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Strength of European Timber

Part 2. Properties of spruce and pine tested in Gradewood project

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Title

Strength of European Timber

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Abstract

More than 6 000 specimens of spruce and pine grown in several European countries were tested by destructive and non-destructive means in laboratory. Five strength grading machines were also used to test the material. This report includes the description of sampling as well as tension and bending properties of material with comparisons to earlier results.

Main purpose of this report is to document experimental results. Analysis includes basic statistical characteristics such as means, coefficients of variation and correlations between grade determining properties and indicating properties. Also the possibility of having same settings in different countries has been focused.

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Preface

The present report documents experimental research performed in Work Package 3 of the Gradewood-project. Gradewood (Grading of timber for engineered wood products) was a transnational project belonging to the WoodWisdom-net programme. The project was funded by several national funding organizations and industries as a result of the initiative of European wood industries (Building With Wood). The project was lead by a Steering Committee (chair Raimund Mauritz, Doka) and the management of work was lead by a Project Management Group (chair Mattias Brännström, Stora Enso Timber). Background of project and results of analysis of existing data have been published earlier [1].

Experimental work published here was made as co-operation of several organisations and their roles, and roles of the authors were as follows:

1. Technical University of Munich, Peter Stapel: co-ordination of Work Package 3, and testing of 900 timbers from Poland.
2. Holzforschung Austria, Julia K. Denzler: testing of 1 900 timbers from Slovakia, Slovenia, Romania and Ukraine.
3. University of Ljubljana, Goran Turk, and Slovenian National Building and Civil Engineering Institute ZAG**:** testing of 1 100 Slovenian timbers.
4. FCBA, France, Didier Reuling: testing of 1 000 timbers from France, Poland and Sweden.
5. ETH, Switzerland, Markus Deublein: tension testing of 450 Swiss spruces.
6. SP, Sweden, Rune Ziethén: testing of 400 Swedish timbers.
7. VTT, Tomi Toratti and Alpo Ranta-Maunus: co-ordination of the project, and Mikael Fonselius, tension testing of 400 Finnish and Russian pine timbers.

Following strength grading machine manufacturing companies have tested the material by using their equipments: Brookhuis, CBS-CBT, Luxscan, MiCROTEC and Rosén. Collaboration between research institutes and grading machine companies was so organised that laboratory test results were made available to grading machine companies, and grading machine results were distributed to researchers.

The authors

Contents

List of symbols

a	distance between support and next loading head in bending test
E_{dyn}	dynamic modulus of elasticity based on measurement of natural frequency of longitudinal vibration and density, adjusted to u = 12%
E_{freq}	E_{dyn} adjusted to u = 12% assuming constant density ρ = 450 kg/m^3
E_{global}	modulus of elasticity determined according to EN408 and adjusted to u = 12% in bending over the distance between the supports
E_{local}	modulus of elasticity determined according to EN408 and adjusted to u = 12% in bending over 5*width between the loading heads in tensionover 5*width
E	for bending E_{local} if only E_{local} has been determined; otherwise 1.3 E_{global} -2690 for tension E_{local}
freq	first natural frequency
f_m	bending strength determined according to EN408, adjusted to 150 mm width and a length of 18*width with distance between the supporters of 6*width
f_t	tension strength determined according to EN408, adjusted to 150 mm width and a length of 9*width
KAR	total knot area ratio
L	length of specimen
l	distance between the supporters (bending) or between the grips (tension)
ρ	density determined according to EN408, adjusted to u = 12%
$\rho_{specimen}$	average density of specimen based on weighing by scale, adjusted to u = 12%
ρ_{450}	assumed constant density of 450 kg/m^3
$\rho_{specimen}$	average density of specimen based on weighing by scale, adjusted to u = 12%
$..._{test}$	tested value without adjustment
u	moisture content
IP1...12	indicating properties given by grading machines

1. Introduction

The background of the Gradewood project and results of a joint analysis of existing experimental values of 26 000 timbers have been published earlier [1]. One reason to make additional experiments in Gradewood was that existing experiments do not cover all commercially interesting growth areas in Europe. Another reason for these experiments was the lack of important measurements in large parts of the existing data. This report is a documentation of 6 000 new experiments. It includes basic analysis of laboratory measurements and values given by grading machines. Spruce and pine tested in bending and tension are covered in this report.

A specific feature of the project is that same timber specimens were measured by different non-destructive methods by the use of grading machines and in laboratory. As a result, we have an opportunity to compare ability of several methods to predict strength, stiffness and density.

2. Materials

Softwood from ten different European countries was strength graded by different machines and tested in bending or tension.
6226 spruce or fir and pine specimens were graded with up to 5 different grading machines. 6061 datasets can be used in this report. Reasons for not considering specimens range from pre-damaged boards to obvious measurement errors or missing laboratory data for single variables.

Scots pine (Pinus sylvestris) makes up a share of 25 % of the total sample, so that the focus is clearly on Norway spruce (Picea abies). A very small number of specimens from European Silver fir (Abies alba) was also included and is analysed together with spruce.

Figure 1 shows the source countries of the specimens divided into species and testing mode. At least one out of the two species was sampled in Switzerland (CH), Slovenia (SI), Poland (PL), Ukraine (UA), Finland (FI), Russia (RU), Sweden (SE), Romania (RO), Slovakia (SK) and France (FR). For each country additional information is available, which allows to specify the origin of the timber more accurately. This information is indicated by the red dots in the figure. There are no red dots in CH and SI, as this would only result in one big dot. There are 3 different geographic samples in CH, while there are even 4 in SI.

Table 1 gives more information on species and testing mode and the related source countries and regions. The label of most regions really refers to different geographic origins where the timber grew, some region labels refer to different sawmills which provided the timber. This is not the case for Bucovina and Iwano-Frankiwsk. The two indices simply result from different sampling times. Pine grown in France from the resource region Auvergne is labelled with -600m and +600m as there is only a minor regional difference. This sample was divided up depending on the altitude in which the timber grew.

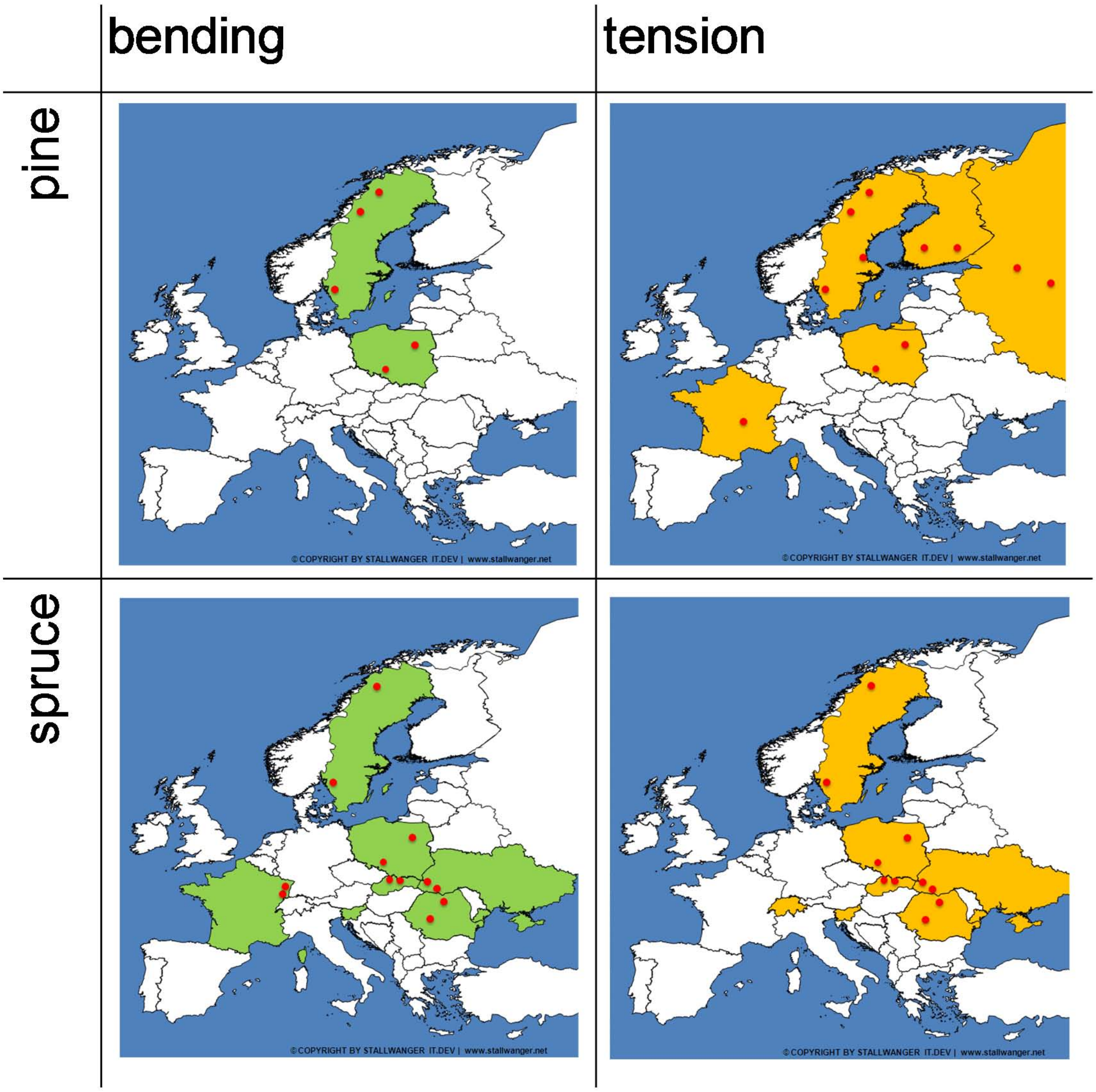


Figure 1. Origin of the test data separated into species and testing mode.

Table 1. Number of tested specimens split into source country, region, species and test mode.

Source country	Region	Spruce		Pine		Total
		bending	tension	bending	tension	
CH	Jura	0	146	0	0	146
	Mittelland	0	148	0	0	148
	Voralpen/Alpen	0	148	0	0	148
FI	East	0	0	0	172	172
	West	0	0	0	85	85
FR	Auvergne ,-600 m	0	0	0	118	118
	Auvergne +600 m	0	0	0	121	121
	Alsace	103	0	0	0	103
	Lorraine	12	0	0	0	12
PL	Murow	214	111	108	107	540
	Swietjano	219	108	111	110	548
RO	Bucovina_1	114	112	0	0	226
	Bucovina_2	88	88	0	0	176
	Transylvania	116	113	0	0	229
RU	Novgorod	0	0	0	87	87
	Vologda	0	0	0	84	84
SE	Gästrikland	0	0	0	35	35
	Lappland	105	111	34	35	285
	Västerbotten	0	0	35	34	69
	Västergötland	105	100	140	102	447
SI	Central Slovenia	489	0	0	0	489
	Inner Carniola	218	0	0	0	218
	Slovenian Carinthia	314	0	0	0	314
	Upper Carniola	104	104	0	0	208
SK	Prešov	107	112	0	0	219
	Žilina	100	99	0	0	199
UA	Iwano-Frankiwsk_1	134	133	0	0	267
	Iwano-Frankiwsk_2	69	70	0	0	139
	Lemberg	112	117	0	0	229
Total		2 723	1 820	428	1 090	6 061

The seven participating laboratories were responsible for sampling. Depending on the source country and the expertise of the research laboratories it was tried to identify the source of the timber as precise as possible. Most specimens were ordered in three different cross-sections in order to account for possible size effects: 38 x 100 mm², 50 x 150 mm² and 44 x 200 mm². Independent of the cross-section a length of 4 meters was aspired. Actually sampled dimensions are visualized in Figure 2, not considering the width of 74 pieces with a specialized cross-section of 140 x 140 mm^2 from Slovenia in the diagram for thickness. While for thickness and width no differences based on the origin were found, the timber from FI, SE and RU clearly differs from the aspired length.

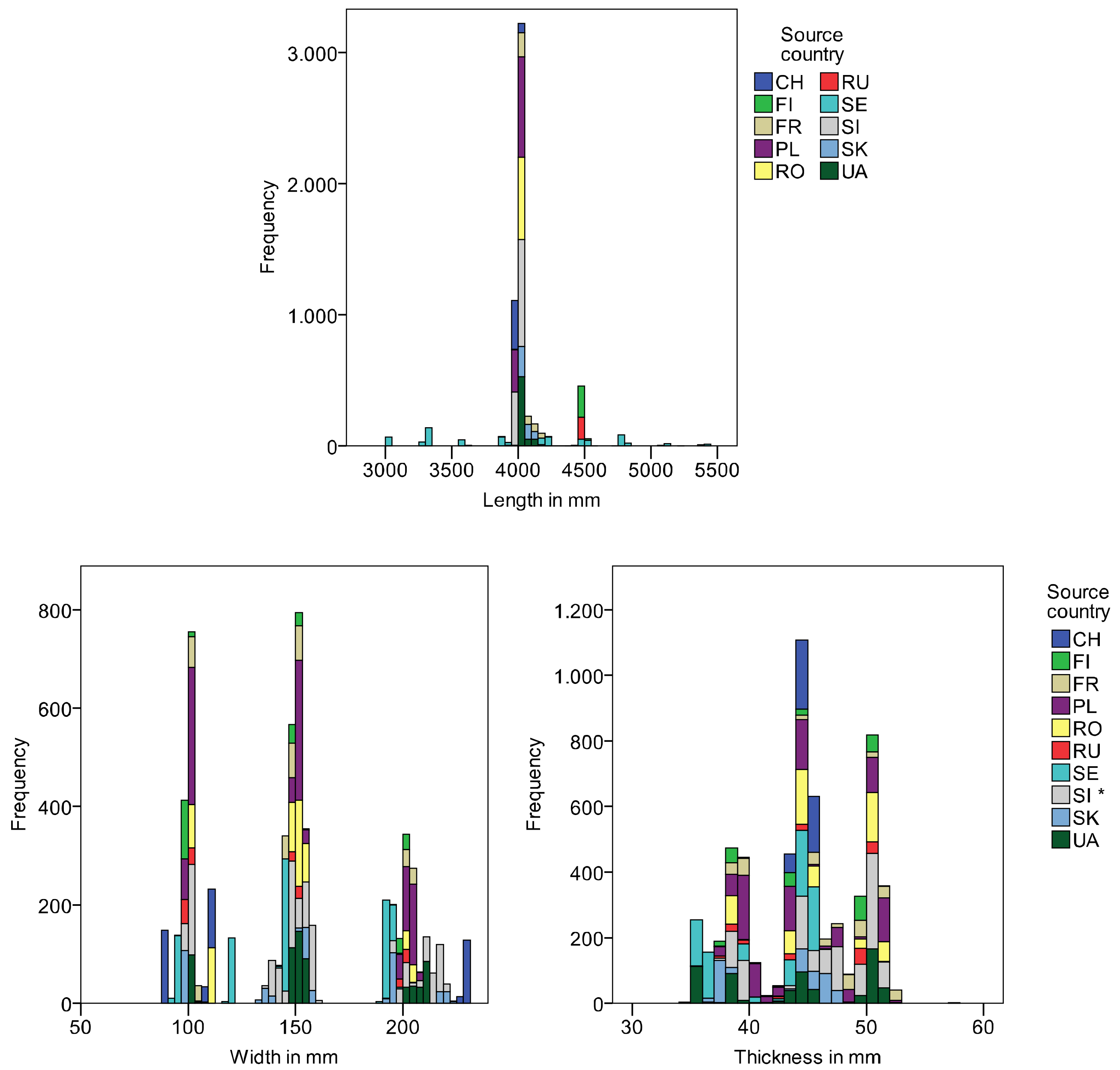


Figure 2. Dimensions of the sampled material.

3. Methods

3.1 Overview

Prior to testing each specimen destructively, nondestructive measurements have been performed by participating laboratories as well as by participating grading machine producers. All measurements are listed in Table 2. A description of methods and calculation of the numerical results is given method by method in the following.

Table 2. Measured property by participants.

Participant (equipment)	Measured property
all laboratories	frequency
	width, thickness. length
	weight
	moisture content
	KAR, KAR position
	local, global modulus of elasticity
	maximum force
	destructive test time
	strength
ETH, FCBA, TUM, UL	running time
Rosegrade	frequency
Escan, MTG	frequency
	density
Triomatic	running time
	local density
GoldenEye-706, Combiscan	frequency
	density
	knots

3.2 Non destructive testing

3.2.1 Laboratory testing

3.2.1.1 Determination of dynamic modulus of elasticity

The dynamic modulus of elasticity was determined based on weight, length, width and thickness as well as on the frequency of longitudinal vibration. In addition some research partners quantified the dynamic modulus of elasticity by means of ultrasonic waves.

Width and thickness were measured at different points over the length. The mean value of the measurements was reported. Measuring the length with a tape and the weight of the timber using a scale allowed to calculation the global density of the board. Obtained density is called ρ_{specimen} here.

Moisture content measurements are necessary to get comparable modulus of elasticity at a moisture content of 12%, as parameters alter depending on it. Depending on the time difference between measuring the variables for the calculation of the dynamic MOE and the destructive tests, the moisture content has been determined based on the difference between the mass before drying (m_u) and after drying (m_0) (EN 13183-1) of a defect free piece of timber or based on the electric resistance method.

For the natural frequency measurement the first resonance frequency in longitudinal vibration was determined. The measurement in laboratory was done by placing each specimen on two elastic supports and hitting one end of it by a hammer, or something similar, which excites the vibration. The vibration was measured in several different ways (microphone, accelerometer, optically). Based on the natural frequency and length measurement only, the dynamic modulus of elasticity can not be calculated. Still the two variables were used to calculate $E_{\text{freq,test}}$, which lets us estimate the dynamic MOE. This was done, as $E_{\text{freq,test}}$ comes close to IPs from grading machines which measure the frequency but not the density. As for laboratory measurements density is available, a real dynamic modulus of elasticity value is obtained ($E_{\text{dyn,test}}$). Obviously the accuracy in prediction static modulus of elasticity and density for the one including information about density is higher than the one without it. The two modulus of elasticity values are calculated as follows:

$$E_{freq,test} = (2 \cdot freq \cdot L)^2 \rho_{450} \tag{1}$$

$$E_{dyn,test} = (2 \cdot freq \cdot L)^2 \rho_{specimen,test} \tag{2}$$

where ρ_{450} is assumed constant value of density (450 kg/m^3) and $\rho_{specimen,test}$ is based on measurement of each specimen. These dynamic modulus of elasticity values are adjusted to 12% moisture content similarly as static modulus of elasticity in Equation (7).

The dynamic modulus of elasticity by use of sound waves was additionally calculated, if an ultrasonic device was available at a laboratory. Therefore, the running time of the waves was measured by attaching two probes on the ends of the specimen. An ultrasonic sound pulse is excited to the specimen at one end. At the other end the transit time and transmitted energy is measured.

3.2.1.2 Knot area measurement

The knot area ratio (KAR) is the ratio of the area of the knots projected on a cross section to the cross sectional area of the piece. Overlapping knot areas were counted only once. The KAR knot cluster was detected over a length of 150 mm. If the board contains pith, the exact position was determined in order to design the knot areas. The KAR value was determined in the relevant testing range only. This means, that for bending tests the range is limited to the distance between the inner load points plus one times the width on the right and the left border. For tension testing the knots were detected on the whole length between the two jaws.

3.2.2 Machine testing

3.2.2.1 Determination of dynamic modulus of elasticity

All machine producers use frequency or running time measurements for predicting timber properties. Main difference is on the measurement device for the frequency and the density measurements. While most machines use scales for calculating the density, one machine uses x-ray radiation for getting a density value. One machine does not measure density at all.

3.2.2.2 Knot measurement

Knot measurements are done by Luxscan and MiCROTEC. Luxscan uses optical knot detection software for calculating knot values, while MiCROTEC uses x-ray radiation. Both manufacturers calculate different knot values to be able to get the best predicting value for different species.

3.2.2.3 Available machine data

Based on the machine measurement, up to three IPs are calculated for each machine. Not every piece was measured by each machine system, as some manufacturers did not grade all specimens (Table 3). Even if manufacturers graded all specimens, the number of available IPs can deviate from the maximum possible number, if necessary information was not recorded by the system.

Table 3. Numbers of specimens which were measured by different machine systems.

Machine & Indicated property	Pine		Spruce	
	bending	tension	bending	tension
GoldenEye-706, Indicating strength	428	1 090	2 723	1 820
GoldenEye-706, Indicating stiffness	428	1 090	2 723	1 820
GoldenEye-706, Indicating density	428	1 090	2 723	1 820
Combiscan, Indicating strength	428	1 053	2 646	1 377
Escan, Indicating strength	428	1 053	2 646	1 377
Escan, Indicating density	428	1 053	2 646	1 377
Triomatic, Indicating strength	427	1 041	2 704	1 808
Triomatic, Indicating density	427	0	2 274	1 590
Rosegrade, Indicating strength	423	1 069	2 705	1 805
MTG, Indicating strength	418	1 073	2 671	1 761
MTG, Indicating stiffness	418	1 073	2 671	1 761
MTG, Indicating density	418	1 073	2 671	1 761

3.3 Destructive testing

3.3.1 Test methods

3.3.1.1 Strength

Destructive tests have been preformed according to EN 408 and calculated to reference values following mainly EN 384.

The critical cross section was chosen visually and placed between the loading heads in bending or between the jaws in tension. Following EN 384, only the critical cross section that can be located between the loading heads in a bending test or between the jaws in a tension test was considered.

Bending tests were performed using a distance between the supports of 18*width of the specimen and a distance between loading heads was 6*width. The load was applied on the edge of the specimen and the tension edge was selected at random.

In tension the critical cross section was located in the range of 9*width. The specimens were gripped by jaws on both endings. The length of gripping was between 800 mm and 1 200 mm on each side.

For some measurements this general set up was not followed: ETH performed tension tests over the maximum possible free test length exceeding 3 000 mm. HFA had to decrease the distance of the supports for some specimens with a width of 220 mm in bending, as these specimens were too short. In this case, the total test length was 16 times the width, the distance of the inner load points was 6 times the width.

3.3.1.2 Modulus of elasticity

Both, static local and static global moduli of elasticity were measured for bending. Except for ETH, which used a different test setup, one modulus of elasticity value was delivered for tension.

The static local modulus of elasticity in edgewise bending and the static local modulus of elasticity in tension are determined in accordance to EN 408, i.e. that the gauge length for the determination of the modulus of elasticity is 5 times the width. If possible, modulus of elasticity was determined in the linear range of the stress-strain diagram between 10% and 40% of the maximum stress.

For some measurements these instructions were not followed. ETH chose a different test setup for the tension tests using the whole length of each specimen. For that reason they had more freedom to choose the position for the static local modulus of elasticity measurement. If possible this was done at the position of the biggest KAR value. Additionally, values for a global modulus of elasticity calculated from the tension test machine were transmitted. UL measured the displacement for the local bending modulus of elasticity on the lower face of the specimens.

3.3.2 Density

The density was measured by taking a section which was cut out of each specimen as close as possible to the fracture. As mentioned in EN 408 the section was of full cross section, free from knots and resin pockets. This section was dried, so that its dry mass, volume and density can be determined. Reported densities based on these small sections are named ρ in the following and were corrected to a moisture content of 12%.

3.3.3 Adjustments

To keep laboratory data comparable EN 384 fixes reference values for moisture content, size and test arrangement. These references are...

...moisture content of 12%
...width of 150 mm
...distance between the supports of 18*width in bending
...distance between the loading heads of 6*width in bending
...distance between the jaws of 9*width in tension.

To adjust laboratory data to these references the following equations were used. Most of the equations are given in EN 384. In the case of length adjustment for tension the exponent was taken from EN 1194.

- Adjustment of bending strength to similar size:

for width: $f_m = (width/150)^{0.2} \, f_{m,test}$ (3)

for length: $f_m = ((\ell + 5 \cdot a)/(48 \cdot width))^{0.2} \cdot f_{m,test}$ (4)

- Adjustment of tensile strength to similar size:

for width: $f_t = (width/150)^{0.2} \, f_{t,test}$ (5)

for length: $f_t = (\ell/(9 \cdot width))^{0.1} \cdot f_{t,test}$ (6)

- Adjustment of modulus of elasticity

to a moisture content u = 12%: $E = E_{test}/(1 - 0.01 \cdot (u - 12))$ (7)

to a pure modulus of elasticity in bending if tested globally:

$E = 1{,}3 \cdot E_{global} - 2690$ (8)

In the case of $E_{freq,test}$ the correction according to SCHNABEL 2006 was used.

- Adjustment of density values to a moisture content u = 12%

$\rho = \rho_{test}/(1 + 0.005\,(u - 12))$ (9)

In the following chapters the authors refer to adjusted values only. Also all regression analysis is based on adjusted values like strength, modulus of elasticity and density.

3.4 Methods of analysis

Statistical analysis of the results is made by using standard methods. In addition, “bandwidth” method was used for analysis of similarity of graded timber grown in different areas [1].

Strength, stiffness or density indicating properties *IP*1–*IP*12 are calculated based on readings of participating grading machines identified in Table 4. These are regression lines between the grade determining property and one or more measured parameters in all data, separately for spruce in bending and tension and for pine in bending and tension. Used *IP*-functions for MTG machine are based on old data from different growth area which may course lower correlation between *IP* and grade determining property in our results. These functions of all machines may be different from those used in commercial grading.

Table 4. Numbering of machine IP’s.

IP1	GoldenEye-706, Indicating strength
IP2	GoldenEye-706, Indicating stiffness
IP3	GoldenEye-706, Indicating density
IP4	Combiscan, Indicating strength
IP5	Escan, Indicating strength
IP6	Escan, Indicating density
IP7	Triomatic, Indicating strength
IP8	Triomatic, Indicating density
IP9	Rosegrade, Indicating strength
IP10	MTG, Indicating strength
IP11	MTG, Indicating stiffness
IP12	MTG, Indicating density

Regression lines are calculated for the grading machine model (*IP1*) with highest coefficient of determination:

$$f = a\,\mathrm{IP1} + b \tag{10}$$

and for the model equivalent to the most commonly used grading method today:

$$f = cE_{freq} + d \tag{11}$$

Obtained values for coefficients *a*, *b*, *c* and *d* are given in Appendix A in the same tables with correlations, separately for each region.

4. Results

4.1 Basic statistical results of ungraded timber

4.1.1 Spruce in bending

Summary of destructive test results for spruce in bending are given in Table 5, which shows means and *CoV*'s of strength, stiffness and density separately for each country and for the combined sample. Same information is given also of existing results from Sweden and Germany as reference of Northern and Central European values. New Swedish sample has on average same density but lower modulus of elasticity and strength than Swedish reference data. Slovenian and French samples have values on the same level as the earlier German data, but all other samples have lower average properties. All mean values of Romanian, Ukraine and Slovakian samples are clearly below Central European reference.

Degrees of determination between destructive and non-destructive test values are shown for combined spruce sample in Table 6. Results for participating grading machines are shown in Table 13. Correlations for each sample are in Appendix A. Also regression lines are calculated for the model (*IP1*) with highest coefficient of determination, and for the model equivalent to the most commonly used grading method today (E_{freq}). Obtained values for coefficients a and b of Equation (10), and c and d of Equation (11) are given in Appendix A in the same tables with correlations, separately for each region.

Some regression lines are shown in Figures 3–6. Figures 3 and 5 show regression lines between strength and *IP1*, and Figures 4 and 6 between strength and E_{freq}. Variation between regression lines based on *IP1* is smaller than between lines based on E_{freq}. Variation between Slovenian regions is clearly larger in case of E_{freq} than between all samples from Slovenia, Ukraine, Poland and some others in case of *IP1* in Figure 5.

Most different from the others were the sample from Västergötland (highest slope) and Alsace (highest level). Sample of Prešov shows exceptionally high slope in case of E_{freq} but low slope in case of *IP1*.

Table 5. Summary of the destructive test results of spruce in bending. For comparison some results of [1] are also shown.

SPRUCE bending	f_m		E		ρ		n
	mean N/mm²	COV	mean N/mm²	COV	mean kg/m³	COV	
Sweden	42.5	0.35	11 300	0.22	435	0.12	210
Poland	38.5	0.31	11 400	0.20	440	0.11	433
Slovenia	43.7	0.30	12 000	0.20	445	0.10	1 163
France	42.9	0.26	11 900	0.17	440	0.10	118
Slovakia	34.8	0.33	10 200	0.20	415	0.10	213
Romania	35.5	0.31	9 600	0.19	387	0.10	321
Ukraine	36.2	0.29	10 000	0.19	389	0.10	204
All above	40.2	0.32	11 200	0.21	428	0.11	2 776
Sweden, earlier data	44.8	0.30	12 300	0.22	435	0.12	4 393
Germany, earlier data	41.5	0.34	12 100	0.26	441	0.11	3 538

Table 6. Coefficient of determination r^2 of individual NDT-measurements to destructively determined properties for spruce in bending.

SPRUCE bending Source	**r^2 of \ to destruct.**	f_m	E_{global}	ρ	n
Destructive test	f_m	1.00	0.66	0.28	2 776
Destructive test	E_{global}	0.66	1.00	0.54	2 776
Destructive test	ρ	0.28	0.54	1.00	2 776
Lab. weighing by scale	$\rho_{specimen}$	0.25	0.50	0.94	2 776
Lab. NDT/Freq.	E_{freq}	0.51	0.68	0.23	2 776
Lab. NDT/Freq. + dens.	E_{dyn}	0.54	0.83	0.66	2 776
Lab. NDT/ultrasonic	E_{dyn}*(running time)*	0.40	0.70	0.66	1 612
Lab. visual	*KAR*	0.31	0.21	0.06	2 776

4. Results

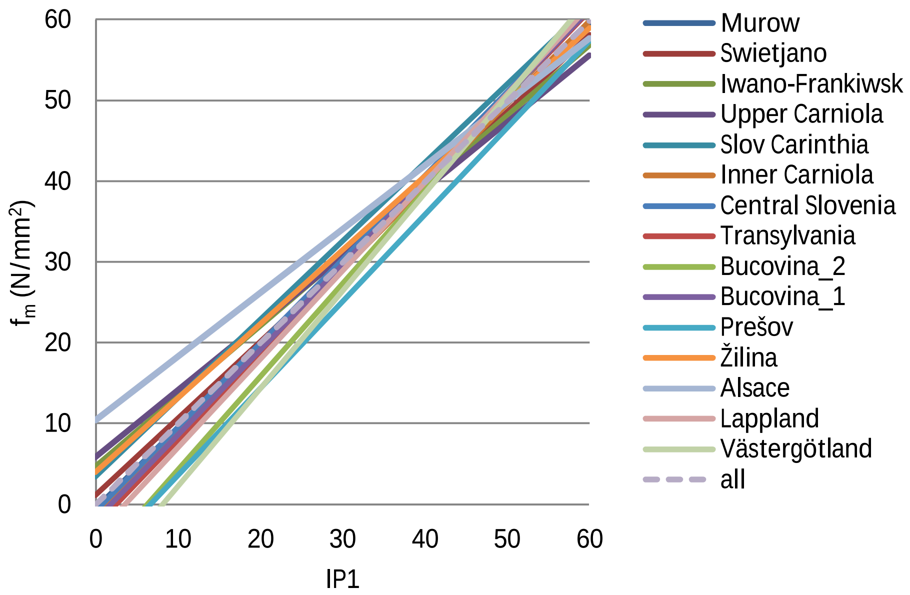


Figure 3. Regression lines between bending strength of spruce and IP1 in all regions.

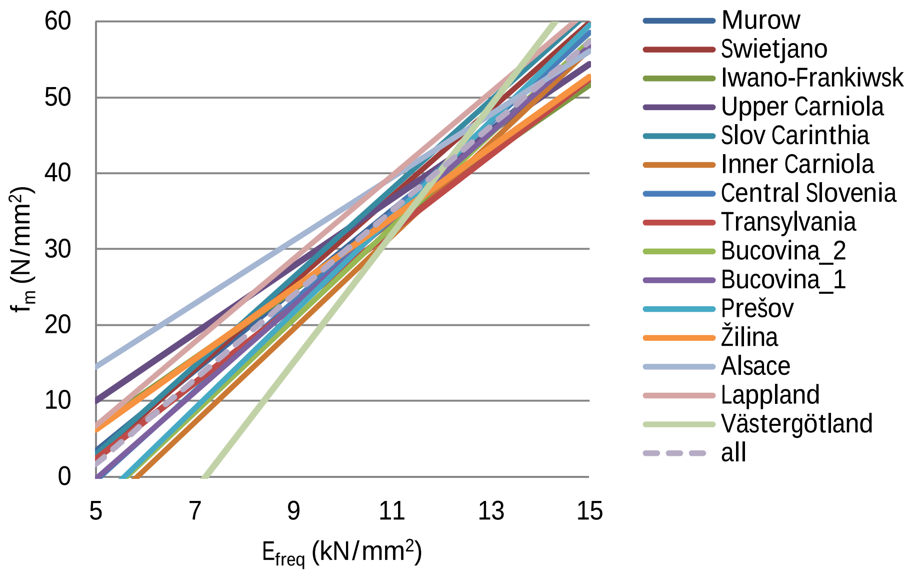


Figure 4. Regression lines between bending strength of spruce and E_{freq} in all regions.

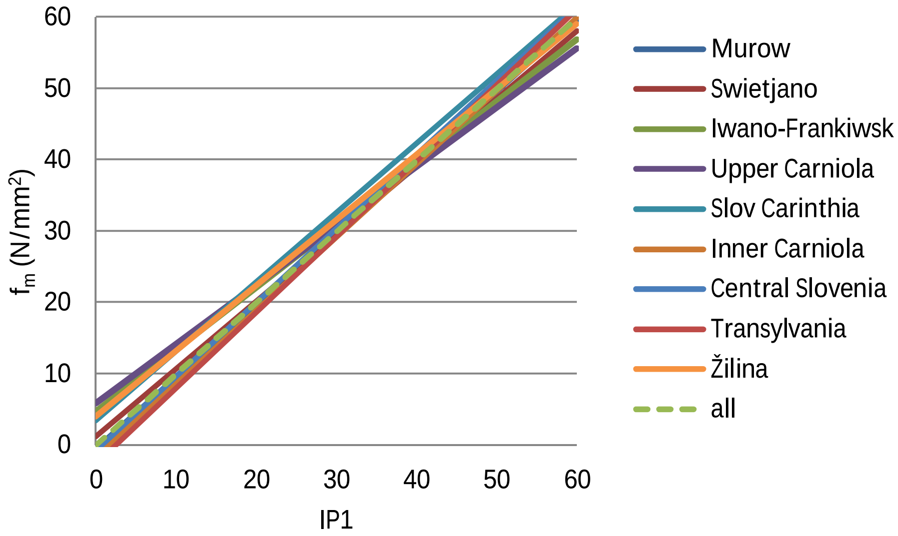


Figure 5. Regression lines between bending strength of spruce and IP1 in all regions except Sweden, Alsace, Bucovina and Presow. "All" refers to all tested data.

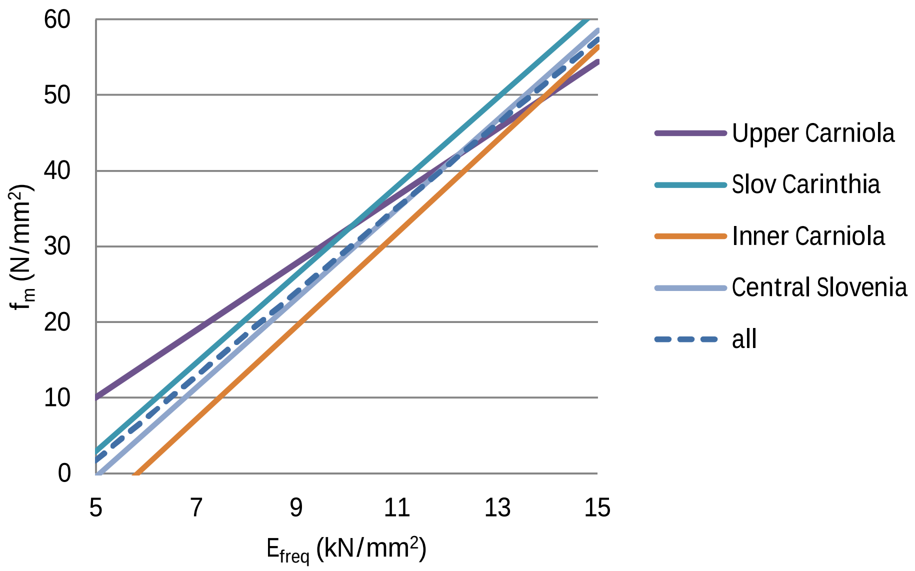


Figure 6. Regression lines between bending strength of spruce and E_{freq} in Slovenian regions. "All" refers to all tested data.

4.1.2 Spruce in tension

Summary of destructive test results for spruce in tension are given in Table 7, which shows means and CoV's of strength, stiffness and density separately for each country and for the combined sample. For reference, earlier results from Finland, Austria and

Germany are also given. New results of Slovenia are the highest and compatible to earlier sample from Schwaben, Germany. The new sample of Sweden shows low values which are below the earlier data from Finland. The old sample of Austria has the lowest strength, but new samples from Romania and Ukraine have the lowest densities and moduli of elasticity.

Coefficients of determination between destructive and non-destructive test values are shown for combined spruce sample in Table 8. Results for participating grading machines are shown in Table 13. Values are on same level as they were in case of spruce in bending. Correlations for each sample are in Appendix A. Also regression lines are calculated for the model (*IP1*) with highest coefficient of determination and for the model equivalent to the most commonly used grading method today (E_{freq}).

Obtained values for coefficients *a* and *b* of Equation (10), and *c* and *d* of Equation (11) are given in Appendix A in the same tables with correlations, separately for each region.

Regression lines of all samples are shown in Figures 7 and 8. Quite similar regression lines can be found in different countries (Figure 9) and some variability within one country (Figure10).

Table 7. Summary of the destructive test results of spruce in tension. For comparison some results of [1] are also shown. Strength values are adjusted to reference width 150 mm and to free length 1 350 mm.

SPRUCE tension	f_t		E		ρ		n
	mean N/mm^2	COV	mean N/mm^2	COV	mean kg/m^3	COV	
Sweden	27.6	0.38	10 200	0.23	416	0.12	218
Poland	28.2	0.38	11 600	0.23	452	0.12	222
Slovenia	34.0	0.44	12 300	0.22	442	0.09	104
Switzerland	27.8	0.44	10 900	0.24	439	0.12	447
Slovakia	27.2	0.40	10 700	0.20	408	0.09	215
Romania	25.6	0.42	10 000	0.21	390	0.08	319
Ukraine	26.7	0.44	10 300	0.21	392	0.11	329
All above	27.5	0.43	10 700	0.23	418	0.12	1 854
Finland, earlier data	33.2	0.34	11 800	0.19	445	0.10	611
Austria, earlier data	25.1	0.42	10 100	0.26	435	0.12	311
GER Schwaben, earlier data	32.6	0.37	12 100	0.21	451	0.11	588

Table 8. Coefficient of determination r^2 of individual NDT-measurements and grading machine IP's to destructively determined properties for spruce in tension. N = 1 854 (883 for "lab NDT/ ultrasonic").

SPRUCE tension Source	r^2 of \ to destruct.	f_t	E	ρ
Destructive test	f_t	1	0.63	0.21
Destructive test	E	0.63	1	0.45
Destructive test	ρ	0.21	0.45	1
Lab. weighing by scale	$\rho_{specimen}$	0.17	0.37	0.86
Lab. NDT/Freq.	E_{freq}	0.59	0.65	0.12
Lab. NDT/Freq. + dens.	E_{dyn}	0.59	0.83	0.56
Lab. NDT/ultrasonic	E_{dyn}(running time)	0.42	0.70	0.66
Lab. visual	KAR	0.33	0.22	0.04

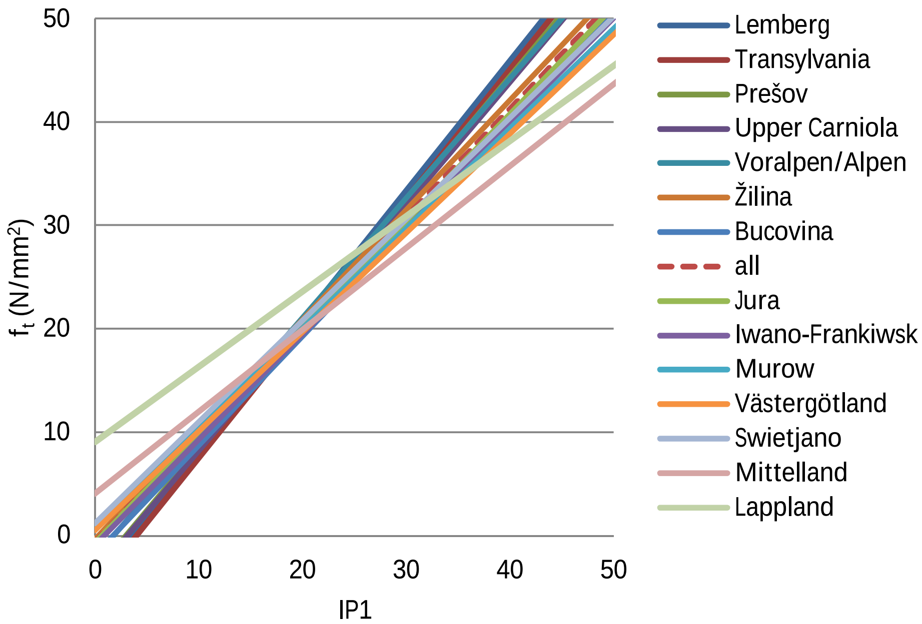


Figure 7. Regression lines between tension strength of spruce and IP1 in all regions.

4. Results

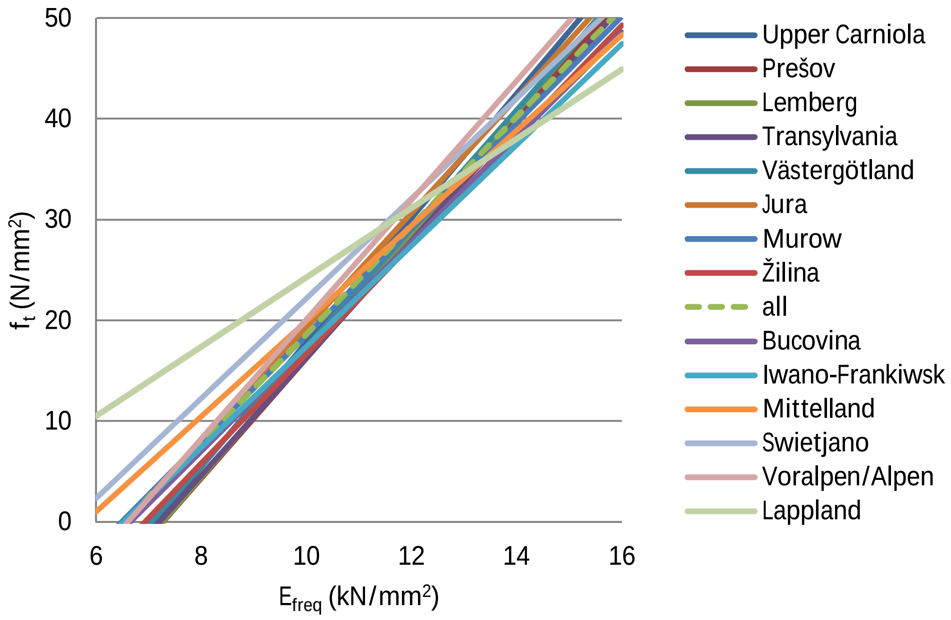


Figure 8. Regression lines between tension strength of spruce and E_{freq} in all regions.

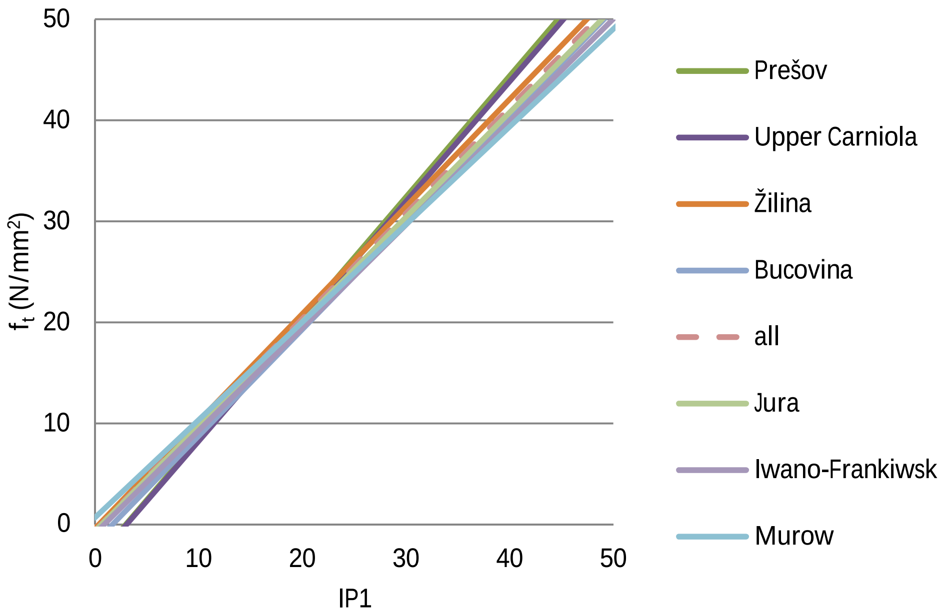


Figure 9. Regression lines between tension strength of spruce and IP1 in selected regions of Poland, Switzerland, Slovakia, Slovenia, Romania and Ukraine. “All” refers to all tested data.

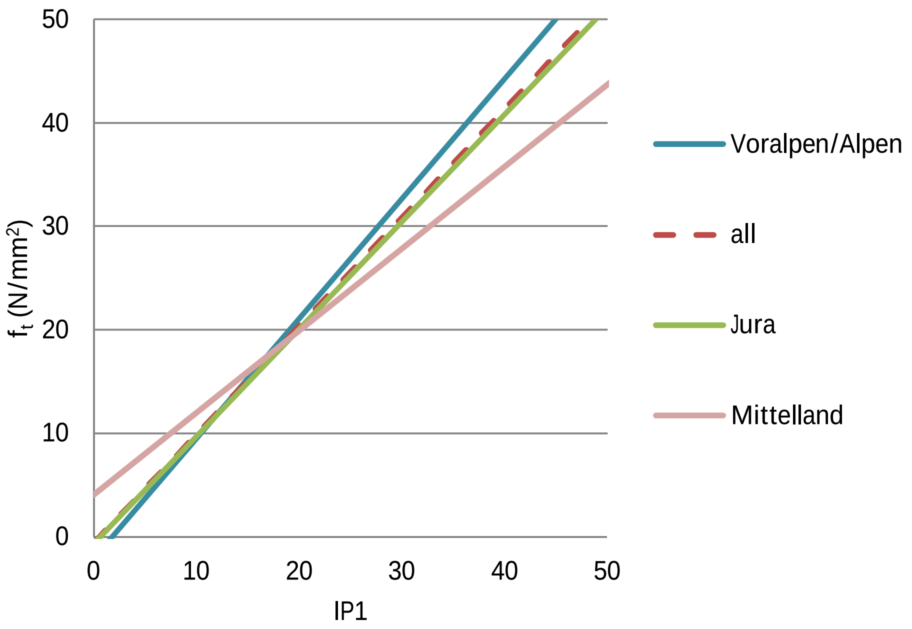


Figure 10. Regression lines between tension strength of spruce and IP1 in tested regions of Switzerland. “All” refers to all tested data.

4.1.3 Pine in bending

Summary of destructive test results for pine in bending are given in Table 9, which shows means and cov’s of strength, stiffness and density separately for each country and for the combined sample. New results from Sweden are on same level as old results from Finland. New results from Poland are similar to old results from North Germany. There is a clear difference in average properties between North and Central Europe: strength is 10% higher in North, and modulus of elasticity and density are higher in Central Europe. The Nordic values of pine are similar to spruce, except for density: pine has higher density than spruce.

Coefficients of determination between destructive and non-destructive test values are shown for combined pine sample in Table 10. Results for participating grading machines are shown in Table 13. Correlations for each sample are in Appendix A. Especially Swedish samples show higher correlation between strength and some indicating properties (density, *KAR*) which have low correlation in case of spruce. However, in combined Swedish-Polish sample, we cannot see higher correlation with density.

Also regression lines are calculated for the model (*IP1*) with highest coefficient of determination, and for the model equivalent to the most commonly used grading method today (E_{freq}). Obtained values for coefficients *a* and *b* of Equation (10), and *c* and *d* of Equation (11) are given in Appendix A in the same tables with correlations, separately for each region.

Regression lines of all samples are shown in Figures 11 and 12. In case of E_{freq} as indicating property one of the Swedish samples (Västerbotten) has regression line on 10 N/mm^2 higher level. In mean values, difference is nearly 20 N/mm^2. When looking at numerical values of E_{freq} one should notice that it is calculated on basis of assumed density ρ = 450 kg/m^3 which is low value for pine and gives about 10% lower values than E_{dyn} based on measured density.

Table 9. Summary of the destructive test results of pine in bending. For comparison some results of [1] are also shown.

PINE bending	f_m		E		ρ		n
	mean N/mm^2	COV	mean N/mm^2	COV	mean kg/m^3	COV	
Sweden	44.7	0.34	11 300	0.19	481	0.09	209
Poland	39.2	0.43	12 500	0.23	516	0.10	221
All above	41.9	0.39	11 900	0.22	499	0.11	430
North Germany, earlier	38.6	0.31	12 200	0.21	522	0.12	421
Finland, earlier data	44.9	0.31	11 900	0.24	493	0.11	849

Table 10. Coefficient of determination r^2 of individual NDT-measurements and grading machine IP's to destructively determined properties for pine in bending, n = 430 (220 for "lab NDT/ ultrasonic").

PINE bending Source	r^2 of \ to destruct.	f_m	E_{global}	ρ
Destructive test	f_m	1	0.53	0.21
Destructive test	E_{global}	0.53	1	0.54
Destructive test	ρ	0.21	0.54	1
Lab. weighing by scale	$\rho_{specimen}$	0.21	0.57	0.89
Lab. NDT/Freq.	E_{freq}	0.46	0.60	0.14
Lab. NDT/Freq. + dens.	E_{dyn}	0.50	0.85	0.54
Lab. NDT/ultrasonic[1]	E_{dyn}*(running time)*	0.44	0.75	0.54
Lab. visual	*KAR*	0.40	0.25	0.09

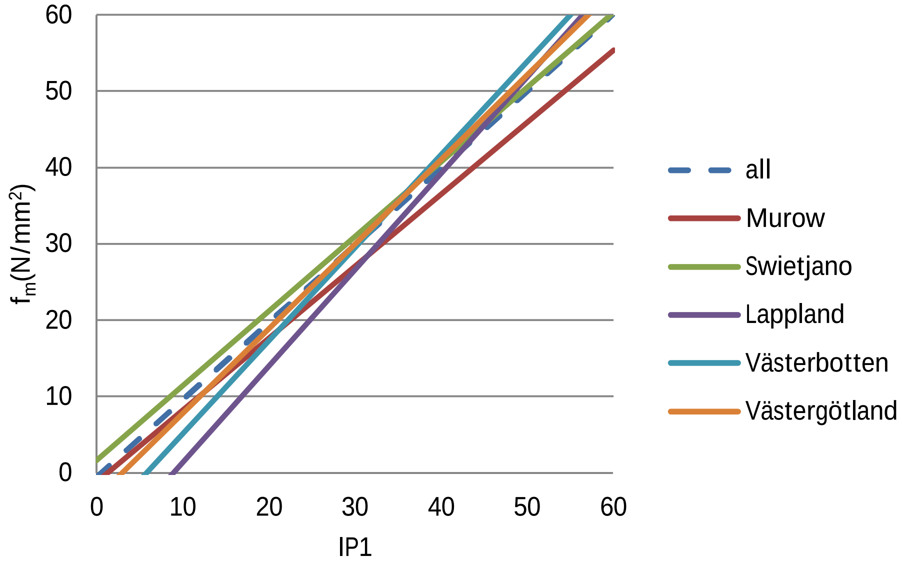


Figure 11. Regression lines between bending strength of pine and IP1 in all regions.

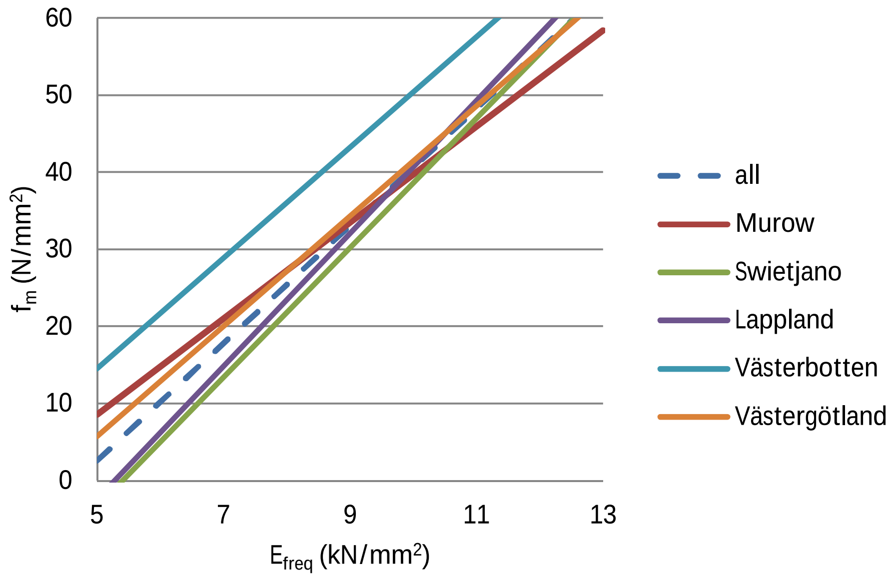


Figure 12. Regression lines between bending strength of pine and E_{freq} (ρ = 450 kg/m^3) in all regions.

4.1.4 Pine in tension

Summary of destructive test results for pine in tension are given in Table 11, which shows means and CoV's of strength, stiffness and density separately for each country and for the combined sample. Coefficients of determination between destructive and non-destructive test values are shown for combined pine sample in Table 12. Results for participating grading machines are shown in Table 13. Correlations for each sample are in Appendix A. Also regression lines are calculated for the model (*IP1*) with highest coefficient of determination, and for the model equivalent to the most commonly used grading method today (E_{freq}). Obtained values for coefficients *a* and *b* of Equation (10), and *c* and *d* of Equation (11) are given in Appendix A in the same tables with correlations, separately for each region.

Regression lines of all samples are shown in Figures 13 and 14. In case of Efreq as indicating property the scatter of the lines is much larger than in case of IP1. Coefficients of determination between strength and IP are 0.73 for IP1, and 0.49 for Efreq in the combined sample. Regression lines of Swedish samples are shown in Figures 15 and 16. Lines with IP1 are close to each other whereas lines of Efreq show clear differences. In case of tension sample of Västergötland is different from others, whereas in case of bending it Västerbotten was different.

Table 11. Summary of the destructive test results of pine in tension. Strength values are adjusted to reference width 150 mm and free length 1 350 mm.

PINE tension	f_t		E		ρ		n
	mean N/mm^2	COV	mean N/mm^2	COV	mean kg/m^3	COV	
Sweden	29.8	0.39	10 300	0.23	484	0.09	211
Poland	28.9	0.45	11 400	0.24	533	0.11	217
Finland	31.7	0.39	11 400	0.20	492	0.11	257
Russia	20.4	0.43	9 600	0.22	442	0.10	174
France	20.3	0.42	8 900	0.26	512	0.09	257
All above	26.4	0.46	10 400	0.25	495	0.12	1 115

Table 12. Coefficient of determination r^2 of individual NDT-measurements and grading machine IP's to destructively determined properties for pine in tension. N = 1 115 (667 for "lab NDT/ ultrasonic").

PINE tension Source	**r^2 of \ to destruct.**	f_t	E	ρ
Destructive test	f_t	1	0.66	0.27
Destructive test	E	0.66	1	0.35
Destructive test	ρ	0.27	0.35	1
Lab. weighing by scale	$\rho_{specimen}$	0.22	0.28	0.82
Lab. NDT/Freq.	E_{freq}	0.50	0.62	0.06
Lab. NDT/Freq. + dens.	E_{dyn}	0.64	0.79	0.41
Lab. NDT/ultrasonic	E_{dyn}*(running time)*	0.46	0.57	0.21
Lab. visual	*KAR*	0.43	0.30	0.11

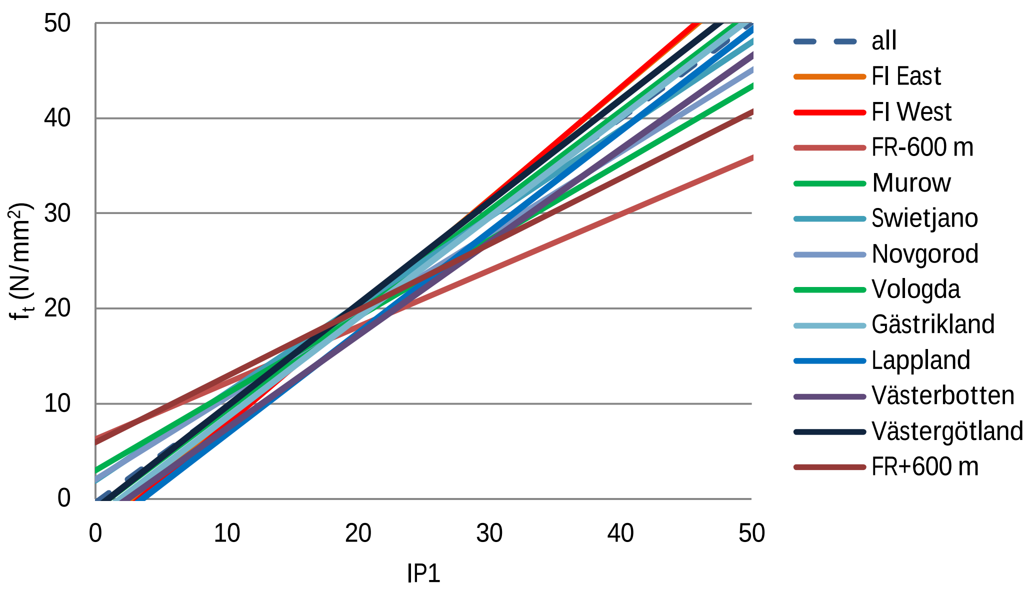


Figure 13. Regression lines between tension strength of pine and IP1 in all regions.

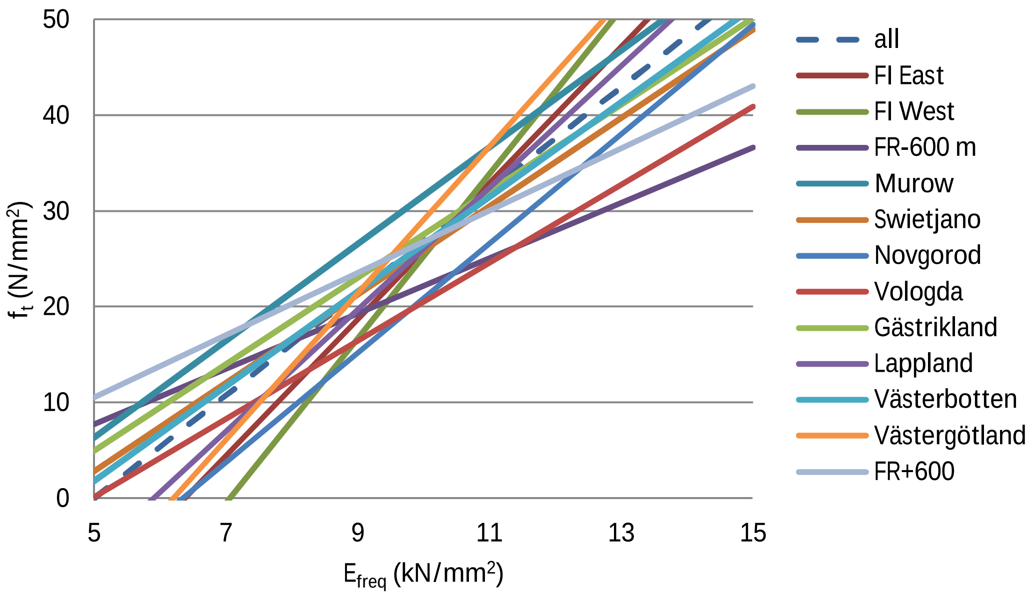


Figure 14. Regression lines between tension strength of pine and E_{freq} (ρ = 450 kg/m^3) in all regions.

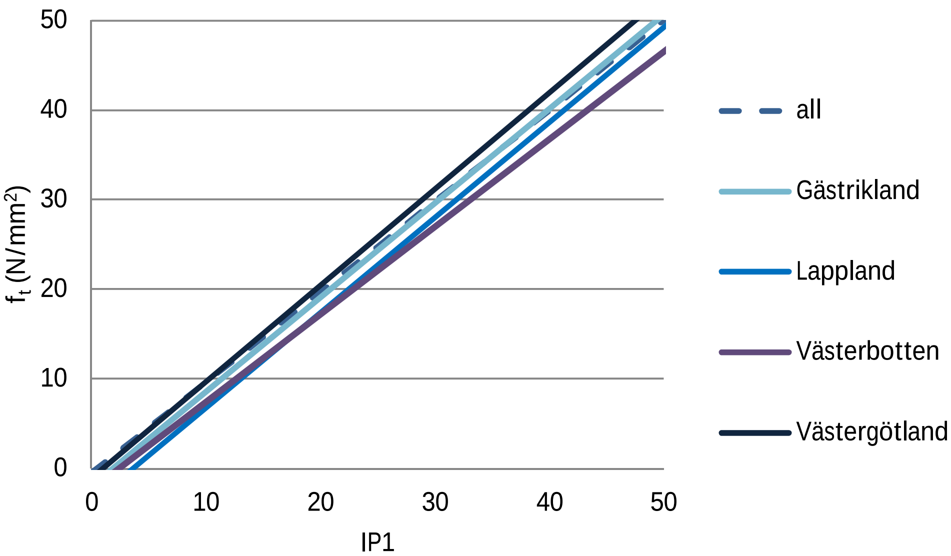


Figure 15. Regression lines between tension strength of pine and IP1 in Swedish regions. “All” refers to all tested data.

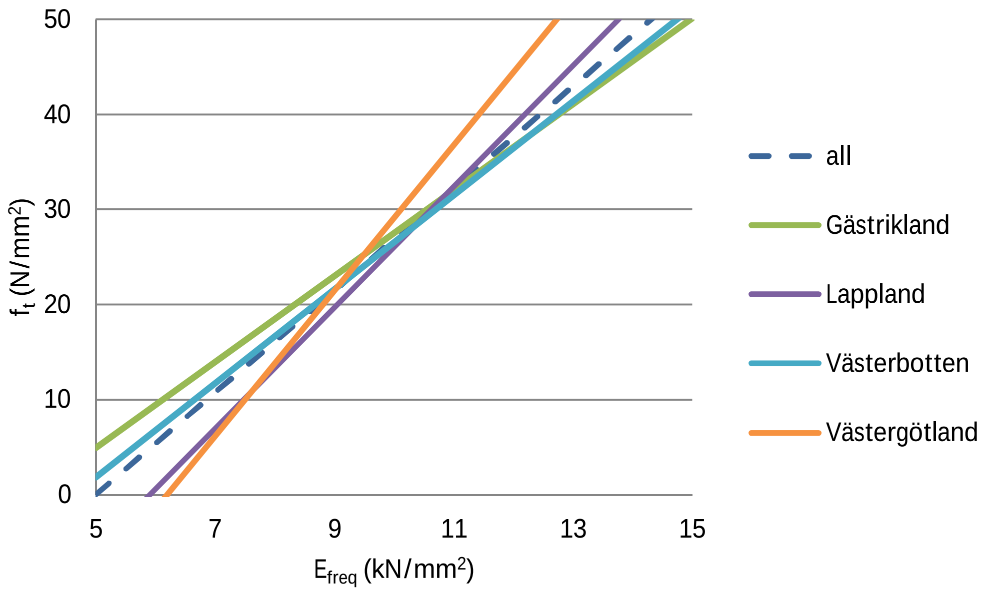


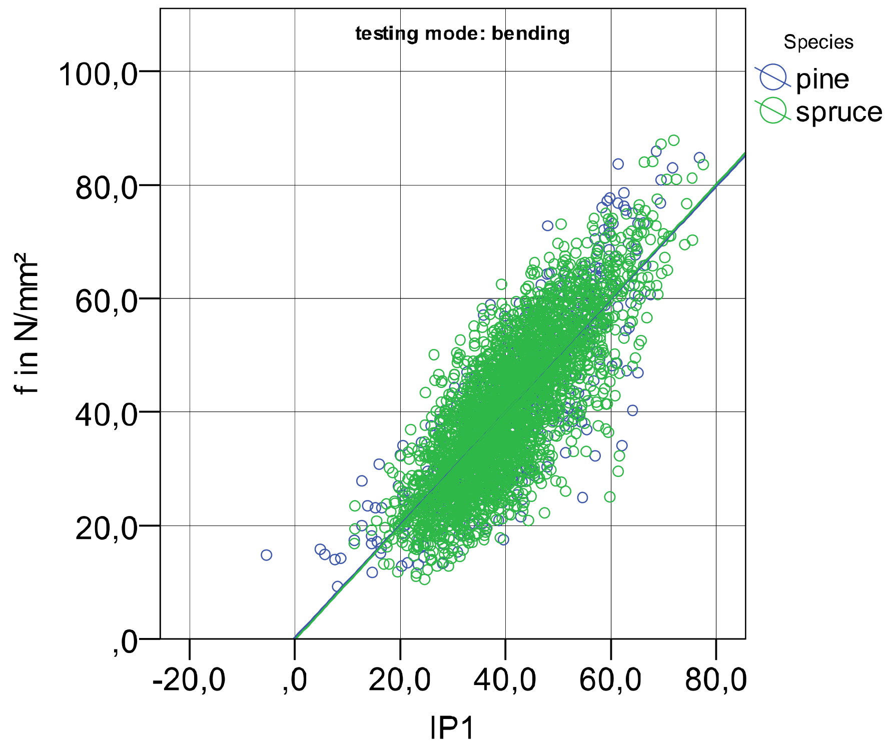
Figure 16. Regression lines between tension strength of pine and E_{freq} (ρ = 450 kg/m^3) in Swedish regions. “All” refers to all tested data.

4.1.5 Summary of machine data

Basical statistic figures for the used grading systems are already considered above. In the following the results are illustrated in Figures 17–22. While the results so far where shown separate for each load mode and species, different species are handeld together in this part. Table 13 summarizes the coefficients of determination.

Table 13. Summary of coefficients of determination r2 of grading machine IP's to destructively determined properties.

IP	Species	*f* in N/mm²		*E* in N/mm²		density in kg/m³	
		bending	tension	bending	tension	bending	tension
IP1	pine	0,67	0,72	0,68	0,74	0,34	0,35
	spruce	0,63	0,70	0,82	0,77	0,51	0,31
IP2	pine	0,52	0,64	0,84	0,78	0,50	0,43
	spruce	0,55	0,58	0,86	0,84	0,66	0,61
IP3	pine	0,28	0,25	0,61	0,29	0,86	0,84
	spruce	0,28	0,20	0,54	0,43	0,93	0,89
IP4	pine	0,56	0,62	0,64	0,72	0,36	0,42
	spruce	0,54	0,58	0,79	0,80	0,50	0,52
IP5	pine	0,39	0,57	0,75	0,76	0,50	0,42
	spruce	0,50	0,53	0,81	0,82	0,56	0,58
IP6	pine	0,17	0,25	0,45	0,31	0,70	0,76
	spruce	0,20	0,15	0,41	0,36	0,69	0,72
IP7	pine	0,43	0,39	0,63	0,50	0,31	0,05
	spruce	0,41	0,46	0,64	0,57	0,24	0,14
IP8	pine	0,42	-	0,63	-	0,36	-
	spruce	0,35	0,38	0,60	0,59	0,41	0,50
IP9	pine	0,41	0,50	0,59	0,63	0,16	0,06
	spruce	0,47	0,58	0,66	0,65	0,18	0,12
IP10	pine	0,48	0,59	0,83	0,76	0,57	0,51
	spruce	0,46	0,50	0,72	0,74	0,58	0,48
IP11	pine	0,51	0,58	0,83	0,75	0,50	0,35
	spruce	0,47	0,53	0,73	0,75	0,56	0,47
IP12	pine	0,16	0,09	0,46	0,12	0,78	0,68
	spruce	0,19	0,11	0,38	0,29	0,71	0,62



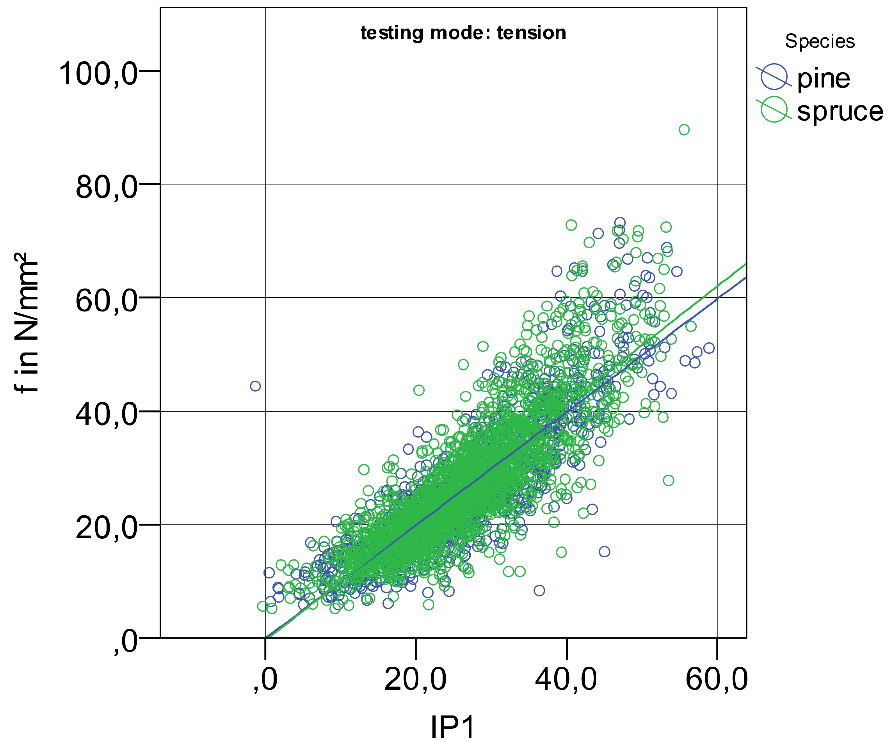
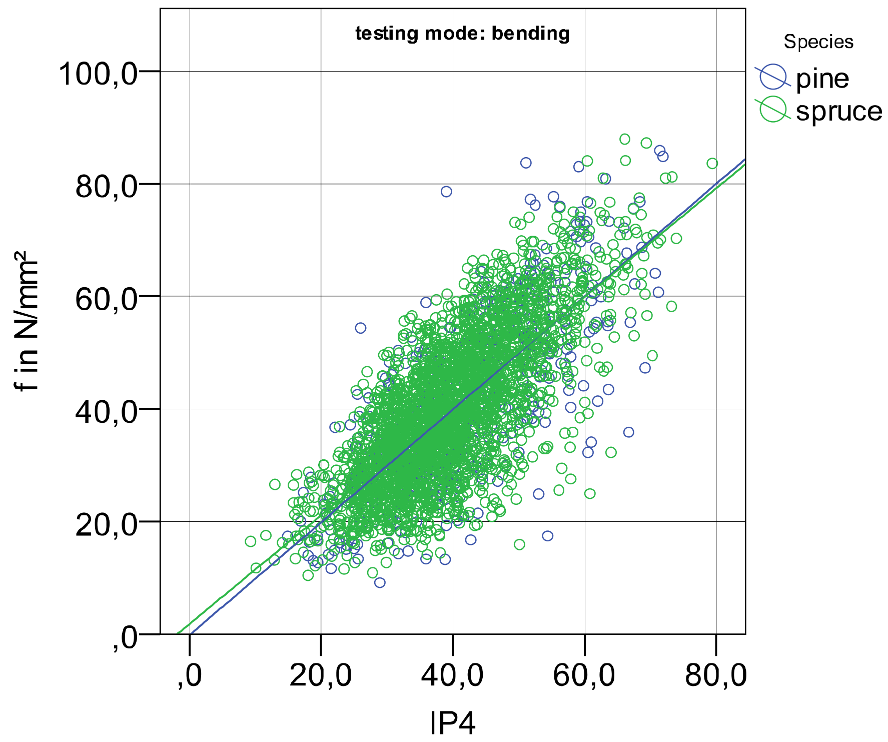


Figure 17. Plot of strength vs. IP1 of all results for bending (above) and tension (below).



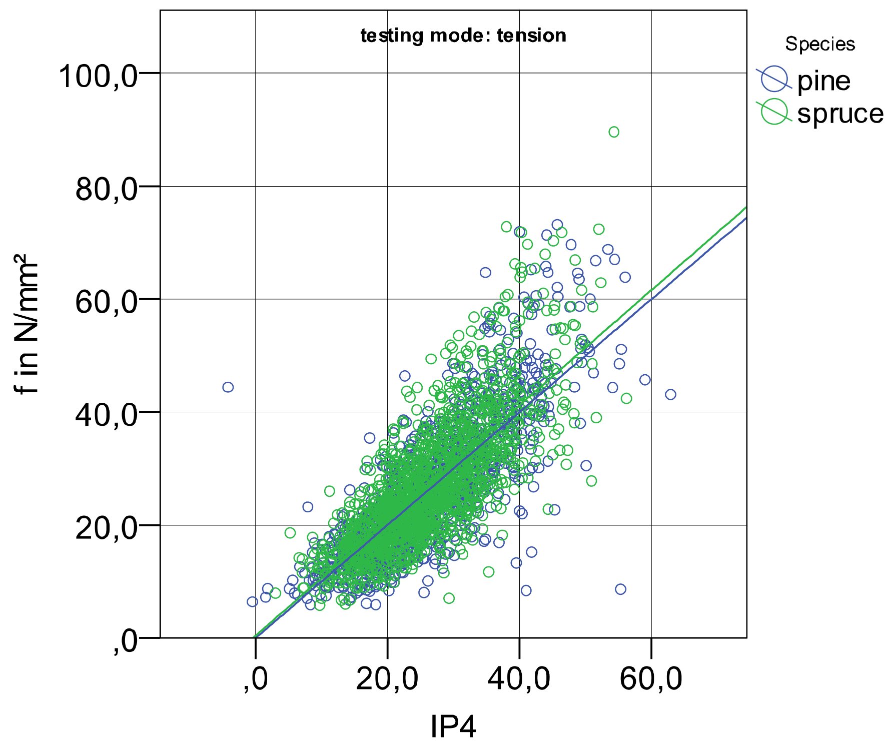


Figure 18. Plot of strength vs. IP4 of all results for bending (above) and tension.

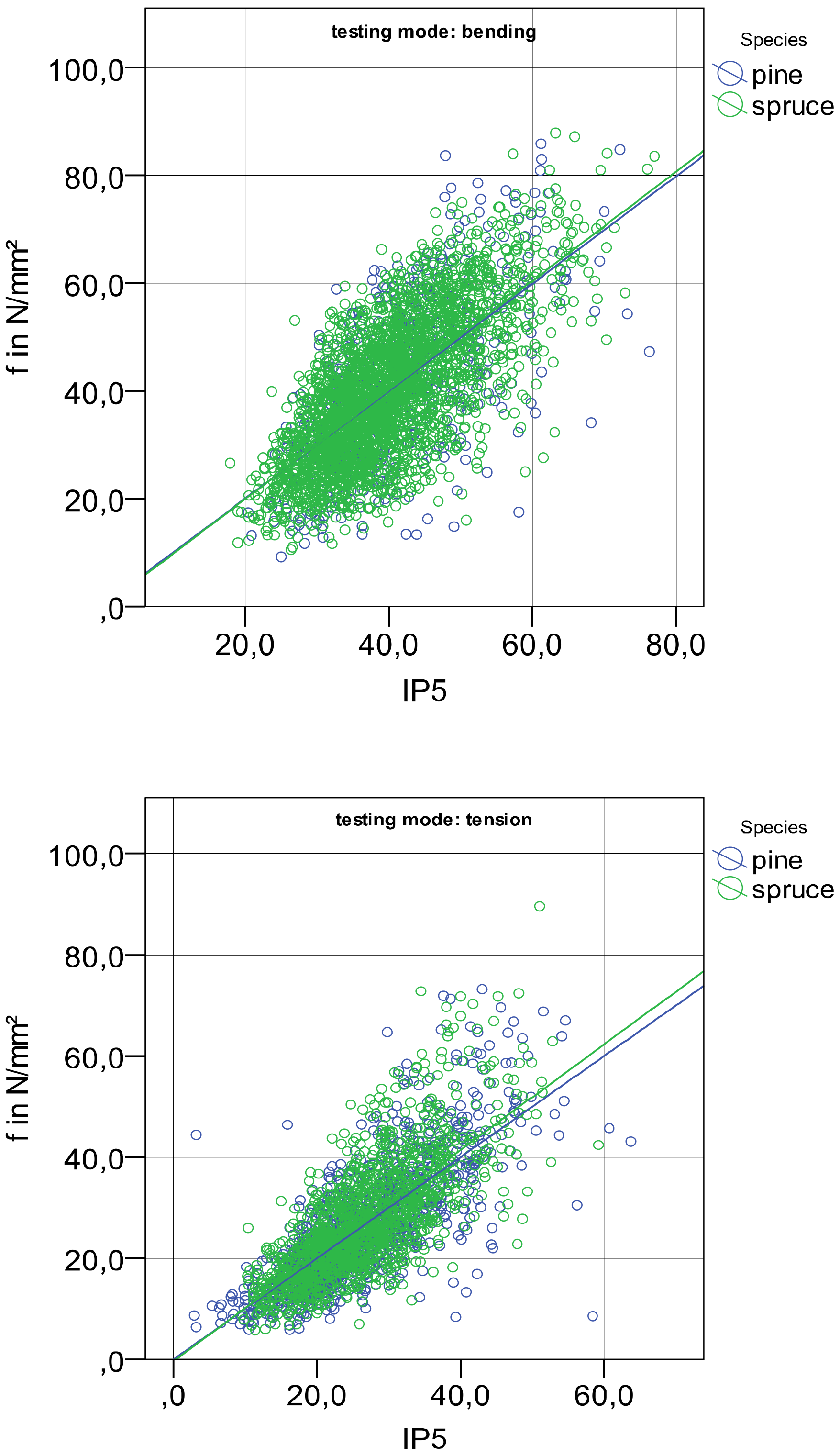


Figure 19. Plot of strength vs. IP5 of all results for bending (above) and tension.

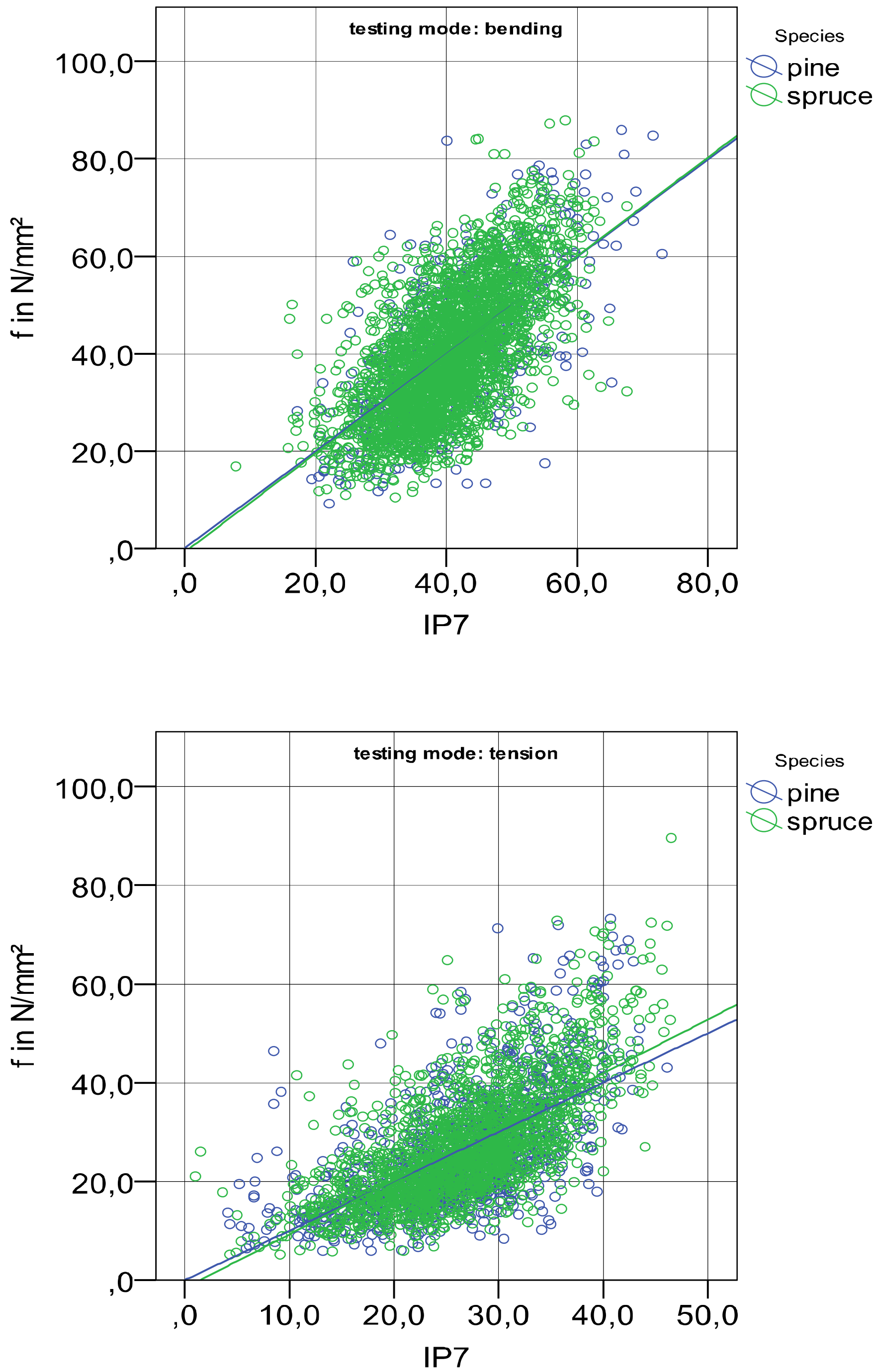


Figure 20. Plot of strength vs. IP7 of all results for bending (above) and tension.

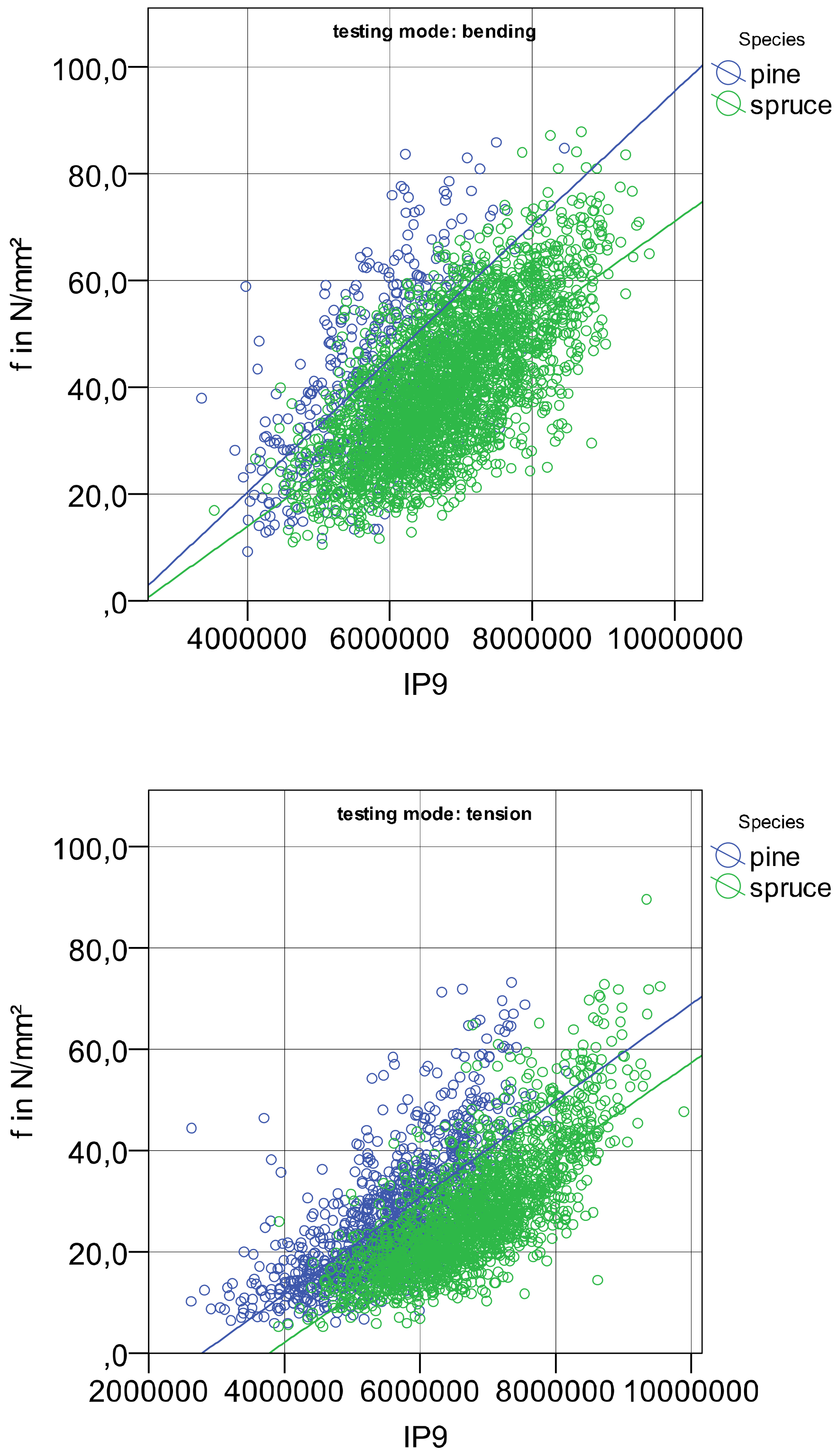
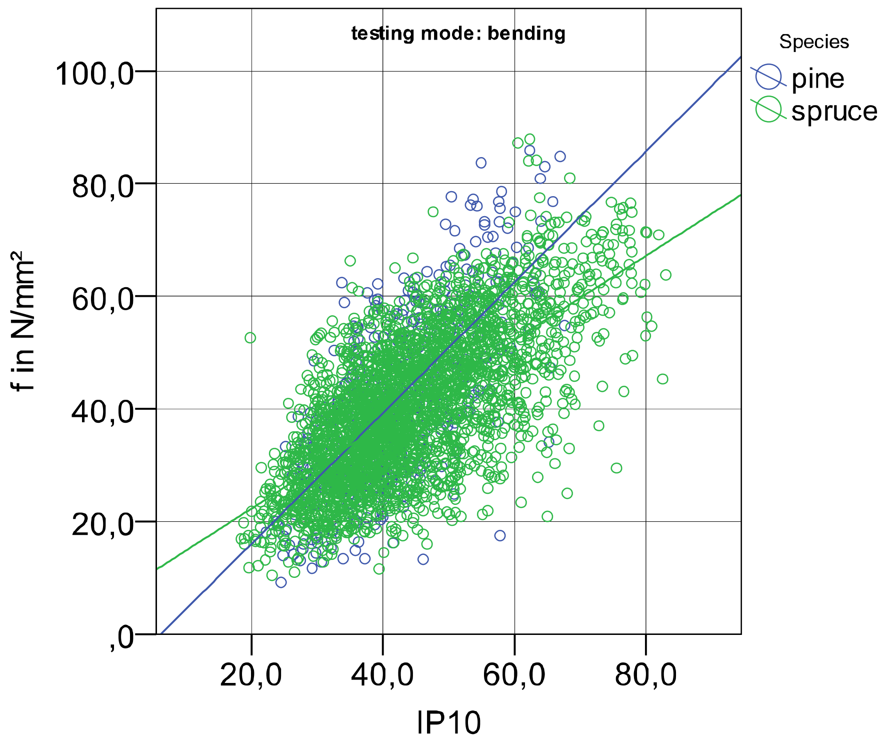


Figure 21. Plot of strength vs. IP9 of all results for bending (above) and tension.



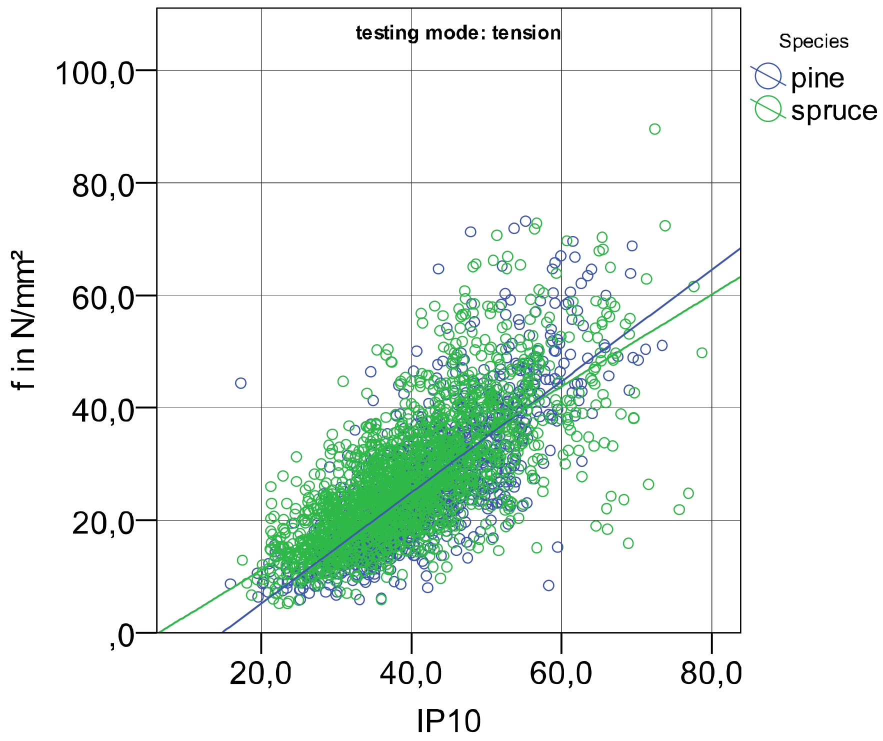


Figure 22. Plot of strength vs. IP10 of all results for bending (above) and tension.

4.2 Bandwidth method results in comparison to earlier data

The previous existing data of spruce in bending and tension as well as pine in bending has been analysed by the use of bandwidth method [1]. Comparison was made by dividing the data into bands of indicating properties (several different functions) and calculation of characteristic strength values (incl. confidence intervals) for these bands of material from different growth regions. This information was planned to be used for determination of grading areas where same settings could be used.

New tested material is now added to some Figures of [1] and comparison is made between new and old sampling regions. Model 2 of [1] (strength *IP* based of E_{dyn}) is used here which is regression line of the old data. Coefficients of equations are given in Tables 34, 41 and 49 of an earlier publication [1]. Confidence interval calculation of 5th percentile values is also explained in [1]. In brief, $\beta = 3$ limit means 90% confidence interval in case of Normal distribution and 99% interval in case of lognormal distribution. The 5th percentile is calculated based on Normal distribution without any sample size dependent factor.

4.2.1 Spruce in bending

New data of Poland, Slovakia, Slovenia, Romania and Ukraine is combined with the existing data of Germany, France and Slovenia in Figure 23. Model 2 equation used for spruce in bending is

$$f_{\mathrm{mod}el} = 0.00337E_{dyn} - 0.51 \qquad (12)$$

Bandwidths corresponding roughly grade combination C35-C30-C20-C14 are shown. All new results are within confidence limits except the Romanian sample which is above in one band. Old Slovenian values are clearly below as shown already in [1]. Old North German values are below in two bands.

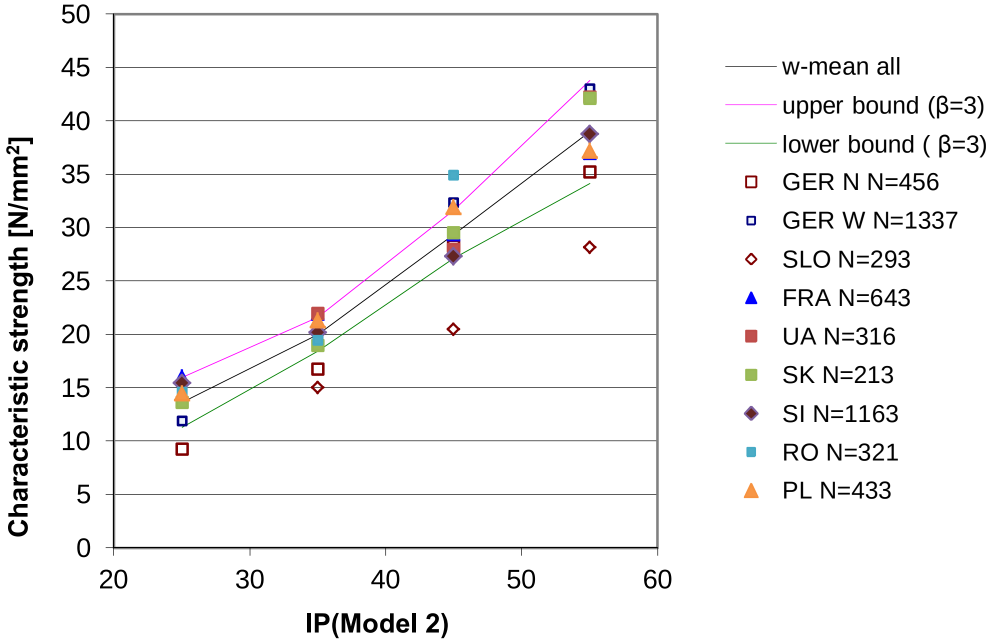


Figure 23. Characteristic bending strength vs. IP(E_{dyn}) of Central and Eastern European spruce. Abbreviations of countries with three characters refer to old data [1] and two letter abbreviations to new test data.

4.2.2 Spruce in tension

New data of Switzerland, Poland, Slovakia, Slovenia, Romania and Ukraine is combined with the existing data of Germany, Austria and Czech Republic in Figure 24. Model 2 equation used for spruce in tension is

$$f_{model} = 0.00337E_{dyn} - 16.82 \tag{13}$$

Bandwidths corresponding roughly grade combination T26-T20-T17-T10 are used. The figure is shown in form of strength vs. E_{dyn}. Nearly all new and old results are within confidence interval.

New data from Sweden has been combined with the existing data from Finland and North West Russia. Same strength model (13) has been used and results are shown in Figure 25. None of the values is below the lower confidence limit.

Tension test specimens of Swizerland, Finland and Russia were longer than standard-length 9*h* of EN 408 and values are adjusted by the use of Equation (6). This adjustment was not made in former publication [1].

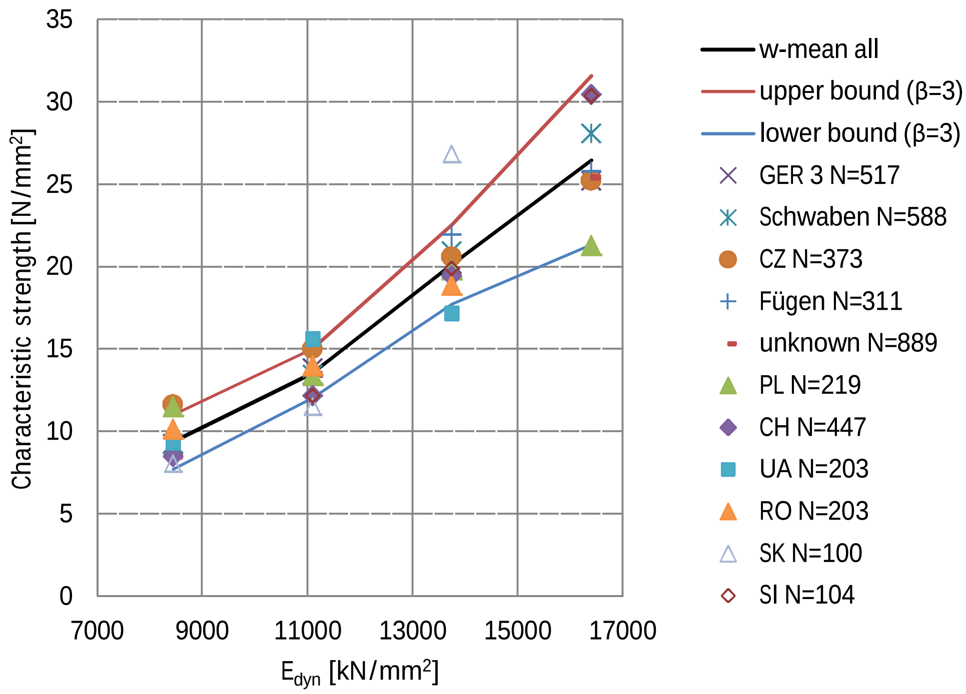


Figure 24. Characteristic tension strength vs. E_{dyn} of Central and Eastern European spruce.

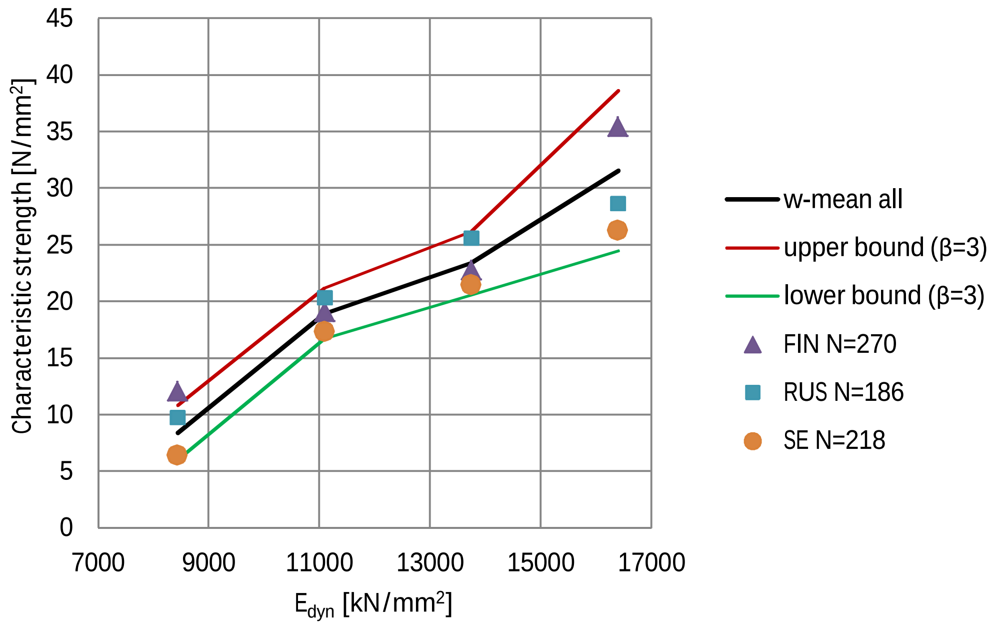


Figure 25. Characteristic tension strength vs. E_{dyn} of North European spruce. Abbreviations of countries with three characters refer to old data [1] and two letter abbreviations to new test data.

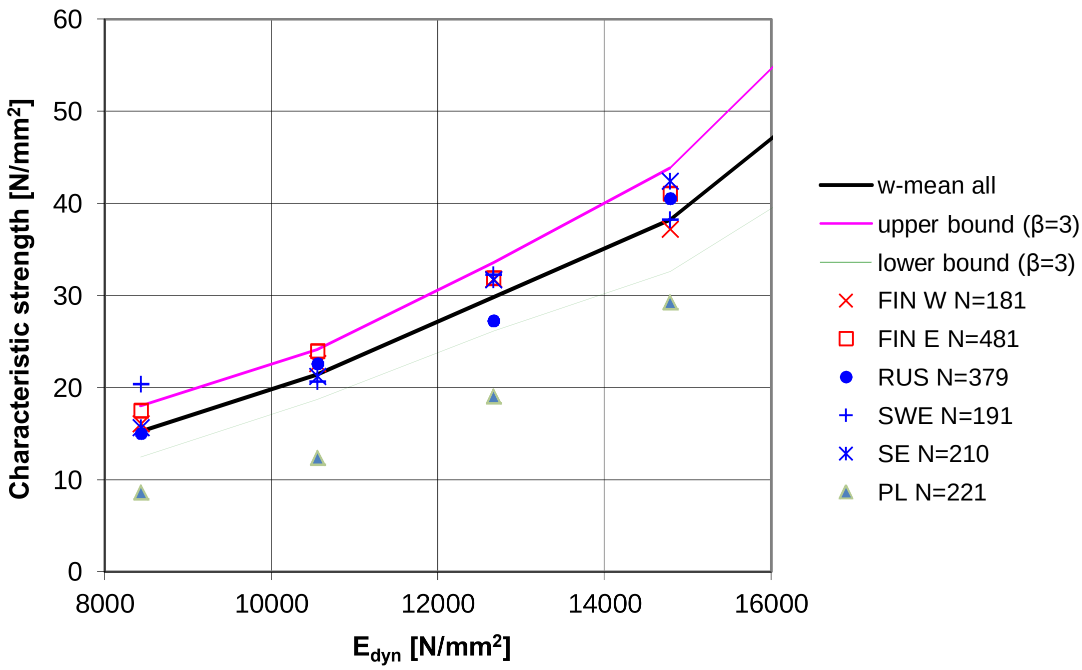


Figure 26. Characteristic bending strength vs. E_{dyn} of Nordic and Polish pine. Abbreviations of countries with three characters refer to old data [1] and two letter abbreviations to new test data.

4.2.3 Pine in bending

Properties of pine are considered in Northern Europe. Finnish and Swedish pines have been found to be very similar [1]. Combination of Finnish, Swedish, North West Russian and Polish data is shown in Figure 26. Bandwidths corresponding roughly to grade combination C40-C30-C22-C16 are shown. Polish values are clearly below confidence interval. Model 2 equation used for pine in bending is

$$f_{model} = 0.00472 E_{dyn} - 14.78 \tag{14}$$

The figure is shown in form of strength vs. E_{dyn}.

4.3 Properties of in-grade timber

4.3.1 Grading procedure

The aim of this chapter is to evaluate the Gradewood data using machine strength grading and the method given in EN 14081-2. The grading process is simulated in this case as the IP used in this chapter is based on adjusted laboratory data. Errors due to measuring uncertainties or errors which will happen during the grading process of a machine are not included in that case. As mentioned in chapter 3.3.3 all laboratory data was correted to reference values before using it for the regression analysis.

The dataset is graded based on linear regression models. Two different machine types are simulated: The “type 1” machine can measure longitudinal frequency (*f*), length (*l*) and cross section, density (ρ) and the total knot area ratio (*KAR*) of each specimen. The “type 2” machine can measure longitudinal frequency (*f*) and length of each piece (*l*).The results of these two machines are compared in the following.

Table 14 summarizes the regression equations separated into species, testing mode and type of machine. For IP the subscript shows the referred characteristic value as an IP can be one for strength, modulus of elasticity or density.

Table 14. Regression equations for the indicating property of strength separated into species, testing mode and machine type.

<table>
<tr><th rowspan="2">Species</th><th rowspan="2">Testing mode</th><th colspan="2">Machine type</th></tr>
<tr><th>1</th><th>2</th></tr>
<tr><td></td><td></td><td>based on:
frequency
length
cross section
density
KAR</td><td>based on:
frequency
length</td></tr>
<tr><td rowspan="6">pine</td><td rowspan="3">bending</td><td>IP_f = +11,0 +0,00345*E_{dyn} -42,0*KAR</td><td rowspan="12">$IP_{f,E,dens}$ = -1750 + 1,1222* E_{freq}</td></tr>
<tr><td>$IP_E = E_{dyn}$</td></tr>
<tr><td>$IP_{dens} = \rho_{specimen}$</td></tr>
<tr><td rowspan="3">tension</td><td>IP_f = +0,47 +0,00314* E_{dyn} -34,8*KAR</td></tr>
<tr><td>$IP_E = E_{dyn}$</td></tr>
<tr><td>$IP_{dens} = \rho_{specimen}$</td></tr>
<tr><td rowspan="6">spruce</td><td>bending</td><td>IP_f = +12,2 +0,00321* E_{dyn} -36,0*KAR</td></tr>
<tr><td></td><td>$IP_E = E_{dyn}$</td></tr>
<tr><td></td><td>$IP_{dens} = \rho_{specimen}$</td></tr>
<tr><td>tension</td><td>IP_f = +0,153 +0,00323* E_{dyn} - 31,2*KAR</td></tr>
<tr><td></td><td>$IP_E = E_{dyn}$</td></tr>
<tr><td></td><td>$IP_{dens} = \rho_{specimen}$</td></tr>
</table>

Figure 27 to Figure 29 show the relationship of strength, modulus of elasticity and density versus the IP of machine type 1 divided into testing mode and species. Figure 30 to Figure 32 show the same figures for the IP of machine type 2.

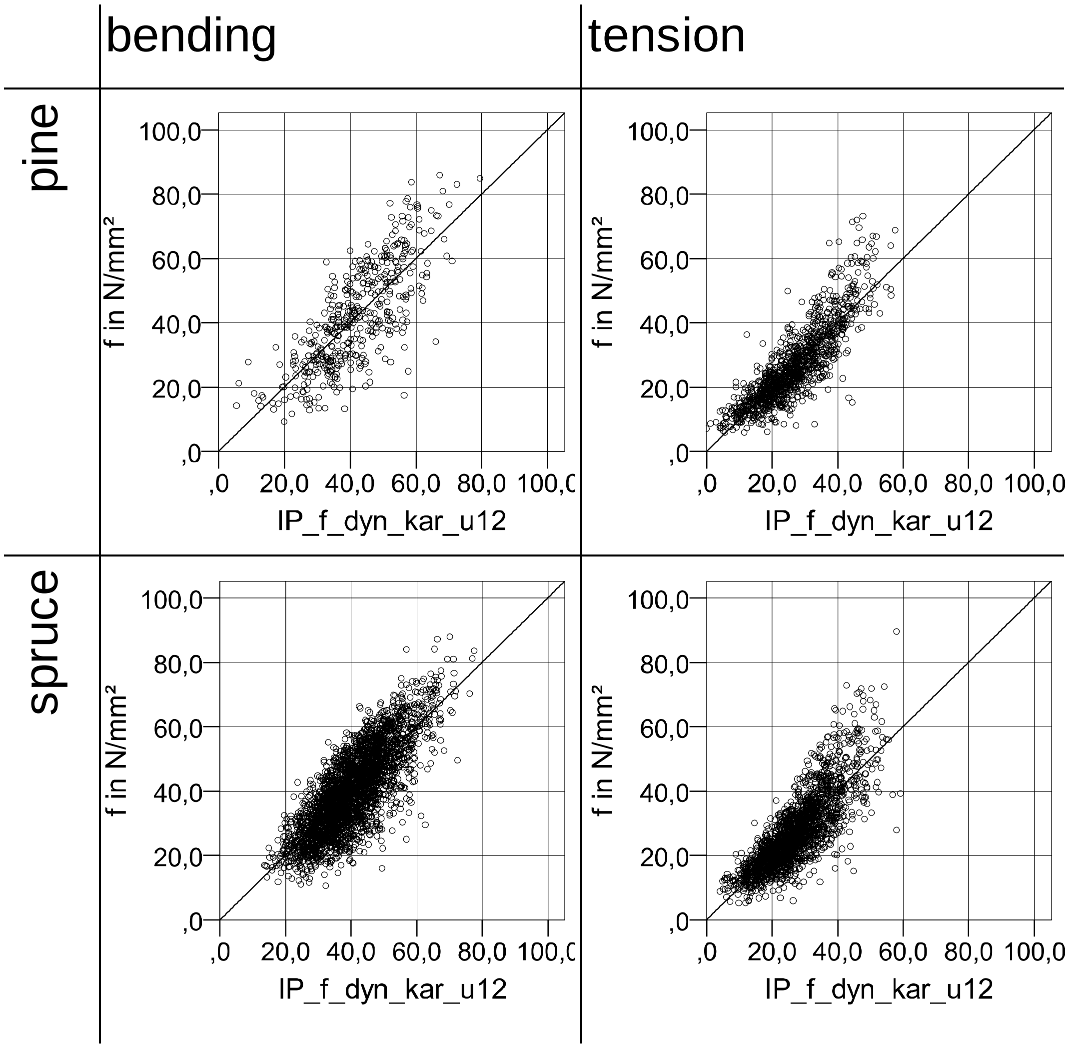


Figure 27. Strength vs. IP of type 1 machine.

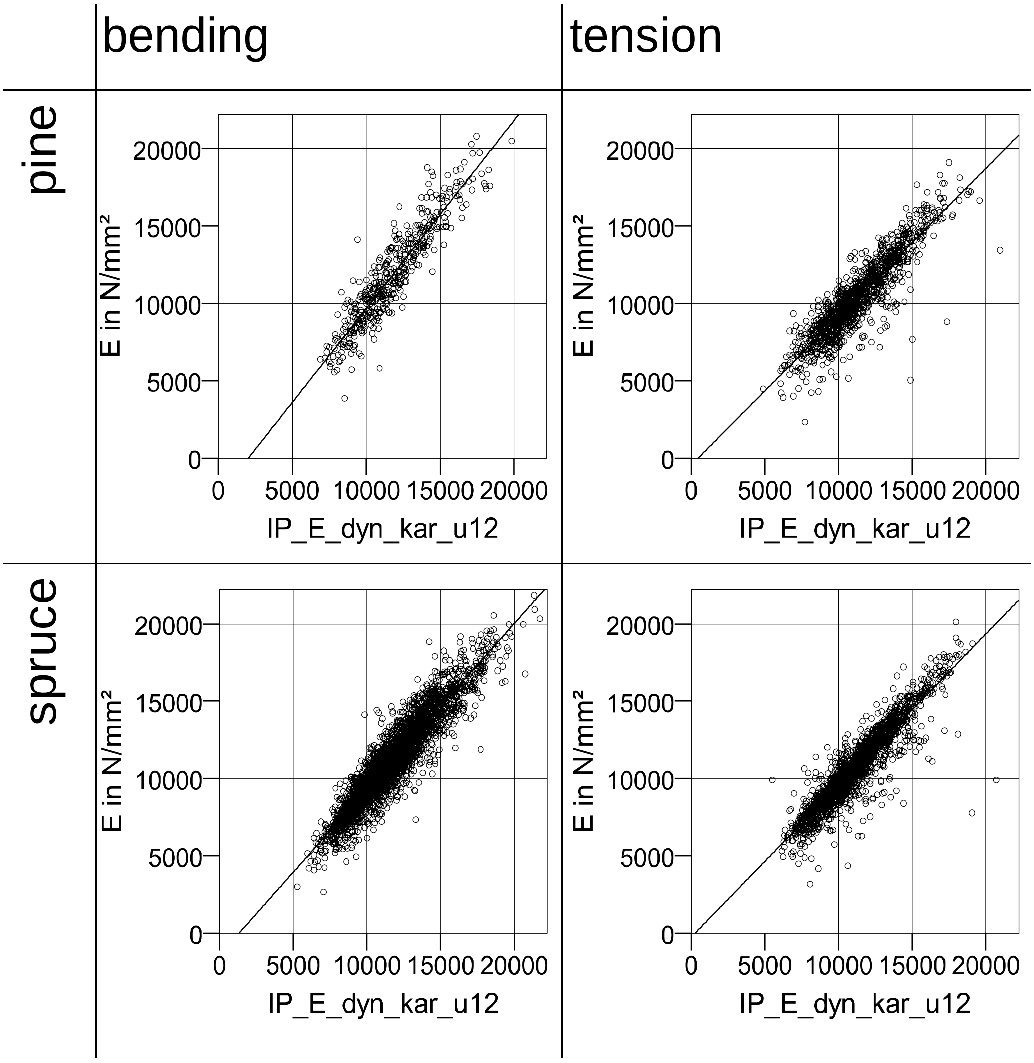


Figure 28. Modulus of elasticity vs. IP of type 1 machine.

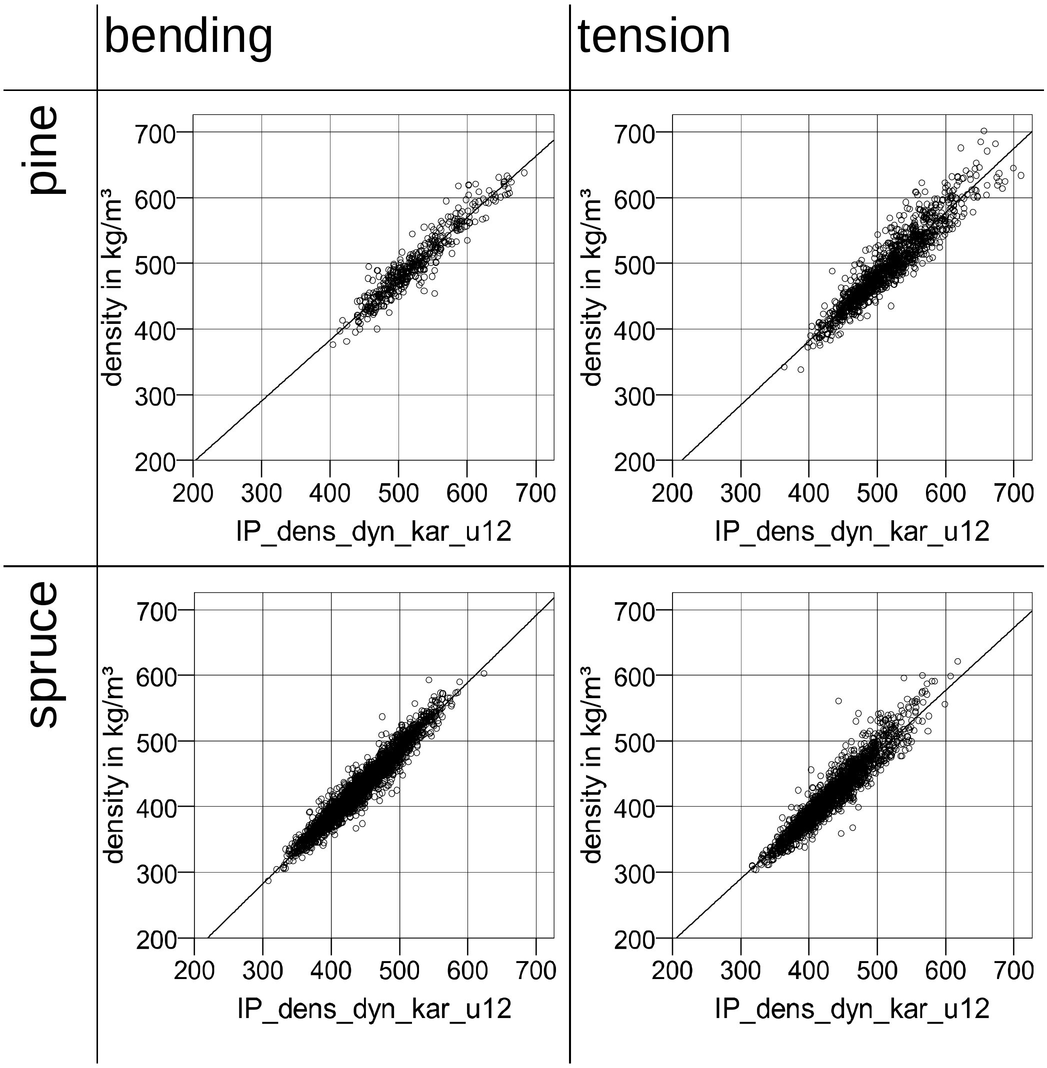


Figure 29. Density vs. IP of type 1 machine.

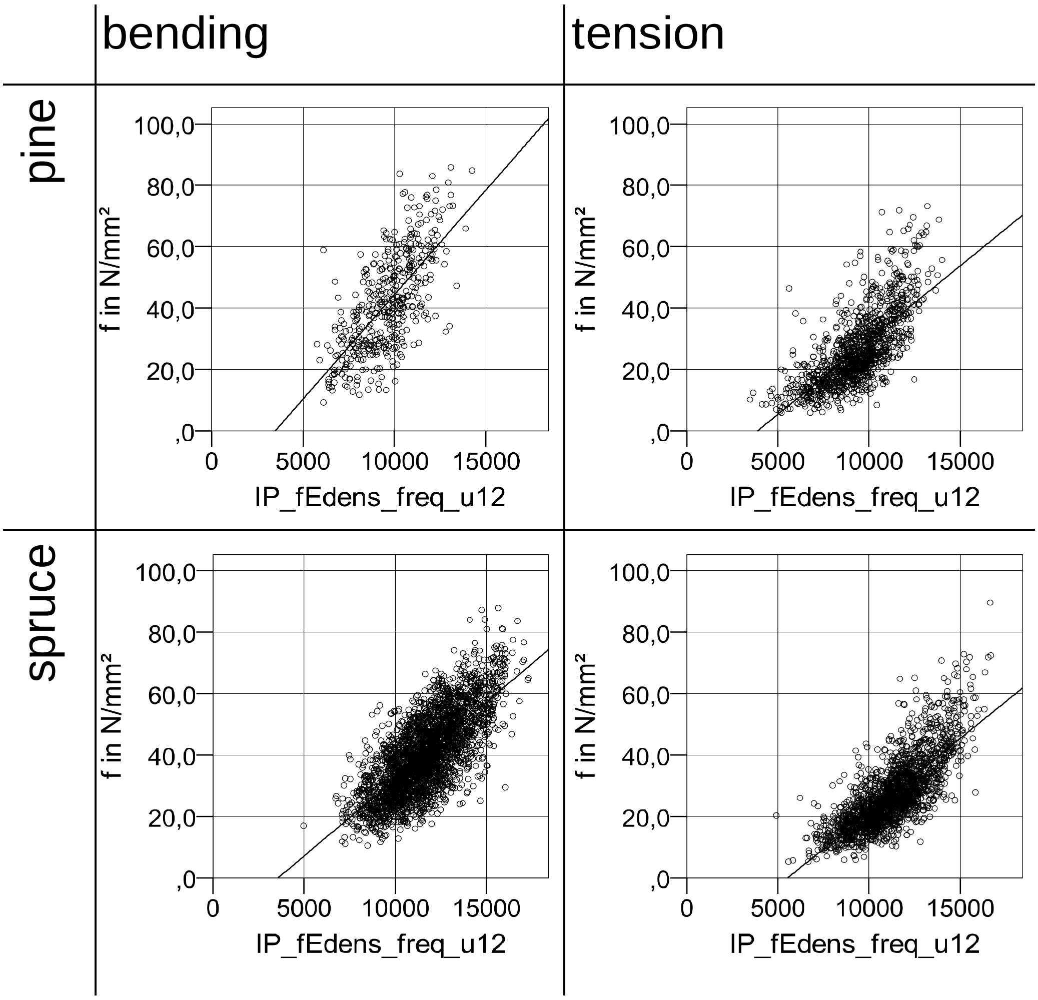


Figure 30. Strength vs. IP of type 2 machine.

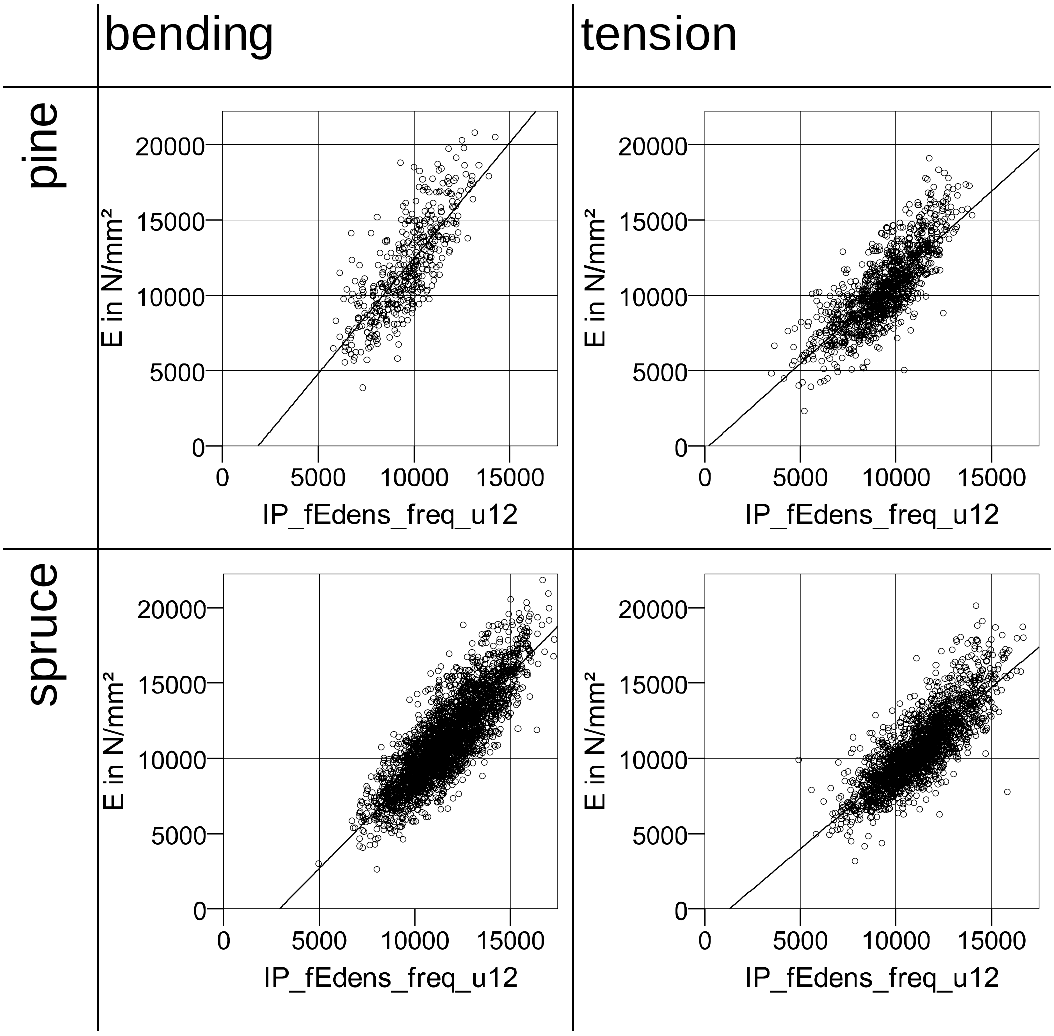


Figure 31. Modulus of elasticity vs. IP of type 2 machine.

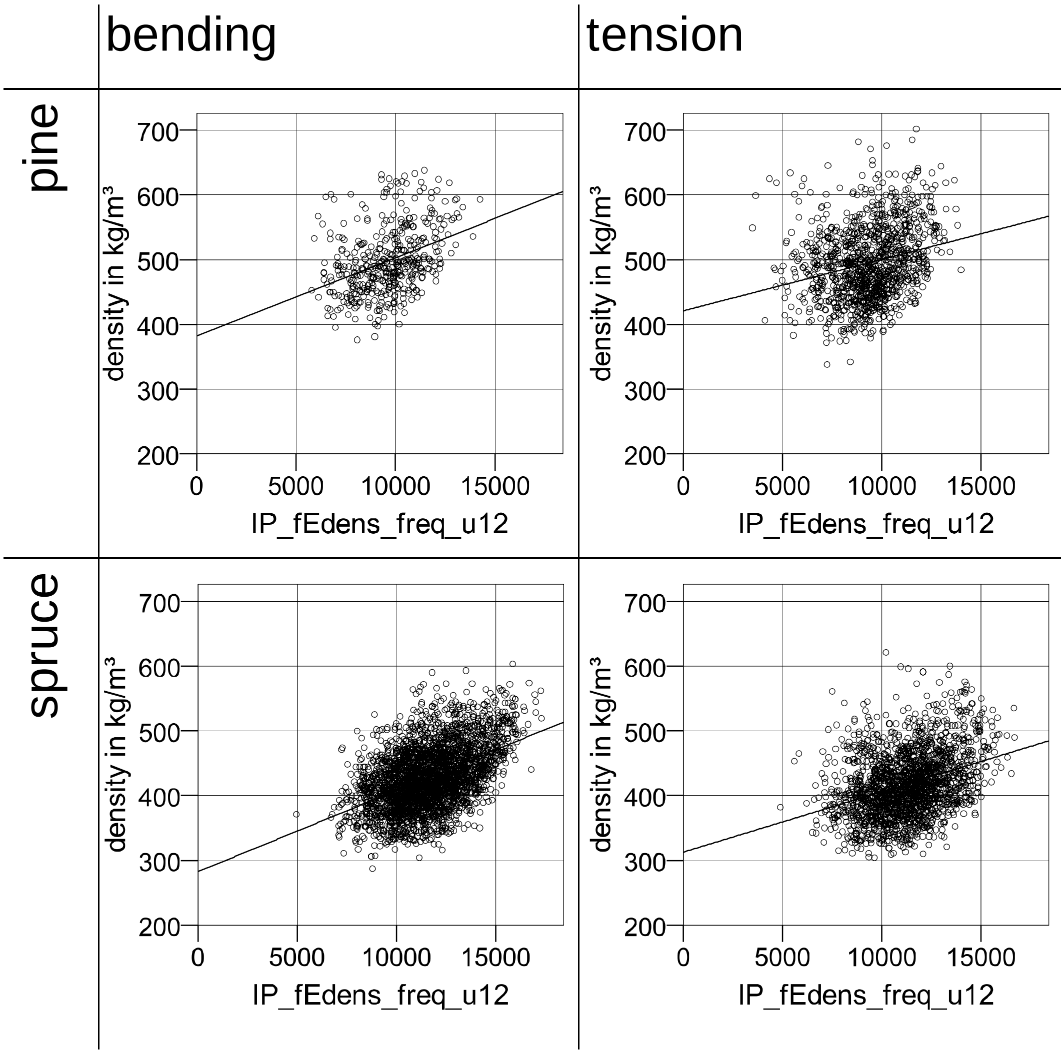


Figure 32. Density vs. IP of type 2 machine.

For grading results with respect to EN 14081-2 the authors focused on spruce in bending. As machine type 2 is based on E_{freq} only, the machine is not possible to use more than one IP to grade the material. To be able to directly compare the results of machine type 2 to the results of machine type 1 only the IP based on strength (IP_f in Table 14) was used for grading the material with machine type 1.

Following EN 14081-2 the settings are calculated for sub-samples based on countries. These settings are used to show differences between countries, regions and within sawmills. To keep results comparable the following grading combinations are used: C35 / C24 / Rej, C30 / C18 / Rej and C24 / Rej. Table 15 summarizes the information of grading procedure.

Table 15. Summary of grading procedure, IPs and settings.

Species	**Spruce**	
Load mode	**Bending**	
settings	calculated following to EN 14081-2, country	
Machine type	**1**	**2**
IP & settings used	IP_f = +12,2 +0,00321* E_{dyn} -36,0*KAR	$IP_{f,E,dens}$ = -1750 + 1,1222* E_{freq}
C24 / reject	21,3 / 0	8 900
C30 / C18 / reject	36,6 / 18,0/ 0	12 400 / 7 300 / 0
C35 / C24 / reject	46,3 /29,3 / 0	13 600 / 9 400 / 0

4.3.2 Grading results

In the following, results were analysed graphically starting with machine type 1 and strength class C24 / reject. Figure 33 shows the results. The first four columns within each country belongs to the highest grade, the following four to the following grade, in our case to the reject grade. The blue columns show the yield, separate into the different source countries, and belong to the right hand ordinate which shows the percentage. For C24 the yield for timber from FR is close to 100 % while the reject is close to 0 %. The red, green and purple columns compare the actually reached values for the strength determining properties to the required values for each strength class. The left hand ordinate shows these readings in percentage. For strength the requirements are not met for four out of seven countries. Strength values for FR are more than 10% higher than the required value, for SK the opposite is the case. While the strength values can be 10 % lower for single source countries, the characteristic values for stiffness and density seem to be unproblematic.

Increasing the zoom level from countries to regions results in bigger deviations from the required characteristic values. Figure 34 additionally shows that the analysis on country level is not enough. While the grading results from RO are similar for timber from Transylvania and Bucovina and therefore, also to country wise analysis shown in Figure 33, this is not the case for other origins. E.g. for SE, PL or FR there are differences if the data is analysed based on regions. Even the ratio between different grade determining properties can vary significantly. Timber from Västergötland has much higher stiffness values in grade C24 than timber from Lapland in this case.

An analysis on an even smaller level revealed no major surprises (Figure 35). Samples were taken from the same sawmill at different times. In this case, SI, RO and UA can be compared. As SI is a very small country, all "regions" have been included also as "sawmills" dividing Central SI to the two samples taken. Still there is a certain influence caused by the general quality of timber from one country. SI timber almost met the requirements for C24, even after being split up and analyzed separately for five different "sawmills".

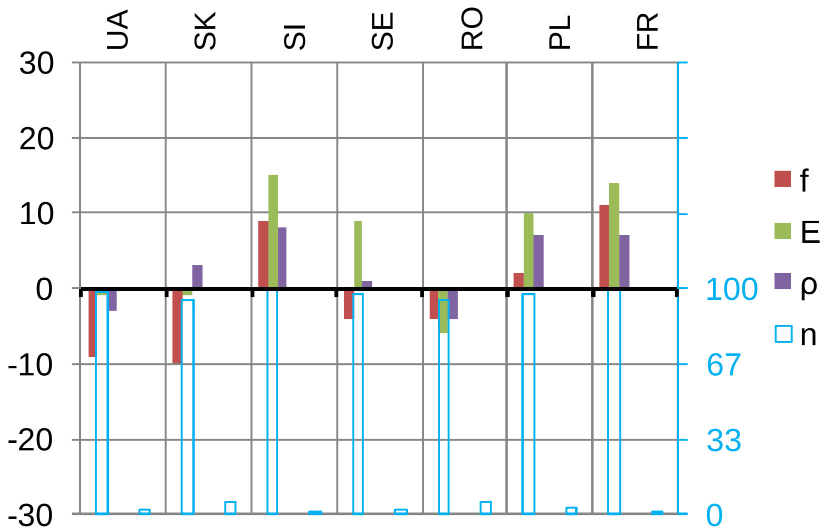


Figure 33. Grading results for machine type 1 analysed for different countries. Grade C24 / reject.

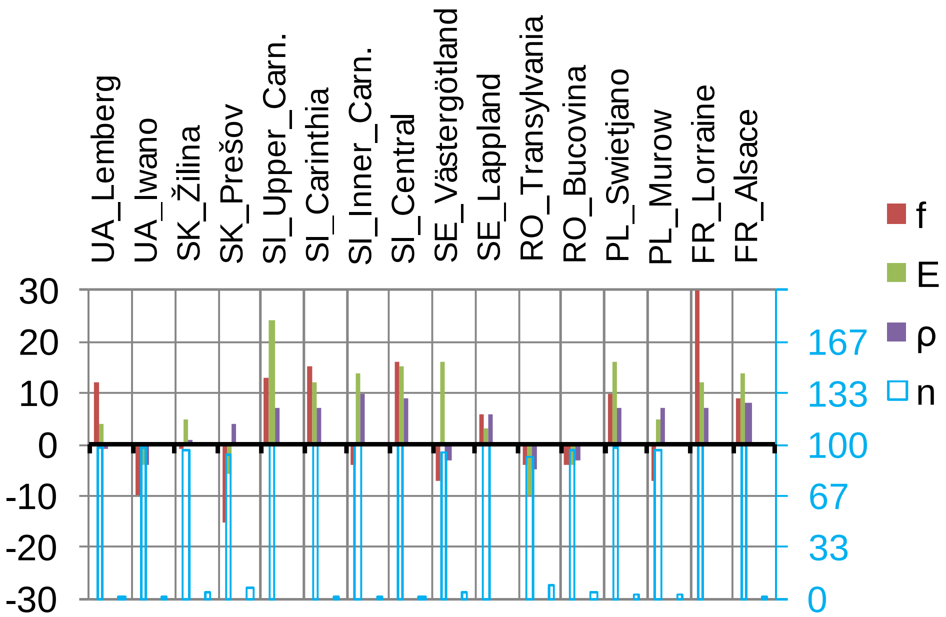


Figure 34. Grading results for machine type 1 analysed for different regions. Grade C24 / reject.

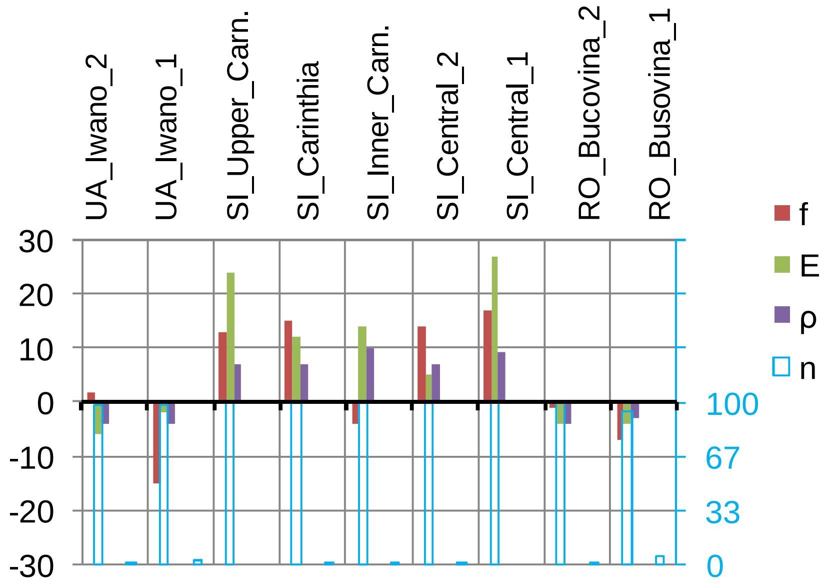


Figure 35. Grading results for machine type 1 analysed for different sawmills. Grade C24 / reject.

If timber is not only graded into one strength class in one pass, conclusions are different. The strength class combination C30 / C18 / reject (Figures 36 and 37) and C35 / C24 / reject (Figures 38 and 39) are analysed in the following. Still, the analysis is based on machine type 1 starting with the different countries. Figure 36 shows 8 columns for each country: the first 4 columns show the result for strength class C30 (column for f, E ,ρ and n), the following 4 columns the result for strength class C18.

Although strength values for FR are always far above the requirement for C24 graded on its own, the strength value for C18 in the strength class combination C30 / C18 / reject and the strength values for C35 in combination C35 / C24 / reject are not met. A different effect is achieved for timber from Eastern Europe. For grade combination C35 / C24 / reject the requirements now are fulfilled in some grades. For both grade combinations, the yield in the highest strength class is clearly lower for the Eastern European countries compared to SI, SE or France. The low yield in the highest strength class and increasing reject amount are connected to a safe grading for timber from Eastern Europe. This statement is only correct as long as machine type 1 is used.

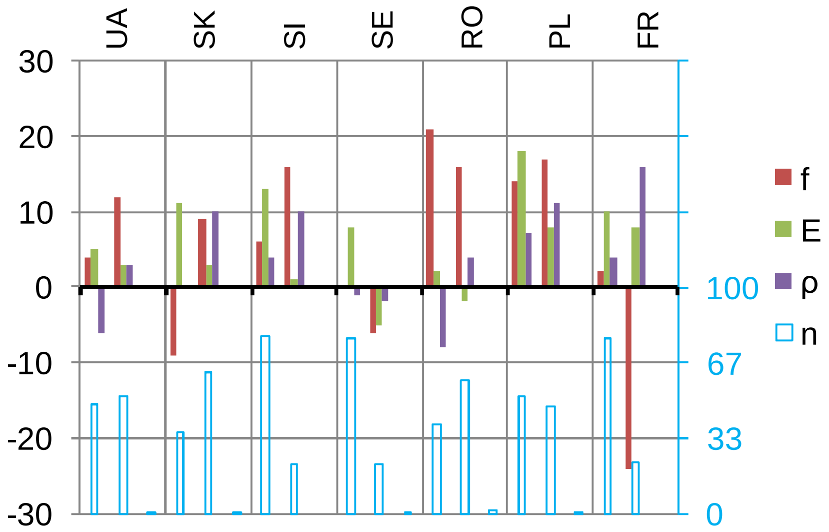


Figure 36. Grading results for machine type 1 analysed for different countries. Grade C30 / C18 / reject.

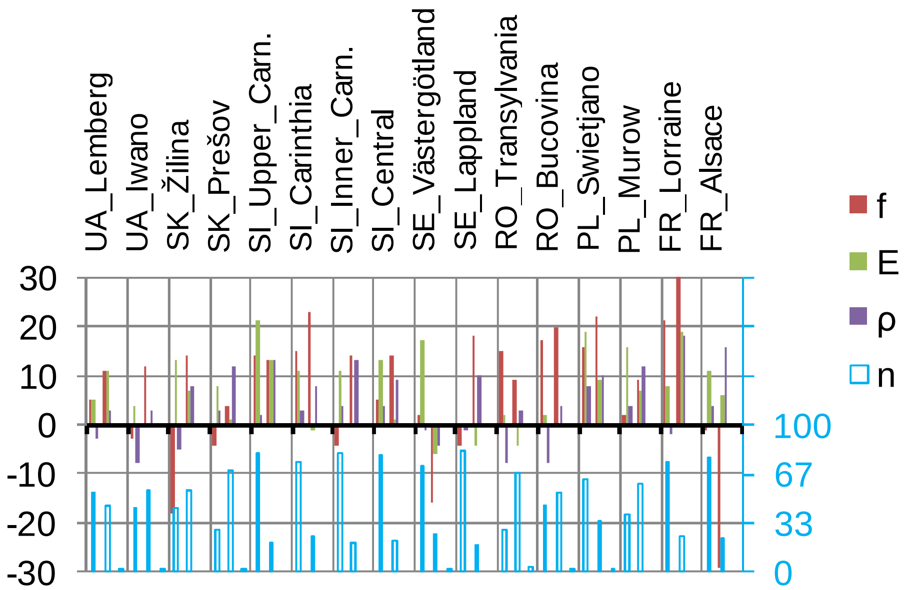


Figure 37. Grading results for machine type 1 analysed for different regions. Grade C30 / C18 / reject.

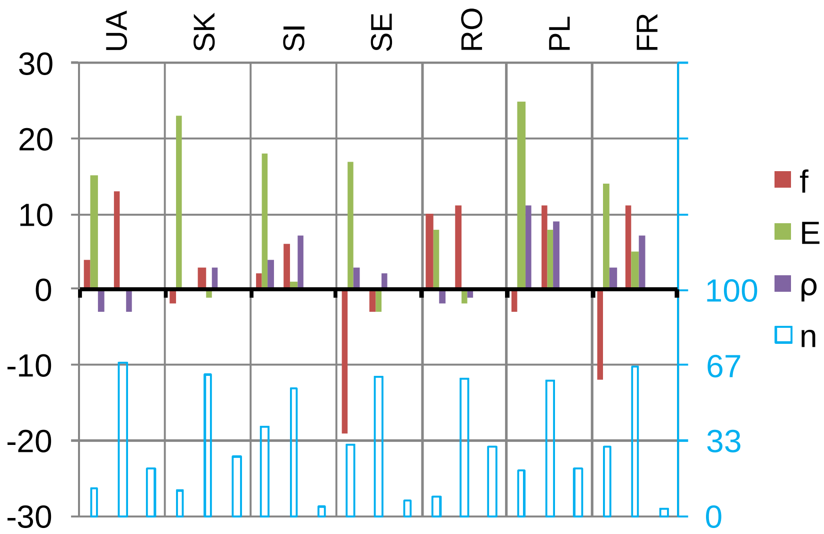


Figure 38. Grading results for machine type 1 analysed for different countries. Grade C35 / C24 / reject.

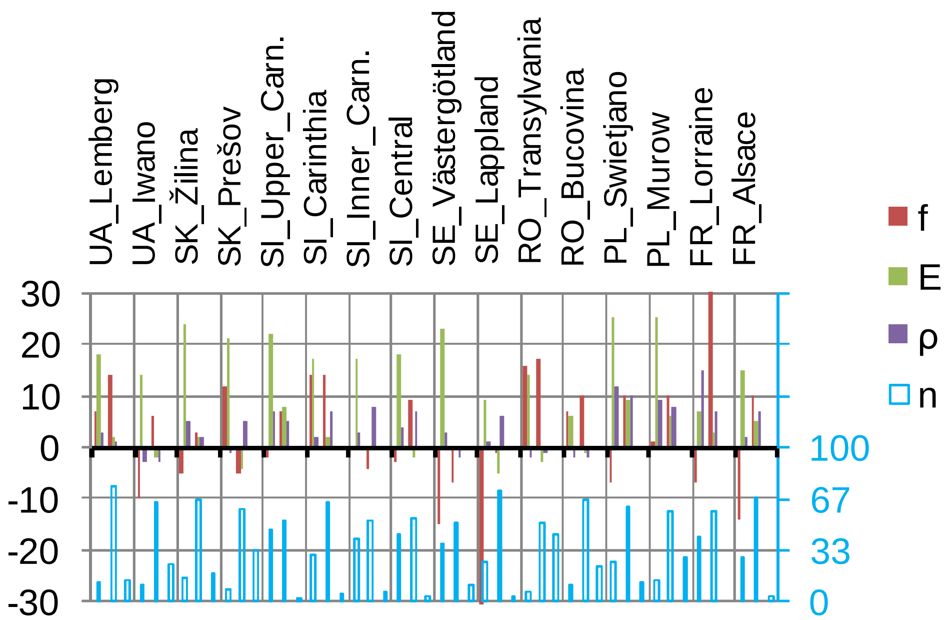


Figure 39. Grading results for machine type 1 analysed for different regions. Grade C35 / C24 / reject.

For machine “type 2” the equivalent diagrams are

- strength class combination C24 / reject, Figure 40 country, Figure 41 regions
- strength class combination C30 / C18 / reject, Figure 42 country, Figure 43 regions
- strength class combination C35 / C24 / reject, Figure 44 country, Figure 45 regions.

Comparing the figures analysed for countries of machine type 1 and machine type 2 (Figure 33 with Figure 40, Figure 36 with Figure 42 and Figure 38 with Figure 44) a considerable larger scatter of the different columns representing the characteristic values can be found. Obviously, the yield in the highest strength class in each combination drops. This is an effect of the lower coefficient of determination of machine type 2 IP compared to machine type 1 IP. This can lead to different effects depending on the source country. Compared to a grading procedure carried out with machine type 1 for strength class combination C35 / C24 / reject, characteristic values for UA are no longer met. On the other hand, the drop in yield leads to safe grading results for French timber in strength class combination C30/ C18 / reject as well as strength class combination C35/ C24 / reject.

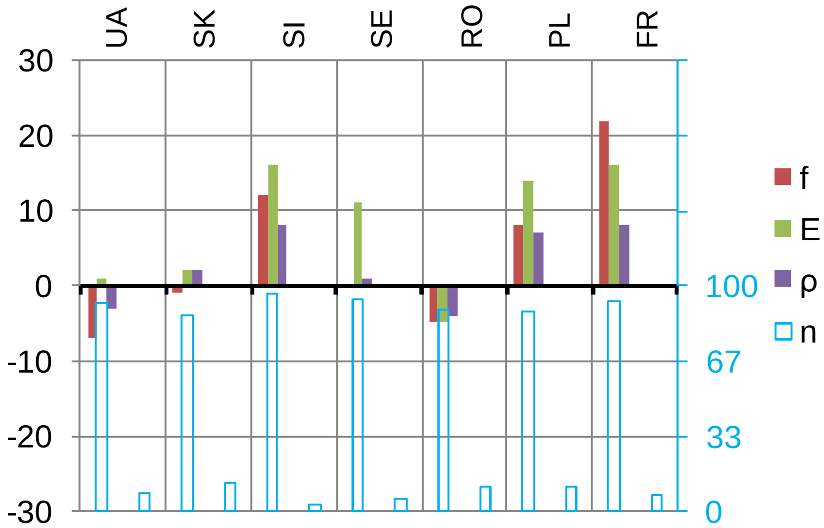


Figure 40. Grading results for machine type 2 analysed for different countries. Grade C24 / reject.

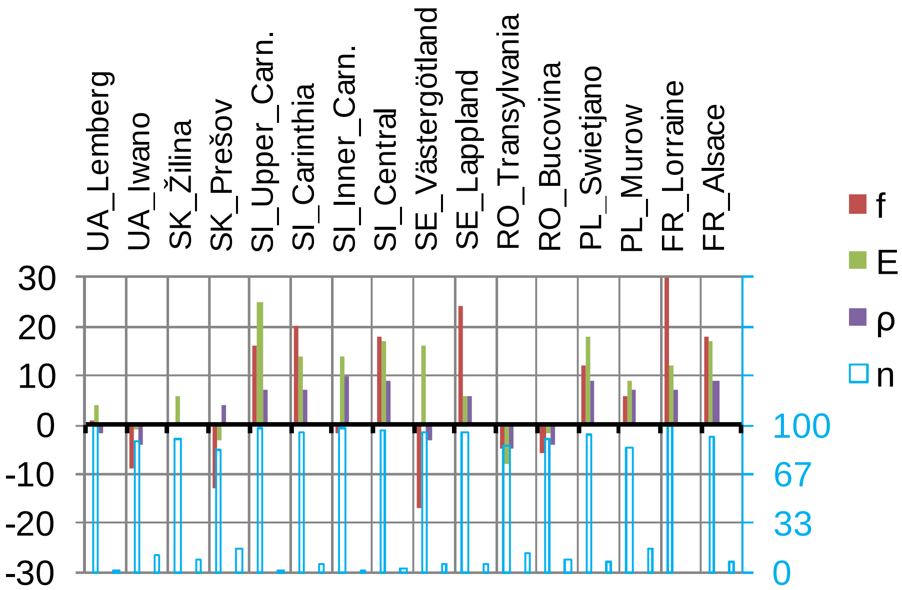


Figure 41. Grading results for machine type 2 analysed for different regions. Grade C24 / reject.

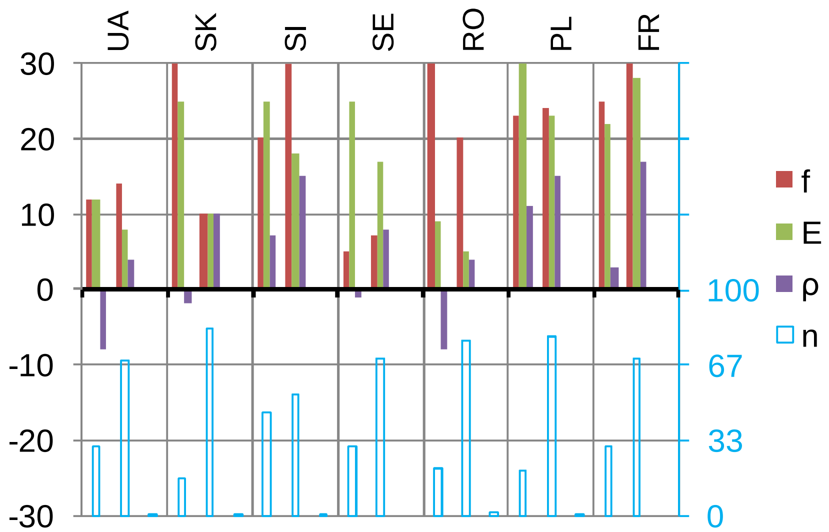


Figure 42. Grading results for machine type 2 analysed for different countries. Grade C30 / C18 / reject.

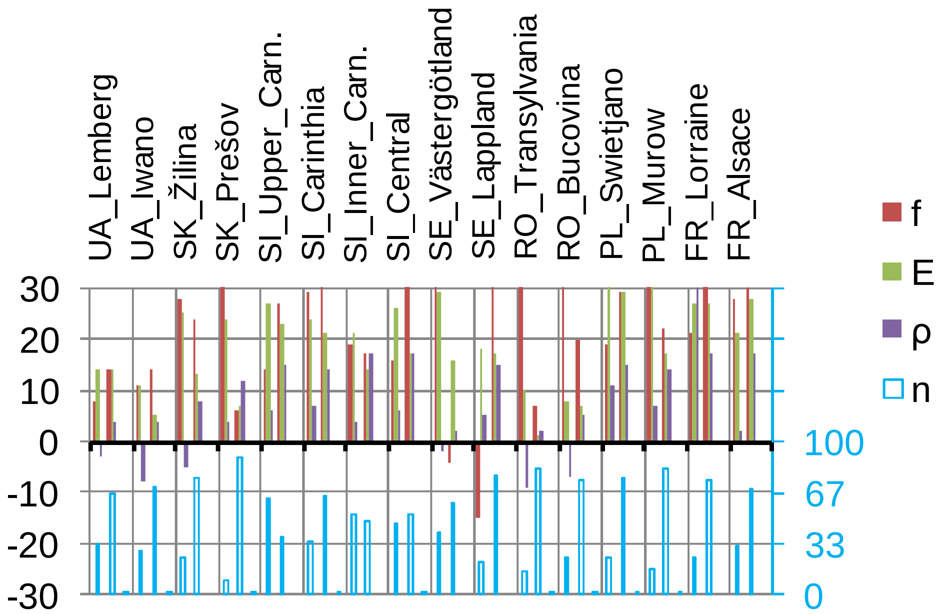


Figure 43. Grading results for machine type 2 analysed for different regions. Grade C30 / C18 / reject.

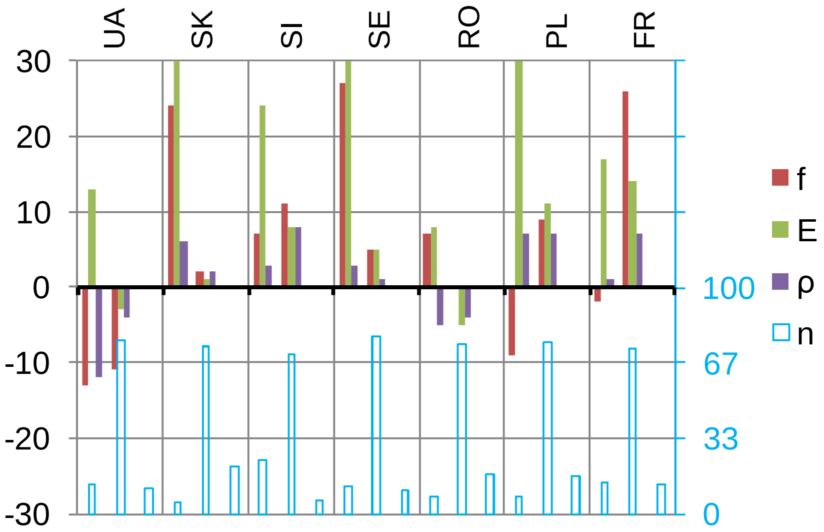


Figure 44. Grading results for machine type 2 analysed for different countries. Grade C35 / C24 / reject.

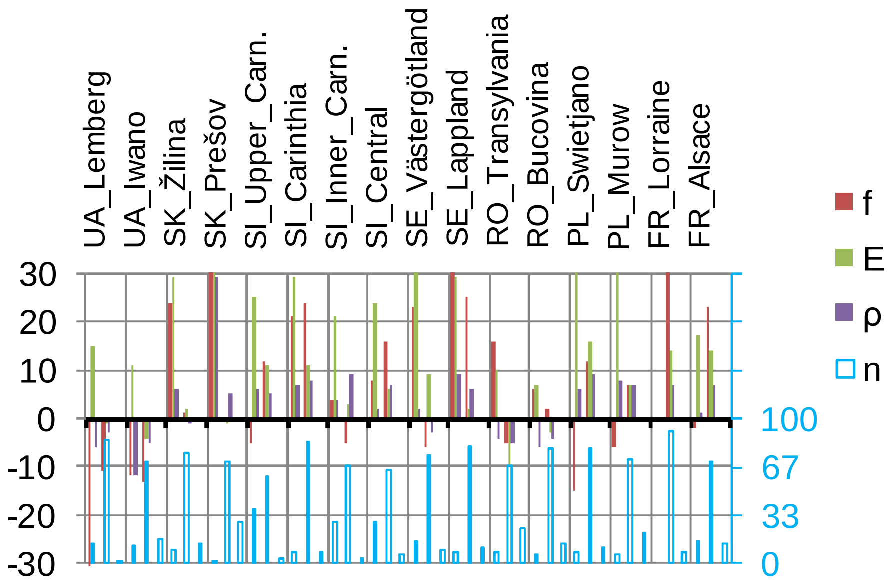


Figure 45. Grading results for machine type 2 analysed for different regions. Grade C35 / C24 / reject.

This chapter clearly shows that there are big differences on country level as well as on region and sawmill level. Therefore, segmentation in different countries does not seem to fit. As wood industry is looking for big grading areas to optimise its trading business, one can assume to separate three main grading areas for spruce in bending in Europe. Figure 46 shows this proposal in different colors, Figure 47 to Figure 49 show the results for machine type 1 and the already chosen grade combinations, Figure 50 to Figure 52 show the results for machine type 2, respectively.

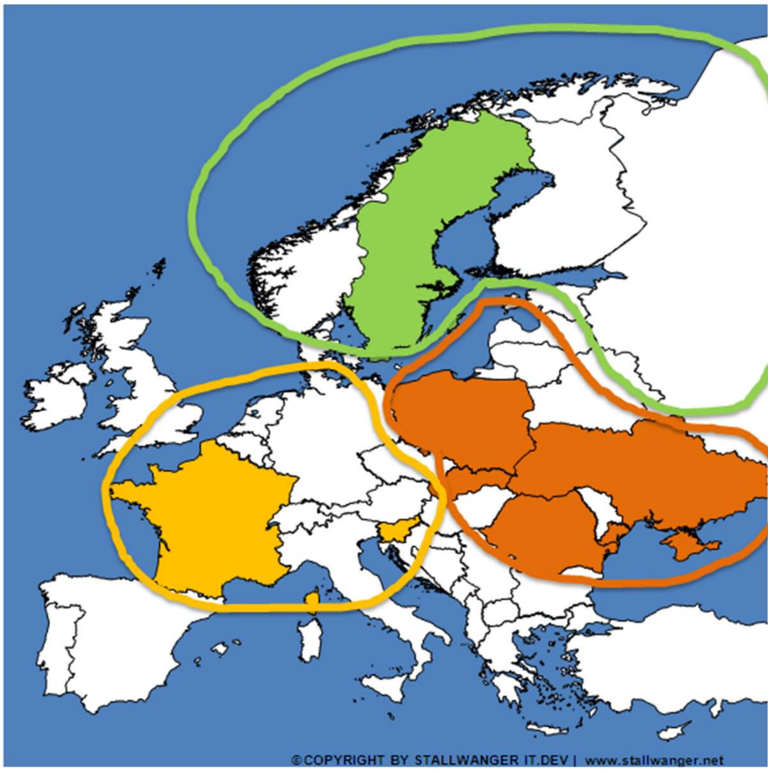


Figure 46. Europe divided into Northern Europe, Eastern Europe and Central Europe for spruce in bending.

The already mentioned differences between the three grading areas for spruce in bending can clearly be seen in Figure 47. Also the drop in yield comparing machine type 1 to machine type 2 and the drop in yield in the highest strength classes for Eastern Europe is emphasised in these graphs.

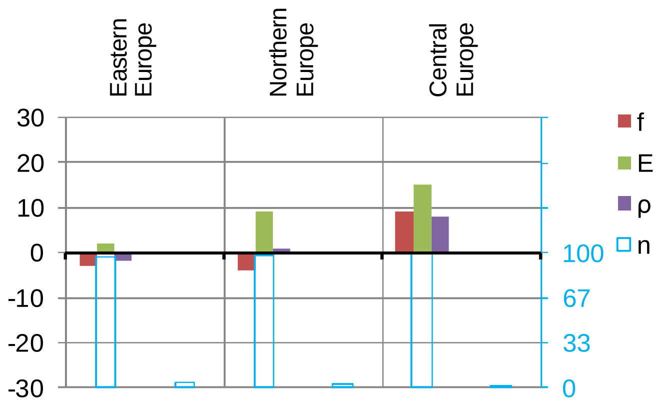


Figure 47. Grading results for machine type 1 analysed for different “continents”. Grade C24 / reject.

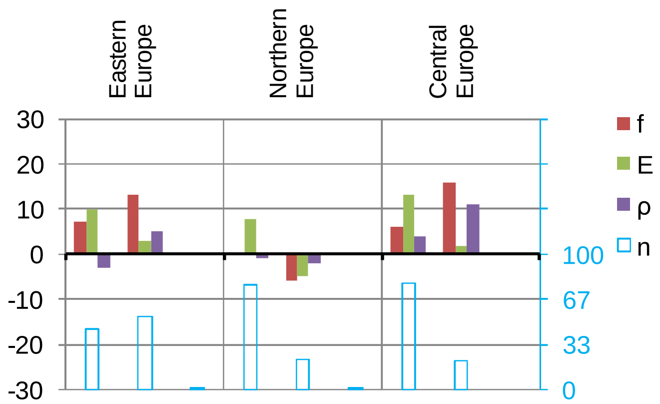


Figure 48. Grading results for machine type 1 analysed for different “continents”. Grade C30 / C18 / reject.

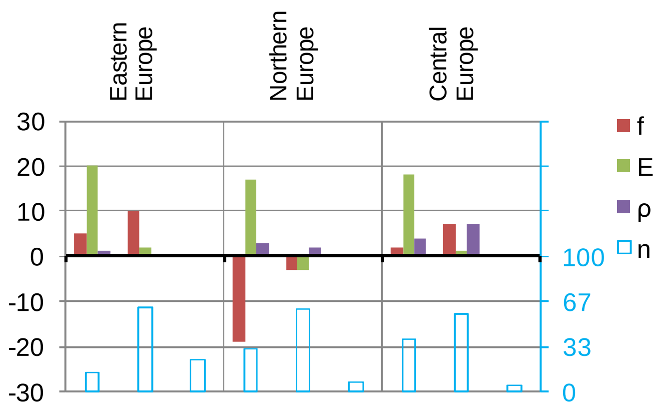


Figure 49. Grading results for machine type 1 analysed for different “continents”. Grade C35 / C24 / reject.

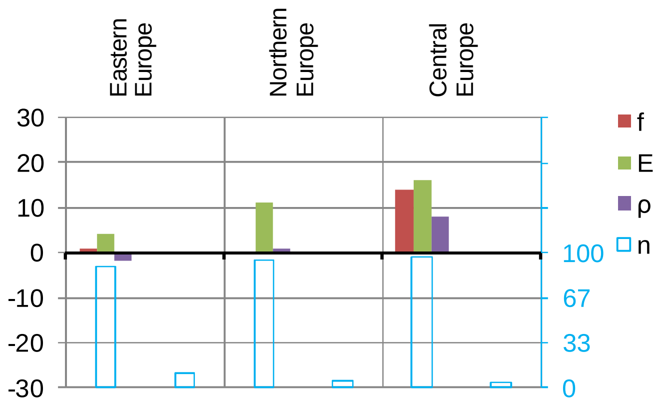


Figure 50. Grading results for machine type 2 analysed for different “continents”. Grade C24 / reject.

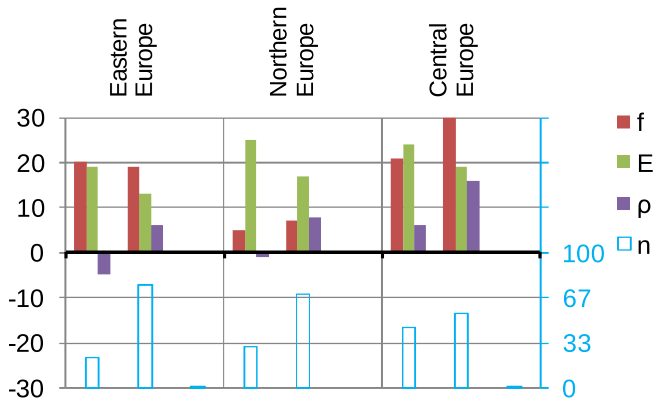


Figure 51. Grading results for machine type 2 analysed for different “continents”. Grade C30 / C18 / reject.

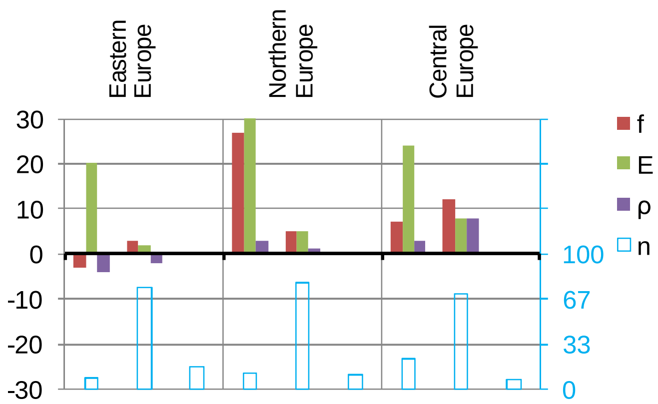


Figure 52. Grading results for machine type 2 analysed for different “continents”. Grade C35 / C24 / reject.

The determination of suitable grading areas is not an easy task. Probably, these grading areas will differ for species, type of testing (bending or tension) and type of grading machine (accuracy, multiple IPs, …). Even if suitable grading areas are found for all kinds of combinations, these grading areas can still be increased by using the most conservative settings for all grading areas or by using more than one IP. Additionally, the responsibility for sawmilling industry may be increased by changing the internal quality control system. This can also have an effect on the definition of grading areas. The Gradewood data perform a very good basis for this future task.

5. Summary

A large European experimental study on strength of timber is documented. Sampling of spruce and pine includes several countries: new information is obtained from Poland, Slovenia, Slovakia, Romania and Ukraine, from where only little data was available earlier. New is also pine in tension data from Nordic region and France, from where spruce has been tested earlier in large amounts. Valuable for coming research is also that samples from same areas can be used for comparison of tension and bending properties. Main part of the 6 000 specimens has been tested by five participating grading machines and in laboratory by non-destructive and destructive means.

Results include characterisation of national samples in terms of mean values and coefficients of variation which have been compared to earlier data from Central and North Europe. Comparisons reveal that Swedish samples of spruce have lower mean strength and larger variation than existing Nordic data, and are obviously not representative for spruce grown in Sweden. This kind of conflict with earlier data we do not observe in other cases, partly also due to lack of earlier data.

Correlations between grade determining properties and measured data have been calculated including indicating properties based on grading machine measurements. Regression lines between strength and two common IP's have been determined for each sample separately. Significant conclusion is that regression lines of different regions are closer to each other when IP is based on several measurements and has high correlation with strength. When IP is based on frequency measurement only, variability within a country can be large which is in conflict with the principle of having same model and same settings in a country.

Properties of in-grade timber have been studied when grading method is based on EN 14081-2. Results suggest that same settings might be used separately for North, Central and Eastern Europe. Size of relevant "same grading area" depends on species, type of testing (bending or tension), type of grading machine and if single or multiple IP's have been applied. The process of defining grading areas has just started and is not finished yet.

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2. Schnabel, R. Pilotstudie zur Vorsortierung von frischem Schnittholz mittels Schwingungsmessung. Endbericht im Rahmen des BMWA Förderprogrammes PROKIS (P2b). Holzforschung Austria. Wien, 2006. 36 p. (Only available in German)

Appendix A: Correlation matrices of samples

A1: Bending of spruce from France, Poland, Romania, Sweden, Slovenia, Slovakia and Ukraine

A2: Tension of spruce from Switzerland, Poland, Romania, Sweden, Slovenia, Slovakia and Ukraine

A3: Bending of pine from Poland and Sweden

A4: Tension of pine from Finland, France, Poland, Russia and Sweden

A1: France

Spruce	**Bending**	**FR**	**Alsace+**	**n = 118**		**a**	**b**	**c**	**d**
						0,787	10,4	4,16	-6,3
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	42,9	11,2	440	452	11,8	12,0	0,22	41,3	437
St. dev.	11,4	1,9	43,6	37,7	1,6	2,2	0,1	9,6	41
Median	42,4	11,1	434	448	11,8	11,8	0,21	40,6	432
5th centile	23,8	8,0	378	396	9,2	8,9	0,09	26,1	375
1st centile	17,2	7,0	374	386	8,5	8,2	0,05	23,1	368
Min	10,5	6,7	371	369	8,2	7,9	0	17,4	366
Max	71,1	16,1	590	589	16,0	17,7	0,53	62,6	585
COV	0,26	0,17	0,10	0,08	0,14	0,18	0,40	0,23	0,09
Correlations									
f_m	1	0,77	0,27	0,27	0,58	0,56	-0,29	0,67	0,27
E_{global}	0,77	1	0,62	0,62	0,77	0,86	-0,23	0,86	0,63
ρ	0,27	0,62	1	0,91	0,40	0,73	-0,10	0,66	0,92
$\rho_{specimen}$	0,27	0,62	0,91	1	0,34	0,73	-0,12	0,65	0,97
E_{freq}	0,58	0,77	0,40	0,34	1	0,89	-0,17	0,79	0,40
E_{dyn}	0,56	0,86	0,73	0,73	0,89	1	-0,18	0,89	0,75
KAR	-0,29	-0,23	-0,10	-0,12	-0,17	-0,18	1	-0,33	-0,13
IP1	0,67	0,86	0,66	0,65	0,79	0,89	-0,33	1	0,71
IP2	0,56	0,87	0,74	0,72	0,85	0,96	-0,20	0,93	0,78
IP3	0,27	0,63	0,92	0,97	0,40	0,75	-0,13	0,71	1
IP4	0,67	0,90	0,64	0,61	0,83	0,90	-0,24	0,88	0,66
IP5	0,61	0,91	0,69	0,68	0,82	0,92	-0,19	0,89	0,73
IP6	0,27	0,63	0,88	0,96	0,30	0,68	-0,11	0,63	0,96
IP7	0,51	0,75	0,43	0,36	0,84	0,78	-0,13	0,74	0,43
IP8	0,44	0,78	0,67	0,64	0,74	0,84	-0,11	0,78	0,69
IP9	0,60	0,79	0,40	0,33	0,95	0,85	-0,14	0,83	0,40

Appendix A: Correlation matrices of samples

A1: Poland

Spruce	**Bending**	**PL**	**Murow**	**n = 214**		**a**	**b**	**c**	**d**
						1,00	-0,50	5,30	-23,2
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	36,0	10,4	425	434	11,2	10,9	0,33	36,4	412
St. dev.	11,0	2,1	39,2	36,2	1,6	2,1	0,1	8,8	37
Median	35,6	10,2	424	433	11,1	10,6	0,34	35,1	409
5th centile	19,9	7,6	368	382	8,9	8,1	0,18	23,6	360
1st centile	15,2	6,6	335	346	8,0	6,9	0,15	20,9	325
Min	11	6,0	311	333	7,5	6,0	0	17,5	307
Max	62,6	16,7	532	535	15,6	18,2	0,69	67,3	514
COV	0,30	0,20	0,09	0,08	0,14	0,20	0,29	0,24	0,09
Correlations									
f_m	1	0,84	0,57	0,50	0,76	0,78	-0,55	0,81	0,54
E_{global}	0,84	1	0,76	0,69	0,88	0,95	-0,50	0,93	0,72
ρ	0,57	0,76	1	0,96	0,55	0,82	-0,25	0,78	0,97
$\rho_{specimen}$	0,50	0,69	0,96	1	0,42	0,74	-0,17	0,70	0,98
E_{freq}	0,76	0,88	0,55	0,42	1	0,92	-0,53	0,85	0,48
E_{dyn}	0,78	0,95	0,82	0,74	0,92	1	-0,47	0,94	0,77
KAR	-0,55	-0,50	-0,25	-0,17	-0,53	-0,47	1	-0,52	-0,25
IP1	0,81	0,93	0,78	0,70	0,85	0,94	-0,52	1	0,75
IP2	0,77	0,95	0,84	0,76	0,90	0,99	-0,46	0,95	0,80
IP3	0,54	0,72	0,97	0,98	0,48	0,77	-0,25	0,75	1
IP4	0,75	0,88	0,73	0,66	0,87	0,93	-0,47	0,89	0,69
IP5	0,75	0,91	0,75	0,67	0,89	0,95	-0,46	0,90	0,70
IP6	0,48	0,63	0,79	0,80	0,46	0,69	-0,20	0,64	0,78
IP7	0,74	0,88	0,60	0,48	0,95	0,91	-0,53	0,85	0,54
IP8									
IP9	0,74	0,87	0,54	0,42	0,98	0,90	-0,52	0,85	0,47

Spruce	Bending	PL	Swietjano	n = 219		a	b	c	d
						0,95	1,19	5,73	-26,0
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	40,9	11,3	454	457	11,7	12,0	0,30	41,9	435
St. dev.	12,7	2,2	50,9	45,2	1,5	2,3	0,1	10,5	49
Median	40,0	11,0	449	452	11,6	11,7	0,29	40,6	432
5th centile	21,4	7,6	375	386	9,1	8,5	0,14	24,6	360
1st centile	17,9	6,7	349	363	8,2	7,7	0,11	20,6	338
Min	14,5	6,6	341	352	8,2	7,1	0,1	19,0	328
Max	84,1	17,2	572	572	16,0	18,6	0,61	69,8	555
COV	0,31	0,20	0,11	0,10	0,13	0,19	0,34	0,25	0,11
Correlations									
f_m	1	0,78	0,55	0,51	0,67	0,73	-0,56	0,79	0,53
E_{global}	0,78	1	0,76	0,72	0,81	0,93	-0,54	0,90	0,73
ρ	0,55	0,76	1	0,98	0,45	0,82	-0,37	0,77	0,98
$\rho_{specimen}$	0,51	0,72	0,98	1	0,38	0,78	-0,31	0,72	0,99
E_{freq}	0,67	0,81	0,45	0,38	1	0,87	-0,50	0,81	0,38
E_{dyn}	0,73	0,93	0,82	0,78	0,87	1	-0,50	0,93	0,78
KAR	-0,56	-0,54	-0,37	-0,31	-0,50	-0,50	1	-0,57	-0,36
IP1	0,79	0,90	0,77	0,72	0,81	0,93	-0,57	1	0,75
IP2	0,75	0,93	0,83	0,79	0,85	0,99	-0,53	0,95	0,80
IP3	0,53	0,73	0,98	0,99	0,38	0,78	-0,36	0,75	1
IP4	0,72	0,87	0,73	0,69	0,81	0,91	-0,52	0,87	0,69
IP5	0,70	0,88	0,76	0,72	0,83	0,94	-0,47	0,87	0,71
IP6	0,46	0,63	0,83	0,84	0,35	0,68	-0,28	0,61	0,83
IP7	0,40	0,61	0,36	0,31	0,72	0,65	-0,31	0,61	0,30
IP8									
IP9	0,66	0,80	0,42	0,35	0,98	0,85	-0,48	0,80	0,35

Appendix A: Correlation matrices of samples

A1: Romania

Spruce	**Bending**	**RO**	**Bucovina**		**n = 205**	**a**	**b**	**c**	**d**
						1,08	-3,43	5,85	-30,8
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	36,8	9,6	389	408	11,5	10,5	0,29	37,4	396
St. dev.	11,2	1,8	42,2	32,0	1,5	1,8	0,1	7,8	33
Median	37,1	9,6	392	409	11,4	10,3	0,27	37,1	397
5th centile	19,8	6,9	337	354	9,1	7,8	0,14	25,4	342
1st centile	16,5	6,5	325	349	8,0	6,9	0,09	21,4	335
Min	14,2	0,0	0	345	7,9	6,6	0,06	11,4	335
Max	65	14,0	480	487	15,3	15,8	0,69	59,6	487
COV	0,30	0,18	0,11	0,08	0,13	0,17	0,35	0,21	0,08
Correlations									
f_m	1	0,79	0,23	0,27	0,78	0,72	-0,57	0,75	0,32
E_{global}	0,79	1	0,47	0,54	0,81	0,87	-0,45	0,79	0,58
ρ	0,23	0,47	1	0,74	0,27	0,56	-0,02	0,37	0,77
$\rho_{specimen}$	0,27	0,54	0,74	1	0,27	0,67	0,08	0,43	0,97
E_{freq}	0,78	0,81	0,27	0,27	1	0,89	-0,53	0,86	0,35
E_{dyn}	0,72	0,87	0,56	0,67	0,89	1	-0,37	0,87	0,72
KAR	-0,57	-0,45	-0,02	0,08	-0,53	-0,37	1	-0,55	0,01
IP1	0,75	0,79	0,37	0,43	0,86	0,87	-0,55	1	0,52
IP2	0,68	0,85	0,53	0,67	0,87	0,98	-0,33	0,87	0,74
IP3	0,32	0,58	0,77	0,97	0,35	0,72	0,01	0,52	1
IP4	0,61	0,79	0,62	0,58	0,79	0,88	-0,32	0,77	0,62
IP5	0,64	0,85	0,65	0,62	0,85	0,94	-0,31	0,81	0,68
IP6	0,24	0,51	0,76	0,79	0,32	0,61	0,03	0,42	0,80
IP7	0,70	0,85	0,44	0,38	0,95	0,91	-0,41	0,82	0,46
IP8	0,66	0,85	0,64	0,60	0,82	0,92	-0,32	0,78	0,66
IP9	0,75	0,85	0,37	0,30	0,99	0,89	-0,47	0,85	0,37

Spruce	**Bending**	**RO**	**Transylvania**		**n = 116**	**a**	**b**	**c**	**d**
						1,06	-2,61	5,02	-22,8
	f_m	E_{global}	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	33,1	9,1	384	399	11,1	9,8	0,32	33,6	381
St. dev.	10,7	1,8	37,5	36,1	1,6	1,9	0,1	8,0	36
Median	31,1	8,9	381	399	11,0	9,5	0,33	33,1	379
5th centile	17,6	6,1	329	344	8,8	6,8	0,17	22,4	328
1st centile	16,3	5,3	308	333	7,7	6,4	0,09	18,6	310
Min	11,6	4,4	287	311	6,0	5,3	0,08	17,4	292
Max	61	14,0	467	479	15,3	15,3	0,57	57,2	464
COV	0,32	0,20	0,10	0,09	0,14	0,19	0,32	0,24	0,10
Correlations									
f_m	1	0,82	0,48	0,39	0,76	0,77	-0,60	0,80	0,45
E_{global}	0,82	1	0,67	0,61	0,86	0,96	-0,50	0,89	0,66
ρ	0,48	0,67	1	0,96	0,32	0,71	-0,25	0,59	0,97
$ρ_{specimen}$	0,39	0,61	0,96	1	0,23	0,65	-0,17	0,51	0,99
E_{freq}	0,76	0,86	0,32	0,23	1	0,88	-0,53	0,85	0,30
E_{dyn}	0,77	0,96	0,71	0,65	0,88	1	-0,49	0,91	0,71
KAR	-0,60	-0,50	-0,25	-0,17	-0,53	-0,49	1	-0,62	-0,24
IP1	0,80	0,89	0,59	0,51	0,85	0,91	-0,62	1	0,58
IP2	0,76	0,95	0,73	0,68	0,86	1,00	-0,48	0,91	0,73
IP3	0,45	0,66	0,97	0,99	0,30	0,71	-0,24	0,58	1
IP4	0,82	0,92	0,56	0,49	0,89	0,92	-0,59	0,89	0,55
IP5	0,75	0,94	0,72	0,66	0,84	0,97	-0,46	0,86	0,70
IP6	0,43	0,66	0,96	0,97	0,28	0,69	-0,21	0,54	0,97
IP7	0,69	0,84	0,38	0,30	0,96	0,88	-0,47	0,83	0,37
IP8	0,64	0,84	0,60	0,55	0,82	0,90	-0,46	0,84	0,61
IP9	0,73	0,82	0,28	0,19	0,98	0,85	-0,49	0,83	0,26

Appendix A: Correlation matrices of samples

A1: Sweden

Spruce	**Bending**	**SE**	**Lapland**		**n = 105**	**a**	**b**	**c**	**d**
						1,09	-3,88	5,50	-20,8
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	43,3	10,4	437	452	11,7	11,8	0,19	43,0	438
St. dev.	13,6	1,8	41,8	38,9	1,5	2,2	0,1	9,2	41,0
Median	42,4	10,3	433	451	11,6	11,6	0,19	42,5	435
5th centile	24,1	7,9	370	393	9,5	8,6	0,08	30,9	372
1st centile	19,0	7,1	358	376	8,4	7,7	0,04	27,6	361
Min	16,9	5,3	351	365	8,2	7,1	0,03	21,5	350
Max	87,9	16,5	572	568	16,0	19,5	0,51	74	563
COV	0,31	0,18	0,10	0,09	0,13	0,19	0,42	0,21	0,09
Correlations									
f_m	1	0,77	0,50	0,46	0,62	0,65	-0,31	0,74	0,48
E_{global}	0,77	1	0,76	0,74	0,85	0,94	-0,21	0,93	0,76
ρ	0,50	0,76	1	0,97	0,51	0,81	-0,05	0,75	0,97
$\rho_{specimen}$	0,46	0,74	0,97	1	0,46	0,79	0,02	0,72	0,99
E_{freq}	0,62	0,85	0,51	0,46	1	0,91	-0,19	0,87	0,49
E_{dyn}	0,65	0,94	0,81	0,79	0,91	1	-0,14	0,94	0,80
KAR	-0,31	-0,21	-0,05	0,02	-0,19	-0,14	1	-0,26	-0,01
IP1	0,74	0,93	0,75	0,72	0,87	0,94	-0,26	1	0,75
IP2	0,65	0,94	0,81	0,79	0,90	1,00	-0,13	0,94	0,81
IP3	0,48	0,76	0,97	0,99	0,49	0,80	-0,01	0,75	1
IP4	0,69	0,93	0,76	0,73	0,89	0,96	-0,20	0,94	0,75
IP5	0,64	0,93	0,79	0,77	0,89	0,98	-0,13	0,93	0,79
IP6	0,40	0,68	0,94	0,97	0,39	0,73	0,05	0,65	0,98
IP7	0,54	0,83	0,59	0,56	0,95	0,91	-0,11	0,84	0,58
IP8	0,53	0,81	0,70	0,68	0,79	0,87	-0,14	0,82	0,71
IP9	0,62	0,85	0,52	0,47	1,00	0,91	-0,19	0,87	0,49

Spruce	**Bending**	**SE**	**Västergötland**		**n = 105**	**a**	**b**	**c**	**d**
						1,21	-9,88	8,48	-61,3
	f_m	E_{global}	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	41,8	11,2	433	451	12,1	12,3	0,25	42,7	436
St. dev.	16,3	2,7	60,6	58,3	1,6	2,7	0,1	11,4	61,8
Median	39,9	11,0	433	457	12,2	12,2	0,22	42,6	443
5th centile	17,2	7,0	340	356	9,4	7,9	0,12	24,5	333
1st centile	14,9	6,3	308	333	8,7	7,0	0,07	20,5	309
Min	12,8	6,1	306	330	8,2	6,9	0,06	19,9	305
Max	84	17,9	573	576	16,2	18,6	0,57	72,4	563
COV	0,39	0,24	0,14	0,13	0,13	0,22	0,43	0,27	0,14
Correlations									
f_m	1	0,87	0,56	0,53	0,83	0,81	-0,63	0,85	0,55
E_{global}	0,87	1	0,75	0,75	0,87	0,96	-0,59	0,94	0,77
ρ	0,56	0,75	1	0,97	0,48	0,84	-0,36	0,79	0,98
$ρ_{specimen}$	0,53	0,75	0,97	1	0,45	0,84	-0,32	0,77	0,99
E_{freq}	0,83	0,87	0,48	0,45	1	0,86	-0,67	0,86	0,48
E_{dyn}	0,81	0,96	0,84	0,84	0,86	1	-0,57	0,96	0,86
KAR	-0,63	-0,59	-0,36	-0,32	-0,67	-0,57	1	-0,65	-0,35
IP1	0,85	0,94	0,79	0,77	0,86	0,96	-0,65	1	0,80
IP2	0,80	0,95	0,86	0,85	0,84	1,00	-0,55	0,96	0,87
IP3	0,55	0,77	0,98	0,99	0,48	0,86	-0,35	0,80	1
IP4	0,84	0,96	0,80	0,78	0,88	0,98	-0,62	0,95	0,80
IP5	0,81	0,95	0,85	0,84	0,84	0,99	-0,57	0,95	0,86
IP6	0,51	0,73	0,97	0,99	0,42	0,83	-0,31	0,75	0,99
IP7	0,77	0,89	0,58	0,58	0,93	0,88	-0,61	0,85	0,61
IP8	0,68	0,82	0,69	0,70	0,74	0,83	-0,49	0,79	0,72
IP9	0,82	0,86	0,43	0,40	0,99	0,83	-0,65	0,84	0,43

Appendix A: Correlation matrices of samples

A1: Slovenia

Spruce	**Bending**	**SI**			**n = 1 163**	**a** 0,99	**b** 1,28	**c** 5,61	**d** -26,32
	f_m N/mm²	E_{global} kN/mm²	ρ kg/m³	$\rho_{specimen}$ kg/m³	E_{freq} kN/mm²	E_{dyn} kN/mm²	KAR -	IP1 -	IP3 -
Mean	43,7	11,3	445	460	12,5	12,8	0,25	43,0	438
St. dev.	13,3	2,2	44	42	1,7	2,5	0,10	10,5	41
Median	42,7	11,1	442	458	12,4	12,6	0,24	41,9	436
5th centile	23,1	7,9	378	394	9,8	9,2	0,10	26,7	373
1st centile	18,5	6,6	354	369	8,8	8,1	0,04	21,2	353
Min	12,2	4,1	329	345	7,6	6,2	0,00	14,6	320
Max	83,6	18,9	603	624	17,0	21,7	0,69	77,5	579
COV	0,30	0,20	0,10	0,09	0,13	0,19	0,40	0,24	0,09
Correlations									
f_b	1	0,80	0,54	0,48	0,70	0,72	-0,54	0,78	0,52
E_{global}	0,80	1	0,75	0,72	0,85	0,93	-0,44	0,91	0,74
ρ	0,54	0,75	1	0,97	0,52	0,82	-0,19	0,72	0,96
$\rho_{specimen}$	0,48	0,72	0,97	1	0,45	0,79	-0,12	0,66	0,98
E_{freq}	0,70	0,85	0,52	0,45	1	0,90	-0,48	0,87	0,48
E_{dyn}	0,72	0,93	0,82	0,79	0,90	1	-0,39	0,92	0,80
KAR	-0,54	-0,44	-0,19	-0,12	-0,48	-0,39	1	-0,53	-0,18
IP1	0,78	0,91	0,72	0,66	0,87	0,92	-0,53	1	0,70
IP2	0,72	0,93	0,81	0,78	0,89	0,98	-0,39	0,93	0,81
IP3	0,52	0,74	0,96	0,98	0,48	0,80	-0,18	0,70	1
IP4	0,72	0,90	0,72	0,68	0,87	0,93	-0,45	0,89	0,70
IP5	0,68	0,89	0,76	0,73	0,86	0,94	-0,37	0,88	0,75
IP6	0,41	0,62	0,79	0,81	0,39	0,65	-0,12	0,56	0,81
IP7	0,64	0,83	0,56	0,51	0,92	0,87	-0,42	0,83	0,54
IP8	0,56	0,75	0,63	0,60	0,71	0,77	-0,35	0,72	0,62
IP9	0,68	0,83	0,51	0,45	0,98	0,88	-0,45	0,86	0,47

Spruce	**Bending**	**SI**	**Central Slovenia**		**n = 498**	**a**	**b**	**c**	**d**
						1,04	-0,79	5,91	-30,1
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	44,3	11,3	447	462	12,6	13,0	0,24	43,5	437
St. dev.	14,0	2,3	45	42	1,7	2,6	0,10	10,9	40
Median	42,4	11,0	445	460	12,4	12,7	0,23	42,2	435
5th centile	24,8	8,0	380	398	9,7	9,3	0,09	27,3	376
1st centile	18,7	7,0	353	367	9,0	8,2	0,04	20,1	345
Min	12,2	4,1	329	345	7,9	6,2	0,00	14,6	320
Max	83,6	18,9	603	624	16,7	21,7	0,55	77,5	579
COV	0,32	0,20	0,10	0,09	0,14	0,20	0,40	0,25	0,09
Correlations									
f_m	1	0,83	0,58	0,51	0,74	0,76	-0,56	0,81	0,54
E_{global}	0,83	1	0,77	0,73	0,88	0,95	-0,47	0,92	0,74
ρ	0,58	0,77	1	0,97	0,51	0,81	-0,25	0,71	0,97
$\rho_{specimen}$	0,51	0,73	0,97	1	0,45	0,78	-0,16	0,65	0,99
E_{freq}	0,74	0,88	0,51	0,45	1	0,91	-0,52	0,88	0,48
E_{dyn}	0,76	0,95	0,81	0,78	0,91	1	-0,44	0,93	0,79
KAR	-0,56	-0,47	-0,25	-0,16	-0,52	-0,44	1	-0,56	-0,21
IP1	0,81	0,92	0,71	0,65	0,88	0,93	-0,56	1	0,69
IP2	0,76	0,96	0,81	0,77	0,89	0,99	-0,44	0,94	0,80
IP3	0,54	0,74	0,97	0,99	0,48	0,79	-0,21	0,69	1
IP4	0,75	0,92	0,71	0,67	0,88	0,93	-0,50	0,90	0,69
IP5	0,72	0,92	0,75	0,72	0,87	0,95	-0,43	0,89	0,74
IP6	0,44	0,65	0,80	0,82	0,44	0,69	-0,17	0,58	0,82
IP7	0,70	0,85	0,54	0,50	0,92	0,87	-0,47	0,84	0,52
IP8	0,64	0,80	0,62	0,60	0,77	0,82	-0,41	0,75	0,62
IP9	0,74	0,88	0,51	0,45	0,98	0,89	-0,52	0,89	0,48

Appendix A: Correlation matrices of samples

Spruce	**Bending**	**SI**	**Inner Carniola**		**n = 238**	**a**	**b**	**c**	**d**
						1,03	-1,62	6,16	-35,97
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	42,6	11,2	450	464	12,8	13,2	0,27	43,2	444
St. dev.	14,2	2,2	45	43	1,6	2,5	0,11	11,0	43
Median	41,7	11,0	444	456	12,8	12,8	0,25	42,0	437
5th centile	20,9	8,0	384	402	10,1	9,8	0,10	25,5	381
1st centile	18,6	7,2	365	378	9,2	8,9	0,04	22,5	357
Min	13,9	6,3	360	368	9,0	8,2	0,03	20,4	346
Max	76,7	17,4	563	574	17,0	20,8	0,69	74,4	542
COV	0,33	0,20	0,10	0,09	0,13	0,19	0,42	0,26	0,10
Correlations									
f_b	1	0,80	0,57	0,52	0,71	0,74	-0,53	0,80	0,56
E_{global}	0,80	1	0,77	0,73	0,86	0,95	-0,46	0,93	0,77
ρ	0,57	0,77	1	0,97	0,52	0,83	-0,20	0,73	0,97
$\rho_{specimen}$	0,52	0,73	0,97	1	0,45	0,79	-0,12	0,67	0,98
E_{freq}	0,71	0,86	0,52	0,45	1	0,90	-0,48	0,88	0,49
E_{dyn}	0,74	0,95	0,83	0,79	0,90	1	-0,38	0,93	0,82
KAR	-0,53	-0,46	-0,20	-0,12	-0,48	-0,38	1	-0,55	-0,22
IP1	0,80	0,93	0,73	0,67	0,88	0,93	-0,55	1	0,72
IP2	0,74	0,95	0,82	0,79	0,89	0,99	-0,40	0,94	0,82
IP3	0,56	0,77	0,97	0,98	0,49	0,82	-0,22	0,72	1
IP4	0,74	0,91	0,77	0,72	0,84	0,93	-0,43	0,90	0,75
IP5	0,71	0,90	0,79	0,76	0,84	0,94	-0,37	0,88	0,78
IP6	0,43	0,61	0,80	0,83	0,35	0,64	-0,12	0,56	0,82
IP7	0,70	0,89	0,61	0,55	0,94	0,90	-0,44	0,87	0,58
IP8	0,56	0,78	0,66	0,64	0,59	0,71	-0,35	0,69	0,67
IP9	0,70	0,84	0,49	0,42	0,99	0,87	-0,48	0,87	0,46

Spruce	**Bending**	**SI**	**Slovenian arinthia**		**n = 323**	**a**	**b**	**c**	**d**
						0,97	3,49	5,85	-26,3
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	43,3	11,0	435	450	11,9	12,0	0,24	41,0	434
St. dev.	11,7	2,1	40	39	1,4	2,1	0,09	9,0	38
Median	43,4	11,1	432	449	12,0	12,0	0,24	40,7	431
5th centile	24,5	7,6	372	388	9,6	8,6	0,11	26,5	369
1st centile	18,5	6,3	346	369	8,6	7,4	0,06	21,1	354
Min	17,5	5,6	337	357	7,6	6,5	0,02	19,8	348
Max	71,4	16,6	562	552	15,1	18,5	0,52	70	554
COV	0,27	0,19	0,09	0,09	0,12	0,18	0,36	0,22	0,09
Correlations									
f_m	1	0,81	0,52	0,51	0,70	0,71	-0,52	0,75	0,52
E_{global}	0,81	1	0,74	0,75	0,82	0,91	-0,46	0,87	0,73
ρ	0,52	0,74	1	0,96	0,53	0,82	-0,17	0,74	0,96
$\rho_{specimen}$	0,51	0,75	0,96	1	0,49	0,81	-0,13	0,70	0,96
E_{freq}	0,70	0,82	0,53	0,49	1	0,90	-0,49	0,86	0,52
E_{dyn}	0,71	0,91	0,82	0,81	0,90	1	-0,39	0,92	0,82
KAR	-0,52	-0,46	-0,17	-0,13	-0,49	-0,39	1	-0,52	-0,19
IP1	0,75	0,87	0,74	0,70	0,86	0,92	-0,52	1	0,75
IP2	0,72	0,89	0,82	0,79	0,89	0,98	-0,42	0,93	0,83
IP3	0,52	0,73	0,96	0,96	0,52	0,82	-0,19	0,75	1
IP4	0,74	0,90	0,67	0,65	0,87	0,90	-0,47	0,89	0,69
IP5	0,69	0,89	0,74	0,73	0,87	0,94	-0,39	0,88	0,75
IP6	0,41	0,59	0,73	0,76	0,36	0,59	-0,13	0,52	0,78
IP7	0,66	0,79	0,59	0,54	0,93	0,87	-0,49	0,84	0,59
IP8	0,59	0,68	0,65	0,60	0,69	0,75	-0,46	0,73	0,69
IP9	0,70	0,82	0,53	0,49	0,98	0,89	-0,48	0,86	0,51

Appendix A: Correlation matrices of samples

Spruce	Bending	SI	Upper Carniola		n = 104	**a**	**b**	**c**	**d**
						0,83	5,87	5,08	-21,7
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	44,0	12,0	457	469	12,9	13,5	0,27	46,0	446
St. dev.	11,8	2,1	43	41	1,6	2,3	0,10	10,6	41
Median	44,9	12,0	461	475	13,0	13,4	0,27	45,3	452
5th centile	24,9	8,6	376	391	10,2	10,1	0,10	30,7	371
1st centile	20,6	7,6	367	379	9,3	9,4	0,05	22,6	357
Min	18,2	6,4	363	378	8,8	8,5	0,00	21,3	356
Max	73,1	16,6	573	571	16,3	18,6	0,48	70,2	560
COV	0,27	0,17	0,09	0,09	0,12	0,17	0,38	0,23	0,09
Correlations									
f_m	1	0,73	0,34	0,22	0,69	0,63	-0,54	0,74	0,31
E_{global}	0,73	1	0,67	0,58	0,86	0,94	-0,38	0,90	0,66
ρ	0,34	0,67	1	0,96	0,35	0,76	-0,07	0,62	0,97
$\rho_{specimen}$	0,22	0,58	0,96	1	0,22	0,68	0,04	0,51	0,98
E_{freq}	0,69	0,86	0,35	0,22	1	0,86	-0,56	0,85	0,33
E_{dyn}	0,63	0,94	0,76	0,68	0,86	1	-0,40	0,90	0,75
KAR	-0,54	-0,38	-0,07	0,04	-0,56	-0,40	1	-0,52	-0,06
IP1	0,74	0,90	0,62	0,51	0,85	0,90	-0,52	1	0,60
IP2	0,61	0,92	0,77	0,70	0,83	0,99	-0,37	0,91	0,77
IP3	0,31	0,66	0,97	0,98	0,33	0,75	-0,06	0,60	1
IP4	0,57	0,88	0,66	0,60	0,83	0,93	-0,44	0,86	0,67
IP5	0,60	0,90	0,74	0,67	0,82	0,96	-0,34	0,87	0,75
IP6	0,18	0,53	0,85	0,88	0,21	0,62	0,09	0,46	0,89
IP7	0,58	0,82	0,46	0,36	0,92	0,87	-0,52	0,84	0,45
IP8	0,58	0,89	0,69	0,62	0,84	0,95	-0,40	0,88	0,69
IP9	0,69	0,84	0,34	0,22	0,99	0,86	-0,57	0,85	0,32

A1: Slovakia

Spruce	**Bending**	**SK**	**Prešov**		**n = 113**	**a**	**b**	**c**	**d**
						1,08	-7,18	6,32	-35,3
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	32,5	9,5	420	438	10,7	10,5	0,36	36,9	422
St. dev.	10,6	1,8	39,6	37,5	1,3	1,7	0,1	7,8	37
Median	30,6	9,2	418	437	10,6	10,1	0,35	36,5	423
5th centile	17,3	6,9	363	379	8,8	8,0	0,19	25,3	363
1st centile	13,6	6,2	334	359	8,3	7,2	0,11	18,1	342
Min	13,2	5,4	331	351	8,0	6,7	0,05	11,3	331
Max	67,4	15,1	543	541	14,9	18,0	0,63	64	534
COV	0,33	0,19	0,09	0,09	0,12	0,17	0,30	0,21	0,09
Correlations									
f_m	1	0,86	0,46	0,36	0,78	0,77	-0,48	0,79	0,43
E_{global}	0,86	1	0,65	0,59	0,84	0,93	-0,45	0,92	0,65
ρ	0,46	0,65	1	0,91	0,34	0,73	-0,14	0,62	0,92
$\rho_{specimen}$	0,36	0,59	0,91	1	0,22	0,68	-0,10	0,56	0,99
E_{freq}	0,78	0,84	0,34	0,22	1	0,86	-0,42	0,84	0,30
E_{dyn}	0,77	0,93	0,73	0,68	0,86	1	-0,36	0,93	0,74
KAR	-0,48	-0,45	-0,14	-0,10	-0,42	-0,36	1	-0,47	-0,14
IP1	0,79	0,92	0,62	0,56	0,84	0,93	-0,47	1	0,64
IP2	0,77	0,93	0,74	0,69	0,84	0,99	-0,36	0,93	0,75
IP3	0,43	0,65	0,92	0,99	0,30	0,74	-0,14	0,64	1
IP4	0,83	0,90	0,62	0,52	0,85	0,91	-0,52	0,89	0,59
IP5	0,77	0,93	0,73	0,68	0,85	0,99	-0,37	0,93	0,74
IP6	0,37	0,60	0,92	0,99	0,24	0,70	-0,09	0,58	0,99
IP7	0,75	0,83	0,39	0,28	0,96	0,86	-0,43	0,85	0,36
IP8	0,75	0,87	0,62	0,55	0,87	0,93	-0,39	0,89	0,62
IP9	0,78	0,83	0,34	0,23	0,96	0,83	-0,46	0,82	0,31

Appendix A: Correlation matrices of samples

Spruce	Bending	SK	Žilina		n = 100	a	b	c	d
						0,92	4,02	4,66	-17,1
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	37,4	10,4	409	420	11,7	10,8	0,29	36,4	396
St. dev.	11,7	2,0	42,1	41,0	1,6	2,2	0,1	9,4	42
Median	37,5	10,1	405	414	11,6	10,5	0,28	34,6	388
5th centile	20,6	7,7	352	366	9,0	8,0	0,17	23,5	342
1st centile	17,5	7,4	345	352	8,5	7,2	0,14	20,6	326
Min	16,8	6,9	344	345	8,2	7,0	0,14	19,0	324
Max	65,6	15,2	525	531	15,4	17,2	0,52	59,4	507
COV	0,31	0,19	0,10	0,10	0,14	0,20	0,31	0,26	0,10
Correlations									
f_m	1	0,76	0,41	0,42	0,66	0,68	-0,58	0,74	0,47
E_{global}	0,76	1	0,70	0,68	0,86	0,96	-0,44	0,93	0,73
ρ	0,41	0,70	1	0,97	0,38	0,75	-0,20	0,69	0,97
$\rho_{specimen}$	0,42	0,68	0,97	1	0,33	0,73	-0,17	0,66	0,99
E_{freq}	0,66	0,86	0,38	0,33	1	0,88	-0,39	0,85	0,40
E_{dyn}	0,68	0,96	0,75	0,73	0,88	1	-0,36	0,94	0,78
KAR	-0,58	-0,44	-0,20	-0,17	-0,39	-0,36	1	-0,53	-0,22
IP1	0,74	0,93	0,69	0,66	0,85	0,94	-0,53	1	0,72
IP2	0,66	0,95	0,76	0,74	0,87	0,99	-0,34	0,94	0,79
IP3	0,47	0,73	0,97	0,99	0,40	0,78	-0,22	0,72	1
IP4	0,54	0,83	0,63	0,62	0,79	0,87	-0,23	0,80	0,66
IP5	0,62	0,89	0,67	0,64	0,85	0,93	-0,30	0,87	0,69
IP6	0,31	0,53	0,76	0,78	0,27	0,57	-0,06	0,48	0,78
IP7	0,62	0,89	0,54	0,49	0,95	0,92	-0,34	0,88	0,55
IP8	0,58	0,89	0,74	0,70	0,82	0,94	-0,27	0,89	0,75
IP9	0,66	0,86	0,39	0,34	0,99	0,89	-0,38	0,85	0,41

A1: Ukraine

Spruce	**Bending**	**UA**	**Iwano-Frankiwsk**		**n = 204**	**a**	**b**	**c**	**d**
						0,87	4,72	4,52	-16,1
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	36,2	9,8	389	404	11,6	10,4	0,28	36,2	391
St. dev.	10,6	1,8	37,1	36,0	1,6	2,0	0,1	9,2	36
Median	35,2	9,4	383	401	11,5	10,2	0,26	36,4	387
5th centile	19,5	7,2	338	352	9,1	7,8	0,13	21,5	335
1st centile	15,7	6,4	317	332	8,3	7,2	0,07	16,9	323
Min	12,8	5,8	304	320	7,9	6,4	0,05	11,4	317
Max	63,6	14,5	485	499	15,6	16,3	0,63	60,1	484
COV	0,29	0,19	0,10	0,09	0,14	0,19	0,36	0,25	0,09
Correlations									
f_m	1	0,78	0,39	0,34	0,69	0,70	-0,48	0,75	0,39
E_{global}	0,78	1	0,65	0,60	0,84	0,94	-0,39	0,87	0,64
ρ	0,39	0,65	1	0,95	0,35	0,72	0,09	0,54	0,94
$\rho_{specimen}$	0,34	0,60	0,95	1	0,25	0,67	0,16	0,48	0,98
E_{freq}	0,69	0,84	0,35	0,25	1	0,88	-0,54	0,88	0,32
E_{dyn}	0,70	0,94	0,72	0,67	0,88	1	-0,33	0,91	0,72
KAR	-0,48	-0,39	0,09	0,16	-0,54	-0,33	1	-0,49	0,08
IP1	0,75	0,87	0,54	0,48	0,88	0,91	-0,49	1	0,56
IP2	0,68	0,92	0,72	0,67	0,87	0,99	-0,32	0,91	0,72
IP3	0,39	0,64	0,94	0,98	0,32	0,72	0,08	0,56	1
IP4	0,63	0,84	0,57	0,54	0,84	0,90	-0,36	0,85	0,59
IP5	0,63	0,86	0,64	0,61	0,84	0,94	-0,29	0,86	0,65
IP6	0,26	0,48	0,71	0,77	0,23	0,55	0,16	0,42	0,77
IP7	0,64	0,84	0,42	0,34	0,95	0,89	-0,45	0,84	0,38
IP8	0,63	0,84	0,55	0,49	0,77	0,83	-0,33	0,73	0,53
IP9	0,68	0,83	0,35	0,26	0,99	0,88	-0,52	0,89	0,32

A2: Switzerland

Spruce	**Tension**	**CH**	**Jura**		**n = 148**	**a**	**b**	**c**	**d**
						1,04	-0,65	5,70	-37,7
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	32,5	11,8	451	449	12,3	12,3	0,21	32,3	434
St. dev.	13,8	2,8	55	43	1,9	2,6	0,11	10,9	44
Median	30,3	11,9	440	441	12,5	12,2	0,20	33,0	426
5th centile	12,1	7,7	378	397	9,2	8,4	0,06	13,4	378
1st centile	7,2	6,3	368	384	7,4	7,2	0,00	9,7	369
Min	5,2	5,0	361	380	6,6	6,7	0,00	7,8	363
Max	70,7	18,7	621	605	15,6	18,3	0,54	52,9	579
COV	0,43	0,24	0,12	0,10	0,15	0,21	0,49	0,34	0,10
Correlations									
f_t	1	0,77	0,48	0,43	0,78	0,78	-0,55	0,83	0,44
E	0,77	1	0,60	0,64	0,82	0,90	-0,51	0,86	0,61
ρ	0,48	0,60	1	0,91	0,40	0,71	-0,19	0,62	0,94
$\rho_{specimen}$	0,43	0,64	0,91	1	0,36	0,73	-0,12	0,60	0,97
E_{freq}	0,78	0,82	0,40	0,36	1	0,90	-0,47	0,91	0,38
E_{dyn}	0,78	0,90	0,71	0,73	0,90	1	-0,40	0,93	0,73
KAR	-0,55	-0,51	-0,19	-0,12	-0,47	-0,40	1	-0,55	-0,15
IP1	0,83	0,86	0,62	0,60	0,91	0,93	-0,55	1	0,63
IP2	0,77	0,88	0,73	0,73	0,88	0,99	-0,38	0,93	0,75
IP3	0,44	0,61	0,94	0,97	0,38	0,73	-0,15	0,63	1
IP4									
IP5									
IP6									
IP7	0,71	0,78	0,39	0,38	0,93	0,86	-0,38	0,84	0,38
IP8	0,69	0,80	0,66	0,65	0,83	0,91	-0,30	0,85	0,68
IP9	0,77	0,81	0,38	0,35	0,99	0,88	-0,46	0,91	0,37

Spruce	**Tension**	**CH**	**Mittelland**		**n = 150**	**a**	**b**	**c**	**d**
						0,79	4,03	4,73	-27,4
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	23,6	10,5	438	454	10,8	11,0	0,33	24,7	435
St. dev.	9,5	2,7	53	49	1,6	2,2	0,12	9,8	48
Median	21,6	10,4	438	454	10,8	10,7	0,33	23,5	434
5th centile	12,1	6,7	345	367	8,4	7,7	0,15	11,2	354
1st centile	9,7	4,9	322	337	7,8	7,0	0,06	5,9	326
Min	5,2	3,2	311	327	7,4	6,2	0,00	2,1	313
Max	52,7	17,9	596	558	15,8	17,3	0,59	53,9	542
COV	0,40	0,26	0,12	0,11	0,15	0,20	0,37	0,40	0,11
Correlations									
f_t	1	0,75	0,26	0,24	0,80	0,75	-0,67	0,82	0,22
E	0,75	1	0,51	0,49	0,80	0,90	-0,62	0,87	0,47
ρ	0,26	0,51	1	0,93	0,19	0,66	-0,14	0,41	0,94
$\rho_{specimen}$	0,24	0,49	0,93	1	0,10	0,64	-0,06	0,33	0,98
E_{freq}	0,80	0,80	0,19	0,10	1	0,83	-0,75	0,91	0,10
E_{dyn}	0,75	0,90	0,66	0,64	0,83	1	-0,62	0,90	0,62
KAR	-0,67	-0,62	-0,14	-0,06	-0,75	-0,62	1	-0,76	-0,05
IP1	0,82	0,87	0,41	0,33	0,91	0,90	-0,76	1	0,34
IP2	0,73	0,89	0,68	0,65	0,80	0,98	-0,60	0,90	0,65
IP3	0,22	0,47	0,94	0,98	0,10	0,62	-0,05	0,34	1
IP4									
IP5									
IP6									
IP7	0,75	0,81	0,28	0,21	0,93	0,84	-0,69	0,89	0,21
IP8	0,68	0,83	0,61	0,58	0,76	0,92	-0,54	0,84	0,58
IP9	0,80	0,80	0,18	0,10	0,99	0,82	-0,77	0,92	0,10

Appendix A: Correlation matrices of samples

Spruce	**Tension**	**CH**	**Voralpen/Alpen**		**n = 149**	**a**	**b**	**c**	**d**
						1,16	-2,11	5,93	-39,1
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	27,3	10,5	429	443	11,2	11,0	0,29	25,4	419
St. dev.	11,3	2,1	41	55	1,4	2,0	0,10	8,3	38
Median	25,5	10,2	431	441	11,1	10,8	0,30	24,6	419
5th centile	13,1	8,0	367	379	9,3	8,4	0,13	13,0	357
1st centile	9,0	6,4	348	364	8,2	7,7	0,05	10,5	339
Min	5,9	4,4	326	349	7,5	6,8	0,00	8,6	326
Max	68,2	17,6	520	937	15,0	20,7	0,65	53,4	507
COV	0,41	0,20	0,09	0,12	0,12	0,19	0,33	0,33	0,09
Correlations									
f_t	1	0,80	0,51	0,38	0,73	0,76	-0,52	0,85	0,54
E	0,80	1	0,55	0,34	0,75	0,76	-0,44	0,82	0,57
ρ	0,51	0,55	1	0,70	0,31	0,69	-0,29	0,56	0,95
$\rho_{specimen}$	0,38	0,34	0,70	1	0,12	0,72	-0,18	0,35	0,70
E_{freq}	0,73	0,75	0,31	0,12	1	0,77	-0,45	0,83	0,28
E_{dyn}	0,76	0,76	0,69	0,72	0,77	1	-0,43	0,81	0,67
KAR	-0,52	-0,44	-0,29	-0,18	-0,45	-0,43	1	-0,51	-0,25
IP1	0,85	0,82	0,56	0,35	0,83	0,81	-0,51	1	0,58
IP2	0,82	0,86	0,74	0,52	0,79	0,91	-0,43	0,91	0,76
IP3	0,54	0,57	0,95	0,70	0,28	0,67	-0,25	0,58	1
IP4									
IP5									
IP6									
IP7	0,72	0,78	0,33	0,16	0,91	0,74	-0,42	0,83	0,33
IP8	0,76	0,78	0,65	0,42	0,73	0,80	-0,33	0,84	0,68
IP9	0,74	0,76	0,30	0,12	0,95	0,74	-0,45	0,83	0,28

A2: Poland

Spruce	**Tension**	**PL**	**Swietjano**		**n = 111**	**a**	**b**	**c**	**d**
						0,98	1,16	4,97	-27,5
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	31,4	12,4	472	475	11,8	12,6	0,27	30,8	452
St. dev.	11,5	2,7	51	46	1,5	2,3	0,11	9,1	47
Median	30,9	12,4	469	474	11,9	12,4	0,26	30,0	452
5th centile	14,6	8,6	390	405	9,3	9,1	0,11	15,5	375
1st centile	8,9	7,2	369	371	8,3	8,3	0,01	12,3	340
Min	5,9	6,0	345	358	7,6	7,6	0,00	8,7	336
Max	64,8	20,1	591	577	15,2	18,1	0,58	49,4	562
COV	0,37	0,22	0,11	0,10	0,13	0,18	0,42	0,29	0,11
Correlations									
f_t	1	0,80	0,45	0,38	0,66	0,69	-0,40	0,77	0,41
E	0,80	1	0,67	0,61	0,85	0,94	-0,37	0,91	0,62
ρ	0,45	0,67	1	0,97	0,39	0,79	-0,07	0,57	0,97
$\rho_{specimen}$	0,38	0,61	0,97	1	0,28	0,72	-0,04	0,49	0,98
E_{freq}	0,66	0,85	0,39	0,28	1	0,86	-0,39	0,90	0,29
E_{dyn}	0,69	0,94	0,79	0,72	0,86	1	-0,31	0,91	0,72
KAR	-0,40	-0,37	-0,07	-0,04	-0,39	-0,31	1	-0,46	-0,09
IP1	0,77	0,91	0,57	0,49	0,90	0,91	-0,46	1	0,51
IP2	0,71	0,94	0,80	0,73	0,84	0,99	-0,35	0,92	0,75
IP3	0,41	0,62	0,97	0,98	0,29	0,72	-0,09	0,51	1
IP4	0,68	0,86	0,67	0,63	0,81	0,90	-0,40	0,88	0,64
IP5	0,64	0,85	0,69	0,65	0,80	0,91	-0,30	0,84	0,64
IP6	0,37	0,51	0,72	0,76	0,26	0,59	-0,05	0,41	0,74
IP7	0,27	0,48	0,38	0,34	0,50	0,54	-0,26	0,45	0,33
IP8									
IP9	0,66	0,85	0,37	0,27	0,99	0,85	-0,41	0,91	0,28

Appendix A: Correlation matrices of samples

Spruce	**Tension**	**PL**	**Murow**		**n = 111**	**a**	**b**	**c**	**d**
						0,97	0,68	5,28	-34,2
	f_t	E	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	25,1	10,7	432	440	11,2	11,1	0,32	25,2	418
St. dev.	9,1	2,3	45	41	1,4	2,0	0,11	8,1	44
Median	23,6	10,4	431	435	11,3	10,9	0,32	25,0	414
5th centile	13,6	7,8	367	382	9,0	8,2	0,16	13,5	354
1st centile	11,4	6,6	339	350	8,3	7,3	0,10	7,2	323
Min	9,0	4,2	335	345	7,9	6,8	0,09	3,2	320
Max	57,4	17,8	591	583	14,2	17,2	0,69	52,5	567
COV	0,36	0,22	0,10	0,09	0,12	0,18	0,33	0,32	0,10
Correlations									
f_t	1	0,83	0,52	0,48	0,79	0,82	-0,53	0,86	0,52
E	0,83	1	0,71	0,69	0,79	0,93	-0,49	0,90	0,71
ρ	0,52	0,71	1	0,97	0,39	0,79	-0,39	0,60	0,98
$ρ_{specimen}$	0,48	0,69	0,97	1	0,31	0,75	-0,29	0,55	0,99
E_{freq}	0,79	0,79	0,39	0,31	1	0,86	-0,44	0,89	0,36
E_{dyn}	0,82	0,93	0,79	0,75	0,86	1	-0,48	0,92	0,78
KAR	-0,53	-0,49	-0,39	-0,29	-0,44	-0,48	1	-0,58	-0,37
IP1	0,86	0,90	0,60	0,55	0,89	0,92	-0,58	1	0,59
IP2	0,82	0,93	0,80	0,76	0,84	0,99	-0,48	0,91	0,80
IP3	0,52	0,71	0,98	0,99	0,36	0,78	-0,37	0,59	1
IP4	0,80	0,84	0,68	0,64	0,80	0,90	-0,48	0,84	0,68
IP5	0,78	0,84	0,70	0,67	0,79	0,91	-0,43	0,82	0,70
IP6	0,40	0,50	0,73	0,75	0,25	0,57	-0,20	0,37	0,74
IP7	0,38	0,36	0,13	0,10	0,57	0,43	-0,16	0,43	0,13
IP8									
IP9	0,80	0,80	0,39	0,32	0,99	0,85	-0,45	0,89	0,36

A2: Romania

Spruce	**Tension**	**RO**	**Bucovina**		**n = 203**	**a**	**b**	**c**	**d**
						1,06	-1,83	5,20	-34,6
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	25,0	10,2	389	407	11,5	10,4	0,30	25,3	394
St. dev.	10,4	2,1	33	32	1,6	2,0	0,10	8,2	33
Median	23,4	10,2	390	408	11,7	10,4	0,30	25,9	391
5th centile	12,5	7,1	338	356	8,8	7,5	0,13	12,0	341
1st centile	9,7	6,4	318	346	8,2	6,5	0,07	9,8	326
Min	7,0	5,3	311	340	7,9	6,1	0,03	5,9	320
Max	71,8	15,8	469	486	16,0	15,8	0,57	49,5	480
COV	0,42	0,21	0,09	0,08	0,14	0,19	0,35	0,32	0,08
Correlations									
f_t	1	0,80	0,46	0,40	0,79	0,75	-0,58	0,83	0,44
E	0,80	1	0,73	0,71	0,90	0,96	-0,44	0,90	0,73
ρ	0,46	0,73	1	0,93	0,54	0,79	-0,13	0,57	0,92
$\rho_{specimen}$	0,40	0,71	0,93	1	0,47	0,76	-0,06	0,52	0,97
E_{freq}	0,79	0,90	0,54	0,47	1	0,93	-0,47	0,93	0,50
E_{dyn}	0,75	0,96	0,79	0,76	0,93	1	-0,38	0,90	0,77
KAR	-0,58	-0,44	-0,13	-0,06	-0,47	-0,38	1	-0,54	-0,13
IP1	0,83	0,90	0,57	0,52	0,93	0,90	-0,54	1	0,56
IP2	0,74	0,95	0,79	0,77	0,91	0,99	-0,35	0,91	0,79
IP3	0,44	0,73	0,92	0,97	0,50	0,77	-0,13	0,56	1
IP4	0,70	0,88	0,72	0,68	0,87	0,92	-0,35	0,84	0,70
IP5	0,72	0,91	0,75	0,72	0,89	0,95	-0,37	0,87	0,74
IP6	0,34	0,58	0,78	0,80	0,41	0,64	-0,10	0,44	0,81
IP7	0,71	0,84	0,54	0,47	0,94	0,88	-0,37	0,87	0,49
IP8	0,67	0,87	0,71	0,69	0,83	0,90	-0,26	0,80	0,68
IP9	0,78	0,90	0,54	0,47	0,99	0,92	-0,45	0,94	0,49

Appendix A: Correlation matrices of samples

Spruce	**Tension**	**RO**	**Transylvania**		**n = 116**	**a**	**b**	**c**	**d**
						1,25	-5,06	5,82	-41,9
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	26,7	9,8	391	404	11,8	10,5	0,32	25,3	387
St. dev.	11,6	2,1	32	30	1,6	1,8	0,11	8,0	31
Median	24,2	9,6	395	409	11,8	10,3	0,32	25,2	389
5th centile	12,4	6,5	330	349	9,2	7,5	0,15	13,0	327
1st centile	10,0	6,2	323	335	8,1	7,1	0,09	6,7	323
Min	9,7	6,1	322	332	7,6	7,1	0,05	6,7	318
Max	72,8	15,6	476	478	16,0	16,1	0,68	47,1	465
COV	0,44	0,21	0,08	0,08	0,13	0,18	0,34	0,32	0,08
Correlations									
f_t	1	0,82	0,54	0,44	0,79	0,81	-0,60	0,87	0,51
E	0,82	1	0,74	0,65	0,86	0,96	-0,45	0,87	0,70
ρ	0,54	0,74	1	0,95	0,43	0,76	-0,17	0,49	0,96
$\rho_{specimen}$	0,44	0,65	0,95	1	0,29	0,66	-0,04	0,36	0,99
E_{freq}	0,79	0,86	0,43	0,29	1	0,90	-0,52	0,93	0,37
E_{dyn}	0,81	0,96	0,76	0,66	0,90	1	-0,42	0,89	0,73
KAR	-0,60	-0,45	-0,17	-0,04	-0,52	-0,42	1	-0,60	-0,12
IP1	0,87	0,87	0,49	0,36	0,93	0,89	-0,60	1	0,45
IP2	0,81	0,95	0,77	0,68	0,89	1,00	-0,41	0,89	0,74
IP3	0,51	0,70	0,96	0,99	0,37	0,73	-0,12	0,45	1
IP4	0,84	0,93	0,67	0,55	0,89	0,94	-0,53	0,89	0,62
IP5	0,77	0,94	0,74	0,65	0,86	0,96	-0,40	0,84	0,70
IP6	0,47	0,69	0,97	0,98	0,32	0,69	-0,09	0,40	0,97
IP7	0,71	0,82	0,43	0,30	0,97	0,88	-0,45	0,88	0,38
IP8	0,68	0,84	0,64	0,59	0,85	0,91	-0,34	0,82	0,65
IP9	0,77	0,83	0,39	0,25	0,99	0,88	-0,51	0,93	0,34

A2: Sweden

Spruce	**Tension**	**SE**	**Lapland**		**n = 113**	**a**	**b**	**c**	**d**
						0,73	9,06	3,44	-10,2
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	29,1	10,0	414	444	11,4	11,3	0,20	27,6	427
St. dev.	9,7	2,0	42	44	1,7	2,4	0,09	9,1	44
Median	27,8	10,1	413	446	11,5	11,0	0,20	27,6	430
5th centile	14,4	7,0	342	375	9,0	7,8	0,08	13,7	358
1st centile	7,0	5,3	333	346	7,2	6,4	0,04	6,5	328
Min	6,0	4,8	325	343	5,9	5,5	0,04	4,7	324
Max	59,4	14,6	520	546	15,6	19,1	0,56	53,5	545
COV	0,33	0,20	0,10	0,10	0,15	0,22	0,47	0,33	0,10
Correlations									
f_t	1	0,78	0,41	0,41	0,61	0,60	-0,48	0,69	0,46
E	0,78	1	0,52	0,54	0,65	0,69	-0,40	0,74	0,57
ρ	0,41	0,52	1	0,97	0,47	0,78	-0,13	0,59	0,95
$\rho_{specimen}$	0,41	0,54	0,97	1	0,47	0,79	-0,10	0,59	0,98
E_{freq}	0,61	0,65	0,47	0,47	1	0,91	-0,40	0,90	0,49
E_{dyn}	0,60	0,69	0,78	0,79	0,91	1	-0,32	0,90	0,80
KAR	-0,48	-0,40	-0,13	-0,10	-0,40	-0,32	1	-0,46	-0,15
IP1	0,69	0,74	0,59	0,59	0,90	0,90	-0,46	1	0,64
IP2	0,61	0,72	0,76	0,77	0,87	0,97	-0,31	0,93	0,80
IP3	0,46	0,57	0,95	0,98	0,49	0,80	-0,15	0,64	1
IP4	0,64	0,73	0,72	0,72	0,88	0,95	-0,39	0,93	0,76
IP5	0,61	0,74	0,75	0,76	0,86	0,96	-0,33	0,91	0,79
IP6	0,41	0,58	0,90	0,93	0,43	0,73	-0,16	0,55	0,95
IP7	0,59	0,68	0,48	0,48	0,90	0,85	-0,30	0,88	0,51
IP8	0,56	0,60	0,66	0,66	0,69	0,79	-0,21	0,73	0,66
IP9	0,60	0,67	0,47	0,47	0,95	0,88	-0,36	0,93	0,50

Appendix A: Correlation matrices of samples

Spruce	**Tension**	**SE**	**Västergötland**		**n = 105**	**a**	**b**	**c**	**d**
						0,96	0,5	5,89	-41,5
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	25,9	10,4	418	447	11,5	11,5	0,28	26,4	431
St. dev.	11,4	2,7	54	57	1,6	2,7	0,11	10,6	60
Median	25,8	10,7	417	447	11,7	11,5	0,28	27,7	431
5th centile	9,9	6,6	337	363	8,9	7,6	0,13	11,5	339
1st centile	8,8	6,1	332	352	8,4	7,3	0,00	7,6	333
Min	7,0	4,5	328	349	8,3	7,1	0,00	3,1	332
Max	63,1	17,7	556	600	15,6	19,3	0,57	58,2	573
COV	0,44	0,26	0,13	0,13	0,14	0,23	0,40	0,40	0,14
Correlations									
f_t	1	0,86	0,68	0,69	0,82	0,86	-0,66	0,90	0,72
E	0,86	1	0,81	0,82	0,81	0,93	-0,59	0,89	0,84
ρ	0,68	0,81	1	0,98	0,56	0,87	-0,46	0,76	0,98
$\rho_{specimen}$	0,69	0,82	0,98	1	0,55	0,87	-0,46	0,76	0,99
E_{freq}	0,82	0,81	0,56	0,55	1	0,88	-0,54	0,92	0,58
E_{dyn}	0,86	0,93	0,87	0,87	0,88	1	-0,57	0,96	0,89
KAR	-0,66	-0,59	-0,46	-0,46	-0,54	-0,57	1	-0,63	-0,50
IP1	0,90	0,89	0,76	0,76	0,92	0,96	-0,63	1	0,78
IP2	0,86	0,92	0,88	0,87	0,88	1,00	-0,57	0,96	0,89
IP3	0,72	0,84	0,98	0,99	0,58	0,89	-0,50	0,78	1
IP4	0,86	0,91	0,85	0,84	0,86	0,98	-0,58	0,95	0,86
IP5	0,85	0,92	0,87	0,87	0,87	0,99	-0,56	0,95	0,88
IP6	0,69	0,82	0,97	0,99	0,54	0,87	-0,48	0,76	0,99
IP7	0,79	0,81	0,64	0,62	0,95	0,90	-0,53	0,92	0,65
IP8	0,77	0,86	0,83	0,84	0,78	0,92	-0,53	0,87	0,84
IP9	0,81	0,78	0,54	0,52	0,99	0,86	-0,56	0,90	0,54

A2: Slovenia

Spruce	**Tension**	**SI**	**Upper Carniola**		**n = 104**	**a**	**b**	**c**	**d**
						1,19	-3,68	6,17	-43,9
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	34,0	12,3	442	451	12,6	12,7	0,25	31,6	429
St. dev.	15,0	2,7	41	38	2,0	2,5	0,11	11,0	38
Median	31,8	12,2	441	452	12,7	12,5	0,25	31,1	426
5th centile	14,0	8,2	386	393	8,7	8,8	0,08	12,2	373
1st centile	10,0	6,9	361	384	7,7	7,7	0,05	6,4	365
Min	8,9	6,5	352	379	7,7	7,6	0,00	3,8	355
Max	89,6	18,7	535	534	16,4	19,1	0,6	56,5	505
COV	0,44	0,22	0,09	0,08	0,16	0,20	0,43	0,35	0,09
Correlations									
f_t	1	0,83	0,44	0,36	0,81	0,81	-0,62	0,87	0,44
E	0,83	1	0,63	0,57	0,92	0,98	-0,53	0,94	0,63
ρ	0,44	0,63	1	0,96	0,34	0,69	-0,26	0,48	0,97
$\rho_{specimen}$	0,36	0,57	0,96	1	0,24	0,63	-0,16	0,40	0,98
E_{freq}	0,81	0,92	0,34	0,24	1	0,91	-0,55	0,93	0,33
E_{dyn}	0,81	0,98	0,69	0,63	0,91	1	-0,50	0,92	0,68
KAR	-0,62	-0,53	-0,26	-0,16	-0,55	-0,50	1	-0,64	-0,26
IP1	0,87	0,94	0,48	0,40	0,93	0,92	-0,64	1	0,49
IP2	0,80	0,98	0,71	0,65	0,88	0,99	-0,48	0,92	0,71
IP3	0,44	0,63	0,97	0,98	0,33	0,68	-0,26	0,49	1
IP4	0,81	0,95	0,66	0,60	0,87	0,96	-0,53	0,91	0,66
IP5	0,77	0,95	0,69	0,64	0,86	0,97	-0,46	0,90	0,69
IP6	0,32	0,49	0,85	0,88	0,20	0,54	-0,13	0,36	0,89
IP7	0,71	0,87	0,41	0,31	0,93	0,87	-0,45	0,86	0,38
IP8	0,71	0,92	0,67	0,61	0,84	0,94	-0,39	0,85	0,66
IP9	0,81	0,92	0,34	0,25	0,99	0,90	-0,53	0,93	0,32

A2: Slovakia

Spruce	Tension	SK	Prešov		n = 115	a	b	c	d
						1,20	3,57	5,95	-43,3
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	28,3	10,7	401	416	12,0	11,1	0,26	26,6	395
St. dev.	12,1	2,2	33	32	1,7	2,1	0,08	8,8	33
Median	25,8	10,6	395	412	12,2	11,1	0,26	26,1	390
5th centile	13,4	7,1	354	373	9,2	7,9	0,13	12,6	351
1st centile	8,4	6,0	348	361	7,7	6,4	0,08	5,7	341
Min	7,0	5,9	340	350	7,4	6,3	0,08	3,3	332
Max	70,3	18,2	507	538	15,6	18,6	0,51	52,3	521
COV	0,43	0,21	0,08	0,08	0,14	0,19	0,32	0,33	0,08
Correlations									
f_t	1	0,86	0,56	0,55	0,82	0,84	-0,62	0,88	0,61
E	0,86	1	0,75	0,74	0,91	0,99	-0,60	0,95	0,80
ρ	0,56	0,75	1	0,97	0,50	0,78	-0,41	0,64	0,98
$\rho_{specimen}$	0,55	0,74	0,97	1	0,45	0,77	-0,37	0,61	0,99
E_{freq}	0,82	0,91	0,50	0,45	1	0,92	-0,57	0,94	0,54
E_{dyn}	0,84	0,99	0,78	0,77	0,92	1	-0,57	0,95	0,83
KAR	-0,62	-0,60	-0,41	-0,37	-0,57	-0,57	1	-0,65	-0,43
IP1	0,88	0,95	0,64	0,61	0,94	0,95	-0,65	1	0,69
IP2	0,84	0,98	0,79	0,77	0,91	0,99	-0,57	0,95	0,83
IP3	0,61	0,80	0,98	0,99	0,54	0,83	-0,43	0,69	1
IP4	0,84	0,95	0,71	0,68	0,92	0,96	-0,64	0,94	0,75
IP5	0,79	0,95	0,76	0,73	0,88	0,96	-0,54	0,91	0,79
IP6	0,54	0,74	0,97	0,99	0,46	0,77	-0,37	0,61	0,98
IP7	0,78	0,88	0,49	0,46	0,97	0,89	-0,57	0,90	0,54
IP8	0,78	0,93	0,76	0,75	0,82	0,93	-0,53	0,87	0,80
IP9	0,83	0,91	0,49	0,45	0,99	0,91	-0,58	0,93	0,53

Spruce	**Tension**	**SK**	**Žilina**		**n = 100**	**a**	**b**	**c**	**d**
						1,06	-0,69	5,43	-37,6
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm²	kN/mm²	kg/m³	kg/m³	kN/mm²	kN/mm²	-	-	-
Mean	25,9	10,7	416	426	11,7	11,0	0,29	24,7	401
St. dev.	9,3	2,0	38	36	1,3	1,9	0,09	7,5	36
Median	24,1	10,7	413	421	11,7	10,7	0,29	23,2	394
5th centile	13,6	7,5	354	366	9,6	8,0	0,16	13,1	342
1st centile	9,9	7,1	341	354	9,3	7,7	0,12	10,7	334
Min	6,8	6,8	334	345	9,0	7,7	0,10	10,3	325
Max	55,3	17,0	516	523	14,8	17,1	0,51	47	508
COV	0,36	0,19	0,09	0,09	0,11	0,17	0,29	0,30	0,09
Correlations									
f_t	1	0,81	0,49	0,44	0,76	0,74	-0,54	0,86	0,51
E	0,81	1	0,76	0,71	0,88	0,96	-0,29	0,90	0,76
ρ	0,49	0,76	1	0,96	0,49	0,82	-0,10	0,60	0,96
$\rho_{specimen}$	0,44	0,71	0,96	1	0,43	0,79	-0,03	0,57	0,99
E_{freq}	0,76	0,88	0,49	0,43	1	0,88	-0,24	0,88	0,49
E_{dyn}	0,74	0,96	0,82	0,79	0,88	1	-0,18	0,88	0,83
KAR	-0,54	-0,29	-0,10	-0,03	-0,24	-0,18	1	-0,42	-0,07
IP1	0,86	0,90	0,60	0,57	0,88	0,88	-0,42	1	0,64
IP2	0,75	0,95	0,80	0,78	0,88	0,99	-0,19	0,90	0,83
IP3	0,51	0,76	0,96	0,99	0,49	0,83	-0,07	0,64	1
IP4	0,67	0,85	0,74	0,77	0,78	0,91	-0,15	0,82	0,79
IP5	0,68	0,88	0,80	0,80	0,79	0,94	-0,12	0,82	0,83
IP6	0,42	0,64	0,78	0,85	0,43	0,72	0,07	0,54	0,85
IP7	0,62	0,81	0,49	0,45	0,92	0,83	-0,18	0,79	0,49
IP8	0,56	0,83	0,77	0,76	0,76	0,89	-0,10	0,73	0,78
IP9	0,77	0,88	0,48	0,43	0,99	0,87	-0,28	0,89	0,49

A2: Ukraine

Spruce	**Tension**	**UA**	**Iwano-Frankiwsk**	**n = 204**		**a**	**b**	**c**	**d**
						1,02	-0,93	5,01	-32,6
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	24,3	9,9	384	402	11,4	10,2	0,30	24,7	389
St. dev.	9,9	2,1	36	35	1,5	1,8	0,10	7,9	35
Median	23,6	9,7	384	402	11,3	10,0	0,30	25,0	392
5th centile	11,9	7,0	327	346	8,9	7,5	0,16	12,0	331
1st centile	8,9	5,8	316	334	8,2	6,9	0,10	9,3	312
Min	1,7	0,0	310	319	8,0	6,6	0,07	3,1	308
Max	66,2	14,8	475	491	14,8	15,0	0,65	46,6	479
COV	0,41	0,21	0,09	0,09	0,13	0,17	0,34	0,32	0,09
Correlations									
f_t	1	0,80	0,36	0,31	0,77	0,75	-0,52	0,81	0,35
E	0,80	1	0,61	0,57	0,79	0,90	-0,40	0,84	0,59
ρ	0,36	0,61	1	0,97	0,29	0,69	0,06	0,43	0,96
$\rho_{specimen}$	0,31	0,57	0,97	1	0,21	0,65	0,14	0,35	0,98
E_{freq}	0,77	0,79	0,29	0,21	1	0,88	-0,54	0,93	0,24
E_{dyn}	0,75	0,90	0,69	0,65	0,88	1	-0,35	0,90	0,67
KAR	-0,52	-0,40	0,06	0,14	-0,54	-0,35	1	-0,57	0,10
IP1	0,81	0,84	0,43	0,35	0,93	0,90	-0,57	1	0,39
IP2	0,74	0,89	0,72	0,68	0,85	0,99	-0,33	0,89	0,70
IP3	0,35	0,59	0,96	0,98	0,24	0,67	0,10	0,39	1
IP4	0,75	0,88	0,59	0,56	0,83	0,91	-0,35	0,84	0,57
IP5	0,73	0,90	0,67	0,64	0,81	0,94	-0,31	0,84	0,64
IP6	0,25	0,47	0,81	0,83	0,15	0,52	0,15	0,27	0,82
IP7	0,72	0,83	0,32	0,27	0,95	0,87	-0,43	0,89	0,27
IP8	0,63	0,76	0,36	0,37	0,78	0,79	-0,38	0,70	0,39
IP9	0,78	0,86	0,29	0,22	0,99	0,87	-0,53	0,93	0,23

Spruce	**Tension**	**UA**	**Lemberg**		**n = 125**	**a**	**b**	**c**	**d**
						1,26	-4,38	6,04	-43,9
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	30,5	11,0	405	417	12,3	11,4	0,28	27,7	394
St. dev.	13,5	2,2	49	46	1,6	2,2	0,10	8,8	47
Median	29,4	10,9	402	420	12,4	11,4	0,27	28,2	393
5th centile	12,5	7,6	339	357	9,7	7,9	0,10	13,8	334
1st centile	10,3	6,8	306	319	9,1	7,1	0,08	10,0	296
Min	8,3	6,6	304	318	8,9	6,9	0,08	9,4	296
Max	74,6	18,0	545	551	16,5	18,2	0,55	53,2	536
COV	0,44	0,20	0,12	0,11	0,13	0,20	0,38	0,32	0,12
Correlations									
f_t	1	0,78	0,55	0,47	0,72	0,74	-0,62	0,82	0,54
E	0,78	1	0,79	0,76	0,83	0,99	-0,36	0,92	0,80
ρ	0,55	0,79	1	0,97	0,39	0,81	-0,22	0,61	0,97
$\rho_{specimen}$	0,47	0,76	0,97	1	0,32	0,78	-0,11	0,55	0,99
E_{freq}	0,72	0,83	0,39	0,32	1	0,84	-0,40	0,90	0,39
E_{dyn}	0,74	0,99	0,81	0,78	0,84	1	-0,32	0,91	0,82
KAR	-0,62	-0,36	-0,22	-0,11	-0,40	-0,32	1	-0,46	-0,17
IP1	0,82	0,92	0,61	0,55	0,90	0,91	-0,46	1	0,62
IP2	0,74	0,98	0,83	0,80	0,80	0,99	-0,32	0,91	0,84
IP3	0,54	0,80	0,97	0,99	0,39	0,82	-0,17	0,62	1
IP4	0,80	0,97	0,75	0,70	0,85	0,97	-0,43	0,95	0,76
IP5	0,74	0,98	0,81	0,79	0,81	0,99	-0,32	0,91	0,83
IP6	0,47	0,74	0,96	0,99	0,30	0,76	-0,11	0,54	0,99
IP7	0,67	0,85	0,47	0,43	0,92	0,85	-0,31	0,88	0,49
IP8	0,71	0,93	0,72	0,70	0,81	0,94	-0,28	0,88	0,75
IP9	0,69	0,81	0,37	0,30	0,94	0,79	-0,38	0,87	0,36

A3: Poland

Pine	**Bending**	**PL**	**Murow**		**n = 110**	**a**	**b**	**c**	**d**
						0,94	-1,24	6,23	-22,60
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	42,0	12,4	539	558	10,4	12,9	0,24	46,1	532
St. dev.	17,1	2,7	54	61	1,7	2,9	0,17	14,1	66
Median	39,9	12,6	536	553	10,4	13,2	0,21	46,8	531
5th centile	16,5	7,8	448	461	7,5	8,3	0,02	23,3	429
1st centile	13,1	6,5	433	451	7,1	7,9	0,00	8,9	408
Min	9,2	5,0	425	439	6,9	7,3	0,00	8,1	396
Max	89,9	17,8	638	687	14,3	19,8	0,8	76,8	678
COV	0,41	0,22	0,10	0,11	0,16	0,22	0,72	0,31	0,12
Correlations									
f_m	1	0,76	0,53	0,52	0,62	0,70	-0,65	0,78	0,56
E_{global}	0,76	1	0,71	0,70	0,79	0,90	-0,61	0,84	0,74
ρ	0,53	0,71	1	0,96	0,37	0,72	-0,47	0,65	0,95
$\rho_{specimen}$	0,52	0,70	0,96	1	0,36	0,73	-0,47	0,65	0,98
E_{freq}	0,62	0,79	0,37	0,36	1	0,90	-0,59	0,80	0,41
E_{dyn}	0,70	0,90	0,72	0,73	0,90	1	-0,65	0,88	0,75
KAR	-0,65	-0,61	-0,47	-0,47	-0,59	-0,65	1	-0,75	-0,52
IP1	0,78	0,84	0,65	0,65	0,80	0,88	-0,75	1	0,69
IP2	0,69	0,91	0,70	0,69	0,87	0,96	-0,63	0,90	0,74
IP3	0,56	0,74	0,95	0,98	0,41	0,75	-0,52	0,69	1
IP4	0,65	0,73	0,57	0,58	0,74	0,81	-0,62	0,79	0,60
IP5	0,59	0,78	0,59	0,58	0,85	0,89	-0,56	0,82	0,61
IP6	0,41	0,59	0,78	0,80	0,38	0,65	-0,36	0,54	0,78
IP7	0,57	0,81	0,59	0,56	0,86	0,90	-0,56	0,81	0,60
IP8	0,58	0,82	0,67	0,66	0,82	0,91	-0,58	0,82	0,69
IP9	0,57	0,75	0,32	0,29	0,97	0,85	-0,56	0,78	0,35

Pine	**Bending**	**PL**	**Swietjano**		**n = 111**	**a**	**b**	**c**	**d**
						0,98	1,61	8,40	-45,34
	f_m	E_{global}	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	36,5	10,9	493	515	9,7	11,2	0,28	35,6	488
St. dev.	16,2	2,5	43	46	1,4	2,2	0,13	13,8	51
Median	34,5	10,5	488	512	9,7	10,9	0,26	35,5	486
5th centile	14,7	7,3	432	448	7,5	8,2	0,10	14,6	410
1st centile	12,9	6,9	414	419	7,3	7,4	0,09	5,9	397
Min	11,7	6,3	381	416	7,0	6,9	0,08	4,8	373
Max	77,2	18,1	620	641	13,4	17,5	0,6	66,2	626
COV	0,44	0,23	0,09	0,09	0,14	0,20	0,47	0,39	0,11
Correlations									
f_m	1	0,80	0,43	0,45	0,72	0,74	-0,54	0,83	0,53
E_{global}	0,80	1	0,69	0,71	0,82	0,94	-0,53	0,89	0,76
ρ	0,43	0,69	1	0,94	0,35	0,71	-0,23	0,54	0,90
$ρ_{specimen}$	0,45	0,71	0,94	1	0,35	0,72	-0,31	0,56	0,98
E_{freq}	0,72	0,82	0,35	0,35	1	0,89	-0,52	0,83	0,43
E_{dyn}	0,74	0,94	0,71	0,72	0,89	1	-0,50	0,87	0,77
KAR	-0,54	-0,53	-0,23	-0,31	-0,52	-0,50	1	-0,62	-0,38
IP1	0,83	0,89	0,54	0,56	0,83	0,87	-0,62	1	0,64
IP2	0,75	0,93	0,70	0,71	0,88	0,99	-0,48	0,88	0,77
IP3	0,53	0,76	0,90	0,98	0,43	0,77	-0,38	0,64	1
IP4	0,79	0,84	0,49	0,49	0,84	0,85	-0,52	0,85	0,56
IP5	0,73	0,88	0,61	0,63	0,87	0,94	-0,44	0,84	0,69
IP6	0,45	0,61	0,74	0,80	0,36	0,64	-0,20	0,53	0,80
IP7	0,70	0,87	0,63	0,61	0,86	0,93	-0,46	0,84	0,66
IP8	0,69	0,86	0,68	0,67	0,82	0,92	-0,47	0,83	0,71
IP9	0,71	0,81	0,36	0,33	0,98	0,87	-0,48	0,82	0,41

Appendix A: Correlation matrices of samples

A3: Sweden

Pine	**Bending**	**SE**	**Lapland**		**n = 34**	**a**	**b**	**c**	**d**
						1,26	-11,3	8,62	-45,5
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	37,8	9,1	458	484	9,7	10,4	0,24	38,9	460
St. dev.	15,7	2,1	44	43	1,5	2,4	0,08	11,5	43
Median	31,3	8,6	450	474	9,7	10,2	0,25	36,7	451
5th centile	19,6	6,7	407	440	7,6	7,6	0,09	23,3	414
1st centile	18,8	6,5	398	422	7,0	7,3	0,08	20,5	399
Min	18,6	6,4	397	414	6,7	7,2	0,08	20,5	393
Max	76,8	15,4	594	617	13,2	18,1	0,39	69,4	599
COV	0,41	0,23	0,10	0,09	0,15	0,23	0,33	0,30	0,09
Correlations									
f_m	1	0,92	0,59	0,66	0,82	0,87	-0,67	0,93	0,70
E_{global}	0,92	1	0,74	0,77	0,90	0,97	-0,58	0,93	0,80
ρ	0,59	0,74	1	0,96	0,50	0,78	-0,35	0,63	0,97
$\rho_{specimen}$	0,66	0,77	0,96	1	0,50	0,80	-0,36	0,65	0,98
E_{freq}	0,82	0,90	0,50	0,50	1	0,92	-0,60	0,91	0,57
E_{dyn}	0,87	0,97	0,78	0,80	0,92	1	-0,60	0,93	0,84
KAR	-0,67	-0,58	-0,35	-0,36	-0,60	-0,60	1	-0,72	-0,44
IP1	0,93	0,93	0,63	0,65	0,91	0,93	-0,72	1	0,72
IP2	0,86	0,97	0,77	0,78	0,93	1,00	-0,60	0,93	0,83
IP3	0,70	0,80	0,97	0,98	0,57	0,84	-0,44	0,72	1
IP4	0,89	0,91	0,62	0,66	0,83	0,88	-0,64	0,90	0,70
IP5	0,88	0,97	0,73	0,75	0,94	0,98	-0,58	0,94	0,79
IP6	0,61	0,71	0,92	0,95	0,45	0,74	-0,36	0,59	0,95
IP7	0,78	0,86	0,60	0,61	0,92	0,91	-0,55	0,88	0,66
IP8	0,74	0,83	0,63	0,64	0,87	0,89	-0,51	0,84	0,69
IP9	0,82	0,89	0,48	0,49	1,00	0,91	-0,58	0,91	0,55

Pine	**Bending**	**SE**	**Västerbotten**		**n = 35**	**a**	**b**	**c**	**d**
						1,22	-7,09	7,18	-21,4
	f_m	E_{global}	ρ	$\rho_{speci-men}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	56,4	11,8	500	522	10,8	12,6	0,14	52,0	511
St. dev.	12,8	2,4	48	49	1,3	2,3	0,08	9,1	50
Median	57,4	11,7	499	516	11,0	12,6	0,13	52,3	504
5th centile	32,2	8,1	440	450	8,7	8,7	0,03	34,7	443
1st centile	29,4	7,7	396	417	8,0	8,1	0,03	31,1	400
Min	29,3	7,5	376	404	7,8	7,9	0,03	30,9	385
Max	80,9	16,8	585	603	13,0	17,2	0,31	69,5	591
COV	0,23	0,20	0,10	0,09	0,12	0,18	0,58	0,18	0,10
Correlations									
f_m	1	0,77	0,63	0,57	0,73	0,77	-0,41	0,87	0,61
E_{global}	0,77	1	0,79	0,82	0,81	0,96	-0,11	0,86	0,84
ρ	0,63	0,79	1	0,95	0,47	0,79	-0,25	0,77	0,96
$\rho_{specimen}$	0,57	0,82	0,95	1	0,45	0,81	-0,08	0,73	0,99
E_{freq}	0,73	0,81	0,47	0,45	1	0,89	-0,14	0,81	0,49
E_{dyn}	0,77	0,96	0,79	0,81	0,89	1	-0,11	0,90	0,83
KAR	-0,41	-0,11	-0,25	-0,08	-0,14	-0,11	1	-0,35	-0,10
IP1	0,87	0,86	0,77	0,73	0,81	0,90	-0,35	1	0,78
IP2	0,78	0,96	0,78	0,79	0,90	1,00	-0,11	0,91	0,82
IP3	0,61	0,84	0,96	0,99	0,49	0,83	-0,10	0,78	1
IP4	0,84	0,83	0,68	0,63	0,82	0,86	-0,38	0,94	0,68
IP5	0,78	0,96	0,78	0,79	0,89	0,99	-0,12	0,91	0,81
IP6	0,56	0,82	0,95	0,99	0,45	0,80	-0,06	0,71	0,99
IP7	0,68	0,92	0,72	0,74	0,87	0,96	-0,01	0,84	0,76
IP8	0,66	0,92	0,77	0,79	0,82	0,95	0,01	0,82	0,81
IP9	0,71	0,76	0,45	0,41	0,95	0,83	-0,16	0,76	0,45

Appendix A: Correlation matrices of samples

Pine	**Bending**	**SE**	**Västergötland**		**n = 140**	**a**	**b**	**c**	**d**
						1,11	-3,38	7,15	-30,0
	f_m	E_{global}	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	43,5	10,9	482	509	10,3	11,6	0,22	42,2	489
St. dev.	13,9	1,8	42	39	1,1	1,8	0,10	9,9	40
Median	41,8	10,7	479	506	10,4	11,4	0,22	41,9	488
5th centile	24,3	8,3	423	452	8,5	8,9	0,06	26,2	435
1st centile	16,3	7,7	402	438	7,7	8,2	0,03	20,7	413
Min	15,3	6,8	395	424	7,6	7,5	0,03	16,0	403
Max	85,9	16,4	618	611	13,2	16,8	0,47	68,6	586
COV	0,32	0,16	0,09	0,08	0,11	0,15	0,46	0,24	0,08
Correlations									
f_m	1	0,76	0,58	0,55	0,59	0,71	-0,64	0,79	0,60
E_{global}	0,76	1	0,67	0,71	0,74	0,91	-0,55	0,80	0,74
ρ	0,58	0,67	1	0,90	0,36	0,72	-0,36	0,64	0,91
$\rho_{specimen}$	0,55	0,71	0,90	1	0,28	0,70	-0,33	0,56	0,98
E_{freq}	0,59	0,74	0,36	0,28	1	0,88	-0,52	0,76	0,36
E_{dyn}	0,71	0,91	0,72	0,70	0,88	1	-0,55	0,84	0,75
KAR	-0,64	-0,55	-0,36	-0,33	-0,52	-0,55	1	-0,69	-0,37
IP1	0,79	0,80	0,64	0,56	0,76	0,84	-0,69	1	0,64
IP2	0,71	0,89	0,71	0,68	0,88	0,99	-0,54	0,85	0,74
IP3	0,60	0,74	0,91	0,98	0,36	0,75	-0,37	0,64	1
IP4	0,72	0,80	0,62	0,61	0,65	0,79	-0,67	0,79	0,66
IP5	0,67	0,88	0,71	0,70	0,84	0,97	-0,53	0,79	0,74
IP6	0,49	0,67	0,87	0,96	0,24	0,66	-0,33	0,48	0,94
IP7	0,61	0,69	0,54	0,48	0,78	0,81	-0,37	0,74	0,55
IP8	0,61	0,70	0,59	0,55	0,73	0,81	-0,37	0,72	0,61
IP9	0,53	0,65	0,33	0,21	0,95	0,81	-0,46	0,73	0,29

A4: Finland

Pine	**Tension**	**FI**	**East**		**n = 172**	**a**	**b**	**c**	**d**
						1,16	-3,34	7,13	-45,5
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	32,1	11,4	491	505	10,9	12,3	0,25	30,5	483
St. dev.	12,2	2,2	48	39	1,3	2,2	0,10	9,1	40
Median	30,9	11,4	484	501	11,0	12,2	0,24	30,9	480
5th centile	16,0	8,0	433	452	8,8	9,0	0,10	17,5	427
1st centile	12,3	7,3	397	414	7,9	7,6	0,04	11,6	392
Min	10,2	6,0	372	398	7,2	7,1	0,03	10,5	376
Max	73,2	17,2	623	618	13,8	17,7	0,48	51,1	598
COV	0,38	0,20	0,10	0,08	0,12	0,18	0,40	0,30	0,08
Correlations									
f_t	1	0,82	0,64	0,73	0,76	0,84	-0,77	0,86	0,75
E	0,82	1	0,65	0,80	0,88	0,94	-0,65	0,91	0,80
ρ	0,64	0,65	1	0,87	0,49	0,71	-0,53	0,67	0,87
$\rho_{specimen}$	0,73	0,80	0,87	1	0,60	0,84	-0,59	0,80	0,98
E_{freq}	0,76	0,88	0,49	0,60	1	0,93	-0,61	0,88	0,62
E_{dyn}	0,84	0,94	0,71	0,84	0,93	1	-0,67	0,95	0,85
KAR	-0,77	-0,65	-0,53	-0,59	-0,61	-0,67	1	-0,76	-0,61
IP1	0,86	0,91	0,67	0,80	0,88	0,95	-0,76	1	0,83
IP2	0,84	0,95	0,70	0,84	0,92	0,99	-0,68	0,95	0,86
IP3	0,75	0,80	0,87	0,98	0,62	0,85	-0,61	0,83	1
IP4	0,86	0,91	0,66	0,77	0,88	0,94	-0,72	0,93	0,78
IP5	0,83	0,93	0,69	0,82	0,89	0,97	-0,67	0,93	0,83
IP6	0,71	0,78	0,87	0,98	0,57	0,82	-0,58	0,77	0,97
IP7	0,62	0,69	0,37	0,46	0,81	0,74	-0,45	0,68	0,49
IP8									
IP9	0,76	0,89	0,47	0,59	0,99	0,92	-0,63	0,88	0,62

Appendix A: Correlation matrices of samples

Pine	**Tension**	**FI**	**West**		**n = 85**	**a**	**b**	**c**	**d**
						1,18	-3,98	8,60	-60,76
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	31,0	11,3	493	508	10,7	12,1	0,27	29,6	486
St. dev.	12,9	2,3	59	46	1,2	2,3	0,11	9,7	47
Median	27,2	11,0	476	500	10,6	11,6	0,28	29,3	478
5th centile	17,8	7,9	419	444	8,8	9,2	0,09	15,9	421
1st centile	13,7	7,0	407	436	8,3	8,1	0,07	12,8	404
Min	11,3	6,8	400	432	8,1	7,7	0,06	11,9	401
Max	69,6	17,2	676	643	13,9	18,8	0,53	53,3	617
COV	0,41	0,21	0,12	0,09	0,11	0,19	0,41	0,33	0,10
Correlations									
f_t	1	0,85	0,72	0,76	0,80	0,87	-0,70	0,89	0,77
E	0,85	1	0,80	0,85	0,85	0,94	-0,63	0,93	0,86
ρ	0,72	0,80	1	0,92	0,64	0,83	-0,52	0,80	0,92
$\rho_{specimen}$	0,76	0,85	0,92	1	0,65	0,89	-0,52	0,83	0,99
E_{freq}	0,80	0,85	0,64	0,65	1	0,92	-0,55	0,89	0,65
E_{dyn}	0,87	0,94	0,83	0,89	0,92	1	-0,60	0,95	0,88
KAR	-0,70	-0,63	-0,52	-0,52	-0,55	-0,60	1	-0,69	-0,52
IP1	0,89	0,93	0,80	0,83	0,89	0,95	-0,69	1	0,84
IP2	0,87	0,96	0,83	0,88	0,92	0,99	-0,59	0,96	0,88
IP3	0,77	0,86	0,92	0,99	0,65	0,88	-0,52	0,84	1
IP4	0,86	0,92	0,80	0,83	0,87	0,94	-0,68	0,91	0,82
IP5	0,86	0,96	0,84	0,88	0,89	0,98	-0,61	0,94	0,88
IP6	0,77	0,85	0,91	0,99	0,64	0,88	-0,54	0,82	0,98
IP7	0,60	0,62	0,47	0,47	0,74	0,68	-0,44	0,65	0,46
IP8									
IP9	0,78	0,89	0,62	0,64	0,98	0,90	-0,55	0,89	0,64

A4: France

Pine	**Tension**	**FR**	**-600 m**		**n = 130**	**a**	**b**	**c**	**d**
						0,59	6,24	2,89	-6,74
	f_t	E	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	17,3	8,4	492	518	8,3	9,5	0,34	18,3	502
St. dev.	7,1	2,1	34	37	1,6	2,0	0,12	8,2	38
Median	15,2	8,3	490	517	8,1	9,3	0,33	16,9	505
5th centile	8,3	5,4	438	457	6,2	6,8	0,14	5,8	443
1st centile	7,2	4,2	422	450	5,7	6,4	0,12	4,2	435
Min	7,0	4,0	409	438	5,7	6,1	0,11	1,7	424
Max	44,4	14,6	585	617	19,5	21,0	0,67	38,3	606
COV	0,41	0,25	0,07	0,07	0,19	0,21	0,36	0,45	0,08
Correlations									
f_t	1	0,71	0,37	0,34	0,66	0,71	-0,40	0,73	0,43
E	0,71	1	0,41	0,46	0,65	0,74	-0,35	0,68	0,50
ρ	0,37	0,41	1	0,91	0,17	0,46	-0,18	0,48	0,88
$ρ_{specimen}$	0,34	0,46	0,91	1	0,13	0,45	-0,17	0,45	0,94
E_{freq}	0,66	0,65	0,17	0,13	1	0,94	-0,23	0,86	0,21
E_{dyn}	0,71	0,74	0,46	0,45	0,94	1	-0,28	0,90	0,51
KAR	-0,40	-0,35	-0,18	-0,17	-0,23	-0,28	1	-0,47	-0,22
IP1	0,73	0,68	0,48	0,45	0,86	0,90	-0,47	1	0,58
IP2	0,55	0,66	0,50	0,51	0,59	0,73	-0,41	0,91	0,65
IP3	0,43	0,50	0,88	0,94	0,21	0,51	-0,22	0,58	1
IP4	0,66	0,66	0,48	0,50	0,85	0,91	-0,43	0,86	0,61
IP5	0,53	0,60	0,52	0,53	0,53	0,68	-0,33	0,87	0,65
IP6	0,31	0,36	0,75	0,84	0,08	0,36	-0,13	0,38	0,83
IP7	0,53	0,54	0,19	0,14	0,92	0,82	-0,23	0,75	0,28
IP8									
IP9	0,46	0,56	0,23	0,22	0,61	0,64	-0,39	0,85	0,36

Appendix A: Correlation matrices of samples

Pine	**Tension**	**FR**	**+600 m**		**n = 125**	**a**	**b**	**c**	**d**
						0,69	5,94	3,25	-5,74
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	23,8	9,8	532	568	9,1	11,4	0,30	25,7	554
St. dev.	8,2	2,1	46	50	1,4	2,1	0,12	8,0	49
Median	23,6	9,9	528	563	9,2	11,3	0,29	25,3	551
5th centile	11,0	5,9	469	500	6,5	8,0	0,12	13,2	490
1st centile	8,4	5,1	416	443	5,9	6,4	0,05	10,1	431
Min	5,9	2,3	402	431	5,5	6,1	0,04	7,8	415
Max	48,5	16,6	645	710	13,4	19,6	0,61	57	695
COV	0,34	0,22	0,09	0,09	0,16	0,18	0,38	0,31	0,09
Correlations									
f_t	1	0,77	0,24	0,24	0,56	0,60	-0,43	0,68	0,32
E	0,77	1	0,27	0,27	0,60	0,65	-0,34	0,68	0,35
ρ	0,24	0,27	1	0,96	0,04	0,46	-0,10	0,38	0,92
$\rho_{specimen}$	0,24	0,27	0,96	1	-0,01	0,44	-0,08	0,36	0,97
E_{freq}	0,56	0,60	0,04	-0,01	1	0,89	-0,23	0,79	0,10
E_{dyn}	0,60	0,65	0,46	0,44	0,89	1	-0,23	0,88	0,51
KAR	-0,43	-0,34	-0,10	-0,08	-0,23	-0,23	1	-0,40	-0,12
IP1	0,68	0,68	0,38	0,36	0,79	0,88	-0,40	1	0,46
IP2	0,62	0,67	0,40	0,39	0,87	0,96	-0,24	0,88	0,49
IP3	0,32	0,35	0,92	0,97	0,10	0,51	-0,12	0,46	1
IP4	0,56	0,60	0,45	0,44	0,67	0,79	-0,36	0,77	0,51
IP5	0,50	0,57	0,48	0,46	0,68	0,81	-0,24	0,73	0,52
IP6	0,28	0,29	0,87	0,90	0,07	0,45	-0,11	0,40	0,91
IP7	0,51	0,59	0,03	-0,01	0,90	0,77	-0,20	0,70	0,08
IP8									
IP9	0,59	0,62	0,00	-0,03	0,96	0,84	-0,25	0,80	0,07

A4: Poland

Pine	**Tension**	**PL**	**Murow**		**n = 107**	**a**	**b**	**c**	**d**
						1,04	-1,07	5,06	-18,94
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	33,6	12,5	556	556	10,4	12,8	0,20	33,1	536
St. dev.	13,4	2,7	55	47	1,4	2,3	0,15	10,0	53
Median	31,9	12,8	548	556	10,4	13,0	0,17	34,6	532
5th centile	12,6	7,8	470	485	7,6	8,4	0,02	15,3	459
1st centile	11,4	6,7	441	467	6,6	8,0	0,00	8,1	429
Min	9,0	6,3	436	460	6,5	7,5	0,00	7,7	419
Max	71,3	19,1	702	670	13,1	17,5	0,81	52,4	683
COV	0,40	0,22	0,10	0,08	0,14	0,18	0,73	0,30	0,10
Correlations									
f_t	1	0,73	0,50	0,45	0,54	0,63	-0,76	0,78	0,50
E	0,73	1	0,70	0,65	0,82	0,94	-0,58	0,92	0,64
ρ	0,50	0,70	1	0,96	0,38	0,75	-0,39	0,70	0,93
$\rho_{specimen}$	0,45	0,65	0,96	1	0,27	0,68	-0,35	0,63	0,94
E_{freq}	0,54	0,82	0,38	0,27	1	0,89	-0,35	0,78	0,28
E_{dyn}	0,63	0,94	0,75	0,68	0,89	1	-0,43	0,90	0,66
KAR	-0,76	-0,58	-0,39	-0,35	-0,35	-0,43	1	-0,69	-0,45
IP1	0,78	0,92	0,70	0,63	0,78	0,90	-0,69	1	0,69
IP2	0,63	0,93	0,74	0,67	0,87	0,98	-0,47	0,92	0,71
IP3	0,50	0,64	0,93	0,94	0,28	0,66	-0,45	0,69	1
IP4	0,70	0,88	0,64	0,59	0,77	0,87	-0,55	0,87	0,61
IP5	0,54	0,86	0,63	0,58	0,81	0,90	-0,34	0,79	0,57
IP6	0,28	0,44	0,67	0,72	0,12	0,44	-0,20	0,40	0,70
IP7	0,40	0,72	0,25	0,16	0,93	0,78	-0,23	0,67	0,15
IP8									
IP9	0,51	0,79	0,32	0,22	0,99	0,85	-0,31	0,75	0,22

Appendix A: Correlation matrices of samples

Pine	**Tension**	**PL**	**Swietjano**		**n = 110**	**a**	**b**	**c**	**d**
						0,92	1,90	4,61	-20,2
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	24,3	10,7	510	521	9,7	11,2	0,31	24,3	492
St. dev.	10,6	2,6	50	46	1,6	2,4	0,10	9,8	50
Median	20,9	10,0	499	517	9,7	10,6	0,31	22,8	487
5th centile	11,7	6,9	444	456	7,5	8,2	0,17	11,1	420
1st centile	8,1	6,6	434	452	5,0	6,7	0,08	8,4	409
Min	6,1	4,8	434	446	4,7	6,1	0,00	7,8	407
Max	57,0	18,1	685	647	13,8	18,3	0,55	53,9	631
COV	0,44	0,25	0,10	0,09	0,17	0,22	0,34	0,40	0,10
Correlations									
f_t	1	0,86	0,62	0,53	0,70	0,79	-0,63	0,86	0,60
E	0,86	1	0,70	0,57	0,87	0,95	-0,56	0,94	0,64
ρ	0,62	0,70	1	0,95	0,40	0,73	-0,33	0,71	0,97
$\rho_{specimen}$	0,53	0,57	0,95	1	0,24	0,61	-0,27	0,58	0,98
E_{freq}	0,70	0,87	0,40	0,24	1	0,91	-0,43	0,85	0,32
E_{dyn}	0,79	0,95	0,73	0,61	0,91	1	-0,47	0,94	0,67
KAR	-0,63	-0,56	-0,33	-0,27	-0,43	-0,47	1	-0,56	-0,34
IP1	0,86	0,94	0,71	0,58	0,85	0,94	-0,56	1	0,65
IP2	0,80	0,95	0,73	0,62	0,90	0,99	-0,49	0,94	0,69
IP3	0,60	0,64	0,97	0,98	0,32	0,67	-0,34	0,65	1
IP4	0,76	0,90	0,63	0,52	0,88	0,94	-0,43	0,88	0,59
IP5	0,70	0,88	0,63	0,52	0,89	0,95	-0,33	0,86	0,58
IP6	0,41	0,51	0,74	0,76	0,32	0,57	-0,08	0,48	0,75
IP7	0,63	0,78	0,46	0,33	0,94	0,85	-0,35	0,80	0,40
IP8									
IP9	0,65	0,84	0,38	0,23	0,95	0,87	-0,40	0,82	0,30

A4: Russia

Pine	**Tension**	**RU**	**Novgorod**		**n = 87**	**a**	**b**	**c**	**d**
						0,86	2,03	5,71	-36,25
	f_t	E	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	20,6	9,8	445	469	9,9	10,4	0,33	21,9	442
St. dev.	9,8	2,4	48	43	1,4	2,2	0,11	9,6	46
Median	18,7	9,3	433	456	9,9	10,0	0,34	21,0	433
5th centile	8,6	7,0	386	418	8,1	7,5	0,13	9,3	390
1st centile	6,3	4,2	370	411	6,4	6,2	0,07	4,6	374
Min	5,9	3,9	338	388	6,1	6,1	0,02	1,8	349
Max	62,1	16,5	590	601	12,8	17,1	0,55	49	584
COV	0,47	0,24	0,11	0,09	0,14	0,22	0,33	0,44	0,10
Correlations									
f_t	1	0,83	0,74	0,71	0,79	0,84	-0,69	0,85	0,74
E	0,83	1	0,80	0,78	0,88	0,92	-0,57	0,91	0,81
ρ	0,74	0,80	1	0,94	0,71	0,88	-0,51	0,83	0,94
$ρ_{specimen}$	0,71	0,78	0,94	1	0,67	0,88	-0,47	0,82	0,98
E_{freq}	0,79	0,88	0,71	0,67	1	0,94	-0,52	0,90	0,71
E_{dyn}	0,84	0,92	0,88	0,88	0,94	1	-0,55	0,94	0,90
KAR	-0,69	-0,57	-0,51	-0,47	-0,52	-0,55	1	-0,63	-0,49
IP1	0,85	0,91	0,83	0,82	0,90	0,94	-0,63	1	0,85
IP2	0,85	0,92	0,86	0,87	0,92	0,99	-0,56	0,95	0,90
IP3	0,74	0,81	0,94	0,98	0,71	0,90	-0,49	0,85	1
IP4	0,85	0,86	0,78	0,79	0,88	0,92	-0,64	0,90	0,80
IP5	0,85	0,92	0,84	0,85	0,93	0,99	-0,55	0,94	0,87
IP6	0,71	0,77	0,93	0,99	0,66	0,87	-0,46	0,82	0,98
IP7	0,64	0,77	0,61	0,57	0,88	0,81	-0,43	0,77	0,60
IP8									
IP9	0,79	0,87	0,66	0,64	0,98	0,91	-0,54	0,90	0,68

Appendix A: Correlation matrices of samples

Pine	Tension	RU	Vologda		n = 87	a	b	c	d
						0,81	2,94	4,08	-20,25
	f_t	E	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	20,3	9,5	439	456	9,9	10,1	0,32	21,5	434
St. dev.	7,7	1,8	37	33	1,3	1,8	0,11	7,7	33
Median	19,5	9,7	433	454	10,0	10,0	0,32	22,4	433
5th centile	9,1	6,6	389	412	7,7	7,3	0,15	8,8	392
1st centile	7,6	5,9	374	395	7,0	6,6	0,11	7,0	367
Min	7,5	4,5	342	364	5,2	4,9	0,11	1,8	335
Max	47,0	14,8	570	571	12,4	14,7	0,62	38,4	557
COV	0,38	0,19	0,08	0,07	0,13	0,18	0,35	0,36	0,08
Correlations									
f_t	1	0,78	0,60	0,59	0,70	0,79	-0,67	0,80	0,65
E	0,78	1	0,55	0,63	0,83	0,90	-0,58	0,89	0,66
ρ	0,60	0,55	1	0,88	0,36	0,65	-0,31	0,55	0,87
$ρ_{specimen}$	0,59	0,63	0,88	1	0,38	0,72	-0,25	0,58	0,96
E_{freq}	0,70	0,83	0,36	0,38	1	0,92	-0,60	0,89	0,47
E_{dyn}	0,79	0,90	0,65	0,72	0,92	1	-0,56	0,92	0,77
KAR	-0,67	-0,58	-0,31	-0,25	-0,60	-0,56	1	-0,66	-0,30
IP1	0,80	0,89	0,55	0,58	0,89	0,92	-0,66	1	0,66
IP2	0,80	0,91	0,62	0,67	0,92	0,98	-0,57	0,94	0,75
IP3	0,65	0,66	0,87	0,96	0,47	0,77	-0,30	0,66	1
IP4	0,81	0,87	0,63	0,68	0,86	0,95	-0,59	0,90	0,74
IP5	0,79	0,90	0,66	0,71	0,90	0,98	-0,56	0,92	0,76
IP6	0,59	0,59	0,87	0,99	0,34	0,68	-0,24	0,54	0,96
IP7	0,52	0,59	0,29	0,25	0,69	0,63	-0,41	0,62	0,29
IP8									
IP9	0,71	0,84	0,34	0,35	0,99	0,89	-0,62	0,89	0,44

A4: Sweden

Pine	**Tension**	**SE**	**Gästrikland**		**n = 35**	**a**	**b**	**c**	**d**
						1,05	-2,01	4,52	-17,69
	f_t	E	ρ	$ρ_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	27,9	10,6	505	522	10,1	11,7	0,25	28,4	496
St. dev.	8,4	1,6	37	37	1,1	1,7	0,10	7,1	37
Median	25,4	10,6	503	521	10,0	11,5	0,24	28,2	495
5th centile	18,1	8,4	452	471	8,4	10,2	0,11	18,3	442
1st centile	15,1	7,8	443	453	7,4	8,0	0,09	17,4	432
Min	14,7	7,5	439	445	6,9	6,9	0,09	17,4	428
Max	48,8	16,2	573	607	12,7	17,2	0,48	50,9	583
COV	0,30	0,15	0,07	0,07	0,11	0,14	0,39	0,25	0,08
Correlations									
f_t	1	0,76	0,49	0,50	0,60	0,74	-0,55	0,89	0,55
E	0,76	1	0,50	0,54	0,70	0,84	-0,46	0,86	0,57
ρ	0,49	0,50	1	0,95	0,15	0,59	-0,30	0,53	0,94
$ρ_{specimen}$	0,50	0,54	0,95	1	0,16	0,63	-0,36	0,58	0,99
E_{freq}	0,60	0,70	0,15	0,16	1	0,86	-0,39	0,63	0,19
E_{dyn}	0,74	0,84	0,59	0,63	0,86	1	-0,48	0,81	0,65
KAR	-0,55	-0,46	-0,30	-0,36	-0,39	-0,48	1	-0,59	-0,38
IP1	0,89	0,86	0,53	0,58	0,63	0,81	-0,59	1	0,63
IP2	0,78	0,90	0,52	0,54	0,78	0,92	-0,43	0,89	0,59
IP3	0,55	0,57	0,94	0,99	0,19	0,65	-0,38	0,63	1
IP4	0,84	0,83	0,53	0,57	0,67	0,84	-0,55	0,88	0,64
IP5	0,81	0,85	0,52	0,55	0,74	0,88	-0,44	0,86	0,61
IP6	0,56	0,55	0,93	0,98	0,19	0,65	-0,38	0,61	0,98
IP7	0,46	0,63	-0,10	-0,13	0,76	0,56	-0,16	0,53	-0,06
IP8									
IP9	0,56	0,68	-0,07	-0,09	0,83	0,63	-0,26	0,63	-0,03

Appendix A: Correlation matrices of samples

Pine	**Tension**	**SE**	**Lappland**		**n = 37**	**a**	**b**	**c**	**d**
						1,06	-3,84	6,37	-37,58
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	23,7	8,9	450	466	9,6	10,0	0,24	25,9	445
St. dev.	9,3	1,7	37	39	1,2	1,8	0,09	8,0	39
Median	21,2	8,7	451	462	9,7	10,2	0,24	24,8	438
5th centile	10,7	6,6	393	409	7,8	7,4	0,10	14,8	386
1st centile	9,4	5,7	389	402	7,2	7,1	0,08	9,5	380
Min	8,9	5,6	388	399	7,0	7,0	0,07	7,6	379
Max	52,9	13,2	552	590	12,4	15,5	0,45	47,5	575
COV	0,39	0,19	0,08	0,08	0,12	0,18	0,39	0,31	0,09
Correlations									
f_t	1	0,84	0,55	0,59	0,81	0,83	-0,64	0,91	0,65
E	0,84	1	0,72	0,74	0,83	0,91	-0,65	0,88	0,78
ρ	0,55	0,72	1	0,96	0,46	0,77	-0,47	0,60	0,93
$\rho_{specimen}$	0,59	0,74	0,96	1	0,50	0,82	-0,50	0,66	0,98
E_{freq}	0,81	0,83	0,46	0,50	1	0,90	-0,47	0,87	0,53
E_{dyn}	0,83	0,91	0,77	0,82	0,90	1	-0,56	0,91	0,83
KAR	-0,64	-0,65	-0,47	-0,50	-0,47	-0,56	1	-0,65	-0,52
IP1	0,91	0,88	0,60	0,66	0,87	0,91	-0,65	1	0,72
IP2	0,81	0,87	0,70	0,74	0,87	0,95	-0,51	0,90	0,81
IP3	0,65	0,78	0,93	0,98	0,53	0,83	-0,52	0,72	1
IP4	0,80	0,87	0,75	0,76	0,90	0,96	-0,52	0,87	0,77
IP5	0,83	0,90	0,77	0,81	0,89	0,99	-0,55	0,91	0,85
IP6	0,59	0,70	0,91	0,95	0,46	0,77	-0,48	0,66	0,98
IP7	0,67	0,77	0,46	0,48	0,96	0,85	-0,40	0,78	0,48
IP8									
IP9	0,79	0,82	0,46	0,51	1,00	0,90	-0,45	0,86	0,54

Pine	**Tension**	**SE**	**Västerbotten**		**n = 34**	**a**	**b**	**c**	**d**
						0,98	-2,39	4,95	-22,93
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	26,4	8,9	469	486	10,0	10,8	0,27	29,4	465
St. dev.	7,0	1,6	30	33	1,0	1,6	0,07	6,1	34
Median	25,2	8,8	475	483	9,7	10,4	0,27	28,7	461
5th centile	17,5	6,4	422	438	8,8	9,0	0,17	20,5	416
1st centile	15,1	5,2	408	434	8,5	8,9	0,13	18,3	412
Min	14,7	5,2	404	433	8,4	8,9	0,13	17,2	410
Max	42,3	12,1	520	545	12,0	14,3	0,48	42,8	523
COV	0,26	0,18	0,06	0,07	0,10	0,14	0,25	0,21	0,07
Correlations									
f_t	1	0,63	0,62	0,67	0,70	0,82	-0,44	0,85	0,71
E	0,63	1	0,42	0,35	0,61	0,60	-0,54	0,68	0,39
ρ	0,62	0,42	1	0,88	0,39	0,68	-0,31	0,60	0,85
$\rho_{specimen}$	0,67	0,35	0,88	1	0,39	0,75	-0,34	0,64	0,96
E_{freq}	0,70	0,61	0,39	0,39	1	0,90	-0,40	0,85	0,51
E_{dyn}	0,82	0,60	0,68	0,75	0,90	1	-0,44	0,91	0,82
KAR	-0,44	-0,54	-0,31	-0,34	-0,40	-0,44	1	-0,64	-0,42
IP1	0,85	0,68	0,60	0,64	0,85	0,91	-0,64	1	0,74
IP2	0,80	0,59	0,64	0,73	0,89	0,99	-0,47	0,92	0,81
IP3	0,71	0,39	0,85	0,96	0,51	0,82	-0,42	0,74	1
IP4	0,70	0,46	0,58	0,72	0,80	0,91	-0,38	0,83	0,78
IP5	0,78	0,53	0,67	0,78	0,84	0,98	-0,41	0,87	0,83
IP6	0,67	0,37	0,86	0,96	0,42	0,75	-0,45	0,67	0,98
IP7	0,50	0,40	0,27	0,32	0,85	0,77	-0,20	0,65	0,35
IP8									
IP9	0,65	0,47	0,32	0,44	0,92	0,87	-0,31	0,78	0,51

Appendix A: Correlation matrices of samples

Pine	**Tension**	**SE**	**Västergötland**		**n = 105**	**a**	**b**	**c**	**d**
						1,08	-1,05	7,66	-47,51
	f_t	E	ρ	$\rho_{specimen}$	E_{freq}	E_{dyn}	KAR	IP1	IP3
	N/mm^2	kN/mm^2	kg/m^3	kg/m^3	kN/mm^2	kN/mm^2	-	-	-
Mean	33,6	11,4	495	522	10,6	12,4	0,24	32,2	505
St. dev.	13,3	2,4	47	49	1,2	2,3	0,11	10,7	52
Median	31,0	11,3	491	519	10,5	12,0	0,21	31,2	501
5th centile	14,7	7,6	426	452	8,8	9,4	0,08	17,3	428
1st centile	13,3	7,0	412	431	8,5	8,9	0,03	12,2	417
Min	13,1	6,4	403	427	7,2	6,9	0,02	10,4	401
Max	71,9	17,8	637	676	14,1	19,0	0,55	58,9	668
COV	0,39	0,21	0,10	0,09	0,12	0,19	0,48	0,33	0,10
Correlations									
f_t	1	0,79	0,55	0,58	0,71	0,76	-0,55	0,87	0,67
E	0,79	1	0,66	0,73	0,82	0,91	-0,41	0,89	0,80
ρ	0,55	0,66	1	0,95	0,42	0,76	-0,31	0,68	0,92
$\rho_{specimen}$	0,58	0,73	0,95	1	0,49	0,83	-0,30	0,74	0,98
E_{freq}	0,71	0,82	0,42	0,49	1	0,89	-0,27	0,81	0,55
E_{dyn}	0,76	0,91	0,76	0,83	0,89	1	-0,34	0,91	0,86
KAR	-0,55	-0,41	-0,31	-0,30	-0,27	-0,34	1	-0,47	-0,36
IP1	0,87	0,89	0,68	0,74	0,81	0,91	-0,47	1	0,82
IP2	0,78	0,92	0,73	0,80	0,89	0,99	-0,38	0,93	0,86
IP3	0,67	0,80	0,92	0,98	0,55	0,86	-0,36	0,82	1
IP4	0,87	0,89	0,63	0,69	0,86	0,92	-0,71	0,94	0,79
IP5	0,80	0,91	0,69	0,76	0,89	0,98	-0,60	0,93	0,83
IP6	0,61	0,76	0,89	0,96	0,50	0,81	-0,49	0,76	0,98
IP7	0,74	0,80	0,39	0,44	0,96	0,87	-0,53	0,83	0,54
IP8									
IP9	0,70	0,83	0,38	0,45	0,98	0,86	-0,29	0,81	0,53

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