

GI2

Installation Guide
January 2021

Note: This document does not constitute an installation plan.
It aims to guide the reader in developing a project-specific
installation plan.

Table of Contents

Foreword.....	4
1. Introduction.....	5
1.1 Purpose.....	5
1.2 Mass Timber.....	5
1.3 Responsibilities.....	5
1.4 Health and Safety.....	5
2. Mass Timber.....	7
2.1 General.....	7
2.2 Nordic Products.....	7
2.3 Physical Properties.....	8
3. Materials.....	9
3.1 General.....	9
3.2 Wood and Humidity.....	9
3.3 Appearance Classifications.....	12
3.4 Visual Characteristics.....	12
3.5 Durability.....	19
4. Workmanship – Fabrication.....	21
4.1 Erection Drawings.....	21
4.2 Manufacturing Tolerances.....	21
4.3 Product Preparation.....	22
4.4 Delivery.....	30
4.5 Handling.....	31
4.6 Storage.....	31
5. Workmanship – Erection.....	33
5.1 Pre-construction Preparation.....	33
5.2 Means and Methods.....	34
5.3 Lifting and Handling.....	35
5.4 Construction Tolerances.....	37
5.5 Fire Safety during Construction.....	38
5.6 Quality Control.....	38
5.7 Handover.....	39
6. Protection and repair.....	40
6.1 Moisture Management.....	40
6.2 Aesthetic Damage.....	46
6.3 Cleaning Wood.....	47
6.4 Repair.....	49
7. Protective Treatment and Finishes.....	51
7.1 Architectural Finishes.....	51
7.2 Fire Protection System.....	51
Annex A. Referenced Documents.....	52
Annex B. Annex B. Non-Structural Touch-Ups and Repairs.....	53
Annex C. Nomenclature.....	57
Annex D. List of Products.....	58
Annex E. Construction Tolerances.....	59
Annex F. Checklists.....	61
Annex G. Sample Moisture Management Plan Outline.....	65
Annex H. Dimensional Change Example.....	66
Annex I. List of Commonly Used Construction Equipment.....	67

Annex J. Preventing Checks and Gaps	69
---	----

Foreword

Nordic Structures is a leading innovator in mass timber construction. Its resources come from responsibly managed lands within the regional boreal forest of northern Québec. Vertical integration, from forest to structure, bolstered by Nordic's experienced design and development team, ensures consistent quality and an unparalleled level of service.

Installation guide

This installation guide aims to inform erectors and general contractors of the unique characteristics of mass timber and to present some common practices for the preparation, workmanship, and protection of mass timber structures. This installation guide also provides procedures for the fabrication, protection, and packaging of Nordic mass timber products.

This document does not constitute an installation plan. It aims to guide the reader in developing a project-specific installation plan.

Mass timber

Research¹ indicates that there is no significant relationship between the material used for a building's structural system and the building's service life. As with all building materials, long-term durability starts with the proper implementation of good design and construction practices such as proper detailing and quality control.

A mass timber structure presents its own unique set of considerations and benefits. As is the case with all buildings, modifications made to building components may impact their ability to serve their intended purpose. All proposed modifications must be approved by a qualified design professional.

Disclaimer

This document is based on information currently available and is subject to change without notice. This document should be used as a general guide and is neither intended to be exhaustive nor project-specific. Referenced documents are listed in Annex A.

¹ Survey on Actual Service Lives for North American Buildings, FPIInnovations, Proceedings, 10th International Conference on Durability of Building Materials and Components, O'Connor, J., Horst J.S., Argeles, C, 2005, cwc.ca/wp-content/uploads/2013/12/DurabilityService_Life_E.pdf

1. INTRODUCTION

1.1 Purpose

This installation guide aims to inform erectors and general contractors of the unique characteristics of mass timber structures and to present some common practices for their preparation, workmanship for erection, and protection. These guidelines are limited to the structural use of mass timber and are not intended to represent a complete building installation plan.

This document does not constitute an installation plan. It aims to guide the reader in developing a project-specific installation plan.

1.2 Mass Timber

The quality of construction is essential to ensure the longevity of the service life of a building, and each construction material presents its own unique considerations. For mass timber to be effectively used as a building material, knowledge and understanding of its unique properties is essential.

Note: For details on Nordic products, refer to the Nordic Lam+ and Nordic X-Lam Technical Guides.

1.3 Responsibilities

This section outlines the typical responsibilities of each party. Exact responsibilities may vary and should be defined on a project-specific basis.

Nordic Structures

Nordic Structures is responsible for the supply of mass timber and any associated components. Unless otherwise noted, the responsibility assumed by Nordic Structures is limited to the product warranty, which stipulates that Nordic products, in accordance with specifications, are free from manufacturing defects in material and workmanship.

Design professionals

Design professionals are responsible for designing building systems, including mass timber structures and components, such that they perform their intended function for a given service life. Due recognition must be given to all aspects relating to the durability of the mass timber structure and the other components of the building system.

Installer

The installer is the entity responsible for the installation of mass timber.

General contractor

The general contractor or construction manager is the entity constructing, coordinating, and supervising construction. Note that specific projects may be set up differently. It is the responsibility of the general contractor or construction manager to clarify roles and responsibilities before work starts on site.

1.4 Health and Safety

Health and safety are the responsibility of all entities present on site. All reasonable precautions should be taken to protect the health and safety of all workers and visitors. The measures that must be enforced are complex and project-specific and are outside the scope of this document. Refer to the regional Occupational Health and Safety Policy for more information.

By carefully considering the key factors affecting the durability and performance of mass timber, manufacturers, specifiers, builders, and stakeholders can create both beautiful and long-lasting timber structures.

2. MASS TIMBER

2.1 General

Wood is one of the few construction materials that is natural, renewable, and recyclable. Because it sequesters carbon and can replace more energy-intensive and polluting materials like steel and concrete, building with mass timber contributes to the fight against climate change. Mass timber is a structural wood product that is widely used in construction.

2.2 Nordic Products

Nordic Lam+ and Nordic X-Lam are primarily comprised of black spruce, with smaller amounts of jack pine and balsam fir. All wood is sourced through the sustainable harvesting of well-managed forests in northern Quebec. Black spruce is a slow-growing coniferous tree, characterized by its long straight trunk and short compact branches. This accounts for the presence of many small knots, a common visual characteristic of Nordic mass timber products.

Nordic Lam+ glued-laminated timber (glulam), shown in Figure 2.1, consists of small wood laminations bonded together in parallel using structural adhesives to form beams and columns. Nordic X-Lam cross-laminated timber (CLT), shown in Figure 2.2, is made of at least three orthogonal layers of graded sawn lumber that are laminated with structural adhesives to form large panels. The adhesives used in Nordic products do not contain any urea formaldehyde resin.



Figure 2.1 Sample of Nordic Lam+



Figure 2.2 Sample of Nordic X-Lam

Glulam laminations are bonded on all sides. CLT panels can be fabricated in two ways: edge-glued or non-edge-glued. Nordic X-Lam is non-edge-glued, which allows the laminations to shrink and expand with changes in moisture. This may result in the formation of gaps between adjacent laminations as individual laminations shrink in dry environments. However, in humid environments, the laminations will expand to close the gaps.

In edge-glued CLT, glue is placed between the edges of adjacent laminations in a layer. The glue restrains movement between laminations, which causes large cracks to form unpredictably when moisture changes occur.

Figure 2.3 and Figure 2.4 show typical gaps in Nordic X-Lam. Gaps in core layers are typically more pronounced than those in face layers; however, these gaps can only be seen at panel edges. The presence of gaps is inherent to Nordic X-Lam as a result of its manufacturing process. These gaps are not a structural concern but should be minimized to avoid moisture ingress into the member.

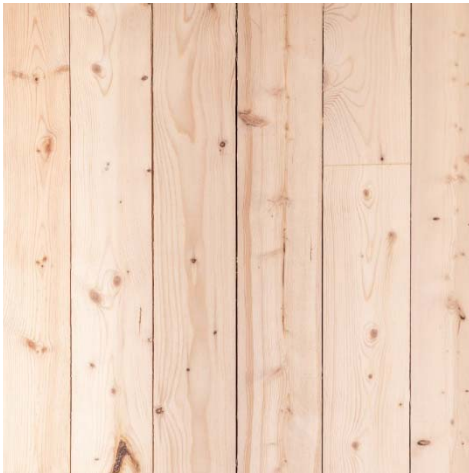


Figure 2.3 Gaps between adjacent lamination edges in a face layer



Figure 2.4 Gaps between adjacent lamination edges in an interior layer

Note: For product and environmental certifications, see nordic.ca.

2.3 Physical Properties

Wood, like many natural materials, is hygroscopic: it absorbs and releases moisture to reach equilibrium with the surrounding environment. Moisture exchange between the wood and ambient air depends on the relative humidity and temperature of the air as well as the current moisture content in the wood. Wood moisture content has an important influence on the properties and performance of mass timber.

The unique cellular structure of wood and the layered composition of mass timber products provide mass timber buildings with several advantageous properties:

- Hygrothermic² performance
- Thermal performance (thermal resistance of R-1.2/in.)
- Considerable thermal mass and low conductivity
- Natural regulation of moisture in the air
- Reduced air infiltration and exfiltration

² The term “hygrothermic” refers to the temperature and humidity levels of the ambient air in a building. Hygrothermic conditions are frequently measured in the building industry, as optimized hygrothermic comfort is sought after for the health of the residents and infrastructure.

3. MATERIALS

3.1 General

Properties of wood

Wood is a natural material comprised of cellulose, hemicellulose, and lignin that form fibers oriented along the length of the tree. This results in anisotropic material properties: wood is stronger parallel to the grain than perpendicular to it.

Wood harvested from different parts of a tree, indicated in Figure 3.1, will have different appearances and properties.

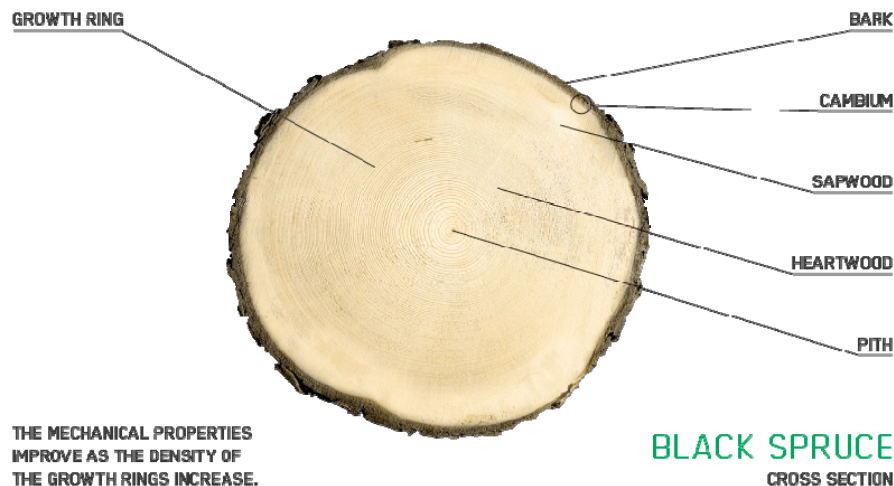


Figure 3.1 Black spruce cross section

3.2 Wood and Humidity

Moisture content

The moisture content is defined as the weight of water present in the wood expressed as a percentage of the oven-dry weight of the wood. The moisture content of the laminations at the time of manufacturing Nordic X-Lam and Nordic Lam+ products is $12\% \pm 2\%$.

Moisture exchange between the wood and the ambient air depends on the relative humidity, temperature, and current moisture content of the wood. Moisture content in mass timber has an important influence on the properties and performance of wood. The moisture content in mass timber typically stabilizes between 6% and 14% in a completed building. Mass timber members are designed to perform well in this range. Certain consequences may arise and should be addressed when the moisture content exceeds 19% for a prolonged period of time. Figure 3.2 shows a moisture content scale and its typical effects on mass timber.

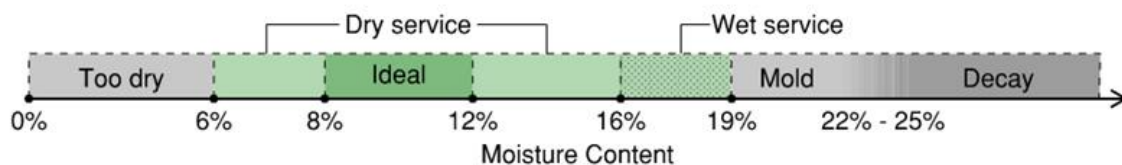


Figure 3.2 Moisture content and its effect on mass timber

Equilibrium moisture content (EMC) is defined as the moisture content at which the wood is neither gaining nor losing moisture from its surrounding environment. The relationship between EMC, relative humidity, and temperature is shown in Table 3.1.

Table 3.1 Relationship between equilibrium moisture content of wood, temperature, and relative humidity

Temperature		Equilibrium moisture content (%) at various relative humidity levels (%)								
°F	°C	15	25	35	45	55	65	75	85	95
30	-1.1	3.7	5.5	7.1	8.7	10.4	12.4	14.9	18.5	24.3
50	10	3.6	5.5	7.1	8.7	10.3	12.3	14.8	18.4	24.3
60	16	3.6	5.4	7.0	8.6	10.2	12.1	14.6	18.2	24.1
70	21	3.5	5.4	6.9	8.5	10.1	12.0	14.4	17.9	23.9
80	27	3.5	5.3	6.8	8.3	9.9	11.7	14.2	17.7	23.6
90	32	3.4	5.1	6.7	8.1	9.7	11.5	13.9	17.3	23.3
100	38	3.3	5.0	6.5	7.9	9.5	11.2	13.6	17.0	22.9
120	49	3.0	4.7	6.1	7.5	8.9	10.6	12.9	16.2	22.0
150	66	2.6	4.1	5.5	6.7	8.1	9.7	11.8	14.9	20.4

The exact rate of moisture movement in and out of wood is a complex topic and depends on many factors, such as fabrication method, wood species, size of the member, presence of internal voids, end grain exposure, adhesives used, and surface treatment. All these factors can affect the surface rate of water absorption and the internal movement and distribution of moisture.

Moisture content measurement

The moisture content of mass timber can be measured by using a portable moisture meter, shown in Figure 3.3. Moisture meters should be calibrated to the wood species being measured. Measurements should be conducted away from characteristics such as knots and pitch pockets and should be taken at multiple locations along the length of a piece, following the instructions from the equipment manufacturer. Local areas with high moisture content should be carefully checked to ensure that no external factors cause the wood to remain wet. A measurement of the surface moisture may not reflect the internal moisture content of the member since the internal moisture content changes more gradually than surface moisture content.



Figure 3.3 Measuring wood moisture content using a capacitance-based meter (left) and a resistance-based meter (right) (Source: FPI)

Dimensional changes

Wood is a natural material that responds to changes in its environment. Wood expands and contracts in accordance with the level of ambient humidity, especially when exposed to moisture for prolonged periods of time.

Wood exhibits different shrinkage rates in each of the three directions relative to the direction of the wood fibers and annual growth rings, as shown in Figure 3.4. Radial and tangential shrinkage (perpendicular to the grain) is typically estimated as 0.2% for every percentage point change in moisture content. Longitudinal shrinkage (parallel to the grain) is generally considered negligible at about 0.007% for every percentage point change in moisture content.

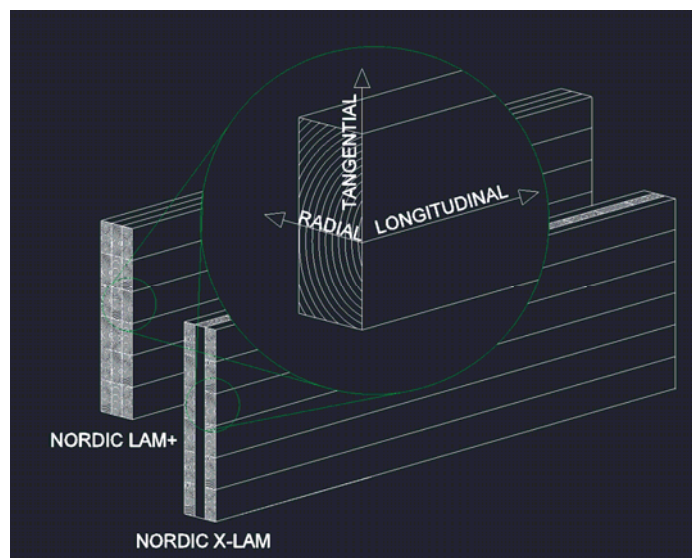


Figure 3.4 Shrinkage directions

An example showing the process for calculating the dimensional change caused by a change in moisture content is given in Annex G.

The adhesives used in Nordic mass timber products are rated for wet use. However, prolonged exposure to moisture may cause significant dimensional changes in the wood that may result in aesthetic or structural damage.

End grain

The end grain of a timber element is more prone to absorbing moisture than the side grain. Care should be taken during construction to protect the end grain from excessive moisture and allow the timber to dry, particularly near exposed column base plates.

3.3 Appearance Classifications

Appearance classifications describe the extent of natural growth and manufacturing characteristics that are visible on the finished product. These classifications are purely visual and do not affect product performance. Nordic Lam+ and Nordic X-Lam are typically manufactured with an architectural appearance classification, suitable for applications where members are visually exposed.

Note: For more details on appearance classifications, refer to the Nordic Lam+ and Nordic X-Lam Technical Guides.

3.4 Visual Characteristics

Appearance classifications describe the extent of natural growth and manufacturing characteristics that are visible on the finished mass timber product. These classifications are purely aesthetic and do not affect product performance. Nordic Lam+ and visible surfaces of Nordic X-Lam are typically manufactured with an architectural appearance classification. For information on how to repair natural and manufacturing visual characteristics, refer to Annex B.

Note: For more details on appearance classifications, refer to the product technical guides.

Natural Visual Characteristics

Wood is a natural material. Living trees continuously react and adapt to their environment including climate, biological systems, and gravity. This natural adaptation process gives each tree unique visual and mechanical characteristics. Color variations and intrinsic growth characteristics such as wane, checks, knots, knots, holes, pitch pockets, and bark pockets are commonly found in wood members. These characteristics are considered in grading rules and are used to determine the mechanical properties of a product. It is worth emphasizing that color variations and growth imperfections are naturally occurring and generally do not affect the structural properties of the material.

The following definitions are based on those found in NLGA Standard Grading Rules for Canadian Lumber.

Stained wood

Marked deviation from the natural color, usually in irregularly shaped patches, may be observed.

Both stained heartwood and stained sapwood have no effect on the mechanical properties of the pieces in the grades which they are permitted, but they affect the appearance to varying degrees.



Figure 3.5 Stained wood

Discoloration

Discoloration can develop through the exposure of the wood to particularly strong ultraviolet (UV) light.

The type and rate of discoloration will vary with the level of exposure. If desired, a finishing product can be applied to reduce discoloration and other effects of UV exposure. Discoloration through exposure to the elements (including UV light) is permitted in all grades of framing lumber.



Figure 3.6 Wood discoloration

Wane

Wane is bark or lack of wood from any cause, except eased edges, found on the edge or corner of a piece of lumber.

Appearance, fabrication, and bearing or nailing surface requirements generally limit the presence of wane in structural lumber. Although the wood is trimmed to remove bark and minimize wane, it is often observed in black spruce lumber.

Wane is not permitted in the face layers of architectural grade products but can be used in core layers of CLT.



Figure 3.7 Wane

Knots

Black spruce, the species predominantly used in Nordic mass timber products, is a slow-growing coniferous tree characterized by its long straight trunk and short compact branches. The latter accounts for the presence of many small knots, characteristics left in wood when branches fall off a healthy growing tree, shown in Figure 4.2.

Knots are classified based on their shape, size, quality, and frequency.

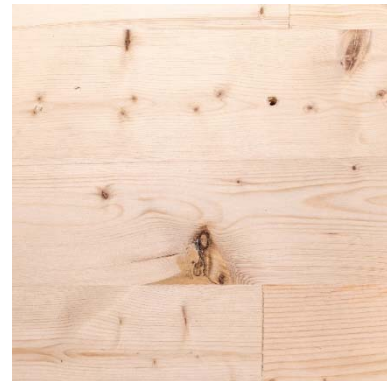


Figure 3.8 Knots

Knot holes

Knot holes are formed when a knot comes loose from the surrounding wood. Holes may extend partially or completely through the piece. An alternate designation for holes which extend only partially through the piece is surface pits.

Unless otherwise specified, holes are classified according to the same criteria as knots.



Figure 3.9 Knot hole

Bark pockets

Bark pockets are well-defined openings between the rings of annual growth which develop during the growth of the tree and contains bark.

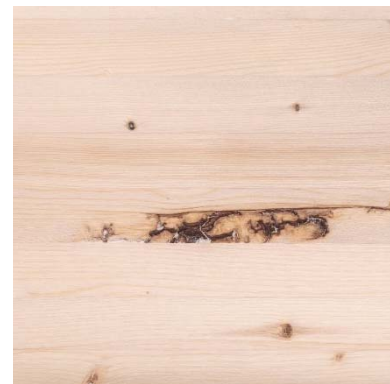


Figure 3.10 Bark pocket

Resin pockets

Resin pockets are well-defined openings between the rings of annual growth which develop during the growth of the tree and contain resin.

Some species of wood are more resinous than others and can contain residual resin pockets, show in Figure 4.1. In hot environments, the resin may liquefy, seep through the surface of the wood, and drip. Once the resin has hardened, it can easily be scraped off with a sharp edge. If the resin is soft, it can be removed with turpentine or mineral spirits. The wood surface may need to be sanded and the finish reapplied.



Figure 3.11 Resin pocket

Blue stain fungi

Blue stain fungi are a type of fungus that causes dark staining of the sapwood.

The staining is most often blue but can also be grey or black. It is not a stage of decay and has little effect on the strength of the wood.



Figure 3.12 Blue stain fungi

Species coloration

Jack pine pieces within laminations will have a slightly different tint than those made from black spruce.



Figure 3.13 Jack pine coloration

Checks

Checks are slits that occur parallel to the natural grain of wood. They are a naturally occurring consequence of the wood seasoning process, during which the outer fibers of the element dry and shrink at a faster rate than the inner portion.

Because checks are associated with shrinkage due to moisture loss, checking will stabilize as the moisture content of the member reaches equilibrium with the surrounding environmental conditions.

Nordic Lam+ has fewer and smaller checks than solid-sawn timber since the individual laminations are much smaller and are seasoned before manufacturing. Checking is uncommon in Nordic X-Lam panels due to the orthogonality of the layers.



Figure 3.14 Checks

Identifying checks

Checks are commonly found near glue lines adjacent to the outermost lamination. The exposed surface area of the outermost lamination is the greatest, leading to highest differential drying stresses.

Delamination refers to the separation of laminations at a glue line and should not be confused with checking, which refers to splitting of the wood fiber itself. Delamination occurs when the glue

bond is not adequate. Unlike in a check, the surfaces of a delamination crack are smooth. Delamination is highly unlikely in glulam members because they are manufactured with durable wet-use adhesives in closely controlled manufacturing environments.

Effects of checks

The effects of checking depend on the structural use of the element and the properties of the checks.

A partial check in a compression member such as a post or column is not a structural concern. In these members, checks only become a structural concern if they cause the element to split along its entire length. In the rare case this occurs, the structural capacity of the member should be verified by a qualified design professional as the integrity of the member may have been compromised.

For bending members such as beams, rafters, or girders, the size and location of the check determines whether it affects the structural performance of the member, as shown in Figures 4.5 and 4.6. If there are any structural concerns, a qualified design professional should evaluate the checks.

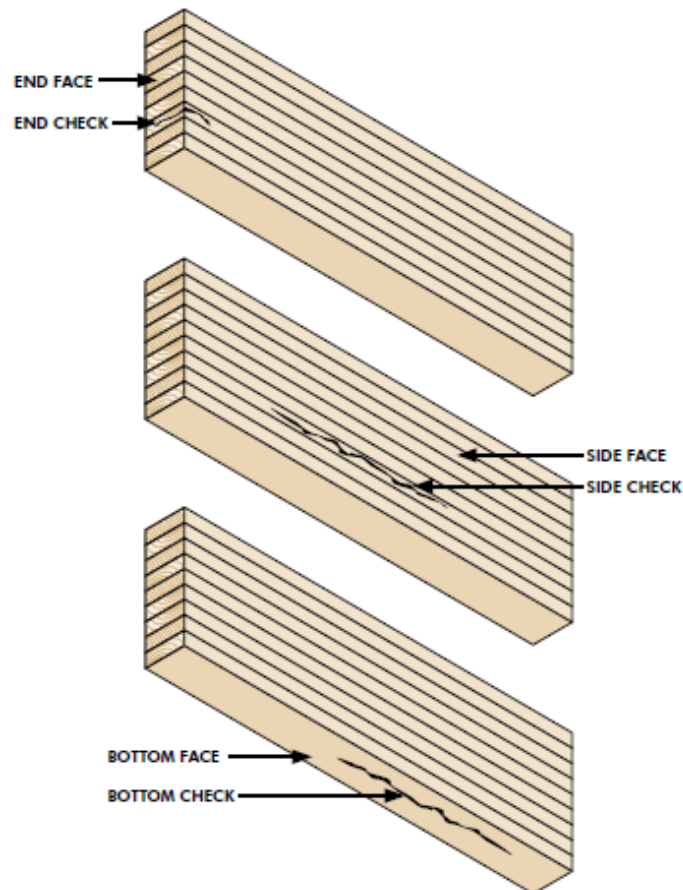


Figure 3.16 Check locations
(Source: APA)

Bottom checks are usually not a structural concern, even if they extend through the full depth of the lamination.



Side checks that are less than one-third the width and one-third the length of the member usually have a negligible effect on the structural capacity of the member. Side checks can appear at any depth of the member.



End checks with a length less than half the depth of the bending member are usually not a structural concern.



Figure 3.17 Types of checks

Source: APA EWS Technical Note: *Evaluation of Check Sizes in Glued Laminated Timber, Form R475*.

Preventing checks

Nordic Lam+ members should be protected from extreme temperatures and humidity during transportation, storage, installation, and use to minimize the extent of checking.

Once the building is enclosed, the interior climate should be adjusted slowly to prevent checking. Unless there are significant changes in the ambient temperature and humidity, additional checking is unlikely to occur after the first year of occupancy.

Site-applied finishes can also help mitigate checking by slowing the movement of moisture into and out of the wood. Refer to section 5 for more information about wood finishes.

Repairing checks

Checks are a natural characteristic of mass timber. If certain checks are deemed to be architecturally unacceptable, they may be filled in with a specialized product (refer to Annex F). These products should not be applied in the first year of building use.

Manufacturing Visual Characteristics

Despite rigorous quality control practices, small non-structural manufacturing characteristics may be found on the final product. These characteristics generally do not require repairs but can be addressed to reduce their aesthetic impact.

Small hole

A small hole is a cavity left in a lamination when a weak section of wood or a dry resin pocket detaches from the growth rings during the planing process.



Figure 3.18 Hole

Torn joint

A torn joint is a small section of wood which is torn off next to a joint during the planing or jointing process.



Figure 3.19 Torn joint

Non-lamination

A non-lamination is a planing irregularity which prevents the laminations from fully gluing together.

A non-lamination less than 12 in. (300 mm) in length, no more than one per lamination, can be considered as a check and be repaired using the methods presented below. A longer non-lamination may require a structural repair. Contact Nordic Structures for more information.

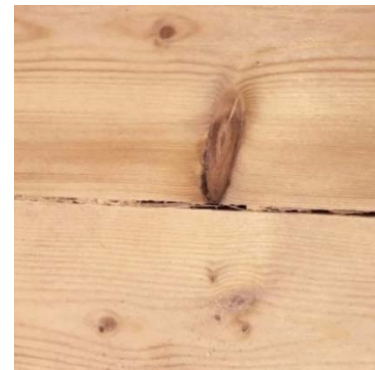


Figure 3.20 Non-lamination

Hole in finger joint

A hole in a finger joint is a small void in a joint, caused by crushing of one or more joint teeth over a small distance, about ¼ in. (6.4 mm), during the jointing process.



Figure 3.21 Hole in finger joint

3.5 Durability

Mold and mildew

Mold is a microscopic fungus that lives off organic matter rather than a photosynthetic process. The terms mold and mildew refer to the same class of fungal species and are commonly used interchangeably.

Mold will grow on numerous building materials, including engineered wood products. They commonly appear as woolly or powdery growths, often black or greenish-brown in color. Mold and mildew grow in conditions with ample moisture, low light, and stagnant airflow.

As an organic material, wood readily supports the growth of mold and mildew if moisture is present. Mold will grow on wood when the moisture content of wood exceeds 19%.

Mold and mildew are types of fungi that do not cause wood to rot. Unlike wood decay fungi, molds do not cause significant loss of strength. Nonetheless, mold and mildew on wood may cause health concerns and indicate that high moisture conditions are present. Prolonged periods of high moisture may also support the growth of wood decay fungi.

Note: For more information on identifying and cleaning mold and mildew, refer to the Maintenance Guide for Mass Timber (NS-GE2).

Chemicals

Wood is resistant to mild acids. However, strong acids with a pH less than 2 and strong alkalis with a pH greater than 10 can degrade the organic compounds found in wood. The degree of degradation is dependent upon many factors, including:

- The species of timber, as softwoods are more resistant to chemical attack than hardwoods;
- The type of chemical, as oxidizing acids are more damaging than non-oxidizing acids;
- The degree of exposure, as harsher environments will hasten the degradation of the wood.

Note: For more information, refer to the Maintenance Guide for Mass Timber (NS-GE2).

Insect damage

Certain insects such as termites, wood-boring beetles, and carpenter ants naturally seek out wood as a source of food and shelter. The types of insects that may attack a building largely depend on the geographical location of the building. Insects typically infest outdoor exposed

wood and are rarely found inside. The protection of mass timber against insect attack usually involves detailing the members to minimize exposure and applying insect-resistant coatings.

Note: For more information on insect damage and control, refer to chapter 14 of the *Wood Handbook*, titled *Biodeterioration of Wood*.

Corrosion of metals

Metal components may corrode if moisture is present. Corrosion itself does not damage the surrounding wood; however, it is indicative of a high moisture content that may be conducive to mold, mildew, or fungal decay growth. Additionally, corrosion of fasteners may stain the surrounding wood and, in extreme circumstances, lead to structural failure of the connection. It is important to ensure that metal components are adequately protected against corrosion, since they are difficult to repair once corrosion has started.

Weathering

Weathering can be defined as the chemical and physical changes that usually affect the outer 2 mm of a mass timber member when it is exposed to the elements. Weathering should not be regarded as a problem, but rather as a natural process.

Weathering occurs through exposure to rain, snow, ice, ultraviolet (UV) light, and wind. The type and rate of weathering will vary depending on the geographical location of a building, the level of exposure of individual components, and the season in which the timber was installed. The extent of weathering can also vary along an element. Uncoated timber exposed to the weather will, over time, develop a silver-gray color.

Due to the variability of the weathering rate, the aesthetics of the member may vary locally in the short term. More exposed areas may become noticeably lighter compared to less exposed areas. However, over time, all timber will fade to a similar silver-gray color.

Weathering effects should be considered when storing and protecting mass timber members.

4. WORKMANSHIP – FABRICATION

This section describes the materials and services provided by the fabricator.

4.1 Erection Drawings

Nordic Structures provides erection drawings that indicate the final position of the mass timber structure. Each member and connection is labelled on the erection drawings following the nomenclature described in Annex C.

In addition to the erection drawings, the 3D cadwork model can be provided for reference and can be viewed using the free cadwork Viewer software. This model can be used to quickly access information like building geometry, connection details, element weights, and piece numbers. Figure 4.1 shows a snapshot of a 3D model.

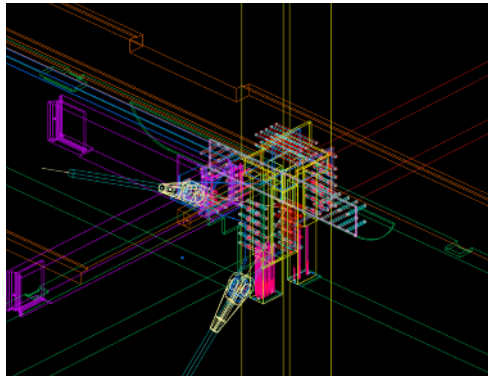


Figure 4.1 Example of a portion of a 3D cadwork model

Unless otherwise specified, the 3D model does not form part of the contract documents and may only be used for general reference. Information presented in the erection drawings and other contract documents govern over any information presented in the 3D model.

4.2 Manufacturing Tolerances

Rigorous quality control practices are implemented during the fabrication of Nordic mass timber products.

Note: For more information, refer to QC/QA for Mass Timber Construction Technical Guide (NS-NT203).

The following tolerances are standard for the production of Nordic X-Lam and Nordic Lam+. The project specification may require stricter tolerances and will govern over those presented here.

Nordic X-Lam (Cross-Laminated Timber)

Standard CLT dimensional tolerances during manufacturing, per ANSI/APA PRG 320, *Standard for Performance-Rated Cross-Laminated Timber*:

- Thickness: $\pm 1/16$ in (1.6 mm) or 2% of the specified thickness, whichever is greater
- Width: $\pm 1/8$ in (3.2 mm)
- Length: $\pm 1/4$ in (6.4 mm)

Squareness: The length of the two panel face diagonals measured between panel corners shall not differ by more than $1/8$ in (3.2 mm).

Straightness: Deviation of edges from a straight line between adjacent panel corners shall not exceed $1/16$ in (1.6 mm).

Nordic Lam+ (Glued-Laminated Timber)

Standard glulam dimensional tolerances during manufacturing, per ANSI A190.1, *Standard for Wood Products – Structural Glued Laminated Timber*:

- Width: $\pm 1/16$ in (2 mm)
- Depth: $+ 1/8$ in (3 mm) per 12 in (305 mm) of depth
 - $3/16$ in (5 mm) or $1/16$ in (2 mm) per 12 in (305 mm) of depth, whichever is greater
- Length: $\pm 1/16$ in (2 mm), for lengths up to 20 ft (6.1 m)
 - $\pm 1/16$ in (2 mm) per 20 ft (6.1 m) of length, for lengths over 20 ft (6.1 m)

Squareness: $\pm 1/8$ in (3 mm) per 12 in (305 mm) of depth. Squareness shall be measured by placing one leg of a square across a top and/or bottom face and measuring the offset from the other leg of the square to the member at the opposite face of the beam, as shown in Figure 4.2.

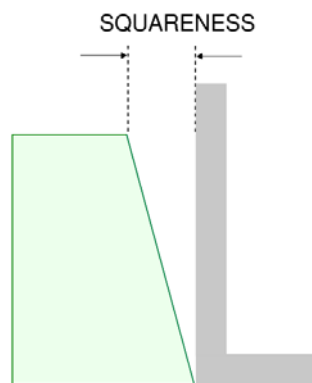


Figure 4.2 Squareness measurement

Straightness: $\pm 1/4$ in (6 mm) for lengths up to 20 ft (6.1 m)

Additional $\pm 1/8$ in (3 mm) per each additional 20 ft (6.1 m) of length

Maximum $\pm 3/4$ in (19 mm) for any length

Field modifications

If field modifications are required for any Nordic mass timber products, the general contractor and Nordic Structures should be notified prior to performing them. The general contractor should obtain any necessary approvals from the engineer, architect, inspector, or stakeholder.

4.3 Product Preparation

This section provides the standard in-house procedures for the packaging and protection of Nordic mass timber products. Project specifications may require procedures that differ from those presented in this section; those specifications govern. If any uncertainty exists with respect to the exact procedures followed in a project, consult Nordic Structures.

Note: For product specifications, refer to the Finishing of Nordic Products (NS-NT205) technical guide.

Protective undercoat sealant

A clear protective undercoat is applied to zero, one, or five sides of Nordic X-Lam and four sides of Nordic Lam+. The undercoat is intended to provide weather protection during transport and erection of the structure.

Protective end grain sealant

A high solid wax emulsion sealant is used to seal the end grain in Nordic Lam+ (Figure 4.11). This is intended to provide end grain weather protection during transport and erection of the structure.

Wrapping

A durable lumber wrap protective packaging is used to protect Nordic X-Lam and Nordic Lam+ from wetting, damage, and discoloration from exposure to sunlight.

Labeling

Nordic mass timber products are labelled using a series of letters and digits which identify the material, orientation and installation order. For more information, refer to Annex C.

Specific procedures for the preparation of Nordic X-Lam and Lam+ products are illustrated below.

Nordic X-Lam (Cross-Laminated Timber)



Figure 4.3 First, wrapping is unrolled over lumber blocking which has been placed on lumber supports.



Figure 4.4 CLT panels are then stacked onto the wrapping, architectural face down. Oriented strand board (OSB) is inserted between the wrapping and the underside of the bottom panel to protect the OSB from damage in case of long-term storage.



Figure 4.5 The protective packaging is then wrapped over the panels and stapled.



Figure 4.6 Oriented strand board (OSB) is then attached to the bottom of the package to provide protection when using a forklift.



Figure 4.7 The entire package, including the lumber blocking that keeps the CLT elevated, is then strapped together.



Figure 4.8 The package is then labeled according to specifications and stacked for storage.



Figure 4.9 Cranes or forklifts are used to load packages onto trucks



Figure 4.10 Forklifts are used to load the packages onto trains.

All packages are strapped down to prevent them from shifting during transport.

Nordic Lam+ (Glued-Laminated Timber)



Figure 4.11 End grain sealer



Figure 4.12 Glulam members are laid onto rollers.



Figure 4.13 The rollers pass the member through a machine that wraps them up. After wrapping, cardboard angles are used to protect the corners of the members.



Figure 4.14 OSB is then placed on equally spaced lumber supports and the wrapped glulam members are stacked on top. For greater stability and safety during handling, glulam members are stacked lying flat.



Figure 4.15 The entire package, including the lumber blocking that keeps the glulam elevated, is then strapped together. The packages are labeled, lifted, and stacked for storage.



Figure 4.16 At the plant, cranes or forklifts are used to load the packages onto trucks; forklifts are used to load the packages onto trains. All packages are strapped down to prevent them from shifting during transport.

4.4 Delivery

Nordic Structures takes the necessary precautions to deliver clean, damage-free products to the construction site. Delivery should be coordinated with Nordic Structures to ensure that the necessary unloading and lifting equipment is available and that the delivery schedule coincides with the erection schedule to minimize site storage. Refer to section 4.6 for information on storing mass timber.

Mass timber members are grouped into divisions for delivery. Each division is generally installable as a unit. The size of a division is limited by the amount of weight that can be supported by a truck.

Upon arrival, the person supervising the reception of materials should verify that all packages indicated on the bill of lading (BOL) are on the trailer. Any discrepancies should be reported to Nordic Structures as soon as possible. Additionally, a signed copy of the BOL should be provided to Nordic Structures for easy tracking of deliveries and contents.

Nordic X-Lam (Cross-Laminated Timber)

Standard practice is to stack packages of Nordic X-Lam in the reverse order of their installation, as shown in

Figure 4.17, so that the top package is the one installed first. This reduces installation time and avoids additional handling on the construction site. However, safety concerns that arise during loading may alter the exact sequence.

Package weights may vary up to a maximum of 80,000 lbs. Different maximum weights may be accommodated but must first be coordinated with Nordic Structures. It is important to coordinate the maximum package weight with the lifting capacity of the equipment available on site.

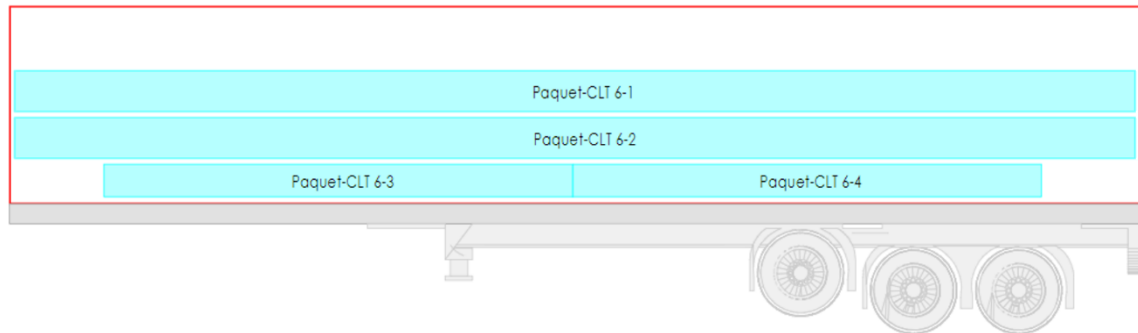


Figure 4.17 Sequenced CLT package on a truck

Trailers may be dropped off at the construction site to allow for direct installation from the trailer bed. This method needs to be discussed and coordinated with Nordic Structures.

Nordic Lam+ (Glued-Laminated Timber)

Glulam members are typically not installed directly from the bed of the truck or train. Packages are typically unloaded by crane or forklift onto a prepared, well-drained storage area, and remain unopened until installation.

Package weights may vary up to a maximum of 30,000 lbs. Different maximum weights may be accommodated but must first be coordinated with Nordic Structures. It is important to coordinate the maximum package weight with the lifting capacity of the equipment available on site.

4.5 Handling

Nordic mass timber products should be lifted by means that will not damage the edges, surfaces, or packaging. It is the responsibility of the contractor and equipment operator to take all the necessary care and precautions when handling mass timber, following all applicable regulations. Refer to section 5.3 for more information on lifting and handling mass timber.

4.6 Storage

Mass timber should be kept dry and protected from exposure to weather at all times. Suggested storage precautions are given below.

Precautions for storage:

- Store mass timber members flat and straight on level blocking, at least 8 in. (200 mm) off the ground, shown in Figure 4.18.
- Ensure that the storage site is level, well drained, and allows for free airflow.
- Use clean lumber blocking or skids.
- Provide enough blocking to prevent the members from bending.
- Place blocking between stacked bundles to promote drainage and airflow. Align the blocking vertically.
- Store glulam members with the edge or seal of the wrapping material facing down.
- Retain the original protective wrapping for as long as possible through the construction process.

- Protect mass timber with opaque, moisture-resistant wraps. Make sure the wrap does not touch the mass timber and does not reach the ground. The factory-supplied plastic packaging does not provide complete and long-term protection against the weather.
- Cut slits on the underside of the wrapping to allow airflow and release any moisture or trapped water. Be careful not to damage the members when cutting.
- Note that any factory-applied coatings are only intended for the short-term protection of mass timber during construction, unless otherwise specified.
- Prevent forklift damage to mass timber members. If the ground is not level in the storage area, reduce the forklift speed to avoid bouncing the members.
- Avoid lengthy storage outdoors on the construction site.
- Protect mass timber members if packages are opened and members are not installed directly.



Figure 4.18 Proper storage of products on lumber blocking to ensure good airflow

5. WORKMANSHIP – ERECTION

This section describes the materials and services provided by the installer.

5.1 Pre-construction Preparation

Documents

The following documents should be prepared prior to beginning construction.

Technical documents:

- Site logistics plan
- Lifting plan
- Rigging plan
- Execution plan
- Material schedules
- Timber frame erection drawings
- Schedule and erection sequence
- Any special instructions/assembly

Contractual documents:

- Agreed work scope and specification
- Communication and liaison agreement

Execution Plan

The execution plan should be coordinated with Nordic Structures, the general contractor, the superintendent on site, and other parties as necessary. The execution plan should include the items discussed below.

Deliveries

All mass timber supplied by Nordic Structures is custom fabricated in Chibougamau, Québec, approximately 9 hours north of Montréal by car. As the shop continuously produces custom products for projects, it is important to plan the delivery schedule well in advance to avoid fabrication delays.

Before Installation

A kick-off meeting should be held with Nordic Structures, the general contractor, and the installer to ensure that all parties understand the execution plan. The general contractor should confirm that the site is prepared for the installer to perform their work, including having access to power and having the latest stamped drawings on site. The installer should survey the as-built anchor bolt locations and check the elevations of the base structure prior to starting installation.

All parties should be familiar with the mass timber moisture management plan for the project and should be aware of their responsibilities for moisture management during and after construction.

Prior to commencing installation, care should be taken to ensure that the job site is free from any obstructions in the work area that may impede the mobilization of the work, as agreed upon by the installer and general contractor.

During installation

The execution plan should include procedures for lifting, handling, and storage of mass timber following the best practices outlined in this document. The installer and site superintendent should provide Nordic Structures with daily progress reports that include a summary of activities performed, issues encountered, and any changes that may affect the production schedule. Refer to Annex F for more information.

No modifications to mass timber members may be done without the approval of Nordic Structures. Should unforeseen circumstances arise that require site modifications, contact Nordic Structures and describe the cause of the change and the proposed solutions.

After installation

The installer should plan to provide pictures to Nordic Structures documenting the completion of the work, including the completion of required cleaning and repairs.

The execution plan should list the responsibilities of the general contractor to protect the mass timber structure for the remainder of construction, including procedures that allow mass timber members to slowly acclimate to the interior environment of the building.

5.2 Means and Methods

Nordic Structures provides erection drawings that indicate the final position of the mass timber structure. It is the responsibility of the installer to establish the means and methods of installation, including plans for temporary stability bracing, shoring, and rigging. This information should be provided to Nordic Structures before starting erection. Erection should not begin until the general contractor has accepted the erection drawings and method. A copy of these documents should be kept and maintained on site. Additionally, the installer should ensure that the conditions of the site are adequate prior to commencing work. The general contractor should ensure that the site conditions meet the expectations of the installer.

The actions described in this section are the responsibility of the installer unless noted otherwise.

Setting out

The general contractor is responsible for establishing the main benchmark to be used by all parties. The installer is responsible for setting out the locations of the timber members. The installer should coordinate with the general contractor to obtain any relevant information.

Base structure

The general contractor is responsible for preparing the structure to receive mass timber members and connections. This typically involves constructing the base structure, installing anchor rods or embed plates, and preparing bearing surfaces. Should any portion of the base structure be out of tolerance, Nordic Structures and the site superintendent should be notified.

As-built anchor bolts

Anchor bolt alignment is generally one of the most problematic areas in mass timber structure erection. Because construction tolerances of mass timber are far smaller than those of other materials, the position and plumbness of anchors bolts are especially important. The general contractor should provide a survey of the anchor bolts to show they have been installed properly. It is recommended that the installer also surveys the anchor bolts before mobilization to preemptively catch any potential problems and adjust installation accordingly.

Base plates, sill plates, and other bearing surfaces

Structural shims should be used to line, level, and support mass timber members on prepared bearing surfaces. Shims must be sufficiently large to avoid locally crushing the wood surface. An approved grout or filler should be used to fill in the gaps between mass timber members and bearing surfaces. The structure should be aligned, leveled, plumbed, and adequately braced before grouting or filling.

Temporary bracing and stability

If temporary bracing is required during erection, bracing should not be removed until the structure is erected, plumbed, lined, and leveled. Temporary bracing may be removed once enough of the permanent stability system has been constructed to provide bracing.

Temporary braces should be installed in such a way that they do not damage the wood. If holes are made in mass timber members when installing temporary braces, they should be repaired following the methods presented in the *Maintenance Guide for Mass Timber (NS-GE2)*.

Erection loads

During erection of the structure, care should be taken to ensure that no part of the structure is permanently distorted as a result of material storage or temporary construction loads. It is the responsibility of the installer to verify the maximum allowable construction load prior to beginning erection. If erection loads exceed the design loads for the permanent structure, the engineer of record should be consulted.

Care should be taken to prevent overstressing members or connections during erection. Permanent connections should not be installed completely until a sufficient amount of the structure has been aligned, leveled, and plumbed, and temporarily connected. This minimizes the risk of overstressing the members during subsequent erection and alignment of the structure.

5.3 Lifting and Handling

Various equipment can be used to handle mass timber products, based on the member type, orientation, and purpose. In all situations, care should be taken to sure that the weight of the mass timber member does not exceed the capacity of the equipment. Approximate product self-weights are presented Table 5.1 Table 3.1in below.

Table 5.1 Average product self-weight

Product Type	Average Self-Weight
Nordic Lam+	35 lb/ft ³ (560 kg/m ³)
Nordic X-Lam	32 lb/ft ³ (515 kg/m ³)

Forklifts

Forklifts or telescopic lift trucks may be used to handle mass timber members, provided that the forks are long enough to support the width of the packages. To ensure stability and safety, it is recommended to place the wide face of a component flat on the forks. Extremely long members may flex excessively when handled and stored. Forklifts should be avoided when handling these members.

Cranes

Mass timber members are typically lifted with a crane for installation. The lifting plan should be developed and executed in collaboration with a qualified rigger with experience in mass timber construction.

The crane should be positioned on site in such a way that the path of the crane is clear of obstacles and that it can reach all locations without needing to be moved. Guy lines should be used to control mass timber members during lifting. Care should be taken to ensure that the soil or supporting structure can withstand the lifting loads without excessive deformation

Pick points for each mass timber member should be established by an experienced rigger. Spreader bars should be used where applicable to eliminate the risk of overstressing and damaging the member during lifting. Follow the manufacturer's guidelines for the maximum loading and attachment specifications of lifting brackets. Ensure that the weight of the load does not exceed the effective capacity of the crane.

Care should be taken to protect the finished surfaces of mass timber products during handling, lifting, and installation. Members should be protected from damage caused by straps, chains, or

wire ropes. Clean gloves, straps, and other lifting devices should be used to avoid unnecessary cleaning.

Nordic X-Lam (Cross-Laminated Timber)

Nordic X-Lam is typically lifted with yokes that are attached directly to the panel, shown in Figure 5.1 and Figure 5.2. The location of the pick points and the specific type of yoke used should be carefully considered by a qualified rigger.

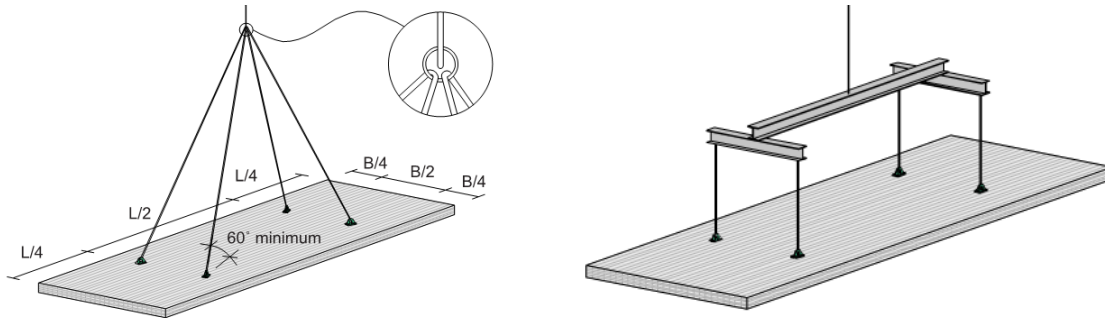


Figure 5.1 Lifting X-Lam floor or roof panels with a crane

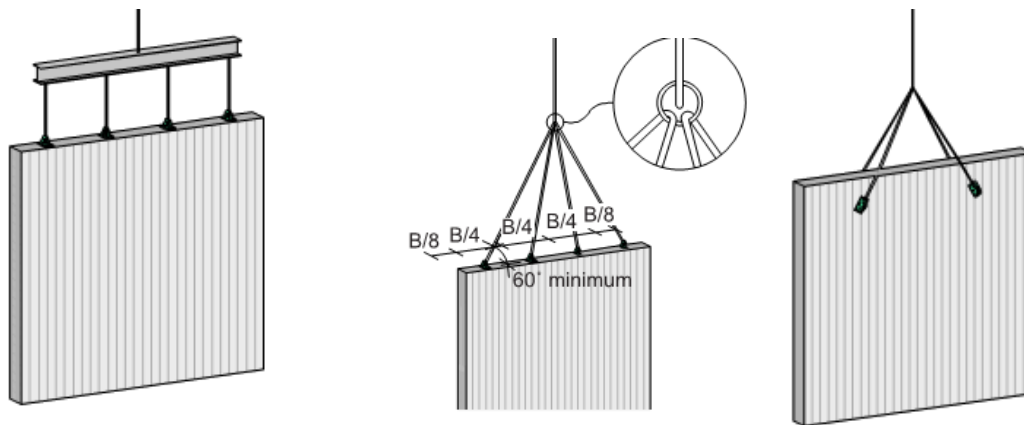


Figure 5.2 Lifting X-Lam wall panels with a crane

Nordic Lam+ (Glued-Laminated Timber)

Nordic Lam+ is typically lifted using slings, shown in Figure 5.3. To avoid damaging the members, only synthetic slings should be used, such as wide fabric belts, plastic belts, or webbing slings. Chains and wire slings are not recommended and may only be used if adequate protection is provided. Slings should be carefully positioned to ensure balanced support. The use of corner protection is always recommended to prevent corner crushing.



Figure 5.3 Lifting Lam+ beams with a crane

Note: For more information about rigging mass timber structures, refer to the CODIFAB Levage Des Structures En Bois Lamellé and the MTC Solutions Rigging Design Guide.

Pick points should be established for Nordic Lam+ and Nordic X-Lam such that the individual panels are not bent to a radius that will damage the members.

5.4 Construction Tolerances

Annex E lists standard tolerances for the base structure, mass timber structures, and structural steelwork. The project specification may require different tolerances and will govern over those listed in this document.

Alignment

The correct alignment of structural members is essential for ensuring that members and connectors work as designed. Care should be taken during construction to place members within allowable tolerances as soon as possible after erection. Ensuring a proper fit between members will result in better performance by minimizing eccentricities that may overstress members, encouraging load sharing, improving fire resistance, and improving thermal performance.

Measurements should be taken progressively as sections of the structure are completed. When progressing from one area of work to another, dimensional deviances should be corrected to prevent the accumulation of misalignment. When assessing the alignment of members, the effects of temperature and moisture on the structure and on measuring instruments should be taken into account.

Tools such as come-alongs and beam or panel pullers can be used to close joints and bring members into their correct position. When using these types of tools, care should be taken to ensure that the holes caused by these tools will not be visible at the end of construction. Once the panels are brought into their correct position, the connections should be installed. Refer to Annex I for product examples.

Connections with mechanical fasteners

Connections should be installed with care to secure and maintain the alignment of members.

Bolts should be installed so that the connecting members fit tightly without crushing the wood under the washers. They should be re-tightened if necessary when the timber has reached equilibrium moisture content to ensure that the load-carrying capacity and stiffness of the structure is maintained.

Wood screws are designed to be driven in in one run without stopping. When installing screws in a steel-to-wood connection, a drill with a torque clutch should be used. Pre-drilled holes are

typically not required for screws 5/16" (8 mm) in diameter or less. During erection, it is important to follow the drawings and specifications for locations of pre-drilled holes; failure to do so may compromise the capacity of the system.

If nails become loose in a connection, they cannot be re-driven. Consult the structural engineer for guidance.

Glued joints

If required, glue should be applied to joints following the recommendations of the manufacturer.

Joint treatment

Treatments can be applied at the interface between members to seal joints and openings. Acoustic membranes may be installed after installation between walls and floors and under metal connectors to improve sound insulation. An adhesive strip or tape may be applied over gaps between components after installation to minimize energy loss and improve airtightness. Alternatively, an impregnated foam can be applied to the width of the joints during the lifting phase.

5.5 Fire Safety during Construction

The general contractor is responsible for managing fire risk during construction, including, but not limited to: access to fire extinguishers, maintaining means of egress, availability of standpipes, and commissioning of the sprinkler system.

In United States, the International Building Code (IBC) (Chapter 33) and the International Fire Code (IFC) provide requirements for fire safety during construction. In Canada, the National Building Code (NBC) and the National Fire Code (NFC) provide similar information.

5.6 Quality Control

Inspections

General field review should be performed by a qualified professional having experience in the field review of mass timber structures. Prior to placing or installing other materials, an inspection of the completed wood structure should take place. Unless otherwise agreed, the verification of tolerances, structural alignment, moisture content, and connections should be carried out by a qualified inspector retained by the owner.

Special inspections for certain construction activities may be required by the structural engineer of record in the United States. The special inspection should be performed by a qualified professional with experience in mass timber construction who is retained by the owner.

Where required for a project, shop inspection of prefabricated components may be carried out at the Nordic facility. Material mill certificates will be provided upon request.

Moisture

The moisture content of structural mass timber members should be monitored by the general contractor following the moisture management plan.

Reporting

The installer and site superintendent should provide Nordic Structures with daily progress reports that include a summary of activities performed, issues encountered, and any changes that may affect the production schedule.

Any deviations from erection drawings resulting from unforeseen field conditions should be clearly documented on the erection drawings and should include sketches of any revised details. At the end of construction, the set of marked up drawings should be returned to Nordic Structures.

5.7 Handover

This section discusses the responsibilities of the installer when erection of the mass timber structure is complete and the responsibilities of the general contractor after the installer has left the site.

After installation

The installer is responsible for ensuring that the mass timber structure is clean and free of damage. Mass timber members should be cleaned and repaired following the guidance in the *Maintenance Guide for Mass Timber* (NS-GE2). Once the work is complete, the installer should take pictures to thoroughly document the work, including any repairs that were made. The return or disposal of any leftover materials on site should be coordinated with Nordic Structures.

The general contractor is responsible for ensuring that mass timber members remain protected against moisture and damage for the remainder of construction. Following trades should be made aware of the moisture management plan and other considerations for working in a mass timber building.

Construction loads

The general contractor should ensure that the weight of materials and equipment placed on the structure by following trades does not exceed the capacity of the structure. If heavy loads are anticipated, the engineer of record should be contacted for additional guidance.

Penetrations through mass timber members

The general contractor should coordinate the locations of building services and penetrations through mass timber members with trade contractors. Notches and holes are only permitted in locations where the reduced strength of affected members will not compromise its structural integrity. The general contractor should submit a proposal for field penetrations with supporting calculations for approval by Nordic Structures and the engineer of record.

Cleaning and repairs

If cleaning or repair of mass timber members is required, refer to the *Maintenance Guide for Mass Timber* (NS-GE2) or contact Nordic Structures.

Final in-service moisture content

Once the building is enclosed, mass timber members should be allowed to gradually adjust to the internal temperature and moisture conditions of the building. Since many parameters affect the time it takes for wood to reach a stable moisture content, existing research does not specify a precise rate of change of moisture content. The most common recommendation is simply to ensure a gradual change.

As a rough ballpark estimate, a change in moisture content of 1% per month may be considered to be an average rate. Note that this pertains to the average change in moisture content of the entire member; the moisture content at the surface of a member will change more rapidly than that in the core.

It is important to schedule the commissioning of the HVAC system to allow for the gradual adjustment of mass timber moisture content. Changing the internal temperature and humidity too rapidly increases the likelihood and severity of checking. The mass timber moisture content should be regularly monitored when the building is being conditioned to ensure that no abrupt changes occur.

6. PROTECTION AND REPAIR

This section outlines methods in which mass timber products should be protected against moisture, soiling, staining, and other forms of damage during transportation and throughout construction. Physical products such as wraps and chemical products such as sealants can be used alone or in combination to offer a wide range of protection. The type of protection should be selected based on the anticipated environmental exposure of the mass timber members. A moisture management plan is an effective tool in minimizing moisture damage during construction. This section also outlines common methods to clean mass timber members and execute non-structural repairs.

6.1 Moisture Management

Developing and executing a moisture management plan during construction is one of the most effective ways of minimizing the effects of moisture on mass timber members. The plan should consider items such as:

- Site-specific weather conditions
- Possible sources of moisture
- Construction sequence
- Additional temporary protection for mass timber members
- Daily and weekly checklists during construction
- On-site storage strategies
- On-site water management team

If needed, a design professional with experience in building science may be consulted for specific advice. Annex G shows the outline of an example moisture management plan.

Sources of moisture

The sources of moisture that can affect mass timber can be broadly divided into two categories: relative humidity and direct wetting. The relative humidity in the air can cause the moisture content in mass timber to change depending on the ambient conditions. Direct wetting is the result of exposure to water in the form of rain, snow, ice, or on-site water sources.

Humidity

In addition to environmental relative humidity, the moisture in the air around mass timber members on a construction site may be affected by the use of equipment such as heaters or as a result of standing water from a recent storm. Mechanical equipment may also cause moisture in the air to condense on mass timber surfaces.

Rainwater

Mass timber members, particularly CLT panels, glulam columns, and perimeter glulam beams, may be exposed to direct wetting from rain. The construction sequence should consider the potential for assemblies to trap rainwater, take steps to avoid ponding, include procedures for removing rainwater, and allow time for mass timber members to dry.

Snow and ice

Snow and ice accumulation on a construction site may create a safety hazard, impede construction, and interfere with the normal workflow. Snow and ice will typically not affect the structural integrity of mass timber structures while they remain frozen, but may start causing problems once they start to melt.

Options for removing snow or ice:

- Remove loose snow from the structure as soon as possible, before it becomes compacted or thaws
- Snow may be removed mechanically using shovels or snow blowers. If required, a crane may be useful for moving the removed snow.

- De-icing salts, which often contain sodium chloride, calcium chloride, or magnesium chloride, are not recommended. While these salts often do not affect the wood or the adhesives used in mass timber products, they may corrode steel fasteners and connectors and could damage concrete surfaces.
- Liquid salt brines or other liquid anti-icing agents that are applied to mass timber before a storm are also not recommended. These products leave behind crystals which melt the snow on contact and prevent it from bonding to the surface but may damage steel and concrete components.
- The effects of proprietary glycol-based and other de-icing products commonly available at retail and distribution centers have not been evaluated. Because the effects of these products on mass timber are untested, Nordic Structures does not endorse their use.
- While mass timber is generally resistant to chemicals, strong acid or alkaline solutions may affect the strength of mass timber.

Additional options for removing ice:

- Apply a thin layer of coarse sand to improve traction and absorb heat from the sun, which can accelerate melting. Sand can be easily cleaned up after the floor or roof is free of ice.
- Chip away the ice with an ice scraper. Note that this may damage the surface being scraped.
- Melt the ice using a torch, space heater, or other heating element. Note that this may damage wood and the resulting water must be cleared off immediately so that it does not refreeze elsewhere.

Active drying during construction

It is often necessary to actively dry the surface of mass timber during construction. In particular, it is important to ensure that the moisture content in the mass timber members does not exceed 19% when installing permeable finishes such as gypsum board or 16% when applying impermeable finishes such as waterproofing membranes.

Considerations for drying mass timber:

- Drying should be implemented on a zone-by-zone basis, commencing only once a zone is enclosed.
- Fans, heaters, or dehumidifiers may be used to accelerate drying.
- In some cases, simply enclosing a portion of the building is sufficient to dry out mass timber.
- Humid environment should not be enclosed if adequate ventilation is not provided.
- When drying mass timber, regular measurements should be taken of the interior air temperature, relative humidity of the air, and moisture content of the wood.
- Mass timber should be dried slowly to avoid checking.

Construction sequence

The construction sequence should include plans to minimize the exposure of mass timber members to direct wetting. In particular, the installation of waterproofing assemblies on the walls and roof should be carefully considered as they can provide protection. If wet conditions are expected during construction, construction practices should be discussed with a qualified professional.

The construction sequence is specific to each project. The list below offers some things to consider when determining the construction sequence:

- Expected weather conditions during construction
- Flexibility in the schedule to allow for construction in dry weather, as certain activities can be severely impeded by wet weather
- Application schedule for sealants based on their intended purpose
- Installation of waterproofing over the roof slab as soon as the roof is dry
- Concrete casting schedule if used as protection

- Moisture content monitoring of mass timber and flexibility in the schedule to adjust moisture content if needed.
- Protection of levels below so that mass timber can be encapsulated or other trades can begin work

Other considerations

The following list includes some other factors that should be considered in the moisture management plan:

- Project-specific details such as the size of the structure, construction schedule, and duration of potential exposure
- Exposure of different members to direct wetting from precipitation or on-site water supplies
- Potential for mass timber and assemblies to trap water
- Ability of members and assemblies to drain and dry
- Strategies to dry wood if the moisture content exceeds recommended limits
- Risks associated with wetting
- Costs
 - o Management and coordination
 - o Construction delay
 - o Moisture protection
 - o Active drying
 - o Waste disposal
 - o Potential remediation
- Products
 - o Availability
 - o Performance
 - o Cost
 - o Ease of application
 - o Environmental impact

It is important to note that not all projects require the same level of moisture protection during construction. Careful evaluation of the risks associated with each project can help to avoid unnecessary construction costs while ensuring adequate protection.

Wood protection solutions

Table 6.1 lists some options for protecting mass timber members and their advantages and disadvantages. Multiple options may be employed on a project and the options selected may vary throughout the project.

Table 6.1 Protection options

Component Protection				
Option	Product	Cost	Protection Level	Remarks
No coating	Nordic Lam+ Nordic X-Lam	None	None	Used when protection is not required. Not typical.
Protective undercoat, factory-applied	Nordic Lam+ (default option) Nordic X-Lam (default option)	Low ⁽¹⁾	Low	Easy to touch up on-site and offers basic protection against moisture.
End grain sealant, factory applied	Nordic Lam+ (default option)	Low ⁽¹⁾	Low-Medium	Default option for Nordic Lam+. Easy to touch up on-site and offers basic protection against moisture.
Protective undercoat, applied on-site	Nordic Lam+ Nordic X-Lam	Low-Medium ⁽²⁾⁽³⁾	Transport: None Installation: Low	May be desirable if the specified undercoat cannot be applied in the factory, but the mass timber would be unprotected during transport and handling.
End grain sealant, applied on-site	Nordic Lam+	Low-Medium ⁽²⁾⁽³⁾	Transport: None Installation: Low-Medium	May be desirable if the specified undercoat cannot be applied in the factory, but the mass timber would be unprotected during transport and handling.
Individual packaging	Nordic Lam+	Low-Medium	Transport: High Installation: None	Option for Nordic Lam+. Offers protection against direct wetting until removed. Produces additional waste.
Galvanization	Steel members and connectors	Medium-High	High	Prevents rust stains from appearing on mass timber members.
System Protection				
Option	Product	Cost	Protection Level	Remarks
Tape on floor or roof panel-to-panel joints, applied on-site	Nordic X-Lam	Medium ⁽²⁾	Low	Difficult to install if mass timber is wet. May peel off due to construction traffic or moisture accumulation. May trap moisture.
Self-adhering membrane, factory-applied	Nordic X-Lam	Medium-High ⁽¹⁾⁽⁴⁾	Medium	May make surfaces slippery. Membrane may trap moisture if damaged. May be removed or kept in place in final structure.
Self-adhering membrane, applied on-site	Nordic X-Lam	Medium-High ⁽²⁾⁽³⁾⁽⁴⁾	Medium	May make surfaces slippery. Membrane may trap moisture if applied over wet wood or if damaged. May be removed or kept in place in final structure.

Concrete topping	Not product-specific	N/A	Medium-high	If present in project, concrete topping slab may offer protection to mass timber elements below. Do not allow ponding to occur on a concrete topping. May be sealed with an epoxy finish. Members should be dry prior to application (MC below 16%).
Seal through-penetrations	Nordic X-Lam	Low ⁽²⁾	Low	Only offers local protection around the penetration.
Storm drain system through floors or roof	Nordic X-Lam	Medium ⁽²⁾	Medium	Drains water through slab penetrations using temporary or permanent storm drain systems.
Temporary vertical perimeter enclosure (tarping)	Not product-specific	Low	Low-Medium	Offers protection for perimeter elements. Can be used as a temporary enclosure for other work to proceed.
Temporary curtain walls	Not product-specific	High ⁽²⁾⁽³⁾	Low-Medium	Offers protection for perimeter elements from wind-driven rain and snow. Can be used as a temporary enclosure for other work to proceed. Produces significant waste if not reused. May hinder the progress of cranes or equipment that need access between levels.
Temporary tent	Not product-specific	Very High ⁽²⁾⁽³⁾	Very High	Improves site working conditions for all trades. May be difficult to implement. Requires special crane considerations.
Construction Sequencing				
Option	Remarks			
Phasing	Refer to <i>Construction Sequence</i> in section 5.1.			
Curtain walls				
Just-in-time delivery				
On-site storage				
Active Water Removal				
Option	Product	Cost	Protection Level	Remarks
Squeegee	Not product-specific	Variable	High	Must consider how to remove the water.
Shop vacuum	Not product-specific	Variable	High	May be hooked up to storm drain system.
Leaf blower	Not product-specific	Variable	Low	May splash dirty water onto vertical wood surfaces.

Monitoring				
Option	Product	Cost	Protection Level	Remarks
Moisture monitoring	Not product-specific	Variable	None	Preventative, not protective.

1. Products applied in the factory have a higher degree of quality control than those applied on site.
2. Cost of option depends on cost of labor, which can vary greatly.
3. Cost of option depends on cost of specific product used.
4. For optimal performance, continuous moisture protection should be provided across joints.

6.2 Aesthetic Damage

Cause and Prevention

The purpose of this section is to provide information on measures to protect the mass timber structure from aesthetic damage on the construction site. Table 6.2 provides examples of common stains along with their preventive measures.

Table 6.2 Examples of stains and preventive measures

Stains and preventive measures	Example
<u>Rust stains</u> Cause: Corrosion of steel. Prevention: Use galvanized or stainless steel.	
<u>Concrete stain</u> Cause: Water from wet concrete leaking through gaps in the mass timber panels. Prevention: Cover or seal joints before pouring concrete.	
<u>Iron stain</u> Cause: Oxidation of steel dust that has been lodged in wood from grinding or welding. Prevention: Avoid cutting steel near wood members or protect members if cutting near them.	

<u>Mold</u> Cause: High moisture content for a prolonged period. Prevention: Keep wood packages off the ground and well protected from moisture; prevent moisture accumulation.	
<u>Marks</u> Cause: Dirty straps or blocking used during storage or handling. Prevention: Use clean equipment when handling and storing mass timber.	
<u>Footprints</u> Cause: Dirty feet. Prevention: Do not walk on exposed mass timber elements; if necessary, protect the wood beforehand.	

Corrective measures

For cleaning and corrective measures, refer to the *Maintenance Guide for Mass Timber* (NS-GE2) or contact Nordic Structures.

6.3 Cleaning Wood

Several methods are available for cleaning wood, depending on the type of stain, amount of dirt, and desired results:

- Surface stains, usually located on the protective undercoat, can be scrubbed with a mild detergent solution using a soft bristle brush.
- Deeper stains can be treated with a wood cleaner following the product manufacturer's recommendations. The protective undercoat may need to be reapplied once the surface of the wood has dried.
- For extreme cases, sanding may be required to remove the stains. The protective undercoat may need to be reapplied after sanding.
- For special cases, dry-ice blasting may be an option. This process involves using compressed air to project 3 mm particles of dry ice that clean the surface. The protective undercoat may need to be reapplied after treatment.

Always follow the product manufacturer's recommendations when using cleaning products and test the product in an inconspicuous location. It may be necessary to feather the treatment area to blend it into the surrounding wood.

Generally, cleaning temporarily makes the wood paler in the treated areas. The color of the wood should become uniform within a few weeks or months, depending on the difference in color and the exposure conditions.

Concrete stains

When concrete is poured, water may leak through gaps in mass timber panels, leaving behind concrete stains as shown in Figure 6.1. Sanding and applying wood cleaners can typically remove these stains. However, this should only be done after testing the procedure in a discrete area.



Figure 6.1 Concrete stain left when concrete is poured above

Extractive stains

Extractives are water-soluble compounds naturally found in wood. When wood comes in direct contact with water, these compounds may leach out and dry on the surface of the wood, leaving stains known as tide marks, as shown in Figure 6.2.



Figure 6.2 Tide marks caused by uneven leaching of extractives

Tide marks can typically be removed using wood cleaners. The longer the tide marks are left on the timber surface, the harder it may be to remove the stains.

Sanding and applying wood cleaners have proven successful in the past for removing tide marks from mass timber surfaces. However, this should only be done after testing the procedure in a discrete area.

Metal stains

The treatment of metal stains in wood depends on the type of metal, species of wood, and cause of stain. One of the most common types of metal stains results from the corrosion of steel in wood. For these stains, a penetrating oxalic acid solution can be an effective treatment, as shown in Figure 6.3. These stains are sometimes caused by tiny flecks of steel that become lodged in the wood as a result of construction activities occurring near the wood. In these cases, removal of any remaining steel in the wood may be necessary to prevent further staining.



Figure 6.3 Iron stains (left) and treatment with oxalic acid (right)

A ferrous sulphite or a sodium hydrosulphite preparation can also be used to remove iron stains. Stains resulting from other metals may require different methods for removal.

The chemicals mentioned above should be used and disposed of with due care and in accordance with the applicable health and safety regulations.

6.4 Repair

All repair work should be based on an accurate diagnosis of the cause of damage or degradation. Structural repairs require evaluation by a qualified design professional and are not included in the scope of this document.

Small undesired characteristics or incidental damage may be locally improved by sanding or applying a filler, as outlined in Annex B. Refer to Annex F for a list of filler products.

7. PROTECTIVE TREATMENT AND FINISHES

This section discusses methods of protecting mass timber products after construction. If more than one protective treatment or finish is required, care should be taken to ensure that the different systems are compatible.

7.1 Architectural Finishes

Preparation

Prior to application of architectural finishes, timber and metal surfaces should be prepared according to the instructions of the manufacturer. It is important to ensure that the moisture content in the mass timber members does not exceed 19% when installing permeable finishes such as gypsum board or 16% when applying impermeable finishes such as waterproofing membranes.

Touching up factory-applied coatings

Care should be taken on-site to avoid damaging the protective undercoat and end-grain sealant coating applied during fabrication, as well as any factory-applied finishes. In the case that unforeseen modifications must be made to the members, exposing the unprotected wood underneath, touch-ups should be applied following the recommendations of the manufacturer.

Site-applied finishes

Finishes such as stains and paints designed to be applied on-site should follow the recommendations of the manufacturer.

7.2 Fire Protection System

Flame retardant

Flame retardants are chemicals that are typically pressure-impregnated into the wood to reduce the spread of flames on the surface of a member; these treatments are generally applied during fabrication. Care should be taken to ensure that they are compatible with any finishes applied during construction. If any cutting or machining is done after the flame retardant is applied, the manufacturer should be consulted to determine what measures are needed to ensure adequate performance of the flame retardant.

Fire-resistant gypsum board

If gypsum board is specified as part of the fire protection system, ensure that the screw pattern used to attach the gypsum board to mass timber members meets the requirements in CSA O86 and AWC TR-10.

Fire caulking

Fire caulking can be used to seal joints if required to ensure the necessary fire rating of joints and through-penetrations, or if specified by the designer. Caulking should be applied following the recommendations of the manufacturer.

ANNEX A. REFERENCED DOCUMENTS

- ANSI. 2017. Standard for Wood Products – Structural Glued Laminated Timber. ANSI A190.1-2017. American National Standards Institute, Washington, DC.
- ANSI/APA, 2019. Standard for Performance-Rated Cross-Laminated Timber. ANSI/APA PRG 320-2019. APA – The Engineered Wood Association, Tacoma, WA.
- APA. 2015. Keep Glulam Looking Its Best with Proper Storage and Handling. Builder Tips, Form No. F455. APA – The Engineered Wood Association, Tacoma, WA.
- APA. 2015. Recommendations for Snow and Ice on Wood Structural Panels. Technical Topics, Form No. TT-019. APA – The Engineered Wood Association, Tacoma, WA.
- AWC. 2018. 2018 National Design Specification (NDS) for Wood Construction. American Wood Council, Leesburg, VA.
- AWC. 2020. Calculating the Fire Resistance of Wood Members and Assemblies. TR 10. American Wood Council, Leesburg, VA.
- BE2S. 2019. Levage des structures en bois lamellé. Bureau d'Études Structures Sauvignat. Paris, France.
- CEN. 2004. EN 1995 Eurocode 5 – Design of timber structures. European Committee for Standardization.
- CISC. 2015. Code of Standard Practice for Structural Steel. Eighth Edition. Canadian Institute of Steel Construction, Markham, ON.
- CSA. 2019. Concrete materials and methods of concrete construction. CSA A23.1. CSA Group, Toronto, ON.
- CSA. 2019. Design of steel structures. CSA S16-14 (R2019). CSA Group, Toronto, ON.
- CSA. 2019. Engineering design in wood. CSA O86-19. CSA Group, Toronto, ON.
- Exova BM TRADA. 2017. National Structural Timber Specification for Building Construction. Version 2. Exova BM TRADA, High Wycombe, Buckinghamshire, UK.
- FPI. 2016. A Guide for On-site Moisture Management of Wood Construction. FPIInnovations, Vancouver, BC.
- FPL. 1998. Equilibrium Moisture Content of Wood in Outdoor Locations in the United States and Worldwide. Research Note FPL-RN-268. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI.
- FPL. 2010. Wood handbook—Wood as an engineering material. General Technical Report FPL-GTR-190. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI.
- ICC and AWC. 2020. Mass Timber Buildings and the IBC 2021 Edition. International Code Council and the American Wood Council, Country Club Hills, IL.
- ICC. 2017. 2018 International Building Code (2018 IBC). International Code Council, Country Club Hills, IL.
- MTC. Rigging Design Guide. MTC Solutions, Surrey, BC.
- NRC. 2015. National Building Code of Canada 2015 (NBC 2015). Canadian Commission on Building and Fire Codes. National Research Council, Ottawa, ON.
- RDH. 2020. Moisture risk management strategies for mass timber buildings. RDH Building Science, Vancouver, BC.
- ThinkWood. Continuing Education – Design for Durability. ThinkWood, Softwood Lumber Board, West Linn, OR.

ANNEX B. ANNEX B. NON-STRUCTURAL TOUCH-UPS AND REPAIRS

Local aesthetic works can offer the possibility to achieve a desired appearance without the presence of unwanted visual characteristics. While the visual characteristics mentioned in section 4 generally do not require repairs, if deemed by the designer, contractor, or owner to be visually unacceptable, they can be repaired or touched up using the appropriate method presented below. Before proceeding with any non-structural touch-ups and repairs, it should be established whether the characteristic is in fact not wanted, as the contractor may run the risk of executing a repair that may not perfectly match the manufactured finish of the surrounding wood. The repair procedures described below can also be used to repair screw or nail holes and local impact damage.

Method 1:

For the improvement of small undesired characteristics (length < 12 in. (300 mm); width < 1/4 in. (6 mm)):

- 1) Fill the imperfection with a wood filler (preferable) or a construction-grade wood glue that matches the natural color of the wood (a dye may be incorporated if required);
- 2) Allow sufficient drying/hardening time, following the instructions of the adhesive manufacturer;
- 3) Sand down with an orbit sander using the grit size recommended by the finish manufacturer;
- 4) Re-apply the required wood finish with a brush over the repaired area until the color matches as much as possible that of the un-repaired wood;
- 5) If a cleaning is required, refer to the Maintenance Guide for Mass Timber (NS-GE2).

Method 2:

For the improvement of larger undesired characteristics, follow the procedure presented below.

Prior to proceeding, if any of the conditions below are satisfied, do not repair the characteristic and contact Nordic Structures:

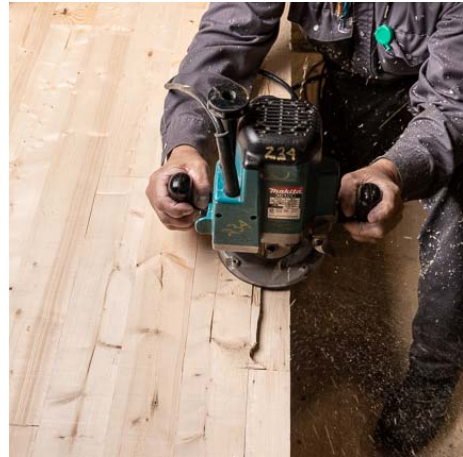
- The repair is more than 4 ft (1.2 m) long;
- The repair affects more than one lamination;
- Doubt exists about the size of the repair area.

Table B.1: Repair procedure for Method 2

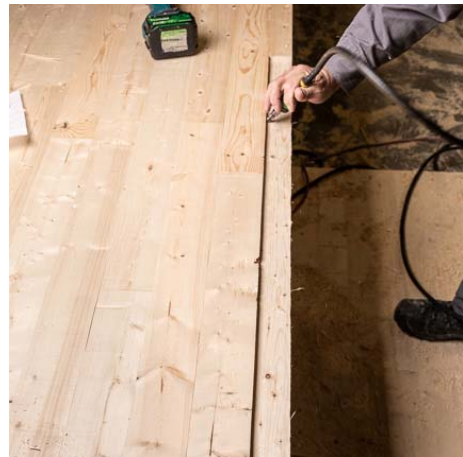
- 1) Identify an imperfection which requires a repair



-
- 2) With a routing tool, remove the wood in the affected area to a depth of between 3/16 to 1/4 in. (5 to 6 mm).



-
- 3) Finish the corners of the routed area with a wood chisel or a rotary tool equipped with a relevant finishing bit.



-
- 4) Prepare a piece of wood used to separate packages during shipping by cutting it to the same size as the routed area. These pieces are made from the same wood species as the Nordic Lam+ (Glulam) or Nordic X-Lam (CLT) products supplied. It is recommended to use a wood piece of 1/16 in. (1 or 2 mm) thicker than the routed area.



-
- 5) Apply a construction-grade adhesive to the routed area, including to edges for better results.



-
- 6) Place the prepared wood piece into the routed area and hold it down using finishing nails or clamps. Allow sufficient drying/hardening time following the instructions of the adhesive manufacturer.



-
- 7) Sand the area down with an 80-grit belt sander to smooth the repair area out and to blend it in with the rest of the member.



-
- 8) It is recommended to apply the same finish as the factory finish. Inquire with Nordic Structure for the current manufacturing finish applied. Prior to applying the finish, prepare the surface by sanding it a second time with an orbit sander using the grit size recommended by the finish manufacturer.



-
- 9) Re-apply the required wood finish with a brush over the repaired area until the color matches as much as possible that of the un-repaired wood.

In the case where the colors do not match perfectly, a uniform color between the repaired area and the untouched area will develop after up to a year. If a cleaning is required, refer to the Maintenance Guide for Mass Timber (NS-GE2).



ANNEX C. NOMENCLATURE

The nomenclature used in the fabrication of wood members and steel parts is shown in Figure C.1. This system is used to label pieces and to identify them in shop drawings and assembly plans.

Nordic Lam+ members are identified by a production number consisting of a descriptive letter followed by a four-digit number. The letter and the first digit identify the member type.

Nordic X-Lam members are identified by a production and sequence number. The production number consists of a letter followed by a five-digit production number. The letter and the first two digits identify the orientation of the member.

The sequence number is comprised of two digits representing the division number and three digits representing the sequence number, separated by an underscore. For example, panel 51_009 corresponds to division 51 and should be installed before panel 51_010. The sequencing is discussed with the erector prior to the start of fabrication to ensure a logical delivery schedule that satisfies any site installation constraints.

Steel parts are identified by a three-digit number (from 100 to 999) preceded by the letter s and a descriptive letter that identifies the member type.

NOMENCLATURE WOOD AND STEEL				V6 (2019-09-03)	
Nomenclature for fabrication of wood and steel pieces					
WOOD (XXXX) 4 digits				X-LAM (XX XXX) 5 digits	
C COLUMN	1000			H HORIZONTAL	10 000 
O ROUND COLUMN	1000			V VERTICAL	11 000 
P MAIN GIRDER	2000			STANDARD WASHER (XX) 2 digits sW01 WASHER (Ø2 1/4"x1/4") FOR Ø3/4" ROD sW02 WASHER (Ø3"x3/8") FOR Ø1" ROD sW03 WASHER (Ø3"x1/4") FOR Ø3/4" ROD sW04 WASHER (Ø3"x1/2") FOR Ø1 1/4" ROD sW05 WASHER (Ø3 1/2"x1/2") FOR Ø1 1/2" ROD	
S SECONDARY	3000				
L SILL	4000				
X BRACING	5000				
F TRUSS	6000				
R DECKING	7000				
A ARCH	8000				
D MISCELLANEOUS	9000		BLOCKING COVER PLATE WINDOW SPLICING STAIR STRINGER ETC.		
STEEL (XXX) 3 digits					
sP BASE PLATE	100				
sE HANGER	200				
sJ JOINT	300				
sC CAP	400				
sG GUSSET	500				
sX BRACING	500				
sF TRUSS	600				
sT TIE BEAM	700				
sD MISCELLANEOUS	900		ANGLE FASTENER CLAMP CLIP ETC.		

Figure C.1 Product nomenclature

ANNEX D. LIST OF PRODUCTS

Note that the list of products is not exhaustive. The commercial products identified do not imply a recommendation or endorsement by Nordic Structures, nor are the products identified the best available for the intended purpose. Nordic Structures does not endorse or guarantee the performance of these products.

Please consult product manufacturers to determine finish options and for additional details. Care should be taken to ensure that any selected products are compatible with any products that may have been applied previously. It is highly recommended to proceed with preliminary samples.

Finishes

- Refer to the *Maintenance Guide for Mass Timber* (NS-GE2).

Membranes

- Tape
 - o SIGA WIGLUV 60
 - o Rothoblaas Frost Band
 - o Huberwood ZIP System Flashing Tape
- Vapor-permeable self-adhered (VP SA) membrane
 - o VaporoShield Slopeshield Plus Self-Adhered
- Vapor-impermeable self-adhered (VIMP SA) membrane
 - o Styrene-Butadiene-Styrene or SBS
- Torched laps
 - o Soprema Elastophene Flam Stick

Repair Products

- Refer to the *Maintenance Guide for Mass Timber* (NS-GE2).

Screws and bits

- MTC Solutions ASSY VG CSK, ASSY SK, ASSY FWH, ASSY Kombi, and ASSY CG CYL, shown in Figure D.1
- MTC Solutions ASSY AW Bits

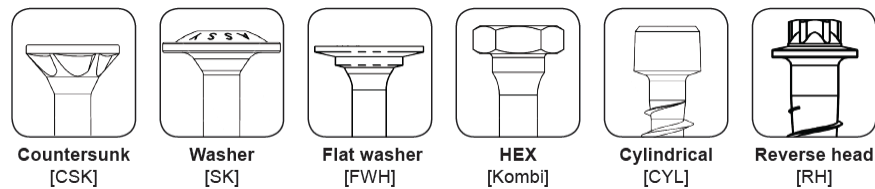


Figure D.1 Common screws

ANNEX E. CONSTRUCTION TOLERANCES

The tolerances provided in this section are based on generally accepted standard practices for mass timber construction. These tolerances are only provided as a guide; other tolerances may govern in specific projects. Where tighter tolerances are required, the required accuracy shall be specified on the structural drawings or specifications.

Concrete tolerances

General tolerances for the placing of anchor bolts, embedded components, and other concrete components should follow CSA A23.1, *Concrete materials and methods of concrete construction* in Canada, or ACI 117, *Specification for Tolerances for Concrete Construction and Materials* in the United States.

Steel tolerances

Fabrication and erection tolerances for steel components should follow CSA S16, *Design of Steel Structures* and the CISC *Code of Standard Practice for Structural Steel* in Canada, or AISC 303, *Code of Standard Practice for Steel Buildings and Bridges* in the United States.

Base structure tolerances

It is important to note that mass timber construction generally requires tighter tolerances than steel or concrete construction. Structures that meet the construction tolerances established in the published steel and concrete standards may not be compatible with mass timber structures. Connections at the interface between mass timber and other materials should include allowances to adjust for misalignment.

Timber manufacturing tolerances

For manufacturing tolerances of timber components, refer to section 4.2.

Pre-construction surveying

When required for the accurate fabrication of mass timber members, a pre-construction survey of as-built supports, bearing surfaces, and embedded items should be carried out by the general contractor.

Construction tolerances

Mass timber structures should comply with the allowable tolerances listed in Table E.1.

Table E.1 Allowable variations of installed mass timber components

<u>Item and Characteristic</u>	<u>Allowable variation</u>
Wall geometry - Verticality - Levelness - Squareness	$\pm L/300$; maximum 50 mm over height of building $\pm L/500$; maximum 25 mm over length of building $\pm 3/16$ in. (5 mm) in 8 ft (2.44 m)
Sheathing fasteners (for glulam decking) - Specified fastener spacing - Nail over-driving in structural wood sheathing	$\pm 1/8$ in. (3 mm) See Note 1.
Floor geometry - Overall floor elevation - Overall floor level	$\pm 3/8$ in. (9.5 mm) $\pm L/500$; maximum 25 over length of building

- Localized floor level	± 5/16 in. (8 mm) in 10 ft (3.05 m)
Floor and roof framing - Joist, purlin, and beam spacing - Joist or purlin depth mismatch - Joist and purlin bearing length - Built-up beam ply depth mismatch - Built-up beam fastener spacing - Beam bearing length - Beam level - Beam verticality	± 1/4 in. (6 mm) ≤ 1/8 in. (3 mm) ± 1/4 in. (6 mm) ≤ 1/8 in. (3 mm) ± 1/4 in. (6 mm) ± 1/8 in. (3 mm) ± L/500; maximum 25 mm over length of building ± 1/8 in. (3 mm)
Columns - Column verticality - Overall column length (incl. multi-storey) - Built-up column fastener spacing	± L/300; maximum 50 over height of building ± L/1500 ± 1/4 in. (6 mm)
Connections - Fastener spacing and location - Fastener alignment - Fastener end distance - Bolt hole diameter oversize - Slot width oversize for steel plate - Pilot holes for lag screws	± 1/8 in. (3 mm) ± 1/8 in. (3 mm) ± 1/8 in. (3 mm) - See Note 2. ≤ 5/32 in. (4 mm) ± 1/32 in. (1 mm)

Notes:

1. Fasteners shall be firmly driven into framing members but shall not be over-driven into sheathing. For structural wood-based sheathing, fasteners shall not be over-driven more than 15% of the panel thickness. (Ref. Clause 11.5.3.4 of CSA O86)
2. Grooves, daps, and holes shall be fabricated and oriented accurately in the contacting faces. Holes in steel plates shall be accurately placed to line up with holes in the adjoining wood and shall not be more than 2 mm larger than the bolt or lag screw diameters. (Ref. Clause 12.2.2.2 of CSA O86)

Correction

Nonconforming material and workmanship shall be brought to the immediate attention of the project team and Nordic Structures. Nonconforming material or workmanship shall be brought into conformance or made suitable for its intended purpose as determined by the designer.

Post-construction surveying

Where required for the verification of structural tolerances, an as-built survey of the erected wood structure should be carried out by the general contractor.

ANNEX F. CHECKLISTS

This section provides an overview of information and logistics that need to be coordinated between all parties before, during, and after installation.

General contractor checklist

This checklist is intended to provide generic examples of common items and is not exhaustive.

Table F.1 General Contractor Checklist

Item	Information
Site logistics and transport	
Site health and safety	☐ Safe access onto site ☐ Site hazards and risks communicated to subcontractors, workers, and others who may be affected ☐ Site-specific safety plan shared with subcontractors ☐ Public protection ☐ Site security
Site information	☐ Site address ☐ Topography, site gradient ☐ Access onto the site ☐ Ground bearing capacity for offloading/storage ☐ Maneuverability for vehicles ☐ Crane access ☐ Crane capacity ☐ Delivery location ☐ Space for offloading/temporary storage ☐ Operating hours ☐ Site logistics and coordination of simultaneous work
Transport and traffic issues, vehicle access	☐ Traffic management plan ☐ Obstacles or traffic issues on the route to the site ☐ Truck staging area ☐ Maximum number of trucks on-site
Obstacles on site	☐ Underground services that could be damaged by heavy vehicles ☐ Proximity to overhead cables, power lines, trees
Design information	
Design information	☐ Latest approved plans and specifications ☐ Latest approved erection drawings
Delivery logistics	
Pre-delivery planning	☐ Delivery dates ☐ Size of loads ☐ Number of trucks required ☐ Exact delivery location on site ☐ Confirm an installer will be on site to receive delivery
Delivery	☐ Report any damages on delivery ☐ Sign bill of lading
Erection	

During installation	☐ Approved lifting and rigging plan if required ☐ Power and lighting available ☐ All handling, rigging, and temporary/permanent fixing procedures communicated to workers ☐ Exclusion zones in place during lifting ☐ Safety measures for working at height
---------------------	--

Installer checklist

This checklist is intended to provide generic examples of common items and is not exhaustive.

Table F.2 Installer Checklist

Item	Information
Health and safety	☐ Compliance with Health and Safety at Work Act requirements ☐ Health and safety plan in place ☐ Safe working practices discussed with general contractor, installer, transport operator, crane operator, and other workers on site ☐ Safety measures for working at height
Design and erection information	☐ Latest approved lifting and rigging plan ☐ Latest approved erection plan ☐ Confirmed construction sequence ☐ Installation crew familiar with erection plan and construction sequence ☐ All handling, rigging, and temporary/permanent fixing procedures communicated to installation crew ☐ Installation crew familiar with emergency plan
Delivery	☐ Check for damage upon delivery ☐ Sign bill of lading upon delivery
Installation	☐ Site visit to approve site conditions before mobilization ☐ Monitor weather conditions during erection ☐ Sufficient number of worker numbers to carry out erection ☐ Appropriate lifting and fixing equipment available ☐ Exclusion zones in place during lifting ☐ Frames erected in accordance with erection plan ☐ Provide daily report ☐ Updated schedule on a regular basis
Close-out	☐ Red-line erection plans ☐ Leftover material inventory

Information to provide in installer daily report checklist

This checklist is intended to provide generic examples of common items and is not exhaustive.

Table F.3 Daily Report Checklist

<u>Item</u>	<u>Information</u>
Daily summary	☐ Number of problems encountered ☐ Completion of any unscheduled work ☐ Total number of workers on site ☐ List of any problems encountered
General	☐ Date ☐ Last modification made to report (name, date, and time) ☐ Project address ☐ Site hours ☐ Superintendent's notes ☐ Schedule tracking
Weather conditions	☐ Cloud cover ☐ Temperature ☐ Precipitation ☐ Humidity ☐ Wind
Work done	☐ Description of work done ☐ Pictures ☐ Cause of any delays
Workers on site	☐ Names ☐ Start and end time ☐ Scheduled hours, breaks, and overtime
Visitors	☐ Names ☐ Start and end time
Additional trades	☐ Nature of work done ☐ Number of workers ☐ Hours on site ☐ Total hours worked
Site management/coordination	☐ Schedule tracking
Health and safety	☐ Report any incidents or near misses
Additional documents	☐ Bills of lading ☐ Receipts

ANNEX G. SAMPLE MOISTURE MANAGEMENT PLAN OUTLINE

Moisture control plan may include the following:

- Basic project information such as:
 - Address and coordinates of the construction site
 - Name of the construction site manager
 - Name of the person responsible for follow-up of the moisture control plan
- Overview of wood materials and products to be used on the construction site
- Limit of moisture content in wood upon delivery to the construction site, during erection and at completion
- Inspections on site and name of the person (s) who perform the inspections
- Possible moisture sources at the construction site (such as rain, snow, groundwater etc.)
- Weather protection measures chosen for the construction phase and an estimate of the necessary duration of protection
- Protection of timber components on site:
 - During storage
 - During assembly (as given by the level of protection)
 - Drying methods for wood above critical moisture level
- Controlled drying of structures down to the level of use of the building
 - Risk assessment and prevention of wetting, including rain
 - The project's vulnerability to unfavorable weather and exceptional circumstances
 - Determination of moisture level in the wood, drying methods, drying times and suitable drying conditions
 - Organization of drying conditions
 - Effects on the building site's time schedule (alternative plans)
- Moisture measurement plan:
 - Measurement method. Moisture controls shall be performed with a calibrated instrument and preferably following a standard measurement method
 - Time schedule
 - Documentation
 - o Type of measuring instrument
 - o Air temperature
 - o Measurement points and positions
 - o Measurement date
 - o Measurements values, any corrections and final values
 - o Assessments and conclusions
 - o The responsible person

A building science professional should be contacted for more information.

ANNEX H. DIMENSIONAL CHANGE EXAMPLE

A 20 ft (6.10 m) long, 11-1/2 x 33-5/8 in. (292 x 854 mm) Nordic Lam+ beam is stored on site at a temperature of 90 °F (32 °C) and relative humidity of 95%. From Table 3.1, its initial equilibrium moisture content (EMC) is 23.3%.

After the beam is installed and the building is complete, the temperature inside the building is set to 70 °F (21 °C) with a relative humidity of 45%. From Table 3.1, the final EMC of the beam is 8.5%.

The total change in moisture content in the beam is calculated as the final EMC minus the initial EMC:

$$\text{Change in EMC} = (\text{final EMC}) - (\text{initial EMC}) = 8.5\% - 23.3\% = -14.8\%$$

From section 3.2, the radial and tangential shrinkage (perpendicular to the grain) is estimated as 0.2% for every percentage point change in EMC. The longitudinal shrinkage (parallel to the grain) is estimated as 0.007% for every percentage point change in EMC:

$$\text{Dimension change} = (\text{rate of change}) \times (\text{change in EMC}) \times (\text{original dimension})$$

The total dimensional changes are therefore:

$$\text{Change in length} = (0.007\%) \times (-14.8) \times (20 \text{ ft}) = -0.021 \text{ ft} = -0.25 \text{ in} (-6.3 \text{ mm})$$

$$\text{Change in width} = (0.2\%) \times (-14.8) \times (11\text{-}1/2 \text{ in}) = -0.34 \text{ in} (-8.6 \text{ mm})$$

$$\text{Change in depth} = (0.2\%) \times (-14.8) \times (33\text{-}5/8 \text{ in}) = -1.0 \text{ in} (-25 \text{ mm})$$

The final dimension of the beam is calculated by adding together the original dimension and the change in dimension.

$$\text{Final dimension} = (\text{original dimension}) + (\text{change in dimension})$$

Note that in this example, the change in dimension is negative, indicating that the member is shrinking.

$$\text{Final length} = (20 \text{ ft}) + (-0.021 \text{ ft}) = 19.98 \text{ ft} (6.09 \text{ m})$$

$$\text{Final width} = (11\text{-}1/2 \text{ in}) + (-0.34 \text{ in}) = 11.16 \text{ in} (283 \text{ mm})$$

$$\text{Final depth} = (33\text{-}5/8 \text{ in}) + (-1.0 \text{ in}) = 32.63 \text{ in} (828 \text{ mm})$$

ANNEX I. LIST OF COMMONLY USED CONSTRUCTION EQUIPMENT

This annex provides a list of equipment commonly used in the construction of mass timber structures. The capacity and number of items required for a project depends on the specifications of the project. This list is not exhaustive and Nordic Structures does not endorse or guarantee the performance of the products listed.

Rigging and Lifting

- Crane (mobile or stationary)
- Articulating boom lift
- Scissor lift
- Basket
- Forklift
- Zoom-boom
- Manlift, etc.
- Rigging chains
- Beam straps
- Yo-Yo

Handling

- Nylon straps
- Yokes
 - o *MTC Solutions*
 - o *Rothoblaas*
- Corner protectors (plastic or vinyl)
- Rigging devices
 - o *MTC Solutions*

Safety protection

- Scaffolding
- Guardrails
- Individual protection equipment
- Harnesses
- Retracting lifelines
 - o *DBI Sala Nano Lock Edge*
- Crew radios
- Platform step ladder with wheels

Weather protection

- Rain shield
- Tarpaulin
- Umbrella

Stability

- Push and pull
 - o *Peri RS650*

Tools

- Toolbox
- Nail gun
 - o *Rothoblaas HH3522*
- Chainsaw
- Circular saw
- Routing tool
- Low speed, high torque drills, no-impact
 - o *DeWalt DCD470X160V Max* In-Line Stud and Joist Drill with E-Clutch System*

- o *DeWalt 60V Max* Mixer/Drill with E-Clutch System*
 - o *De-Walt FlexVolt 60V Max* VSR Stud and Joist Drill with E-Clutch System*
 - o *Makita DS4000 ½" Spade Handle Drill*
 - o *Milwaukee 1854-1 ¾" Large Drill 350 RPM*
- Impact drills³
- Measuring tools
- Batteries and charging stations
 - o *Hilti*
- Heavy duty drill with spade handle
 - o *Dewalt*
- Nail gun
- Air compressor
- Torque wrenches
- Spectra laser
- Levels
- Rubber mallet
- Adjustable wrenches
- Large crowbars
- Beam/Panel puller
 - o *Rothoblaas Skorpion and Geko*
- Anker nailing machine
 - o *Rothoblaas*
- Multimaster
 - o *Fein*

Miscellaneous⁴

- Structural adhesives
- Cleaning
- Caulking / sealing tape
- Pre-compressed impregnated foam
- Anti-capillarity barrier
- Soundproofing profile (stripe)
- Leaf blower
 - o *Kaercher*

³ Care should be taken to ensure that the drill is compatible with the screw used. Some screw manufacturers do not allow the use of impact drills.

⁴ For more information, refer to the *Maintenance Guide for Mass Timber* (NS-GE2).

ANNEX J. PREVENTING CHECKS AND GAPS

Mass timber products should be protected from extreme temperatures and humidity during transportation, storage, installation, and use to minimize the extent of checking. During and after installation, it is important that mass timber members not be exposed to rapid movement of air or to concentrated heating and cooling sources.

Once the building is enclosed, the interior climate should be adjusted slowly to prevent checking. Unless there are significant changes in the ambient temperature and humidity, additional checking is unlikely to occur after the first year of occupancy.

Taking the precautionary steps below will reduce the likelihood and severity of checking. It is important to coordinate delivery schedules to minimize construction site storage. Sudden shifts in temperature and humidity caused by direct exposure to extreme temperature, precipitation, or sun can create optimal conditions for checks to form. If these conditions cannot be avoided, extra precautions must be taken during storage and installation to protect mass timber members.

Some precautions to minimize checking may include:

At the planning stage:

- Order members double-coated if the structure is being erected in an area where severe weather conditions are expected.

On the construction site:

- Ensure proper storage.
- Keep mass timber members covered and protected from exposure to the elements.
- Avoid contact between mass timber members and moist or wet surfaces like fresh concrete.
- Use dry lumber blocking to raise mass timber members off the ground and provide ventilation.
- Keep mass timber members wrapped with a secondary cover until installation.
- Leave protective wrappings intact except for a slit on the bottom side to allow for drainage of any trapped water.

After installation:

- Keep mass timber members covered and protected as long as practical after installation.
- Remove wrapping after the building enclosure is complete and allow the moisture content of the mass timber member to stabilize naturally.
- Avoid rapidly drying mass timber members with temporary heating units.
- After the building is enclosed, adjust the interior relative humidity and temperature gradually.
- Apply any specified finishes.
- Avoid rapid changes in temperature during the first full heating cycle.