

GE2

Maintenance Guide
January 2021

Note: This document does not constitute a maintenance or inspection plan. It aims to guide the reader in developing these documents for a specific project.

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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.

Maintenance guide

This maintenance guide aims to inform owners and stakeholders of the unique qualities of mass timber structures and to present some common practices for inspecting and maintaining them. This guide should be given to the owner and relevant stakeholders, and should be passed on in the case of a change in ownership or management. When applicable, this document should be included or referenced in the co-ownership contract.

This document does not constitute a maintenance or inspection plan. It aims to guide the reader in developing these documents for a specific project.

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 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 can 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, FPInnovations, 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 maintenance guide aims to inform owners and stakeholders of the unique characteristics of mass timber structures and to present some common practices for inspecting and maintaining them. These guidelines are limited to the structural use of mass timber and are not intended to represent a complete building maintenance plan.

This document does not constitute a maintenance or inspection plan. It aims to guide the reader in developing these documents for a specific project.

1.2 Mass Timber

All buildings require regular maintenance to ensure the longevity of their service life, and each building material presents its unique considerations. For mass timber to be effectively used as a building material, knowledge and understanding of its specific properties is essential. For more details on Nordic products, refer to the Nordic Lam+ and Nordic X-Lam Technical Guides.

Note: For product technical guides, see nordic.ca.

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, including 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, to 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.

Building owner

The building owner is responsible for inspecting and maintaining their building to ensure that it remains in a safe and proper working condition. This includes, but is not limited to, completing regular inspection of the structure and performing repair and maintenance works as necessary. All inspections and maintenance activities should be documented.

1.4 Health and Safety

Health and safety are the responsibility of all entities involved in the maintenance of a structure. 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, designers, builders, and stakeholders can create beautiful and long-lasting mass 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. As a natural material, wood can be used in biophilic design, which aims to better connect inhabitants and users of a space with the natural world and seeks improve morale, productivity, and sense of wellness.

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 of 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. DURABILITY

3.1 Wood and Water

Wood naturally contains moisture. The moisture content of mass timber depends on a number of variables such as wood species, exposure to direct wetting, temperature, relative humidity, and drying potential of the system in which it is contained.

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, as shown in Figure 3.1. Certain consequences may arise and should be addressed when the moisture content exceeds 19% for a prolonged period of time, as discussed in section 3.3.

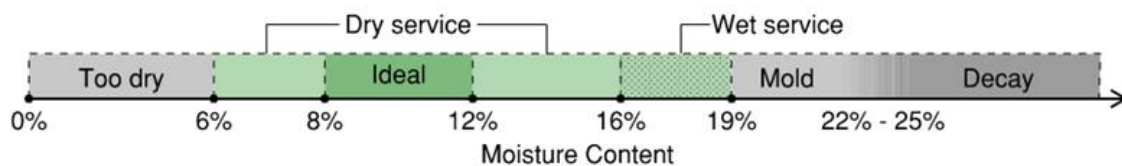


Figure 3.1 Moisture content and its effect on mass timber

As with all structures, protecting against moisture damage relies on proper system design, installation, and maintenance. Should incidental wetting or moisture accumulation occur, an adequate system must be in place that will enable the wood to dry.

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. Generally, denser species tend to respond more slowly to rapid moisture changes. However, they also tend to result in greater overall dimensional changes due to moisture changes.

Equilibrium moisture content (EMC) is defined as the moisture content at which the wood is neither gaining nor losing moisture from its surrounding environment. For large timber members, it can take weeks or months for the member to reach EMC. The relationship between EMC, relative humidity, and temperature is shown in Table 3.1. It is more accurate to consider average rather than peak temperatures and humidity when estimating EMC.

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

Moisture content measurement

The moisture content of mass timber can be measured by using a portable moisture meter, shown in Figure 3.2. 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 3.2 Measuring wood moisture content using a capacitance-based meter (left) and a resistance-based meter (right) (Source: FPI)

Service conditions

A mass timber structure can be designed for either dry- or wet-service conditions.

In Canada, per CSA O86, the term “dry-service condition” refers to a climate condition in which the equilibrium moisture content of wood is on average 15% or less over a year without exceeding 19%. The term “wet-service condition” refers to all service conditions other than dry.

In the U.S., per the NDS, the term “dry-service condition” applies when the service moisture content is less than 16%, and “wet-service condition” when the service moisture content is 16% or greater, as may occur in exterior or submerged construction, or in humid environments. The indoor climate of a mass timber building is no different than that of any other building. Indoor relative humidity is a complex function of moisture sources, ventilation rate, and outdoor humidity conditions.

Mass timber buildings perform well with respect to long-term durability when the interior relative humidity is between 20% and 60%. For optimal performance, HVAC and humidity control systems should be implemented in mass timber buildings to regulate the indoor environment such that the relative humidity is between 30% and 50% and the temperature is approximately 20°C. These conditions are also ideal for building occupants. In all situations, condensation should be prevented from forming on the surfaces of mass timber members and metal assemblies.

End grain

The end grain of a timber element is much more prone to absorbing moisture than the side grain. Care should be taken during inspection and maintenance to protect the end grain from excessive moisture and allow the timber to dry.

3.3 Mold and Mildew

The discovery of mold in a building raises concerns about the building's overall performance. Mold growth is an indication of excessive moisture. Fortunately, most moisture problems in a building can be prevented or corrected with proper design, construction, and maintenance.

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 may be mistaken for dirt or, conversely, dirt or other discolorations may be mistaken for mold. While a clinical verification for mold can be conducted at many labs, a simple test can be performed instead, in which a few drops of a 5% solution of household bleach are added to the areas in question. Mold will usually lighten and nearly disappear within one to two minutes of application. Other substances that remain the same color are likely dirt or another form of discoloration. When performing this test, it is important to use fresh bleach, since bleach deteriorates in potency after six months.

Environments that support mold growth

Mold and mildew grow in conditions with ample moisture, darkness or low light, and stagnant airflow. Found nearly everywhere, mold spores spread through the air and rapidly multiply when they find suitable growing conditions.

Mold requires the following conditions to grow:

- Nutrients: Almost any organic substance can provide the needed nutrients for mold growth, including wood, paper, plaster, cloth, and dirt. Since even a thin film of dust will suffice, mold will grow on nearly any surface, including plastics, metals, and glass.
- Moderate Temperatures: Mold and mildew grow easily in temperatures ranging between 68 °F to 86 °F (20 °C to 30 °C). Since this is similar to the comfort range for humans, it is natural that buildings provide a suitable temperature range for mold growth. Outside this

- range, mold will grow at a slower rate and may even become inactive. Growth may resume when the temperature returns to this range.
- Oxygen: Mold will not grow without oxygen.
 - Moisture: Mold growth requires high moisture conditions and becomes inactive when the relative humidity drops below about 70%. Growth may resume if the moisture increases.

Effect of mold and mildew growth on wood components

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 the wood exceeds 20%.

Mold and mildew are types of fungi that do not cause wood to rot. Unlike wood decay fungi, mold and mildew do not cause significant loss of strength. Nonetheless, they 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.

Control of mold in wood structures

Since mold can grow on many different materials in a building, moisture control is widely recognized as the only viable method of controlling mold growth. Moisture control measures address, among others, the maintenance and operation of the building, including control of interior humidity levels.

Controlling moisture generated after occupancy

It is important to ensure proper ventilation or moisture control as sources of occupancy moisture can increase the interior humidity and may result in mold growth. For more information, refer to APA A525 *Mold and Mildew*.

Cleaning mold

The first step in mold remediation is to identify and eliminate the source of moisture that enabled the mold to grow.

Guidelines on Assessment and Remediation of Fungi in Indoor Environments from the New York City Health Department is widely recognized as a good reference for mold remediation. This publication recommends removing mold with detergent, followed by cleaning with a vacuum fitted with a high efficiency particle arrestor (HEPA) filter.

Additionally, mold can be removed or cleaned with commercial mold/mildew removers, following the manufacturer's directions. Bleach may be effective in cleaning severe cases of mold, but this should only be done by a qualified professional as bleach can damage the wood. For a list of products that may be used to clean mold, refer to Annex F.

3.4 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 and the level of exposure of individual components.

Uncoated timber exposed to the weather will, over time, develop a silver-gray color. The weathering rate is difficult to predict as it depends on the extent of exposure to the elements, as well as the season in which the timber was installed. Additionally, the extent of weathering can vary along an element.

Due to the variability of the weathering rate, in the short term, the aesthetics of the member may vary locally. 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.

Wood consists of three types of organic compounds: fibers, lignin, and extractives; weathering affects each of these components differently. The consequent physical and chemical changes that occur due to weathering affect the ability of the member to be finished or painted. Surface treatments applied to weathered wood are less effective than the same treatments applied to wood that has not weathered.

The effects of weathering can be mitigated by the application and maintenance of finishes such as paints, stains, and water repellents, and appropriate architectural and design detailing such as overhangs, capping, and shading. For more details on weathering and finishes, refer to section 5.

3.5 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 attacks 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

The inherent resistance of mass timber to mild chemical attack is essential in the following applications:

- Enclosed swimming pool structures
- Tanneries
- Chemical storage buildings such as fertilizer sheds
- Wastewater treatment works
- Piles in acidic soils
- Water reservoir roof structures

It should be noted that metal components are susceptible to damage induced by some chemicals.

As the complexity of the reactions between chemical agents and wood or steel is outside the scope of this document, guidance from industry professionals or recognized research sources should be sought.

3.6 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 attacks usually involves detailing the members to minimize exposure and applying insect-resistant coatings. For more information on insect damage and control, refer to chapter 14 of the *Wood Handbook*, titled *Biodeterioration of Wood*.

3.7 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 damaged.

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.

4.1 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, 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.

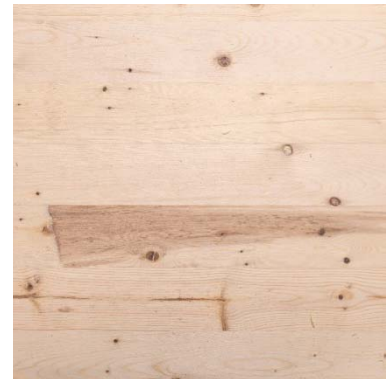


Figure 4.1 Stained wood

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.

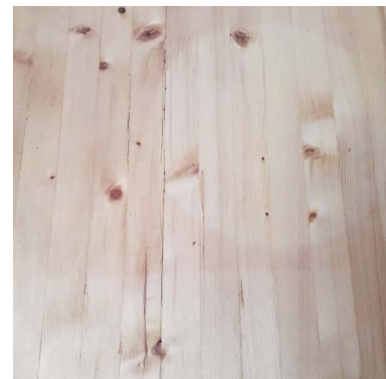


Figure 4.2 Wood discoloration

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 4.3 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.

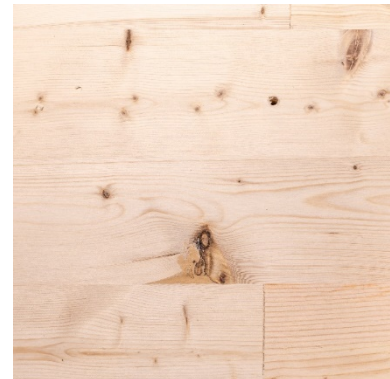


Figure 4.4 Knots

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.

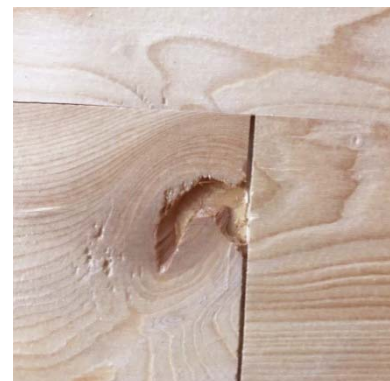


Figure 4.5 Knot hole

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.

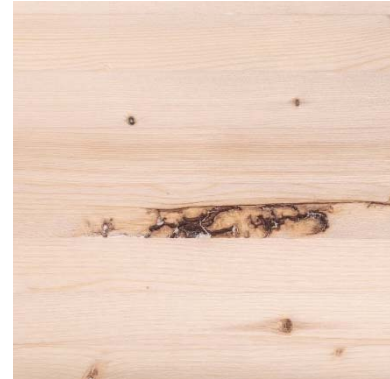


Figure 4.6 Bark pocket

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 4.7 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 4.8 Blue stain fungi

Species coloration

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



Figure 4.9 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 4.10 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.

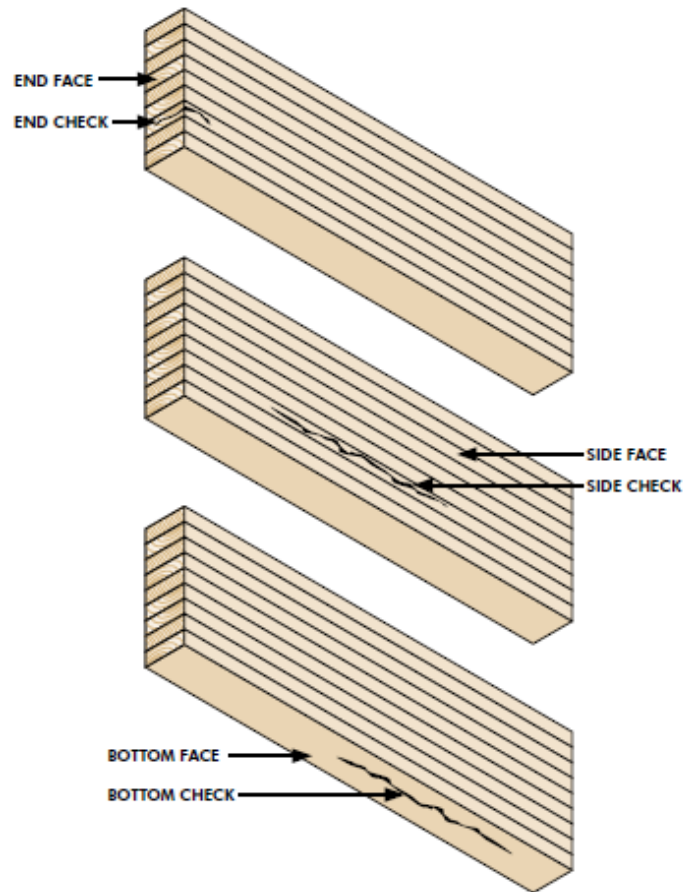
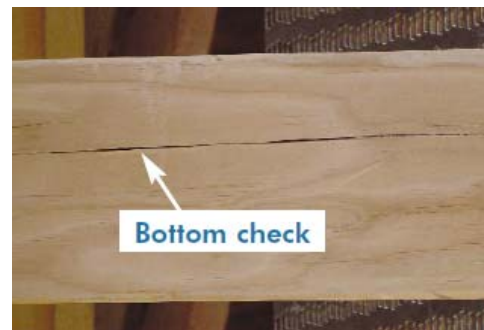


Figure 4.5 Check locations
(Source: APA)

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 4.6 Types of checks, from *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.

4.2 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 4.11 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 4.12 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 4.13 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 $\frac{1}{4}$ in. (6.4 mm), during the jointing process.



Figure 4.14 Hole in finger joint

5. FINISHING PRODUCTS

Finishes are used to enhance and protect wood. However, it is not always necessary for mass timber to be finished. Unfinished mass timber will be more sensitive to UV and moisture than finished mass timber, but this may be acceptable depending on the exposure and intended use of the members.

Three main types of finishes are used on mass timber and are either applied directly to mass timber or, preferably, over a protective undercoat: paints, varnishes, and stains. Most finishes are available in a wide variety of colors and opacity, ranging from completely clear to completely opaque. Clear finishes can offer a more natural appearance, semi-transparent stains can enhance the natural grain pattern of the wood, and opaque finishes can offer better protection against weather.

When selecting the type of finish to use on a mass timber member, it is important to consider the wood species, the exposure of the member, the ease of application, and the cost of maintaining the finish. Additionally, a quality-control plan should be implemented to ensure proper application and performance of the finishes.

The following sections describe different products for several applications. Annex F lists some commercially available products for each category.

5.1 Nordic Products

A penetrating, low-VOC sealer is typically applied to Nordic Lam+ and Nordic X-Lam products in the factory, unless otherwise specified. This protective undercoat reduces moisture absorption and protects against UV degradation. While this product is specifically intended for weather protection during transport and construction, it can form part of the final architectural coating system. The protective undercoat alone should not be considered permanent protection.

5.2 Interior Wood Finishes

Most mass timber is used in protected conditions where decay is not a hazard. However, even in interior conditions, the appearance of mass timber may be affected by foot traffic, human touch, or air pollutants.

Interior wood finishes are typically transparent latex- or water-based varnishes that protect mass timber members from minor incidental damage and make the surface of the members easier to clean. It is always important to ensure that additional wood finishes are compatible with finishes applied in the factory.

The following should be considered when selecting finishes for interior mass timber:

- Glossy finishes can emphasize textural imperfections compared to satin finishes.
- Wood stains or oils require care to maintain in damp conditions where there is a risk of condensation.

Refer to Table D.1 in Annex D for a list of finishes appropriate for indoor use.

5.3 Exterior Wood Protection

This section presents various types of finishes and treatments applicable to outdoor mass timber. However, it is difficult to provide quantitative information on the effectiveness of finishes and treatments exposed to weather. When selecting finishes and treatments for exposed mass timber, it is important to consult the manufacturer to understand their capabilities and warranties.

Most finishes do not provide a complete moisture seal; instead, they slow the movement of moisture in and out of the wood and protect the surface of the wood against weather. In all cases, end grain and joint surfaces should be sealed with an oil-based primer, stain, or water repellent.

The following should be considered when selecting finishes for exterior mass timber:

- Pale colors absorb less heat, reducing the effects of drying
- Darker tints are typically more effective at limiting UV degradation
- Oil-based paints are generally more effective vapor barriers than acrylic finishes
- Good quality primers and undercoats are designed to seal the timber and provide a binding surface for topcoats
- Stains and water repellents require more frequent reapplication than paints
- Sawn surfaces hold on to stains and water repellents better than dressed surfaces do, particularly for denser species

Refer to Table E.1 in Annex E for a list of finishes appropriate for outdoor use.

Paints

Paints are opaque wood finishes that are applied in multiple coats to achieve a uniform color. Paints can reduce the transfer of moisture between the wood and the environment, protect the wood from UV light, prevent the surface of the wood from coming into direct contact with rainwater, and form a solid barrier against insect attacks. However, if water does breach the coat of paint, the paint can have the undesirable effect of trapping moisture and accelerating decay. Insects can also take advantage of defects in the coat of paint to bore into the unprotected wood beneath. Dark colored paints may increase the rate of decay as they absorb more heat from the sun.

Properly applied, paint in an external environment should last four to five years. However, the paint may not be flexible enough to move with the mass timber member as it shrinks and swells due to moisture changes. As a result, the paint may start to crack, blister, or flake, compromising the coating and making it difficult to apply new coats.

Varnishes

Varnishes are essentially paints without pigment, allowing the natural grain and texture of the wood to show through. Like paints, varnishes leave a solid coating on the surface of the timber and have similar problems with damage and reapplication. Varnishes can reduce the transfer of moisture between the wood and the environment and can delay timber discoloration; however, they will not prevent either of these from occurring. Additionally, varnished can act as a physical barrier against insects. Varnishes can discolor and become brittle when exposed to UV light. To prevent this, varnishes containing UV inhibitors can be specified.

Conventional varnishes, such as those commonly found at hardware stores, are not advised for external treatment of mass timber.

Stains

Stains are translucent wood finishes that are absorbed into the surface of the wood. Unlike paints and varnishes, stains do not form a moisture barrier, allowing the timber to breathe and react to changes in ambient humidity.

Stains are available in a wide range of natural wood colors and can enhance or conceal the grain pattern of the wood. Reapplication of stains is simpler than it is for paints and varnishes, as it is usually not necessary to remove previous coats prior to reapplication. Locally faded or discolored areas can be easily touched up without having to re-finish the entire member.

Research³ has shown that the application and regular maintenance of pigmented oil-based stains or water repellent preservatives on mass timber will extend service life by delaying the onset of decay and weathering from UV exposure.

Residual resin or gum on the surface of timber elements may prevent the stain from absorbing into the wood fibers, leaving the area lighter than the surrounding wood. Care should be taken to ensure that the surface of the wood is free of these compounds in order to achieve a uniform application of stain.

Protective undercoats

Undercoats are protective coats applied directly to the wood surface and are designed to seal the mass timber member and provide a key for additional topcoats.

Preservative treatments

In addition to surface finishes, preservative treatments may be used to augment the durability of the wood. Because of the toxicity of the chemicals used, preservative treatments can be very effective at extending the service life of mass timber, but often have a visual impact. In addition, treated timber may be difficult to finish, leaving little opportunity to change the final appearance of the mass timber.

Most preservative treatments only penetrate a few millimeters into the wood, creating a protective envelope around an untreated inner core. To ensure that the core remains protected, the outer protective layer must remain intact. Nordic products are particularly resistant to preservative treatment and cannot be pressure treated.

Sacrificial wood elements

Sacrificial wood elements protect mass timber members by forming a physical barrier between the mass timber and the weather. These elements are typically finished to match the aesthetic of the mass timber members but are connected in such a way that they can be easily replaced as they deteriorate. Well designed and maintained sacrificial elements continue to offer protection even as they begin to degrade. However, poorly designed or maintained sacrificial elements can trap moisture against structural members, accelerating decay beneath the elements.

Borate rods

Borate rods are a decay and insect control system that protects the wood from the inside. Borate rods are solid, water-soluble rods made of boron compounds that are inserted into mass timber members. When the moisture content around the rod rises above approximately 25%, the rods react with water in the wood to form boric acid, a natural preservative and insecticide. The boric acid then leaches into the wet portions of the member, locally protecting the member at its most vulnerable locations. When the moisture levels drop, the boric acid becomes dormant and remains in the wood, ready to reactivate should the moisture level rise again. When combined with weather-resistant surface finishes, borate rods offer excellent protection against wood decay.

³ Wood Solutions. 2015. Timber service life design; Design guide for durability. Technical Design Guide 05. Forest and Wood Products Australia Ltd (FWPA), Wood Solutions, Australia.

6. INSPECTION AND MAINTENANCE

Unless designed for a specific purpose or for a short life span, all structures require maintenance. The purpose of maintenance is to preserve the original condition of a material so that it can continue to effectively perform its intended function.

Maintenance must be considered during the design phases of a project, as the extent of maintenance is dependent upon the original design and materials specified. It is important that future maintenance and repair costs be considered in conjunction with initial construction costs.

An inspection and maintenance plan should be developed by the design team, owner, and other stakeholders. The plan should list out the type and frequency of inspection and maintenance activities required throughout the life of the building.

Refer to Table C.1 in Annex C for general guidelines on the different types of maintenance procedures common to timber structures.

6.1 Inspection

Numerous methods exist to assess the condition of a mass timber structure. The simplest and most common method is to have a visual inspection performed on-site by a qualified professional. Non-destructive measurements such as moisture content can be taken to supplement the visual inspection and can be used to form a more quantitative assessment. If any microbial growth or fungal attack is observed, specialist companies can help to establish the type, species, and treatment necessary.

Routine inspections that systematically examine all timber components should be performed on a regular basis. The findings from the inspections can then serve as the basis for determining the type and urgency of maintenance and repair activities to be carried out.

The following lists some examples of what should be taken into consideration when inspecting mass timber structures. This list is not exhaustive, and is only provided as a guideline:

- Presence of mold, mildew, or decay
- Moisture content in the timber element
- Presence or traces of insects
- Presence of checks, delamination, and gaps
- Any noticeable sagging in the floor structure, including at balconies and verandas
- Abnormal deformations, warping, or dimensional changes
- Condition of connections
- Corrosion or deterioration of any metal components, particularly at connections
- Condition of sacrificial elements and borate rods

6.2 Maintenance

Finishes

Finishes need to be maintained throughout the life of the building to ensure their effectiveness. The frequency and extent of maintenance depends on the types of finishes used on the timber member and the exposure of the timber members to weather or damage. Different timber members may require different maintenance intervals.

Maintaining paints and varnishes typically involves removing damaged coats by scraping or sanding before reapplying new coats. Maintaining stains typically involves washing the surface of the wood to remove any dirt or loose fibers before touching up areas that have faded. Maintaining preservatives typically involves removing outer finish coats, reapplying the preservatives, and reapplying the protective outer coats.

Refer to Annexes D and E for general guidance on available finishes and their maintenance.

Sacrificial wood elements

Sacrificial elements should be replaced as they approach the end of their useful service life. When replacing sacrificial elements, the structural member being protected should be carefully inspected to ensure that no degradation has occurred.

Borate rods

Borate rods should be replaced before they are fully depleted to ensure no lapse in protection. Follow the manufacturer's instructions for replacing borate rods.

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.

6.5 Special Attention

Special attention must be given when mass timber is exposed to water or high humidity. Among these are outdoor structures, swimming pool complexes, and greenhouses.

Building systems

As with all buildings, issues that arise from mechanical or plumbing systems should be addressed as soon as possible. These systems may become sources of moisture: pipes may burst or leak, temperature and humidity settings may cause condensation to form, and mechanical units may drip condensation.

Waterproofing assemblies

Structural members that support exterior areas such as balconies or form the exterior enclosure of a building are generally protected from weather by a waterproofing assembly. If the waterproofing assembly is damaged, water may infiltrate and compromise the integrity of mass timber. These assemblies should be routinely checked to ensure that they remain sealed. If a leak is discovered, repair work on the waterproofing assembly must be carried out quickly. Mass timber members in the vicinity of the leak should be inspected to ensure that no mold or decay has initiated. Any wet wood should be dried.

Outdoor columns

Outdoor columns require regular inspection; different seasons and weather conditions require different types of inspection. Throughout the year, drainage paths should be kept clear to prevent flooding that may submerge column bases. Inspections that take place in the fall and winter should check that rainwater or snow does not accumulate at column bases, particularly after large storm events. Inspections in the spring should check column finishes to ensure that no cracks

have formed as a result of the column swelling, freezing, or thawing. Inspections in the summer should check for insect infestations.

7. ALTERATIONS

When making alterations to a building, it is important to ensure that the systems for fire safety, structural safety, weatherproofing, and occupant comfort continue to function as intended. This section presents some considerations for altering mass timber buildings.

7.1 Building Code

The building code sets out technical requirements for the design and construction of new buildings and the alterations of existing buildings, including provisions for fire protection, structural design, and environmental separation.

7.2 Fire Safety

Fire resistance

Although wood is a combustible material, mass timber offers good fire resistance. As the outer fibers burn, they form a layer of charred wood that insulates and protects the inner fibers, leaving a core of undamaged wood. Additionally, mass timber elements can be directly protected from fire using materials with low thermal conductivity such as fire-rated gypsum board.

Fire separations

Fire separations are wall, floor, or roof assemblies designed to limit the spread of smoke and fire between adjacent spaces. These assemblies are specifically designed and constructed in accordance with the governing building code, and any modification to these assemblies can compromise their integrity. It is therefore essential that no modifications be made to these assemblies without the written approval of a design professional.

7.3 Structural Integrity

The structural members and connections of the building have been carefully designed. Therefore, timber members and their assemblies must not be modified under any circumstances without the written approval of an engineer.

7.4 Enclosure and Acoustics

Wall, floor, and roof assemblies that separate dissimilar environments have been designed to control the transfer of heat, air, moisture, and sound. It is therefore essential that no modifications be made to these components without the written approval of a design professional. Note that any modification may have an impact on the integrity of the building.

7.5 Building Performance

The building-specific maintenance plan should be regularly updated to account for alterations. Routine inspection and maintenance should be carried out to achieve satisfactory, long-term performance and maximize service life.

ANNEX A. REFERENCED DOCUMENTS

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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:

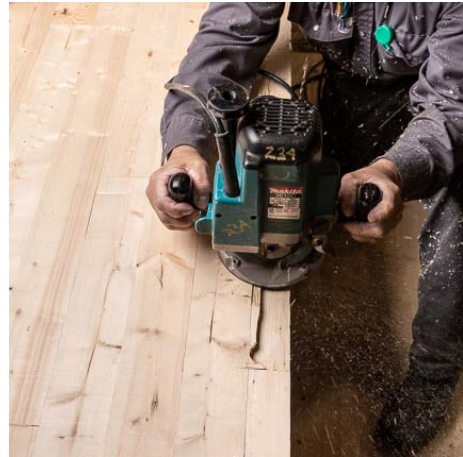
- The repair is more than 4 ft (1.2 m) long;
- The repair affects more than one lamination;
- Doubt exists about the size of the repair area.

Table B.1: Repair procedure for Method 2

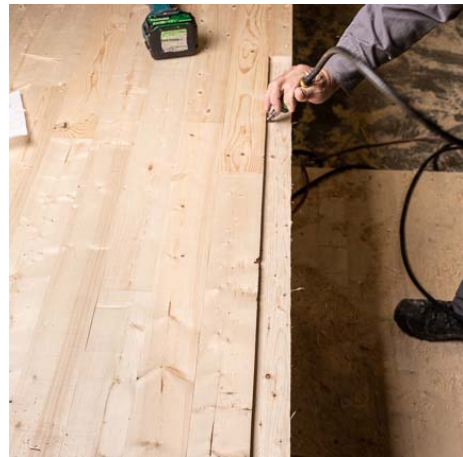
- 1) Identify an imperfection which requires a repair



-
- 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. MAINTENANCE PLANNING

Table C.1 provides general guidance on the selection and scheduling of different maintenance procedures for mass timber structures. This is meant to serve as a general guide only, as maintenance frequencies vary greatly depending on the products used. Always consult with the product manufacturer when determining the appropriate schedule for maintenance and inspection.

Table C.1. Selection and scheduling of possible maintenance activities

<u>Item</u>	<u>Recommended Maintenance and Inspection Period</u>	<u>Remarks</u>
Internal finishes	Typically approximately every 10-15 years.	
External finishes	Refer to Table D.1.	
Termite protection		
Physical barriers	Approximately every 10 years.	Any signs of termites should prompt action.
Chemical barriers	Replenish as required by the supplier, typically 2-20 years.	
Ventilation: Subfloor, wall, and roof	Ensure vents remain unblocked. Clean as required, approximately every 10 years.	
Vapor barriers: Subfloor and roof	Check integrity of vapor barriers approximately every 15 years.	
Metal fasteners		
Integrity	Retighten bolts 6 months and one year after project completion if needed.	This typically applies to structures that use unseasoned wood.
Corrosion	Varies depending on initial quality of materials and presence of hazards.	If corrosion is detected, replace the affected parts immediately to prevent further damage.
Plumbing	Repair or replace leaking or defective plumbing immediately and repair any affected finishes.	Presence of moisture increases possibility of decay.
Decay	Repair or replace defective material immediately and re-apply finish.	
Preservatives, end grain sealants, and end grain plating	Typically every 3-5 years, depending on type of treatment and application.	This typically applies to timber used in adverse environments, such as wharves and posts in ground.
Cleaning	Clean surfaces as required. Remove build-up of soil against timber near ground.	Dirt and mold, trap moisture and increase potential for decay.
Borate rods	Replace as required by the supplier.	

Source: Wood Solutions TDG 05 Timber Service Life Design Technical Design Guide

ANNEX D. INTERIOR WOOD FINISHES

Table D.1 provides a summary of finishes and maintenance appropriate for timber used indoors. Significant differences exist in the effective service life of various coating systems, which should be considered when selecting the coating system. Note that clear finishes have a much shorter life than opaque finishes. This table meant to serve as a general guide only, as procedures vary greatly depending on the products used.

Table D.1. Interior wood finishes: types, treatments, and maintenance

<u>Finish</u>	<u>Initial Application</u>	<u>Appearance of Wood</u>	<u>Maintenance Procedure</u>	<u>Additional Remarks</u>
Paint	Two coats over one coat of primer	Grain and natural color obscured	For minor touch-ups: Clean affected areas and sand lightly before re-applying topcoat. For severely damaged or degraded areas: Sand to bare wood and repeat initial treatment.	Enamels, high-gloss, and semi-gloss paints may accentuate imperfection. New paint may not exactly match existing paint, even if the same paint is used.
Stain (water-based)	One coat, brushed on and wiped off. Apply over sealer for uniform color.	Grain visible; colored as desired	Sand affected areas to bare wood and re-apply stain, taking care to blend in the new stain with the surrounding wood. Re-apply topcoat if used.	Dries slowly Raises grain of wood, which may require sanding before applying topcoat.
Stain (organic solvent-based)	One coat, brushed on and wiped off. Apply over penetrating sealer for uniform color.		Sand affected areas to bare wood and re-apply stain, taking care to blend in the new stain with the surrounding wood. Re-apply topcoat if used.	Dries quickly
Sealers	One brush coat		Sand to bare wood and reapply.	Sealers are thinned varnish, shellac, or lacquer used to moderate the absorption of finish into the wood and prevent bleeding of stains into surface coatings. Lacquer and shellac sealers dry quickly
Varnish topcoat	One to two coats, brushed on		Sand affected areas and reapply varnish to match thickness of original coat.	Many different types of varnish exist with different intended applications
Shellac topcoat	Three to four coats, brushed or wiped on		Remove shellac by sanding or rubbing with alcohol. Reapply shellac to match thickness of original coat.	Dries quickly Not very durable; sensitive to heat and humidity
Lacquer topcoat	One or two coats, sprayed or brushed on		Sand affected areas and reapply lacquer to match thickness of original coat.	Dries quickly Typically contains high concentrations of VOCs and can be difficult to apply
Wax	Apply two or more coats, followed by paste wax. Buff to desired sheen.		Remove wax with mineral spirits and reapply.	Provides protection without forming a thick coating. Easy to apply and maintain, but scratches and wears easily.

ANNEX E. EXTERIOR WOOD FINISHES

Table E.1 provides a summary of finishes and maintenance appropriate for timber used outdoors. Significant differences exist in the effective service life of various coating systems, which should be considered when selecting the coating system. Note that clear finishes have a much shorter life than opaque finishes. This table meant to serve as a general guide only, as procedures vary greatly depending on the products used.

Table E.1. Exterior wood finishes: types, treatments, and maintenance ⁽¹⁾

<u>Finish</u>	<u>Initial Application</u>	<u>Appearance of Wood</u>	<u>Initial Cost</u>	<u>Maintenance Procedure</u>	<u>Maintenance Period</u>	<u>Maintenance Cost</u>
Paint	Primer and two topcoats	Grain and natural color obscured	Medium to High	Clean and apply topcoat or remove and repeat initial treatment	7-10 years ⁽²⁾	Medium
Clear varnishes (film-forming)	Four or more coats	Grain and natural color unchanged if adequately maintained	High	Clean and stain faded areas and apply two more coats	2 years or when breakdown begins	High
Water Repellent ⁽³⁾	One or two coats, preferably dip-applied	Grain and natural color visible; darkens and becomes rougher	Low	Clean and reapply per manufacturer's instructions	1-3 years	Low to Medium
Stains	One or two brush coats	Grain visible; colored as desired	Low to Medium	Clean and reapply per manufacturer's instructions	3-6 years	Low to Medium
Organic Solvents Preservatives ⁽⁴⁾⁽⁵⁾⁽⁶⁾	Pressure, steeping, dipping, brushing	Grain visible; colored as desired	Low to Medium	Brush down and reapply	2-3 years	Medium
Waterborne Preservatives ⁽⁵⁾⁽⁶⁾	Pressure-treatment	Grain visible; greenish or brownish; fades with age	Medium	Brush to remove surface dirt	None	None

Notes:

1. This table is a compilation of data from the observations of many researchers.
2. Using high quality acrylic latex paints.
3. With or without added preservatives; addition of preservative helps control mildew and mold growth.
4. Pentachlorophenol, tri-n-butyltin oxide, copper naphthenate, and similar materials.
5. Contain VOCs, which have adverse health effects.
6. Not feasible/available for Nordic products.

Source: Wood Solutions TDG 05 Timber Service Life Design Technical Design Guide

ANNEX F. LIST OF PRODUCTS

Note that the list of products is not exhaustive. In no case do the commercial products identified 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. Before finalizing the finish selection, it is recommended to evaluate product samples.

Notes:

- For the selection criteria, including product availability, refer to Annex C.
- Product descriptions and attributes are as indicated by the suppliers.

F.1 Repair Products and Tools

Strong MDI Bouche-pores

- Can be used to repair small surface imperfections or holes by filling them in before applying a finishing varnish.
- May be applied over old varnishes in good condition.

Amarok Hot Filler-0810

- A hot melt adhesive suitable for larger repairs such as knot holes, cracks, or other cavities.

Knottec Wood Repair Adhesives

- A filling adhesive especially formulated for the fast and effective repair of not only knot defects, but also deep scratches and other forms of deep wood damage.

Rothoblaas Wood Repair Items

- Wood repair items including injection system for wood repairs, indoor repair putty, bi-component putty for indoor, timber caps, and timber pins.

F.2 Cleaning Products

Sansin Multi-Wash

- A concentrated, biodegradable cleaner designed to be diluted to remove mildew, dirt, rust stains, and more.

Bleach (Javex)

Ferrous sulphite or sodium hydrosulphite preparation

Oxalic acid

- A solution to be used for the removal of staining resulting from rust spots.
- Care should be taken to limit the application area as the solution has the potential to permanently bleach the wood and may affect the application of future finishes.

Sun Frog Deck Cleaner

- A biodegradable, plant friendly, cleaner.
- Easy to use in a wide array of applications.

Sun Frog Born Again Wood Rejuvenator

- Contains crystal powders of oxalic and citric acids.

- Reverses the tanning darkening and restores original wood color.

Tri-sodium phosphate (TSP)

DRY ICE CLEANING

Cryotechnic

Eco2 Glace Seche

F.3 End Grain Protection

Société Laurentide Protect'air 474

- A high solid clear wax emulsion for solid wood (474-237) designed to be applied as an end-sealer before the drying process to reduce humidity loss at the extremities responsible for cracks.

Sansin End Sealer

- Provides a protective water barrier that prevents moisture absorption and fast water evaporation from cross cut ends on mass timber. End Seal is UV resistant, water-repellent and low in VOC's, and provides deep wood penetration ensuring wood stability and long term protection while also reduce warping, shrinking and checking. This breathable, environmentally-friendly formula repels water, offers strong adhesion and offers easy soap and water clean-up.

F.4 Finishing Products – Undercoats

Sansin KP-12UVW

- A penetrating protective undercoat for mass timber that enhances dimensional stability and protects wood from UV degradation and moisture absorption.
- Combines long-term UV protection with enhanced water repellence and excellent hold-out against water absorption for mass timber.
- Protects wood against wood rot and weathering during construction.
- Improves topcoat performance, while also protecting wood during the manufacturing and construction process and reducing in situ preparation and topcoat application costs.
- Ideal for projects where beautiful clear or light wood tones are desired.

F.5 Finishing Products – Interiors

Sansin Purity Products

- Water-based interior wood stain with a base free from any harmful volatile organic compounds (VOCs) that penetrates both soft and hard woods with consistent, uniform coverage.

Vermont Natural Coatings

F.6 Finishing Products – Exteriors

Care should be taken to ensure that any topcoat applied is compatible with the primer used, preferably an all-acrylic latex formulation from the same manufacturer.

Sansin SDF

- Provides tough, effective protection for wood siding.

- Contains specially formulated with oils and resins that penetrate into the wood, providing weather and UV protection in a wide range of natural, semi-transparent and even solid colors.
- Unique water-borne technology that can provide complete protection in just one coat, although a second coat will provide an even more beautiful and richer finish.
- Available in four tintable bases: SDF-0 Base for Natural and Translucent colors and SDF-2 Base for Saturated, Ultra Saturated and Deep or White Base for semi-solid and solid colors.
- Can provide complete protection in just one coat, although a second coat will provide an even more beautiful and richer finish.

Sansin SDF Topcoat

- A durable top-coat system that can be applied to any SDF base coat system.
- High solids builds a satin like finish that is highly durable to moisture and weathering.
- Highly resistant to wear, does not discolor over time, and enhances the natural UV protection of the existing Sansin SDF finish.
- Enhances the look of the base coat with beautiful saturated color and a full, rich finish.

Sansin ENS

- A durable finish that can be applied to virtually any surface and can even to improve the performance of other coatings.
- Often used with a first coat of Sansin SDF, resulting in a satin or gloss finish of exceptional beauty on projects with longer maintenance cycles.
- Highly resistant to wear, does not discolor over time, and provides some of the toughest UV protection available.
- Medium or high luster film forming

Sansin Coating schedule

For covered locations, the following schedule is suggested:

Finish	1 st coat*	2 nd coat	3 rd coat
Natural finish	SDF	SDF	
Full finish	SDF	SDF Topcoat	SDF Topcoat

Note: A second coat should be applied for added protection. When applying only one coat, care should be taken to apply an adequate amount. Doubling the tint load for Natural and Translucent formulas should be considered.

For swimming pools, the following coating schedule is suggested:

- 2 coats of SDF + 1 coat of ENS
- 1 coat of SDF + 2 coats of SDF Topcoat

For exposed locations, the following schedule is suggested:

- 2 coats of SDF + 1 coat of ENS



Figure F.1 KP-12 and ENS applied to covered columns

Vermont Natural Coatings

- Several products available.

Société Laurentide Protection System

- Opaque or semi-transparent finishing system, designed to be applied in industrial settings, offering great exterior durability on different wood types intended for textured or brushed exterior siding or other similar application.
- Société Laurentide Innoprep 84: Impregnation coat designed to be applied on wood parts prior assembly; waterborne product.
- Société Laurentide Innocryl: exterior topcoat conceived to be applied to members subjected to be exposed to exterior conditions.
 - Innocryl B: Waterborne acrylic, opaque version.
 - Innocryl BT: Waterborne acrylic tinted varnish.
 - Innocryl HD: Waterborne paint based on acrylic and urethane resin, available in opaque or semi-transparent version.
- One coat of Innoprep 84 and two coats of Innocryl are suggested.

Sikkens Cetol SRD Translucent Wood Finish

- One-coat translucent exterior wood finish created for use on a variety of exterior wood surfaces.
- Easy-to-use finish with excellent UV protection that allows beautiful wood clarity.

F.7 Other Products

Sansin Impel Borate Rods

- Highly concentrated, solid-formed, water-diffusible boron rod derived from a naturally occurring preservative element.