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Wood Features and Defects

Understanding the most common features and defects found in wood is important for grading purposes and to understand timber's mechanical properties.

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Wood Features and Defects

When trees are cut, some features that were vital for the tree's existence are perceived by us as defects in the timber, while others are considered desirable. Other wood defects result from manners of processing, useage, or storing the timber. These features are assessed and communicated by the timber grading process.

Using Wood Features in Grading

The relationship between timber's mechanical properties and its visual characteristics must be established before making a grading assignment. Both visual and machine grading use wood features to exclude pieces that are likely to have the lowest mechanical properties. Visual grading relies on wood features, while machine grading might include optical measurements or scanning technologies to assess features. Any area that is not included in the machine's assessment needs to be covered by a "visual override" – a trained person rejecting the timber that shows non-admissible features.

The grading assignment, and therefore the limits for certain wood features, are dependent on wood species and growing area. The technique of how features are measured is often defined in national standards, but custom rules might be defined for certain species, growth areas, and applications.

However, there are still fundamental requirements detailing how certain features need to be covered and how to demonstrate that admissible features do not affect mechanical properties.

Roundwood Features

Trees do not necessarily grow as perfectly straight cylinders. They grow branches that result in knots, and they grow in different directions, which leads to grain deviations. Some tree features will not be visible in the sawn timber, but lead to lower timber yields, as some sections of the stem must be cut off. Even though grading is mostly focused on sawn timber, standing trees or roundwood can be pre-graded to select only the most promising specimens for sawing timber.

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Sometimes high-value logs, used to produce musical instruments for example, are auctioned before processing. Experts need to judge the quality of the timber from the stem shape and tree features.

- **Ovality** is the deviation from roundness. In more oval stems, the position of the pith is not always clear from the outside, and eccentric pith might occur, so that the presence of pith in the sawn timber cannot be planned accurately.
- **Fluting** is another form of deviation from a round stem cross-section where the stem shows many irregular bulges.
- **Taper** is the degree to which the diameter of the stem decreases with height. For a higher yield, it is desirable to cut the stem into logs that have the same diameter on both ends.
- **Sweep** is the degree to which the stem deviates from straightness in a longitudinal direction. Sweep can be “simple” or “multiple,” depending on how often the stem changes direction.
- **Tree forks** occur where branches fork the stem into two leaders, each containing a pith. The wood fibres deviate in this area of the stem, as the diameter reduces drastically.
- **Water pots** can form between forks or where branches have broken off. They form small cavities in the bark where water is trapped. This can be a point for fungal attack.

IMAGE: Fluting

IMAGE: Tree fork

IMAGE: Water pot offering access to decay

- The size and number of **branches** gives a good indication of **knots** in the sawn timber, but not only live branches result in knots. If branches break off or are pruned early in the tree's life, bark grows over the branches, producing **covered knots**. There might still be indications of these branches in the roundwood.

- **Burls, buckles,** and **burrs** are bulbous excesses that are clearly visible in roundwood. Small burls and buckles might not affect timber quality, and have similar implications as branches, but they can also reach considerable size and affect timber quality. The severe grain deviations inside burrs might also be a desirable decorative feature, as seen in marblewood or pippy oak. Extreme grain deviations of the whole stem, like **spiral grain** and **interlocked grain**, can often already be detected in the bark of trees or logs.

Trees might also experience damage from animals (squirrel and deer bites, bird holes, beetle attack), fungi, parasitic plants (such as mistletoe in temperate zones), and natural events (like fire, lightning, drought stress, and storms). The damage might limit tree growth, or it might be incompatible with timber production. If possible, damaged trees are removed in thinning or retained as standing deadwood.

Growth Rings

Growth rings are present in all timber and can hardly be regarded as a defect. Nonetheless, they are used in visual grading as an estimator for density.

In softwoods, where growth rings are wider, they contain more earlywood, which is less dense. Wide growth rings might therefore be a reject criterion in visual grading. However, the relationship between growth ring width and density is not necessarily strong in all softwoods.

In hardwoods, a relationship would only be expected in ring-porous species, and in that case, wider growth rings contain less earlywood and the wood is denser.

It is important to keep in mind that growth ring width is not a useful predictor for density or for wood quality in all wood species. In fact, it does not seem to be a good predictor for individual pieces of timber in any species, but it can be used in grading to assess populations.

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Sawn Timber - Natural Wood Features

Pith might be present in the timber cut from the central parts of the stem. The pith itself can be softer and weaker than the surrounding timber, but, more importantly, the growth rings close to the pith contain juvenile wood, which has lower mechanical properties compared to adult wood from the same tree. Therefore, the pith can be an important visual grading criterion.

Knots are one of the most abundant wood features. They result from the tree's branches that grow outwards from the pith, meaning that knots do not only appear on the timber's surface, but form cones towards the pith.

Knots are often darker than the surrounding wood because they contain more lignin. Severe grain angle deviations are common around knots. This is one of the reasons why knots can present weak spots in the timber, and they are an important visual grading feature. However, mechanical properties are not necessarily related to knot size and number. While the relationship can be complicated, both mechanical properties and knot characteristics are related to growing conditions.

Measuring knots is treated differently in different grading standards. Some measure the maximum and minimum diameter, while others measure the diameter perpendicular to the board edge. **BS EN 4978** measures the "projected cross sectional area" of the worst section – meaning the area that all the cone-shaped knot surfaces take as a share of the cross section.

Knots can also be of several types, depending on the state of the branch when the tree was felled.

They are commonly round or oval, but depending on how the wood is cut, knots can take different shapes:

- **Splay knots** and **Spike knots** are elongated instead of round. The distinction between the two terms important for some national grading standards, where knots on the broad side and the small side of a board, as well as knots touching arises, are treated differently, e.g., the Canadian National Lumber Grading rules. Splay knots are connected to an arris, while spike knots appear only on the face.

IMAGE: Pith and growth rings

IMAGE: Splay knot

- **Branched knots** are a pair of elongated knots that originate from the same point. They can be exposed when the timber is cut through the pith and through a whorl of branches.

- **Pin knots** are small knots. They are commonly defined as less than 5mm in diameter and are ignored in most visual grading standards.

Besides their shape, knots are defined by other characteristics. **Sound knots** or **intergrown knots** are completely (or almost completely) connected to the surrounding wood. They have not been affected by rot.

Unsound knots have been affected by decay. **Dead knots** result from dead branches. They are loosely connected to the surrounding wood. In some cases, they can become loose knots, or fall out of the wood and leave holes. **Encased knots** contain some bark that is connected to the wood. They can be surrounded by or contain only small sections of bark.

Knot clusters are groups of knots that are close together. Often “close together” is defined by the fibre deviation around a knot: if the fibres do not go back to straight between knots, they form a cluster. The question of whether knots form a cluster is only relevant in visual grading, and it is treated differently in different national standards. Clusters of pin knots are also called cat paws.

Grain deviations outwith knot areas also occur quite commonly. They can be an important feature in visual grading, although they are not always easy to measure, as the direction of the grain cannot always be seen clearly and can only be assessed on the surface.

IMAGE: Encased knot

IMAGE: Cat paw knot cluster

Severe grain deviations can be weak sections in the timber since the mechanical properties perpendicular to the fibre are much lower than parallel to the fibre. Grain deviations like **spiral grain** and **interlocked grain**, which is spiral grain that changes direction along the circumference of the stem, can also lead to drying deformations.

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Sawn Timber - Defects from Processing Timber

Resin pockets are present in some conifers and tropical hardwoods. They excrete resin, which is not desirable in some end uses where the timber is exposed to touch, but they are not a major feature in strength grading.

Discolorations do not usually affect mechanical properties unless they result from certain types of fungal decay. False core wood might have a distinct colour, for example redheart in beech or blackheart in alder, but unless the appearance of the timber has certain colour requirements, these do not need to be rejected.

Reaction wood is formed by trees as a reaction to stresses and is especially visible in logs that are not perfectly round, or in wood that is close to knots. In conifers, **compression wood** is formed in areas of the stem that are under compression, so on the lower side of branches and leaning stems. Compression wood appears darker than normal wood because it contains more lignin. It is often harder and denser than normal wood, but also shows more moisture movement.

IMAGE: Resin pockets

Wane results from the round shape of the stem when it is cut into boards with rectangular cross section. Sometimes, one or more edges of the board keep the curved stem shape rather than being perfectly rectangular. Wane reduces the cross section of parts of the boards, but other than that has no effect on mechanical properties and is often permitted to some extent in visual grading standards.

IMAGE: Wane

Distortion, also called **warp**, can result from drying stresses or because of shrinking movements during drying.

Certain wood features, such as spiral grain or reaction wood can exacerbate deformations.

They can occur as **bow** (longitudinal bending normal to the face), **spring** (longitudinal bending normal to the edge), **cup** (transversal), or **twist** (spiral distortion along the length).

Bow and spring can be “simple” or “complex/ compound,” depending on whether one or more bends occur in a piece of timber. Distortions along the length of a piece of timber (bow, spring, twist) are usually measured as millimetres of deviation from perfect shape over two metres of length. Cup is commonly measured over the full width.

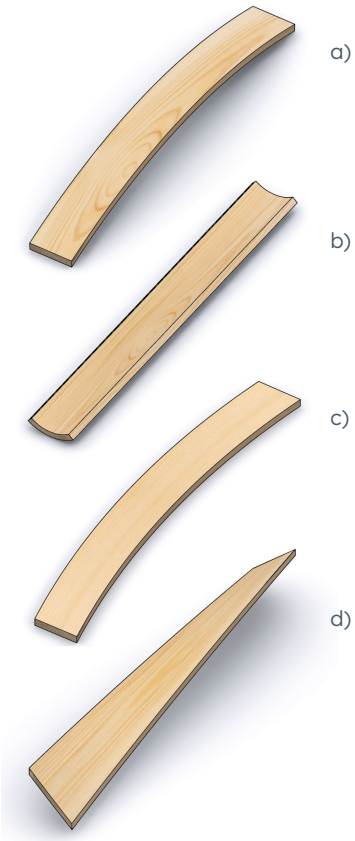

IMAGE: Distortion

a) Bow
b) Cup
c) Spring
d) Twist

Stain can also be the result of enzymatic or chemical reactions during drying or other processes under elevated temperatures. Some wood species that contain tannins or other chemicals might react with metals, which results in stains as well. These stains are disregarded in strength grading, but they might be relevant in appearance grading.

Fissures can also be a result of incorrect drying. Many words for different fissures exist such as **checks, shakes** and **cracks**, and these terms are sometimes used interchangeably. Usually, radial cracks are called shakes, for example cracks separating growth rings (ring shakes), radial cracks in the end grain (end shakes), or cracks running outwards from the pith (heart shakes and star shakes). Small surface fissures are also called checks. Fissures separating the ends of boards are called splits.

Small fissures do not necessarily affect mechanical properties, and they might be permitted in visual grading. Their length and depth might be limited by different standards, however.

Broadleaf trees form **tension wood** in areas of the stem that are under tension, for example on the upper side of leaning stems or branches. Tension wood has a thicker secondary cell wall layer that is gelatinous. Tension wood contains less lignin and more cellulose and appears lighter than normal wood. Since the properties of reaction wood vary from normal wood but are quite unpredictable, boards that contain reaction wood are commonly rejected in visual grading or in visual override of machine grading.

Defects from Decay

Bore tunnels can become visible when timber is cut from trees or green timber that was infected by insects. Often only the area under the bark or the sapwood is affected. Decay by live- or green-timber decaying insects is not ongoing in sawn timber, but affected pieces are still usually rejected. If insect attack is ongoing in sawn (dry) timber, damage is commonly visible as small, round, or oval **bore holes** on the timber surface. The damage can be greater beneath the surface, however, so these pieces need to be rejected.

Fungal decay can result in **discolouration**. Some stain might not affect mechanical properties, for example **blue stain**, which might be permitted in structural timber. Brown- or white rot fungi can also leave zone lines or leave the wood lighter than normal, but such discolouration is not necessarily linked to a decrease in mechanical properties.

Timber that shows **dote** (early signs of decay) might not be rejected, while more severe decay, including **soft rot** or **cubic rot**, should be rejected.