EDITION 1:2022

Guide to assessing CLT surface quality

SWEDISH WOOD

Holiday home, Skellefteå.

Cover: Interior featuring CLT and glulam.

Foreword

Over the past decade, cross laminated timber (CLT) has become a popular choice in construction. More and more projects are specifying CLT, as an attractive, sustainable, high quality and competitive construction material. CLT is now used for the structural frame in all kinds of buildings, including apartment blocks, schools, administrative buildings, commercial buildings, halls and car parks.

This growing use of CLT is also increasingly prompting questions about what surface quality the client can expect, not least in buildings designed to have visible CLT surfaces. The end user might contact the CLT manufacturer once the building has been in use for a while, to ask questions about changes in appearance that they have noticed. Even inspectors sometimes wonder how they should be assessing CLT surfaces during the final inspection.

This *Guide to assessing CLT surface quality* is intended to provide support for developers, project managers, architects, purchasers and others at the start of a project and for inspectors and contractors at the end.

Surface qualities other than these industry standards may be offered by CLT manufacturers, but they must be given different designations than those presented in this publication.

Inspectors should be able to use this guide to assess knots, checks and other features that affect the surface quality of a CLT element. The guide also aims to provide assurance to clients about the basic surface qualities available when choosing exposed CLT surfaces in a building. This helps to ensure realistic expectations and an acceptance that some checks or other visual changes may occur due to the nature of wood as a living material. For developers and contractors, the guide contains information that can be used to support tenders and quotations. Furthermore, the publication lays the foundation for reducing additional work after the CLT project — from clients asking a long list of questions about knots, checks and other features — and for less in the way of costly complaints.

The publication has been produced jointly by industry body Swedish Wood and Sweden's CLT manufacturers.

Further technical information and guidance on wood, CLT and timber construction is available in TräGuiden, **www.traguiden.se**, which is constantly updated with new knowledge and practical advice. TräGuiden is an extensive resource with tables, drawings and illustrations and available in English using Google Translate.

Information on wood, glulam, CLT and timber construction can also be found at **www.swedishwood.com**.

Stockholm, December 2022

Jan Brundin, Gert Eriksson and Patrice Godonou

CLT panel

Contents

Description of the different surface quality grades

CLT floor system in industrial hotel, Älta.

The following CLT images are examples of what the different surface qualities might look like. The images do not represent the limits of each quality — they show that there is a variation within the different surface qualities.

Instructions for assessing/inspecting surface quality

The purpose of these instructions on how to assess surface quality is to ensure that assessments are conducted the same way every time.

1. When performing an overall assessment of surface quality, a visual inspection should be conducted at a viewing distance of 2–5 metres.
2. If a closer assessment is required, the visual inspection should be conducted at a minimum viewing distance of 1 metre.
3. Examination of specific details such as the size of features in the wood should be performed at whatever distance is necessary.

Visual Quality

The highest grade, Visual Quality, has a relatively homogenous finish, with sound knots and a small number of dead knots. Other features only occur to a very small extent.

Industrial Visual Quality

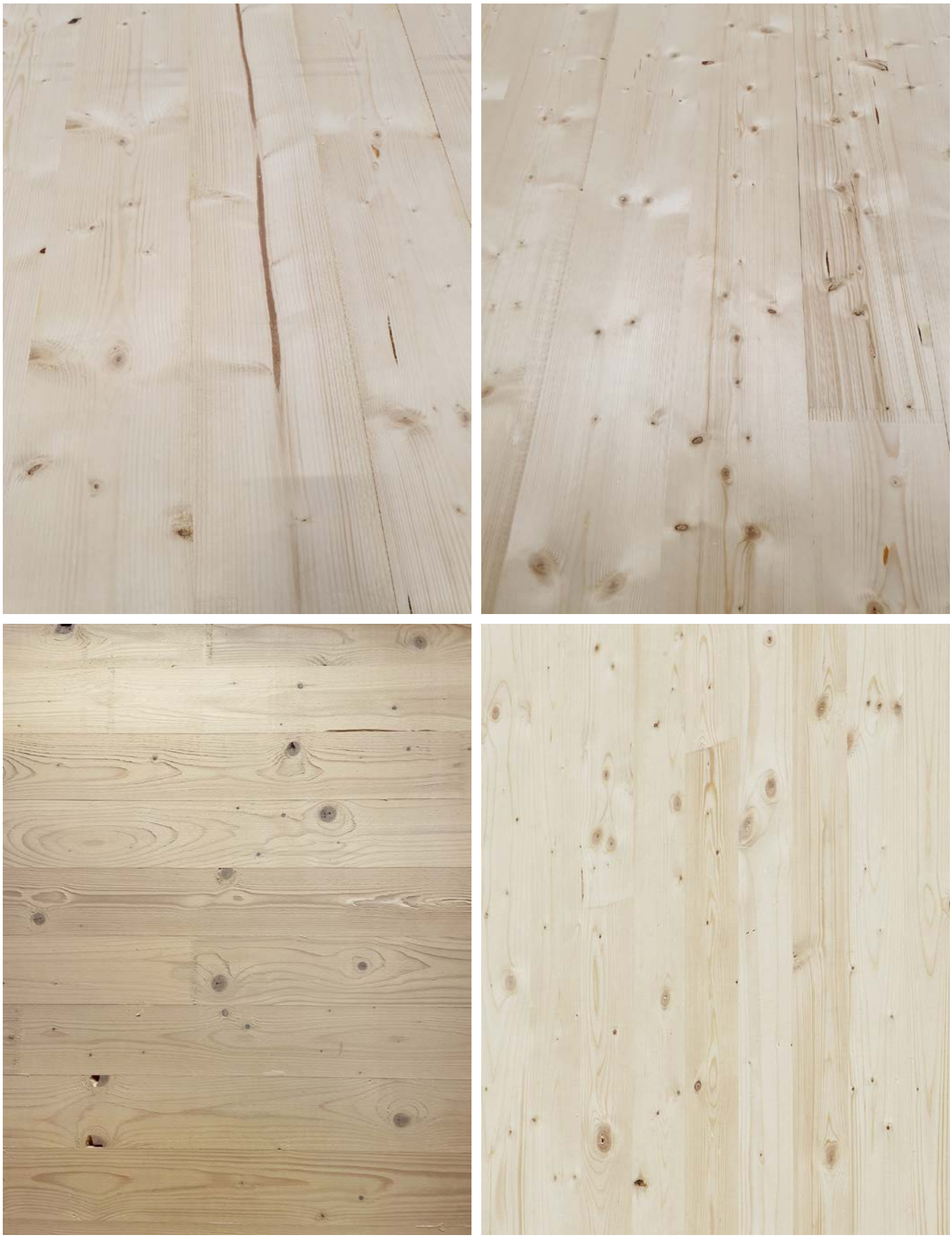
The next-highest grade, Industrial Visual Quality, allows most features to occur more widely than in Visual Quality, including small isolated bark pockets and scars. The surface quality can vary more, to the extent that it will sometimes be equivalent to Visual Quality.

Non-Visual Quality

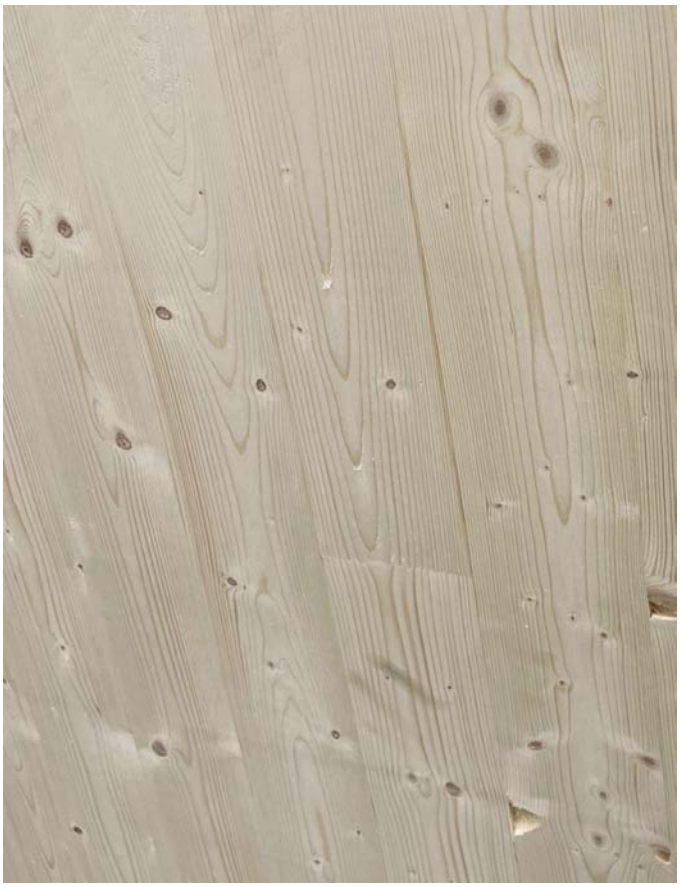
The lowest grade is Non-Visual Quality, which permits most features to a widespread degree. Examples of such features include unsound knots, knot holes, not traversing bark pockets and blue stain. This grade can vary greatly, as it might contain all three surface qualities.

Examples of Visual Quality

Examples of Industrial Visual Quality



Examples of Non-Visual Quality



Surface quality requirements for CLT on delivery

The surface quality requirements are based on the standards *EN 13017-1 Solid wood panels. Classification by surface appearance. Part 1: Softwood and EN 16351 Timber structures. Cross laminated timber. Requirements*.

The relevant parts of the regulations on appearance grading of wood products, *Commercial Grading of Timber*, and the rules for strength graded timber as expressed in *EN 14081-1 Timber structures. Strength graded structural timber with rectangular cross section. Part 1: General requirements*, have also been taken into account in developing the surface quality requirements.

As described in the surface quality requirements for CLT, Visual Quality, Industrial Visual Quality and Non-Visual Quality correspond, more or less, to the grades US, Fifths and Sixths in *Commercial Grading of Timber*.

CLT panels reading for wrapping and delivery.

Table 1 **Features of different types of CLT surface**
The table's requirements apply to 95 percent of the lamellae in a CLT panel. This means that no more than 5 percent of the lamellae in a panel may have features that slightly exceed the permitted levels for the particular surface quality.

Feature	Visual Quality	Industrial Visual Quality	Non-Visual Quality
Edge-glued joints	No open joints	Max. length 100 mm /1 metre	Max. length 100 mm /1 metre
Non-glued joints width EN 16351, section F.6	Max. 2 mm, at least 90 percent of all joints. Occasional joints max. 3 mm. Median value max. 0.6 mm.	Max. 2 mm, at least 90 percent of all joints. Occasional joints max. 4 mm. Median value max. 0.6 mm.	Max. 2 mm, at least 90 percent of all joints. Occasional joints max. 6 mm. Median value max. 0.6 mm.
Mixture of wood species (surface layer)	Not permitted	Not permitted	Permitted
Colour variation	Normal variation within the wood species permitted	Normal variation within the wood species permitted	Permitted
Surface finish of lamellae and element/panel	Planed, smooth	Planed	No requirements
Visible finger joints	Permitted	Permitted	Permitted
Knots			
Sound and light coloured dead, larger than 10 mm No. at max. size. More permitted if knots are smaller. Max. total knot diameter = max. size × max. no. Compensation rule.	40 mm 28 per m^2	50 mm 35 per m^2	Permitted
Black dead and/or encased Quantity	20 mm 4 per m^2	28 mm 6 per m^2	Permitted
Unsound	Not permitted	Not permitted	Permitted
Not traversing arris knot (fallen out) Quantity	10 mm 1 per m^2	20 mm 2 per m^2	Permitted
Knot hole (Loose knot) Quantity	10 mm 1 per 5 m^2	20 mm 1 per 5 m^2	Permitted
Cracked knots	Permitted	Permitted	Permitted
Chipped grain in knots	10 mm	15 mm	Permitted
Round and oval plugs, measure as knots.	Permitted	Permitted	Permitted
Other features			
Resin pockets Quantity	Length 50 mm, width 5 mm 5 per m^2	Length 75 mm, width 7 mm 5 per m^2	Permitted
Repaired resin pockets	Permitted	Permitted	Permitted
Bark pockets and scars	Not permitted	Not traversing, max. length 50 mm	Not traversing
Checks No. of checks including end shakes	10 percent of lamella's length. Max. length end shakes 50 mm 2 per m^2	20 percent of lamella's length. Max. length end shakes 50 mm 2 per m^2	Permitted
Visible pith length Quantity	400 mm 1 per 2 m^2	Permitted	Permitted
Reaction (compression) wood	10 percent of surface per m^2	Permitted	Permitted
Insect attack	Not permitted	Not permitted	Occasional max. 2 mm
Discolouration, blue stain Quantity	Not permitted	Width 15 mm Length 300 mm 1 per 2 m^2	Permitted
Dote	Not permitted	Not permitted	Not permitted
Surface finish. Planing, sanding. Quantity	Occasional small defects permitted 1 per 2 m^2	Occasional defects permitted 1 per m^2	Permitted
Wane Quantity	Not permitted	Width 5 mm Length 200 mm 1 per m^2	As per the finger-jointing standard Unlimited
Glue deposits	Not permitted	Permitted	Permitted
Other repairs	Permitted	Permitted	Permitted

Specific features – description and measurement rules

The images below, taken from *Commercial Grading of Timber*, illustrate some of the features, along with their definition and measurement rules. *See table 1, page 11*.

Knots

Sound knot

Definition
A knot that, on the surface in question, is intergrown with the surrounding wood along more than 75 percent of its circumference and is free of rot.

Encased knot

Definition
A knot that, on the surface in question, is surrounded by bark on 25 percent or more of its circumference.

Dead knot

Definition
A knot that, on the surface in question, is intergrown with the surrounding wood along 75 percent or less of its circumference and is free of rot. This definition encompasses both partially sound knots – see Section 2.10.15 in EN 844:2019 – and dead knots – see Section 2.10.16 in EN 844:2019.

Unsound knot

Definition
A knot affected by rot.

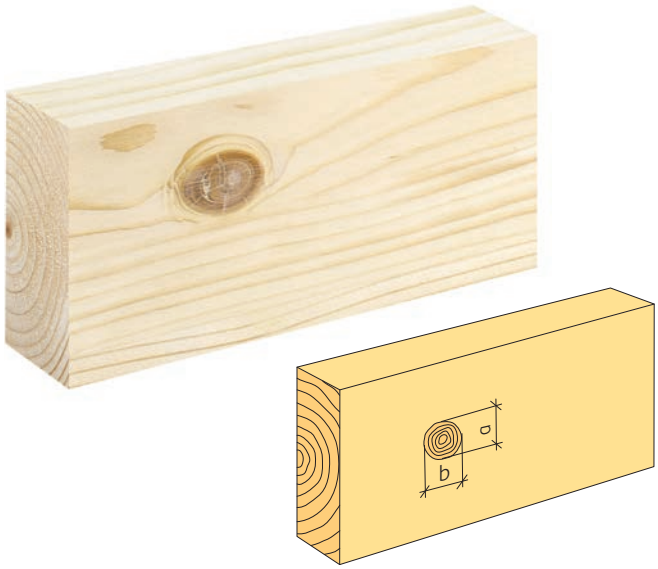
Loose knot

Definition
A dead knot that is not held firmly in place by the surrounding wood.

Not traversing arris knot (fallen out)

Definition
A knot that was located on an arris on the inside face of a piece of timber.

Round knot



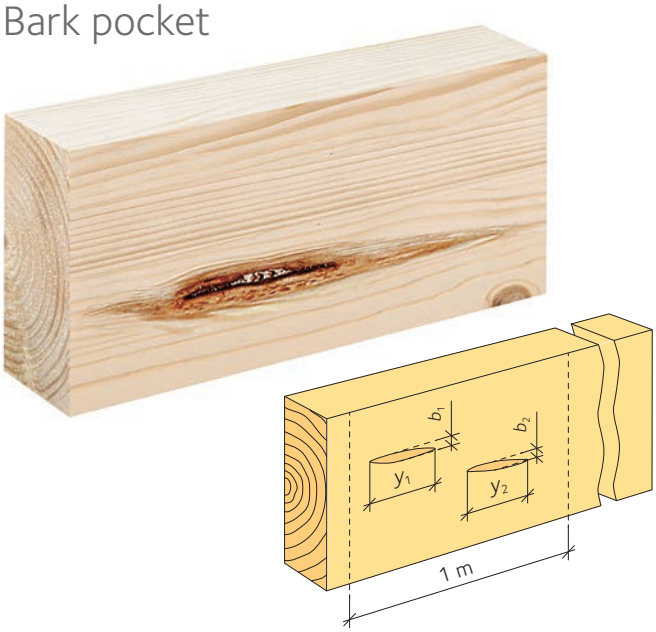
Definition	Measurement rule
A knot that has been cut more or less straight through, so that the ratio between the largest and smallest diameter is no more than 1.5.	Face: Average of the largest and smallest diameter $d = (a + b)/2$.

Oval knot

Definition	Measurement rule
A knot that has been cut more or less straight through, so that the ratio between the largest and smallest diameter is greater than 1.5 but no more than 4.	Face: Average of the largest and smallest diameter $d = (a + b)/2$.

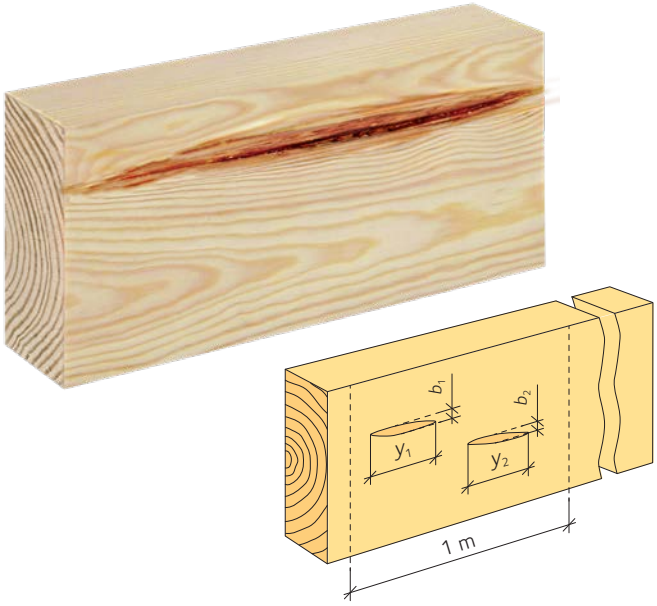
Other features

Bark pocket



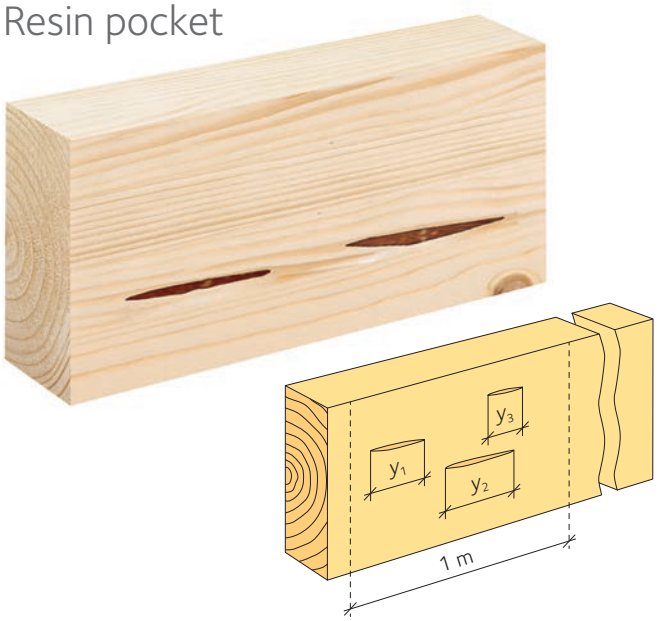
Definition	Measurement rule
Bark that is partly or wholly enclosed in the wood.	Length, *y*, on the longitudinal axis of the piece of timber. $y = y_1 + ... + y_n$ Greatest width, *b*.

Scar



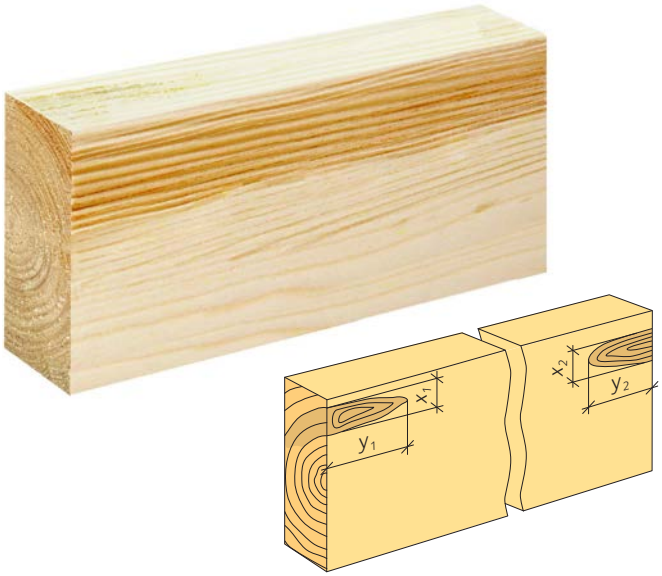
Definition	Measurement rule
An opening formed after damage to the tree while it is growing, which has become enclosed in the trunk through the surrounding wood.	Length, *y*, on the longitudinal axis of the piece of timber. $y = y_1 + ... + y_n$ Greatest width, *b*.

Resin pocket



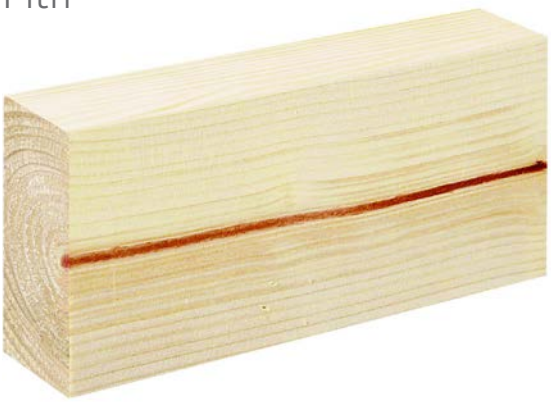
Definition	Measurement rule
Lens shaped cavity in the wood that contains (or has previously contained) resin. Depending on how a saw has cut into the cavity, the resin pocket may appear as a wide, shallow depression, or as an oblong opening in the surface. It may also be a round cavity.	Length, *y*, on the longitudinal axis of the piece of timber. $y = y_1 + ... + y_n$

Reaction wood (compression wood)



Definition	Measurement rule
Wood with a distinctive anatomical character and unusual properties, which normally occurs in crooked or leaning trees and in branches. Among the most distinctive features are very large moisture movements in the grain direction.	Total area on the side. $A = x_1 \cdot y_1 + ... + x_n \cdot y_n$.

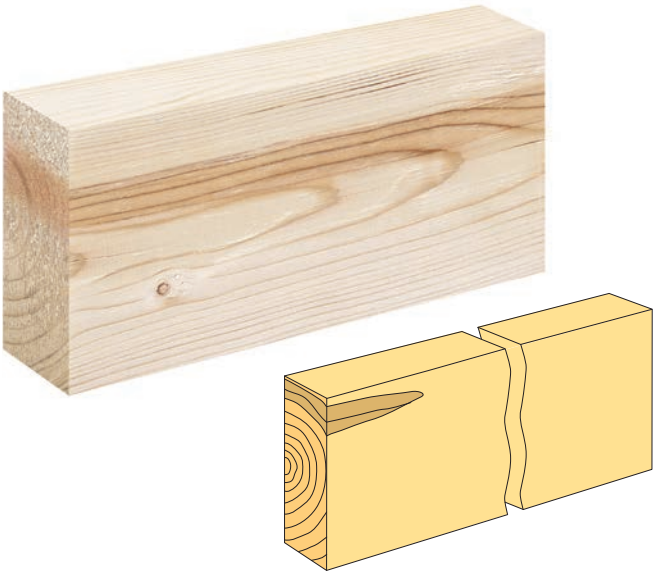
Pith



Definition

Zone within the first annual growth ring, consisting chiefly of soft tissue. Dark colour.

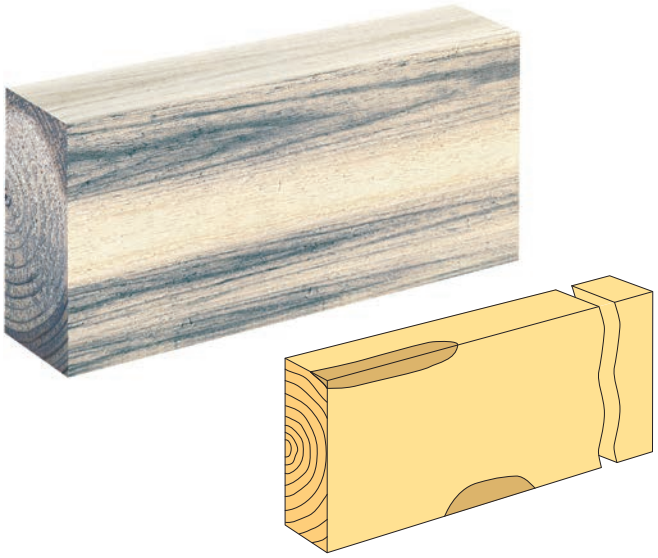
Dote



Definition

Early stage of rot, characterised by discoloured streaks or spots (often at knots) in the wood. The general structure and strength properties of the wood remain more or less unchanged.

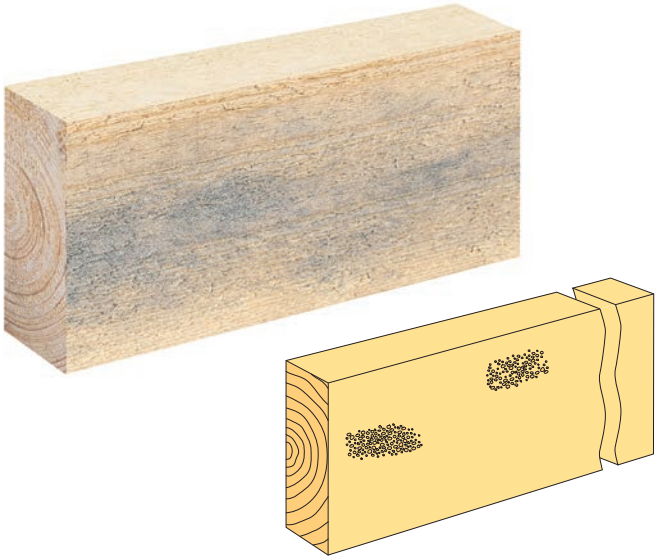
Deep blue stain



Definition

Blue stain that cannot be removed by surface planing. Normally found in the log even before sawing (log blue stain).

Surface blue stain and mould



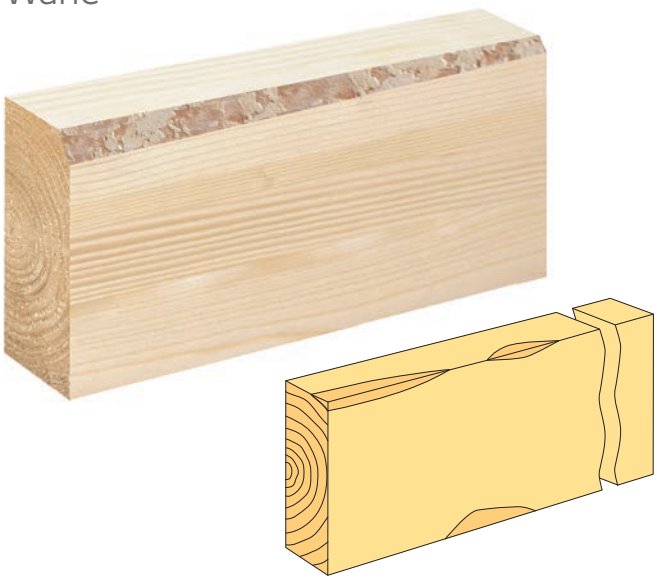
Definition

Superficial blue stain and mould caused by fungi, less than 2 mm deep; can be removed by surface planing.

Insect attack

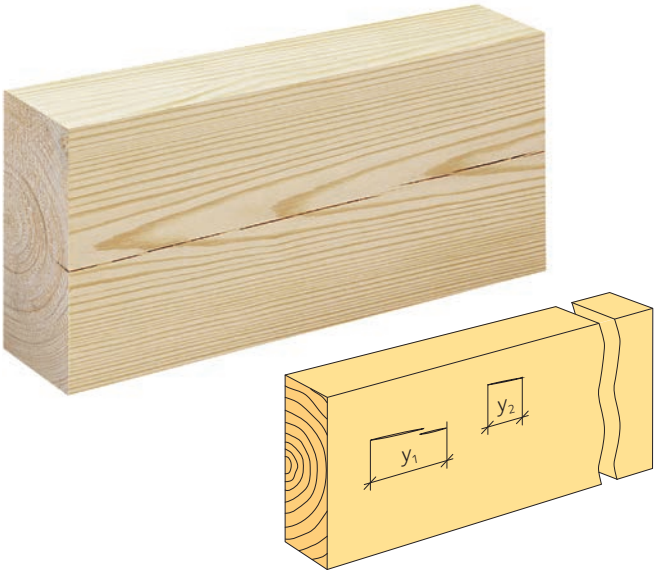
Definition
Bore holes or pinholes in timber, caused by insects or insect larvae.

Wane



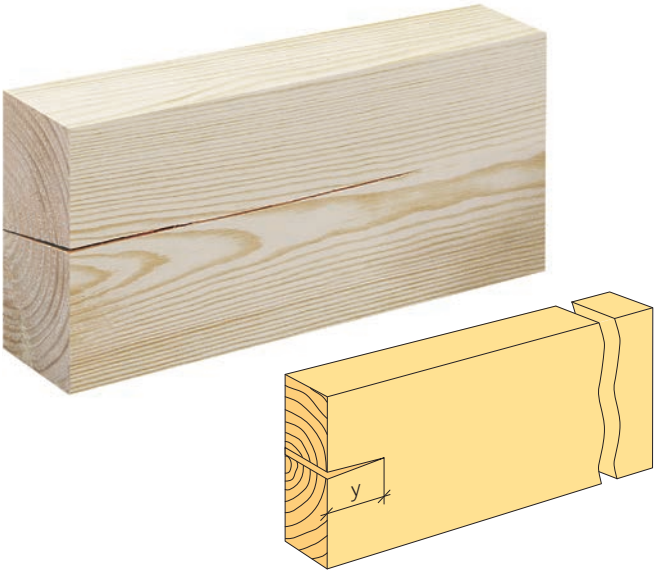
Definition
The original mantle surface of the log, with or without bark, on an arris in sawn timber. Or: a surface formed during ring chipping.

Check



Definition	Measurement rule
Not traversing check: a check that is only visible on one side of the piece of timber. Traversing check: a check that extends from one side to another.	Total length of checks: $y = y_1 + ... + y_n$ (= check length), measured parallel with the longitudinal axis of the piece of timber.

End shake



Definition	Measurement rule
A check fissure that is visible on the end surface of the timber piece, extends from one side of the piece to another, and is of limited length.	Length of an individual fissure, *y*, measured parallel with the longitudinal axis of the piece of timber.

Expected changes in CLT 12–24 months after delivery

When CLT is installed in an environment where the temperature is around 20 °C throughout the year, the air is very dry during the winter months. This causes the surface of the wood to dry out and shrink, resulting in varying degrees of cracking. Over time, the colour of the surface wood is also likely to change. A pine surface will become darker, while a spruce surface will turn more of a yellow colour.

General

Over time, wood will inevitably be affected by its surroundings. UV light affects the surface colour of the wood, for example. The colour change is gradual and varies depending on the wood species.

Wood is a hygroscopic material, which means that it absorbs and releases moisture. Wood in direct contact with water will become damp. The humidity in the air (relative humidity, RH) also affects the wood's moisture content.

As the wood's moisture content changes within the range of 0—30 %, the wood will either swell or shrink. Shrinkage creates stresses that can cause checks in the wood.

Occurrence of checks in the CLT surface

The climate in heated premises is at its driest between December and February in Sweden, and the indoor climate is at its most humid from July—September. The surface layer of CLT is therefore going to shrink, with a significant risk of checks to occur, during the period December—February. It is likely that a large proportion of the outer lamellae will get checks along the whole length. These checks will then reduce in spring, summer and autumn.

Relative humidity, RH, and the wood's moisture content

The relative humidity of the air, RH, varies both indoors and out over the year. The relative humidity also varies across Sweden, depending on the temperature and proximity to the sea and lakes.

Outdoors and in unheated premises, the relative humidity is highest in November—February, with a daily average of 80—90 %, and lowest in May—June, daily average 65—75 %. This means that the variation in moisture content theoretically varies by between 12 and 20 %.

In heated premises where the temperature is 20 °C all year round, the relative humidity is highest in July—September, daily average 50—60 %, and lowest in December—February, daily average 10—25 %. Here, the variation in moisture content theoretically varies by between 3 and 11 %. In the driest part of Sweden, the variation lies between 3 and 9 %, while in the most humid area it lies between 5 and 11 %.

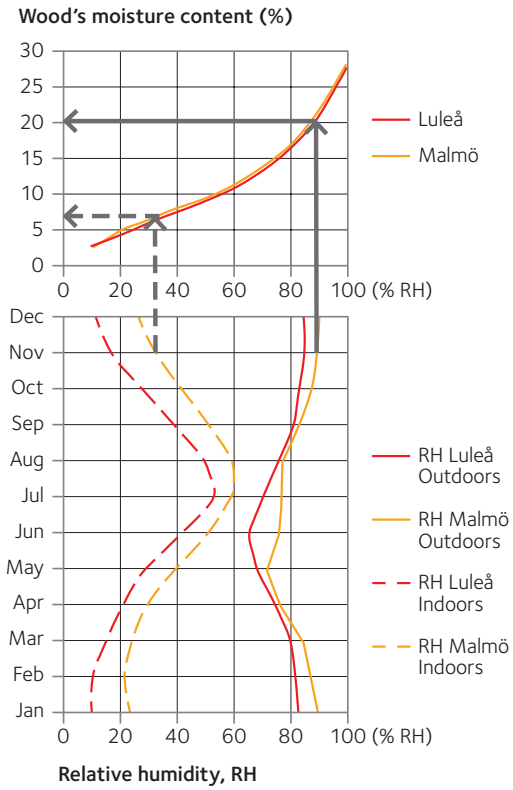


Figure 1 **Wood's moisture content in relation to relative humidity, RH**

The top section shows the correlation between ambient relative humidity, RH, and moisture content. The temperature also affects the correlation, but the effect is less than 1 percent of the moisture content in the temperature range 0 – 20 °C.

The lower section shows the monthly average value for RH in the north of Sweden (Luleå) and the south (Malmö). The solid curves show RH outdoors and the dotted curves show RH indoors. The RH curves for indoors should be increased by around 18 % RH to account for the moisture added by a normal family (cooking, shower, laundry, breathing, perspiring and so on).

Example: What is the RH and average moisture content indoors in Malmö in November?
Following the black arrows, RH = 32 % and the moisture content 7 %. (Outdoors, the corresponding figures are RH = 89 % and moisture content = 20 %). At an RH of around 32 %, the wood's moisture content is thus around 7 %.

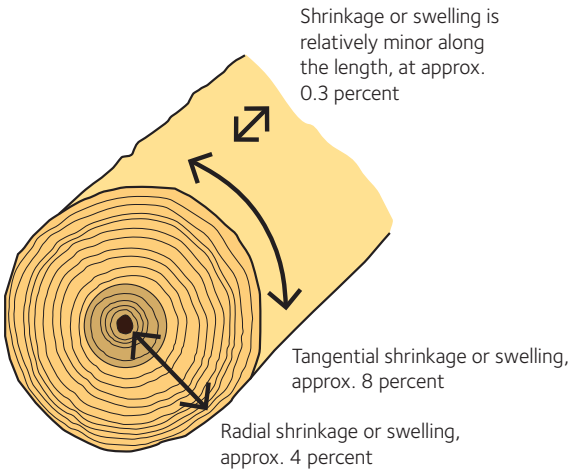


Figure 2 Shrinkage or swelling in a softwood log from fresh to fully dry. Shrinkage or swelling in a piece of timber varies depending on how the growth rings are positioned in the wood. The smallest dimensional changes occur in wood where the growth rings are perpendicular with the face, known as vertical grain.

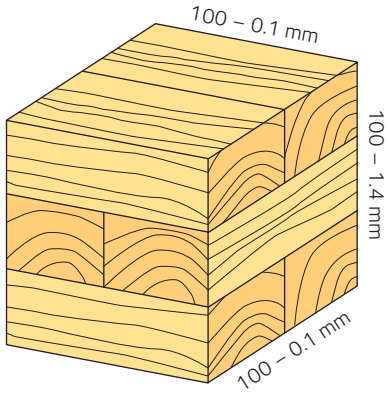


Figure 3 Shrinkage and swelling
Shrinkage in a cube of softwood CLT with 100 mm sides during drying from 20 % to 10 % moisture content.

Moisture-related wood movement

Spruce shrinks or swells by around 8 percent along the curvature of the growth rings (tangentially) and by around 4 percent across the growth rings (radially). Along the length of the timber, shrinkage or swelling is approximately 0.3 percent. Shrinkage and swelling occur within the moisture content range of 0—30 percent. A rule of thumb is that, across the length of the timber, spruce will move by around 0.26 percent per percentage point of change in the moisture content.

Example of shrinkage: Timber width 145 mm, moisture content 11 %.

After a year, the timber's moisture content is 7 %, representing a drop in the moisture content of 4 percentage points. The shrinkage will thus be: 145 × 4 × 0.0026 = 1.5 mm in width.

Cracking in the timber

Since the relative humidity, RH, in heated premises is lowest in December—February, this is the period when the wood shrinks most.

As it shrinks, this creates stresses that often cause checks to occur. Because the wood shrinks as a percentage of the wood's dimension (width), the stresses and the checks in the wood will be larger, the wider the timber is.

Since the inside of the outer lamella is bonded to wood that is oriented at 90 degrees to the surface layer, the inside of the outer lamella will not move but its outside will. As it shrinks, this creates tensile stresses in the surface, which often cause checks to occur.

Essentially, checks are going to appear in the winter, with their extent depending on the relative humidity in the immediate surroundings. Low relative humidity means more cracking. If the outdoor temperature is low and the indoor temperature high, the relative humidity will be low. Relative humidity is also affected by factors such as the amount of ventilation. The extent of the check occurrence is likely to increase if the lamellae in the surface layer are edge-glued to each other. The checks will lessen in the spring, summer and autumn, before increasing again in the winter.

When the timbers in CLT crack, a distinct bang can sometimes be heard.

Examples of checks in the outer lamellae






References

The content of the Guide to assessing CLT surface quality is based on the following grading rules and standards:

EN 844:2019 Round and sawn timber — Terminology.

EN 13017-1 Solid wood panels. Classification by surface appearance. Part 1: Softwood. 2001.

EN 14081-1:2016 + A1:2019 Timber structures. Strength graded structural timber with rectangular cross section. Part 1: General requirements.

EN 16351:2021 Timber structures. Cross laminated timber. Requirements.

Commercial Grading of Timber, Edition 1:2020. Swedish Wood, 2020.

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Publisher

Swedish Forest Industries Federation
Swedish Wood
P.O Box 55525
SE-102 04 STOCKHOLM
Sweden
Tel: +46 8 762 72 60
E-mail: info@swedishwood.com
www.swedishwood.com

Editor
Patrice Godonou — Swedish Wood

Authors
Jan Brundin — Consultant
Gert Eriksson —Erikssons Kvalitet & Ledarskap AB

Reference group
Daniel Anderson — Södra Skogsägarna ekonomisk förening
Jonas Berglund — Setra Trävaror AB
Gabriel Eriksson — Swedish Wood
Jennifer Eriksson — Stora Enso Timber AB
Johan Fröbel — Swedish Wood
Patrice Godonou — Swedish Wood
Gunnar Lundmark — Martinsons Byggsystem AB / Holmen Wood Products AB

Fact checkers
Jonas Berglund — Setra Trävaror AB
Jennifer Eriksson — Stora Enso Timber AB
Johan Fröbel — Swedish Wood
Gunnar Lundmark — Martinsons Byggsystem AB / Holmen Wood Products AB

Language reviewers
Barnaby Dickens — Consultant
Tony Traynor — Swedish Wood UK Projects Manager

Illustrations
Cornelia Thelander — Thelander Arkitektur & Design AB
Visualisera arkitektur AB

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baraBild, page 6
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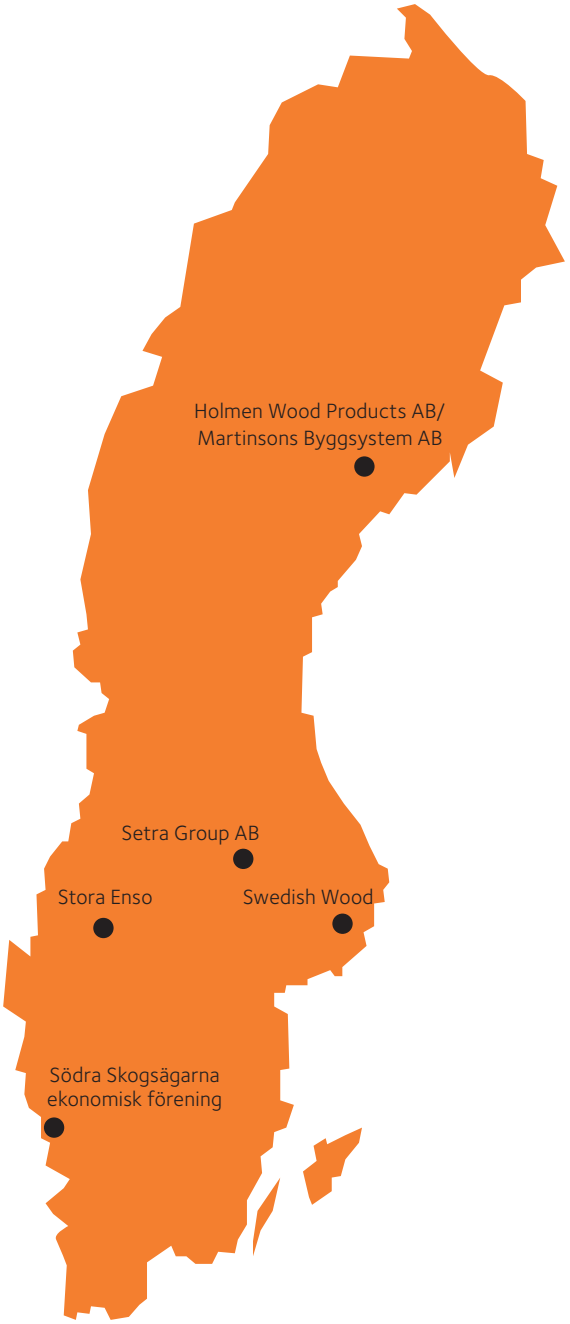
CLT manufacturing mills in Sweden

All the CLT manufacturers have an environmental declaration and are certified by accredited certification bodies.



HOLMEN

martinsons
En del av Holmen

Holmen Wood Products AB/
Martinsons Byggsystem AB
Burträskvägen 53
SE-937 80 Bygdsiljum
Sweden
Tel: +46 914 207 00
www.martinsons.se

Setra

Setra Group AB
Amungsvägen 17
SE-770 70 Långshyttan
Sweden
Tel: +46 225 635 00
www.setragroup.com

storaenso

Stora Enso
Gruvöns sågverk
Timmervägen 2
SE-664 33 Grums
Sweden
Tel: +46 10 463 91 00
www.storaenso.com

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Södra Skogsägarna
ekonomisk förening
SE-432 86 Väröbacka
Sweden
Tel: +46 340 628 00
www.sodra.com

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Swedish Wood represents the Swedish sawmill industry and is part of the Swedish Forest Industries Federation. Swedish Wood represents the Swedish glulam, CLT and packaging industries, and collaborates closely with Swedish builders' merchants and wholesalers of wood products.

P.O Box 55525
SE-102 04 Stockholm
Sweden
Tel: +46 8 762 72 60
info@swedishwood.com
swedishwood.com

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