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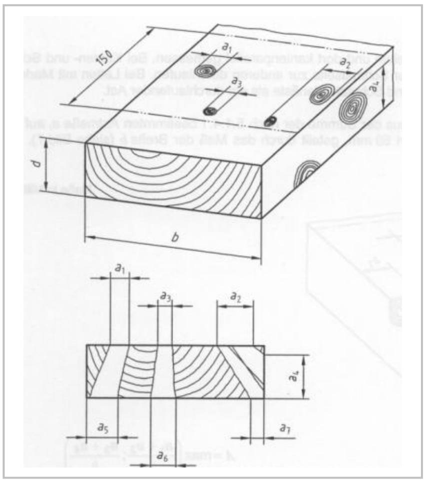

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Contents

1 Background

The Chinese standard for structural glulam – glued laminated timber – under preparation and intended to be published in the near future contains visual strength grading rules for the boards or planks to be used for the production of the glulam. Further, it has defined 4 species groups, where the strongest species have been allocated to SZ1 and the weakest to SZ4.

Several European wood species relevant for glulam production are listed in the draft Chinese glulam standard. The suggested allocation of the European species is relatively similar to the one in the Japanese glulam standard, which was evaluated years ago. From European tests doubts have been raised concerning the documentation of the allocation of the European spruce – picea abies - into the 4 species groups. The new tests show that EU spruce should be allocated into a better species class.

In Europe a lot of information on the strength and stiffness properties of glulam has emerged recently because of the elaboration and the implementation of the European harmonised glulam standard EN 14080 supported by the strength class standard EN 1194 for use by the design of glulam structures in accordance to Eurocode 5, EN 1995 part 1 and 2. Therefore, it is found correct to contribute with this information to the classification of European spruce in the Chinese glulam standard.

2 Objective

The objective of this paper has been to document the strength of European spruce, picea abies - when visually strength graded in accordance to the rules in the draft Chinese glulam standard and by comparing with the strength profiles of that standard to be able to allocate the European spruce into the correct species groups defined in the standard.

3 Method of documentation

The visual strength grading rules in the Chinese glulam standard have grading requirements which differ from those used in Europe, but not very much. However, the European visual strength grading rules have typically 2 or 3 grade classes, for which the strength properties have been determined. Therefore, it is possible by estimation to place the Chinese visual strength grading classes among the similar European classes for which the strength and stiffness properties have been determined by standardised methods.

This provides a basis for a good estimate of the strength and stiffness of European spruce visually strength graded in accordance with the rules in the Chinese glulam standard.

The strength and stiffness properties obtained in this way can be compared with the requirements to the characteristic values stated in the Chinese glulam standard for the very laminations and such a comparison can form the basis for allocating European spruce – picea abies – into the correct species group.

4 Visual strength grading rules in the Chinese glulam standard and in the European grading standards

The selected visual strength grading standards are described in partly the Nordic rules used in Scandinavia and Finland /INSTA 142 – Nordic visual strength grading rules for timber/ ,partly the German rules used in Germany and Austria /DIN 4074-1 – Strength grading of wood – part 1: Coniferous sawn timber/ and partly the French standard NF B 52-001 /Régles d’utilisation du bois dans les constructions: Classement visual pour employ en structure pour les principales essence résineuses et feuillues/. The strength properties of coniferous timber graded by these rules are well defined from large scale testing in accordance with the European testing standard EN 408, which is similar to the international draft testing standard /ISO/CD 8375 – ISO/TC 165 N414 – Timber structures – Glued Laminated Timber – test Methods: Determination of Physical and Mechanical Properties/.

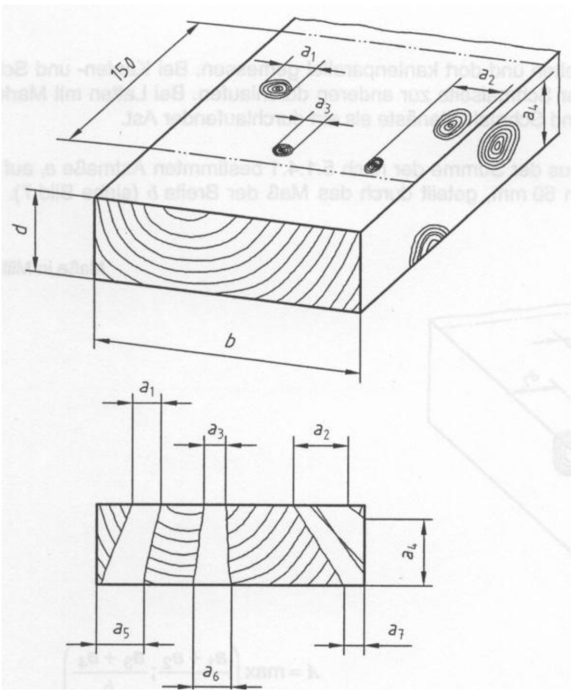
The table 4.1 gives a comparison between the requirements according to the Chinese visual strength grading rules stated in the draft Chinese glulam standard, table 3.1.3-1 and the European ones. For groups of knots – a knot cluster –the definition of the knot diameter ratio is different in the 3 standards. See figure 4.1 for the exact definitions. In order to be able to compare the requirements to the knot diameter ratio a transformation of the requirements to the definition in the draft Chinese glulam standard has been performed.

In INSTA 142 the requirement to a knot cluster is defined as the sum of the diameters of the knots in the wide side plus the knots in the 2 edges. This has been transformed to $\Sigma d_{knot}/b$ by using a typical lamination cross section of 40x150 mm. See figure 4.1 and the Annex A.

Table 4.1. Visual requirements to the strength grades in the draft Chinese glulam standard, INSTA 142, DIN 4074-1 and NF B 52-001. The left column states the grading standard and the grading requirements are mentioned in one or some of the 4 columns to the right. The European requirements have been put in the columns, where they best fit those of the draft Chinese glulam standard. "No req." signifies that the standard has no requirement to this type of defect.

	Chinese grade			
	I	II	III	IV
Diameter ratio of knot groups (knot cluster). For all grading rules transformed to = $\Sigma d_{knot}/b$ and summation over knots on the surface with the largest sum of knots as in the draft Chinese glulam standard. For DIN 4074-1 it has been assumed that ⅔ of the knot sum are on the side with the largest diameter sum.				
Draft glulam standard	20%	33%	40%	50%
INSTA 142 LT30 – LT20		32%		51%
DIN 4074-1 C30 – C24			43%	65%
NF B 52-001, STI, STII	17%			50%
Diameter ratio of knots in the edge - the narrow side - of a timber member. d_{knot}/thickness				
Draft glulam standard	No req.	No req.	No req.	No req.
INSTA 142 LT30 – LT20		50%		80%
DIN 4074-1 C30 – C24	No req.	No req.	No req.	No req.
NF B 52-001, STI, STII	67%			67%
Diameter ratio of max. knot in the wide side of a timber member				
Draft glulam standard	17%	25%	33%	50%
INSTA 142 LT30 – LT20		25%	40%	
DIN 4074-1 C30 – C24	20%		33%	
NF B 52-001, STI, STII	17% <30mm			50% <40mm
Inclination of grain				
Draft glulam standard	1:17	1:14	1:12,5	1:8
INSTA 142 LT30 – LT20			1:10	1:8
DIN 4074-1 C30 – C24		1:14		1:8
NF B 52-001, STI, STII			1:10	1:4
Decay				
Draft glulam standard	Not allowed	Not allowed	Not allowed	Not allowed
INSTA 142 LT30 – LT20	Not allowed	Allow-knot[1)]	Allow-knot	Allow-knot
DIN 4074-1 C30 – C24			Not allowed	Not allowed
NF B 52-001, STI, STII	Not allowed			Not allowed
Checks radial				
Draft glulam standard	Very small checks allowed with allowed up to a length of 0,5 m over 3 m length			
INSTA 142 LT30 – LT20	Check through the board allowed up to a length of 0,5 m over 3 m length			
DIN 4074-1 C30 – C24	Allowed			
NF B 52-001, STI, STII	Check through the board allowed up to a length of 2 times the board width			
Ring checks				
Draft glulam standard, I and II	Grade I and II: Not allowed			
III and IV	Grade III and IV: Width<25% of width but not closer to the edge than 25% of width			
INSTA 142 LT30 – LT20	LT30 not allowed.			

  DIN 4074-1 C30 – C24 NF B 52-001, STI, STII	LT20: Width<25% of width but not closer to the edge than 25% of width Not allowed Non mentioned			
Spiral grain				
Draft glulam standard INSTA 142 LT30 – LT20 DIN 4074-1 C30 – C24 NF B 52-001, STI, STII	Not allowed within 100 mm from finger joints Not allowed at finger joints Not allowed at finger joints Not allowed at finger joints			
Width of annular rings, average over the outer part of the cross section				
Draft glulam standard INSTA 142 LT30 – LT20 DIN 4074-1 C30 – C24 NF B 52-001, STI, STII	<6 mm <5 mm <4 mm < 6 mm	<6 mm <8 mm <6 mm	<6 mm	<6 mm < 8 mm



Definition of knot diameter ratio in a knot cluster in draft Chinese glulam standard. However the draft considers all knots over a length of 200 mm. The knot pattern typically results in that the largest sum occurs on the sapwood side i.e.

$$R_{kc} = \frac{a_5 + a_6 + a_7}{b}$$

Definition of knot diameter ratio in a knot cluster in INSTA 142

$$R_{kc} = \frac{a_4 + a_5 + a_6 + a_7}{b}$$

Definition of knot diameter ratio in a knot cluster in DIN 4074-1

$$R_{kc} = \frac{a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7}{2b}$$

Figure 4.1 Definition of knot diameter ratio in a knot cluster consisting of knots over a length of 150 mm.

The special requirements in the draft Chinese glulam standard to pith in radiata pine has not been dealt with, since they are not relevant to European spruce – picea abies.

In INSTA 142 and DIN 4074-1 there are requirements to a single knot in the wide side of a timber member. Such requirements are not stated in the draft Chinese glulam standard.

Further, there are in INSTA 142 requirements to “top rupture” which is the result of the braking of the top of a coniferous tree when it is growing. An upper branch of the tree substitutes the top shoot resulting in local inclined grain. This defect is not so common but rather severe so it is not allowed for LT30 and only over the middle of the cross section in LT20.

The grade S7 defined in DIN 4074-1 has not been evaluated because it allows larger knots than any of the 4 Chinese visual grades. In EN 1912 S7 has been allocated into class C16.

4.1 Evaluation and comparison of grading requirements

It appears from table 4.1 that there is no fixed relation between any Chinese visual grade and a European grade. Thus it is necessary to perform an estimation in order to state which European visual grade results in similar strength properties of the timber when graded in accordance to the Chinese visual grading rules.

From experience gained during testing of glulam produced from picea abies the knots typically cause the failure. Inclination of grain is not so pronounced in the rupture surfaces and the other defects are of less significance. For pine e.g. pinus sylvestris the inclination of grain can influence the strength to a higher degree.

From a comparison of the maximum allowed defects, and having focus on the maximum knots, it is estimated that the visual strength grading in accordance to the 3 different grading methods should result in that Chinese grades can be related to the European ones as

- Grade I should result in timber being
  * as strong as ST I
- Grade II should result in timber being
  * a little stronger than LT30
- Grade III should result in timber being
  * as strong as C30
- Grade IV should result in timber being
  * as strong as LT20
  * as strong as ST II
  * stronger than C24.

For the evaluation in the following chapters it has been assumed that

- Grade I = ST I
- Grade II = LT30

- Grade III = grade C30
- Grade IV = LT20 and ST II
- Grade IV = stronger than C24.

This assumption has the consequence that the allocation of European wood species into the Chinese species groups SZ1 to SZ4 will be done conservatively.

5 European spruce – picea abies, Strength and stiffness

5.1 General – EN Standards

With the implementation of the European timber code, Eurocode 5 a lot of full size testing of picea abies has been conducted to verify its strength and stiffness properties. Timber with dimensions relevant for the production of glulam has primarily been tested in tension because according to the European system the bending strength of the glulam is determined form the tensile strength of the laminations. However, in some cases the bending strength has also been determined.

The standard EN 338 states the strength classes used for full size European structural timber. The standard EN 1912 specifies how picea abies and other timber species graded according to the different visual grades used in Europe have been allocated into the strength classes defined in EN 338. Table 5.1 gives the information for the relevant grades.

Table 5.1 Strength classes defined in EN 338 and some visual grading methods allocated into the strength classes. Characteristic values i.e. 5% percentiles of the strength properties and mean values of the E-moduli.

Strength class	$f_{m,k}$, MPa	$f_{t,k}$, MPa	E_{mean}, GPa	Visual grades
C16	16	10	8	S7
C18	18	11	9	ST-III
C24	24	14	11	S10, ST-II
C30	30	18	12	S13, ST-

The tests conducted within the last years have all had the objective to document a certain strength class of the visual grades used for the testing.

5.2 Test results with European spruce

The full size tests conducted with picea abies have all been performed in accordance with EN 408 which specifies that the timber shall be conditioned at a climate of (20±2) ^{o}C and (65±5) % relative humidity. The span in bending tests shall be 18 times the depth *h* of the timber. The free length of the specimen for tensile tests shall contain the defect and shall be at least 9 times the maximum cross-sectional dimension.

5.2.1 Small clear specimens of picea abies

The mechanical properties of small clear specimens of picea abies have been taken from the most reputed and well known book on such properties, namely: /Technologie des Holzes und der Holzwerkstoffe. By F. Kollmann. Springer Verlag, Berlin. 1951/

Table 5.2.1.1. Mechanical properties of small clear specimens according to Kollmann, 1951.

	Unit	Picea abies		
		Minimum	Mean	Maximum
Dry density	g/cm^3	0,30	0,43	0,64
E-modulus from bending	kp/cm^2	73.000	110.000	214.000
Tensile strength, parallel to grain	kp/cm^2	210	900	2.450
Compression strength, parallel to grain	kp/cm^2	350	500	790
Bending strength, parallel to grain	kp/cm^2	490	780	1.360
Shear strength, parallel to grain	kp/cm^2	40	67	120

Further, French tests conducted recently have resulted in the properties in table 5.2.1.2.

Table 5.2.1.2. Mechanical properties of picea abies measured from small clear specimens of the sizes indicated. Measurements on French picea abies.

	Dimensions specimens	Mean value	Standard Deviation
$fc,0$ (MPa)	20*20*60 mm3	44	7,0
f_{t0} (MPa)	20*20*300 mm3	105	31,7
f_m (MPa)	20*20*360 mm3	100	25,9
E_0 (GPa)	20*20*360 mm3	13,1	3
f_v (MPa)	4 cm2 (shear surface)	8	1

5.2.2 Testing with full size structural timber

Test results have been collected from growth regions in Northern Europe to growth regions in the Central to South-western Europe.

Tests with picea abies from the Nordic countries, Finland, Norway and Sweden

The strength and stiffness values are documented in the SP report /Laminations for glued laminated timber – Establishment of strength classes for visual strength grades and machine settings for glulam laminations of Nordic origin/. 1600 pieces of timber 40x145 mm from 8 sawmills in Sweden, Norway and Finland have been tested. The values of E, f_m and f_t have been determined in accordance to the test standard EN 408. The average values of these properties have been taken from the report. The characteristic values have been determined according to the rather conservative methods on EN 384, so they are rather conservative.

Table 5.2.2.1. Strength and stiffness properties of picea abies from the Nordic countries.

Standard with the visual grading rules and the grades	Modulus of elasticity, MPa		Bending strength, MPa		Tensile strength, MPa	
	Mean	5% percent.	Mean	5% percent.	Mean	5% percent.
INSTA 142 LT30	13.200	13.100	53,1	31,3	37,7	22,1
INSTA 142 LT20	11.300	11.200	39,8	22,2	28,3	15,3

Tests with picea abies from France

The strength and stiffness values from over 1000 specimens in sizes relevant for glulam production are documented in a report from CTBA – Centre Technic du Bois et Ameublement in France received by E-mail. The growth regions are the hilly parts at the central and east part of France. The visual grading rules are defined in the French national standard NF B 52 001. The average values of the properties have been taken from the report. The characteristic values have been determined as 5% percentiles. The tensile strength has been determined by the safe rule that it is 60% of the bending strength.

Table 5.2.2.2. Strength and stiffness properties of picea abies from the France.

Standard with the visual grading rules and the grades	Modulus of elasticity, MPa		Bending strength, MPa		Tensile strength, MPa	
	Mean	5% percent.	Mean	5% percent.	Mean	5% percent.
NF B 52 001 ST-I	13.000			36		21,6
NF B 52 001 ST-II	12.000			24		14,4
NF B 52 001 ST-III	11.000			20		12,0

Tests with picea abies from Austria

The strength and stiffness values are documented in the report /IFP 2.3 Large dimension timber – Mechanical potential of boards of spruce for glulam production/ from the Technical University of Graz. Total 2200 pieces of timber were tested in tension of which some had been machine strength graded and some had been visually graded. Further, 300 machine graded pieces in four point bending were tested but not in accordance with present standards. The visual grading rules are defined in DIN 4074-1. The values of E, f_m and f_t have been determined in accordance with the test standard EN 408. The average values of these properties have been taken from the reports performed since 2001 where the European test standards and methods for determination of strength properties had found their final form. The characteristic values have been determined according to EN 14358 with a confidence level of 75%.

Table 5.2.2.3. Strength and stiffness properties of picea abies from Austria.

Standard with the visual grading rules and the grades	Modulus of elasticity, MPa		Bending strength, MPa		Tensile strength, MPa	
	Mean	5% percent.			Mean	5% percent.
Visually graded						
DIN 4074-1 S13 = C30	12.800	9.800			41,1	22,0
DIN 4074-1 S10 = C24	11.100	8.300			31,0	15,9
Machine stress graded						
DIN 4074 MS13 = C30	12.400	10.700			34,8	22,1
DIN 4074 MS10 = C24	10.800	8.900			24,6	14,4

Only the strength and stiffness data from visually graded timber will be used by the comparison in chapter 6.

The strength and stiffness data of machine stress graded have also been stated in table 5.2.2.3 to show that the 5% percentile of the tensile strength is larger than the characteristic value allocated to the strength classes by EN 338. The same applies to the mean value of the E-modulus.

Tests with picea abies from Germany
The strength and stiffness values from 1048 bending specimens and 1526 tensile specimens in sizes relevant for glulam production are documented in a report / European Spruce data (picea abies) / from the Technical University in Munich, Germany received by E-mail. The bending tests were performed with the worst growth defect in the tension side, which has resulted in a little lower value than if they had been positioned randomly, approximately 7 % to 12 % lower. The growth regions are within Germany. The visual grading rules are defined in DIN 4701-1. The average values of the properties have been taken from the report. The characteristic values have been determined as 5% percentiles.

Table 5.2.2.2. Strength and stiffness properties of picea abies from the France.

Standard with the visual grading rules and the grades	Modulus of elasticity, MPa		Bending strength, MPa		Tensile strength, MPa	
	Mean	5% percent.	Mean	5% percent.	Mean	5% percent.
DIN 4074-1 S13 = C30	12.810	9.903	57,2	33,8	38,6	19,6
DIN 4074-1 S10 = C24	11.587	8.146	43,9	23,4	29,2	14,1
DIN 4074-1 S7 = C16	10.640	7.580	35,3	18,8	24,9	11,9

6 Allocation into species groups based on lamination properties

Table 3.1.3-2 in the draft Chinese glulam standard states the requirements to the average values and the 5% percentile values of the modulus of elasticity, the bending strength and the tensile strength of the graded laminations. The required values are repeated at the top of table 6.1.

These strength and stiffness values can be compared with the results of a very comprehensive test series with timber graded into the LT20 and LT30 classes documented in the SP report

/Laminations for glued laminated timber – Establishment of strength classes for visual strength grades and machine settings for glulam laminations of Nordic origin, dated 1998/.

Table 6.1 of this report states the relevant strength and stiffness values in the above mentioned Chinese glulam standard table 3.1.3-2 together with the average values and the characteristic values reported in the SP report. The characteristic values are mean values of the properties determined from timber visually grading by either the production site or the laboratory, however, these values differ only slightly.

Table 6.1. Strength and stiffness properties relevant for a comparison with the properties of picea abies.

Species and visual grades				Modulus of elasticity, MPa		Bending strength, MPa		Tensile strength, MPa	
SZ1	SZ2	SZ3	SZ4	Mean	5% percent.	Mean	5% percent.	Mean	5% percent.
I				13.700	11.300	52,9	39,7	31,4	23,5
II	I			12.300	10.300	47,5	35,8	27,9	21,1
III	II	I		10.600	9.300	44,1	33,3	26,0	19,6
	III	II	I	9.800	8.300	41,2	30,9	24,0	18,1
		III	II	8.800	7.400	38,2	28,9	23,0	17,2
			III	7.800	6.400	35,3	26,5	21,1	15,7
INSTA 142 LT30				13.200	13.100	53,1	31,3	37,7	22,1
INSTA 142 LT20				11.300	11.200	39,8	22,2	28,3	15,3
DIN 4074-1 C30 AUS				12.800	9.800			41,1	22,0
DIN 4074-1 C30 D				12.810	9.903	57,2	33,8	38,6	19,6
DIN 4074-1 C24 AUS				11.100	8.300			31,0	15,9
DIN 4074-1 C24 D				11.587	8.146	43,9	23,4	29,2	14,1
DIN 4074-1 C16 D				10.640	7.580	35,3	18,8	24,9	11,9
NF B 52-001 ST I				13.000			36		21,6
NF B 52-001 ST II				12.000			24		14,4

It appears from table 6.1 that the strength and stiffness properties of picea abies in the strength classes C24 and C30 grown in Germany and Austria are almost identical. The mechanical properties of timber from the Nordic countries and from France can't be compared directly because different visual grading criteria have been used. However, the general trend is the same that there appears to be not much difference in the mechanical properties if the timber had been graded using the same visual grading rules. So the differences in the mechanical properties caused by different growth regions are negligible.

Considering that the characteristic bending, tension and compression strength of glulam is correlated to the characteristic tensile strength of the laminations and that the E-modulus of the glulam is very closely correlated to that of the laminations it appears that the strength and stiffness of laminations produced from European spruce, picea abies fulfil the requirements to Chinese species and visual grades as follows:

- ST I and LT30 corresponds to SZ1/II or SZ2/I
- C30 corresponds to SZ2/III or SZ3/II or SZ4/I

- C24 corresponds to SZ4/III
- LT20 corresponds almost to SZ4/III
- ST II corresponds hardly to SZ4/III
- C16 has a lower strength than SZ4/III

Since the visual requirements of the grade French grade ST I correspond to the Chinese visual grade I the European spruce picea abies has to be allocated to species class SZ2 if agreement between the strength and stiffness profiles shall be reasonable.

Since the visual requirements of the Nordic grade LT30 corresponds to the Chinese visual grade II the European spruce picea abies has to be allocated to species class SZ1 if agreement between the strength and stiffness profiles shall be reasonable.

Since the visual requirements of the grade C30 corresponds to the Chinese grade III the European spruce picea abies has to be allocated to species class SZ2 if agreement between the strength and stiffness profiles shall be reasonable.

Since the visual requirements of the grades C24, LT20 and ST II correspond to the Chinese grade IV, which is lower than the classes mentioned in the table 6.1, the European spruce picea abies can't be allocated to any species group. However, the results indicate that it at least shall be allocated to species class SZ3 or better.

As expected the class S7 = C16 has a lower strength than required by any Chinese grade.

The allocation of picea abies should be done based on the comparisons between the mechanical properties of visually graded timber where the grading criteria are most similar. This is the case for the European visual grades ST I, LT30 and C30, whereas the European visual grades LT20, C24 and ST II are similar to the Chinese visual grade IV for which no strength and stiffness data are stated in the Chinese glulam standard.

So it can be concluded that based on the comparisons between the strength and stiffness properties of the European visual grades ST I, LT30 and C30 and the Chinese visual grades I, II and III it can be concluded that picea abies – European spruce – should be allocated into species group SZ2. A similar comparison between the European visual grades LT20, C24 and ST II and the Chinese visual grade IV indicates the same.

7 Conclusions

It is clear that there are several similarities between the visual strength grading requirements to laminations for glulam in the draft Chinese glulam standard and the European standards.

In order to have agreement between the characteristic strength and stiffness properties listed in the draft Chinese glulam standard and the measured strength and stiffness properties of laminations produced from European spruce, picea abies, using the visual grading rules in the draft Chinese glulam standard the wood species picea abies should be allocated into species group SZ2 as defined in the draft Chinese glulam standard.

8 References . Some of the documents are available as Word files or pdf files. Their names are listed after the document.

DIN 4074-1 – Sortierung von Holz nach der Tragfähigkeit. „Strength grading of wood – part 1: Coniferous sawn timber”. Dated June 2003. German standard

EN 338:2003. Structural timber – Strength classes.

EN 384:2004. 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

EN 1194:1999. Timber structures – Glued laminated timber – Strength classes and determination of characteristic values

EN 1912:2004. Structural timber – Strength classes – Assignment of visual grades and species

EN 1995-1:2004, part 1 and 2. Eurocode 5. Design of timber structures

EN 14080:2004. Timber structures – Glued laminated timber – Requirements.

European Spruce data (picea abies). Technical University in Munich, Germany. Received by E-mail 2007-12-20. FILE NAME: D_european_lamellae_3010PK.pdf

IFP 2.3 Large dimension timber – Mechanical potential of boards of spruce for glulam production. Technische Universität Graz, Holz.Bau forschungs gmbh. Austria. November 2007. FILE NAME: Bericht_gesamt_2007-11-23.pdf

INSTA 142 – Nordic visual strength grading rules for timber

ISO/CD 8375 – ISO/TC 165 N414 – Timber structures – Glued Laminated Timber – test Methods: Determination of Physical and Mechanical Properties. Dated 2004-06-12

Laminations for glued laminated timber – Establishment of strength classes for visual strength grades and machine settings for glulam laminations of Nordic origin. SP Swedish National Testing and Research Institute, Building Technology, Trätek. SP Report 1998:38. 2 FILE NAMES: SP Report 1998 38_Chapter1-4.pdf – AND - SP Report 1998 38_Chapter 5-7 + appendices.pdf

NF B 52-001 Régles d’utilisation du bois dans les constructions: Classement visual pour employ en structure pour les principales essence résineuses et feuillues. Application rules for structural timber. “Visual classification of the main coniferous and deciduous timber species”. French standard. FILE NAME: sapin épicéa NFB52 001.pdf

Report received by E-mail from CTBA – Centre Technic du Bois et Ameublement in France. November and December 2007. 2 FILE NAMES: French data picea abies.doc – AND - Epicéa commun ou European Spruce GB.pdf

Technologie des Holzes und der Holzwerkstoffe. By F. Kollmann. Springer Verlag, Berlin. 1951

Annex A. The transformation of grading requirements for knot groups in INSTA 142 and DIN 4074 to the measurement method of the JAS glulam standard.

DIN 4074-1 17-08-2007

Requirement: $\boxed{\dfrac{a_{side,\max} + a_{side,\min} + a_{edge}}{2b} \leq 33\%}$

Transformed requirement: $\boxed{\dfrac{a_{side,\max}\left(1 + a_{side,\min}/a_{side,\max} + a_{edge}/a_{side,\max}\right)}{b} \leq 66\%}$

Similar to: $\boxed{\dfrac{a_{side,\max}}{b} \leq \dfrac{66\,\%}{1 + a_{side,\min}/a_{side,\max} + a_{edge}/a_{side,\max}}}$

a_side,min / a_side max =	0,4		
a_edge / a_side,max =	0,15		
		C30	C24
Transformed requirement to the side with max knots.		0,33	0,5
a_side,max / b =		43%	65%

Insta 142 17-08-2007

Requirement: $\boxed{a_{side,\max} + a_{edge} \leq a_{side,allowed} + a_{edge,allowed} = k_{side} b + k_{edge} t}$

Transformed requirement: $\boxed{\dfrac{a_{side,\max}}{b} \leq k_{side} + k_{edge}\, t/b - a_{edge}/b = k_{side} + 0{,}5\, k_{edge}\, t/b}$

				LT30	LT20
Typically	b =	150	k_side	0,25	0,4
	t =	40	k_edge	0,5	0,8

a_side,min / a_side max = 0,4

a_edge / a_side,max = 0,15

Transformed requirement to the side with max knots.

	LT30	LT20
a_side,max / b =	32%	51%