BS EN 14081-2:2010+A1:2012

BSI Standards Publication

Timber structures — Strength graded structural timber with rectangular cross section

Part 2: Machine grading; additional requirements for initial type testing

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National foreword

This British Standard is the UK implementation of EN 14081-2:2010+A1:2012. It supersedes BS EN 14081-2:2010, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by [A1) (A1].

The UK participation in its preparation was entrusted to Technical Committee B/518, Structural timber.

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Timber structures - Strength graded structural timber with rectangular cross section - Part 2: Machine grading; additional requirements for initial type testing

Structures en bois - Bois de structure de section rectangulaire classé selon la résistance - Partie 2: Classement mécanique - Exigences supplémentaires concernant les essais de type initiaux

Holzbauwerke - Nach Festigkeit sortiertes Bauholz für tragende Zwecke mit rechteckigem Querschnitt - Teil 2: Maschinelle Sortierung; zusätzliche Anforderungen an die Erstprüfung

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Foreword

This document (EN 14081-2:2010+A1:2012) has been prepared by Technical Committee CEN/TC 124 "Timber structures", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2013, and conflicting national standards shall be withdrawn at the latest by May 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes [A1) EN 14081-2:2010. (A1]

This document includes Amendment 1 approved by CEN on 8 October 2012.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1) (A1].

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

Other parts of the EN 14081 series are:

— EN 14081-1, *Timber structures — Strength graded structural timber with rectangular cross section — Part 1: General requirements*;

— EN 14081-3, *Timber structures — Strength graded structural timber with rectangular cross section — Part 3: Machine grading; additional requirements for factory production control*

— EN 14081-4, *Timber structures — Strength graded structural timber with rectangular cross section — Part 4: Machine grading — Grading machine settings for machine controlled systems*

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Machine grading is in common use in a number of countries. The countries use two basic systems, referred to as "output controlled" and "machine controlled". Both systems require a visual override inspection to cater for strength-reducing characteristics that are not automatically sensed by the machine.

The output-controlled system is suitable for use where the grading machines are situated in sawmills grading limited sizes, species and grades in repeated production runs of around one working shift or more. This enables the system to be controlled by testing timber specimens from the daily output. These tests together with statistical procedures are used to monitor and adjust the machine settings to maintain the required strength properties for each strength class. With this system it is permissible for machine approval requirements to be less demanding and for machines of the same type to have non-identical performance.

The machine controlled system was developed in Europe. Because of the large number of sizes, species and grades used it was not possible to carry out quality control tests on timber specimens drawn from production. The system relies therefore on the machines being strictly assessed and controlled, and on considerable research effort to derive the machines settings, which remain constant for all machines of the same type.

The acceptability of grading machines and the derivation of settings rely on statistical procedures and the results will therefore depend on the method used. For this reason this document gives appropriate statistical procedures.

The requirements in this European Standard are based on machines in current use and on future types of machines as far as these can be foreseen. It is recognised that additional clauses or standards may be required if unforeseen developments take place.

1 Scope

This European Standard specifies requirements, additional to those in EN 14081-1, for initial type testing of machine graded structural timber with rectangular cross sections shaped by sawing, planing or other methods, and having deviations from the target sizes corresponding to EN 336. This includes requirements for strength grading machines and test equipment for proof loading graded material.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 338, *Structural timber — Strength classes*

EN 384, *Structural timber — Determination of characteristic values of mechanical properties and density*

EN 408:2003, *Timber structures — Structural timber and glued laminated timber — Determination of some physical and mechanical properties*

[A1〉 EN 14081-1, *Timber structures — Strength graded structural timber with rectangular cross section — Part 1: General requirements* 〈A1]

EN 14081-3, *Timber structures — Strength graded structural timber with rectangular cross section — Part 3: Machine grading; additional requirements for factory production control*

EN 14081-4, *Timber structures — Strength graded structural timber with rectangular cross section — Part 4: Machine grading — Grading machine settings for machine controlled systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given [A1〉 in EN 14081-1 and the following apply. 〈A1]

3.1
characteristic strength
population 5-percentile value obtained from the results of tests with a duration of (300 ± 120) s using test pieces at an equilibrium moisture content resulting from a temperature of 20 °C and a relative humidity of 65 %

3.2
characteristic stiffness
population mean value obtained under the same test conditions as defined in 3.1

3.3
critical feed speed
speed within the intended usable range at which the grading machine is least accurate in measuring its indicating property

3.4
depth
dimension perpendicular to the longitudinal axis of a timber beam, in the plane of the bending forces

3.5
grade determining property
mechanical or physical property for which a particular value of that property should be achieved for the material to be assigned to that grade, e.g. bending strength, mean modulus of elasticity and density for the strength classes of EN 338

3.6
indicating property
IP
measurement or combination of measurements made by the grading machine, which are closely related to one or more of the grade determining properties

NOTE For grading machines which compute and predict values of the grade determining properties directly from numerous measuring devices, the indicating property may be a predicted value of a grade determining property.

3.7
optimum grade
highest grade, of those for which settings are required, to which a piece of timber can be assigned, such that the grade determining properties of the graded sample will meet the values required for the grade

3.8
settings
values of the parameters used to set the machine to grade timber, which are mathematically related to the indicating property

3.9
sub-sample
number of specimens of timber of one species or species combination, from one growth area or source of production

3.10
thickness
lesser dimension perpendicular to the longitudinal axis of a piece of timber

4 Symbols

b width of cross section (in millimetres)

E theoretical modulus of elasticity (in newtons per square millimetre)

E_{p} actual modulus of elasticity measured in a proof load test (in newtons per square millimetre)

E_{assigned} mean modulus of elasticity for assigned grade (in newtons per square millimetre)

E_{optimum} mean modulus of elasticity for optimum grade (in newtons per square millimetre)

$E_{0,\text{mean}}$ characteristic mean modulus of elasticity parallel to grain (in newtons per square millimetre)

F applied force (in newtons)

F_{p} proof load (in newtons)

$f_{\text{m,k}}$ characteristic bending strength (in newtons per square millimetre)

f_{p} proof stress (in newtons per square millimetre)

h depth of cross section (in millimetres)

k_h size factor

ℓ span (in millimetres)

t thickness (in millimetres)

w deflection or deformation (in millimetres)

β_{ach} achieved safety index

β_{tar} target safety index

δ deflection (in millimetres)

μ mean value of bending strength for the optimum or assigned strength classes (in newtons per square millimetre)

5 Requirements for strength grading machines

5.1 The machine shall be of a type that meets the requirements given in Clauses 5 and 6 if it is part of a machine-controlled system, or Clauses 5 and 7 if it is part of an output controlled system. It shall be installed and set up according to the manufacturer's specification and to any additional requirements resulting from the tests given here. In addition, except when a grading machine operates by measuring the bending stiffness of timber, the installation and calibration shall be checked by the use of control planks, using the procedures given in EN 14081-3 under requirements for the use of control planks.

5.2 The following information shall be provided in the manufacturer's specification for the machine:

a) specification and description of the mechanical and electrical operation of the machine, and the software (this includes information on data processing such as smoothing of the output signals) used by the machine to grade timber;

b) range of environmental conditions under which the machine will operate;

c) installation, maintenance and operating instructions;

d) method, extent and frequency of calibration procedures, including the use of control planks if applicable;

e) species populations, sizes, tolerances, surface finish, moisture content, grades, environmental operating temperature range, throughput speed, and limits of warp of the timber to be graded;

f) manufacturing tolerances of the machine;

g) checking and adjustment procedures for all components that may affect the machine’s grading accuracy.

5.3 Manufacturing tolerances and transducer accuracy tolerances shall ensure that production machines meet the requirements of this European Standard, and are compatible with grade settings derived for the machine type.

5.4 The grading machine shall not damage the timber during the grading operation to an extent that it affects the intended use of the timber.

NOTE For example, in bending type machines, damage should not be caused by large compression perpendicular to grain stresses and/or large bending stresses.

5.5 Grading machines whose indicating property does not take account of the material properties along the whole length of each piece of timber, but whose indicating property measurements are influenced by strength reducing characteristics away from the measuring position (as in bending type machines), shall measure the indicating property to within 800 mm of each end of the piece of timber. Where the indicating property is influenced only by strength reducing characteristics at the measuring position (as in radiation type machines), the measurements shall be made to within 150 mm of each end.

5.6 The grading machine shall be capable of comparing each indicating property measurement with pre-set boundary settings, which correspond to individual grades, and of marking each piece of timber according to the lowest grade sensed within the length of that piece.

5.7 The infeed and outfeed equipment shall provide the correct height and angle of entry/exit for the timber to/from the grading machine and shall not interfere significantly with the sensing of the indicating property, even when the timber is distorted within the limits given in item 5.2, e). If the infeed and outfeed equipment is not part of the grading machine then this requirement shall appear in the manual for the machine.

5.8 The grading machine shall be fitted with the means to enable the accuracy of each measuring device to be checked individually, to ensure correct operation of the machine.

6 Additional requirements for initial type testing for machine controlled systems

6.1 General

For machine controlled systems the acceptance of machine graded timber to meet the requirements of this European Standard predominantly depends on the grading machine and the settings used.

6.2 Requirements for the derivation and verification of machine settings

6.2.1 When a new species is required to be graded by a machine that has already been shown to meet the requirements of this European Standard, those requirements that are not likely to be affected by species differences may be disregarded for the new species.

NOTE Annex B gives background information and guidance on the procedure required here to derive grading machine settings.

6.2.2 The requirements for selecting the total test sample are given below. Note that the numbers of sub-samples and specimens given are minimums and the reason for the number actually used shall be given in the report (see 6.2.6). The overriding requirement which determines the number of sub-samples and the number of specimens to be tested is that the test sample shall be representative of the timber source from which the production timber is taken.

To derive settings for a new machine type and/or a new species (or species combination) or growth area, the total test sample shall be selected as a minimum number of four sub-samples (see 3.9), to represent the range of timber for which the settings are applicable (see EN 14081-1 under the requirements for machine grading). The minimum number of pieces in a sub-sample shall be 100. The minimum number of pieces in the total test sample shall be 900 for the derivation of settings for the full range of grades and sizes of a grading machine. To derive settings for new species for a machine that has previously met the requirements of this European Standard with different species, a minimum of 450 pieces shall be required.

To test whether existing settings in EN 14081-4 are acceptable for use with a new growth area of the same species, the new growth area shall supply a minimum of two sub-samples (see first paragraph of this clause) each containing a minimum of 100 pieces. Each piece shall be graded by the machine using the existing settings and then tested to determine the grade determining properties as given in EN 384 using the k_v (bending strength only) factor on strength and the 0,95 factor on $E_{0,\text{mean}}$, but in addition, the use of k_s also for $E_{0,\text{mean}}$. The grade determining properties shall equal or exceed those required for the grade.

The number of pieces in the total sample shall ensure that there are a minimum number of 20 pieces in each assigned grade for which settings are required.

If more than two grades are to be graded in one pass then it may be necessary to increase the number of pieces up to 40 pieces per grade.

The timber shall represent the timber source (see EN 14081-1 under the requirements for machine grading), range of sizes, and quality to be graded in production (with the exception of 6.2.3, c) below), with the most demanding surface finish, and grading shall be carried out at the critical feed speed. The range of permitted sizes for which settings shall be used in production shall not be extrapolated more than 10 % from the maximum and minimum sizes tested.

It is acceptable for machines not to measure density, but if density is a grade determining property it shall be checked in accordance with 6.2.4. If density is not a grade determining property the characteristic value for the assigned grade (see 6.2.4.6) shall be determined in accordance with EN 384 and given in the report (see 6.2.6).

NOTE The grade determining properties for meeting the requirements of EN 338 are bending strength, MOE and density. For other grades the grade determining properties may be different.

If a grading machine does not detect certain strength reducing characteristics in timber, and those characteristics are not detected by visual override inspection or other procedures, care shall be taken to ensure that those characteristics are present in the test sample in the same proportions as will exist in production. Mention of such characteristics shall also be made in the report on the approval tests to ensure that they are taken into account when settings are required for other species.

6.2.3 In addition to the requirements given in 6.2.2 the number of pieces shall be influenced by the following:

NOTE 1 Justification for the number of sub-samples tested should be made in the report (see 6.2.6).

a) number of grades and sizes to be graded. At least three sizes shall be tested;

b) level of the grades;

NOTE 2 Grades with very high critical properties, e.g. above strength class C30, should require more test data because errors in the model are more significant.

c) strength and/or stiffness requirement for the strength class to be graded compared to the grade determining property range within the sample. Where the characteristic properties of almost all the timber sample meet the requirements for the grade being tested, the grades assigned by the grading machine have little chance of being in error. Where possible, a greater quantity of weaker material of the same species shall be included in the sample to ensure that the grading machine is making valid decisions when assigning timber to grades (see 6.2.4);

d) number of sensing devices used by the machine and the complexity of the model;

NOTE 3 A simple regression model based on one independent variable is likely to require less data than a complex neural network model involving a number of sensing devices.

e) similarity of the species being considered to other species already graded by that type of grading machine.

6.2.4

6.2.4.1 For each species, the effect of the variables given in 6.2.2 (where relevant) on the indicating property shall be established (interpolation is permitted), and used to develop the mathematical model relating the machine's indicating property to the grade determining properties. For this purpose sub-samples may be taken from the sample required for 6.2.2. The effect of variables which are not dependent on the particular population of timber may, after establishing the effect on one species, be used for other species. The model may include variables such as size and moisture content, or the model may be determined from the data after adjusting the properties for such variables.

Settings shall be derived to grade one or more grades in one pass.

6.2.4.2 The parameters of the model and resulting settings shall be verified for all species and grade combinations, using the procedure below. Having verified the settings for particular sizes, species (or species combinations) and grade combinations, settings for other sizes shall be derived directly from the model, where the model contains such adjustments.

6.2.4.3 All sub-samples of timber referred to in 6.2.2 shall be passed through the machine to record the indicating property values for each piece and then tested to obtain values of the grade determining properties in accordance with EN 384 and EN 408.

6.2.4.4 The grade determining property values shall be adjusted to the same timber size (see factors k_{h} and k_{l} in EN 384) and moisture content and rounded to three significant figures.

NOTE If the grade is for glulam laminations the factors given in EN 14080 should be used instead of those above.

6.2.4.5 All the pieces shall be sorted on the basis of the grade determining properties into the highest possible grades that are graded together and for which settings are required, such that they meet the required values for the grade. If there are less than twenty pieces in a grade then the pieces shall be downgraded to achieve twenty or zero pieces in that grade. The grade so determined for each piece is its optimum grade. The required characteristic values shall be taken from EN 338 and applying factor k_{v} from EN 384 and the 95 % factor on $E_{0,\text{mean}}$ from EN 338 where applicable.

NOTE 1 If the grade is for glulam laminations the factors given in EN 14080 should be used instead of those above.

NOTE 2 The procedure with the following steps has been shown to give accurate values when determining the optimum grade:

1) Rank the data set for a grade determining property, then determine and identify the maximum number of pieces that meet the required value for that property for the highest grade.

2) Repeat 1) for all other grade determining properties.

3) Label the grade determining properties named as e,g. (a), (b) and (c) with (a) having the largest number of pieces identified in 1) and 2) above, and (c) the least.

4) Using only the pieces identified for property (a), rank them primarily for property (b) with secondary rankings for properties (c) and (a), and determine the maximum number of pieces that meet the required value for property (b). Using only these pieces rank them primarily for property (c) with secondary rankings for properties (b) and (a). Determine and identify the maximum number of pieces that meet the required value for property (c). Check that these pieces meet the other required properties and if so identify them as that grade. Otherwise adjust as appropriate.

5) Remove the pieces assigned to that grade and repeat 1) to 5) for all grades beginning with the next highest grade.

6.2.4.6 Using the model derived in 6.2.4 from the total sample, settings shall be determined for each grade to be graded together such that the required grade determining properties are achieved for the total sample less one sub-sample in turn.

NOTE For example, if there are four sub-samples then a setting is determined from a sample comprising sub-samples 2, 3 and 4, then from a sample comprising sub-samples 1, 3 and 4, then from a sample comprising sub-samples 1, 2 and 4, and then finally from a sample comprising sub-samples 1, 2 and 3.

The production setting shall be calculated as the mean value of all the above settings for each grade. If this is more than 15 % different from the most conservative setting, then the production setting shall be that setting adjusted by 15 % towards the mean value.

The production settings shall then be used to grade each piece according to its indicating property value. If there are less than twenty pieces in a grade then the setting shall be adjusted to achieve at least twenty pieces in that grade. These grades are known as assigned grades.

It is acceptable when determining the assigned grades to change the setting value of the higher grade to increase the number of pieces in the lower grade.

6.2.4.7 A size matrix giving the numbers of pieces in each of the optimum and assigned grades shall be determined for the total sample.

NOTE Table 1 is an example of where a machine is required to grade C35, C27 and C22 in one pass.

Table 1 — Example: Size matrix

Optimum grade	**Assigned grade**			
	C35	C27	C22	Reject
C35	207	32	16	2
C27	10	168	12	1
C22	4	13	84	2
Reject	0	2	2	24

6.2.4.8 A global cost matrix shall be determined with the value in each cell equal to the number of pieces in each cell in the size matrix multiplied by the value in the equivalent cell of Table 2 divided by the total number of pieces in the assigned grade.

Where settings are required for grades that are not part of the strength class system in EN 338, elementary cost matrix values shall be calculated from the equations given in Annex A.

Elementary cost matrix values for reject shall be calculated from the equations given in Annex A using characteristic values that are 75 % of the required values for the lowest grade from which the pieces are rejected.

Table 2 — Elementary cost matrix

Optimum grade	**Assigned grade**											
	C50	C45	C40	C35	C30	C27	C24	C22	C20	C18	C16	C14
C50	0,0	0,22	0,45	0,72	1,01	1,16	1,33	1,69	1,90	2,11	2,60	3,17
C45	0,37	0,0	0,23	0,49	0,77	0,92	1,09	1,45	1,64	1,85	2,33	2,89
C40	0,83	0,42	0,0	0,25	0,53	0,68	0,84	1,19	1,38	1,59	2,05	2,60
C35	1,43	0,95	0,48	0,0	0,27	0,42	0,57	0,91	1,10	1,30	1,76	2,29
C30	2,22	1,67	1,11	0,56	0,0	0,14	0,29	0,63	0,81	1,01	1,45	1,97
C27	2,84	2,22	1,60	0,99	0,37	0,0	0,15	0,48	0,66	0,85	1,29	1,80
C24	3,61	2,92	2,22	1,53	0,83	0,42	0,0	0,32	0,50	0,69	1,12	1,63
C22	4,24	3,48	2,73	1,97	1,21	0,76	0,30	0,0	0,17	0,36	0,77	1,26
C20	5,00	4,17	3,33	2,50	1,67	1,17	0,67	0,33	0,0	0,18	0,59	1,07
C18	5,93	5,00	4,07	3,15	2,22	1,67	1,11	0,74	0,37	0,0	0,40	0,87
C16	7,08	6,04	5,00	3,96	2,92	2,29	1,67	1,25	0,83	0,42	0,0	0,46
C14	8,57	7,38	6,19	5,00	3,81	3,10	2,38	1,90	1,43	0,95	0,48	0,0

NOTE As an example, the global cost matrix for the example size matrix given in 6.2.4.7 is shown in Table 3.

Table 3 — Example: Global cost matrix

Optimum grade	**Assigned grade**			
	C35	C27	C22	Reject
C35	0,0	0,06	0,13	0,14
C27	**0,04**	0,0	0,05	0,05
C22	**0,04**	**0,05**	0,0	0,07
Reject	**0,0**	**0,02**	**0,02**	0,0

6.2.4.9 None of the cells in the global cost matrix, which indicate pieces wrongly upgraded (shown in **bold** type), shall be greater than 0,2.

NOTE 1 It can be seen that the example shown above passes.

NOTE 2 The values in the wrongly downgraded cells should still be calculated as they represent a further indication of the accuracy of the machine, which is of interest to prospective purchasers.

6.2.4.10 Characteristic values of the grade determining properties for the assigned grades, derived according to EN 384 (including the factor k_v but excluding k_s), shall equal or exceed the values required for the grade.

6.2.4.11 If the requirements of 6.2.4.9 and 6.2.4.10 are met then a check shall be carried out on the setting for the lowest grade to be graded providing that there shall be a minimum of five pieces and not less than 0,5 % of the total sample in the number of assigned rejects.

6.2.5 Repeatability of the machine shall be checked by randomly selecting at least 100 pieces of timber of one size. These pieces shall be passed through the machine five times at its critical feed speed, to obtain a grade determining indicating property value for each pass. This range of indicating property values shall then be divided into a number of fictitious grades equal to the number of grades to be graded in one pass in production plus one (to allow for the rejects) such that there are approximately the same number of pieces in each grade. These grades are called the assigned grades.

The most frequent grade assigned by the machine for each piece over the five passes shall be designated its optimum grade, to determine a size matrix (as in 6.2.4). The values for the elementary cost matrix shall equal the number of grades the assigned grade is away from the optimum grade.

EXAMPLE The value 0 if the assigned grade equals the optimum, 1 if the assigned grade is one away from the optimum, etc.

No cell value in the global cost matrix shall exceed 0,1 when calculated as the elementary cost value times the number in the equivalent cell of the size matrix divided by the sum of the pieces in all cells for the assigned grade.

Where varying numbers of grades are to be graded in production, the above procedure shall be repeated for all such numbers of grades.

6.2.6 The following is a list of information that shall be included in a report on the derivation of grading machine settings for inclusion in EN 14081-4.

NOTE It is assumed that the author of the report is familiar with all aspects of the sampling, grading, testing and data analysis.

a) General:

   1) Confirmation that the requirements in Clause 5 are met.

   2) Details of the grading machine, the timber species and growth area and the grades to be graded.

   3) A note of any strength reducing characteristics that are not detected by the grading machine nor by the visual override inspection, and their frequency in the test sample (see 6.2.2).

   4) The method of sampling (see 6.2.2) and the reason for the number of sub-samples tested.

   5) Details of the testing which shall be carried out to EN 408 as required by EN 384. For MOE the clause number in EN 408 shall be given in the report.

   6) Range of timber sizes to be graded in production. These shall not exceed the minimum and the maximum dimensions tested by more than 10 %.

   7) If the settings are for a new machine then a diagram and description of its method of operation shall be included.

   8) Table showing the different cross sections, number of specimens, growth area and the moisture content for each sub-sample.

   9) Table with means and coefficients of variation of the grade determining properties for all sub-samples and the total sample.

   10) The critical feed speed used during grading of the total sample (see 6.2.2).

11) The equation for the mathematical model involving the indicating property, grade determining properties and the settings.

12) Details of the repeatability test for a new grading machine which shall include a graph of all five indicating property values for each pass of each piece plotted against the mean value of indicating property for each piece. If the report deals with an existing grading machine, a reference shall be made to the corresponding document, in which the repeatability was shown to be acceptable.

13) A table for inclusion in EN 14081-4, giving the settings. This shall include in the heading a reference to the report that presents the settings model used in the software.

14) The following scatter plots for the total sample, with each sub-sample in a different colour, including coefficients of determination for each sub-sample referenced to the IP model to be used in production:

    i) Strength versus IP;

    ii) Modulus of elasticity versus IP;

    iii) Density versus IP.

b) For each strength class or strength class combination each report shall include:

    1) Table giving the required characteristic values for the grades.

    2) Table giving the number of pieces and characteristic values for the optimum grades.

    3) Table giving all settings, the mean setting value and the characteristic values for the assigned grades. Where density is not a grade determining property (as for some glulam grades) the characteristic density values achieved for the assigned grades shall be listed in the report and included in the table for EN 14081-4.

    4) Table giving the size matrix.

    5) Table giving the elementary cost matrix.

    6) Table giving the global cost matrix.

    7) Check of the lowest grade (see 6.2.4.11).

6.3 Machine installation check

This check shall be carried out once to verify that the machine has been correctly installed and that, for example, the conveyors and measuring devices are correctly aligned, in accordance with the manufacturers' instructions.

After the initial installation of a grading machine for the production of strength graded timber, at least 40 pieces of timber shall be selected, without bias, from the highest grade, ignoring pieces graded by visual overrides. These specimens shall be tested for the grade determining properties according to EN 384 and EN 408 and shall meet the requirements in EN 384 under verification.

7 Additional requirements for initial type testing for output controlled systems

7.1 General

Output controlled systems provide for adjustment of settings on the basis of proof load test results. These additional requirements provide a means to derive initial settings, which may then be adjusted during production.

7.2 Requirements for the assessment of initial settings

NOTE 1 Initial estimated settings should be deduced from any relevant available information on relations between bending strength and indicating property.

NOTE 2 If density is also a grade determining property the density should be measured according to EN 384. The grade determining properties for meeting the requirements of EN 338 are bending strength, MOE and density. For other grades the grade determining properties may be different.

7.2.1 The settings shall be tested as follows:

a) Static proof loading machine shall be used. This machine shall be capable of bending each specimen using edgewise third-point loading in accordance with Clause 10 of EN 408:2003. The deflection and load transducers shall be accurate to within 3 % of the actual measurement.

b) Proof load to F_p (as specified in 7.2.2) in accordance with EN 408, a random sample of 60 specimens of each combination of strength class/species/size/source, ignoring pieces graded by visual overrides. Specimens shall be tested edgewise with the tension edge selected at random and the estimated weakest cross section positioned where possible within the centre third of the span.

c) Determine the actual modulus of elasticity E_p (as specified in 7.2.2) in accordance with Clause 10 in EN 408:2003 by measuring the deflection at the span centre relative to the supports, with the tension edge selected at random and the estimated weakest cross section positioned where possible within the centre third of the span.

The rate of applied stress shall be 110 N/mm^2/min. If more than one strength class is to be graded in one pass through the machine in production, then these classes shall also be graded in one pass to obtain specimens for the assessment tests.

If the results do not meet the requirements of 7.2.2, then the settings shall be modified and the tests repeated.

7.2.2 When tested in accordance with 7.2.1, the initial settings for the machine shall meet the following requirements:

Mean actual modulus of elasticity E_p of the 60 specimens shall be not less than 95 % of the strength class characteristic mean value $E_{0,mean}$:

$$E_p = 1\,242 \times F / (t \times w) \quad (1)$$

where

F is the applied force in newtons;

t is the thickness in millimetres;

w is the deflection at the span centre in millimetres.

No more than two specimens shall fail to sustain the proof load F_p:

$$F_p = t \times h \times f_p / 18 \quad (2)$$

where

f_p is the proof stress = $0,96 \times k_h \times f_{m,k}$ in newtons per square millimetre;

k_h is the size factor for h as given in EN 384;

$f_{m,k}$ is the characteristic bending strength for 150 mm depth in newtons per square millimetre.

7.2.3 The following records shall be kept:

a) species population;

b) timber size and surface finish (planed or sawn);

c) number of specimens in each strength class and the number of pieces rejected by the machine;

d) all machine settings;

e) results of tests;

f) date of test;

g) identification number or name of the machine operator and the identification number of the grading machine.

Annex A
(normative)

Calculation of elementary cost matrix values for 6.2.4.8

A.1 General

The elementary cost matrix (Table 2) gives the weighting factors for the pieces wrongly upgraded or downgraded to determine the acceptability of a grading machine.

A.2 Factors for wrongly upgraded pieces

These factors represent an increased relative cost due to the increased probability of failure, and shall be calculated as the difference between the target safety index (β_{tar}) and the achieved safety index (β_{ach}).

Therefore

$$\text{Cost} = 10 \times (\beta_{tar} - \beta_{ach}) \quad \text{(A.1)}$$

where

β_{tar} = 3,0;

β_{ach} = $[\mu(f_{optimum})-\mu(f_{assigned}) + 0{,}9\ \mu(f_{assigned})\ ]\ /\ [0{,}3\mu(f_{optimum})\ ]$;

μ I is the mean value of bending strength for the optimum or assigned strength grades;

$\mu(f_{optimum})$ = $e^{[\ln(f_{k.optimum}) + 0{,}54]}$;

$\mu(f_{assigned})$ = $e^{[\ln(f_{k.assigned}) + 0{,}54]}$;

$f_{k.optimum}$ is the required characteristic strength for the optimum grade;

$f_{k.assigned}$ is the characteristic strength for the assigned grade.

NOTE 1 None of the strength values in this clause should contain the k_v factor given in EN 384.

NOTE 2 A simplification of Equation (A.1) is:

$$\text{Cost} = 3{,}33 \times ((f_{k.assigned}\ /\ f_{k.optimum}) - 1)$$

A.3 Factors for wrongly downgraded pieces

These factors represent an increased relative cost due to the increased amount of timber required for a structural member. For example, the size (depth) of bending members is governed by deformations through equations of the form:

$$\delta = c \times F \times \ell^3 / (E \times b \times h^3) \quad \text{(A.2)}$$

where

c is a constant;

F is the force;

ℓ is the span;

b is the thickness;

h is the depth

and therefore

$$h = (c \times F \times \ell^3 / E \times b \times \delta)^{1/3} = K(1/E)^{1/3}$$

Similar expressions can be derived for tension and compression members. Therefore, cost shall be calculated as:

$$\text{Cost} = 10[(E_{\text{optimum}} / E_{\text{assigned}})^{\alpha} - 1] \quad \text{(A.3)}$$

where

E_{optimum} = mean E of optimum grade;

E_{assigned} = mean E of assigned grade;

α = 1 for tension and compression members, and ⅓ for bending members.

NOTE None of the E values in this clause should contain the 95 % factor given in EN 338.

Annex B
(informative)

Guidance on the procedure of initial type testing for machine controlled systems

B.1 Introduction

This annex gives background information and guidance on the procedures given in Clause 6.

B.2 Guidance

A grading machine assigns timber to a grade on the basis of the machine's ability to accurately measure an indicating property that is closely related to the grade determining properties, and the accuracy of the machine settings used. The machine and its settings are therefore an integral part of the machine's capacity to grade timber to an acceptable accuracy, and so form part of the acceptance requirements for the product, which is machine graded timber.

The basis of the approach is to compare the machine's performance (in terms of the grade it assigns to each piece) with the performance of a perfect machine that would grade each piece of timber into its optimum grade. This comparison uses a cost analysis approach involving weighting factors for the pieces that are wrongly upgraded and wrongly downgraded. For pieces wrongly upgraded the weighting factors have a severe adverse effect on acceptance of the machine and its settings because such pieces are a safety liability, whilst for pieces wrongly downgraded the effect of the factors is less severe because the penalty is the cost of using larger cross sections or more pieces of timber.

The factors are calculated as given in Annex A. It can be seen that for wrongly upgraded pieces the factors represent an increased relative cost due to the increased probability of failure, and are calculated as the difference between the target safety index and the achieved safety index. For the wrongly downgraded pieces the factors represent an increased relative cost due to the increased amount of timber required for a structural member.

To derive settings, a model has to be developed that takes account of the relevant variables, many of which are listed in 6.2.2. The model parameters are determined from the test data. Sub-samples of timber are selected to represent all growth areas within the country/countries for which the settings will be applicable. The sub-samples are graded and tested and the data are adjusted for size, load configuration and moisture content. Each of these sub-samples is then deducted from the total sample to produce a number of truncated samples, each of which is used to derive settings.

The species/grade settings are taken as the means of those for the individual truncated samples and used to assign a grade to each piece. A cost analysis is then performed on the grading results of the total sample, involving three matrices:

a) The size matrix

   Gives the number of pieces in the optimum and assigned grades.

b) The elementary cost matrix

   Gives the weighting factors calculated from Annex A.

c) The global cost matrix

Gives values calculated according to 6.2.4.8. It is these values that determine whether the machine and its settings are acceptable.

If all the results in the global cost matrix values are acceptable, the characteristic values for the assigned grades meet the required values and a further check on the lowest grade is met, then the machine and settings are acceptable.

The above system, in relating the acceptability of the machine and its settings directly to the relative cost of its errors, makes a machine's acceptance or non-acceptance more transparent. It also allows machines designed for specific purposes to be judged solely on their ability to grade for that purpose. For example, a less sophisticated machine could be found acceptable to grade two grades in a pass but not three or more.

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