

Key points

- This information sheet provided basic information on the strength grading of structural timber.
- Structural timber should be graded in accordance with EN 14081-1.
- Structural timber should be CE marked and have a Declaration of Performance (DoP).
- Article 9 of the CPR lays down the rules for CE marking.
- CE marking indicates that the manufacturer takes responsibility for the conformity of the timber with the information in the Declaration of Performance.
- The manufacturer states the characteristics of the graded timber that they wish to declare in the Declaration of Performance; these relate to the essential characteristics described in EN 14081-1.
- A manufacturer has to declare the performance of at least one essential characteristic.
- National standards still apply for visual strength grading.
- The visual strength grading standard of any member state of the EU can be used for grading providing the standard complies with EN 14081-1; these standards are listed in EN 1912.

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Grading structural timber

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Introduction

This information sheet gives basic information on the strength grading of structural timber and the current Irish and EU standards which should be used in relation to timber grading. Strength grading is a means of assessing each piece of timber to a specific set of rules. The rules are developed by relating graded timber to strength properties based on laboratory testing. If timber is not strength graded then it cannot be used structurally for building purposes. As the main strength grading standard EN 14081-1 is harmonised it is a requirement under the Construction Products Regulations (CPR) that timber is CE marked and accompanied by a Declaration of Performance (DoP). Building design in Ireland must now comply with the Eurocodes for structural design and timber for structural use must comply with the EN standard on timber grading.

Reference standards

- EN 14081-1: Timber structures – Strength graded structural timber with rectangular cross-section – Part 1: General requirements
- EN 338: Structural timber – Strength classes
- I.S.127: Structural timber – Visual strength grading – Sawn softwoods with rectangular cross-section
- BS 4978: Visual strength grading of softwood. Specification
- S.R.82: Irish code of practice – Slating and tiling

Terms and definitions

Knots: natural strength reducing features in timber arising from tree branches.

Warp: distortion of timber examples of the principal modes are bow, spring, cup and twist are shown in Fig 1.

Knot area ratio (KAR): the ratio of the sum of the projected cross-sectional areas of knots to the cross-sectional area of the timber at a specific location.

Visual strength grader: a person who has successfully completed a visual strength grading course and responsible for the grading of structural timber within an approval/certification scheme operated by a Notified Body.

Machine strength grading: the process by which timber is graded by a machine into appropriate strength classes suitable for structural use within an approval/certification scheme operated by a Notified Body.

Strength class: classification of structural timber into defined strength classes based on its mechanical properties and density.

Reject timber: timber which has been assessed by either a visual or machine strength grading process and which has failed to comply with requirements for allocation into a grade or strength class.

Structural timber

Strength grading of timber can be undertaken either visually by a trained strength grader or by a grading machine. The factory production control of both methods should be supervised and regularly audited by a notified certification body.

Timber grading in Ireland

In Ireland, the predominant forestry trees are Sitka and Norway spruce which are both conifers. These are cone-bearing trees which produce softwood timber when processed in a sawmill. Where this timber was intended for structural use in construction it was necessary to determine the strength properties and a research programme for this purpose was undertaken in state-funded laboratories. The very first system of assessing timber strength was based on the results of testing small clear specimens of timber for a range of sizes and species. This gave the strength properties (in this case bending and stiffness) for a small number of different sizes. However, this did not accurately reflect the sizes and actual quality of the timber being sold and used in the market place. It was known that knots, in particular, had an effect on timber strength and therefore strength properties were given based on a percentage of knots in the timber. This theoretical approach was eventually replaced by the testing of full-sized timber sections which were initially selected and assessed according to a set of visual grading rules, based on characteristic features which occur in timber including strength reducing features such as knots and knot clusters.

The first grading rules described two timber grades – General structural grade (GS) and a higher Special structural grade (SS). These grades are still used today and the rules have not changed very much since their introduction.

To determine the basic design properties, Irish Sitka spruce timber was selected from a range of forests so as to be representative of timber grown in Ireland. The timber was then processed into a range of different sizes and then visually graded into the two grades GS and SS; timber that failed to meet the lower GS requirements was deemed to be rejected and not suitable for structural use. The timber sections

were then laboratory tested to determine the actual strength properties and after statistical analysis, design values were published for Irish Sitka spruce; which enabled Irish Sitka spruce to be used structurally for the first time using the GS and SS rules referred to above. This work was funded by the Forest Service and the test information is now archived in the National University of Galway (NUIG).

The set of rules for GS and SS were then published in an Irish Standard – I.S. 127 currently entitled “Structural timber – Visual strength grading – Sawn softwoods with rectangular cross-section”. This standard has been updated over the years and it has been amended to comply with the harmonized European standard EN 14081-1 “Timber structures - Strength graded structural timber with rectangular cross-section - Part 1: General requirements”. EN 14081-1 is a harmonised standard covering both visual and machine strength grading; and while it gives some common rules for visual strength grading, it does not provide a complete set of rules and therefore national standards containing more detailed rules are still needed for visual grading. EN 14081-1 also requires that timber complying with the standard is CE marked; the Construction Products Regulation requires that before a CE mark is applied the producer must draft a Declaration of Performance (DoP) – see Information Sheet numbers 1 and 4.

The system of visual grading depends largely on the measurement of knots; however, the rules also include limits on distortion and warp (bow, spring, twist and cup) as well as limits on characteristics such as fissures (splits, checks and shakes), insect damage, decay and wane (missing edge) and rate of growth. Knot area and warp are probably the more important limits placed on timber from a structural point of view.

Warp is dependent on the moisture content of timber and really only begins once the moisture content of timber falls below the fibre saturation point, a figure of around 28-30%, and moisture begins to leave the cell walls. For this reason, timber grading takes place when the timber is dry i.e. the average moisture content is 20% with no reading exceeding 24%.

The standard used for assessing the strength reducing effects of knots in Ireland is I.S.127 and in the UK BS 4978; the standards are essentially identical although the status of BS 4978 in relation to CE marking is unclear. Visual grading is based on relating the cross-sectional area of the knots at that location with the overall cross-sectional area of the timber. This system is known as ‘Knot Area Ratio’ or ‘KAR’ grading. There are two defined knot area ratios; the margin knot area ratio (MKAR) which is measured over the outer one-quarter of the width of the piece from either edge. The other ratio of the total knot area ratio (TKAR) is measured over the whole cross-section; the permitted limits on the ratios for GS and SS grade are given in I.S. 127.

Knots which occur in the margin areas tend to have a greater strength reducing effect on the timber member.

Figure 1: Examples of warp and its measurement

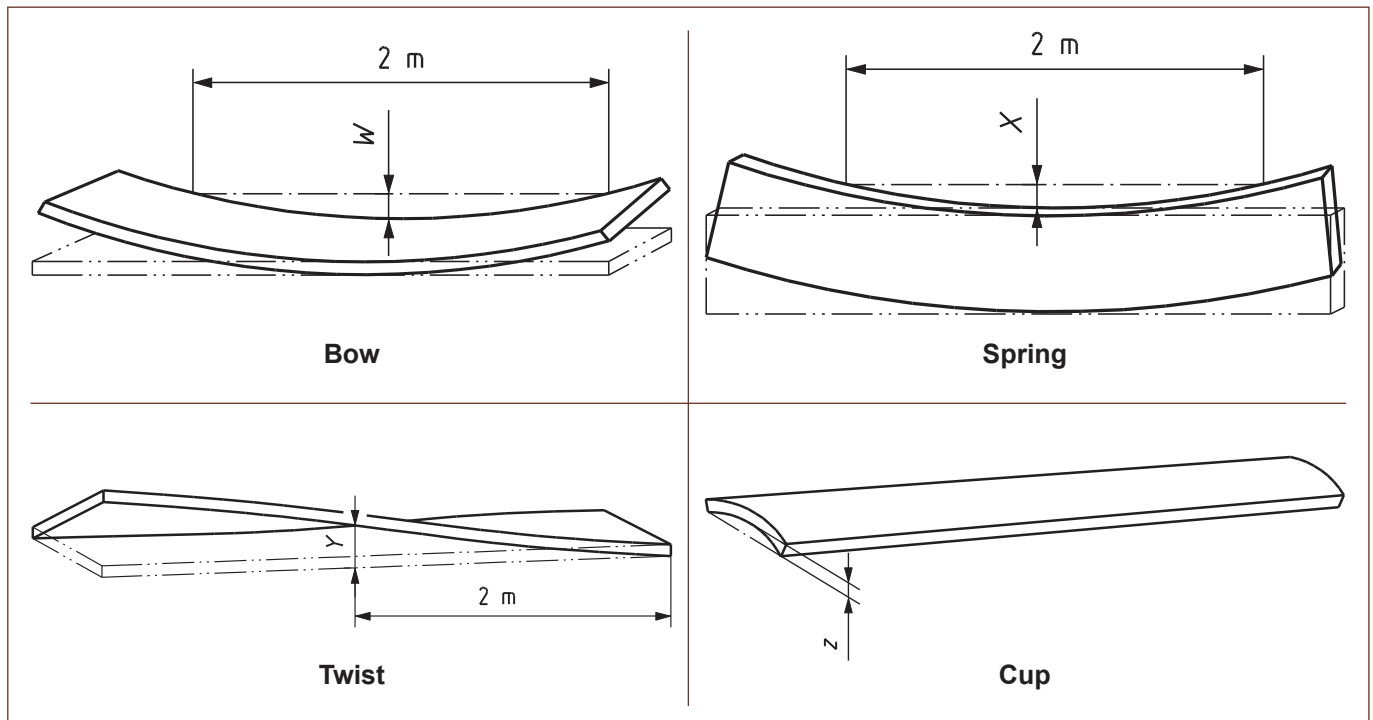
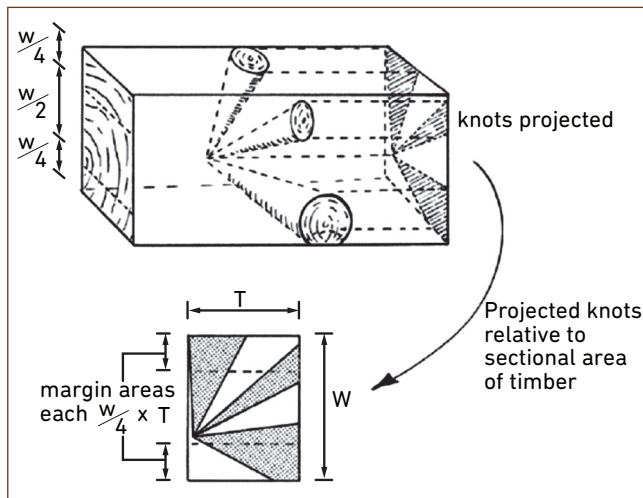


Figure 2: Knot Area Ratio (KAR) measurement



Visual strength graders should be trained and the grading operation monitored by a notified body. A notified body is a body nominated by a government to carry out certain tasks in relation to the surveillance of factory production control systems relating to European standards.

Today the means of determining timber properties have largely remained the same, although the test standards and the statistical analysis have changed to some extent. For new timber species, the process is similar to that carried out in the past except that there are European committees (mainly CEN TC 124 WG2 and TG 1 - WG stands for the working group and TG for task group) which are required to approve the test process.

When timber is tested three properties are determined; bending strength, stiffness and density. From these properties other strength properties can be calculated (e.g. tensile and compressive strengths) based on known relationships between the different properties.

Characteristic strength design properties are given in EN 338 while EN 1912 assigns visual strength grades to the strength class systems of EN 338.

Native GS and SS Sitka and Norway spruce are assigned to the European C strength class system of EN 338; C14 for GS and C18 for SS grade provided they have been graded to the rules in I.S. 127 or a similar visual grading standard complying with EN 14081-1. This enables the design properties given in EN 338 “Structural timber – strength classes” for the particular strength class to be used in structural design. Where imported European whitewood (spruce) is graded to the same GS and SS rules, the applicable strength classes are C16 and C24.

Irish Standard Recommendation S.R. 82: 2017 covers slating and tiling and it has its own visual grading rules for timber battens. These rules are outside the I.S. 127 and EN 14081-1 requirements and therefore timber battens visually graded to these rules cannot be CE marked.

Machine grading

The first machines measured the load and deflection applied to a timber section and determined the grade based on the stiffness of the timber member. The relationship between stiffness and timber grade was determined by test in a

similar manner to the visual strength grading tests. However, usually, timber is directly graded into a strength class rather than into a grade.

Machine grading is more accurate than visual grading and usually results in a higher yield i.e. there is less timber rejected by the machine grading process.

Since the first machines were designed machine grading had developed using other techniques including X-rays and ultrasonic means of assessing timber properties. The machine manufacturers have developed settings for their machines based on extensive testing and again these settings have to be approved by European committees if the timber is to claim compliance with EN 14081-1 and is to be CE marked.

Marking requirements

I.S.127 gives detailed requirements and examples of marks for visually graded timber. Each individual piece of the timber shall have the following information clearly and indelibly marked on at least one face:

- a. Identification number of notified body
- b. Name or identifying mark of the manufacturer
- c. Last two digits of the year in which the manufacturer was first certified for grading and marking d. I.S.127: The visual grading standard
- e. The European timber grading standard
- f. CE mark
- g. DG indicating the timber was graded when dry
- h. Identification code linking the timber to accompanying documents
- i. Reference number of the Declaration of Performance
- j. Strength class
- k. Grade
- l. Species code

I.S.EN 14081-1 gives detailed requirements and examples of marks for both visual and machine graded timber including requirements for CE marking and Declaration of Performance. CE marking and DoP only apply where the timber is graded to I.S.EN 14081-1.

Declaration of Performance (DoP)

Producers of graded timber are permitted under EN 14081-1 to produce their own specific timber grades. These grades would normally be for specific end uses e.g. timber frame studs or roof truss members. Again the grading process in each case would have to get approval from the relevant European committees referred to above. The timber design properties can be declared in a DoP and the timber can then be CE marked.

In general, the idea behind this is that if a timber species has a particular secondary property that is superior to the value listed in EN 338 then it might be advantageous to use the specific design property for specific end-use. For example, if a timber had high compressive strength then it could be graded to take advantage of this property and the timber might be suitable for compression members such as timber studs.

Further advice on timber grading can be sought from Wood Technology Ireland (woodtechnologyireland.ie) or Dr David Gil-Moreno (DAVID.GIL-MORENO@nuigalway.ie), Timber Engineering Research Group at NUIG (www.nuigalway.ie/terg).

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