

Wood Information Sheet

WIS 4-7

Subject: Structural uses
Revised: March 2021

Timber strength grading and strength classes

The way a tree grows varies with species, but is naturally optimised in response to its environment and growing conditions, so no two trees are identical. Consequently timber, the natural building material obtained from trees, is inherently variable not only between species but also between individual pieces from the same tree. This variability is obvious in the appearance of timber but it affects its stiffness and strength as well.

When using timber to carry structural loads the basic requirement for safety is that the material is more than strong enough for the highest expected load. Strength grading provides a prediction of the strength of individual pieces, so that those pieces that are not strong enough are rejected and the remainder are assigned to an appropriate strength class.

This Wood Information Sheet (WIS) is about strength grading of timbers used for structural purposes. It is an overview of the subject with signposts to more detailed sources which are listed at the end. It does not cover grading for appearance, which is a separate process.

BM TRADA recommends *BS EN 1995-1-1 Eurocode 5. Design of timber structures. General. Common rules and rules for buildings* [1] for structural design of timber.

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Key points

- Structural timber falls within the framework created by the UK Construction Products Regulations (UK CPR), and there is a legal obligation on manufacturers to UKCA mark the product for it to be placed on the market.
- Timber can be graded either visually or by machine. There is normally a supplementary visual assessment for defects the machine cannot detect, which will vary depending on the machine technology.
- Strength grading is a structured assessment of some characteristics of each piece of timber that are strongly correlated to its strength and stiffness.
- Once the strength grade is known, together with the species and the source, the piece can be assigned to a strength class, which leads to the characteristic values needed for structural design.
- To control quality, grading processes are certified by Approved Bodies, such as BM TRADA. On the basis of this certification, the manufacturer issues a Declaration of Performance (DoP) and the timber is UKCA marked. The manufacturer may also be a member of an independent quality scheme such as Q-Mark.
- Tables that summarise data for common species are included.
- This WIS does not address transitional arrangements for CE marking that apply in the UK during 2021, nor the special status of the Northern Ireland market. For details on these subjects please consult BM TRADA's Technical Bulletin *UKCA marking* at www.bmtrada.com/certification-services/third-party-certification-non-fire/ukca-marking-for-construction-products.

Types of grading

There are two methods of strength grading: visual strength grading (VSG) and machine strength grading (MSG). Visual strength grading applies a set of rules defining permissible limits of strength-reducing characteristics so that each piece can be rejected or assigned to a grade. The combination of the grade, the species and the source allows the allocation to a strength class.

Machine strength grading relies on established correlations between the strength of timber, which cannot be directly measured without breaking the piece, and some other property that can be measured by a non-destructive test. Stiffness is one such property, but increasingly machines combine other properties, such as the size and location of knots, and density. These direct measurements allow each piece to be allocated to a strength class by the machine.

Strength grading is not to be confused with appearance grading which is suitable for joinery and non-structural uses. WIS 4-16: *Timber in joinery* [2] includes guidance on appearance. It is unsafe to assume that a piece of timber that has a high appearance grade will also have a high strength grade.

In the UK there are specific grading rules for tiling battens in *BS 5534* and for scaffold boards in *BS 2482*. These are outside the scope of this WIS.

Regulations and Standards

A construction product

In common with other building materials, the use of timber in construction in England and Wales is governed by the Building Regulations and the guidance given in the Approved Documents (similar regulations apply in Scotland and Northern Ireland). These documents refer to the structural timber design code, *Eurocode 5 (EC5)* and its National Annex as evidence of compliance for the structural use of timber. *EC5* requires that solid timber for structural use is strength graded.

Structural timber also falls within the framework created by the EU Construction Products Regulations, which came into force 1 June 2013. A harmonised Standard is available, *BS EN 14081-1* [3], so there is a legal obligation on manufacturers to CE mark the product for it to be placed on the European single market. As the UK leaves the European Union, this obligation is maintained in the UK market by the UK Construction Products Regulations that came into force 1 January 2021. The UK CPR has created UKCA marking and the UK Government has included *BS EN 14081-1* in its list of designated Standards.

To this end, manufacturers of strength-graded timber (usually sawmills) must make an agreement with an Approved Body for the UK market or a Notified Body for the European single market. Approved Bodies have the responsibility to verify that manufacturers of structural timber have systems in place that ensure the UKCA marking is applied consistently. BM TRADA is one such Approved Body.

A designated Standard describes what must be done for a product to be UKCA marked in a way that is consistent throughout Great Britain. The same Standard is referred to as a harmonised Standard in the EU, since the approach to CE marking is harmonised across all member states, allowing it to be sold anywhere in the EU. As an undertaking that they comply with the designated Standard, manufacturers must produce and make freely available a Declaration of Performance that lists the performance characteristics of the UKCA marked product.

For structural timber, UKCA marking is similar to the assessment and certification schemes that have ensured high standards for strength-graded timber in the UK for several decades.

The British and European Standard governing the grading of structural timber is *BS EN 14081 Timber structures. Strength graded structural timber with rectangular cross section*, which has three parts as follows:

- *Part 1 – General requirements* [4]. This Standard defines the requirements for visual grading and machine grading to be acceptable in the UK or the EU. *BS EN 14081-1* is both a designated Standard and a harmonised Standard and it prescribes a route to grading that leads to UKCA marking for the GB market and CE marking for the European single market.
- *Part 2 – Machine grading; additional requirements for initial type testing* [5]. This Standard specifies requirements for initial type of testing of machine-graded structural timber to establish the relationship between strength and the indicating property measured by the machine (such as stiffness) for timber from a particular source and species.
- *Part 3 – Machine grading; additional requirements for factory production control* [6]. This Standard specifies requirements for the factory production control of machine grading of structural timber.

Part 4 of *BS EN 14081* has been withdrawn. This part contained machine settings that had been reviewed and accepted by the codes committee, but the frequency of updates required was not compatible with its work programme.

For visual strength grading, *BS EN 14081-1* sets out the requirements for a set of visual grading rules by listing the growth and processing characteristics that must be considered. However, it does not provide a complete set of grading rules itself, due to the wide variety of species and growth conditions within Europe, as well as the differing construction practices. Most European countries have developed their own rules, usually as national Standards, and these Standards have been adapted to conform to Annex A of *BS EN 14081-1*.

New versions of *BS EN 14081-1* have been published by BSI (and other Standards bodies throughout Europe) in 2016 and 2019, but have not been cited in the Official Journal of the European Union. Without this citation, the Standard may not be used for CE marking, so Notified Bodies must work to the earlier 2011 version. The UK citation of *BS EN 14081-1* as a designated Standard follows the Official Journal, so Approved Bodies in the UK must also work to the 2011 amendment. This situation has persisted in the EU for several years and is unlikely to change until the CPR itself is revised. However, where the 2019 version provides guidance that is in addition to that in the 2011 version but does not conflict with it or extend its scope, this guidance may be useful to a manufacturer and an Approved Body in certifying strength grading operations.

Visual grading rules

The visual strength grading rules most commonly used in the UK are:

- *BS 4978 Visual strength grading of softwood – Specification* [7]
- *BS 5756 Visual strength grading of temperate hardwood – Specification* [8].

Timber graded to other published visual grading rules that comply with Annex A of *BS EN 14081-1* may also be used in the UK if it is correctly UKCA marked. These rules are usually published by EU Member States, but may be provided by other countries that export to the UK, such as Canada or the USA.

The arguments for maintaining separate grading rules for different countries within Europe do not apply to tropical hardwood, since it is all imported. Therefore a common set of grading rules has been drawn up and published and the rules for tropical hardwood have been withdrawn from *BS 5756*.

- *BS EN 16737 Structural timber. Visual strength grading of tropical hardwood* [9]. A recent European Standard that provides common European grading rules for tropical hardwoods.

Strength classes

Timber of a particular species, source and strength grade may be assigned to a strength class. Strength classes are sets of characteristic values for strength, stiffness and density that are listed in *BS EN 338 Structural timber. Strength classes* [10]. Combinations of grades and species from a particular source are assigned to strength classes on the basis of characteristic values established by testing and calculation in accordance with *BS EN 384 Structural timber. Determination of characteristic values of mechanical properties and density* [11]. Test programmes for new strength class assignments are substantial projects that require testing over one hundred full size specimens.

For visually graded timber, *BS EN 1912 Structural timber. Strength classes. Assignment of visual grades and species* [12] lists combinations of visual strength grades, species and sources of timber, and specifies the strength classes from *BS EN 338* to which they are assigned. These assignments have been reviewed by the codes committee and may be adopted without further evidence.

Strength class assignments not listed in *BS EN 1912* may be accepted by Approved Bodies under certain conditions. Approved Bodies have the responsibility to determine if proposed strength class assignments for particular species and sources have been determined correctly, and may allow manufacturers to use them for UKCA marking. The assignments must be based on a published set of visual grading rules that conform to the requirements of *BS EN 14081-1*, but not necessarily a national Standard. However, these assignments should not conflict with those in *BS EN 1912*.

European oak and sweet chestnut, graded to *BS 5756*, are not included in *BS EN 1912*. However, their strength class assignments are listed in *PD 6693-1:2019 Recommendations for the design of timber structures to Eurocode 5* [13], a UK complementary document to *EC5* published by BSI.

Treatment with preservatives might conceivably affect strength. *BS EN 15228 Structural timber – Structural timber preservative treated against biological attack* [14] specifies general requirements for structural timber that has been treated with a preservative. In UK practice, compliance with *BS EN 15228* is achieved by recording details of the preservative treatment and the treatment company on the UKCA marking documentation that accompanies the timber.

WIS 1-37: *Introduction to Eurocode 5* [15] is a good starting point on design to *EC5* and WIS 1-17: *Structural use of hardwoods* [16] gives additional information on hardwood types and design.

Strength grading and structural design

The structural designer specifies the minimum strength class of a structural timber component of a certain size, but is not involved in the grading. *BS EN 338* provides characteristic strengths and stiffnesses for use in *EC5* designs, and these values are built in to many widely available design tools. Although the strength classes are inherently conservative, the designer is rarely in a position to determine design values for particular species and grades by another means.

BS EN 338 contains representative values for strength-graded timber that an engineer can use in design. The process of strength grading ensures that, overall, any strength value on which the design relies is exceeded by at least 95% of the graded pieces. This gives the designer the confidence that the assumptions of the Eurocodes for material reliability are met, since fewer than 5% of the pieces are likely to have a strength value lower than declared. The value of this 5% probability is called the 'fifth percentile' and it is the characteristic value for the strength property.

For stiffness properties, the mean is the value used most frequently, but the fifth percentile is used occasionally. For example, the mean stiffness is used to calculate the deflection of a joist where there is no risk of failure, but the lower fifth percentile is used to calculate the resistance to buckling. Both the mean and the fifth percentile are recognised as characteristic values.

To be confident that the strength of at least 95% of pieces exceed the declared characteristic value, the manufacturer that carries out the grading should know the source of the material. This implies not only that the manufacturer knows the region where the timber was grown, but also knows that the timber has not been sorted in such a way that its expected strength range has been reduced, eg by removing the best quality material.

Designers may wish to apply additional constraints within the specification, such as a particular species or appearance requirement, or tighter limitations on the degree of distortion than allowed by the grading rules. However, these are not part of the normal specification of strength-graded timber.

Strength grading in practice

Most pieces of timber contain growth characteristics, such as knots and slope of grain, which were vital to the living tree but are defects in structural timber. If these timbers were excluded from structural

use and only defect-free timbers were permitted, the volume of timber available would be too small for the market's needs, and the price too high. The market for structural timber must accommodate timber of the quality that is readily available, but there will always be some timbers that are too weak for structural use and they are prevented from being placed on the market by strength grading.

Strength grading may be considered as a kind of non-destructive test that makes a basic prediction of the structural performance of a batch or sample of timber. Grading provides a reasonable assurance that the strength of a parcel of timber will exceed the design requirements and that the very weakest timbers will be rejected. A good grading system increases the safety of using timber and also uses its available strength efficiently. Strength grading transforms a variable material into a reliable structural product.

Strength grading can be carried out by visual inspection according to strictly defined rules, or by a grading machine.

Visual strength grading rules define the extent of strength-reducing characteristics allowed in each grade by their size, location or severity. Strength-reducing characteristics include natural features such as knots, wane and slope of grain, as well as defects that arise from processing, such as splits and shakes that develop as a result of drying. The grader assesses each piece and stamps it with the appropriate mark. Visual grading operations in the UK are regularly audited by independent Approved Bodies, whereby the operator must demonstrate that grading is carried out competently.

Machine grading measures an indicating property, such as stiffness, that is closely correlated with strength. The machine grades each piece and stamps it with the appropriate mark. An additional visual assessment takes account of strength-reducing characteristics not automatically sensed by the machine. Machine grading operations are regularly audited by independent Approved Bodies.

Marking and documentation

There is a simple expectation in the UK that anyone involved in supplying or using strength-graded timber, including the end user or a Building Control officer on site, should be able to find a stamp that they can trust on any piece of graded timber, and that stamp should contain the strength class, eg C16 or C24. This expectation is unchanged, but every other aspect of the marking and documentation of strength-graded timber has become more complicated in recent years.

Complications arise due to:

- Competing requirements – which version of *BS EN 14081-1* applies and how does it correspond with the BS (or other) grading Standards?
- Divergence – different marking requirements apply in the EU single market, in Great Britain and in Northern Ireland. Currently there is no divergence in the technical requirements.
- The different information to be provided in the stamp, the accompanying documentation and the Declaration of Performance – what is the status of each of these?
- The additional information given by third party certification schemes that usually appears on the stamp.

The requirements for CE marking given in Article 9 of the CPR override any conflicting requirements found elsewhere, and have been adopted by the UK CPR for UKCA marking. They are not specific to any particular construction product, so require some interpretation in the context of strength-graded timber.

The CPR came into force in June 2013 and some of its marking provisions (and the equivalent provisions in the UK CPR) override the 2011 version of *BS EN 14081-1*, which nevertheless remains the version to be used both in the UK and the European single market. Subsequent versions of *BS EN 14081-1* (ie 2016 and the 2019 amendment) contain a UK National Annex which provides a useful summary of marking requirements that conform to the CPR and UK practice.

Since 2011, *BS EN 14081-1* has allowed either marking of each piece of visually strength-graded timber or marking of an entire package without piece marking, although the Standard notes that National Regulations may limit the method to be used. Machine graded timber must always be piece marked.

In the UK, Standards committees have decided to place strict limitations and penalties on the use of package marking due to the difficulty of identifying such timber on site. These limitations are summarised in the National Annex to *BS EN 14081-1:2016*. For the UK, each piece of strength-graded timber should be marked with a grade stamp. The grade stamp must be applied clearly and indelibly on at least one face or edge a minimum of 600mm from the end. It is permissible to stamp the end of a piece of timber, but this should be in addition to an edge or face stamp.

Timber not marked in this way is regarded as package marked, provided it has the correct accompanying documentation, and the UK

National Annex to *EC5* applies a punitive partial factor that reduces its design strength to reflect the risk that it cannot be reliably identified on site.

As an exception, at the request of a customer, package marked timber is allowed for aesthetic reasons for a single structure where the timbers are exposed on completion. In this case, the partial factor is not applied.

For piece-marked timber, following the National Annex to *BS EN 14081-1:2016*, each piece of strength-graded softwood must be stamped clearly and indelibly on one face or edge with:

- the name or identifying mark of the manufacturer
- a reference to the Declaration of Performance made available by the manufacturer. This can also serve as a link to the accompanying documents
- the strength class
- 'DG' where the timber has been dry graded. Note that other wordings or letters such as 'Dry Graded' or 'KD' (kiln dried) are permitted if their definition meets the requirements of 'dry graded' in *BS EN 14081-1*
- 'M' when the timber has been machine graded
- the UKCA or CE symbol as appropriate, whereby dual marking is allowed provided that it does not create competing claims of conformity.

Further complementary information may be provided in the stamp such as:

- the identification number of the Approved Body providing certification, eg 1224 for BM TRADA
- grade and grading rule or Standard, where visually graded
- the code or botanical name for the wood species or species combination. Commonly used codes are given in *BS EN 14081-1*
- the letters 'PT' if the timber is preservative treated. This is a requirement in some countries.

The information listed above for the stamp does not fulfil all the UKCA marking requirements of the UK Construction Product Regulations. Assuming the complete UKCA marking is not on the product, it should be provided on a label or in documentation that accompanies the product.

The items for UKCA marking, which are transferred from Article 9.2 of the EU Construction Products Regulations are not specific to any particular construction product, but in the context of strength-graded timber they require that the UKCA symbol is followed by:

- the last two digits of the year when the manufacturer first issued the DoP for the timber, ie when UKCA marking was first affixed. This only changes if the DoP is revised
- an unambiguous means of identifying the name and address of the manufacturer, which could be a logo
- a unique code for the product type (allocated by the manufacturer)
- a reference number for the DoP (allocated by the manufacturer)
- the declared characteristic performance, usually by means of the strength class
- a reference to the harmonised specification, ie *BS EN 14081-1:2005+A1:2011*
- the number of the Approved Body, eg 1224 for BM TRADA
- the intended use, ie 'strength-graded structural timber intended to be used in buildings and bridges'.

The marking clauses of *BS EN 14081-1:2011* have the following additional requirements. Further requirements were introduced in the 2016 version, but these are not yet enforceable:

- a. the number of the Attestation and Verification of Constancy of Performance (AVCP) certificate issued by the Approved Body
- b. parameters describing the timber and intended use, including:
 - generic name, eg 'graded structural timber with rectangular cross-section'
 - grade and grading Standard, if visually graded
 - letter 'M' when machine graded
 - words 'Dry Graded' where relevant. Note that other wordings or letters such as 'DG' or 'KD' (kiln dried) are permitted if their definition meets the requirements of 'Dry Graded' in *BS EN 14081-1*
 - Species code for single species or species combination, from *BS EN 13556* [17] or *BS EN 14081-1*
 - identification code relating accompanying documents to the timber or package
- c. all the essential performance characteristics, including:
 - mechanical performance of all the required strength and stiffness properties, usually declared as a strength class

- reaction to fire class, usually D-s2, d0
- fire resistance (charring rate), declared as the dimensions of the cross-section (usually part of the timber description above)
- release of dangerous substances, if relevant
- durability performance, declared where relevant as classification against fungi, insects, termites and marine borers, either by natural durability to *BS EN 350* [18] or enhanced by preservative treatment, declared in accordance with *BS EN 15228* and indicated by 'PT'.

The general requirements for the Declaration of Performance are given in Annex III of the EU CPR and have been transferred to the UK CPR with some amendments to the terminology. The DoP is a signed undertaking by the manufacturer that the product they place on the market meets the declared performance. The required performance items are the same as those for the UKCA marking documentation.

Visual grading of softwood (*BS 4978*)

Softwood that is visually graded in the UK to *BS 4978* must be marked so that specifiers, inspectors and site staff are able to identify immediately the strength class and the moisture content at grading of the timber supplied.

The Standard defines two grades for pieces that are not rejected:

GS – General Structural

SS – Special Structural.

Sizes

BS 4978 allows a minimum cross-sectional area of 2,000mm² and a minimum thickness of 20mm for strength-graded softwood. Permissible tolerances on the stated size for constructional timber are given in *BS EN 336:2013 Structural timber. Sizes, permitted deviations* [19].

Visual grading of temperate hardwood (*BS 5756*)

Temperate hardwoods are assigned to one of two groups, depending upon the size of section:

- Grades THA and THB apply to temperate hardwoods of large cross-section, that is a cross-sectional area of 20,000mm² or more and with a thickness of 100mm or more.
- Grades TH1 and TH2 apply to temperate hardwoods of cross-sectional area less than 20,000mm².

Tropical hardwoods were previously graded to a single Hardwood Structural (HS) strength grade in this Standard. However, with the publication of the new European tropical hardwood strength grading Standard, *BS EN 16737*, the HS grade has been removed from *BS 5756*. See 'Visual grading of tropical hardwood' below.

Sizes

The Standard defines a minimum cross-sectional area of 2,000mm² and a minimum thickness of 20mm for all hardwoods strength-graded to these rules. Other size restrictions are defined for the grades as above.

Visual grading of tropical hardwood (*BS EN 16737*)

Tropical hardwoods can now be assigned a strength grade of STH – Structural Tropical Hardwood. The STH grade is recognised everywhere in Europe that is grading to this Standard.

The UK foreword to the Standard notes that there are many published strength class assignments for named species and sources of tropical hardwood timber that rely on the HS grade of *BS 5756*. The minor nature of the differences between the STH grade in *BS EN 16737* and the HS grade of *BS 5756* means that these assignments can adopt the STH grading rules in their published form.

Sizes

The graded timber shall conform to *BS EN 336* with respect to its permissible deviations with the following exceptions:

- the minimum thickness at the time of grading shall be 22mm
- the minimum cross-sectional area at the time of grading shall be 2,200mm².

Machine grading (*BS EN 14081-2*)

The Standard recognises two types of strength grading: machine-controlled and output-controlled.

Most strength grading machines in the UK are machine-controlled rather than output controlled and were historically mostly operated by applying a defined load to each piece of timber as it passes through the machine. The resulting deflection indicates the grade/strength class which is then marked on the piece.

Developments in grading machines have introduced a number of new parameters to improve the predictive accuracy of the machine. These include X-ray equipment to measure timber density, vibration or ultrasonic excitation to measure dynamic stiffness, non-contact moisture content measurement and image capture and processing. The greatest accuracy is obtained when these techniques are combined. Such machines will commonly be found in high-volume, high-speed production sawmills.

Whatever the nature of the indicating property, the effectiveness of the machine type must be demonstrated by a test programme in accordance with *BS EN 14081-2* and *BS EN 384*. Each set of machine settings is determined for the make and model of machine, and the timber species, source and size range. The approved machine settings are made available to Notified and Approved Bodies for auditing purposes and need to be strictly controlled on machines in service to maintain consistency of grading.

Timber that is machine strength graded in North America is likely to have been graded in an output-controlled machine. The consistency and quality of grading is checked and refined by frequently measuring the strength of timber specimens from the daily output of the machine. There are a few output controlled machines operating in Europe.

Softwood timber strength graded by machine in the UK or in Europe to *BS EN 14081* will normally be graded directly to one of the softwood strength classes defined in *BS EN 338*. No machine settings have been determined for the machine strength grading of hardwoods.

Sizes

BS EN 14081-1 requires timber to meet the permitted deviations of *BS EN 336*, which stipulates a minimum and maximum thickness for structural timber. However, the range of sizes for which the machine is approved is likely to be more restrictive than the Standard. (see WIS 2/3-37: *Softwood sizes* [20]).

Strength classes

A strength class is a set of characteristic values for strength, stiffness and density for the design of timber structures. The testing standards, minimum numbers of tests and methods of calculation for establishing characteristic values are given in *BS EN 384*. The tests are for graded timber from a particular source.

26 bending strength classes are defined in the latest 2016 version of *BS EN 338* – 12 for softwoods, prefixed C (Coniferous), and 14 for hardwoods, prefixed D (Deciduous), some of which are new to this edition. *BS EN 338* also gives 18 new softwood strength classes prefixed T (Tension), intended for timber used in engineered wood products where tension is the dominant stress, such as glued laminated timber and I-Joist flanges.

Timber can be allocated to a strength class if characteristic values determined by test in accordance with *BS EN 384* are available for strength, stiffness and density. For the C and D classes, bending test results are required; for the T classes, tension test results. Since the strength, stiffness and density results must each be higher than the corresponding value for the strength class, the strength class assignment is inherently conservative. The remaining properties listed in the strength class are usually calculated in accordance with *BS EN 384* and assumed to apply to the timber without the need for test results. The assumptions in these calculations are valid for solid timber only and cannot be applied to other materials such as wood or fibre based composites.

The strength class designation also gives the relevant characteristic bending or tension strength, ie C16 is for softwood with a characteristic bending strength of 16 N/mm². In the UK, the most common *BS EN 338* strength classes are C16 and C24, but this is not the case elsewhere in Europe. Strength classes may be defined that are not listed in *BS EN 338*, for instance a particular machine grade called TR26 is in widespread use within the UK trussed rafter industry. Characteristic values for this strength class are published by the Trussed Rafter Association.

BS EN 1912 lists strength class assignments for combinations of species, source and visual strength grades. It covers temperate and tropical species that are graded to the national rules of a number of countries, including the UK. The list includes recognised groupings of similar species, such as spruce-pine-fir from Canada. Other strength class assignments may be accepted by an Approved Body as described below, but they should not conflict with *BS EN 1912*.

Tropical hardwood strength class assignments that relied on the HS grade of *BS 5756* have been transferred to the STH grade of *BS EN 16737*.

For sawmills and their clients who find the strength classes published in *BS EN 338* too restrictive or wish to create strength class assignments beyond those in *BS EN 1912*, characteristic values can be obtained in accordance with *BS EN 384*. When these are accepted

by an Approved Body they also become acceptable for design. Such bespoke classes and assignments usually rely on an existing set of published rules to assign the timber to a grade.

Machine graded timber is usually graded directly to the appropriate *BS EN 338* strength class limits so the individual grade information is not available. Alternative sets of machine settings may be determined, but this involves considerable effort and preferably the cooperation of the machine manufacturer.

Strength classes for glued laminated timber, such as GL24, are described in WIS 1-6: *Glued laminated timber* [21].

Moisture content

The control of moisture content is vital in designing and specifying timber for structural use. It has a direct effect on strength, on dimensions and on durability.

Grading machine settings are approved for timber of a specific range of moisture contents and manufacturers should have procedures to ensure that they comply.

For visual grading, *BS EN 14081-1* and the grading rules that conform to it recognise two levels of moisture content at the time of grading, so timber may be dry-graded or wet-graded. A change in moisture content can alter the size and length of fissures, the amount of distortion and the cross-section dimensions. Other grading characteristics are unaffected, so they may be assessed on wet or dry timber, irrespective of the marking.

Dry-graded timber is assessed when the batch of timber has an average moisture content of 20% or less, with no reading exceeding 24%. Dry-graded timber should be used for Service Classes 1 and 2.

Timber sections over 100mm in thickness are difficult to dry and may be graded and installed wet. In this case, wet stresses must be used in structural calculations and extra care must be taken in the detail design to take account of shrinkage if the timber dries out. Wet-graded timber is graded at a moisture content above 20%. It should be specified for use in Service Class 3 and for timber in contact with water.

BS EN 14081 does not require wet-graded timber to be marked as such. Therefore, if no moisture condition is marked on the timber, the user should assume that the timber was wet-graded. The preferred marking for dry graded timber is 'DG', but equivalent words and markings, including 'DRY GRADED' or 'KD' are permissible.

Maintaining quality

All structural timber used in the UK should be strength graded and marked in accordance with Annex ZA of *BS EN 14081-1*, under the continuing surveillance of an Approved Body. The Approved Body identification code forms part of the grade stamp that appears on strength-graded timber.

An Approved Body is an organisation designated by the Secretary of State as technically competent to undertake independent third party assessments for product conformity in the UK. In the European single market the equivalent Notified Body is notified to the European Commission by accredited sources within the Member States.

Approved Bodies oversee the certification of visual grading activities and the operation of grading machines through regular surveillance visits. The aim of a visit is to verify that the manufacturer continues to operate in accordance with its factory product control system.

BM TRADA is an Approved Body for visual and machine grading of timber. Certified visual and machine grading operations are based in the UK, as well as in supplying countries.

BM TRADA also operates an enhanced certification scheme under its Q-Mark brand that maintains the registration of individual graders. Timber graded under this scheme will be stamped with the Q-Mark illustrated in *Figure 1*.

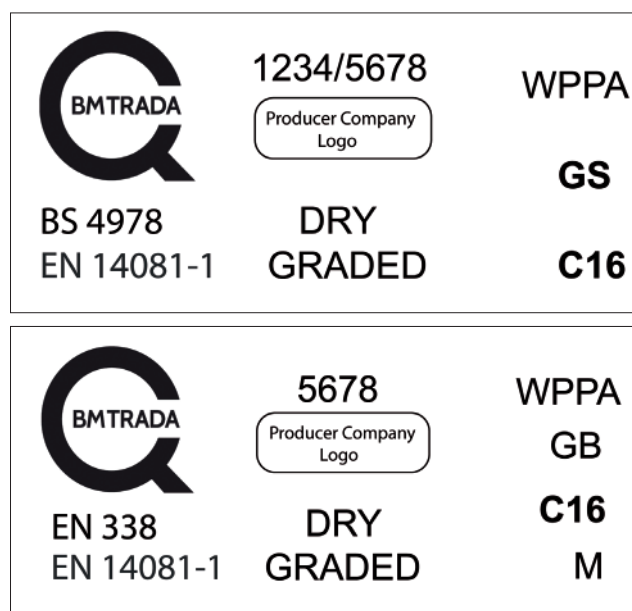


Figure 1: Examples of BM TRADA certification mark: visually graded (top) and machine-graded (bottom)

UKCA marked strength-graded timber

For graded timber to be UKCA marked it has to comply with *BS EN 14081-1*, in particular Annex ZA, making allowance for the terminology of the UK legislation. To demonstrate compliance, tasks are designated by the UK CPR to both the manufacturer and the Approved Body according to the System to which the product is assigned. Strength-graded structural timber is assigned to System 2+, which means that, after the initial assessment, the manufacturer must maintain a factory production control (FPC) system. The effectiveness of the FPC system is monitored by an Approved Body by means of regular surveillance audits, at least annually.

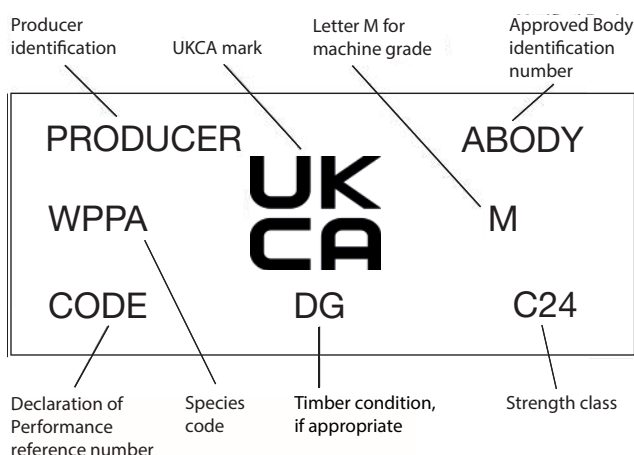


Figure 2: Example of UKCA grade stamp with typical information for untreated machine-graded timber

Marking

The following information usually appears on the grade stamp, as described above:

- Manufacturer name / logo
- Declaration of Performance reference number
- Strength class
- 'DG' or alternative marking for Dry Graded timber
- 'M' for Machine Graded timber.
- 'UKCA' symbol
- Number or logo of the Approved Body
- Visual grade and appropriate visual grading Standard, for visually graded timber
- Wood species or species combination code.

Availability of strength-graded material

There are many possible combinations of sizes, strength grades and species available in the UK. The availability of any particular species, grade and size may vary around the country. When only a strength class is specified in a contract, suppliers may provide any species/grade combination that meets the requirements of that strength class.

Tables 1–3 show the softwoods included in *BS EN 1912* which are likely to be available strength-graded to the Standards indicated. This Standard contains tables which assign species and grades into strength classes, including timbers graded to national Standards of other European countries and to North American grading rules which are accepted under *BS EN 14081*.

Table 1: Softwoods graded to *BS 4978*

Species or species group	Source	Species code (from <i>BS EN 13556</i> / <i>BS EN 14081-1</i>)
British pine (Corsican/Scots pine)	UK	WPNN
British spruce (Norway/Sitka spruce)	UK	WPCS
Caribbean pitch pine	Caribbean	WPNC
Douglas fir	UK	PSMN
Douglas fir-larch	Canada, USA	WPSM
Hem-fir	Canada, USA	WABA
Larch	UK	WLAD
Parana pine	Brazil	ARAN
Redwood	CNE Europe	PNSY
Southern pine	USA	WPNE
Sitka spruce	Canada	C/PCST
Spruce-pine-fir	Canada, USA	WPCE
Western red cedar	Canada, USA	THPL
Western white woods	USA	WABB
Whitewood	CNE Europe	WPCA
Redwood/Whitewood combined	CNE Europe	WPPA
CNE Europe = Central, Northern and Eastern Europe		

Table 2: Examples of softwood machine graded to *BS EN 14081*

Species or species group	Source	Species code (from <i>BS EN 13556</i> / <i>BS EN 14081-1</i>)
British pine (Corsican/Scots pine)	UK	WPNN
British spruce (Norway/Sitka spruce)	UK	WPCS
Hem-fir	Canada	WABA
Radiata pine	Chile and New Zealand	PNRD
Redwood	CNE Europe	PNSY
Spruce-pine-fir	Canada	WPCE
Whitewood	CNE Europe	WPCA
CNE Europe = Central, Northern and Eastern Europe		

Table 3: Hardwoods graded to *BS 5756* and *BS EN 16737*

Species	Source	Species code (from <i>BS EN 13556</i> / <i>BS EN 14081-1</i>)
Balau	S E Asia	SHBL
Ekki	W Africa	LOAL
Greenheart	S America	OCRD
Iroko	Africa	MIXX
Jarrah	Australia	EUMR
Kapur	S E Asia	DRXX
Karri	Australia	EUDV
Kempas	S E Asia	KOML
Keruing	S E Asia	DPXX
Merbau	UK	INXX
Oak	UK	QCXE
Opepe	Africa	NADD
Sweet chestnut	Europe	CTST
Teak	S E Asia, Africa	TEGR

Tables 4 and 5 show examples of softwoods which can meet the requirements of strength classes C16 and C24.

Table 4: Examples of assignment of grades of softwood species to strength class C16 (from *BS EN 1912*)

Grade	Grading rule publishing country	Species commercial name	Source
S7	Germany	Douglas fir (60mm thickness and above)	Germany
	Germany and Austria	Spruce, pine, fir, larch	CNE Europe
GS	UK	Parana pine	Brazil
GS	UK	Redwood, whitewood	CNE Europe
GS	UK	Douglas fir, larch, hem-fir, S-P-F	USA and Canada
J&P No 1	USA and Canada	Douglas fir, larch, hem-fir, S-P-F	USA and Canada
J&P No 2	USA and Canada	Douglas fir, larch, hem-fir, S-P-F	USA and Canada
CNE Europe = Central, Northern and Eastern Europe J&P = Joist and Plank S-P-F = Spruce-Pine-Fir			

Table 5: Examples of assignment of grades of softwood species to strength class C24 (from *BS EN 1912*)

Grade	Grading rule publishing country	Species commercial name	Source
ST-11	France	Spruce & fir, Douglas fir, pine, larch	France
S10K	Germany	Douglas fir (60mm thickness and above)	Germany
S10K	Germany and Austria	Spruce, pine, fir, larch	CNE Europe
T2	Nordic Countries	Pine (redwood), spruce (whitewood), fir, larch, Sitka spruce	NNE Europe
ME1	Spain	Radiata pine, maritime pine	Spain
J&P Sel	USA and Canada	Douglas fir, larch, Hem-fir, S-P-F	USA and Canada
SS	UK	Parana pine	Brazil
		Redwood, whitewood	CNE Europe
		Douglas fir, larch, hem-fir, S-P-F	USA and Canada
		Southern pine	USA
		Caribbean pitch	Caribbean
		Larch	UK
CNE Europe = Central, Northern and Eastern Europe NNE Europe = Northern and Central Europe J&P = Joist and Plank S-P-F = Spruce-Pine-Fir			

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