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Light composite wood-based beams

Nordic Round Robin test

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Abstract

A method for testing the load capacity and rigidity of light composite wood-based beams has been studied. Round Robin test has been performed including three laboratories in Finland, Norway and Sweden. Three beams types were tested in bending and shear according to NT Build 327 and an EOTA Technical Report. The results from the different laboratories were comparable and the test method seems to be reliable.

Key words: light composite wood-based beams, round robin test

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Preface

The Norwegian Wood Technology Institute (NTI), Technical Research Centre of Finland (VTT) and the Swedish National Testing and Research Institute (SP) have performed this project jointly.

Funding from Nordtest as well as from the participating institutes has financed the work. Test objects have been supplied by Masonite Beam AB, Forestia A/S and PRT Wood Oy.

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1 Introduction

1.1 Background

Light composite wood-based beams are a good example of how wood can be processed to well functioning structural components. In Scandinavia production started in the 1970´s and now there is a handful of manufacturers. There are also producers in Germany and France, but the volumes are small.

In the USA light composite wood-based beams have been on the market since the 1960´s and during 1990´s the development has been very rapid. The number of plants has grown from 16 to 43 (Zylkowski 2000). A major field of application is in residential floors, not least in multi-storey residential buildings. APA – The Engineered Wood Association points out that an important success factor is standardisation. In the USA a standard for determination of capacities and quality control exists (Anon, 1990). A corresponding standard does not yet exist in Europe.

To enable producers to easily get access to the whole European market the European Organisation for Technical Approval (EOTA) has set up a working group (WG 03.04/05) to draw up a guideline for approval of light composite wood-based beams and columns. The Nordic countries have initiated this work and the ambition has been to use the experiences gained over the years in Finland, Norway and Sweden. Here methods for determination of capacity and stiffness of light composite wood-based beams have been developed. The methods are presented in NT Build 327 (Anon. 1987) and based on this standard national approvals have been issued.

NT Build 327 has been proposed as a reference method in the EOTA guideline, which is underway. In connection with this some changes have been made and the test methods are presented in a so-called EOTA Technical Report (Anon. 2000).

1.2 Purpose

The purpose of the present project has been to support the work of EOTA and to demonstrate that NT Build 327, including the changes in the EOTA Technical Report, is a reliable test method by carrying out a round robin test. An important issue to study is whether or not the method gives the same results when applied by different laboratories on beams of equal quality.

1.3 Participating testing and research institutes

Three testing institutes have been involved in the project: NTI, Norwegian Institute of Wood Technology, VTT, Technical Research Centre of Finland, and SP, Swedish National Testing and Research Institute.

1.4 Participating manufacturers

Three manufacturers of light composite wood-based beams have participated in the project, mainly by making test beams available. The manufacturers are Forestia A/S in Norway, Masonite Beams AB in Sweden and PRT Wood OY in Finland.

1.5 Co-ordination with the EOTA guideline work

During the drafting of the EOTA guideline it became evident that a direct reference to NT Build 327 was not possible for a number of reasons. Firstly the format was not acceptable and secondly additional test methods were needed. Therefore it was decided to draft a so-called Technical Report which includes most of NT Build 327 and the extra test methods, and to which reference will be made in the guideline.

1.6 Scope

The round robin test includes the three most important parts of NT Build 327 and the Technical (Anon. 2000) Report, namely determination of moment capacity, bending stiffness and shear capacity.

Three different beam types available on the market have been used as test objects and a total of 90 beams have been tested, 60 beams in bending tests and 30 beams in shear tests.

2 Test objects and principles for choosing test objects

2.1 Test objects

The chosen test objects were beams of different types and sizes, representing the smallest and largest normally available on the market. Beam size, materials and manufacturers are presented in Table 1 below.

Table 1. Test objects, their main properties and their use in the test.

Manufacturer	Series No	Flange material and width, depth	Web material and thickness	Depth *[mm]*	Length *[mm]*	Test
Masonite Beams AB	M5	Solid wood, 47 x 47 mm²	Hard fibre board, 8 mm	400	7600	Bending
Forestia A/S	F1	Solid wood, 47 x 47 mm²	Particle board, 10 mm	200	3600	Bending
PRT WOOD OY	P2	Solid wood, 45 x 45 mm²	Hard fibre board, 6 mm	200	2200	Shear

Series M5 and F1 had finger-jointed flanges and the webs were butt jointed. The joint between flanges and the web was bonded with an EN 301 (Anon. 1992) type I adhesive. Series P2 had an adhesive according to the British standard BS 1204 (Anon. 1979) both for the flanges and for the joint between flange and web.

Figure 1. Principle cross section of a beam and a detail of the connection between flange and web.

For more details on dimensions see appendices.

2.2 Sampling

From each manufacturer beams were selected for tests at three laboratories. Because of the expense the number of beams for each laboratory and test method had to be kept at a relatively low number, only 10. Therefore a special selection procedure was designed to ensure that the laboratories obtained beams of basically the same quality.

The following instructions were given to the persons responsible for selection of test objects:

- Beams in a test series (10 beams for one laboratory) shall be sampled from three different production shifts, which would normally involve 3 or 4 beams per shift.
- Each beam shall be marked with the production shift number (1-3) and a serial number (1-10).
- Distribute the 30 beams in three groups, one for each laboratory in the way described below.

Table 2. Principle for selecting test beams.

	Group 1	Group 2	Group 3
Beam number, X:Y (X is shift number, Y is serial number)	1:1, 2:1, 3:1, 1:4, 2:4, 3:4, 1:7, 2:7, 3:7, 1:10	1:2, 2:2, 3:2, 1:5, 2:5, 3:5, 1:8, 2:8, 3:8, 3:10	1:3, 2:3, 3:3, 1:6, 2:6, 3:6, 1:9,2:9, 3:9, 2:10

2.3 Conditioning

The conditioning was to be conducted in standard climate according to ISO 554 (Anon. 1976), temperature at 20°C ± 2°C with a humidity of 65 ± 5%. One laboratory was however not able to maintain this climate.

3 Test method

3.1 General

Measurements and testing have been conducted according to NT Build 327. In the following a summary of what was done is given, together with deviations from the prescribed methods. It is also described how the tests were carried out in relation to the EOTA Technical Report.

3.1.1 Physical properties

3.1.1.1 Dimensions

The dimensions of the beams were measured at the time of testing. Forms had been distributed by SP to the other laboratories for recording beam depth, flange depth and width and web thickness.

In NT Build 327 the beam depth, flange depth, flange width must be measured in millimetres to three significant figures, and the web thickness to two significant figures. The measurements must be made at the time of testing. It is however not indicated whether measurements shall be taken in one or several sections. Measurements were however taken in three sections, at both ends and in the middle. That is also what is recommended in EOTA Technical Report.

Individual values are presented in the appendices.

3.1.1.2 Density and moisture content

In NT Build 327 (Anon. 1987) it is recommended to use ISO 3130 (Anon 1975a), ISO 767 (Anon. 1975b) or other applicable methods. The pieces must also be cut out close to the location of rupture.

In EOTA Technical Report (Anon. 2000) it is recommended to use an EN method or another applicable method.

In this test, pieces were cut out close to the location of rupture in the flanges (both top and bottom) and the webs. In case of a finger joint in the maximum moment zone, test pieces were cut out on each side of the joint.

3.1.1.3 Remarks

A comment about special characteristics for the manufactured quality of the beams and the mode of the rupture was also recorded. See appendices.

3.1.2 Moment capacity and bending stiffness

The test method described in NT Build 327 and also in EOTA Technical Report, was applied in the bending test series (M5 and F1). The principle test arrangement in figure 2 was used.

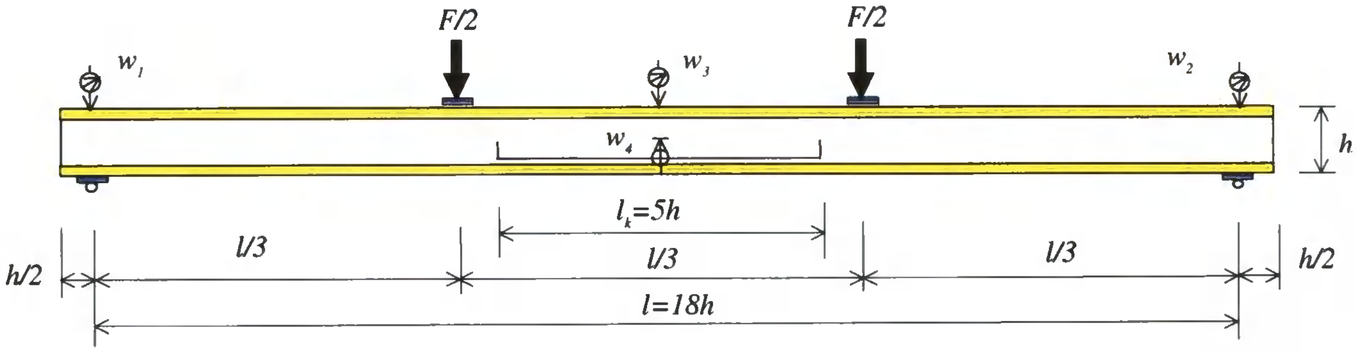

Figure 2. Four-point loading test

NT Build 327 prescribes that the compression flange shall be supported with lateral restraints, which shall be applied astride of the compression flange to prevent buckling of that flange. The restraints shall be placed along the flange with a centre distance of 7.78 b. In the Technical Report the center distance is set as *8 b*, where *b* is the width of the flange.

The supports shall be designed to avoid concentrated stresses: In both NT Build and the Technical Report the recommended dimensions of steel plates are thickness = 15 mm, length = 200 mm and width equal to the width of the loaded flange.

All objects were loaded until collapse. The loading procedure was performed according to NT Build and the Technical Report. During the loading procedure, measurements of the centre deflection (global) of the beam as well as the compression at the supports and the deflection at the middle 5 · depth, (5 · *h*) (local deflection) of the beam were made. In the latter case the gauge was removed from the upper flange of the beams when approximately 40% of the estimated ultimate load had been reached.

3.1.3 Shear capacity

3.1.3.1 Shear test according to NT Build 327

NT Build 327 prescribes a three-point test for determining the shear capacity. The length of the beam shall be 4.5 times the depth of the beam section. The centre deflection and the load shall be measured. Lateral restraints shall be applied on the compression flange. Steel plates with a thickness of 15 mm, length of 100 mm and a width same as the beam flange shall be applied under point loads with high local stress. See figure 3 below.

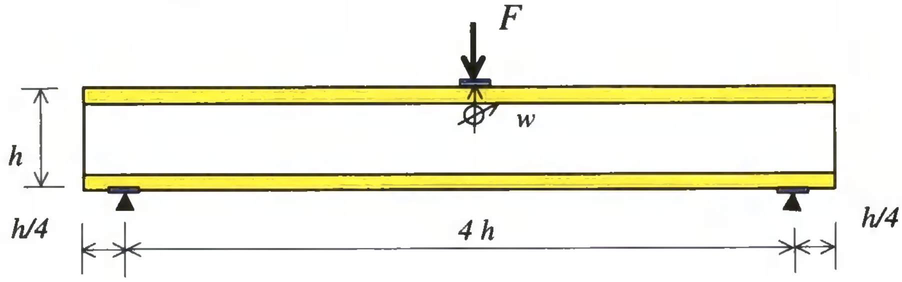

Figure 3. Three-point test model for shear according to NT Build 327.

3.1.3.2 Shear test used in this test, according to EOTA Technical Report
(Anon. 2000).

The four-point test model in the EOTA Technical Report was used in the round robin test. The position of a web joint, if present, as well as the point load are defined. Lateral restraints were applied with center distance of 350 mm on the compression flange. Steel plates under point loads were applied. The deflection at the center of the beam was measured. See figure 4 below. The ultimate shear load at rupture is $F_u/2$.

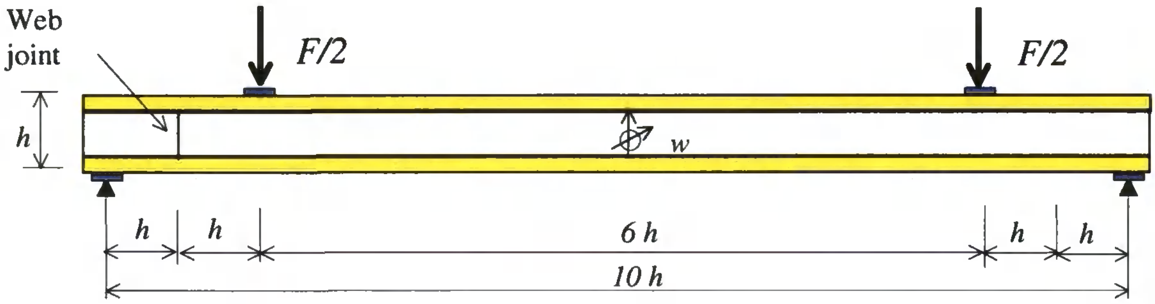

Figure 4. Four-point test loading shear test.

The shear tests were done with one series, series P2.

Picture 1. Test arrangement at SP Swedish National Testing and Research Institute

4 Evaluation

4.1 Descriptions of evaluation methods

4.1.1 Bending

4.1.1.1 Moment capacity

The ultimate moment capacity is calculated by

$$M_u = \frac{F_u \cdot l}{6}$$

where F_u is the ultimate total load,

l is the total span.

4.1.1.2 Flexural rigidity

Both NT Build 327 and the Technical Report state that the flexural rigidity should be determined using the following formula:

$$(EI)_{beam,l} = \frac{\Delta F \cdot l \cdot l_k^2}{48 \cdot \Delta w_4}$$

where ΔF is the force increment, l is the span, and w_4 is the local deflection measured over the length, l_k (5·h) at mid-span. $(EI)_{beam,l}$ is denoted local flexural rigidity.

In this study, however, the flexural rigidity has also been determined based on the mid-span deflection according to the following formula:

$$(EI)_{beam,g} = \frac{23 \cdot \Delta F \cdot l^3}{1296 \cdot \Delta w_3}$$

where w_3 is the mid-span deflection.

$(EI)_{beam,g}$ is denoted global flexural rigidity. In this case the flexural rigidity includes a contribution from the shear deformations.

4.1.2 Shear

The evaluation of the shear test has been restricted to the shear capacity, F_v which has been calculated by the following formula:

$$F_v = \frac{F_u}{2}$$

4.1.3 Recalculations due to differences in moisture content

Calculations due to differences in moisture content are used in connection with mean value estimations of the flanges density. The EN standard 384 (Anon. 1995) recommends a correction of the density due to moisture content with adjustment value of 0.5% of the density for every percent of moisture content above 12%. That calculation is done for the flanges and shown in the tables.

4.2 Comparison between and within the participating laboratories

4.2.1 Statistical methods

4.2.1.1 General

A number of statistical methods have been applied to analyse the test results. In connection with this it has been assumed that the variables are normally distributed.

4.2.1.2 Student's t-test

An appropriate procedure for testing whether samples are from the same underlying population is the t-test. The sampled groups are taken in production from the same population, and the laboratories' results will, if equivalence exists, show that this is the case. A first step could be to make a hypothesis about the mean value between every pair of the participating laboratories. The null hypothesis was set up for equivalent mean value and equal as well as unequal variances at significance level, α, of 5% and 1%, the alternative hypothesis a two-sided hypothesis $\mu_1 \neq \mu_2$. However one can assume that equal variances are the most relevant presupposition. The judgement of the results follows a common terminology:

P > 5%, not significant
1% < P > 5%, almost significant *
0.1 % < P > 1%, significant **
P < 0.1%, most significant ***

In tables of the comparison results the term "Accept" means that there is no significant statistical difference between the two compared values. "Reject" means that significance of any degree is statistically proved.

4.2.1.3 ANOVA

An analysis of the mean values through the variance has also been calculated (ANOVA, ANalysis Of VAriance). The difference from Student's t-test is that in an ANOVA-analysis all three of the group are compared instead of pairs. However with big differences between the groups' standard deviations the ANOVA analysis gives less accurate results.

4.2.1.4 Scheffe's multiple comparisons

To determine whether the means of the samples differ or not, the difference between the means was estimated using Scheffe's multiple comparisons in those cases where a reject in Student's significance test is found. A 95% confidence interval for the difference between pairs is calculated. If the difference between two means is outside the 95% interval, then we have a statistical significance for one of the means.

4.2.1.5 Test method and laboratories

4.2.1.5.1 General

To estimate the precision of each method, repeatability within one laboratory and the reproducibility between laboratories of the chosen test method, statistics from ISO5725 (Anon. 1994a) were used. The calculations according to (Anon. 1994b) are made using an Excel macro (Tang Luping 2000a).

The repeatability describes the minimum variability in the results, and the reproducibility describes the maximum variability of the test results. The precision is quantified by calculation of the standard deviation of the repeatability S_r and the standard deviation of the reproducibility S_R or the repeatability limit *r* and the reproducibility limit *R*. The r and R values are values less than, or equal to, values that are to be expected with a probability of 95% under repeatability, respectively reproducibility, conditions.

For estimating the precision of a measurement method it is useful to assume that every test result, *y*, is the sum of three components:

$y = m + B + e$

where *m* is the general mean.

B is the laboratory component of bias under repeatability conditions (bias is the difference between the expectation of the test results and an excepted reference value, bias is the systematic error in comparison to random error *e*). This term is to be considered as constant during any tests performed under repeatability conditions. When comparing results between laboratories the individual biases have to be considered. ISO 5725-2 assumes that the laboratories' biases are normally distributed. In this test the systematic manufacturing errors are also included in the results.

e is the random error occurring in every measurement under repeatability conditions. The repeatability variance is measured as the variance of the error term *e*. Once again the random error in manufacturing is included in the results.

The variance in the reproducibility depends on the sum of repeatability variance and the between-laboratory variance (variance of *B*).

4.2.1.5.2 Consistency between laboratories

The deviation between the mean value from one laboratory and the mean value of all the laboratories can be described with a so-called h-statistic, Mandel's h-statistics is a "between-laboratory consistency statistic" which indicates a deviation of the mean measured from one laboratory when compared with the general mean (quasi-true value if the true value is unknown) obtained from all the laboratories in a round robin test. The statistical formula is as follows:

$$h_i = \frac{\overline{x_i} - \overline{x_{tot}}}{\sqrt{SS / p(n-1)}}$$

where $\overline{x_i}$ is the mean value from one laboratory,

$\overline{x_{tot}}$ is the mean value of all values,

SS is between laboratories sum of squares

p is level of significance,

n is the number of values.

If all the h values for one lab are negative or positive a laboratory bias could exist. The significance level 1% is plotted to identify outliers.

4.2.1.5.3 Consistency within a laboratory

Mandel's k-statistic is a "within-laboratory consistency statistic" which indicates a measurement deviation in one laboratory when compared with the pooled standard deviation for one beam. The definition is:

$$k_i = \frac{s_i}{s_r}$$

where s_i is the standard deviation within one laboratory and s_r is repeatability standard deviation.

If one laboratory in the k-plot has many low or high values it could indicate poor repeatability. 1% and 5% significance are plotted to guide in examining the data pattern.

5 Results and discussion

5.1 Bending

5.1.1 Series M5

Table 3. Series M5. Moment capacity, density and moisture content. Mean density adjusted to be valid for 12% moisture content is shown in brackets.

	NTI			SP			VTT		
	Moment capacity *[kNm]*	**Mean flange density** *[kg/m³]*	**Mean flange moisture content** *[%]*	**Moment capacity** *[kNm]*	**Mean flange density** *[kg/m³]*	**Mean flange moisture content** *[%]*	**Moment capacity** *[kNm]*	**Mean flange density** *[kg/m³]*	**Mean flange moisture content** *[%]*
	24.5	504	13.6	19.8	449	13.2	20.7	417	14.9
	17.7	406	13.3	23.3	431	13.7	19.0	463	15.1
	20.1	445	13.3	22.8	422	13.7	21.4	428	15.3
	24.8	445	13.7	27.7	487	13.8	21.7	436	15.4
	21.1	448	13.6	20.4	430	13.8	23.6	484	15.3
	22.5	414	13.4	27.7	458	13.5	22.8	436	15.5
	24.4	432	13.5	25.6	454	13.1	21.4	438	15.4
	23.3	474	13.7	26.4	501	13.1	22.6	472	15.7
	20.0	468	13.5	24.8	459	13.2	24.3	516	15.7
	26.8	480	13.5	22.9	438	13.2	21.5	479	15.5
Mean	*22.5*	*451(448)*	*13.5*	*24.1*	*453(450)*	*13.4*	*21.9*	*457(449)*	*15.4*
Std. dev	*2.78*	*30.5*	*0.1*	*2.79*	*25.3*	*0.28*	*1.51*	*31.2*	*0.2*
CoV	*0.12*	*0.07*	*0.01*	*0.12*	*0.06*	*0.02*	*0.07*	*0.07*	*0.02*

Table 4. Series M5. Flexural rigidity based on local measurement.

	Local flexural rigidity, *EI*		
	NTI *[kNm²]*	**SP** *[kNm²]*	**VTT** *[kNm²]*
	1633	1264	1499
	1530	1431	1552
	1731	1365	1407
	1589	1882	1595
	1419	1637	1545
	1511	1801	1797
	1667	1761	1698
	1832	1862	1777
	1773	1777	1839
	1793	1544	1795
Mean	*1648*	*1632*	*1650*
Std. dev	*129*	*209*	*142*
CoV	*0.08*	*0.13*	*0.09*

Due to comparably higher moisture content in the beams tested at VTT, the moment capacity is significantly lower than for the beams tested at SP. This is shown in Table 5. The relatively low standard deviation for VTT is also due to high moisture content. Seven of ten beams had a rupture in the compressed flange and the compression strength normally has a lower standard deviation than tensile strength.

Table 5. Result of the Student's t-test significance test of moment capacity concerning M5. H_0: $\mu_1 = \mu_2$, H_1 : $\mu_1 \neq \mu_2$.

$\alpha = 0.05$	SP	VTT	$\alpha = 0.01$	SP	VTT
NTI	Accept	Accept	NTI	Accept	Accept
VTT	Reject*		VTT	Reject*	

*almost significant

For SP-VTT there is a reject of null-hypothesis at 5% significance value (α), and deviation from the hypothetical value is "almost significant", the probability, P = 0.04 for equal means. For the other pair the P-value is on the level "not significant". This means that the null-hypothesis cannot be rejected in those cases. However, in this case the influence of differences in the standard deviation affect the accuracy of the statistical the result. VTT and SP are at each end of the standard deviation range.

A null-hypothesis with (H_0: $\mu_1 = \mu_2 = \mu_3$) and an analysis of variance (ANOVA) for the total load of the group M5, with the assumption of equal variance at significance level $\alpha = 5\%$, gives a probability of 12%, ($p_{crit.} < 5\%$) for the means to be equal. The null-hypothesis cannot be rejected according to the ANOVA analysis.

The multiple comparison calculation according to Scheffe's method does not show any significant differences that exceed the calculated 95 % confidence standard deviation = 3.03 kNm for moment capacity. See table 6.

Table 6. Result of the Scheffe's multiple comparisons of the mean moment capacity concerning M5 at 95% confidence level. Range ± 3.03 kNm

Differences *[kNm]*	SP	VTT
NTI	1.6	0.6
VTT	2.2	

Table 7. Result of the Student's significance test of the local flexural rigidity for M5. H_0: $\mu_1 = \mu_2$, H_1: $\mu_1 \neq \mu_2$.

$\alpha = 0.05$	SP	VTT	$\alpha = 0.01$	SP	VTT
NTI	Accept	Accept	NTI	Accept	Accept
VTT	Accept		VTT	Accept	

For the flexural rigidity there is no significance. But here too the differences in the standard deviations influence the accuracy of the statistical result. The null-hypothesis cannot be rejected for the tested pairs.

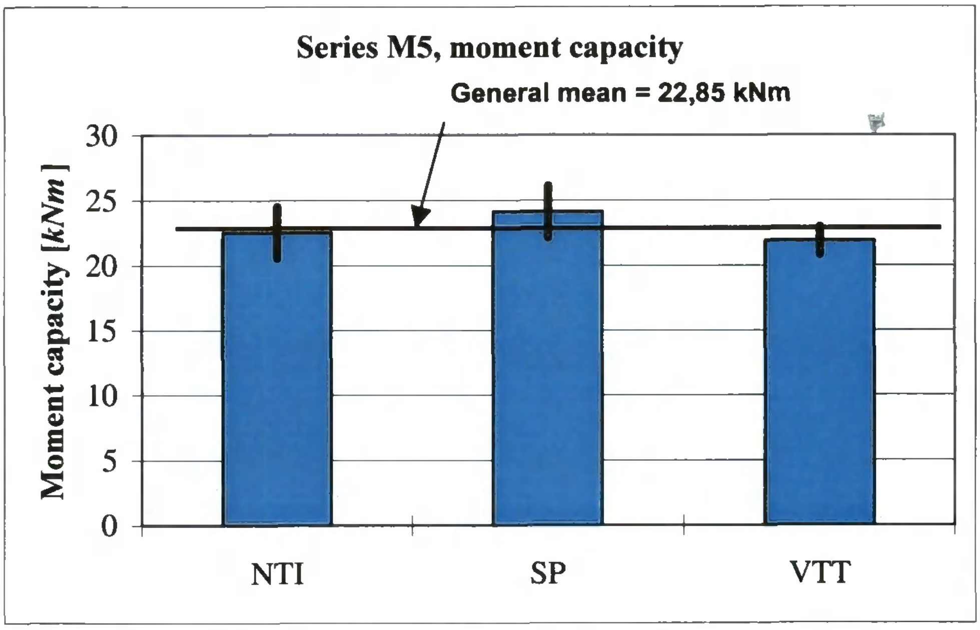

Diagram 1. Series M5, mean value of moment capacity and the 95% confidence interval for the mean values.

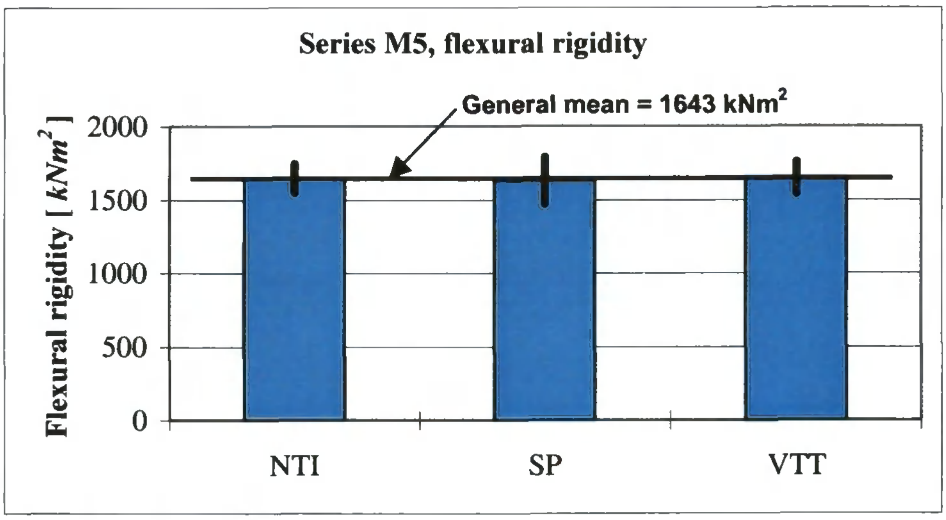

Diagram 2. Series M5, mean value of local flexural rigidity and the 95% confidence interval for the mean values.

5.1.2 Summary series M5

The adjusted values of the mean flange density show a high degree of equality. The t-test gives an "almost significance" between SP and VTT for total load. SP has the highest mean and VTT the lowest and the smallest CoV. The cause of significance is the moisture difference between VTT and SP. The result of local flexural rigidity shows a much higher degree of consistency. That consistency could be assigned to measurements in the lower range of the strength property. The diagrams show overlapping 95% intervals.

5.1.3 Series F1

Table 8. Series F1. Moment capacity, density and moisture content. Mean density adjusted to be valid for 12% moisture content is shown in brackets. Calculation with the marked low VTT value excluded is shown in brackets in the column for moment capacity.

	NTI			SP			VTT		
	Moment capacity	**Mean flange density**	**Mean flange moistu-re content**	**Moment capacity**	**Mean flange density**	**Mean flange moistu-re content**	**Moment capacity**	**Mean flange density**	**Mean flange moistu-re content**
	[kNm]	*[kg/m³]*	*[%]*	*[kNm]*	*[kg/m³]*	*[%]*	*[kNm]*	*[kg/m³]*	*[%]*
	10.2	497	13.7	12.9	492	14.2	7.0	417	16.1
	10.3	406	13.3	11.3	489	14.2	**4.3**	463	16.1
	9.2	445	13.3	12.1	478	14.5	6.4	428	15.9
	7.8	445	13.7	11.0	454	14.2	10.0	436	15.9
	9.1	448	13.6	9.8	465	14.1	10.1	484	16.1
	10.7	414	13.4	11.3	469	13.9	9.3	436	15.8
	10.4	432	13.5	10.4	497	14.1	11.5	438	15.9
	12.2	474	13.7	7.2	474	14.0	9.8	472	15.7
	11.4	471	13.5	10.9	441	14.2	10.9	516	15.9
	12.5	482	13.5	8.2	482	14.1	9.5	479	16.1
Mean	***10.4***	***451(448)***	***13.5***	***10.5***	***474(469)***	***14.1***	***8.9(9.3)***	***474(465)***	***15.9***
Std. dev	***1.43***	***29.6***	***0.2***	***1.73***	***17.6***	***0.2***	***2.26(1.67)***	***36.2***	***0.1***
CoV	***0.14***	***0.07***	***0.01***	***0.16***	***0.04***	***0.01***	***0.25(0.17)***	***0.08***	***0.01***

Table 9. Calculated local flexural rigidity for F1.

	Local flexural rigidity, *EI*,		
	NTI	**SP**	**VTT**
	[kN/m²]	*[kN/m²]*	*[kN/m²]*
	286	245	302
	271	288	290
	295	259	276
	302	276	341
	307	359	352
	290	298	358
	306	399	343
	321	330	343
	301	311	351
	317	332	286
Mean	***300***	***310***	***324***
Std. dev.	***14***	***45***	***30***
CoV	***0.05***	***0.14***	***0.09***

The sampling of the F1 series was not done according to the given instructions. See section 2.2. This can be seen in Appendix 1.1.1.4 – 1.1.1.6, where the sequence should have been for instance 1:2, 1:5, 1:8, 2:2 etc it is instead 2:1, 2:2, 2:3 etc. Despite this and the fact that the VTT beams had higher moisture content there is no significant difference in mean moment capacity between the laboratories. See Table 10.

Table 10. Result of Student's significance test concerning moment capacity for F1, H_0: $\mu_1=\mu_2$, H_1 : $\mu_1\neq\mu_2$.

$\alpha = 0.05$	SP	VTT	$\alpha = 0.01$	SP	VTT
NTI	Accept	Accept	NTI	Accept	Accept
VTT	Accept		VTT	Accept	

An analysis of variance (ANOVA) for the whole group, total load with $\alpha = 0.05$ gives P-value = 0.11. That is: The probability for equal means is 11%. The calculated difference in variance can be considered as "not significant", in spite of the moisture difference and one remarkably low single value for VTT. However the relatively high CoV for VTT's moment capacity influences the analysis accuracy. The low VTT value is noted in appendix 1.1.1.6 as: defective finger joint in tensioned flange. That value could be excluded when it does not affect the test method's ability. An ANOVA analysis with the excluded value with $\alpha = 0.05$ gives P-value = 0.27, of course a higher probability that the means are equal. The Student's t-test gives no signs of significance.

Table11. Result of Student's significance test for local flexural rigidity concerning F1. H_0 : $\mu_1=\mu_2$, H_1 : $\mu_1\neq\mu_2$.

$\alpha = 0.05$	SP	VTT	$\alpha = 0.01$	SP	VTT
NTI	Accept	Reject*	NTI	Accept	Reject*
VTT	Accept		VTT	Accept	

*The P-value for NTI-VTT is 0.04 which is interpreted as "almost significant".

An analysis of variance with $\alpha = 0.05$ gives P = 0.07. This means that the probability of equal means is higher than the significance level of 5%. There is no support for the alternative hypothesis. The null hypothesis cannot be rejected. The difference between NTI and VTT is mainly due to the difference in moisture content.

The multiple comparison calculation according to Scheffe's method, where the difference between pairs are compared to the simultaneous standard deviation that gives 95% confidence level for all compared pairs, does not show any significant differences that exceed this standard deviation = 37.04 kN/m^2 for local flexural rigidity. See table 12

Table 12. Result of the Scheffe's multiple comparisons of the mean moment capacity concerning F1 at 95% confidence level. Range ± 37.04 kN/m^2

Differences *[kNm]*	SP	VTT
NTI	10	24
VTT	-14	

There is little support for rejecting the null hypothesis.

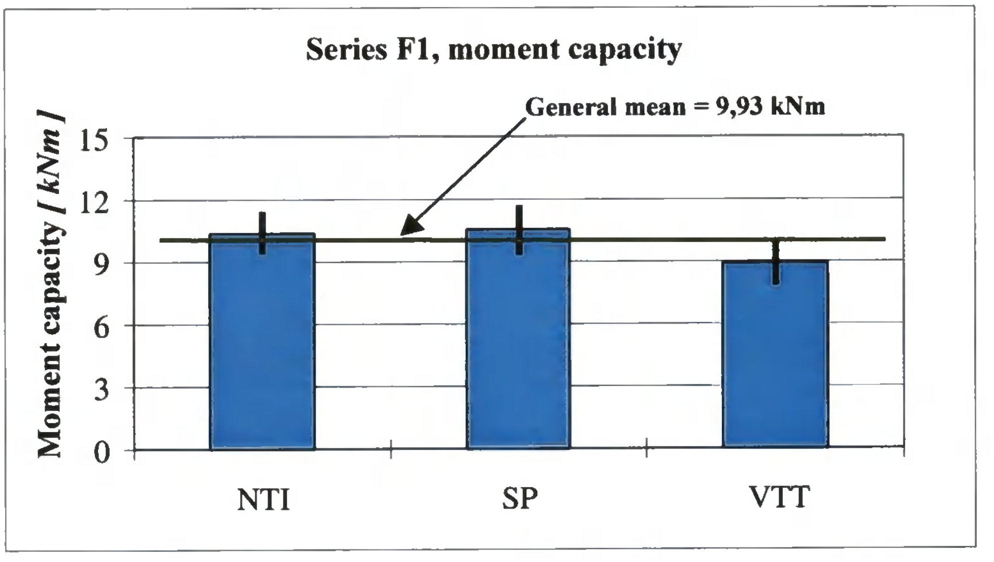

Diagram 3. Mean moment capacity and 95% confidence interval for the mean value.

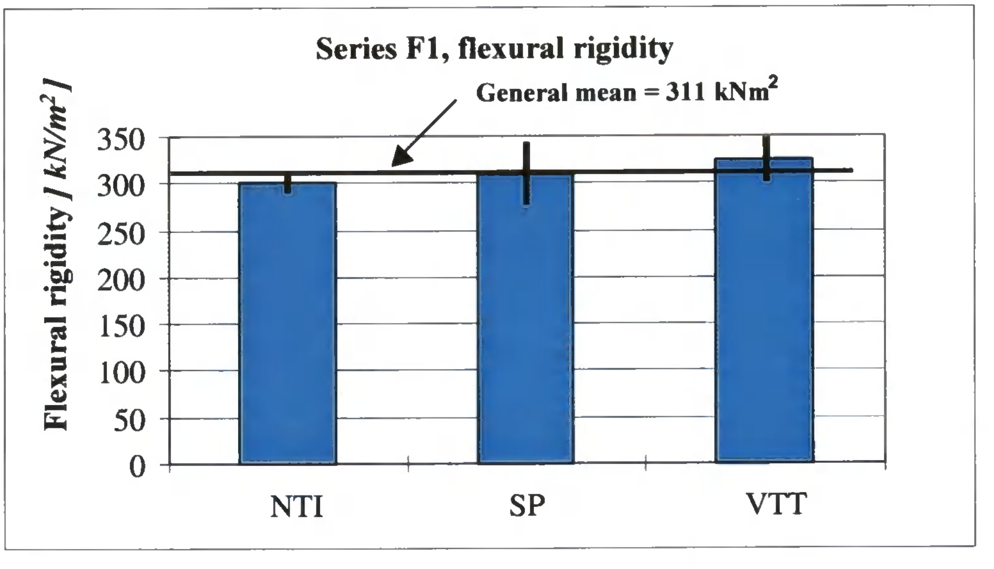

Diagram 4. Series F1 mean local flexural rigidity and 95% confidence interval.

5.1.4 Summary series F1

Due to a defective finger joint the scatter of the moment capacity is almost twice that of SP and NTI. Despite this there is no significant difference between the laboratories.

There is an "almost significant" difference for the flexural rigidity. The difference is larger than in series M5. The reason for this may be, that the F1 series beams were incorrectly sampled so that one laboratory tested beams from one shift and the other laboratory beams from another shift instead each laboratory testing a mixture of beams from three shifts.

5.2 Shear

5.2.1 Series P2

Table 13. Series P2. Shear load, density and moisture content.

	NTI			SP			VTT		
	Shear load at rupture *[kN]*	**Mean flange density** *[kg/m³]*	**Mean flange moisture content** *[%]*	**Shear load at rupture** *[kN]*	**Mean flange density** *[kg/m³]*	**Mean flange moisture content** *[%]*	**Shear load at rupture** *[kN]*	**Mean flange density** *[kg/m³]*	**Mean flange moisture content** *[%]*
	12.07	445	12.9	13.90	477	13.0	13.43	472	12.1
	15.18	482	12.6	14.35	513	13.2	14.65	478	12.3
	16.64	459	13.0	14.85	498	13.0	14.34	505	12.9
	14.59	468	12.5	14.25	441	13.3	15.21	465	12.4
	15.91	457	12.6	15.25	499	13.1	13.60	446	12.2
	12.88	494	12.6	12.55	478	12.9	14.46	488	12.3
	15.65	450	12.5	14.30	487	13.0	15.05	466	11.7
	14.83	468	12.6	11.20	520	13.0	15.17	477	12.5
	13.40	486	13.2	14.70	446	13.1	14.03	446	12.1
	14.97	462	13.1	13.05	497	13.1	14.52	490	12.1
Mean	*14.61*	*467(465)*	*12.7*	*13.84*	*485(482)*	*13.1*	*14.45*	*473(473)*	*12.2*
Std. dev	*1.35*	*16.0*	*0.3*	*1.17*	*25.9*	*0.1*	*0.59*	*18.7*	*0.3*
CoV	*0.09*	*0.03*	*0.02*	*0.08*	*0.05*	*0.01*	*0.04*	*0.04*	*0.03*

Table 14. Result of Student's significance test of shear capacity, concerning P2, $H_0 : \mu_1=\mu_2$, $H_1 : \mu_1 \neq \mu_2$.

$\alpha = 0.05$	SP	VTT	$\alpha = 0.01$	SP	VTT
NTI	Accept	Accept	NTI	Accept	Accept
VTT	Accept		VTT	Accept	

An ANOVA analysis gives for α=0.05 a P=30%. This means that the probability of equal means is 30%, the null hypothesis cannot be rejected. The two analyses support the null hypothesis.

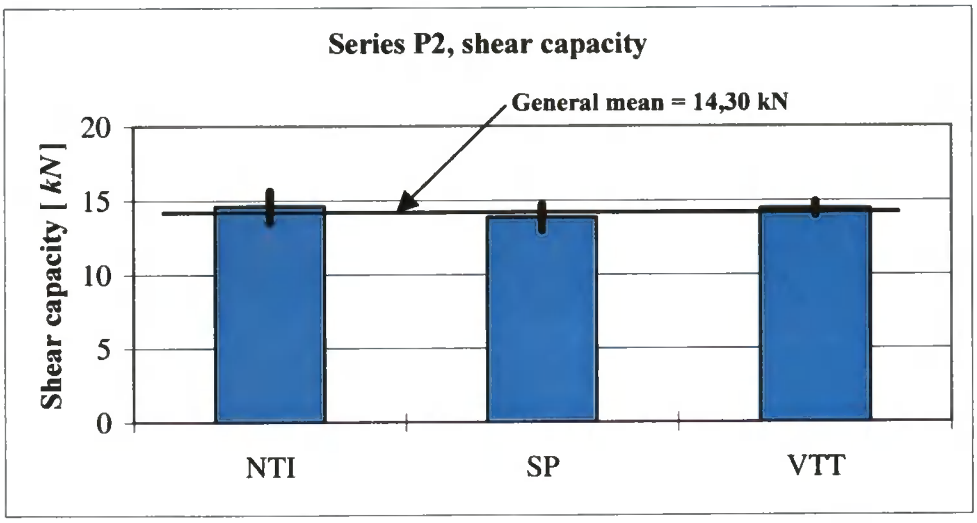

Diagram 3. Shear capacity of series P2 and 95% confidence interval of means.

5.2.2 Summary series P2

The absence of obvious differences in moisture content and correct sampling contributes to consistent results. The diagrams show overlapping confidence intervals.

5.3 Repeatability and reproducibility.

Calculations of the test method's ability to give consistently trustworthy results were carried out in spite of the fact that the number of laboratories is small.

In this calculation a need for adjustment was identified and the result from that possible alternative is shown in table 18. No other correction to the values has been made. The calculation follows ISO5725.

Table 15. Repeatability and reproducibility for tested failure load (total load) with respect to moment capacity in order of 95% probability according to ISO5725. Values in brackets show the result with the lowest value of F1 excluded.

	Series F1	Series M5	Dimension
General mean m	16.5 (16.9)	19	*[kN]*
Repeatability std. dev. s_r	3.1 (2.7)	2	*[kN]*
Reproducibility std. dev. s_R	3.3 (2.7)	2.1	*[kN]*
Repeatability CoV (s_r)	18.8 (16.0)	10.5	%
Reproducibility CoV (s_R)	20.0 (16.0)	11.1	%
Repeatability limit r = 2.8sr	8.7 (7.6)	5.6	*[kN]*
Reproducibility limit $R = 2.8s_R$	9 (8)	6	*[kN]*

Table 16. Repeatability and reproducibility for calculated flexural rigidity in order of 95% probability according to ISO5725.

	Series F1	Series M5	Dimension
General mean m	311.25	1643.53	*[kNm²]*
Repeatability std. dev. s_r	33.8	172.7	*[kNm²]*
Reproducibility std. dev. s_R	34.4	172.7	*[kNm²]*
Repeatability CoV (s_r)	10.9	10.5	%
Reproducibility CoV (s_R)	11.1	10.5	%
Repeatability limit $r = 2.8s_r$	94.6	483.6	*[kNm²]*
Reproducibility limit $R = 2.8s_R$	96	484	*[kNm²]*

Table 17. Repeatability and reproducibility for total load with respect to the shear capacity in order of 95% probability according to ISO5725.

	Series P2	Dimension
General mean m	28.6	*[kN]*
Repeatability std. dev. s_r	2.3	*[kN]*
Reproducibility std. dev. s_R	2.3	*[kN]*
Repeatability CoV (s_r)	8.0	%
Reproducibility CoV (s_R)	8.0	%
Repeatability limit $r = 2.8s_r$	6.4	*[kN]*
Reproducibility limit $R = 2.8s_R$	6	*[kN]*

The precision depends on the number of laboratories. (Tang Luping 2000a) discusses how the number of laboratories, as well as the number of replicates (size of test series), influences the value of the precision test. In this test three laboratories are involved. That number is low and reduces the accuracy of the reproducibility. However, the test series consist of ten objects and that compensates for the low number of laboratories. (Tang Luping) recommends at least 6 laboratories, and where the replicates are very inhomogeneous, 10 replicates.

Therefore the S_R value is to be handled with caution. The laboratories' bias cannot be estimated and the h-statistics in appendix 1.1.2.1, 1.1.2.2, 1.1.2.3 are also to be handled with caution. The sign of equality between S_r and S_R indicating very low "between-laboratory variance" is consequently uncertain. The dependency of the repeatability and the reproducibility of the general mean is not relevant to calculate due to the small number of laboratories. However the number of laboratories that can perform the used test methods is limited.

In this test no reference value has been established. The natural variations of the material in the beams could though be a comparable variable to the CoV (s_r) and CoV (s_R).

The repeatability values, total load, for all beams except for F1 are in the range of 8–10.8%. The result for F1 from VTT has a high CoV for the total load depending on one separate beam. If that result is excluded the CoV is in the same range as the other laboratories. The test series F1 to SP was not correctly sampled.

The same case, as for F1 and repeatability, applies to reproducibility, though caution has to be taken due to few laboratories.

Uncertainty calculations performed by SP for SP's equipment and staffs show an uncertainty of measurements for both total load and flexural rigidity at the level of 4%. In H. Källgren et al. it is shown that if one of two errors is 1/3 of the total error it contributes to the sum of error at the 5% level. In other words the other total error part has to be at least 10% (twice as high) to have adequate limits. The coefficient of strength variation of the strength properties for wood is normally in the range of 15% to 20% at one moisture content level, for hard fibreboard and particleboard it is on the level of 10% to 15%. The flanges are both machine-graded and visually graded; they are also arranged systematically to the webs. One can therefore assume that the CoV for total load in bending tests should be at the lower end of 15% to 20%. In these tests the variation in manufacturing is also included, in the appendices the CoV is calculated for flange widths, beam heights and web thickness. All these CoVs are low. However some records refer to defective joints. The CoV (s_r) and CoV (s_R) for each group do not show reasonable deviation from the expected total CoVs for the material, manufacturing and uncertainty of measurements and laboratory bias. The total CoV could be expected to be at least above the 10% level.

6 Conclusions

The test method is well described and can be performed in a way that gives results that can be considered as comparable among independent laboratories.

For series M5 and P2 the relatively small number of test objects sampled at three different occasions seems to give significant results in spite of differences in moisture content. The results from the F1 series show the importance of sampling. Here the instructions were not followed and the differences between the laboratories is mainly due to difference in quality between shifts

The calculations of repeatability and reproducibility show that the method could be valued as a reliable method. The CoV is less then 15%-20% for both repeatability and reproducibility when the total load at rupture is calculated, and in the case of flexural rigidity the values of CoV are considerably lower than 15%-20%. This indicates a very accurate way of testing and assessing object conformity during the initial elastic stage.

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Appendices

Appendix 1.1.1.1 Tables of series M5 NTI
Dimensions and other characteristics

Beam 1)	Depth			Flange depth 2)			Flange width 2)			Web thickness	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	*[mm]*			*[mm]*			*[mm]*			*[mm]*	*[mm]*	*[m]*	*[m]*		
	at support 1	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
M5 1:1	410	410	413	46,4	47,2	46,9	47,5	47,8	47,8		3,53	3,44	6,62	Solid wood	Hard fibre board
Compr.	-	-	-	47,4	47,0	47,8	47,3	47,4	46,8	8,1					
M5 1:4	413	414	407	47,2	46,8	47,4	47,5	47,4	47,5		3,53	1,08	3,86	"-"	"-"
Compr.	-	-	-	47,6	47,5	46,4	47,2	47,0	46,8	7,8					
M5 1:7	412	407	412	45,4	46,4	47,1	47,6	47,5	47,7		3,53	2,31	-	"-"	"-"
Compr.	-	-	-	49,2	47,1	46,9	47,3	47,1	47,4	7,9					
M5 1:10	407	409	411	47	47,7	47,1	47,7	47,7	47,6		3,53	2,22	7,14	"-"	"-"
Compr.	-	-	-	46,9	46,9	46,9	47,0	47,0	47,1	7,9					
M5 2:1	397	398	399	47,9	47,4	47,0	47,4	47,3	47,2		3,53	2,74	-	"-"	"-"
Compr.	-	-	-	46,1	46,0	45,8	47,3	47,4	46,8	8,3					
M5 2:4	402	405	402	47,9	48,7	48,2	47,4	47,3	47,4		3,53	0,87	4,07	"-"	"-"
Compr.	-	-	-	45,9	46,0	46,3	47,3	47,3	47,1	8,5					
M5 2:7	400	395	401	47,8	46,2	46,4	47,2	46,8	46,9		3,53	2,13	5,91	"-"	"-"
Compr.	-	-	-	46	45,8	45,6	47,0	47,0	47,9	8,5					
M5 3:1	399	399	405	47,9	47,8	46,8	47,2	47,0	46,8		5,24	4,375	-	"-"	"-"
Compr.	-	-	-	46,6	46,3	48,3	46,9	47,1	47,4	7,9	1,86				
M5 3:4	397	399	390	47,6	47,9	47,3	47,3	47,2	47,1		5,26	2,63	5,63	"-"	"-"
Compr.	-	-	-	46,3	47,0	46,1	46,9	46,9	47,0	8,4	1,88				
M5 3:7	406	401	398	48,6	48,3	48,3	47	46,8	46,9		5,26	1,37	5,43	"-"	"-"
Compr.	-	-	-	46,2	46,0	45,9	47,4	47,4	47,0	8,7	1,88				
Mean	404,3	403,7	403,8	47,1	47,0	46,9	47,3	47,2	47,2	8,2	3,5	2,2	5,3		
Std. dev.	6,1	6,2	7,3	1,0	0,8	0,8	0,2	0,2	0,3	0,3	1,2	1,1	1,2		
CoV	0,02	0,02	0,02	0,02	0,02	0,02	0,00	0,01	0,01	0,04	0,35	0,48	0,23		

Appendix 1.1.1.1 Series M5 NTI
Test data

Beam	Failure load (*Total load*)	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density	Moisture content in compressed flange		Moisture content in tensioned flange		Moisture content in the web	Cause of collapse x) special remarks
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
M5 1:1	20,4	3,45	*9)*	1633	477	-	459	576	994	13,7	-	13,5	13,7	8,6	Tension, finger joint *3)*
M5 1:4	14,7	3,22	*9)*	1530	373	-	438	-	1003	13,4	-	13,3	-	8,3	Compression, knots *4)*
M5 1:7	17,7	2,45	*9)*	1731	393	-	496	-	1040	13,2	-	13,3	-	8,2	Tension *5)*
M5 1:10	20,7	2,9	*9)*	1589	442	-	447	-	987	13,6	-	13,8	-	8,5	Tension, knot
M5 2:1	17,6	3,5	*9)*	1419	451	-	445	-	1031	13,7	-	13,5	-	8,7	Tension (long rupture area) *6)*
M5 2:4	18,7	3,34	*9)*	1511	409	-	419	-	980	13,2	-	13,5	-	8,5	Tension, knot *7)*
M5 2:7	20,3	4,08	*9)*	1667	441	-	422	-	978	13,5	-	13,6	-	8,5	Tension
M5 3:1	19,4	2,73	*9)*	1832	443	-	504	-	977	13,6	-	13,7	-	9,2	Tension, knot
M5 3:4	16,7	2,62	*9)*	1773	480	-	456	469	1019	13,5	-	13,5	13,6	8,7	Tension, finger joint *8)*
M5 3:7	22,3	5,43	*9)*	1793	485	-	496	460	986	13,5	-	13,5	13,4	8,9	Tension, finger joint
Mean	18,5	3,4		1647,8	439,4		458,2	501,7	999,5	13,5		13,5	13,6	8,6	
Std. dev.	2,0	0,9		136,1	37,7		30,8	64,5	23,0	0,2		0,2	0,2	0,30	
CoV	0,11	0,26		0,08	0,09		0,07	0,13	0,02	0,01		0,01	0,01	0,03	

Remarks

1) Two rows for each beam, one for tensioned flange and one for compressed flange
2) Values are given for both tension and compression flange
3) Group of knots in the tensioned flange
4) Compressed grains, hole, marks from insects in the tensioned flange
5) Group of knots in the compressed flange
6) Group of knots, one knot with diameter 28 mm and a scar in the tensioned flange
7) Knot 36 mm in the compression flange
8) Big knots in the tensioned flange (37 mm and 40 mm)
9) Failure during test. No values are available.

Appendix 1.1.1.2 Series M5 SP
Dimensions and other characteristics

Beam	Depth			Flange depth *1)*			Flange width *1)*			Web thickness *2)*	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	*[mm]*			*[mm]*			*[mm]*			*[mm]*	*[m]*	*[m]*	*[m]*		
	at support 1	*Center*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
M5 1:2	400,5	400,5	400,0	47,1	47,1	46,6	47,2	47,4	46,9	8,0	3,66	1,87	4,91	Solid wood	Hard fibre board
M5 1:5	400,5	401,0	400,0	46,7	47,2	46,9	47,0	47,2	46,7	7,9	3,66	3,35	6,61	"-"	"-"
M5 1:8	401,0	401,0	400,0	47,2	47,6	47,0	47,4	47,4	46,8	8,0	3,66	3,49	-	"-"	"-"
M5 2:8	400,0	400,0	399,0	45,8	46,6	46,2	46,7	47,3	46,5	8,0	3,66	4,85	-	"-"	"-"
M5 2:2	400,0	400,5	399,0	46,9	47,1	47,1	46,7	47,1	46,8	8,0	3,66	4,39	-	"-"	"-"
M5 2:5	400,0	399,5	399,0	47,3	47,1	46,9	47,0	47,2	46,7	8,0	3,68	3,91	-	"-"	"-"
M5 3:2	400,0	399,5	399,0	47,5	47,5	47,8	47,2	47,2	46,9	8,0	1,95 ; 5,39	0,79	5,14	"-"	"-"
M5 3:5	399,0	399,0	398,5	46,8	46,8	46,7	46,7	47,3	46,5	8,0	1,96 ; 5,35	4,18	-	"-"	"-"
M5 3:8	399,0	399,5	399,0	46,3	46,3	46,3	46,8	47,1	46,3	8,0	1,95 ; 5,34	0,79	4,13	"-"	"-"
M5 3:10	399,0	399,0	399,0	46,6	47,3	47,5	47,0	47,1	46,6	8,3	1,95 ; 5,34	3,85	-	"-"	"-"
Mean	399,9	400,0	399,3	46,8	47,1	46,9	47,0	47,2	46,7	8,0	3,7	3,1	5,2		
Std dev.	0,70	0,76	0,54	0,51	0,40	0,49	0,25	0,12	0,19	0,10	0,01	1,47	1,04		
CoV	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,00	0,00	0,01	0,00	0,47	0,20		

Appendix 1.1.1.2 Series M5 SP
Test data

Beam	Failure load (*Total load*)	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density [3)]	Moister content in compressed flange		Moister content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
M5 1:2	16,5	4,03	1371	1264	489	467	390	-	963	13,1		13,3	13,1	9,4	Tension at 11 mm knot
M5 1:5	19,4	3,37	1382	1431	425	444	451	402	985	13,6	13,2	13,7	14,1	9,5	Tension
M5 1:8	19,0	3,54	1405	1365	442	-	412	411	993	13,5	-	13,8	13,7	9,4	Buckling of upper flange
M5 2:8	23,1	3,32	1824	1882	471	-	502	-	958	14,1	-	13,4	-	9,5	Buckling of upper flange
M5 2:2	17,0	2,54	1573	1637	421	-	409	459	945	13,5	-	13,8	14	9,5	Buckling of upper flange
M5 2:5	23,1	3,30	1684	1801	452	-	474	447	992	13,2	-	13,6	13,7	9,3	Tension at minor knot
M5 3:2	21,3	3,89	1796	1761	462	442	458	-	1024	13,2	13,2	13	-	8,9	Buckling of upper flange
M5 3:5	22,0	2,59	1808	1862	523	487	501	501	1014	12,7	13	13,6	13,2	9,1	Tension
M5 3:8	20,7	4,14	1726	1777	429	-	469	489	987	13,4	-	13	13,1	8,6	Tension in finger joint
M5 3:10	19,1	1,83;5,56	1487	1544	420	424	376	532	963	13,3	13,4	12,9	13,2	9,3	Tension near and in web joint
Mean	20,1		1605,6	1632,4	453,4	449,3	444,2	463,0	984,41	13,4	13,2	13,4	13,5		
Std.dev.	2,33		184,38	220,23	33,66	26,73	44,93	47,57	25,97	0,37	0,16	0,34	0,41		
CoV	0,12		0,11	0,13	0,07	0,06	0,10	0,10	0,03	0,03	0,01	0,03	0,03		

Remarks

1) Mean values of upper and lower flanges

2) Mean values of two web parts

3) Mean values of two web parts for 3:2, 3:5, 3:8 and 3:10 it is three parts

* Consoling at support: 400 mm

Appendix 1.1.1.3 Series M5 VTT
Dimensions and other characteristics

Beam 1)	Depth			Flange depth 2)			Flange width 2)			Web thickness	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	*[mm]*			*[mm]*			*[mm]*			*[mm]*	*[m]*	*[m]*	*[m]*		
	at support 1	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
M5 1:3	402	402	402	47,6	47,1	47,7	47,8	47,7	47,8	7,9	3,66	1,29	3,81	Solid wood	Hard fibre board
compr.	-	-	-	47,4	47,4	47,5	47,6	47,3	47,4	-	-	-	-	"-"	"-"
M5 1:6	402	402	402	47,4	47,9	47,1	47,8	47,8	47,8	7,8	3,67	2,88	-	"-"	"-"
compr.	-	-	-	47,1	47,8	47,4	47,8	48,0	47,8	-	-	-	-	"-"	"-"
M5 1:9	402	402	402	47,4	47,0	46,0	47,7	47,9	47,7	7,9	3,67	1,24	5,48	"-"	"-"
compr.	-	-	-	47,6	46,9	48,7	47,1	47,5	47,3	-	-	-	-	"-"	"-"
M5 2:3	400	400	401	47,4	47,7	46,8	47,2	47,3	47,3	7,9	3,68	4,01	-	"-"	"-"
compr.	-	-	-	46,1	46,7	46,0	47,2	47,7	47,2	-	-	-	-	"-"	"-"
M5 2:6	401	400	400	48,3	46,4	47,9	47,4	47,2	47,4	8,0	3,67	1,98	5,66	"-"	"-"
compr.	-	-	-	46,2	46,1	46,5	47,4	47,3	47,2	-	-	-	-	"-"	"-"
M5 2:9	400	400	400	47,7	48,3	46,5	47,4	47,6	47,3	7,9	3,68	0,98	5,32	"-"	"-"
compr.	-	-	-	46,4	46,5	46,6	47,3	47,4	47,1	-	-	-	-	"-"	"-"
M5 2:10	400	401	400	47,6	47,9	47,8	47,5	47,3	47,1	7,8	3,68	0,85	4,75	"-"	"-"
compr.	-	-	-	46,4	45,8	46,3	47,4	47,8	47,3	-	-	-	-	"-"	"-"
M5 3:3	400	400	400	47,4	47,5	48,7	47,1	47,1	47,5	8,3	1,94:5,32	3,28	-	"-"	"-"
compr.	-	-	-	46,4	46,5	46,0	47,1	47,5	47,6	-	-	-	-	"-"	"-"
M5 3:6	400	400	400	48,1	48,3	48,5	47,3	47,3	47,4	8,3	1,98:5,36	3,96	6,56	"-"	"-"
compr.	-	-	-	45,8	46,0	45,8	47,3	47,3	47,4	-	-	-	-	"-"	"-"
M5 3:9	400	400	400	46,9	47,9	48,1	47,4	47,5	47,1	8,5	1,95:5,33	1,36	3,81	"-"	"-"
compr.	-	-	-	47,8	46,2	46,3	47,1	47,3	47,4	-	-	-	-	"-"	"-"

Mean	400,7	400,7	400,7	47,2	47,1	47,1	47,4	47,5	47,4	8,0	3,7	2,2	5,1
Std.dev.	0,9	0,9	0,9	0,7	0,8	1,0	0,2	0,3	0,2	0,2	0,0	1,2	1,0
CoV	0,00	0,00	0,00	0,01	0,02	0,02	0,01	0,01	0,00	0,03	0,00	0,57	0,20

Appendix 1.1.1.3 Series M5 VTT
Test Data

Beam	Failure load *(Total load)*	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flange		Density of tensioned flange		Web density	Moisture content in compressed flange		Moisture content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
M5 1:3	17,3	2,4-2,9	1457	1499	418	-	415	-	997	14,9	-	14,9	-	9,6	Tensioned flange, knot
M5 1:6	15,8	4,0-5,0	1551	1552	461	-	465	-	1002	15,0	-	15,1	-	9,7	Compressed flange, knot
M5 1:9	17,8	3,1-3,8	1395	1407	420	-	436	-	995	15,7	-	14,9	-	9,6	Compressed flange, knot
M5 2:3	18,1	3,1-3,8	1615	1595	421	-	450	-	990	15,6	-	15,2	-	9,6	Compressed flange, knot
M5 2:6	19,6	3,5-4,2	1500	1545	492	-	476	-	973	15,4	-	15,2	-	9,3	Compressed flange, knot
M5 2:9	19,0	3,1-3,8	1691	1797	456	-	415	-	976	15,1	-	15,8	-	9,7	Compressed flange
M5 2:10	17,8	4,8	1559	1698	400	-	503	410	1006	15,1	-	15,6	15,4	9,5	Tensioned flange, finger joint
M5 3:3	18,8	2,7-3,3	1776	1777	468	-	476	-	996	15,5	-	15,8	-	10,2	Compressed flange
M5 3:6	20,2	4,0-4,2	1737	1839	491	-	541	-	1000	15,5	-	15,8	-	10,2	Compressed flange, knot
M5 3:9	17,9	3,8	1750	1795	496	-	441	501	988	15,8	-	15,2	15,6	10,5	Tensioned flange, finger joint
Mean	18,2		1603,1	1650,4	452,3		461,8	455,5	992,3	15,4		15,4		15,5	
Std. dev.	1,3		132,2	149,9	35,4		39,4	64,3	10,8	0,3		0,4		0,1	
CoV	0,07		0,08	0,09	0,08		0,09	0,14	0,01	0,02		0,02		0,01	

Remarks

1) Two rows for each beam, one for tension flange and one for compressed flange

2) Mean values of upper and lower flanges

Appendix 1.1.1.4 Series F1 NTI
Dimensions and other characteristics

Beam 1)	Depth			Flange depth 2)			Flange width 2)			Web thickness	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	*[mm]*			*[mm]*			*[mm]*			*[mm]*	*[m]*	*[m]*	*[m]*		
	at support 1	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
F1 1:1	199,7	199,2	199,4	46,9	46,3	46,3	46,7	46,5	46,5	10,0	-	-	-	Solid wood	Particle board
compr.	-	-	-	46,1	45,9	46,1	46,8	46,6	46,8	-	-	-	-	"-"	"-"
F1 1:2	199,9	199,6	199,9	46,2	48,2	46,6	46,7	46,8	46,8	10,1	-	1,7	-	"-"	"-"
compr.	-	-	-	46,3	46,4	46,5	46,6	46,9	47	-	-	-	-	"-"	"-"
F1 1:3	200,1	198,9	199,6	46,2	46,1	46,4	46,6	46,8	46,9	10,1	-	2,5	-	"-"	"-"
compr.	-	-	-	46,9	46,2	46,3	46,8	46,6	46,7	-	-	-	-	"-"	"-"
F1 1:3A 4)	199,5	199,4	199,4	46,2	46,2	46,4	46,5	46,7	46,5	10,1	-	1,25	-	"-" 1)	"-"
compr.	-	-	-	46,1	46,2	46,3	46,7	46,8	46,2	-	-	-	-	"-"	"-"
F1 1:6	199,8	199,9	199,9	46,3	46,2	46,2	46,4	46,3	46,5	10,0	1,77	0,15	-	"-"	"-"
compr.	-	-	-	46,3	46,0	46,2	46,3	46,2	46,2	-	-	-	-	"-"	"-"
F1 1:6A 4)	200,3	199,4	199,6	46,2	46,2	45,9	46,3	46,4	46,5	10,1	-	2,57	-	"-"	"-"
Compr.	-	-	-	46,5	46,3	46,1	46,4	46,2	46,3	-	-	-	-	"-"	"-"
F1 1:7	200,0	200,3	199,7	46,3	46,5	46,1	46,6	46,4	46,5	10,0	-	2,21	-	"-"	"-"
compr.	-	-	-	46,3	46,7	46,6	46,7	46,7	46,5	-	-	-	-	"-"	"-"
F1 1:8	200,2	200,8	200,9	46,8	46,8	46,6	46,6	46,7	46,4	10,0	-	2,92	-	"-"	"-"
compr.	-	-	-	46,6	46,4	46,7	46,7	46,5	46,6	-	-	-	-	"-"	"-"
F1 1:9	199,8	200,0	200,0	46,1	46,2	46,3	46,4	46,5	46,7	10,0	-	0,51	3,49	"-"	"-"
compr.	-	-	-	46,5	46,1	46,2	46,6	46,5	46,6	-	-	-	-	"-"	"-"
F1 1:10	199,9	200,0	199,7	46,0	46,2	46,3	46,5	46,6	46,5	10,0	-	-	-	"-"	"-"
compr.	-	-	-	46,9	46,3	46,3	46,7	46,5	46,5	-	-	-	-	"-"	"-"
Mean	199,9	199,8	199,8	46,4	46,4	46,3	46,6	46,6	46,6	10,0		1,7			
Std. dev.	0,2	0,6	0,4	0,3	0,5	0,2	0,2	0,2	0,2	0,1		1,0			
CoV	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,01		0,59			

Appendix 1.1.1.4 Series Fl NTI
Test data

Beam	Failure load *(Total load)*	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density	Moisture content in compressed flange		Moisture content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
Fl 1:1	17,0	2,0	317,5	285,9	488,5		495,3		751,0	14,1		13,96		9,0	Knot in tensioned flange
Fl 1:2	17,2	1,70	522,5	270,7	477,6	485,6	420,9	445,0	771,7	13,9	13,9	13,9	13,8	8,7	Finger joint in tensioned flange
Fl 1:3	15,4	2,50	334,4	295,3	428,6	461,2	478,9	421,2	776,4	13,9	13,9	14,0	13,8	8,6	Finger joint in tensioned flange
Fl 1:3A 4)	13,0	1,25	321,9	301,6	508,3	-	455,4	484,0	777,6	13,8	-	13,9	14,2	8,9	Finger joint in tensioned flange 3)
Fl 1:6	15,2	2,57	347,8	307,4	495,8	-	468,4	-	720,3	13,8	-	13,8	-	8,7	Knot in tensioned flange
Fl 1:6A 4)	17,9	1,70	316,8	290,1	418,1	-	496,0	-	734,5	13,9	-	14,1	-	8,5	Knot in tensioned flange
Fl 1:7	17,4	2,53	349,3	305,8	523,9	-	601,4	-	609,3	13,9	-	14,2	-	8,3	Knot in tensioned flange
Fl 1:8	20,3	1,90	358,5	321	460,5	-	482,3	-	746,6	13,9	-	13,5	-	8,1	Buckling of compressed flange.
Fl 1:9	19,0	1,15	327,8	300,7	447,4	-	476,9	-	740,9	13,6	-	14,0	-	8,2	Wood rupture tensioned flange
Fl 1:10	20,8	1,80	318,8	317,2	483,4	-	485,2	-	800,6	13,8	-	13,8	-	8,0	Wood rupture tensioned flange
Mean	17,3	1,9	351,5	299,6	473,2	473,4	486,1	450,1	742,9	13,9	13,9	13,9	13,9	8,5	
Std.dev.	2,4	0,5	61,9	14,9	34,2	17,3	46,1	31,7	52,7	0,1	0,0	0,2	0,2	0,33	
CoV	0,14	0,26	0,18	0,05	0,07	0,04	0,09	0,07	0,07	0,01	0,00	0,01	0,02	0,04	

Remarks

1) Two rows for each beam, one for tensioned flange and one for compressed flange

2) Mean values of upper and lower flanges

3) Bad finger joint in the tensioned flange (to little glue?)

4) Correction of mistake in marking

Appendix 1.1.1.5 Series F1 SP
Dimensions and other characteristics

Beam	Depth			Flange depth 1)			Flange width 1)			Web thickness	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	[mm]			[mm]			[mm]			[mm]	[m]	[m]	[m]		
	at support 1	centre	at support 2	at support 1	centre	at support 2	at support 1	centre	at support 2						
F1 2:1	200,2	200,5	200,3	46,6	46,6	46,7	47,0	47,0	46,7	10,1	-	1,56	-	Solid wood	Particle board
F1 2:2	200,5	200,3	199,8	46,7	46,7	46,5	46,7	47,0	46,6	10,1	-	3,17	-	" - "	" - "
F1 2:3	200,3	200,6	200,4	46,5	47,0	46,4	46,5	46,9	46,6	10,2	-	1,48	-	" - "	" - "
F1 2:4	200,0	199,4	200,4	46,5	46,5	46,4	46,9	46,8	46,7	10,2	-	0,03	-	" - "	" - "
F1 2:5	200,4	200,1	199,7	46,4	46,3	45,9	46,2	46,5	46,2	10,1	-	-	-	" - "	" - "
F1 2:6	200,4	200,5	200,3	46,4	46,5	46,1	46,4	46,6	46,2	9,9	-	2,21	-	" - "	" - "
F1 2:7	200,5	200,1	199,9	46,3	46,5	46,5	46,5	46,7	46,6	10,2	-	1,29	-	" - "	" - "
F1 2:8	200,5	200,6	200,3	46,5	46,8	46,3	46,4	46,8	46,6	10,0	-	1,75	-	" - "	" - "
F1 2:9	200,3	199,8	200,0	46,5	46,7	46,5	47,1	47,1	46,8	10,0	-	0,63	-	" - "	" - "
F1 2:10	200,5	199,8	200,4	46,6	46,7	46,4	46,4	46,5	46,3	10,2	-	3,48	-	" - "	" - "
Mean	200,4	200,2	200,2	46,5	46,6	46,4	46,6	46,8	46,5	10,1		1,7			
Std dev.	0,16	0,41	0,27	0,12	0,19	0,23	0,30	0,21	0,22	0,11		1,10			
CoV	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,01		0,64			

Remarks

1) Mean values of upper and lower flange

* Consoling 200 mm at support

Appendix 1.1.1.5 Series F1 SP
Test data

Beam	Failure load	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density	Moisture content in compressed flange		Moisture content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
Fl 2:1	12,0	1,56	289	330	406	386	448	425	707	13,7	13,9	14,1	14,3	9,2	Tension in finger joint
Fl 2:2	17,3	0,76	344	399	450	-	422		671	14,2	-	14,0	-	9,5	Tension at 16 mm knot outside the moment max zone
Fl 2:3	13,7	2,11	316	332	396	-	521	378	702	14,1	-	14,0	14,2	9,2	Tension in a part with grain slope
Fl 2:4	16,3	1,43	318	359	472	-	457	-	758	14,0	-	14,2	-	9,4	Tension at minor knot
Fl 2:5	18,2	1,49	291	311	396	-	376	-	701	14,0	-	14,4	-	9,3	Buckling of upper flange 3)
Fl 2:6	18,3	2,21	285	276	449	-	491	426	725	14,1	-	14,1	14,3	9,3	Tension in finger joint 2)
Fl 2:7	20,2	1,47	298	259	499	-	479	435	704	14,6	-	14,5	14,3	9,0	Buckling of upper flange
Fl 2:8	18,9	2,08	294	298	535	463	456	422	704	14,5	14,3	13,4	13,5	8,9	Tension at minor knot 3)
Fl 2:9	21,5	1,69	290	248	480	469	510	-	745	13,8	14,2	14,3	-	8,7	Buckling of upper flange
Fl 2:10	18,9	1,92	305	288	510	-	468	-	736	14,4	-	14,0	-	8,4	Tension at 15 mm knot 1)

Mean	17,5	1,67	306,5	366,3	459	439	463	417	713	14,1	14,1	14,1	10,8
Std. dev	2,88	0,43	18,31	46,47	48,89	46,29	42,42	22,44	26,03	0,29	0,21	0,30	0,35
CoV	0,16	0,26	0,06	0,13	0,11	0,11	0,09	0,05	0,04	0,02	0,01	0,02	0,03

1) No linearity over 5 kN (total load) in curvature measurement

2) No linearity over 6 kN (total load) in curvature measurement

3) No linearity over 4 kN (total load) in curvature measurement

Appendix 1.1.1.6 Series F1 VTT
Dimensions and other characteristics

Beam 1)	Depth			Flange depth 2)			Flange width 2)			Web thickness	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	[mm]			[mm]			[mm]			[mm]	[m]	[m]	[m]		
	at support 1	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
F1 3:1	200	200	201	46,9	46,9	46,9	47,2	47,2	47,2	10,4	-	1,26	-	Solid wood	Particle board
compr.	-	-	-	46,8	46,8	46,8	47,2	47,0	47,2	-	-	-	-	"-"	"-"
F1 3:2	200	201	201	46,9	46,7	46,8	47,2	47,0	47,1	10,4	-	1,76	-	"-"	"-"
compr.	-	-	-	46,9	46,9	46,7	47,1	47,2	47,1	-	-	-	-	"-"	"-"
F1 3:3	200	201	200	46,8	46,8	46,8	47,2	47,0	47,1	10,2	-	2,15	-	"-"	"-"
compr.	-	-	-	46,4	46,6	46,6	46,9	46,9	47,3	-	-	-	-	"-"	"-"
F1 3:4	200	200	200	46,4	46,5	46,5	46,8	47,0	46,9	10,2	-	-	-	"-"	"-"
compr.	-	-	-	46,7	46,5	46,3	47,1	46,9	46,8	-	-	-	-	"-"	"-"
F1 3:5	200	201	200	46,6	46,8	46,9	46,4	46,5	46,4	10,2	-	2,07	-	"-"	"-"
compr.	-	-	-	46,4	46,5	46,6	46,7	46,7	46,7	-	-	-	-	"-"	"-"
F1 3:6	200	201	200	46,7	46,8	46,8	46,8	46,5	46,6	10,3	-	1,21	-	"-"	"-"
compr.	-	-	-	46,7	46,7	46,8	46,7	46,7	46,6	-	-	-	-	"-"	"-"
F1 3:7	201	200	201	46,4	46,4	46,7	46,8	46,8	46,7	10,2	-	3,05	-	"-"	"-"
compr.	-	-	-	47,1	47,0	47,1	46,7	47,2	47,0	-	-	-	-	"-"	"-"
F1 3:8	200	201	201	46,6	46,7	46,9	46,8	46,7	46,9	10,2	-	2,5	-	"-"	"-"
compr.	-	-	-	47,1	47,1	47,0	47,0	47,2	47,0	-	-	-	-	"-"	"-"
F1 3:9	201	201	201	46,9	46,9	46,8	47,0	47,0	46,8	10,2	-	3,74	-	"-"	"-"
compr.	-	-	-	46,9	46,8	46,7	47,0	46,4	46,5	-	-	-	-	"-"	"-"
F1 3:10	201	201	200	46,9	46,7	46,8	47,1	47,0	47,0	10,2	-	3,62	-	"-"	"-"
compr.	-	-	-	46,7	47,0	46,9	46,6	47,0	47,0	-	-	-	-	"-"	"-"
Mean	200,3	200,7	200,5	46,7	46,8	46,8	46,9	46,9	46,9	10,3		2,4			
Std.dev.	0,5	0,5	0,5	0,2	0,2	0,2	0,2	0,2	0,3	0,1		0,9			
CoV	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01		0,39			

Appendix 1.1.1.6 Series F1 VTT
Test data

Beam	Failure load	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flange		Density of tensioned flange		Web density	Moisture content in compressed flange		Moisture content in tensioned the flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
F1 3:1	11,7	1,25	265	302	452	-	438	400	794	16,2	-	15,6	16,3	9,5	Tensioned flange, finger joint
F1 3:2	7,1	1,57	279	290	464	-	447	435	762	16,3	-	15,9	?	9,4	Tensioned flange, finger joint is defective
F1 3:3	10,7	2,17	260	276	412	-	465	469	691	16,0	-	15,8	15,8	10,6	Tensioned flange, finger joint
F1 3:4	16,6	1,54	313	341	465	426	469	-	751	15,9	?	15,9	-	10,3	Compressed flange, finger joint and knot
F1 3:5	16,8	2,00	301	352	523	-	500	-	743	16,2	-	16,0	-	9,8	Compressed flange 3)
F1 3:6	15,9	1,78	313	358	502	-	465	-	755	15,9	-	15,6	-	9,5	Tensioned flange, knot
F1 3:7	19,2	1,95	315	343	523	-	540	-	689	15,8		15,9	-	9,5	Tensioned flange, no finger joint
F1 3:8	16,4	2,20	325	343	492	-	486		723	15,6	-	15,8	-	9,4	Compressed flange 4)
F1 3:9	18,2	1,23	331	351	488	-	529	-	737	15,9	-	15,9	-	9,7	Compressed flange, finger joint
F1 3:10	15,9	2,50	272	286	443	-	412	-	736	16,0	-	16,2	-	9,5	Tensioned flange, no finger joint
Mean	14,8	1,8	324,2	1,8	476,4		475,1	434,7	738,1	16,0		15,9		9,7	
Std.dev.	3,8	0,4	31,7	0,4	35,8		39,8	34,5	31,7	0,2		0,2		0,4	
CoV	0,26	0,23	0,10	0,23	0,08		0,08	0,08	0,04	0,01		0,01		0,04	

Remarks

1) Two rows for each beam, one for tension flange and one for compressed flange

2) Mean values of upper and lower flanges

3) Secondary in a finger joint in the tensioned flange.

4) Secondary rupture in the tensioned flange.

Appendix 1.1.1.7 Series P2 NTI
Dimensions and other characteristics

Beam 1)	Depth 2)			Flange depth 2)			Flange width 2)			Web thick-ness 3)	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	[mm]			[mm]			[mm]			[mm]	[m]	[m]	[m]		
	at support 1	centre	at support 2	at support 1	centre	at support 2	at support 1	centre	at support 2						
P2 1:1	201,1	201,1	201,1	44,1	44,4	44,3	44,9	44,9	44,8	-	-	-	-	Solid wood	Hard fibre board
compr.	-	-	-	45	44,5	44,3	44,8	44,9	44,9	6	0,2	-	-	"-"	"-"
P2 1:4	202,3	201,9	201,9	45,5	44,1	44,8	45,6	44,7	44,6	-	-	1,35	-	"-"	"-"
compr.	-	-	-	45,2	45,0	45,3	45,7	45,1	44,8	6,2	0,2	-	-	"-"	"-"
P2 1:7	200,8	200,8	200,9	44,1	44,3	44,4	44,8	45,0	44,7	-	-	-	-	"-"	"-"
compr.	-	-	-	44,7	44,9	44,9	44,9	45,0	44,6	5,9	0,2	-	-	"-"	"-"
P2 1:10	202,4	201,7	201,3	44,7	45,1	44,2	44,9	45,0	44,8	-	-	1,55	-	"-"	"-"
compr.	-	-	-	44,7	44,7	44,4	45,0	45,0	44,8	6,1	0,2	-	-	"-"	"-"
P2 2:1	201	201,8	202,3	43,8	44,9	44,8	44,7	44,7	44,6	-	-	-	-	"-"	"-"
compr.	-	-	-	45,1	45,1	44,8	44,8	44,8	45	6,1	0,2	-	-	"-"	"-"
P2 2:4	202,2	202,2	203,7	44,8	44,6	44,2	44,7	44,5	44,6	-	-	-	-	"-"	"-"
compr.	-	-	-	45,6	44,1	44,7	44,7	44,2	44,7	6	0,2	-	-	"-"	"-"
P2 2:7	201,3	201,4	200,9	44,3	44,3	44	45,1	44,9	44,9	-	-	0,51	-	"-"	"-"
compr.	-	-	-	45,1	44,9	44,6	44,9	44,7	44,9	5,8	0,2	-	-	"-"	"-"
P2 3:1	200,9	201,1	202	45	45,0	44,8	44,7	44,7	44,6	-	-	-	-	"-"	"-"
compr.	-	-	-	44,9	44,9	45,1	44,8	44,8	44,7	6,1	0,2	-	-	"-"	"-"
P2 3:4	200,3	200,5	200,9	44,2	44,1	44,3	44,8	44,9	45,0	-	-	-	-	"-"	"-"
compr.	-	-	-	44,6	44,7	45,1	45,2	45,2	45,0	6,1	0,2	-	-	"-"	"-"
P2 3:7	201,2	201,1	201,4	45,1	45,0	45,2	44,9	44,9	44,9	-	-	-	-	"-"	"-"
compr.	-	-	-	45,6	44,7	44,5	44,9	44,9	44,8	6	0,2	-	-	"-"	"-"
Mean	201,4	201,4	201,6	44,8	44,7	44,7	44,9	44,8	44,8	6,0	0,2				
Std. dev.	0,71	0,53	0,88	0,50	0,35	0,37	0,28	0,23	0,15	0,12	0,00				
CoV	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,00	0,02	0,00				

Appendix 1.1.1.7 Series P2 NTI
Test data

Beam	Failure load *(Shear load)*	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density	Moister content in compressed flange		Moister content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
P2 1:1	12,1	0,45	-	-	440,0	-	450,6	-	963,9	13,0	-	12,8	-	7,8	Shear in the web
P2 1:4	15,2	0,22	-	-	480,6	-	483,9	-	932,3	12,6	-	12,5	-	8,3	Shear in the web
P2 1:7	16,6	0,22	-	-	423,1	-	494,7	-	926,5	13,0	-	13,0	-	8,0	Shear in the web
P2 1:10	14,6	0,18	-	-	473,1	-	462,7	-	917,3	12,5	-	12,5	-	8,0	Shear in the web
P2 2:1	15,9	0,4	-	-	457,4	-	456,7	-	960,9	12,6	-	12,5	-	8,0	Shear in the web
P2 2:4	12,9	0,23	-	-	497,3	-	491,1	-	989,6	12,5	-	12,6	-	7,6	Shear in the web
P2 2:7	15,7	1,45	-	-	444,4	-	454,8	-	982,4	12,5	-	12,5	-	8,0	Shear in the web
P2 3:1	14,8	0,2	-	-	446,7	-	489,4	-	966,7	12,6	-	12,6	-	7,9	Shear in the web
P2 3:4	13,4	0,2	-	-	488,7	-	483,3	-	940,1	13,0	-	13,3	-	8,8	Shear in the web
P2 3:7	15,0	1,75	-	-	462,2	-	461,0	-	1003,9	13,1	-	13,1	-	8,1	Shear in the web
Mean	14,6	0,5			461,4		472,8		958,4	12,7		12,7		8,1	
Std.dev.	1,43	0,58			23,54		17,13		28,77	0,25		0,30		0,30	
CoV	0,10	1,09			0,05		0,04		0,03	0,02		0,02		0,04	

Remarks

1) Two rows for each beam, one for tension flange and one for compressed flange

2) Mean values of upper and lower flanges

3) Two joints in the centre part

Appendix 1.1.1.8 Series P2 SP
Dimensions and other characteristics

Beam	Depth 1)			Flange depth 1)			Flange width 1)			Web thickness 2)	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	*[mm]*			*[mm]*			*[mm]*			*[mm]*	*[mm]*	*[m]*	*[m]*		
	at support 1	*Center*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
P2 1:2	201,8	-	-	45,5	-	-	45,4	-	-	6,4	200	-	-	Solid wood	Hard fibre board
P2 3:2	200,9	-	-	44,4	-	-	45,4	-	-	6,2	200	-	-	" - "	" - "
P2 2:2	202,0	-	-	44,7	-	-	45,0	-	-	6,0	200	-	-	" - "	" - "
P2 3:10	201,4	-	-	44,9	-	-	45,3	-	-	6,4	200	-	-	" - "	" - "
P2 2:8	200,9	-	-	44,6	-	-	45,5	-	-	6,1	200	-	-	" - "	" - "
P2 3:5	200,8	-	-	44,8	-	-	45,3	-	-	6,3	200	-	-	" - "	" - "
P2 2:5	201,3	-	-	44,5	-	-	45,1	-	-	6,1	200	-	-	" - "	" - "
P2 1:8	201,9	-	-	44,7	-	-	45,3	-	-	6,1	200	-	-	" - "	" - "
P2 3:8	201,3	-	-	45,0	-	-	45,2	-	-	6,1	200	-	-	" - "	" - "
P2 1:5	200,9	-	-	44,6	-		44,8	-	-	6,0	200	-	-	" - "	" - "
Mean	201,3			44,7			45,2			6,1	200,0				
Std. dev.	0,44			0,19			0,21			0,13	0,00				
CoV	0,00			0,00			0,00			0,02	0,00				

1) One value in end 1 was recorded
2) Mean of two values

Appendix 1.1.1.8 Series P2 SP
Test data

Beam	Failure load *(Shear load)*	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density 2)	Moisture content in compressed flange		Moisture content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
P2 1:2	13,9	1,68	-	-	490	-	464	-	957	13,1	-	12,8	-	7,3	Tension in finger joint. 3)
P2 3:2	14,4	-	-	-	512	-	513	-	967	13,3	-	13,1	-	7,7	Shear between the web and the lower flange
P2 2:2	14,9	-	-	-	490	-	505	-	975	12,9	-	13,1	-	7,4	Shear in web joint (big knot, 22 mm)
P2 3:10	14,3	-	-	-	437	-	445	-	915	13,3	-	13,2	-	8,5	Shear in web joint
P2 2:8	15,3	-	-	-	487	-	511	-	953	13,2	-	13	-	7,8	Shear in web joint
P2 3:5	12,6	-	-	-	456	-	500	-	943	12,9	-	12,9	-	8,1	Shear in part without web joint
P2 2:5	14,3	-	-	-	483	-	490	-	946	12,9	-	13,1	-	7,9	Shear in the web 4)
P2 1:8	11,2	1,46	-	-	510	-	530	-	945	13	-	13	-	7,5	Shear in the part without web joint. 5)
P2 3:8	14,7	-	-	-	436	-	456	-	970	13,1	-	13,1	-	7,9	Shear in web joint. 6)
P2 1:5	13,1	-	-	-	494	-	500	-	975	13	-	13,2	-	7,3	Shear in part without web joint
Mean	13,9	1,6			479,5		491,4		954,5	13,1		13,1			
Std. dev.	1,24	0,16			27,36		27,55		18,7	0,16		0,13			
CoV	0,09	0,10			0,06		0,06		0,0	0,01		0,01			

Remarks

1) Mean values of upper and lower flange

2) Mean values of two parts

3) Finger play in the bottom for about 3 mm

4) Great play in finger joint bottom, up to 2,5 mm.

5) Great play in finger bottom.

6) Great play in finger bottom. Divided fingers

Appendix 1.1.1.9 Series P2 VTT
Dimensions and other characteristics

Beam 1)	Depth			Flange depth 2)			Flange width 2)			Web thick-ness 3)	Distance from support 1 to web joint	Distance from support 1 for finger joint 1 in tensioned flange	Distance from support 1 to finger joint 2 in compressed flange	Material in flanges	Material in web
[No]	*[mm]*			*[mm]*			*[mm]*			*[mm]*	*[m]*	*[m]*	*[m]*		
	at support 1	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*	*at support 1*	*centre*	*at support 2*						
P2 1:3	201	200	200	44,7	44,7	44,9	45,6	45,1	45,3	6,2	0,20	0,66	-	Solid wood	Hard board
compr.	-	-	-	45,5	45,0	45,3	45,2	45,2	45,3	-	-	-	-	"-"	"-"
P2 1:6	202	201	202	45,1	45,0	44,9	45,3	45,2	45,2	6,0	0,20	0,09	-	"-"	"-"
compr.	-	-	-	45,4	45,3	45,2	45,5	45,3	45,2	-	-	-	-	"-"	"-"
P2 1:9	200	200	200	44,5	44,4	44,5	45,2	45,2	45,0	6,2	0,20	1,62	-	"-"	"-"
compr.	-	-	-	45,3	45,2	45,2	45,1	45,2	44,8	-	-	-	-	"-"	"-"
P2 2:3	201	201	201	44,9	44,5	44,8	45,3	44,9	45,1	6,4	0,20	1,28	-	"-"	"-"
compr.	-	-	-	45,3	45,3	44,7	45,3	45,3	45,3	-	-	-	-	"-"	"-"
P2 2:6	202	201	201	44,7	44,4	44,4	45,1	45,3	45,2	6,3	0,20	-	-	"-"	"-"
compr.	-	-	-	45,4	44,9	44,7	45,1	45,1	45,1	-	-	-	-	"-"	"-"
P2 2:9	202	200	200	45,2	44,5	44,5	45,1	45,2	45,0	6,3	0,20	1,65	-	"-"	"-"
compr.	-	-	-	45,2	45,5	45,4	45,0	45,1	45,1	-	-	-	-	"-"	"-"
P2 2:10	200	200	201	44,6	44,5	44,4	45,3	45,1	45,2	6,4	0,20	0,86	-	"-"	"-"
compr.	-	-	-	45,4	45,4	45,3	45,2	45,0	45,4	-	-	-	-	"-"	"-"
P2 3:3	201	201	201	44,7	44,2	44,3	45,1	45,0	45,0	6,4	0,20	-	-	"-"	"-"
compr.	-	-	-	45,2	45,4	45,5	45,1	45,3	45,3	-	-	-	-	"-"	"-"
P2 3:6	200	200	200	44,3	44,7	44,6	45,0	45,2	45,1	6,5	0,20	-	-	"-"	"-"
compr.	-	-	-	45,4	44,9	45,2	45,0	45,1	45,2	-	-	-	-	"-"	"-"
P2 3:9	201	200	200	44,5	44,6	44,5	45,1	45,2	45,2	6,4	0,20	-	-	"-"	"-"
compr.	-	-	-	45,3	45,4	45,8	45,2	45,2	45,4	-	-	-	-	"-"	"-"

Mean	201,0	200,4	200,6	45,0	44,9	44,9	45,2	45,2	45,2	6,3	0,2	1,0
Std.dev.	0,82	0,52	0,70	0,38	0,41	0,43	0,16	0,11	0,15	0,13	0,00	0,61
CoV	0,00	0,00	0,00	0,01	0,01	0,01	0,00	0,00	0,00	0,02	0,00	0,59

Appendix 1.1.1.9 Series P2 VTT
Dimensions and other characteristics

Beam	Failure load *(Shear load)*	Distance from support 1 to rupture	Global flexural rigidity	Local flexural rigidity	Density of compressed flanges		Density of tensioned flange		Web density	Moisture content in compres-sed flange		Moisture content in tensioned flange		Moisture content in the web	Cause of collapse
[No]	*[kN]*	*[m]*	*[kNm²]*	*[kNm²]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[kg/m³]*	*[%]*	*[%]*	*[%]*	*[%]*	*[%]*	
P2 1:3	13,4	0,2	-	-	469	-	475	-	906	12,1	-	12,0	-	7,8	Beside the web joint, diagonal rupture
P2 1:6	14,7	0,2	-	-	486	-	470	-	965	12,2	-	12,3	-	7,4	Web joint
P2 1:9	14,3	0,2	-	-	509	-	500	-	964	12,8	-	12,9	-	7,7	Web joint
P2 2:3	15,2	0,2	-	-	454	-	475	-	908	12,3	-	12,4	-	7,9	Web joint
P2 2:6	13,6	0,2	-	-	441	-	450	-	952	12,1	-	12,2	-	7,9	Beside web joint
P2 2:9	14,5	0,2	-	-	486	-	490	-	912	12,4	-	12,2	-	7,6	Web joint
P2 2:10	15,1	0,2	-	-	466	-	466	-	881	11,7	-	11,7	-	7,7	Web joint
P2 3:3	15,2	0,2	-	-	481	-	473	-	893	12,5	-	12,4	-	8,2	Web joint
P2 3:6	14,0	0,2	-	-	444	-	448	-	936	12,0	-	12,2	-	7,6	Web joint
P2 3:9	14,5	1,8	-	-	494	-	485	-	944	12,0	-	12,0	-	7,6	The web, diagonal rupture
Mean	14,5	0,4			473,0		473,2		926,1	12,2		12,2		7,7	
Std.dev.	0,64	0,5			22,2		16,3		30,0	0,3		0,3		0,2	
CoV	0,04	1,41			0,05		0,03		0,03	0,03		0,03		0,03	

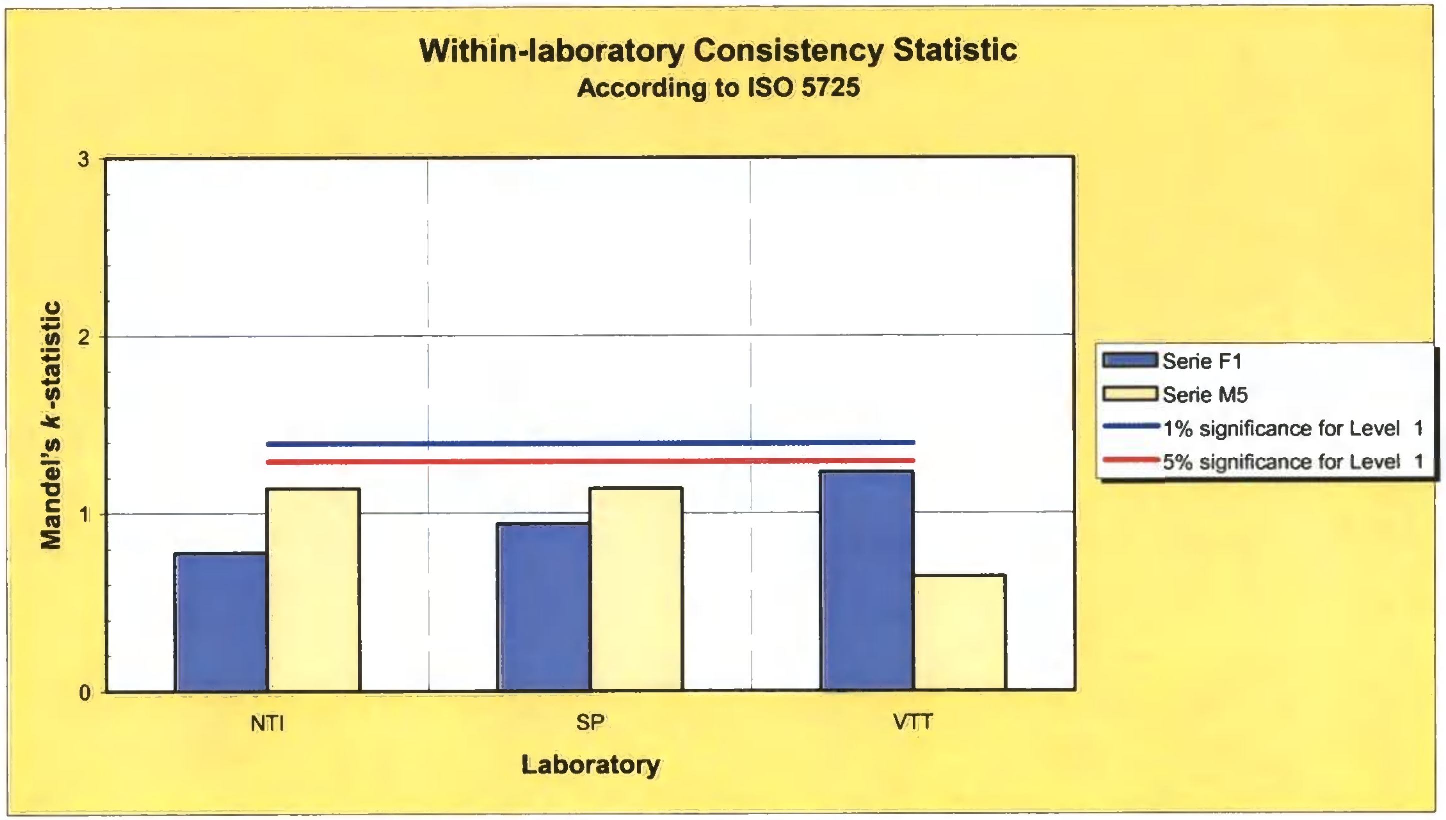
Remarks

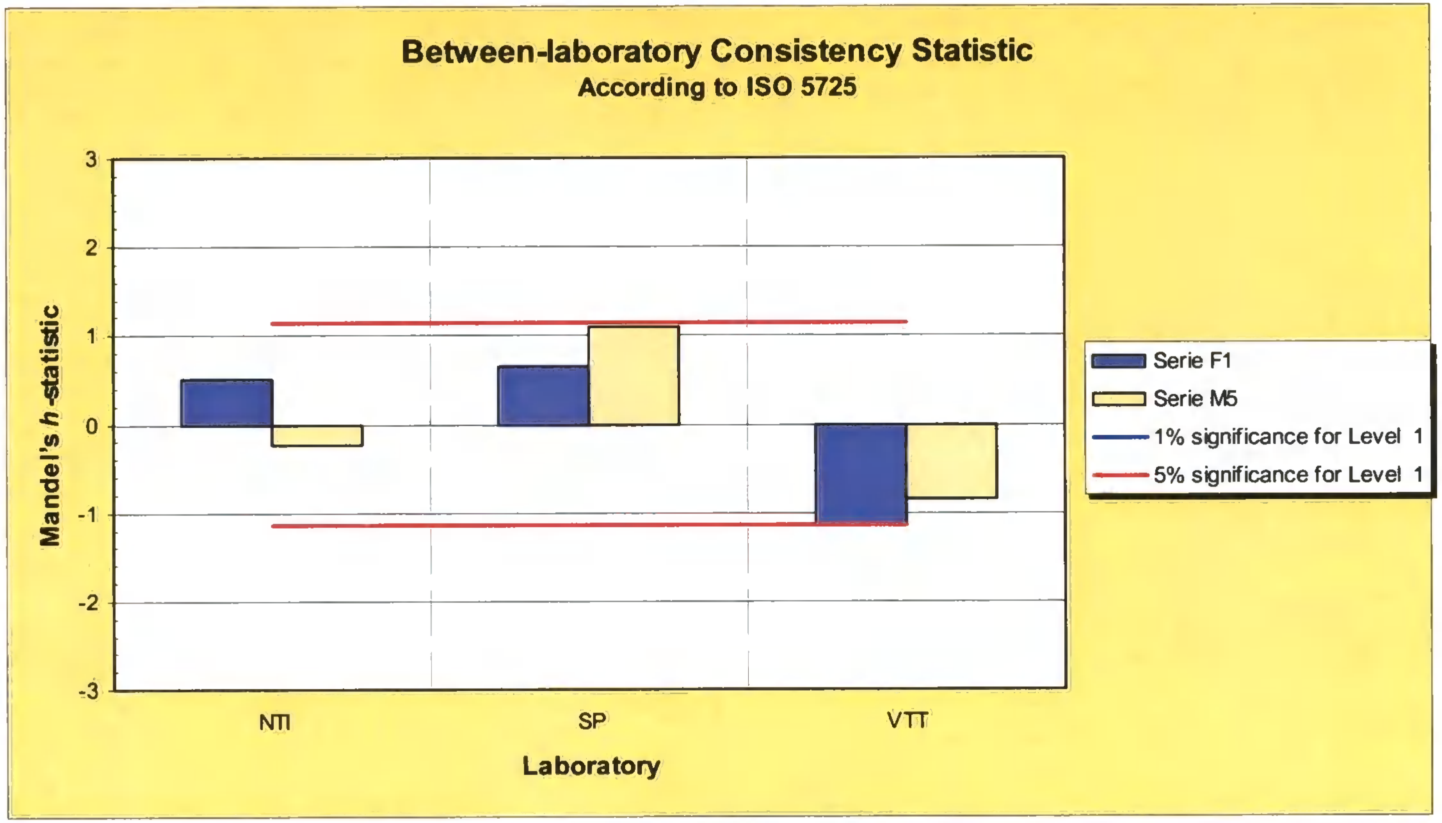
1) Two rows for each beam, one for tension flange and one for compressed flange

2) Mean values of upper and lower flanges

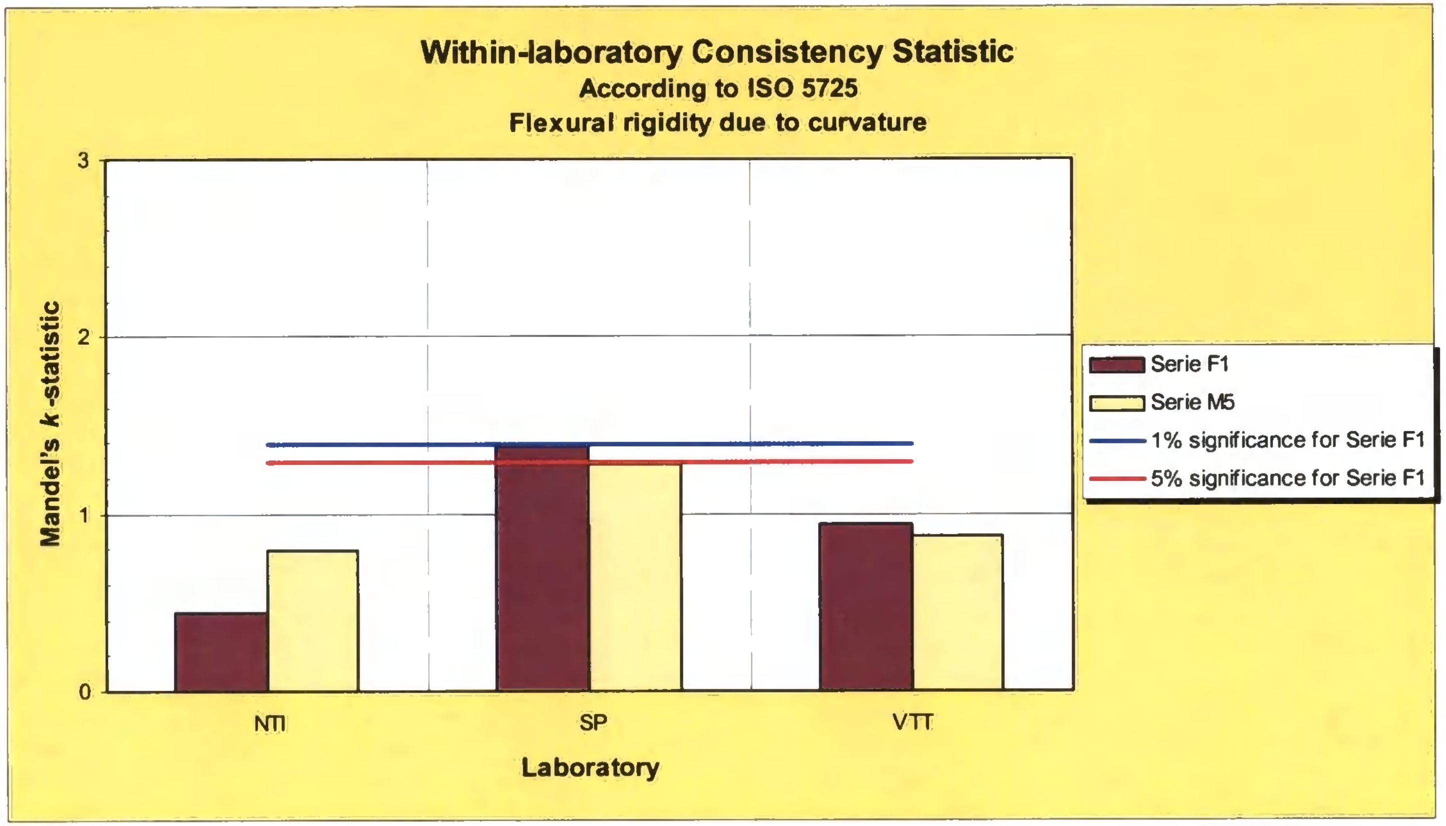
3) Mean values of two parts

Appendix 1.1.2.1
Mandel´s k-statistics according to ISO 5725, M5, F1 total load

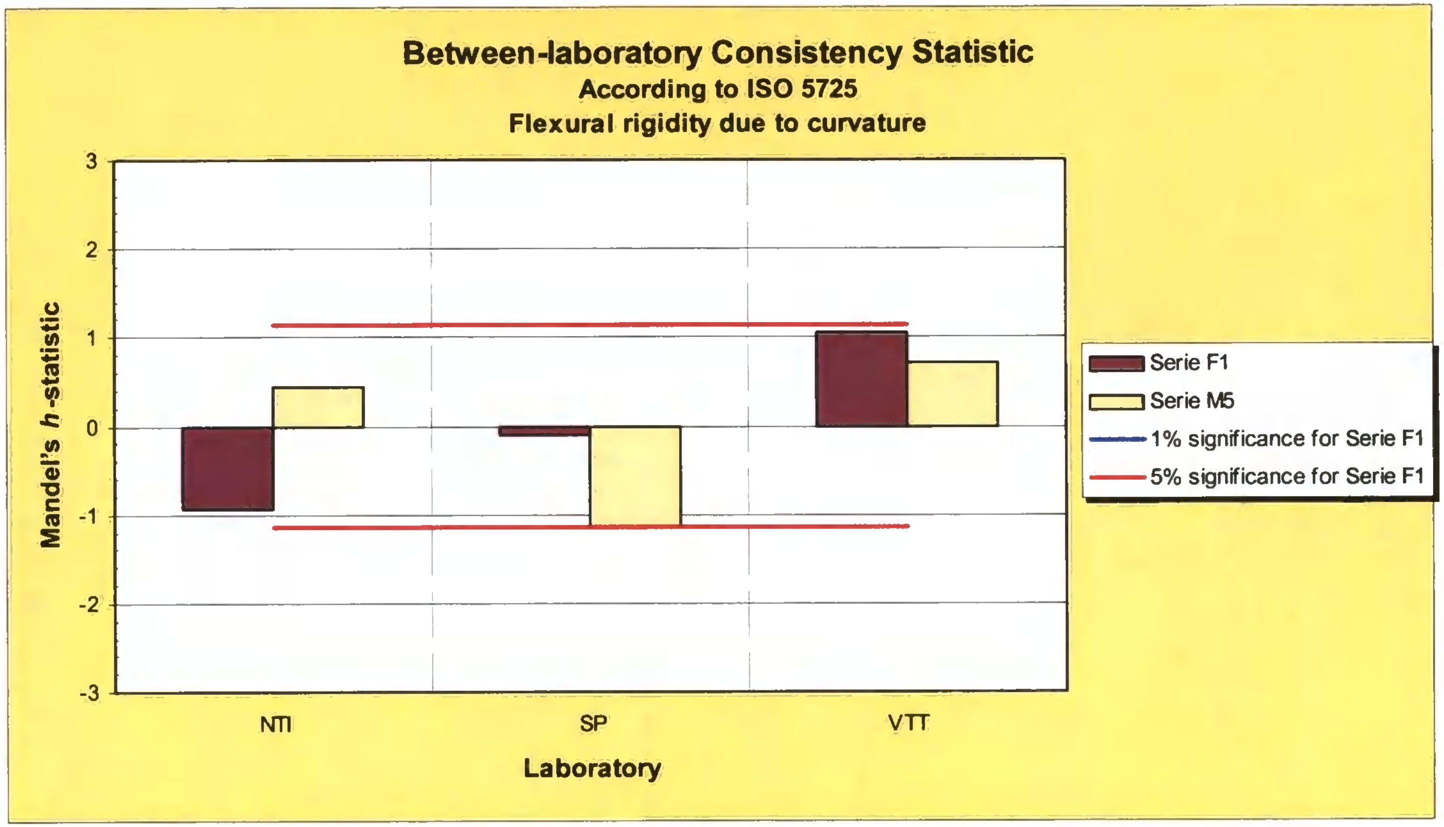



Between-laboratory Consistency Statistic
According to ISO 5725
Mandel's h -statistic
3
2
1
0
-1
-2
-3
NTI
SP
VTT
Laboratory
Serie F1
Serie M5
1% significance for Level 1
5% significance for Level 1

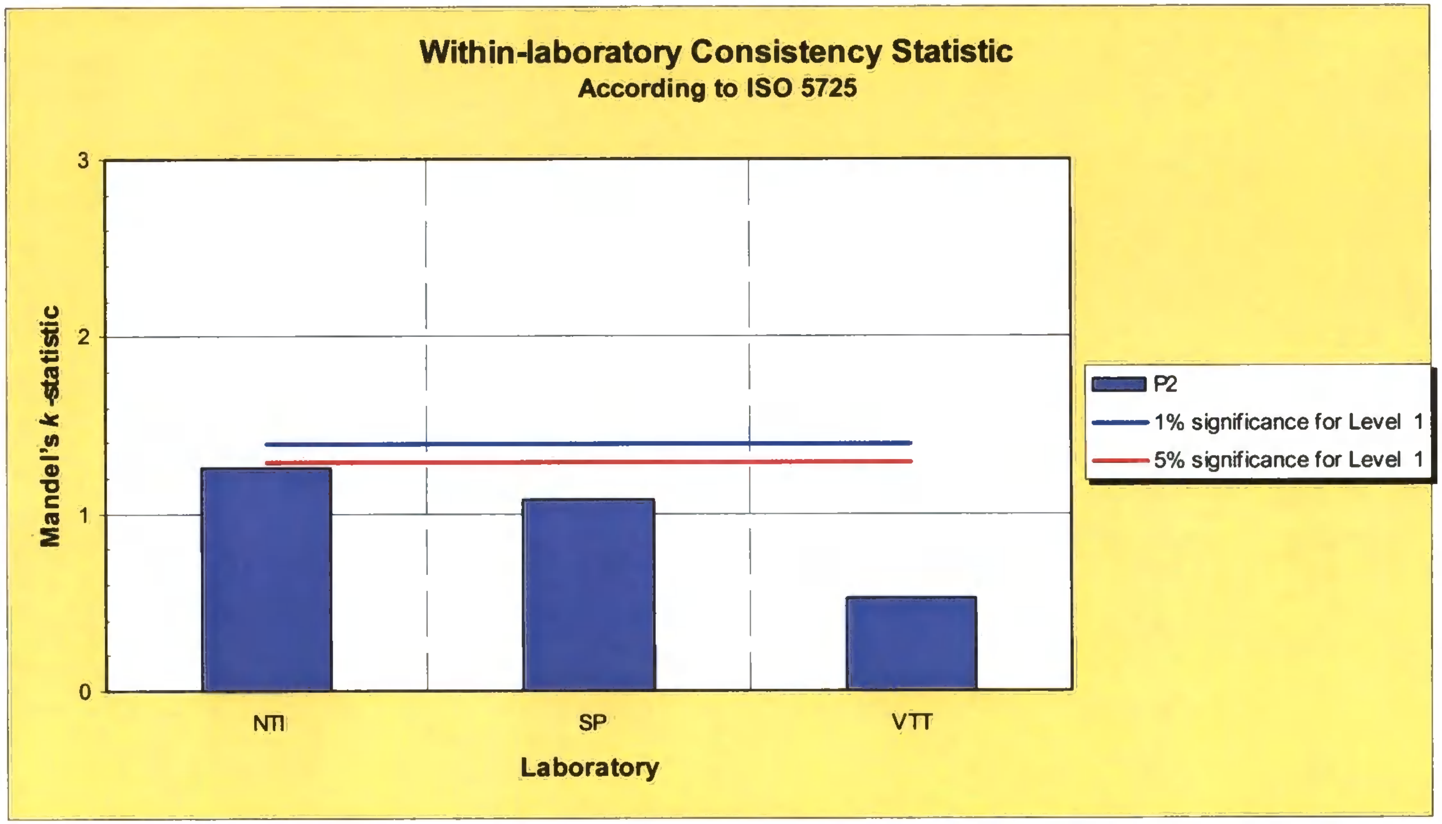
Appendix 1.1.2.2
Mandel´s k-statistic according to ISO 5725, M5, F1 flexural rigidity



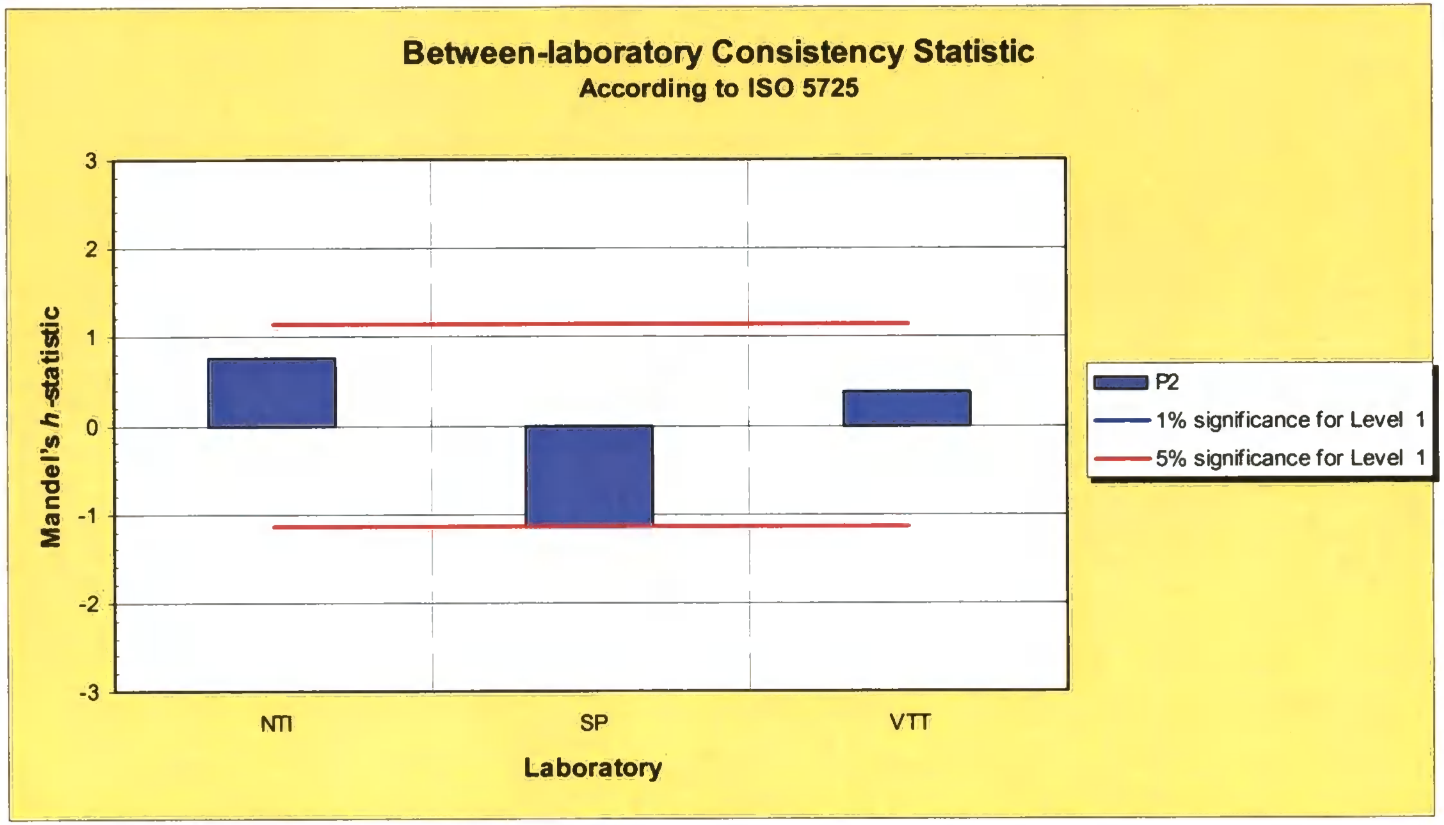
Appendix 1.1.2.2
Mandel´s h-statistic according to ISO 5725, M5, F1 flexural rigidity



Appendix 1.1.2.3
Mandel´s k-statistic according to ISO 5725, P2 total load



Appendix 1.1.2.3
Mandel´s h-statistic according to ISO 5725, P2 total load



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