^{hi^{k}}),$	ASCE 7-1	0 Eqn. 12.8	-12, page 91
	.			<u> </u>	-	
Seismic	Weight, Wx	hx^k	Wx*h^k	Cvx	Shear, Fx	Σ Story
Level x	(kips)	(ft.)	(ft-kips)	(%)	(kips)	Shears
5	262.30	92.688	24312.2	0.079	33.98	33.98
4	2657.98	71.008	188/3/./	0.617	263.82	297.80
3	883.82	52.875	46731.6	0.153	65.32	303.13
2	090.00	34.894	31303.1	0.102	43.04	400.97
	000.59	17.148	14000.0	0.049	20.77	421.14
		-	1			
$\Sigma =$	5569.49		306004.5	1.000	427.74	
$\Sigma =$	5569.49		306004.5	1.000	427.74	
<u>Σ</u> =	5569.49		306004.5	1.000	427.74	
<u>Σ</u> =	5569.49		306004.5	1.000	427.74	
Σ =	5569.49		306004.5	1.000	427.74	
Σ =	5569.49		306004.5	1.000	427.74	

Figure 22: Seismic Analysis Program Spreadsheet

4.3.1 Wind Loading

Wind Loading was determined with the use of *ASCE 7-10* and a wind loads spreadsheet, created by FLSmidth. This spreadsheet combined risk category, regional wind speed, exposure category, and enclosure classification to calculate the wind loads on the building. The building was classified as a risk category II and basic wind speed of 124 mph, per *ASCE 7-10 Table 1.5-1* and *Figure 26.5-1A*. Since there is no physical site for the building, it was classified as an exposure category C. The building was determined to be an enclosed structure, due to lack of openings or partially enclosed areas. The shorter side of the building was selected as the windward wall, while the longer side was the leeward wall. Similar to seismic loading, the wind loads varied per floor due to the differing height. In the end, wind load was determined to be the governing lateral load. The FLSmidth wind loads spreadsheet can be found below in Figure 23.
					MWFF	RS Wind Lo	oads			Job No:	11054	
CI C.			ASCE 7-10							Designer: DCB		
	יסווו	H	Enclosed & Partially Enclosed Buildings of All Heights						Checker:			
			Notes:	Grinding Build	ling (+/- Z Di	rection)				Date:	3/1/2022	
Basic Paran	neters									T-1-1-0 5 0		
RISK Catego	ry Second M			11 124 mmh						Table 1.5-1	1.4	
Basic Wind	Speed, V	or K		124 mpn						Figure 26.5	-1A	
	Ionality Fact	.01, K _d		0.85						Table 26.6-	1	
Exposure Ca	ategory									Section 26.	/	
Topographi	c Factor, K _{zt}	-		1.00						Section 26.	8	
Gust Effect	Factor, G or	G _f		0.850						Section 26.	9	
Enclosure C	lassification			Enclosed						Section 26.	10	
Internal Pre	ssure Coeffic	cient, GC _{pi}		+/- 0.18						Table 26.11	-1	
Terrain Exp	osure Consta	ant, α		9.5						Table 26.9-	1	
Terrain Expo	osure Consta	ant, z _g		900 ft						Table 26.9-	1	
Wall Press	ire Coefficie	nts										
Windward \	Nall Width.	B		126 ft								
Side Wall W	/idth, L			165 ft								
L/B Ratio				1.31								
Windward V	Nall Coefficie	ent, C _p		0.80						Figure 27.4	-1	
Leeward Wa	all Coefficien	nt, Cp		-0.44						Figure 27.4	-1	
Side Wall Co	pefficient, C			-0.70						Figure 27.4	-1	
Roof Pressu	re Coefficie	nts										
Roof Slope,	θ			9.5°								
Median Roc	of Height, h			83 ft								
Velocity Pre	essure Expos	ure Coef., I	K _h	1.22						Table 27.3-	1	
Velocity Pre	essure, q _h			40.7 psf			Equation 27.3-1					
h/L Ratio				0.50								
Windward F	Roof Area			0 ft ²								
Roof Area V	Vithin 42 ft o	of WW Edg	e	0 ft ²				т				
	Location		Min/Max	Horiz Di	stance From	Windward	Edge					
Minduce		ficient		υft	42 JT	83 Jt	166 JT					
Nor	nal to Ridgo	C	Min	-0.90	-0.90	-0.50	-0.30			Figure 27.4	-1	
NOT	nai to nidge,	, Cp	Max	-0.18	-0.18	-0.18	-0.18	ł				
Leewar	a Koot Coeff	C	IVIIN	-0.90	-0.90	-0.50	-0.30					
Norr	nai to kidge,	, С _р	Max	-0.18	-0.18	-0.18	-0.18	ł				
Ro	of Coefficier	nt	Min	-0.90	-0.90	-0.50	-0.30	ł				
Para	llel to Ridge,	, C _p	Max	-0.18	-0.18	-0.18	-0.18	l				
Structure P	ressure Sum	mary (Add	Internal P	essure a GC	or a. CC . ac	Necessary						
Sci uccure P	cooure our		a internal Pl	cooure q _z oc _{pi}	o, q _h oc _{pi} as	Trecessol y	<u>.</u>	Roof		1		
				Wa	ls		Normal	to Ridge	Parallel	Inte	rnal	
				w u		Side	WW	LW	to Ridae	Positive	Negative	
Height, z	K z	q z	WW	LW	WW + LW							
Height, z	К _z 0.85	<i>q</i> _z 28.4 psf	WW 19.3 psf	LW	34.5 psf					7.3 psf		
Height, z 0 ft 8 ft	κ _z 0.85 0.85	<i>q</i> _z 28.4 psf 28.4 psf	WW 19.3 psf 19.3 psf	LW	34.5 psf 34.5 psf		Min:	Min:	Min:	7.3 psf 7.3 psf		
Height, z 0 ft 8 ft 16 ft	κ _z 0.85 0.85 0.86	<i>q</i> _z 28.4 psf 28.4 psf 28.8 psf	WW 19.3 psf 19.3 psf 19.6 psf	LW	34.5 psf 34.5 psf 34.7 psf		Min: -31.2 psf	Min: -31.2 psf	Min: -31.2 psf	7.3 psf 7.3 psf 7.3 psf		
<i>Height, z</i> 0 ft 8 ft 16 ft 24 ft	κ _z 0.85 0.85 0.86 0.94	<i>q</i> _z 28.4 psf 28.4 psf 28.8 psf 31.4 psf	WW 19.3 psf 19.3 psf 19.6 psf 21.3 psf	LW	34.5 psf 34.5 psf 34.7 psf 36.5 psf		Min: -31.2 psf	Min: -31.2 psf	Min: -31.2 psf	7.3 psf 7.3 psf 7.3 psf 7.3 psf		
Height, z 0 ft 8 ft 16 ft 24 ft 32 ft	κ _z 0.85 0.85 0.86 0.94 1.00	<i>q</i> _z 28.4 psf 28.4 psf 28.8 psf 31.4 psf 33.3 psf	WW 19.3 psf 19.3 psf 19.6 psf 21.3 psf 22.7 psf	LW	34.5 psf 34.5 psf 34.7 psf 36.5 psf 37.8 psf		Min: -31.2 psf	Min: -31.2 psf	Min: -31.2 psf	7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf		
Height, z 0 ft 8 ft 16 ft 24 ft 32 ft 40 ft	K₂ 0.85 0.85 0.86 0.94 1.00 1.04	<i>q</i> _z 28.4 psf 28.4 psf 28.8 psf 31.4 psf 33.3 psf 34.9 psf	WW 19.3 psf 19.3 psf 21.3 psf 22.7 psf 23.7 psf	<i>LW</i> -15.2 psf	34.5 psf 34.5 psf 34.7 psf 36.5 psf 37.8 psf 38.9 psf	-24.2 psf	Min: -31.2 psf	Min: -31.2 psf	Min: -31.2 psf	7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf	-7.3 psf	
Height, z 0 ft 8 ft 16 ft 24 ft 32 ft 40 ft 48 ft	Kz 0.85 0.85 0.86 0.94 1.00 1.04	<i>q</i> _z 28.4 psf 28.4 psf 28.8 psf 31.4 psf 33.3 psf 34.9 psf 36.3 psf	WW 19.3 psf 19.3 psf 19.6 psf 21.3 psf 22.7 psf 23.7 psf 24.7 psf	<i>LW</i> -15.2 psf	WW + LW 34.5 psf 34.5 psf 34.7 psf 36.5 psf 37.8 psf 38.9 psf 39.8 psf	-24.2 psf	Min: -31.2 psf	Min: -31.2 psf	Min: -31.2 psf	7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf	-7.3 psf	
Height, z 0 ft 8 ft 16 ft 24 ft 32 ft 40 ft 48 ft 56 ft	Kz 0.85 0.85 0.86 0.94 1.00 1.04 1.08 1.12	<i>q</i> _z 28.4 psf 28.4 psf 31.4 psf 33.3 psf 34.9 psf 36.3 psf 37.5 psf	WW 19.3 psf 19.3 psf 21.3 psf 22.7 psf 23.7 psf 24.7 psf 25.5 psf	<i>LW</i> -15.2 psf	WW + LW 34.5 psf 34.5 psf 36.5 psf 36.5 psf 37.8 psf 38.9 psf 39.8 psf 40.6 psf	-24.2 psf	Min: -31.2 psf Max:	Min: -31.2 psf Max:	Min: -31.2 psf Max:	7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf	-7.3 psf	
Height, z 0 ft 8 ft 16 ft 24 ft 32 ft 40 ft 48 ft 56 ft 64 ft	Kz 0.85 0.85 0.86 0.94 1.00 1.04 1.08 1.12 1.15	<i>q</i> _z 28.4 psf 28.4 psf 31.4 psf 33.3 psf 34.9 psf 36.3 psf 37.5 psf 38.5 psf	WW 19.3 psf 19.3 psf 21.3 psf 22.7 psf 23.7 psf 24.7 psf 25.5 psf 26.2 psf	<i>LW</i> -15.2 psf	34.5 psf 34.5 psf 34.7 psf 36.5 psf 37.8 psf 38.9 psf 39.8 psf 40.6 psf 41.4 psf	-24.2 psf	Min: -31.2 psf Max: -6.2 psf	Min: -31.2 psf Max: -6.2 psf	Min: -31.2 psf Max: -6.2 psf	7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf 7.3 psf	-7.3 psf	
Height, z 0 ft 8 ft 16 ft 24 ft 32 ft 40 ft 56 ft 64 ft 73 ft	Kz 0.85 0.85 0.86 0.94 1.00 1.04 1.08 1.12 1.15 1.18	<i>q</i> z 28.4 psf 28.4 psf 31.4 psf 33.3 psf 34.9 psf 36.3 psf 37.5 psf 38.5 psf 39.6 psf	WW 19.3 psf 19.3 psf 21.3 psf 22.7 psf 23.7 psf 24.7 psf 25.5 psf 26.2 psf 26.9 psf	<i>LW</i> -15.2 psf	34.5 psf 34.5 psf 34.7 psf 36.5 psf 37.8 psf 38.9 psf 39.8 psf 40.6 psf 41.4 psf 42.1 psf	-24.2 psf	Min: -31.2 psf Max: -6.2 psf	Min: -31.2 psf Max: -6.2 psf	Min: -31.2 psf Max: -6.2 psf	7.3 psf 7.3 psf	-7.3 psf	

Figure 23: FLSmidth Wind Loads Spreadsheet

4.3.3: Shear Walls

To withstand the lateral loads, CLT shear walls were designed within the core of the building. The lateral load path started at the edges of the CLT flooring from the exterior of the building to the interior of the building and into the shear walls. From this, the required shear wall lengths in both East-West and North-South directions were finalized. The overturning effects were resisted through the dead loads accumulated throughout the building.

Chapter 5: Fire Analysis

5.1: Post-Fire Structural Damage

For the initial building design, members were sized to support gravitational and lateral loads before and during a time-equivalent fire event for a Type IV-A building. In the initial design of CLT members, the initial member sizes were influenced by allowable stress design and by manufacturer-provided fire ratings for various CLT sizes.

For each member, the initial design was confirmed by examining specific char rates and calculating the strength of the remaining cross-section. For fire design, ultimate strength of the member was used, rather than allowable strength for regular occupancy in accordance with the 2021 Fire Design Specification for Wood Construction (*2021 fire design specification for wood construction*). To design to fire rating, the ultimate strength of the beam is assessed, rather than the allowable load for regular occupancy, because confirmation is needed that emergency personnel have adequate time to evacuate occupants without structural failure. The typical FDS procedure does not design for occupancy after a fire event, and repairs may be needed with this method. A table below shows some design values for a typical member.

Member	Total Req. Fire Rating (hr)	Member Req. Fire Rating (hr)	GYP fire protection (hr)	Member Remaining Cross Section	Allowable Moment (ft-lbs)	Ultimate Moment (x2.85) (ft- lbs)	Design Moment (ft-lbs)
11.5" x 15.5"	3	2	1	5.18" x 12.34"	19,167	54,627	43,062

Figure	24.
riguic	4.



Figure 25: Illustration of building Cross-Section with Charred Girder

For each member of the initial design, it was also noted whether that member would be able to support an allowable occupancy load after the fire event. It was found that most members were not able to support such a load, and for a time-equivalent fire, extensive repairs were needed.

5.2: Repair Methods

Several repair methods for damaged structural elements such as: CLT floors, GLT beams, GLT columns, and CLT shear walls were researched. For mass timber and CLT is the charring if localized, it can be removed with sanding, scraping, or abrasive blasting. This is done for minor fire damage and if the structural integrity can remain intact. If small areas are damaged, they can be repaired with equivalent wood sections, such as sections around doors or windows (Ranger, Lindsay, et al, 2019).

If the char or fire damage impacts multiple layers of the CLT it is best to replace all layers affected. One solution is to remove and clean the damaged portions and replace them with new laminations attached with adhesive. This solution does not restore full structural capacity of the CLT panel, but it does restore the FRR. Another option is to remove the damaged portions and replace them with new laminations attached with adhered and screwed scarf joints or adhered only. This option reestablishes pre-fire structural capacity, maintains exposed CLT, and restores FRR ("*Post-Fire Restoration*," 2018). Chapter 6: Post Fire Class A to a Class B Office Building

6.1: Structural Design Change Overview

Three building options were examined for various levels of post-fire resiliency. These options are presented in the list and table below:

Option 1: Designed for Class A

Option 2: Designed for Class A, with ability to become Class B after a fire event

Option 3: Designed for Class A, with ability to remain Class A after a fire event

Option	Building Class Before Fire Event 1*	Building Type Before Fire Event 1	Building Class after Fire Event 1*	Building Type After Fire Event 1*
Option 1	Class A 100 psf Occupancy Rating	Rated as a Type IV-A building 3-hour rating for structural frame, except 2 hours at floor and roof frame	N/A members may not be fit for continued occupancy, may require extensive structural repair	N/A Members may no longer meet required fire rating, may require extensive structural repair
Option 2	Class A 100 psf Occupancy Rating	Rated as a Type IV-A building 3-hour rating for structural frame, except 2 hours at floor and roof frame	Class B 50 psf Occupancy Rating	Rated as a Type IV-A building 3-hour rating for structural frame, except 2 hours at floor and roof frame
Option 3	Class A 100 psf Occupancy Rating	Rated as a Type IV-A building 3-hour rating for structural frame, except 2 hours at floor and roof frame	Class A 100 psf Occupancy Rating	Rated as a Type IV-A building 3-hour rating for structural frame, except 2 hours at floor and roof frame

Table 6.1.1: Building Options

*Fire Event 1 is defined using time equivalence

6.2: Option 1: Designed for Class A

The first option was designed to support gravitational and lateral loads before and during a time-equivalent fire event for a Type IV-A building. Chapter 4 details the design of this option, and Chapter 5 details the fire analysis.

6.3: Option 2: Designed for Class B post fire

From the fire analysis of option 1, strategies to improve the resilience of the building design were formed. Multiple strategies were used in the Option 2 design. First, members had to be resized to be large enough to sustain a Class B occupancy with minimal structural repairs post-fire. This specifically meant that member widths had to increase. Second, more layers of gypsum were added onto particularly vulnerable structural elements, such as CLT, Girders, and Columns, to minimize the member exposure time and char depth. Finally, certain joists were added below the penthouse to further distribute the equipment load and reduce member size. After a time-equivalent fire event, in this option damaged gypsum board would still have to be replaced, but there would still be sufficient member cross sections to maintain a Type IV-A fire rating and serve a Class B occupancy with minimal structural repairs. Below are various box-and-whisker plots which display the average increase in percent perimeter and area for members to be sufficient from Option 1 to Option 2. Percent increase in perimeter suggests the increase in Gypsum fireproofing needed.







42

Figure 26















Figure 32: Option 2 Joist Sizing, level 3 and 4



Figure 34: Special Case Joists, level 1 and 2

1 LEVEL 03 AND 04 OVERALL PLAN

1) LEVEL 03 AND 04 OVERALL PLAN

F



Figure 36 : Option 2 Girders, level 1 and 2

1) LEVEL 03 AND 04 OVERALL PLAN

1) LEVEL 03 AND 04 OVERALL PLAN



Figure 38 : Special Case Girders, Level 1 and 2



Figure 40: Option 2 Columns, level 1 and 2



Figure 42: Special Case Columns, levels 1 and 2

From the design of Option 2, it was discovered that there would be significantly more material needed to design a building that did not need major structural repairs after a time-

equivalent fire. At the point with the most load under the equipment penthouse, the structure took up over 5 feet of ceiling height. Especially on the first floor and under the equipment penthouse, member sizes started to increase past the point of some standard fabrication.

6.4: Option 3: Designed for Class A, with ability to remain Class A after a fire event

Based on the design of option 2 and comparison with option 1, it can be concluded that in order to remain Class A after a time-equivalent fire, member sizes would increase significantly. Following percentages found in the option 2 design, the point that took up over 5 feet of ceiling height would now take up over 6.5 feet of ceiling height, leaving only a 9.5' clearance. This option would also be more expensive than option 1 or 2.

Chapter 7: Evaluation

A final evaluation of our building and its alternative designs are significant in understanding the impacts of structural engineering decisions. Although, as a client or general contractor, it is important to evaluate the differences in design and how it may impact construction costs and duration. It must also be noted the constructability of a design directly effects the duration of a project. Labor and equipment were not directly included in the evaluation but as the construction project duration increases these factors would increase as well.

7.1: Cost Considerations in Design and Construction

The final cost estimates are shown in Table 7.1.1 and Table 7.1.2. The average market price of CLT was assumed as \$21 per cubic foot which considered for the roof, floors, and shear walls in our structural system *CAWBIOM* (2015). The cost of GLT members averaged \$0.03 per cubic inch according to *Building Construction Costs with RSMeans Data 2021*.

Table 7.1.1: Summarized Cost Estimate for Building Option 1											
Structural Element	Quantity (total area)	Unit Cost	Total Cost								
CLT Panels	50,156 ft^3	\$21/ft^3	\$1,053,266.16								
GLT Beams	23,452,673 in^3	\$0.03/in^3	\$703,580.18								
GLT Columns	7,044,257 in^3	\$0.03/in^3	\$211,327.72								
	·	TOTAL	\$1,968,174.05 \$23.67 per sqft								

When determining the post-fire cost of repairs for building option 1, each mass timber element had major structural damage. For the CLT floors, roof, and walls it was safe to assume one lamination had been charred off and stripped equaling a total of 2.75 inches removed. To replace these laminations after a fire event costs upwards of \$370,221. For the glue laminated beams and columns, there was significant damage where nearly every member would need to be replaced post-fire to withstand any occupancy load. In the case of repairing the building back to its initial Class A requirements, the GLT replacement would cost nearly the same as the original

of \$914,908. In addition to these structural components, the original FRR would require full replacement of all gypsum wall board.

Table 7.1.2: Summarized Cost Estimate for Building Option 2											
Structural Element	Quantity (total area)	Unit Cost	Total Cost								
CLT Panels	56,340 ft^3	\$21/ft^3	\$1,183,140.66								
GLT Beams	53,199,840 in^3	\$0.03/in^3	\$1,593,595.19								
GLT Columns	10,789,895 in^3	\$0.03/in^3	\$323,696.86								
		TOTAL	\$3,100,432.71 \$32.28 per sqft								

For the third building option, the structural elements and respective costs were statistically analyzed through a box-and-whisker chart to determine the scale up values.

7.2: Constructability of a Mass Timber Building

In comparison to standard construction materials such as concrete and steel, mass timber has a wide range of capabilities. The fabrication process for CLT ensures precision through Computer Numerical Controlled (CNC) machines which contributes to quicker completion for delivery on-site. Additionally, with the precut panels, safety increases and less demand for skilled laborers can be factored in labor costs. Stacked framing was utilized in the structural design phase which assisted in the freedom of mechanical, electrical, plumbing, and fire protection equipment to move throughout the building. The last constructability consideration was with the transportation of materials from the NORDIC mill in the region of Quebec, Canada to the on-site delivery of materials in Worcester, MA. Both CLT and glulam elements were sized appropriately to fit standard transportation vehicles under 53 feet in length and 8.5 foot width. The weight limit of a 5-axle semi-trailer is just over 25 tons in the United States which limits the number of materials delivered on-site at a time. Additionally, the route of delivery must be considered to accommodate local highway and motor carrier regulations. On-site considerations include wrapping all six sides of the mass timber and place on skids to account for thermal and moisture protection *FPInnovations* (2019).

Chapter 8: Conclusion

The four original objectives were completed for this project. The first objective was completed through the challenging building layout with the atrium and significant weight of the rooftop penthouse alongside all gravitational and lateral loading effects. The second objective was completed through fire analysis and evaluation of damage. The third objective was completed through the redesign of not only one but two alternative buildings considering different occupancy cases. The fourth and final objective was completed with a final cost estimate of the alternative structural designs and post-fire respective repair costs. In conclusion, building option two was the most cost effective for repairs and preventative measures.

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Appendix A: Project Proposal



Cross-Laminated Timber and Structural Resilience A Major Qualifying Project

Submitted on:

March 4th, 2022

Submitted to:

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Table of Contents	Table	of	Conten	ts
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Abstract		1
Acknowledgements		2
Authorship		3
Capstone Design Statement		4
Professional Licensure Statement		6
Chapter 1: Introduction		56
Chapter 2: Background		60
2.1: The Growth of CLT		61
2.2: Design of Cross-Laminated Timber		63
2.3: Building Codes		65
2.4: CLT and Fire		66
Chapter 3: Methodology		70
Objective 1: Design a Type IV-B CLT Office Building		70
Objective 2: Evaluate Fire Resilience and Repair Options of	Building	71
Objective 3: Design a CLT Office Building for Advanced Str	ructural Resilience	71
Objective 4: Cost Analysis of Building Options		72
Chapter 4: Results		73
4.1: Final Design for a Type IV-B Office Building	Error! Bookmark no	t defined.
4.2: Fire Analysis	Error! Bookmark no	t defined.
Chapter 5: Conclusion		73
Works Cited		73

Capstone Design Statement

Worcester Polytechnic Institute requires all capstone design projects to meet ABET (Accreditation Board for Engineering and Technology) standards. At WPI, the Major Qualifying Project (MQP) is a high level research project that addresses a problem found in a student's professional discipline. This MQP will design a four-story office building constructed of Cross-Laminated Timber (CLT) and glue-laminated timber (Glulam). This design will address a fire analysis of CLT and a more structural resilient design of the building will be completed. A costbenefits analysis will be provided for the two designs. The following constraints were identified based on the following categories: Economic, Social, Political, Health & Safety, Manufacturability, Sustainability, and Ethics.

Economic

To address the economic constraint of our capstone design we will compare the cost of our building designed to the current code standard, the cost of our fire repairs, and the cost of the structural resilient building design. We will look at the cost of the materials, manufacturing, transportation, labor, and construction time. In addition, we will consider the market flux of CLT.

Social

To address the social constraints of our capstone design we will be demystifying the public stigma that wood and timber materials are less fire resistant than other common construction materials.

Health & Safety

To address the health and safety constraints of our capstone design, we will utilize current building codes and requirements during our design. We ensure that fire protection materials and the building height and area are sufficient for a Type IV-B office building.

Manufacturability

To address manufacturability constraints of our capstone design, we will consider the location and accessibility of CLT manufacturers in North America, including analyzing which regions have better access to CLT than others with the few current manufacturer locations. We will use standard sections of CLT with section cutouts that are easily prefabricated with CNC machines. We will also take into account availability of wood in the current climate, as the COVID-19 pandemic has created various material shortages.

Sustainability

To address the sustainability constraints of our capstone design, we will be using CLT as our main design material. CLT produces less greenhouse gasses, less waste, significantly lighter when compared to concrete, and has faster construction times than both concrete and steel.

Ethics

To maintain an ethical approach, we will conduct ourselves with integrity and professionalism and use our project to advance the health, safety, and welfare of the public. We will consider both the socioeconomic and health impacts of the growth of CLT on society. We will also utilize the principles of sustainable development in our designs, act professionally to clients, communicate potential issues, and adequately credit the previous extensive research on CLT.

Chapter 1: Introduction

Cross-Laminated Timber (CLT) is a type of prefabricated solid wood panel that consists of crosswise layers of kiln-dried lumber board. After CLT was first patented in 1985 in France, the concept spread across Europe. After refining press technology between 1995-1996, the first multi-story building was constructed in Austria by 1998. CLT started to make an appearance within the United States in 2013 (American Wood Council, 2017). Since then, CLT has grown rapidly throughout the United States. However, there is hesitation to construct multi-story buildings out of wood because of historical events that resulted in mass fire damage to wood structures.

The goal of this project is to design a CLT office building, present the client with a fire resistance evaluation, design an option for advanced structural resilience, and provide a repair scope and cost-benefit analysis for each option. We will be designing a four story Type IV-B office building in Massachusetts based on a case study provided to us from the project sponsor.

To help us achieve our goal, we have identified 4 objectives:

Objective 1: Design a Type IV-B CLT Office Building
Objective 2: Evaluate Fire Resilience and Repair Options of Building
Objective 3: Design a CLT Office Building for Advanced Structural Resilience
Objective 4: Cost Analysis of Building Options

The first phase of this project is the design of a Type IV-B CLT office building. This will be our base design used to evaluate the fire resilience of the office building. The fire resilience evaluation will consider fire exposure and damage, charring, repairs, and post-fire capacity. Our second design will also be a Type IV-B CLT office building, but will be designed for advanced structural resilience. Finally, we will present two CLT office designs and the cost of multiple fire repair options.

Chapter 2: Background

2.1: The Growth of CLT

During the early 2000s, CLT production and usage increased significantly in Europe due to its energy efficiency. This led to the construction of over 500 CLT buildings within England

alone. One notable project was the first "timber tower", Murray Grove, which was constructed in Hackney, London in 2009. This nine story residential building was completely constructed with mass timber and featured a tight honeycomb design using CLT structural panels. This building paved the way for the potential of CLT as an environmentally sustainable and financially viable solution within construction, especially in urban areas. The use of CLT for Murray Grove allowed a faster project schedule by 30% (total of 49 weeks), saved 300 metric tons of CO2, and provided 29 fully insulated and soundproof apartment units simply by avoiding the use of precast concrete and other standard construction materials (Waughthistleton.com, 2021; American Wood Council, 2017). As of June 2021, there have been 1,169 mass timber projects in the United States, 249 of which are in construction or built and 365 in design (see Figure 1) (WoodWorks - Wood Products Council, 2021).





CLT has many benefits compared to standard construction materials such as steel, concrete, and masonry. The carbon emissions from the production of CLT is 50% of what is required for concrete and a shocking 1% of what is required for steel production. Since CLT does not have an abundance of production facilities in the United States, the carbon emissions for

travel are far more. However, they still do not reach the emission level of concrete or steel (The B1M, 2017). Another advantage of CLT is the minimal waste during production, due to the ability to reuse sawdust, timber cutouts, and other byproducts. CLT is very energy efficient in performance, with an R-value of 1.25 per inch of thickness. For seismic performance, it is more forgiving due to its ability to flex without losing structural stability. It also provides high performing acoustics, especially with an added acoustic mat layer, which is beneficial for urban construction. Besides the performance and environmental benefits, CLT is 75% lighter than concrete which can reduce groundwork costs for buildings. It also has a significantly lower construction time because panels are prefabricated, so they can be installed immediately on site. This is especially beneficial for urban areas with minimal on-site storage of materials, because the panels can be produced and transported the day they are needed (Landreman, Archie, and WoodWorks - Wood Products Council, 2017). CLT has grown significantly and has many benefits, but the common misconception of all wood as unsafe for fire conditions causes hesitation.

2.2: Design of Cross-Laminated Timber

Cross-Laminated Timber, or "CLT' is made up of layers, or laminations, that are generally stacked crosswise with the direction of fiber 90 degrees to the previous. An illustration of a sample CLT panel is shown at right in Figure 2. Pairs of parallel layers can be included at the core or the outer layer for special applications. Layers are glued with structural adhesive. To

create CLT panels, individual boards are finger jointed and glued. Odd numbers of layers are used so that both outer layers of wall panels can be oriented parallel to the vertical load path axis to maximize vertical load capacity in wall panels. For floor and roof panel systems, outer layers are oriented parallel to the span axis. Most commonly, CLT panels are



Figure 2: Sample CLT Panel Illustration

composed of three, five, and seven layers (FPInnovations, 2013). Three and five layer panels are the most accessible to produce and are the most readily available from manufacturers.

When designing CLT structures, one important factor is the material constraint. For Nordic X-Lam Cross-Laminated Timber, the maximum dimensions of panels are

Nordic X-Lam Panel	Longitudinal Layer Thickness	Transverse Layer Thickness	Layup Combination	Total Thickness
89-3s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ¾ in	L-T-L	89 mm = 3 ½ in
105-3s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	35 mm = 1-3/8 in	L-T-L	105 mm = 4 ¹ / ₈ in
143-5s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ¾ in	L-T-L-T-L	143 mm = 5 ⁵ / ₈ in
175-5s	35 mm = 1-3/8 in	35 mm = 1-3/8 in	L-T-L-T-L	175 mm = 6 ⁷ / ₈ in
197-7s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ¾ in	L-T-L-T-L-T-L	197 mm = 7 ³ ⁄ ₄ in
213-71	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ³ / ₄ in	L-L-T-L-T-L-L	213 mm = 8 3/8 in
244-7s	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	35 mm = 1-3/8 in	L-T-L-T-L-T-L	244 mm = 9 ⁵ / ₈ in
244-71	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	$35 \text{ mm} = 1 - \frac{3}{8} \text{ in}$	L-L-T-L-T-L-L	244 mm = 9 5/8 in
267-91	$35 \text{ mm} = 1-\frac{3}{8} \text{ in}$	19 mm = ³ / ₄ in	L-L-T-L-T-L-T-L-L	267 mm = 10 ½ in

106.25"(8.854') x 64' (Nordic Structures, 2020). Standard layup combinations for Nordic X-Lam are listed in Table 1 seen below.

Table 1: Nordic X-Lam Standard Panel Layup Combinations (Nordic Structures, 2020)

CLT has a light unit-weight, so vibration and deflection often determine allowable spans, rather than bending or shear. Much of CLT design includes balancing panel capacity with desired interior clear height, as a larger required number of laminations lowers clear height (McLain, Ricky, and Greg Kingsley, 2020).

Another important factor in CLT design is grid efficiency. The most efficient grid designs of CLT often differ from that of steel or concrete. On average, CLT square floor grids are sized between 20' x 20' and 30'x 30', and rectangular grids are sized between 10'x 20' and 20'x 32'. Grids are generally made with glulam girders supporting CLT panels. When designing a larger square grid, intermediate glulam purlins can be utilized, but these usually are not needed in rectangular grids. There are also alternative grid solutions that account for challenges such as MEP placement and unusual required spans. One alternative that has been previously utilized included 2 layers of CLT panels running perpendicular to each other, providing room for MEP structures and negating the need for glulam girders. For larger spans, a composite system of mass timber with a concrete topping or a combination system of CLT floor panels and parallel glulam beams could be utilized (McLain, Ricky, and Greg Kingsley, 2020).

The final important factor for CLT building design is the type of member connections. There are many types of CLT connections, and different options may offer different advantages. Factors to consider in CLT connection designs are load transfer, cost-effectiveness, aesthetic impact, height impact, and crushing or shrinkage leading to differential material movement. Additionally, the connection must have the same fire resistance as the members (McLain, Ricky, and Greg Kingsley, 2020).

2.3: Building Codes

According to the 2021 IBC, there are five construction types. The construction types include I, II, III, IV, and V. Of these, there are further specification categories (see figure below - eg: A, B, C, HT). The purpose of these classification types is to evaluate and define the severity of building material combustibility and the fire resistance rating of its building elements. Each construction type has a different fire resistance rating (FRR) requirement per building element. Different elements such as bearing walls or floors receive higher or lower classifications (see Figure 3) (Codes.iccsafe.org, Oct. 2020).

BUILDING ELEMENT		YPEI	TYF	PE II	TYPE III		I TYPE IV				TYP	ΈV
		в	Α	в	Α	в	Α	в	С	нт	Α	в
Primary structural frame ^f (see Section 202)	3 ^{a, b}	2 ^{a, b,} c	1 ^{b,} c	0 ^c	1 ^{b,} c	0	3 ^a	2 ^a	2 ^a	HT	1 ^{b,} c	0
Bearing walls												
Exterior ^{e, f}	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	3	2	2	1/HT ⁹	1	0
Nonbearing walls and partitions Exterior							See Ta	ble 7	05.5			-
Nonbearing walls and partitions Interior ^d	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ¹ /2 ^b	1 ^{b,c}	1 ^{b,c}	0 ^c	1 ^{b,c}	0	1 ¹ / ₂	1	1	HT	1 ^{b,c}	0

For SI: 1 foot = 304.8 mm

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required

Not less than the fire-resistance rating required by other sections of this code.

e. Not less than the fire-resistance rating based on fire separation distance (see Table 705.5).

f. Not less than the fire-resistance rating as referenced in Section 704.10.

g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

For our case study building, we will initially focus on a two-hour rating for a Type IV-B office building. Type IV-B was selected because it allows for a four story building, but doesn't require fire resistance ratings that are impractical for standard CLT construction. The height and square footage for our four story case-study building is 64 feet high and just under an 80,250

Figure 3: Fire-Resistance Rating Requirements for Building Elements (Table 601 IBC, 2021)

square foot area. Our building features an atrium to the second floor and a rooftop penthouse with stair and elevator access. The rooftop penthouse is 6,790 square feet with a height of 19 feet. According to the 2021 IBC, rooftop penthouses cannot exceed a third of the square area of the supporting roof deck and cannot exceed a height of 18 feet. However, there is an exception for penthouses that include an elevator to have a maximum height of 28 feet, hence our building is compliant. Our building is also within the 2021 IBC limit for Type IV-B buildings by a significant margin because we will include an automatic sprinkler system. By including an automatic sprinkler system, our building can be up to 12 stories with a total height of 180 ft and a 216,000 total square footage area (WoodWorks - Wood Products Council, et al., 2019).

2.4: CLT and Fire

For this case study, we will be analyzing a fire that occurs in a 4-story office building. The number one cause of office fires is cooking equipment, which accounts for 29% of all office fires. Other causes of office fires include electrical distribution and lighting equipment, heating equipment, intentional, smoking materials, exposure, and electronic or entertainment equipment. The peak times of days for office fires were between noon and 2:00 PM. This is the time of day where the greatest number of people are in the office. However, fires that occur between 7:00 PM and 7:00 AM cause the greatest amount of property damage. Improving automatic detection systems, extinguishing equipment, and the fire resistance rating prevent further damage to be caused to the building ("NFPA Report").

Fire resistance rating (FRR) is the ability of a material to confine fire, continue to provide a structural function during fire, or both (International Code Council, 2021). The FRR is measured from the start of the fire until the material fails to function. Fire resistance of CLT depends upon the number of layers, thickness, adhesive, and panel assembly. Often, noncombustible materials are applied to mass timber to increase the FRR. Wall and floor assemblies that are made of CLT and exposed and covered with non-combustible material can provide up to a 3 hour FRR (Pogue, 2021). CLT's fire resistance is provided through charring. The charring of CLT is different from other timber panels due to the number of layers, glue composition, and joints. Charring is when a timber panel is exposed to a fire greater than 400 degrees C and causes the timber to ignite and burn at a steady rate. As the timber continues to burn, the char becomes an insulating layer. This layer protects the unburnt core of the panel and prevents an excess rise in temperature ("GreenSpec: Cross-Laminated").

Fire Dynamics Simulator (FDS) and Consolidated Model of Fire and Smoke Transport (CFAST) are the two main fire simulation software in use today. FDS is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flows. It is most appropriate for simulations of low-speed, thermally-driven flow, with an emphasis on smoke and heat transfer from fires. CFAST is a two-zone fire model. It is best used to calculate the evolving distribution of smoke, fire gases and temperature throughout compartments of a building during a fire. From both softwares, a heat transfer model can be developed. This can be used to determine thermal gradients of the wood elements, and the impacts on the structural capacity. For the sake of our project, we will not be using fire simulation software. Instead we will borrow parametric models and equations from literature, such as Figure 4, 5, and 6 shown below, to analyze various fire scenarios. This alternative is best suited for our short time frame to complete this project (NIST, 2011).

Table 16.2.1BEffective Char Depths (for CLTwith $\beta_n = 1.5$ in./hr.)

Required Fire Resistance			Ef lamii	fectiv	e Char (in. thickn	Depths) esses, h ₁	, a_{eff} am (in.)		
(hr.)	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1 ¹ / ₂ -Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

Figure 4: Effective Char Depths for CLT

Step	Floor Design
Lamination fall-off time	$t_{fo} = \left(\frac{h_{lam}}{\beta_n}\right)^{1.23}$
Calculation of the effective char depth	$a_{char} = 1.2 [n_{lam} \cdot h_{lam} + \beta_n (t - (n_{lam} \cdot t_{fo}))^{0.813}]$
Determination of effective residual cross- section	$h_{fire} = h - a_{char}$
Determination of location of neutral axis and section properties of the effective residual cross-section	$\underline{y} = \frac{\Sigma y_i h_i}{\Sigma h_i} \qquad I_{eff} = \Sigma \frac{b_i h_i^3}{12} + \Sigma b_i h_i d_i^2$
Calculation of design resisting moment	$S_{eff} = \frac{I_{eff}}{h_{fire} - \underline{y}} \qquad M' = KF_b S_{eff}$

Figure 5: Char Equations for Floor Design

Step	Wall Design
Lamination fall-off time	$t_{fo} = \left(\frac{h_{lam}}{\beta_n}\right)^{1.23}$
Calculation of the effective char depth	$a_{char} = 1.2\beta_n t^{0.813}$
Determination of effective residual cross- section	$h_{fire} = h - a_{char}$
Determination of location of neutral axis and section properties of the effective residual cross-section	$\frac{y}{A_{eff}} = \frac{\Sigma y_i h_i}{\Sigma h_i} \qquad I_{eff} = \Sigma \frac{b_i h_i^3}{12} + \Sigma b_i h_i d_i^2$
Calculation of resisting axial compression capacity	$S_{eff} = \frac{I_{eff}}{h_{fire} - \underline{y}}$ $M' = KF_b S_{eff}$

Figure 5: Char Equations for Wall Design

When CLT is damaged in a fire, there are multiple ways of fixing or replacing it. When charing is localized and can be removed with sanding, scraping, or abrasive blasting. This is done for minor fire damage and if the structural integrity can remain intact. If small areas are damaged they can be repaired with equivalent wood sections, such as sections around doors or windows (Ranger, Lindsay, et al, 2019). If the char or fire damage impacts multiple layers of the CLT it is best to replace all layers affected. One solution is to remove and clean the damaged

portions and replace it with new laminations attached with adhesive. This solution does not restore full structural capacity of the CLT panel, but it does restore the FRR. Another option is to remove the damaged portions and replace them with new laminations attached with adhered and screwed scarf joints or adhered only. This option reestablishes pre-fire structural capacity, maintains exposed CLT, and restores FRR ("*Post-Fire Restoration*," 2018).

Our case study building will have some form of automatic sprinklers. Sprinklers are used as a means of active fire suppression, but can be a balance between fire damage and damage from excess water discharge. Accidental or excess water discharge from sprinklers can result in frozen pipes, mechanical damage, installation defects, or corrosion of sprinkler elements. This water can adversely affect the wood structure and cause moisture damage. A high moisture content can affect the strength and stiffness, and lead to decay or mold. CLT does not absorb water very quickly and would only be an issue for prolonged water exposure. This exposure can be limited by concrete toppings which protect the wood from direct water contact (Ranger, Lindsay, et al, 2019).

Chapter 3: Methodology

Goal: Design a CLT office building, present the client with a fire resistance evaluation, design an option for advanced structural resilience, and provide a repair scope and cost-benefit analysis for each option.

Steps	Scope	References
Option A: Office Building Design (Type IV-B)	 Design floors, walls, and ceilings with CLT based on floor plans provided by sponsor - For Class A office rating requirements Design for gravitational and vertical loads Design for lateral loads Design Foundations Use glulam for beams and columns Complete design calculations Check design calculations with Excel/Risa 	 Sponsor provided building floor plans IBC 2021 2303.1.4 2304.11.3.1 2304.11.4.1 2305 2306 2307 CLT Handbook Example problems ANSI/APA PRG 320 - manufacturing Standard for Performance Rated CLT Nordic website Adhesive types Variable key AWC NDS Chapter 10, AWC Manual M10, SDPWS Equations and tables for CLT Wind - lateral forces ASCE 7-10 Minimum design loads (ASD vs LRFD), factors
Office building economic cost	• Calculate total cost of construction and materials	 Nordic Material Costs / website Engineering News Record Material and standard labor costs

Objective	1: Design	a Type I	V-B CLT	Office	Building

Steps	Scope	References
Office Building fire damage evaluation	 Establish time equivalence for the fire exposure and location Recalculate loading Excel and Graphs 	 AWC NDS Specification: Chapter 16 Connections and design procedures for timber CLT Design Manual Examples 4.1.8 and 4.1.9 Flooring and wall assembly fire examples - post-fire loads
Discuss on post-fire options	 Assess fire damage and charring Recalculate loading Discuss repair options: Stripping the char Replacing layers with various methods Exposed CLT options for lower classification Connection options to assist in fire resilience and repairs 	 AWC Powerpoint Sprinkler Damage

Objective 2: Evaluate Fire Resilience and Repair Options of Building

Objective 3: Design a CLT Office Building for Advanced Structural Resilience

Steps	Scope	References
Design for structural resilience	 Design floors, walls, and ceilings with CLT based on floor plans provided by sponsor - For above Class A office rating requirements Design for gravitational and 	 Sponsor provided building floor plans IBC 2021 Chapter 23 CLT Handbook Example problems ANSI Nordic website
 vertical loads Design for over Class A office so it will remain class A post-fire Use glulam for beams and columns Complete design calculations Check design calculations with Excel/Risa 	 AWC NDS Equations for CLT ASCE 7-10 Minimum design loads (ASD vs LRFD) 	
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Objective 4: Cost Analysis of Building Options

Steps	Scope	References
To code cost of repair to desired building classification (Type IV-B repaired to Type IV-B)	 Determine repair options for scope of damage Determine cost of repairs 	Engineering News RecordAWC Powerpoint
To code cost of repair to closest* building classification (Type IV-B cosmetic repair to lower building type)	 Assess the damage and cosmetic repairs Determine the new building classification 	Engineering News RecordAWC Powerpoint
Structurally resilient design option economic cost (Type IV-A)	• Determine cost of preventative options to minimize damage	CLT HandbookIBC 2021
Conclusion	• Economic summary and cost breakdown of each option	CLT HandbookIBC 2021

*Closest building code relates to the amount of fire damage and the cost required for the building to be a lower code classification.

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Appendix B: Mass Timber Calculations

Calculation Results - Joist

Number (if special)	Floor	Section	Length 1	Length 2	Length 3	CLT Tributary Areas 1 (ft)	CLT Tributary Area 2 (ft)	CLT weight	b (in)	d (in)	Practical b (in)	Practical d (in)
4-1	4th floor ceiling	Edge	16.5			4.6875		11.1	9.5	13.5	11.5	13.5
4-2	4th floor ceiling	Middle	16.5			15.625		11.1	11.5	15.5	11.5	15.5
4-3	4th floor ceiling	larger cit outer edge	16.5			9.375		13.1 avg	11.5	13.5	11.5	13.5
4-4	4th floor ceiling	Penthouse 13 edge	16.5			15.625		15.1	11.5	10.5	11.5	15.5
4-5	4th floor ceiling	Penthouse 13 middle	16.5			16.25		15.1	11.5	23.5	11.5	23.5
4-25	4th floor ceiling	special case A-B, 3-4 upper edges (2x)	16.5	8		9.5625	0	15.1	11.5	15.5	11.5	15.5
4-3s	4th floor ceiling	special case A-B, 3-4 lower edges (2x)	10.5	6		9.5625	4.6875	15.1	11.5	11.5	11.5	11.5
4-4s	4th floor ceiling	special case A-B, 3-4 short middle	10.5			16.25		15.1	11.5	15.5	11.5	15.5
4-6s	4th floor ceiling	special case B-C, 3-4 right edge	16.5			9.5625	4.6875	15.1	11.5	17.5	11.5	17.5
4-5s	4th floor ceiling	special case B-C, 3-4 middle	16.5			16.25	6.5	15.1	11.5	19.5	11.5	19.5
4-7s	4th floor ceiling	special case D, 3-4 elevator edges	8.25			4.6875		15.1	9.5	11.5	9.5	11.5
4-8s	4th floor ceiling	special case D, 3-4 lobby edges	8.25			9.5625		15.1	11.5	11.5	11.5	11.5
4-9s	4th floor ceiling	special case D, 3-4 stair edges	6	10.5		4.6875		15.1	9.5	11.5	9.5	11.5
4-10s	4th floor ceiling	special case D, 3-4 short middle	8.25			16.25		15.1	11.5	13.5	11.5	13.5
		0.1	10.5			1.0075		15.1	0.5			10.5
3-1	3rd floor ceiling	Outer Edge	16.5			4.6875		15.1	9.5	11.5	11.5	13.5
3-2	3rd floor ceiling	Middle	10.0			0.275		15.1	11.5	17.5	11.5	17.5
3-4	3rd floor ceiling	12.5 Middle	16.5			15.625		15.1	11.5	17.5	11.5	17.5
3-5	3rd floor ceiling	13 Outer Edge	16.5			9.5625		15.1	9.5	15.5	11.5	15.5
3-6	3rd floor ceiling	13 Middle	16.5			16.25		15.1	11.5	17.5	11.5	17.5
3-2s	3rd floor ceiling	special case A-B, 3-4 upper edges (2x)	16.5	8		4.78125	0	15.1	11.5	15.5	11.5	15.5
3-3s	3rd floor ceiling	special case A-B, 3-4 lower edges (2x)	10.5	6		9.5625	4.6875	15.1	11.5	11.5	11.5	11.5
3-4s	3rd floor ceiling	special case A-B, 3-4 short middle	10.5			16.25		15.1	11.5	13.5	11.5	13.5
3-6s	3rd floor ceiling	special case B-C, 3-4 right edge	16.5			9.5625	4.6875	15.1	11.5	13.5	11.5	13.5
3-5s	3rd floor ceiling	special case B-C, 3-4 middle	16.5			16.25	6.5	15.1	11.5	15.5	11.5	15.5
3-7as	3rd floor ceiling	special case D, 3-4 elevator edges	8.25			4.6875		15.1	9.5	11.5	9.5	11.5
3-8s	3rd floor ceiling	special case D, 3-4 lobby edges	8.25			9.5625		15.1	9.5	11.5	9.5	11.5
3-9as	3rd floor ceiling	special case D, 3-4 stair edges	6	10.5		4.6875		15.1	9.5	11.5	9.5	11.5
3-10s	3rd floor ceiling	special case D, 3-4 short middle	8.25			16.25		15.1	11.5	11.5	11.5	11.5
2.4	2nd floor coiling	Outor Edge	16.5			4 6975		15.1	0.5	11.5	11 5	12 5
2-1	2nd floor ceiling	Middle	16.5			4.0075		15.1	11.5	17.5	11.5	17.5
2-3	2nd floor ceiling	12.5 Inner Edges	16.5			9.375		15.1	11.5	15.5	11.5	15.5
2-4	2nd floor ceiling	12.5 Middle	16.5			15.625		15.1	11.5	17.5	11.5	17.5
2-5	2nd floor ceiling	13 Outer Edge	16.5			9.5625		15.1	9.5	15.5	11.5	15.5
2-6	2nd floor ceiling	13 Middle	16.5			16.25		15.1	11.5	17.5	11.5	17.5
2-2s	2nd floor ceiling	special case A-B, 3-4 upper edges (2x)	16.5	8		4.78125	0	15.1	11.5	15.5	11.5	15.5
2-3s	2nd floor ceiling	special case A-B, 3-4 lower edges (2x)	10.5	6		9.5625	4.6875	15.1	11.5	11.5	11.5	11.5
2-4s	2nd floor ceiling	special case A-B, 3-4 short middle	10.5			16.25		15.1	11.5	13.5	11.5	13.5
2-6s	2nd floor ceiling	special case B-C, 3-4 right edge	16.5			9.5625	4.6875	15.1	11.5	13.5	11.5	13.5
2-5s	2nd floor ceiling	special case B-C, 3-4 middle	16.5			16.25	6.5	15.1	11.5	15.5	11.5	15.5
2-7as	2nd floor ceiling	special case D, 3-4 elevator edges	8.25			4.6875		15.1	9.5	11.5	9.5	11.5
2-05	2nd floor ceiling	special case D, 3-4 lobby edges	6.20	10.5		9.5025		15.1	9.5	11.5	9.5	11.5
2-545	2nd floor ceiling	special case D, 3-4 stall edges	8.25	10.5		4.0875		15.1	11.5	11.5	11.5	11.5
2-103	2nd floor ceiling	special case D.9-F. Outside overhand	16.5	16.5	6	3.5		11.1	9.5	11.5	9.5	11.5
2-11s	2nd floor ceiling	special case D.9-F, Inside overhangs	16.5			3.5	4.6875	11.1/15.1	11.5	15.5	11.5	15.5
1-1	1st floor ceiling	Outer Edge	16.5			4.6875		15.1	9.5	11.5	11.5	13.5
1-7	1st floor ceiling	Column Line 3 D-F	16.5			9.875		15.1	11.5	15.5	11.5	15.5
1-8	1st floor ceiling	Edge of Walkway	16.5			5		15.1	9.5	11.5	11.5	13.5
1-2	1st floor ceiling	Middle	16.5			15.625		15.1	11.5	17.5	11.5	17.5
1-3	1st floor ceiling	12.5 Inner Edges	16.5			9.375		15.1	11.5	15.5	11.5	15.5
1-4	1st floor ceiling	12.5 Middle	16.5			15.625		15.1	11.5	17.5	11.5	17.5
1-5	1st floor ceiling	13 Outer Edge	16.5			9.5625		15.1	9.5	15.5	11.5	15.5
1-6	1st floor ceiling	13 MIGGIO	16.5	0		16.25	0	15.1	11.5	17.5	11.5	17.5
1-25	1st floor ceiling	special case A-B, 3-4 upper edges (2x)	10.5	8		4.76125	4 6975	15.1	11.5	10.5	11.5	10.5
1-38	1st floor ceiling	special case A-B, 3-4 lower edges (2X)	10.5	0		16.25	4.0075	15.1	11.5	13.5	11.5	13.5
1-65	1st floor ceiling	special case B-C, 3-4 right edge	16.5			9.5625	4.6875	15.1	11.5	13.5	11.5	13.5
1-5s	1st floor ceiling	special case B-C, 3-4 middle	16.5			16.25	6.5	15.1	11.5	15.5	11.5	15.5
1-7as	1st floor ceiling	special case D, 3-4 elevator edges	8.25			4.6875		15.1	9.5	11.5	9.5	11.5
1-7bs	1st floor ceiling	special case D, 3-4 elevator edges	8.25			5		15.1	9.5	11.5	9.5	11.5
1-8as	1st floor ceiling	special case D, 3-4 lobby edges	8.25			9.5625		15.1	9.5	11.5	9.5	11.5
1-8bs	1st floor ceiling	special case D, 3-4 lobby edges	8.25			6.75		15.1	9.5	9.5	9.5	11.5
1-9as	1st floor ceiling	special case D, 3-4 stair edges	6	10.5		4.6875		15.1	9.5	11.5	9.5	11.5
1-9bs	1st floor ceiling	special case D, 3-4 stair edges	6	10.5				15.1	9.5	11.5	9.5	11.5
1-10s	1st floor ceiling	special case D, 3-4 short middle	8.25			16.25		15.1	11.5	11.5	11.5	11.5
1-1s	1st floor ceiling	special case D.9-F, outside overhang	16.5	16.5	6	3.5		11.1	9.5	11.5	9.5	11.5
1-11s	1st floor ceiling	special case E-F, 3	16.5			9.875		15.1	11.5	17.5	11.5	17.5
1-12s	1st floor ceiling	special case E-F, walkway	16.5			5		15.1	11.5	13.5	11.5	13.5
1-135	1st floor ceiling	special case D.9-F, inside overhangs	16.5			3.5		11.1	9.5	11.5	9.5	11.5
1-148	ist noor cening	Loosy middle joists	10.5			15.625		16.1	9.5	11.5	9.0	11.0

Calculation Results - Girders

Number	Floor	Section	Length 1	Length 2	Girder Tributary Width	Girder Tributary Width 2	b (in)	d (in)	Practical b (in)	Practical d (in)
4-1	4th floor ceiling	1- Ext	25		8.25		11.5	17.5	11.5	17.5
4-2	4th floor ceiling	1- Int	25		16.5		11.5	23.5	11.5	23.5
4-3	4th floor ceiling	2- Ext	25		8.25		11.5	17.5	11.5	17.5
4-4	4th floor ceiling	2- Int	25		16.5		11.5	23.5	15.5	19.5
4-5	4th floor ceiling	3- Ext	26		8.25		11.5	25.5	11.5	25.5
4-6	4th floor ceiling	3- Int	26		16.5		17.5	29.5	17.5	29.5
4-7	4th floor ceiling	4- Ext	25		8.25		11.5	17.5	11.5	17.5
4-8	4th floor ceiling	4- Int	25		16.5		11.5	23.5	15.5	19.5
4-9	4th floor ceiling	5- Ext	25		8.25		11.5	17.5	11.5	17.5
4-10	4th floor ceiling	5- Int	25		16.5		11.5	23.5	11.5	23.5
4-1s	4th floor ceiling		26		0		11.5	11.5	11.5	11.5
4-2s	4th floor ceiling		26		8.25		11.5	25.5	11.5	27.5
4-3s	4th floor ceiling		26		13.5		17.625	27.5	17.625	27.5
4-4s	4th floor ceiling		26		5.25		11.5	19.5	11.5	19.5
4-5s	4th floor ceiling	Same as 4-5	26		8.25		11.5	25.5	11.5	25.5
4-6s	4th floor ceiling		26		16.5	8.25	11.5	31.625	15.5	27.5
4-7s	4th floor ceiling		26		16.5		17.625	29.5	17.625	29.5
4-8s	4th floor ceiling	Same as 4-5	26		8.25		11.5	25.5	11.5	25.5
4-9s	4th floor ceiling		26		4.125		11.5	19.5	11.5	19.5
4-10s	4th floor ceiling		26		4.125+portion	4.125	11.5	19.5	11.5	19.5
4-11s	4th floor ceiling		26		0		any	any	11.5	17.5
4-12s	4th floor ceiling	Same as 4-5	26		8.25		11.5	25.5	11.5	25.5
3-1	3rd floor ceiling	1- Ext	25		8.25		11.5	21.5	11.5	21.5
3-2	3rd floor ceiling	1- Int	25		16.5		11.5	27.5	11.5	27.5
3-3	3rd floor ceiling	2- Ext	25		8.25		11.5	21.5	11.5	21.5
3-4	3rd floor ceiling	2-Int	25		16.5		11.5	27.5	11.5	27.5
3-5	3rd floor ceiling	3- Ext	26		8.25		11.5	21.5	11.5	21.5
3-6	3rd floor ceiling	3- Int	26		16.5		11.5	27.5	11.5	27.5
3-7	3rd floor ceiling	4- Ext	25		8.25		11.5	21.5	11.5	21.5
3-8	3rd floor ceiling	4- Int	25		16.5		11.5	27.5	11.5	27.5
3-9	3rd floor ceiling	5- Ext	25		8.25		11.5	21.5	11.5	21.5
3-10	3rd floor ceiling	5- Int	25		16.5		11.5	27.5	11.5	27.5
3-1s	3rd floor ceiling		26		0		11.5	11.5	11.5	11.5
3-2s	3rd floor ceiling		26		8.25		11.5	23.5	11.5	23.5
3-3s	3rd floor ceiling		26		13.5		11.5	17.5	11.5	27.5
3-4s	3rd floor ceiling		26		5.25		11.5	11.5	11.5	17.5
3-5s	3rd floor ceiling	Same as 3-5	26		8.25		11.5	21.5	11.5	21.5
3-6s	3rd floor ceiling		26		16.5	8.25	15.5	23.5	15.5	23.5
3-7s	3rd floor ceiling		26		16.5		15.5	23.5	15.5	23.5
3-8s	3rd floor ceiling	Same as 3-5	26		8.25		11.5	21.5	11.5	21.5
3-9s	3rd floor ceiling		26		4.125		11.5	17.5	11.5	17.5
3-10s	3rd floor ceiling		26		4.125+portion	4.125	11.5	17.5	11.5	17.5
3-11s	3rd floor ceiling		26		0		11.5	17.5	11.5	17.5
3-12s	3rd floor ceiling	Same as 3-5	26		8.25		11.5	21.5	11.5	21.5

2-1	2nd floor ceiling	1- A	25		8.25		11.5	21.5	11.5	21.5
2-2	2nd floor ceiling	1- B-E	25		16.5		11.5	27.5	11.5	27.5
2-3	2nd floor ceiling	2- A, F	25		8.25		11.5	21.5	11.5	21.5
2-4	2nd floor ceiling	2- B-E	25		16.5		11.5	27.5	11.5	27.5
2-5	2nd floor ceiling	3- A, F	26		8.25		11.5	21.5	11.5	21.5
2-6	2nd floor ceiling	3- B-E	26		16.5		11.5	27.5	11.5	27.5
2-7	2nd floor ceiling	4- A, F	25		8.25		11.5	21.5	11.5	21.5
2-8	2nd floor ceiling	4- B-E	25		16.5		11.5	27.5	11.5	27.5
2-9	2nd floor ceiling	5- A, F	25		8.25		11.5	21.5	11.5	21.5
2-10	2nd floor ceiling	5- B-E	25		16.5		11.5	27.5	11.5	27.5
2-1s	2nd floor ceiling				0		11.5	11.5	11.5	11.5
2-2s	2nd floor ceiling				8.25		11.5	23.5	11.5	23.5
2-3s	2nd floor ceiling				13.5		11.5	17.5	11.5	27.5
2-4s	2nd floor ceiling				5.25		11.5	11.5	11.5	17.5
2-5s	2nd floor ceiling	Same as 2-5	26		8.25		11.5	21.5	11.5	21.5
2-6s	2nd floor ceiling		26		16.5	8.25	15.5	23.5	15.5	23.5
2-7s	2nd floor ceiling		26		16.5		15.5	23.5	15.5	23.5
2-8s	2nd floor ceiling	Same as 2-5	26		8.25		11.5	21.5	11.5	21.5
2-9s	2nd floor ceiling		26				11.5	17.5	11.5	17.5
2-10s	2nd floor ceiling		26				11.5	17.5	11.5	17.5
2-11s	2nd floor ceiling		26		0		11.5	17.5	11.5	17.5
2-12s	2nd floor ceiling	Same as 2-5	26		8.25		11.5	21.5	11.5	21.5
2-13s	2nd floor ceiling		25	7	16.5	15.69(weigh	11.5	27.5	11.5	27.5
2-14s	2nd floor ceiling		25	7	16.5		11.5	27.5	11.5	27.5
2-15s	2nd floor ceiling		25	7	8.25		11.5	21.5	11.5	21.5
1_1	1st floor ceiling	1- Δ	25		8 25		11 5	21.5	11 5	21.5
1-1	1st floor ceiling	1- A 1- B-E	25		16.5		11.5	21.0	11.5	27.5
1-2	1st floor ceiling	2- A F	25		8 25		11.5	21.5	11.5	21.5
1-3	1st floor ceiling	2- A, T	25		16.5		11.5	21.0	11.5	27.5
1-4	1st floor coiling	3 4 5	20		8.25		11.5	21.5	11.5	21.5
1-5	1st floor coiling	3-A,1	20		16.5		11.5	21.0	11.5	21.5
1.7	1st floor coiling	J- D-L	20		8.25		11.5	21.5	11.5	21.5
1.9	1st floor coiling	4-A,T	25		16.5		11.5	21.0	11.5	21.5
1.0	1st floor coiling	4- D-L	25		8.25		11.5	21.5	11.5	21.5
1 10	1st floor coiling	5 R E	25		16.5		11.5	21.5	11.5	21.5
1-10	1st floor coiling	J- B-E	20		10.5		11.5	11.5	11.5	21.5
1-13	1st floor coiling				8.25		11.5	22.5	11.5	23.5
1.36	1st floor coiling				12.5		11.5	17.5	11.5	23.5
1.46	1st floor coiling				5.25		11.5	11.5	11.5	17.5
1-45	1st floor coiling	Samo as 1.5	26		8.25		11.5	21.5	11.5	21.5
1-55	1st floor coiling	Same as 1-5	20		16.5	8.25	15.5	21.5	15.5	21.5
1-05	1st floor coiling		20		16.5	0.20	15.5	23.5	15.5	23.5
1-75	1st floor ceiling	Same as 1.5	20		8.25		11.5	23.5	11.5	23.5
1.95	1st floor coiling	Same as 1-5	20		4 125		11.5	17.5	11.5	17.5
1.10c	1st floor coiling		20		4.125	4 125	11.5	17.5	11.5	17.5
1 11c	1st floor coiling		20		4.123+portion	4.125	11.5	17.5	11.5	17.5
1 126	1st floor coiling	Samo as 1.5	20		8.25		11.5	21.5	11.5	21.5
1 136	1st floor coiling	Same as 1-5	20	15	8.25	16.5	11.5	15.5	11.5	15.5
1-135	1st floor ceiling	Same as 1.1	25	13	8.25	10.0	11.5	21.5	11.5	21.5
1-145	1st floor ceiling	Came as I-I	20	15	16.5	0	9.5	11.5	9.5	21.5
1-166	1st floor ceiling		25	13	10.0	0	9.0	11.5	9.5	11.5
1-176	1st floor coiling		20	15	16.5	0	9.5	11.5	9.0	11.5
1-1/5	1st floor coiling		10	10	0.01 8.05	0	9.0	17.5	9.0	17.5
1-105	1st floor coiling		20	15	0.20	0	0.5	11.5	0.5	11.5
1-195	1st floor coiling		10	10	10.0	0	9.0	10.5	9.0	10.5
1-205	1st floor coiling		20	15	0 8.05	0	0.5	11.5	0.5	19.5
1-215	1st floor celling		10	13	0.20	0	9.0	11.5	9.5	11.5
1-225	ist noor cening		20	1	0.25		9.5	11.5	9.5	11.5

Calculation Results - Columns

Number	Floor	Section	Height	Left Girder	Right Girder	b (in)	d (in)
4-1	4th floor ceiling	1- Ext	12	N/A	4-1	11.5	11.5
4-2	4th floor ceiling	1- Int	12	N/A	4-2	11.5	11.5
4-3	4th floor ceiling	2- Ext	12	4-1	4-3	11.5	11.5
4-4	4th floor ceiling	2- Int	12	4-2	4-4	11.5	11.5
4-5	4th floor ceiling	3- Ext	12	4-3	4-5	11.5	11.5
4-6	4th floor ceiling	3- Int	12	4-4	4-6	13.625	13.625
4-7	4th floor ceiling	4- Ext	12	4-5	4-7	11.5	11.5
4-8	4th floor ceiling	4- Int	12	4-6	4-8	13.625	13.625
4-9	4th floor ceiling	5- Ext	12	4-7	4-9	11.5	11.5
4-10	4th floor ceiling	5- Int	12	4-8	4-10	11.5	11.5
4-11	4th floor ceiling	6-Ext	12	4-9	N/A	11.5	11.5
4-12	4th floor ceiling	6-Int	12	4-10	N/A	11.5	11.5
4-1s	4th floor ceiling		12	N/A	4-1s	9.5	9.5
4-2s	4th floor ceiling		12	4-3	4-2s	11.5	11.5
4-3s	4th floor ceiling		12	4-4	4-3s	13.625	13.625
4-4s	4th floor ceiling		12	N/A	4-4s	11.5	11.5
4-5s	4th floor ceiling		12	4-4	4-5s	11.5	11.5
4-6s	4th floor ceiling		12	4-4	4-6s	13.625	13.625
4-7s	4th floor ceiling		12	4-4	4-7s	13.635	13.625
4-8s	4th floor ceiling		12	4-4	4-8s	11.5	11.5
4-9s	4th floor ceiling		12	N/A	4-9s	11.5	11.5
4-10s	4th floor ceiling		12	4-4	4-10s	11.5	11.5
4-11s	4th floor ceiling		12	N/A	4-11s	9.5	9.5
4-12s	4th floor ceiling		12	4-4	4-12s	11.5	11.5
4-13s	4th floor ceiling		12	4-6s	4-8	13.625	13.625
4-14s	4th floor ceiling		12	4 - 7s	4-8	13.625	13.625
3-1	3rd floor ceiling	1- Ext	12	N/A	3-1	11.5	11.5
3-2	3rd floor ceiling	1-Int	12	N/A	3-2	11.5	11.5
3-3	3rd floor ceiling	2- Ext	12	3-1	3-3	11.5	11.5
3-4	3rd floor ceiling	2-Int	12	3-2	3-4	13.625	13.615
3-5	3rd floor ceiling	3- Ext	12	3-3	3-5	13.625	13.615
3-6	3rd floor ceiling	3- Int	12	3-4	3-6	13.625	13.615
3-7	3rd floor ceiling	4- Ext	12	3-5	3-7	13.625	13.625
3-8	3rd floor ceiling	4- Int	12	3-6	3-8	13.625	13.625
3-9	3rd floor ceiling	5- Ext	12	3-7	3-9	11.5	11.5
3-10	3rd floor ceiling	5- Int	12	3-8	3-10	13.625	13.625
3-11	3rd floor ceiling	6-Ext	12	3-9	N/A	11.5	11.5
3-12	3rd floor ceiling	6-Int	12	3-10	N/A	11.5	11.5
3-1s	3rd floor ceiling		12	N/A	3-1s	9.5	9.5
3-25	3rd floor celling		12	3-3	3-25	13.625	13.625
3-35	3rd floor ceiling		12	3-4	3-35	13.625	13.625
3-45	and floor ceiling		12	N/A	3-45	11.5	11.0
3-55	and floor ceiling		12	3-4	3-05	13.625	13.625
3.7c	3rd floor ceiling		12	3-4	2.7c	13.025	13.025
3-75	ard floor ceiling		12	2.4	2.80	12.625	12.025
3.00	3rd floor coiling		12	3-4	3-05	13.023	13.025
3-10-	3rd floor ceiling		12	N/A	3-95	13 625	13 625
3-105	3rd floor ceiling		12	5-4 N/A	3-105	9.5	9.5
3-125	3rd floor ceiling		12	3-4	3-65	13 625	13 625
3-135	3rd floor ceiling		12	3-65	3-8	13.625	13.625
3-14s	3rd floor ceiling		12	3-7s	3-8	13.625	13.625

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2-1	2nd floor ceiling	1- Ext	12	N/A	2-1	11.5	11.5
2-2	2nd floor ceiling	1- Int	12	N/A	2-2	13.625	13.625
2-3	2nd floor ceiling	2- Ext	12	2-1	2-3	13.625	13.625
2-4	2nd floor ceiling	2- Int	12	2-2	2-4	13.625	13.625
2-5	2nd floor ceiling	3- Ext	12	2-3	2-5	11.5	11.5
2-6	2nd floor ceiling	3- Int	12	2-4	2-6	13.625	13.625
2-7	2nd floor ceiling	4- Ext	12	2-5	2-7	13.625	13.625
2-8	2nd floor ceiling	4- Int	12	2-6	2-8	13.625	13.625
2-9	2nd floor ceiling	5- Ext	12	2-7	2-9	13.625	13.625
2-10	2nd floor ceiling	5- Int	12	2-8	2-10	13.625	13.625
2-11	2nd floor ceiling	6-Ext	12	2-9	N/A	11.5	11.5
2-12	2nd floor ceiling	6-Int	12	2-10	N/A	13.625	13.625
2-1s	2nd floor ceiling		12	N/A	2-1s	9.5	9.5
2-2s	2nd floor ceiling		12	2-3	2-2s	13.625	13.625
2-3s	2nd floor ceiling		12	2-4	2-3s	13.625	13.625
2-4s	2nd floor ceiling		12	N/A	2-4s	11.5	11.5
2-5s	2nd floor ceiling		12	2-4	2-5s	13.625	13.625
2-6s	2nd floor ceiling		12	2-4	2-6s	13.625	13.625
2-7s	2nd floor ceiling		12	2-4	2-7s	13.625	13.625
2-8s	2nd floor ceiling		12	2-4	2-8s	13.625	13.625
2-9s	2nd floor ceiling		12	N/A	2-9s	11.5	11.5
2-10s	2nd floor ceiling		12	2-4	2-10s	13.625	13.625
2-11s	2nd floor ceiling		12	N/A	2-11s	11.5	11.5
2-12s	2nd floor ceiling		12	2-4	2-6s	13.625	13.625
2-13s	2nd floor ceiling		12	2-6s	2-8	13.625	13.625
2-14s	2nd floor ceiling		12	2-7s	2-8	13.625	13.625
2-15s	2nd floor ceiling		12	2-13s	2-4	13.625	13.625
2-16s	2nd floor ceiling		12	2-14s	2-4	13.625	13.625
2-17s	2nd floor ceiling		12	2-15s	2-3	13.625	13.625
2-18s	2nd floor ceiling		12	2-15s		11.5	11.5
2-19s	2nd floor ceiling		12	2-14s		13.625	13.625
2-20s	2nd floor ceiling		12	2-13s		13.625	13.625
1-1	1st floor ceiling	1- Ext	12	N/A	1-1	13.625	13.625
1-2	1st floor ceiling	1- Int	12	N/A	1-2	13.625	13.625
1-3	1st floor ceiling	2- Ext	12	1-1	1-3	13.625	13.625
1-4	1st floor ceiling	2- Int	12	1-2	1-4	15.5	15.5
1-5	1st floor ceiling	3- Ext	12	1-3	1-5	13.625	13.625
1-6	1st floor ceiling	3- Int	12	1-4	1-6	15.5	15.5
1-7	1st floor ceiling	4- Ext	12	1-5	1-7	13.625	13.625
1-8	1st floor ceiling	4- Int	12	1-6	1-8	15.5	15.5
1-9	1st floor ceiling	5- Ext	12	1-7	1-9	13.625	13.625
1-10	1st floor ceiling	5- Int	12	1-8	1-10	15.5	15.5
1-11	1st floor ceiling	6-Ext	12	1-9	N/A	13.625	13.625
1-12	1st floor ceiling	6-Int	12	1-10	N/A	13.625	13.625

1-1s	1st floor ceiling	12	N/A	1-1s	9.5	9.5
1-2s	1st floor ceiling	12	1-3	1-2s	13.625	13.625
1-3s	1st floor ceiling	12	1-4	1-3s	15.5	15.5
1-4s	1st floor ceiling	12	N/A	1-4s	11.5	11.5
1-5s	1st floor ceiling	12	1-4	1-5s	13.625	13.625
1-6s	1st floor ceiling	12	1-4	1-6s	15.5	15.5
1-7s	1st floor ceiling	12	1-4	1-7s	15.5	15.5
1-8s	1st floor ceiling	12	1-4	1-8s	13.625	13.625
1-9s	1st floor ceiling	12	N/A	1-9s	11.5	11.5
1-10s	1st floor ceiling	12	1-4	1-10s	13.625	13.625
1-11s	1st floor ceiling	12	N/A	1-11s	11.5	11.5
1-12s	1st floor ceiling	12	1-4	1-6s	13.625	13.625
1-13s	1st floor ceiling	12	1-6s	1-8	15.5	15.5
1-14s	1st floor ceiling	12	1-7s	1-8	15.5	15.5
1-15s	1st floor ceiling	12	1-13s		11.5	11.5
1-16s	1st floor ceiling	12	1-15s		11.5	11.5
1-17s	1st floor ceiling	12	1-17s		11.5	11.5
1-18s	1st floor ceiling	12	1-19s		11.5	11.5
1-19s	1st floor ceiling	12	1-21s		9.5	9.5
1-20s	1st floor ceiling	12	1-22s	1-21s	13.625	13.625
1-21s	1st floor ceiling	12	1-20s	1-19s	13.625	13.625
1-22s	1st floor ceiling	12	1-18s	1-17s	13.625	13.625
1-23s	1st floor ceiling	12	1-16s	1-15s	13.625	13.625
1-24s	1st floor ceiling	12	1-1	1-13s	13.625	13.625
1-25s	1st floor ceiling	12	1-14s		13.625	13.625
1-26s	1st floor ceiling	12	1-16s		13.625	13.625
1-27s	1st floor ceiling	12	1-18s		13.625	13.625
1-28s	1st floor ceiling	12	1-20s		11.5	11.5
1-29s	1st floor ceiling	12	1-22s		11.5	11.5

CLT Flooring

Roof Section 1

Location		Nordic Reference	CLT Type	
Roof		NS-DA2301	105-3s	
	Nordic R	eference Material		
	For CL1	T Layup E1 (psi)		
Variable	Description	Major Strength Direction:	Minor Direction:	Units
Fb	Bending at Extreme Fiber	1,950	500	psi
E	Modulus of Elasticity	1700000	1200000	psi
Ft	Tension Parallel to Grain	1,375	250	psi
Fc	Compression Parellel to Grain	1,800	650	psi
Fv	Shear Parallel to Grain Strength	135	135	psi
Fs	Rolling Shear Strength	45	45	psi
Fcp	Compression Perpendicular to Grain	425	425	psi
G	Shear Modulus	106250	75000	psi
Gs	Rolling Shear Modulus	10625	7500	psi
	For	r Roof CLT		
Variable	Description	Major Direction:	Minor Direction:	Units
FbS(eff)	Bending Moment Capacity	4525	160	lbf-ft/ft
V0	Shear Capacity	1490	495	lbf/ft
EI(eff,0)	Bending Stiffness	115000000	3100000	lbf-in.^2/f
EI(eff,0)	Total Bending Stiffness of Section	69000000	18600000	lbf-in^2
GA(eff,0)	Shear Rigidity	460000	610000	lbf/ft
GA(eff,0)	Total Shear Rigidity	2760000	3660000	lbf
	Section-Specific	Loading and Dimensions		
Floor			4	
Section:				
Longth			1A - 1	
Lengui		12.5	IA - 1	ft
Width		12.5	1A - 1	ft ft
Width Thickness		12.5 6 1.375	1A - 1 1.375	ft ft in
Width Thickness Ply		12.5 6 1.375 5	1A - 1 1.375	ft ft in ply
Width Thickness Ply Total Thick	ness (tv)	12.5 6 1.375 5 6.875	IA - 1 1.375	ft ft in ply in
Width Thickness Ply Total Thick Roof Live I	ness (tv) Load (Lr)	12.5 6 1.375 5 6.875 20	1A - 1 1.375	ft ft in ply in psf
Width Thickness Ply Total Thick Roof Live I Ground sno	ness (tv) Load (Lr) w load (S)	12.5 6 1.375 5 6.875 20 50	IA - 1 1.375	ft ft in ply in psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads	ness (tv) Load (Lr) w load (S) 3 - Total	12.5 6 1.375 5 6.875 20 50 14.1	IA - 1 1.375	ft ft in ply in psf psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads	ness (tv) Load (Lr) w load (S) 5 - Total Insulation on CLT (D)	12.5 6 1.375 5 6.875 20 50 14.1 3	IA - 1 1.375	ft ft in ply in psf psf psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads	ness (tv) Load (Lr) w load (S) 3 - Total Insulation on CLT (D) Mechanical (D)	12.5 6 1.375 5 6.875 20 50 14.1 3 0	IA - 1 1.375	ft ft in ply in psf psf psf psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads	ness (tv) Load (Lr) w load (S) s - Total Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D)	12.5 6 1.375 5 6.875 20 50 14.1 3 0 11.1	IA - 1 1.375	ft ft in ply in psf psf psf psf psf psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads	ness (tv) Load (Lr) w load (S) s - Total Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D) Point Loads	12.5 6 1.375 5 6.875 20 50 14.1 3 0 11.1 0	IA - 1 1.375	ft ft in ply in psf psf psf psf psf psf psf psf psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads Wind (W)	ness (tv) Load (Lr) w load (S) s - Total Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D) Point Loads	12.5 6 1.375 5 6.875 20 50 14.1 3 0 14.1 0 11.1 0 0	IA - 1 1.375	ft ft in ply in psf psf psf psf psf psf psf psf psf psf
Width Thickness Ply Total Thick Roof Live I Ground sno Dead Loads Wind (W) Earthouake	ness (tv) Load (Lr) w load (S) s - Total Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D) Point Loads	12.5 6 1.375 5 6.875 20 50 14.1 3 0 11.1 0 0 0 0 0 0	IA - 1 1.375	ft ft in ply in psf psf psf psf psf psf psf psf psf psf

/Q)eff		
z (in)	Ehz	Units
1.375	3214062.5	
0.6875	37812.5	
Sum of EHZ	3251875	lb
Ib/Q)eff	212.1852777	in^2
Tapp		
	11.5	
	611822660.1	15.62

Actual Loading								
Variable	Description	Calculation	Units					
LC1	D	14.1	psf					
LC2	D+L	14.1	psf					
LC3	D+(Lr or S or R)	64.1	psf					
LC4	D + 0.75L + 0.75(Lr or S or R)	51.6	psf					
LC5	D + (0.6W or 0.7E)	14.1	psf					
LC6a	D + 0.75L + 0.75(0.6W) + 0.75(Lr or S or R)	51.6	psf					
LC6b	D + 0.75L + 0.75(0.7E) + 0.75S	51.6	psf					
LC7	0.6D + 0.6W	8.46	psf					
LC8	0.6D + 0.7E	8.46	psf					
	NDS Calculation	ons						
Variable	Description	Calculation	Units					
Cd		0.9						
Cm		1						
Ct		1						
Cl		1						
	Allowable Valu	ies						
Variable	Description	Calculation	Units					
Fb(Seff)'	Fb(Seff)(Cd)(Cm)(Ct)(Cl)	24435	lb-ft					
Fs(Ib/Q)eff	Fs(Ib/Q)eff(Cm)(Ct)	9548.337498	lb					
(EI)app'	(EI)app(Cm)(Ct)	611822660.1	lb-ft2					

Allowable Deflection
Calculation
0.0

 Units

 0.03472222222
 ft

 0.03472222222
 ft

 0.03472222223
 ft

 0.05208333333
 ft

 Variable
 Description

 Delta L
 L/360

 Delta S
 L/360

 Delta D+L
 L/240

Actual Loading Calculation

		Elapp			
Ks	constant for uniform with pinned		11.5		
EIapp	(EIeff)/(1+((Ks*EIeff)/(GAeff(L^2	:))))	611822660.1	lb-ft2	
2 span					
	Actual Values				
Variable	Description	Calculation	Units		
Mmax	(w*width*L^2)/8	7511.71875	lb-ft		
Vmax	(5*w*width*L)/8	3004.6875	lb		
2 span					
	Actual Deflection	on			
Variable	Description	Calculation	Units	Calc in inches	Demand/capacity
Delta L	(Lr*width(L^4))/(EIapp'*185)	0.0000258835601	ft	0.000310602722	0.0007454465335
Delta S	(S*width*L^4)/(EI(app)'*185)	0.0000647089004	ft	0.000776506805	0.001863616334
Delta D+L	((L+D)*width*L^4)/(EI(app)*185	0.0000441314701	ft	0.000529577641	0.0008473242264

(11

1700000 40000

E

2

Layer

Penthouse Section 1

Location		Nordic Reference	CLT Type							
Roof		NS-DA2301	175-5s							
Nordic Reference Material										
For CLT Layup E1 (psi)										
Variable	Description	Major Strength Direction:	Minor Direction:	Units						
Fb	Bending at Extreme Fiber	1,950	500	psi						
Е	Modulus of Elasticity	1700000	1200000	psi						
Ft	Tension Parallel to Grain	1,375	250	psi						
Fc	Compression Parellel to Grain	1,800	650	psi						
Fv	Shear Parallel to Grain Strength	135	135	psi						
Fs	Rolling Shear Strength	45	45	psi						
Fcp	Compression Perpendicular to Grain	425	425	psi						
G	Shear Modulus	106250	75000	psi						
Gs	Rolling Shear Modulus	10625	7500	psi						
For Roof CLT (175-5s)										
Variable	Description	Major Direction:	Minor Direction:	Units						
FbS(eff)	Bending Moment Capacity	10400	1370	lbf-ft/ft						
V0	Shear Capacity	2480	1490	lbf/ft						
EI(eff,0)	Bending Stiffness	44000000	81000000	lbf-in.^2/ft						
EI(eff,0)	Total Bending Stiffness of Section	264000000	486000000	lbf-in^2						
GA(eff,0)	Shear Rigidity	920000	1200000	lbf/ft						
GA(eff,0)	Total Shear Rigidity	5520000	7200000	lbf						
	Section-Specific L	oading and Dimensions								
Floor			4							
Section:		1A - 1								
Length		13		ft						
Width		6		ft						
Thickness		1.375	1.375	in						
Ply		5		ply						
Total Thickn	ness (tv)	6.875		in						
Roof Live L	oad (Lr)	0		psf						
Ground snov	w load (S)	0		psf						
Dead Loads - Total		168.1		psf						
	Insulation on CLT (D)	3		psf						
	Mechanical (D)	150		psf						
	CLT Self-Weight (D)	15.1		psf						
	Point Loads	0		psf						
Wind (W)		0		mph						
Earthquake	(E)	0		psf						
Live Load (I	L)	20		psf						

	Actual Loadin	ıg	
Variable	Description	Calculation	Units
LC1	D	168.1	psf
LC2	D+L	188.1	psf
LC3	D+(Lr or S or R)	168.1	psf
LC4	D + 0.75L + 0.75(Lr or S or R)	183.1	psf
LC5	D + (0.6W or 0.7E)	168.1	psf
LC6a	D + 0.75L + 0.75(0.6W) + 0.75(Lr or S or R)	183.1	psf
LC6b	D + 0.75L + 0.75(0.7E) + 0.75S	183.1	psf
LC7	0.6D + 0.6W	100.86	psf
LC8	0.6D + 0.7E	100.86	psf
	NDS Calculatio	ons	
Variable	Description	Calculation	Units
Cd		0.9	
Cm		1	
Ct		1	
Cl		1	
	Allowable Valu	ies	
Variable	Description	Calculation	Units
Fb(Seff)'	Fb(Seff)(Cd)(Cm)(Ct)(Cl)	56160	lb-ft
Fs(Ib/Q)eff	Fs(Ib/Q)eff(Cm)(Ct)	14647.17101	lb
(EI)app'	(EI)app(Cm)(Ct)	2153339590	lb-ft2
	Allowable Deflec	ction	
Variable	Description	Calculation	Units
Delta L	L/360	0.0361111111	ft
Delta S	L/360	0.0361111111	ft
Delta D+L	L/240	0.05416666667	ft

Normal Floors

Location		Nordic Reference	CLT Type							
Roof		NS-DA2301	175-5s							
Nordic Reference Material										
For CLT Lavup E1 (psi)										
Variable	Description	Major Strength Direction:	Minor Direction:	Units						
Fb	Bending at Extreme Fiber	1,950	500	psi						
Е	Modulus of Elasticity	1700000	1200000	psi						
Ft	Tension Parallel to Grain	1,375	250	psi						
Fc	Compression Parellel to Grain	1,800	650	psi						
Fv	Shear Parallel to Grain Strength	135	135	psi						
Fs	Rolling Shear Strength	45	45	psi						
Fep	Compression Perpendicular to Grain	425	425	psi						
G	Shear Modulus	106250	75000	psi						
Gs	Rolling Shear Modulus	10625	7500	psi						
For CLT										
Variable	Description	Major Direction:	Minor Direction:	Units						
FbS(eff)	Bending Moment Capacity	10400	1370	lbf-ft/ft						
V0	Shear Capacity	2480	1490	lbf/ft						
EI(eff,0)	Bending Stiffness	44000000	8100000	lbf-in.^2/ft						
EI(eff,0)	Total Bending Stiffness of Section	264000000	486000000	lbf-in^2						
GA(eff,0)	Shear Rigidity	920000	1200000	lbf/ft						
GA(eff,0)	Total Shear Rigidity	5520000	7200000	lbf						
	Section-Specific L	oading and Dimensions								
Floor			All							
Section:		All except E1								
Length		13		ft						
Width		6		ft						
Thickness		1.375	1.375	in						
Ply		5		ply						
Total Thickn	ness (tv)	6.875		in						
Roof Live L	oad (Lr)	0		psf						
Ground snov	v load (S)	50		psf						
Dead Loads - Total		18.1		psf						
	Insulation on CLT (D)	3		psf						
	Mechanical (D)	0		psf						
	CLT Self-Weight (D)	15.1		psf						
	Point Loads	0		psf						
Wind (W)		0		mph						
Earthquake ((E)	0		psf						
Live Load (L)		100		psf						

	Actual Loadir	ıg	
Variable	Description	Calculation	Units
LC1	D	18.1	psf
LC2	D+L	118.1	psf
LC3	D+(Lr or S or R)	68.1	psf
LC4	D + 0.75L + 0.75(Lr or S or R)	130.6	psf
LC5	D + (0.6W or 0.7E)	18.1	psf
LC6a	D+0.75L+0.75(0.6W)+0.75(Lr or S or R)	130.6	psf
LC6b	D+0.75L+0.75(0.7E)+0.75S	130.6	psf
LC7	0.6D + 0.6W	10.86	psf
LC8	0.6D + 0.7E	10.86	psf
	NDS Calculation	ons	
Variable	Description	Calculation	Units
Cd		0.9	
Cm		1	
Ct		1	
Cl		1	
	Allowable Valı	ies	
Variable	Description	Calculation	Units
Fb(Seff)'	Fb(Seff)(Cd)(Cm)(Ct)(Cl)	56160	lb-ft
Fs(Ib/Q)eff'	Fs(Ib/Q)eff(Cm)(Ct)	14647.17101	lb
(EI)app'	(EI)app(Cm)(Ct)	2153339590	lb-ft2
	Allowable Deflet	ction	
Variable	Description	Calculation	Units
Delta L	L/360	0.0361111111	ft
Delta S	L/360	0.0361111111	ft
Delta D+L	L/240	0.05416666667	ft
	Fire Rating Calcs (igno	pre for now)	
Variable	Description	Calculation	Units
Bt	1.5	0.1388888889	ft
a -char	Char Depth	0.1388888889	ft
Delta D+L	L/240	0.2083333333	ft

Atrium Ceiling

Location		Nordic Reference	CLT Type							
Roof		NS-DA2301	175-5s							
Nordic Reference Material										
For CLT Layup E1 (psi)										
Variable	Description	Major Strength Direction:	Minor Direction:	Units						
Fb	Bending at Extreme Fiber	1,950	500	psi						
E	Modulus of Elasticity	1700000	1200000	psi						
Ft	Tension Parallel to Grain	1,375	250	psi						
Fc	Compression Parellel to Grain	1,800	650	psi						
Fv	Shear Parallel to Grain Strength	135	135	psi						
Fs	Rolling Shear Strength	45	45	psi						
Fcp	Compression Perpendicular to Grain	425	425	psi						
G	Shear Modulus	106250	75000	psi						
Gs	Rolling Shear Modulus	10625	7500	psi						
	Fo	r CLT								
Variable	Description	Major Direction:	Minor Direction:	Units						
FbS(eff)	Bending Moment Capacity	10400	1370	lbf-ft/ft						
V0	Shear Capacity	2480	1490	lbf/ft						
EI(eff,0)	Bending Stiffness	44000000	81000000	lbf-in.^2/ft						
EI(eff,0)	Total Bending Stiffness of Section	264000000	486000000	lbf-in^2						
GA(eff,0)	Shear Rigidity	920000	1200000	lbf/ft						
GA(eff,0)	Total Shear Rigidity	5520000	7200000	lbf						
	Section-Specific Lo	ading and Dimensions								
Floor			All							
Section:		2nd Floor Ceiling above atrium								
Length		16		ft						
Width		6		ft						
Thickness		1.375	1.375	in						
Ply		5		ply						
Total Thickn	ness (tv)	6.875		in						
Roof Live L	oad (Lr)	0		psf						
Ground snov	v load (S)	50		psf						
Dead Loads	- Total	18.1		psf						
	Insulation on CLT (D)	3		psf						
	Mechanical (D)	0		psf						
	CLT Self-Weight (D)	15.1		psf						
	Point Loads	0		psf						
Wind (W)		0		mph						
Earthquake ((E)	0		psf						
Live Load (I	L)	100		psf						

	Actual Loadii	ıg	
Variable	Description	Calculation	Units
.C1	D	18.1	psf
LC2	D+L	118.1	psf
LC3	D+(Lr or S or R)	68.1	psf
LC4	D + 0.75L + 0.75(Lr or S or R)	130.6	psf
LC5	D + (0.6W or 0.7E)	18.1	psf
LC6a	D + 0.75L + 0.75(0.6W) + 0.75(Lr or S or R)	130.6	psf
LC6b	D + 0.75L + 0.75(0.7E) + 0.75S	130.6	psf
LC7	0.6D + 0.6W	10.86	psf
LC8	0.6D + 0.7E	10.86	psf
	NDS Calculation	ons	1
Variable	Description	Calculation	Units
Cd		0.9	
Cm		1	
Ct		1	
Cl		1	
	Allowable Valu	les	
Variable	Description	Calculation	Units
Fb(Seff)'	Fb(Seff)(Cd)(Cm)(Ct)(Cl)	56160	lb-ft
Fs(Ib/Q)eff	Fs(Ib/Q)eff(Cm)(Ct)	14647.17101	lb
(EI)app'	(EI)app(Cm)(Ct)	2297256161	lb-ft2
	illowable Defle	ation	
Variable	Description	Calculation	Units
Delta L	L/360	0 04444444444	ft
Delta S	L/360	0.04444444444	Ĥ
Delta D+L	L/240	0.06666666666	ft
Dona D. D	2.2.10	0.0000000000	**
	Fire Rating Calcs (igno	pre for now)	
Variable	Description	Calculation	Units
Bt	1.5	0.1388888889	ft
a -char	Char Depth	0.1388888889	ft
Delta D+L	L/240	0.2083333333	ft

Typical Glulam Joist

4th Floor Outer Edge

Joists				Loading					
Variable	Name	Value	Unit	Se	ection-Specific Loading and I	imensions			
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:			1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		4.6875	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		20	psf		
				Reduced Roof LL		20	psf	93.75	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		50	psf	234.375	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total	1	27.7	psf	167.578125	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	1	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	11.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	37.734375	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)					
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf	0	plf
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L) 0 psf		psf	0	plf	
				Actual Loading					
Axial Load	ling			Variable	Description	Calculation	Units		
Fc	Compression parallel to grain	2300	psi	LC1	D	27.7	psf	167.578125	plf
Ft	Tension parallel to grain	1600	psi	LC2	D+L	27.7	psf	167.578125	plf
Ea	modulus of elasticity	1900000	psi	LC3	D+(Lr or S or R)	77.7	psf	401.953125	plf
CD		1.15	-	LC4	D + 0.75L + 0.75(Lr or S or	65.2	psf	343.359375	plf
СМ		1	-	LC5	D + (0.6W or 0.7E)	27.7	psf	167.578125	plf
Ct		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0.000	65.2	psf	343.359375	plf
Cfu		1	-	LC6b	D+0.75L+0.75(0.7E)+0.7	65.2	psf	343.359375	plf
Cc		1	-	LC7	0.6D + 0.6W	16.62	psf	100.546875	plf
Cb		1	-	LC8	0.6D + 0.7E	16.62	psf	100.546875	plf
CI		1	-						
Cvr		1	-		Allowable Deflection				
E'x		1800000	psi	Variable	Description	Calculation	Units		
E'xmin		1450	psi	Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft		

Member Lengths and Properties								
Variable		Value	Unit					
1		16.5	ft					
b		11.5	in					
d		13.5	in					
р	density	35	pcf					
SG	Specific gravity	0.46						
Ag		155.25	in^2					
Sxx		349.3	in^3					
Ixx		2357.9	in^4					
Isupport		6	in					
Beam Stability Factor								

	Boarn orability radion		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		3.885	
FBe		115	psi

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fh*Cd*Cm*Ct*Cc*Ci	2160	
CI		2100	
UL IN	length (inches)	198	
Lu	$1.63L_{\rm H}+3D_{\rm H}$	363.24	
Rb	sart((le*d)/b^2)	6 08927906	
Emin'	Emin*Cm*Ct	950400	
Ehmi	(1.2*Emin)/(DLA2)	30757 8460	5
FDe	(1.2°Emin)/(K0°2)	1	,
Ciu		1	`
CL		0.99623280	2
CV	look at nds	0.72834939	05
Fire Resistance A	Adjustment Factor	0.75	- ·
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	1179.926013	s psi
Allowable Mome	ent	34346.9087	7 π-lb
Moment		13678.967	29 ft-lb
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	3316.11328	1 lb
Actual fv	3V/2bd	4613.722820	5 psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	3316.11328	ı lb
Fc actual		48.0596127	7 psi
Adjusted Modulı	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
Е'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
	(5*0*(T A 4))/(T) *T *004)*144	0.00767462050	<u>م</u>
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0.00/6/463852	n

4th Floor Inner

Joists				Loading					
Variable	Namo	Value	Unit		Section Specific Loading and L	Dimensions			
X-X Bondi	name	value	Om	Floor	Section-Specific Loading and I	Jimensions	4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		1.	A - 1		
Fbx-	Top of Beam in Tension	1450	nsi	Tributary Width		15.625	ft		
Fex	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		20	psf		
	compression r expensional to gram		Por	Reduced Roof LL (if allo	owed)	18.84375	psf	294.4335938	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)	,	50	psf	781.25	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		29.7	psf	507.3871528	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	1	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	13.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	43.32465278	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)	Wind (W)				
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)	Earthquake (E)		psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)	Live Load (L) 0 psf			0	plf
Axial Load	ling			Variable	Description	Calculation	Units		
Fc	Compression parallel to grain	2300	psi	LC1	D	29.7	psf	507.3871528	plf
Ft	Tension parallel to grain	1600	psi	LC2	D+L	29.7	psf	507.3871528	plf
Ea	modulus of elasticity	1900000	psi	LC3	D+(Lr or S or R)	79.7	psf	1288.637153	plf
CD		1.15	-	LC4	D+0.75L+0.75(Lr or S or	67.2	psf	1093.324653	plf
СМ		1	-	LC5	D + (0.6W or 0.7E)	29.7	psf	507.3871528	plf
Ct		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0	. 67.2	psf	1093.324653	plf
Cfu		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.	67.2	psf	1093.324653	plf
Cc		1	-	LC7	0.6D + 0.6W	17.82	psf	304.4322917	plf
Cb		1	-	LC8	0.6D + 0.7E	17.82	psf	304.4322917	plf
CI		1	-						
Cvr		1	-		Allowable Deflection	1			
E'x		1800000	psi	Variable	Description	Calculation	Units		
E'xmin		1450	psi	Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft		

Member Lengths and Properties								
Variable		Value	Unit					
1		16.5	ft					
b		11.5	in					
d		15.5	in					
р	density	35	pcf					
SG	Specific gravity	0.46						

1 b d

р	density	35	pcf
SG	Specific gravity	0.46	
Ag		178.25	in^2
Sxx		460.5	in^3
Ixx		3568.7	in^4
Isupport		6	in

Beam Stability Factor

Value	Unit
2760	psi
96	in
148	in
4.163	
100	psi
	Value 2760 96 148 4.163 100

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	198	
Le	1.63Lu+3D	369.24	
Rb	$sqrt((le*d)/b^2)$	6.578431849	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	26353.77987	
Cfu		1	
CL	look at nds	0.9955771883	
CV	look at nds	0.7183564047	
Fire Resistance A	Adjustment Factor	0.81	
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	1256.836366	psi
Allowable Mome	nt	48228.91352	ft-lb
Moment		43853.93311	ft-lb
Adjusted Shear l	Parallel to Grain Design Value (F'v) using ASD	7	
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	10631.25651	lb
Actual fv	3V/2bd	12882.75684	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp	-	600	psi
Reaction forces	1/2 * wl	10631.25651	lb
Fc actual		154.0761813	psi
		1	
Adjusted Module	as of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0.01690218634	ft
Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.02787940516	ft

4th Floor Middle

Joists				Loading					
Variable	Name	Value	Unit		Section-Specific Loading and I	Dimensions			
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		12	A - 1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		16.25	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		0	psf	0	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		0	psf	0	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		176.7	psf	2937.060764	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	150	psf		
Y-Y Bendin	ng				Roofing Membrane	1	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	65.68576389	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		20	psf	325	plf
				Reduced Live Load - no	because Kll*At <400 ft2	17.95500551	psf	291.7688396	plf
Axial Load	ing				Actual Loading				
Fc	Compression parallel to grain	2300	psi	Variable	Description	Calculation	Units		
Ft	Tension parallel to grain	1600	psi	LC1	D	176.7	psf	2937.060764	plf
Ea	modulus of elasticity	1900000	psi	LC2	D+L	196.7	psf	3228.829603	plf
CD		1.15	-	LC3	D+(Lr or S or R)	176.7	psf	2937.060764	plf
СМ		1	-	LC4	D+0.75L+0.75(Lr or S or	191.7	psf	3155.887394	plf
Ct		1	-	LC5	D+(0.6W or 0.7E)	176.7	psf	2937.060764	plf
Cfu		1	-	LC6a	D+0.75L+0.75(0.6W)+0	. 191.7	psf	3155.887394	plf
Cc		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	191.7	psf	3155.887394	plf
Cb		1	-	LC7	0.6D + 0.6W	106.02	psf	1762.236458	plf
CI		1	-	LC8	0.6D + 0.7E	106.02	psf	1762.236458	plf
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection	1			
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft		

Member Lengths and Properties							
Variable		Value	Unit				
1		16.5	ft				
b		11.5	in				
d		23.5	in				
р	density	35	pcf				
SG	Specific gravity	0.46					
Ag		270.25	in^2				
Sxx		1058.5	in^3				
Ixx		12437.1	in^4				
Isupport		6	in				
	Beam Stability Factor						
Variable		Value	Unit				
Fbx+*		2760	psi				
lu		96	in				
le		148	in				
RB		5.125					
FBe		66	psi				

Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.01823296483	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
Variable	Description	Calculation	Units
	Actual Defle	ection	
Manual pg 72			
E'	E*CME*CtE*CiE	1800000	
CiE	Incising Factor	1	NDS Table 4.3.8
CtE	Temperature Factor	1	NDS Table 2.3.3
CME	Wet Service Factor	1	NDS Supplement Table 4A
Adjusted Modul	us of Elasticity (E')		
a c actual		000,0007100	r
Fc actual	1/2 11	386.0557135	psi
Reaction forces	1/2 * wl	26637 84423	lb
 Fc nern	remperature racion	600	DSI
Ct	Temperature Factor	1	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Cb	Bearing Area Factor	1	
Fc perp			
Fc actual		386.0557135	psi
Reaction forces	1/2 * wl	26637.84423	lb
Ec perp		600	psi
Ct	Temperature Factor	1	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 44
<u>Ch</u>	Bearing Area Factor	1	
Fc perp			
Actual fv	3V/2bd	21290.5619	psf
Actual V	wL/2	26637.84423	lb
F'v		38880	pst
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
Ci	Incising Factor	1	NDS Table 4.3.8
Ct	Temperature Factor	1	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD		
Moment		109881.107	4 ft-lb
Allowable Mome	ent	126035.3595	ft-lb
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	st 1428.865453	psi
Fire Resistance 2	Adjustment Factor	0.96	
CV	look at nds	0.689074774	7
CL	look at nds	0.9924962547	
Cfu		1	
Fbe	(1.2*Emin')/(Rb^2)	16321.41489	
Emin'	Emin*Cm*Ct	950400	
Rb	sqrt((le*d)/b^2)	8.359204202	
Le	1.63Lu+3D	393.24	
Lu	length (inches)	198	
CL			
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
Ci	Incising Factor	1	
Cc	Curvature Factor	1	
Ct	Temperature Factor	1	
Cm	Wet Service Factor	1	
Cd	Load Duration Factor	0.9	

Typical Glulam Joist

$3^{rd} - 1^{st}$ Floor Outer Edge

Joists				Loading					
Variable	Variable Name Value Unit			Section-Specific Loading and Dimensions					
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		17	A - 1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		4.6875	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		0	psf	0	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		0	psf	0	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		30.7	psf	181.640625	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	0	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	37.734375	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		100	psf	468.75	plf
				Reduced Live Load - edge	beam- no bc KllAt<400 ft	100	psf	468.75	plf
Axial Load	ing				Actual Loading				
Fc	Compression parallel to grain	2300	psi	Variable	Description	Calculation	Units		
Ft	Tension parallel to grain	1600	psi	LC1	D	30.7	psf	181.64	plf
Ea	modulus of elasticity	1900000	psi	LC2	D+L	130.7	psf	650.39	plf
CD		1.15	-	LC3	D+(Lr or S or R)	30.7	psf	181.64	plf
СМ		1	-	LC4	D + 0.75L + 0.75(Lr or S or	105.7	psf	533.20	plf
Ct		1	-	LC5	D + (0.6W or 0.7E)	30.7	psf	181.64	plf
Cfu		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0.000	105.7	psf	533.20	plf
Cc		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	105.7	psf	533.20	plf
Cb		1	-	LC7	0.6D + 0.6W	18.42	psf	108.98	plf
CI		1	-	LC8	0.6D + 0.7E	18.42	psf	108.98	plf
-									
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection				
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	tt		
				Delta D+L	L/240	0.06875	tt		

Member Lengths and Properties

Variable		Value	Unit
1		16.5	ft
b		11.5	in
d		13.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		155.25	in^2
Sxx		349.3	in^3
Ixx		2357.9	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		3.885	
FBe		115	psi

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Eh*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	198	
Le	1.63Lu+3D	363.24	
Rb	sqrt((le*d)/b^2)	6.08927906	
Emin'	Emin*Cm*Ct	950400	
Fhe	$(1.2*Emin')/(Bb^2)$	30757.84605	
Cfu	(1.2 Linii)/(K0 2)	1	
CI	look at nds	0.996252802	
CL		0.970232002	
CV		0.01	
Fire Resistance	Adjustment Factor	1212.2	nci
F'D	F6*Cd*CM*Ct*(CL of CV)*Cc*Cfu*Cl*Fire adjust	28107.22	psi ft lb
Allowable Mome	111	30197.32	ft lb
Moment		22155.01	
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	5365.722656	lb
Actual fv	3V/2bd	7465.353261	psf
Fc perp	1		
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	5365.722656	lb
Fc actual		77.76409647	psi
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CHE	Incising Factor	1	NDS Table 4.3.8
CIE	mensing r detor		
E'	E*CME*CtE*CiE	1800000	
E' *Manual pg 72*	E*CME*CtE*CiE	1800000	
E' *Manual pg 72*	E*CME*CtE*CiE Actual Deflection	1800000	
E' *Manual pg 72* Variable	E*CME*CtE*CiE Actual Deflection Description	1800000	Units
Manual pg 72 Variable Delta L	E*CME*CtE*CiE Actual Deflection Description (5*Lr*(L^4))/(E'app*Lxx*384)*144	1800000 I </td <td>Units ft</td>	Units ft

$3^{rd} - 1^{st}$ Floor Inner

Joists				Loading					
Vanishla	N	Value	Tinit		Continu Currific Tradius and T				
V X Dondi	Name	value	Um	Floor	Section-Specific Loading and L	Jimensions	4		
A-A Dellui	Bottom of Beam in Tension	2400	nci	Section:		14			
The	Top of Deem in Tension	1450	por .	Tributerry Width		15 625	L-1 6		
FOX-	Compression Perpendicular to grain	600	psi	Poof Live Load (Lr)		15.025	n	0	nlf
Fux	Shear parallal to grain	200	psi	Ground snow load (S)		0	psi	0	plf
FVA	Modulus of elasticity	1900000	psi	Dead Loads - Total		30.7	psi	528 6024306	plf
Ex app	Modulus of elasticity (applied)	1800000	psi	Dead Loads Total	Insulation on CLT (D)	9	psi	520.002 1500	Pir
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	nsi		MEP Allowance (D)	5	nsf		
Y-Y Bendi	lg				Roofing Membrane	0	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	48.91493056	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ev	Modulus of elasticity	1900000	psi	Earthquake (E)	Earthquake (E)		psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)	Live Load (L)		psf	1562.5	plf
				Reduced Live Load - ed	Reduced Live Load - edge beam- ves bc KllAt>400 ft		psf	1422.77853	plf
Axial Load	ing				Actual Loading				-
Fc	Compression parallel to grain	2300	psi	Variable	Description	Calculation	Units		
Ft	Tension parallel to grain	1600	psi	LC1	D	30.7	psf	528.60	plf
Ea	modulus of elasticity	1900000	psi	LC2	D+L	130.7	psf	1951.38	plf
CD		1.15	-	LC3	D+(Lr or S or R)	30.7	psf	528.60	plf
СМ		1	-	LC4	D+0.75L+0.75(Lr or S or	105.7	psf	1595.69	plf
Ct		1	-	LC5	D + (0.6W or 0.7E)	30.7	psf	528.60	plf
Cfu		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0	. 105.7	psf	1595.69	plf
Cc		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	105.7	psf	1595.69	plf
Cb		1	-	LC7	0.6D + 0.6W	18.42	psf	317.16	plf
CI		1	-	LC8	0.6D + 0.7E	18.42	psf	317.16	plf
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection	2			
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.04583333333	ft	-	
				Delta S	L/360	0.04583333333	ft	-	
				Delta D+L	L/240	0.06875	ft]	

96

Member Lengths and Properties							
Variable		Value	Unit				
1		16.5	ft				
b		11.5	in				
d		17.5	in				
р	density	35	pcf				
SG	Specific gravity	0.46					
Ag		201.25	in^2				
Sxx		587.0	in^3				
Ixx		5136.1	in^4				
Isupport		6	in				
	Beam Stability Factor						
Variable		Value	Unit				
Fbx+*		2760	psi				
lu		96	in				
le		148	in				
RB		4.423					
FBe		89	psi				

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Ce	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	198	
Le	1.63Lu+3D	375.24	
Rb	$sqrt((le*d)/b^2)$	7.046537178	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	22968.68747	
Cfu		1	
CL	look at nds	0.9948657544	
CV	look at nds	0.81	
Fire Resistance A	Adjustment Factor	0.86	
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	1504.656	psi
Allowable Momen	at	73600.14	ft-lb
Moment		66407.93	ft-lb
Adjusted Shear I	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	16098.89292	lb
Actual fv	3V/2bd	17278.81178	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	16098.89292	lb
Fc actual		233.3172887	psi
Adjusted Modul	us of Flasticity (F')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CIE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.007946263443	ft

$3^{rd} - 1^{st}$ Floor Core

Joists				Loading					
Variable	Name	Value	Unit		Section-Specific Loading and I	Dimensions			
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		14	A - I		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		16.25	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		0	psf	0	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		0	psf	0	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		30.7	psf	547.7899306	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	0	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	48.91493056	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		100	psf	1625	plf
				Reduced Live Load - ed	ge beam- yes bc KllAt>400 ft	89.77502756	psf	1458.844198	plf
Axial Load	ling				Actual Loading	1			
Fc	Compression parallel to grain	2300	psi	Variable	Description	Calculation	Units		
Ft	Tension parallel to grain	1600	psi	LC1	D	30.7	psf	547.79	plf
Ea	modulus of elasticity	1900000	psi	LC2	D+L	130.7	psf	2006.63	plf
CD		1.15	-	LC3	D+(Lr or S or R)	30.7	psf	547.79	plf
СМ		1	-	LC4	D + 0.75L + 0.75(Lr or S or	105.7	psf	1766.54	plf
Ct		1	-	LC5	D + (0.6W or 0.7E)	30.7	psf	547.79	plf
Cfu		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0	. 105.7	psf	1641.92	plf
Cc		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	105.7	psf	1641.92	plf
Cb		1	-	LC7	0.6D + 0.6W	18.42	psf	328.67	plf
CI		1	-	LC8	0.6D + 0.7E	18.42	psf	328.67	plf
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection	2			
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft		

Member Lengths and Properties						
	Value	Unit				
	16.5	ft				
	11.5	in				
	17.5	in				
density	35	pcf				
Specific gravity	0.46					
	201.25	in^2				
	587.0	in^3				
	5136.1	in^4				
	6	in				
Beam Stability Factor						
	Value	Unit				
	2760	psi				
	96	in				
	148	in				
	4.423					
	89	psi				
	Member Lengths and Properties density Specific gravity Beam Stability Factor	Member Lengths and Properties Value 16.5 11.5 11.5 11.5 17.5 density 35 Specific gravity 0.46 201.25 587.0 5136.1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 1 <td< td=""></td<>				

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	198	
Le	1.63Lu+3D	375.24	
Rb	$sqrt((le*d)/b^2)$	7.046537178	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	22968.68747	
Cfu		1	
CL	look at nds	0.9948657544	
CV	look at nds	0.81	
Fire Resistance	Adjustment Factor	0.86	
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	1504.656	psi
Allowable Mome	ent	73600.14	ft-lb
Moment		68288.27	ft-lb
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	16554.73156	lb
Actual fv	3V/2bd	17768.05971	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	16554.73156	lb
Fc actual		239.9236458	psi
Adjusted Modu	lus of Elasticity (F')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CIE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
2		100000	
Manual pg 72	•		
Manaa pg 12			
	Actual Deflection	1	
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.008234701258	ft

Special Glulam Joist

4th Floor Core

Joists				Loading					
				Top Half - Single Span					
Variable	Name	Value	Unit		Section-Specific Loading and Dimensio	ns			
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		1.	A - 1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		4.6875	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		20	psf	93.75	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		50	psf	234.375	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		31.7	psf	175.1475694	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	1	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	26.55381944	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		0	psf	0	plf
					Actual Loading				
Axial Load	ling			Variable	Description	Calculation	Units		
Fc	Compression parallel to grain	2300	psi	LC1	D	31.7	psf	175.1475694	plf
Ft	Tension parallel to grain	1600	psi	LC2	D+L	31.7	psf	175.1475694	plf
Ea	modulus of elasticity	1900000	psi	LC3	D+(Lr or S or R)	81.7	psf	409.5225694	plf
CD		1.15	-	LC4	D + 0.75L + 0.75(Lr or S or R)	69.2	psf	350.9288194	plf
СМ		1	-	LC5	D + (0.6W or 0.7E)	31.7	psf	175.1475694	plf
Ct		1	-	LC6a	D+0.75L+0.75(0.6W)+0.75(Lr or S or R)	69.2	psf	350.9288194	plf
Cfu		1	-	LC6b	D+0.75L+0.75(0.7E)+0.75S	69.2	psf	350.9288194	plf
Cc		1	-	LC7	0.6D + 0.6W	19.02	psf	105.0885417	plf
Cb		1	-	LC8	0.6D + 0.7E	19.02	psf	105.0885417	plf
CI		1	-						
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection				
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta S Delta D+L	L/360 L/240	0.04583333333 0.06875	ft ft		

Member Lengths and Properties

Variable		Value	Unit
1		16.5	ft
b		9.5	in
d		11.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		109.25	in^2
Sxx		209.4	in^3
Ixx		1204.0	in^4
Isupport		6	in
	Beam Stability Factor		

Variable	Value	Unit
Fbx+*	2760	psi
lu	96	in
le	148	in
RB	4.340	
FBe	92	psi

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	198	
Le	1.63Lu+3D	357.24	
Rb	sqrt((le*d)/b^2)	6.746916809	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	25053.99366	
Cfu	(1	
CL	look at nds	0.9953286347	
CV	look at nds	0 7543984327	
C v Fina Rasistanas /	diretment Fester	0.7545984527	
Fire Resistance F	Ehercharcharcharcharcharcharcharcharcharcha	0.5 814 7502072	nei
F D	FB*Cd*CM*Ct*(CL of CV)*Cc*Clu*Cl*Fife adjust	14217 10006	psi # lb
Anowable Mome		14217.10990	ft lb
Moment		4260	IL-ID
Adjusted Shear l	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v	allowable	38880	psf
Actual V	wL/2	2560	lb
Actual fv	3V/2bd	5061	psf
Fanorn		1	
Ch	Bearing Area Faster	1	
CMU	Bearing Area Factor	1	NDS Supplement Table 44
CMV		1	NDS Table 2.2.2
	Temperature Factor	1	
Fc perp	1/2 * 1	600	psi lb
Reaction forces	1/2 ⁺ WI	2360	
Fc actual		45	hei
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L		0.006011736543	ft
Delta S		0.01502934136	ft

3rd Floor Core

Joists				Loading					
37 . 11	Y	¥7.1	T T 1/						
Variable V V Dondi	Name	value	Unit	Floor	Section-Specific Loading and I	Dimensions	4		
A-A Denui	Bottom of Ream in Tension	2400	nei	Floor Section:		14	4 A - 1		
The	Top of Doom in Toppion	1450	pai	Tuibuterry Width		9 5625			
Fox-	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		0	n	0	plf
Fux	Shear parallel to grain	300	psi	Ground snow load (S)		0	psi	0	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		30.7	psf	320 1225694	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		F
Emin	Modulus of elasticity (min) = $0.528Exapp$	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng		•		Roofing Membrane	0	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	26.55381944	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		100	psf	956.25	plf
				Reduced Live Load - no	bc Kll*At<400	100	psf	956.25	plf
Axial Load	ling				Actual Loading				
Fc	Compression parallel to grain	2300	psi	Variable	Description	Calculation	Units		
Ft	Tension parallel to grain	1600	psi	LC1	D	30.7	psf	320.12	plf
Ea	modulus of elasticity	1900000	psi	LC2	D+L	130.7	psf	1276.37	plf
CD		1.15	-	LC3	D+(Lr or S or R)	30.7	psf	320.12	plf
СМ		1	-	LC4	D + 0.75L + 0.75(Lr or S or	105.7	psf	1037.31	plf
Ct		1	-	LC5	D + (0.6W or 0.7E)	30.7	psf	320.12	plf
Cfu		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0	. 105.7	psf	1037.31	plf
Cc		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.	105.7	psf	1037.31	plf
Cb		1	-	LC7	0.6D + 0.6W	18.42	psf	192.07	plf
CI		1	-	LC8	0.6D + 0.7E	18.42	psf	192.07	plf
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection	2			
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.02291666667	ft	-	
				Delta S	L/360	0.022916666667	ft		
				Delta D+L	L/240	0.034375	ft		

Member Lengths and Properties

Variable		Value	Unit
1		8.25	ft
b		9.5	in
d		11.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		109.25	in^2
Sxx		209.4	in^3
Ixx		1204.0	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		4.340	
FBe		92	psi

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	99	
Le	1.63Lu+3D	195.87	
Rb	sqrt((le*d)/b^2)	4.995848692	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	45695.04618	
Cfu		1	
CL	look at nds	0.9975317733	
CV	look at nds	0.81	
Fire Resistance A	djustment Factor	0.5	
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	874.8	psi
Allowable Momer	at	15,264.96	ft-lb
Moment		10,859.14	ft-lb
Adjusted Shear I	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	5265	lb
Actual fv	3V/2bd	10409.59231	psf
		_	
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	5265.036849	lb
Fc actual		92.36906753	psi
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.001282995033	ft

2nd Floor Outside Overhang

FBe

Joists				Loading					
Variable	Name	Value	Unit		Section-Specific Loading and Dimensio	ns			
X-X Bendi	1g			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		14	A - 1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		3.5	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		20	psf	70	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		50	psf	175	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		27.7	psf	123.5038194	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendin	ıg				Roofing Membrane	1	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	11.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	26.55381944	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		0	psf	0	plf
					Actual Loading				
Axial Load	ing			Variable	Description	Calculation	Units		
Fc	Compression parallel to grain	2300	psi	LC1	D	27.7	psf	123.5038194	plf
Ft	Tension parallel to grain	1600	psi	LC2	D+L	27.7	psf	123.5038194	plf
Ea	modulus of elasticity	1900000	psi	LC3	D+(Lr or S or R)	77.7	psf	298.5038194	plf
CD		1.15	-	LC4	D + 0.75L + 0.75(Lr or S or R)	65.2	psf	254.7538194	plf
СМ		1	-	LC5	D+(0.6W or 0.7E)	48.7	psf	139.4361111	plf
Ct		1	-	LC6a	D+0.75L+0.75(0.6W)+0.75(Lr or S or R)	80.95	psf	266.7030382	plf
Cfu		1	-	LC6b	D+0.75L+0.75(0.7E)+0.75S	65.2	psf	254.7538194	plf
Cc		1	-	LC7	0.6D + 0.6W	37.62	psf	90.03458333	plf
Cb		1	-	LC8	0.6D + 0.7E	16.62	psf	74.10229167	plf
CI		1	-						
Cvr		1	-		Allowable Deflection				
E'x		1800000	psi	Variable	Description	Calculation	Units		
E'xmin		1450	psi	Delta L	L/360	0.1083333333	ft		
				Delta S	L/360	0.1083333333	ft		
				Dalta D+I	I /240	0.1625	۵		

Member Lengths and Properties								
Variable		Value	Unit					
1		39	ft					
b		9.5	in					
d		11.5	in					
р	density	35	pcf					
SG	Specific gravity	0.46						
Ag		109.25	in^2					
Sxx		209.4	in^3					
Ixx		1204.0	in^4					
Isupport		6	in					
	Beam Stability Factor							
Variable		Value	Unit					
Fbx+*		2760	psi					
lu		96	in					
le		148	in					
RB		4.340						

92 psi

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	468	
Le	1.63Lu+3D	797.34	
Rb	$sqrt((le*d)/b^2)$	10.07968803	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	11225.18461	
Cfu		1	
CL	look at nds	0.9883933388	
CV	look at nds	0.6922177178	
Fire Resistance A	Adjustment Factor	0.5	
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	747.5951352	psi
Allowable Mome	nt	13045.27553	ft-lb
Moment		8820	ft-lb
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	3000	lb
Actual fv	3V/2bd	5931.350114	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp	1	600	psi
Reaction forces	1/2 * wl	5670	lb
Fc actual		99	psi
		1	•
Adjusted Moduli	is of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0.1401036194	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0.3502590484	ft
Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.00592	ft

1st Floor Atrium

Joists				Loading					
Variable	Name	Value	Unit		Section-Specific Loading and Dimension	ns			
X-X Bendin	1g			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		12	A - 1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		5	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Li	:)	0	psf	0	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load	(S)	0	psf	0	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		30.7	psf	191.234375	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendin	g				Roofing Membrane	0	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	37.734375	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf		
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		100	psf	500	plf
					Actual Loading				
Axial Loadi	ing			Variable	Description	Calculation	Units		
Fc	Compression parallel to grain	2300	psi	LC1	D	30.7	psf	191.234375	plf
Ft	Tension parallel to grain	1600	psi	LC2	D+L	130.7	psf	691.234375	plf
Ea	modulus of elasticity	1900000	psi	LC3	D+(Lr or S or R)	30.7	psf	191.234375	plf
CD		1.15	-	LC4	D + 0.75L + 0.75(Lr or S or R)	105.7	psf	566.234375	plf
СМ		1	-	LC5	D + (0.6W or 0.7E)	51.7	psf	213.875	plf
Ct		1	-	LC6a	D+0.75L+0.75(0.6W)+0.75(Lr or S or R)	121.45	psf	583.2148438	plf
Cfu		1	-	LC6b	D+0.75L+0.75(0.7E)+0.75S	105.7	psf	566.234375	plf
Cc		1	-	LC7	0.6D + 0.6W	39.42	psf	137.38125	plf
Cb		1	-	LC8	0.6D + 0.7E	18.42	psf	114.740625	plf
CI		1	-						
Cvr		1	-		Allowable Deflection				
E'x		1800000	psi	Variable	Description	Calculation	Units		
E'xmin		1450	psi	Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft		

Member Lengths and Properties

Variable		Value	Unit
1		16.5	ft
b		11.5	in
d		13.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		155.25	in^2
Sxx		349.3	in^3
Ixx		2357.9	in^4
Isupport		6	in

Beam Stability Factor

Variable	Value	Unit
Fbx+*	2760	psi
lu	96	in
le	148	in
RB	3.885	
FBe	115	psi

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	198	
Le	1.63Lu+3D	363.24	
Rb	sqrt((le*d)/b^2)	6.08927906	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	30757.84605	
Cfu		1	
CL	look at nds	0.996252802	
CV	look at nds	0.7283493905	
Fire Resistance	Adjustment Factor	0.75	
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	1179.926013	psi
Allowable Mome	ent	34346.90877	ft-lb
Moment		23523.56982	ft-lb
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	- 1	NDS Table 2.3.2
Ci	Incising Factor	- 1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wI /2	5702 683594	lb
Actual fy	3V/2bd	7934.168478	psf
/iciuii iv	5 17204	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	P
Fc perp			
Ch	Bearing Area Factor	1	
CMV	Wet Service Factor	- 1	NDS Supplement Table 4A
Ct	Temperature Factor	- 1	NDS Table 2.3.2
Ec perp		600	psi
Reaction forces	1/2 * w	5702 683594	lb
Fc actual		82.64758832	psi
]
Adjusted Modulı	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
Е'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection	п	
Variable	Description	Calculation	Units
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144	0	ft
Delta D+L	(5*(L+D)*(L^4))/(E'app*Ixx*384)*144	0.00626199339	ft
Typical Glulam Girder

4th Floor 4-2

	Member Lengths and Properties	5	
Variable		Value	Unit
1		25	ft
b		11.5	in
d		23.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		270.25	in^2
Sxx		1058.5	in^3
Ixx		12437.1	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		5.125	
FBe		66	psi
CL			

Loading					
Point Load 1 - left					
	Section-Specific Loading and D	Dimensions			
Joist Number			4-1		
Joist b		11.5	in		
joist d		13.5	in		
Girder Tributary Widt	h	16.5	ft		
CLT Tributary Area		4.6875	ft		
Roof Live Load (Lr) (enter reduced load if reduced)	20	psf	1546.875	lbs
Ground snow load (S)		50	psf	3867.1875	lbs
Dead Loads - Total		27.7	psf	2765.039063	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	11.1	psf		
	Joist Weight	35	pcf	622.6171875	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter r	educed load if reduced)	0	psf	0	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	2765.04	lbs
LC2	D+L	27.7	psf	2765.04	lbs
LC3	D+(Lr or S or R)	77.7	psf	6632.23	lbs
LC4	D + 0.75L + 0.75(Lr or S or)	65.2	psf	5665.43	lbs
LC5	D + (0.6W or 0.7E)	27.7	psf	2765.04	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	65.2	psf	5665.43	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psf	5665.43	lbs
LC7	0.6D + 0.6W	16.62	psf	1659.02	lbs
LC8	0.6D + 0.7E	16.62	psf	1659.02	lbs

Point Load 2 - Middle					
S	ection-Specific Loading and I	Dimensions			
Joist Number		2	4-2		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary Width		16.5	ft		
CLT Tributary Area		15.625	ft		
Roof Live Load (Lr) (ente	r reduced load if reduced)	18.84375	psf	4858.154297	lbs
Ground snow load (S)		50	psf	12890.625	lbs
Dead Loads - Total		27.7	psf	7856.263021	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	I	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	11.1	psf		
	Joist Weight	35	pcf	714.8567708	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ced load if reduced)	0	psf	0	lbs
	Actual Loading	_			
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	7856.26	lbs
LC2	D+L	27.7	psf	7856.26	lbs
LC3	D+(Lr or S or R)	77.7	psf	20746.89	lbs
LC4	D + 0.75L + 0.75(Lr or S or)	65.2	psf	17524.23	lbs
LC5	D + (0.6W or 0.7E)	27.7	psf	7856.26	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	. 65.2	psf	17524.23	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psf	17524.23	lbs
LC7	0.6D + 0.6W	16.62	psf	4713.76	lbs
LC8	0.6D + 0.7E	16.62	psf	4713.76	lbs

Point Load 3 - Right					
S	ection-Specific Loading and D	Dimensions			
Joist Number		2	4-3		
Joist b		11.5	in		
joist d		13.5	in		
Girder Tributary Width		16.5	ft		
CLT Tributary Area		4.6875	ft		
Roof Live Load (Lr) (ente	r reduced load if reduced)	20	psf	1546.875	lbs
Ground snow load (S)		50	psf	3867.1875	lbs
Dead Loads - Total		29.7	psf	2919.726563	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	I	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	13.1	psf		
	Joist Weight	35	pcf	622.6171875	lbs
Wind (W)		0	mph		
Earthquake (E)	0	psf			
Live Load (L) (enter reduc	0	psf	0	lbs	
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	29.7	psf	2919.73	lbs
LC2	D+L	29.7	psf	2919.73	lbs
LC3	D+(Lr or S or R)	79.7	psf	6786.91	lbs
LC4	$D + 0.75L + 0.75(Lr \text{ or } S \text{ or } 10^{-1})$	67.2	psf	5820.12	lbs
LC5	D + (0.6W or 0.7E)	29.7	psf	2919.73	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	67.2	psf	5820.12	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	67.2	psf	5820.12	lbs
LC7	0.6D + 0.6W	17.82	psf	1751.84	lbs
LC8	0.6D + 0.7E	17.82	psf	1751.84	lbs
Uniform Load from Gl					
S	ection-Specific Loading and D	Dimensions			
Floor			4		
Section:	14	A - 1			
Dead Load - from Glulam	self weight	35	pcf	65.68576389	plf
Wind (W)		0	mph		
Earthquake (E)	0	psf			

	Actual Loading							
Variable	Description	Calculation	Units	Total DL (lbs)	Total LI	Total Roo	of SL (lbs)	
LC1	D	15183.17	lbs	0	0	0		
LC2	D+L	15183.17	lbs	0	0	0		
LC3	D+(Lr or S or R)	35808.17	lbs	15183.17274	0	7951.904	1	
LC4	D + 0.75L + 0.75(Lr or S or	30651.92	lbs	0	0	0		
LC5	D + (0.6W or 0.7E)	15183.17	lbs	0	0	0		
LC6a	D + 0.75L + 0.75(0.6W) + 0	30651.92	lbs	0	0	0		
LC6b	D + 0.75L + 0.75(0.7E) + 0.	30651.92	lbs	0	0	0		
LC7	0.6D + 0.6W	9109.90	lbs	0	0	0		
LC8	0.6D + 0.7E	9109.90	lbs	0	0	0		
Column reaction	Formula	Value	Unit					
Total	112	35808.17	lb					
Left Column	Formula	Value	Unit		Right c	Formula	Value	Unit
Total	Pt load 1 + (12.5*self weig	17826.74	lb		Total	Pt load 3	17981.43	lb
Dead		7558.791525	lb		Dead		7624.381218	lb
live		0	lb		live		0	lb
Snow		3958.776458	lb		Snow		3993.127839	lb

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	300	
Le	1.63Lu+3D	559.5	
Rb	sqrt((le*d)/b^2)	9.970940765	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	11471.373	
Cfu		1	
CL	look at nds	0.9886917832	
CV	look at nds	0.81	
Fire Resistance A	Adjustment Factor	0.96	0.96
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*Cfu*Ci*Fire adjust	1679.616	psi
Allowable Mome	nt	148,153.21	ft-lb
Moment		134,799.75	ft-lb

A dimete J Char J	Popullal to Chain Design Value (71-)	1	
Adjusted Shear	Parallel to Grain Design Value (FV) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38,880.00	psf
Actual V	wL/2	11,194.52	lb
Actual fv	3V/2bd	8,947.33	psf
-			
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	11194.51606	lb
Fc actual		162.2393632	psi
Adjusted Modul	us of Elasticity (E')		
СМЕ	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	See next column	0.0101723173	ft
Delta S	See next column	0.02699122336	ft
Delta D+L	See next column	0.01232134173	ft
	Allowable Deflection		
Variable	Description	Calculation	Units
Delta L	L/360	0.06944444444	ft
Delta S	L/360	0.0694444444	ft
Delta D+L	L/240	0.1041666667	ft
1			

$3^{rd} - 1^{st}$ Floor 2

	Member Lengths and Properties	S	
Variable		Value	Unit
1		25	ft
b		11.5	in
d		27.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		316.25	in^2
Sxx		1449.5	in^3
Ixx		19930.3	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		5.545	
FBe		57	psi
CL			

Loading					
Point Load 1 - left					
S	ection-Specific Loading and I	Dimensions			
Joist Number			3-1		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary Width		16.5	ft		
CLT Tributary Area		4.6875	ft		
Roof Live Load (Lr) (ente	r reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	0	lbs
Dead Loads - Total		30.7	psf	3089.309896	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	714.8567708	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter redu	ced load if reduced)	100	psf	7734.375	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	30.7	psf	3089.31	lbs
LC2	D+L	130.7	psf	10823.68	lbs
LC3	D+(Lr or S or R)	30.7	psf	3089.31	lbs
LC4	D + 0.75L + 0.75(Lr or S or	105.7	psf	8890.09	lbs
LC5	D + (0.6W or 0.7E)	30.7	psf	3089.31	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	105.7	psf	8890.09	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	105.7	psf	8890.09	lbs
LC7	0.6D + 0.6W	18.42	psf	1853.59	lbs
LC8	0.6D + 0.7E	18.42	psf	1853.59	lbs

Point Load 2 - Middle					
S	ection-Specific Loading and I	Dimensions			
Joist Number		3	3-2		
Joist b		11.5	in		
joist d		17.5	in		
Girder Tributary Width		16.5	ft		
CLT Tributary Area		15.625	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	0	lbs
Dead Loads - Total		30.7	psf	8721.940104	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	807.0963542	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	91.0578	psf	23475.83906	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	30.7	psf	8721.94	lbs
LC2	D+L	121.7578	psf	32197.78	lbs
LC3	D+(Lr or S or R)	30.7	psf	8721.94	lbs
LC4	D + 0.75L + 0.75(Lr or S or)	98.99335	psf	26328.82	lbs
LC5	D + (0.6W or 0.7E)	30.7	psf	8721.94	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	98.99335	psf	26328.82	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	98.99335	psf	26328.82	lbs
LC7	0.6D + 0.6W	18.42	psf	5233.16	lbs
LC8	0.6D + 0.7E	18.42	psf	5233.16	lbs

Point Load 3 - R	ight				
	Section-Specific Loading a	nd Dimensions			
Joist Number		3	3-3		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary W	ïdth	16.5	ft		
CLT Tributary Area	a	4.6875	ft		
Roof Live Load (L	r) (enter reduced load if reduced)) 0	psf	0	lbs
Ground snow load	(S)	0	psf	0	lbs
Dead Loads - Total		30.7	psf	3089.309896	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	<u> </u>	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	714.8567708	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduced load if reduced)		100	psf	7734.375	lbs
	Actual Loadii	ng			
Variable	Description	Calculation	Units		
LC1	D	30.7	psf	3089.31	lbs
LC2	D+L	130.7	psf	10823.68	lbs
LC3	D+(Lr or S or R)	30.7	psf	3089.31	lbs
LC4	D + 0.75L + 0.75(Lr or 300)	S or 105.7	psf	8890.09	lbs
LC5	D + (0.6W or 0.7E)	30.7	psf	3089.31	lbs
LC6a	D + 0.75L + 0.75(0.6W)) + 0. 105.7	psf	8890.09	lbs
LC6b	D + 0.75L + 0.75(0.7E)	+ 0.1 105.7	psf	8890.09	lbs
LC7	0.6D + 0.6W	18.42	psf	1853.59	lbs
LC8	0.6D + 0.7E	18.42	psf	1853.59	lbs
Uniform Load fr	om Glulam Self weight				
	Section-Specific Loading a	and Dimensions			
Floor			4		
Section:		17	A - 1		
Dead Load - from (Glulam self weight	35	pcf	76.86631944	plf
Wind (W)		0	mph		
Earthquake (E)		0	psf		

	ular Oalfan inkt										
Uniform Load from Gi	ulam Self weight	nd Dimensions									
Floor	ection-specific Loading a	nd Dimensions	4								
Section:		12	A - 1								
Dead Load - from Glulam	self weight	35	pcf	76.86631944	plf						
Wind (W)		0	mph								
Earthquake (E)	1	0	psf								
	A starl T as die										
Variable	Actual Loadir	Calculation	Unite	Total DL (lbs)	Total I I	Total Roc	f SL (lbs)				
LC1	D	16822.22	lbs	10tal DL (103)		0	1 SE (103)				
LC2	D+L	55766.81	Ibs	16822.21788	38944.	0					
LC3	D+(Lr or S or R)	16822.22	Ibs	0	0	0					
LC4	D + 0.75L + 0.75(Lr or \$	5 or 46030.66	Ibs	0	0	0					
LC5	D + (0.6W or 0.7E)	16822.22	lbs	0	0	0					
LC6a	D+0.75L+0.75(0.6W)	+ 0. 46030.66	lbs	0	0	0					
LC6b	D+0.75L+0.75(0.7E)	+ 0.7 46030.66	lbs	0	0	0					
LC7	0.6D + 0.6W	10093.33	Ibs	0	0	0					
LC8	0.6D + 0.7E	10093.33	lbs	0	0	0					
Column reaction	Formula	Value	Unit								
Total		112 55766.81	lb								
Left Column	Formula	Value	Unit		Right o	Formula	Value		Unit		
Total	Pt load 1 + (12.5*self v	veig 27883.40	lb		Total	Pt load 3	278	383.40	lb		
Dead		8411.108941	lb		Dead		8411.1	08941	b		
live		19472.29453	lb		live		19472.	29453	lb		
Snow		0	lb		Snow			0	lb		
C	Cd	Load Duration	Factor						0.9		
C	m	Wet Service E	actor						1		
	×	Tommonotumo E	laatan						1		
	- L		actor						-		
C	Ce	Curvature Fac	tor						1		
C	2i	Incising Facto	r						1		
F	'b*	Fb*Cd*Cm*C	t*Cc*Ci						2160		
C	L										
L	u	length (inches))						300		
L	.e	1.63Lu+3D							571.5		
R	lb.	sqrt((le*d)/b^2	2)					10.9	90125814		
E	lmin'	Emin*Cm*Ct						9	50400		
F	`be	(1.2*Emin')/(Rb^2)						959	6.976378		
C	fu								1		
C	CL.	look at nds						0.98	59408423		
C	V	look at nds							0.81		
F	ire Resistance A	djustment Fa	ctor						1		
F	"b	Fb*Cd*CM*C	Ct*(CL or Cv))*Cc*Cfu*C	i*Fire	adjust		1	1749.6	psi	
A	llowable Momen	t							211334.06	ft-lb	
Ν	Ioment								207241.30	ft-lb	

Adjusted Shear I	Parallel to Grain Design Value (F'v) using ASD		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	17059.71858	lb
Actual fv	3V/2bd	11651.85522	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	17059.71858	lb
Fc actual		247.2422982	psi
Adjusted Modul	1s of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual Deflection		
Variable	Description	Calculation	Units
Delta L	See next column	0.03067433974	ft
Delta S	See next column	0	ft
Delta D+L	See next column	0.03224366012	ft
	Allowable Deflection	I	
Variable	Description	Calculation	Units
Delta L	L/360	0.06944444444	ft
Delta S	L/360	0.06944444444	ft
Delta D+L	L/240	0.1041666667	ft

Special Glulam Girder

4th Floor Core Member

	Member Lengths and Properties							
	Varia	ble	-		Value		Unit	
	1					26	ft	
	b				17.	525	in	
	d				2	7.5	in	
	p	de	ensity			35	pcf	
	SG	Specif	ic gravity		C	.46	P*2	
	Ag	Speen	ie gravity		484.6	375	in^2	
	Sxx				222	1.5	in^3	
	Ixx				3054	5.4	in^4	
	Isuppo	rt				6	in	
	15uppo.					0		
		Be	am Stability Fa	ctor				
	Varia	ble			Value		Unit	
	Fbx+*				27	60	psi	
	lu					96	in	
	le					48	in	
	RB				3.6	618		
	FBe					33	psi	
	CL							
Loading								
Point Load 1 - le	eft							
	Se	ction-Specific Loading and I	Dimensions					
Joist Number			4	l-3s				
Joist b			11.5	i	in			
ioist d			11.5	i	in			
Girder Tributary W	Vidth		13.5		ft			
CIT Tributary Are			4,875		fi l			_
Roof Live Load (L	r) (enter	reduced load if reduced)	0	n	n sf			0
Ground snow load	(S)		0	r r	osf		433 945312	5
Dead Loads - Total	1		176.7	r D	osf		12063.0140	6
		Insulation on CLT (D)	9	r r	osf			
		MEP Allowance (D)	150	p	osf			
		Roofing Membrane	1	ŗ	osf			
		Misc. Hung Ceiling	1.6	P	osf			
		CLT Weight (D)	15.1	ļ	osf			
		Joist Weight	35	q	cf		433.945312	5
Wind (W)			0	m	ph			
Earthquake (E)			0	p	sf			
Live Load (L) (ent	er reduce	d load if reduced)	20	p	sf		1316.2	5
		Actual Loading						
Variable		Description	Calculation	Units				
LC1		D	176.7	psf			12063.0	1
LC2		D+L	196.7	psf			13379.2	6
LC3		D+(Lr or S or R)	176.7	psf			12496.9	6
LC4		D + 0.75L + 0.75(Lr or S or	191.7	psf			13375.6	6
LC5		D + (0.6W or 0.7E)	176.7	psf			12063.0	1
LC6a		D + 0.75L + 0.75(0.6W) + 0	. 191.7	psf			13375.6	6
LC6b		D + 0.75L + 0.75(0.7E) + 0.75	191.7	psf			13375.6	6
LC7		0.6D + 0.6W	106.02	psf			7237.8	1
LC8		$0.6D \pm 0.7E$	106.02	psf			7237.81	

Point Load 2 - I	Middle				
	Section-Specific Loading and I	Dimensions			
Joist Number			4-4		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary	Width	13.5	ft		
CLT Tributary Ar	ea	16.25	ft		
Roof Live Load (Lr) (enter reduced load if reduced)	0	psf	0	lbs
Ground snow load	d (S)	0	psf		
Dead Loads - Tota	al	176.7	psf	39348.44531	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	150	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	584.8828125	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (en	ter reduced load if reduced)	20	psf	4387.5	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	176.7	psf	39348.45	lbs
LC2	D+L	196.7	psf	43735.95	lbs
LC3	D+(Lr or S or R)	176.7	psf	39348.45	lbs
LC4	D + 0.75L + 0.75(Lr or S or	191.7	psf	42639.07	lbs
LC5	D + (0.6W or 0.7E)	176.7	psf	39348.45	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0	. 191.7	psf	42639.07	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	191.7	psf	42639.07	lbs
LC7	0.6D + 0.6W	106.02	psf	23609.07	lbs
LC8	0.6D + 0.7E	106.02	psf	23609.07	lbs

Point Load 3 - Right					
S	ection-Specific Loading and I	Dimensions			
Joist Number		4	-3s		
Joist b		11.5	in		
joist d		11.5	in		
Girder Tributary Width		13.5	ft		
CLT Tributary Area		4.875	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	433.9453125	
Dead Loads - Total	_	176.7	psf	12063.01406	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	150	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	433.9453125	lbs
Wind (W)	0	mph			
Earthquake (E)	0	psf			
Live Load (L) (enter reduc	20	psf	1316.25	lbs	
Variable	Description	Calculation	Units		
LC1	D	176.7	psf	12063.01	lbs
LC2	D+L	196.7	psf	13379.26	lbs
LC3	D+(Lr or S or R)	176.7	psf	12496.96	lbs
LC4	D + 0.75L + 0.75(Lr or S or)	. 191.7	psf	13375.66	lbs
LC5	D + (0.6W or 0.7E)	176.7	psf	12063.01	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	. 191.7	psf	13375.66	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	191.7	psf	13375.66	lbs
LC7	0.6D + 0.6W	106.02	psf	7237.81	lbs
LC8	0.6D + 0.7E	106.02	psf	7237.81	lbs
Uniform Load from Glu	ulam Self weight				
S	Dimensions				
Floor		4			
Section:	14	A - 1			
Dead Load - from Glulam	self weight	35	pcf	117.8059896	plf
Wind (W)		0	mph		
Earthquake (E)		0	psf		

Uniform Load from G	lulam Self weight							
	Section-Specific Loading and I	Dimensions						
Floor			4					
Section:		1.	A - 1					
Dead Load - from Glular	n self weight	35	pcf	117.8059896	plf			
Wind (W)		0	mph					
Earthquake (E)		0	psf					
	Actual Loading	1						
Variable	Description	Calculation	Units	Total DL (lbs)	Total LL (lbs)	Total Roof SL (lbs)		
LC1	D	66537.43	lbs	0	0	0		
LC2	D+L	73557.43	lbs	66537.42917	7020	0		
LC3	D+(Lr or S or R)	67405.32	lbs	0	0	0		
LC4	D + 0.75L + 0.75(Lr or S or	72453.35	lbs	0	0	0		
LC5	D + (0.6W or 0.7E)	66537.43	lbs	0	0	0		
LC6a	D + 0.75L + 0.75(0.6W) + 0	. 72453.35	lbs	0	0	0		
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	72453.35	lbs	0	0	0		
LC7	0.6D + 0.6W	39922.46	lbs	0	0	0		
LC8	0.6D + 0.7E	39922.46	lbs	0	0	0		
Column reaction	Formula	Value	Unit					
Total		73557.43	lb					
Left Column	Formula	Value	Unit		Right column	Formula	Value	Unit
Total	Pt load 1 + (12.5*self weig	36778.71	lb		Total	Pt load 3 + (12.5*s	36778.71	lb
Dead		33268.71458	lb		Dead		33268.71458	lb
live		3510	lb		live		3510	lb
Snow		0	lb		Snow		0	lb

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	312	
Le	1.63Lu+3D	591.06	
Rb	$sqrt((le*d)/b^2)$	7.233575287	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	21796.24404	
Cfu		1	
CL	look at nds	0.9945628646	
CV	look at nds	0.81	
Fire Resistance Adjustment Factor		1	0.86
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*C	1749.6	psi
Allowable Momer	nt	323892.42	ft-lb
Moment		294,238.25	ft-lb

Adjusted Shear	Parallel to Grain Design Value (F		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	23399.45052	lb
Actual fv	3V/2bd	10427.9176	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	23399.45052	lb
Fc actual		221.2713997	psi
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
Е'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual	Deflection	
Variable	Description	Calculation	Units
Delta L	See next column	0.004207653436	ft
Delta S	See next column	0	ft
Delta D+L	See next column	0.006043545297	ft
	Allowabl	e Deflection	
Variable	Description	Calculation	Units
Delta L	L/360	0.0722222222	ft
Delta S	L/360	0.0722222222	ft
Delta D+L	L/240	0.1083333333	ft

3rd Floor Core Member

Member Lengths and Properties								
Variable		Value	Unit					
1		26	ft					
b		11.5	in					
d		11.5	in					
р	density	35	pcf					
SG	Specific gravity	0.46						
Ag		132.25	in^2					
Sxx		253.5	in^3					
Ixx		1457.5	in^4					
Isupport		6	in					
	Beam Stability Factor							
Variable		Value	Unit					
Fbx+*		2760	psi					
lu		96	in					
le		148	in					
RB		3.585						
FBe		135	psi					
CL								

Loading					
Point Load 1 - left					
5	Section-Specific Loading and I	Dimensions			
Joist Number		3	-2s		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary Width		0	ft		
Joist Tributary Area		4.875	ft		
Roof Live Load (Lr) (ente	er reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	0	
Dead Loads - Total		21.7	psf	0	lbs
	Insulation on CLT (D)	0	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	0	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter redu	ced load if reduced)	109	psf	0	lbs
	Actual Loading	_			
Variable	Description	Calculation	Units		
LC1	D	21.7	psf	0.00	lbs
LC2	D+L	130.7	psf	0.00	lbs
LC3	D+(Lr or S or R)	21.7	psf	0.00	lbs
LC4	D + 0.75L + 0.75(Lr or S or	103.45	psf	0.00	lbs
LC5	D + (0.6W or 0.7E)	21.7	psf	0.00	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0	103.45	psf	0.00	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	103.45	psf	0.00	lbs
LC7	0.6D + 0.6W	13.02	psf	0.00	lbs
LC8	0.6D + 0.7E	13.02	psf	0.00	lbs

ection-Specific Loading and I	Dimensions			
	11.5	in		
	23.5	in		
	8.25	ft		
	16.25	ft		
r reduced load if reduced)	0	psf	0	lbs
	0	psf		
	0	psf	0	lbs
Insulation on CLT (D)	0	psf		
MEP Allowance (D)	0	psf		
Roofing Membrane	0	psf		
Misc. Hung Ceiling	0	psf		
CLT Weight (D)	0	psf		
Joist Weight	0	pcf	0	lbs
	0	mph		
	0	psf		
ed load if reduced)	0	psf	0	lbs
Actual Loading				
Description	Calculation	Units		
D	0	psf	0.00	lbs
D+L	0	psf	0.00	lbs
D+(Lr or S or R)	0	psf	0.00	lbs
D + 0.75L + 0.75(Lr or S or)	0	psf	0.00	lbs
D + (0.6W or 0.7E)	0	psf	0.00	lbs
LC6a $D + 0.75L + 0.75(0.6W) + 0.$		psf	0.00	lbs
D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	0	psf	0.00	lbs
0.6D + 0.6W	0	psf	0.00	lbs
0.6D + 0.7E	0	psf	0.00	lbs
	ection-Specific Loading and I reduced load if reduced) Insulation on CLT (D) MEP Allowance (D) Roofing Membrane Misc. Hung Ceiling CLT Weight (D) Joist Weight ed load if reduced) CLT Weight (D) Joist Weight ed load if reduced) Actual Loading Description D D+L D+(Lr or S or R) D + 0.75L + 0.75(Lr or S or D + (0.6W or 0.7E) D + 0.75L + 0.75(0.6W) + 0 D + 0.75L + 0.75(0.7E) + 0.' 0.6D + 0.7E	ection-Specific Loading and Dimensions ection-Specific Loading and Dimensions 11.5 11.5 11.5 23.5 8.25 16.25 reduced load if reduced) 0 100 11.5 <td>Image: controm system Image: controm system 11.5 in 11.5 in 11.5 in 23.5 in 8.25 ft 16.25 ft 16.25 ft reduced load if reduced) 0 psf 16.25 ft ft reduced load if reduced) 0 psf 16.25 ft ft reduced load if reduced) 0 psf 16.25 ft ft 15.26 ft ft 15.26 ft ft 15</td> <td>Image: constant of the section-Specific Loading and Dimensions Image: constant of the section of the sectin of the section of the section of the section of the</td>	Image: controm system Image: controm system 11.5 in 11.5 in 11.5 in 23.5 in 8.25 ft 16.25 ft 16.25 ft reduced load if reduced) 0 psf 16.25 ft ft reduced load if reduced) 0 psf 16.25 ft ft reduced load if reduced) 0 psf 16.25 ft ft 15.26 ft ft 15.26 ft ft 15	Image: constant of the section-Specific Loading and Dimensions Image: constant of the section of the sectin of the section of the section of the section of the

Point Load 3 - Right									
Section-Specific Loading and Dimensions									
Joist Number		3	-2s						
Joist b		11.5	in						
joist d		15.5	in						
Girder Tributary Width		0	ft						
CLT Tributary Area		4.875	ft						
Roof Live Load (Lr) (enter	r reduced load if reduced)	0	psf	0	lbs				
Ground snow load (S)		0	psf	0					
Dead Loads - Total		21.7	psf	0	lbs				
	Insulation on CLT (D)	0	psf						
	MEP Allowance (D)	5	psf						
	Roofing Membrane	0	psf						
	Misc. Hung Ceiling	1.6	psf						
	CLT Weight (D)	15.1	psf						
	Joist Weight	35	pcf	0	lbs				
Wind (W)		0	mph						
Earthquake (E)	Earthquake (E)								
Live Load (L) (enter reduc	Live Load (L) (enter reduced load if reduced)			0	lbs				
	_								
Variable	Description	Calculation	Units						
LC1	D	21.7	psf	0.00	lbs				
LC2	D+L	130.7	psf	0.00	lbs				
LC3	D+(Lr or S or R)	21.7	psf	0.00	lbs				
LC4	D + 0.75L + 0.75(Lr or S or 1	103.45	psf	0.00	lbs				
LC5	D + (0.6W or 0.7E)	21.7	psf	0.00	lbs				
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	103.45	psf	0.00	lbs				
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	103.45	psf	0.00	lbs				
LC7	0.6D + 0.6W	13.02	psf	0.00	lbs				
LC8	0.6D + 0.7E	13.02	psf	0.00	lbs				
Uniform Load from Glu	ulam Self weight								
S	Dimensions								
Floor			4						
Section:	14	A - 1							
Dead Load - from Glulam	self weight	35	pcf	32.14409722	plf				
Wind (W)		0	mph						
Earthquake (E)		0	psf						

Uniform Load from G	lulam Self weight							
	Section-Specific Loading and I	Dimensions						
Floor			4					
Section:		1.	A - 1					
Dead Load - from Glular	n self weight	35	pcf	32.14409722	plf			
Wind (W)		0	mph					
Earthquake (E)		0	psf					
	Actual Loading	1	1					
Variable	Description	Calculation	Units	Total DL (lbs)	Total LL (lbs)	Total Roof SL (lbs)		
LC1	D	835.75	lbs	835.7465278	C	0		
LC2	D+L	835.75	lbs	835.7465278	C	0		
LC3	D+(Lr or S or R)	835.75	lbs	835.7465278	C	0		
LC4	D+0.75L+0.75(Lr or S or	835.75	lbs	835.7465278	e	0		
LC5	D+(0.6W or 0.7E)	835.75	lbs	835.7465278	C	0		
LC6a	D + 0.75L + 0.75(0.6W) + 0	. 835.75	lbs	835.7465278	e	0		
LC6b	D + 0.75L + 0.75(0.7E) + 0.	835.75	lbs	835.7465278	e	0		
LC7	0.6D + 0.6W	501.45	lbs	0	C	0		
LC8	0.6D + 0.7E	501.45	lbs	0	C	0		
Column reaction	Formula	Value	Unit					
Total		835.75	lb					
Left Column	Formula	Value	Unit		Right column	Formula	Value	Unit
Total	Pt load 1 + (12.5*self weig	417.87	lb		Total	Pt load 3 + (12.5*	417.87	lb
Dead		417.8732639	lb		Dead		417.8732639	lb
live		0	lb		live		0	lb
Snow		0	lb		Snow		0	lb

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	312	
Le	1.63Lu+3D	543.06	
Rb	$sqrt((le*d)/b^2)$	6.871870829	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	24151.14352	
Cfu		1	
CL	look at nds	0.9951388836	
CV	look at nds	0.81	
Fire Resistance A	djustment Factor	0.67	0.86
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*C	1172.232	psi
Allowable Moment		24,761.37	ft-lb
Moment		2,716.18	ft-lb

Adjusted Shear	Parallel to Grain Design Value (F		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	417.8732639	lb
Actual fv	3V/2bd	682.5	psf
Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp	-	600	psi
Reaction forces	1/2 * wl	417.8732639	lb
Fc actual		6.056134259	psi
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
Е'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual	Deflection	
Variable	Description	Calculation	Units
Delta L	See next column	0	ft
Delta S	See next column	0	ft
Delta D+L	See next column	0.01049816215	ft
	Allowabl	le Deflection	
Variable	Description	Calculation	Units
Delta L	L/360	0.0722222222	ft
Delta S	L/360	0.0722222222	ft
Delta D+L	L/240	0.1083333333	ft

2rd Floor Atrium Member

		Memb	er Lengths and Pro	operties	
	Variable			Value	Unit
	1			26	ft
	b			11.5	in
	d			21.5	in
	р		density	35	pcf
	SG	Spec	cific gravity	0.46	
	Ag			247.25	in^2
	Sxx			886.0	in^3
	Ixx			9524.3	in^4
	Isupport			6	in
		E	Beam Stability Fact	or	
	Variable			Value	Unit
	Fbx+*			2760	psi
	lu			96	in
	le			148	in
	RB			4.902	
	FBe			72	psi
	CL				
_oading					
Point Load 1 - left					
	Section-Spec	cific Loading and I	Dimensions		
loist Number			2	-1s	
		Actual Loading			
Variable	Descriptio	on	Calculation	Units	
.C3	D+(Lr or	S or R)	31.7	psf	
oint Load 2 - Middle	•				
	Contion Cross	ific Looding and I	Dimonsions		

	Actual Loading				
Variable	Description	Calculation	Units		
LC3	D+(Lr or S or R)	31.7	psf	1930.00	lbs
Point Load 2 - Middle					
Se	ection-Specific Loading and I	Dimensions			
Joist Number		2.	-11s		
Joist b		11.5	in		
joist d		17.5	in		
Girder Tributary Width		8.25	ft		
	Actual Loading				
Variable	Description	Calculation	Units		
LC3	D+(Lr or S or R)		psf	6140.48	lbs

Point Load 3 and 4 - M	iddle				
Se	ection-Specific Loading and D	Dimensions			
Joist Number		2	2-2		
Joist b		11.5	in		
joist d		17.5	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area		15.625	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	403.5481771	
Dead Loads - Total		30.7	psf	4360.970052	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	403.5481771	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	100	psf	12890.625	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	30.7	psf	4360.97	lbs
LC2	D+L	130.7	psf	17251.60	lbs
LC3	D+(Lr or S or R)	30.7	psf	4764.52	lbs
LC4	D + 0.75L + 0.75(Lr or S or	105.7	psf	14331.60	lbs
LC5	D + (0.6W or 0.7E)	30.7	psf	4360.97	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	105.7	psf	14331.60	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	105.7	psf	14331.60	lbs
LC7	0.6D + 0.6W	18.42	psf	2616.58	lbs
LC8	0.6D + 0.7E	18.42	psf	2616.58	lbs

Point Load 4 - end					
Se					
Joist Number		2	2-3		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area		9.375	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	357.4283854	
Dead Loads - Total	-	30.7	psf	2731.88151	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	15.1	psf		
	Joist Weight	35	pcf	357.4283854	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	100	psf	7734.375	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	30.7	psf	2731.88	lbs
LC2	D+L	130.7	psf	10466.26	lbs
LC3	D+(Lr or S or R)	30.7	psf	3089.31	lbs
LC4	D + 0.75L + 0.75(Lr or S or 1	105.7	psf	8800.73	lbs
LC5	D + (0.6W or 0.7E)	30.7	psf	2731.88	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	105.7	psf	8800.73	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	105.7	psf	8800.73	lbs
LC7	0.6D + 0.6W	18.42	psf	1639.13	lbs
LC8	0.6D + 0.7E	18.42	psf	1639.13	lbs
			1/2 weight	5233.128255	lbs

Uniform Load from Glulam Self weight							
Section-Specific Loading and	Dimensions						
Floor		4					
Section:	1.	A - 1					
Dead Load - from Glulam self weight	35	pcf	60.09548611	plf			
Wind (W)	0	mph					
Earthquake (E)	0	psf					
Left Column Formula	Value	Unit		Right column	Formula	Value	Unit
Total Manual enter	18800	lb		Total	Manual Enter	14200	lb

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	312	
Le	1.63Lu+3D	573.06	
Rb	sqrt((le*d)/b^2)	9.652091657	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	12241.78644	
Cfu		1	
CL	look at nds	0.9895341357	
CV	look at nds	0.81	
Fire Resistance A	Adjustment Factor	0.93	0.86
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*C	1627.128	psi
Allowable Mome	nt	120133.46	ft-lb
Moment		106,000.00	ft-lb
Adjusted Shear	Parallel to Grain Design Value (F		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	10200	lb
Actual fv	3V/2bd	8910.819009	psf

Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	10200	lb
Fc actual		147.826087	psi
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual	Deflection	
Variable	Description	Calculation	Units
Delta L	See next column		ft
Delta S	See next column		ft
Delta D+L	See next column	0.04541666667	ft
	Allowab	le Deflection	
Variable	Description	Calculation	Units
Delta L	L/360	0.07222222222	ft
Delta S	L/360	0.07222222222	ft
Delta D+L	L/240	0.1083333333	ft

1st Floor Atrium Walkway Member

Member Lengths and Properties					
Variable		Value	Unit		
1		32	ft		
b		9.5	in		
d		11.5	in		
р	density	35	pcf		
SG	Specific gravity	0.46			
Ag		109.25	in^2		
Sxx		209.4	in^3		
Ixx		1204.0	in^4		
Isupport		6	in		
	Beam Stability Factor				
Variable		Value	Unit		
Fbx+*		2760	psi		
lu		96	in		
le		148	in		
RB		4.340			
FBe		92	psi		
CL					

Loading					
Point Load 1 - left					
Se	ection-Specific Loading and I	Dimensions			
Joist Number		1	-1s		
	Actual Loading				
Variable	Description	Calculation	Units		
LC3	D+(Lr or S or R)	31.7	psf	1230.00	lbs
Point Load 2 - Middle					
Se	ection-Specific Loading and I	Dimensions			
Joist Number		1	-13s		
Joist b		9.5	in		
joist d		11.5	in		
Girder Tributary Width		8.25	ft		

Point Load 3 - end					
Se	ection-Specific Loading and I	Dimensions			
Joist Number		1-	-14s		
Joist b		9.5	in		
joist d		11.5	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area		0.7916666667	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	0	psf	0	lbs
Ground snow load (S)		0	psf	219.0690104	
Dead Loads - Total		6.6	psf	262.1752604	lbs
	Insulation on CLT (D)	0	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	0	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	0	psf		
	Joist Weight	35	pcf	219.0690104	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	0	psf	0	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	6.6	psf	262.18	lbs
LC2	D+L	6.6	psf	262.18	lbs
LC3	D+(Lr or S or R)	6.6	psf	481.24	lbs
LC4	D + 0.75L + 0.75(Lr or S or T)	6.6	psf	426.48	lbs
LC5	D + (0.6W or 0.7E)	6.6	psf	262.18	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	6.6	psf	426.48	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	6.6	psf	426.48	lbs
LC7	0.6D + 0.6W	3.96	psf	157.31	lbs
LC8	0.6D + 0.7E	3.96	psf	157.31	lbs

Uniform Load from Glulam Self weight								
Se	ection-Specific Loading and I	Dimensions						
Floor			4					
Section:		12	A - 1					
Dead Load - from Glulam self weight		35	pcf	26.55381944	plf			
Wind (W)		0	mph					
Earthquake (E)		0	psf					
Left Column	Formula	Value	Unit		Right column	Formula	Value	Unit
Total	Manual enter	4160	lb]	Total	Pt load 3 + (12.5*	760	lb

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	384	
Le	1.63Lu+3D	660.42	
Rb	$sqrt((le*d)/b^2)$	9.173507562	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	13552.41921	
Cfu		1	
CL	look at nds	0.990711658	
CV	look at nds	0.81	
Fire Resistance A	Adjustment Factor	0.5	0.86
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*C	874.8	psi
Allowable Mome	nt	15264.96	ft-lb
Moment		9,670.00	ft-lb
Adjusted Shear	Parallel to Grain Design Value (F		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	1530	lb
Actual fv	3V/2bd	3024.988558	psf

Fc perp				
Cb	Bearing Area Factor	1		
CMV	Wet Service Factor	1	NDS Supplement Table 4A	
Ct	Temperature Factor	1	NDS Table 2.3.2	
Fc perp		600	psi	
Reaction forces	1/2 * wl	1530	lb	
Fc actual		26.84210526	psi	
Adjusted Modulu	us of Elasticity (E')			
CME	Wet Service Factor	1	NDS Supplement Table 4A	
CtE	Temperature Factor	1	NDS Table 2.3.3	
CiE	Incising Factor	1	NDS Table 4.3.8	
E'	E*CME*CtE*CiE	1800000		
Manual pg 72				
	Actual	Deflection		
Variable	Description	Calculation	Units	
Delta L	See next column		ft	
Delta S	See next column		ft	
Delta D+L	See next column	0.002341666667	ft	
-				
	Allowab	le Deflection		
Variable	Description	Calculation	Units	
Delta L	L/360	0.08888888889	ft	
Delta S	L/360	0.08888888889	ft	
Delta D+L	L/240	0.1333333333	ft	

Typical Glulam Column

4th Floor

Variable	Name	Value	Unit
X-X Bendi	ng		
Fbx+	Bottom of Beam in Tension	2400	psi
Fbx-	Top of Beam in Tension	1450	psi
Fcx	Compression Perpendicular to grain	600	psi
Fvx	Shear parallel to grain	300	psi
Ex	Modulus of elasticity	1900000	psi
Ex app	Modulus of elasticity (applied)	1800000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi
Y-Y Bendi	ıg		
Fby+	Bottom of Beam in Tension	2400	psi
Fby-	Top of Beam in Tension	1450	psi
Fcy	Compression Perpendicular to grain	600	psi
Fvy	Shear parallel to grain	300	psi
Ey	Modulus of elasticity	1900000	psi
Ey app	Modulus of elasticity (applied)	1800000	psi
Axial Load	ing		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
b		11.5	in
d		11.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		132.25	in^2
Sxx		253.5	in^3
Ixx		33522.6	in^4

Point Load 1 - left Section-Specific Loading and Dimensions Load from girder to the left 0.00 lbs LC 3 Governs Self-weight of column 385.73 lbs LC 3 Governs Self-weight of column 385.73 lbs LC 3 Governs Cp Calculations! Fc* adjusted compression parallel to grain Table 2.3 Cd Load Duration Factor 1.15 Cm Wet Service Factor 1 Ct Temperature Factor 1 Ct Size Factor 1 Ct Section*Ct*CF*Ci 2116 psi Ce* (Fc)*Cd*Cm*Ct*CF*Ci 2116 psi Emin Minimum Modulus of elasticity 1 1 Ci<-Emin
Section-Specific Loading and Dimensions Load from girder to the left 0.00 lbs Load from girder to the right 17,826.74 lbs LC 3 Governs Self-weight of column 385.73 lbs LC 3 Governs Self-weight of column 385.73 lbs LC 3 Governs Cp Calculations!
Load from girder to the left0.00lbsLoad from girder to the right17,826.74lbsLC 3 GovernsSelf-weight of column385.73lbsLC 3 GovernsCp Calculations!Fc*adjusted compression parallel to grainTable 2.3CdLoad Duration Factor1.15CmWet Service Factor1CtTemperature Factor1CFSize Factor1Ci - FcIncising Factor0.8Fc*(Fc)*Cd*Cm*Ct*CF*Ci2116psipsiCTBuckling Stiffness Factor1Ci - EminIncising Factor0.95E'minMinimum Modulus of elasticity0.95E'minEmin*Cm*Ci*Ct*CT953040leEffective Length1KeEffective length factor1leLength*Ke12ftle/dMust be less than 5012.52173913in/in112.52173913in/in
Load from girder to the right 17,826.74 lbs LC 3 Governs Self-weight of column 385.73 lbs LC 3 Governs Self-weight of column 385.73 lbs LC 3 Governs Cp Calculations! Fc* adjusted compression parallel to grain Table 2.3 Cd Load Duration Factor 1.15 Cm Wet Service Factor 1 Ct Temperature Factor 1 CF Size Factor 1 CF Buckling Factor 0.8 Fc* (Fc)*Cd*Cm*Ct*CF*Ci 2116 psi
Self-weight of column 385.73 lbs LC 3 Governs Cp Calculations! Image: column state of the state of th
Cp Calculations! Image: constraint of the second secon
Cp Calculations! Image: constraint of the second secon
Fc*adjusted compression parallel to grainTable 2.3CdLoad Duration Factor1.15CmWet Service Factor1CtTemperature Factor1CFSize Factor1Ci - FcIncising Factor0.8Fc*(Fc)*Cd*Cm*Ct*CF*Ci2116PriminMinimum Modulus of elasticityCTBuckling Stiffness Factor1Ci - EminIncising Factor0.95E'minEinen*Cm*Ci*Ct*CT953040ISize Factor1LeEffective Length12IcIncising Factor1IcIncising Factor1IIncising Factor1IInci
Table 2.3CdLoad Duration Factor1.15CmWet Service Factor1CtTemperature Factor1CFSize Factor1Ci - FcIncising Factor0.8Fc*(Fc)*Cd*Cm*Ct*CF*Ci2116 psiE'minMinimum Modulus of elasticityCTBuckling Stiffness Factor1Ci - EminIncising Factor0.95E'minEmin*Cm*Ci*Ct*CT953040IEffective Length1KeEffective length factor1leLength*Ke12ftle/dMust be less than 5012.52173913in/in
CmWet Service Factor1CtTemperature Factor1CFSize Factor1Ci - FcIncising Factor0.8Fc*(Fc)*Cd*Cm*Ct*CF*Ci2116 psiE'minMinimum Modulus of elasticityCTBuckling Stiffness Factor1Ci - EminIncising Factor0.95E'minEmin*Cm*Ci*Ct*CT953040IIncising Factor1LeEffective Length1KeEffective length factor1IeLength*Ke12ftIe/dMust be less than 5012.52173913 in/in
CtTemperature Factor1CFSize Factor1Ci - FcIncising Factor 0.8 Fc*(Fc)*Cd*Cm*Ct*CF*Ci 2116 psiE'minMinimum Modulus of elasticityCTBuckling Stiffness Factor1Ci - EminIncising Factor 0.95 E'minEmin*Cm*Ci*Ct*CT 953040 IIncising Factor1LeEffective Length1KeEffective length factor1IeLength*Ke12ftIe/dMust be less than 5012.52173913in/in
CFSize Factor1Ci - FcIncising Factor 0.8 Fc*(Fc)*Cd*Cm*Ct*CF*Ci 2116 psiE'minMinimum Modulus of elasticityCTBuckling Stiffness Factor1Ci - EminIncising Factor 0.95 E'minEmin*Cm*Ci*Ct*CT 953040 IIncising Factor1LeEffective LengthKeEffective length factor1leLength*Ke12ftI2.52173913in/inIn/in
Ci - Fc Incising Factor 0.8 Fc* (Fc)*Cd*Cm*Ct*CF*Ci 2116 psi E'min Minimum Modulus of elasticity 1 CT Buckling Stiffness Factor 1 Ci - Emin Incising Factor 0.95 E'min Emin*Cm*Ci*Ct*CT 953040 Image: Stiffness Factor 1 1 Ci - Emin Incising Factor 0.95 E'min Emin*Cm*Ci*Ct*CT 953040 Image: Stiffness Factor 1 1 Image: Stiffness Factor 1
Fc* (Fc)*Cd*Cm*Ct*CF*Ci 2116 psi E'min Minimum Modulus of elasticity CT Buckling Stiffness Factor 1 <t< td=""></t<>
E'min Minimum Modulus of elasticity CT Buckling Stiffness Factor 1 Ci - Emin Incising Factor 0.95 E'min Emin*Cm*Ci*Ct*CT 953040 Ie Effective Length 1 Ke Effective length factor 1 Ie Length*Ke 12 ft Ie/d Must be less than 50 12.52173913 in/in
E'min Minimum Modulus of elasticity CT Buckling Stiffness Factor 1 Ci - Emin Incising Factor 0.95 E'min Emin*Cm*Ci*Ct*CT 953040 le Effective Length Ke Effective length factor 1 le Length*Ke 12 ft le/d Must be less than 50 12.52173913 in/in
CT Buckling Stiffness Factor 1 Ci - Emin Incising Factor 0.95 E'min Emin*Cm*Ci*Ct*CT 953040 le Effective Length Ke Effective length factor le Length*Ke le/d Must be less than 50
Ci - Emin Incising Factor 0.95 E'min Emin*Cm*Ci*Ct*CT 953040 le Effective Length Ke Effective length factor 1 le Length*Ke 12 ft le/d Must be less than 50 12.52173913 in/in
E'min Emin*Cm*Ci*Ct*CT 953040 le Effective Length 1 Ke Effective length factor 1 le Length*Ke 12 ft le/d Must be less than 50 12.52173913 in/in
le Effective Length Ke Effective length factor le Length*Ke le/d Must be less than 50
le Effective Length Ke Effective length factor 1 le Length*Ke 12 ft le/d Must be less than 50 12.52173913 in/in
Ke Effective length factor 1 le Length*Ke 12 ft le/d Must be less than 50 12.52173913 in/in
le Length*Ke 12 ft le/d Must be less than 50 12.52173913 in/in
le/d Must be less than 50 12.52173913 in/in
FcE critical buckling design value
FcE ((0.822)*E'min)/((le/d)^2) 4996.35908 psi
Cp Column Stability Factor
c_glulam a constant for glulam 0.9
FcE/Fc* 2.361228299
0.9381529001
$\begin{pmatrix} F_{cF} \end{pmatrix} \begin{bmatrix} F_{cF} \end{bmatrix}^2 \begin{pmatrix} F_{cF} \end{bmatrix}$
$\left \begin{array}{c} 1 + \overline{F_{-*}} \\ \overline{F_{-*}} \end{array} \right \left \begin{array}{c} 1 + \overline{F_{-*}} \\ \overline{F_{-*}} \\ \overline{F_{-*}} \end{array} \right \left \begin{array}{c} \overline{F_{-*}} \\ $
$C_{\mathbf{p}} \coloneqq \frac{\left(1 + \overline{F_{\mathbf{c}^*}}\right)}{2\alpha} - \left\ \frac{\left(1 + \overline{F_{\mathbf{c}^*}}\right)}{2\alpha} - \frac{\left(\overline{F_{\mathbf{c}^*}}\right)}{\alpha} \right\ $
$C_{\mathbf{p}} := \frac{\left(\frac{1+\overline{F_{\mathbf{c}^*}}\right)}{2c_{sawn}} - \sqrt{\left(\frac{1+\overline{F_{\mathbf{c}^*}}\right)}{2c_{sawn}}\right) - \frac{\left(\overline{F_{\mathbf{c}^*}}\right)}{c_{sawn}}$
$C_{p} := \frac{\left(\frac{1+\overline{F_{c^{*}}}\right)}{2c_{sawn}} - \sqrt{\left\lfloor\frac{1+\overline{F_{c^{*}}}\right)}{2c_{sawn}}\right\rfloor} - \frac{\left(\overline{F_{c^{*}}}\right)}{c_{sawn}}$
$C_{p} = \frac{\left[1 + \overline{F_{c^{*}}}\right]}{2c_{sawn}} - \sqrt{\left[\frac{\left[1 + \overline{F_{c^{*}}}\right]}{2c_{sawn}}\right]} - \frac{\left(\overline{F_{c^{*}}}\right)}{c_{sawn}}$ $F'c Axial Buckling Capacity$
$Cp = \frac{\left(\frac{1+\overline{F_{c^*}}\right)}{2c_{sawn}} - \sqrt{\left(\frac{1+\overline{F_{c^*}}\right)}{2c_{sawn}}\right) - \frac{\left(\overline{F_{c^*}}\right)}{c_{sawn}}}$ $F'c = Axial Buckling Capacity$ $F'c = Fc^*Cd^*Cm^*Ct^*Cf^*Ci^*Cp = 1,985.13 \text{ psi}$
Cp $C_{p} := \frac{\begin{pmatrix} 1 + \overline{F_{c^*}} \\ 2c_{sawn} \end{pmatrix}}{2c_{sawn}} - \sqrt{\begin{bmatrix} \frac{1 + \overline{F_{c^*}}}{2c_{sawn}} \end{bmatrix}} - \frac{\overline{F_{c^*}}}{c_{sawn}}$ F'cAxial Buckling CapacityF'cFc*Cd*Cm*Ct*Cf*Ci*CpI,985.13psiOverall Tributary Area132.25
Cp $C_{\mathbf{p}} := \frac{\begin{pmatrix} 1 + \overline{F_{c^*}} \\ 2c_{sawn} \end{pmatrix}}{2c_{sawn}} - \sqrt{\begin{bmatrix} \frac{1 + \overline{F_{c^*}}}{2c_{sawn}} \end{bmatrix}} - \frac{\overline{F_{c^*}}}{c_{sawn}}$ F'cAxial Buckling CapacityF'cFc*Cd*Cm*Ct*Cf*Ci*CpImage: Display trace in the same interval of the same
Cp $C_{\mathbf{p}} := \frac{\begin{pmatrix} 1 + \overline{F_{c^*}} \end{pmatrix}}{2c_{sawn}} - \sqrt{\begin{bmatrix} 1 + \overline{F_{c^*}} \end{pmatrix}}{2c_{sawn}} - \frac{\overline{F_{c^*}}}{c_{sawn}}$ F'cAxial Buckling CapacityF'cFc*Cd*Cm*Ct*Cf*Ci*Cp1,985.13psiOverall Tributary Area132.25Allowable Load262,533.65Allowable Load for 2h fire (90 min + gyp)52,000.00
Cp $C_{p} := \frac{\begin{pmatrix} 1 + \overline{F_{c^*}} \\ 2c_{sawn} \end{pmatrix}}{2c_{sawn}} - \sqrt{\begin{bmatrix} \frac{1 + \overline{F_{c^*}}}{2c_{sawn}} \end{bmatrix}} - \frac{\overline{F_{c^*}}}{c_{sawn}}$ F'cAxial Buckling CapacityF'cFc*Cd*Cm*Ct*Cf*Ci*Cp1,985.13psiOverall Tributary Area132.25Allowable Load262,533.65Allowable Load for 2h fire (90 min + gyp)52,000.00Total Actual Load17,826.74

3rd Floor

Variable	Name	Value	Unit
X-X Bendi	ng		
Fbx+	Bottom of Beam in Tension	2400	psi
Fbx-	Top of Beam in Tension	1450	psi
Fcx	Compression Perpendicular to grain	600	psi
Fvx	Shear parallel to grain	300	psi
Ex	Modulus of elasticity	1900000	psi
Ex app	Modulus of elasticity (applied)	1800000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi
Y-Y Bendin	ıg		
Fby+	Bottom of Beam in Tension	2400	psi
Fby-	Top of Beam in Tension	1450	psi
Fcy	Compression Perpendicular to grain	600	psi
Fvy	Shear parallel to grain	300	psi
Ey	Modulus of elasticity	1900000	psi
Ey app	Modulus of elasticity (applied)	1800000	psi
Axial Load	ing		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
b		11.5	in
d		11.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		132.25	in^2
Sxx		253.5	in^3
Ixx		33522.6	in^4
Isupport		6	in

Loading				
Point Lo	ad 1 - left			
	Section	-Specific Loading and Dimer	nsions	
Load from	n girder to the left	0	lbs	
Load from	n girder to the right	27,883.40	lbs	
Load from	n column above	18,212.47	lbs	
Self-weig	ht of column	385.73	lbs	
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*Ci	i	2116	psi
E'min	Minimum Modulus of el	asticity		
	CT	Buckling Stiffness Factor	1	
	Ci - Emin	Incising Factor	0.95	
E'min	Emin*Cm*Ci*Ct*CT		953040	
le	Effective Length			
	Ke	Effective length factor	1	
le	Length*Ke		12	ft
le/d	Must be less than 50		12.52173913	in/in
FcE	critical buckling design	value		
FcE	((0.822)*E'min)/((le/d)^2	2)	4996.35908	psi
Ср	Column Stability Factor	1		
	c_glulam	a constant for glulam	0.9	
	FcE/Fc*		2.361228299	
	Г		0.9381529001	
Cn	$C_{\mathbf{p}} \coloneqq \frac{\left(1 + \frac{F_{\mathbf{c}E}}{F_{\mathbf{c}*}}\right)}{2c_{sawn}} - \sqrt{\left(1 + \frac{F_{\mathbf{c}E}}{F_{\mathbf{c}*}}\right)}$	$\left[\frac{\left(1+\frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$		
CP TI				
F'C	Axial Buckling Capacity	/	1.005.10	la si
F'C	FerCarCm*Ct*Cf*Cf*Cf	_p	1,985.13	psi in 2
Overall 1	noutary Area		132.25	102
Allowabl	e Load		262,533.65	IDS
Allowabl	e Load for 2h fire (90 mi	n + gyp)	52,000.00	Ibs
Total Act	ual Load		46,095.87	Ibs
Total Act	ual Load including colun	m	46,481.60	lbs

2nd Floor

Variable	Name	Value	Unit
X-X Bendi	ng		
Fbx+	Bottom of Beam in Tension	2400	psi
Fbx-	Top of Beam in Tension	1450	psi
Fcx	Compression Perpendicular to grain	600	psi
Fvx	Shear parallel to grain	300	psi
Ex	Modulus of elasticity	1900000	psi
Ex app	Modulus of elasticity (applied)	1800000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi
Y-Y Bendir	ıg		
Fby+	Bottom of Beam in Tension	2400	psi
Fby-	Top of Beam in Tension	1450	psi
Fcy	Compression Perpendicular to grain	600	psi
Fvy	Shear parallel to grain	300	psi
Ey	Modulus of elasticity	1900000	psi
Ey app	Modulus of elasticity (applied)	1800000	psi
Axial Load	ing		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
b		13.625	in
d		13.625	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		185.640625	in^2
~		421.6	in^3
Sxx		121.0	
Sxx Ixx		78258.5	in^4

Loading				
Point Lo	ad 1 - left			
	Section-	Specific Loading and Dimer	nsions	
Load fror	n girder to the left	0	lbs	
Load fror	n girder to the right	27,883.40	lbs	
Load fror	n column above	46,481.60	lbs	
Self-weig	tht of column	541.45	lbs	
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*Ci		2116	psi
E'min	Minimum Modulus of el	asticity		
	CT	Buckling Stiffness Factor	1	
	Ci - Emin	Incising Factor	0.95	
E'min	Emin*Cm*Ci*Ct*CT		953040	
le	Effective Length			
	Ke	Effective length factor	1	
le	Length*Ke		12	ft
le/d	Must be less than 50		10.56880734	in/in
FcE	critical buckling design	value		
FcE	((0.822)*E'min)/((le/d)^2	2)	7013.438354	psi
Ср	Column Stability Factor			
	c_glulam	a constant for glulam	0.9	
	FcE/Fc*		3.314479373	
			0.9607808776	
	$C_{\mathbf{P}} \coloneqq \frac{\left(1 + \frac{F_{\mathbf{c}E}}{F_{\mathbf{c}}*}\right)}{2c_{\mathrm{sawn}}} - \sqrt{\left(1 + \frac{F_{\mathbf{c}E}}{F_{\mathbf{c}}*}\right)}$	$\left[\frac{\left(1+\frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$		
Ср				
F'c	Axial Buckling Capacity			
F'c	Fc*Cd*Cm*Ct*Cf*Ci*C	р р	2,033.01	psi
Overall T	ributary Area		185.64	in2
Allowable	Load		377,409.68	lbs
Allowable	e Load for 2h fire (90 min	n + gyp)	188,750.00	lbs
Total Actu	ial Load		74,365.00	lbs
Total Actu	ial Load		74,906.45	lbs

1st Floor

Variable	Name	Value	Unit	
X-X Bendir	Ig			
Fbx+	Bottom of Beam in Tension	2400	psi	
			1	
Fbx-	Top of Beam in Tension	1450	psi	
Fcx	Compression Perpendicular to grain	600	psi	
Fvx	Shear parallel to grain	300	psi	
Ex	Modulus of elasticity	1900000	psi	
Ex app	Modulus of elasticity (applied)	1800000	psi	
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi	
Y-Y Bendin	g			
Fby+	Bottom of Beam in Tension	2400	psi	
Fby-	Top of Beam in Tension	1450	psi	
Fcy	Compression Perpendicular to grain	600	psi	
Fvy	Shear parallel to grain	300	psi	
Ey	Modulus of elasticity	1900000	psi	
Ey app	Modulus of elasticity (applied)	1800000	psi	
Axial Loadi	ing			
Fc	Compression parallel to grain	2300	psi	
Ft	Tension parallel to grain	1600	psi	
Ea	modulus of elasticity	1900000	psi	
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi	
	Member Lengths and Properties			
Variable		Value	Unit	
1		12	ft	
b		13.625	in	
d		13.625	in	
р	density	35	pcf	
SG	Specific gravity	0.46		
Ag		185.640625	in^2	
Sxx		421.6	in^3	
Ixx		78258.5	in^4	
Isupport		6	in	
Loading				
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Point Lo	ad 1 - left			
	Section-	Specific Loading and Dime	nsions	
Load fror	n girder to the left	0	lbs	
Load fror	n girder to the right	27,883.40	lbs	
Load from	n column above	74,906.45	lbs	
Self-weig	ht of column	541.45	lbs	
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*Ci		2116	psi
E'min	Minimum Modulus of el	asticity		
	CT	Buckling Stiffness Factor	1	
	Ci - Emin	Incising Factor	0.95	
E'min	Emin*Cm*Ci*Ct*CT		953040	
le	Effective Length			
	Ke	Effective length factor	1	
le	Length*Ke		12	ft
le/d	Must be less than 50		10.56880734	in/in
FcE	critical buckling design	value		
FcE	((0.822)*E'min)/((le/d)^2	2)	7013.438354	psi
Ср	Column Stability Factor			
	c glulam	a constant for glulam	0.9	
	FcE/Fc*		3.314479373	
	_		0.9607808776	
	$\left(1 + \frac{F_{cE}}{F_{cE}}\right)$	$\left[\left(1 + \frac{F_{cE}}{F_{cE}}\right)\right]^2 \left(\frac{F_{cE}}{F_{cE}}\right)$		
	$C_{\mathbf{p}} := \frac{\left(F_{\mathbf{c}^*} \right)}{2} - \left(F_{\mathbf{c}^*} \right)$	$\left(\begin{array}{c} F_{c^*} \end{array}\right) - \left(\begin{array}{c} F_{c^*} \end{array}\right)$		
Cn	² c _{sawn}	² c _{sawn} ^c _{sawn}		
Ср				
F'c	Axial Buckling Capacity	7		
F'c	Fc*Cd*Cm*Ct*Cf*Ci*C	Cp	2,033.01	psi
Overall T	ributary Area		185.64	in2
Allowabl	e Load		377,409.68	lbs
Allowabl	e Load for 2h fire (90 min	n + gyp)	188,750.00	lbs
Total Act	ual Load		102,789.85	lbs
Total Act	ual Load		103,331.30	lbs

Special Glulam Column

4th Floor Core

Variable	Name	Value	Unit
Axial Load	ling		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
1 b		12 11.5	ft in
l b d		12 11.5 11.5	ft in in
l b d p	density	12 11.5 11.5 35	ft in in pcf
l b d p SG	density Specific gravity	12 11.5 11.5 35 0.46	ft in in pef
l b d p SG Ag	density Specific gravity	12 11.5 11.5 35 0.46 132.25	ft in in pcf in^2
l b d p SG Ag Sxx	density Specific gravity	12 11.5 11.5 35 0.46 132.25 253.5	ft in in pcf in^2 in^3
l b d p SG Ag Sxx Ixx	density Specific gravity	12 11.5 11.5 35 0.46 132.25 253.5 33522.6	ft in in pcf in^2 in^3 in^4

Loading				
Point Lo	ad 1 - left			
	Sect	ion-Specific Loading and Di	mensions	
Load fror	n girder to the left	19025.68	1bs	4-4
Load fror	n girder to the right	22,068.72	1bs	4-5s
Self-weig	tht of column	385.73	1bs	
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*C		2116	psi
Therein	Maximum Madadam af at			
E mm	CT	Pupiling Stiffness Factor	1	
	Ci Emin	Incising Factor	0.05	
Elmin	CI - EIIIII	Incising Factor	0.95	
Emm	Emm Chr Cr Cr Cr		903040	
le	Effective Length			
	Ke	Effective length factor	1	
1e	Length*Ke		12	ft
le/d	Must be less than 50		12.52173913	in/in
FcE	critical buckling design	value		
FcE	((0.822)*E'min)/((le/d)^	2)	4996.35908	psi
Ср	Column Stability Factor			
	c_glulam	a constant for glulam	0.9	
	FcE/Fc*		2.361228299	
	$C_{\mathbf{p}} := \frac{\left(1 + \frac{F_{\mathbf{c}E}}{F_{\mathbf{c}*}}\right)}{2c_{\mathrm{sawn}}} - \int_{\mathbf{c}}$	$\left[\frac{\left(1+\frac{F_{eE}}{F_{e^*}}\right)}{2c_{sawn}}\right]^2 - \frac{\left(\frac{F_{eE}}{F_{e^*}}\right)}{c_{sawn}}$	0.9381529001	
Ср	4L			
F'c	Axial Buckling Canacity	7		
F'c	Fc*Cd*Cm*Ct*Cf*Ci*(Cp	1.985.13	psi
Overall T	ributary Area	·	132.25	in2
Allowabl	e Load		262 533 65	lbs
Allowabl	e Load for 3h fire (2 hr +	2. gvp)	52,000,00	lbs
Total Act	ual Load on column	- 0/8/	41.094.40	lbs
Total Act	ual Load including active	10	41 480 13	lbs
Total Act	dan Load metuding colum		41,400.15	105

3rd Floor Core

Variable	Name	Value	Unit
X-X Bendin	ng		
Fbx+	Bottom of Beam in Tension	2400	psi
Fbx-	Top of Beam in Tension	1450	psi
Fcx	Compression Perpendicular to grain	600	psi
Fvx	Shear parallel to grain	300	psi
Ex	Modulus of elasticity	1900000	psi
Ex app	Modulus of elasticity (applied)	1800000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi
Y-Y Bendir	Ig		
Fby+	Bottom of Beam in Tension	2400	psi
Fby-	Top of Beam in Tension	1450	psi
Fcy	Compression Perpendicular to grain	600	psi
Fvy	Shear parallel to grain	300	psi
Ey	Modulus of elasticity	1900000	psi
Ey app	Modulus of elasticity (applied)	1800000	psi
Axial Load	ing		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
b		13.625	in
d		13.625	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		185.640625	in^2
Sxx		421.6	in^3
Ixx		78258.5	in^4
Isupport		6	in

Loading				
Point Lo	ad 1 - left			
	Section	-Specific Loading and Dime	nsions	
Load fro	m girder to the left	27883.4	lbs	3-4
Load from	m girder to the right	14,331.98	lbs	3-5s
Load from	m column above	41,480.13	lbs	
Self-weig	ght of column	541.45	lbs	
Cp Calc	ulations!			
Fc*	adjusted compression pa	arallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*C	i	2116	psi
E'min	Minimum Modulus of e	lasticity		
	CT	Buckling Stiffness Factor	1	
	Ci - Emin	Incising Factor	0.95	
E'min	Emin*Cm*Ci*Ct*CT		953040	
-				
le	Effective Length			
	Ke	Effective length factor	1	
		0	-	
le	Length*Ke		12	ft
le le/d	Length*Ke Must be less than 50	č	12 10.56880734	ft in/in
le le/d	Length*Ke Must be less than 50		12 10.56880734	ft in/in
le le/d FcE	Length*Ke Must be less than 50 critical buckling design	value	12 10.56880734	ft in/in
le le/d FcE FcE	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^	value 2)	12 10.56880734 7013.438354	ft in/in psi
le le/d FcE FcE	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^	value 2)	12 10.56880734 7013.438354	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor	value 2)	12 10.56880734 7013.438354	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam	value 2) a constant for glulam	12 10.56880734 7013.438354 0.9	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc*	value 2) a constant for glulam	12 10.56880734 7013.438354 0.9 3.314479373	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc*	value 2) a constant for glulam = (12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $\left(1 + \frac{F_{cE}}{1 + C_{cE}}\right)$	value 2) a constant for glulam $\left[\left(1 + \frac{F_{cE}}{1 + F_{cE}}\right)\right]^2 \left(\frac{F_{cE}}{1 + F_{cE}}\right)$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2}$	value 2) a constant for glulam $\left[\left(1 + \frac{F_{cE}}{F_{c*}}\right)^2 - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{\left(\frac{F_{cE}}{F_{c*}}\right)}\right]$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\frac{1}{2}}$	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^2 - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{\mathbf{p}} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{1}{2}}$	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi
le le/d FcE FcE Cp	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{\mathbf{P}} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{1}{2}}$	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi
le le/d FcE FcE Cp Cp F'c	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\frac{1}{2}}$ Axial Buckling Capacity	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776	ft in/in psi psi
le le/d FcE FcE Cp Cp F'c F'c	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{\mathbf{P}} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{F_{cE}}{F_{c}*}}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$ V	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776 2,033.01	ft in/in psi psi psi psi
le le/d FcE FcE Cp Cp F'c F'c F'c Overall T	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{F_{c}}{2c_{sawn}}}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*	value 2) a constant for glulam $ \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}} $ y	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776 2,033.01 185.64	ft in/in psi psi
le le/d FcE FcE Cp Cp F'c F'c Overall T Allowabl	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{1}{2}}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*e Tributary Area le Load	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776 2,033.01 185.64 377,409.68	ft in/in psi psi psi psi in2 lbs
le le/d FcE FcE Cp Cp F'c F'c Overall T Allowabi Allowabi	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{\mathbf{p}} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{F_{c}*Cd*Cm*Ct*Cf*Ci*}{Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*Ci*C$	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$ y Cp 2 gyp)	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776 2.033.01 185.64 377,409.68 188,750.00	ft in/in psi psi
le le/d FcE FcE Cp Cp Cp F'c F'c Overall T Allowab Allowab	Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^ Column Stability Factor c_glulam FcE/Fc* $C_{\mathbf{p}} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\frac{F_{cE}}{F_{c}*Cd*Cm*Ct*Cf*Ci*d}}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*d Fributary Area le Load le Load for 3h fire (2 hr + trual Load on column	value 2) a constant for glulam $\left[\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$ V Cp 2 gyp)	12 10.56880734 7013.438354 0.9 3.314479373 0.9607808776 2.033.01 185.64 377,409.68 188,750.00 83,695.51	ft in/in psi psi psi in2 lbs lbs lbs

2nd Floor Atrium

Variable	Name	Value	Unit
X-X Bendi	ng		
Fbx+	Bottom of Beam in Tension	2400	psi
Fbx-	Top of Beam in Tension	1450	psi
Fcx	Compression Perpendicular to grain	600	psi
Fvx	Shear parallel to grain	300	psi
Ex	Modulus of elasticity	1900000	psi
Ex app	Modulus of elasticity (applied)	1800000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi
Y-Y Bendi	ng		
Fby+	Bottom of Beam in Tension	2400	psi
Fby-	Top of Beam in Tension	1450	psi
Fcy	Compression Perpendicular to grain	600	psi
Fvy	Shear parallel to grain	300	psi
Ey	Modulus of elasticity	1900000	psi
Ey app	Modulus of elasticity (applied)	1800000	psi
Axial Load	ling		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
b		13.625	in
d		13.625	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		185.640625	in^2
Sxx		421.6	in^3
Ixx		78258.5	in^4
Isupport		6	in
FF			

Loading				
	Section-	Specific Loading and Dime	nsions	
Load from	n girder to the left	14200	lbs	2-15s
Load from	n girder to the right	14,212.48	lbs	2-3
Load from	n column above	47,714.97	lbs	3-3
Self-weig	th of column	541.45	lbs	
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		-
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*Ci		2116	psi
E'min	Minimum Modulus of el	asticity		
	CT	Buckling Stiffness Factor	1	
	Ci - Emin	Incising Factor	0.95	
E'min	Emin*Cm*Ci*Ct*CT		953040	
1	T C			
le	Effective Length	Tiffe stime law ath feature		
1	Ke Longth#Ke	Effective length factor	1	A.
le/d	Must be less than 50		12	It in/in
le/d	Must be less than 50		10.30880734	<u>111/111</u>
FcF	critical buckling design	value		
FCE	$((0.822)*E'min)/((le/d)^{2})$	2)	7013 438354	nsi
TCL	((0.022) E min)/((10/d) .		/015.450554	psi
Cn	Column Stability Factor			
Ср	c glulam	a constant for glulam	0.9	
	FcE/Fc*	d constant for glandin	3,314479373	
			0.9607808776	
	(Fr)	$\left(F_{\rm F} \right)^2 \left(F_{\rm F} \right)$	0.9007808770	
	$1 + \frac{1}{E}$	$1 + \frac{1}{E}$ $\frac{1}{E}$ $\frac{1}{E}$		
	$C_{\mathbf{p}} := \frac{\left(\begin{array}{c} \Gamma_{\mathbf{c}^*}\right)}{2} - \left(\begin{array}{c} \end{array}\right)$	$\frac{\left(\begin{array}{c} \mathbf{r}_{c^*}\right)}{2} - \frac{\left(\begin{array}{c} \mathbf{r}_{c^*}\right)}{2} \right)$		
Cn	^{2c} sawn	^{2c} _{sawn} ^c _{sawn}		
-P				
F'c	Axial Buckling Capacity	7		
F'c	Fc*Cd*Cm*Ct*Cf*Ci*C	Ср	2,033.01	psi
Overall T	ributary Area	-	185.64	in2
Allowabl	e Load		377,409.68	lbs
Allowabl	e Load for 3h fire (2 hr +	2 gyp)	188,750,00	lbs
Total Act	ual Load on column		76,127.45	lbs
Total Act	ual Load including colum	n	76,668.90	lbs
10.0011100	and 2000 meruding colum		-,,-	

1st Floor Atrium Walkway

Variable	Name	Value	Unit
X-X Bendi	ng		
Fbx+	Bottom of Beam in Tension	2400	psi
Fbx-	Top of Beam in Tension	1450	psi
Fcx	Compression Perpendicular to grain	600	psi
Fvx	Shear parallel to grain	300	psi
Ex	Modulus of elasticity	1900000	psi
Ex app	Modulus of elasticity (applied)	1800000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi
Y-Y Bendi	ng		
Fby+	Bottom of Beam in Tension	2400	psi
Fby-	Top of Beam in Tension	1450	psi
Fcy	Compression Perpendicular to grain	600	psi
Fvy	Shear parallel to grain	300	psi
Ey	Modulus of elasticity	1900000	psi
Еу арр	Modulus of elasticity (applied)	1800000	psi
Axial Load	ling		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
b		11.5	in
d		11.5	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		132.25	in^2
Sxx		253.5	in^3
Ixx		33522.6	in^4
Isupport		6	in

Loadinș	g				
	Section	Specific Loading and Dime	nsions		
Load fro	om girder to the left		lbs		
Load fro	om girder to the right	8 870 00	lbs	1.	-20
Load fro	om column above	85 100 55	lbs	2-195	-20
Self-wei	ight of column	385.73	lbs	2-173	
Sell-we		565.75	103		
Cp Calo	culations!				
Fc*	adjusted compression pa	rallel to grain			
Table 2.	3 Cd	Load Duration Factor	1.15		
	Cm	Wet Service Factor	1		
	Ct	Temperature Factor	1		
	CF	Size Factor	1		
	Ci - Fc	Incising Factor	0.8		
Fc*	(Fc)*Cd*Cm*Ct*CF*C	i	2116	psi	
E'min	Minimum Modulus of e	lasticity			
	CT	Buckling Stiffness Factor	1		
	Ci - Emin	Incising Factor	0.95		
E'min	Emin*Cm*Ci*Ct*CT		953040		
le	Effective Length				
	Ke	Effective length factor	1		
le	Length*Ke		12	ft	
le/d	Must be less than 50		12.52173913	in/in	
FcE	critical buckling design	value			
FcE	((0.822)*E'min)/((le/d)^	2)	4996.35908	psi	
Ср	Column Stability Factor				
	c glulam	a constant for glulam	0.9		
	FcE/Fc*		2.361228299		
			0.9381529001		
-	$C_{\mathbf{p}} \coloneqq \frac{\left(1 + \frac{F_{\mathbf{c}E}}{F_{\mathbf{c}^*}}\right)}{2c_{\mathrm{sawn}}} - \sqrt{\frac{1}{2c_{\mathrm{sawn}}}}$	$\left[\frac{\left(1+\frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}}\right]^{2}-\frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$			
Ср					
F'c	Axial Buckling Capacity	7			
F'c	Fc*Cd*Cm*Ct*Cf*Ci*	Ср	1,985.13	psi	
Overall	Tributary Area		132.25	in2	
	•		262 522 65	lba	
Allował	ole Load		262.533.65	105	
Allowat Allowat	ble Load ble Load for 3h fire (2 hr +	2 gvp)	123,650,00	lbs	
Allowat Allowat	ble Load ble Load for 3h fire (2 hr + Stual Load on column	2 gyp)	262,533.65 123,650.00 93,970.55	lbs lbs	

Shear Walls

Floor b (width, ft) Wind (ade (pf) (ft) Height of story (ft) Wind wu (pf) (ft) Wind wu (pf) (HS) Wind wu (pf) (HS) Length of shear walls Mind (shear walls C=T=Vt*height of walls 4 126 314.4 8 331.2 20,865.60 115.5 180.6545455 2529.163636 3 126 39.8 16 638.8 40,118.40 115.5 5528 7392 2 126 37.8 16 604.8 38,102.40 115.5 857.8909091 12010.47273 1 126 34.7 16 555.2 34.977.60 115.5 1160.727273 16250.18182 Capacity - loading per to layers, wwitw Floor Allowable shear Store 134,064.00 160.72727 16250.18182 175.5 4.5 325.49 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05 14647.05	Windward/Leev	vard side							
4 126 41.4 8 331.2 20,865.60 115.5 180,6545455 2529,163636 3 126 39.8 16 636.8 40,118.0 115.5 57.8900901 12010,47273 1 126 33.47 16 6555.2 34,977.60 115.5 57.890091 12010,47273 1620,18182 Capacity ioadimetric proto lay=retro to lay=retro t	Floor	b (width, ft)	Wind load (psf)	Height of story (ft)	Wind wu (plf)	Vu=(wu*b)/2 (LBS)	Length of shear walls	Vt (distributed shear applied on top of wall) lb/ft	C=T=Vt*height of wall
3 126 39.8 16 636.8 40,118.40 115.5 528 7392 2 126 37.8 16 604.8 38,102.40 115.5 857.8909091 12010.47273 1 126 34.7 16 552.2 34.977.60 115.5 857.8909091 12010.47273 Capacity - loading perp to layers, wwiw 134,064.00 134,064.00 134,064.00 105.3 1650.18182 Chapcity - loading perp to layers, wwiw Rolling shear (pt [B/Q Allowable shear shear 134,064.00 120.0	4	126	41.4	8	331.2	20,865.60	115.5	180.6545455	2529.163636
2 126 37.8 16 604.8 38,102.40 115.5 857.8909091 12010.47273 1 126 34.7 16 55.2 34,977.60 115.5 1160.72273 16250.18182 Capacity - loading perp to lay=	3	126	39.8	16	636.8	40,118.40	115.5	528	7392
1 126 34.7 166 555.2 34.977.60 115.5 1160.727273 16250.18182 Capacity - load//- load/	2	126	37.8	16	604.8	38,102.40	115.5	857.8909091	12010.47273
Image: Capacity - loading perp to layers, wwilw Image: Capacity - layers, wwilw	1	126	34.7	16	555.2	34,977.60	115.5	1160.727273	16250.18182
Capacity - loading space (p)Allowable shearAllowable CatterAllowable shearAllowable CatterAllowable ShearAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable CatterAllowable 							134,064.00		
Floor DIAPHRAM CLT Rolling shear (p) IBQ BQ Allowable shear 4 105-3s 4.45 321.182.77 9548.337497 -	Capacity - load	ing perp to layer	rs, ww/lw						
4105-3s445212.18527779548.3374979648.3374973175-5s445325.4914647.05666661175-5s445325.4914647.05666	Floor DIAPHRAM	CLT	Rolling shear (ps	IB/Q	Allowable shear				
3 175-5s 445 325.49 14647.05 1 175-5s 445 325.49 14647.05 14647.05 1 175-5s 445 325.49 14647.05 14647.05 1 175-5s 445 325.49 14647.05 14647.05 Capacity - load parallel to lavers, wwllw edgewise shear design val Fy (psi) through the thickness Allowable Ve (bis/ft) allowable C=T=Vt*height of wall Image: C=T=Vt*height of w	4	105-3s	45	212.1852777	9548.337497				
2 175-5s 45 325.49 14647.05 1 175-5s 45 325.49 14647.05 6	3	175-5s	45	325.49	14647.05				
1 175-5s 445 3325.49 14647.05 Image: Constraint of the second	2	175-5s	45	325.49	14647.05				
Capacity - loadImage: constraint of the second	1	175-5s	45	325.49	14647.05				
Capacity - loating analysis of the series									
Floor WALLS CLT edgewise shear design val Fv (psi)through the thickness width (in) Allowable Ve (lbs/ft) allowable of wall showable of wall showable company	Capacity - load	ing parallel to la	yers, ww/lw						
4 175-5s 215 6.875 1,478.13 20693.75 3 175-5s 215 6.875 1,478.13 20693.75 <t< td=""><td>Floor WALLS</td><td>CLT</td><td>edgewise shear design val Fv (psi) through the thickness</td><td>Width (in)</td><td>Allowable Ve (lbs/ft)</td><td>allowable C=T=Vt*height of wall</td><td></td><td></td><td></td></t<>	Floor WALLS	CLT	edgewise shear design val Fv (psi) through the thickness	Width (in)	Allowable Ve (lbs/ft)	allowable C=T=Vt*height of wall			
3 175-5s 215 6.875 1,478.13 20693.75 2 175-5s 215 6.875 1,478.13 20693.75 <t< td=""><td>4</td><td>175-5s</td><td>215</td><td>6.875</td><td>1,478.13</td><td>20693.75</td><td></td><td></td><td></td></t<>	4	175-5s	215	6.875	1,478.13	20693.75			
2 175-5s 215 6.875 1,478.13 20693.75 1 175-5s 215 6.875 1,478.13 20693.75 <t< td=""><td>3</td><td>175-5s</td><td>215</td><td>6.875</td><td>1,478.13</td><td>20693.75</td><td></td><td></td><td></td></t<>	3	175-5s	215	6.875	1,478.13	20693.75			
Ing side Vind load (psf) Height of story (t) Vind wu (plf) Vu=(wu*b)/2 (on shear wall) Length of shear walls Vt (distributed shear applied on top of wall) C=T=Vt*height of wall Floor b (width, ft) Wind load (psf) Height of story (tt) Wind wu (plf) Vu=(wu*b)/2 (on shear wall) Length of shear walls Vt (distributed shear applied on top of wall) C=T=Vt*height of wall 4 165 24.4 8 195.2 16104 78 206.4615385 2477.538462 3 165 24.4 16 390.4 32208 78 619.3846154 7432.615385 2 165 24.4 16 390.4 32208 78 1032.307692 12387.69231 1 165 24.4 16 390.4 32208 78 1445.230769 17342.76923	2	175-5s	215	6.875	1,478.13	20693.75			
Iong side Iong side <t< td=""><td>1</td><td>175-5s</td><td>215</td><td>6.875</td><td>1,478.13</td><td>20693.75</td><td></td><td></td><td></td></t<>	1	175-5s	215	6.875	1,478.13	20693.75			
Iong side Iong side <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>									
Floor wind load (psf) Height of story (ft) wind wu (plf) wu=(wu*b)/2 (on shear wall) Length of shear walls Vt (distributed shear applied on top of wall) C=T=Vt*height of wall 4 165 24.4 8 195.2 16104 78 206.4615385 2477.538462 3 165 24.4 16 390.4 32208 78 619.3846154 7432.615385 2 165 24.4 16 390.4 32208 78 1032.307692 12387.69231 1 165 24.4 16 390.4 32208 78 1445.230769 17342.76923	long side								
4 165 24.4 8 195.2 16104 78 206.4615385 2477.538462 3 165 24.4 16 390.4 32208 78 619.3846154 7432.615385 2 165 24.4 16 390.4 32208 78 1032.307692 12387.69231 1 165 24.4 16 390.4 32208 78 1045.2307692 12387.69231	Floor	b (width, ft)	Wind load (psf)	Height of story	Wind wu (plf)	Vu=(wu*b)/2 (on shear wall)	Length of shear walls	Vt (distributed shear applied on top of wall) lb/ft	C=T=Vt*height of wall
3 165 24.4 16 390.4 32208 78 619.3846154 7432.615385 2 165 24.4 16 390.4 32208 78 1032.307692 12387.69231 1 165 24.4 16 390.4 32208 78 1445.2307692 17342.76923	4	165	24.4	8	195.2	16104	78	206.4615385	2477.538462
2 165 24.4 16 390.4 32208 78 1032.307692 12387.69231 1 165 24.4 16 390.4 32208 78 1445.2307692 17342.76923	3	165	24.4	16	390.4	32208	78	619.3846154	7432.615385
1 165 24.4 16 390.4 32208 78 1445.230769 17342.76923	2	165	24.4	16	390.4	32208	78	1032.307692	12387.69231
	1	165	24.4	16	390.4	32208	78	1445.230769	17342.76923

Capacity - load	ing perp to layer					
Floor DIAPHRAM	CLT	Rolling shear (psi)	IB/Q	Allowable shear		
4	105-3s	45	212 1852777	9548 337497		
3	175-5s	45	325.49	14647.05		
2	175-5s	45	325.49	14647.05		
1	175-5s	45	325.49	14647.05		
Capacity - load	ing parallel to la	yers, Long side				
Floor WALLS	CLT	edgewise shear design val Fv (psi) through the thickness	Gross cross sectional area (in2)	Allowable Ve (lbs)	allowable C=T=Vt*height of wall	
4	175-5s	215	6.875	1478.125	20693.75	
3	175-5s	215	6.875	1478.125	20693.75	
2	175-5s	215	6.875	1478.125	20693.75	
1	175-5s	215	6.875	1478.125	20693.75	

154

Appendix C: Fire Analysis – Option 1

Fire Analysis Results - CLT

Floor	CLT	Req total fire rating	req. Fire rating of member	Initial layers of Gyp	Char loss	Final Laminations	New resistance rating	Good for Ratio	Good at initial load	Good for ultimate load	Good for initial load after 100->50
4	105-3s	2	1	2	1.8	1		Yes	Yes	Yes	
3,2,1	175-5s	2	1	2	1.8	3		Yes	No	Yes	

Fire Analysis Results - Joist

	Width	Initial Depth	Req total fire rating	req. Fire rating of member	Initial layers of Gyp	Char loss	Final Width	Final Depth	Good for Ratio	Good at initial load	Good for ultimate load	Good for initial load after 100->50	Notes
4-1	11.5	13.5	2	1	2	1.8	7.9	11.7	Yes	Yes	Yes		
4-2	11.5	15.5	2	1	2	1.8	7.9	13.7	Yes	No	Yes		
4-3	11.5	13.5	2	1	2	1.8	7.9	11.7	Yes	No	Yes		
4-4	11.5	15.5	2	1	2	1.8	7.9	13.7	Yes	No	Yes		
4-5	11.5	19.5	3	2	2	3.16	5.18	16.34	Yes	No	Yes		
4-6	11.5	23.5	3	2	2	3.16	5.18	20.34	Yes	No	Yes		
3-1	11.5	13.5	3	2	2	3.16	5.18	10.34	Yes	No	Yes	No	
3-2	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	
3-3	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
3-4	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	
3-5	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
3-6	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	Resize Up
2-1	11.5	13.5	3	2	2	3.16	5.18	10.34	Yes	No	Yes	No	
2-2	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	
2-3	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
2-4	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	
2-5	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
2-6	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	Resize Up
1-1	11.5	13.5	3	2	2	3.16	5.18	10.34	Yes	No	Yes	No	
1-7	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
1-8	11.5	13.5	3	2	2	3.16	5.18	10.34	Yes	No	Yes	No	
1-2	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	
1-3	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
1-4	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	
1-5	11.5	15.5	3	2	2	3.16	5.18	12.34	Yes	No	Yes	No	
1-6	11.5	17.5	3	2	2	3.16	5.18	14.34	Yes	No	Yes	No	Resize Up

	Width	Initial Depth	Initial total hours fire	Initial member fire rating	Initial layers of Gyp	Char loss	Final Width	Final Depth	Good for Ratio	Good at initial load	Good for ultimate load	Good after initial load 100->50
4-1	11.5	17.5	2	1	2	1.8	7.9	13.9	Yes	No	Yes	
4-2	11.5	23.5	2	1	2	1.8	7.9	19.9	Yes	No	Yes	
4-3	11.5	17.5	2	1	2	1.8	7.9	13.9	Yes	No	Yes	
4-4	11.5	19.5	2	0.66666	2(5/8 in)	1.2	9.1	17.1	Yes	No	Yes	
4-5	11.5	25.5	3	1.5	3	2.5	6.5	20.5	Yes	No	Yes	
4-6	17.5	29.5	3	2	2	3.16	11.18	23.18	Yes	No	Yes	
4-7	11.5	17.5	2	1	2	1.8	7.9	13.9	Yes	No	Yes	
4-8	11.5	19.5	2	0.66666	2(5/8 in)	1.2	9.1	17.1	Yes	No	Yes	
4-9	11.5	17.5	2	1	2	1.8	7.9	13.9	Yes	No	Yes	
4-10	11.5	23.5	2	1	2	1.8	7.9	19.9	Yes	Yes	Yes	
3-1	11.5	21.5	3	1.5	3	2.5	6.5	16.5	Yes	No	Yes	No
3-2	11.5	27.5	3	1.5	3	2.5	6.5	22.5	Yes	No	Yes	No
3-3	11.5	21.5	3	1.5	3	2.5	6.5	16.5	Yes	No	Yes	No
3-4	11.5	27.5	3	1.5	3	2.5	6.5	22.5	Yes	No	Yes	No
3-5	11.5	21.5	3	1.5	3	2.5	6.5	16.5	Yes	No	Yes	No
3-6	11.5	27.5	3	1.5	3	2.5	6.5	22.5	Yes	No	Yes	No
3-7	11.5	21.5	3	1.5	3	2.5	6.5	16.5	Yes	No	Yes	No
3-8	11.5	27.5	3	1.5	3	2.5	6.5	22.5	Yes	No	Yes	No
3-9	11.5	21.5	3	1.5	3	2.5	6.5	16.5	Yes	No	Yes	No
3-10	11.5	27.5	3	1.5	3	2.5	6.5	22.5	Yes	No	Yes	No
2-1	11.5	21.5	3	1.5	5 3	2.5	6.5	16.5	Yes	No	Yes	No
2-2	11.5	27.5	3	1.5	5 3	3 2.5	6.5	22.5	Yes	No	Yes	No
2-3	11.5	21.5	3	1.5	5 3	3 2.5	6.5	16.5	Yes	No	Yes	No
2-4	11.5	27.5	3	1.5	5 3	3 2.5	6.5	22.5	Yes	No	Yes	No
2-5	11.5	21.5	3	1.5	5 3	3 2.5	6.5	16.5	Yes	No	Yes	No
2-6	11.5	27.5	3	1.5	5 3	3 2.5	6.5	22.5	Yes	No	Yes	No
2-7	11.5	21.5	3	1.5	5 3	3 2.5	6.5	16.5	Yes	No	Yes	No
2-8	11.5	27.5	3	1.5	5 3	3 2.5	6.5	22.5	Yes	No	Yes	No
2-9	11.5	21.5	3	1.5	5 3	3 2.5	6.5	16.5	Yes	No	Yes	No
2-10	11.5	27.5	3	1.5	5 3	3 2.5	6.5	22.5	Yes	No	Yes	No
1-1	11.5	21.5	3	1.5	5 3	2.5	6.5	16.5	Yes	No	Yes	No
1-2	11.5	27.5	3	1.5	5 3	2.5	6.5	22.5	Yes	No	Yes	No
1-3	11.5	21.5	3	1.5	5 3	2.5	6.5	16.5	Yes	No	Yes	No
1-4	11.5	27.5	3	1.5	5 3	2.5	6.5	22.5	Yes	No	Yes	No
1-5	11.5	21.5	3	1.5	5 3	2.5	6.5	16.5	Yes	No	Yes	No
1-6	11.5	27.5	3	1.5	5 3	2.5	6.5	22.5	Yes	No	Yes	No
1-7	11.5	21.5	3	1.5	5 3	2.5	6.5	16.5	Yes	No	Yes	No
1-8	11.5	27.5	3	1.5	5 3	2.5	6.5	22.5	Yes	No	Yes	No
1-9	11.5	21.5	3	1.5	5 3	2.5	6.5	16.5	Yes	No	Yes	No
1-10	11.5	27.5	3	1.5	5 3	25	6.5	22.5	Yes	No	Yes	No

Fire Analysis Results – Girders

	Width	Initial Depth	Initial layers of Gyp	Initial hours fire rating	Char loss	Final Width	Final Depth	New resistance rating	Good at initial Ioad	Good at ultimate Load	Good after 100->50
4-1	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	
4-2	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	
4-3	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	
4-4	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	
4-5	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	
4-6	13.625	13.625	2	3	3.16	7.305	7.305		Yes	Yes	
4-7	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	
4-8	13.625	13.625	2	3	3.16	7.305	7.305		Yes	Yes	
4-9	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	
4-10	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	
4-11	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	
4-12	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	
3-1	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	No
3-2	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	No
3-3	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	No
3-4	13.625	13.625	2	3	3.16	7.305	7.305		No	Yes	No
3-5	13.625	13.625	2	3	3.16	7.305	7.305		Yes	Yes	No
3-6	13.625	13.625	2	3	3.16	7.305	7.305		No	Yes	No
3-7	13.625	13.625	2	3	3.16	7.305	7.305		Yes	Yes	No
3-8	13.625	13.625	2	3	3.16	7.305	7.305		No	Yes	No
3-9	11.5	11.5	2	3	3.16	5.18	5.18		No	Yes	No
3-10	13.625	13.625	2	3	3.16	7.305	7.305		No	Yes	No
3-11	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	No
3-12	11.5	11.5	2	3	3.16	5.18	5.18		Yes	Yes	No
24	44 E	44 E	2	2	2.40	E 40	E 49		Nie	Maa	Na
2-1	12 625	12 625	2		2.10	7 205	J. 10 7 205		No	Yee	No
2-2	12.625	12.625	2	3	2.10	7.305	7.303		Vec	Yee	No
2-3	13.025	12.625	2	3	3.10	7.305	7.305		No	Vec	No
2-4	13.025	13.025	2	3	3.10	7.305	7.305		No	Voc	No
2-5	13.025	13.025	2	3	3.10	7.305	7.305		No	Voc	No
2-0	13.625	13.625	2	3	3.10	7.305	7.305		No	Voc	No
2-1	13.625	13.625	2	3	3.10	7.305	7.305		No	Vos	No
2-0	13.625	13.625	2	3	3.10	7.305	7.305		Vos	Vos	No
2-5	13.625	13.625	2	3	3.16	7 305	7.305		No	Ves	No
2-10	11.025	11.025	2	3	3.10	5 18	5.18		No	Voc	No
2-11	13 625	13 625	2	3	3.16	7 305	7 305		Vos	Ves	No
2-12	10.020	10.020	2	0	5.10	1.505	7.505		103	105	
1_1	13 625	13 625	2	3	3 16	7 305	7 305		Yes	Yes	No
1.2	13 625	13 625	2	3	3 16	7 305	7.305		No	Ves	No
1-2	13 625	13.625	2	3	3.16	7.305	7.305		No	Ves	No
1-3	15.025	15.025	2	3	3.16	9.18	9.18		No	Ves	No
1-5	13 625	13 625	2	3	3.16	7 305	7 305		No	Ves	No
1-5	15.025	15.025	2	ງ ຊ	3.10	Q 18	Q 18		No	Yes	No
1.7	13 625	13 625	2	3	3.10	7 305	7 305		No	Yes	No
1_9	15.025	15.025	2	3	3.10	Q 18	0 1R		No	Yes	No
1_0	13 625	13.625	2	3	3.10	9.10 7 305	3.10 7 305		No	Yes	No
1-10	15.025	15.025	2	3	3.10	0.1Q	0.1Q		No	Ves	No
1_11	13 625	13.625	2	3	3.10	7 305	7 305		Ves	Ves	No
1-11	13.625	13.025	2	3	3.10	7 305	7 305		No	Vos	No
1-12	15.025	15.025	۷ ک	5	5.10	1.303	1.303		NO	105	

Fire Analysis Results – Columns

	Lamination Fall-Off Ti	те				
Variable	Description	Calculation	Units			
h_lam	Lamella thickness	1.375	in			
Bn	Char Rating	1.5	in/hr			
t_fo	Time to reach glued interface	54	min			
n_lam	Number of laminations that fall	1 laminations				
t	Required FRR	60	min			
	Effective Char Depth					
Variable	Description	Calculation	Units			
a_char	Effective Char Depth	1.93	in			
	Effective Residual Cross S	ection				
Variable	Description	Calculation	Units			
h	Initial Cross-Section Depth	4.125	in			
h_fire	Effective Cross-Section Depth	2.19	in			
	Ply Effected - Manually Enter	2	ply			
	Section-Specific Load	ing and Dimensior	IS			
Floor		4				
Section:		1A-1				
Length		13		ft		
Width		6		ft		
Roof Live Load (1	Lr)	20		psf		
Ground snow load	d (S)	50		psf		
Deal Leader Tet						
Dead Loads - Tota	al	14.10		psf		
Dead Loads - Tota	al Insulation on CLT (D)	14.10 <i>3</i>		psf psf		
	al Insulation on CLT (D) Mechanical (D)	14.10 3 0		psf psf psf		
	al Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D)	14.10 3 0 11.1		psf psf psf psf		
	al Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D) Point Loads	14.10 3 0 11.1 0		psf psf psf psf psf psf		
Wind (W)	al Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D) Point Loads	14.10 3 0 11.1 0 0		psf psf psf psf psf mph		
Wind (W) Earthquake (E)	Al Insulation on CLT (D) Mechanical (D) CLT Self-Weight (D) Point Loads	14.10 3 0 11.1 0 0 0 0		psf psf psf psf mph psf		

Fire Analysis Calculations – Option 1CLT

	Section-Specific Loading and Dimensions										
Floor			4								
Section:			1A-1								
Length		13		ft							
Width		6		ft							
Roof Live Load	(Lr)	20		psf							
Ground snow lo	ad (S)	50		psf							
Dead Loads - To	otal	14.10		psf							
	Insulation on CLT (D)	3		psf							
	Mechanical (D)	0		psf							
	CLT Self-Weight (D)	11.1		psf							
	Point Loads	0		psf							
Wind (W)		0		mph							
Earthquake (E)		0		psf							
Live Load (L)				psf							
	Actual Loading										
Variable	Description	Calculation	Units								
LC1	D	14.10	psf								
LC2	D+L	14.10	psf								
LC3	D+(Lr or S or R)	64.10	psf								
LC4	D + 0.75L + 0.75(Lr or S or R)	51.60	psf								
LC5	D + (0.6W or 0.7E)	14.10	psf								
LC6a	D + 0.75L + 0.75(0.6W) + 0.75(Lr or S	51.60	psf								
LC6b	D + 0.75L + 0.75(0.7E) + 0.75S	51.60	psf								
LC7	0.6D + 0.6W	8.46	psf								
LC8	0.6D + 0.7E	8.46	psf								
	Important Values										
Variable	Description	Calculation	Units								
М	Induced Bending Moment (Fire)	8124.68	lb-ft								
V	Induced Shear (Fire)	3124.88	lb								
n_lam	Number of laminations that fall	1	laminations								

Fire Analysis Calculations – Option 1 Joist

Joists				Loading					
Variable	Name	Value	Unit		Section-Specific Loading and I	Dimensions			
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:		17	A - 1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		15.625	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		0	psf	0	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		0	psf	0	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		30.7	psf	497.6160556	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	0	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	15.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	17.92855556	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)	Earthquake (E)				
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		100	psf	1562.5	plf
				Reduced Live Load - e	dge beam- yes bc KllAt>400 ft	91.05782591	psf	1422.77853	plf
Axial Load	ling				Actual Loading				
Fc	Compression parallel to grain	2300	psi	Variable	Description	Calculation	Units		
Ft	Tension parallel to grain	1600	psi	LC1	D	30.7	psf	497.62	plf
Ea	modulus of elasticity	1900000	psi	LC2	D+L	130.7	psf	1920.39	plf
CD		1.15	-	LC3	D+(Lr or S or R)	30.7	psf	497.62	plf
СМ		1	-	LC4	D + 0.75L + 0.75(Lr or S or	105.7	psf	1564.70	plf
Ct		1	-	LC5	D+(0.6W or 0.7E)	30.7	psf	497.62	plf
Cfu		1	-	LC6a	D+0.75L+0.75(0.6W)+0	. 105.7	psf	1564.70	plf
Cc		1	-	LC6b	D+0.75L+0.75(0.7E)+0.	105.7	psf	1564.70	plf
Cb		1	-	LC7	0.6D + 0.6W	18.42	psf	298.57	plf
CI		1	-	LC8	0.6D + 0.7E	18.42	psf	298.57	plf
Cvr		1	-						
E'x		1800000	psi		Allowable Deflection	1			
E'xmin		1450	psi	Variable	Description	Calculation	Units		
				Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft		

	Member Lengths and Properties	5	
Variable		Value	Unit
1		16.5	ft
b		5.18	in
d		14.24	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		73.7632	in^2
Sxx		175.1	in^3
Ixx		1246.5	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		8.858	
FBe		22	psi

Cd	Load Duration Factor	0.9		
Cm	Wet Service Factor	1		
Ct	Temperature Factor	1		
C.		1		
Ce		1		
		1		
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160		
CL				
Lu	length (inches)	198		
Le	1.63Lu+3D	365.46	5	
Rb	$sqrt((le*d)/b^2)$	13.92660	186	
Emin'	Emin*Cm*Ct	950400)	
Fbe	(1.2*Emin')/(Rb^2)	5880.271	168	
Cfu		1		
CL	look at nds	0.9729444	626	
CV	look at nds		0.81	
Fire Resistance	Adjustment Factor	1		
F'h	Eb*Cd*CM*Ct*(CL or Cv)*Co*Cfu*Ci*Eire adjust	1749 6		nsi
I Iltimate Fire Fb		1986 3	6	nsi
Allowable Mom	1 0 2.85	25524.4	2	ft lb
Allowable Mollie		25524.4	14 62	11-1D
Ultimate Allowa	ible Moment	1212	4.62	Π-ID
Moment		653	53.43	di-1
Adjusted Shear	Parallel to Grain Design Value (F'v) using ASD			
Cd	Load Duration Factor	0.9		NDS Table 2.3.2
CMV	Wet Service Factor	1		NDS Supplement Table 4A
Ct	Temperature Factor	1		NDS Table 2.3.2
Ci	Incising Factor	1		NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270		psi
F'v		38880		psf
Actual V	wL/2	15843.25	533	lb
Actual fv	3V/2bd	46393.63	736	psf
		-		
Fc perp				
Cb	Bearing Area Factor	1		
CMV	Wet Service Factor	1	ND	S Supplement Table 4A
Ct	Temperature Factor	1	ND	S Table 2.3.2
Fc perp		600	psi	
Reaction forces	1/2 * wl	15843.25533	lb	
Fc actual		509.75725	psi	
		_		
Adjusted Module	as of Elasticity (E')		_	
CME	Wet Service Factor	1	ND	S Supplement Table 4A
CtE	Temperature Factor	1	ND	S Table 2.3.3
CiE	Incising Factor	1	ND	S Table 4.3.8
E'	E*CME*CtE*CiE	1800000		
Manual pg 72				
TT 11	Actual Deflection	01.1.2		
Variable		Calculation	Uni	ts
Delta L	(5*Lr*(L^4))/(E'app*Ixx*384)*144	-	U II	
Delta S	(5*S*(L^4))/(E'app*Ixx*384)*144		U III	
Delta D+L	$(5^{(L+D)*(L^4))/(E'app^{Ixx^384})^{144}$	0.0308233932	1 ft	

Fire Analysis Calculations – Option 1 Girder

	Member Lengths and Properties	6	
Variable		Value	Unit
1		25	ft
b		7.9	in
d		13.9	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		109.81	in^2
Sxx		254.4	in^3
Ixx		1768.0	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
DD		5 700	

lu	96	in
le	148	in
RB	5.738	
FBe	53	psi
CL		

Loading					
Point Load 1 - left					
S	ection-Specific Loading and I	Dimensions			
Joist Number			4-1		
Joist b		11.5	in		
joist d		13.5	in		
Girder Tributary Width	8.25	ft			
CLT Tributary Area		4.6875	ft		
Roof Live Load (Lr) (ente	r reduced load if reduced)	20	psf	1933.59375	lbs
Ground snow load (S)		50	psf		
Dead Loads - Total		27.7	psf	1382.519531	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	11.1	psf		
	Joist Weight	35	pcf	311.3085938	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ced load if reduced)	0	psf	0	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	1382.52	lbs
LC2	D+L	27.7	psf	1382.52	lbs
LC3	D+(Lr or S or R)	77.7	psf	3316.11	Ibs
LC4	D + 0.75L + 0.75(Lr or S or	65.2	psf	2832.71	lbs
LC5	D + (0.6W or 0.7E)	27.7	psf	1382.52	Ibs
LC6a	D + 0.75L + 0.75(0.6W) + 0	65.2	psf	2832.71	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psf	1382.52	lbs
LC7	0.6D + 0.6W	16.62	psf	829.51	lbs
LC8	0.6D + 0.7E	16.62	psf	829.51	lbs

Point Load 2 - Middle					
Se	ection-Specific Loading and D	Dimensions			
Joist Number		2	4-2		
Joist b		11.5	in		
joist d		15.5	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area		15.625	ft		
Roof Live Load (Lr) (enter	reduced load if reduced)	18.84375	psf	6445.3125	lbs
Ground snow load (S)		50	psf		
Dead Loads - Total		27.7	psf	3928.13151	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	I	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	11.1	psf		
	Joist Weight	35	pcf	357.4283854	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	0	psf	0	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	3928.13	lbs
LC2	D+L	27.7	psf	3928.13	lbs
LC3	D+(Lr or S or R)	77.7	psf	10373.44	lbs
LC4	D + 0.75L + 0.75(Lr or S or	65.2	psf	8762.12	lbs
LC5	D + (0.6W or 0.7E)	27.7	psf	3928.13	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	65.2	psf	8762.12	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psf	3928.13	lbs
LC7	0.6D + 0.6W	16.62	psf	2356.88	lbs
LC8	0.6D + 0.7E	16.62	psf	2356.88	Ibs

Point Load 3 - Righ	t									
	Section-Specific Loadir	ng and Din	nensi	ons						
Joist Number				4	4-3					
Joist b				11.5		in				
joist d				13.5		in				
Girder Tributary Widtl	h			8.25		ft				
CLT Tributary Area				4.6875		ft				
Roof Live Load (Lr) (e	enter reduced load if reduc	ced)		20		psf		1933.59375	lb	S
Ground snow load (S)				50		psf				
Dead Loads - Total				29.7		psf		1459.863281	lb	5
	Insulation on CLT (L))		9		psf				
	MEP Allowance (D)			5		psf				
	Roofing Membrane			1		psf				
	Misc. Hung Ceiling			1.6		psf				
	CLT Weight (D)			13.1		psf				
	Joist Weight			35		pcf		311.3085938	lb	S
Wind (W)				0		mph				
Earthquake (E)				0		psf				
Live Load (L) (enter re	educed load if reduced)			0		psf		0	lb	5
	Actual Los	ading								
Variable	Description	C	alcul	ation	Units					
LC1	D			29.7	psf			1459.86	lb	S
LC2	D+L			29.7	psf			1459.86	lb	S
LC3	D+(Lr or S or R)			79.7	psf			3393.46	lb	5
LC4	D+0.75L+0.75(Lr	or S or		67.2	psf			2910.06	lb	5
LC5	D + (0.6W or 0.7E)			29.7	psf		-	1459.86	lb	5
LC6a	D + 0.75L + 0.75(0.6)	5W) + 0.		67.2	psf			2910.06	lb	5
LC6b	D + 0.75L + 0.75(0.7)	7E) + 0.1		67.2	psf			1459.86	lb	S
LC7	0.6D + 0.6W			17.82	psf			875.92	lb:	S
LC8	0.6D + 0.7E			17.82	pst			875.92	Ib	5
Uniform Load from	Glulam Self weight	1.51								
FI	Section-Specific Loadir	ig and Din	nensi	ons	4					
Floor				1.4	4				-	
Deed Load from Glu	lam salf waight			25	1-1	pof		26 68002056	nl	e
Wind (W)	iani sen weight			0		mph		20.08775050	pi	
Farthquake (F)				0		nsf				
Eurinquine (E)						Por			-	
	Actual Loading									
Variable	Description	Calculation	n	Units		Total DL (lbs)		Total LL (lbs)		Total Roof SL (lbs)
LC1	D	743	37.76	lbs					0	0
LC2	D+L D+(L = == C == P)	1775	57.76	Ibs		7427 7621	0		0	10212.5
	D+(Lr or S or R) D+0.75L+0.75(Lr or S or C)	1//3	72 14	Ibs		1431.102	01		0	10312.5
LC5	D + (0.6W or 0.75)	743	37.76	lbs			0		0	0
LC6a	D + 0.75L + 0.75(0.6W) + 0	1517	72.14	lbs			0		0	0
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	743	37.76	lbs			0		0	0
LC7 0.6D + 0.6W 44			4462.66 lbs			6			0	0
LC8	0.6D + 0.7E	446	52.66	lbs			0		0	0

Cd	Load Duration Factor	0.9		
Cm	Wet Service Factor	1		
Ct	Temperature Factor	1		
Cc	Curvature Factor	1		
Ci	Incising Factor	1		
EL*	Eh*Cd*Cm*Ct*Co*Ci	2160		
CI		2100		
UL IN	length (inches)	300		
La	$1.63L_{\rm H}+3D_{\rm H}$	530.7		
Rb	$sart((le*d)/b^2)$	10.8718850	07	
Emin'	Emin*Cm*Ct	950400		
Fbe	(1.2*Emin')/(Rb^2)	9648.9036	2	
Cfu	(), ()	1		
CL.	look at nds	0.98603489	21	
CV	look at nds	(81	
C v	A diustment Factor	1		0.86
File Resistance. F'h	Eb*Cd*CM*Ct*(CL or Cv)*C	*(1749.6		nsi
Ultimate F ^t h	x2.85	408	5.36	psi
Allowable Mome	ent	3709	0.52	ft-lb
Ultimate Allows	ible Moment	10570	7.99	ft-lb
Moment		6691	9.18	ft-lb
Adjusted Shear	Parallel to Grain Design Value	(F		
Cd	Load Duration Factor	0.9		NDS Table 2.3.2
CMV	Wet Service Factor	1		NDS Supplement Table 4A
Ct	Temperature Factor	1		NDS Table 2.3.2
Ci	Incising Factor	1		NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270		psi
F'v		38880		psf
Actual V	wL/2	5520.34613	37	lb
Actual fv	3V/2bd	10858.7083	37	psf
-				
Fc perp		1		
Cb	Bearing Area Factor	1		9 Supplement Table 44
CMV	Wet Service Factor	1		
Ct	Temperature Factor	1	ND I	S Table 2.3.2
Fc perp		600	psi	
Reaction forces	1/2 * wl	5520.346137	D al	
Fc actual		116.4629987	psi	
A dimensional Data dan la	er ef Electicite (El)			
CMF	Wet Service Factor	1	ND	S Supplement Table 44
CtE	Temperature Factor	1	ND	S Table 2.3.3
CiE	Incising Factor	1	ND	S Table 4.3.8
E'	E*CME*CtE*CiE	1800000		
_				
Manual pg 72				
	Actual	Deflection		
Variable	Description	Calculation	Uni	ts
Delta L	See next column	0.09493415924	ft	
Delta S	See next column	0	ft	
Delta D+L	See next column	0.1010766968	ft	
	(22)	- D - A		
Variable	Allowabl	e Deflection	I.I.	to
variaole Delta I	L/360	0.0694/4/4/44	0ni fi	15
Delta S	L/360	0.06944444444	fi	
Delta D+L	L/240	0.1041666667	ft	
		0.10.100000/		

Variable	Name	Value	Unit
Axial Load	ing		
Fc	Compression parallel to grain	2300	psi
Ft	Tension parallel to grain	1600	psi
Ea	modulus of elasticity	1900000	psi
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi
	Member Lengths and Properties		
Variable		Value	Unit
1		12	ft
1			
b		5.18	in
b d		5.18 5.18	in in
b d p	density	5.18 5.18 35	in in pcf
d p SG	density Specific gravity	5.18 5.18 35 0.46	in in pcf
b d p SG Ag	density Specific gravity	5.18 5.18 35 0.46 26.8324	in in pcf in^2
b d p SG Ag Sxx	density Specific gravity	5.18 5.18 35 0.46 26.8324 23.2	in in pcf in^2 in^3
b d p SG Ag Sxx Ixx	density Specific gravity	5.18 5.18 35 0.46 26.8324 23.2 621.6	in in pcf in^2 in^3 in^4

Fire Analysis Calculations – Option 1 Column

Loading				
Point Lo	ad 1 - left			
	Sect	ion-Specific Loading and Di	mensions	
Load from	n girder to the left	0	lbs	
Load fror	n girder to the right	9,114.27	lbs	LC 3 Governs
Self-weig	ht of column	78.26	lbs	LC 3 Governs
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	-
Fc*	(Fc)*Cd*Cm*Ct*CF*Ci		2116	psi
T				
E'min	Minimum Modulus of el	asticity		
	CI C' F '	Buckling Stiffness Factor	1	
Therein	Ci - Emin	Incising Factor	0.95	
Emin	Emin*Cm*Ci*Ct*CI		953040	
la	Effective Longth			
le		Effective length factor	1	
	K A			
le	Ke Length*Ke	Effective length factor	12	ft
le le/d	Ke Length*Ke Must be less than 50		12 27,7992278	ft in/in
le le/d	Ke Length*Ke Must be less than 50		1 12 27.7992278	ft in/in
le le/d FcE	Ke Length*Ke Must be less than 50 critical buckling design	value	12 27.7992278	ft in/in
le le/d FcE FcE	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2	value	1 12 27.7992278 1013.718755	ft in/in psi
le le/d FcE FcE	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2)	value	12 27.7992278 1013.718755	ft in/in psi
le le/d FcE FcE	Ke Length*Ke Must be less than 50 critical buckling design ((0.822)*E'min)/((le/d)^2 Column Stability Factor	value	12 27.7992278 1013.718755	ft in/in psi
le le/d FcE FcE Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam	value 2) a constant for glulam	1 12 27.7992278 1013.718755 0.9	ft in/in psi
le le/d FcE FcE Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc*	value 2) a constant for glulam	12 27.7992278 1013.718755 0.9 0.4790731357	ft in/in psi
le le/d FcE FcE Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc*	value 2) a constant for glulam	12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293	ft in/in psi
le le/d FcE FcE	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc*	a constant for glulam $\frac{F_{cE}}{\left(1 + \frac{F_{cE}}{2}\right)^2} \left(\frac{F_{cE}}{2}\right)$	12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293	ft in/in psi
le le/d FcE FcE Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc* $\left(1 + \frac{F_{cE}}{F_{c*}}\right)$	a constant for glulam $\overline{\left(1 + \frac{F_{cE}}{F_{c*}}\right)^2} \left(\frac{F_{cE}}{F_{c*}}\right)$	12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293	ft in/in psi
le le/d FcE FcE Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\frac{1}{2}}$	$\frac{1}{\left(1 + \frac{F_{cE}}{F_{c*}}\right)^2} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{\frac{1}{c_{sawn}}}$	12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293	ft in/in psi
le le/d FcE FcE Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2) Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\left[1 + \frac{F_{cE}}{F_{c*}}\right]}$	a constant for glulam $ \frac{\left[1 + \frac{F_{cE}}{F_{c*}}\right]^2}{2c_{sawn}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}} $	12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293	ft in/in psi
le le/d FcE FcE Cp Cp Cp	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\left[2 + \frac{F_{cE}}{F_{c}*}\right]}$ Axial Buckling Capacity	$\frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}}$	12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293	ft in/in psi
le le/d FcE FcE Cp Cp F'c F'c	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2) Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\left[2 + \frac{F_{cE}}{F_{c}}\right]^2}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*	a constant for glulam $ \frac{\left[\left(1 + \frac{F_{cE}}{F_{c*}}\right)\right]^2}{2c_{sawn}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}} $	1 12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293 0.4436869293 938.84	ft in/in psi
le le/d FcE FcE Cp Cp Cp F'c F'c F'c Ultimate	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\left[2 + \frac{F_{cE}}{F_{c}}\right]^2}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*Cf	a constant for glulam $ \frac{\left[1 + \frac{F_{cE}}{F_{c*}}\right]^2}{2c_{sawn}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}} $	1 12 27.7992278 1013.718755 0.4 0.9 0.4790731357 0.4436869293 0.4436869293 938.84 2,422.21	ft in/in psi
le le/d FcE FcE Cp Cp F'c F'c Ultimate Overall T	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\left[2 + \frac{F_{cE}}{F_{c}*}\right]^{2c_{sawn}}} - \sqrt{\left[2 + \frac{F_{cE}}{F_{c}}\right]^{2c_{sawn}}}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*C	$\frac{\left[1 + \frac{F_{cE}}{F_{c*}}\right]^2}{\frac{2c_{sawn}}{2c_{sawn}}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{\frac{c_{sawn}}{c_{sawn}}}$	1 12 27.7992278 1013.718755 0.4790731357 0.4436869293 0.4436869293 938.84 2,422.21 26.83	ft in/in psi psi psi psi psi psi in2
le le/d FcE FcE Cp Cp F'c F'c Ultimate Overall T Allowabl	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2) Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \sqrt{\left[}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*cf F'c ributary Area e Load	a constant for glulam $ \frac{\left[\left(1 + \frac{F_{cE}}{F_{c*}}\right)\right]^2}{2c_{sawn}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}} $	1 12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293 0.4436869293 938.84 2,422.21 26.83 25,191.37	ft in/in psi psi psi psi psi in2 Ibs
le le/d FcE FcE Cp Cp F'c F'c Ultimate Overall T Allowabl Ultimate	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2) Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\left[}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*C F'c ributary Area e Load Allowable Load	a constant for glulam $ \frac{\left[1 + \frac{F_{cE}}{F_{c*}}\right]^2}{2c_{sawn}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{c_{sawn}} $	1 12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293 0.443686929268 0.443686929268 0.4436869298 0.4436869298 0.4436869298 0.4	ft in/in psi psi psi psi psi in2 lbs
le le/d FcE FcE Cp Cp F'c F'c Ultimate Overall T Allowabl Ultimate Allowabl	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2 Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c}*}\right)}{2c_{sawn}} - \sqrt{\left[}$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*C F'c Tibutary Area e Load Allowable Load e Load for 3h fire (2 hr +	$\frac{\left[1 + \frac{F_{cE}}{F_{c*}}\right]^2}{\frac{2c_{sawn}}{2c_{sawn}}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{\frac{c_{sawn}}{c_{sawn}}}$	1 12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293 0.4436869293 938.84 2,422.21 26.83 25,191.37 64,993.74 52,000.00	ft in/in psi psi psi psi psi psi psi psi
le le/d FcE FcE Cp Cp F'c F'c Ultimate Overall T Allowabl Ultimate Allowabl Total Act	Ke Length*Ke Must be less than 50 critical buckling design v ((0.822)*E'min)/((le/d)^2) Column Stability Factor c_glulam FcE/Fc* $C_{p} := \frac{\left(1 + \frac{F_{cE}}{F_{c*}}\right)}{2c_{sawn}} - \left[$ Axial Buckling Capacity Fc*Cd*Cm*Ct*Cf*Ci*(CF'c) + Ci*(CF'c)	$\frac{\left[1 + \frac{F_{cE}}{F_{c*}}\right]^2}{\frac{2}{2c_{sawn}}} - \frac{\left(\frac{F_{cE}}{F_{c*}}\right)}{\frac{1}{c_{sawn}}}$	1 12 27.7992278 1013.718755 0.9 0.4790731357 0.4436869293 0.4436869293 938.84 2,422.21 26.83 25,191.37 64,993.74 52,000.00 9,114.27	ft in/in psi psi psi psi psi in2 lbs lbs lbs

Appendix D: Fire Analysis – Option 2

Fire Analysis Results – CLT

Floors	CLT	Req total fire rating	req. Fire rating of member	Initial layers of Gyp	Final Laminations	New resistance rating	Good for Ratio	Good at initial Ioad	Good for ultimate load	Good for initial load after 100->50
	4 105-3s	2	1	2	1.8	1	Yes	Yes	Yes	Yes
1,2,3	175-5s	2	1	2	3		Yes	Yes	Yes	Yes
penthouse	197-7s	2	1	2 (5/8 in)	5		Yes	Yes	Yes	Yes

Fire Analysis Results – Shear Walls

Floors	CLT	Req total fire rating	req. Fire rating of member	Initial layers of Gyp	Final Laminations	New resistance rating	Good for Ratio	Good at initial load	Good for ultimate load	Good for initial load after 100->50
4,3,2	175-5s	2	1	2	3		Yes	Yes	Yes	Yes
1	197-7s	2	1	2 (5/8 in)	5		Yes	Yes	Yes	Yes

Fire Analysis Results – Joist

	Width	Initial Depth	Req total fire rating	Fire rating of member	Initial layers of Gyp	Char loss	Final Width	Final Depth	Post fire- fire rating of member	Layers of gyp to add post fire	Post-fire Nordic fire estimate (check column E)	Good for Ratio	Good at initial load	Good for ultimate load	Good for initial load after 100->50
4-1	11.5	13.5	2	1	2	1.8	7.9	11.7	1	2	1	Yes	Yes	Yes	
4-2	11.5	17.5	2	1	2	1.8	7.9	15.7	1	2	1	Yes	Yes	Yes	
4-3	11.5	15.5	2	1	2	1.8	7.9	13.7	1	2	1	Yes	Yes	Yes	
4-4	11.5	19.5	2	1	2	1.8	7.9	17.7	1	2	1	Yes	Yes	Yes	
4-5	15.5	19.5	3	1.5	3	2.5	10.5	17	1.5	3	0.95	Yes	Yes	Yes	
4-6	15.5	21.5	3	1.5	3	2.5	10.5	19	1.5	3	1	Yes	Yes	Yes	
3-1	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	Yes	Yes	Yes
3-2	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
3-3	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	Yes
3-4	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
3-5	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	Yes
3-6	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
2-1	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	Yes	Yes	Yes
2-2	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
2-3	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	Yes
2-4	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
2-5	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	Yes
2-6	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
1-1	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	Yes	Yes	Yes
1-7	15.5	17.5	3	2	2	3.16	9.18	14.34	1.5	3	0.852	Yes	No	Yes	Yes
1-8	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	No
1-2	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
1-3	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	Yes
1-4	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes
1-5	15.5	15.5	3	2	2	3.16	9.18	12.34	1.5	3	0.8294 (int)	Yes	No	Yes	Yes
1-6	15.5	19.5	3	2	2	3.16	9.18	16.34	1.5	3	0.8943	Yes	No	Yes	Yes

Fire Analysis Results – Girder

	Width	Initial Depth	Initial total hours fire rating	Initial member fire rating	Initial layers of Gyp	Char loss	Final width (1 fire exp)	Final depth (1 fire exp)	Post fire- fire rating of membe r	Layers of gyp to add post fire	Char rate 2nd fire	Final Width (2 fire exp)	Final Depth (2 fire exp)	Good for Ratio	Good at initial load before fire	Good at initial load after fire	Good after initial load 100->50	Good for Ultimate Loads for 2nd fire with 50 psf
4-1	15.5	19.5	2	1	2	1.8	11.9	15.9	1	2	1.8	8.3	12.3	Yes	Yes	Yes		Yes
4-2	15.5	25.5	2	1	2	1.8	11.9	21.9	1	2	1.8	8.3	18.3	Yes	Yes	Yes		Yes
4-3	15.5	21.5	2	1	2	1.8	11.9	17.9	1	2	1.8	8.3	14.3	Yes	Yes	Yes		Yes
4-4	15.5	27.5	2	1	2	1.8	11.9	23.9	1	2	1.8	8.3	20.3	Yes	Yes	Yes		Yes
4-5	17.5	29.5	3	1.5	3	2.5	12.5	24.5	1.5	3	2.5	7.5	19.5	Yes	Yes	Yes		Yes
4-6	19.5	35.675	3	1.5	3	2.5	14.5	30.675	1.5	3	2.5	9.5	25.675	Yes	Yes	Yes		Yes
4-7	15.5	21.5	2	1	2	1.8	11.9	17.9	1	2	1.8	8.3	14.3	Yes	Yes	Yes		Yes
4-8	15.5	27.5	2	1	2	1.8	11.9	23.9	1	2	1.8	8.3	20.3	Yes	Yes	Yes		Yes
4-9	15.5	21.5	2	1	2	1.8	11.9	17.9	1	2	1.8	8.3	14.3	Yes	Yes	Yes		Yes
4-10	15.5	25.5	2	1	2	1.8	11.9	21.9	1	2	1.8	8.3	18.3	Yes	Yes	Yes		Yes
							10.5											
3-1	15.5	25.5	3	1.5	3	2.5	10.5	20.5	3	1.5	3	5.5	15.5	Yes	Yes	No	Yes	Yes
3-2	15.5	29.5	3	1.5	3	2.5	10.5	24.5	3	1.5	3	5.5	19.5	Yes	Yes	No	Yes	Yes
3-3	15.5	25.5	3	1.5	3	2.5	10.5	20.5	3	1.5	3	5.5	15.5	Yes	Yes	NO	Yes	Yes
3-4	15.5	29.5	3	1.5	3	2.5	10.5	24.5	3	1.5	3	5.5	19.5	Yes	Yes	NO	Yes	Yes
3-0	10.0	20.5	3	1.5	3	2.5	10.5	20.5	3	1.5	3	5.5	10.5	Yes	Yes	NO	Yes	Yes
3-0	10.0	29.5 25.5	3	1.0	3	2.5	10.5	24.5	3	1.5	3	5.5 E.E.	19.0	Yes	Yes	No	Yee	Yes
3-7	15.5	20.0	3	1.5	3	2.0	10.5	20.5	3	1.5	3	5.5	10.5	Vec	Ves	No	Vec	Ves
2.0	15.5	29.5	3	1.5	3	2.5	10.5	24.5	3	1.5	3	5.5	15.5	Voc	Voc	No	Voc	Voc
3-10	15.5	29.5	3	1.5	3	2.5	10.5	20.5	3	1.5	3	5.5	19.5	Ves	Ves	No	Ves	Ves
0-10	10.0	20.0		1.0		2.0	10.0	24.0		1.0		0.0	10.0	100	100			100
2-1	15.5	25.5	3	1.5	5	3 2.5	5 10.5	20.5	3	1.5	3	5.5	5 15.	5 Yes	Yes	No	Yes	Yes
2-2	15.5	29.5	3	1.5		3 2.5	5 10.5	24.5	3	1.5	3	5.5	5 19.	5 Yes	Yes	No	Yes	Yes
2-3	15.5	25.5	3	1.5		3 2.5	5 10.5	20.5	3	1.5	3	5.5	5 15.	5 Yes	Yes	No	Yes	Yes
2-4	15.5	29.5	3	1.5		3 2.5	5 10.5	24.5	3	1.5	3	5.5	5 19.	D Yes	Yes	No	Yes	Yes
2-5	15.5	25.5	3	1.0		3 2.5	5 10.5	20.5		1.5	3	5.5	5 15.	5 Yes	Yes	No	Yes	Yes
2-0	15.5	29.5	3	1.0		2.0	5 10.5	24.5	3	1.5	3	5.5	19.	o res	Yes	No	Yes	Yes
2-1	15.5	20.0	3	1.0		2.0	5 10.5	20.5	3	1.5	3	5.5	5 10	5 Voc	Yes	No	Yes	Yes
2-0	15.5	25.5	3	1.5		3 2.0	5 10.5	24.0	3	1.5	3	5.5	5 15	5 Voe	Voe	No	Voe	Voe
2-0	15.5	20.5	3	1.5	, ,	3 2.0	5 10.5	20.5	3	1.5	3	5.5	5 10	5 Ves	Voc	No	Voc	Voc
2-10	15.5	20.0		1.5	, <u> </u>	5 2.0	10.0	24.0		1.5		0.0	10.	5 165	165	NO	165	100
1-1	15.5	25.5	3	1.5	1	3 25	5 10.5	20.5	3	15	3	5.5	5 15	5 Yes	Yes	No	Yes	Yes
1-2	15.5	29.5	3	1.5		3 25	5 10.5	24.5	3	1.5	3	5.5	5 19	5 Yes	Yes	No	Yes	Yes
1-3	15.5	25.5	3	1.5	5	3 2.5	5 10.5	20.5	3	1.5	3	5.5	5 15	5 Yes	Yes	No	Yes	Yes
1-4	15.5	29.5	3	1.5	5	3 2.5	5 10.5	24.5	3	1.5	3	5.5	5 19.	5 Yes	Yes	No	Yes	Yes
1-5	15.5	25.5	3	1.5	5 5	3 2.5	5 10.5	20.5	3	1.5	3	5.5	5 15.	5 Yes	Yes	No	Yes	Yes
1-6	15.5	29.5	3	1.5	5	3 2.5	5 10.5	24.5	3	1.5	3	5.5	5 19.	5 Yes	Yes	No	Yes	Yes
1-7	15.5	25.5	3	1.5	5 3	3 2.5	5 10.5	5 20.5	3	1.5	3	5.5	5 15.	5 Yes	Yes	No	Yes	Yes
1-8	15.5	29.5	3	1.5	5	3 2.5	5 10.5	24.5	3	1.5	3	5.5	5 19.	5 Yes	Yes	No	Yes	Yes
1-9	15.5	25.5	3	1.5	5 3	3 2.5	5 10.5	5 20.5	3	1.5	3	5.5	5 15.	5 Yes	Yes	No	Yes	Yes
1-10	15.5	29.5	3	1.5	5 5	3 2.5	5 10.5	5 24.5	3	1.5	3	5.5	5 19.	5 Yes	Yes	No	Yes	Yes

Fire Analysis Results – Columns

	Width	Initial Depth	Initial layers of Gyp (1/2 in unless noted)	Memb er fire rating	Initial hours fire rating	Char loss	Final Width	Final Depth	New resistan ce rating	Initial layers of Gyp (1/2 in unless noted)	Membe r fire rating	new char rate	Good at initial load	Good at ultimate Load	Good after 100->5 0
4-1	11.5	11.5	2	1	2	1.8	7.9	7.9		2	1		Yes	Yes	
4-2	11.5	11.5	2	1	2	1.8	7.9	7.9	Detail ana	2	1		Yes	Yes	
4-3	11.5	11.5	2	1	2	1.8	7.9	7.9	Detail ana	2	1		Yes	Yes	
4-4	13.625	13.625	2	1	2	1.8	10.025	10.025		2	1		Yes	Yes	
4-5	15.5	15.5	3	1.5	3	2.5	10.5	10.5	53375	3	1.5		Yes	Yes	
4-6	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail ana	3	1.5		Yes	Yes	
4-7	15.5	15.5	3	1.5	3	2.5	10.5	10.5	53375	3	1.5		Yes	Yes	
4-8	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail ana	3	1.5		Yes	Yes	
4-9	11.5	11.5	2	1	2	1.8	7.9	7.9	Detail and	2	1		Yes	Yes	
4-10	13.625	13.625	2	1	2	1.8	10.025	10.025		2	1		Yes	Yes	
4-11	11.5	11.5	2	1	2	1.8	7.9	7.9	Detail An	2	1		Yes	Yes	
4-12	11.5	11.5	2	1	2	1.8	7.9	7.9	Detail An	2	1		Yes	Yes	
3-1	15.5	15.5	3	1.5	3	2.5	10.5	10.5		3	1.5		Yes	Yes	Yes
3-2	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
3-3	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
3-4	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
3-5	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3 (5/8+1/2+1/2 = 100 minutes	1.33333	2.4	Yes	Yes	Yes
3-6	17.625	17.625	3	1.5	3	2.5	12.625	12.625	Detail An	3	1.5		Yes	Yes	Yes
3-7	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
3-8	17.625	17.625	3	1.5	3	2.5	12.625	12.625	Detail An	3	1.5		Yes	Yes	Yes
3-9	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
3-10	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3 (5/8+1/2+1/2 = 100 minutes	1.33333	2.4	Yes	Yes	Yes
3-11	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
3-12	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3	1.5		Yes	Yes	Yes
2-1	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	2			Yes	Yes	Yes
2-2	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	2			Yes	Yes	Yes
2-3	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	2			Yes	Yes	Yes
2-4	17.625	17.625	3	1.5	3	2.5	12.625	12.625	Detail An	2			Yes	Yes	Yes
2-5	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3 (5/8+1/2+1/2 = 100 minutes	1.33333	2.4	Yes	Yes	Yes
2-6	17.625	17.625	3	1.5	3	2.5	12.625	12.625	Detail An	2			Yes	Yes	Yes
2-7	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	3 (5/8+1/2+1/2 = 100 minutes	1.33333	2.4	Yes	Yes	Yes
2-8	17.625	17.625	3	1.5	3	2.5	12.625	12.625	Detail An	2			Yes	Yes	Yes
2-9	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	2			Yes	Yes	Yes
2-10	17.625	17.625	3	1.5	3	2.5	12.625	12.625	Detail An	2			Yes	Yes	Yes
2-11	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	2			Yes	Yes	Yes
2-12	15.5	15.5	3	1.5	3	2.5	10.5	10.5	Detail An	2			Yes	Yes	Yes
1-1	15.5	15.5	6 3	1.5	3	2.5	10.5	10.5	5	2	2		Yes	Yes	Yes
1-2	15.5	15.5	3	1.5	3	2.5	10.5	10.5	5	3 (5/8+1/2+1/2 = 100 minute	s 1.33333	2.4	Yes	Yes	Yes
1-3	15.5	15.5	i 3	1.5	3	2.5	10.5	10.5	5	3 (5/8+1/2+1/2 = 100 minute	s 1.33333	2.4	Yes	Yes	Yes
1-4	17.625	17.625	3	1.5	3	2.5	12.625	12.625	5	2	2		Yes	Yes	Yes
1-5	17.625	17.625	3	1.5	3	2.5	12.625	12.625	5	2	2		Yes	Yes	Yes
1-6	17.625	17.625	i 3	1.5	3	2.5	12.625	12.625	5	2	2		Yes	Yes	Yes
1-7	17.625	17.625	3	1.5	3	2.5	12.625	12.625	5	2	2		Yes	Yes	Yes
1-8	17.625	17.625	3	1.5	3	2.5	12.625	12.625	5	2	2		Yes	Yes	Yes
1-9	15.5	15.5	3	1.5	3	2.5	10.5	10.5	5	3 (5/8+1/2+1/2 = 100 minute	s 1.33333	2.4	Yes	Yes	Yes
1-10	17.625	17.625	3	1.5	3	2.5	12.625	12.625	5	2	2		Yes	Yes	Yes
1-11	15.5	15.5	i 3	1.5	3	2.5	10.5	10.5	5	2	2		Yes	Yes	Yes
1-12	15.5	15.5	3	1.5	3	2.5	10.5	10.5	5	3 (5/8+1/2+1/2 = 100 minute	s 1.33333	2.4	Yes	Yes	Yes

Fire Analysis Calculations – Option 2 CLT

	Lamination Fall-	Off Time		1	
Variable	Description	Calculatio	n	Units	
h_lam	Lamella thickness		1.375	in	
Bn	Char Rating		1.5	in/hr	
t_fo	Time to reach glued interface	e	54	min	
n_lam	Number of laminations that t	fal	1	laminations	
t	Required FRR		60	min	
	T.C	D /			
TT : 11	Effective Char	Depth		** 1.	
variable	Description	Calculatio	n 1.02	Units	
a_chai	Effective Char Depth		1.93	111	
	Effective Residual C	tross Section			
Variable	Description	Calculatio	n	Units	
h	Initial Cross-Section Depth		4.125	in	
h fire	Effective Cross-Section Dep	th	2.19	in	
_	Ply Effected - Manually Ente	er	2	ply	
	Section-Specific	e Loading and	l Dimer	nsions	
Floor				4	
Section:				1A-1	
Length			13		ft
Width			6		ft
Roof Live Load	(Lr)		20		psf
Ground snow lo	oad (S)		50		psf
Dead Loads - T	otal		14.10		psf
	Insulation on CLT (D)		3		psf
	Mechanical (D)		0		psf
-	CLT Self-Weight (D)		11.1		psf
TTT ¹ 1 (TTT)	Point Loads		0		<i>psf</i>
Wind (W)			0		mpn
Earthquake (E)			0		psi
Live Load (L)	, 		1		psi
	Act	tual Loadir	ıg		
Variable	Description		Calcu	lation	Units
[C1	D			14.10	nsf
				14.10	psr c
LC2	D+L			14.10	psi
LC3	D+(Lr or S or R)			64.10	psf
LC4	D + 0.75L + 0.75(L)	r or S or R		51.60	psf
LC5	D + (0.6W or 0.7E)			14.10	psf
LC6a	D + 0.75L + 0.75(0)	6W) + 0.7		51.60	nsf
LC6b	D + 0.75L + 0.75(0)	$7E) \pm 0.75$		51.60	psf
	D + 0.75L + 0.75(0.	(E) + 0.75		51.00	psi
LC7	0.6D + 0.6W			8.46	pst
LC8	0.6D + 0.7E			8.46	psf
	Imp	ortant Valı	ies		• •
Variable	Description		Cala	Ilation	Units
variable			Caret	induon	
M	Induced Bending M	oment (Fir		8124.68	lb-ft
V	Induced Shear (Fire)		3124.88	lb
n_lam	Number of lamination	ons that fal		1	laminations
_			I		

Fire Analysis Calculations – Option 2 Joist

Variable	Name	Value	Unit	S	Section-Specific Loading and I	Dimensions			
X-X Bendi	ng			Floor			4		
Fbx+	Bottom of Beam in Tension	2400	psi	Section:			1		
Fbx-	Top of Beam in Tension	1450	psi	Tributary Width		4.6875	ft		
Fcx	Compression Perpendicular to grain	600	psi	Roof Live Load (Lr)		20	psf		
				Reduced Roof LL		20	psf	93.75	plf
Fvx	Shear parallel to grain	300	psi	Ground snow load (S)		50	psf	234.375	plf
Ex	Modulus of elasticity	1900000	psi	Dead Loads - Total		27.7	psf	163.409375	plf
Ex app	Modulus of elasticity (applied)	1800000	psi		Insulation on CLT (D)	9	psf		
Emin	Modulus of elasticity (min) = 0.528Exapp	950400	psi		MEP Allowance (D)	5	psf		
Y-Y Bendi	ng				Roofing Membrane	1	psf		
Fby+	Bottom of Beam in Tension	2400	psi		Misc. Hung Ceiling	1.6	psf		
Fby-	Top of Beam in Tension	1450	psi		CLT Weight (D)	11.1	psf		
Fcy	Compression Perpendicular to grain	600	psi		Glulam Self-weight	35	pcf	22.465625	plf
					Gyp weight	4	psf	11.1	plf
Fvy	Shear parallel to grain	300	psi	Wind (W)		0	mph		
Ey	Modulus of elasticity	1900000	psi	Earthquake (E)		0	psf	0	plf
Ey app	Modulus of elasticity (applied)	1800000	psi	Live Load (L)		0	psf	0	plf
					Actual Loading				
Axial Load	ling			Variable	Description	Calculation	Units		
Fc	Compression parallel to grain	2300	psi	LC1	D	27.7	psf	163.409375	plf
Ft	Tension parallel to grain	1600	psi	LC2	D+L	27.7	psf	163.409375	plf
Ea	modulus of elasticity	1900000	psi	LC3	D+(Lr or S or R)	77.7	psf	397.784375	plf
CD		1.15	-	LC4	D + 0.75L + 0.75(Lr or S or	65.2	psf	339.190625	plf
СМ		1	-	LC5	D + (0.6W or 0.7E)	27.7	psf	163.409375	plf
Ct		1	-	LC6a	D + 0.75L + 0.75(0.6W) + 0	65.2	psf	339.190625	plf
Cfu		1	-	LC6b	D + 0.75L + 0.75(0.7E) + 0.7	65.2	psf	339.190625	plf
Cc		1	-	LC7	0.6D + 0.6W	16.62	psf	98.045625	plf
Cb		1	-	LC8	0.6D + 0.7E	16.62	psf	98.045625	plf
CI		1	-						
Cvr		1	-		Allowable Deflection	1			
E'x		1800000	psi	Variable	Description	Calculation	Units		
E'xmin		1450	psi	Delta L	L/360	0.04583333333	ft		
				Delta S	L/360	0.04583333333	ft		
				Delta D+L	L/240	0.06875	ft	1	

Member Lengths and Properties

Variable		Value	Unit
1		16.5	ft
b		7.9	in
d		11.7	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		92.43	in^2
Sxx		180.2	in^3
Ixx		1054.4	in^4
Isupport		6	in

	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		5.265	
FBe		63	psi

Fire Analysis Calculations – Option 2 Girder Post Fire 1

	Member Lengths and Properties	5	
Variable		Value	Unit
1		25	ft
b		11.9	in
d		15.9	in
р	density	35	pcf
SG	Specific gravity	0.46	
Ag		189.21	in^2
Sxx		501.4	in^3
Ixx		3986.2	in^4
Isupport		6	in
	Beam Stability Factor		
Variable		Value	Unit
Fbx+*		2760	psi
lu		96	in
le		148	in
RB		4.074	
FBe		105	psi
CL			

Loading					
Point Load 1 - left					
S	ection-Specific Loading and I	Dimensions			
Joist Number		4	4-1		
Joist b		7.9	in		
joist d		11.7	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area		4.6875	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	20	psf	773.4375	lbs
Ground snow load (S)		50	psf	1933.59375	lbs
Dead Loads - Total		27.7	psf	1348.127344	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	11.1	psf		
	Joist Weight	35	pcf	185.3414063	lbs
	Gyp weight	4	psf	91.575	lbs
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	0	psf	0	lbs
	Actual Loading	1			
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	1348.13	lbs
LC2	D+L	27.7	psf	1348.13	lbs
LC3	D+(Lr or S or R)	77.7	psf	3281.72	lbs
LC4	D + 0.75L + 0.75(Lr or S or	65.2	psf	2798.32	lbs
LC5	D + (0.6W or 0.7E)	27.7	psf	1348.13	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	65.2	psf	2798.32	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psf	2798.32	lbs
LC7	0.6D + 0.6W	16.62	psf	808.88	lbs
LC8	0.6D + 0.7E	16.62	psf	808.88	lbs

Point Load 2 - Middle					
Se	ection-Specific Loading and I	Dimensions			
Joist Number			4-2		
Joist b		7.9	in		
joist d		15.7	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area		15.625	ft		
Roof Live Load (Lr) (enter	r reduced load if reduced)	18.84375	psf	2429.077148	lbs
Ground snow load (S)		50	psf	6445.3125	lbs
Dead Loads - Total	1	27.7	psf	3932.984115	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Celling	1.0	psj		
	CLI Weight (D)	25	psf	248 7050806	lbc
	Gyn weight	4	per	113 575	lbs
Wind (W)	Gyp weight		mph	115.575	105
Earthquake (E)		0	psf		
Live Load (L) (enter reduc	ed load if reduced)	0	psf	0	lbs
	Actual Loading				
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	3932.98	lbs
LC2	D+L	27.7	psf	3932.98	lbs
LC3	D+(Lr or S or R)	77.7	psf	10378.30	lbs
LC4	D + 0.75L + 0.75(Lr or S or)	65.2	psf	8766.97	Ibs
LC5	D + (0.6W or 0.7E)	27.7	psf	3932.98	lbs
LC6a	D + 0.75L + 0.75(0.6W) + 0.000	65.2	pst	8/66.9/	Ibs
	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psi	8/66.9/	Ibs
	$0.6D \pm 0.7E$	16.62	psi	2359.79	lbs
		10.02	Por	2003113	100
Point Load 3 - Right					
S	ection-Specific Loading and I	Dimensions	1.2		
Joist Number			4-3		
Joist b		7.9	in		
joist d		13.7	in		
Girder Tributary Width		8.25	ft		
CLT Tributary Area	n understand land (funderstand)	4.0873	tt	772 4275	llee
Ground snow load (S)	r reduced load II reduced)	20	psi	1922 59275	lbs
Dead Loads - Total		29.7	psi	1468 153385	lbs
Dend Donab Total	Insulation on CLT (D)	9	psf	11001100000	100
	MEP Allowance (D)	5	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	13.1	psf		
	Joist Weight	35	pcf	217.0236979	lbs
	Gyp weight	4	psf	102.575	plf
Wind (W)		0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter reduced load if reduced)		0	psf	0	lbs
Actual Loading					
Variable	Description	Calculation	Units		
LC1	D	29.7	psf	1468.15	lbs
LC2	D+L	29.7	psf	1468.15	lbs
LC3	D+(Lr or S or R)	79.7	psf	3401.75	Ibs
LC4	D + 0.75L + 0.75(Lr or S or)	67.2	pst	2918.35	Ibs
LC5	D + (0.6W or 0.7E)	29.7	pst	1468.15	Ibs
LC6a	D + 0.75L + 0.75(0.6W) + 0	67.2	pst	2918.35	Ibs
LC6b	D + 0.75L + 0.75(0.7E) + 0.7	67.2	pst	2918.35	Ibs
LC7	0.6D + 0.6W	17.82	pst	880.89	Ibs
111 A	IUDUTU/E	1/.82	LOST	880.89	LIUS

Uniform Load f	rom Glulam Self weight				
	Section-Specific Lo	oading and Dimens	sions		
Floor			4		
Section:			1A - 1		
Dead Load - from	Glulam self weight +gyp	35	pcf	65.85520833	plf
	Gyp weight	4	psf	19.86666667	plf
Wind (W)		0	mph		
Earthquake (E)		0	psf		

	Actua	l Loading				
Variable	Description	Calculation	Units	Total DL (lbs)	Total LL (lbs)	Total Roof SL (lbs
LC1	D	8395.65	lbs	0	0	0
LC2	D+L	8395.65	lbs	0	0	0
LC3	D+(Lr or S or R)	18708.15	lbs	8395.645052	0	3975.952148
LC4	D + 0.75L + 0.75(Lr or S or R)	16130.02	lbs	0	0	0
LC5	D + (0.6W or 0.7E)	8395.65	lbs	0	0	0
LC6a	D + 0.75L + 0.75(0.6W) + 0.75(L)	16130.02	lbs	0	0	0
LC6b	D+0.75L+0.75(0.7E)+0.75S	16130.02	lbs	0	0	0
LC7	0.6D + 0.6W	5037.39	lbs	0	0	0
LC8	0.6D + 0.7E	5037.39	Ibs	0	0	0

Cd	Load Duration Factor	0.9	
Cm	Wet Service Factor	1	
Ct	Temperature Factor	1	
Cc	Curvature Factor	1	
Ci	Incising Factor	1	
Fb*	Fb*Cd*Cm*Ct*Cc*Ci	2160	
CL			
Lu	length (inches)	300	
Le	1.63Lu+3D	536.7	
Rb	sqrt((le*d)/b^2)	7.762782147	
Emin'	Emin*Cm*Ct	950400	
Fbe	(1.2*Emin')/(Rb^2)	18925.74032	
Cfu		1	
CL	look at nds	0.9936451077	
CV	look at nds	0.81	
Fire Resistance	Adjustment Factor	1	0.86
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*C	1749.6	psi
Ultimate F'b	x2.85	4986.36	psi
Allowable Mom	ent	73105.07	ft-lb
Ultimate Allowa	ble Moment	208349.44	ft-lb
Moment		70009.29	ft-lb
Adjusted Shear	Parallel to Grain Design Value (F		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	6012.338411	lb
Actual fv	3V/2bd	6863.617657	psf

Fc perp							
Cb	Bearing Area Factor	1					
CMV	Wet Service Factor	1	NDS Supplement Table 4A				
Ct	Temperature Factor	1	NDS Table 2.3.2				
Fc perp		600	psi				
Reaction forces	1/2 * wl	6012.338411	lb				
Fc actual		84.20642033	psi				
Adjusted Modul	as of Elasticity (E')						
CME	Wet Service Factor	1	NDS Supplement Table 4A				
CtE	Temperature Factor	1	NDS Table 2.3.3				
CiE	Incising Factor	1	NDS Table 4.3.8				
E'	E*CME*CtE*CiE	1800000					
Manual pg 72							
	Actual	Deflection					
Variable	Description	Calculation	Units				
Delta L	See next column	0.01586912554	ft				
Delta S	See next column	0.04210713243	ft				
Delta D+L	See next column	0.02259149812	ft				
	Allowable Deflection						
Variable	Description	Calculation	Units				
Delta L	L/360	0.06944444444	ft				
Delta S	L/360	0.06944444444	ft				
Delta D+L	L/240	0.1041666667	ft				

Fire Analysis Calculations – Option 2 Girder Post Fire 2

Member Lengths and Properties						
Variable		Value	Unit			
1		25	ft			
b		8.3	in			
d		12.3	in			
р	density	35	pcf			
SG	Specific gravity	0.46				
Ag		102.09	in^2			
Sxx		209.3	in^3			
Ixx		1287.1	in^4			
Isupport		6	in			
	Beam Stability Factor					
Variable		Value	Unit			
Fbx+*		2760	psi			
lu		96	in			
le		148	in			
RB		5.138				

	FBe			66 psi	
	CL				
Loading					
Point Load 1 - left					
	Section-Specific Loading and I	Dimensions			
Joist Number			4-1		
Joist b		7.9	in		
joist d		11.7	in		
Girder Tributary Wid	th	8.25	ft		
CLT Tributary Area		4.6875	ft		
Roof Live Load (Lr)	(enter reduced load if reduced)	20	psf	773.4375	lbs
Ground snow load (S)	50	psf	1933.59375	lbs
Dead Loads - Total	,	27.7	psf	1348.127344	lbs
	Insulation on CLT (D)	9	psf		
	MEP Allowance (D)	5	psf		
	Roofing Membrane	1	psf		
	Misc. Hung Ceiling	1.6	psf		
	CLT Weight (D)	11.1	psf		
	Joist Weight	35	pcf	185.3414063	lbs
	Gyp weight	4	psf	91.575	lbs
Wind (W)	· ·	0	mph		
Earthquake (E)		0	psf		
Live Load (L) (enter	reduced load if reduced)	0	psf	0	lbs
	Actual Loading		1		
Variable	Description	Calculation	Units		
LC1	D	27.7	psf	1348.13	lbs
LC2	D+L	27.7	psf	1348.13	lbs
LC3	D+(Lr or S or R)	77.7	psf	3281.72	lbs
LC4	D + 0.75L + 0.75(Lr or S or	65.2	psf	2798.32	lbs
LC5	D + (0.6W or 0.7E)	27.7	psf	1348.13	lbs
LC6a	D+0.75L+0.75(0.6W)+0	. 65.2	psf	2798.32	lbs
LC6b	D + 0.75L + 0.75(0.7E) + 0.	65.2	psf	2798.32	lbs
LC7	0.6D + 0.6W	16.62	psf	808.88	lbs
LC8	0.6D + 0.7E	16.62	psf	808.88	lbs

Image: Section of the	Point Load 2 - Middle								
Joat hImage of the set of the	Se	ection-Specific Loading and I	Dimensions						
Joarb70inIndjaitd157inInGade Tributary Wath1.823ftInCIT Tributary Area1.8335ftInGade Tributary Call Cart1.83457ppf2420.07148IbsGround acow load (S)52ppf6445.3125IbsDand Loads- TotalInsulation on CLT (O)9.076445.3125IbsDand Loads- TotalInsulation on CLT (O)9.076445.3125IbsDand Loads- TotalInsulation on CLT (O)9.076445.3125IbsMarce Hang Celling1.59.071.011.01Roofing Machine1.59.071.01IbsMarce Hang Celling1.59.071.011.01NameRoofing Machine1.59.071.01Marce Hang Celling1.59.071.011.01Cart Cart Hangling (D)1.019.01.011.01Cart Cart Hangling (D)0.001.011.01Cart Cart Hangling (D)1.01001.01Cart Cart Cart Cart Cart Cart Cart Cart	Joist Number		-	4-2					
jaidinlenkGide Tributary Wath8.23ftInGide Tributary Yana15.63ft1429.07148ItsRoof Lev Cloud (L) (entr reduced loal if reduced)9.84375opf6445.312ItsSroud now Yok Mark27.0p.ff3932.984115ItsDand Loads - Total0.72p.ff3932.994115ItsMEZ Alloware (D)3.94p.ff1.00ItsMEZ Alloware (D)0.9p.ffItsItsMEZ Alloware (D)0.9p.ffItsItsMEZ Alloware (D)0.9p.ffItsItsMEZ Alloware (D)0.9p.ffItsItsMark May8.8p.ff248.7099.96ItsNaidel (E)0.01p.ffItsItsLev Load (L) (enter reduced)0p.ffItsKerta LandsD.112.77p.ff3932.98ItsLC1D1.27.7p.ff3932.98ItsLC2D-L2.77p.ff3932.98ItsLC3D.127.7p.ff3932.98ItsLC4D+0.75L+0.75L.075G52p.ff3932.98ItsLC5D+0.60 W 0.752.77p.ff1037.33ItsLC4D+0.75L+0.75L.075L.762.77p.ff3932.98ItsLC5D+0.60 W 0.752.77p.ff1037.33ItsLC6D+0.75L+0.75L.075L.762.77p.ff3932.98Its <td>Joist b</td> <td></td> <td>7.9</td> <td>in</td> <td></td> <td></td>	Joist b		7.9	in					
Ginder Turbinary WidthI.S. 19f.I.S. 20f.I.S. 20G.I.S. 20G.I.S. 20G. <td>joist d</td> <td></td> <td>15.7</td> <td>in</td> <td></td> <td></td>	joist d		15.7	in					
CLT Thready Area15.62nnNReaf Live Load (L.) (were vere vere vere vere vere vere vere	Girder Tributary Width		8.25	ft					
Roof Live Load (L) (enter reduced) online (T)9.89.49.49.49.49.49.49.49.49.49.49.29.49.2 <td>CLT Tributary Area</td> <td></td> <td>15.625</td> <td>ft</td> <td></td> <td></td>	CLT Tributary Area		15.625	ft					
Ground unow load (S) → V950p.f.6443.31.2lisDaed Loads - TotalInsulation on CLT (D)09.473392.984.115lisMacR Hong Cenfurg	Roof Live Load (Lr) (enter	reduced load if reduced)	18.84375	psf	2429.077148	lbs			
Dead Loads - Totalmutators on CLT (D)opf9332.984115bisMEP - Allowance (D)SptfMEP - Allowance (D)SptfMice - Hang Celling10ptfMice - Hang Celling10ptfLet May Celling10ptfGiri Weight35pcf245.705966ItsGroup Weight0pffWind (W)00pff0Let Load LC) (enter rebreet load if reduced)0pff0Natable (E)0pff3932.98ItsLet Load LC) (enter rebreet load if reduced)0pff3932.98ItsLC1D27.7pff3932.98ItsLC2D+L27.7pff3932.98ItsLC3D+L ers Ser R)77.7pff3932.98ItsLC4D + 0.75L + 0.75(L or S or65.2pf8766.97ItsLC5D + 0.6W ero 7.E2.2pf3932.98ItsLC6D + 0.75L + 0.75(L or S or65.2pf8766.97ItsLC6D + 0.75L + 0.75(L or S or16.62pf2259.79ItsLC6D + 0.75L + 0.75(L or S or16.62pf2259.79ItsLC6D + 0.75L + 0.75(L or S or16.62pf2259.79ItsLC6D + 0.75L + 0.75(L or S or16.62pf2259.79ItsLC70.6	Ground snow load (S)		50	psf	6445.3125	lbs			
Image in the second of the	Dead Loads - Total		27.7	psf	3932.984115	lbs			
MEP allowane (D)SprfNRogling MontaneIprfIMasc. Hang CeilingI.6prfIL2T Weight (D)IIIprfIJoirt Weight35pcf248.7039806IisGuny Roglin4prfIII.5.75IisKind (W)0prfIII.5.75IisLardiquake (D)0prf0IisLardiquake (D)0prf0IisLive Load (L) (enter relevation of reduced)0prf0LC1D27.7prf3932.98LC2D+L27.7prf13932.30LC3D+L cor S or R)77.7prf13932.30LC4D+0.751 + 0.75(L or S or65.2prf3932.98LC5D +0.06W or O.72)27.7prf3932.98LC6D +0.751 + 0.75(O.6W) +065.2prf38766.97LC6D +0.751 + 0.75(O.6W) +065.2prf2359.79LC6D +0.6W16.62prf2359.79LC70.6D + 0.7E16.62prf2359.79Iost Sumber13.7iin14.11Joirt b14.11iin14.11Joirt b14.11iin14.11Joirt b14.11iin14.11Joirt b14.11iin14.11Joirt Codd J - Right14.11iin14.11Joirt Codd J - Right14.11iin14.11Joirt b14.11		Insulation on CLT (D)	9	psf					
Roding MembraneIppfppfppfLC1 Regin (D)U.UppfPIoat Weight35op248.703996IsIoat Weight36oppf18.157IsWind (W)Ioa0ppfIsIsEarthque (E)Ioa0opIsIsKind (W)Ioa Service0opIsIsKind (W)Ioa Service0pf18IsCallDescriptionCalueTotal3932.98IsIC1DCalue27.7pf3932.98IsIC2D+LC3.77pf3932.98IsIC3D+1.075.1C3.77pf3932.98IsIC4D+0.75.10.72.7pf3932.98IsIC5D+0.6W or 07.10G5.2pf3932.98IsIC6D+0.75.10.50.2pf3932.98IsIC6D+0.75.10.50.2pf3932.98IsIC6D-0.75.10.50.2pf3932.98IsIC70.6D + 0.6W0.62.2pf2359.79IsIC6D-0.75.10.50.2pf3932.98IsIC70.6D + 0.7EISpf3932.98IsIC6D-0.6W0.7EISpf3932.98IsIC7ISISISISIsIsIC6DISpfISIsIsI		MEP Allowance (D)	5	psf					
Max. Hung Celling1.6pcf1.0CLT Weight (D)0.019pf100Joint Weight3.69pf248.705906Iba09pf1113.575Brachquake (D)09pf1113.575Live Load (L) (enter retwee Iosal if reduces)09pf100VariableDescriptionCalculation100Live Load (L) (enter retwee Iosal if reduces)09pf3932.98Live Load (L) (enter retwee Iosal if reduces)01015LC1D27.7pf3932.98LC2D+L27.7pf3932.98LC3D+L (or S or R)77.7pf10378.30LC4D+0.751 + 0.750.680) +065.2pf8766.97LC5D +0.751 + 0.750.690) +065.2pf8766.97LC6D +0.751 + 0.750.07D) +065.2pf8766.97LC6D +0.751 + 0.750.07D) +065.2pf2359.79LC6D +0.751 + 0.750.07D) +065.2pf2359.79LC6D +0.751 +0.750.07D) +016.20pf2359.79LC70.6D +0.6W16.62pf2359.79LC80.6D +0.7E16.62pf2359.79LC80.6D +0.7E16.62pf2359.79Joist bT16.62pf2359.79Joist bT16.62pf2359.79Joist bT16.62pf2359.79Joist bT16.62pf2359.79<		Roofing Membrane	1	psf					
CLT Weight (D)IIIprf248.009806ItsIoits Weight4pcf248.009806ItsWind (V)0mph111.557ItsEarthquake (E)0ppf00ItsLev Load (L) tenter returned is freduced)0ppf0ItsMinikeCaculationUnitsLev Load (L) tenter returned is freduced)010073932.08ItsLC1D27.7pcf3932.08ItsLC3D+L cor S or R)77.7pcf10378.30ItsLC4D + 0.75L + 0.75(L tor S or65.2pcf8766.97ItsLC5D + 0.75L + 0.75(O, TC) + 065.2pcf8766.97ItsLC6D + 0.75L + 0.75(O, TC) + 065.2pcf2359.79ItsLC60.6D + 0.75L + 0.75(O, TC) + 065.2pcf2359.79ItsLC60.6D + 0.75L + 0.75(O, TC) + 065.2pcf2359.79ItsLC70.6D + 0.6W16.62pcf2359.79ItsLC80.6D + 0.75L + 0.75(O, TC) + 065.2pcf2359.79ItsLC80.6D + 0.75L + 0.75(O, TC) + 065.2pcf2359.79ItsLC80.6D + 0.75L + 0.75(O, TC) + 065.2pcf2359.79ItsJoit Number		Misc. Hung Ceiling	1.6	psf					
joist Weight95pef248.7059896[bsWind (W)0000000Earthquake (E)000 <td></td> <td>CLT Weight (D)</td> <td>11.1</td> <td>psf</td> <td></td> <td></td>		CLT Weight (D)	11.1	psf					
Gyp weight(A)(Ppf(113.575)(bs)Wind (W)00ppf00Larhaquake (E)00ppf00Live Load (L) (enter reduced)00000VariableBeeriptionCalculationUraits00LC1D+L27.7psf3932.9800LC3D+L27.7psf10373.8000LC4D+L27.7psf13932.9800LC3D+L7.77psf10373.8000LC4D+0.75L+0.75(0.6V) 0.52.2psf8766.9710sLC5D+0.6W0.75.2psf8766.9710sLC6D+0.75L+0.75(0.6V) 0.65.2psf8766.9710sLC6D+0.75L+0.75(0.6V) 0.65.2psf2359.7910sLC70.6D +0.6W16.62psf2359.7910sLC80.6D +0.7E16.62psf2359.7910sLC80.6D +0.7E7.9714.6210.1210.12joist 1T7.97psi14.8310.1210.12joist 2Specific Loading and Timeusions10.1210.1210.12joist 4F7.97psf14.83.1310.12joist 4Specific Loading and Timeusions10.1210.1210.12joist 4F7.97psf14.83.1310.12joist 5F7.97		Joist Weight	35	pcf	248.7059896	lbs			
Wind (W)ImpImpImpImpEarthquake (E) (utter returned load if reduced)0pgf00Live Load (.) (utter returned load if reduced)0000VariableDescriptionCalculationUnits0LC1D2.7.7pf3.932.9810sLC2D+L2.7.7pf3.932.9810sLC3D+(L or S or R)2.7.7pf3.932.9810sLC4D +0.7SL +0.7.5(L or S or 66.5.2pf8.766.9710sLC5D +0.0ST +0.7.5(L or S or 65.2pf8.766.9710sLC6D +0.7SL +0.7.5(D +06.5.2pf8.766.9710sLC6D +0.7SL +0.7.5(D +06.5.2pf8.766.9710sLC6D +0.7SL +0.7.5(D +06.5.2pf8.766.9710sLC70.6D +0.7E16.62pf2.359.7910sJoit D0.6D +0.7E16.62pf2.359.7910sJoit SD.6D +0.7E16.62pf3.769.7910sJoit D0.6D +0.7E7.7310s10s10sJoit SD.6D +0.7E16.62pf10s10sJoit SD.6D +0.7E7.7310s10s10sJoit SD.6D +0.7E7.7310s10s10sJoit SD.6D +0.7E7.7310s10s10sJoit SD.6D +0.7E7.7310s10s10sJoit S<		Gyp weight	4	psf	113.575	lbs			
Earthquake (E)(b)(c)(c)Live Load (L) (enter reluced load if reduced)(c)(c)(c)(c)VariableDescriptionCalculationVaris(c)LC1D2.7.7psf3932.98(b)LC2D+L2.7.7psf3932.98(b)LC3D+U.T or S or R)7.7.7psf3932.98(b)LC4D+0.7SL + 0.7S(L or S or6.5.2psf8766.97(b)LC5D + (0.0W or 0.7E)2.7.7psf3932.98(b)LC6D + 0.7SL + 0.7S(0.6W) + 06.5.2psf8766.97(b)LC6D + 0.7SL + 0.7S(0.7E) + 06.52psf8766.97(b)LC70.6D + 0.6W16.62psf2359.79(b)LC80.6D + 0.7E10.62psf2359.79(b)LC80.6D + 0.7E10.62psf2359.79(b)LC70.6D + 0.6W16.62psf2359.79(b)LC80.6D + 0.7E10.62psf2359.79(b)LC70.6D + 0.6W16.62psf2359.79(b)LC80.6D + 0.7E13.7in11Joist Momber4.875ft11Joist J14.814.814.814.814.8Joist L 2.04 (L1 relutary Area2.97psf14.815.8C1 Tributary MAC2.97psf14.815.8C1 Tributary MAC2.97psf14.	Wind (W)		0	mph					
Live Load (L) (enter reture load if reduced)0ppf0bsActual LoadingUnitsLC1D27.7pf3932.98bsLC2D+L27.7pf3932.98bsLC3D+Lf or S or R)77.7pf1078.30bsLC4D + 0.75L + 0.75(Lr or S or65.2pf8766.97bsLC5D + (0.6W or 0.7E)27.7pf3932.98bsLC6D + 0.75L + 0.75(0.6W) +065.2pf8766.97bsLC6D + 0.75L + 0.75(0.7E) +0.65.2pf2359.79bsLC6D + 0.75L + 0.75(0.7E) +0.65.2pf2359.79bsLC6D + 0.75L + 0.75(0.7E) +0.65.2pf2359.79bsLC70.6D + 0.7E116.62pf2359.79bsLC80.6D + 0.7E7.9in1.01.0JC8J6.8J6.81.01.01.0JC70.6D + 0.7E7.9in1.01.0JC8J6.8J6.81.01.01.0JC8J6.8J6.81.01.01.0J0ist JT7.9j61.01.0J0ist QJ6.9J6.9J6.9J6.9J6.9J0ist QJ6.9J6.9J6.9J6.9J6.9J0ist QJ6.9J6.9J6.9J6.9J6.9J0ist QJ6.9J6.9J6.9J6.9J6.9J0ist Q </td <td>Earthquake (E)</td> <td></td> <td>0</td> <td>psf</td> <td></td> <td></td>	Earthquake (E)		0	psf					
Variable Variable Variable Description Calculation Unit LC1 D 27.7 pcf 3932.98 lbs LC2 D+L 27.7 pcf 3932.98 lbs LC3 D+(L or S or R) 77.7 pcf 3932.98 lbs LC4 D +0.7SL +0.75(L or S or 65.2 pcf 3766.97 lbs LC6 D +0.7SL +0.75(0.7E) +0 65.2 pcf 3766.97 lbs LC6 D +0.7SL +0.75(0.7E) +0 65.2 pcf 2359.79 lbs LC7 0.6D +0.6W 116.62 pcf 2359.79 lbs LC8 0.6D +0.7E 16.62 pcf 2359.79 lbs Sist S Sector-Specific Loading and Demonsions 16.2 pcf 2359.79 lbs Joist D Sector-Specific Loading and Demonsions 16.3 in 16.3 16.3 Joist D Ground snow load (L3) Sin 16.3 16.3	Live Load (L) (enter reduc	ed load if reduced)	0	psf	0	lbs			
Variable Description Calculation Units LC1 D 27.7 prf 3932.98 hs LC2 D-L 27.7 prf 3932.98 hs LC3 D+(L or S or R) 77.7 prf 10378.30 hs LC4 D - 0.7SL - 0.7S(L or S or 65.2 prf 8766.97 hs LC5 D + 0.06W or 0.7D: 27.7 prf 8766.97 hs LC6 D + 0.7SL + 0.7S(0.7E) + 0. 65.2 prf 8766.97 hs LC6 D + 0.7SL + 0.7S(0.7E) + 0. 65.2 prf 2359.79 hs LC7 0.6D + 0.7E 16.62 prf 2359.79 hs LC8 0.D + 0.7E 16.82 prf 2359.79 hs Joist Number 4.3 in 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015 1015		Actual Loading	L						
LC1 D 27.7 psf 3932.98 bs LC2 D+L 27.7 psf 3932.98 bs LC3 D+Lr or S or R) 77.7 psf 3932.98 bs LC4 D + 0.75L + 0.75(Lr or S or 65.2 psf 8766.97 bs LC5 D + 0.6W or 0.7E) 27.7 psf 3932.98 bs LC6 D + 0.7SL + 0.75(0.6W)+0 65.2 psf 8766.97 bs LC6 D + 0.7SL + 0.75(0.7E) + 0. 65.2 psf 2359.79 bs LC7 0.6D + 0.7E 16.62 psf 2359.79 bs LC8 0.6D + 0.7E 14.37 in	Variable	Description	Calculation	Units					
LC2 D+L 27.7 pf 3932.98 lbs LC3 D+(L or S or R) 77.7 psf 10378.30 lbs LC4 D+(0.75L+0.75(L or S or 65.2 psf \$766.97 lbs LC5 D+(0.6W or 0.7E) 27.7 psf 3932.98 lbs LC6a D+0.75L+0.75(0.7E)+0 65.2 psf \$766.97 lbs LC7 0.6D+0.6W 16.62 psf 2359.79 lbs LC7 0.6D+0.7E 16.62 psf 2359.79 lbs LC8 0.6D+0.7E 16.62 psf 2359.79 lbs Joist Mumber 4.3 in	LC1	D	27.7	psf	3932.98	lbs			
LC3 D+(L or S or R) 77.7 pcf 10378.30 lbs LC4 D + 0.75L + 0.75(Lr or S or 65.2 pcf 8766.97 lbs LC5 D + 0.05W or 0.75 lp 27.7 pcf 3932.98 lbs LC6a D + 0.75L + 0.75(0.6W) + 0 65.2 pcf 8766.97 lbs LC6b D + 0.75L + 0.75(0.7E) + 0. 65.2 pcf 8766.97 lbs LC7 0.6D + 0.7E 16.62 pcf 2359.79 lbs LC8 0.6D + 0.7E 16.62 pcf 2359.79 lbs Point Lcad 3 - Right 7.9 in 1063 Joist Number 1.37 Joist b 7.7 joist 1 10.7 Grider Tributary Mea 8.25 ft	LC2	D+L	27.7	psf	3932.98	lbs			
LC4 D + 0.75L + 0.75(L or S or 65.2 psf 3766.97 lbs LC5 D + (0.6W or 0.7E) 27.7 psf 3932.98 lbs LC6a D + 0.75L + 0.75(0.0W) + 0 65.2 psf \$766.97 lbs LC6b D + 0.75L + 0.75(0.7E) + 0. 65.2 psf \$376.97 lbs LC7 0.6D + 0.7E 16.62 psf 2359.79 lbs Point Load 3 - Right	LC3	D+(Lr or S or R)	77.7	psf	10378.30	lbs			
LC5 D + (0.6W re 0.7E) 27.7 psf 3936.298 [bs LC6a D + 0.7SL + 0.7S(0.6W) + 0 65.2 psf 8766.97 [bs LC6b D + 0.7SL + 0.7S(0.7E) + 0. 65.2 psf 2359.79 [bs LC7 0.6D + 0.7E 16.62 psf 2359.79 [bs LC8 0.6D + 0.7E 16.62 psf 2359.79 [bs Point Load 3 - Right - - - - - Joist Number - 4.3 - - - Joist M 8.25 ft -	LC4	D + 0.75L + 0.75(Lr or S or)	65.2	psf	8766.97	lbs			
LC6a D + 0.75L + 0.75(0.6W) + 0 65.2 pf 8766.97 lbs LC6b D + 0.75L + 0.75(0.7E) + 0. 65.2 psf 8766.97 lbs LC7 0.6D + 0.7E 16.62 psf 2359.79 lbs LC8 0.6D + 0.7E 16.62 psf 2359.79 lbs Point Load 3 - Right	LC5	D + (0.6W or 0.7E)	27.7	psf	3932.98	lbs			
LC6b D + 0.75L + 0.75(0.7E) + 0. 65.2 pf 8766.97 [bs LC7 0.6D + 0.6W 16.62 pf 2359.79 [bs LC8 0.6D + 0.7E 16.62 pf 2359.79 [bs Point Load 3 - Right Joist Number Joist Sumber Joist b 7.9 In 1 Girder Tributary Width 8.25 Grider Tributary Width 8.25 Grider Tributary Width 8.25 Colspan="2">Grider Tributary Width Colspan="2">Colspan="2" Colspan="2"Colspan="2	LC6a	D + 0.75L + 0.75(0.6W) + 0	65.2	psf	8766.97	lbs			
LC7 0.6D + 0.6W 16.62 psf 22359.79 lbs LC8 0.6D + 0.7E 16.62 psf 23359.79 lbs Point Load 3 - Right Section-Specific Loading and Dimensions Joist Number 4-3 Image: Section-Specific Loading and Dimensions Joist Mumber 191 Joist Mumber 9 Image: Section Specific Loading and Dimensions Gerupt colspan= 2 Posf 173.4375 lbs Image: Section Specific Loading Mumbrane 1 po	LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	65.2	psf	8766.97	Ibs			
LCS $0.6D + 0.7E$ 16.62 psf 2359.79 lbs Point Load 3 - Right Section-Specific Loading and Dimensions $4-3$ -10 Joist Number $4-3$ -10 -10 -10 Joist b 7.9 in -10 -10 Girder Tributary Width 8.25 ft -100 -100 -1000 $-1000000000000000000000000000000000000$	LC7	0.6D + 0.6W	16.62	psf	2359.79	Ibs			
Point Load 3 - RightImage: Section-Specific Loading and DimensionsSection-Specific Loading and DimensionsJoist bJoist bJoist bJoist bJoist bJoist bColspan="2">Joist bColspan="2">Colspan="2"Joist bColspan="2">Colspan="2"Colspan="2">Colspan="2"Colspa	LC8 0.6D + 0.7E		16.62	psf	2359.79	lbs			
Section-Specific Loading and Dimensions Identify the section of the section	Point Load 3 - Right								
Joist Number 4-3 4-3 Joist b 7.9 in 1000000000000000000000000000000000000	Se	ection-Specific Loading and I	Dimensions						
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Joist Number			4-3					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Joist b		7.9	in					
Girder Tributary Width 8.25 ft Image: constraint of the second seco	joist d		13.7	in					
CLT Tributary Area 4.6875 ft Image: constraint of the second	Girder Tributary Width		8.25	ft					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	CLT Tributary Area		4.6875	ft					
Ground snow load (S) 50 psf 1933.59375 lbs Dead Loads - Total 29.7 psf 1468.153385 lbs MEP Allowance (D) 5 psf MEP Allowance (D) 5 psf Main Ambrane 1 psf Misc. Hung Ceiling 1.6 psf Joist Weight 35 pcf 217.0236979 lbs Gyp weight 4 psf 102.575 plf Wind (W) 0 mph Live Load (L) (enter reduced load if reduced) 0 psf 0 lbs Actual Loading Variable Description Calculation Units LC2 D+L 29.7 psf 1468.15 lbs LC3 D+(Lr or S or R) 79.7 psf 1468.15 lbs LC4 D + 0.75L + 0.75(Lr or S or 67.2 psf 2918.3	Roof Live Load (Lr) (enter	r reduced load if reduced)	20	psf	773.4375	lbs			
Dead Loads - Total 29.7 psf 1468.153385 lbs Insulation on CLT (D) 9 psf	Ground snow load (S)		50	psf	1933.59375	lbs			
$\begin{tabular}{ c c c c c } \hline Insulation on CLT (D) & 9 & psf & & & & & & \\ \hline MEP Allowance (D) & 5 & psf & & & & & & \\ \hline MEP Allowance (D) & 5 & psf & & & & & & \\ \hline Roofing Membrane & 1 & psf & & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 1.6 & psf & & & & & \\ \hline Misc. Hung Ceiling & 0 & & & & & & \\ \hline Misc. Hung Ceiling & 0 & & & & & & \\ \hline Misc. Hung Ceiling & 0 & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & & & & & & \\ \hline Mind (W) & & & & & & & & & & & & & & & & & & &$	Dead Loads - Total		29.7	psf	1468.153385	lbs			
MEP Allowance (D) 5 psf Roofing Membrane 1 psf Misc. Hung Ceiling 1.6 psf CLT Weight (D) 13.1 psf Joist Weight 35 pcf 217.0236979 lbs Gyp weight 4 psf 102.575 plf Wind (W) 0 mph Earthquake (E) 0 psf 0 lbs Live Load (L) (enter reduced load if reduced) 0 psf 0 lbs LC1 D 29.7 psf 1468.15 lbs LC2 D+L 29.7 psf 1468.15 lbs LC3 D+(Lr or S or R) 79.7 psf 3401.75 lbs LC4 D + 0.75L + 0.75(Lr or S or 67.2 psf 2918.35 lbs LC5 D + (0.6W or 0.7E) 29.7 psf 1468.15 lbs LC6a D + 0.75L		Insulation on CLT (D)	9	psf					
$\begin{tabular}{ c c c c c } \hline Roofing Membrane & 1 & psf & & & & & & & & & & & & & & & & & & &$		MEP Allowance (D)	5	psf					
Misc. Hung Ceiling 1.6 psf CLT Weight (D) 13.1 psf Joist Weight 35 pcf 217.0236979 lbs Gyp weight 4 psf 102.575 plf Wind (W) 0 mph Earthquake (E) 0 psf 0 lbs Live Load (L) (enter reduced load if reduced) 0 psf 0 lbs Variable Description Calculation Units LC1 D 29.7 psf 1468.15 lbs LC2 D+L 29.7 psf 1468.15 lbs LC3 D+(Lr or S or R) 79.7 psf 3401.75 lbs LC4 D + 0.75L + 0.75(Lr or S or 67.2 psf 2918.35 lbs LC5 D + (0.6W or 0.7E) 29.7 psf 1468.15 lbs LC6a D + 0.75L + 0.75(0.6W) + 0 67.2 psf 2918.35 lbs L		Roofing Membrane	1	psf					
$\begin{tabular}{ c c c c c } \hline $CLT Weight (D) & 13.1 psf & $$10$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$		Misc. Hung Ceiling	1.6	psf					
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		CLT Weight (D)	13.1	psf					
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		Joist Weight	35	pcf	217.0236979	Ibs			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Gyp weight	4	psf	102.575	plf			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Wind (W)		0	mph		-			
Live Load (L) (enter reduced load if reduced) 0 psf 0 lbs Live Load (L) (enter reduced load if reduced) 0 psf 0 lbs Actual Loading Variable Description Calculation Units LC1 D 29.7 psf 1468.15 lbs LC2 D+L 29.7 psf 1468.15 lbs LC3 D+(Lr or S or R) 79.7 psf 3401.75 lbs LC4 D + 0.75L + 0.75(Lr or S or 67.2 psf 2918.35 lbs LC5 D + (0.6W or 0.7E) 29.7 psf 1468.15 lbs LC6a D + 0.75L + 0.75(0.6W) + 0 67.2 psf 2918.35 lbs LC6b D + 0.75L + 0.75(0.7E) + 0 67.2 psf 2918.35 lbs LC7 0.6D + 0.6W 17.82 psf 880.89 lbs LC8 0.6D + 0.7E 17.82 psf 880.89 lbs	Farthquake (F)		0	psf					
Actual Loading Variable Description Calculation Units LC1 D 29.7 psf 1468.15 lbs LC2 D+L 29.7 psf 1468.15 lbs LC3 D+L 29.7 psf 1468.15 lbs LC3 D+(Lr or S or R) 79.7 psf 3401.75 lbs LC4 D+0.75L+0.75(Lr or S or 67.2 psf 2918.35 lbs LC5 D+(0.6W or 0.7E) 29.7 psf 1468.15 lbs LC6a D+0.75L+0.75(0.6W) + 0 67.2 psf 2918.35 lbs LC6b D+0.75L+0.75(0.7E) + 0. 67.2 psf 2918.35 lbs LC7 0.6D+0.6W 17.82 psf 880.89 lbs LC8 0.6D+0.7E 17.82 psf 880.89 lbs	Live Load (L) (enter reduced load if reduced)		0	nsf	0	lbs			
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		Actual Loading							
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LC2 D+L 29.7 psf 1468.15 lbs LC3 D+(Lr or S or R) 79.7 psf 3401.75 lbs LC4 D+0.75L+0.75(Lr or S or 67.2 psf 2918.35 lbs LC5 D+(0.6W or 0.7E) 29.7 psf 1468.15 lbs LC6a D+0.75L+0.75(0.6W)+0 67.2 psf 2918.35 lbs LC6b D+0.75L+0.75(0.7E)+0. 67.2 psf 2918.35 lbs LC7 0.6D+0.6W 17.82 psf 880.89 lbs LC8 0.6D+0.7E 17.82 psf 880.89 lbs	LC1	D	29.7	psf	1468.15	Ibs			
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	LC2	D+L	29.7	psf	1468.15	Ibs			
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	LC3	D+(Lr or S or R)	79.7	psf	3401.75	Ibs			
LC5 D + (0.6W or 0.7E) 29.7 psf 1468.15 lbs LC6a D + 0.75L + 0.75(0.6W) + 0 67.2 psf 2918.35 lbs LC6b D + 0.75L + 0.75(0.7E) + 0. 67.2 psf 2918.35 lbs LC7 0.6D + 0.6W 17.82 psf 880.89 lbs LC8 0.6D + 0.7E 17.82 psf 880.89 lbs	LC4	D + 0.75L + 0.75(Lr or S or	67.2	psf	2918.35	Ibs			
	LC5	D + (0.6W or 0.7E)	29.7	psf	1468.15	lbs			
LC6b D + 0.75L + 0.75(0.7E) + 0. 67.2 psf 2918.35 lbs LC7 0.6D + 0.6W 17.82 psf 880.89 lbs LC8 0.6D + 0.7E 17.82 psf 880.89 lbs	LC6a	D+0.75L+0.75(0.6W)+0	67.2	psf	2918.35	lbs			
LC7 0.6D + 0.6W 17.82 psf 880.89 lbs LC8 0.6D + 0.7E 17.82 psf 880.89 lbs	LC6b	D + 0.75L + 0.75(0.7E) + 0.75(0.7E)	67.2	psf	2918.35	Ibs			
LC8 0.6D + 0.7E 17.82 psf 880.89 lbs	LC7	0.6D + 0.6W	17.82	psf	880 89	Ibs			
	LC8	0.6D + 0.7E	17.82	psf	880.89	Ibs			
Uniform Load	l from Glulam Se	lf weight							
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	S	ection-Specific L	oading and Dimen	sions					
Floor					4				
Section:				14	A - 1				
Dead Load - fro	m Glulam self weig	ht +gyp	35		pcf		39.88020833	plf	
	Gyp weight		4		psf		15.06666667	plf	
Wind (W)			0		mph				
Earthquake (E)			0		psf				
** * 1 1		Actua	l Loading				T - 1 DT (11 -)		
Variable	Description		Calculation	Units			Iotal DL (lbs)	Iotal LL (Ibs)	Iotal Roof SL (lbs)
			7746.27	lbc			0	0	0
LC2	D+L D+(L r or S or P)		18058 77	lbc			7746 270052	0	3075 052148
LC3	D+0.751+0.75	5(IrorSorP)	15480.65	lbc			0	0	0970.902140
LC4	D + 0.75L + 0.75L	7E)	7746.27	lbc			0	0	0
LC62	D + 0.751 + 0.751	$5(0.6W) \pm 0.75(I)$	15480.65	lbs		0	0	0	
LC6b	D + 0.75L + 0.75	$5(0.7E) \pm 0.75(E)$	15480.65	lbs		0	0	0	
LC7	$0.6D \pm 0.6W$	(0.7 <u>L</u>) + 0.755	4647.76	lbs		0	0	0	
LC8	0.6D + 0.7E		4647.76	lbs		0	0	0	
200	0.02 + 0.72		1017.70	100				0	•
	Cd	Load D	uration Factor		0.9				
	Cm	Wet Set	rvice Factor		1				
	Ct	Temper	rature Factor		1				
	Cc	Curvatu	ure Factor		1				
	Ci	Incising	g Factor		1				
	Fb*	Fb*Cd	*Cm*Ct*Cc*Ci		2160				
	CL								
	Lu	length ((inches)		300				
Le 1.63Lu+ Rb sqrt((le* Emin' Emin*C		+3D		525.9					
		*d)/b^2)		9.690050686					
		Cm*Ct		950400					
	Fbe	(1.2*E)	$\min')/(Rb^2)$		12146.06431				
	Cfu	(······································		1				
	CL	look at	nds		0.989436352				
	CV	look at	nde		0.81				

Fire Resistance A	djustment Factor	1	0.86
F'b	Fb*Cd*CM*Ct*(CL or Cv)*Cc*C	1749.6	psi
Ultimate F'b	x2.85	4986.36	psi
Allowable Mome	nt	30513.68	ft-lb
Ultimate Allowa	ble Moment	86963.99	ft-lb
Moment		67980.00	ft-lb

Adjusted Shear I	Parallel to Grain Design Value (F		
Cd	Load Duration Factor	0.9	NDS Table 2.3.2
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Ci	Incising Factor	1	NDS Table 4.3.8
F'v	Fvx*Cd*CMV*Ct*Ci	270	psi
F'v		38880	psf
Actual V	wL/2	5687.650911	lb
Actual fv	3V/2bd	12033.81915	psf

Fc perp			
Cb	Bearing Area Factor	1	
CMV	Wet Service Factor	1	NDS Supplement Table 4A
Ct	Temperature Factor	1	NDS Table 2.3.2
Fc perp		600	psi
Reaction forces	1/2 * wl	5687.650911	lb
Fc actual		114.2098577	psi
Adjusted Modul	us of Elasticity (E')		
CME	Wet Service Factor	1	NDS Supplement Table 4A
CtE	Temperature Factor	1	NDS Table 2.3.3
CiE	Incising Factor	1	NDS Table 4.3.8
E'	E*CME*CtE*CiE	1800000	
Manual pg 72			
	Actual	Deflection	
Variable	Description	Calculation	Units
Delta L	See next column	0.04914710075	ft
Delta S	See next column	0.1304069008	ft
Delta D+L	See next column	0.06175478309	ft
	Allowab	le Deflection	
Variable	Description	Calculation	Units
Delta L	L/360	0.06944444444	ft
Delta S	L/360	0.06944444444	ft
Delta D+L	L/240	0.1041666667	ft

Variable	Name	Value	Unit				
Axial Load	ing						
Fc	Compression parallel to grain	2300	psi				
Ft	Tension parallel to grain	1600	psi				
Ea	modulus of elasticity	1900000	psi				
Emin	Modulus of elasticity (min) = 0.528Exapp	1003200	psi				
Member Lengths and Properties							
Variable	Initial	final Value	Unit				
1		12	ft				
b	11.5	7.9	in				
d	11.5	7.9	in				
р	density	35	pcf				
SG	Specific gravity	0.46					
Ag		62.41	in^2				
Sxx		82.2	in^3				
Ixx		5128.4	in^4				
Isupport		6	in				
SG Ag	Specific gravity	0.46 62.41	in^2				

Fire Analysis Calculations – Option 2 Column

Loading				
Point Lo	ad 1 - left			
	Sect	ion-Specific Loading and Dir	mensions	
Load from	n girder to the left	0	lbs	
Load from	n girder to the right	9,930.59	lbs	LC 3 Governs
Self-weig	ht of column	385.73	lbs	LC 3 Governs
Cp Calcu	ilations!			
Fc*	adjusted compression pa	rallel to grain		
Table 2.3	Cd	Load Duration Factor	1.15	
	Cm	Wet Service Factor	1	
	Ct	Temperature Factor	1	
	CF	Size Factor	1	
	Ci - Fc	Incising Factor	0.8	
Fc*	(Fc)*Cd*Cm*Ct*CF*Ci		2116	psi
E'min	Minimum Modulus of el	asticity		
	CT	Buckling Stiffness Factor	1	
	Ci - Emin	Incising Factor	0.95	
E'min	Emin*Cm*Ci*Ct*CT		953040	
le	Effective Length			
	Ke	Effective length factor	1	
le	Length*Ke		12	ft
le/d	Must be less than 50		18.2278481	in/in
FcE	critical buckling design	value		
FcE	((0.822)*E'min)/((le/d)^2	2)	2357.82813	psi
Ср	Column Stability Factor	[]		
	c_glulam	a constant for glulam	0.9	
	FcE/Fc*		1.114285506	
			0.7983088397	
	$\left(1 + \frac{F_{cE}}{E}\right)$	$\left(1 + \frac{F_{cE}}{CE}\right) = \left(\frac{F_{cE}}{CE}\right)$		
	$C_{\mathbf{r}} := \frac{\left(F_{\mathbf{c}^*} \right)}{\left(F_{\mathbf{c}^*} \right)} =$	$\left(F_{c^*} \right) \left(F_{c^*} \right)$		
	2c _{sawn}	2c _{sawn} c _{sawn}		
Ср				1
F'c	Axial Buckling Capacity	,		
F'c	Fc*Cd*Cm*Ct*Cf*Ci*C	Cp	1,689.22	psi
Ultimate	F'c		4,358.19	psi
Overall T	ributary Area		62.41	in2
Allowabl	e Load		105,424.31	lbs
Allowabl	e Load for 2h fire (1 hr +	2 gyp)	13,150.00	lbs
Total Act	ual Load on column		9,930.59	lbs
Total Act	ual Load including colum	n	10,316.32	lbs
	-			

Appendix E: Inventory and Cost Estimate

Inventory - Option 1 Building

CLT Inventory							
Dermone	Territor		Aı				
Purpose	Location	Ply lype	Length (ft)	Width (ft)	Quantity		
			12.5	5	72		
			12.5	6	76		
Roofing	Roof	105-3s	13	5	6		
			13	6	6		
			62	107	1		
	Roof/Penthouse Floor	175-5s	12.5	5	48		
Roof/Penthouse			12.5	6	44		
Floor			13	5	24		
			13	6	22		
			12.5	5	330		
	Elean 2.2.1		12.5	6	328		
Flooring	F10015 5-2-1	175.50	13	5	72		
Flooring		175-55	13	6	70		
	Atrium		16	5	6		
	Atrium		16	6	7		

CLT							
Dire Truno	Are	ea	Opportite				
Fly Type	Length (ft)	Width (ft)	Quantity				
	12.5	5	72				
	12.5	6	76				
105-3s	13	5	6				
	13	6	6				
	62	107	1				
	12.5	5	378				
-	12.5	6	372				
175.50	13	5	96				
175-58	13	6	92				
	16	5	6				
	16	6	7				

GLT Vertical Members							
	Orientita						
b (in)	d (in)	Quantity					
15.5	15.5	12	24				
13.625	13.625	12	149				
11.5	11.5	12	111				
9.5	9.5	12	9				

Simplified Holistic Inventory (not by location/purpose)

GLT Horizontal Members								
	Area		Quantity					
b (in)	d (in)	Length (ft)	Quantity					
17.625	29.5	26	1					
17.625	27.5	26	1					
15.5	27.5	26	1					
15.5	23.5	26	6					
11.5	29.5	26	2					
11.5	27.5	32	2					
11.5	27.5	26	4					
11.5	25.5	26	4					
11.5	23.5	26	3					
11.5	23.5	25	18					
11.5	23.5	16.5	6					
11.5	21.5	32	1					
11.5	21.5	26	9					
11.5	21.5	25	1					
11.5	19.5	32	1					
11.5	19.5	26	3					
11.5	19.5	25	18					
11.5	19.5	16.5	8					
11.5	17.5	32	1					
11.5	17.5	26	13					
11.5	17.5	25	8					
11.5	17.5	16.5	133					
11.5	15.5	16.5	140					
11.5	15.5	10.5	1					
11.5	15.5	8	8					
11.5	13.5	16.5	97					
11.5	13.5	16.5	7					
11.5	13.5	10.5	3					
11.5	13.5	8.25	1					
11.5	11.5	26	4					
11.5	11.5	16.5	3					
11.5	11.5	10.5	8					
11.5	11.5	8.25	5					
11.5	11.5	6	8					
9.5	11.5	32	1					
9.5	11.5	25	1					
9.5	11.5	16.5	11					
9.5	11.5	15	4					
9.5	11.5	10.5	8					
9.5	11.5	10	4					
9.5	11.5	8.25	14					
9.5	11.5	6	10					

CLT Cost Estimate								
Ply Type		Area		Quantity	Volume (ft^3)	Cost per ft^3	Tatal Cast	
	Length (ft)	Width (ft)	Thickness (ft)	Quantity	volume (it 3)	cost per fit 5	Total Cost	
	12.5	5	0.3438	72	21.48	\$21.00	\$32,484.38	
	12.5	6	0.3438	76	25.78	\$21.00	\$41,146.88	
105-3s	13	5	0.3438	6	22.34	\$21.00	\$2,815.31	
	13	6	0.3438	6	26.81	\$21.00	\$3,378.38	
	62	107	0.3438	1	2,280.44	\$21.00	\$47,889.19	
	12.5	5	0.5729	378	35.81	\$21.00	\$284,238.28	
	12.5	6	0.5729	372	42.97	\$21.00	\$335,671.88	
	13	5	0.5729	96	37.24	\$21.00	\$75,075.00	
175.5-	13	6	0.5729	92	44.69	\$21.00	\$86,336.25	
1/5-5s	16	5	0.5729	6	45.83	\$21.00	\$5,775.00	
	16	6	0.5729	7	55.00	\$21.00	\$8,085.00	
	14	115.5	0.5729	4	926.41	\$21.00	\$77,818.13	
	14	78	0.5729	4	625.63	\$21.00	\$52,552.50	
						TOTAL	\$1,053,266.16	
	i i	1		I I				

Cost Estimate – Option 1 Building

GLT Vertical Members Cost Estimate								
	Area		Orrentitu	Mahama (in 62)		Tetal Cent		
b (in)	d (in)	Length (ft)	Quantity Volume (In 3		Cost per in^3	Total Cost		
15.5	15.5	12	24	34,596.00	\$0.03	\$24,909.12		
13.625	13.625	12	149	26,732.25	\$0.03	\$119,493.16		
11.5	11.5	12	111	19,044.00	\$0.03	\$63,416.52		
9.5	9.5	12	9	12,996.00	\$0.03	\$3,508.92		
					TOTAL	\$211,327.72		

GLT Horizontal Members Cost Estimate									
Area		Quantity	Volume (in^3)	Cost non in∆2	Total Cost				
b (in)	d (in)	Length (ft)	Qualitity	volume (m 3)	Cost per III 5	Total COSt			
17.625	29.5	26	1	162,220.50	\$0.03	\$4,866.62			
17.625	27.5	26	1	151,222.50	\$0.03	\$4,536.68			
15.5	27.5	26	1	132,990.00	\$0.03	\$3,989.70			
15.5	23.5	26	6	113,646.00	\$0.03	\$20,456.28			
11.5	29.5	26	2	105,846.00	\$0.03	\$6,350.76			
11.5	27.5	32	2	121,440.00	\$0.03	\$7,286.40			
11.5	27.5	26	4	98,670.00	\$0.03	\$11,840.40			
11.5	25.5	26	4	91,494.00	\$0.03	\$10,979.28			
11.5	23.5	26	3	84,318.00	\$0.03	\$7,588.62			
11.5	23.5	25	18	81,075.00	\$0.03	\$43,780.50			
11.5	23.5	16.5	6	53,509.50	\$0.03	\$9,631.71			
11.5	21.5	32	1	94,944.00	\$0.03	\$2,848.32			
11.5	21.5	26	9	77,142.00	\$0.03	\$20,828.34			
11.5	21.5	25	1	74,175.00	\$0.03	\$2,225.25			
11.5	19.5	32	1	86,112.00	\$0.03	\$2,583.36			
11.5	19.5	26	3	69,966.00	\$0.03	\$6,296.94			
11.5	19.5	25	18	67,275.00	\$0.03	\$36,328.50			
11.5	19.5	16.5	8	44,401.50	\$0.03	\$10,656.36			
11.5	17.5	32	1	77,280.00	\$0.03	\$2,318.40			
11.5	17.5	26	13	62,790.00	\$0.03	\$24,488.10			
11.5	17.5	25	8	60,375.00	\$0.03	\$14,490.00			
11.5	17.5	16.5	133	39,847.50	\$0.03	\$158,991.53			
11.5	15.5	16.5	140	35,293.50	\$0.03	\$148,232.70			

TOTAL COST OF STRUCTURAL MATERIALS						
					TOTAL	\$703,580.18
9.5	11.5	6	10	7,866.00	\$0.03	\$2,359.80
9.5	11.5	8.25	14	10,815.75	\$0.03	\$4,542.62
9.5	11.5	10	4	13,110.00	\$0.03	\$1,573.20
9.5	11.5	10.5	8	13,765.50	\$0.03	\$3,303.72
9.5	11.5	15	4	19,665.00	\$ <mark>0.03</mark>	\$2,359.80
9.5	11.5	16.5	11	21,631.50	\$0.03	\$7,138.40
9.5	11.5	25	1	32,775.00	\$0.03	\$983.25
9.5	11.5	32	1	41,952.00	\$0.03	\$1,258.56
11.5	11.5	6	8	9,522.00	\$0.03	\$2,285.28
11.5	11.5	8.25	5	13,092.75	\$0.03	\$1,963.91
11.5	11.5	10.5	8	16,663.50	\$0.03	\$3,999.24
11.5	11.5	16.5	3	26,185.50	\$0.03	\$2,356.70
11.5	11.5	26	4	41,262.00	\$0.03	\$4,951.44
11.5	13.5	8.25	1	15,369.75	\$0.03	\$461.09
11.5	13.5	10.5	3	19,561.50	\$0.03	\$1,760.54
11.5	13.5	16.5	7	30,739.50	\$0.03	\$6,455.30
11.5	13.5	16.5	97	30,739.50	\$0.03	\$89,451.95
11.5	15.5	8	8	17,112.00	\$0.03	\$4,106.88
11.5	15.5	10.5	1	22,459.50	\$0.03	\$673.79

Inventory – Option 2 Building

CLT Inventory								
December	Terretien	Dis True	A	Orantita				
Purpose	Location	Ply lype	Length (ft)	Width (ft)	Quantity			
			12.5	5	72			
			12.5	6	76			
			13	5	6			
Poofing	Poof	105-3s	13	6	6			
Roomig	Root							
	Roof/Penthouse Floor	197-7s	12.5	5	48			
Roof/Penthouse			12.5	6	44			
Floor			13	5	24			
			13	6	22			
			12.5	5	330			
	Floors 3-2-1		12.5	6	328			
Flooring	110013 5-2-1	175-55	13	5	72			
Thooming		1/3-35	13	6	70			
	Atrium		16	5	6			
	Autum		16	6	7			

	C.	LT	
Dire Truno	A	Orrentites	
Ply Type	Length (ft)	Width (ft)	Quantity
	12.5	5	72
	12.5	6	76
	13	5	6
105-35	13	6	6
105-55			
		Penthouse roof	
	12.5	5	48
197.76	12.5	6	44
197-75	13	5	24
	13	6	22
175-5s	12.5	5	378
	12.5	6	372
	13	5	96
	13	6	92
	16	5	6
	16	6	7

GLT Columns										
Area										
b (in)	d (in)	Quantity								
11.5	11.5	12	26							
13.625	13.625	12	18							
15.5	15.5	12	166							
17.625	17.625	12	91							

GLT								
	Area	Opportity						
b (in)	d (in)	Length (ft)	Quantity					
11.5	13.5	16.5	20					
11.5	15.5	16.5	20					
11.5	17.5	16.5	20					
11.5	19.5	16.5	20					
15.5	15.5	8.00	8					
15.5	15.5	8.25	21					
15.5	15.5	10.00	5					
15.5	15.5	16.50	185					
15.5	15.5	25.00	10					
15.5	15.5	39.00	2					
15.5	17.5	16.50	4					
15.5	19.5	16.50	138					
15.5	19.5	25.00	3					
15.5	21.5	16.50	6					
15.5	21.5	25.00	7					
15.5	21.5	26.00	13					
15.5	25.5	25.00	41					
15.5	25.5	26.00	15					
15.5	27.5	25.00	19					
15.5	27.5	26.00	3					
15.5	29.5	25.00	100					
15.5	29.5	26.00	20					
19.5	25.5	26	4					
17.5	29.5	26	1					
19.5	29.5	26	2					
19.5	35.625	26	4					
19.5	37.625	26	1					

CLT Cost Estimate												
Ply Type			Area			Quan	tity	Volume (ft	:^3)	Cost per ft^3	,	Total Cost
	Length (ft)	W	Vidth (ft)	Thick	ness (ft)			,	<i>.</i>			
	12.5		5	0.3	3438		72		21.48	\$21.	.00	\$32,484.38
105-35	12.5		5	0.3	3438		/6	•	25.78	\$21.	00	\$41,146.88
105-55	13		5	0.3	3438		6		26.81	\$21.	00	\$3 378 35
	62		107	0.3	3438		1	2.2	80.44	\$21.	.00	\$47.889.19
	12.5		5	0.0	6458		48		40.36	\$21	.00	\$40,687.50
	12.5		6	0.0	6458		44		48.44	\$21.	.00	\$44,756.25
19/-/s	13		5	0.0	6458		24	4	41.98	\$21.	.00	\$21,157.50
	13		6	0.0	6458		22	:	50.38	\$21.	.00	\$23,273.25
175-5s	12.5		5	0.5	5729		378	:	35.81	\$21.	.00	\$284,238.28
	12.5		6	0.5	5729		372		42.97	\$21.	.00	\$335,671.88
	13		5	0.5	5729		96		37.24	\$21.	.00	\$75,075.00
	13		6	0.5	5729		92		44.69	\$21.	.00	\$86,336.25
	16		5	0.:	5729		6		45.83	\$21.	.00	\$5,775.00
	16		115.5	0	5729		/	0	26.41	\$21.	00	\$8,085.00
	14		78	0.	5729		4	9.	25.63	\$21.	00	\$52 552 50
	14		70	0			-	0.	25.05	TOT	AL	\$1,183,140.66
1					-						_	
	<u> </u>		GL	T Horiz	ontal Me	mbers Co	st Estin	nate				
h (in)	Area		Longth	(ft)	Qua	intity	Volu	me (in^3)	C	ost per in^3		Total Cost
0 (11)	1.5	13.5	Lengui	16.5		20		30 739 50		\$0.03		\$18 443 70
1	1.5	15.5		16.5		20		35 293 50		\$0.03	\vdash	\$21,176,10
1	1.5	17.5		16.5		20		39 847 50		\$0.03		\$23,908,50
1	1.5	19.5		16.5		20		44 401 50		\$0.03	-	\$26,640.90
1	5.5	15.5		8.00		8		23 064 00		\$0.03		\$5 535 36
1	5.5	15.5		8.25		21		23,784,75		\$0.03	\vdash	\$14 984 39
1	5.5	15.5		10.00		5		28,830,00		\$0.03	-	\$4 324 50
1	5.5	15.5		16.50		185		47 569 50		\$0.03	-	\$264 010 73
1	5.5	15.5		25.00		105		72 075 00		\$0.03	-	\$21,622,50
1	5.5	15.5		20.00		10		112 427 00		\$0.03	-	\$6.746.22
1	5.5	17.5		16.50		2		52 707 50		\$0.03	-	\$6,740.22
1	5.5	10.5		16.50		129		50.845.50		\$0.03		\$0,444.90
1	5.5	19.5		25.00		150		39,843.30		\$0.03		\$247,760.37
1	5.5	19.5		25.00		3		90,673.00		\$0.03		\$8,160.73
1	5.5	21.5		16.50		6		65,983.50		\$0.03	-	\$11,877.03
	5.5	21.5		25.00		/		99,975.00		\$0.03	<u> </u>	\$20,994.75
1	5.5	21.5		26.00		13		103,974.00		\$0.03	_	\$40,549.86
1	5.5	25.5		25.00		41		118,575.00		\$0.03		\$145,847.25
1	5.5	25.5		26.00		15		123,318.00		\$0.03	<u> </u>	\$55,493.10
1	5.5	27.5		25.00		19		127,875.00		\$0.03		\$72,888.75
1	5.5	27.5		26.00		3		132,990.00		\$0.03		\$11,969.10
1	5.5	29.5		25.00		100		137,175.00		\$0.03		\$411,525.00
1	5.5	29.5		26.00		20		142,662.00		\$0.03		\$85,597.20
1	9.5	25.5		26		4		155,142.00		\$0.03		\$18,617.04
1	7.5	29.5		26		1		161,070.00		\$0.03		\$4,832.10
1	9.5	29.5		26		2		179,478.00		\$0.03	L_	\$10,768.68
1	9.5 35	5.625		26		4		216,742.50		\$0.03		\$26,009.10
1	9.5 37	7.625		26		1		228,910.50		\$0.03		\$6,867.32
										TOTAL		\$1,593,595.19

Cost Estimate – Option 2 Building

GLT Vertical Members Cost Estimate									
Area					G (TILCI			
b (in)	d (in)	Length (ft)	Quantity	volume (in^3)	Cost per in^3	Total Cost			
11.5	11.5	12	26	19,044.00	\$0.03	\$14,854.32			
13.625	13.625	12	18	26,732.25	\$0.03	\$14,435.42			
15.5	15.5	12	166	34,596.00	\$0.03	\$172,288.08			
17.625	17.625	12	91	44,732.25	\$0.03	\$122,119.04			
					TOTAL	\$323,696.86			
TOTAL COST OF STRUCTURAL MATERIALS									