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Characteristic Perpendicular to Grain Bearing Test on Common Australian and Imported Timber Species

Project number: PNA462-1718 December 2019

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Forest & Wood Products Australia

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Prepared for

Forest & Wood Products Australia

By

Timber Development Association

Publication: Characteristic Perpendicular to Grain Bearing Test on Common Australian and Imported Timber Species

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IMPORTANT NOTICE

This work is supported by funding provided to FWPA by the Department of Agriculture.

ISBN: 978-1-920883-57-7

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Final report received by FWPA in December, 2019

Executive Summary

The research aimed to re-establish the characteristic perpendicular to grain values for common timber species used in construction from Australia and overseas and to develop a method to calculate deformation due to perpendicular to the grain compression. This work's purpose was to inform the design methodology used in the WoodSolutions Mid-rise Timber Building Structure Engineering guide, in calculating the axial shortening of lightweight mid-rise timber-framed buildings.

The research was successful in determining the characteristic perpendicular to grain bearing values for 15 separate timber species used in construction, including an investigation into different stress grades and locations of supply. When comparing the results against the characteristic design values contained in AS 1720.1, it found for Radiata pine that the values for stress graded timber were significantly lower for MGP10 but reasonable for MGP12. Only one sample was tested for MGP15 stress grade, and this result was significantly lower than the AS 1720.1 value. One hybrid species Caribbea was tested, and the result for this species was in line with Radiata pine. Cypress was also tested and was found to have properties twice that of the AS 1720.1 design value.

Imported softwood species European/Norway spruce and Scot pine were found to be considerably lower than the AS 1720.1 design values. For hardwood species, the results were closer to the AS 1720.1 design values, but for Alpine Ash, Karri, Blackbutt and Southern Mahogany the results were lower. For Spotted gum, Grey Ironbark and Jarrah the values were higher to significantly higher, than the AS 1720.1 design values.

The research found that AS 1720.1 method of assigning characteristic design values for bearing perpendicular to grain by the strength group or by assigning a value for MGP stress graded timber did not match the values found from testing. The characteristic perpendicular to grain bearing values showed a closer relationship to the timber species' density. Some of this variation could be assigned to the absence of direction within AS/NZS 4063.1 in calculating the characteristic values. The main issue being the lack of guidance on using the appropriate off-set method for determining the Fc,90 value.

The AS 1720.1 K_7 factor is a modification factor for length and position of the bearing and was found from the limited work conducted to be valid for small bearing areas, but was not conservative for larger bearing areas. The research found an inconsistency between AS/NZS 4063.1 and AS 1720.1 in that the test method detailed in AS/NZS 4063.1 was conducted on 50 mm along the grain bearing but the AS 1720.1 K_7 factor, allowed this value for 50 mm to be increased by 20%.

For the characteristic value determined by AS/NZS 4063.1 to align better with the AS 1720.1 K_7 factor, the value should be reduced by 1.2 factor, bring the value in line with the K_7 factor for 150 mm bearing length.

The Modulus of Elasticity Perpendicular to Grain was also determined from the test but the method used was not in direct accordance with AS/NZS 4063.1. However, during the process

of testing perpendicular to grain bearing, an elastic load/deformation relationship was observed, and excellent indicative values of MoE perpendicular to grain could be found.

The new WoodSolutions guide on Mid-rise timber building structural design currently suggests that the MOE perpendicular to the grain is 1:25 relationship between MoE Parallel to the Grain and MoE Perpendicular to the Grain. The results from this research could not confirm this relationship, as the ratio was found to be highly variable from the limited testing program undertaken. Pending further research being carried out, this research suggests a relationship between the Joint Group and average MoE Perpendicular to the Grain, giving greater accuracy than the method currently proposed within the WoodSolutions guide. Suggested amendments to the WoodSolutions guide were made to make better use of a more accurate average MoE Perpendicular to Grain values.

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Introduction

Research recently completed into a method to reduce the crushing of wall plates in timber-framed mid-rise buildings found that the current process within the Australian Standard AS1720.1 Timber Design for assigning perpendicular to grain properties of various timber species either over predicted the capacity of low to medium density timber species or grossly under-predicted high-density timber's capacity. The research further found that perpendicular to grain bearing capacity was better aligned to the density of the timber species and not to its strength group or stress grade, which is how the properties are currently assigned.

For traditional house timber frame construction, perpendicular to grain bearing is rarely an issue, and therefore the inconsistencies within AS1720.1 have never troubled designers. With timber buildings now getting taller and heavier, bearing capacities of studs onto wall plates are now determining the size of studs and subsequently the building's economies. In most cases, studs will be required to be a size or two greater than the size determined from axial compression alone for the first two storeys of a six-storey mid-rise timber-framed building.

Furthermore, the current method in AS1720.1 for checking bearing perpendicular to the grain is a strength calculation. Bearing failure in timber design is not catastrophic, as illustrated in Figure 1 of a stud crushing into a timber wall plate after the stud has buckled. Consequently, the engineering design method, being a pass/fail strength criteria, is missing the objective that crushing is an actual serviceability (displacement) issue. Bearing failure is not the element breaking, but the amount of displacement or crushing occurring on a wall plate or beam. Designers checking the bearing capacity are presently unaware of the limits used and are not able to make subjective decisions regarding the adequacy of the bearing capacity.

Figure 1: Crushing of wall plate after buckling of the wall stud has occurred

Research Objectives

The primary objective of this research is to re-establish the characteristic perpendicular to grain values for common timber species used in construction from Australia and overseas and also to establish load-deformation relationships and bearing area effects. From this information, a method to calculate deformation due to perpendicular to the grain will be developed. This work intends to inform the design methodology used in the Mid-rise Timber Engineering guide to calculate axial shortening.

To assist in the design consideration, research into the effect of loading in the middle of the sample and on the end will be investigated, as well as varying the width of bearing area, to model, half, one, two, three and four studs bearing onto a wall plate or beam.

Methodology

The testing program was carried out in accordance with AS/NZS 4063.1- Characterization of Structural Timber Test Methods. The analysis of the results was determined in accordance with AS/NZS 4063.2:2010 Characterization of Structural Timber Determination of Characteristic Values. The test facilities, set-up, procedure, and what was tested is discussed in the following.

Test Facilities

The test facility used was the Institute for Infrastructure Engineering, Western Sydney University, located at their Kingswood campus.

The equipment used was a multi-purpose structural testing facility for testing specimens and assemblies up to 4 m high with a static compressive load maximum capacity of 10,000 kN (1,000 tonnes), refer to Figure 2.

Figure 2: Structural testing lab of Western Sydney University

Test set-up

Every species was tested in accordance with the procedure detailed in AS/NZS 4063.1. This involved a load applied through a metal bearing plate approximately 50 mm in width, placed perpendicular to its length, across the upper surface of the test piece, and in the middle of a 200 mm long specimen, refer to Figures 3 and 4. A slight departure was taken to the code in that the metal plate is 48 mm wide and not 50 mm. This reduced width was accounted for in the determination of the characteristic values. The rate of loading was set to 0.03 mm/s to achieve a

minimum deformation of 2.5 mm typically within 2 to 5 minutes. For each timber species investigated a minimum of 30 samples were tested.

Figure 3: Test set up

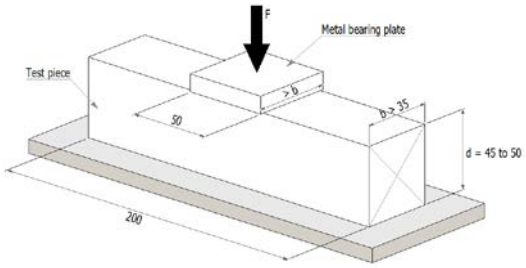

Figure 4: Bearing test configuration

The investigation into the effect of the bearing area using varying widths of metal plates is shown in Table 1. This test method was varied to model a half stud, one stud and then two studs, refer Figure 5, for three and four studs, and refer to Figure 6. To avoid the metal plate bending during the four-stud testing, two plates were used, and refer to Figure 6.

Figure 5: Two studs test set up

Figure 6: Four studs test set up

Table 1: Size of metal plates used to model varying combination of studs

Test area	Length [mm]	Wide [mm]	Thick [mm]	Weight [g]	Density [kg/m^3]
Four studs	199	199	15.8	4,895	7,823
Three studs	199	150	24.6	5,720	7,790
Two studs	176	101	31.8	4,390	7,766
One stud	199	48	24.6	1,845	7,852
Half stud	199	30	19.8	915	7,741

The characteristic values of the timber species were evaluated by AS/NZS 4063.2 Characterization of Structural Timber.

Sampling of Specimens

The aim of the species collected was to represent major timber species used in building construction within Australia. In addition to this, some species were collected to provide a range of density for both hardwoods and softwood; so that there was a spread of low, medium and high-density timbers.

Sampling of the timber species was carried out to be representative of the reference population of that species. The species selected were determined by the project's steering committee. Sample pieces were selected from the reference population using random sampling so that unintentional bias caused by the operator is minimized.

The Australian pine samples were found from various regions across Australia and included a common hybrid species. Samples were procured by contacting the technical staff of major pine producing mills, asking them to send random samples taken from their production line. Samples were provided by the pine producers across Australia, from Queensland, New South Wales, South Australia, Tasmania and Victoria. The pine samples also included varying stress grades, to investigate if stress grade affects the characteristic values of the perpendicular to grain bearing.

For the hardwood samples, Blackbutt was sourced from NSW while the remainder of the samples were drawn from timber merchants in and around Sydney. For European/Norway Spruce and Scot pine, samples were sourced directly from European suppliers. All other imported timber was selected from timber merchants in and around Sydney. The method of selection of sample pieces was recorded.

Some of these species collected such as Meranti and Western Red Cedar are not considered as construction timber but were selected to represent low-density species.

Fifteen different wood species from Australia and overseas were used for testing; Table 2 shows a list of all the different species. The major timber species investigated was Radiata pine as this is the most common timber species used in construction within Australia. For this species 12 configurations of Radiata pine were investigated, these included a variation to stress grade, location and country of growth and density. For every test, there is a minimum sample size of 30, except for the four studs and the half stud geometry testing. The four-stud test was carried out with 15 samples investigated while the half stud test had three samples. These two tests should show the tendency of the compression behaviour to the testing surface area and should not be considered as characteristic values.

Table 2: Timber Species investigated, their location of the source of procurement and identification number

		Trade Name	Species	Location
Softwood				
1	**S1**	Radiata Pine MGP10	Pinus radiata	Australia
2	**S2**	Radiata Pine MGP10	Pinus radiata	Australia
3	**S3**	Radiata Pine MGP10	Pinus radiata	Australia
4	**S4**	Radiata Pine MGP10	Pinus radiata	Australia
5	**S5**	Radiata Pine MGP10	Pinus radiata	Australia
6	**S12**	Radiata Pine MGP10	Pinus radiata	Australia
7	**S6**	Radiata Pine MGP12	Pinus radiata	Australia
8	**S7**	Radiata Pine MGP12	Pinus radiata	Australia
9	**S8**	Radiata Pine MGP12	Pinus radiata	Australia
10	**S11**	Radiata Pine MGP15	Pinus radiata	Australia
11	**S14**	Caribbea and Hybrid	Pinus Caribbea var. hondurensis	Australia
12	**S17**	Cypress	Callitris Columellaris	Australia
Hardwood				
13	**H1**	Alpine Ash	Eucalyptus delegatensis	Australia
14	**H4**	Jarrah	Eucalyptus marginata	Australia
15	**H5**	Karri	Eucalyptus diversicolor	Australia
16	**H6**	Blackbutt	Eucalyptus pilularis	Australia
17	**H9**	Southern Mahogany	Eucalyptus botryoides	Australia
18	**H8**	Spotted gum	Eucalyptus maculata	Australia
19	**H7**	Grey Ironbark	Eucalyptus panicularis	Australia
Imported Timber				
20	**I1**	European/Norway spruce	Picea abies	Europe
21	**I2**	Scots Pine	Pinus sylvestris	Europe
22	**I4**	Douglas fir US (New)	Pseudotsuga menziesii	Nth America
23	**I5**	Douglas fir US (old)	Pseudotsuga menziesii	Nth America
24	**I3**	NZ Radiata	Pinus radiata	New Zealand
25	**H10**	Meranti, light red	Shorea leprosula	Asia
26	**I6**	Western Red cedar	Thuja plicata	Canada
Geometry				
27	**I7**	One 45 wide stud	Pinus sylvestris	Europe
28	**I7**	Two 45 wide studs	Pinus sylvestris	Europe
29	**I7**	Three 45 wide studs	Pinus sylvestris	Europe
30	**I7**	Four 45 wide stud	Pinus sylvestris	Europe
31	**S10**	End of plate	Radiata Pine MGP10	Australia
32	**S10**	Middle of plate	Radiata Pine MGP10	Australia

The dimensions of a typical sample was:

- Length 200 mm
- Width 90 mm
- Thickness 45 mm

Some samples were not exactly this size because they are variations due to reworking the sample's surface, thickness and width tolerances, which is allowed in manufacturing.

Parameters Recorded and the Equipment Used to Measure

The following measurements were taken before the test:

- Moisture content
- Dimension
- Weight
- Temperature
- Size and angle of the tree rings
- Photos of the samples and the test set up

Dimensions

The width and thickness are evaluated by a 150 mm digital calliper manufactured from the company “Craft Right; Engineering Works; Stainless Hardened”, refer to Figure 7. Both values are measured in the middle of the 200 mm wood sample. Because some samples are a few tenths of a millimetre and conical in shape, the mean is taken and rounded to 0.1 mm.

The length is measured by a tape measure from the company “HART”, refer to Figure 8. Before undertaking and measuring, the tape used was compared with other tapes and the calliper described above, to minimise the deviation. It was found that the results were within 0.25 mm.

Because the sample’s length is aimed to be 200 mm, the accuracy is around 0.25 mm for the tape measure system used. This accuracy was considered adequate as each sample was measured and evaluated using the sample measuring tape.

Figure 7: Calliper

Figure 8: Measuring Tape

Moisture Content

The moisture content is evaluated by the “Professional PTM 2.0” from the company “TRAMEX”, Figure 9. The wood samples I1, I2, S1, S3, S5, S6, S8 and S11 are measured by pressing the “Professional PTM 2.0” into the wood. For timber samples that were high in density and to avoid damaging the “Professional PTM 2.0” pins, two small holes were first drilled in the middle of the

sample and afterwards with less pressure the moisture content was evaluated. Multiple samples were done with both systems to discover if there were any differences within the methods, refer to Figure 10. No differences were observed.

Figure 9: Moisture meter

Figure 10: Sample with both measuring systems employed

Weight

The weight is measured with the scale “BSK200R” from the company “Breville”, refer to Figure 11. The accuracy obtained was ± 1 gram.

Figure 11: Weight Scale

Reworking the Sample's Surface

The samples collected had a variety of surface finishes from sawn, rougher headed to smooth milled surfaces. It was found during the preliminary work undertaken by TDA[1], that the surface finish affected the results. To alleviate this, all samples were tested with a smooth surface. For timber species Cypress, Karri and Douglas fir" and for the rougher headed Radiata Pine from Hyne Timber, the samples were sanded with a machine "HAFCO WOODMASTER".

Figure 12 shows the sanding machine, which is used for all the rough sawn species. Since the pressure on the sample during the sanding process is not controlled, the surface level was not always 100% flat.

Figure 12: Sander with sample

The angle of the Tree's Growth Rings to the Wide Face

This value is an assessment made by the researcher. A gradation of 0°, 22.5°, 45°, 67.5° and 90° were made by observing the angle of the tree's growth ring to the wide face of the sample being tested.

In some samples, the tree's growth ring angle changed within the length, so in these cases, a "mean" angle was recorded.

Size of the Tree's Growth rings

The size of the tree rings is measured with the calliper, refer to Figure 7 above. It was observed that some species had a variation to the size of the tree's growth rings, so in these cases, the average value was taken.

Temperature

The temperature is measured with the thermometer "FLUKE 62 MAX", refer to Figure 13. The temperature is required for the calibration of wood species for moisture content.

[1] Study the influence of perpendicular to grain compression and creep in 4 to 8 Storey Lightweight Timber Framed Buildings, TDA 2018

Figure 13: Thermometer

Testing Apparatus

The Testing was carried out at the Centre for Infrastructure Engineering at the Western Sydney University in Penrith. The hydraulic actuator brand name is MTS with a load capacity of 250 kN, refer to Figures 14 and 15. The sensors used to measure the deformation of the sample are LP 1449 and LP 1524. The loading rate for the tests is 0.03 mm/s.

Figure 14: Test Setup

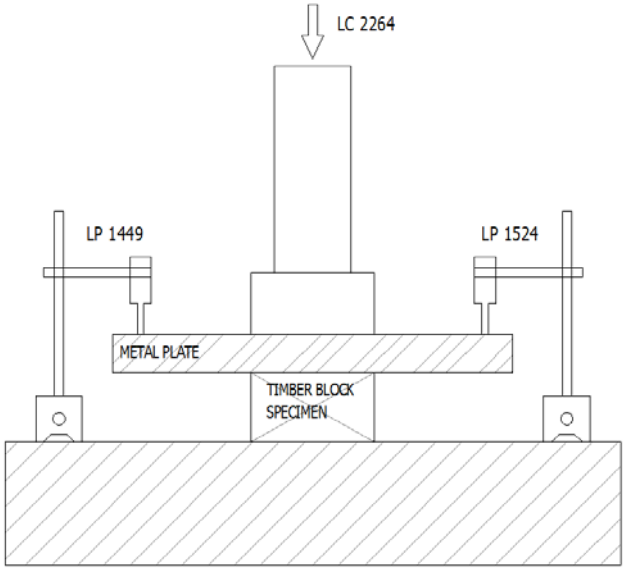

Figure 15: Test set up illustration

Statistical Evaluation Procedure and Analysis

AS/NSZ 4063.2 outlines the statistical method for evaluating values of structural properties from sample test data obtained using AS/NZS 4063. The Standard gives four statistical evaluation methods to assess the characteristic values of strength properties. These methods are based on data distribution:

Method 1: Lognormal
Method 2: Weibull distribution
Method 3: Non-parametric empirical cumulative frequency distribution
Method 4: Non-parametric estimate of the 5th percentile value

Method 1 was used within the research.

Density

The density is calculated using the formula within AS/NSZ 4063.1:

$$\rho_{test} = \frac{m * 10^9}{L * b * d} \tag{3}$$

m	=	mass [kg]
L	=	length [mm]
b	=	breath [mm]
d	=	depth [mm]
ρ_{test}	=	effective density [kg/m^3]

The results had to be converted as the measurement of density was not done at 12% moisture content. The formula to calculate the moisture content is given as:

$$u = \frac{\rho_u - \rho_o}{\rho_o} * 100\% \tag{4}$$

u	=	moisture content [%]
ρ_u	=	density [kg/m^3]
ρ_o	=	density by 0% moisture content [kg/m^3]

By transforming the following formula:

$$\rho_o = \frac{\rho_u * 100\%}{u + 100\%} \tag{5}$$

u	=	moisture content [%]
ρ_u	=	density [kg/m^3]
ρ_o	=	density by 0% moisture content [kg/m^3]

From ρ_o we can calculate back to ρ_{12}:

$$\rho_{12} = \frac{u + 100\% * \rho_o}{100\%} \tag{6}$$

u	=	moisture content [%]
ρ_{12}	=	density by 12% moisture content [kg/m^3]
ρ_o	=	density by 0% moisture content [kg/m^3]

The **characteristic value** is calculated in accordance with AS/NSZ 4063.2:

$$f_{k,mean} = k_s * \bar{\rho} \tag{7}$$

k_s	=	sampling factor
$\bar{\rho}$	=	mean density of test data, in kilograms per cubic meters:

The values k_s and $\bar{\rho}$ are calculated after:

$$k_s = 1 - \frac{0.7V_p}{\sqrt{n}} \tag{8}$$

$$\bar{\rho} = \frac{1}{n}\sum_{i=1}^{n}\rho_i \tag{9}$$

$$V_p = \frac{S}{\bar{\rho}} \tag{10}$$

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\rho_i - \bar{\rho})^2} \tag{11}$$

V_p = coefficient of variation of strength property for the complete test data
n = sample size

Bearing strength perpendicular to the grain

The bearing strength perpendicular to the grain is calculated using the formula within AS/NSZ 4063.1:

$$f_p = \frac{F_p}{b_m * b_w} \tag{12}$$

F_p = Bearing strength perpendicular to grain (MPa)
b_m = breadth of the metal plate (mm)
b_w = breadth of the test piece (mm)
F_p = value of applied load corresponding to a 2.0 mm off set deformation (N)

The **characteristic value** is calculated after the code AS/NSZ 4063.2:

$$f_k = k_s * f_{05} \tag{13}$$

k_s = sampling factor
f_{05} = 5th percentile strength calculated from a log-normal distribution through the test data

The values k_s and f_{05} are calculated with:

$$k_s = 1 - \frac{1.15V_R}{\sqrt{n}} \tag{14}$$

$$f_{05} = \exp(\bar{y} - 1.645 * S_y) \tag{15}$$

$$V_R = \sqrt{\exp(S_y^2) - 1} \tag{16}$$

$$S_y = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\ln(f_i) - \bar{y})^2} \tag{17}$$

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} \ln(f_i) \quad (18)$$

V_R	=	coefficient of the complete test data
n	=	sample size
S_y	=	standard deviation of the natural logarithms of the complete test data
f_i	=	i-th ranked strength value in the test data, in megapascals
$\exp$	=	exponential
ln	=	natural logarithm
$\bar{y}$	=	mean of the natural logarithms of the sample test values

Determining the Maximum Compression Force at 2.0 mm Deformation

Prior to determining the characteristic value, the maximum compressive force at 2.0 mm deformation has to be determined from the 30 samples tested for each species. The compression force perpendicular to grain Fc,90 is estimated from a procedure detailed in EN 408:2010 but modified to express the 2.0 mm deformation sought. This procedure was followed as AS/NSZ 4063.1 does not directly detail the method to be used for determining characteristic perpendicular to grain Fc,90 values. Therefore a combination of AS/NSZ 4063.1 Appendix A3 Compressive strength and Modulus of Elasticity Perpendicular to Grain and EN 408:2010 has been used. In the procedure adopted several steps are required and they are:

Step 1: The load-deformation curve is plotted, refer to Figure 15. From this curve an estimated value for the Fc,90,max,est is made.

Step 2: From the estimated value for the Fc,90,max,est, two values are determined, the 10% (0.1Fc,90,max,est) and 40% (0.4Fc,90,max,est) value of Fc,90,max,est.

Step 3: Plot 0.1Fc,90,max,est and 0.4Fc,90,max,est onto the load-deformation curve. Then a straight line is drawn through these two points as shown in Figure 15, called Line 1.

Step 4: Another line is then drawn parallel to line 1, with the deformation at the origin load F=0 equal to 2.00 mm as shown in Figure 15, called Line 2.

The value of the compressive strength Fc,90, max then corresponds to the load value that corresponds to the intersection of Line 2 and the load-deformation curve of test results. If the value of Fc,90, max is found to be within 5% of the estimated Fc,90,max,est, originally made, then that value may be used to determine the bearing strength. Otherwise, the procedure is repeated until a value within the tolerance is obtained.

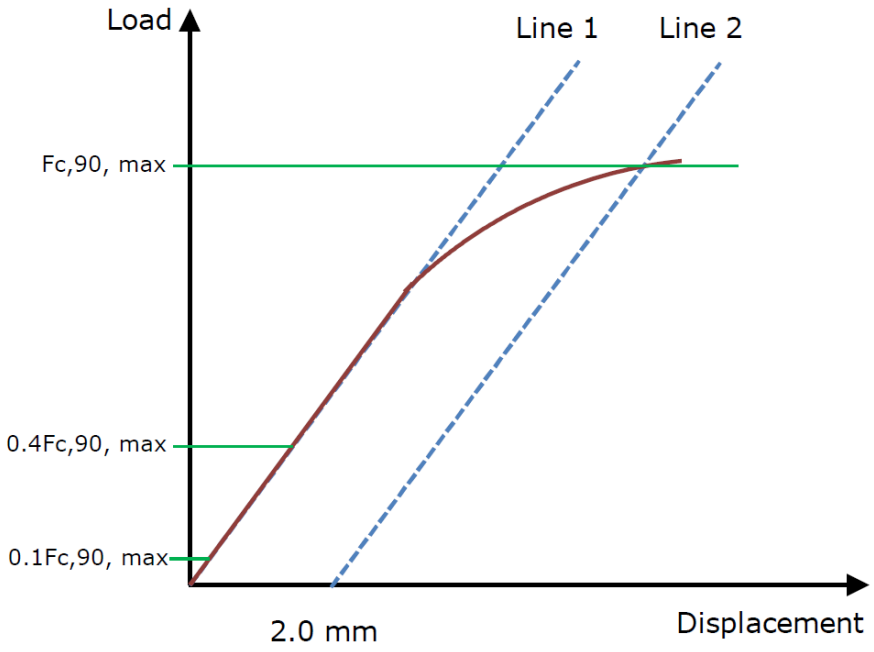

Figure 16: Load-deformation curve for compression perpendicular to the grain, definition of compression strength $F_{c,90,max}$ at 2.0 mm off-set

Modulus of Elasticity Perpendicular to Grain

The calculation of the modulus of elasticity (E (k,mean)) the slope of the off-set line in Figure 15, i.e. Line 2, is used.

$$E = \frac{\sigma}{\varepsilon} \tag{19}$$

σ = stress
ε = stain
E = modulus of elasticity

For the calculation the strain value is needed. This is given as:

$$\varepsilon = \frac{\Delta l}{l} \tag{20}$$

Δl = deformation
l = original length of the sample

and the stress is given as:

$$\sigma = \frac{F}{A} \tag{21}$$

F = force
A = stress area

If the formulas are combined:

$$E = \frac{\frac{F}{A}}{\frac{\Delta l}{l}} \tag{22}$$

The **characteristic value** is taken as the lesser of $E_{k,mean,1}$ and $E_{k,mean,2}$ calculated after the code AS/NSZ 4063.2:

$$E_{k,mean,1} = k_s \bar{E} \tag{23}$$

$$E_{k,mean,2} = \frac{k_s E_{05}}{0.7} \tag{24}$$

k_s	=	sampling factor
$\bar{E}$	=	mean modulus of elasticity of the test data, in MPa
E_{05}	=	5th percentage of elasticity of the test data, in MPa

The values of k_s, $\bar{E}$ and E_{05} are calculated with the formulas:

$$k_s = 1 - \frac{0.7 V_E}{\sqrt{n}} \tag{25}$$

$$\bar{E} = \exp(\bar{y} + \frac{S_y^2}{2}) \tag{26}$$

$$E_{05} = \exp(\bar{y} - 1.645 * S_y) \tag{27}$$

$$V_E = \sqrt{\exp(S_y^2) - 1} \tag{28}$$

$$S_y = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (\ln(E_i) - \bar{y})^2} \tag{29}$$

$$\bar{y} = \frac{1}{n} \sum_{i=1}^{n} \ln(E_i) \tag{30}$$

V_E	=	coefficient of variation for modulus of elasticity of the test data
n	=	sample size
$\bar{y}$	=	mean of the natural logarithms of the sample test values
S_y	=	standard deviation of the natural logarithms of the samples test values
E_i	=	test values for sample rank i, in MPa
exp	=	exponential
ln	=	natural logarithm

Results

Timber Species Identification

For the hardwood timber species selected from the market place, the timber species were identified by Know Your Wood identification services, refer to Table 3.

Table 3: Summary of Timber Species Independently Identified

Specimen Number	Scientific Name	Commercial Name
H1	*Eucalyptus delegatensis*	Alpine Ash
H4	*Eucalyptus marginata*	Jarrah
H5	*Eucalyptus diversicolor*	Karri
H6	*Eucalyptus pilularis*	Blackbutt
H7	*Eucalyptus panicularis*	Grey Ironbark
H8	*Eucalyptus maculata*	Spotted gum
H9	*Eucalyptus botryoides*	Southern Mahogany
H10	*Shorea leproosula*	Light Red Meranti

Result of all species

The following contains the results for all tests conducted. The format is, name of species or geometry investigated, average density, characteristic bearing stress perpendicular to the grain, average Modulus of Elasticity perpendicular to grain and ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to the grain. The Coefficient of variations also given for Modulus of Elasticity perpendicular to grain and Modulus of Elasticity perpendicular to the grain.

For each configuration, the average load versus deformation plot is shown as well as the combined load versus deformation plot of all the test conducted for that sample or geometric configuration.

European/ Norwegian Spruce – I1

Scientific name: Picea abies
Identification number: I1
Characteristic Density: 510 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 6.6 MPa, Coefficient of Variation: 12.3
Characteristic perpendicular to grain Modulus of Elasticity: 358 MPa, Average perpendicular to grain Modulus of Elasticity: 367, Coefficient of Variation: 19.8, The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/28.0

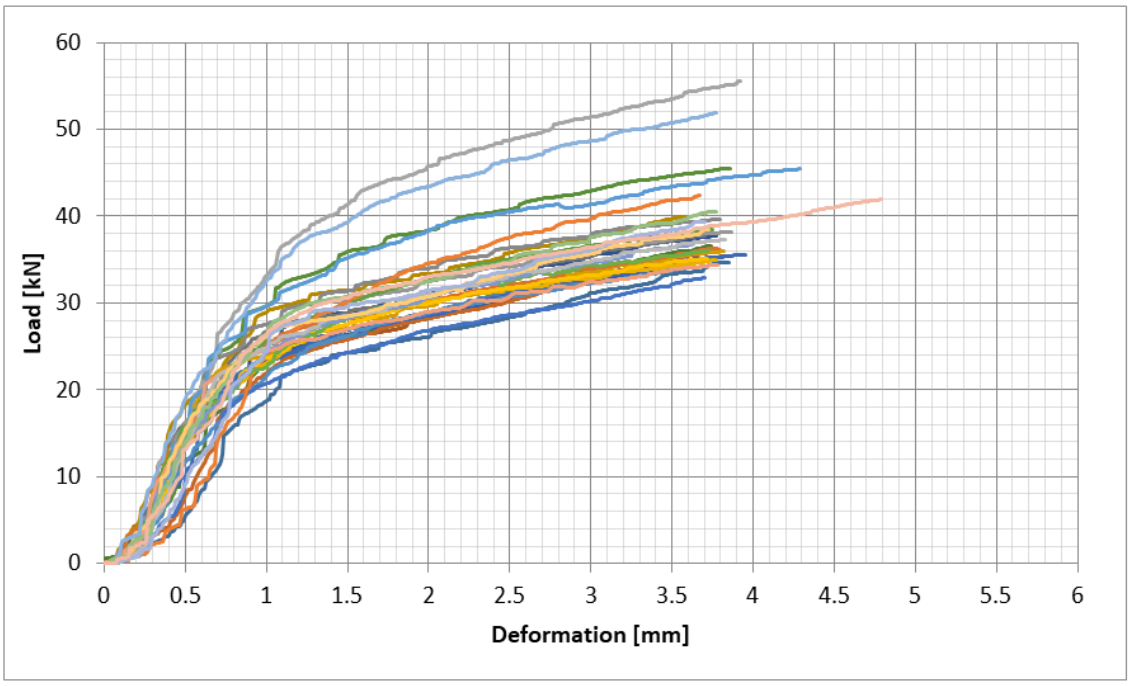

Figure 17: Spruce (I1), All test results – Perpendicular to the grain bearing - Load/Deformation

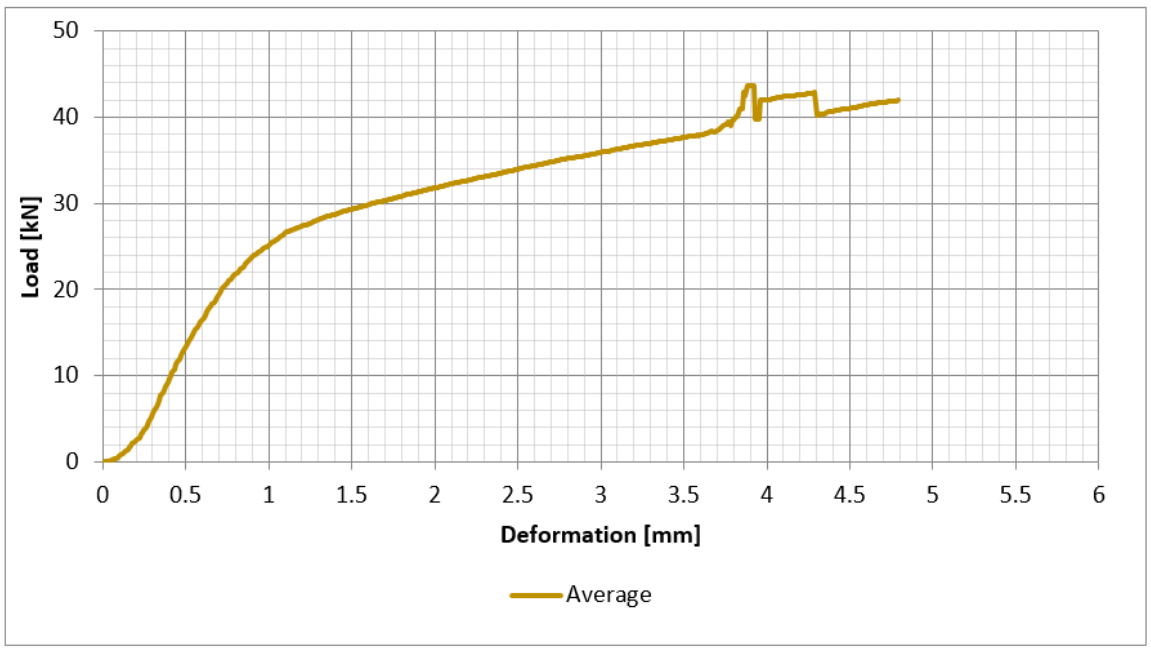

Figure 18: Spruce (I1), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Scots Pine – I2

Scientific name: Pinus sylvestris
Identification number: I2
Characteristic Density: 516 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 6.1 MPa, Coefficient of Variation: 17.7
Characteristic perpendicular to grain Modulus of Elasticity: 291 MPa, Average perpendicular to grain Modulus of Elasticity: 318 MPa, Coefficient of Variation: 23.9
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/34.0

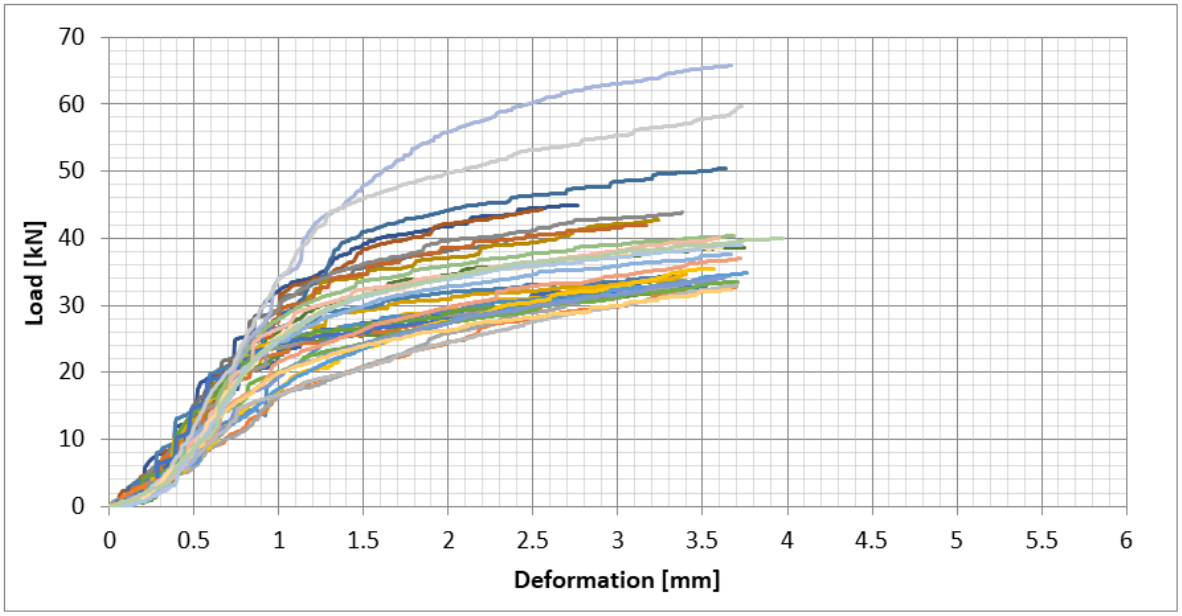

Figure 19: Spruce (I1), All test results – Perpendicular to the grain bearing - Load/Deformation

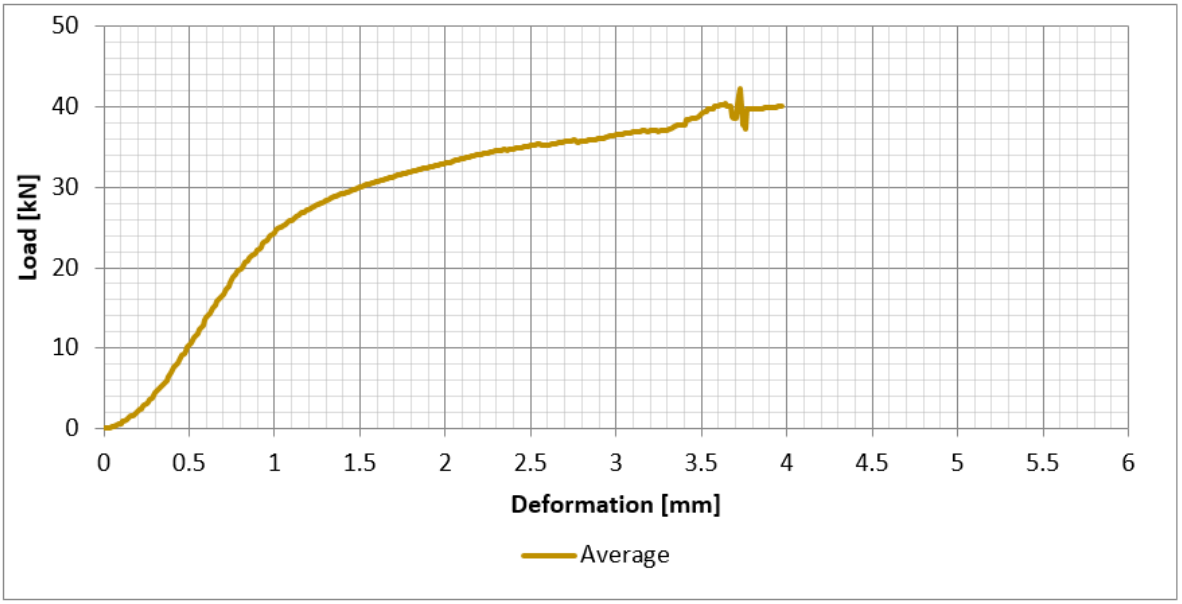

Figure 20: Scots Pine (I2), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – New Zealand – I3

Scientific name: Pinus radiata
Identification number: I3
Characteristic Density: 449 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 6.9 MPa, Coefficient of Variation: 23.4
Characteristic perpendicular to grain Modulus of Elasticity: 554 MPa, Average perpendicular to grain Modulus of Elasticity: 605 MPa, Coefficient of Variation: 23.9
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/18.0

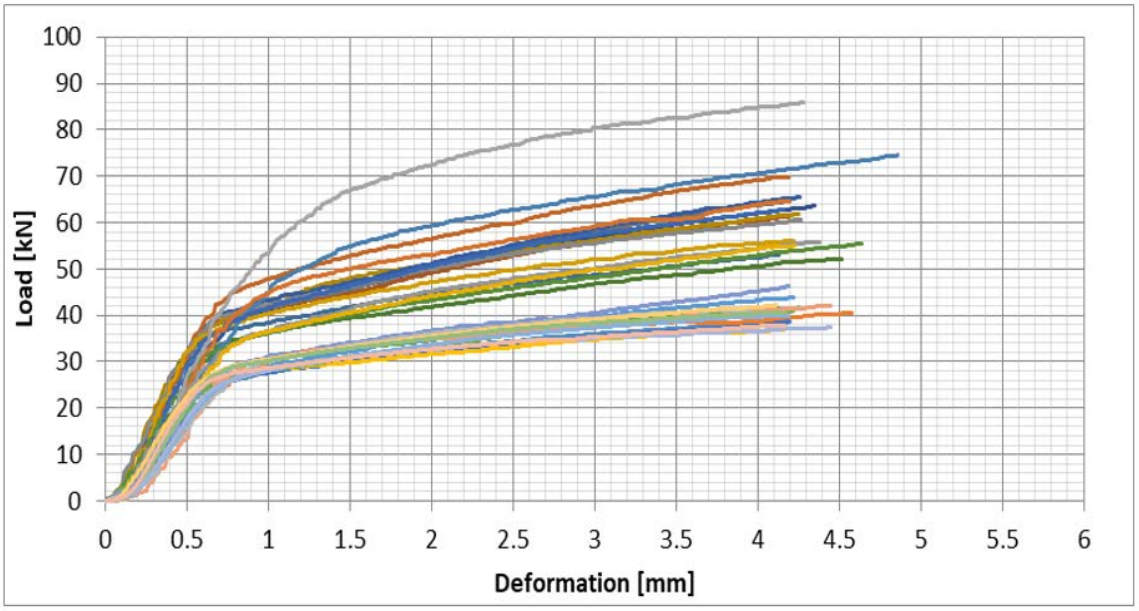

Figure 21: Radiata Pine New Zealand (I3), All test results – Perpendicular to the grain bearing - Load/Deformation

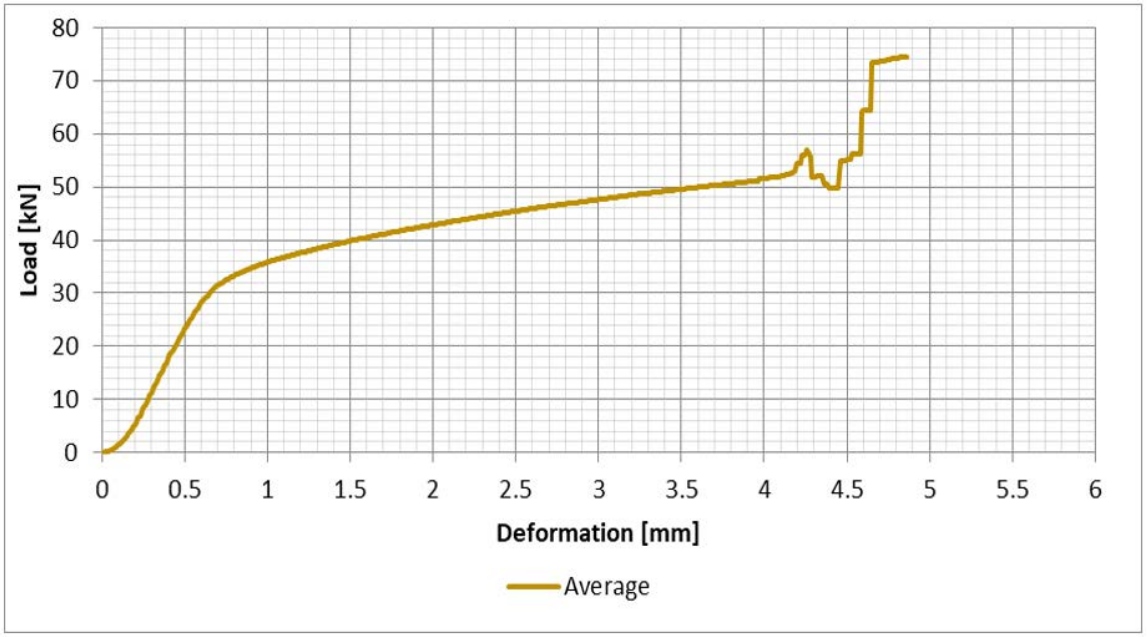

Figure 22: Radiata Pine New Zealand (I3), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Douglas Fir – New – I4

Scientific name: Pseudotsuga menziesii
Identification number: I4
Characteristic Density: 476 kg/m^3
Stress grade: F7
Characteristic perpendicular to grain bearing stress: 5.1 MPa, Coefficient of Variation: 10.1
Characteristic perpendicular to grain Modulus of Elasticity: 291 MPa, Average perpendicular to grain Modulus of Elasticity: 356 MPa, Coefficient of Variation: 26.5 The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/27.0

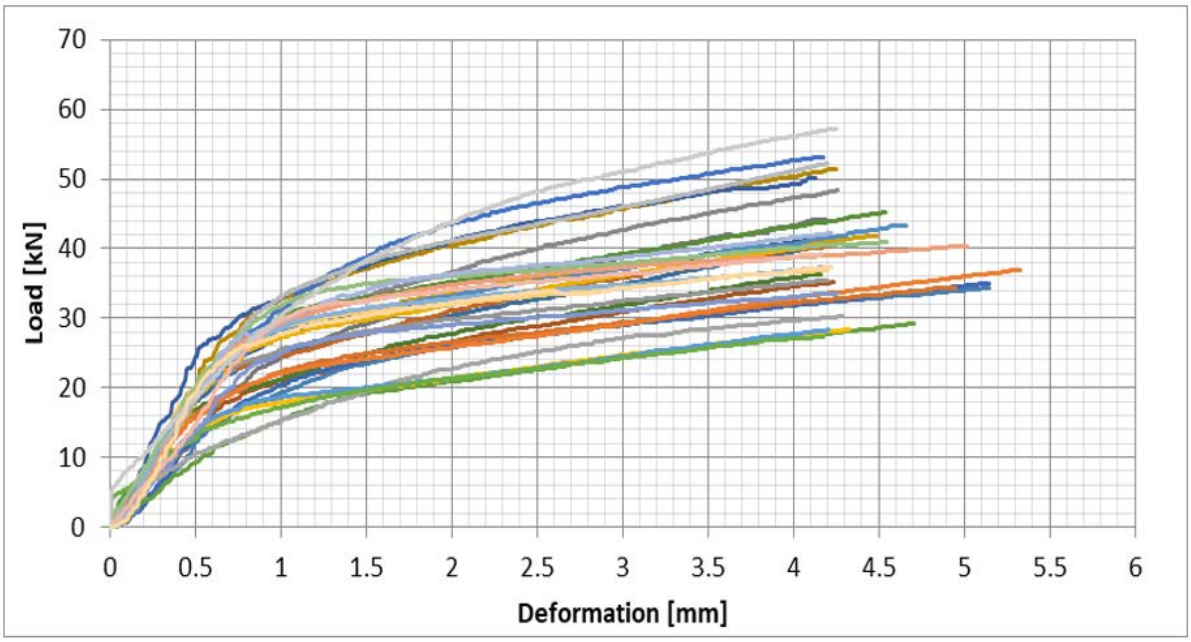

Figure 23: Douglas fir (New) (I4), All test results – Perpendicular to the grain bearing - Load/Deformation

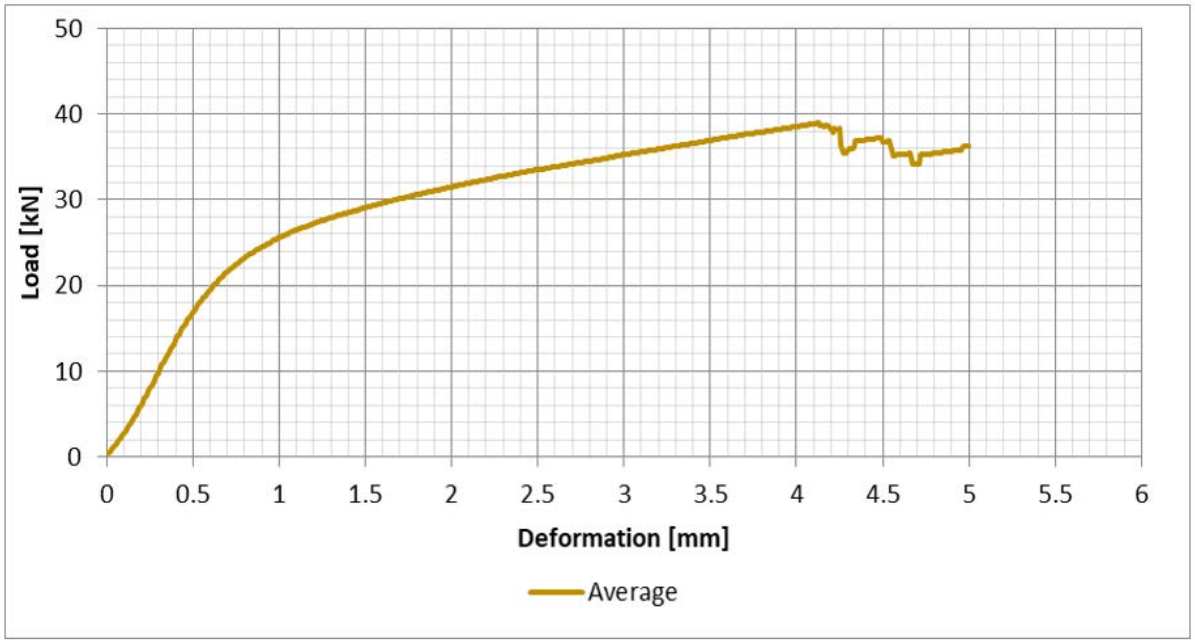

Figure 24: Douglas Fir (new) (I4), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Comments on the Results: The average moisture content was found to be 17.9% which is significantly higher than 12% for the other timber species tested. This moisture content has likely affected the perpendicular to grain bearing capacity.

Douglas Fir – Old – I5

Scientific name: Pseudotsuga menziesii
Identification number: I5
Average Density: 596 kg/m^3
Stress grade: F7
Characteristic perpendicular to grain bearing stress: 8.8 MPa
Characteristic perpendicular to grain Modulus of Elasticity: 447 MPa, Average perpendicular to grain Modulus of Elasticity: 514 MPa,
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/17.7

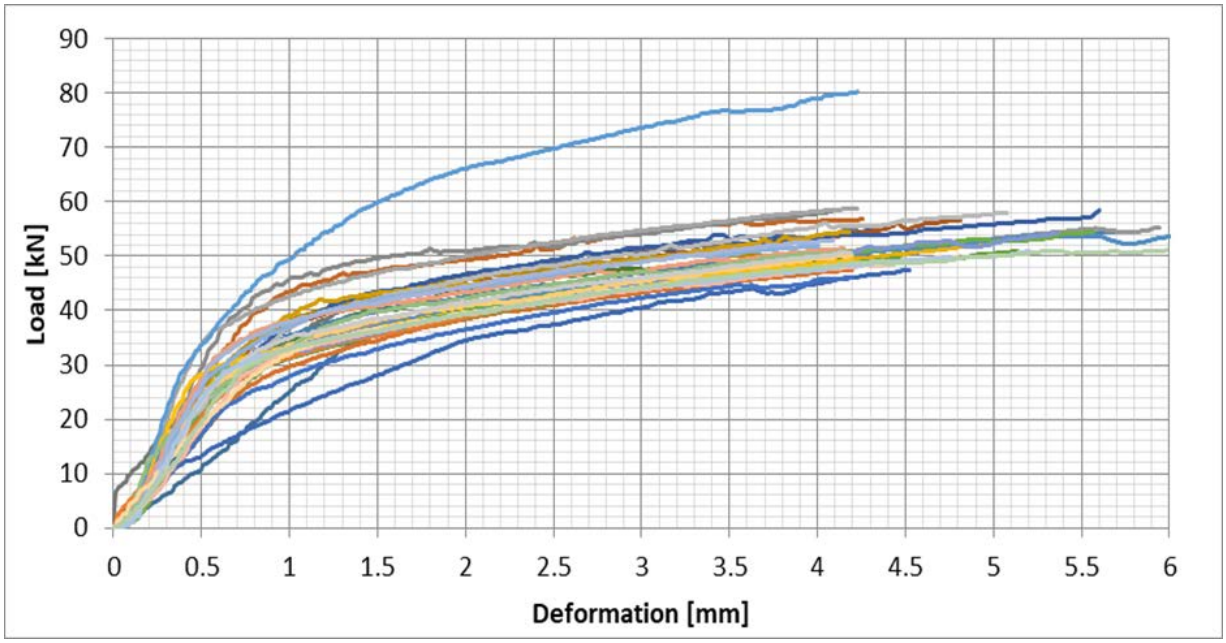

Figure 25: Douglas fir (old) (I5), All test results – Perpendicular to the grain bearing - Load/Deformation

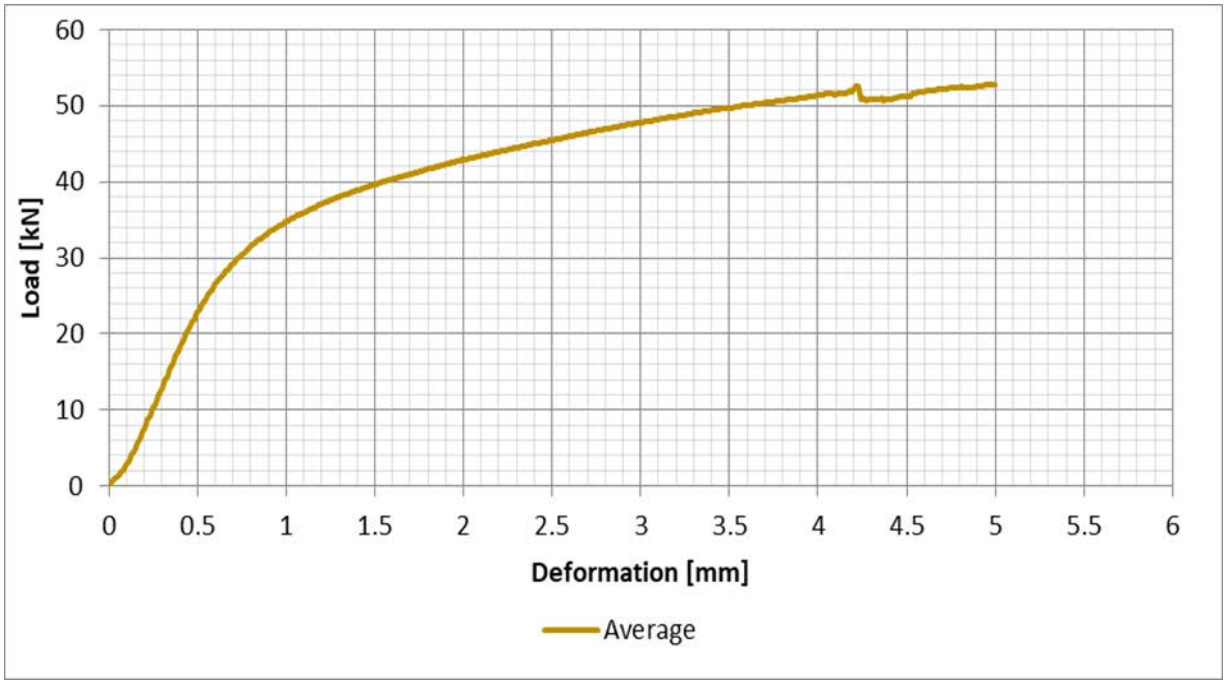

Figure 26: Douglas Fir (old) (I5), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Western Red Cedar – I6

Scientific name: Thuja plicata
Identification number: I6
Characteristic Density: 381 kg/m^3
Stress grade: F4
Characteristic perpendicular to grain bearing stress: 4.9 MPa, Coefficient of Variation: 22.9
Characteristic perpendicular to grain Modulus of Elasticity: 329 MPa, Average perpendicular to grain Modulus of Elasticity: 675 MPa, Coefficient of Variation: 56.3 The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/18.5

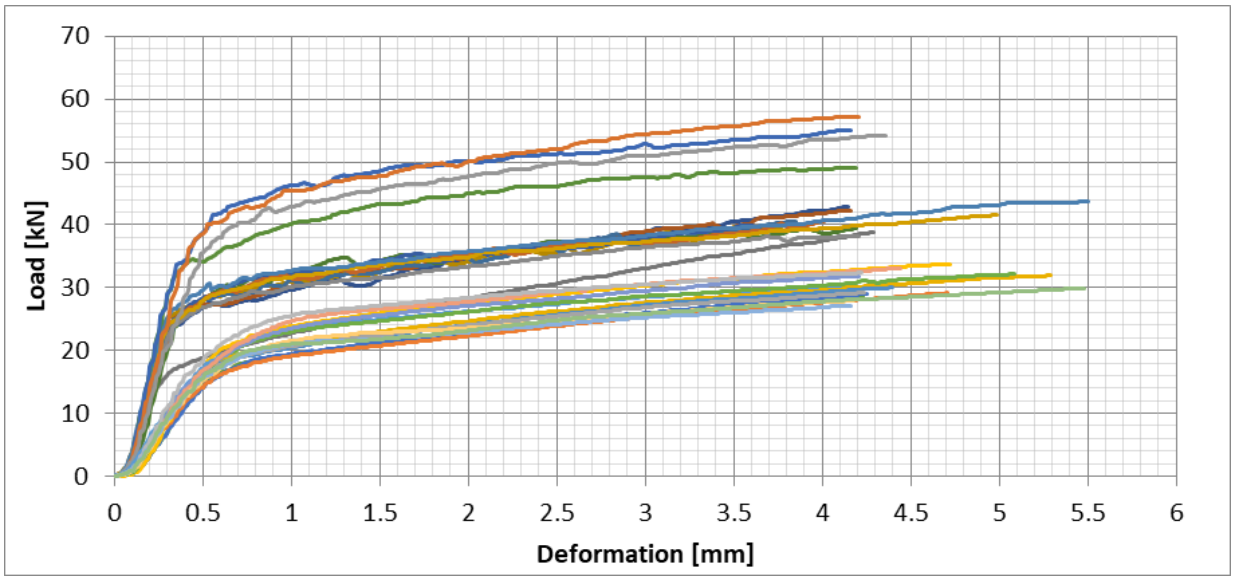

Figure 27: Western Red Cedar (I6), All test results – Perpendicular to the grain bearing - Load/Deformation

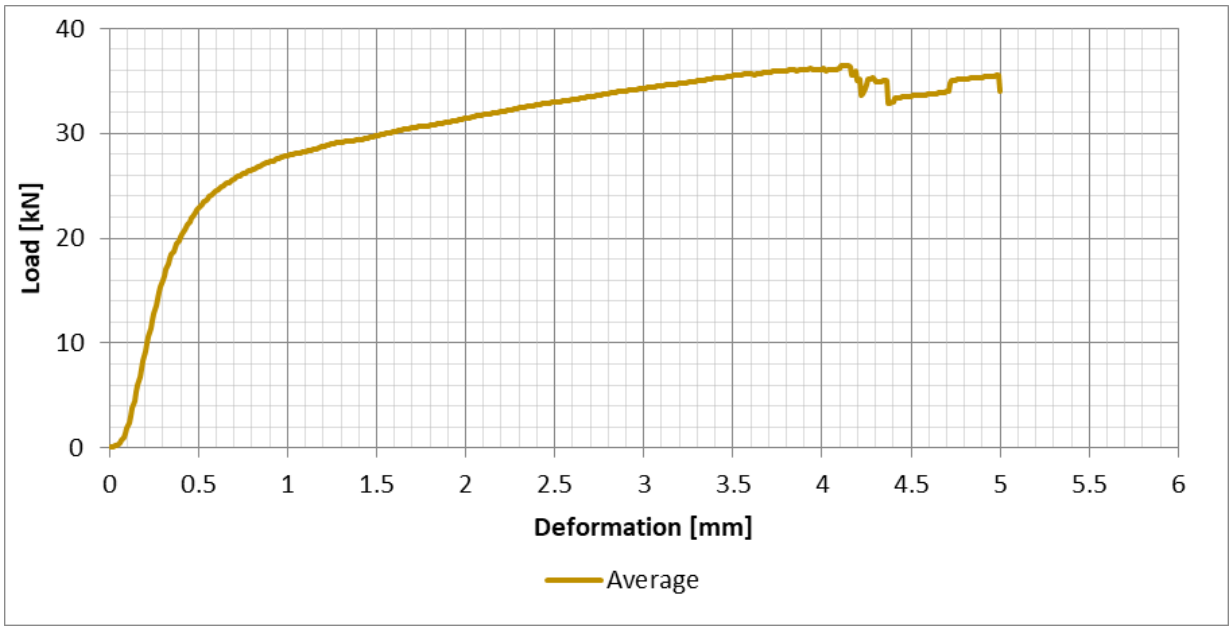

Figure 28: Western Red Cedar (I6), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Comments to Results: Western Red Cedar results had the large coefficient of variation compared to any other timber species tested. This was due to a variation of the density found, ranging between 353 and 415 kg/m^3, impacting on the results. The samples were homogeneously throughout without any knots, gum pockets, etc. but the samples of the lower values were generally quarter sawn in comparison to the higher value material which were back sawn.

Radiata Pine – S1

Scientific name: Pinus radiata
Identification number: S1
Characteristic Density: 480 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 7.4 MPa, Coefficient of Variation: 17.6
Characteristic perpendicular to grain Modulus of Elasticity: 465 MPa, Average perpendicular to grain Modulus of Elasticity: 500 MPa, Coefficient of Variation: 23.1
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/21.5

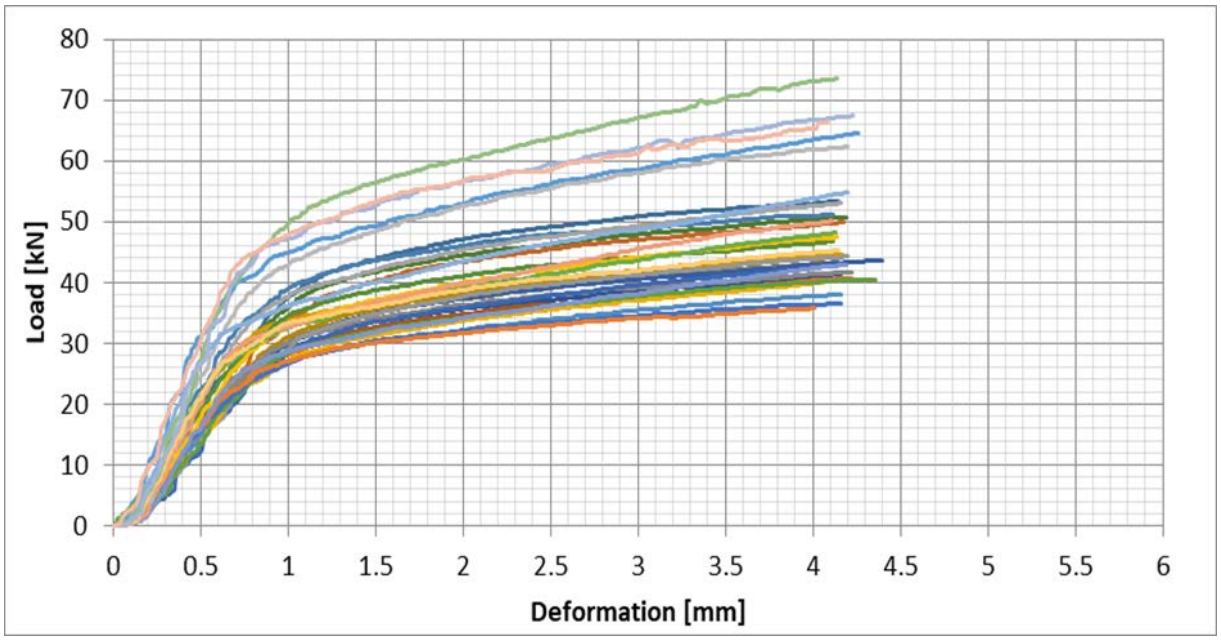

Figure 29: Radiata Pine (S1), All test results – Perpendicular to the grain bearing - Load/Deformation

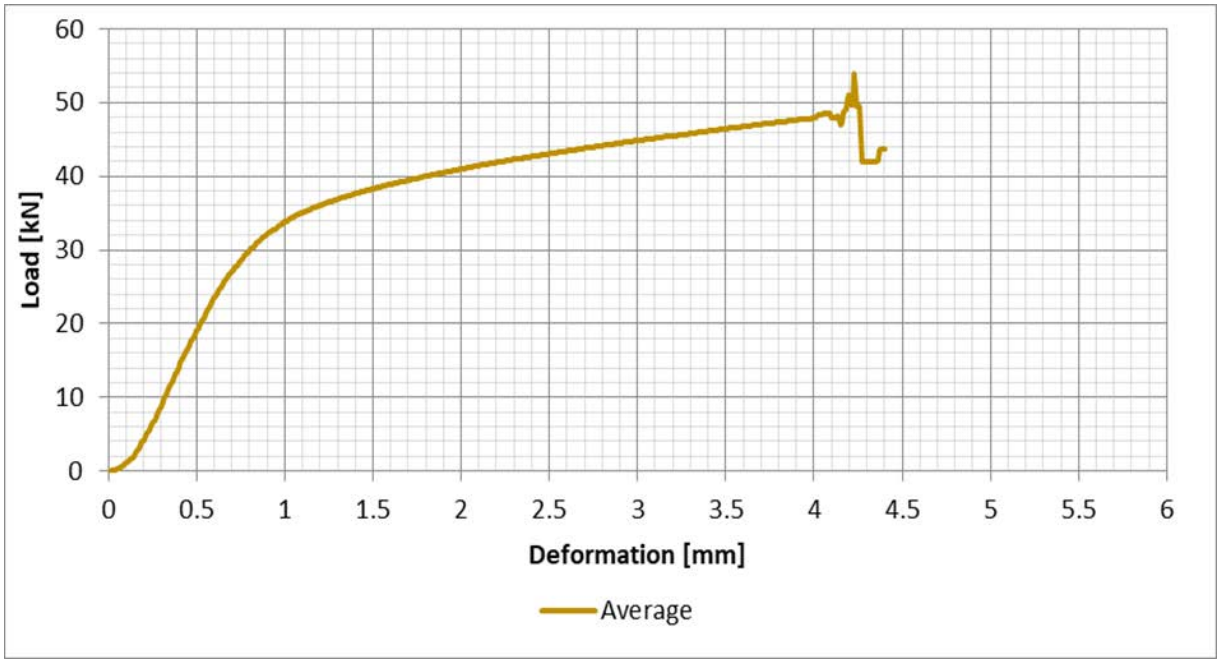

Figure 30: Radiata Pine (S1), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S2

Scientific name: Pinus radiata
Identification number: S2
Characteristic Density: 498 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 7.5 MPa, Coefficient of Variation: 17.6
Characteristic perpendicular to grain Modulus of Elasticity: 556 MPa, Average perpendicular to grain Modulus of Elasticity: 615 MPa, Coefficient of Variation: 23.1
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/18.0

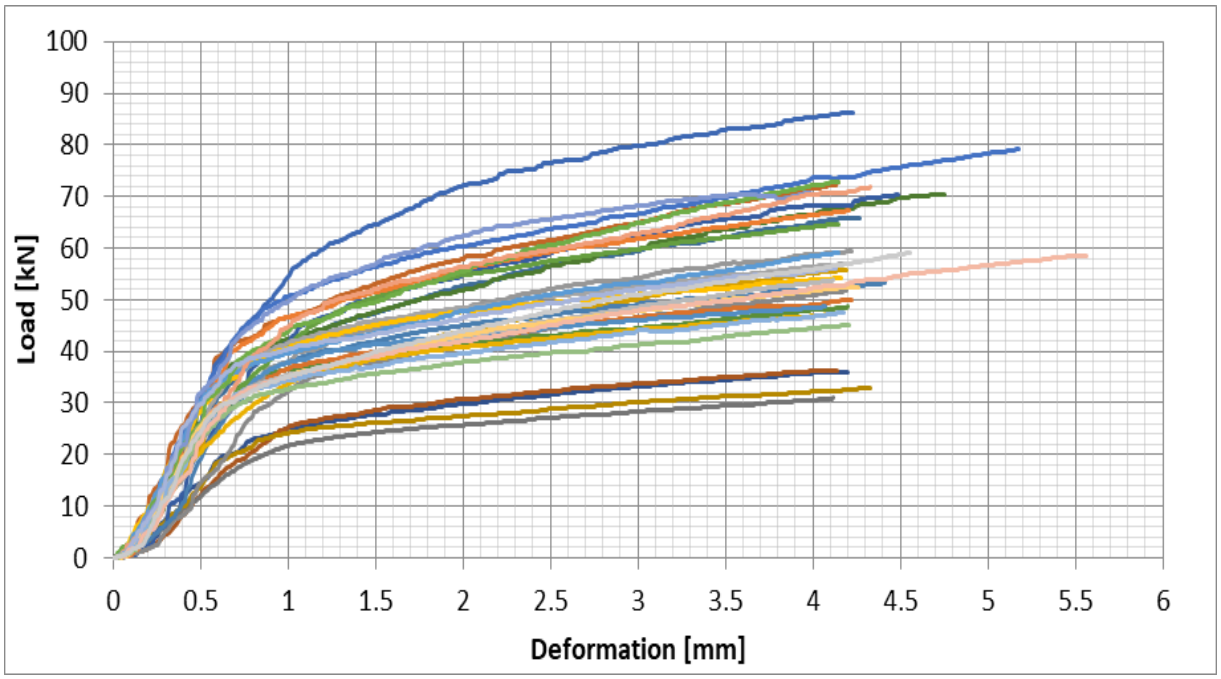

Figure 31: Radiata Pine (S2), All test results – Perpendicular to the grain bearing - Load/Deformation

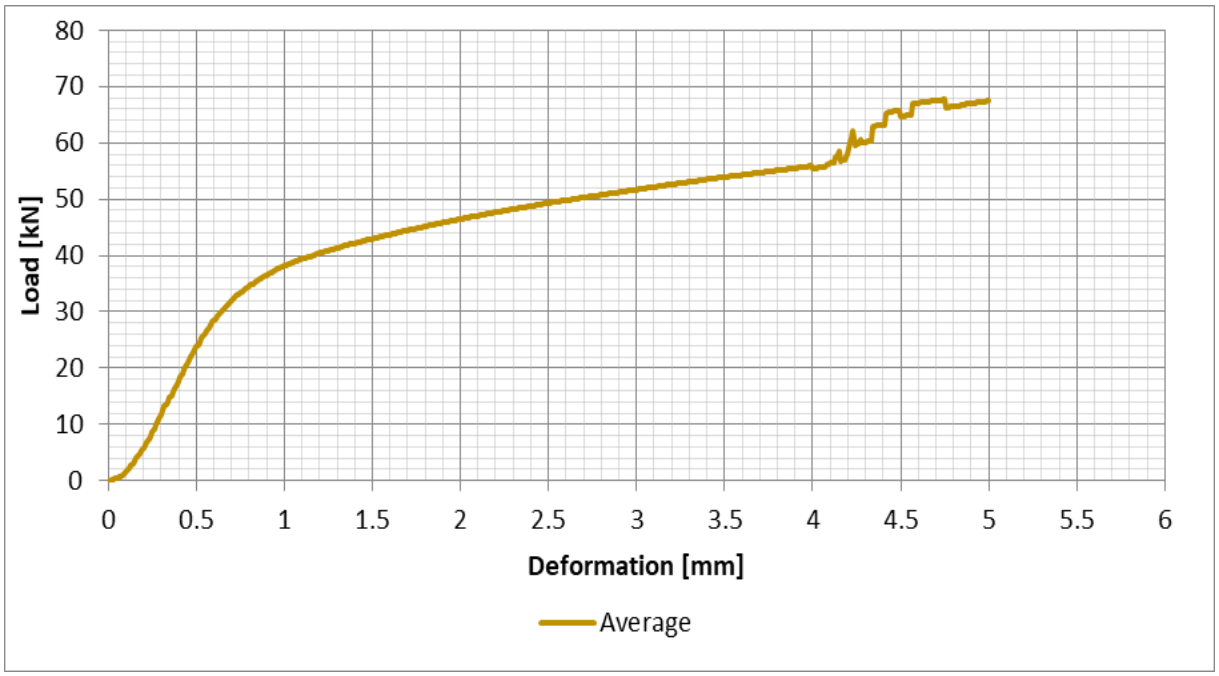

Figure 32: Radiata Pine (S2), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S3

Scientific name: Pinus radiata
Identification number: S3
Characteristic Density: 506 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 7.2 MPa, Coefficient of Variation: 21.0
Characteristic perpendicular to grain Modulus of Elasticity: 396 MPa, Average perpendicular to grain Modulus of Elasticity: 464 MPa, Coefficient of Variation: 27.5
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/25.3

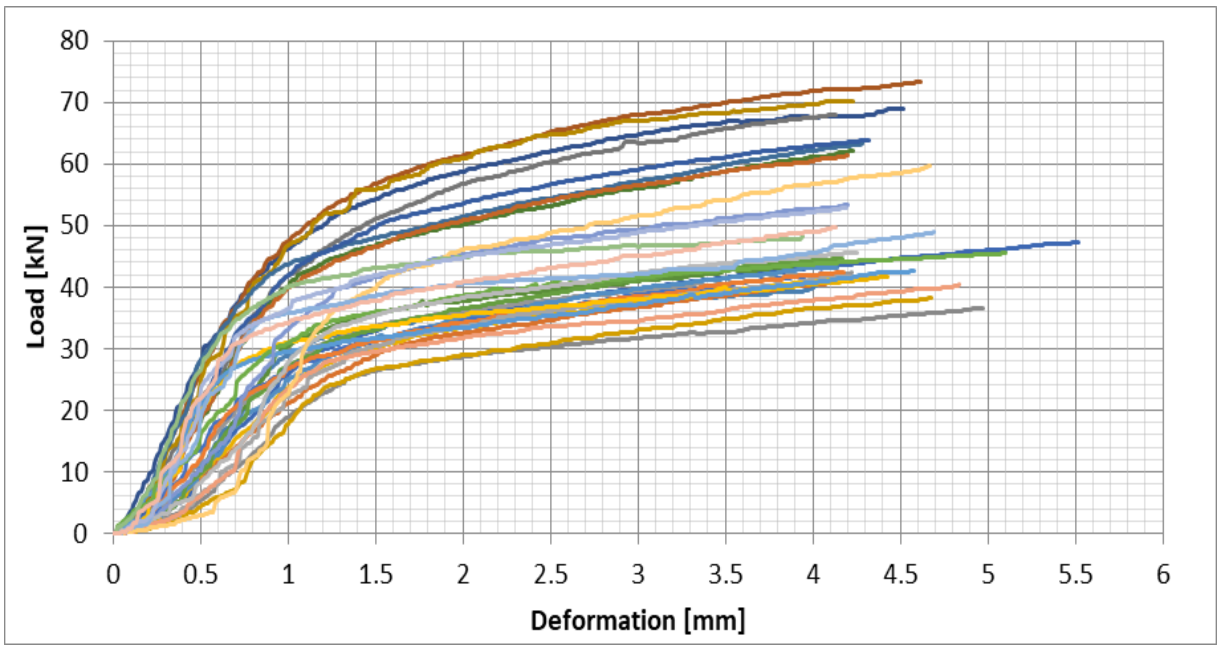

Figure 33: Radiata Pine (S3), All test results – Perpendicular to the grain bearing - Load/Deformation

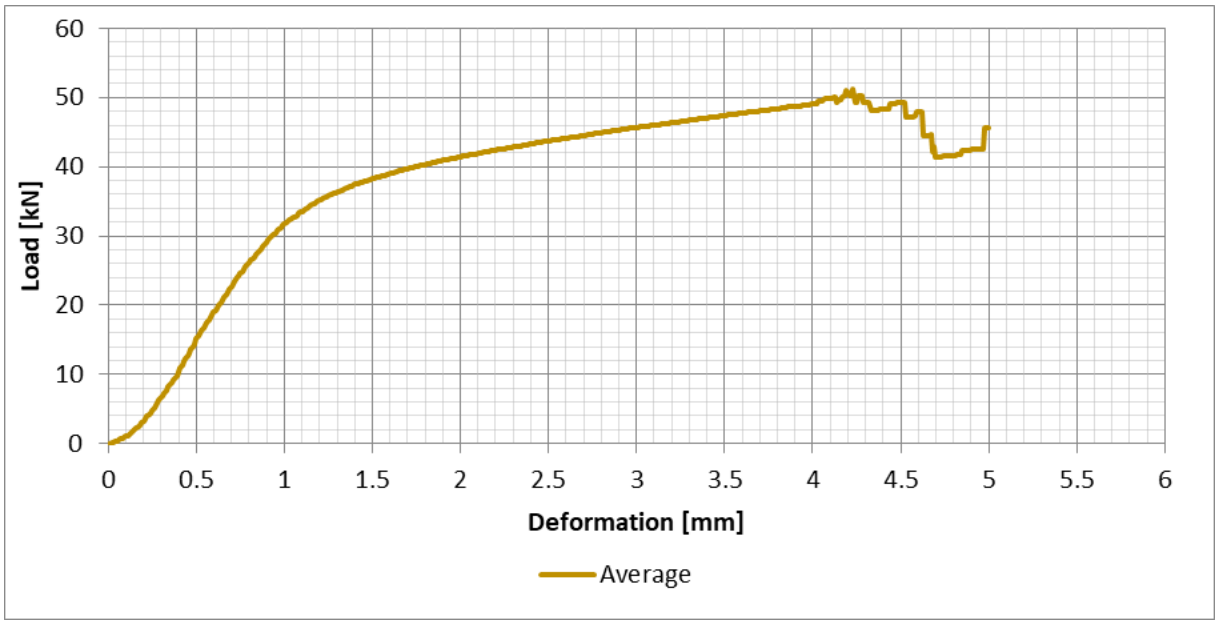

Figure 34: Radiata Pine (S3), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S4

Scientific name: Pinus radiata
Identification number: S4
Characteristic Density: 490 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 8.2 MPa, Coefficient of Variation: 20.
Characteristic perpendicular to grain Modulus of Elasticity: 639 MPa, Average perpendicular to grain Modulus of Elasticity: 652 MPa, Coefficient of Variation: 15.9
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/15.6

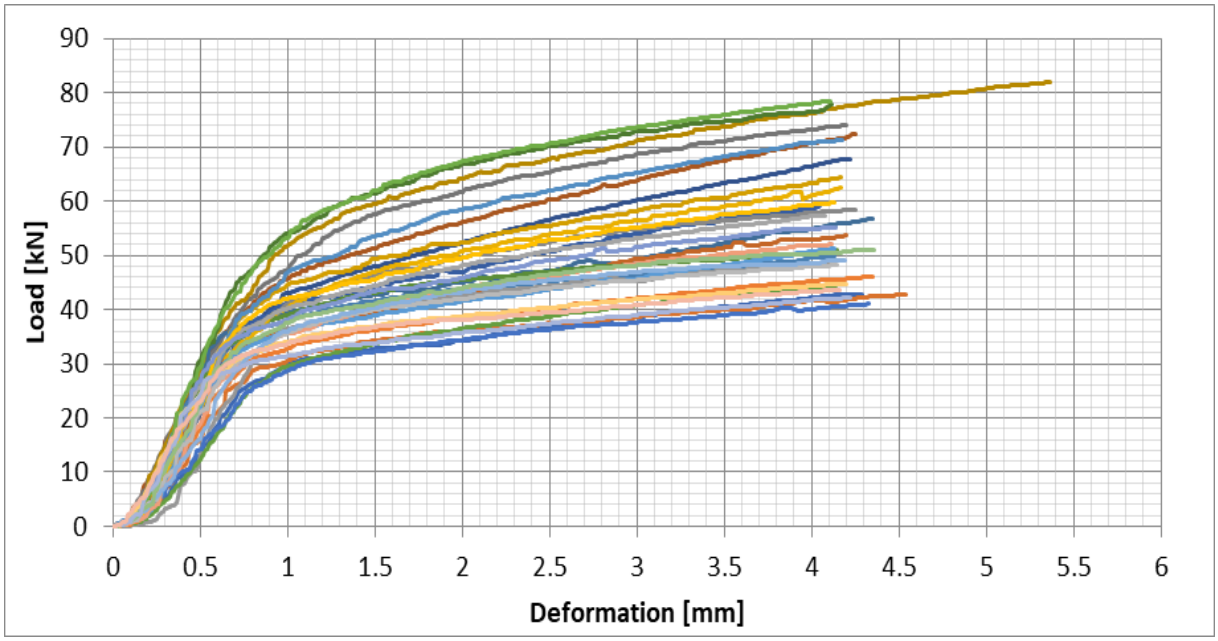

Figure 35: Radiata Pine (S4), All test results – Perpendicular to the grain bearing - Load/Deformation

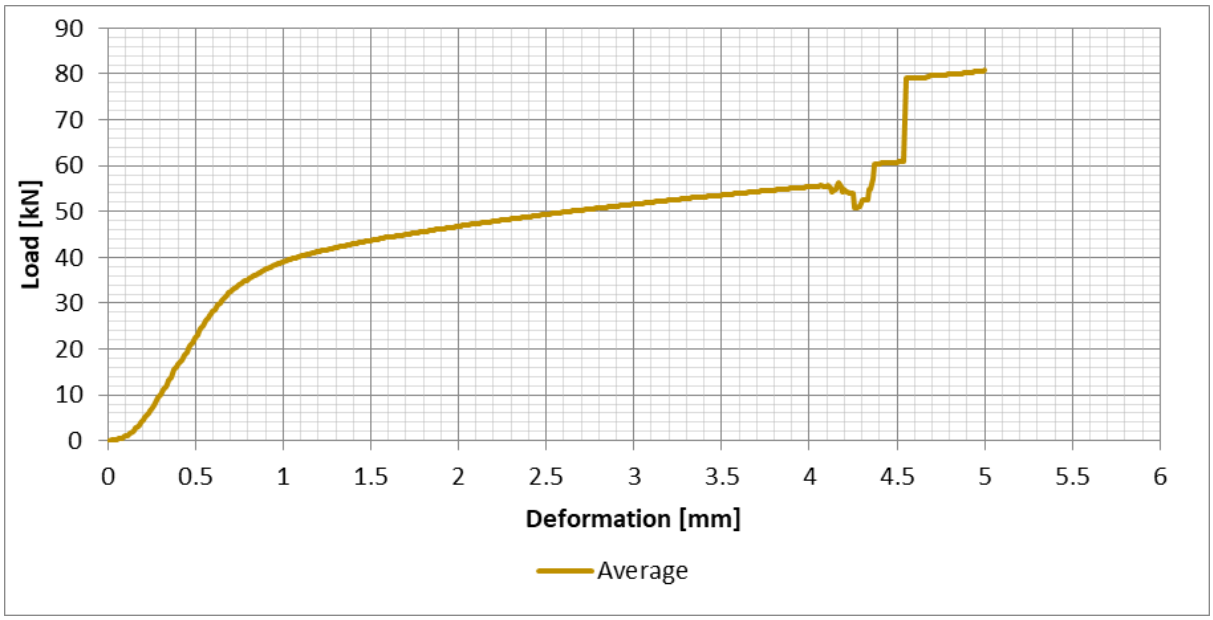

Figure 36: Radiata Pine (S4), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S5

Scientific name: Pinus radiata
Identification number: S5
Characteristic Density: 551 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 8.9 MPa, Coefficient of Variation: 20.6
Characteristic perpendicular to grain Modulus of Elasticity: 476 MPa, Average perpendicular to grain Modulus of Elasticity: 488 MPa, Coefficient of Variation: 19.5
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/21.0

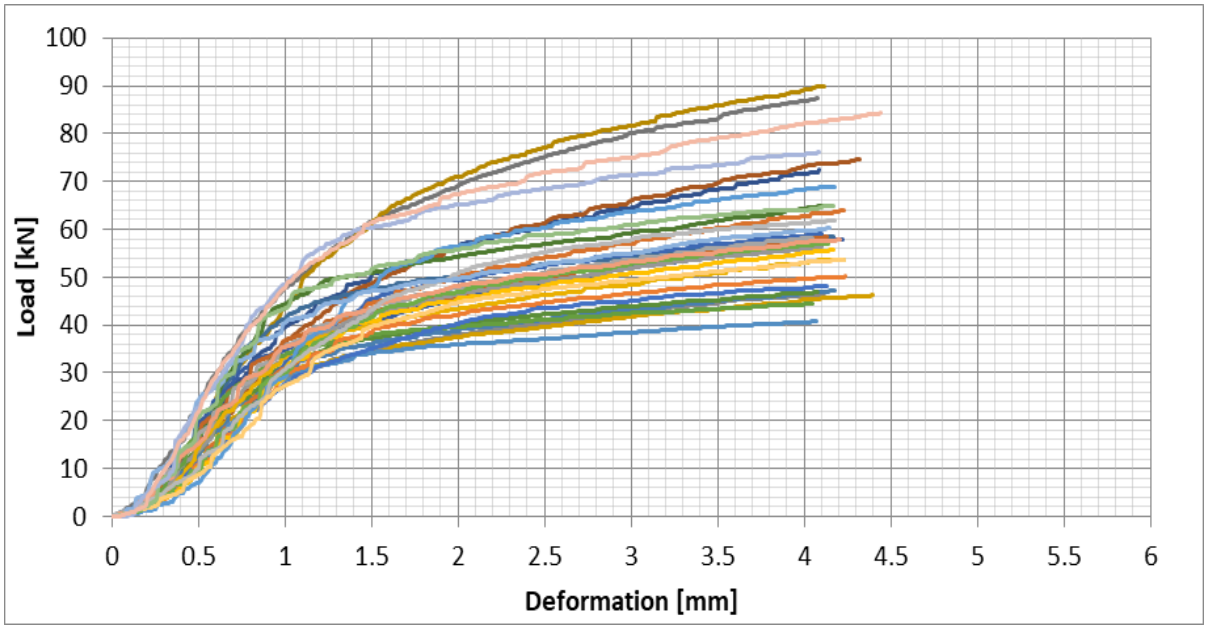

Figure 37: Radiata Pine (S5), All test results – Perpendicular to the grain bearing - Load/Deformation

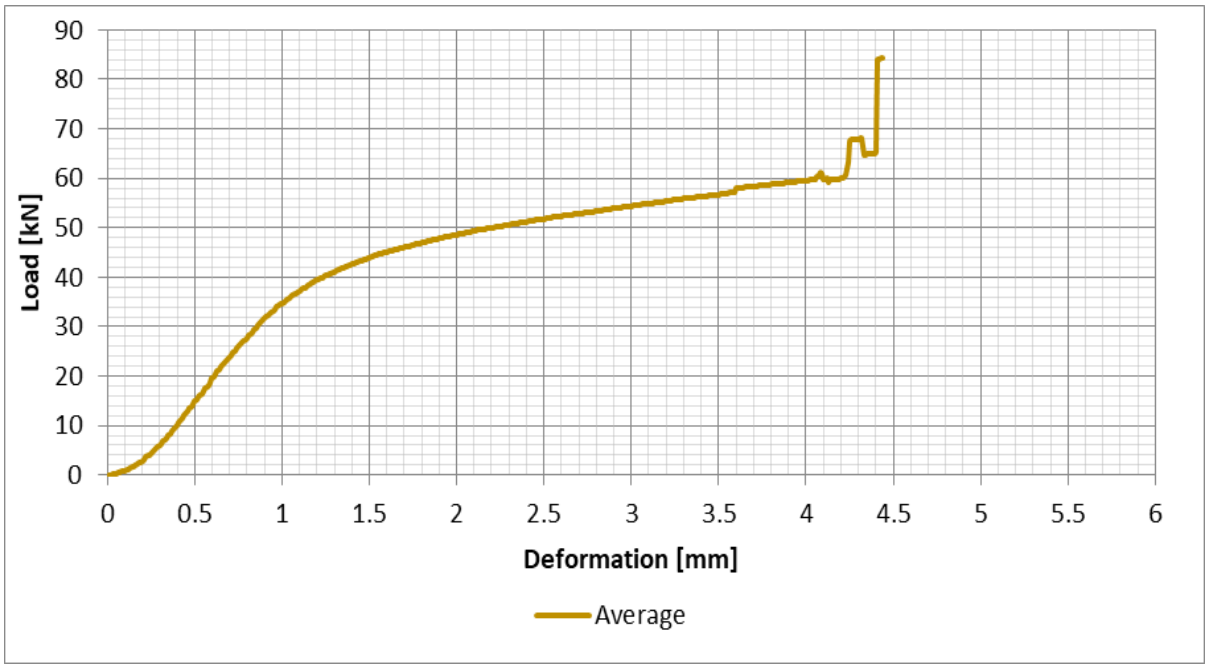

Figure 38: Radiata Pine (S5), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S6

Scientific name: Pinus radiata
Identification number: S6
Characteristic Density: 567 kg/m^3
Stress grade: MGP12
Characteristic perpendicular to grain bearing stress: 10.3 MPa, Coefficient of Variation: 14.5
Characteristic perpendicular to grain Modulus of Elasticity: 712 MPa, Average perpendicular to grain Modulus of Elasticity: 727 MPa, Coefficient of Variation: 17.1
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/17.8

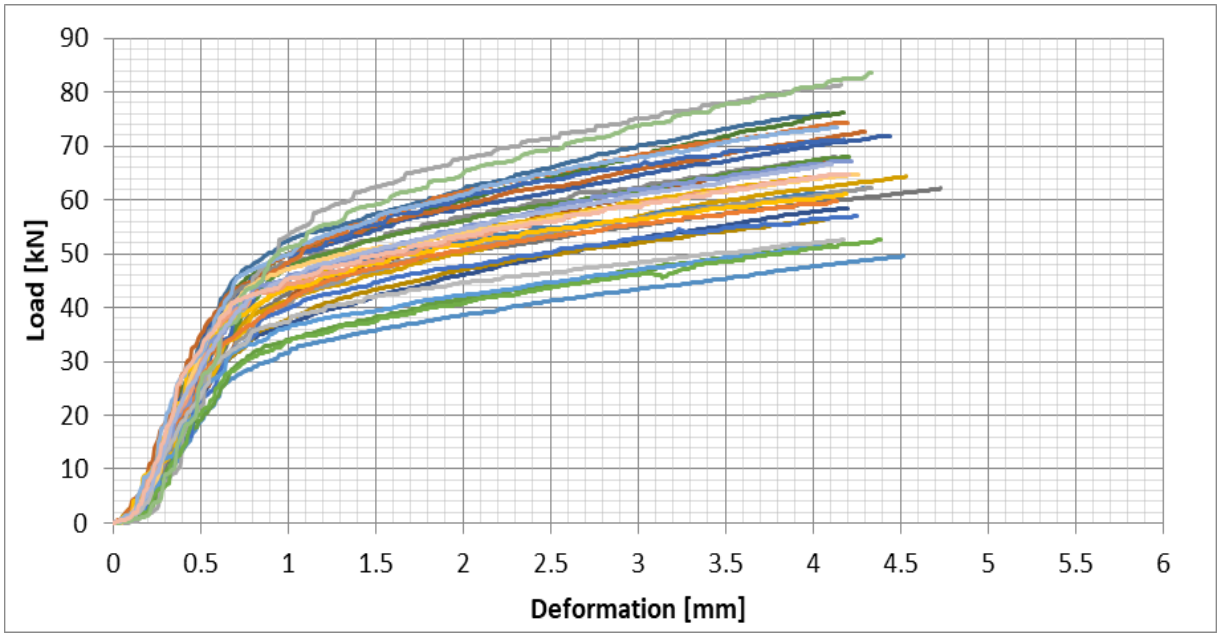

Figure 39: Radiata Pine (S6), All test results – Perpendicular to the grain bearing - Load/Deformation

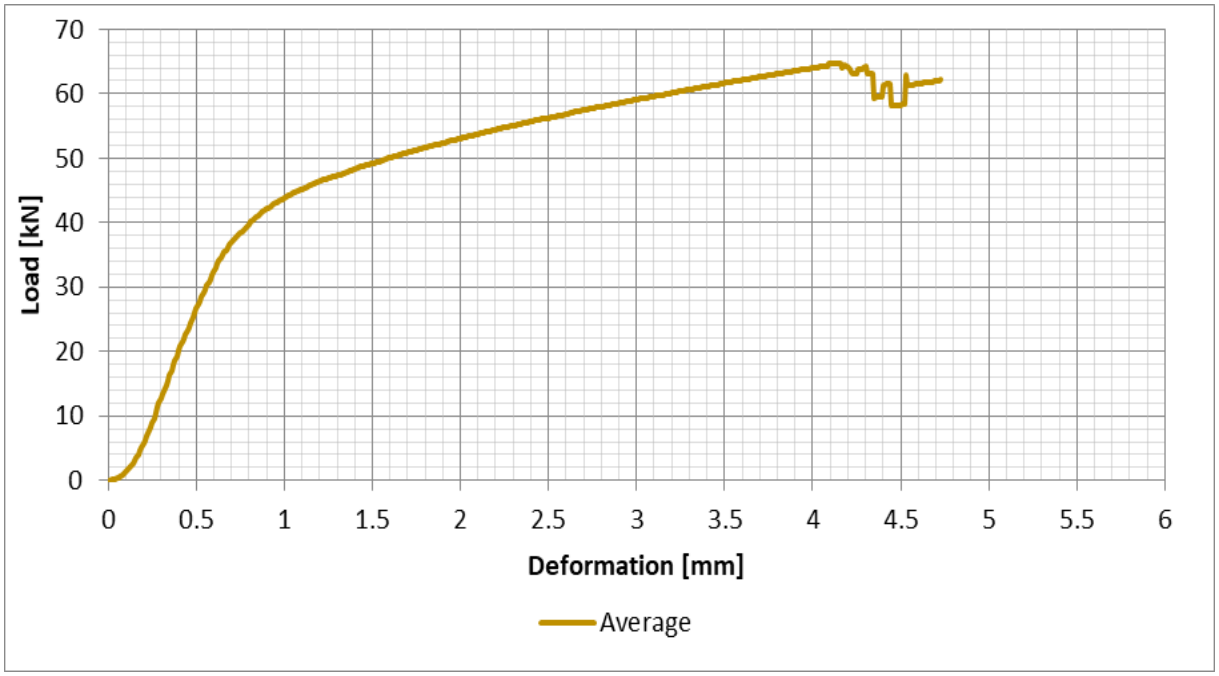

Figure 40: Radiata Pine (S6), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S7

Scientific name: Pinus radiata
Identification number: S7
Characteristic Density: 606 kg/m^3
Stress grade: MGP12
Characteristic perpendicular to grain bearing stress: 12.9 MPa, Coefficient of Variation: 12.1
Characteristic perpendicular to grain Modulus of Elasticity: 745 MPa, Average perpendicular to grain Modulus of Elasticity: 780 MPa, Coefficient of Variation: 15.5
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/17.0

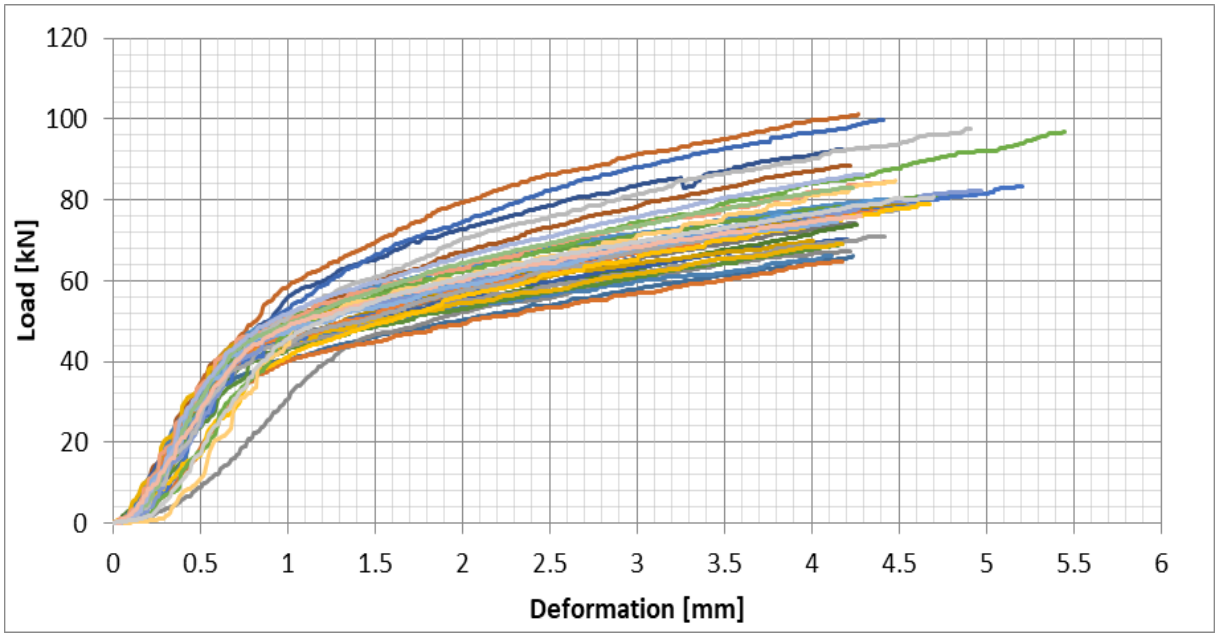

Figure 41: Radiata Pine (S7), All test results – Perpendicular to the grain bearing - Load/Deformation

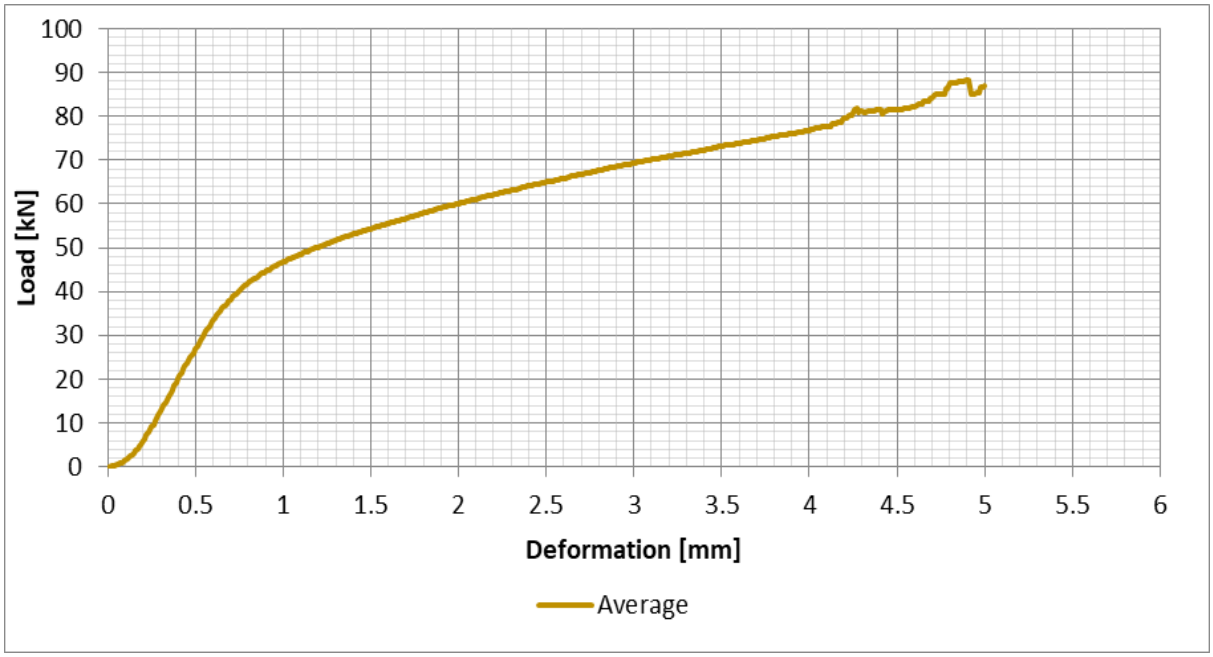

Figure 42: Radiata Pine (S7), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S8

Scientific name: Pinus radiata
Identification number: S8
Characteristic Density: 569 kg/m^3
Stress grade: MGP12
Characteristic perpendicular to grain bearing stress: 11 MPa, Coefficient of Variation: 8.9
Characteristic perpendicular to grain Modulus of Elasticity: 623 MPa, Average perpendicular to grain Modulus of Elasticity: 632 MPa, Coefficient of Variation: 10.5
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/20.4

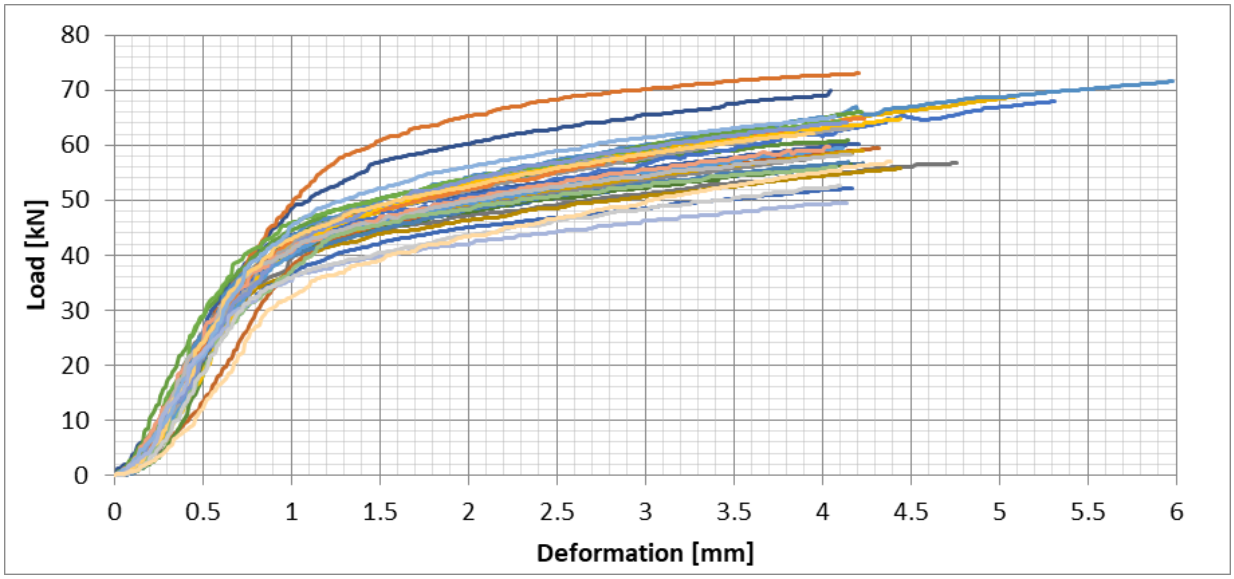

Figure 43: Radiata Pine (S8), All test results – Perpendicular to the grain bearing - Load/Deformation

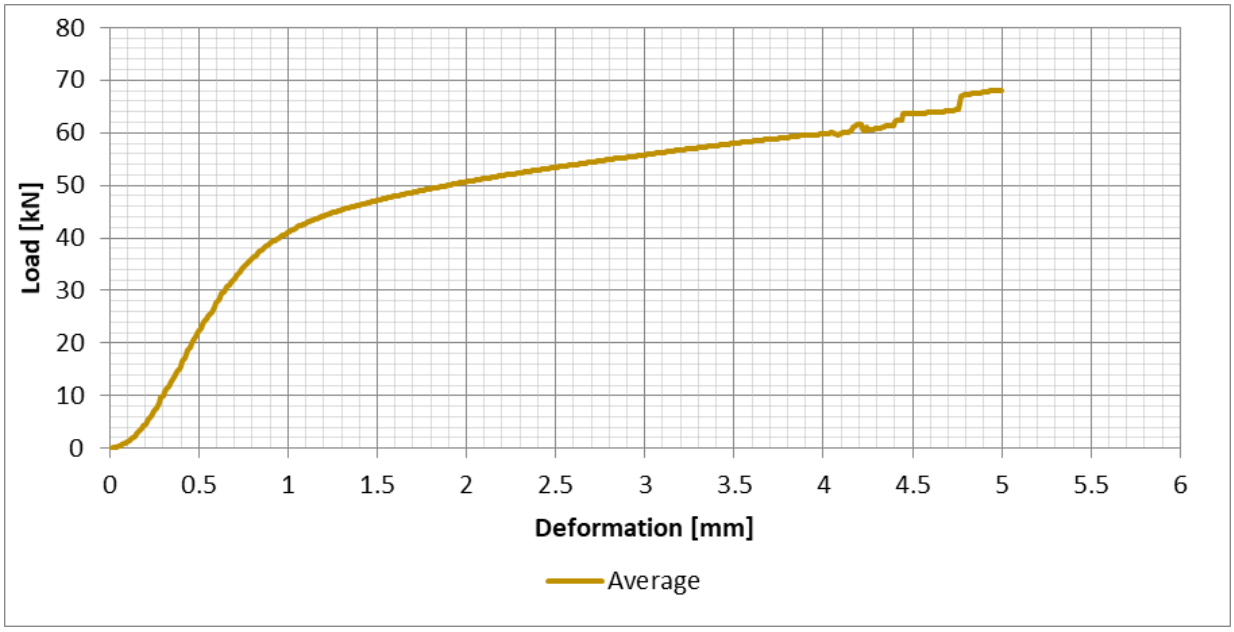

Figure 44: Radiata Pine (S8), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S11

Scientific name: Pinus radiata
Identification number: S11
Characteristic Density: 536 kg/m^3
Stress grade: MGP15
Characteristic perpendicular to grain bearing stress: 8.4 MPa, Coefficient of Variation: 12.7
Characteristic perpendicular to grain Modulus of Elasticity: 526 MPa, Average perpendicular to grain Modulus of Elasticity: 546 MPa, Coefficient of Variation: 14.2
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/28.9

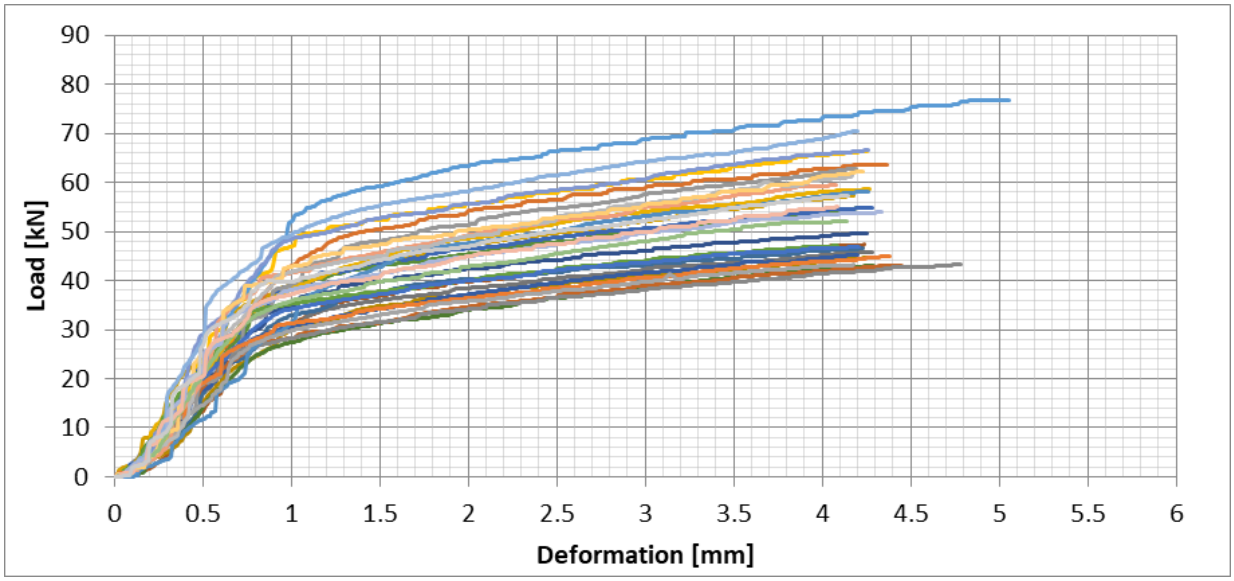

Figure 45: Radiata Pine (S11), All test results – Perpendicular to the grain bearing - Load/Deformation

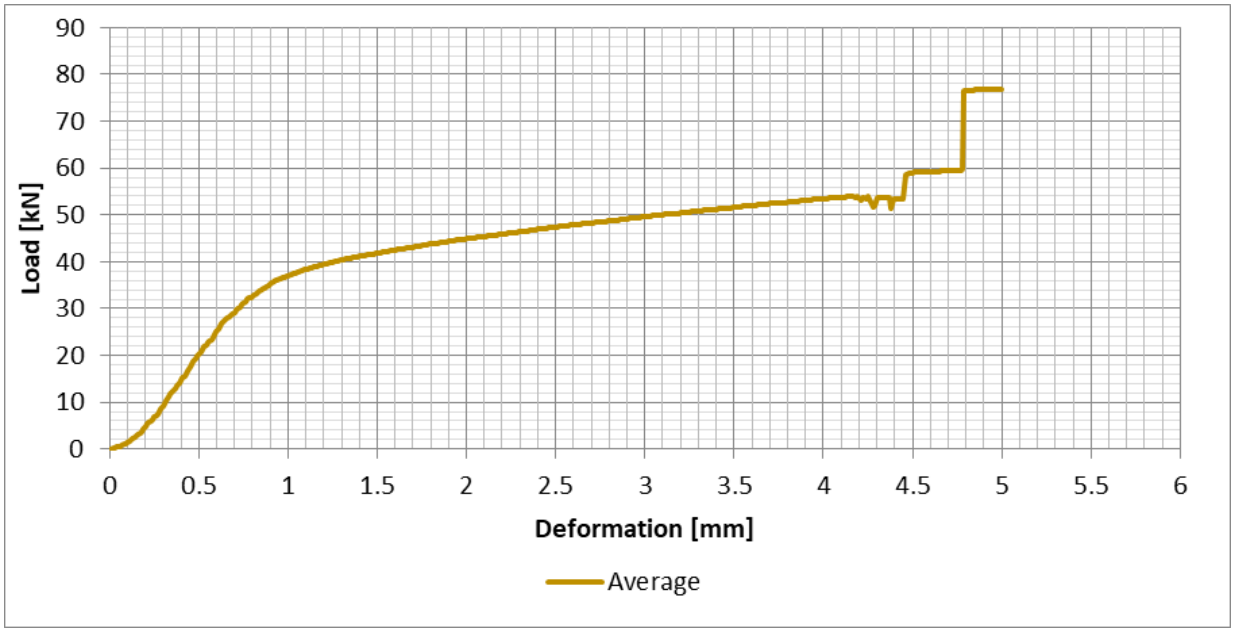

Figure 46: Radiata Pine (S11), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S12

Scientific name: Pinus radiata
Identification number: S12
Characteristic Density: 476 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 7.4 MPa, Coefficient of Variation: 16.6
Characteristic perpendicular to grain Modulus of Elasticity: 399 MPa, Average perpendicular to grain Modulus of Elasticity: 433 MPa, Coefficient of Variation: 21.2
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/25.1

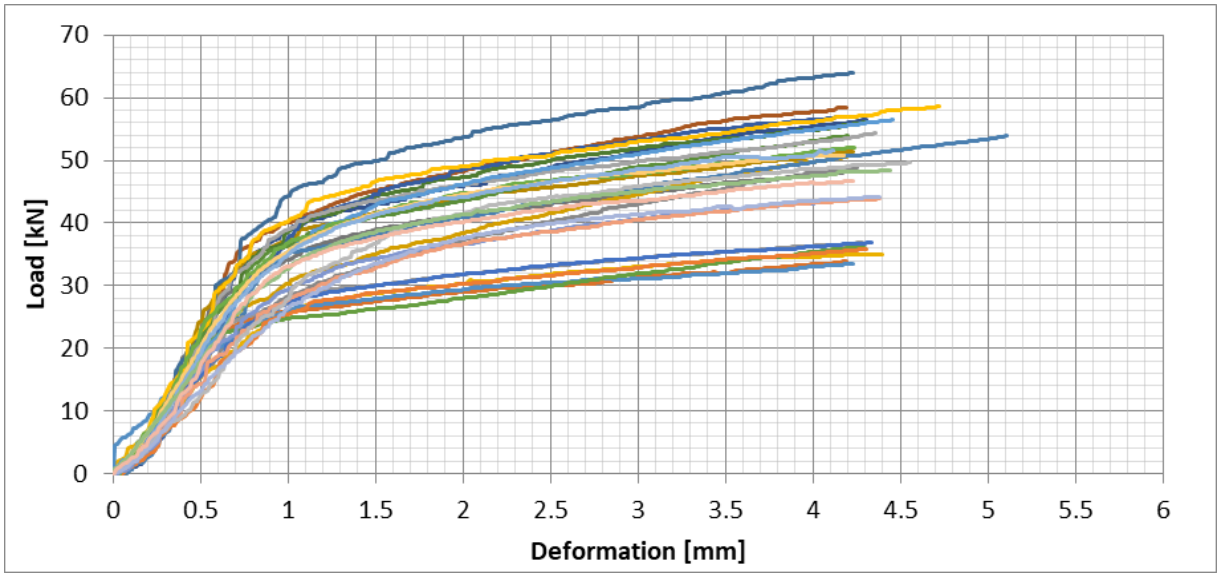

Figure 47: Radiata Pine (S12), All test results – Perpendicular to the grain bearing - Load/Deformation

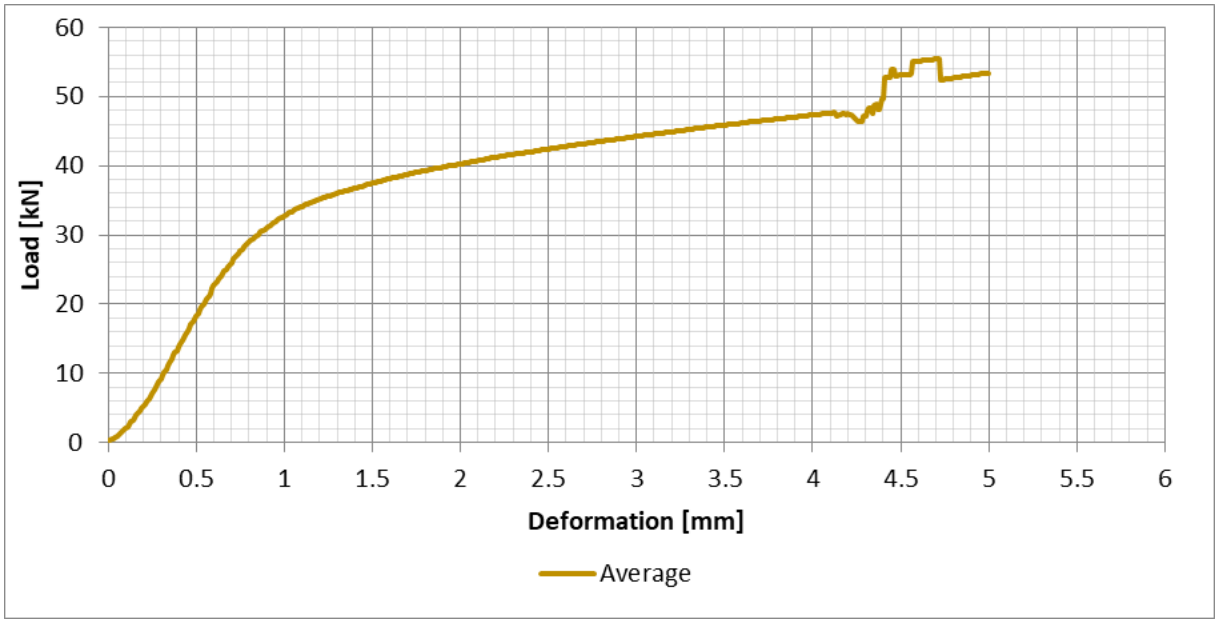

Figure 48: Radiata Pine (S12), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Caribbea Hybrid – S14

Scientific name: Pinus Caribbea var. hondurensis
Identification number: S14
Characteristic Density: 562 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 8.7 MPa, Coefficient of Variation: 17.8
Characteristic perpendicular to grain Modulus of Elasticity: 502 MPa, Average perpendicular to grain Modulus of Elasticity: 530 MPa, Coefficient of Variation: 23.6
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/19.9

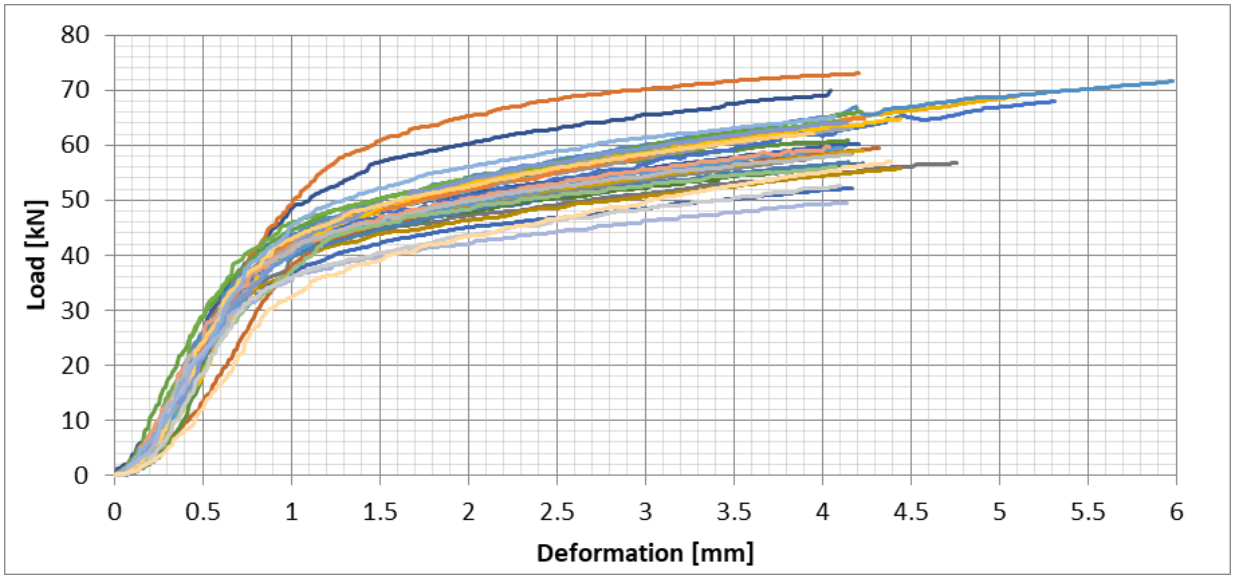

Figure 49: Caribbea Hybrid (S14), All test results – Perpendicular to the grain bearing - Load/Deformation

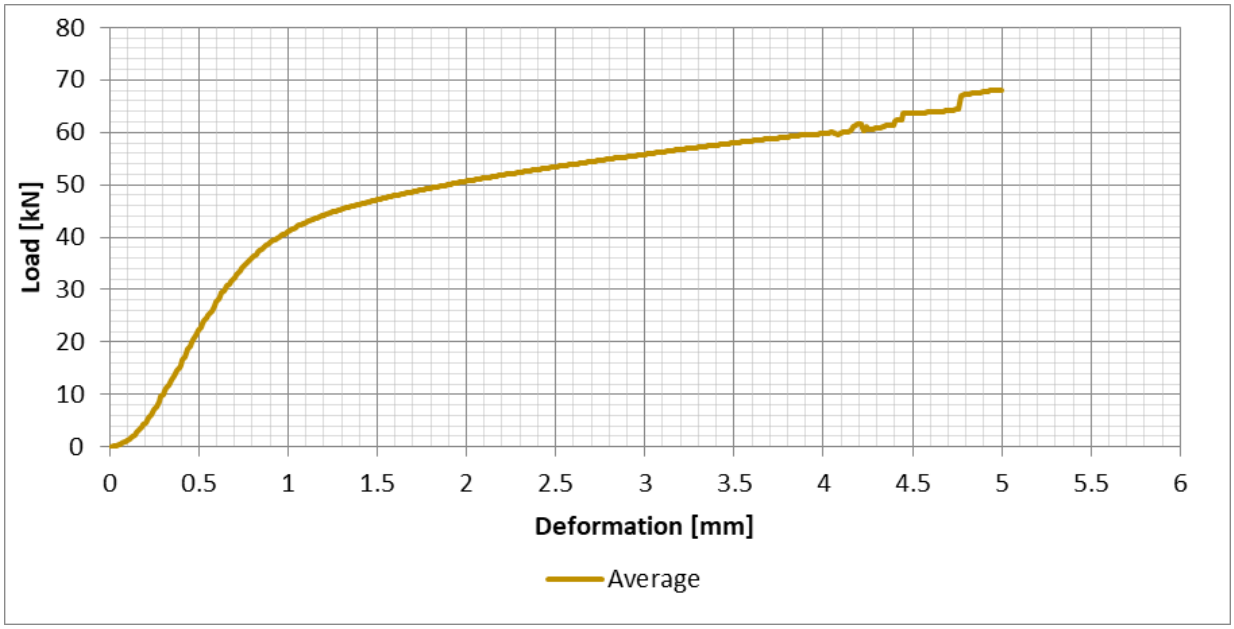

Figure 50: Caribbea Hybrid (S14), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Cypress - S17

Scientific name: Pinus Callitris columellaris
Identification number: S17
Characteristic Density: 679 kg/m^3
Stress grade: F7
Characteristic perpendicular to grain bearing stress: 21.7 MPa, Coefficient of Variation: 10.4
Characteristic perpendicular to grain Modulus of Elasticity: 921 MPa, Average perpendicular to grain Modulus of Elasticity: 942 MPa, Coefficient of Variation: 19.2
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/8.6

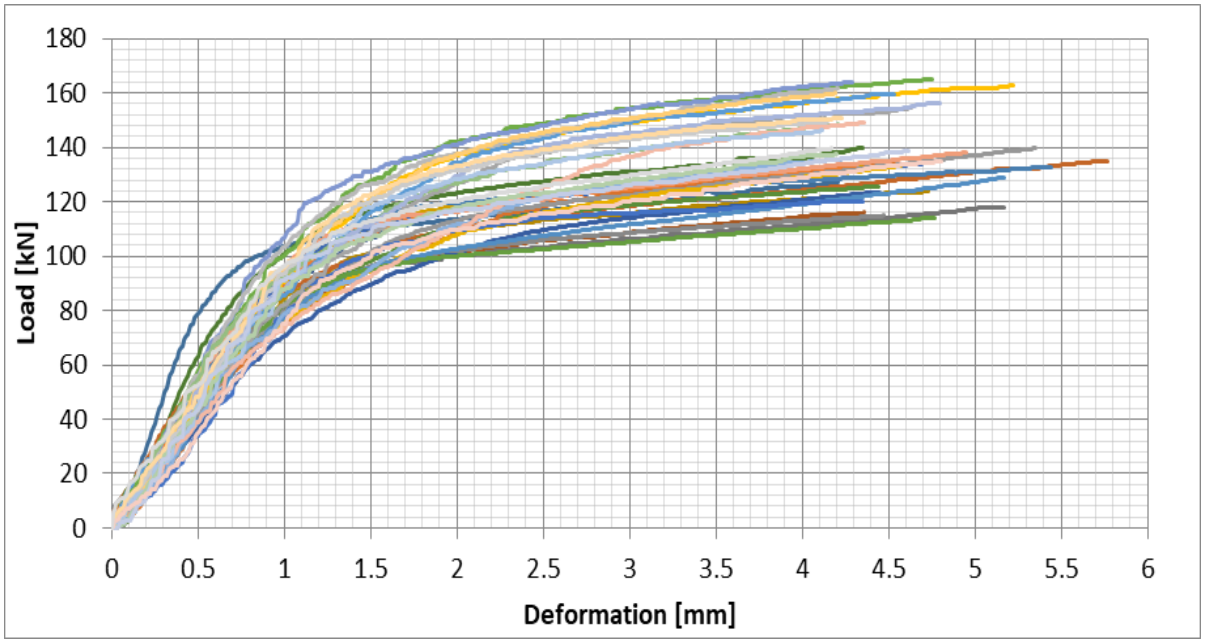

Figure 50: Caribbea Hybrid (S14), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

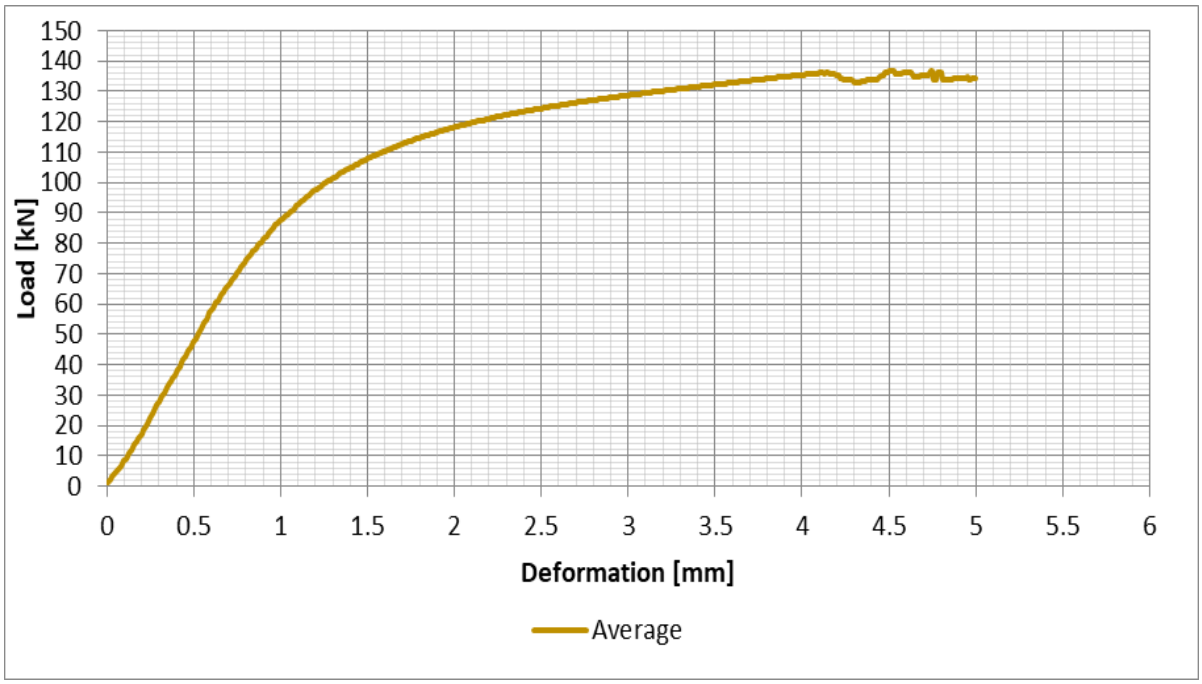

Figure 52: Cypress (S17), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Alpine Ash – H1

Scientific name: Eucalyptus delegatensis
Identification number: H1
Characteristic Density: 708 kg/m^3
Stress grade: F17
Characteristic perpendicular to grain bearing stress: 15.5 MPa, Coefficient of Variation: 7.6
Characteristic perpendicular to grain Modulus of Elasticity: 785 MPa, Average perpendicular to grain Modulus of Elasticity: 803 MPa, Coefficient of Variation: 18.0
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/17.8

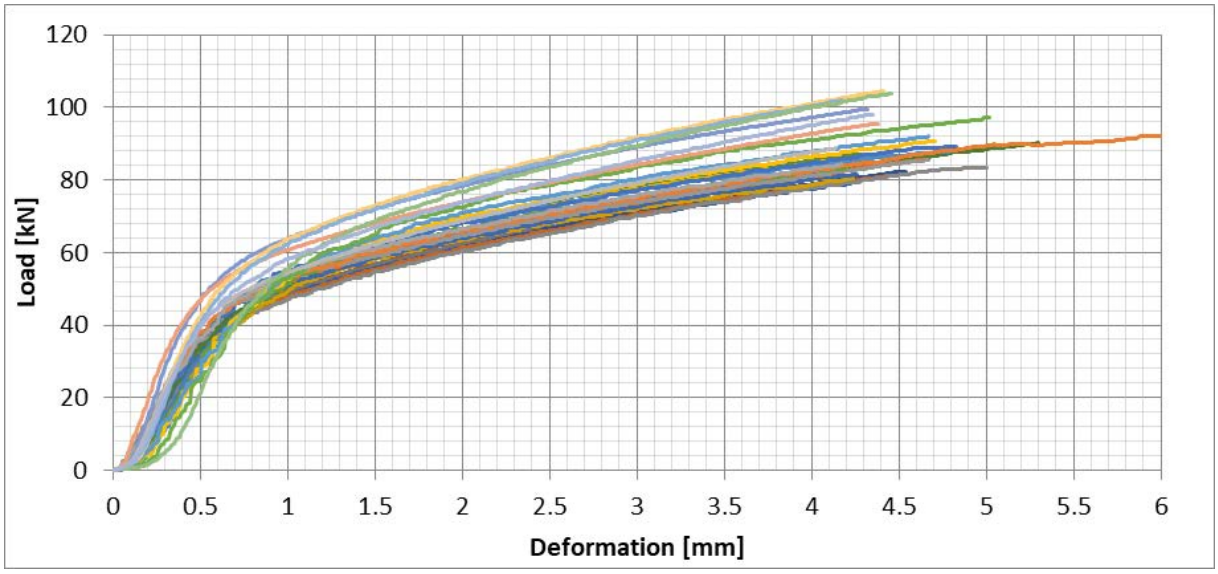

Figure 53: Alpine Ash (H1), All test results – Perpendicular to the grain bearing - Load/Deformation

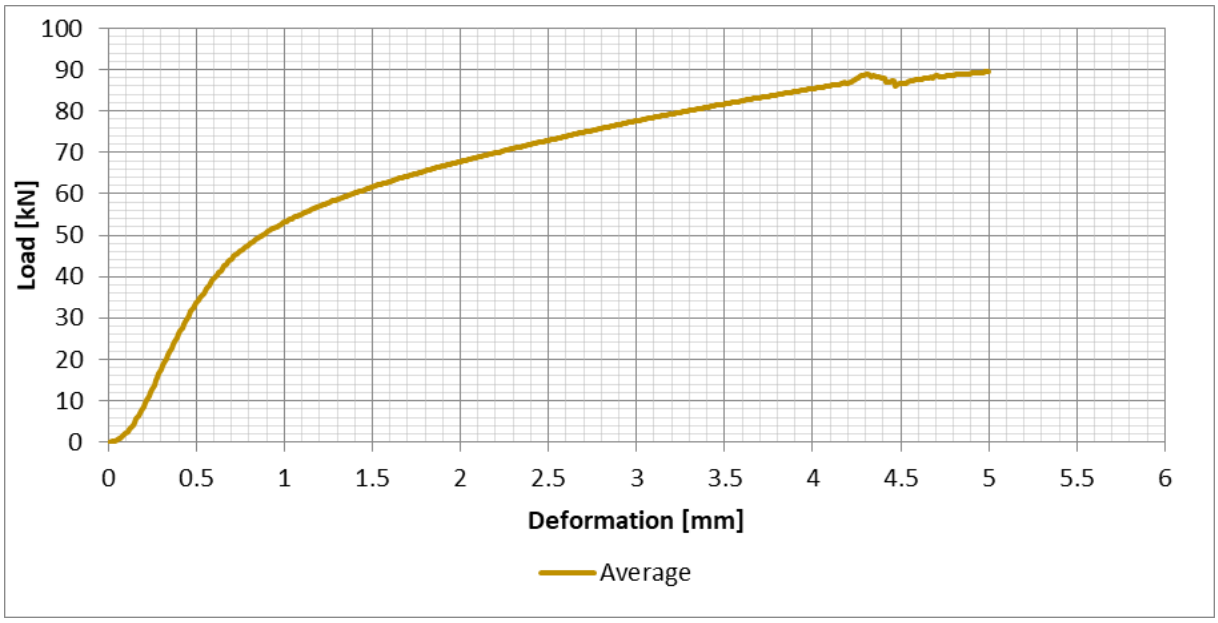

Figure 54: Alpine Ash (H1), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Jarrah - H4

Scientific name: Eucalyptus marginata
Identification number: H4
Characteristic Density: 833 kg/m^3
Stress grade: F17
Characteristic perpendicular to grain bearing stress: 23.9 MPa, Coefficient of Variation: 4.8
Characteristic perpendicular to grain Modulus of Elasticity: 1,233 MPa, Average perpendicular to grain Modulus of Elasticity: 1,271 MPa, Coefficient of Variation: 20.8
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/11.4

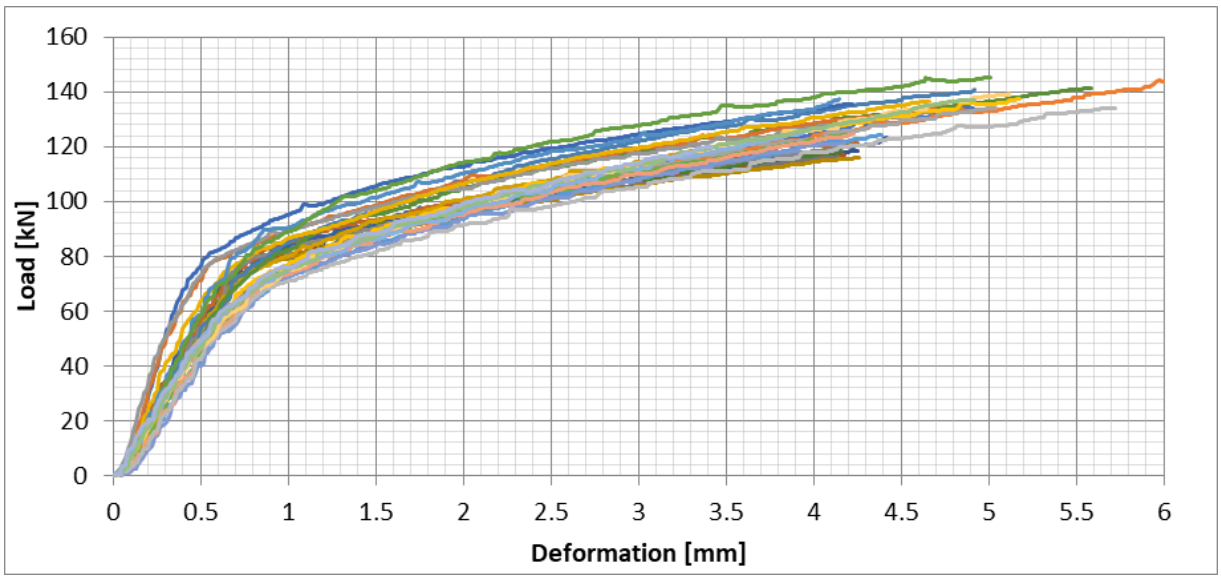

Figure 55: Jarrah (H4), All test results – Perpendicular to the grain bearing - Load/Deformation

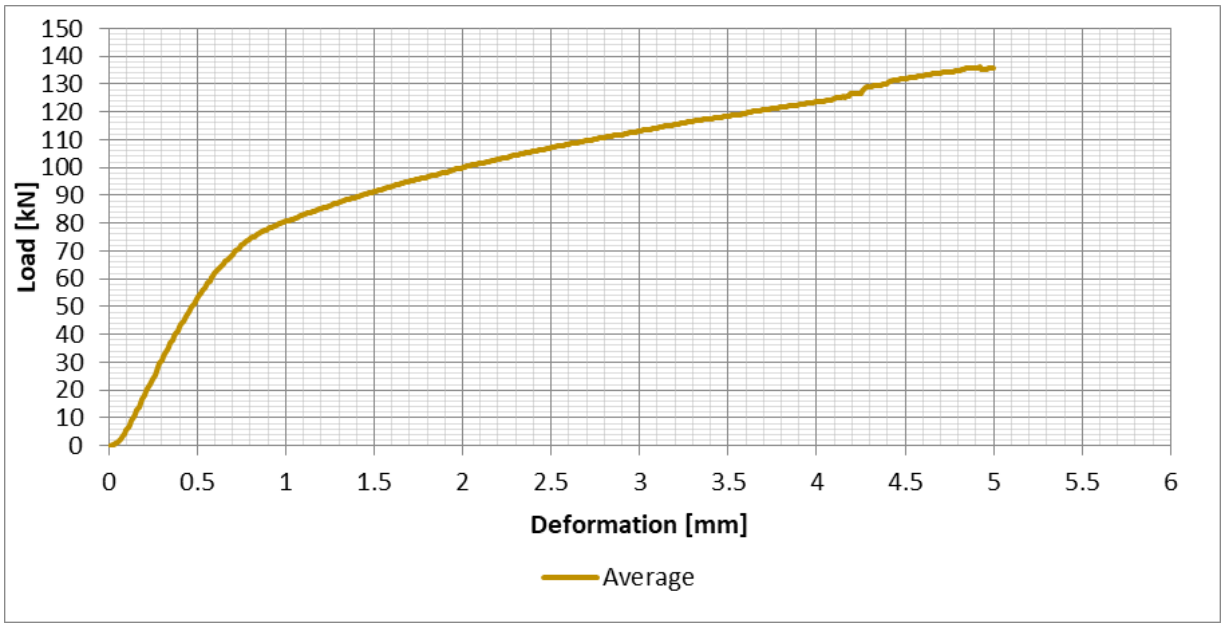

Figure 56: Jarrah (H4), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Karri – H5

Scientific name: Eucalyptus marginata
Identification number: H5
Characteristic Density: 866 kg/m^3
Stress grade: F17
Characteristic perpendicular to grain bearing stress: 16.7 MPa, Coefficient of Variation: 14.6
Characteristic perpendicular to grain Modulus of Elasticity: 700 MPa, Average perpendicular to grain Modulus of Elasticity: 797 MPa, Coefficient of Variation: 26.0
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/11.4

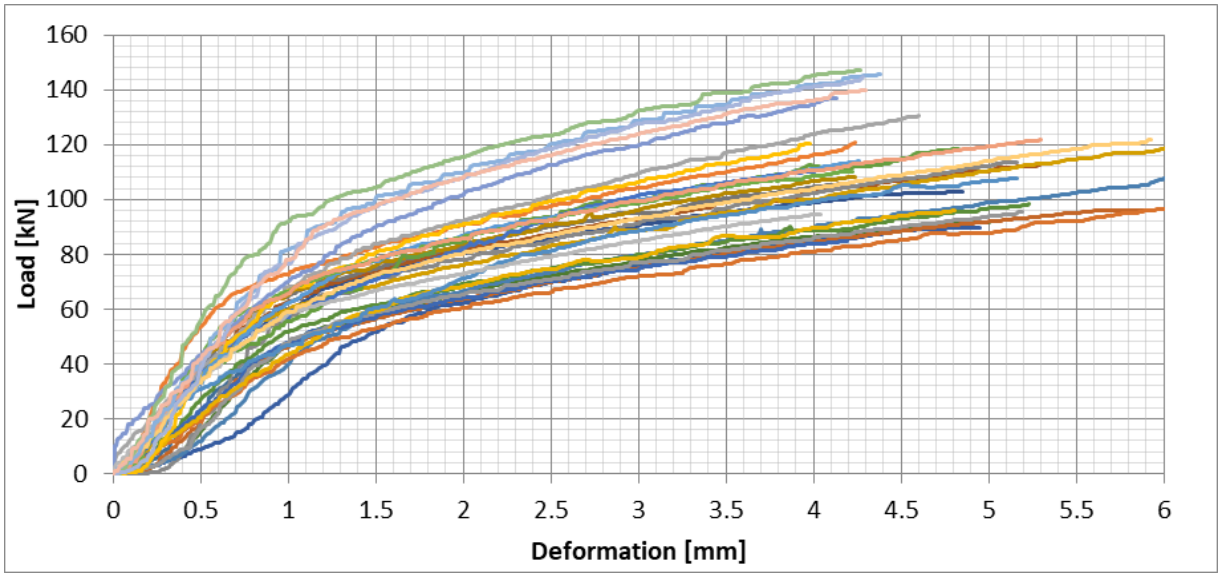

Figure 57: Karri (H5), All test results – Perpendicular to the grain bearing - Load/Deformation

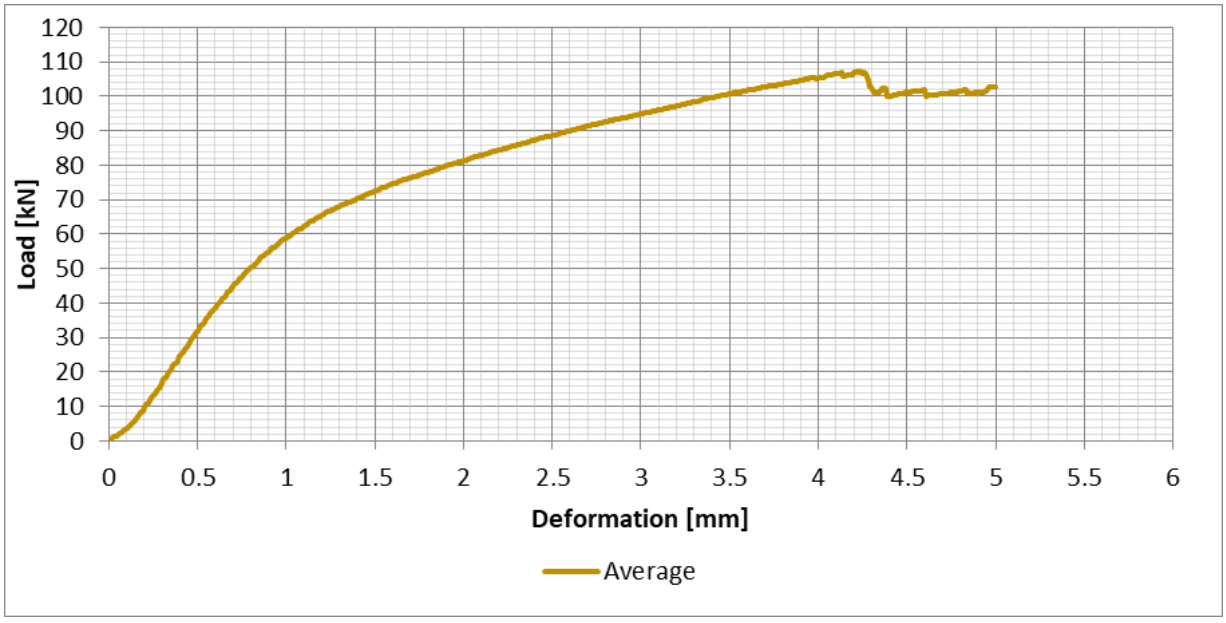

Figure 58: Karri (H5), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Blackbutt – H6

Scientific name: Eucalyptus pilularis
Identification number: H6
Characteristic Density: 903 kg/m^3
Stress grade: F27
Characteristic perpendicular to grain bearing stress: 19.9 MPa, Coefficient of Variation: 17.9
Characteristic perpendicular to grain Modulus of Elasticity: 932 MPa, Average perpendicular to grain Modulus of Elasticity: 944 MPa, Coefficient of Variation: 10.4
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/19.8

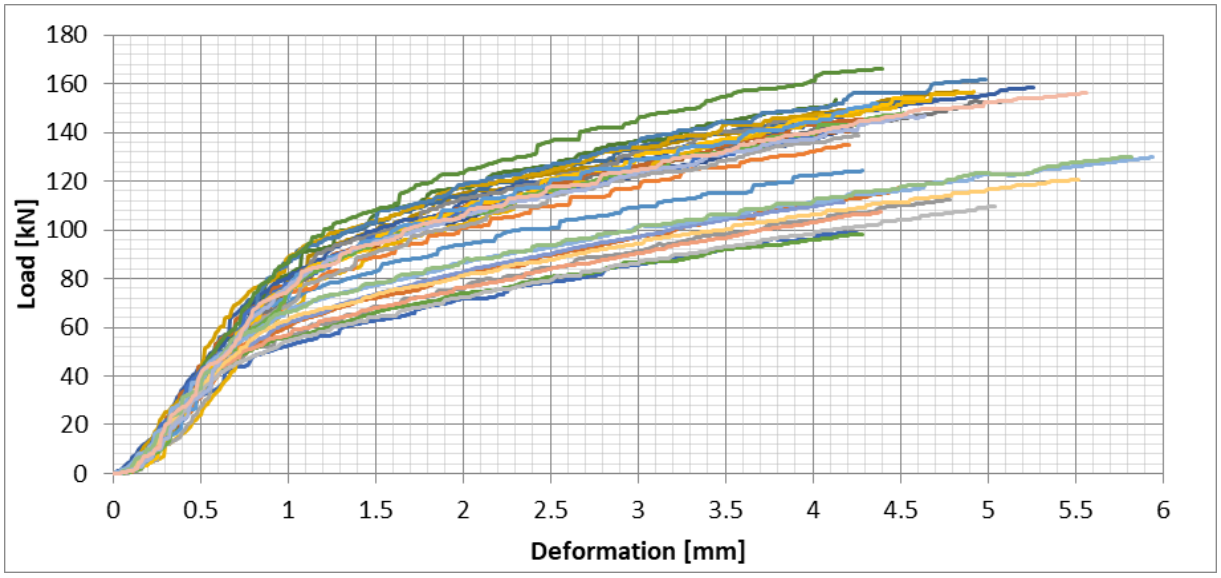

Figure 59: Blackbutt (H6), All test results – Perpendicular to the grain bearing - Load/Deformation

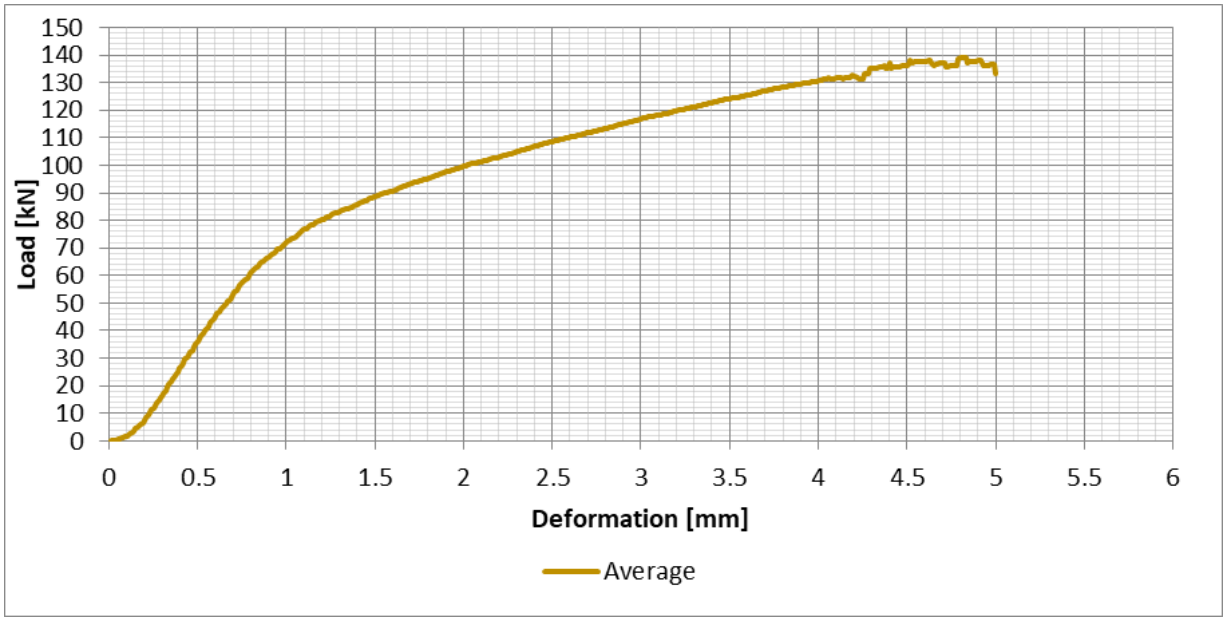

Figure 60: Blackbutt (H6), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Grey Ironbark – H7

Scientific name: Eucalyptus panicularis
Identification number: H7
Characteristic Density: 1142 kg/m^3
Stress grade: F27
Characteristic perpendicular to grain bearing stress: 46.4 MPa, Coefficient of Variation: 6.3
Characteristic perpendicular to grain Modulus of Elasticity: 999 MPa, Average perpendicular to grain Modulus of Elasticity: 1,474 MPa, Coefficient of Variation: 39.2
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/18.5

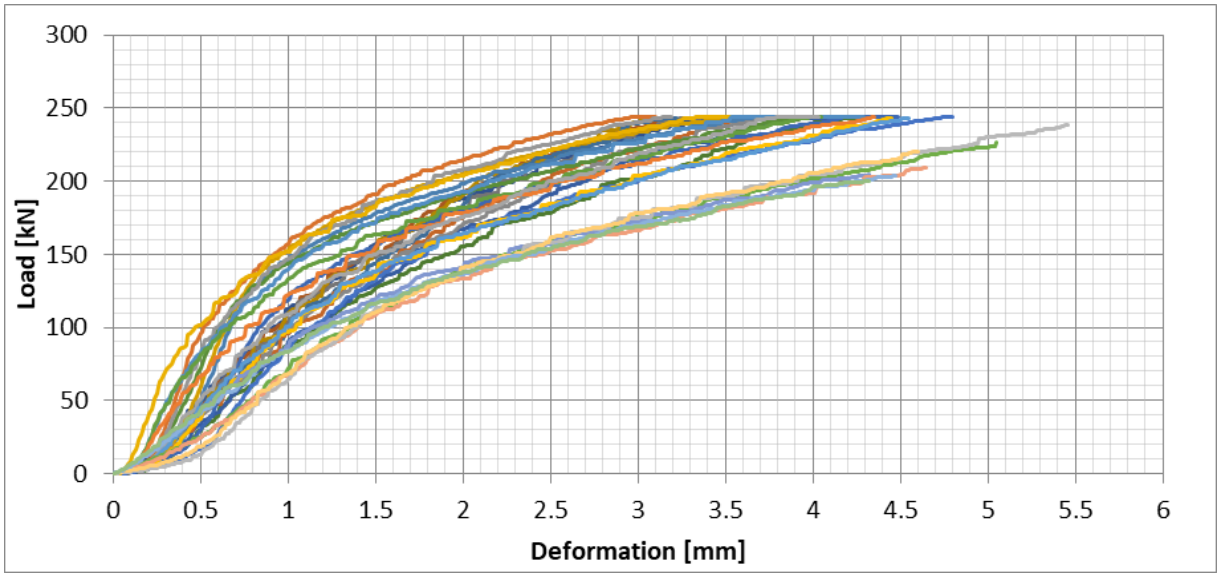

Figure 60: Blackbutt (H6), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Note: The truncation of the load at 250 kN is due to the limit of the machine applying the load

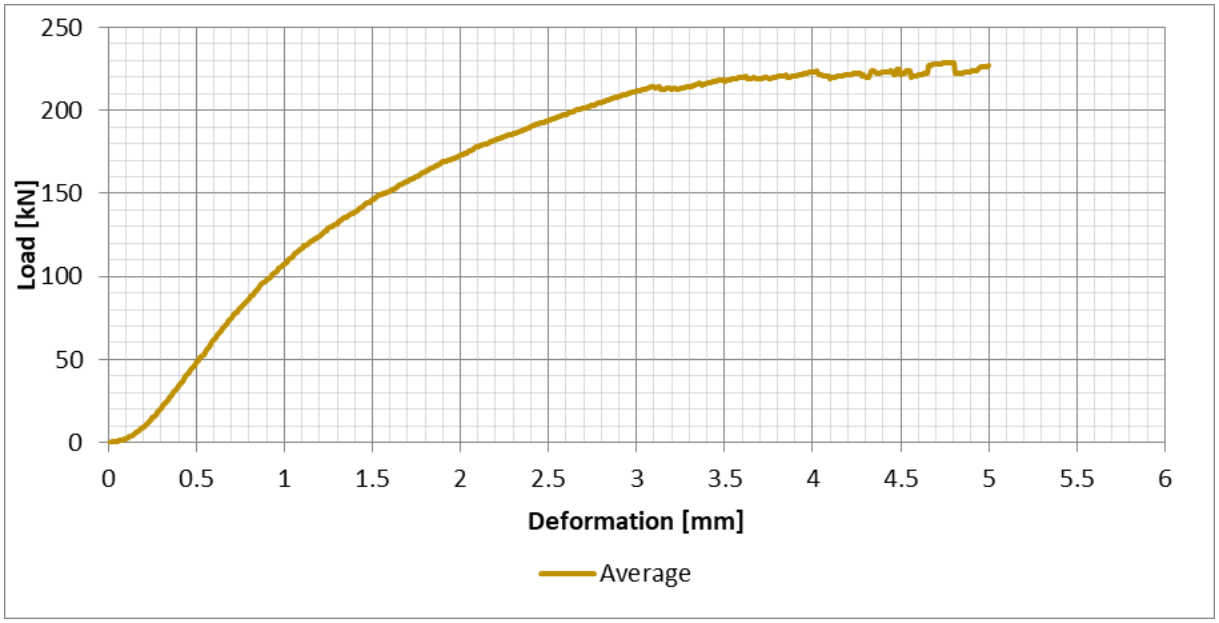

Figure 62: Grey Ironbark (H6), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Spotted Gum – H8

Scientific name: Eucalyptus macularis
Identification number: H8
Characteristic Density: 1,058 kg/m^3
Stress grade: F27
Characteristic perpendicular to grain bearing stress: 38.7 MPa, Coefficient of Variation: 6.4
Characteristic perpendicular to grain Modulus of Elasticity: 1,143 MPa, Average perpendicular to grain Modulus of Elasticity: 1,165 MPa, Coefficient of Variation: 15.2
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/16.9

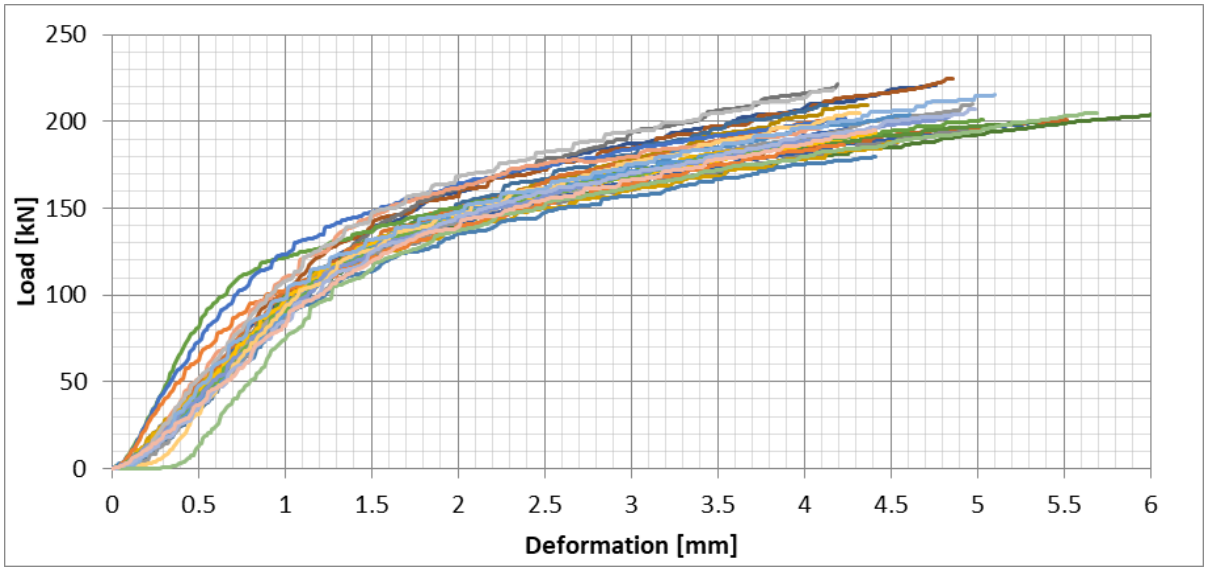

Figure 63: Spotted Gum (H8), All test results – Perpendicular to the grain bearing - Load/Deformation

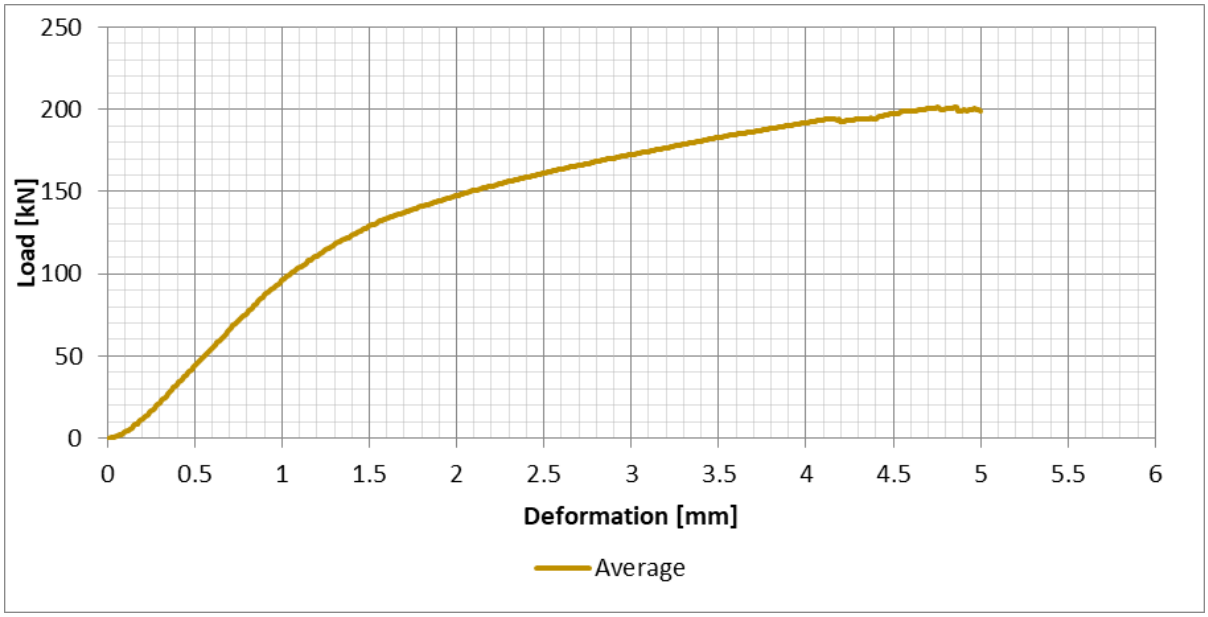

Figure 64: Spotted Gum (H8), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Southern Mahogany – H9

Scientific name: Eucalyptus botryoides
Identification number: H9
Characteristic Density: 945 kg/m^3
Stress grade: F17
Characteristic perpendicular to grain bearing stress: 21.6 MPa, Coefficient of Variation: 12.6
Characteristic perpendicular to grain Modulus of Elasticity: 471 MPa, Average perpendicular to grain Modulus of Elasticity: 519 MPa, Coefficient of Variation: 24.4
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/29.7

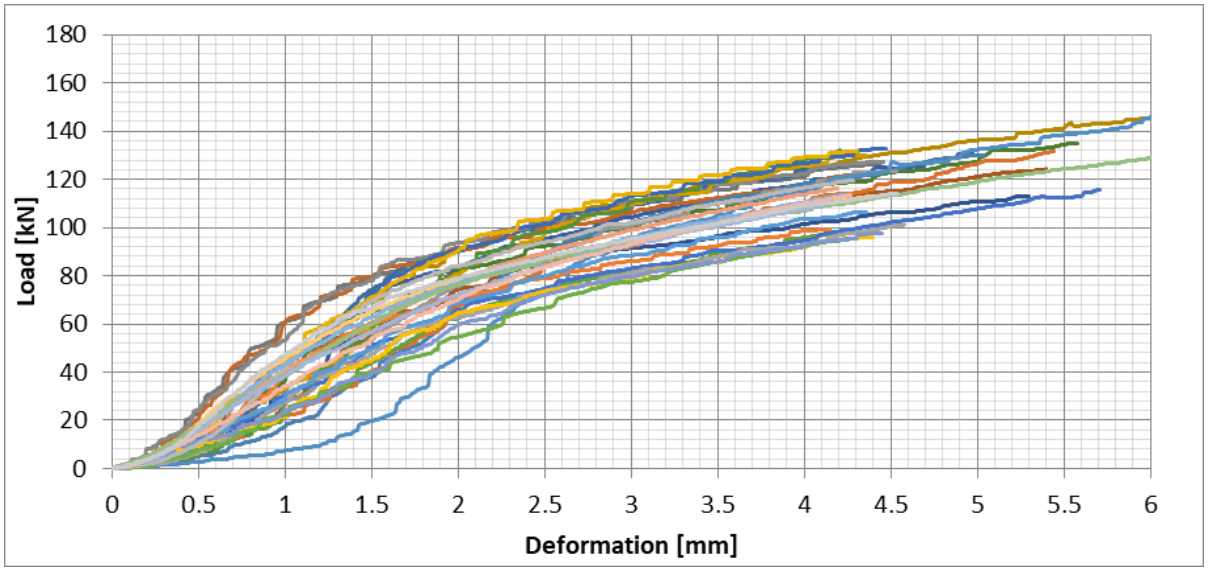

Figure 65: Southern Mahogany (H9), All test results – Perpendicular to the grain bearing - Load/Deformation

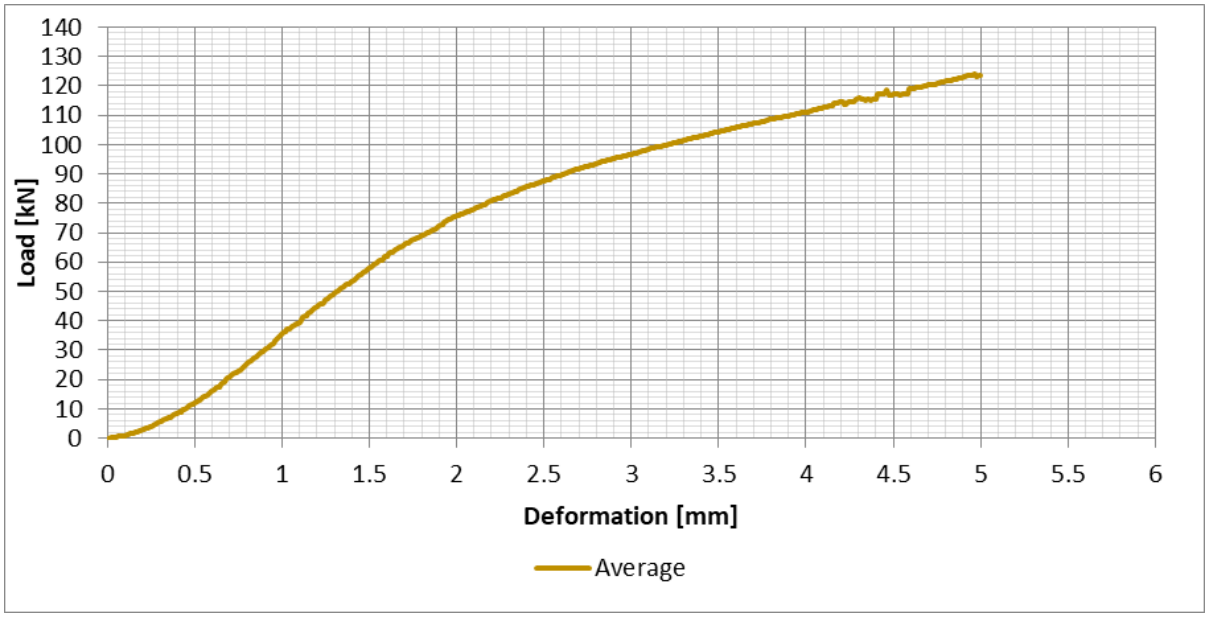

Figure 66: Southern Mahogany (H9), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Meranti, Light red – H10

Scientific name: Shorea leprosula
Identification number: H10
Characteristic Density: 443 kg/m^3
Stress grade: F4
Characteristic perpendicular to grain bearing stress: 7.7 MPa, Coefficient of Variation: 12.1
Characteristic perpendicular to grain Modulus of Elasticity: 586 MPa, Average perpendicular to grain Modulus of Elasticity: 617 MPa, Coefficient of Variation: 22.0
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/10.4

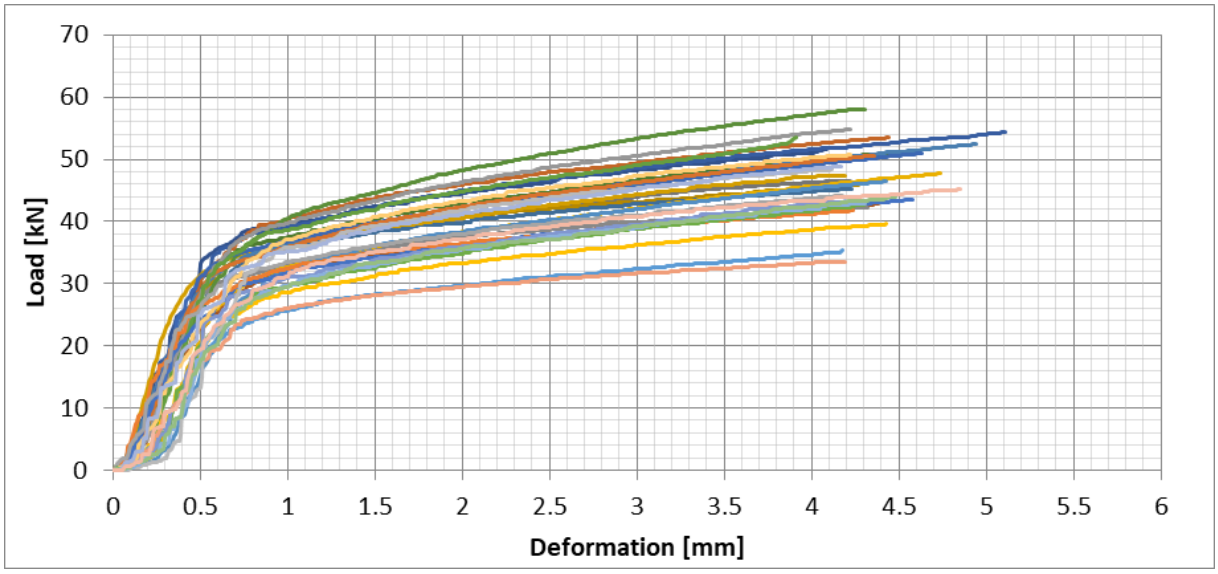

Figure 67: Southern Mahogany (H9), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

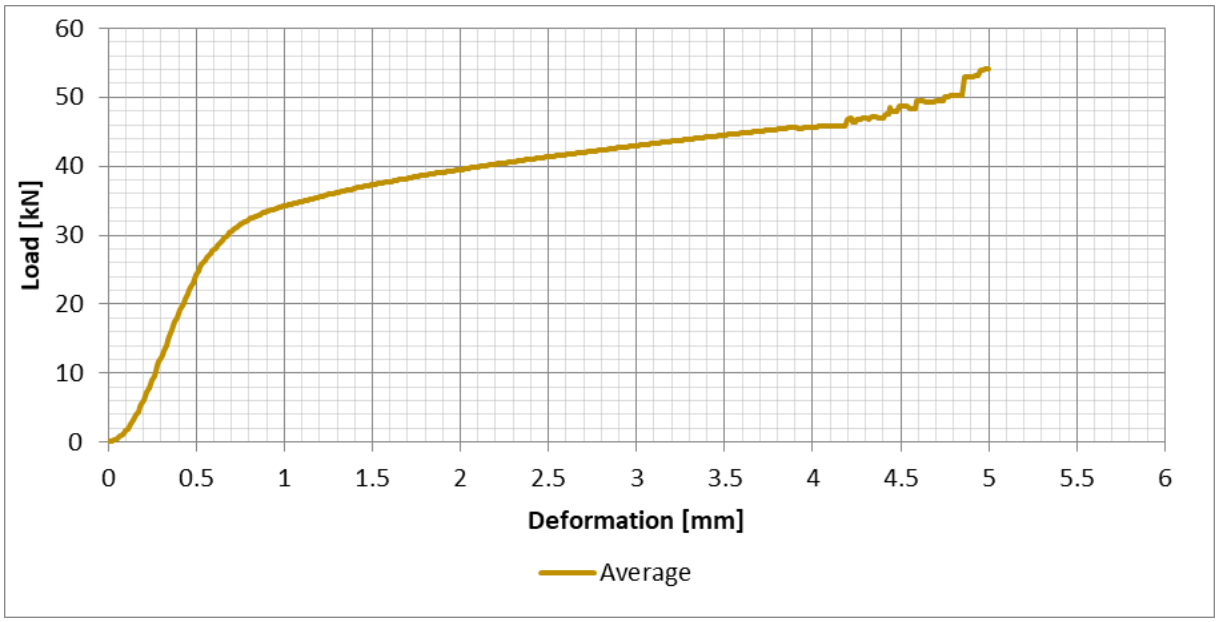

Figure 68: Meranti, Light red (H10), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Geometry

Various geometry features are investigated in this section. The first is the effect of the bearing area on the resulting bearing stress and the second is the effect of the bearing at the end of the sample when compared to the centre of the sample. The same timber species and grade were used to investigate this, i.e. bearing area – Scot Pine, End of the sample, radiata pine.

Scot Pine – 48 mm Bearing (one stud) – I7

Scientific name: Pinus sylvestris
Identification number: I7
Characteristic Density: 424 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 4.4 MPa, Coefficient of Variation: 16.6
Characteristic perpendicular to grain Modulus of Elasticity: 310 MPa, Average perpendicular to grain Modulus of Elasticity: 318 MPa, Coefficient of Variation: 20.4 The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/32.3

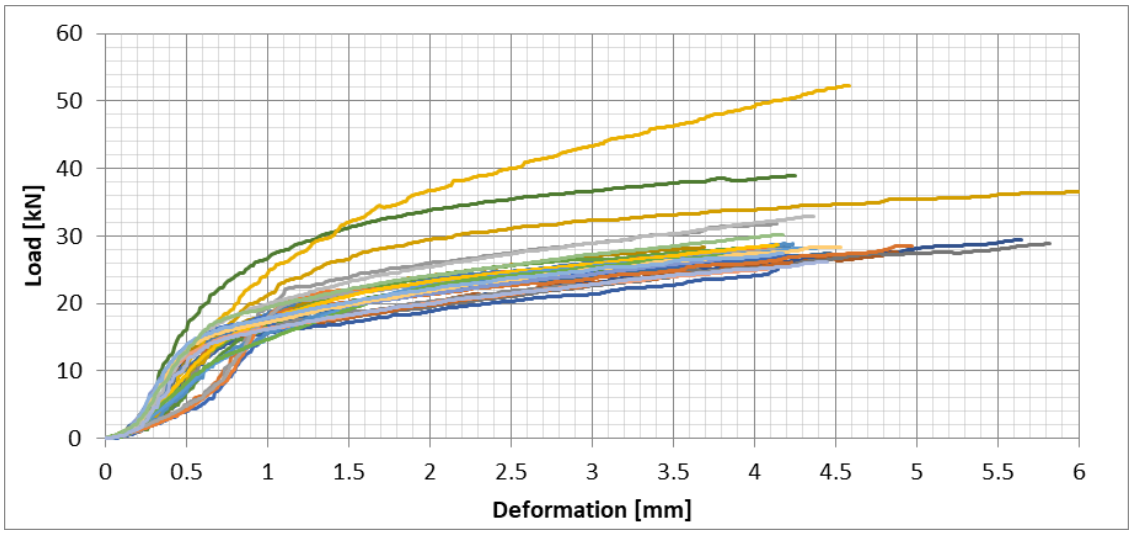

Figure 69: Scot Pine – 48 mm Bearing (one stud) (I7), All test results – Perpendicular to the grain bearing - Load/Deformation

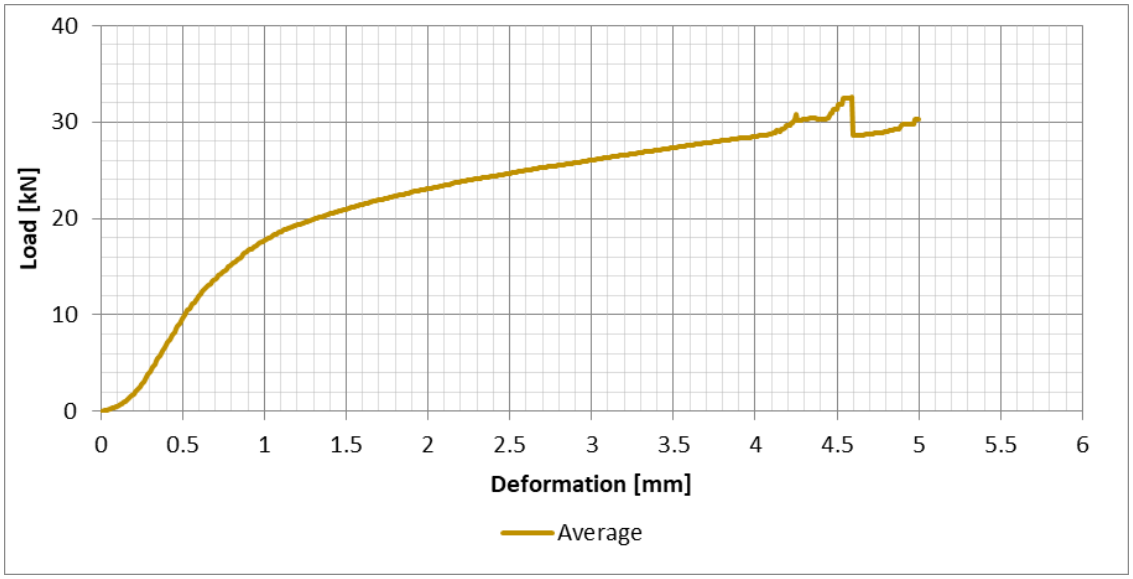

Figure 70: Scot Pine – 48 mm Bearing (one stud) (I7), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Scot Pine – 100 mm Bearing (Two studs) – I7

Scientific name: Pinus sylvestris
Identification number: I7 two
Characteristic Density: 441 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 3.4 MPa, Coefficient of Variation: 16.5
Characteristic perpendicular to grain Modulus of Elasticity: 251 MPa, Average perpendicular to grain Modulus of Elasticity: 256 MPa, Coefficient of Variation: 17.0
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/39.8

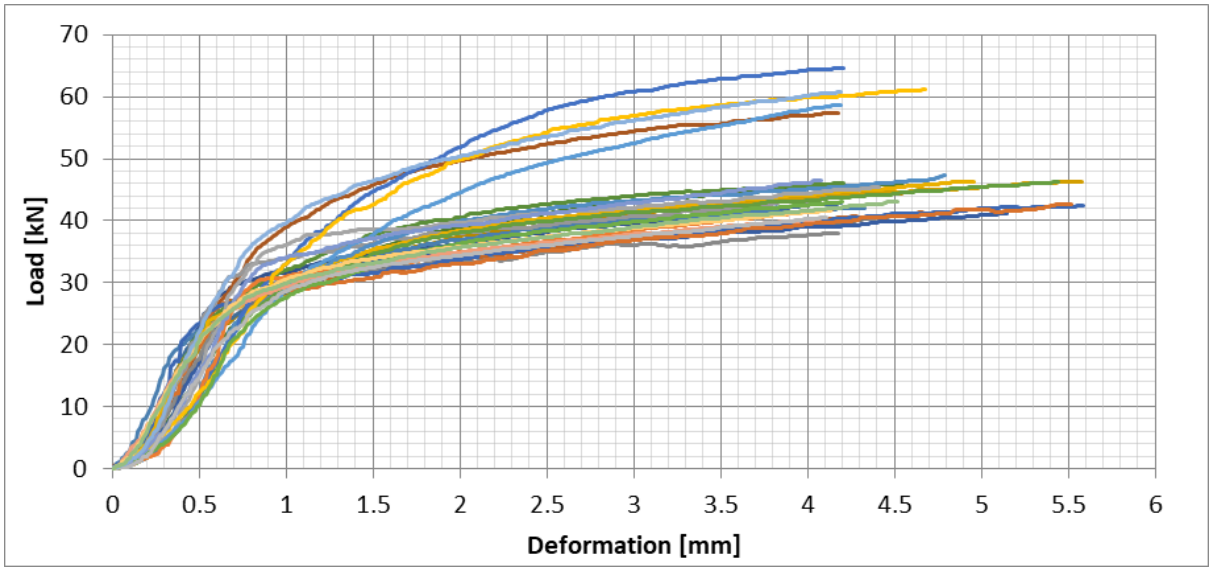

Figure 71: Scot Pine – 100 mm Bearing (Two studs) (I7), All test results – Perpendicular to the grain bearing - Load/Deformation

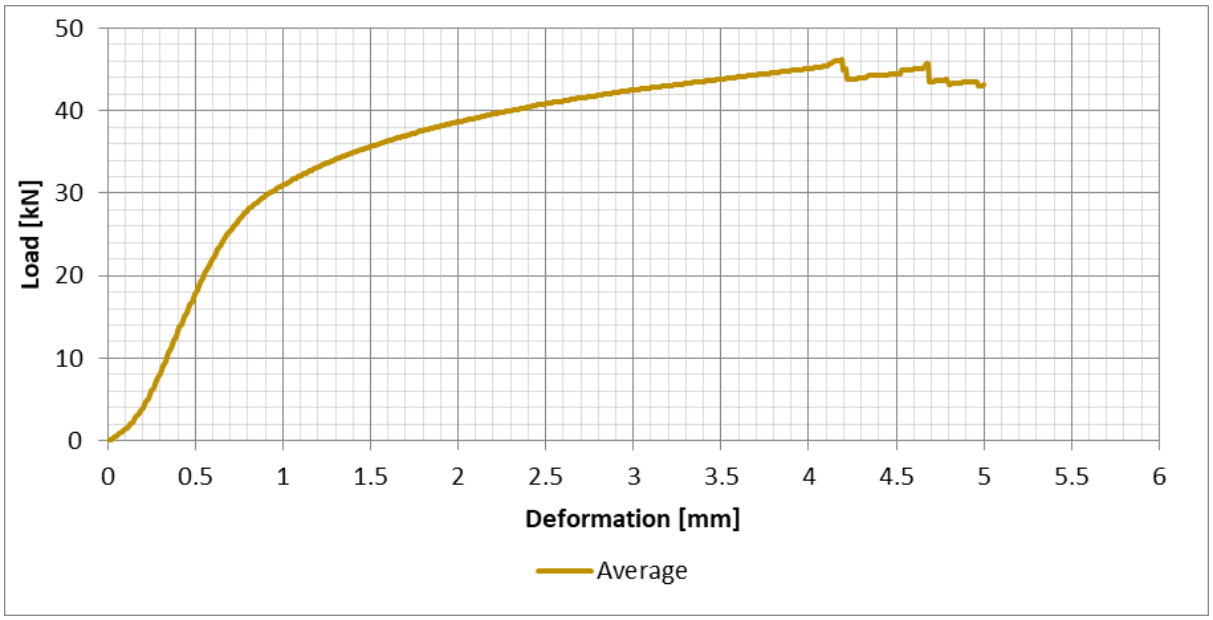

Figure 72: Scot Pine – 100 mm Bearing (Two studs) (I7), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Scot Pine – 150 mm Bearing (Three studs) – I7

Scientific name: Pinus sylvestris
Identification number: I7 three
Characteristic Density: 429 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 3.2 MPa, Coefficient of Variation: 14.0
Characteristic perpendicular to grain Modulus of Elasticity: 208 MPa, Average perpendicular to grain Modulus of Elasticity: 216 MPa, Coefficient of Variation: 21.1
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/48.1

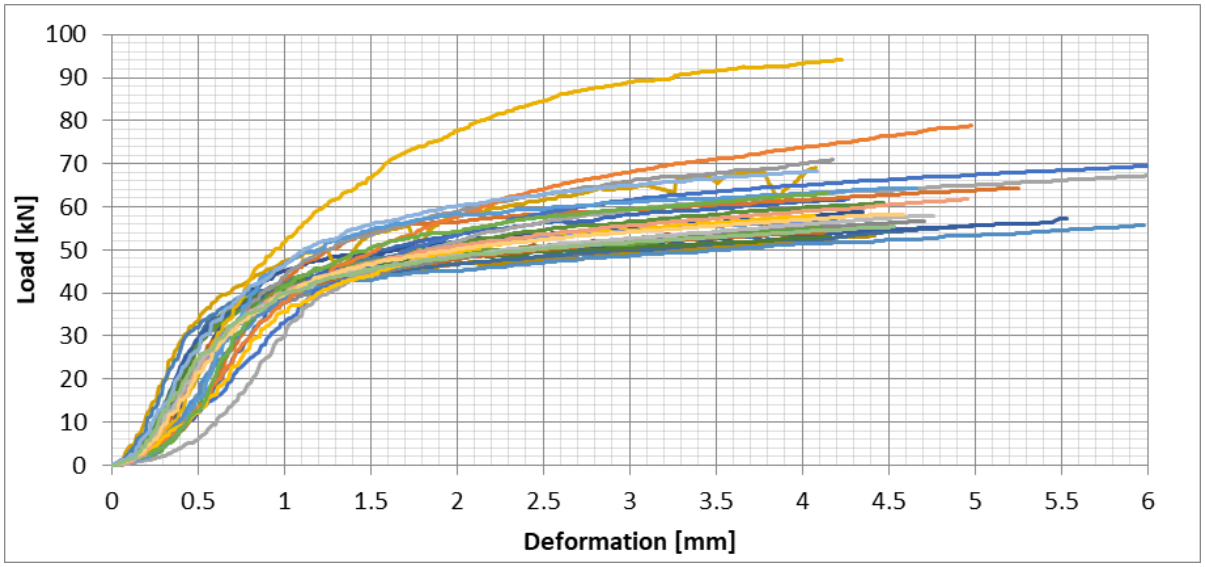

Figure 73: Scot Pine – 150 mm Bearing (Three studs) (I7), All test results – Perpendicular to the grain bearing - Load/Deformation

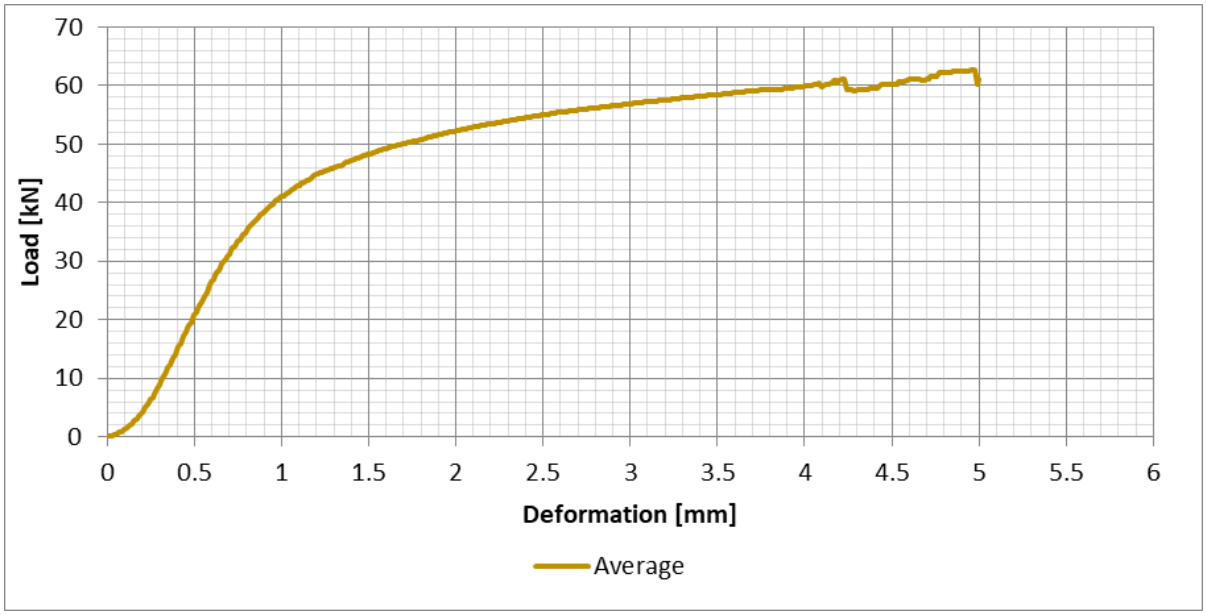

Figure 74: Scot Pine – 150 mm Bearing (Three studs) (I7), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Scot Pine – 200 mm Bearing (Four studs) – I7

Scientific name: Pinus sylvestris
Identification number: I7 four
Characteristic Density: 430 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 3.1 MPa, Coefficient of Variation: 12.5
Characteristic perpendicular to grain Modulus of Elasticity: 262 MPa, Average perpendicular to grain Modulus of Elasticity: 268 MPa, Coefficient of Variation: 14.0
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/38.2

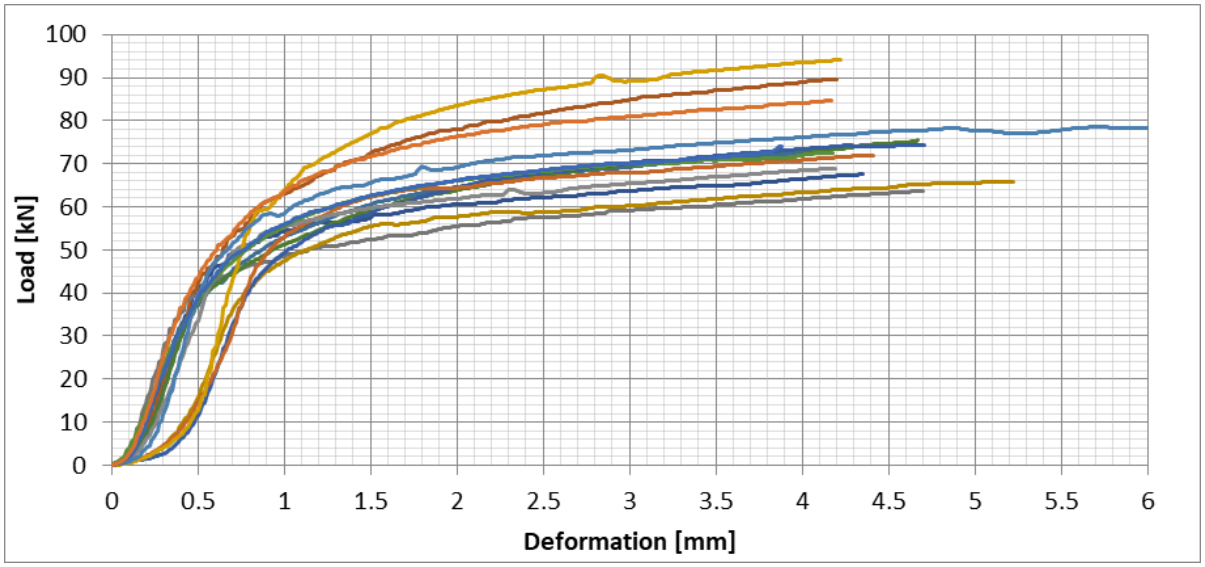

Figure 75: Scot Pine – 200 mm Bearing (Four studs) (I7), All test results – Perpendicular to the grain bearing - Load/Deformation

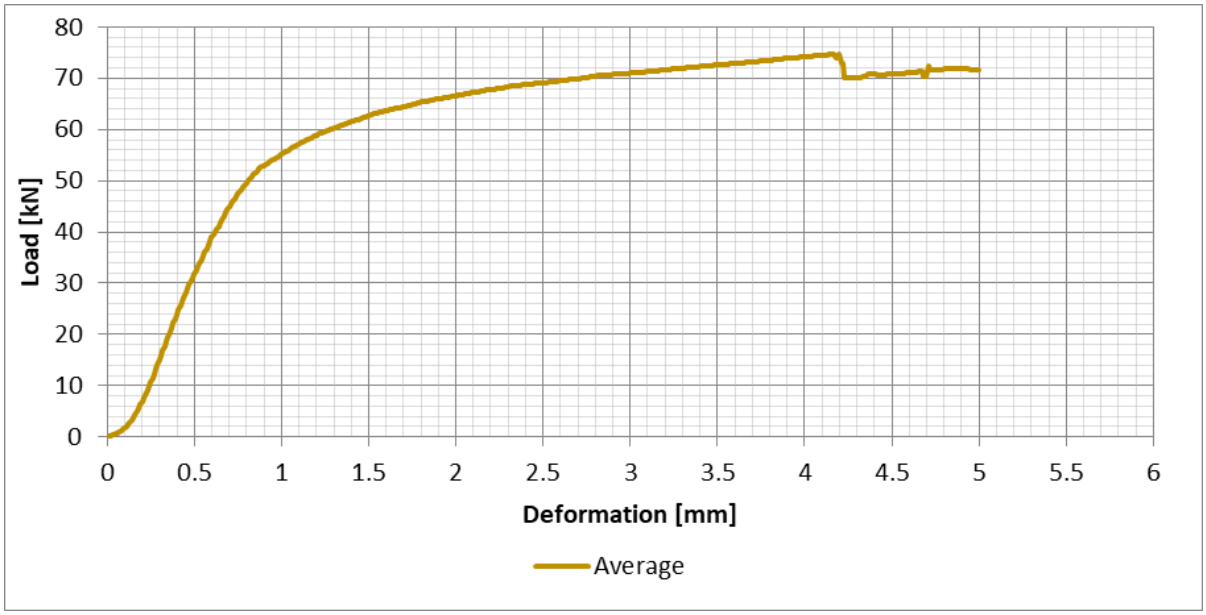

Figure 76: Scot Pine – 200 mm Bearing (Four studs) (I7), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Scot Pine – 25 mm Bearing (Half studs) – I7

Scientific name: Pinus sylvestris
Identification number: I7 half
Characteristic Density: 468 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 6.3 MPa, Coefficient of Variation: 6.3
Characteristic perpendicular to grain Modulus of Elasticity: 384 MPa, Average perpendicular to grain Modulus of Elasticity: 410 MPa, Coefficient of Variation: 15.9
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/26.0

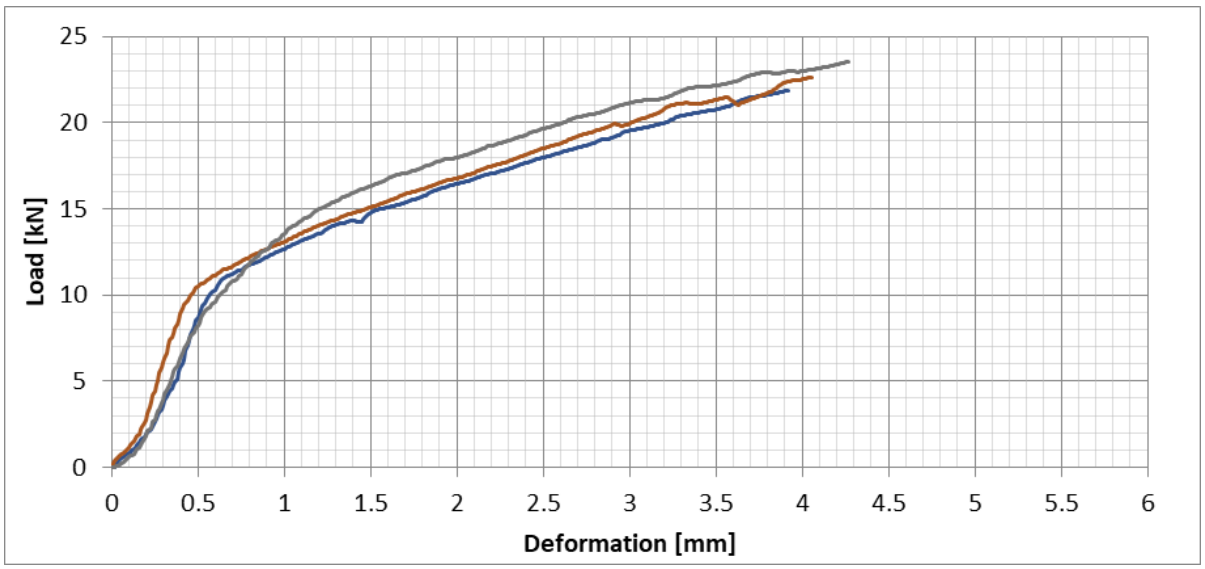

Figure 77: Scot Pine – 25 mm Bearing (Half studs) (I7), All test results – Perpendicular to the grain bearing - Load/Deformation

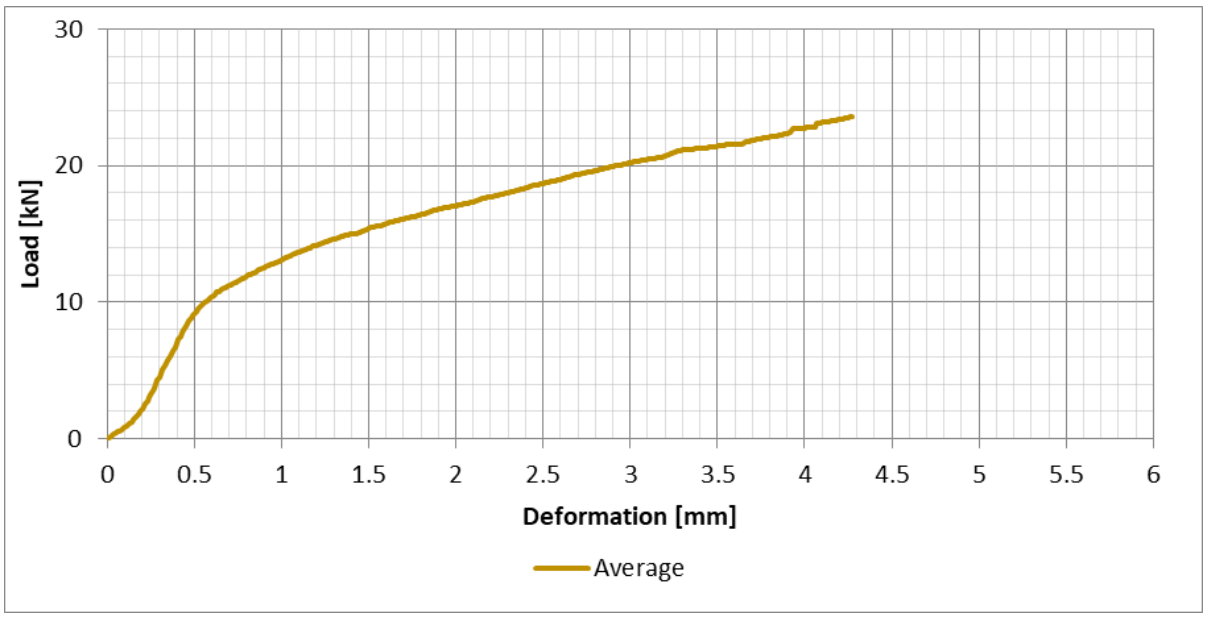

Figure 78: Scot Pine – 25 mm Bearing (Half studs) (I7), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S10 – Middle of Plate

Scientific name: Pinus radiata
Identification number: S10
Characteristic Density: 483 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 8.6 MPa, Coefficient of Variation: 12.7
Characteristic perpendicular to grain Modulus of Elasticity: 494 MPa, Average perpendicular to grain Modulus of Elasticity: 503 MPa, Coefficient of Variation: 14.2
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/20.2

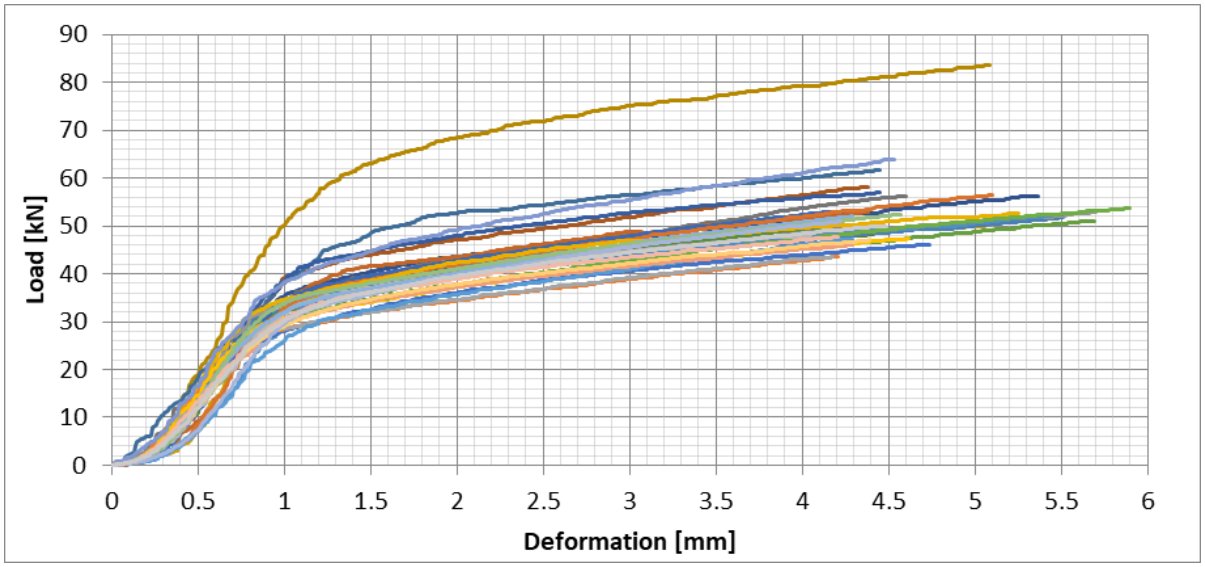

Figure 79: Radiata Pine – Middle of Plate (S10), All test results – Perpendicular to the grain bearing - Load/Deformation

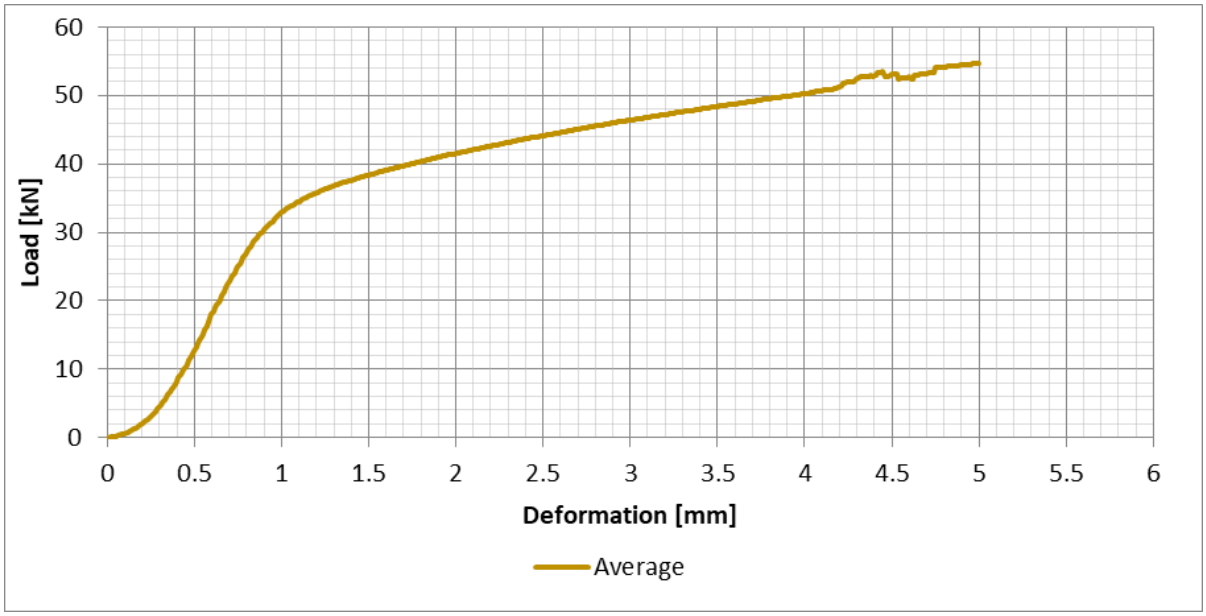

Figure 80: Radiata Pine – Middle of Plate (S10), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Radiata Pine – S10 – End of Plate

Scientific name: Pinus radiata
Identification number: S10 - End
Characteristic Density: 501 kg/m^3
Stress grade: MGP10
Characteristic perpendicular to grain bearing stress: 7.4 MPa, Coefficient of Variation: 9.7
Characteristic perpendicular to grain Modulus of Elasticity: 399 MPa, Average perpendicular to grain Modulus of Elasticity: 408 MPa, Coefficient of Variation: 16.5
The ratio of Modulus of Elasticity perpendicular to the grain to Modulus of Elasticity parallel to grain: 1/25.1

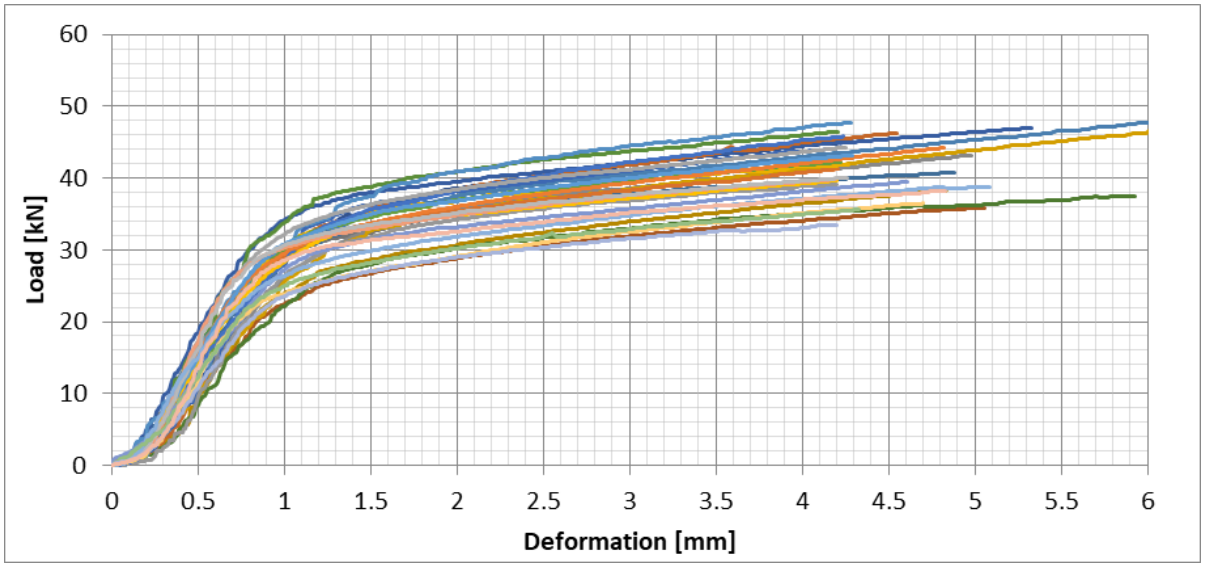

Figure 81: Radiata Pine – End of Plate (S10), All test results – Perpendicular to the grain bearing - Load/Deformation

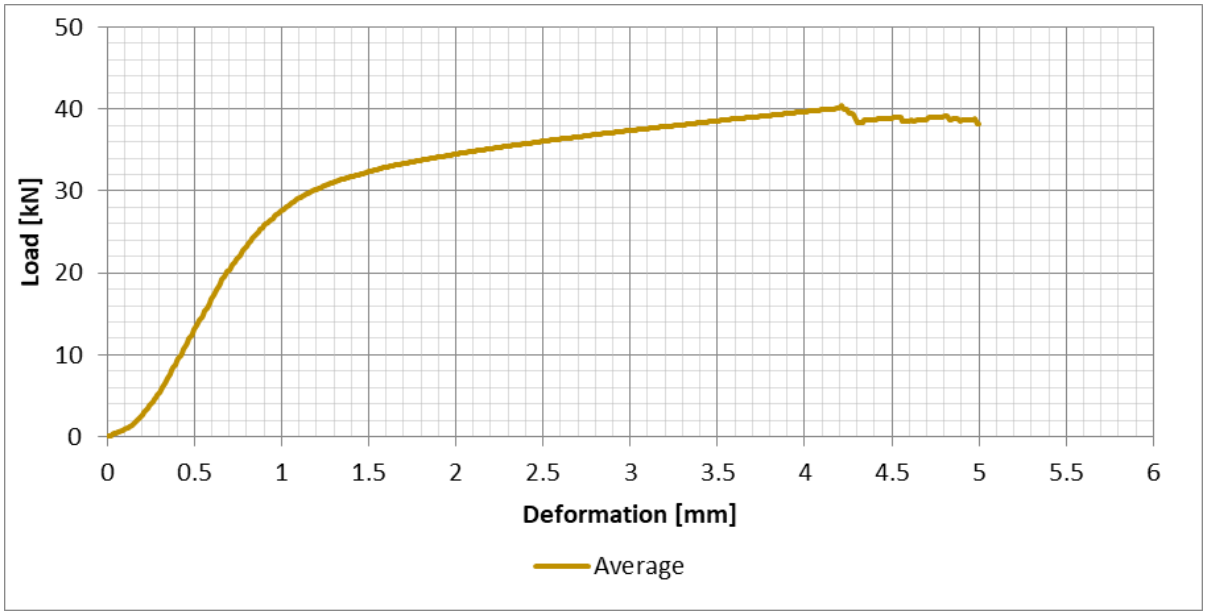

Figure 82: Radiata Pine – End of Plate (S10), Average of all test results – Perpendicular to the grain bearing - Load/Deformation

Discussion

The following discusses the outcomes of the research and testing.

Bearing Perpendicular to Grain

Table 3 compares the Characteristic Bearing Perpendicular to the Grain results from the research conducted against the AS 1720.1 permissible Bearing Perpendicular to the Grain values and the same values corrected by the K_7 factor. (K_7 factor is discussed in the next section.)

Table 4: Characteristic Bearing Perpendicular to the Grain results Against AS 1720.1 Values

	Trade Name	Measured Average Density (kg/m^3)	Characteristic Perpendicular to the Grain Bearing	AS 1720.1	
				f'p (MPA)	Corrected for k_7
Softwood					
S1	Radiata Pine MGP10	480	7.4	10	12.0
S2	Radiata Pine MGP10	498	7.5	10	12.0
S3	Radiata Pine MGP10	506	7.2	10	12.0
S4	Radiata Pine MGP10	490	8.2	10	12.0
S5	Radiata Pine MGP10	551	8.9	10	12.0
S12	Radiata Pine MGP10	476	7.4	10	12.0
S6	Radiata Pine MGP12	567	10.3	10	12.0
S7	Radiata Pine MGP12	606	12.9	10	12.0
S8	Radiata Pine MGP12	569	11.0	10	12.0
S11	Radiata Pine MGP15	536	8.4	10	12.0
S14	Caribbea Hybrid	562	8.7	10	12.0
S17	Cypress	679	21.7	10	12.0
Hardwood					
H1	Alpine Ash	712	15.5	17	20.4
H4	Jarrah	833	23.9	17	20.4
H5	Karri	866	16.7	23	27.6
H6	Blackbutt	903	19.9	23	27.6
H9	Southern Mahogany*	945	21.6	23	27.6
H8	Spotted gum	1,059	38.7	23	27.6
H7	Grey Ironbark	1,141	46.6	26	31.2
Imported					
I1	European/Norwegian spruce	510	6.6	10# to 13^	12 to 15.6
I2	Scots Pine	516	6.1	10	12.0
I3	NZ Radiata	449	6.9	10	12.0
I4	Douglas fir US (New)	476	5.1	13	15.6
I5	Douglas fir US (old)	596	8.8	13	15.6
H10	Meranti, Light red	443	7.7	8.6	10.32
I6	Western Red cedar	381	4.9	8.6	10.32
Geometry					
I7	Half stud	468	6.3		
I7	One 45 (50) wide stud	424	4.4	10	12.0
I7	Two 45 (100) wide studs	441	3.4	10	11.13
I7	Three 45 (150) wide studs	429	3.2	10	10
I7	Four 45 (200)wide stud	430	3.1	10	10

S10	End of plate	501	7.4	10	10
S10	Middle of plate	483	8.6	10	11.6

Notes: * Result from non-twisted samples only
MGP10 value
^ Strength group value

For Radiata pine, all MGP10 stress grade values were less than the AS 1720.1 values. The worst characteristic values for bearing perpendicular to the grain (f'p) were found to be 28% less, and the corrected value for K_7 was 40% less. Radiata pine MGP12 values were better than the AS 1720.1 f'p values but not the corrected value for K_7.

Imported softwood, European/Norway Spruce and Scot Pine were significantly lower being half to two thirds lower than AS 1720.1 values. Cypress, on the other hand, was double the capacity of the AS 1720.1 value.

Low to medium density hardwood was less than the AS 1720.1 values while the high-density species Spotted gum and Grey Ironbark were considerably better than the AS 1720.1 values.

The timber species Douglas fir was tested in two forms, a recently milled sample and an old sample found from recycled stock. The aim was to investigate if the values over time have changed. The new Douglas fir density was found to be 20% lower in capacity, but both values were found to be considerably below the AS 1720.1 values.

Figure 83 illustrates the characteristic perpendicular to the grain bearing values against the average density at 12% moisture content for the group of samples tested. The graph shows that the bearing resistance perpendicular to grain improves as the density of the timber increases. The values are roughly in line with the trend line, but there are exceptions to this. Some of this can be explained by the sample's inclusion of knots, surface roughness and twists in the samples themselves.

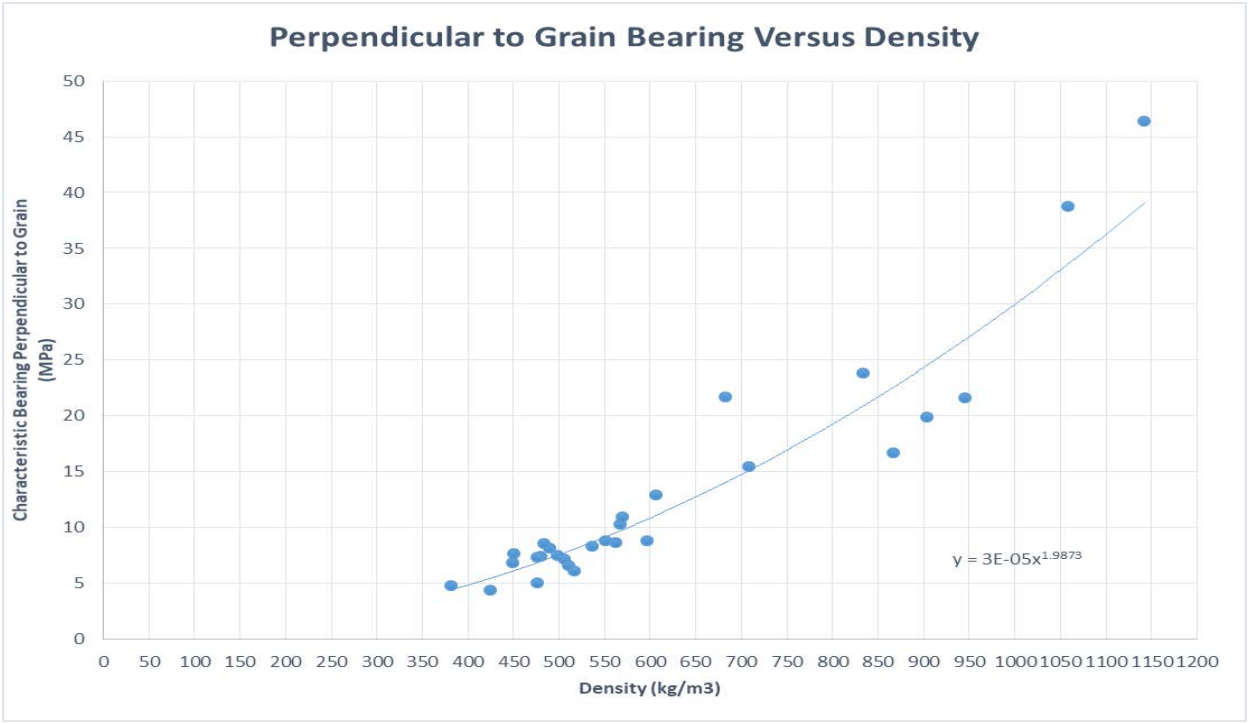

Figure 83: Characteristic perpendicular to the grain bearing values against the average density at 12% moisture

The comparison between the characteristic perpendicular to the grain bearing capacity and density was compared separately between hardwood and softwood. Figure 84 is for softwood, and Figure 85 is for hardwood.

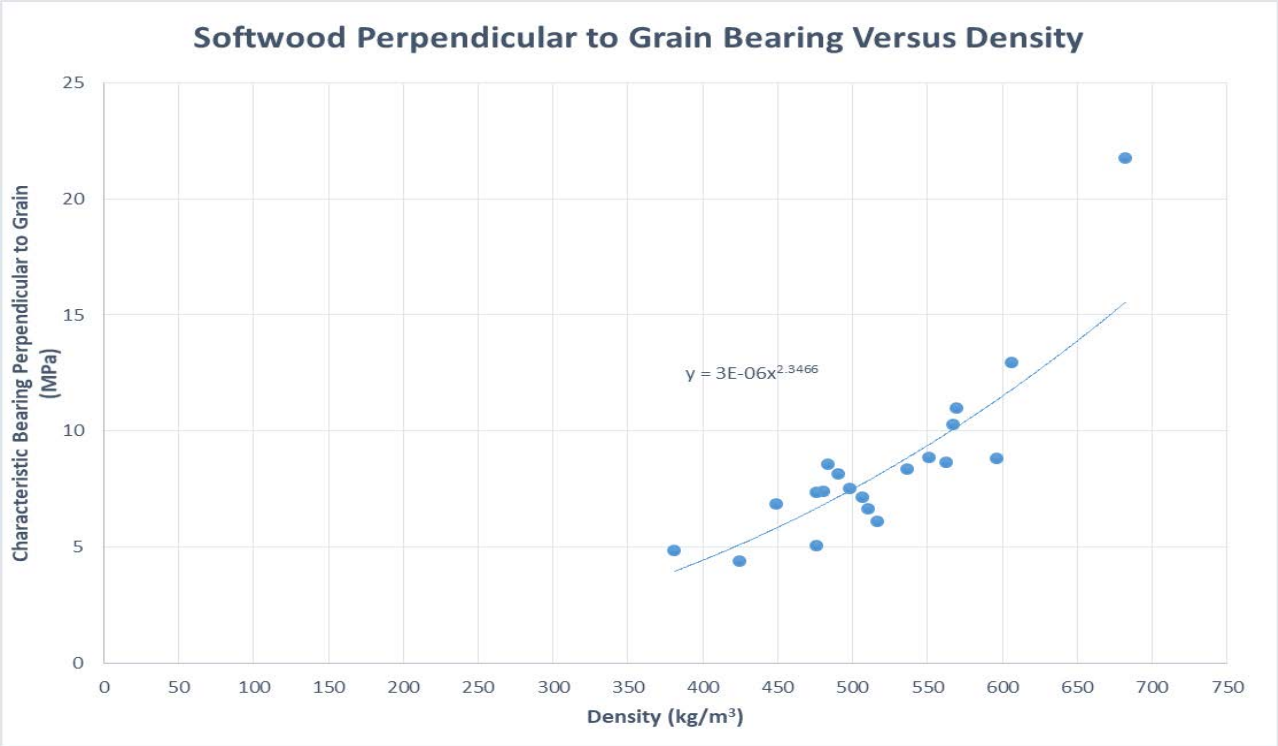

Figure 84: Softwood's Characteristic Perpendicular to the Grain Bearing against Density at 12% moisture

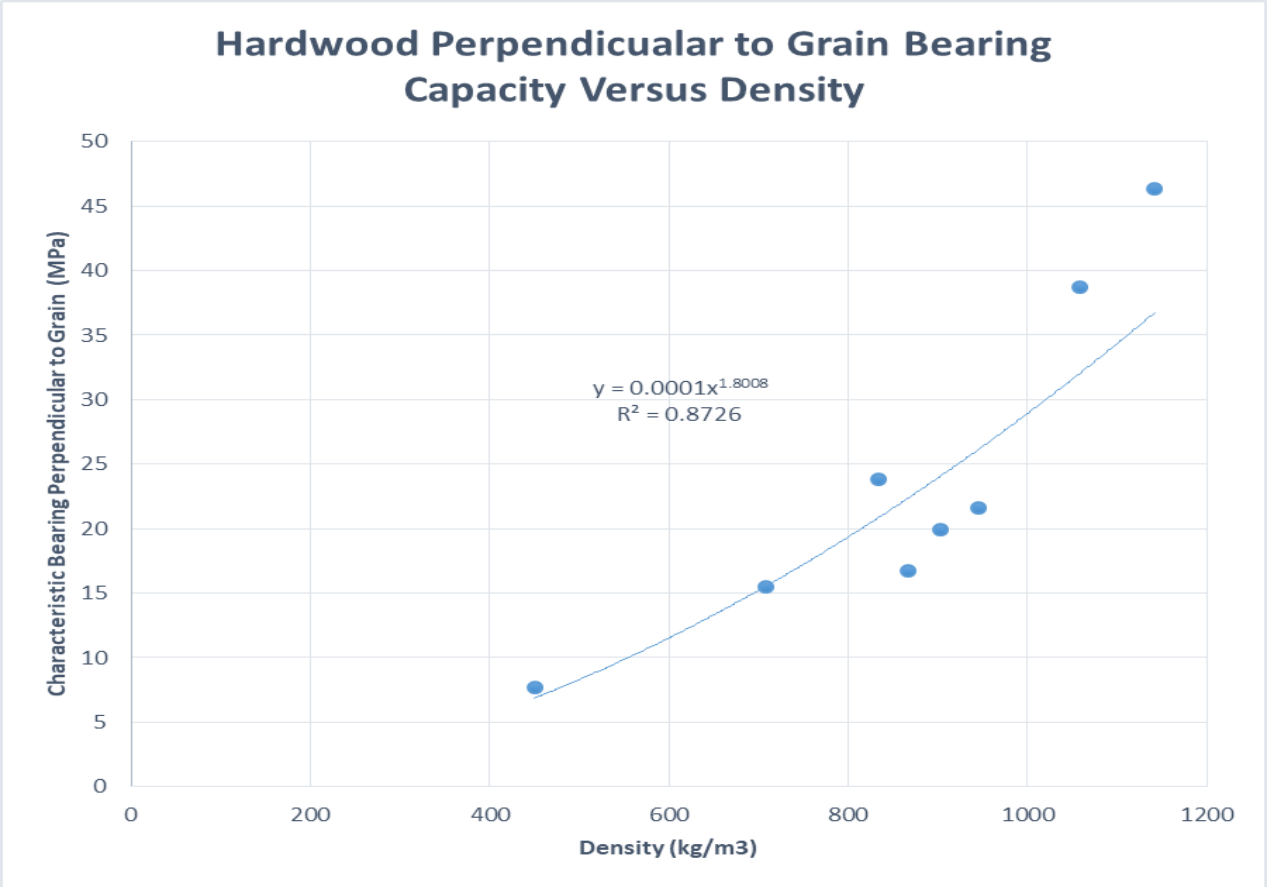

Figure 85: Hardwood Characteristic Perpendicular to Grain Bearing against Density at 12% moisture

K_7 *Value*

K_7 is the length and position of the bearing factor within AS 1720.1. When a rectangular bearing is located 75 mm or greater from the end of the timber element, the K_7 values increases the permissible stress for small bearing areas, refer to Table 4.

Table 5: AS 1720.1 K_7 Length of Bearing Factor

Length of Bearing Factor									
Length of bearing of member (mm)	**12**	**25**	**30**	**50**	**75**	**100**	**125**	**150**	**200**
Value of K_7 (AS 1720.1)	1.75	1.40	-	1.20	1.15	-	1.10	1.00	1.00

Therefore, when the bearing area is at least 150 mm along the grain, the permissible values for perpendicular to the grain bearing is the same as the characteristic perpendicular to the grain bearing. The concern is that the AS/NZS 4063.1 test method requires samples to be tested with 50 mm bearing along the grain. If the characteristic values determined by the test are implemented unmodified, then AS 1720.1 would allow these characteristic values to be increased by 20%, for a 50 mm bearing length, without any logical reason.

Figure 86 shows Scot Pine's characteristic perpendicular to the grain bearing with the different width metal plates being applied. The results confirm that the bearing perpendicular to grain stress increases as the bearing area decreases. It must be noted that not all of the samples tested were carried out in accordance to AS/NZS 4063, as the half stud test (I7 half) is based on a sample size of 3 samples and the value of the four-stud test is based on 14 samples.

Furthermore, the density of the sample of the half stud test had the highest density of the width samples investigated. As found in the above discussion, the perpendicular to the grain bearing capacity is, to some extent, influenced by the sample's density.

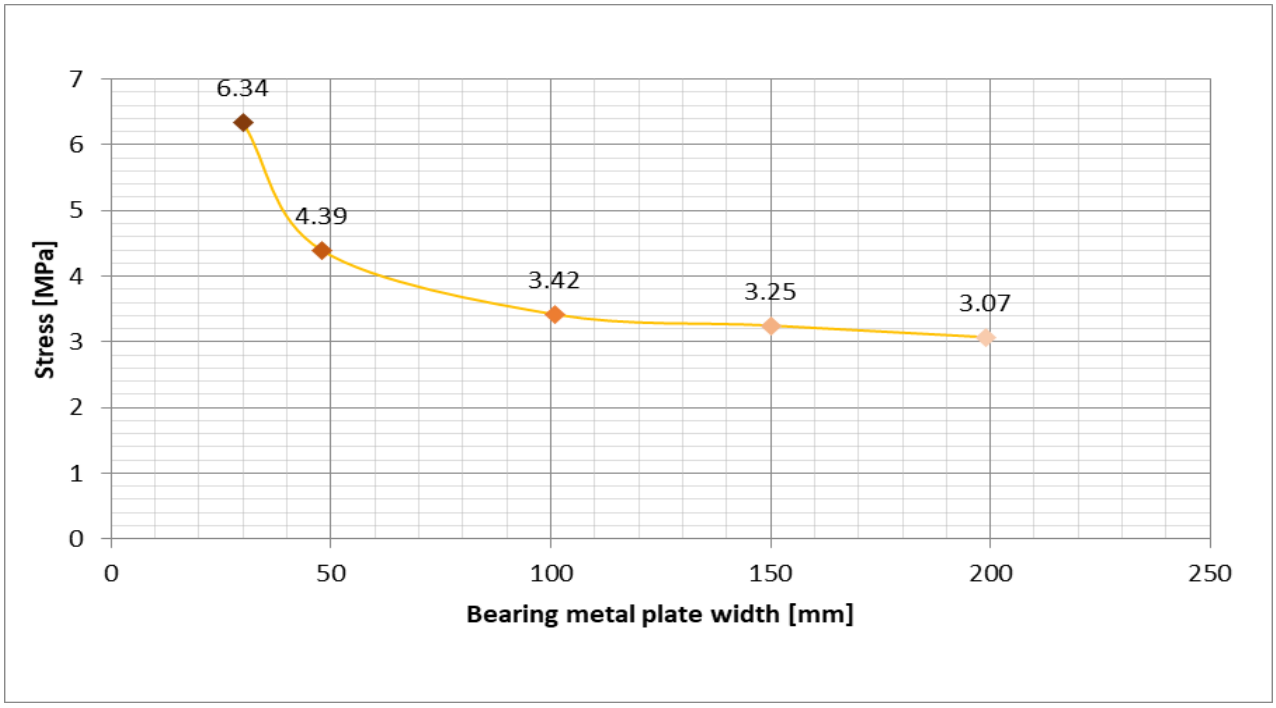

Figure 86: Characteristic Bearing Perpendicular to the Grain Compared with the Size of the Bearing Area

Table 5 and Figure 87 show the current values of K_7 in AS 1720.1 compared with the tested values. The K_7 factor decreases as the bearing area increases, corresponding with the values of K_7. The reason the bearing area affects the bearing capacity is due to the bending of the fibres at the side of the bearing area, refer to Figure 88. As the metal plate is squashed into the timber sample, the fibres at the side resist the bearing action to some extent. Therefore, for a small bearing area, the fibre bending at the side has greater effect than for a large bearing area. The K_7 factor accounts for this, and from the research, the impact of the bending fibres and the length of bearing becomes insignificant at around 200 mm. AS 1720.1 has K_7 equal to one, at 150 mm, which is in line with the outcome of the research.

Table 6: Comparison of AS 1720.1 K_7 value and the research results

Length of Bearing Factor									
Length of bearing of member (mm)	**12**	**25**	**30**	**50**	**75**	**100**	**125**	**150**	**200**
Value of K_7 (AS 1720.1)	1.75	1.40	-	1.20	1.15	-	1.10	1.00	1.00
Value of K_7 (Tested)	-	-	1.44	1.0	-	0.78	-	0.74	0.7

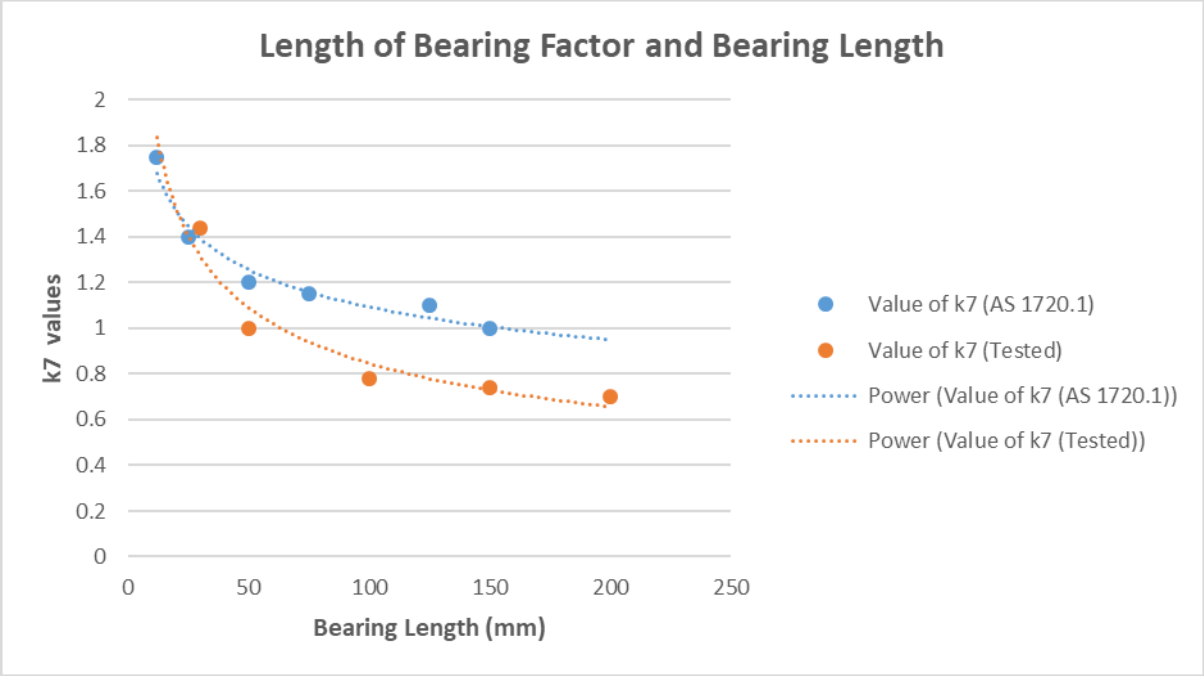

Figure 87: Comparison of K_7 factor: AS 1720.1 and test results

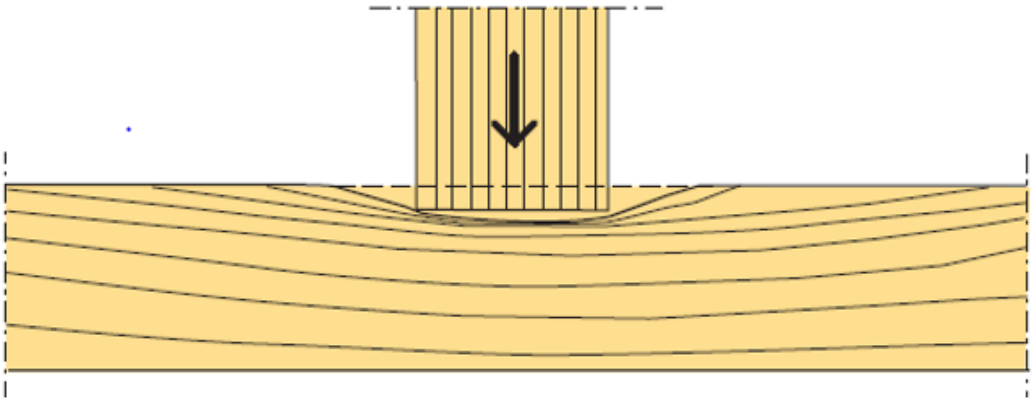

Figure 88: Perpendicular to grain bearing (Swedish Wood, 2015)

Therefore, to better compare the results for the determination of the characteristic perpendicular to grain test results against AS 1720.1 values, the tested results should be multiplied by 0.74, to align them with the 150 mm bearing length. Table 7 compares the characteristic perpendicular to the grain bearing capacity modified to align with 150 mm bearing length against AS 1720.1 values.

Table 7: Characteristic Bearing Perpendicular to Grain Research Results versus AS 1720.1 Values

	Trade Name	Characteristic Perpendicular to Grain Bearing		AS 1720.1	
		Tested Values (MPa)	Tested Values multiplied by 0.74 to obtain 150 mm bearing area value equivalence (MPA)	Correction value to AS 1720.1 k_7 (1/1.2)	f'p (MPA)
Softwood					
S1	Radiata Pine MGP10	7.4	5.5	6.2	10
S2	Radiata Pine MGP10	7.5	5.5	6.3	10
S3	Radiata Pine MGP10	7.2	5.3	6.0	10
S4	Radiata Pine MGP10	8.2	6.1	6.8	10
S5	Radiata Pine MGP10	8.9	6.6	7.4	10
S12	Radiata Pine MGP10	7.4	5.5	6.2	10
S6	Radiata Pine MGP12	10.3	7.6	8.6	10
S7	Radiata Pine MGP12	12.9	9.5	10.8	10
S8	Radiata Pine MGP12	11.0	8.1	9.2	10
S11	Radiata Pine MGP15	8.4	6.2	7.0	10
S14	Caribbea Hybrid	8.7	6.4	7.3	10
S17	Cypress	21.7	16.1	18.0	10
Hardwood					
H1	Alpine Ash	15.5	11.6	12.9	17
H4	Jarrah	23.9	17.7	19.9	17
H5	Karri	16.7	12.4	20.0	23
H6	Blackbutt	19.9	14.7	16.6	23
H9	Southern Mahogany*	25.6	16.0	21.3	23
H8	Spotted gum	38.7	28.6	23.8	23
H7	Grey Ironbark	46.6	34.5	38.8	26
Imported					
I1	European/Norway spruce	6.6	4.9	4.1	10# to 13^
I2	Scots Pine	6.1	4.5	5.1	10
I3	NZ Radiata	6.9	5.1	5.8	10
I4	Douglas fir US (New)	5.1	3.8	4.3	13
I5	Douglas fir US (old)	8.8	6.5	7.3	13
H10	Meranti, Light red	7.7	5.7	6.4	8.6
I6	Western Red cedar	4.9	3.6	4.1	8.6
Geometry					
I7	One 45 (50) wide stud	4.4	3.3	3.7	10
S10	Middle of plate	8.6	6.4	7.2	10

Notes: * Result from non-twisted samples only
MGP10 value
^ Strength group value

When the tested values are modified to a bearing area of 150 mm, the values of bearing perpendicular to grain decrease further away from the f'p values within AS 1720.1. The benefit from this is that the K_7 factor relating to bearing area within AS 1720.1 can remain as long as the characteristic values determined by AS/NZS 4063 are modified from their 50 mm bearing length to 150 mm.

Effect on Bearing Location

AS 1720.1 K_7 factor is only allowed if the bearing occurs 75 mm or greater from the end of the timber piece. The research investigated this by testing the bearing capacity for samples tested at the end and also in the middle of the sample's area. The tests were conducted from one source of Radiata Pine from one mill, with the specimens having similar density, growth ring and stress grade. Figure 89 displays the characteristic values of the end and the middle of the sample. It was found that the test value load at the end was 14% less than the values tested in the middle.

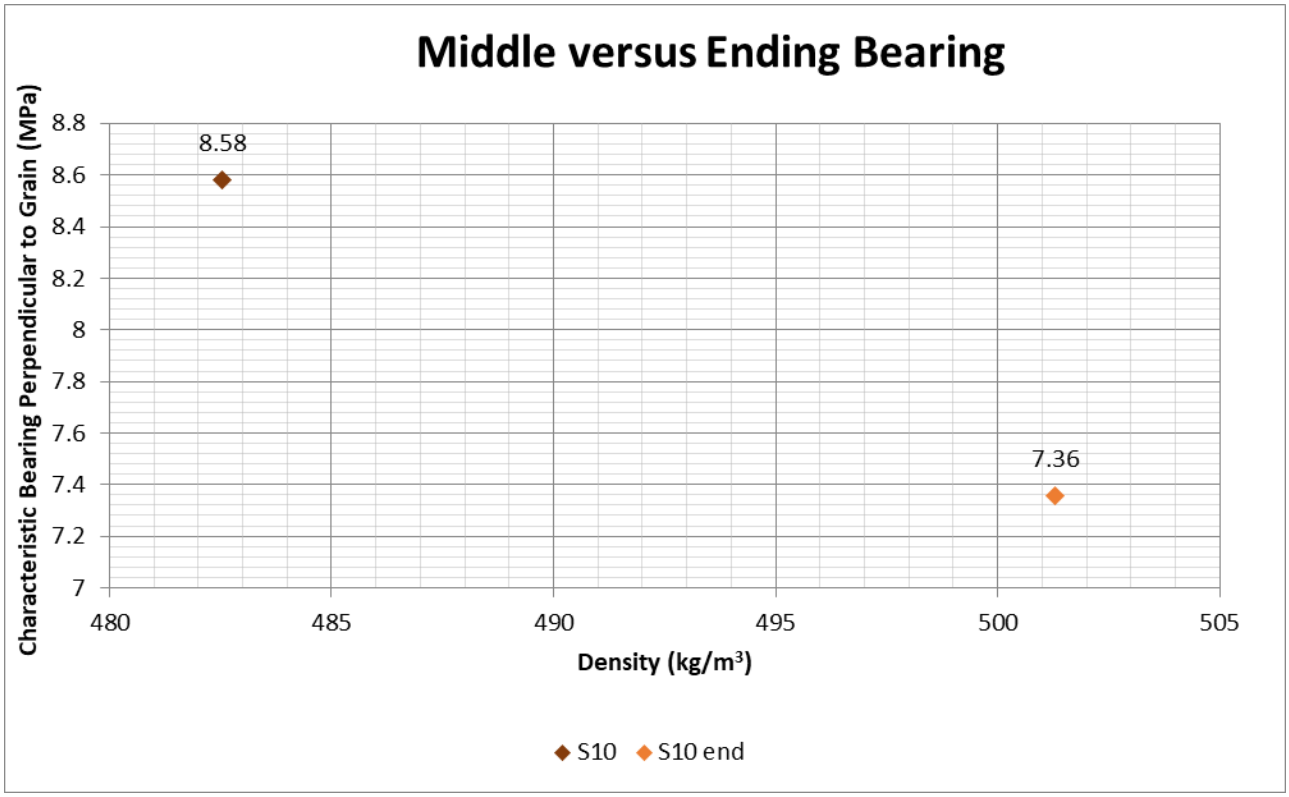

Figure 89: Comparison between the bearing location: the middle and the end

This was further explored with other timber species and densities. The values from the testing conducted on the end of the additional species was based on three tests per species, and because of the low volume of test data, the mean values were taken in the comparison.

Figure 90 displays the mean values of different species. The different percentages of the middle to the end values vary from 6% to 27%; greater variation was found for timber that had a high density. The average variation was found to be approximately 18%. This value was found to be closer to the correction factor of 1/1.2 (0.83) found in AS 1720.1 than the single species characteristic value investigated above.

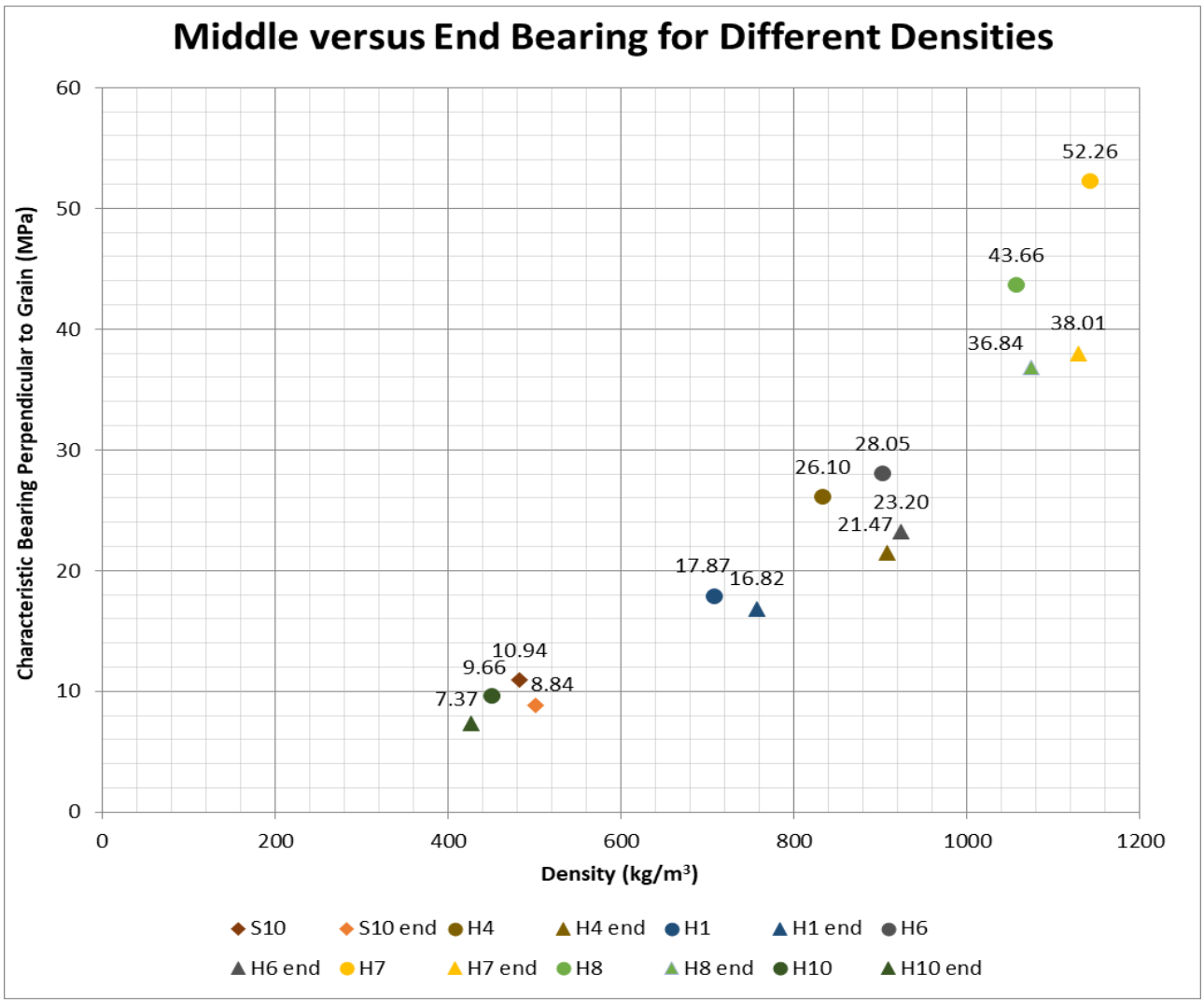

Figure 90: Comparison between the bearing location: the middle and at the end for different wood species

Comparing Timber Species Published Density to Tested Bearing Strength Values

The research found that there is a relationship between the characteristic perpendicular to the grain bearing and the sample's density. As the research was conducted with samples that did not align with the published density values for the various timber species within AS 1720.1, an exercise was conducted to determine what these values would be using the results of the trend line from the research and the published density values. Table 7 summaries the bearing capacity from the trend line for each timber species investigated and their published values for average density.

The second set of values showing bearing capacity have been included, and this set represents the modified values for a 150 mm bearing area utilising the K_7 modification which was discussed previously.

Table 7: Characteristic Bearing Perpendicular to Grain research results against AS 1720.1 Values

Trade Name	AS 1720.1 Published Density (kg/m3)	Characteristic Perpendicular to Grain Bearing		AS 1720.1	
		Tested Values (MPa)	Tested Value multiplied by k_7 correction (1/1.2) to obtain 150 mm bearing area value (MPA)	f'p (MPA)	Corrected for K_7
Softwood					
Radiata Pine MGP10	550	9.0	7.5	10	12.0
Caribbea Hybrid	550	9.0	7.5	10	12.0
Cypress	700	15	12.5	10	12.0
Hardwood					
Alpine Ash	650	12.5	10.4	17	20.4
Jarrah	800	19.2	16.0	17	20.4
Karri	900	24.2	20.2	23	27.6
Blackbutt	900	24.2	20.2	23	27.6
Southern Mahogany*	920	24.5	20.4	23	27.6
Spotted gum	1100	36.5	30.4	23	27.6
Grey Ironbark	1100	36.5	30.4	26	31.2
Imported					
European/Norway spruce	420	5.0	4.2	10# to 13^	12 to 15.6
Scots Pine	500	7.5	6.3	10	12.0
NZ Radiata	550	9.0	7.5	10	12.0
Douglas fir US (New)	550	9.0	7.5	13	15.6
Meranti, Light red	400	4.9	4.1	8.6	10.32
Western Red cedar	350	4.0	3.3	8.6	10.32

Notes:
MGP10 value
^ Strength group value

Where the published densities of the timber species was used, the bearing capacity was closer to the AS 1720.1 published values than the values from the actual species density. For the low to medium density timber there still remains significant difference between the research results and the AS 1720.1 published values.

Modulus of Elasticity Perpendicular to Grain

From the perpendicular to grain bearing testing, it is possible to determine a MoE perpendicular to the grain for the timber species tested, as the test output from the perpendicular to the grain bearing testing is a load versus deformation curve. However, the test setup of bearing perpendicular to the grain required by AS/NZS 4063.1 is not the same method described in AS/NZS 4063.1 Appendix A3 to determine the Modulus of Elasticity (MoE) perpendicular to the grain. The process differs in the arrangement of the applied load, as the perpendicular bearing procedure requires one steel plate on top of the sample while the procedure for perpendicular to grain MoE requires two plates, one on top of the sample and the other below the sample.

Nevertheless, the procedure outlined in AS/NZS 4063.1 Appendix A3 have been followed to determine the MoE values, however, as it is not possible to claim direct compliance to AS/NZS 4063.1 Appendix A3, consequently the values are considered indicative only.

Refer to the result section of this report for the characteristic and average MoE Perpendicular to Grain for each timber species tested. Figure 91 illustrates the average MoE Perpendicular to Grain for the different timber species against their densities.

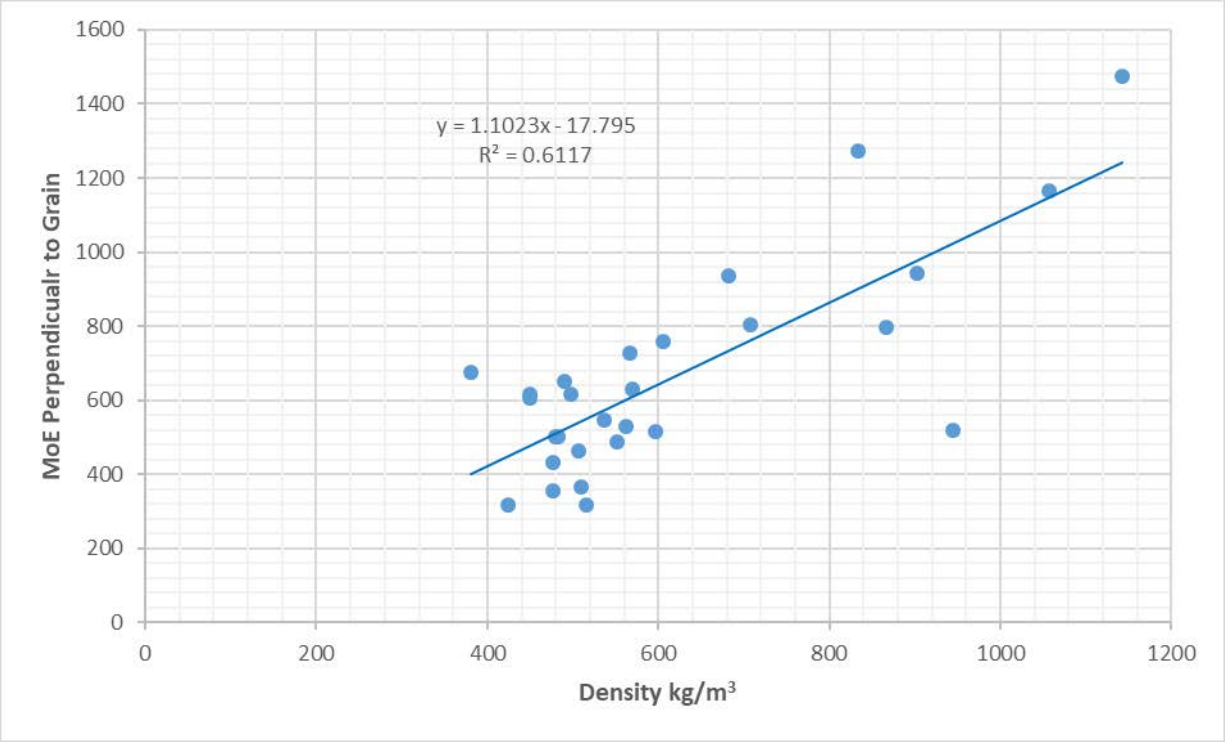

Figure 91: Average MoE Perpendicular to the grain against density for all species investigated

Figure 92 displays the average MoE Perpendicular to the Grain for softwood species tested, and Figure 93 illustrates hardwood species.

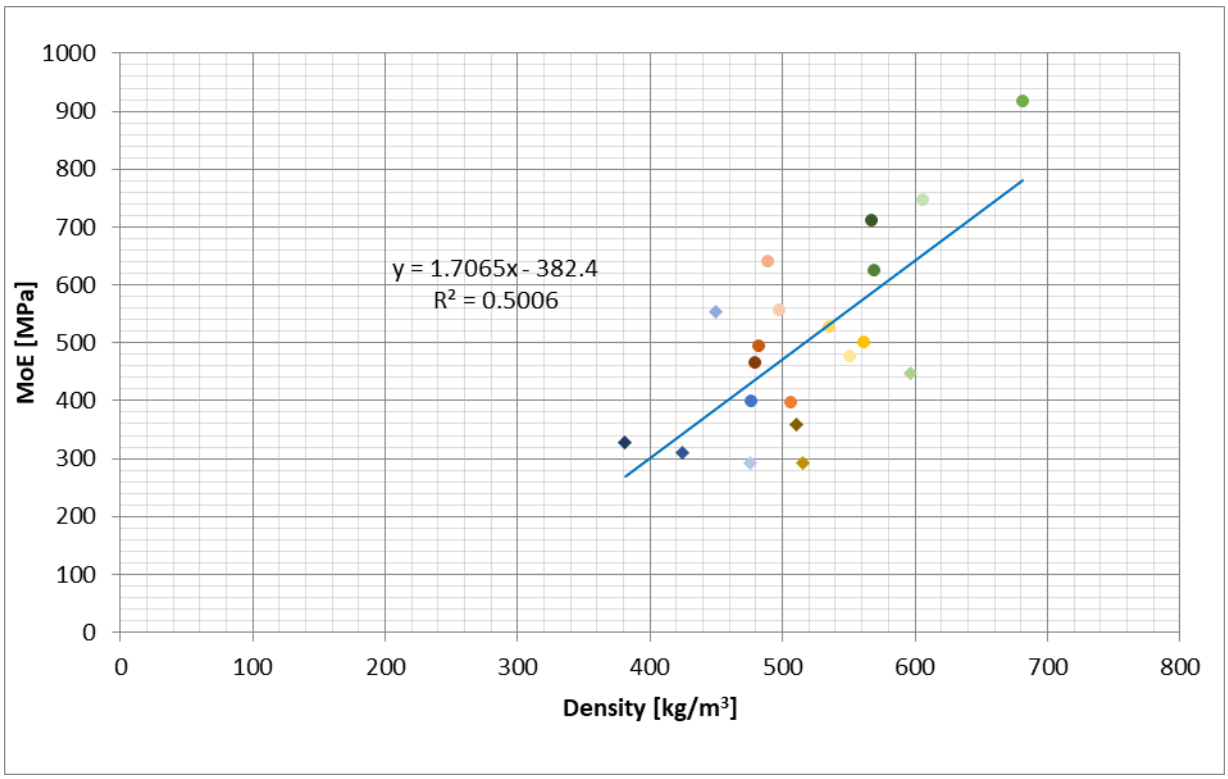

Figure 92: Average MoE Perpendicular to the grain against softwood density

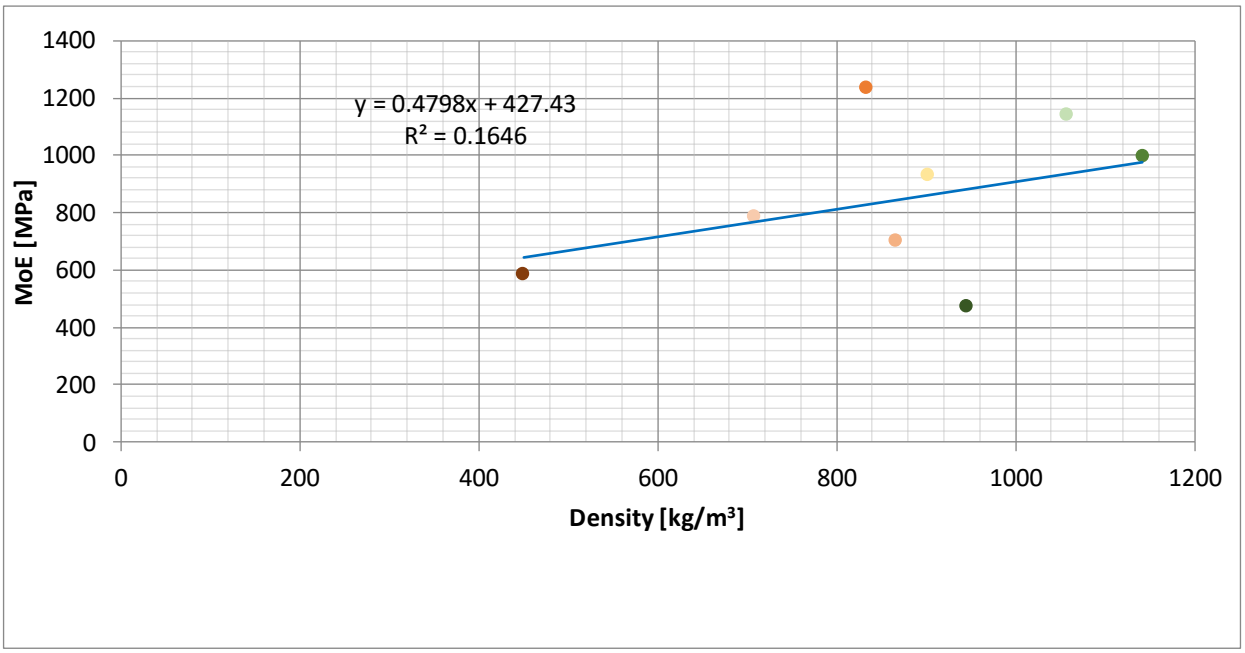

Figure 93: Average MoE Perpendicular to the grain against hardwood density

AS 1720.1 does not contain information on MoE Perpendicular to the Grain for any timber species. The assumption used in the WoodSolutions guide[2] is MoE Perpendicular to Grain is MoE Parallel to the Grain divided by 30, or 25 when knots are present. Table 8 compares the ratio of MoE Perpendicular to the Grain is MoE Parallel to the Grain for the various timber species tested.

[2] WoodSolutions Guide 50 Mid-rise Timber Building Structural Engineering Design Guide

Table 9: MoE Perpendicular to Grain

	Trade Name	AS 1720.1		Research	
		Stress Grade	Average MoE MPA	Characteristic MoE Perpendicular to Grain MPA	Ratio of Parallel to Perp to Grain MoE
Softwood					
S1	Radiata Pine MGP10	MGP10	10,000	465	1/21.5
S2	Radiata Pine MGP10	MGP10	10,000	556	1/18
S3	Radiata Pine MGP10	MGP10	10,000	396	1/25.3
S4	Radiata Pine MGP10	MGP10	10,000	639	1/15.6
S5	Radiata Pine MGP10	MGP10	10,000	476	1/21
S12	Radiata Pine MGP10	MGP10	10,000	399	1/25.1
S6	Radiata Pine MGP12	MGP12	12,700	712	1/17.8
S7	Radiata Pine MGP12	MGP12	12,700	745	1/17
S8	Radiata Pine MGP12	MGP12	12,700	623	1/20.4
S11	Radiata Pine MGP15	MGP15	15,200	526	1/28.9
S14	Caribbea Hybrid	MGP10	10,000	502	1/19.9
S17	Cypress	F7	7,900	921	1/8.6
Hardwood					
H1	Alpine Ash	F17	14,000	785	1/17.8
H4	Jarrah	F17	14,000	1,233	1/11.4
H5	Karri	F17	14,000	700	1/11.4
H6	Blackbutt	F27	18,500	932	1/19.8
H9	Southern Mahogany	F17	14,000	1/29.7	1/29.7
H8	Spotted gum	F27	18,500	1,143	1/16.9
H7	Grey Ironbark	F27	18,500	999	1/18.5
Imported					
I1	European/Norway spruce	MGP10	10,000	358	1/28
I2	Scots Pine	MGP10	10,000	291	1/34
I3	NZ Radiata	MGP10	10,000	554	1/18
I4	Douglas fir US (New)	F7	7,900	291	1/27
I5	Douglas fir US (old)	F7	7,900	447	1/17.7
H10	Meranti, Light red	F4	6,100	586	1/10.4
I6	Western Red cedar	F4	6,100	329	1/18.5
Geometry					
I7	One 45 (48) wide stud	MGP10	10,000	310	1/32.3
S10	Middle of plate	MGP10	10,000	494	1/20.2

The results contained in Table 8 suggest that there is no common ratio between MoE Perpendicular to the Grain and MoE Parallel to the Grain. There are potentially several reasons for this, the main one being the assigning of MoE parallel to the grain values, are not the values found from the sample themselves, but from the stress grade of the timber used. The comparison is particularly unfair for “F” graded material, as “F” grades are strength grades, usually determined by visual grading methods, where no MoE parallel to the grain is evaluated. Also, as the stress grading process assigns the lowest grade for the length of timber, the individual pieces cut from the length may have higher values, further complicating the matter. Therefore, the results are

inconclusive in determining if there is a ratio of MoE Perpendicular to the Grain to Parallel to the Grain.

Calculation of Axial Shortening in Timber Framed Buildings

The soon to be published WoodSolutions Guide 50 – Mid-rise Timber Building Structural Engineering Design Guide, contains a calculation method for deformation for bearing perpendicular to the grain. The equation below is repeated from the guide and represents the method to calculate shortening due to compression caused by perpendicular to the grain.

$$\delta_{c,p} = \sum_{floors} \frac{j_2 N_{c,i} d_{2,i}}{E_{p,i} A_{p,i}} \qquad \textit{Equation 6.5}$$

where:

$\delta_{c,p}$ = Total compression shortening perpendicular to the grain (mm)
j_2 = Duration of load factor for long-term loads = 2
$N_{c,i}$ = Long-term compression forces in a stud in the storey *i* (kN)
$d_{2,i}$ = Height of elements perpendicular to the grain in the storey *i* (mm)
$E_{p,i}$ = Modulus of elasticity perpendicular to the grain in the storey *i* (MPa)
$A_{p,i}$ = Loaded cross-sectional area of elements perpendicular to the grain in the storey *i* (mm^2)

The determination of the total compression of shortening perpendicular to the grain requires the Modulus of Elasticity perpendicular to the grain to be used. The guide suggests for clear wood that the ratio between parallel to the grain and perpendicular to the grain MoE is 1/30. It also suggests that if knots are present in the loaded area, the MoE perpendicular to the grain can be close to the MoE parallel to the grain and recommends the ratio of 1/25 to be used.

The results from above found that the ratio assumption of MoE Parallel to Grain to Perpendicular to Grain in the guide was not found.

Indicator of MoE Perpendicular to Grain by Joint Group

MoE perpendicular to grain determined above requires the knowledge of the timber species and density. Designers are often not aware of the actual timber species that they may be used in the construction of the structure and therefore the timber's density. What designers do have control over is the specification of the timber, and this specification may include timber size, stress grade, seasoned condition, i.e. seasoned or unseasoned, preservative treatment if applied and occasionally appearance grade. None of these specifications correlates to the MoE Perpendicular to Grain.

However, the research above found that density had a correlation to MoE Perpendicular to Grain. Now considering what tools are available to the structural designer within AS 1720.1, the only specification within timber engineering that has density as a criterion is Joint Group. The capacity of the joint is related to timber density, as the connection strength is frequently dominated by perpendicular to grain bearing. Table 9 indicates the range of densities for various timber Joint Groups.

Table 10: Timber Joint Group and Calculated MoE Perpendicular to Grain from Research results

	Hardwood		Softwood	
Joint Group (AS 1720.1)	**Range of Density of Timber Species with same Joint Group[1] (12% MC)**	**Average Density for Joint Group**	**Range of Density of Timber Species with same Joint Group[1] (12% MC)**	**Average Density for the Group (kg/m^3)**
JD1	950 to 1200	1075	-	-
JD2	750 to 950	850	-	-
JD3	650 to 750	700	650 to 700	675
JD4	-	-	500 to 550	525
JD5	-	-	500 to 550	525
JD6	-	-	400	400

Note:

1. Data is based on AS 1720.1 Table H2.3 and H2.4
2. JD4 for hardwood is for rainforest species and meranti have been ignored
3. MoE Perpendicular to Grain best-fit equation = 1.1023x – 17.795

Figure 94 graphs the average density of the timber tested and the average MoE Perpendicular to Grain. Average MoE perpendicular to grain has been used as the principle being investigated is a serviceability issue, i.e. deformation. Deflection within timber design also uses average MoE. The research found a linear relationship that had an equation of

$$MoE\ perp\ to\ Grain = 0.8209x + 143.23 \qquad \text{– Eqn 1}$$

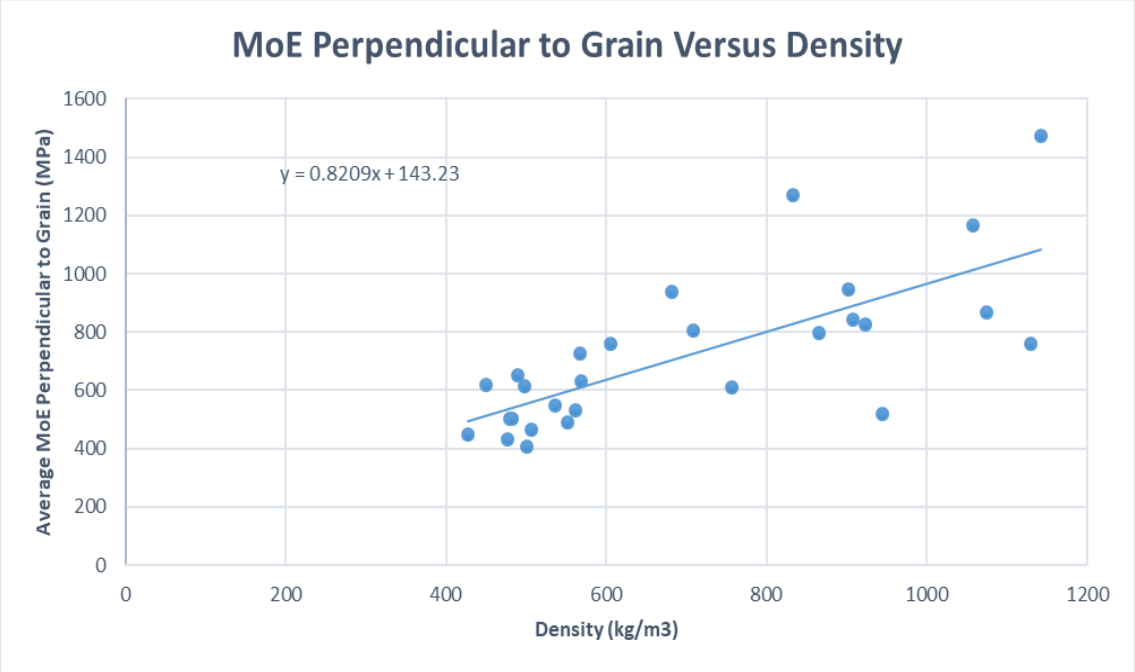

Figure 94: Average MoE Perpendicular to Grain versus Timber Density at 12 % MC

To check whether the assumption is valid, the tested timber species average MoE Perpendicular to Grain is compared to the average MoE perpendicular to grain calculated using the Joint Group's average density.

Table 11: Compares the test results of MoE perpendicular to Grain for individual timber species against the value obtained from the joint group average density, calculated in Table 9.

Timber Species	Joint Group	Average MoE Perpendicular to Grain from Test Results (MPa)	MoE Perpendicular to Grain calculated form Test Results using Average Joint Group Density (MPa)
European/Norway spruce	JD6	367	471
Scots Pine*	JD6	318	471
Radiata Pine MGP10	JD5	522#	574
Radiata Pine MGP12	JD4	706+	574
Douglas Fir (US)	JD4	514	574
Alpine Ash	JD3	802	718
Karri	JD2	797	841
Blackbutt	JD2	944	841
Jarrah	JD2	1,271	841
Grey Ironbark	JD1	1,473	1,026
Spotted gum	JD1	1,164	1,026

Note: # Average of 210 tests, +Average of 90 test and *Average of 60 test

For Radiata pine, the average density from AS1720.1 is the same for each joint group, JD4 and JD5. Reviewing the density data from the results of the tests, it was found that the average density for MGP10 radiata pine was approximately 500 kg/m^3, while for MGP12 radiata pine the density was 581 kg/m^3. The density for MGP10 is greater than expected for a Joint Group JD5 where JD5 is considered to have a density of 480 kg/m^3 or less.

Investigating the MGP10 radiata pine that has a density of 480 kg/m^3 or less, lowers the MoE Perpendicular to Grain considerably to 466 MPa. Table 11 repeats Table 10 but uses the revised Radiata MGP10 JD5 density of 480 kg/m^3 or less results only. Also the joint group average MoE Perpendicular to grain calculated value uses a density of 480 kg/m^3 to represent JD5 material.

Table 12: Compares the test results of MoE perpendicular to Grain for individual timber species against the value obtained from the Joint Group average density, calculated in Table 9.

Timber Species	Joint Group	Average MoE Perpendicular to Grain from Test Results (MPa)	MoE Perpendicular to Grain calculated form Test Results using Average Joint Group Density (MPa)
European spruce	JD6	367	471
Scots Pine*	JD6	318	471
Radiata Pine MGP10	JD5	466#	537
Radiata Pine MGP12	JD4	706+	574
Douglas Fir (US)	JD4	514	574
Alpine Ash	JD3	802	718
Karri	JD2	797	841
Blackbutt	JD2	944	841
Jarrah	JD2	1,271	841
Grey Ironbark	JD1	1,473	1,026
Spotted gum	JD1	1,164	1,026

Note: # Average of 60 tests, +Average of 90 test and *Average of 60 test

Comparing the test result MoE perpendicular to grain values against the average density for the representative Joint Group, it was found that, the result was less conservative for Joint Groups 5 and 6 but conservative for Joint Groups 1, 2, 3 and 4. For the purpose of calculating deformation perpendicular to grain, the MoE Perpendicular to Grain based on average density of Joint Groups was found to be adequate. Table 12 summaries MoE Perpendicular to Grain value for each Joint Group.

Table 13: Average MoE Perpendicular to Grain by Joint Group

Joint Group	Average MoE Perpendicular to Grain (MPa)
JD1	1,025
JD2	840
JD3	720
JD4	575
JD5	535
JD6	470

Conclusions

The objective of this research was to re-establish the characteristic perpendicular to the grain values for common timber species used in construction from Australia and overseas and to develop a method to calculate the deformation due to perpendicular to the grain. The aim was to look at the design methodology used in the Mid-rise Timber Engineering guide in calculating the axial shortening of lightweight timber-framed buildings.

Also investigated was the effect of loading in the middle of the sample compared to the end of the sample, and validate the AS 1720.1 K_7 factor.

Characteristic Perpendicular to Grain Bearing Values

The research was successful in determining the characteristic perpendicular to grain bearing values for 15 separate timber species used in construction. When comparing the results against the characteristic design values contained in AS 1720.1, it found that for Radiata pine, the values were significantly lower for MGP10 stress grade but reasonable for MGP12 stress grade. Only one sample was tested for MGP15 stress grade, and this result was significantly lower than AS 1720.1 values.

One hybrid species Caribbea was tested, and the result for this species was in line with Radiata pine. Cypress was also tested, and it was found to have properties twice that of AS 1720.1 values. Imported softwood species European/Norway spruce and Scot pine were found to be considerably lower than the AS 1720.1 values.

For hardwood species, the results were closer to the AS 1720.1 results, but for Alpine Ash, Karri, Blackbutt and Southern Mahogany the results were lower. For Spotted gum, Grey Ironbark and Jarrah the values were higher to significantly higher than the AS 1720.1 values.

AS 1720.1 Characteristic Perpendicular to Grain Bearing Values

AS 1720.1 the timber engineering standard has two ways of assigning characteristic design values for bearing perpendicular to grain f'p. The first method is by assignment by the strength group, AS 1720.1 Clause H2.3 and Table H2.2. This applies to timber species that use their strength group to assign an F grade. The second method is just for MGP and A17 stress graded timber; in these cases, AS1720.1 Table H3.1 assigns a value. This value is also associated with the strength group and is independent of the stress grade.

As discussed above the Characteristic Perpendicular to the Grain Bearing values do not align with the AS 1720.1 values. A problem was observed for low-density species, particularly MGP graded material. The opposite was found for high-density timber species, where AS 1720.1 values were found to be conservative. The characteristic perpendicular to the grain bearing values showed a closer relationship to their density. The following equation represents a better determination of the characteristic perpendicular to grain bearing capacity.

$$\textit{Characteristic Perpendicular to Grain Bearing} = 3E^{-0.5}\rho^{1.9873} \text{ - EQN 2}$$

$$P = \text{timber density at } 12\ \% \text{ moisture content}$$

Recommendation: The AS 1720.1 Characteristic perpendicular to the grain bearing values should not be assigned by strength group or stress grade, but be assigned by the density relationship found in the research.

AS 1720.1 K_7 Factor

K_7 is the length and position of bearing factor within AS 1720.1, and this factor modifies the characteristic design values. K_7 has limitations in where it can be used, requiring the rectangular bearing to be located 75 mm or greater from the end of the timber element. If this condition is met, the values of K_7 allow the permissible stress to increase, as the bearing area reduces.

From the limited work conducted in this research project, it found that K_7 was valid for small bearing areas, but was not conservative for larger bearing areas. This issue is due to an inconsistency between AS/NZS 4063.1 and AS 1720.1. In the test method detailed in AS/NZS 4063.1, the test derives the characteristic values on a 50 mm bearing plate that is along the grain. Then the AS 1720.1 K_7 factor allows this characteristic value for 50 mm to be increased by 20% if the conditions of location are met. This is inconsistent as the characteristic perpendicular to the grain bearing is determined using a 50 mm bearing and therefore the K_7 factor for 50 mm bearing should be a value of 1.

For the characteristic value determined by AS/NZS 4063.1 to align better with the AS 1720.1 K_7 factor, this value should be modified, to bring it in line with the K_7 factor for 150 mm bearing length, as this value is 1 in AS 1720.1 The research project found the characteristic value determined by AS/NZS 4063.1 would need to be reduced by a factor of 1.2 to achieve this.

The K_7 factor also accounts for bearings at the end of a timber element. The research investigating this, and was conducted on one species and found that the end condition had a reduction in bearing capacity of 14 per cent. To supplement the data, six additional timber species of varying densities were also tested, but with a limited sample size of three. The results of the

supplementary testing showed that the bearing capacity reduction varied from 6 to 27 per cent. The average variation was found to be approximately 18%. This value was found to be closer to the correction factor of 1/1.2 (0.83) found in AS 1720.1 than the single species characteristic value investigated above.

Recommendation: To account for the inconsistency between AS/NZS 4063.1 and AS 1720.1, the test method described in AS/NZS 4063.1 should include a 1.2 reduction factor for the determination of characteristic perpendicular to grain values.

Modulus of Elasticity Perpendicular to the Grain

The values determined from testing cannot be declared as characteristic values as they were not tested directly in accordance with AS/NZS 4063.1. However, in the process of testing perpendicular to the grain bearing an elastic stress/strain relationship was observed. This relationship was used as a very good indicator of MoE perpendicular to the grain, instead of carrying out further work.

From the research, it was shown that it is an error to assume a relationship between MoE parallel to the grain to perpendicular to the grain, as the ratio were highly variable from the limited testing undertaken. Most of this variability is likely due to the estimation of parallel to the grain MoE, as only stress grade values were used and, not the tested values of parallel to the grain MoE.

Instead of more research being carried out, the equation found for MoE perpendicular to the grain against density would provide the degree of accuracy needed. This equation is:

$$\text{MoE Perpendicular to Grain} = 1.1023\rho - 17.795 \qquad \text{– EQN 3}$$

$$P = \text{timber density at } 12\ \% \text{ moisture content}$$

This relationship is derived using the measured density of the test specimens. This is very different from the tabulated species density in AS 1720.1. A designer will never know the actual density of the timber to be used as a bottom or top plate, so will have to use the species density which is independent of the stress grade. To account for this inability of a designer not knowing the species density, a relationship was found between the timber species' Joint Group and average MoE Perpendicular to Grain. Table 12 above illustrates average MoE Perpendicular to Grain values that could be assigned to each Joint Group. Therefore a designer needing to limit deformation on perpendicular to the grain loaded elements would just need to assign a Joint Group to the bearing element.

Calculation of Axial Shortening in Timber Framed Buildings

Appendix C contains suggested text on calculating perpendicular to the grain bearing deformation that could be used to amend the words used in the WoodSolutions Guide 50. The fundamental change in the method is that it uses the relationship between Joint Group and MoE Perpendicular to Grain to determine MoE Perpendicular to Grain.

Recommendations

The research made two recommendations; they are:

- The AS 1720.1 characteristic perpendicular to the grain bearing values should not be assigned by strength group or stress grade, but be assigned by the density relationship, found in the research.

- To account for the inconsistencies between AS/NZS 4063.1 and AS 1720.1, the test method described in AS/NZS 4063.1 should include a 1.2 reduction factor for the determination of characteristic perpendicular to the grain values.

References

1. AS 1720.1 (2010) Timber structures Design methods
2. AS/NZS 4063.1. (2010) Characterization of structural timber - Test methods
3. AS/NZS 4063.2. (2010) Characterization of structural timber - Determination of characteristic values
4. EN 408:2010 Timber structures. Structural timber and glued laminated timber. Determination of some physical and mechanical properties
5. Timber Development Association NSW Limited (2019), Characteristic Perpendicular to Grain Bearing Test on Common Australian and Imported Timber Species

Acknowledgements

The Timber Development Association would like to acknowledge the assistance from the timber industry that supplied timber to the project; being AKD, Boral Timber, Hyne, OnefourtyOne, Timberlink, and Stora Enso. We would also like to thank the research staff at Western University Centre for Infrastructure Engineering and the project's steering committee, Duncan Mayes, Timberlink, Erkki Valikangas, and Andy McNaught, EWPAA. Finally, we would like to thank TimberEd for their review of the research.

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Appendix A – Test Samples

Table A1 Description

Moisture content and the weight

The moisture content and the sample's weight are measured at the same time, to acquire the density.

Angle of the tree rings

To provide a more precise description of the timber sample used, the angle of the tree's growth rings to the wide surface are given. The meaning of the angles is shown in Figure A1. Table A1 contains the angle description of the timber pieces in the shown in Figure 1 would be:

Back-sawn	=	-45-45
Quarter-sawn	=	90
In-between-sawn	=	22.5-67.5

The first number is the angle of the tree growth ring on the left side of the sample and the second number the angle on the right side. If both angles are the same, there is just one number given. Where negative numbers are given, the angles on the left does not correspond to the right side.

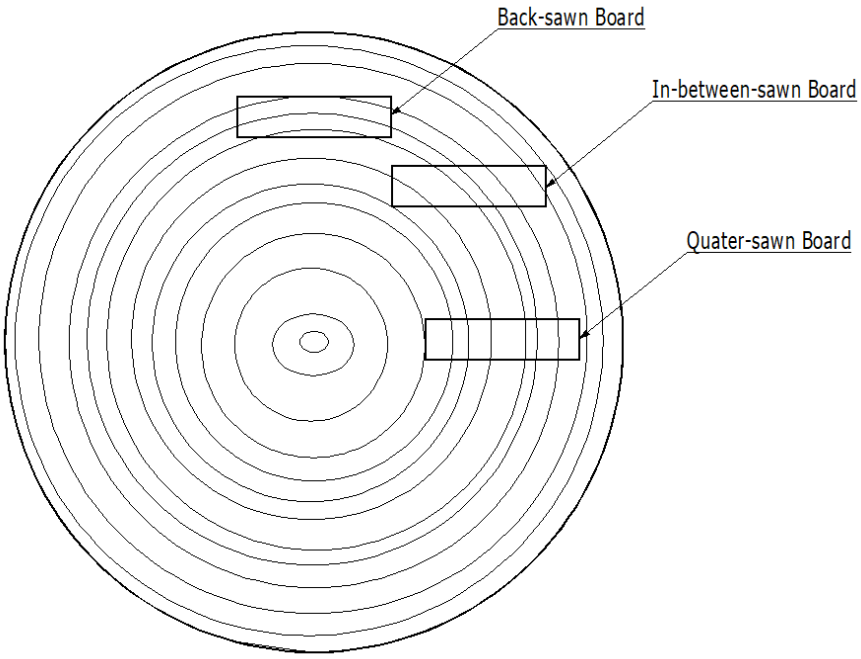


Figure A1: Sawn timber Cutting Directions

Size of the Annual Tree Growth Ring and Late Wood Portion

This is the measure of the early and late wood tree growth ring size.

Test direction from sap to heartwood

The value of the test direction is "Yes" or "No" depending on which side the metal bearing plate (bearing side) is. If the statement is "Yes" the bearing plate is on the sapwood side if "No" the bearing plate is on the heartwood side.

Density

The sample's density is calculated with the weight, wide, depth and length. The values of the wide and depth are average values, which are calculated with a measuring on both edges.

Density p_{12}

The sample's density p_{12} is the density adjusted to 12% moisture content.

Comments

Figure A2 shows more or less the subdivision of the sample, to enhance the location of different "special elements" within a sample.

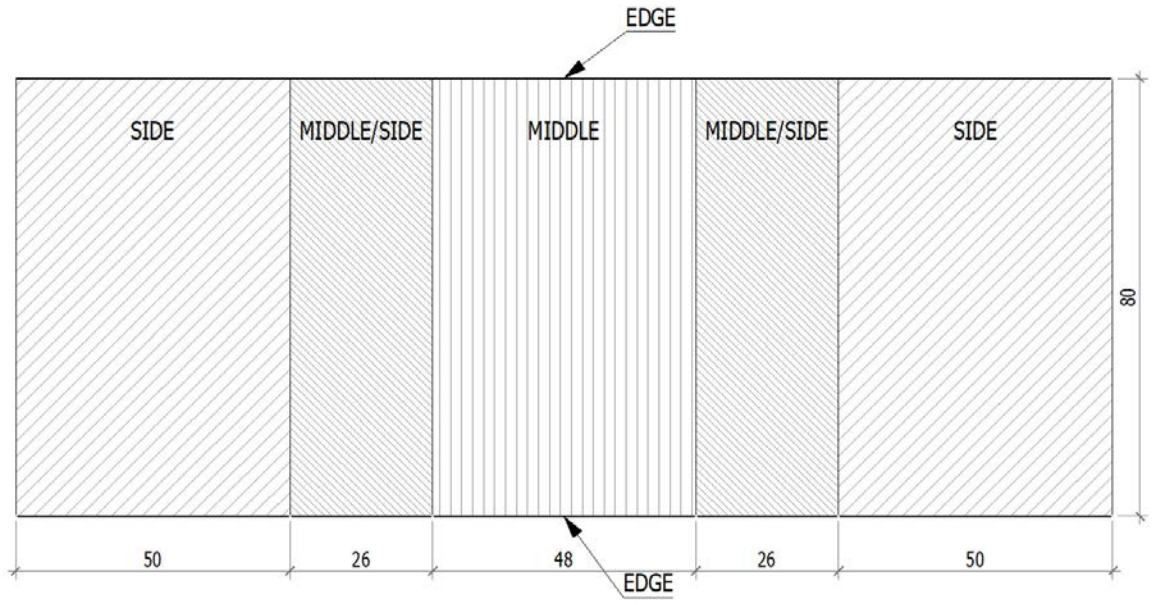


Figure A2: Subdivision of timber samples

By the knot description the descripting value is the diameter.

The comment "on the bottom" is used for damages, pitch pockets…, which are located on the non-bearing side.

The comment "u-shaped" describes a cupping effect which can happen if the sample shrinks after the planning. As a result the sample is in the middle thinner then on the edges, shown in Figure A3.

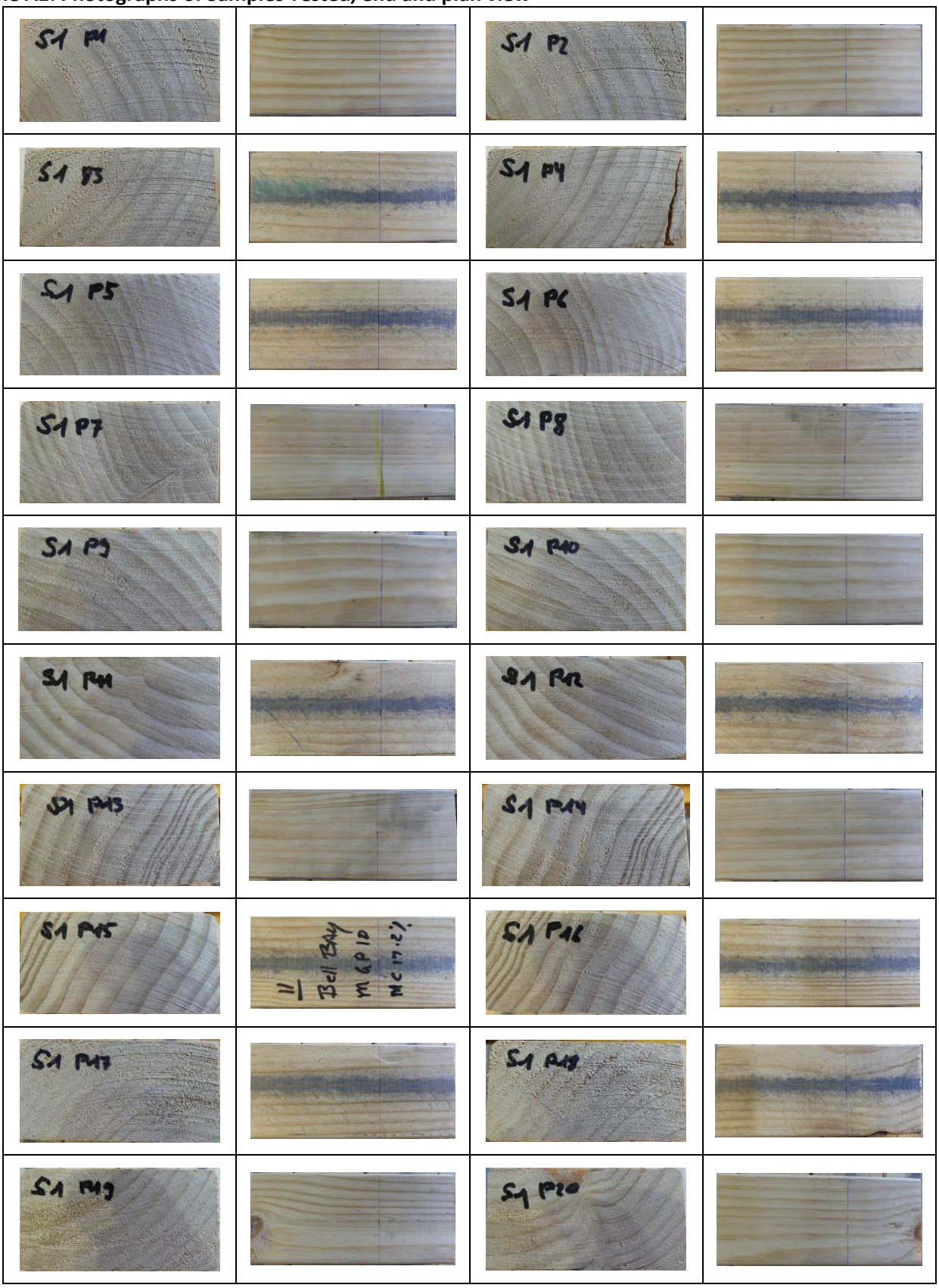
The comment "-" is used for missing data, not evaluated data or insignificant data.

Figure A3: Cross section of sample Southern Mahogany showing cupping

Radiata Pine – S1

Scientific name: Pinus radiata
Source location: Australia
Identification number: S1
Stress grade: MGP10

Table A1: Photographs of Samples Tested, end and plan view



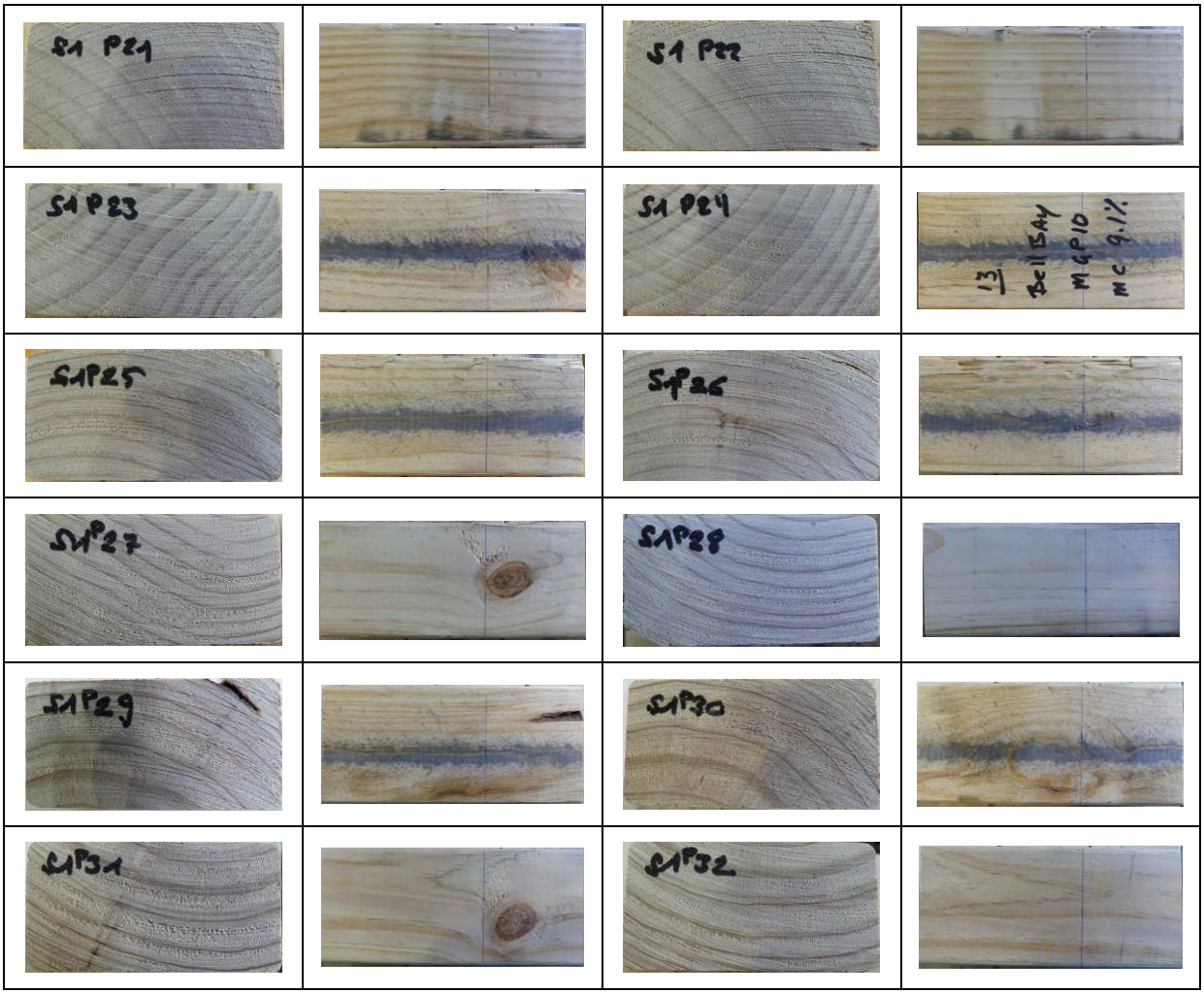


Table A2: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	484	480	5.9
Bearing perpendicular to grain [MPa]	10.4	7.4	17.6
MOE perpendicular to grain [MPa]	500	465	23.1

Table A3: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S1 p1	472	9.02	396.13
S1 p2	477	8.83	360.23
S1 p3	469	9.52	427.17
S1 p4	475	9.78	473.36

S1 p5	529	11.94	450.82
S1 p6	528	11.19	503.57
S1 p7	526	9.51	417.28
S1 p8	537	11.04	436.43
S1 p9	465	9.18	385.61
S1 p10	459	9.73	482.13
S1 p11	475	11.30	601.12
S1 p12	470	10.21	530.53
S1 p13	500	9.33	418.31
S1 p14	488	8.81	388.39
S1 p15	496	9.82	407.65
S1 p16	484	8.69	381.12
S1 p17	440	8.26	410.23
S1 p18	469	8.89	396.40
S1 p19	464	8.03	372.21
S1 p20	459	7.95	402.40
S1 p21	490	11.42	508.28
S1 p22	469	10.21	451.42
S1 p23	537	13.45	698.52
S1 p24	473	10.00	490.57
S1 p25	437	8.83	486.31
S1 p26	447	10.46	564.47
S1 p27	484	13.43	711.74
S1 p28	438	9.63	554.83
S1 p29	497	11.10	706.94
S1 p30	520	15.54	759.59
S1 p31	508	14.34	713.05
S1 p32	490	14.10	725.23

Table A4: Table of Sample Properties

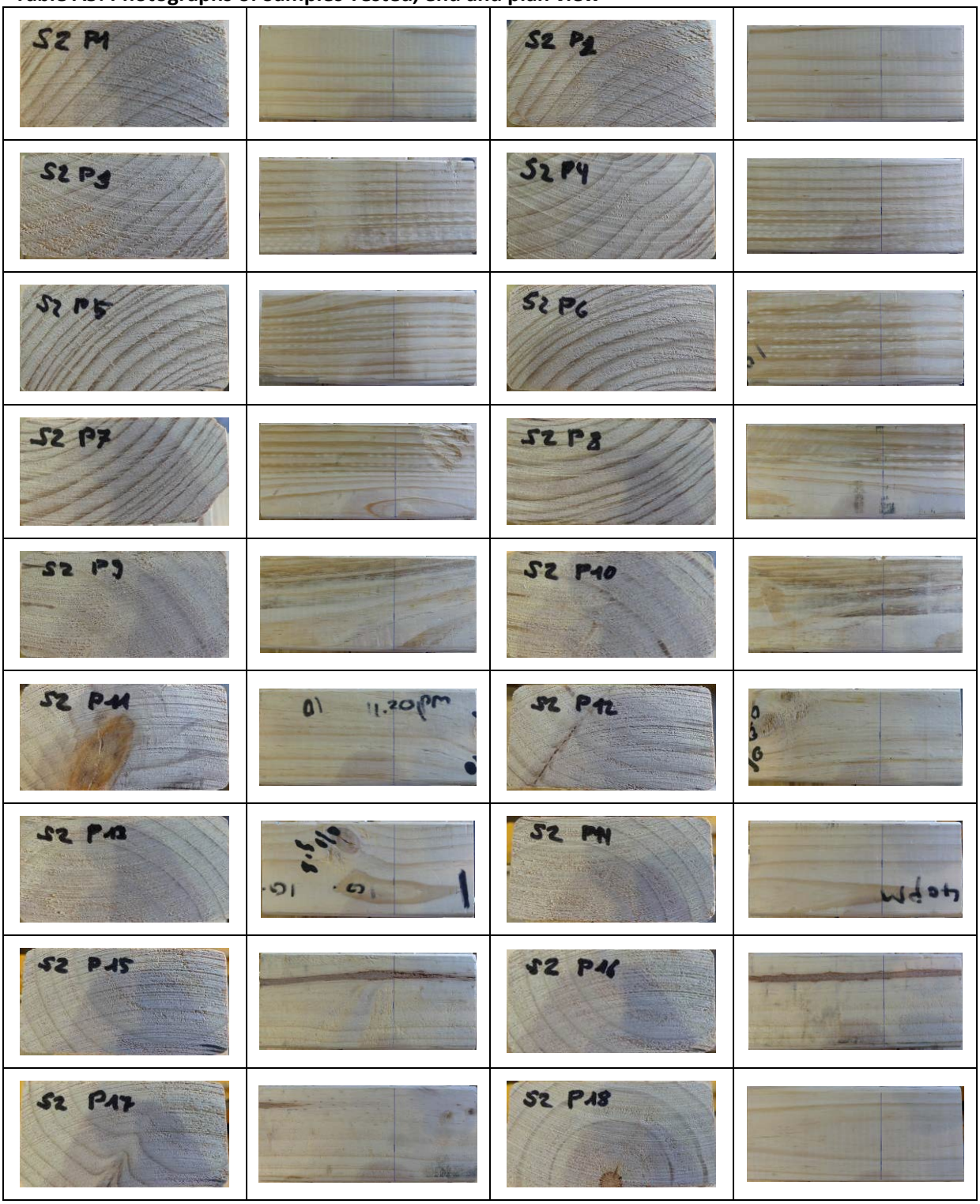
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S1 p1	15.7	67.5	8.5	3.5	41	yes	389	199.5	89.6	44.6	488	Little damage on the side
S1 p2	16.1	67.5	8.5	3.5	41	yes	397	199.5	89.7	44.9	494	Little damage on the side
S1 p3	16.6	67.5	8.5	3.5	41	no	391	199.5	89.6	44.8	488	-
S1 p4	16.6	67.5	8.5	3.5	41	no	394	199.75	89.6	44.6	494	One edge is not stable
S1 p5	13.7	67.5	6	1.5	25	yes	432	199.5	90	44.8	537	Missing knot on the side, 1.5mm
S1 p6	14.5	67.5	6	1.5	25	yes	433	199.5	90	44.7	540	-
S1 p7	15.2	67.5	6	1.5	25	no	432	199.5	89.9	44.5	541	-
S1 p8	14.4	67.5	6	1.5	25	no	438	199.75	90	44.5	548	Knot on the side, 5mm
S1 p9	13.8	0-45	9	3	33	yes	384	199.75	90.1	45.2	472	-
S1 p10	13.9	0-45	9	3	33	yes	381	199.75	90.2	45.3	467	-
S1 p11	13.6	0-45	9	3	33	no	388	199.75	90.2	44.7	482	-
S1 p12	13.6	0-45	9	3	33	no	387	199.5	90.3	45	477	-
S1 p13	16.8	67.5	6.5	3	46	yes	414	199.5	89.7	44.4	521	-
S1 p14	17.8	67.5	6.5	3	46	yes	405	199.5	89.5	44.2	513	-
S1 p15	16.6	67.5	6.5	3	46	no	409	199.5	89.2	44.5	516	-

S1 p16	17.9	67.5	6.5	3	46	no	408	199.75	89.7	44.7	509	-
S1 p17	16.5	22.5-67.5	6	1.2	20	yes	368	199	89.8	45	458	-
S1 p18	15.1	22.5-67.5	6	1.2	20	yes	389	199.5	89.9	45	482	Knot on the side, 19mm
S1 p19	15	22.5-67.5	6	1.2	20	no	383	199.5	90	44.8	476	Knot on the side, 19mm
S1 p20	14.3	22.5-67.5	6	1.2	20	no	372	199.5	89.6	44.5	468	Knot on the side, 15mm
S1 p21	10.2	45-67.5	8	2	25	yes	397	199.25	90.7	45.6	482	-
S1 p22	10.3	45-67.5	8	2	25	yes	379	199.5	90.9	45.2	462	-
S1 p23	11.1	45-67.5	8	2	25	no	438	199.5	90.8	45.4	533	Knot in the middle/side, 20mm
S1 p24	10.5	45-67.5	8	2	25	no	384	199.75	90.8	45.3	467	-
S1 p25	11	0-45	5.5	1.2	22	yes	350	199.5	90.3	44.9	433	Damaged in the middle on the edge
S1 p26	10.3	0-45	5.5	1.2	22	yes	355	199.5	90.3	44.8	440	Damaged in the middle on the edge
S1 p27	11.9	0-45	5.5	1.2	22	no	393	199.75	90	45.2	484	Knot in the middle/side, 16mm
S1 p28	11.7	0-45	5.5	1.2	22	no	355	200	90.3	45	437	Damaged on the edge on the bottom
S1 p29	11.4	0-45	8.5	2.2	26	yes	401	199.5	90.3	45.1	494	Pitch pocket on the side, 40mm long 4mm thick
S1 p30	11.5	0-45	8.5	2.2	26	yes	422	199.5	90.3	45.2	518	2 knots in the middle, 20mm and 10mm
S1 p31	13.6	-25-45	8.5	2.2	26	no	419	200	90.2	45.1	515	pitch pocket on the side, 15mm long 4mm thick; knot in the middle/side, 20mm
S1 p32	12.3	-25-45	8.5	2.2	26	no	400	199.75	90.2	45.2	491	-
Mean:	13.9		7.3	2.1	25.4		393.5	199.5	90.0	44.9	488.0	
σ:	2.4		1.3	0.8	9.0		23.8	0.2	0.4	0.3	30.7	

Radiata Pine – S2

Scientific name: Pinus radiata
Source location: Australia
Identification number: S2
Stress grade: MGP10

Table A5: Photographs of Samples Tested, end and plan view



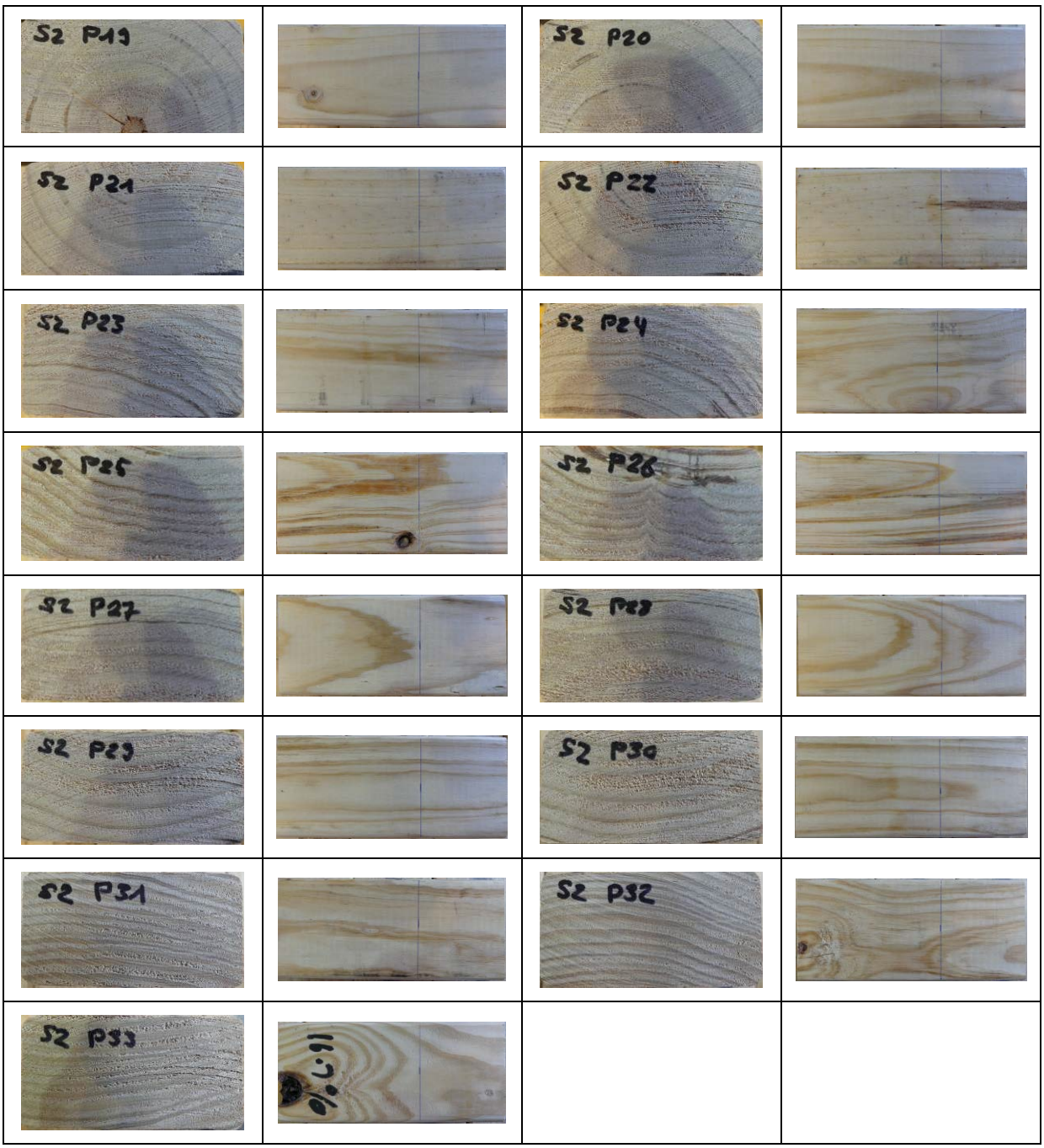


Table A6: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	484	480	5.9
Bearing perpendicular to grain [MPa]	10.4	7.4	17.6
MOE perpendicular to grain [MPa]	500	465	23.1

Table A7: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S2 p1	434	7.77	417.91
S2 p2	435	8.00	363.49
S2 p3	438	6.71	294.60
S2 p4	434	7.03	407.54
S2 p5	605	13.73	695.27
S2 p6	606	13.72	777.65
S2 p7	612	14.94	595.91
S2 p8	613	14.90	794.18
S2 p9	439	10.94	484.31
S2 p10	459	11.50	637.51
S2 p11	474	11.42	589.94
S2 p12	471	10.22	581.91
S2 p13	465	18.71	781.37
S2 p14	425	10.61	690.73
S2 p15	438	12.93	501.40
S2 p16	411	10.21	479.54
S2 p17	439	10.53	604.54
S2 p18	478	14.15	502.92
S2 p19	514	15.37	706.84
S2 p20	497	14.04	880.58
S2 p21	492	12.08	630.03
S2 p22	488	11.67	621.28
S2 p23	551	12.17	726.08
S2 p24	579	15.41	610.61
S2 p25	582	15.76	783.94
S2 p26	617	15.05	545.89
S2 p27	490	11.14	614.22
S2 p28	479	10.90	665.51
S2 p29	478	10.03	549.31

S2 p30	484	9.38	638.94
S2 p31	559	11.87	789.76
S2 p32	563	11.13	577.69
S2 p33	589	11.74	698.22
S2 p34	561	-	-

Table A8: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S2 p1	14.8	22.5-67.5	7.5	1.5	20	yes	351	199.5	89	44.4	445	-
S2 p2	14.4	22.5-67.5	7.5	1.5	20	yes	351	199.5	89	44.5	444	-
S2 p3	13.4	22.5-67.5	7.5	1.5	20	no	352	199.5	89	44.8	443	-
S2 p4	12.5	22.5-67.5	7.5	1.5	20	no	344	199.75	88.8	44.5	436	-
S2 p5	11.7	0-67.5	5.5	1.4	25	yes	494	199.5	90.1	45.6	603	Big chamber-bevel in the middle/side and side
S2 p6	12.3	0-67.5	5.5	1.4	25	yes	498	199.5	90.1	45.6	608	-
S2 p7	10.8	0-67.5	5.5	1.4	25	no	495	199.5	90.2	45.5	605	Damage on one side on the bottom
S2 p8	11	0-67.5	5.5	1.4	25	no	497	199.75	90.3	45.3	608	-
S2 p9	11	0-67.5	15	4.5	30	yes	355	199.75	90.2	45.3	435	-
S2 p10	10.6	0-67.5	15	4.5	30	yes	369	199.5	90.2	45.3	453	-
S2 p11	12.8	0-67.5	15	4.5	30	no	387	199.25	90.3	45.1	477	Knot on the side, 18mm
S2 p12	13	0-67.5	15	4.5	30	no	388	199.5	90.3	45.3	475	2 knots on the side, 18mm and 11mm
S2 p13	9.8	-67.5-67.5	9	1.7	19	yes	373	199.5	90.5	45.3	456	2 knots on the middle, 20mm and 9mm
S2 p14	9.7	-67.5-67.5	9	1.7	19	yes	340	199.5	90.4	45.3	416	-
S2 p15	9.7	-67.5-67.5	9	1.7	19	no	349	199.25	90.3	45.2	429	Cut through the pith; 2 knots in the middle, 2 x 12mm

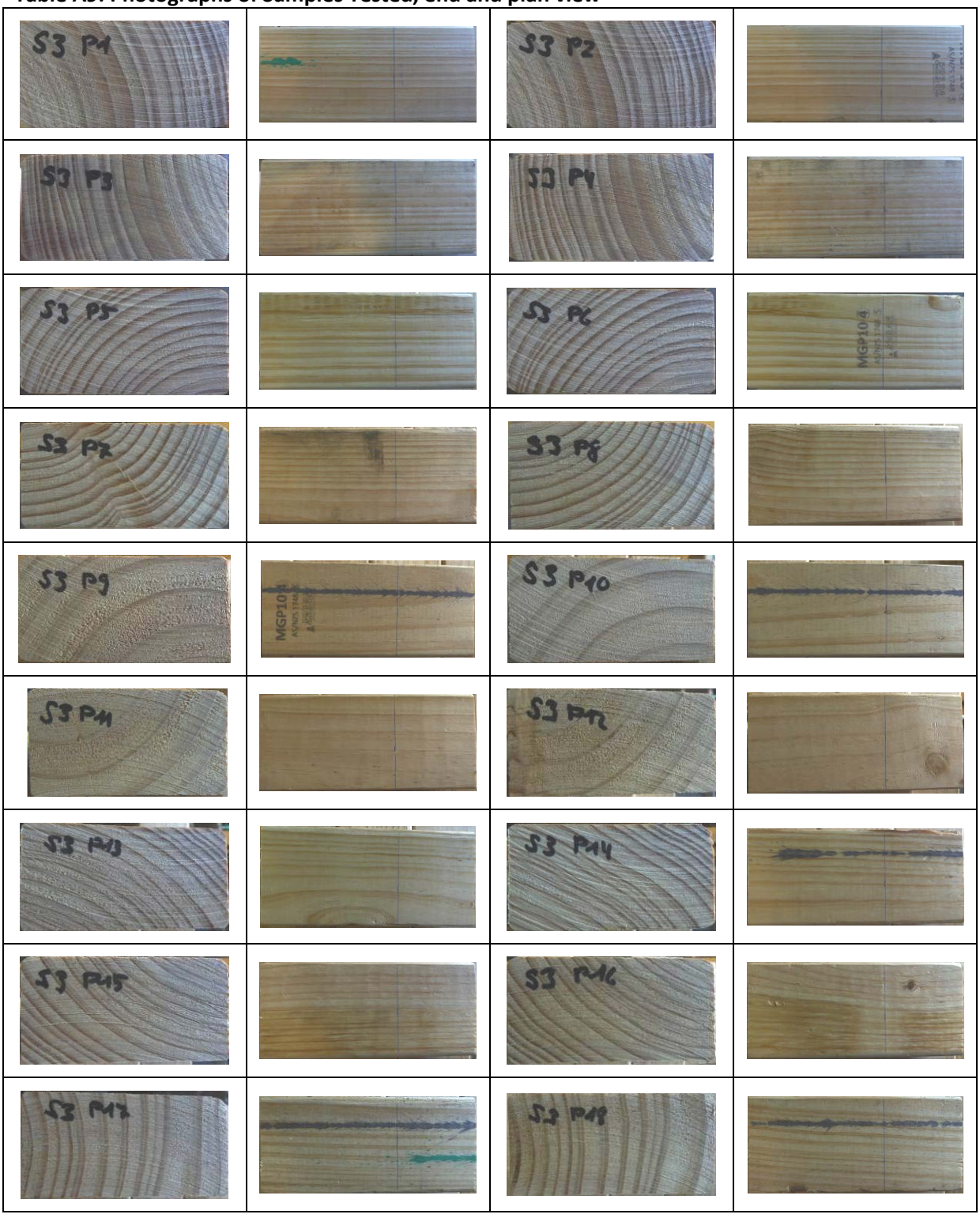
S2 p16	9.8	-67.5-67.5	9	1.7	19	no	329	199.25	90.5	45.3	403	Cut through the pith
S2 p17	9.4	-67.5-67.5	9	1.7	19	no	350	199.25	90.4	45.3	429	Cut through the pith; 2 knots on the side, 9mm and 6 mm
S2 p18	10.4	-90-90	13.5	2.4	18	yes	380	199.5	90.2	44.8	471	Cut through the pith
S2 p19	10.5	-90-90	13.5	2.4	18	yes	409	199.5	90.3	44.8	507	Cut through the pith; 2 knots on the side, 2 x 6 mm; knot in the middle, 14mm
S2 p20	10.4	-90-90	13.5	2.4	18	yes	396	199.5	90.4	44.8	490	Cut through the pith
S2 p21	10.7	-90-90	13.5	2.4	18	no	392	199.5	90.2	44.8	486	-
S2 p22	10.8	-90-90	13.5	2.4	18	no	389	199.5	90.2	44.8	483	Cut through the pith
S2 p23	11	0-45	5.5	3	55	yes	445	199.5	90.2	45.3	546	-
S2 p24	10.8	0-45	5.5	3	55	yes	468	199.5	90.1	45.4	573	-
S2 p25	10.8	0-45	5.5	3	55	no	469	199.5	90.1	45.3	576	Missing knot in the middle, 10mm
S2 p26	11	0-45	5.5	3	55	no	499	199.5	90.1	45.4	611	-
S2 p27	12.3	-22.5-22.5	6	2.5	42	yes	398	199.5	90.1	45.1	491	-
S2 p28	12	-22.5-22.5	6	2.5	42	yes	390	199.5	90.1	45.3	479	-
S2 p29	12.6	-22.5-22.5	6	2.5	42	no	390	199.25	90	45.2	481	-
S2 p30	12.8	-22.5-22.5	6	2.5	42	no	395	199.25	89.9	45.3	487	-
S2 p31	14	-22.5-22.5	4	2.3	58	yes	456	199.5	89.3	45	569	-
S2 p32	13.8	-22.5-22.5	4	2.3	58	yes	459	199.75	89.3	45	572	Knot on the side, 20mm
S2 p33	13.2	-22.5-22.5	4	2.3	58	no	475	199.25	89.2	44.9	595	Missing knot on the side, 23mm
S2 p34	14.3	-22.5-22.5	4	2.3	58	no	458	199.5	89	45	573	Injury on the bottom, 60mm long 3.5mm bright; data lost

Mean:	11.0		7.5	2.4	25.5		391.0	199.5	90.2	45.3	484.5	
σ:	1.5		3.8	0.9	15.2		55.1	0.1	0.5	0.3	66.6	

Radiata Pine – S3

Scientific name: Pinus radiata
Source location: Australia
Identification number: S3
Stress grade: MGP10

Table A9: Photographs of Samples Tested, end and plan view



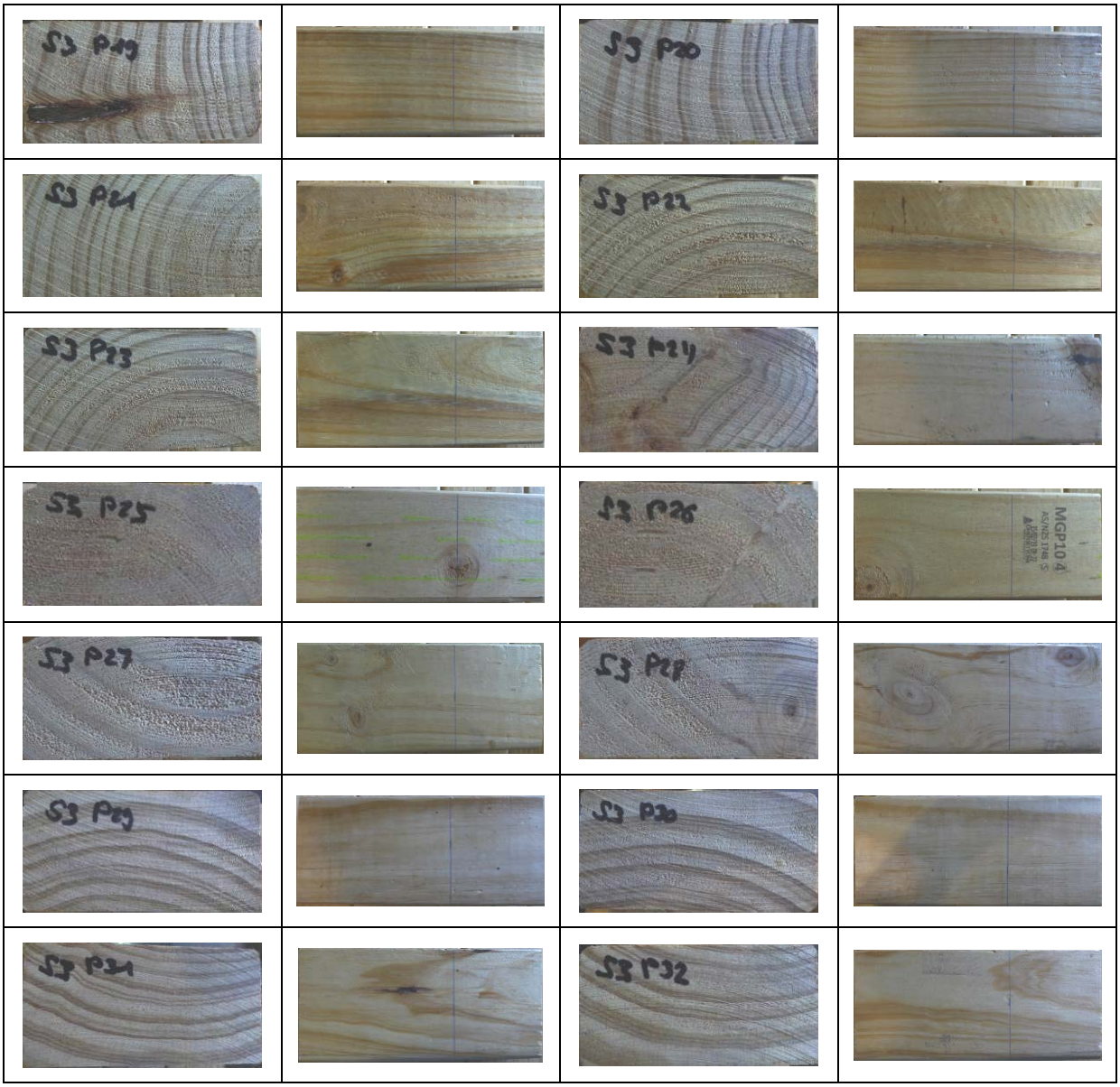


Table A10: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	515	506	13.1
Bearing perpendicular to grain [MPa]	10.8	7.2	21
MOE perpendicular to grain [MPa]	463	396	27.5

Table A11: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S3 p1	641	15.14	575.19

S3 p2	635	15.71	646.27
S3 p3	637	15.02	483.74
S3 p4	641	15.59	576.85
S3 p5	597	13.14	637.06
S3 p6	607	13.21	508.61
S3 p7	587	13.81	615.73
S3 p8	601	13.18	583.18
S3 p9	446	7.68	272.89
S3 p10	451	8.14	351.43
S3 p11	424	8.78	436.10
S3 p12	475	9.64	444.39
S3 p13	535	9.62	349.72
S3 p14	528	9.17	254.68
S3 p15	527	9.28	369.14
S3 p16	521	9.11	305.37
S3 p17	470	9.48	373.36
S3 p18	471	9.89	358.26
S3 p19	463	9.09	393.33
S3 p20	474	9.11	381.07
S3 p21	473	9.22	329.74
S3 p22	468	8.70	515.48
S3 p23	457	8.49	489.21
S3 p24	456	9.76	388.86
S3 p25	454	11.74	443.87
S3 p26	452	8.32	325.21
S3 p27	444	10.20	409.83
S3 p28	505	12.58	580.86
S3 p29	499	9.67	619.21
S3 p30	503	10.62	644.04
S3 p31	519	11.29	570.51
S3 p32	508	10.34	587.07

Table A12: Table of Sample Properties

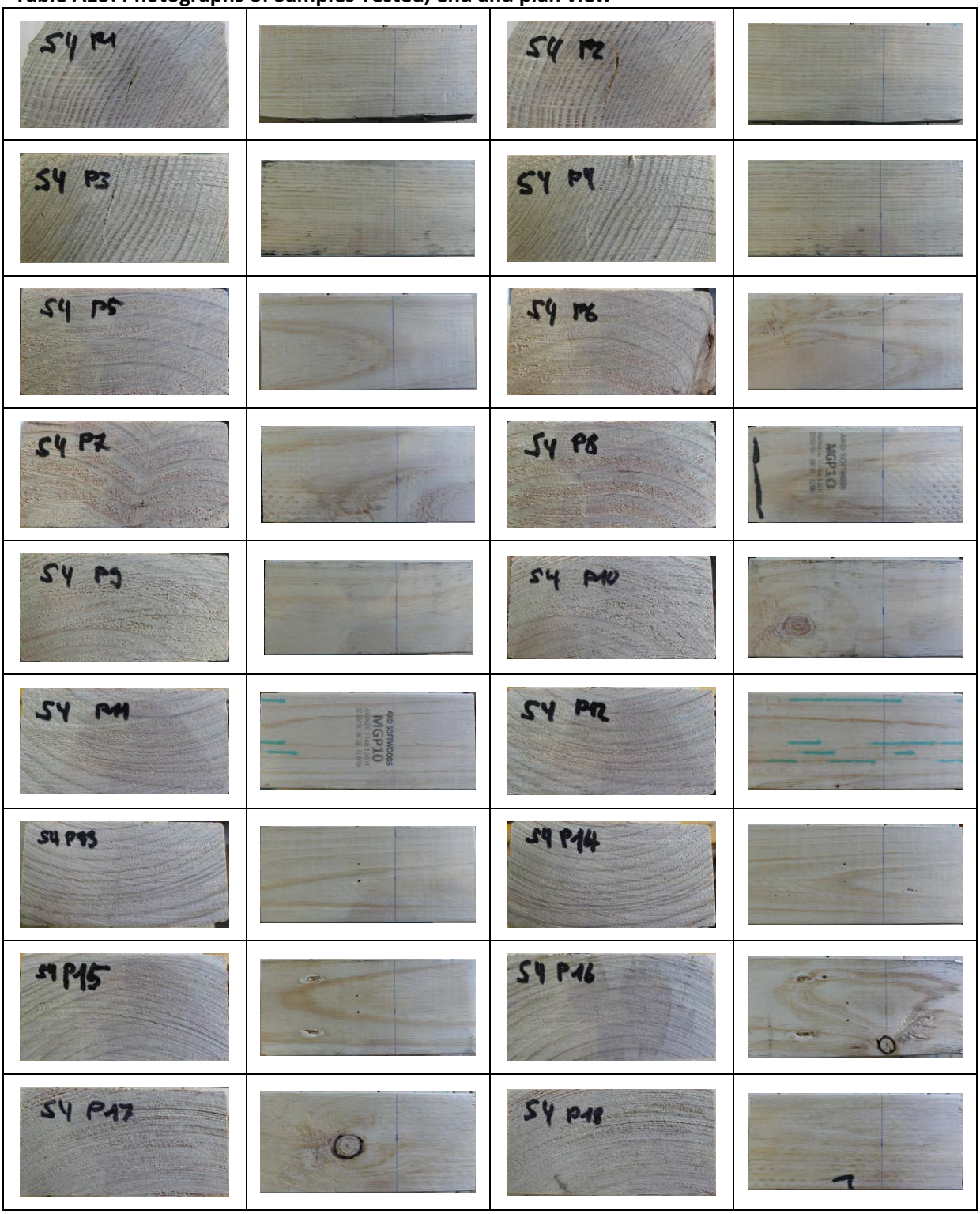
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S3 p1	13.4	90	6	2	33	yes	526	199	90.7	44.9	649	-
S3 p2	12.7	90	6	2	33	yes	522	199.25	90.9	45.1	639	-
S3 p3	14.6	90	6	2	33	no	530	199.5	90.9	44.8	652	-
S3 p4	12.1	90	6	2	33	no	523	199.5	91	44.9	642	-
S3 p5	11.8	0-67.5	5.5	1.7	31	yes	489	199.5	90.8	45.3	596	-
S3 p6	12	0-67.5	5.5	1.7	31	yes	497	199.5	90.6	45.3	607	-
S3 p7	12.2	0-67.5	5.5	1.7	31	no	482	199.5	90.5	45.4	588	-
S3 p8	12.2	0-67.5	5.5	1.7	31	no	498	199.5	90.8	45.7	602	-
S3 p9	12.7	0-67.5	15	3	20	yes	360	199.5	89	45.2	449	-
S3 p10	12.4	0-67.5	15	3	20	yes	365	200	89.4	45.1	453	-
S3 p11	15.7	0-67.5	15	3	20	no	350	199.5	89.6	44.7	438	-
S3 p12	15	0-67.5	15	3	20	no	390	199.5	89.8	44.6	488	Knot on the side, 10mm; knot in the middle/side, 15mm
S3 p13	12	0-45	5.5	1.3	24	yes	431	199.5	89.8	45	535	-
S3 p14	13.1	0-45	5.5	1.3	24	yes	430	199.75	89.8	45	533	-
S3 p15	13.1	0-45	5.5	1.3	24	no	429	199.5	90	44.9	532	-

S3 p16	14.8	0-45	5.5	1.3	24	no	429	199.5	89.5	45	534	Knot on the side, 5mm
S3 p17	14.8	90	9.5	3	32	-	387	199.75	90	44.7	482	-
S3 p18	15.1	90	9.5	3	32	-	386	199.75	89.7	44.5	484	-
S3 p19	15.2	90	9.5	3	32	-	386	199.75	90	45.1	476	Knot on the side, 5mm
S3 p20	14.9	90	9.5	3	32	-	392	199.75	89.5	45.1	486	Knot on the side, 7mm
S3 p21	10.7	90	6.5	2.5	38	-	381	199.75	90	45.3	468	4 knots on the side, 2 x 5mm and 2 x 13mm
S3 p22	10.3	22.5-45	6.5	2.5	38	yes	378	199.75	90.8	45.2	461	-
S3 p23	11.2	22.5-45	6.5	2.5	38	no	373	199.75	90.8	45.3	454	-
S3 p24	13.4	22.5-45	6.5	2.5	38	no	380	199.25	90.2	45.8	462	2 knots on the side, 13mm
S3 p25	11	-22.5-45	14	3	21	yes	364	199.5	90.2	45	450	Knot in the middle, 20mm; knot in the middle/side, 13mm
S3 p26	10.9	-22.5-45	14	3	21	yes	361	199.5	89.8	45	448	Knot on the side, 35mm
S3 p27	15.5	-22.5-45	14	3	21	no	365	199.5	89.2	44.8	458	2 knots on the side,10mm and 5mm; knot in the middle/side, 19mm
S3 p28	14.4	-22.5-45	14	3	21	no	419	199.5	90	45.2	516	Knot on the side, 15mm; knot in the middle/side, 16mm
S3 p29	11.1	-22.5-22.5	9	3.5	39	yes	405	199.5	90.7	45.2	495	-
S3 p30	10.6	-22.5-22.5	9	3.5	39	yes	408	199.5	91	45.2	497	-
S3 p31	10.1	-22.5-22.5	9	3.5	39	no	418	199.5	90.7	45.3	510	Pitch pocket in the middle, 30mm long and 4mm bright
S3 p32	10.2	-22.5-22.5	9	3.5	39	no	411	199.5	90.9	45.3	500	-
mean:	12.6		7.8	2.8	31.2		406.5	199.5	90.1	45.1	496.0	
σ:	1.8		3.6	0.7	7.0		56.5	0.2	0.6	0.3	67.5	

Radiata Pine – S4

Scientific name: Pinus radiata
Source location: Australia
Identification number: S4
Stress grade: MGP10

Table A13: Photographs of Samples Tested, end and plan view



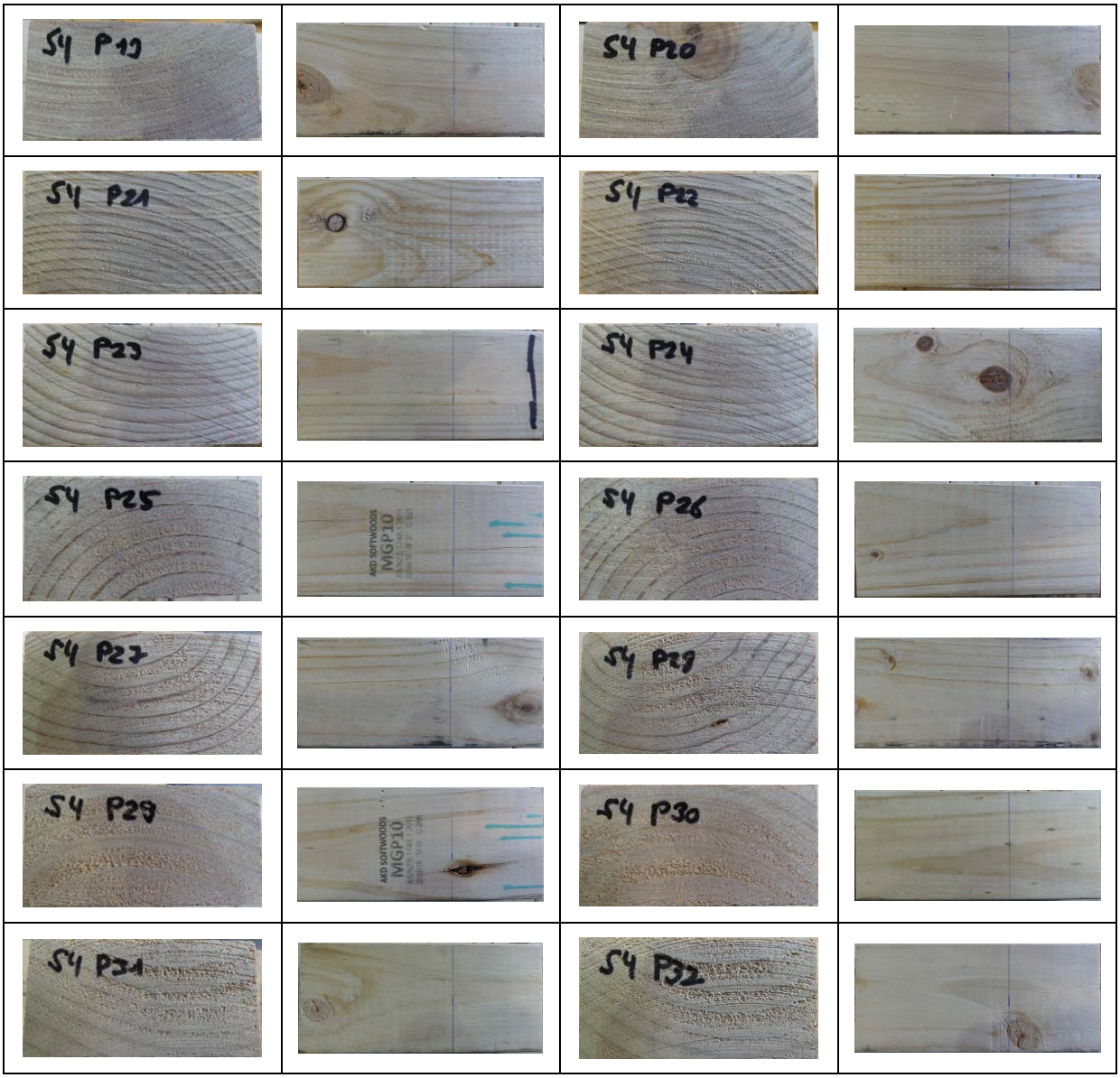


Table A14: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	496	490	11
Bearing perpendicular to grain [MPa]	12.0	8.2	20
MOE perpendicular to grain [MPa]	651	639	15.9

Table A15: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S4 p1	594	14.07	659.72

S4 p2	607	14.88	690.66
S4 p3	606	16.05	651.45
S4 p4	611	16.59	748.06
S4 p5	453	11.22	774.52
S4 p6	506	16.86	861.91
S4 p7	459	12.47	652.41
S4 p8	458	11.25	674.41
S4 p9	485	12.70	663.70
S4 p10	526	13.40	746.27
S4 p11	483	10.64	648.63
S4 p12	477	11.10	687.00
S4 p13	454	-	-
S4 p14	448	8.86	548.54
S4 p15	438	10.53	606.64
S4 p16	453	13.10	654.08
S4 p17	460	15.33	639.51
S4 p18	436	9.56	455.13
S4 p19	439	8.79	391.86
S4 p20	473	9.73	524.08
S4 p21	550	12.25	639.12
S4 p22	528	12.72	682.53
S4 p23	537	10.53	709.95
S4 p24	568	17.12	828.67
S4 p25	499	11.78	698.48
S4 p26	489	11.17	663.52
S4 p27	541	10.49	634.56
S4 p28	498	9.57	622.39
S4 p29	448	10.90	578.67
S4 p30	446	11.10	691.43
S4 p31	453	8.84	623.73
S4 p32	458	9.37	542.02

Table A16: Table of Sample Properties

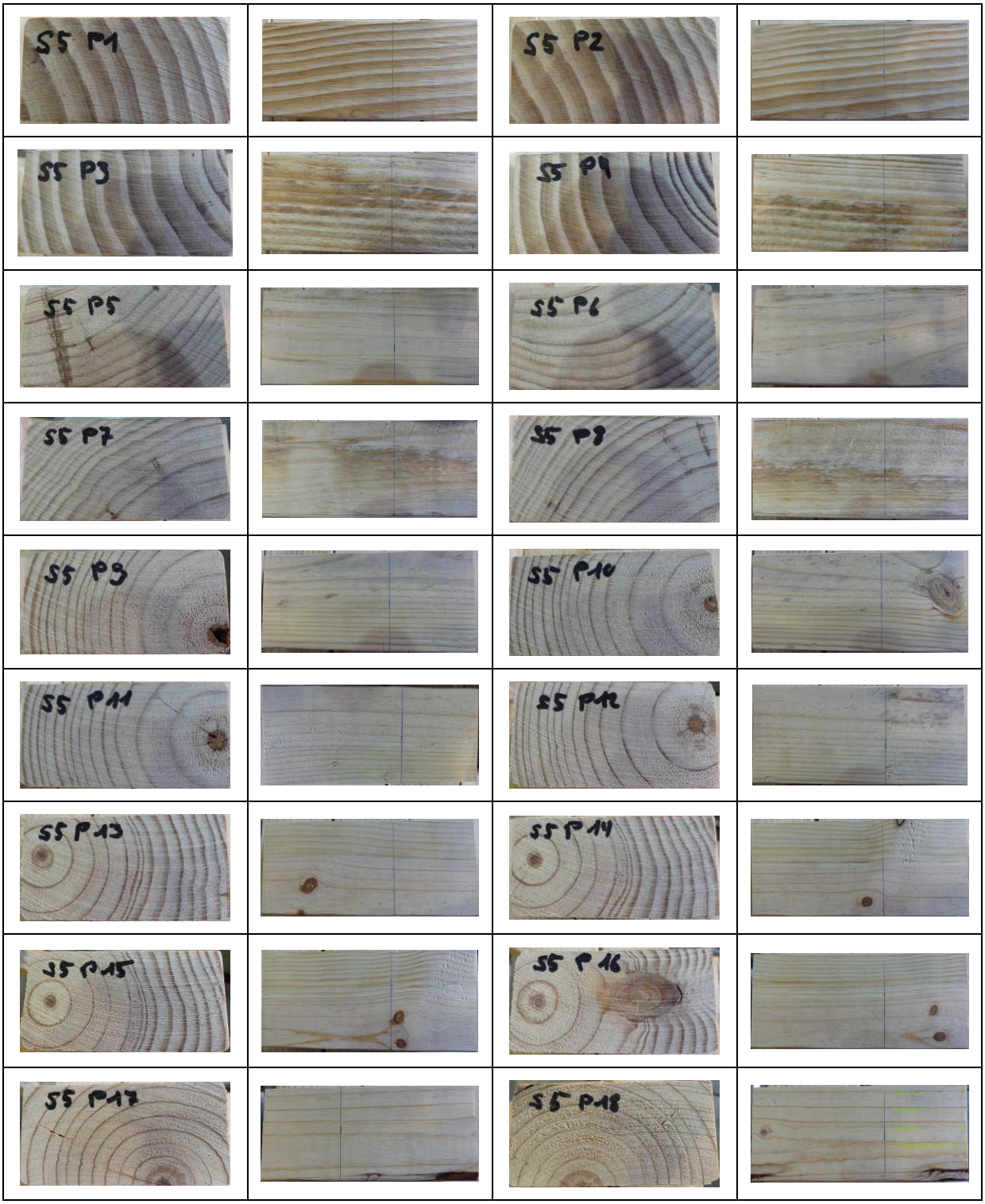
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S4 p1	10.6	67.5-90	2.5	1	40	yes	480	199.75	90.3	45.3	587	Big chamber-bevel, 5mm loos of surface
S4 p2	10.2	67.5-90	2.5	1	40	yes	486	199.75	90.2	45.2	597	Big chamber-bevel, 3mm loos of surface
S4 p3	10	67.5-90	2.5	1	40	no	486	199.75	90.3	45.3	595	-
S4 p4	9.1	67.5-90	2.5	1	40	no	486	199.75	90.3	45.3	595	Small chamber-bevel on the bottom, 3mm
S4 p5	9	-22.5-22.5	10	1.5	15	yes	362	199.5	90.3	45.6	441	-
S4 p6	9.5	-45-45	10	1.5	15	yes	406	199.5	90.2	45.6	495	Knot in the middle, 5mm; wavy year rings
S4 p7	10.1	-22.5-22.5	10	1.5	15	no	368	199.5	90.1	45.4	451	Wavy year rings
S4 p8	10.5	-22.5-22.5	10	1.5	15	no	371	199.5	90.2	45.6	452	-
S4 p9	9.8	-22.5-22.5	5.5	1.3	24	yes	387	199.5	90.2	45.3	475	-
S4 p10	10.8	-22.5-22.5	5.5	1.3	24	yes	425	199.25	90.4	45.4	520	Knot in the middle, 20mm; missing knot on the side, 8mm
S4 p11	10.2	-22.5-22.5	5.5	1.3	24	no	386	199.5	90.2	45.2	475	-
S4 p12	10.5	-22.5-22.5	5.5	1.3	24	no	385	199.75	90.2	45.4	471	-
S4 p13	9.9	-22.5-22.5	5.5	1.3	24	no	363	199.5	90.3	45.3	445	Big chamber-bevel, 30mm to 10mm on the bottom; data not used
S4 p14	9.8	-22.5-22.5	5.5	1.3	24	no	359	199.5	90.4	45.3	439	Small chamber-bevel, 5mm on the bottom; other damages on the bottom

S4 p15	10.5	-22.5-22.5	5.5	1.3	24	yes	353	199.5	90.2	45.4	432	-
S4 p16	10.6	-22.5-22.5	5.5	1.3	24	yes	366	199.5	90.2	45.5	447	Knot in the middle, 12mm
S4 p17	9.3	0-45	5.5	1.7	31	yes	367	199.5	90.2	45.4	449	Knot in the middle, 19mm; knot on the side, 7mm
S4 p18	9.4	0-45	5.5	1.7	31	yes	349	199.5	90.3	45.5	426	-
S4 p19	10.9	0-45	5.5	1.7	31	no	356	199.5	90.2	45.5	435	Knot on the side, 27mm
S4 p20	10.8	0-45	5.5	1.7	31	no	380	199.5	90.1	45.2	468	Knot on the side, 28mm
S4 p21	11.5	-22.5-45	3.5	1	29	yes	448	199.75	90.3	45.3	548	Knot on the side, 13mm
S4 p22	11.6	-22.5-45	3.5	1	29	yes	430	199.75	90.3	45.3	526	-
S4 p23	10.9	-22.5-45	3.5	1	29	no	434	199.75	90.2	45.3	532	-
S4 p24	10.8	-22.5-45	3.5	1	29	no	457	199.75	90.2	45.1	562	Knot in the middle, 20mm; knot in the middle/side, 12mm
S4 p25	11.2	-22.5-22.5	6.5	1	15	yes	405	199.75	90.2	45.4	495	-
S4 p26	11	-22.5-22.5	6.5	1	15	yes	397	199.75	90.1	45.5	485	Knot on the side, 4mm
S4 p27	10.7	-45-45	6.5	1	15	no	437	199.75	90.1	45.4	535	Knot in the middle/side, 24mm
S4 p28	10.8	-45-45	6.5	1	15	no	401	199.75	90.1	45.2	493	3 knots on the side, 3 x 4mm
S4 p29	11.4	-22.5-22.5	8	1.7	21	yes	361	199.5	90.1	45	446	Knot in the middle/side, 6mm not nice grown
S4 p30	11.3	-22.5-22.5	8	1.7	21	yes	359	199.5	90.1	45.1	443	-
S4 p31	11	-22.5-22.5	8	1.7	21	no	366	199.5	90.1	45.3	449	Knot on the side,17mm
S4 p32	10.6	-22.5-22.5	8	1.7	21	no	368	199.5	90.1	45.3	452	knot in the middle/side, 20mm
mean:	10.6		5.5	1.3	23.6		385.5	199.5	90.2	45.34	489.41	
σ:	0.7		2.3	0.3	7.9		44.0	0.1	0.1	0.15	53.91	

Radiata Pine – S5

Scientific name: Pinus radiata
Source location: Australia
Identification number: S5
Stress grade: MGP10

Table A17: Photographs of Samples Tested, end and plan view



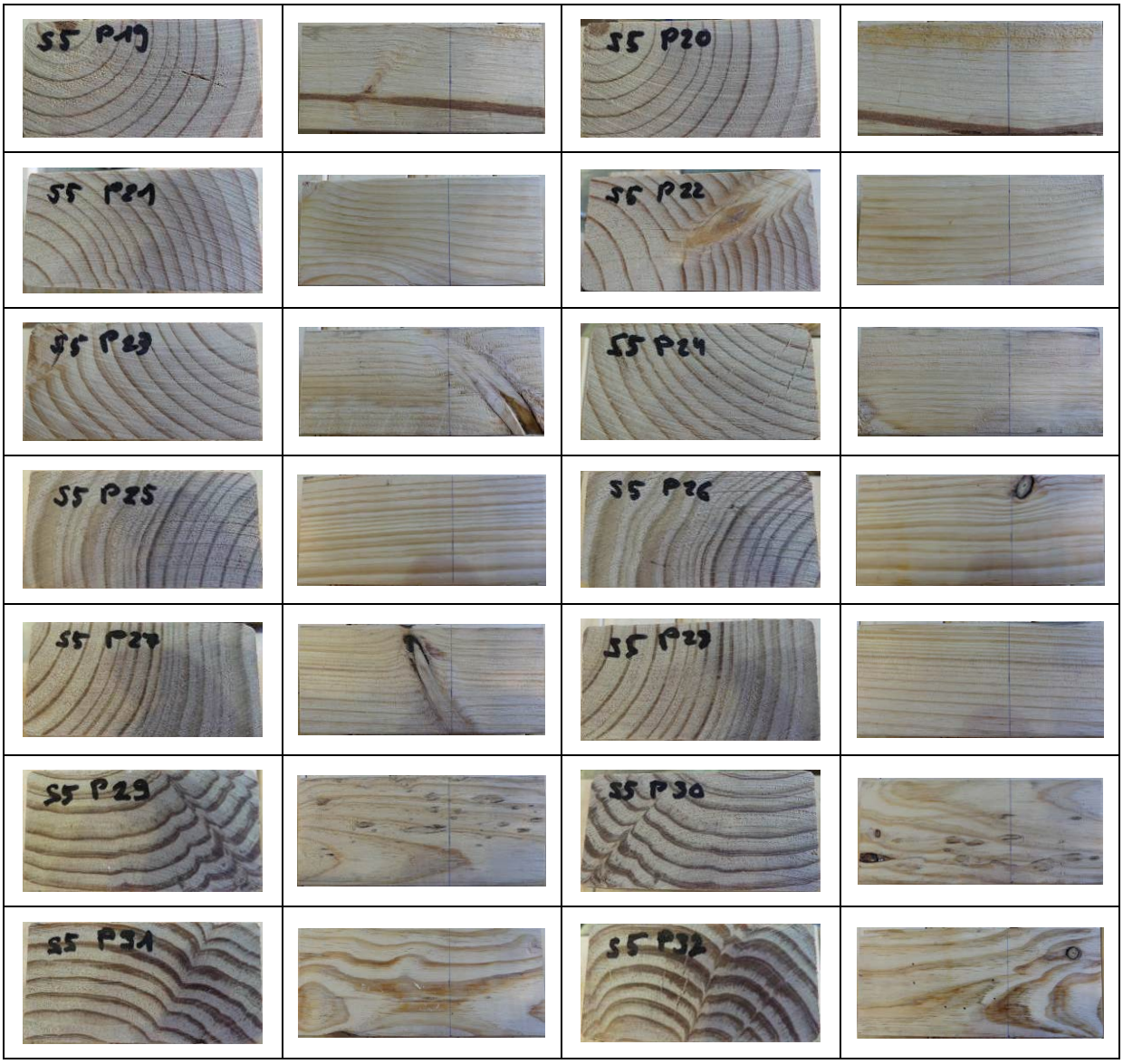


Table A18: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	561	551	13.6
Bearing perpendicular to grain [MPa]	13.2	8.9	20.6
MOE perpendicular to grain [MPa]	487	476	19.5

Table A19: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S5 p1	665	15.82	540.30

S5 p2	672	16.52	480.83
S5 p3	664	19.31	625.20
S5 p4	660	20.23	572.54
S5 p5	513	12.50	676.95
S5 p6	515	13.70	655.74
S5 p7	506	12.13	524.26
S5 p8	512	12.60	472.18
S5 p9	472	10.14	407.94
S5 p10	489	9.77	439.50
S5 p11	460	10.17	405.59
S5 p12	451	10.32	431.16
S5 p13	570	13.12	427.96
S5 p14	546	14.07	424.72
S5 p15	543	12.34	484.19
S5 p16	533	11.63	442.03
S5 p17	474	9.05	355.38
S5 p18	487	9.80	542.84
S5 p19	500	10.83	358.84
S5 p20	489	11.22	364.52
S5 p21	554	12.91	443.81
S5 p22	553	12.24	438.62
S5 p23	573	15.51	491.34
S5 p24	547	12.80	403.34
S5 p25	568		
S5 p26	595	12.58	455.45
S5 p27	574	14.02	401.26
S5 p28	526	11.92	373.59
S5 p29	629	12.87	577.71
S5 p30	674	14.39	618.90
S5 p31	700	16.94	625.06
S5 p32	730	18.17	649.24

Table A20: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S5 p1	11.8	67.5	10	7	70	yes	541	199.5	90.2	45.3	664	-
S5 p2	11.7	67.5	9	6	67	yes	544	199.5	90.2	45.1	670	-
S5 p3	12	67.5	10	7	70	no	545	199.5	90.4	45.5	664	Knots in the middle/side;6mm
S5 p4	11.5	67.5	9	6	67	no	537	199.25	90.4	45.4	657	-
S5 p5	10	22.5-45	5	1.3	26	no	417	199.5	91	45.6	504	-
S5 p6	10.1	0-45	5	1.3	26	no	420	199.5	91.2	45.6	506	Pitch pocket from the side to the middle, 72mm long
S5 p7	9.5	22.5-45	5	1.3	26	yes	412	199.25	91	45.9	495	-
S5 p8	9.9	22.5-67.5	5	1.3	26	yes	417	199.5	91	45.8	502	-
S5 p9	9.3	90	5	1.3	26	-	378	199.5	90.8	45.3	461	With pith, the tree rings near the pith are 12mm thick
S5 p10	9.9	90	5	1.3	26	-	395	199.5	91	45.3	480	With pith, the tree rings near the pith are to 12mm thick; 2 knots on the side, 15mm and 6mm
S5 p11	9.8	90	5	1.3	26	-	370	199.5	91	45.2	451	With pith, the tree rings near the pith are 12mm thick
S5 p12	10.8	90	5	1.3	26	-	365	199.5	90.7	45.2	446	With pith, the tree rings near the pith are 12mm thick
S5 p13	10.5	90	5.5	2	36	-	459	199.5	91	45	562	With pith, the tree rings near the pith are 12mm thick; knot on the side, 10mm; knot in the middle/side, 10mm

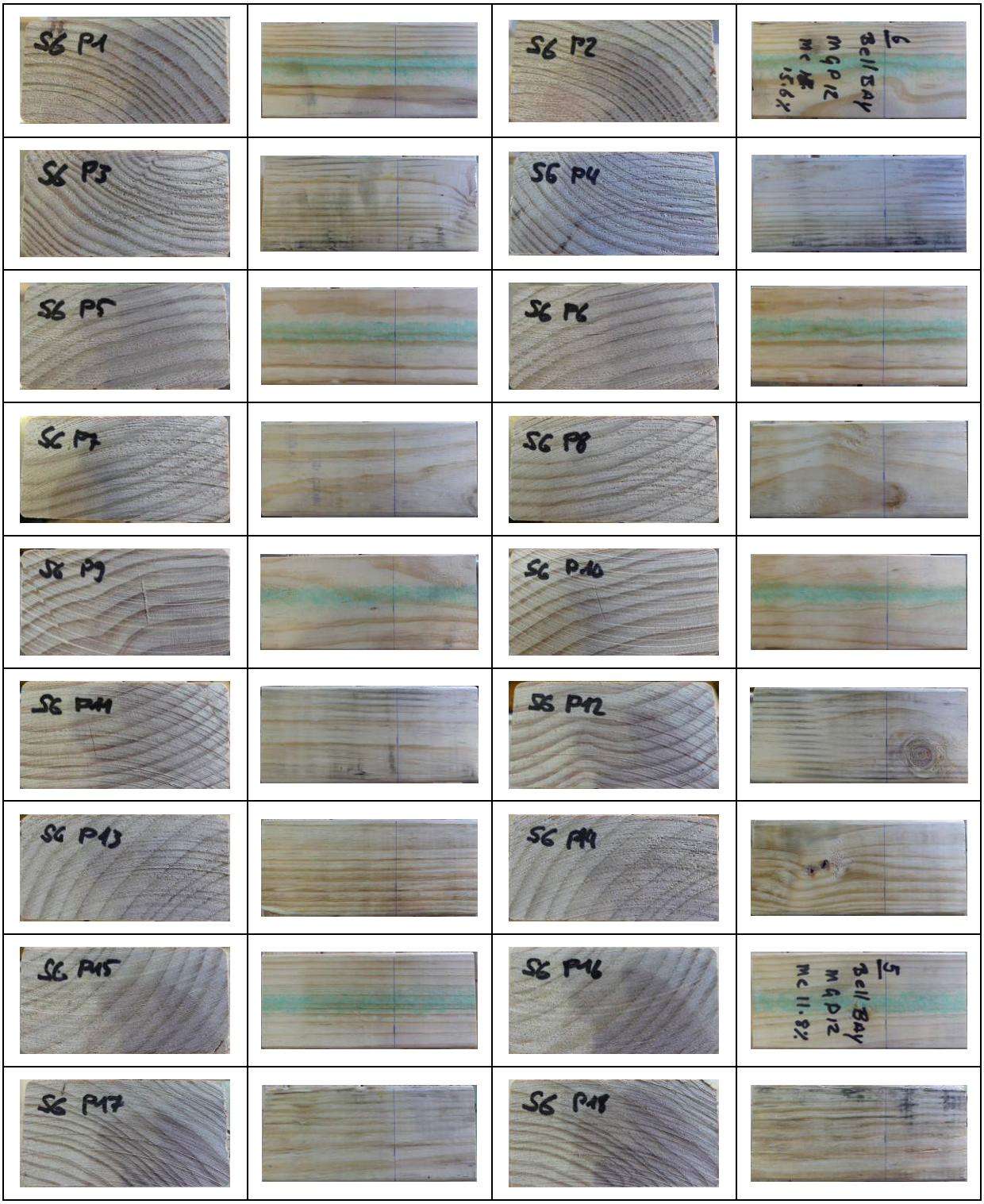
S5 p14	10.5	90	5.5	2	36	-	445	199.5	91	45.5	539	With pith, the tree rings near the pith are 12mm thick; 2 knots in the middle/side, 10mm and 8mm
S5 p15	11.1	90	5.5	2	36	-	441	199.5	90.7	45.2	539	With pith, the tree rings near the pith are 12mm thick; 3 knots in the middle/side, 10mm, 7mm and 6mm
S5 p16	10.6	90	5.5	2	36	-	429	199.5	90.6	45.1	526	With pith, the tree rings near the pith are 12mm thick; 3 knots on the side, 15mm, 8mm and 8mm
S5 p17	13.9	-90-90	6	1	17	yes	397	199.5	90.8	45.5	482	Cut through the pith, pith pocket from the side to the middle 100mm long and 8mm wide
S5 p18	13.1	-90-90	6	1	17	yes	403	199.25	90.6	45.4	492	Cut through the pith; knot on the side, 6mm
S5 p19	11.7	-90-90	6	1	17	no	408	199.5	90.4	45.32	499	Cut through the pith; 2 knots in the middle/side;12mm and 10mm
S5 p20	11	0-90	6	1	17	no	391	199.5	90.4	44.7	485	Cut through the pith; knots on the side, 10mm
S5 p21	10.4	45-90	5.5	1.6	29	yes	446	199.5	90.4	45.3	546	Knots on the side, 7mm
S5 p22	10	67.5-90	5.5	1.6	29	yes	446	199.5	90.7	45.4	543	Knots on the side, 7mm
S5 p23	10.7	45-90	5.5	1.7	31	no	461	199.5	90.7	45	566	Knot on the side, 23mm, some parts are missing
S5 p24	10.3	22.5-67.5	5.5	1.6	29	no	441	199.5	90.6	45.3	539	-
S5 p25	13.4	67.5-90	5	2	40	yes	470	199.75	90.5	45.2	575	Not enough data recorded
S5 p26	12.3	67.5-90	5	2	40	yes	490	199.5	90.8	45.3	597	Knots in the middle/side, 10mm not nice grown
S5 p27	15.3	67.5-90	5	1.8	36	no	481	199.5	90.5	45.1	591	Knot in the middle, 15mm
S5 p28	13.4	67.5-90	5	1.5	30	no	435	199.5	90.5	45.2	533	-
S5 p29	12.6	0-90	8	2.1	26	no	515	199.5	90.3	45.2	632	-
S5 p30	13.2	0-45	7	2.3	33	no	552	199.25	90	45.2	681	Knot on the side, 6mm
S5 p31	12.6	0-45	7	2.8	40	yes	570	199.5	89.8	45.2	704	Missing knots on the side, 16mm
S5 p32	11.9	0-45	7	3.4	49	yes	592	199.5	90	45.2	729	Knots on the side, 9mm not nice grown

mean:	11.1		5.5	1.7	29.5		443.0	199.5	90.6	45.3	539.0	
σ:	1.5		1.5	1.7	15.0		62.8	0.1	0.3	0.2	78.9	

Radiata Pine – S6

Scientific name: Pinus radiata
Source location: Australia
Identification number: S6
Stress grade: MGP12

Table A21: Photographs of Samples Tested, end and plan view



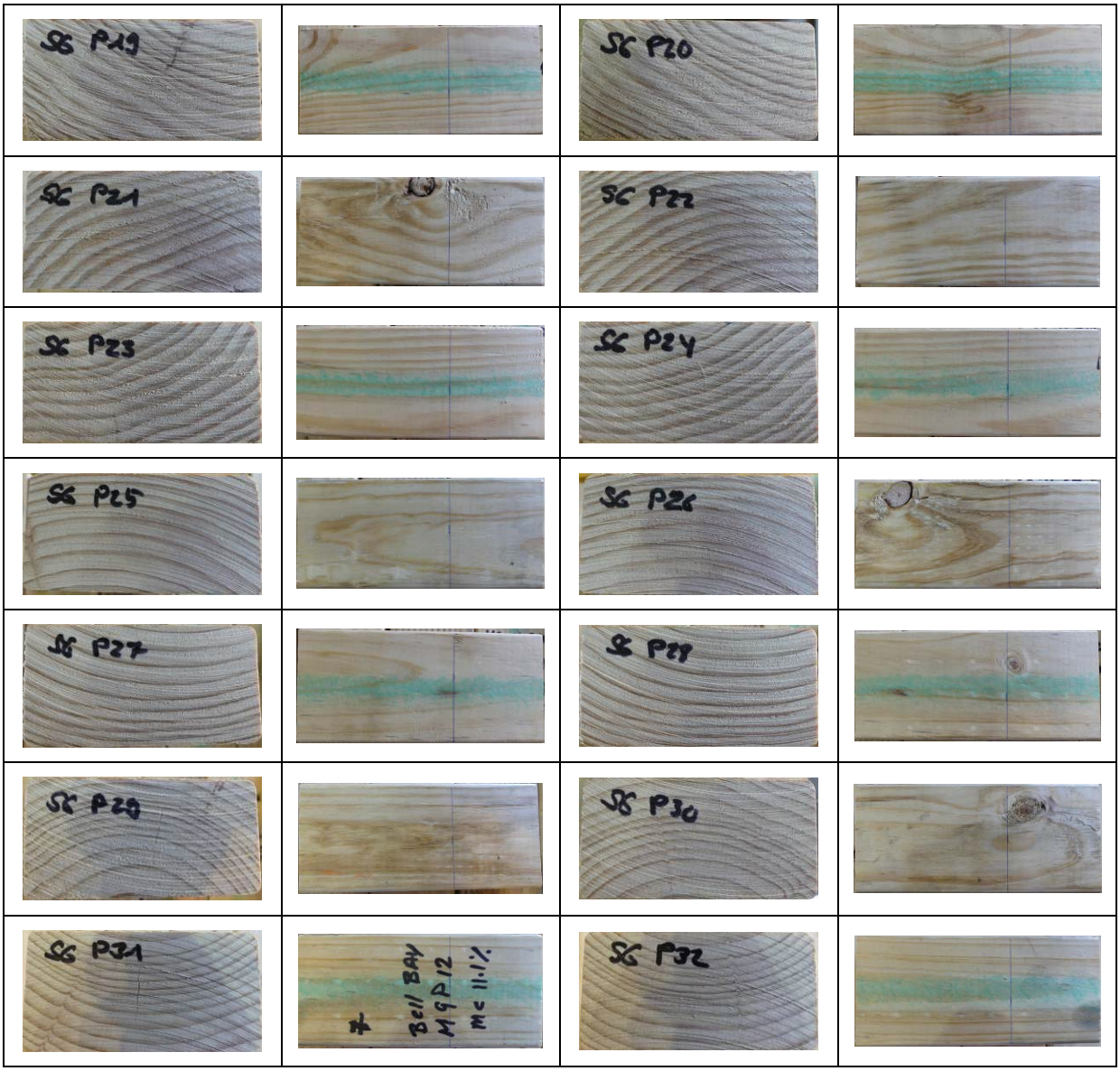


Table A22: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	570	567	3.9
Bearing perpendicular to grain [MPa]	13.6	10.3	14.5
MOE perpendicular to grain [MPa]	727	712	17.1

Table A23: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S6 p1	588	12.20	634.38

S6 p2	607	14.28	615.02
S6 p3	607	12.73	673.51
S6 p4	585	12.00	591.98
S6 p5	561	15.99	833.26
S6 p6	565	15.68	788.34
S6 p7	564	14.62	914.03
S6 p8	575	14.86	902.43
S6 p9	577	14.31	745.37
S6 p10	575	13.06	721.79
S6 p11	574	12.94	793.17
S6 p12	594	14.27	807.14
S6 p13	576	15.44	677.42
S6 p14	599	15.81	749.35
S6 p15	579	13.09	644.45
S6 p16	581	13.80	696.38
S6 p17	542	10.05	508.88
S6 p18	545	10.87	558.03
S6 p19	548	12.23	625.65
S6 p20	550	12.79	635.54
S6 p21	593	17.68	742.25
S6 p22	582	12.98	755.12
S6 p23	584	10.81	572.24
S6 p24	517	9.73	512.65
S6 p25	531	14.10	803.23
S6 p26	550	13.58	679.10
S6 p27	533	11.07	689.38
S6 p28	552	13.47	827.72
S6 p29	560	15.60	816.62
S6 p30	591	17.19	826.90
S6 p31	579	13.79	870.51
S6 p32	576	13.24	1036.82

Table A24: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S6 p1	14	0-45	5	1.5	30	yes	483	199.75	89.8	45	598	-
S6 p2	13.2	0-45	5	1.5	30	yes	493	199.75	90	44.7	613	knot in the middle/side, 18mm
S6 p3	12	0-45	5	2	40	no	490	199.5	90.1	44.9	607	-
S6 p4	12.7	0-45	5	1.5	30	no	477	199.5	90	45.1	589	pitch pocket on the side on the bottom
S6 p5	10.6	0-45	7	2.5	36	yes	453	199.75	90.7	45.1	554	-
S6 p6	10.6	0-45	7	2.5	36	yes	455	199.75	90.5	45.1	558	-
S6 p7	10.8	0-45	7	2.5	36	no	458	199.5	90.6	45.4	558	-
S6 p8	10.8	0-45	7	2.5	36	no	469	199.5	90.6	45.6	569	-
S6 p9	11.3	0-45	6.5	2.4	37	yes	468	199.5	90.3	45.3	573	-
S6 p10	12.1	0-45	6.5	2.4	37	yes	465	199.5	90.1	44.9	576	-
S6 p11	12.3	0-45	6.5	2.4	37	no	470	199.5	90.3	45.3	576	-
S6 p12	11.6	0-45	6.5	2.4	37	no	483	199.5	90.3	45.3	592	knot in the middle/side, 23mm
S6 p13	12.1	22.5-67.5	7	1.5	21	yes	473	199.5	90.5	45.4	577	-
S6 p14	12.6	22.5-67.5	7	1.5	21	yes	492	199.5	90.4	45.3	602	knot in the middle/side, 12mm
S6 p15	11.9	22.5-67.5	7	1.5	21	no	475	199.5	90.5	45.5	578	-
S6 p16	11.8	22.5-67.5	7	1.5	21	no	476	199.75	90.5	45.4	580	knot in the middle, 6mm

S6 p17	12.7	0-45	4.5	1.8	40	yes	443	199.5	90	45.3	545	-
S6 p18	11.7	0-45	4.5	1.8	40	yes	442	199.5	90.3	45.1	544	small injury on the side
S6 p19	11.6	0-45	4.5	1.8	40	no	442	199.5	90.2	45	546	-
S6 p20	11.9	0-45	4.5	1.8	40	no	450	199.5	90.5	45.3	550	injury on the bottom
S6 p21	13.2	0-45	5	2.5	50	yes	485	199.5	90.2	45	599	knot in the middle, 21.5mm
S6 p22	13.2	0-45	5	2.5	50	yes	478	199.5	90.1	45.2	588	-
S6 p23	13.7	0-45	5	2.5	50	no	480	199.5	89.9	45.1	593	-
S6 p24	14	0-45	5	2.5	50	no	469	199.5	98.9	45.2	526	-
S6 p25	11.8	-22.5-22.5	5	1.2	24	yes	431	199.5	90.4	45.1	530	-
S6 p26	11.9	-22.5-22.5	5	1.2	24	yes	448	199.5	90.4	45.2	550	knot on the side, 17mm
S6 p27	11.8	-22.5-22.5	5	1.2	24	no	435	199.5	90.3	45.4	532	-
S6 p28	11.1	-22.5-22.5	5	1.2	24	no	446	199.5	90.5	45.1	548	knot in the middle/side, 9mm
S6 p29	10.6	-45-45	4.5	1.3	29	yes	453	199.5	90.5	45.4	553	-
S6 p30	11	-45-45	4.5	1.3	29	yes	479	199.5	90.5	45.3	586	knot in the middle, 17mm
S6 p31	11.4	-22.5-22.5	4.5	1.3	29	no	473	199.5	90.6	45.4	576	-
S6 p32	11.5	-22.5-22.5	4.5	1.3	29	no	468	199.5	90.4	45.3	573	-
mean:	11.9		5.0	1.8	35.7		469.0	199.5	90.4	45.3	574.5	
σ:	1.0		1.0	0.5	8.9		17.3	0.1	1.5	0.2	23.5	

Radiata Pine – S7

Scientific name: Pinus radiata
Source location: Australia
Identification number: S7
Stress grade: MGP12

Table A25: Photographs of Samples Tested, end and plan view

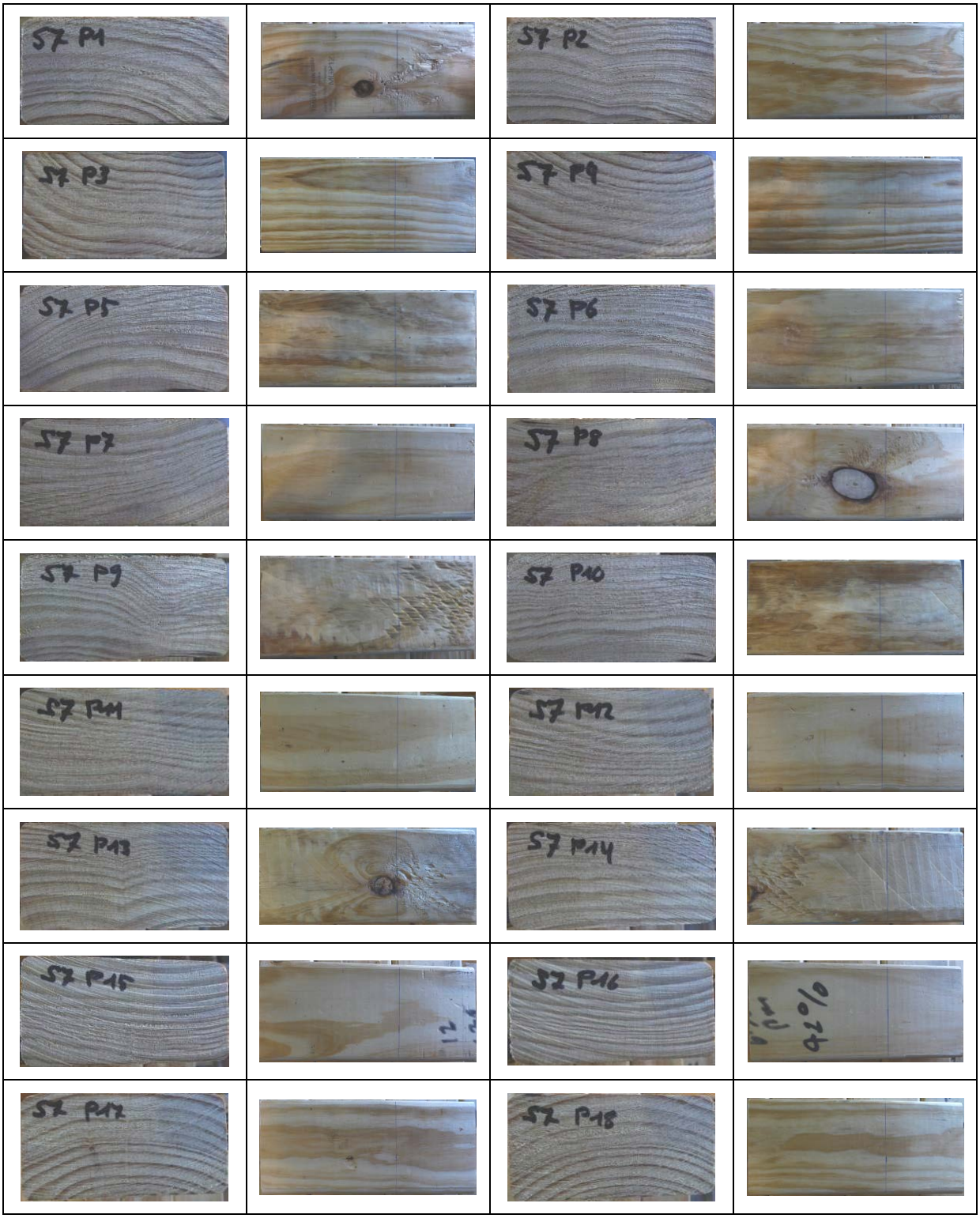


Table A26: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	611	606	6.9
Bearing perpendicular to grain [MPa]	16.3	12.9	12.1
MOE perpendicular to grain [MPa]	759	745	15.5

Table A27: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S7 p1	634	19.73	791.61
S7 p2	622	18.32	871.89
S7 p3	627	15.09	798.73
S7 p4	625	15.61	894.12
S7 p5	562	13.34	680.95
S7 p6	574	14.50	682.09
S7 p7	551	14.54	791.60
S7 p8	596	21.27	924.93
S7 p9	554	15.26	453.24
S7 p10	551	14.67	859.83
S7 p11	543	13.62	725.11
S7 p12	556	14.35	657.25
S7 p13	568	20.86	864.22
S7 p14	558	13.44	602.46
S7 p15	542	14.20	812.85
S7 p16	535	14.16	746.35
S7 p17	622	16.67	761.47
S7 p18	621	16.63	758.67
S7 p19	623	15.85	740.71
S7 p20	624	15.44	841.86
S7 p21	627	15.73	738.39
S7 p22	642	16.10	551.96
S7 p23	650	16.23	772.40
S7 p24	654	18.32	642.92
S7 p25	632	16.00	851.35
S7 p26	626	17.18	813.40
S7 p27	683	19.68	774.72
S7 p28	687	17.19	691.96
S7 p29	642	15.88	786.91
S7 p30	625	16.98	882.42

S7 p31	622	17.45	941.69
S7 p32	657	16.07	689.62
S7 p33	639	16.74	645.05
S7 p34	634	-	-
S7 p35	647	-	-
S7 p36	638	-	-

Table A28: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S7 p1	10.3	-22.5-22.5	5	1.2	24	yes	513	199.5	90.2	45.7	624	Missing knot in the middle, 16mm
S7 p2	10.6	-22.5-22.5	5	1.2	24	yes	505	199.25	90.2	45.8	614	-
S7 p3	10.1	-22.5-22.5	5	1.2	24	no	507	199.25	90.2	45.8	616	-
S7 p4	10	-22.5-22.5	5	1.2	24	no	505	199.5	90.2	45.7	614	-
S7 p5	9.5	-22.5-22.5	4.5	2	44	yes	450	199.25	90.4	45.5	549	-
S7 p6	9.4	-22.5-22.5	4.5	2	44	yes	457	199.25	90.5	45.2	561	Missing knot in the middle, 12mm
S7 p7	10.1	-22.5-22.5	4.5	2	44	no	448	199.75	90.4	45.8	542	-
S7 p8	9.5	-22.5-22.5	4.5	2	44	no	478	199.5	90.2	45.6	583	Knot in the middle, 27mm, no smooth surface on the bottom
S7 p9	8.5	0	3	1.5	50	yes	436	199	90.2	45.2	537	Not a smooth surface
S7 p10	9.4	0	3	1.5	50	yes	443	199.5	90.3	45.7	538	-
S7 p11	9.7	0	3	1.5	50	no	436	199.5	90.3	45.5	532	-
S7 p12	9.1	0	3	1.5	50	no	448	200	90.3	45.8	542	-
S7 p13	9.3	0	4.5	2	44	yes	453	199.5	90.3	45.4	554	Knot in the middle, 16mm
S7 p14	9.3	0	4.5	2	44	yes	446	199.5	90.3	45.4	545	Knot on the side, 18mm; knot in the middle, 6mm
S7 p15	9.6	0	4.5	2	44	no	437	199.5	90.4	45.7	530	-
S7 p16	11.5	0	4.5	2	44	no	439	199.75	90.3	45.7	533	-

S7 p17	10.8	-22.5-22.5	4.5	1.4	31	yes	506	199.5	90.2	45.7	615	Little damage in the middle
S7 p18	11.3	-22.5-22.5	4.5	1.4	31	yes	506	199.5	90.2	45.6	617	-
S7 p19	11	-22.5-22.5	4.5	1.4	31	no	508	199.5	90.3	45.7	617	-
S7 p20	10.8	-22.5-22.5	4.5	1.4	31	no	506	199.25	90.2	45.6	617	-
S7 p21	10.2	-22.5-22.5	4.5	1.4	31	no	508	199.25	90.2	45.8	617	-
S7 p22	10.9	-22.5-22.5	6.5	2.3	35	yes	521	199.5	90.3	45.5	636	Missing knot on the side, 16mm; knot on the side, 6mm
S7 p23	11	-22.5-22.5	6.5	2.3	35	yes	530	199.5	90.3	45.7	644	3 knots on the side, 2 x 5mm and 22mm; 2 knots in the middle, 2 X 5mm
S7 p24	10.5	-22.5-22.5	6.5	2.3	35	no	526	199.5	90.1	45.4	645	Knot on the side, 26mm; not a smooth surface on the bottom
S7 p25	10.2	-22.5-22.5	6.5	2.3	35	no	507	199.5	89.6	45.6	622	-
S7 p26	10.7	-22.5-22.5	6.5	2.3	35	no	508	199.5	89.8	45.8	619	3 knot in the middle, 3 x 5mm; 2 knots on the side, 2 x 5mm
S7 p27	10.5	0-22.5	5	2.4	48	yes	558	199.5	90.4	45.9	674	2 knot in the middle, 15mm and 6mm, knot on the side, 25mm
S7 p28	10.2	-22.5-22.5	5	2.4	48	no	555	199.5	90.3	45.6	676	Knot on the middle/side, 24mm; not a smooth surface on the bottom
S7 p29	10.7	-22.5-22.5	5	2.4	48	yes	522	199.5	90.3	45.6	635	-
S7 p30	10.2	-22.5-22.5	6	2.6	43	no	506	199.5	90.4	45.6	615	Knot on the side, 5mm
S7 p31	10	0-22.5	6	2.6	43	no	508	200	90.2	46.1	611	-
S7 p32	11	-22.5-22.5	5	1.5	30	yes	531	199.5	90.1	45.4	651	Knot on the side, 25mm
S7 p33	11	-22.5-22.5	5	1.5	30	yes	521	199.5	90.3	45.7	633	Knot on the side, 26mm; knot in the middle, 4mm
S7 p34	10.8	-22.5-22.5	5	1.5	30	yes	516	199.5	90.4	45.6	627	Not tested
S7 p35	10.2	-22.5-22.5	5	1.5	30	no	520	199.25	90.3	45.4	637	2 knots on the side, 2 x 5mm, bark which is grown

												into the tree rings; not tested
S7 p36	10	-22.5-22.5	5	1.5	30	no	515	199.25	90.4	45.6	627	Not tested
mean:	10.2		5.0	1.8	35.4		506.5	199.5	90.3	45.6	616.5	
σ:	0.7		1.0	0.4	8.7		35.9	0.2	0.2	0.2	43.5	

Radiata Pine – S8

Scientific name: Pinus radiata
Source location: Australia
Identification number: S8
Stress grade: MGP12

Table A29: Photographs of Samples Tested, end and plan view

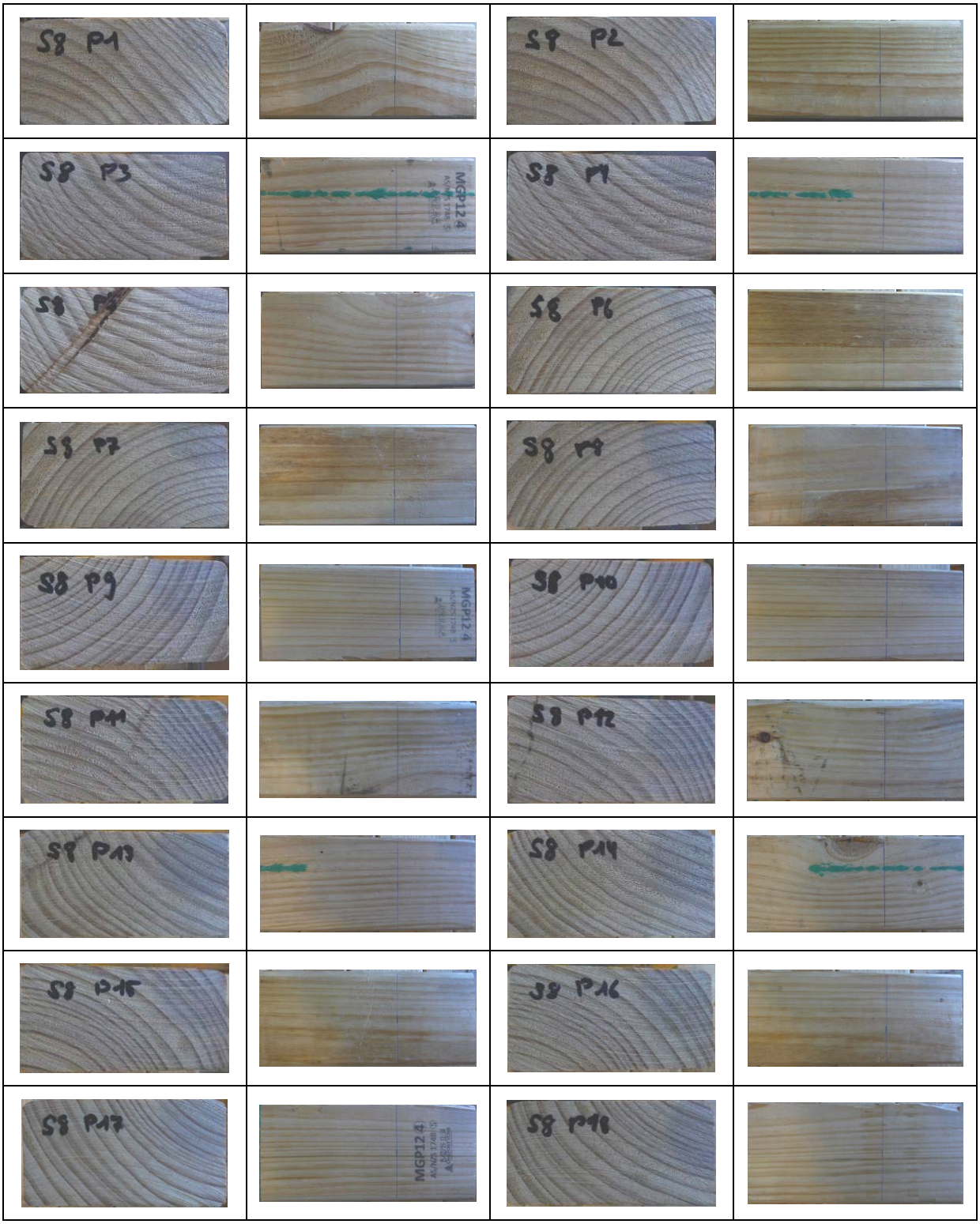


Table A30: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	573	569	4.8
Bearing perpendicular to grain [MPa]	13.0	11.0	8.9
MOE perpendicular to grain [MPa]	631	623	10.5

Table A31: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S8 p1	566	15.33	617.78
S8 p2	555	12.48	749.41
S8 p3	555	11.85	643.21
S8 p4	549	11.84	598.95
S8 p5	561	12.17	618.02
S8 p6	539	11.93	661.79
S8 p7	533	12.58	788.25
S8 p8	530	12.68	507.43
S8 p9	543	12.18	662.37
S8 p10	545	12.34	675.12
S8 p11	560	12.28	599.59
S8 p12	565	13.32	705.85
S8 p13	551	11.19	637.03
S8 p14	595	16.43	644.31
S8 p15	573	13.41	584.34
S8 p16	570	13.70	594.07
S8 p17	567	13.75	655.14
S8 p18	572	13.71	653.63
S8 p19	631	13.47	581.76
S8 p20	626	13.66	616.37
S8 p21	610	13.68	606.51
S8 p22	602	13.74	566.55
S8 p23	605	12.79	639.64
S8 p24	614	13.64	817.71
S8 p25	620	14.09	555.78
S8 p26	611	12.95	575.15
S8 p27	555	12.59	659.12
S8 p28	575	13.58	700.37
S8 p29	575	14.33	642.42
S8 p30	554	12.35	564.64

S8 p31	558	10.68	608.18
S8 p32	561	-	-
S8 p33	567	11.37	589.53
S8 p34	579	12.18	518.13

Table A32: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S8 p1	11.8	0-45	6.5	2.3	35	yes	459	199.5	90.1	45.2	565	Missing knot in the middle, 26mm
S8 p2	11.3	0-45	6.5	2.3	35	yes	447	199.75	90.1	45	552	-
S8 p3	11.5	0-45	6.5	2.3	35	no	454	199.75	90.3	45.5	553	-
S8 p4	11.7	0-45	6.5	2.3	35	no	450	199.75	90.1	45.6	548	-
S8 p5	11	0-45	6.5	2.3	35	no	455	199.75	90	45.5	556	Knot on the side, 5mm
S8 p6	9.6	0-45	5	1.2	24	yes	436	199.5	91.3	45.4	527	-
S8 p7	9.9	0-45	5	1.2	24	yes	434	199.5	91.3	45.6	523	-
S8 p8	9.4	0-45	5	1.2	24	yes	434	199.75	91.3	45.9	518	-
S8 p9	10.1	0-45	5	1.2	24	no	441	199.75	91.3	45.3	534	-
S8 p10	9.6	0-45	5	1.2	24	no	440	199.5	91.1	45.4	533	-
S8 p11	13.1	0-67.5	5	2.5	50	yes	457	199	90.1	45.1	565	-
S8 p12	12.3	0-67.5	5	2.5	50	yes	459	199.25	90.1	45.1	567	Knot on the side, 8mm; little injury on the bottom
S8 p13	14	0-67.5	5	2.5	50	no	453	199	89.9	45.1	561	-
S8 p14	12	0-67.5	5	2.5	50	no	486	199.25	90.1	45.5	595	Knot on the side, 5mm; knot in the middle, 32mm; crack through the knot on the middle/side
S8 p15	8.9	0-67.5	5.5	1.5	27	yes	462	199.5	91.1	45.6	557	-

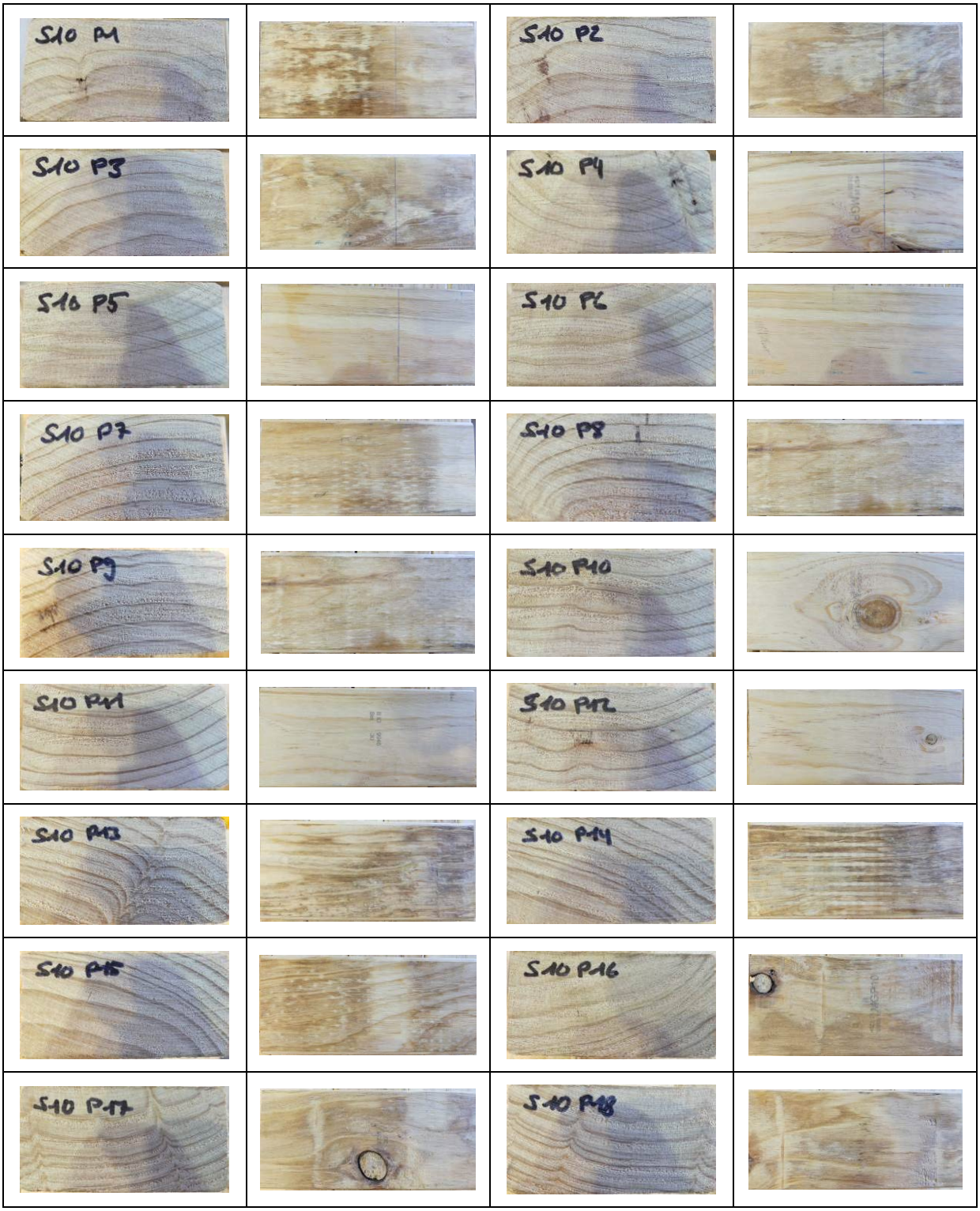
S8 p16	9.6	0-67.5	5.5	1.5	27	yes	461	199.5	91.2	45.4	558	-
S8 p17	9.9	0-67.5	5.5	1.5	27	no	460	199.25	91.2	45.5	556	Little damage on the side
S8 p18	10.1	0-67.5	5.5	1.5	27	no	465	199.25	91.2	45.5	562	Little damage in the middle, grown in bark in the middle 45mm long and 1mm wide
S8 p19	10.1	0-45	4.5	1.8	40	yes	498	199.5	89.5	45	620	-
S8 p20	10	0-45	4.5	1.8	40	yes	496	199.5	89.7	45.1	615	-
S8 p21	11	0-45	4.5	1.8	40	no	490	199.25	90.2	45.1	605	-
S8 p22	10.8	0-45	4.5	1.8	40	no	488	199.5	90.4	45.4	596	-
S8 p23	9.7	0-45	4.5	1.5	33	yes	479	199.75	89.8	45	593	Damaged on one edge
S8 p24	10.7	0-45	4.5	1.5	33	yes	493	199.75	90	45.2	607	Grown in bark on the side 45mm long and 3mm wide
S8 p25	11.1	0-45	4.5	1.5	33	no	496	199.5	89.5	45.2	615	-
S8 p26	11	0-45	4.5	1.5	33	no	490	199.5	89.7	45.2	606	-
S8 p27	10.5	0-45	5.5	2	36	yes	443	199.5	89.8	45.1	548	Grown in bark on the side 45mm long and 4mm wide
S8 p28	12	0-45	5.5	2	36	yes	464	199.75	89.7	45	575	Knot on the side 25mm
S8 p29	11.6	0-45	5.5	2	36	no	464	199.5	90	45.1	573	Knot on the side, 8mm; knot on the middle/side, res18mm
S8 p30	11.7	0-45	5.5	2	36	no	447	199.75	89.9	45	553	-
S8 p31	13.5	0-45	5.5	2	36	yes	451	199.5	89.3	44.8	565	-
S8 p32	13.7	0-45	5.5	2	36	yes	455	199.5	88.9	45	570	No test data
S8 p33	12.9	0-45	5.5	2	36	no	457	199.5	89.4	44.8	572	-
S8 p34	13	0-45	5.5	2	36	no	467	199.5	89	45	584	-

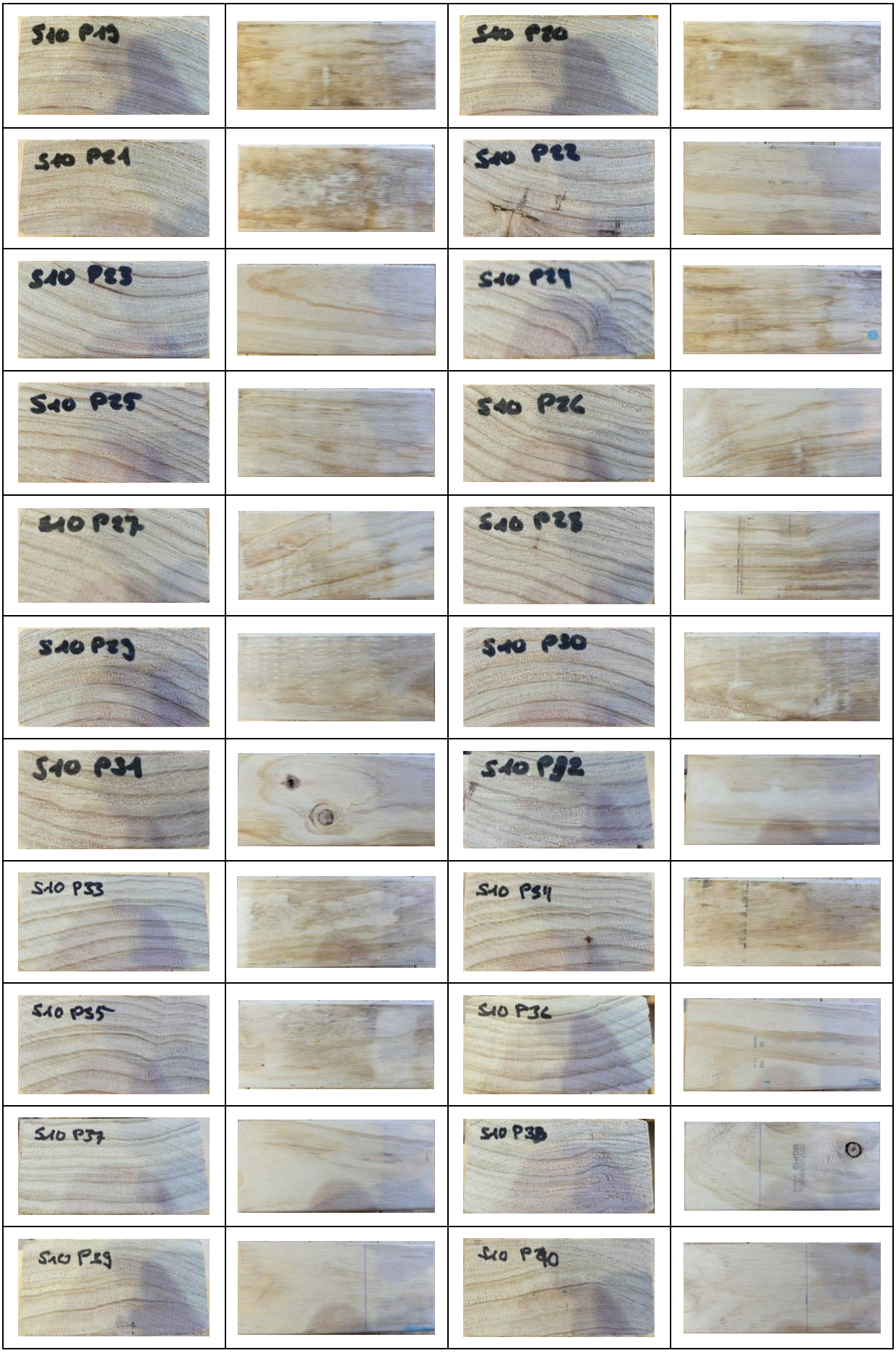
mean:	11.0		5.3	1.9	35.4		459.0	199.5	90.1	45.2	565.0	
σ:	1.4		0.6	0.4	7.5		19.3	0.2	0.7	0.3	27.3	

Radiata Pine – S10

Scientific name: Pinus radiata
Source location: Australia
Identification number: S10
Stress grade: MGP10

Table A33: Photographs of Samples Tested, end and plan view




S10 P19
S10 P20
S10 P21
S10 P22
S10 P23
S10 P24
S10 P25
S10 P26
S10 P27
S10 P28
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S10 P30
S10 P31
S10 P32
S10 P33
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S10 P35
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S10 P37
S10 P38
S10 P39
S10 P40

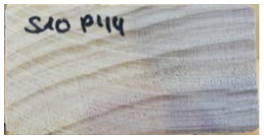
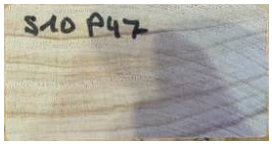
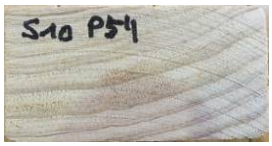
 S10 P41		 S10 P42	
 S10 P43		 S10 P44	
 S10 P45		 S10 P46	
 S10 P47		 S10 P48	
 S10 P49		 S10 P50	
 S10 P51		 S10 P52	
 S10 P53		 S10 P54	
 S10 P55		 S10 P56	
 S10 P57		 S10 P58	
 S10 P59		 S10 P60	
S10 P61		S10 P62	

Table A34: Summary of Characteristic Values Middle of Sample of Sample

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	486	483	6.1
Bearing perpendicular to grain [MPa]	10.9	8.6	12.7
MOE perpendicular to grain [MPa]	503	494	14.2

Table A35: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S10 p1	472	11.16	490.69
S10 p2	500	12.23	546.87
S10 p3	494	11.43	447.25
S10 p4	499	17.56	699.68
S10 p5	457	13.41	428.86
S10 p38	474	10.36	602.79
S10 p39	465	12.30	602.49
S10 p40	460	11.31	547.79
S10 p41	471	10.84	461.90
S10 p42	460	10.39	633.44
S10 p43	458	10.23	595.72
S10 p44	474	10.71	549.99
S10 p45	480	11.50	505.12
S10 p46	469	11.34	533.61
S10 p47	455	10.48	536.95
S10 p48	455	10.95	567.02
S10 p49	461	10.56	456.75
S10 p50	456	9.72	460.45

S10 p51	451	9.33	535.36
S10 p52	460	9.00	440.22
S10 p53	456	9.06	453.67
S10 p54	457	9.57	497.97
S10 p55	515	10.07	387.24
S10 p56	514	10.26	414.50
S10 p57	536	13.23	511.37
S10 p58	529	9.82	420.11
S10 p59	535	10.48	477.78
S10 p60	527	10.02	433.13
S10 p61	515	10.93	495.37
S10 p62	520	10.82	541.26
S10 p63	535	10.99	474.14
S10 p64	507	10.31	414.06
S10 p65	527	10.60	421.47

Table A36: Summary of Characteristic Values End of Sample

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	505	501	6.1
Bearing perpendicular to grain [MPa]	8.8	7.4	9.7
MOE perpendicular to grain [MPa]	408	399	16.5

Table A37: Individual Samples Density, Perpendicular to Grain Bearing and MOE End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S10 p6	459	9.77	395.43
S10 p7	496	7.48	310.11
S10 p8	503	8.53	428.87
S10 p9	499	7.92	379.03
S10 p10	561	8.85	318.77
S10 p11	502	7.80	312.31

S10 p12	507	9.77	455.20
S10 p13	552	9.84	421.05
S10 p14	545	9.12	317.19
S10 p15	542	9.17	301.04
S10 p16	538	9.46	385.03
S10 p17	551	10.12	477.57
S10 p18	523	9.63	382.08
S10 p19	461	8.83	445.45
S10 p20	460	8.59	436.63
S10 p21	469	9.18	414.34
S10 p22	475	10.36	402.31
S10 p23	482	9.21	418.46
S10 p24	536	9.92	375.89
S10 p25	526	9.04	470.63
S10 p26	528	9.45	506.44
S10 p27	523	8.70	391.97
S10 p28	527	9.27	437.44
S10 p29	503		
S10 p30	510	8.32	338.14
S10 p31	526	8.57	570.94
S10 p32	485	8.61	514.71
S10 p33	479	7.47	403.49
S10 p34	481	8.02	397.03
S10 p35	467	7.61	384.32
S10 p36	471	7.34	332.49
S10 p37	476	8.04	512.69

Table A38: Table of Sample Properties Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S10 p1	10	-22.5-22.5	9	1.5	17	yes	390	200.5	90.7	46.2	464	-
S10 p2	10.5	-22.5-22.5	9	1.5	17	yes	406	200.5	90.6	45.3	493	-
S10 p3	9.6	-22.5-22.5	9	1.5	17	yes	404	200.5	90.7	46	483	-
S10 p4	11.8	-22.5-22.5	9	1.5	17	no	413	200	90.8	45.7	498	Could be compression or tension wood or the area around a knot in the middle
S10 p5	11.5	0-22.5	9	1.5	17	no	381	200	90.6	46.2	455	-
S10 p38	12.4	0-22.5	6	1.5	25	no	398	200.25	90.8	46	476	Knot on the side, 14mm
S10 p39	11.8	0	8	1.5	19	yes	382	200	90.1	45.7	464	-
S10 p40	11.6	0	8	1.5	19	yes	377	200	90	45.7	458	-
S10 p41	12.3	0	8	1.5	19	no	388	200	89.7	45.8	472	-
S10 p42	13	0	8	1.5	19	no	381	200	89.8	45.7	464	-
S10 p43	13.6	0	8	1.5	19	no	380	200	89.4	45.7	465	Pitch pocked in the middle 5 mm bright and 50 mm long
S10 p44	12.8	0-22.5	11	2.5	23	yes	383	200	88.7	45.3	477	-
S10 p45	12.9	0-22.5	11	2.5	23	yes	393	200.25	89.3	45.4	484	-
S10 p46	13.2	0-22.5	11	2.5	23	yes	385	200.25	89.4	45.4	474	-
S10 p47	13.4	0-22.5	11	2.5	23	no	377	200.75	89.6	45.5	461	-

S10 p48	14.4	0-22.5	11	2.5	23	no	376	200.25	89.4	45.2	465	-
S10 p49	14	0-22.5	11	2.5	23	no	381	200	89.6	45.3	469	-
S10 p50	12.2	0-22.5	6	2	33	yes	381	200	90.7	46	457	-
S10 p51	13.3	0-22.5	6	2	33	yes	382	200	90.8	46.1	456	-
S10 p52	11.4	0-22.5	6	2	33	yes	382	200	90.6	46	458	-
S10 p53	11.1	0-22.5	6	2	33	no	378	200.25	90.8	46	452	-
S10 p54	11	0-22.5	6	2	33	no	378	200	90.8	45.9	453	-
S10 p55	14	45	7	2	29	yes	425	200.5	89.9	45	524	-
S10 p56	13.2	45	7	2	29	yes	429	200.25	90.1	45.7	520	-
S10 p57	13.7	45	7	2	29	yes	450	200	90.5	45.7	544	Knot in the middle, 23mm
S10 p58	13.6	45	7	2	29	no	442	200.25	90	45.7	537	-
S10 p59	12.8	45	7	2	29	no	446	200.25	90.2	45.8	539	-
S10 p60	12.4	45	7	2	29	no	431	200.25	89.8	45.3	529	-
S10 p61	12.9	45	5	1.2	24	yes	431	200.5	90.4	45.8	519	Knot in the middle, 12mm
S10 p62	12.9	45	5	1.2	24	yes	434	200.25	90.3	45.8	524	-
S10 p63	13	45	5	1.2	24	yes	444	200.25	89.8	45.7	540	-
S10 p64	12	45	5	1.2	24	no	420	200	90.3	45.9	507	-
S10 p65	12.5	45	5	1.2	24	no	434	200	90.1	45.5	529	-
mean:	12.8		7.0	2.0	24.0		390.0	200.3	90.1	45.7	476.0	
σ:	1.2		2.0	0.4	5.5		25.4	0.2	0.5	0.3	31.3	

Table A39: Table of Sample Properties End of Sample

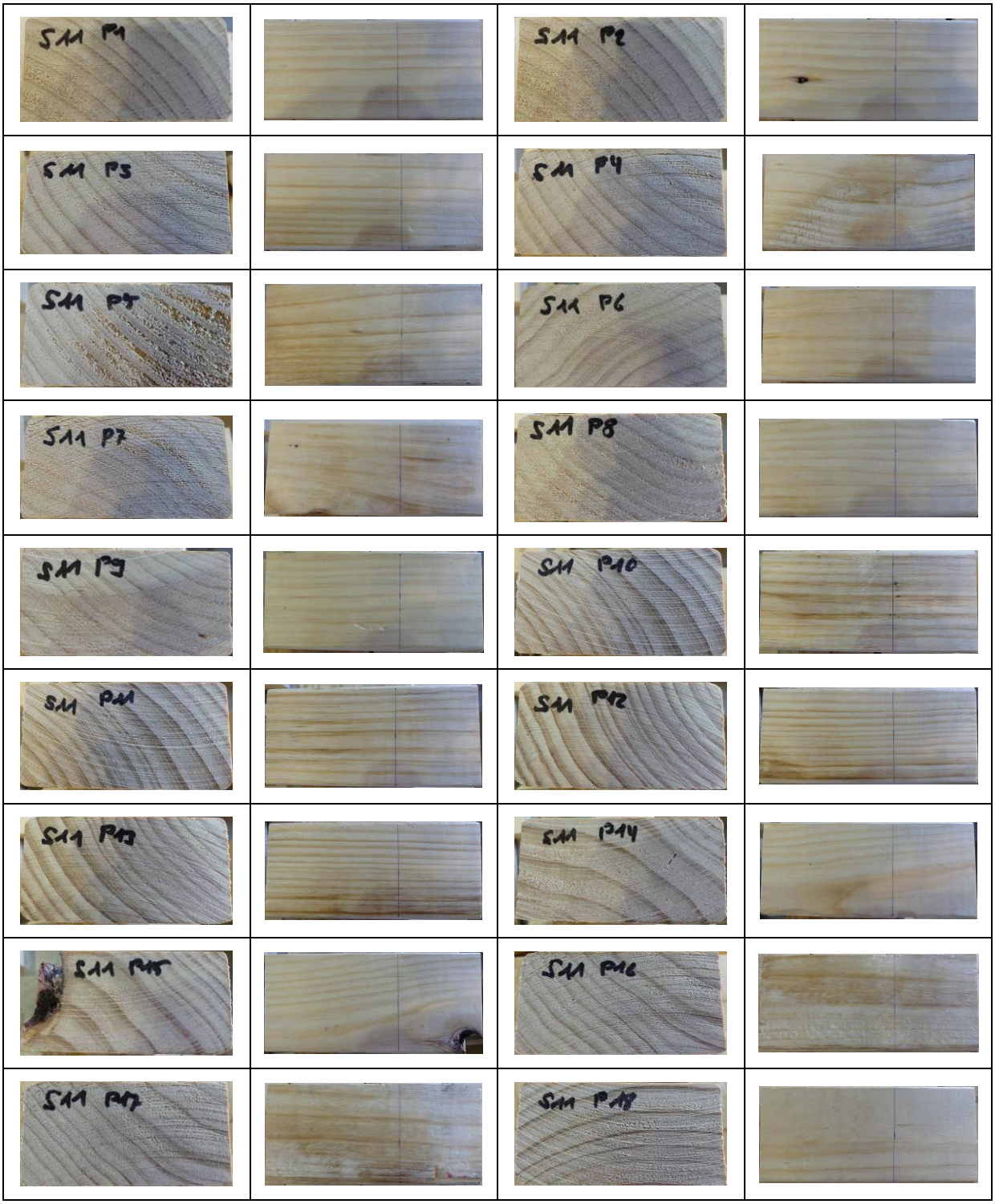
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S10 p6	11.3	0-22.5	9	1.5	17	no	377	200	91.1	45.4	456	-
S10 p7	11.9	-22.5-22.5	9	1.5	17	yes	416	200	90.7	46.2	496	-
S10 p8	11.1	-22.5-22.5	9	1.5	17	yes	421	200	90.9	46.4	499	Missing knot on the side, 40mm
S10 p9	11.6	-22.5-22.5	9	1.5	17	yes	416	200	90.8	46.1	497	-
S10 p10	12.6	-22.5-22.5	9	1.5	17	no	466	200.25	90.7	45.5	564	Knot in the middle, 36mm
S10 p11	12	-22.5-22.5	9	1.5	17	no	421	200.5	90.7	46.1	502	-
S10 p12	11.9	-22.5-22.5	9	1.5	17	no	421	200.5	90.7	45.7	507	Knot on the side, 10mm
S10 p13	11.8	22.5-45	5.5	2	36	yes	464	200	90.8	46.4	551	-
S10 p14	11.3	22.5-45	5.5	2	36	yes	452	200	90.9	45.9	542	-
S10 p15	11.6	0-45	7	2	29	yes	449	200	90.8	45.8	540	-
S10 p16	11.5	0-45	7	2	29	no	447	200	90.9	45.9	536	Knot on the side 28mm
S10 p17	12	0-45	6	2	33	no	462	200.25	90.8	46.1	551	Knot in the middle, 24mm; not a smooth surface on the bottom
S10 p18	11.3	0-22.5	6	2	33	no	432	200.25	90.9	45.6	520	Missing knot on the side, 18mm
S10 p19	10.6	-22.5-22.5	10	3	30	yes	381	200	90.8	46.1	455	-

S10 p20	10.1	-22.5-22.5	10	3	30	yes	377	200	90.6	46	452	-
S10 p21	9.8	-22.5-22.5	10	3	30	yes	387	200	90.7	46.4	460	-
S10 p22	10.7	-22.5-22.5	10	3	30	no	395	200	90.9	46.3	469	-
S10 p23	10.7	-22.5-22.5	10	3	30	no	397	200	90.6	46	476	-
S10 p24	10.3	0-22.5	7	2	29	yes	440	200	90.9	45.8	528	-
S10 p25	12.5	0-22.5	7	2	29	yes	437	200	90.9	45.5	528	-
S10 p26	12.3	0-22.5	7	2	29	no	438	200	90.8	45.6	529	-
S10 p27	12.9	0-22.5	7	2	29	no	442	200.25	90.7	46.2	527	-
S10 p28	12.4	0-22.5	7	2	29	no	444	200	90.8	46.2	529	-
S10 p29	12.8	0	8	2	25	yes	425	200	90.7	46.2	507	No test data
S10 p30	12.2	0	8	2	25	yes	430	200	90.9	46.3	511	Missing knot in the middle, 25mm
S10 p31	12.8	0	8	2	25	no	440	200	90.6	45.8	530	Missing knot in the middle, 6mm; knot in the middle, 15mm
S10 p32	12.9	0	8	2	25	no	408	200.25	90.8	45.9	489	-
S10 p33	10.2	0-22.5	6	1.5	25	yes	396	200	90.8	46.3	471	-
S10 p34	9.4	0-22.5	6	1.5	25	yes	395	200	90.8	46.3	470	-
S10 p35	9.3	0-22.5	6	1.5	25	yes	382	200	90.7	46.2	456	-
S10 p36	10.4	0-22.5	6	1.5	25	no	389	200	90.7	46.2	464	-
S10 p37	10.6	0-22.5	6	1.5	25	no	394	200	90.8	46.2	470	-
mean:	mean:	11.6		7.5	2.0	26.8		421.0	200.0	90.8	46.1	
σ:	σ:	1.0		1.5	0.5	5.9		27.3	0.1	0.1	0.3	

Radiata Pine – S11

Scientific name: Pinus radiata
Source location: South Australia
Identification number: S11
Stress grade: MGP15

Table A40: Photographs of Samples Tested, end and plan view



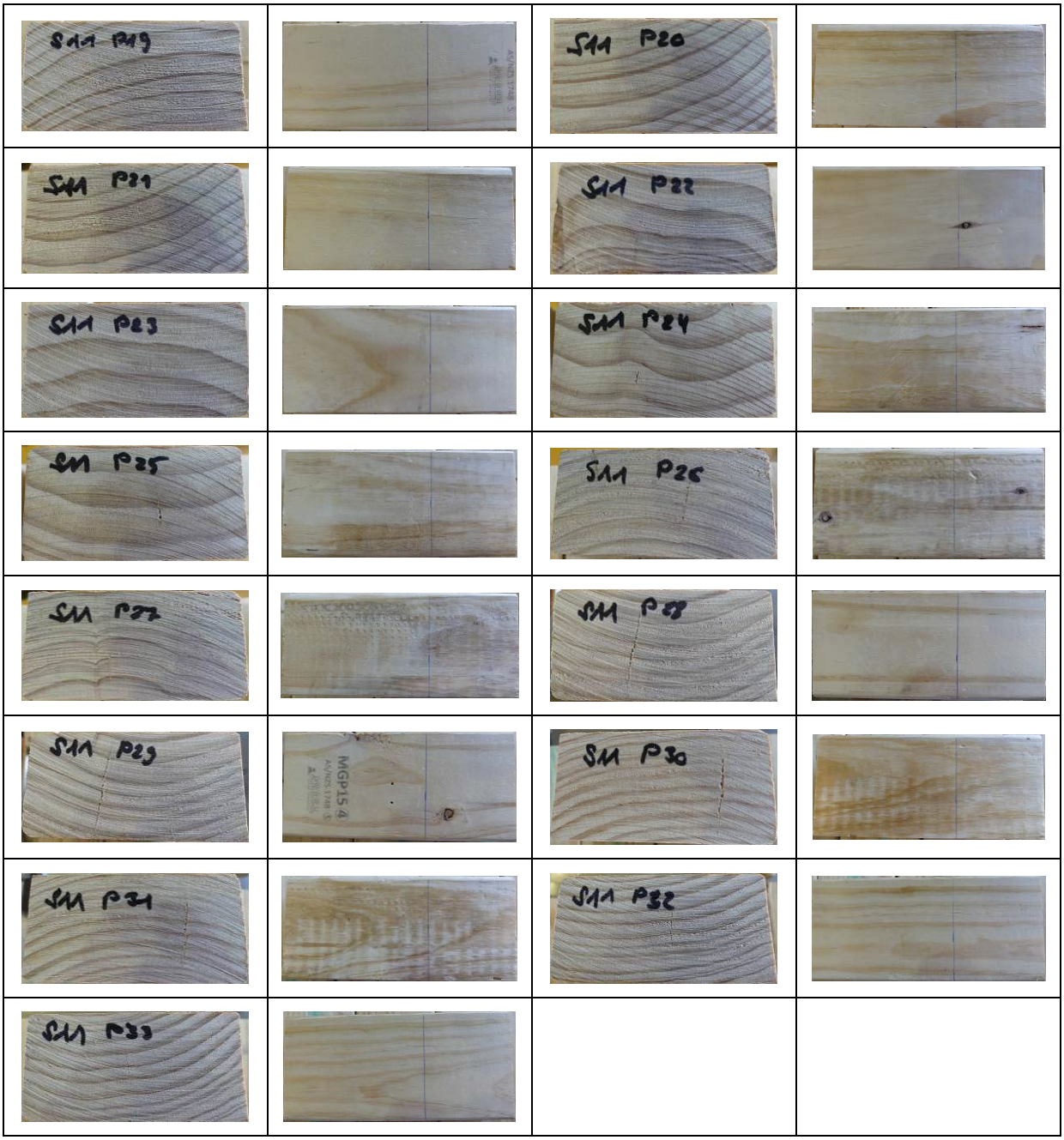


Table A41: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	540	536	6
Bearing perpendicular to grain [MPa]	11.5	8.4	16.6
MOE perpendicular to grain [MPa]	546	526	21.2

Table A42: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S11 p1	534	10.75	491.23
S11 p2	536	10.26	496.09
S11 p3	545	9.90	427.61
S11 p4	542	9.47	504.67
S11 p5	529	10.14	400.07
S11 p6	482	9.06	392.27
S11 p7	488	9.58	478.26
S11 p8	481	9.05	365.48
S11 p9	482	8.71	452.56
S11 p10	559	11.95	574.82
S11 p11	556		
S11 p12	552	11.77	467.74
S11 p13	551	11.73	529.31
S11 p14	576	13.93	492.72
S11 p15	590	13.62	543.98
S11 p16	581	12.59	503.90
S11 p17	589	12.66	442.81
S11 p18	497	10.17	530.67
S11 p19	494	10.11	503.98
S11 p20	510	9.33	511.19
S11 p21	507	9.25	429.74
S11 p22	580	14.31	658.92
S11 p23	568	16.15	613.78
S11 p24	568		
S11 p25	571	14.24	642.38
S11 p26	531	12.25	816.18
S11 p27	531	12.87	566.83
S11 p28	524	12.51	795.80
S11 p29	550	14.48	887.55

S11 p30	552	11.03	577.36
S11 p31	561	11.33	653.08
S11 p32	552	11.49	616.83
S11 p33	553	12.05	561.46

Table A43: Table of Sample Properties

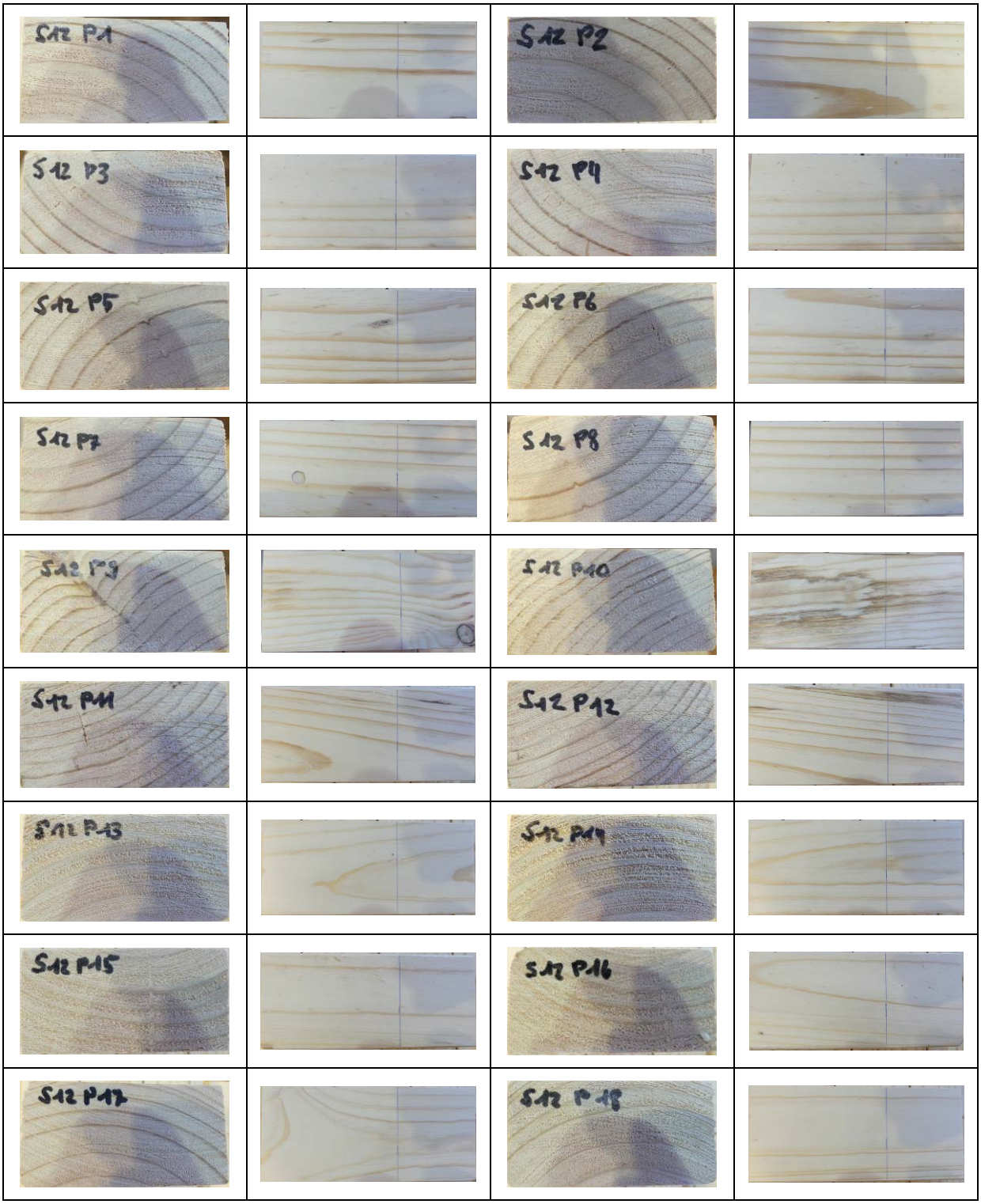
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S11 p1	13.5	22.5-67.5	9	2.4	27	yes	436	199.5	90.4	44.7	541	-
S11 p2	13.4	22.5-67.5	9	2.4	27	yes	437	199.5	90.1	44.8	543	Knot on the side, 6mm
S11 p3	14	22.5-67.5	9	2.4	27	no	448	199.25	90.1	45	555	-
S11 p4	14.3	22.5-67.5	9	2.4	27	no	450	199.25	90.6	45.1	553	-
S11 p5	13.4	22.5-67.5	9	2.4	27	no	435	199.25	90.7	44.9	536	-
S11 p6	11.2	22.5-45	7	2.2	31	yes	393	199.5	90.8	45.3	479	-
S11 p7	11.1	22.5-45	7	2.2	31	yes	401	199.5	91	45.6	484	-
S11 p8	10.7	22.5-45	7	2.2	31	no	390	199.5	90.8	45.3	475	-
S11 p9	10.7	22.5-45	7	2.2	31	no	391	199.5	90.9	45.3	476	Little injury in the middle
S11 p10	10.1	45-67.5	7	2.5	36	yes	454	199.5	91	45.5	550	-
S11 p11	10.6	45-67.5	7	2.5	36	yes	451	199.25	91	45.3	549	No test data
S11 p12	10.3	45-67.5	7	2.5	36	no	448	199.25	90.3	45.8	544	-
S11 p13	10.5	45-67.5	7	2.5	36	no	452	199.25	90.6	46	544	-
S11 p14	10.6	22.5-45	8.5	2.3	27	yes	467	199.5	90.8	45.3	569	-
S11 p15	10.7	22.5-45	8.5	2.3	27	yes	475	199.5	90.4	45.2	583	Missing knot on the side, 22mm
S11 p16	10.5	22.5-45	8.5	2.3	27	no	475	199.5	90.9	45.7	573	-

S11 p17	11.2	22.5-45	8.5	2.3	27	no	476	199.5	90.5	45.1	585	-
S11 p18	11.6	0-45	7	1.8	26	yes	403	199.5	90.2	45.2	495	-
S11 p19	12	0-45	7	1.8	26	yes	404	199.5	90.3	45.4	494	-
S11 p20	11.4	0-45	7	1.8	26	no	411	199.25	90.4	45	507	Big chamber-bevel on one edge, sharp edge on the other side
S11 p21	10.9	0-45	7	1.8	26	no	408	199.5	90.5	45	502	Big chamber-bevel on one edge, sharp edge on the other side
S11 p22	10.2	-25-25	12	4	33	yes	470	199.5	90.5	45.6	571	Knots on the middle/side, 6mm; knot on the side, 16mm
S11 p23	10.8	-25-25	12	4	33	yes	462	199.5	90.9	45.3	562	-
S11 p24	10.6	-25-25	12	3	25	no	465	199.25	90.5	46	561	No test data
S11 p25	10.8	-25-25	12	3	25	no	462	199.5	90.7	45.2	565	-
S11 p26	9.3	-25-25	7.5	1.5	20	yes	436	199.5	91.5	46.1	518	2 knots on the side, 2 x 6mm
S11 p27	9.2	-25-25	7.5	1.5	20	yes	435	199.25	91.6	46	518	Knots on the side, 3mm
S11 p28	9.5	-25-25	7.5	1.5	20	no	425	199.5	91.3	45.6	512	-
S11 p29	9.1	-25-25	7.5	1.5	20	no	446	199.5	91.7	45.5	536	2 knots on the side, 7mm and 18mm
S11 p30	9.6	-25-25	5.5	2.3	42	yes	444	199.5	90.9	45.3	540	-
S11 p31	9.5	-25-25	5.5	2.3	42	yes	452	199.5	90.9	45.5	548	Missing knot on the side, 12mm
S11 p32	9.9	-25-25	5.5	2.3	42	no	448	199.5	90.7	45.7	542	-
S11 p33	10.1	-25-25	5.5	2.3	42	no	446	199.5	91.1	45.1	544	-
mean:	10.7		7.5	2.3	27.1		446.0	199.5	90.7	45.3	543.0	
σ:	1.4		1.8	0.6	6.4		25.9	0.1	0.4	0.4	31.5	

Radiata Pine – S12

Scientific name: Pinus radiata
Source location: Australia
Identification number: S12
Stress grade: MGP12

Table A44: Photographs of Samples Tested, end and plan view



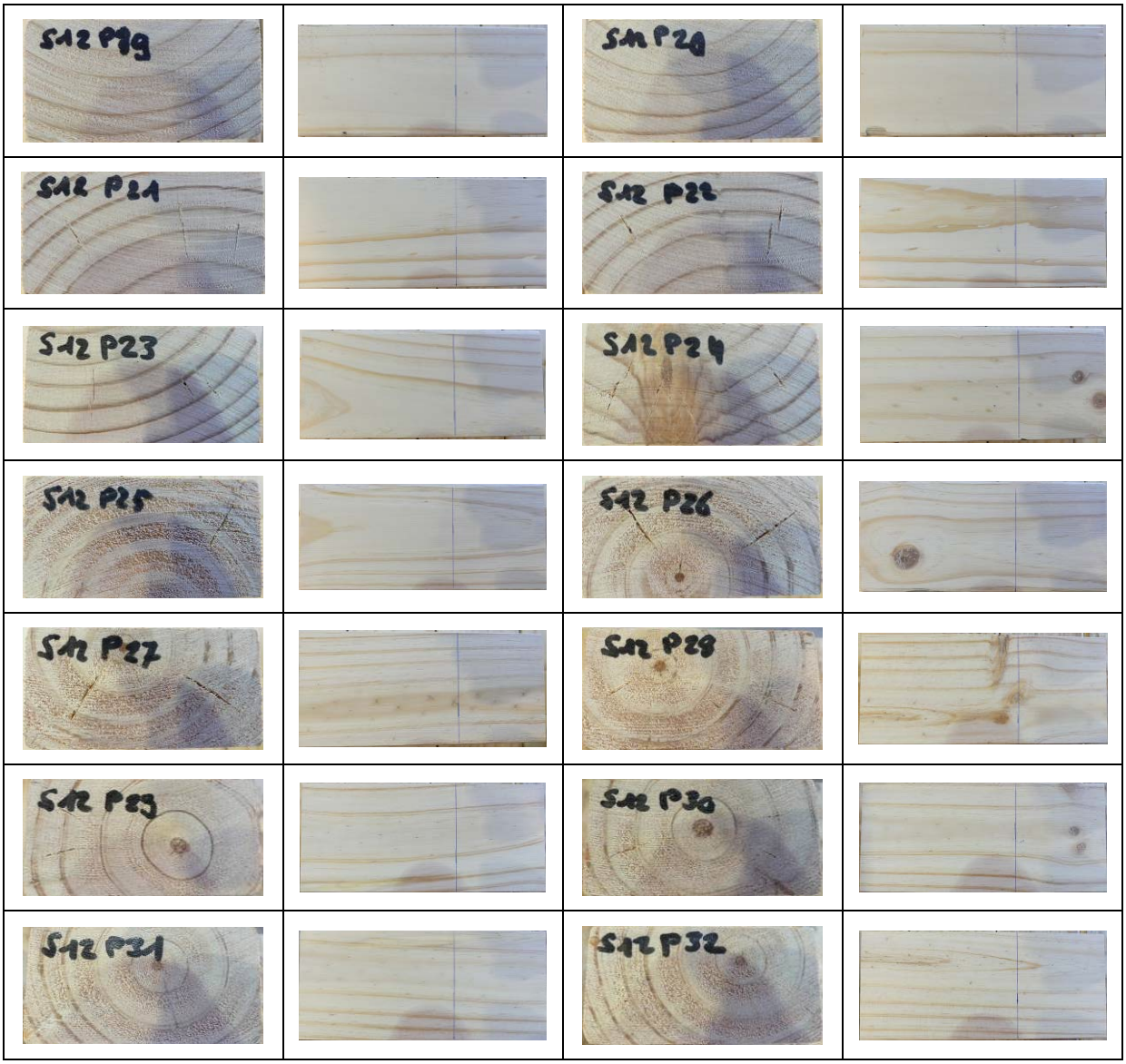


Table A45: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	481	476	7.6
Bearing perpendicular to grain [MPa]	10.4	7.4	17.8
MOE perpendicular to grain [MPa]	433	399	23.6

Table A46: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S12 p1	496	11.89	608.12

S12 p2	488	12.37	643.50
S12 p3	471	10.31	508.57
S12 p4	473	10.94	536.31
S12 p5	508	13.69	581.59
S12 p6	507	12.15	489.46
S12 p7	490	12.44	510.47
S12 p8	497	-	-
S12 p9	554	10.27	359.70
S12 p10	553	10.56	438.32
S12 p11	507	10.68	471.06
S12 p12	522	11.36	452.93
S12 p13	492	-	-
S12 p14	496	7.60	358.35
S12 p15	486	8.41	370.43
S12 p16	490	8.26	262.50
S12 p17	425	7.24	265.31
S12 p18	406	7.19	433.92
S12 p19	402	8.06	342.16
S12 p20	399	7.73	334.62
S12 p21	491	11.60	457.12
S12 p22	486	12.24	560.37
S12 p23	502	12.03	442.72
S12 p24	491	11.09	463.05
S12 p25	448	9.52	430.62
S12 p26	474	9.64	322.66
S12 p27	457	11.03	308.38
S12 p28	506	11.41	436.59
S12 p29	458	11.27	475.76
S12 p30	477	10.57	379.32
S12 p31	457	9.85	318.61
S12 p32	481	10.25	415.29

Table A47: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S12 p1	9.6	0-45	10	1.8	18	yes	393	200.5	90.6	44.6	485	-
S12 p2	9.4	0-45	10	1.8	18	yes	385	200.25	90.5	44.5	477	-
S12 p3	9.7	0-45	10	1.8	18	no	371	200.5	90.4	44.4	461	-
S12 p4	10.1	0-45	10	1.8	18	no	375	200.25	90.5	44.5	465	-
S12 p5	9.7	0-45	10	1.8	18	yes	403	200.25	90.6	44.6	498	Knot in the middle, 8mm
S12 p6	9.3	0-45	10	1.8	18	yes	400	200.25	90.4	44.6	495	-
S12 p7	9.7	0-45	10	1.8	18	no	389	200.25	90.9	44.5	480	Damage on the side
S12 p8	9.8	0-45	10	1.8	18	no	396	200.25	90.8	44.7	487	No test data
S12 p9	9.9	22.5-45	5	1.2	24	yes	442	200.75	90.8	44.6	544	Knot on the side, 15mm
S12 p10	9.4	22.5-45	5	1.2	24	yes	442	200.5	90.6	45.1	540	-
S12 p11	9.8	22.5-45	5	1.2	24	no	406	200.25	90.8	44.9	497	-
S12 p12	9.7	22.5-45	5	1.2	24	no	417	200	90.6	45	511	-
S12 p13	12.5	-22.5-22.5	9	2.5	28	yes	327	200.5	84.5	39.1	494	No test data
S12 p14	11.1	-22.5-22.5	9	2.5	28	yes	326	200.5	84.6	39.1	492	-
S12 p15	13.3	-22.5-22.5	9	2.5	28	no	328	200.5	84.8	39.2	492	-

S12 p16	13	-22.5-22.5	9	2.5	28	no	329	200.75	84.5	39.3	494	-
S12 p17	12.2	-22.5-22.5	10	1.8	18	yes	336	200.25	89.8	43.9	426	Knot on the side, 30mm
S12 p18	12.3	-22.5-22.5	10	1.8	18	yes	322	200.25	90	43.9	407	-
S12 p19	12.9	-22.5-22.5	10	1.8	18	no	322	200.25	89.8	44.2	405	-
S12 p20	12.4	-22.5-22.5	10	1.8	18	no	318	200.25	89.9	44.2	400	-
S12 p21	8.9	-22.5-22.5	10	1.8	18	yes	388	200.5	90.6	44.8	477	-
S12 p22	9.4	-22.5-22.5	10	1.8	18	yes	386	200.5	90.5	44.8	475	-
S12 p23	9.2	-22.5-22.5	10	1.8	18	no	394	201	90.7	44.2	489	Knot on the side, 24mm
S12 p24	9.2	-22.5-22.5	10	1.8	18	no	389	200.25	90.7	44.7	479	2 knots on the side, 10mm and 12mm
S12 p25	13.3	90	10	2.5	25	yes	363	200.25	90	44.5	453	Cut through the pith
S12 p26	12	90	10	2.5	25	yes	383	200.5	90.2	44.7	474	Cut through the pith; 2 knots on the side, 2 x 20mm
S12 p27	11	90	10	2.5	25	-	366	200.5	90.2	44.7	453	With pith
S12 p28	12.2	90	10	2.5	25	-	408	200.5	90	44.6	507	With pith; 3 knots in the middle, 3 x 10mm
S12 p29	10.7	90	13	2.5	19	-	368	200	90.4	44.9	453	With pith
S12 p30	10.7	90	13	2.5	19	-	380	200	90.2	44.7	471	With pith; 4 knots on the side, 3x 8mm and 11mm
S12 p31	11.6	90	13	2.5	19	-	365	200.25	90.3	44.4	455	With pith
S12 p32	11.1	90	12	2.5	21	-	382	200	90.3	44.3	477	With pith
mean:	10.4		10.0	1.8	18.6		382.5	200.3	90.4	44.6	478.0	
σ:	1.4		2.0	0.4	3.8		34.1	0.2	2.0	1.8	33.2	

Caribbean Pine – S14

Scientific name: Pinus Caribbea
Source location: Australia
Identification number: S14
Stress grade: -

Table A48: Photographs of Samples Tested, end and plan view

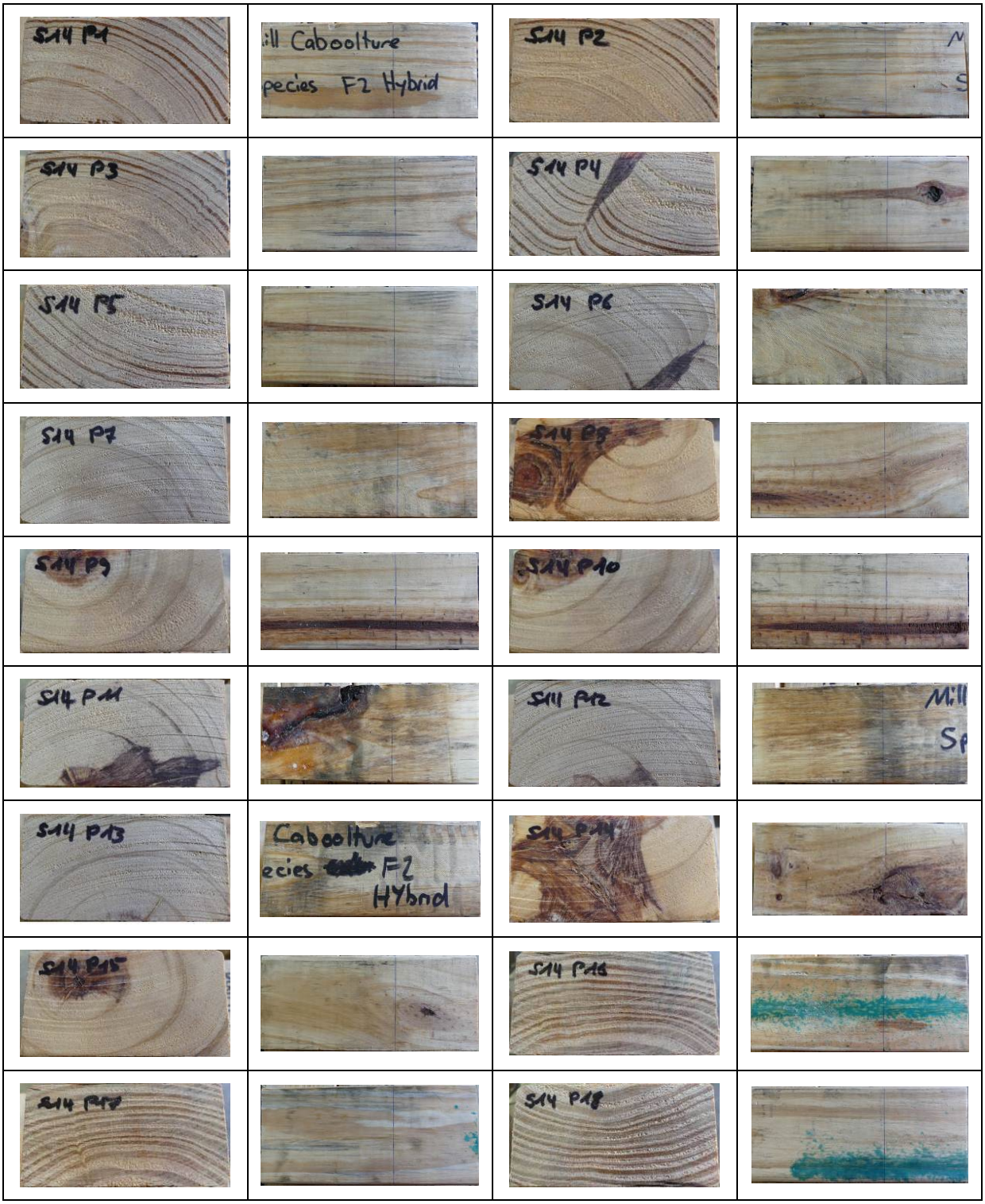


Table A49: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	571	562	14
Bearing perpendicular to grain [MPa]	11.9	8.7	16.3
MOE perpendicular to grain [MPa]	529	502	22.2

Table A50: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S14 p1	510	10.70	427.71
S14 p2	510	10.24	352.21
S14 p3	514	9.84	448.80
S14 p4	565	9.83	517.02
S14 p5	545	9.40	464.71
S14 p6	596	14.47	357.95
S14 p7	503	12.91	473.90
S14 p8	586	15.91	556.22
S14 p9	473	11.71	471.98
S14 p10	505	12.87	463.79
S14 p11	690	15.77	660.91
S14 p12	516	11.73	500.04
S14 p13	435	11.48	461.53
S14 p14	655	18.96	508.00
S14 p15	481	15.34	702.98
S14 p16	719	12.22	670.01
S14 p17	693	11.45	690.61
S14 p18	709	11.96	642.67
S14 p19	731	11.21	338.70
S14 p20	712	10.99	469.64
S14 p21	641	10.86	385.88
S14 p22	638	11.74	446.66
S14 p23	621	10.98	399.62
S14 p24	622	9.42	468.16
S14 p25	630	11.46	509.17
S14 p26	548	11.93	646.26
S14 p27	544	11.72	665.69
S14 p28	541	10.05	711.26
S14 p29	534	9.68	698.04
S14 p30	542	10.27	665.42

S14 p31	583	11.52	561.11
S14 p32	589	11.03	626.11
S14 p33	579	11.62	506.70
S14 p34	591	-	-
S14 p35	592	-	-
S14 p36	504	-	-
S14 p37	481	-	-
S14 p38	446	-	-
S14 p39	501	-	-
S14 p40	467	-	-

Table A51: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S14 p1	13	0-45	5	1.2	24	yes	415	199.5	89.6	45.1	515	-
S14 p2	11.8	0-45	5	1.2	24	yes	412	200.25	89.8	45	509	Big chamber-bevel on one side, 6.2mm less surface
S14 p3	13.1	-45-45	5	1.2	24	yes	418	200.25	89.4	45	519	-
S14 p4	12.5	0-45	5	1.2	24	no	455	200	89.2	44.9	568	Pitch pocket form the side to the middle, in the middle 8mm thick; knot on the side, 13mm
S14 p5	12.5	0-45	5	1.2	24	no	439	200	89.5	44.8	547	Pitch pocket form the side to the middle, in the middle 8mm thick
S14 p6	11.9	0-45	13	1.4	11	yes	476	200	88.9	45	595	Not a smooth surface, little differences from sawing (not planed everywhere); knot on the side, 12mm
S14 p7	11.8	-45-45	13	1.4	11	yes	404	200	87.8	45.8	502	Not a smooth surface, little differences from sawing (not planed everywhere)
S14 p8	11.5	-90-90	13	1.4	11	no	482	200	90.3	45.8	583	Pitch pocket form a knot to the pith at the side; cut through the pith of the tree; knot on the side, 10mm; knot in the middle/side, 10mm
S14 p9	10.8	-90-90	13	1.4	11	no	386	199.5	90.4	45.7	468	Cut through the pith
S14 p10	10.2	0-90	13	1.4	11	no	410	199.5	90.5	45.7	497	Cut through the pith; knot on the side, 10mm
S14 p11	10.6	-90-90	13	1.4	11	yes	546	199.5	87.9	45.7	681	Cut through the pith; a lot of pitch pockets from the side to the middle

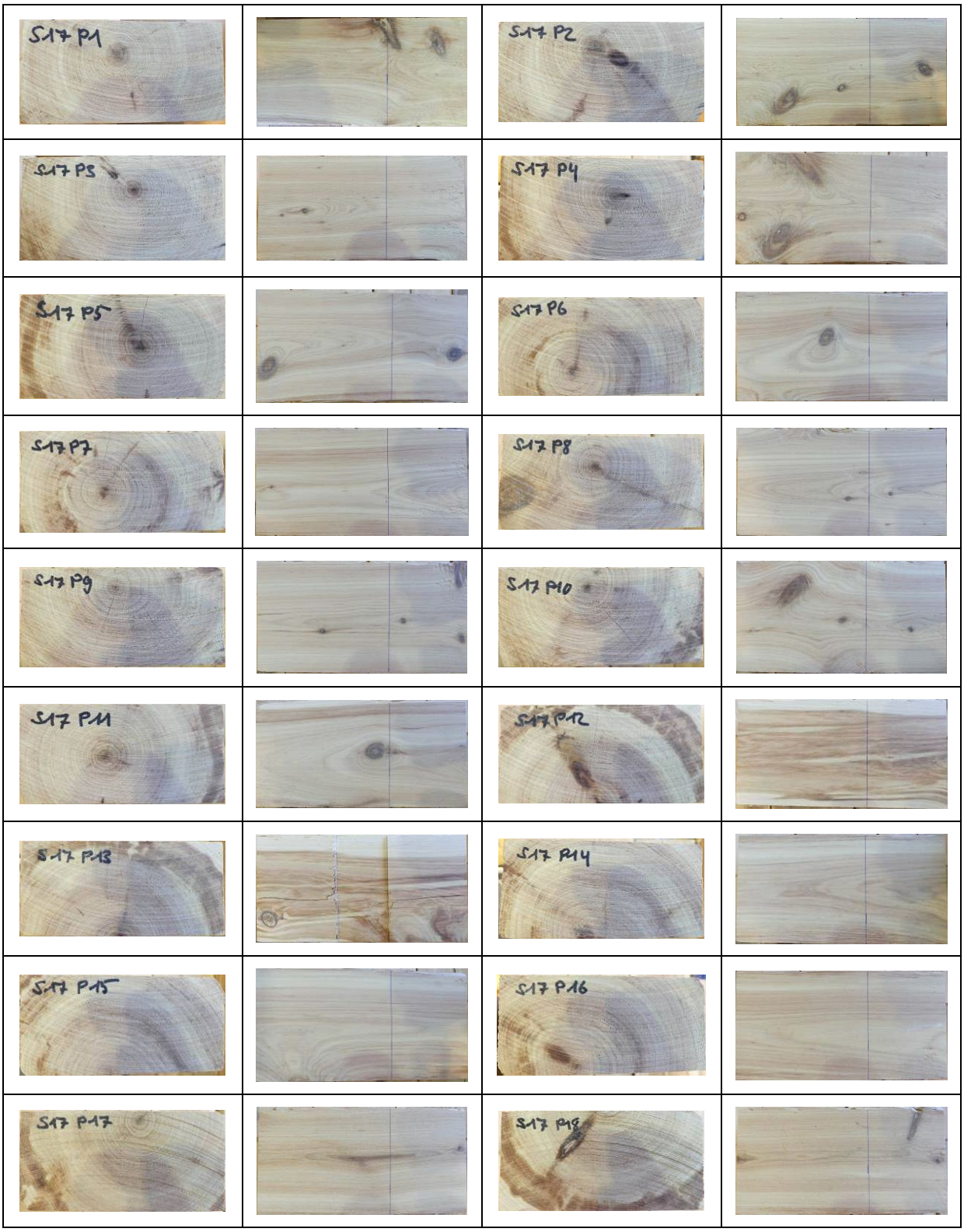
S14 p12	10	-90-90	13	1.4	11	yes	412	199.5	89	45.8	507	Cut through the pith; a lot of pitch pockets on the bottom
S14 p13	10.4	-90-90	14	1.4	10	yes	354	199.5	89.9	46	429	-
S14 p14	10	-90-90	16	1.4	9	no	516	199.5	87.6	45.9	643	Cut through the pith, a lot of pitch pockets on the bottom; 2 knots on the side, 8mm; knot in the middle/side, 18mm
S14 p15	10.4	-90-90	18	1.4	8	no	376	199.5	86.9	45.8	474	Cut through the pith (on the side)
S14 p16	11.7	-22.5-22.5	3.7	2.5	68	yes	583	199.5	90	45.3	717	-
S14 p17	11.7	-22.5-22.5	3.7	2.5	68	yes	563	199.5	90.2	45.3	691	-
S14 p18	11.2	-22.5-22.5	3.7	2.5	68	no	575	199.5	90.4	45.3	704	-
S14 p19	10.9	-22.5-22.5	3.7	2.5	68	no	586	199.5	90.1	45	724	-
S14 p20	12.2	-22.5-22.5	3.7	2.5	68	no	580	199.5	90	45.3	713	Knot on the side, 10mm
S14 p21	10.5	-22.5-45	2.5	1.2	48	yes	517	199.5	90.5	45.3	632	Not a smooth surface, little differences from sawing (not planed everywhere); big chamber-bevel on one side, 8mm less surface
S14 p22	11.2	-22.5-45	2.5	1.2	48	yes	518	199.5	90.5	45.3	633	Not a smooth surface, little differences from sawing (not planed everywhere)
S14 p23	10.5	-22.5-45	2.5	1.2	48	yes	501	199.5	90.4	45.3	613	Not a smooth surface, little differences from sawing (not planed everywhere)
S14 p24	10.5	-22.5-45	2.5	1.2	48	no	502	199.5	90.4	45.3	614	-
S14 p25	10.7	-22.5-45	2.5	1.2	48	no	508	199.5	90.2	45.3	623	-
S14 p26	12.8	-22.5-45	5	1	20	yes	444	199.5	89.6	45	552	Knot on the side, 10mm
S14 p27	12.9	-22.5-45	5	1	20	yes	443	199.5	89.7	45.2	548	-
S14 p28	12.4	-22.5-45	5	1	20	no	439	199.5	89.9	45.1	543	Knot on the side, 8mm; pitch pocket form the side to the middle, in the middle 2mm thick

S14 p29	12.5	-22.5-45	5	1	20	no	434	199.5	90	45.1	536	-
S14 p30	12.2	-22.5-45	5	1	20	no	437	199.5	89.5	45.1	543	-
S14 p31	12.3	-22.5-45	3.3	1	30	yes	478	199.5	90.2	45.4	585	-
S14 p32	12.8	-22.5-45	3.3	1	30	yes	482	199.5	90.1	45.2	593	-
S14 p33	12.5	-22.5-45	3.3	1	30	yes	472	199.5	90.1	45.1	582	-
S14 p34	11.7	-22.5-45	3.3	1	30	no	481	199.5	90.3	45.3	589	Not tested-
S14 p35	11.5	-22.5-45	3.3	1	30	no	481	199.5	90.3	45.3	589	Not tested-
S14 p36	11.7	-90-90	8	1.2	15	yes	420	199.5	90.6	46.2	503	Not tested-
S14 p37	11.9	-67.5-67.5	10	1.2	12	yes	399	199.5	90.8	45.8	481	Not tested-
S14 p38	11.1	-67.5-67.5	8	1.2	15	no	366	199.5	90.3	46	442	Not tested-
S14 p39	11.4	-45-67.5	8	1.2	15	no	412	199.5	90.7	45.7	498	Not tested-
S14 p40	11.1	-45-67.5	8	1.2	15	no	383	199.5	90.7	45.7	463	Not tested-
mean:	11.7		5.0	1.2	22.0		449.5	199.5	90.1	45.3	560.0	
σ:	0.9		4.5	0.5	19.2		63.5	0.2	0.9	0.4	79.2	

Cypress – S17

Scientific name: Callitris Columellaris
Source location: Abbey Timber, Caboolture, QLD
Identification number: S17
Stress grade: F7

Table A52: Photographs of Samples Tested, end and plan view



 S17 P19		 S17 P20	
 S17 P21		 S17 P22	
 S17 P23		 S17 P24	
 S17 P25		 S17 P26	
 S17 P27		 S17 P28	
 S17 P29		 S17 P30	
 S17 P31		 S17 P32	
 S17 P33		 S17 P34	
 S17 P35		 S17 P36	
 S17 P37		 S17 P38	
S17 P39			

Table A53: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	681	679	2.1
Bearing perpendicular to grain [MPa]	26.4	21.7	10.4
MOE perpendicular to grain [MPa]	942	921	19.2

Table A54: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
S17 p1	686	26.46	853.90
S17 p2	669	22.66	869.50
S17 p3	662	22.19	743.67
S17 p4	667	24.16	946.35
S17 p5	676	24.13	1684.54
S17 p6	666	26.35	1501.49
S17 p7	665	24.28	707.95
S17 p8	694	24.16	922.18
S17 p9	664	22.91	929.22
S17 p10	689	25.68	1033.13
S17 p11	670	25.60	1054.08
S17 p12	668	25.27	708.87
S17 p13	689	25.43	1049.15
S17 p14	674	26.24	954.28
S17 p15	684	25.69	861.75
S17 p16	669	25.21	842.83
S17 p17	682	23.48	819.39
S17 p18	680	21.62	783.38
S17 p19	683	23.53	833.05
S17 p20	689	25.82	823.23
S17 p21	700	30.60	834.52
S17 p22	694	31.28	863.97

S17 p23	700	30.98	870.15
S17 p24	692	31.55	1067.58
S17 p25	712	31.50	1254.95
S17 p26	688	24.86	1108.50
S17 p27	700	30.08	1167.97
S17 p28	699	30.16	1015.96
S17 p29	699	25.31	924.06
S17 p30	694	27.48	1054.79
S17 p31	694	29.06	902.13
S17 p32	688	29.02	747.54
S17 p33	656	28.39	885.33
S17 p34	662	28.65	906.76
S17 p35	663	29.15	787.94
S17 p36	689	25.38	898.05
S17 p37	666	24.72	1025.02
S17 p38	664	25.69	664.44
S17 p39	666	25.70	849.27

Table A55: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
S17 p1	12	90	1.5	0.4	27	-	673	200	100.9	48.6	686	With pith; 2 knots on the side, 10mm and 8mm; 4 knots in the middle; 16mm, 2 x 13mm and 10mm
S17 p2	12.4	90	1.5	0.4	27	-	672	200	101.4	49.4	671	With pith; 2 knots on the side; 10mm; knot in the middle; 5mm
S17 p3	12.6	90	1.5	0.4	27	-	665	200	101.5	49.2	666	With pith; knot on the side, 8mm
S17 p4	12.5	90	1.5	0.4	27	-	670	199.75	101.7	49.2	670	With pith; 2 knots on the side, 10mm and 5mm; knot in the middle side, 12mm
S17 p5	12.4	90	1.5	0.4	27	-	680	200	101.9	49.2	678	With pith; 2 knots on the side, 2 x 12 mm; 2 knots in the middle, 2 x 16mm
S17 p6	12.1	90	1.5	0.4	27	-	666	200	103.2	48.4	667	With pith; 2 knots on the side, 7 mm and 15mm; knot in the middle, 12mm
S17 p7	12	90	1.5	0.4	27	-	664	200.5	103.5	48.1	665	With pith; 2 knots in the middle, 9mm; knot on the side, 9mm
S17 p8	12.3	90	1.5	0.4	27	-	686	200	103.3	47.7	696	With pith; 2 knots in the middle, 26mm and 16mm; knot on the side, 12mm
S17 p9	11.9	90	1.5	0.4	27	-	667	200	103.3	48.7	663	With pith; 6 knots on the side 3 x5mm, 13mm, 16mm and 9mm
S17 p10	12.4	90	1.5	0.4	27	-	692	200	103.6	48.3	691	With pith; 2 knots in the middle, 21mm and 7mm; 3 knots on the side, 2 x 20mm and 13mm
S17 p11	12.3	90	1.5	0.4	27	-	666	200.25	102.1	48.5	672	With pith; 2 knots in the middle,15mm and 8mm;

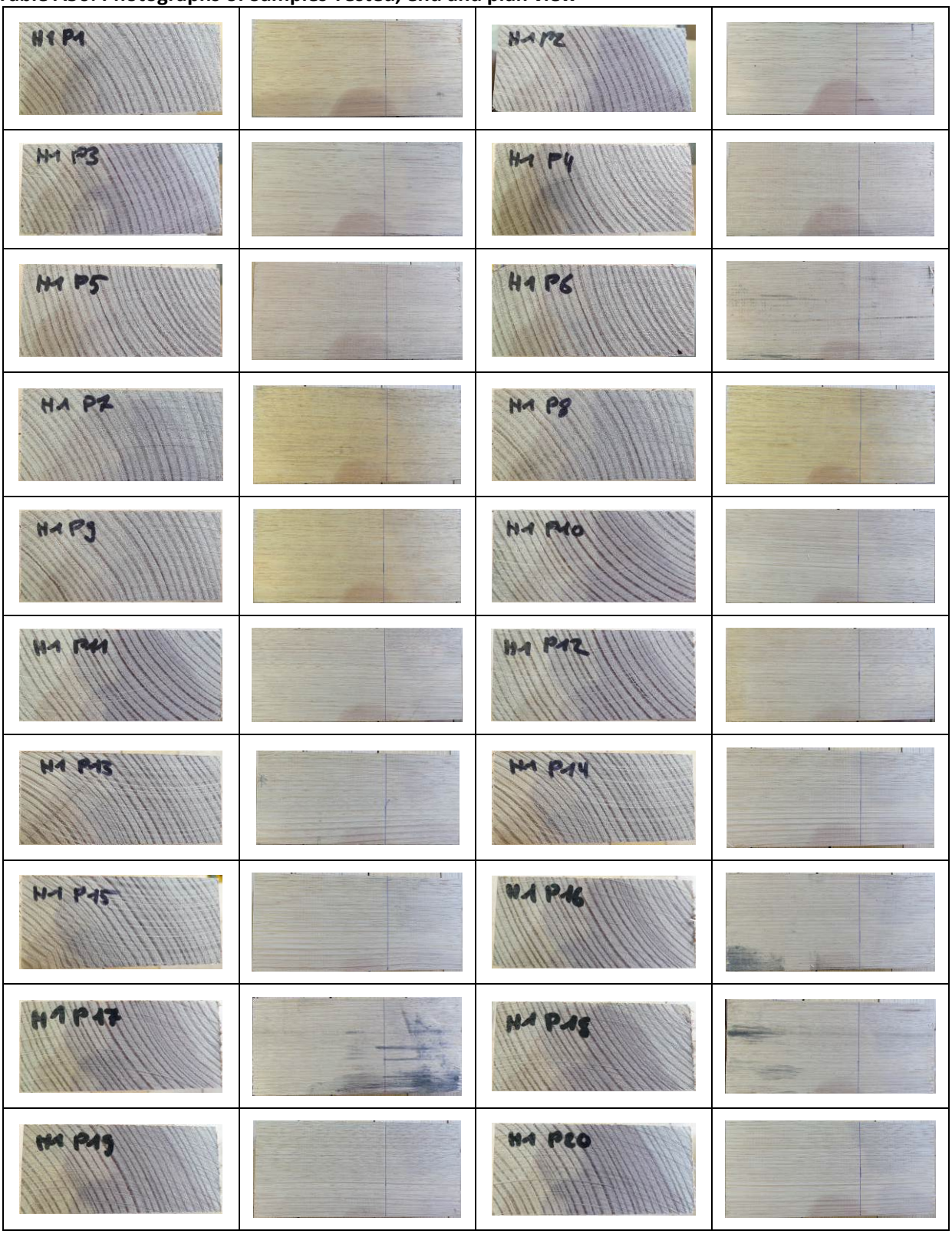
												3 knots on the side, 12mm, 5mm and 3mm
S17 p12	12.1	90	1.5	0.4	27	yes	674	200	103.2	48.8	669	Cut through the pith
S17 p13	11.8	90	1.5	0.4	27	yes	684	200	102.9	48.3	688	Cut through the pith; knot in the middle, 5mm; 4 knots on the side, 28mm,12mm and 2 x 5mm
S17 p14	11	90	1.5	0.4	27	yes	660	200	102.7	48.1	668	Cut through the pith
S17 p15	11.5	90	1.5	0.4	27	yes	672	200	102.8	48	681	Cut through the pith; 2 knots on the side 30mm and 12mm
S17 p16	11	90	1.5	0.4	27	yes	656	200	103.1	48	663	Cut through the pith
S17 p17	12.2	90	1.5	0.4	27	no	682	200	102.8	48.6	683	Cut through the pith; knot in the middle, 32mm
S17 p18	12.2	90	1.5	0.4	27	no	682	200.25	102.7	48.7	681	Cut through the pith; 3 knots on the side, 7mm and 2 x 5mm
S17 p19	11.9	90	1.5	0.4	27	no	680	200	103.5	48.2	682	Cut through the pith; knot in the middle, 14mm
S17 p20	11.5	90	1.5	0.4	27	no	688	200.25	103.3	48.5	686	Cut through the pith; knot in the middle, 16mm
S17 p21	12.9	-67.5-67.5	1.5	0.4	27	yes	711	200	105.3	47.8	706	Knot on the side, 16mm
S17 p22	12.5	-67.5-67.5	1.5	0.4	27	yes	701	200.25	104.9	47.9	697	Knot on the side, 3mm
S17 p23	12.4	-67.5-67.5	1.5	0.4	27	yes	706	200	104.5	48.1	702	2 knots on the side, 24mm and 15mm
S17 p24	12.2	-67.5-67.5	1.5	0.4	27	yes	699	200.25	103.8	48.5	693	Knot on the side, 14mm
S17 p25	11.3	-67.5-67.5	1.5	0.4	27	yes	715	200.25	103.3	48.8	708	Knot on the side, 22mm
S17 p26	12	-67.5-67.5	1.5	0.4	27	no	690	200.5	105.6	47.4	688	Knot in the middle, 4mm; 2 knots on the side, 2 x 7mm; damage on the side
S17 p27	12.2	-67.5-67.5	1.5	0.4	27	no	711	200.75	106.4	47.5	701	Knot in the middle, 23mm
S17 p28	12.2	-67.5-67.5	1.5	0.4	27	no	711	200.5	106.5	47.6	700	2 knots in the middle, 17mm and 7mm; knot on the side, 6mm
S17 p29	12.3	-67.5-67.5	1.5	0.4	27	no	710	200.25	106.7	47.4	701	2 knots on the side, 10mm and 6mm

S17 p30	12	-67.5-67.5	1.5	0.4	27	no	705	200.25	107.1	47.4	694	knot in the middle, 11mm
S17 p31	12.7	-67.5-67.5	1.5	0.4	27	yes	712	200	107.3	47.5	698	knot on the side, 5mm
S17 p32	13	-67.5-67.5	1.5	0.4	27	yes	707	200	107.2	47.5	694	-
S17 p33	13.4	-67.5-67.5	1.5	0.4	27	yes	659	200	107.2	46.3	664	-
S17 p34	13.8	-67.5-67.5	1.5	0.4	27	yes	669	200	107.1	46.4	673	knot on the side, 22mm
S17 p35	13.1	-67.5-67.5	1.5	0.4	27	yes	657	200	107.1	45.8	670	-
S17 p36	11.6	-67.5-67.5	1.5	0.4	27	no	688	200	107.3	46.7	687	2 knots on the side,2 x 6mm; knot in the middle, 16mm
S17 p37	12.9	-67.5-67.5	1.5	0.4	27	no	670	200	107.1	46.6	671	-
S17 p38	13.1	-67.5-67.5	1.5	0.4	27	no	665	200	107.2	46.2	671	knot on the side, 6mm
S17 p39	12.7	-67.5-67.5	1.5	0.4	27	no	670	200.5	107.2	46.5	670	knot on the side, 9mm
mean:	12.2		1.5	0.4	26.7		680.0	200.0	103.5	48.1	682.0	
σ:	0.6		0.0	0.0	0.0		18.4	0.2	2.1	1.8	34.6	

Alpine Ash – H1

Scientific name: Eucalyptus delegatensis
Source location: Australia
Identification number: H1
Stress grade: F17

Table A56: Photographs of Samples Tested, end and plan view



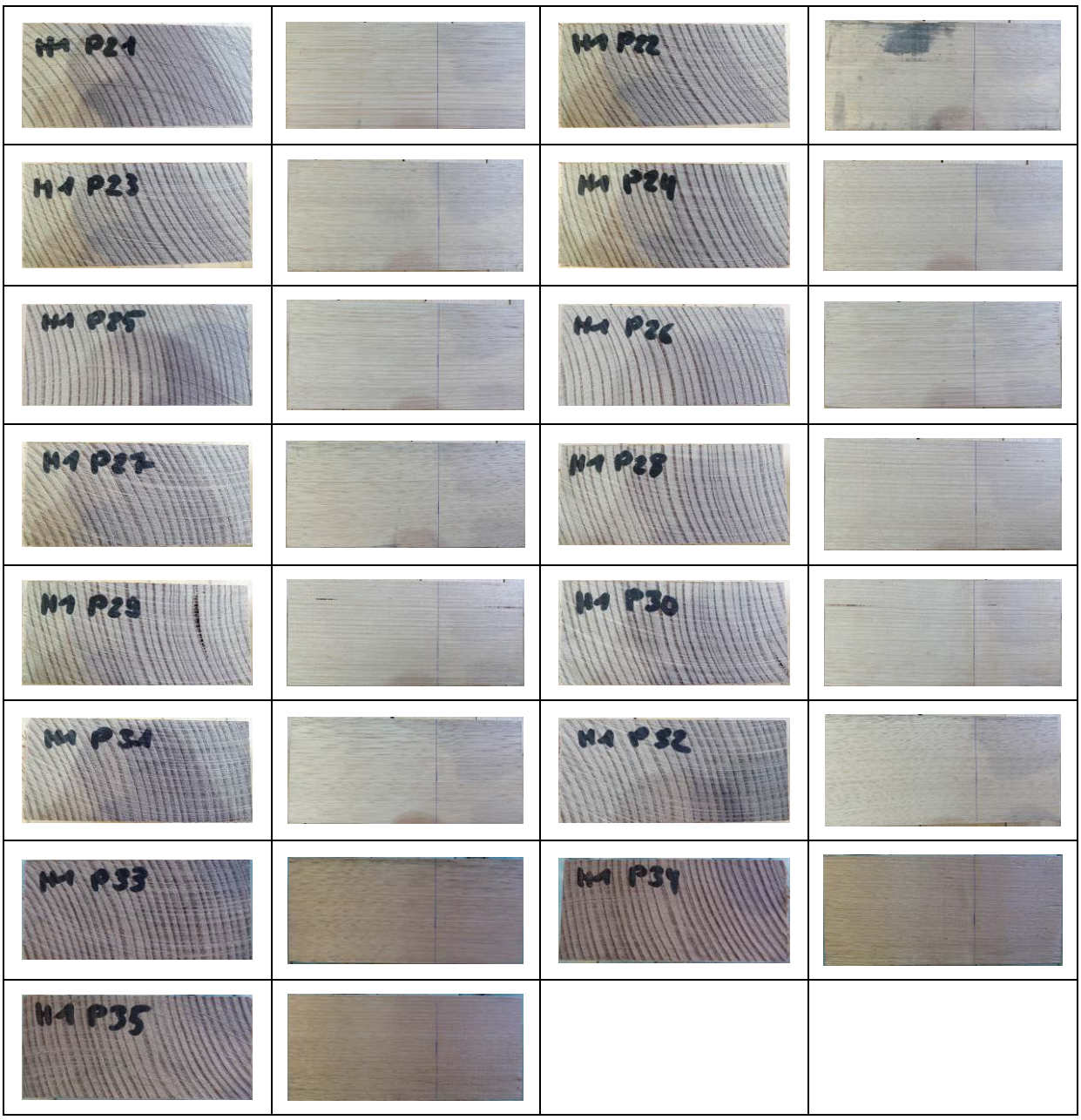


Table A57: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	710	708	2.4
Bearing perpendicular to grain [MPa]	17.9	15.5	7.6
MOE perpendicular to grain [MPa]	803	785	18.0

Table A58: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H1 p1	701	16.16	820.81
H1 p2	733	17.00	702.61
H1 p3	727	16.59	780.42
H1 p4	717	16.73	796.24
H1 p5	724	16.97	728.07
H1 p6	726	17.12	773.87
H1 p7	686	16.34	674.03
H1 p8	697	16.44	668.34
H1 p9	703	16.14	703.99
H1 p10	696	16.66	706.74
H1 p11	697	17.28	693.79
H1 p12	698	18.20	718.96
H1 p13	693	16.51	892.86
H1 p14	696	16.92	782.68
H1 p15	699	17.18	704.42
H1 p16	700	18.02	757.49
H1 p17	703	18.02	702.92
H1 p18	693	17.63	700.87
H1 p19	705	18.05	701.69
H1 p20	704	17.15	827.56
H1 p21	703	17.68	681.76
H1 p22	702	18.53	705.68
H1 p23	704	19.10	660.75
H1 p24	709	19.78	670.84
H1 p25	713	19.88	1266.78
H1 p26	742	18.72	1171.07
H1 p27	708	17.85	982.86

H1 p28	718	20.57	1148.97
H1 p29	716	20.61	1011.77

H1 p30	712	20.79	828.60
H1 p31	764	19.39	940.58
H1 p32	739	-	-

Table A59: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H1 p33	758	16.30	576.92
H1 p34	764	17.38	623.87
H1 p35	755	16.79	623.54

Table A60: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H1 p1	13.5	45-67.5	5	2	40	yes	507	200	89.5	39.9	710	-
H1 p2	13.2	45-67.5	5	2	40	yes	529	200	89.5	39.9	741	-
H1 p3	13.4	45-67.5	5	2	40	yes	526	200.25	89.5	39.9	736	-
H1 p4	13.7	45-67.5	5	2	40	no	522	200.75	89.5	39.9	728	-
H1 p5	12.8	45-67.5	5	2	40	no	521	200.25	89.5	39.9	729	-
H1 p6	12.7	45-67.5	5	2	40	no	522	200.25	89.4	39.9	731	-
H1 p7	11.4	45-67.5	5	2	40	yes	490	200.5	89.6	40	682	-
H1 p8	12.6	45-67.5	5	2	40	yes	501	200.5	89.4	39.9	701	-
H1 p9	12.5	45-67.5	5	2	40	yes	507	200.5	89.5	40	706	-
H1 p10	12.1	45-67.5	5	2	40	no	499	200.5	89.5	39.9	697	-
H1 p11	12.4	45-67.5	5	2	40	no	500	200.25	89.5	39.9	699	-
H1 p12	11.9	45-67.5	5	2	40	no	502	200.25	89.7	40.1	697	-
H1 p13	13.2	45-67.5	5	2	40	yes	500	200	89.5	39.9	700	-
H1 p14	13.6	45-67.5	5	2	40	yes	504	200.25	89.4	39.9	706	-
H1 p15	13.7	45-67.5	5	2	40	yes	508	200.25	89.5	39.9	710	-
H1 p16	13.7	45-67.5	5	2	40	no	508	200	89.5	39.9	711	-

H1 p17	13.3	45-67.5	5	2	40	no	508	200	89.5	39.9	711	-
H1 p18	13.7	45-67.5	5	2	40	no	503	200.25	89.4	39.9	704	-
H1 p19	12.5	45-67.5	5	2	40	yes	506	200.25	89.5	39.9	708	-
H1 p20	12.7	45-67.5	5	2	40	yes	506	200.25	89.5	39.9	708	-
H1 p21	12.8	45-67.5	5	2	40	yes	506	200.25	89.5	39.9	708	-
H1 p22	13.7	45-67.5	5	2	40	no	511	200.25	89.5	40	713	-
H1 p23	13.8	45-67.5	5	2	40	no	514	200.25	89.5	40.1	715	-
H1 p24	13.7	45-67.5	5	2	40	no	517	200.5	89.5	40	720	-
H1 p25	13.2	67.5-90	5	2	40	yes	516	200	89.5	40	721	-
H1 p26	11.9	67.5-90	5	2	40	yes	532	200.5	89.5	40	741	-
H1 p27	12.5	67.5-90	5	2	40	yes	510	200.25	89.6	40	711	-
H1 p28	12.6	67.5-90	5	2	40	no	516	200.25	89.5	39.9	722	-
H1 p29	12.7	67.5-90	5	2	40	no	518	200	89.7	40.1	720	Pitch pocket on the side, 25 mm bright
H1 p30	13.4	67.5-90	5	2	40	no	522	200.75	89.7	40.2	721	Pitch pocket on the side, 25 mm bright
H1 p31	13	67.5-90	5	2	40	yes	553	200.25	89.6	40	771	-
H1 p32	13.1	67.5-90	5	2	40	yes	536	200.25	89.7	40	746	No test data
mean:	13.0		5.0	2.0	40.0		513.1	200.3	89.5	40.0	716.4	
σ:	0.6		0.0	0.0	0.0		12.8	0.2	0.1	0.1	17.6	

Table A61: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H1 p33	13.1	67.5-90	5	2	40	yes	548	200	89.6	40	765	-
H1 p34	13.4	67.5-90	5	2	40	no	555	199.75	89.7	40	774	-
H1 p35	13.6	67.5-90	5	2	40	no	550	200	89.7	40	766	-
mean:	13.4		5.0	2.0	40.0		551.0	199.9	89.7	40.0	768.3	
σ:	0.3		0.0	0.0	0.0		3.6	0.1	0.1	0.0	4.9	

Jarrah – H4

Scientific name: Eucalyptus marginata
Source location: Australia
Identification number: H4
Stress grade: -

Table A62: Photographs of Samples Tested, end and plan view

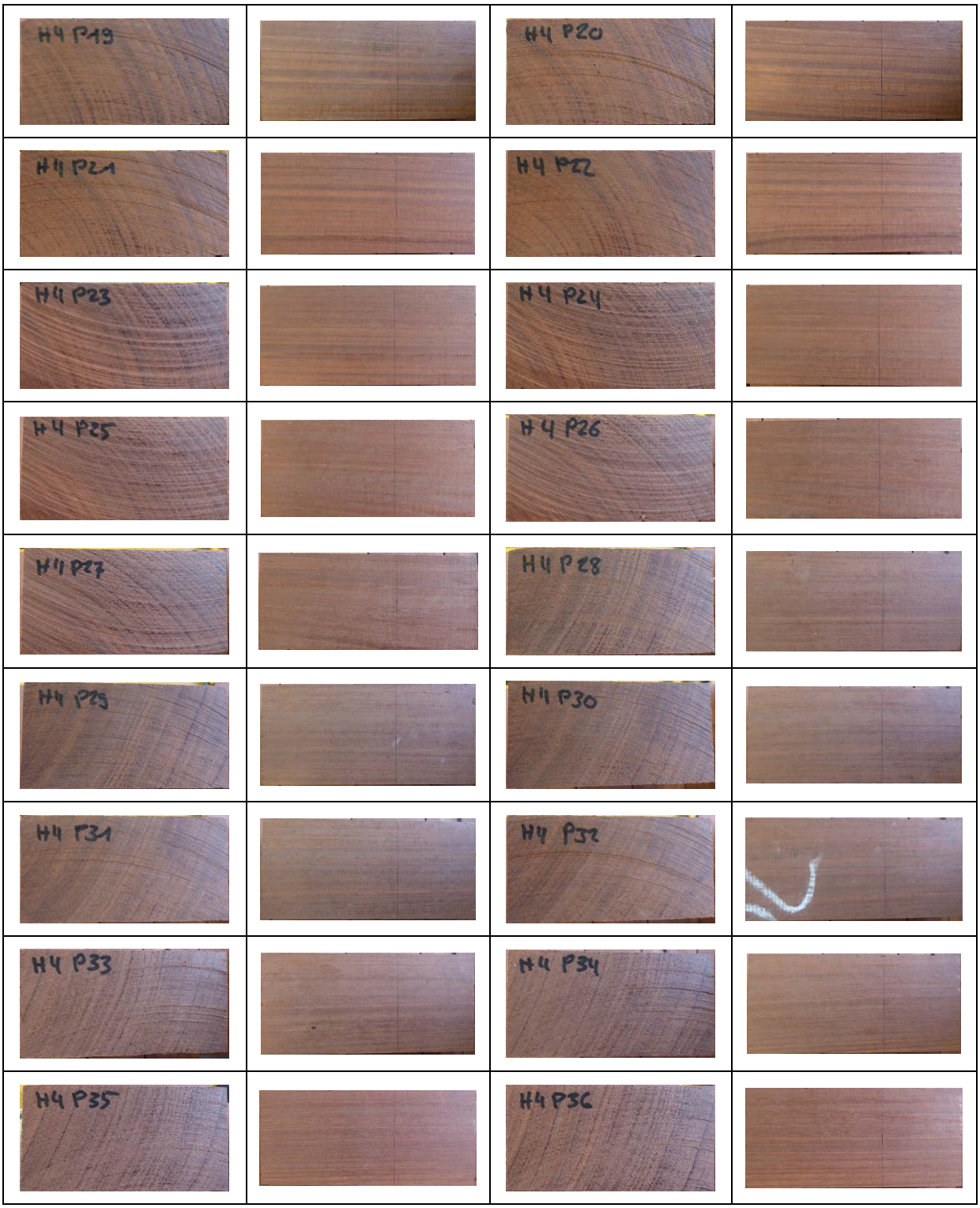


Table A63: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	837	833	4.2
Bearing perpendicular to grain [MPa]	26.1	23.9	4.8
MOE perpendicular to grain [MPa]	1274	1233	20.8

Table A64: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H4 p1	793	24.88	1232.22
H4 p2	794	24.77	1232.14
H4 p3	801	24.26	1311.27
H4 p4	802	24.26	1190.23
H4 p5	807	25.46	1109.57
H4 p6	786	24.92	1152.48
H4 p7	790	25.17	1324.68
H4 p8	799	25.45	1299.58
H4 p9	798	24.79	1281.23
H4 p10	811	26.70	1162.45
H4 p11	841	28.37	1193.37
H4 p12	830	27.21	1199.66
H4 p13	826	27.69	2249.60
H4 p14	820	26.48	2122.09
H4 p15	820	26.30	2019.56
H4 p16	817	27.17	1554.02
H4 p17	837	28.48	1282.86
H4 p18	842	29.45	1424.11
H4 p19	869	25.79	1129.36
H4 p20	858	25.99	1069.56
H4 p21	853	25.85	1177.80
H4 p22	854	26.28	1230.72
H4 p23	860	25.77	955.32
H4 p24	863	26.03	1024.76

H4 p25	861	25.48	1032.08
H4 p26	873	25.82	1020.45
H4 p27	864	24.22	1138.64
H4 p28	903	26.69	1075.39
H4 p29	895	25.90	1134.53
H4 p30	892	26.64	1050.87
H4 p31	894	26.68	1099.94

Table A65: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H4 p32	902	20.89	882.70
H4 p33	913	21.19	901.59
H4 p34	910	21.66	821.96
H4 p35	908	21.64	751.50
H4 p36	913	21.98	840.33

Table A66: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H4 p1	10.6	0-22.5	4	0.8	20	yes	637	200.5	90	45.1	783	-
H4 p2	10.4	0-22.5	4	0.8	20	yes	635	200	89.9	45.1	783	-
H4 p3	10.5	0-22.5	4	0.8	20	yes	641	200	89.9	45.1	790	-
H4 p4	10.6	0-22.5	4	0.8	20	yes	643	200.25	89.9	45.1	792	-
H4 p5	10.5	0-22.5	4	0.8	20	yes	647	200	89.9	45.2	796	-
H4 p6	10.4	0-22.5	4	0.8	20	yes	631	200.5	90	45.1	775	-
H4 p7	10.5	0-22.5	4	0.8	20	yes	633	200.5	89.9	45.1	779	Knot on the side, 4mm
H4 p8	10.2	0-22.5	4	0.8	20	yes	637	200	89.9	45.1	786	-
H4 p9	10.9	0-22.5	4	0.8	20	yes	641	200	89.9	45.1	790	Crack at the end
H4 p10	11	0-22.5	4	0.8	20	no	650	200	89.8	45	804	-
H4 p11	10.6	0-22.5	4	0.8	20	no	672	200	90	45	830	-
H4 p12	10.2	0-22.5	4	0.8	20	no	663	200	90	45.1	817	-
H4 p13	10.2	0-22.5	4	0.8	20	no	660	200	90	45.1	813	Crack at the end
H4 p14	10.1	0-22.5	4	0.8	20	no	652	200	89.9	45	806	-
H4 p15	9.8	0-22.5	4	0.8	20	no	651	200	89.8	45.1	804	-

H4 p16	9.9	0-22.5	4	0.8	20	no	650	200	89.8	45.1	802	Gum veins on the surface
H4 p17	10.3	0-22.5	4	0.8	20	no	667	200	89.7	45.1	824	Gum veins on the surface
H4 p18	10	0-22.5	4	0.8	20	no	674	200.5	89.9	45.2	827	-
H4 p19	10.5	45-67.5	4	2	50	yes	693	200	89.9	45	857	-
H4 p20	11.3	45-67.5	4	2	50	yes	690	200	89.9	45	853	-
H4 p21	10.5	45-67.5	4	2	50	yes	681	200	89.9	45	842	-
H4 p22	10.4	45-67.5	4	2	50	yes	681	200	89.9	45	842	-
H4 p23	10.6	45-67.5	4	2	50	yes	687	200	89.9	45	849	-
H4 p24	10.8	45-67.5	4	2	50	yes	690	200.25	89.7	45	854	-
H4 p25	11.2	45-67.5	4	2	50	yes	690	200	89.7	45	855	-
H4 p26	10.2	45-67.5	4	2	50	yes	694	200	89.8	45	859	-
H4 p27	10.8	45-67.5	4	2	50	yes	689	200	89.7	44.9	855	-
H4 p28	10.5	45-67.5	5	3	60	no	722	200.5	89.8	45	891	-
H4 p29	10.9	45-67.5	5	3	60	no	718	200.25	89.9	45	886	-
H4 p30	11	45-67.5	5	3	60	no	717	200.25	90	45	884	-
H4 p31	10.9	45-67.5	5	3	60	no	717	200	90	45	885	-
mean:	10.5		4.1	1.4	33.9		669.5	200.1	89.9	45.1	826.2	
σ:	0.4		0.3	0.8	16.9		28.0	0.2	0.1	0.1	35.6	

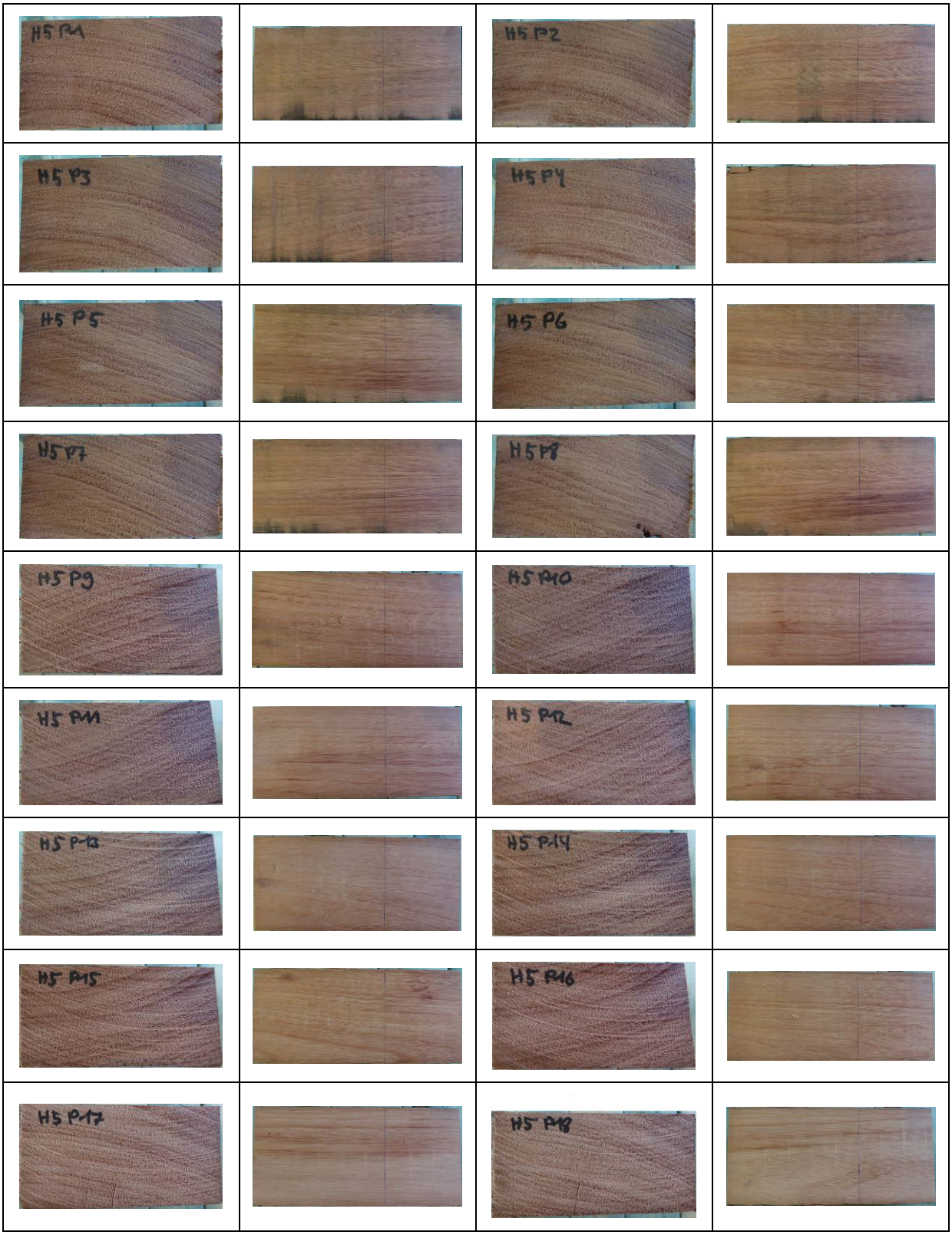
Table A67: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H4 p32	10.6	45-67.5	5	3	60	no	721	200	89.9	45	891	-
H4 p33	10.7	45-67.5	5	3	60	no	730	200.25	89.8	45	902	-
H4 p34	10.8	45-67.5	5	3	60	no	727	200	89.8	45	900	-
H4 p35	11.4	45-67.5	5	3	60	no	730	200	89.8	45	903	-
H4 p36	11	45-67.5	5	3	60	no	731	200	89.7	45	905	-
mean:	10.9		5.0	3.0	60.0		727.8	200.1	89.8	45.0	900.2	
σ:	0.3		0.0	0.0	0.0		4.1	0.1	0.1	0.0	5.4	

Karri – H5

Scientific name: Eucalyptus diversicolor
Source location: Australia
Identification number: H5
Stress grade: F17

Table A68: Photographs of Samples Tested, end and plan view



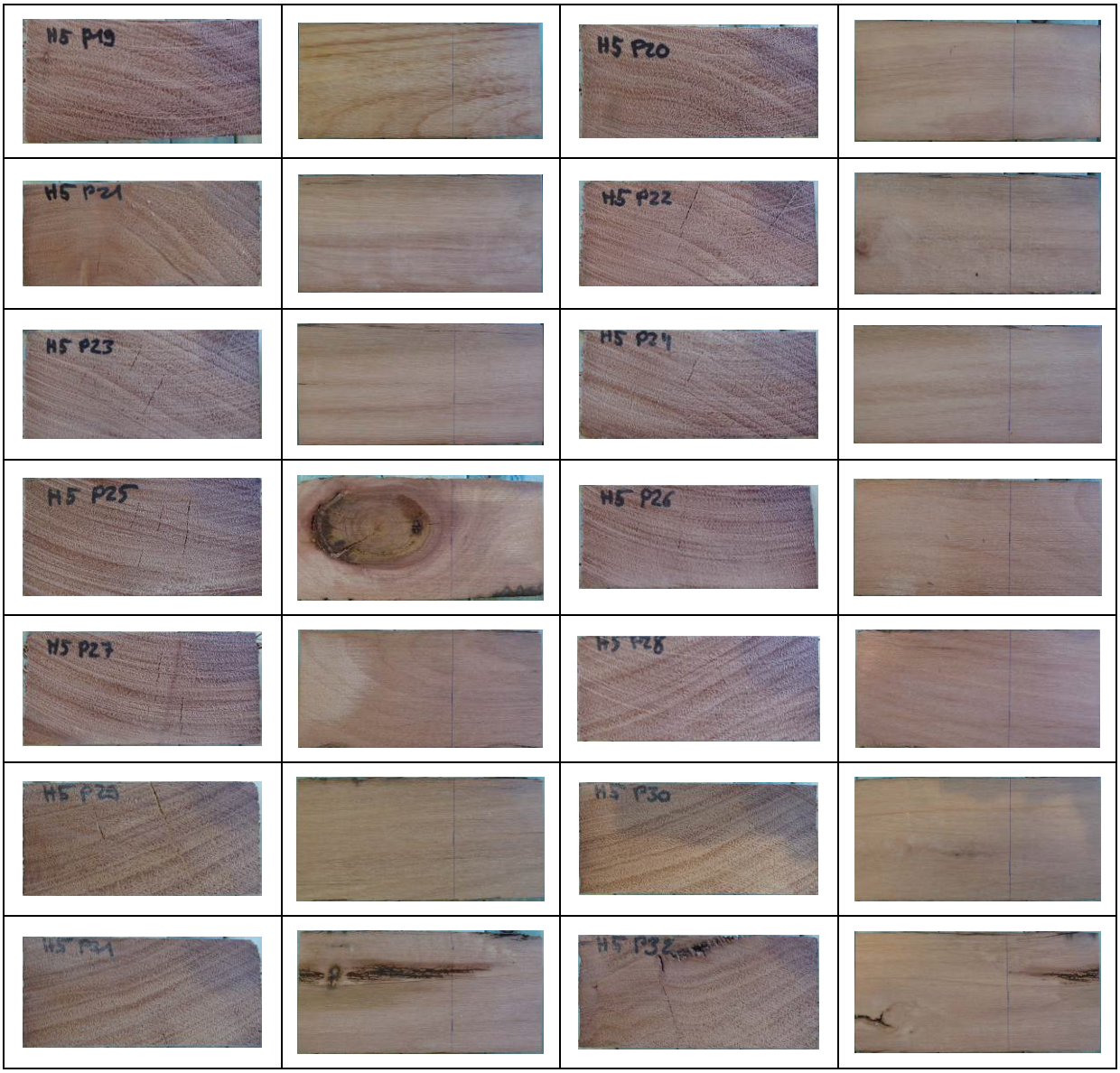


Table A69: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	869	866	2.5
Bearing perpendicular to grain [MPa]	22.1	16.7	14.6
MOE perpendicular to grain [MPa]	797	700	26.0

Table A70: Individual Samples Density, Perpendicular to Grain Bearing and MOE

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H5 p1	865	21.34	968.98

H5 p2	863	21.99	958.18
H5 p3	862	22.26	1000.61
H5 p4	868	22.39	1107.65
H5 p5	852	17.99	647.72
H5 p6	839	18.48	671.36
H5 p7	838	18.27	575.18
H5 p8	847	17.53	687.17
H5 p9	893	21.76	1011.09
H5 p10	903	20.91	902.44
H5 p11	868	20.56	582.29
H5 p12	865	19.25	650.18
H5 p13	850	18.37	585.37
H5 p14	858	18.42	500.64
H5 p15	866	18.00	727.07
H5 p16	868	21.35	504.65
H5 p17	864	21.87	752.66
H5 p18	878	23.87	813.86
H5 p19	885	23.25	945.14
H5 p20	895	22.38	1397.87
H5 p21	883	25.90	571.02
H5 p22	869	23.35	823.05
H5 p23	854	22.60	674.70
H5 p24	847	21.20	971.79
H5 p25	930	28.39	661.30
H5 p26	843	21.99	872.28
H5 p27	832	19.65	577.55
H5 p28	877	21.21	613.81
H5 p29	882	28.68	896.54
H5 p30	884	28.63	1107.70
H5 p31	876	27.69	927.86
H5 p32	899	27.93	811.61

Table A71: Table of Sample Properties

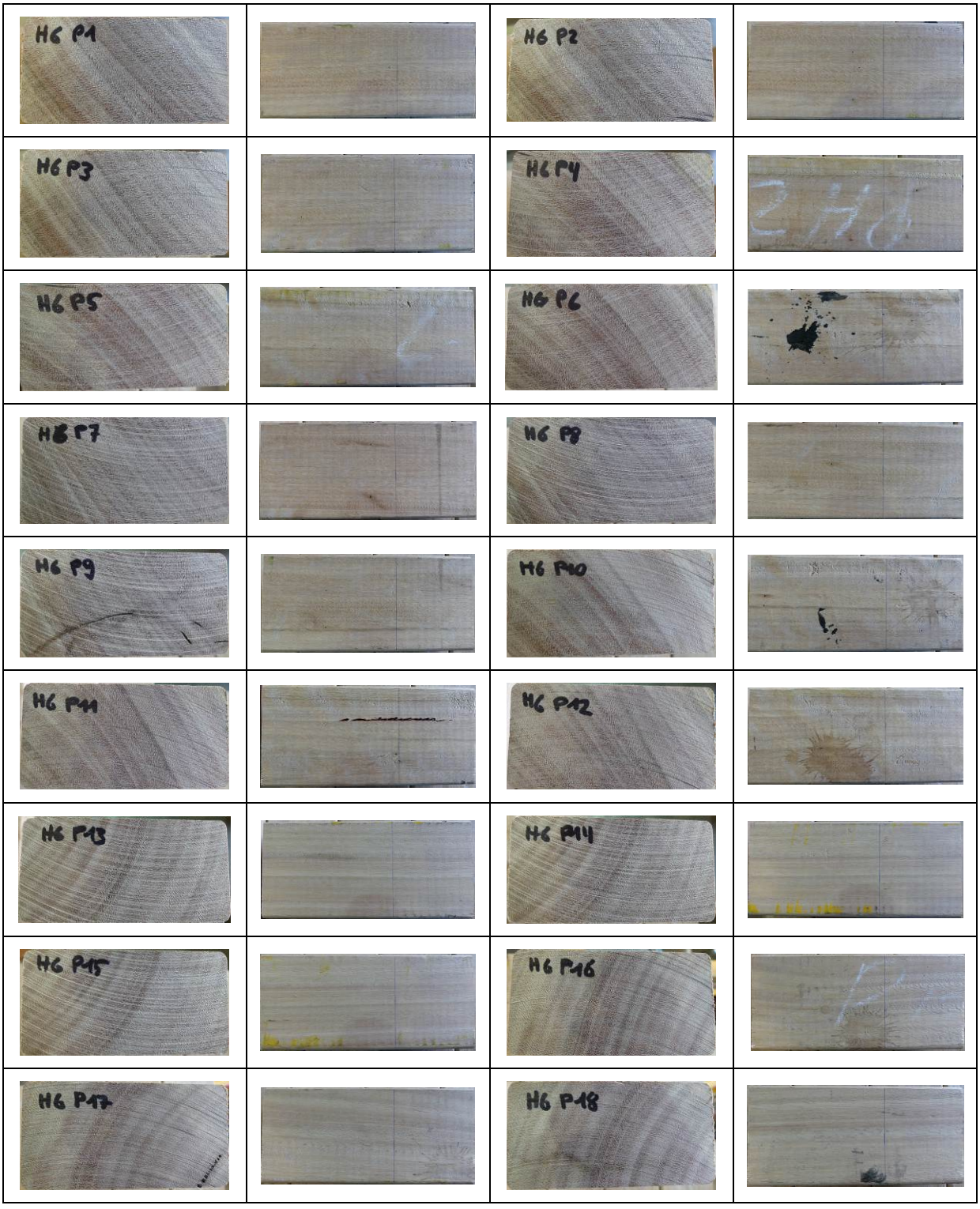
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H5 p1	19.7	0-22.5	3.5	2.5	71	yes	794	200.25	89.1	48.1	925	-
H5 p2	19.3	0-22.5	3.5	2.5	71	yes	790	200	89.2	48.2	919	-
H5 p3	17.6	0-22.5	3.5	2.5	71	yes	786	200.5	88.9	48.7	905	-
H5 p4	17.2	0-22.5	3.5	2.5	71	yes	777	200.5	89.1	47.9	908	-
H5 p5	23.9	0-22.5	3.5	2.5	71	yes	789	200	90.9	46	943	-
H5 p6	24.5	0-22.5	3.5	2.5	71	yes	793	200.25	90.7	46.8	933	-
H5 p7	23.9	0-22.5	3.5	2.5	71	yes	788	200.5	90.6	46.8	927	Gum veins on the bottom surface, 30mm long and 6mm wide
H5 p8	23.5	0-22.5	3.5	2.5	71	yes	790	200.5	91.3	46.2	934	Gum veins on the bottom surface, 30mm long and 6mm wide
H5 p9	13.6	0-22.5	3.5	2.5	71	no	764	200.5	88.4	47.6	906	-
H5 p10	14.2	0-22.5	3.5	2.5	71	no	775	200.25	88.7	47.4	921	-
H5 p11	18	0-22.5	3.5	2.5	71	no	775	200.5	89.1	47.4	915	-
H5 p12	19.9	0-22.5	3.5	2.5	71	no	787	200.5	90.6	46.8	926	-
H5 p13	23	0-22.5	3.5	2.5	71	no	788	200	89.8	47	934	-
H5 p14	22.9	0-22.5	3.5	2.5	71	no	789	200	89.5	46.8	942	-

H5 p15	21.7	0-22.5	3.5	2.5	71	no	790	200.25	89.6	46.8	941	-
H5 p16	19.3	0-22.5	3.5	2.5	71	no	790	200.5	89.5	47.6	925	-
H5 p17	15.5	0-22.5	3.5	2.5	71	yes	787	200	94.2	46.9	891	-
H5 p18	13.7	0-22.5	3.5	2.5	71	yes	781	200.25	93.3	46.9	891	-
H5 p19	13.4	0-22.5	3.5	2.5	71	yes	767	200.5	92	46.4	896	-
H5 p20	12.5	0-22.5	3.5	2.5	71	yes	711	200	92.6	42.7	899	-
H5 p21	23.2	0-22.5	3.5	2.5	71	yes	776	200.5	97.5	40.9	971	-
H5 p22	22.9	0-22.5	3.5	2.5	71	yes	791	200.75	97	42.6	954	Knot on the side, 8mm
H5 p23	21.4	0-22.5	3.5	2.5	71	yes	795	200.5	96.9	44.2	926	-
H5 p24	21.8	0-22.5	3.5	2.5	71	yes	779	200.75	96.4	43.7	921	-
H5 p25	19.2	0-22.5	3.5	2.5	71	no	855	200.5	97.9	44	990	-
H5 p26	21.4	0-22.5	3.5	2.5	71	no	719	200.5	94.3	41.6	914	-
H5 p27	18.8	0-22.5	3.5	2.5	71	no	744	200.5	95.3	44.1	883	-
H5 p28	17.3	0-22.5	3.5	2.5	71	no	736	200.5	96.3	41.5	919	-
H5 p29	15.3	0-22.5	3.5	2.5	71	no	790	200.5	97.3	44.6	908	-
H5 p30	17.2	0-22.5	3.5	2.5	71	no	799	200.5	97.3	44.3	925	-
H5 p31	17.7	0-22.5	3.5	2.5	71	no	806	200.5	98.3	44.4	921	Gum veins on the side, 15mm wide 150mm long
H5 p32	17.5	0-22.5	3.5	2.5	71	no	818	200.5	98.3	44	943	Gum veins on the side, 15mm wide and 50mm long; crack on the side
mean:	19.1		3.5	2.5	71.4		781.8	200.4	92.8	45.6	923.6	
σ:	3.5		0.0	0.0	0.0		26.5	0.2	3.5	2.2	22.6	

Blackbutt – H6

Scientific name: Eucalyptus pilularis
Source location: Australia
Identification number: H6
Stress grade: F27

Table A72: Photographs of Samples Tested, end and plan view



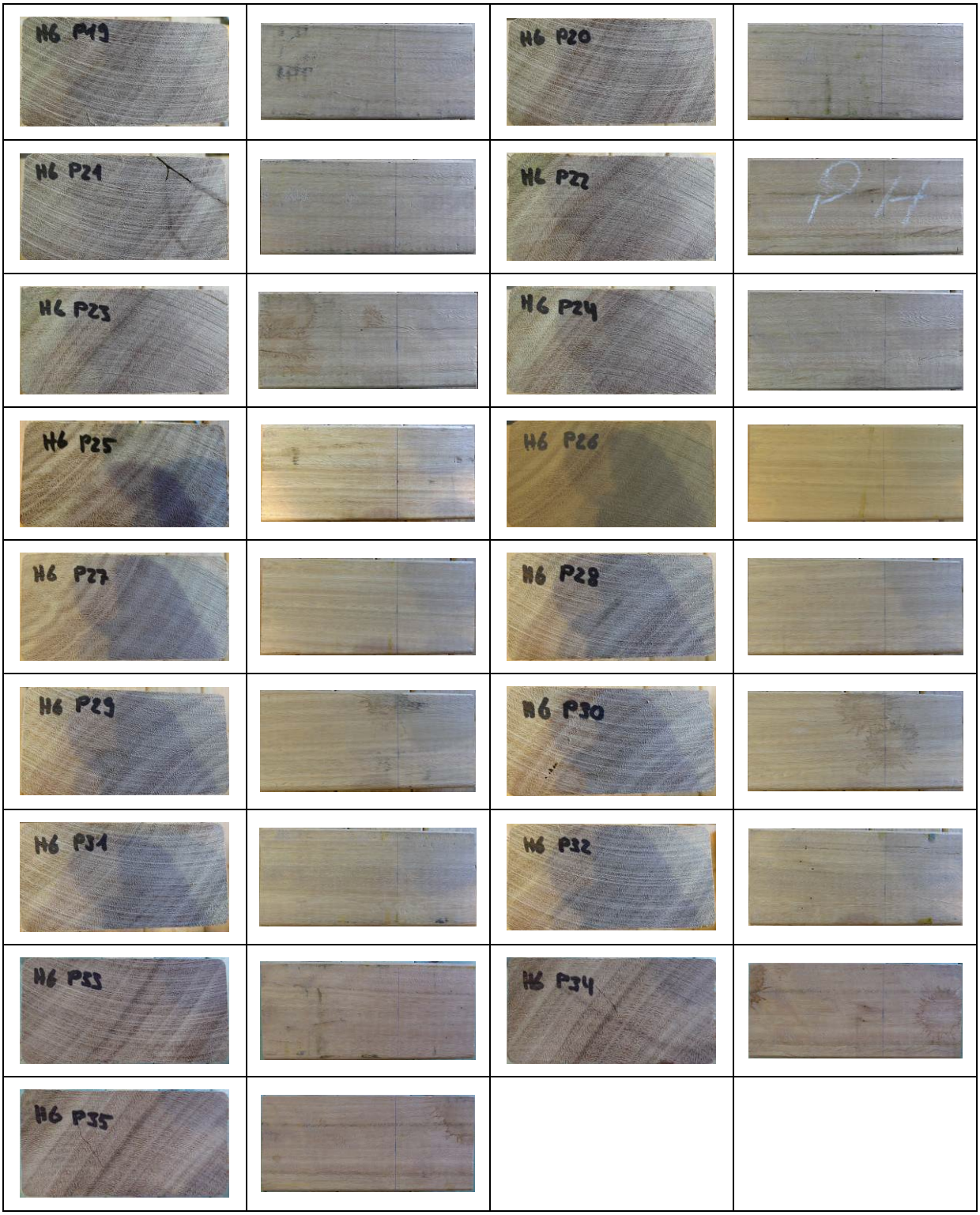


Table A73: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m3]	908	903	4.9
Bearing perpendicular to grain [MPa]	28.0	19.9	17.9
MOE perpendicular to	944	932	10.4

grain [MPa]			

Table A74: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m³]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H6 p1	921	29.02	1049.79
H6 p2	937	31.02	854.72
H6 p3	942	30.73	954.11
H6 p4	950	32.26	895.15
H6 p5	958	31.91	1055.94
H6 p6	951	33.12	1009.50
H6 p7	932	31.06	970.33
H6 p8	927	29.98	1084.38
H6 p9	943	32.29	942.25
H6 p10	948	31.71	1162.40
H6 p11	945	32.31	1093.83
H6 p12	954	35.77	1063.45
H6 p13	833	20.33	735.41
H6 p14	860	22.38	892.69
H6 p15	861	21.45	845.87
H6 p16	923	32.05	866.78
H6 p17	900	25.71	920.36
H6 p18	829	19.88	848.59
H6 p19	933	30.04	946.68
H6 p20	934	28.94	898.10
H6 p21	927	28.82	969.98
H6 p22	957	30.75	1064.46
H6 p23	947	32.09	916.00
H6 p24	952	30.44	882.51

H6 p25	854	22.95	876.84
H6 p26	861	20.68	925.84
H6 p27	852	20.23	805.14
H6 p28	837	22.55	792.81
H6 p29	840	23.23	963.27
H6 p30	857	23.90	908.25
H6 p31	865	29.96	993.71
H6 p32	931	29.90	1026.37

Table A75: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H6 p33	916	24.62	806.32
H6 p34	923	23.16	811.54
H6 p35	933	21.81	852.41
H6 p36	934	-	-

Table A76: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H6 p1	12.8	45	7	6	86	no	770	199.5	90.8	45.8	928	-
H6 p2	11.5	45	7	6	86	no	775	199.5	90.9	45.8	933	-
H6 p3	11.4	45	7	6	86	no	777	199.5	90.8	45.8	937	-
H6 p4	11.7	45	7	6	86	yes	784	199.75	90.7	45.7	947	-
H6 p5	10.5	45	7	6	86	yes	784	199.75	90.9	45.7	945	-
H6 p6	10.6	45	7	6	86	yes	781	200	91	45.7	939	-
H6 p7	10.5	45-67.5	6	5	83	no	766	199.75	90.8	45.9	920	-
H6 p8	11.4	45-67.5	6	5	83	no	766	199.75	90.8	45.8	922	-
H6 p9	11.1	45-67.5	6	5	83	no	775	200	90.7	45.7	935	-
H6 p10	10.7	45-67.5	6	5	83	yes	782	200	91.1	45.8	937	-
H6 p11	10.1	45-67.5	6	5	83	yes	774	199.75	91.1	45.8	929	Gum veins on the surface in the middle, 2mm bright
H6 p12	10.1	45-67.5	6	5	83	yes	778	199.75	90.9	45.7	938	-
H6 p13	10.7	45-67.5	5.5	4	73	no	688	199.5	91.3	45.9	823	-
H6 p14	11.7	45-67.5	5.5	4	73	no	718	199.75	91.5	45.8	858	-
H6 p15	11.5	45-67.5	5.5	4	73	no	715	199.5	91.5	45.7	857	-
H6 p16	11.4	45-67.5	5.5	4	73	yes	763	199.5	91	45.8	918	Knot on the side, 12mm; gum veins on the bottom,

												80mm long 4mm bright
H6 p17	11.7	45-67.5	5.5	4	73	yes	749	199.5	91.3	45.8	898	Gum veins on the bottom, 2mm bright
H6 p18	11.3	45-67.5	5.5	4	73	yes	689	199.75	91.2	45.9	824	-
H6 p19	11.5	45-67.5	6.5	5.5	85	no	769	199.75	90.7	45.7	929	-
H6 p20	11.6	45-67.5	6.5	5.5	85	no	769	200	90.6	45.6	931	-
H6 p21	12.2	45-67.5	6.5	5.5	85	no	770	200	90.7	45.7	929	-
H6 p22	10.5	45-67.5	6.5	5.5	85	yes	786	200	90.9	45.8	944	-
H6 p23	12	45-67.5	6.5	5.5	85	yes	789	200	91	45.8	947	-
H6 p24	10.7	45-67.5	6.5	5.5	85	yes	783	199.75	91	45.8	941	-
H6 p25	11.5	45-67.5	6.5	4.5	69	no	708	200	91.1	45.7	850	-
H6 p26	10.6	45-67.5	6.5	4.5	69	no	707	200	91	45.7	850	-
H6 p27	10.6	45-67.5	6.5	4.5	69	no	699	200	90.9	45.7	841	-
H6 p28	11.3	45-67.5	6.5	4.5	69	yes	694	200.25	91.1	45.7	832	-
H6 p29	11.9	45-67.5	6.5	4.5	69	yes	697	200	90.9	45.7	839	-
H6 p30	11.7	45-67.5	6.5	4.5	69	yes	706	200.25	90	45.8	855	Gum veins on the bottom, 40mm long and 3mm bright
H6 p31	11.5	45-45	6	5	83	no	712	199.75	90.6	45.7	861	-
H6 p32	11.4	45-45	6	5	83	no	766	199.75	90.6	45.7	926	-
mean:	11.2		6.3	5.0	79.4		749.7	199.8	90.9	45.8	902.0	
σ:	0.6		0.5	0.7	6.8		35.6	0.2	0.3	0.1	43.9	

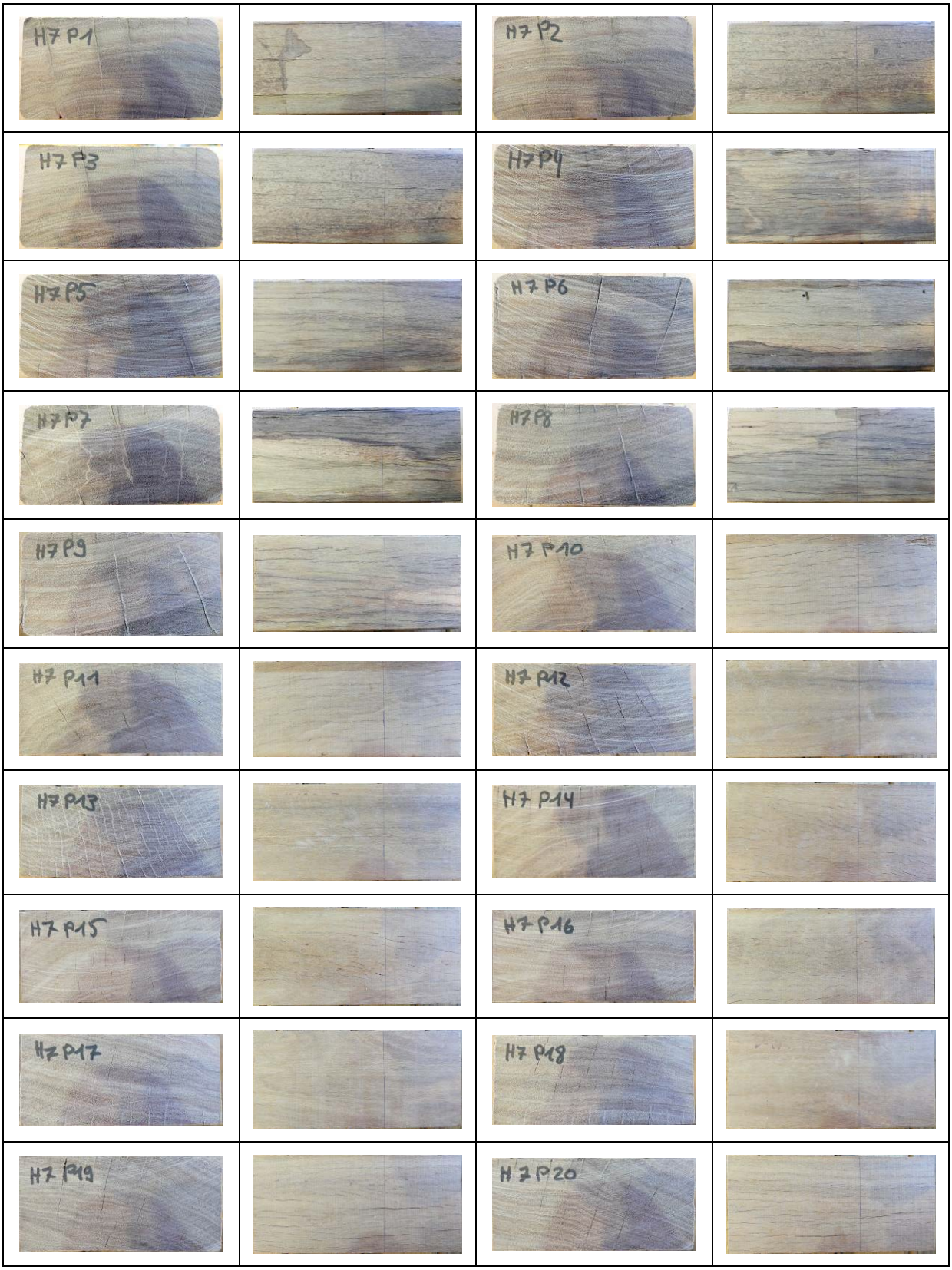
Table A77: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H6 p33	13	45-45	6	5	83	no	766	199.75	90.8	45.7	924	-
H6 p34	12.7	45-45	6	5	83	yes	770	200	90.7	45.7	929	-
H6 p35	11.6	45-45	6	5	83	yes	771	199.75	90.8	45.7	930	-
H6 p36	11.7	45-45	6	5	83	yes	770	199.75	90.8	45.6	931	-
mean:	12.3		6.0	5.0	83.3		769.3	199.8	90.8	45.7	928.5	
σ:	0.7		0.0	0.0	0.0		2.2	0.1	0.0	0.1	3.1	

Grey Ironbark – H7

Scientific name: Eucalyptus paniculari*s*
Source location: Australia
Identification number: H7
Stress grade: F27

Table A78: Photographs of Samples Tested, end and plan view



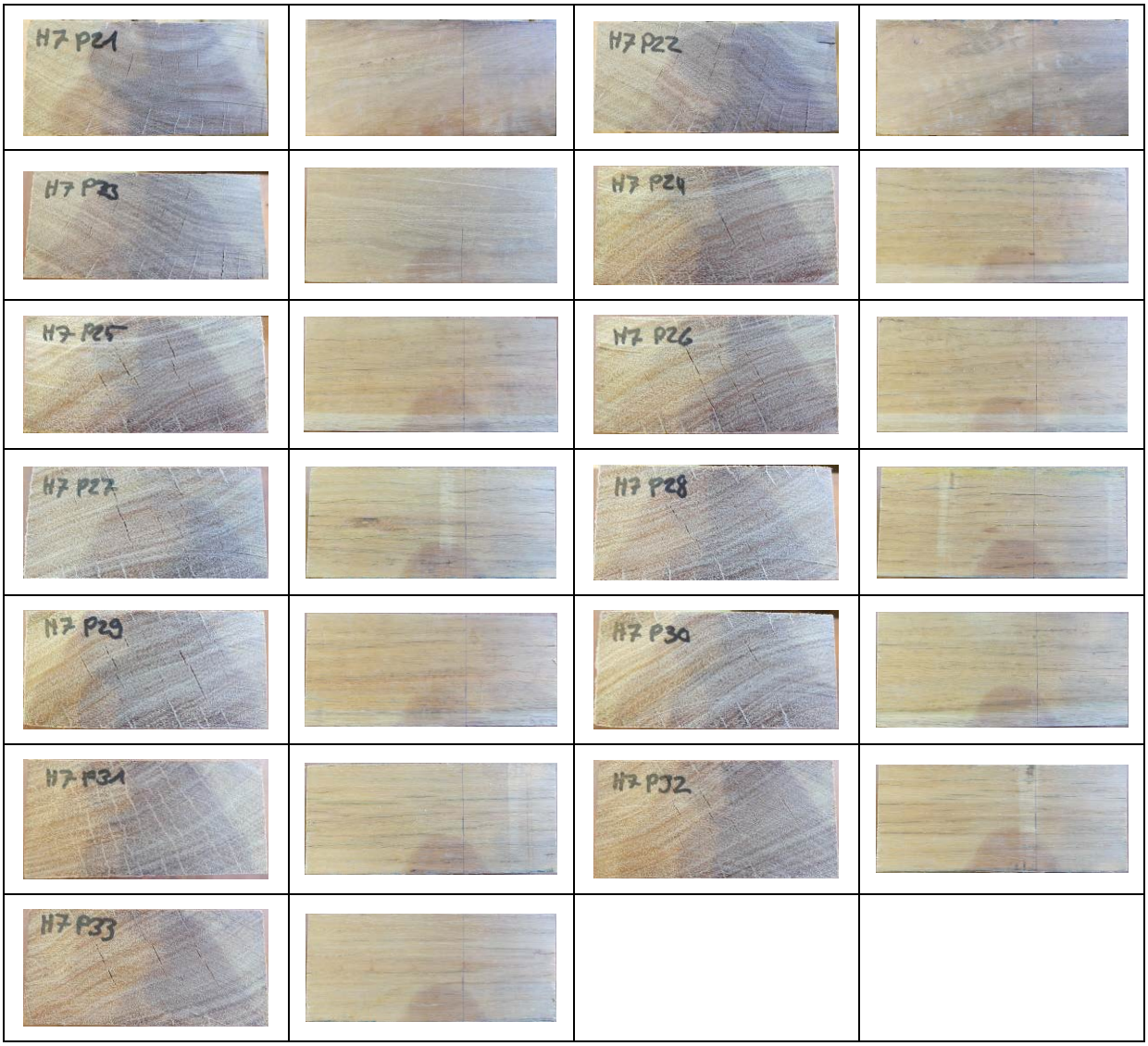


Table A79: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	1146	1142	2.7
Bearing perpendicular to grain [MPa]	52.3	46.4	6.3
MOE perpendicular to grain [MPa]	1477	999	39.2

Table A80: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H7 p1	1196	55.99	1308.27
H7 p2	1204	56.01	1318.49

H7 p3	1205	56.01	1347.56
H7 p4	1209	56.19	1267.92
H7 p5	1206	56.13	1054.44
H7 p6	1162	55.70	1067.59
H7 p7	1167	55.52	997.31
H7 p8	1184	55.76	1131.50
H7 p9	1177	55.88	1176.23
H7 p10	1119	53.20	2351.40
H7 p11	1112	52.01	2425.65
H7 p12	1130	50.99	2147.85
H7 p13	1134	50.66	1727.47
H7 p14	1113	54.59	3041.39
H7 p15	1123	54.50	2376.19
H7 p16	1122	52.55	2765.51
H7 p17	1132	52.31	1940.38
H7 p18	1132	48.97	2111.59
H7 p19	1126	49.21	1379.30
H7 p20	1124	52.27	1319.23
H7 p21	1137	55.38	1335.53
H7 p22	1139	52.02	1126.18
H7 p23	1141	50.95	1179.07
H7 p24	1129	49.59	859.91
H7 p25	1128	47.31	919.83
H7 p26	1129	48.01	832.92
H7 p27	1132	48.42	997.29
H7 p28	1122	48.24	1013.90
H7 p29	1131	46.52	899.80
H7 p30	1123	46.79	894.50

Table A81: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]

H7 p31	1132	37.12	852.68
H7 p32	1127	37.12	748.29
H7 p33	1133	39.77	667.96

Table A82: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H7 p1	11.6	0	4	3.5	88	yes	981	200.5	90.6	45.3	1192	-
H7 p2	11.2	0	4	3.5	88	yes	978	200.25	90.6	45.1	1195	-
H7 p3	11.5	0	4	3.5	88	yes	984	200.25	90.6	45.2	1200	-
H7 p4	11	0	4	3.5	88	no	992	200.25	90.3	45.8	1198	-
H7 p5	11.6	0	4	3.5	88	no	986	200.25	90.4	45.3	1202	-
H7 p6	12.3	0-22.5	4	3.5	88	yes	969	200.25	91.1	45.6	1165	-
H7 p7	13.2	0-22.5	4	3.5	88	yes	986	200	91.4	45.7	1180	-
H7 p8	11.9	0-22.5	4	3.5	88	no	981	200.75	91	45.4	1183	-
H7 p9	11.8	0-22.5	4	3.5	88	no	972	200.25	90.8	45.5	1175	-
H7 p10	15.1	0-22.5	4	3	75	yes	844	200.25	90.5	40.5	1150	-
H7 p11	15.1	0-22.5	4	3	75	yes	841	200.25	90.3	40.7	1143	-
H7 p12	13.5	0-22.5	4	3	75	no	841	200.5	90.2	40.6	1145	-
H7 p13	13.4	0-22.5	4	3	75	no	845	200.5	90.4	40.6	1148	-
H7 p14	16	0-22.5	4	3	75	yes	859	200.25	91	40.9	1153	-
H7 p15	15.5	0-22.5	4	3	75	yes	864	200.25	91.3	40.8	1158	-

H7 p16	15.6	0-22.5	4	3	75	yes	865	200.5	90.9	41	1158	-
H7 p17	13	0-22.5	4	3	75	no	863	200.75	92	40.9	1142	-
H7 p18	13.8	0-22.5	4	3	75	no	859	200.25	91.4	40.8	1150	-
H7 p19	13.7	0-22.5	4	3	75	yes	847	200.75	90.5	40.8	1143	-
H7 p20	14.2	0-22.5	4	3	75	yes	849	200.25	90.7	40.8	1146	-
H7 p21	13.2	0-22.5	4	3	75	no	859	200.75	90.8	41	1149	-
H7 p22	12.7	0-22.5	4	3	75	no	850	200.5	90.7	40.8	1146	-
H7 p23	12.3	0-22.5	4	3	75	no	850	200.5	90.8	40.8	1144	-
H7 p24	15.3	22.5-45	4	3	75	yes	875	200.5	88.8	42.3	1162	-
H7 p25	15.3	22.5-45	4	3	75	yes	864	200.25	88.5	42	1161	-
H7 p26	15	22.5-45	4	3	75	yes	868	200.25	88.6	42.2	1159	-
H7 p27	15.5	22.5-45	4	3	75	no	872	200.5	88.3	42.2	1167	-
H7 p28	16	22.5-45	4	3	75	no	870	200.5	88.7	42.1	1162	-
H7 p29	15	22.5-45	4	3	75	yes	864	200.5	88.4	42	1161	-
H7 p30	15.2	22.5-45	4	3	75	yes	865	200.75	88.6	42.1	1155	-
mean:	13.7		4.0	3.2	78.8		894.8	200.4	90.3	42.5	1163.1	
σ:	1.6		0.0	0.2	5.8		58.2	0.2	1.0	2.0	18.9	

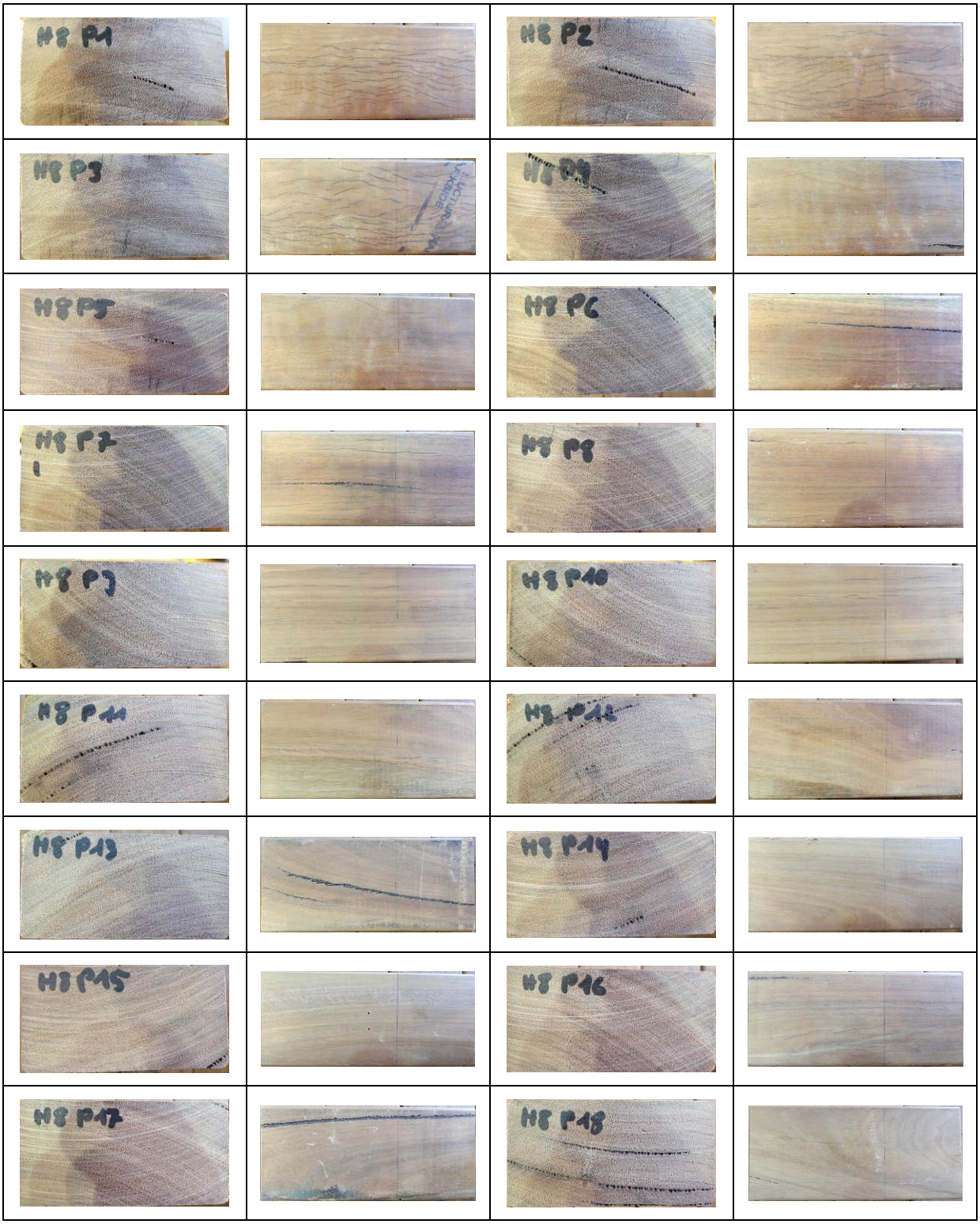
Table A83: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H7 p31	15	22.5-45	4	3	75	no	868	200.75	88.2	42.2	1162	-
H7 p32	15.4	22.5-45	4	3	75	no	864	200.25	88.3	42.1	1161	-
H7 p33	15.2	22.5-45	4	3	75	no	862	200.25	88	42	1165	-
mean:	15.2		4.0	3.0	75.0		864.7	200.4	88.2	42.1	1162.7	
σ:	0.2		0.0	0.0	0.0		3.1	0.3	0.2	0.1	2.1	

Spotted gum – H8

Scientific name: Eucalyptus maculata
Source location: Australia
Identification number: H8
Stress grade: F27

Table A84: Photographs of Samples Tested, end and plan view



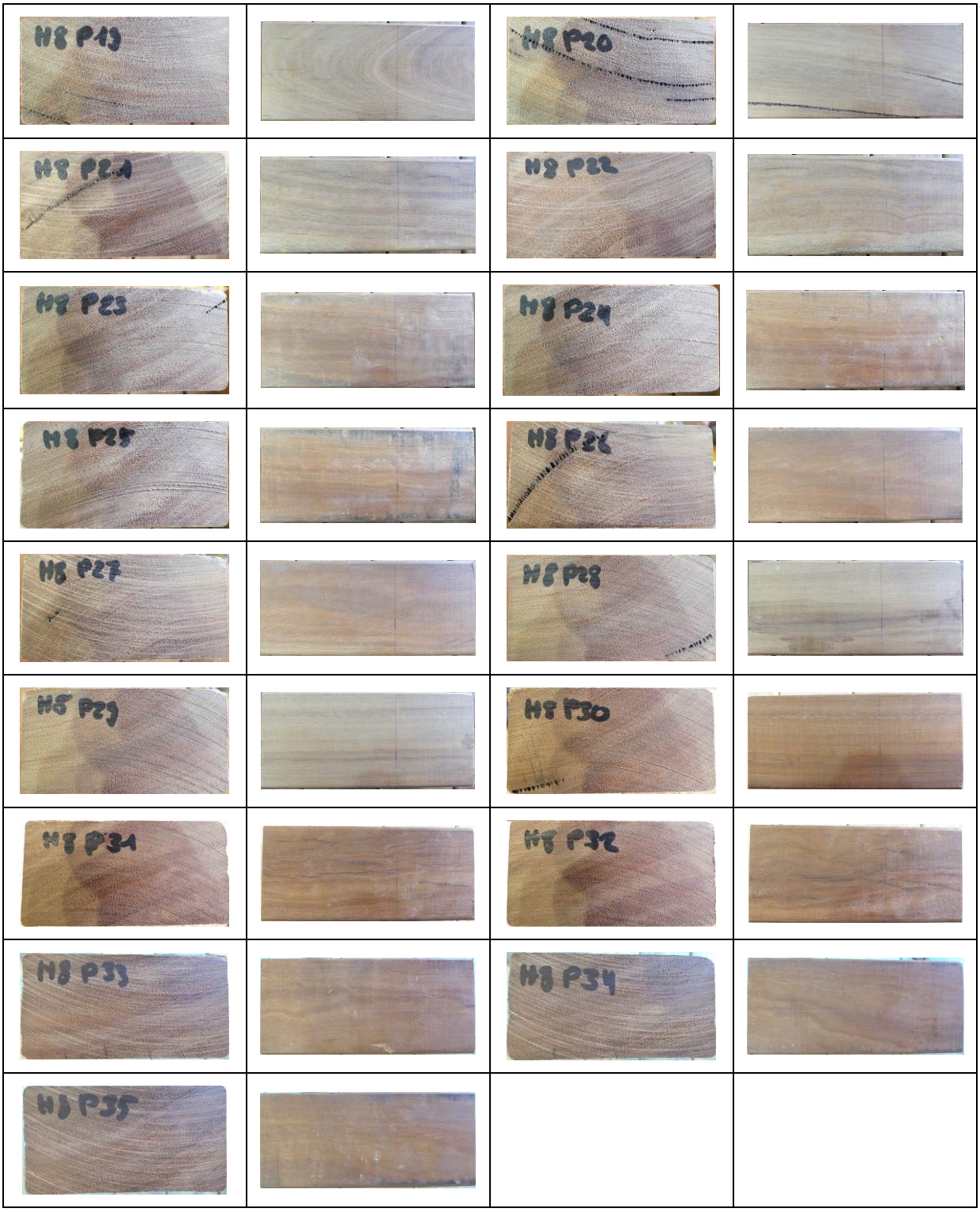


Table A85: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	1061	1058	2.6
Bearing perpendicular to grain [MPa]	43.7	38.7	6.4
MOE perpendicular to	1166	1143	15.2

grain [MPa]			

Table A86: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H8 p1	1101	47.53	1186.15
H8 p2	1104	47.56	1170.51
H8 p3	1114	50.22	1139.65
H8 p4	1094	47.14	1045.79
H8 p5	1103	48.11	1077.08
H8 p6	1037	40.55	1060.75
H8 p7	1039	41.34	1127.56
H8 p8	1033	41.77	1184.53
H8 p9	1058	40.84	1085.16
H8 p10	1046	40.25	1088.79
H8 p11	1012	40.65	930.71
H8 p12	1032	42.77	1057.24
H8 p13	1039	43.13	1109.93
H8 p14	1063	44.68	1208.27
H8 p15	1060	43.73	1103.56
H8 p16	1057	43.53	1063.75
H8 p17	1046	45.55	1029.91
H8 p18	1022	39.49	1942.89
H8 p19	1031	43.51	1694.54
H8 p20	1017	39.36	1398.12
H8 p21	1072	42.59	1111.35
H8 p22	1069	42.19	1123.48
H8 p23	1046	43.90	1015.71
H8 p24	1055	43.35	1045.23
H8 p25	1048	43.79	1011.03
H8 p26	1079	44.05	1278.32
H8 p27	1083	49.35	1215.81

H8 p28	1097	43.81	1317.90
H8 p29	1080	43.64	1223.32
H8 p30	1062	39.91	1261.17
H8 p31	1079	44.18	1070.70
H8 p32	1074	44.51	925.68

Table A87: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H8 p33	1089	36.95	975.71
H8 p34	1074	37.38	774.76
H8 p35	1073	36.19	844.10

Table A88: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H8 p1	13.5	0-22.5	10	9	90	yes	902	200	89.4	45.2	1116	Gum vein, 40mm right and 60mm long on the bottom side
H8 p2	12.6	0-22.5	10	9	90	yes	903	200.5	89.6	45.3	1110	Gum vein 30mm right through the hollow piece in the middle
H8 p3	12.2	0-22.5	10	9	90	yes	907	200.5	89.5	45.3	1116	Gum vein 30mm right in the middle
H8 p4	13.2	0-22.5	10	9	90	no	900	200.5	89.6	45.3	1106	Gum vein 40mm right and 40mm long on the top/side
H8 p5	13	0-22.5	10	9	90	no	905	201	89.5	45.2	1113	-
H8 p6	10.7	0-45	6	5	83	yes	833	200.5	89.5	45.3	1025	Gum vein in the middle 2mm thick
H8 p7	10.8	0-45	6	5	83	yes	835	200.5	89.6	45.2	1028	Gum vein in the middle 2mm thick
H8 p8	12	0-45	6	5	83	yes	837	200.5	89.4	45.2	1033	-
H8 p9	10.9	0-45	6	5	83	no	848	200.5	89.5	45.1	1048	Gum vein on the bottom side
H8 p10	10.7	0-45	6	5	83	no	840	200.75	89.5	45.2	1034	Gum vein on the bottom side
H8 p11	12	0-22.5	10	8	80	yes	823	200	89.8	45.3	1012	Gum vein in the middle
H8 p12	11.9	0-22.5	10	8	80	yes	836	200.5	89.5	45.2	1031	Gum vein in the middle
H8 p13	12.5	0-22.5	10	8	80	yes	842	200.25	89.3	45.1	1044	Gum vein in the middle on surface 3mm right
H8 p14	11.3	0-22.5	10	8	80	no	855	201	89.3	45.1	1056	Gum vein on the side at the bottom, damaged edge on the bottom

H8 p15	11.7	0-22.5	10	8	80	no	852	200.75	89.2	45	1057	Gum vein on the side at the bottom, big chamber- on the bottom
H8 p16	11.1	0-22.5	10	8	80	yes	846	200.5	89.2	45.1	1049	-
H8 p17	11.4	0-22.5	10	8	80	yes	843	200.75	89.5	45.1	1040	Gum vein on the edge at the top 4mm bright, little damage on the middle side, missing knot in the middle/side 3mm
H8 p18	11.1	0-22.5	10	8	80	no	822	201	89.4	45.1	1014	Gum vein in the middle
H8 p19	11.2	0-22.5	10	8	80	no	831	201	89.3	45.2	1024	Gum vein on the bottom
H8 p20	10.7	0-22.5	10	8	80	no	817	201	89.3	45.3	1005	Gum vein in the middle and at the edge on the top 3mm right
H8 p21	12.8	22.5-45	8	7	88	yes	870	200.5	89.1	45.1	1080	Gum vein from the side to the middle 45 right and 60 visible long
H8 p22	13.1	22.5-45	8	7	88	yes	874	200.5	89.5	45.1	1080	-
H8 p23	15.2	22.5-45	8	7	88	no	870	200.5	89.2	45.2	1076	-
H8 p24	14	22.5-45	8	7	88	no	869	200.25	89.4	45.2	1074	-
H8 p25	15	22.5-45	8	7	88	no	872	200.5	89.4	45.2	1076	-
H8 p26	12.8	22.5-45	8	7	88	yes	880	200.5	89.3	45.2	1087	Gum vein from the side to the middle 45 right and 60 visible long
H8 p27	13	22.5-45	8	7	88	yes	883	200.5	89.3	45.1	1093	Gum vein from the side to the middle 25 right and 110 visible long
H8 p28	10.9	22.5-45	8	7	88	no	880	200.75	89.5	45.1	1086	Gum vein from the side to the middle 25 bright and 60 visible long
H8 p29	11	22.5-45	8	7	88	no	867	200.75	89.5	45.1	1070	Gum vein from the side to the middle 25 bright through
H8 p30	11.2	22.5-45	8	7	88	no	852	200.5	89.4	45.1	1054	Gum vein through 40mm on the bottom

H8 p31	12.7	0-22.5	10	9	90	yes	880	201	89.2	45.2	1086	-
H8 p32	13	0-22.5	10	9	90	yes	881	201	89.3	45.3	1084	-
mean:	12.2		8.8	7.4	85.1		861.1	200.6	89.4	45.2	1062.7	
σ:	1.2		1.5	1.3	4.0		26.5	0.3	0.2	0.1	32.6	

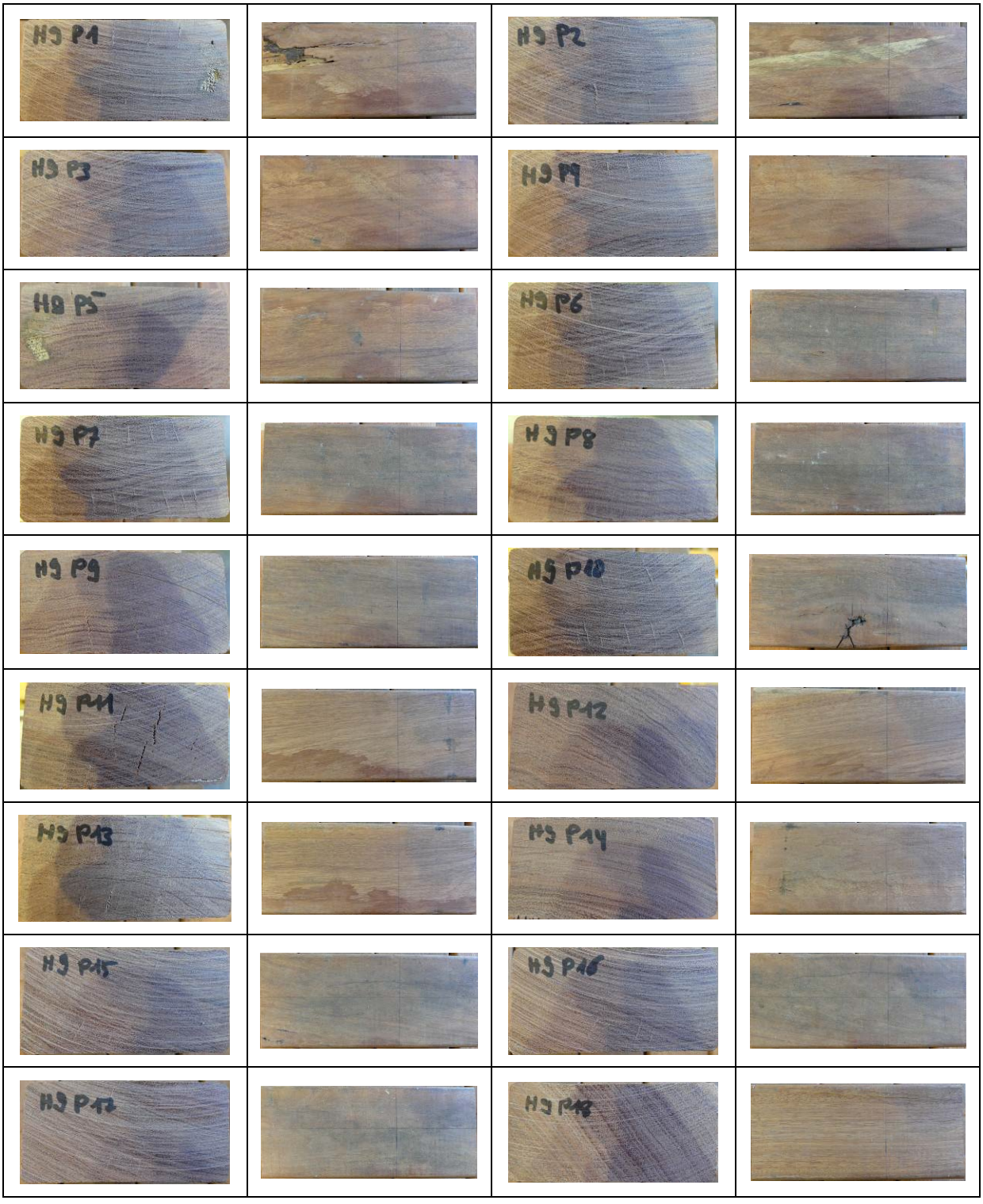
Table A89: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H8 p33	13.9	0-22.5	10	9	90	no	901	200.75	89.5	45.3	1107	-
H8 p34	14.8	0-22.5	10	9	90	no	897	200.5	89.7	45.3	1101	-
H8 p35	14.4	0-22.5	10	9	90	no	892	200.5	89.6	45.3	1096	-
mean:	14.4		10.0	9.0	90.0		896.7	200.6	89.6	45.3	1101.3	
σ:	0.5		0.0	0.0	0.0		4.5	0.1	0.1	0.0	5.5	

Southern Mahogany – H9

Scientific name: Eucalyptus botryoides
Source location: Australia
Identification number: H9
Stress grade: -

Table A90: Photographs of Samples Tested, end and plan view



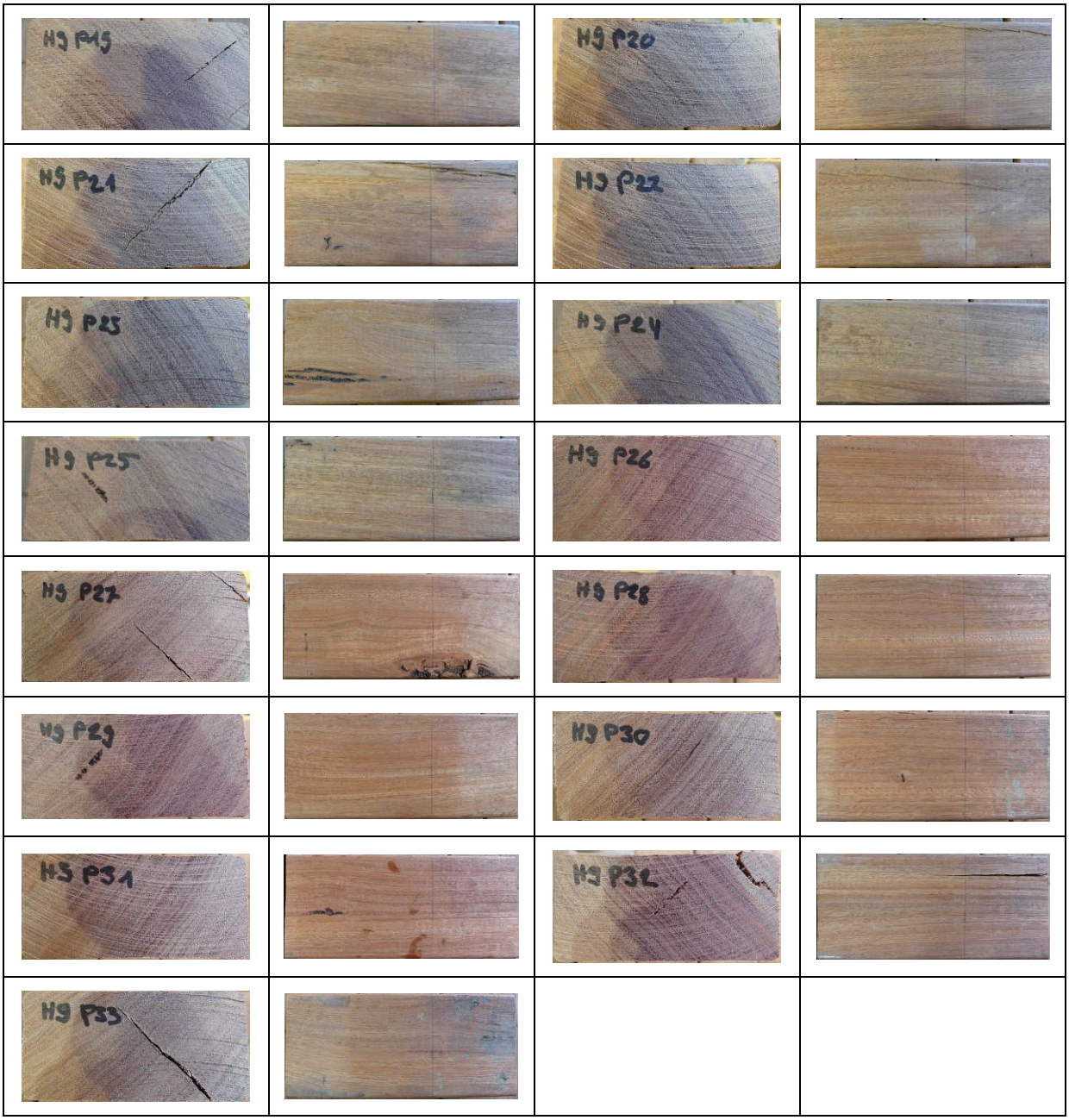


Table A91: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	950	945	4.8
Bearing perpendicular to grain [MPa]	27.5	21.6	12.6
MOE perpendicular to grain [MPa]	518	471	24.4

Table A92: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]

H9 p1	951	25.03	552.33
H9 p2	967	27.72	576.93
H9 p3	976	28.60	728.92
H9 p4	982	31.74	608.76
H9 p5	998	30.36	656.46
H9 p6	1003	29.67	587.84
H9 p7	1004	30.08	574.83
H9 p8	999	27.67	764.92
H9 p9	990	30.08	668.22
H9 p10	1002	30.86	484.03
H9 p11	997	31.55	452.16
H9 p12	998	31.94	624.68
H9 p13	1014	31.83	664.48
H9 p14	984	31.49	447.30
H9 p15	989	29.81	499.61
H9 p16	990	31.83	538.93
H9 p17	1006	33.38	564.37
H9 p18	899	22.69	412.31
H9 p19	916	25.24	365.42
H9 p20	894	22.73	575.92
H9 p21	888	23.19	421.93
H9 p22	895	22.13	419.91
H9 p23	927	24.47	362.29
H9 p24	910	22.06	292.82
H9 p25	918	22.57	324.29
H9 p26	920	26.81	424.51
H9 p27	926	26.91	665.75
H9 p28	905	25.73	516.79
H9 p29	912	26.12	511.74
H9 p30	885	26.86	416.06
H9 p31	913	25.35	417.82
H9 p32	906	26.06	380.52

H9 p33	894	25.05	602.28

Table A93: Table of Sample Properties

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H9 p1	16.8	-22.5-22.5	3	2	67	yes	741	199.5	87.7	42.7	992	rotted wood on the side, crack in the middle
H9 p2	18.8	-22.5-22.5	3	2	67	yes	766	200	87	42.9	1026	rotted wood in the middle
H9 p3	18.3	-22.5-22.5	3	2	67	yes	772	200.25	87	43	1031	rotted wood on the side on the bottom
H9 p4	17.8	0-22.5	3	2	67	yes	775	200.25	86.9	43.1	1033	-
H9 p5	17.8	0-22.5	3	2	67	yes	776	200.25	86.4	42.7	1050	knot in the middle, 3mm
H9 p6	20.6	0	3	2	67	no	791	199.5	86	42.7	1080	-
H9 p7	19.4	0	3	2	67	no	789	199.5	86.6	42.7	1070	-
H9 p8	19.2	0	3	2	67	no	780	200.25	86.2	42.5	1063	-
H9 p9	20.4	0	3	2	67	no	781	199.75	86.3	42.6	1064	-
H9 p10	19.1	0-22.5	3	2	67	no	800	199.5	88	42.8	1065	knot in the middle, 25mm
H9 p11	17.8	0-22.5	3	2	67	yes	763	200	86	42.3	1049	sample is twisted
H9 p12	18.4	0-45	3	2	67	yes	772	200	86.5	42.3	1055	sample is twisted
H9 p13	20.2	0-22.5	3	2	67	yes	801	199.5	86.8	42.5	1088	damaged on the bottom
H9 p14	18.5	0-22.5	3	2	67	yes	774	199.5	87.3	42.7	1041	crack from the side to the middle; u-shaped
H9 p15	18.2	0-22.5	3	2	67	no	762	200	86.5	42.2	1044	sample is twisted

H9 p16	18.3	0-22.5	3	2	67	no	771	200	87.1	42.3	1046	-
H9 p17	17.6	0-22.5	3	2	67	no	783	200	87.2	42.5	1056	sample is twisted
H9 p18	14.8	45	4	2	50	yes	707	200.5	90.3	42.4	921	u-shaped
H9 p19	15.2	45	4	2	50	yes	726	200	90.5	42.6	942	3 cracks from the side to the middle; u-shaped
H9 p20	16	45	4	2	50	yes	716	200	90.5	42.7	926	u-shaped
H9 p21	15.8	45	4	2	50	yes	721	200	91.3	43	918	big crack through the whole piece; u-shaped
H9 p22	14.7	45	4	2	50	yes	712	200	90.5	42.9	917	u-shaped
H9 p23	14.3	45	4	2	50	yes	722	200	90.9	42	946	c on the side, 70mm long and 4 mm bright; u-shaped
H9 p24	16.5	45	4	2	50	yes	720	200	90.5	42	947	u-shaped
H9 p25	16.2	45	4	2	50	yes	724	200	90.5	42	952	u-shaped
H9 p26	14.3	45	4	2	50	no	717	200	90.9	42	939	bark grown in to the wood on the middle/side on the bottom; u-shaped
H9 p27	15.2	45	4	2	50	no	727	200	90.9	42	952	bark grown in to the wood in the middle; u-shaped
H9 p28	15.7	45	4	2	50	no	722	200	90.6	42.6	935	u-shaped
H9 p29	16.5	45	4	2	50	no	728	200	90.7	42.3	949	u-shaped
H9 p30	16.4	45	4	2	50	no	709	200	90.5	42.6	920	u-shaped
H9 p31	15.1	45	4	2	50	no	725	200	90.5	42.7	938	gum veins on the side, 30mm long and 3mm bright; u-shaped
H9 p32	15.7	45	4	2	50	no	734	200	90.8	43.2	936	crack form the side to the middle; u-shaped
H9 p33	15.4	45	4	2	50	no	729	200	91.4	43.3	921	crack through the whole sample; u-shaped
mean:	17.1		3.5	2.0	58.6		749.6	199.9	88.7	42.6	994.3	

σ:	1.8		0.5	0.0	8.5		30.3	0.2	2.0	0.4	61.2	

Meranti, Light red – H10

Scientific name: Shorea leprosula
Source location: Australia
Identification number: H10
Stress grade: F4

Table A94: Photographs of Samples Tested, end and plan view

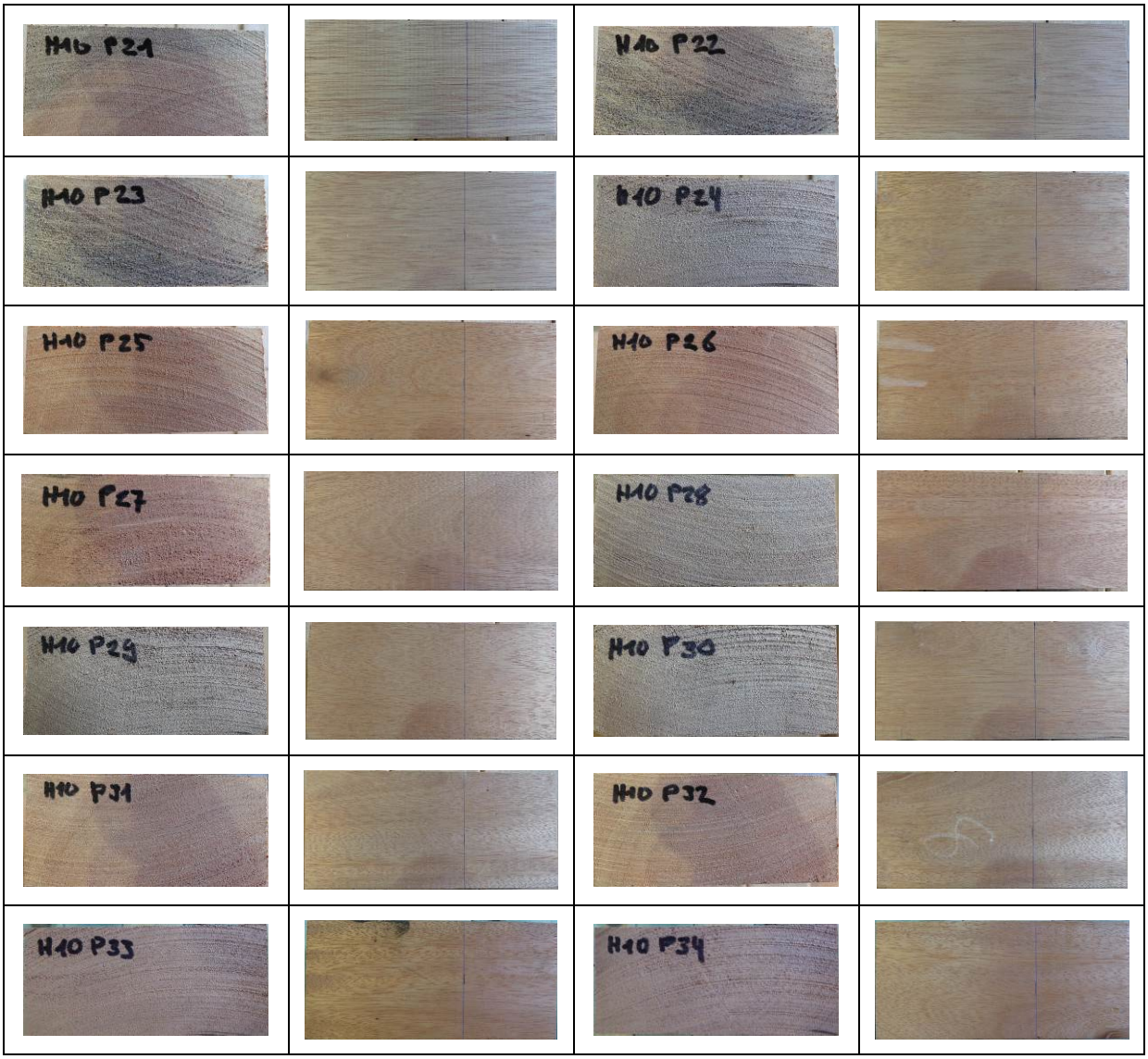


Table A95: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	447	443	6.6
Bearing perpendicular to grain [MPa]	9.7	7.7	12.1
MOE perpendicular to grain [MPa]	616	586	22.0

Table A96: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H10 p1	454	10.83	736.12
H10 p2	413	8.89	465.03

H10 p3	415	9.79	597.78
H10 p4	400	9.68	716.69
H10 p5	405	9.64	494.71
H10 p6	464	10.42	669.10
H10 p7	469	10.95	602.85
H10 p8	484	11.14	714.21
H10 p9	392	8.88	776.58
H10 p10	440	9.74	860.86
H10 p11	462	10.23	692.38
H10 p12	488	12.07	602.03
H10 p13	470	10.12	842.27
H10 p14	461	10.33	815.44
H10 p15	477	11.35	703.15
H10 p16	450	9.43	664.66
H10 p17	456	9.58	537.36
H10 p18	487	10.91	826.11
H10 p19	415	8.74	611.66
H10 p20	421	8.71	582.09
H10 p21	424	9.12	671.00
H10 p22	424	8.10	517.67
H10 p23	425	7.26	488.48
H10 p24	464	8.78	467.06
H10 p25	490	8.91	511.56
H10 p26	399	7.17	370.01
H10 p27	430	10.31	597.35
H10 p28	461	10.85	441.07
H10 p29	448	8.76	692.05
H10 p30	476	8.97	445.37
H10 p31	469	10.28	501.89
H10 p32	469	9.27	499.78

Table A97: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
H10 p33	456	7.36	493.60
H10 p34	422	7.38	392.52

Table A98: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H10 p1	8	-22.5-22.5	12	-	-	yes	329	199.75	91.4	41.1	438	-
H10 p2	8	-22.5-22.5	12	-	-	yes	300	199.75	91.6	41.2	398	-
H10 p3	8.1	-22.5-22.5	12	-	-	yes	302	199.5	91.7	41.2	401	-
H10 p4	7.9	-22.5-22.5	12	-	-	yes	290	199.5	91.6	41.2	385	-
H10 p5	7.8	-22.5-22.5	12	-	-	yes	294	199.75	91.7	41.2	390	-
H10 p6	8.2	-22.5-22.5	12	-	-	yes	334	199.75	91.1	41	448	-
H10 p7	7.6	-22.5-22.5	12	-	-	yes	336	199.75	91.1	40.9	451	-
H10 p8	7.4	-22.5-22.5	12	-	-	yes	346	199.75	91.1	41	464	-
H10 p9	8.6	-22.5-22.5	12	-	-	yes	284	199.75	91.1	41.1	380	-
H10 p10	8.6	-22.5-22.5	12	-	-	yes	320	200	91.1	41.1	427	-
H10 p11	9.4	-22.5-22.5	12	-	-	no	336	199.5	91.1	41	451	-
H10 p12	9.2	-22.5-22.5	12	-	-	no	353	199.5	91.2	40.8	476	-
H10 p13	9.2	-22.5-22.5	12	-	-	no	341	199.75	91.2	40.9	458	-
H10 p14	10	-22.5-22.5	12	-	-	no	335	199.5	90.6	40.9	453	-
H10 p15	9.7	-22.5-22.5	12	-	-	no	348	199.5	91.2	41	467	-

H10 p16	8.7	-22.5-22.5	12	-	-	no	326	199.75	91.1	41	437	little damage on edge on the bottom
H10 p17	8.4	-22.5-22.5	12	-	-	no	329	199.75	91.1	41	441	-
H10 p18	8.5	-22.5-22.5	12	-	-	no	352	199.75	91.1	41	472	-
H10 p19	8.3	0-45	12	-	-	yes	303	199.75	91.5	41.3	401	-
H10 p20	8.1	0-45	12	-	-	yes	306	199.75	91.6	41.2	406	-
H10 p21	8.9	0-45	12	-	-	yes	310	200	91.6	41.1	412	-
H10 p22	9.1	0-45	12	-	-	no	312	200	91.7	41.2	413	-
H10 p23	8.9	0-45	12	-	-	no	312	200	91.4	41.3	413	-
H10 p24	9.3	-22.5-22.5	12	-	-	no	339	199.5	91.5	41	453	-
H10 p25	9.5	-22.5-22.5	12	-	-	no	359	199.75	91.5	41	479	-
H10 p26	9.4	0-45	12	-	-	no	294	199.75	91.6	41.2	390	-
H10 p27	9.3	-22.5-22.5	12	-	-	yes	315	200	91.5	41	420	-
H10 p28	9.6	-22.5-22.5	12	-	-	yes	339	200	91.4	41.1	451	-
H10 p29	9	-22.5-22.5	12	-	-	no	327	199.5	91.5	41.1	436	-
H10 p30	9.6	-22.5-22.5	12	-	-	no	349	199.5	91.4	41.1	466	-
H10 p31	9.2	0-45	12	-	-	yes	344	199.5	91.4	41.3	457	-
H10 p32	9.6	0-45	12	-	-	yes	344	200	91.3	41	459	-
mean:	8.8		12.0				325.3	196.6	91.3	41.1	448.4	
σ:	0.7		0.0				20.9	17.7	0.3	0.1	88.8	

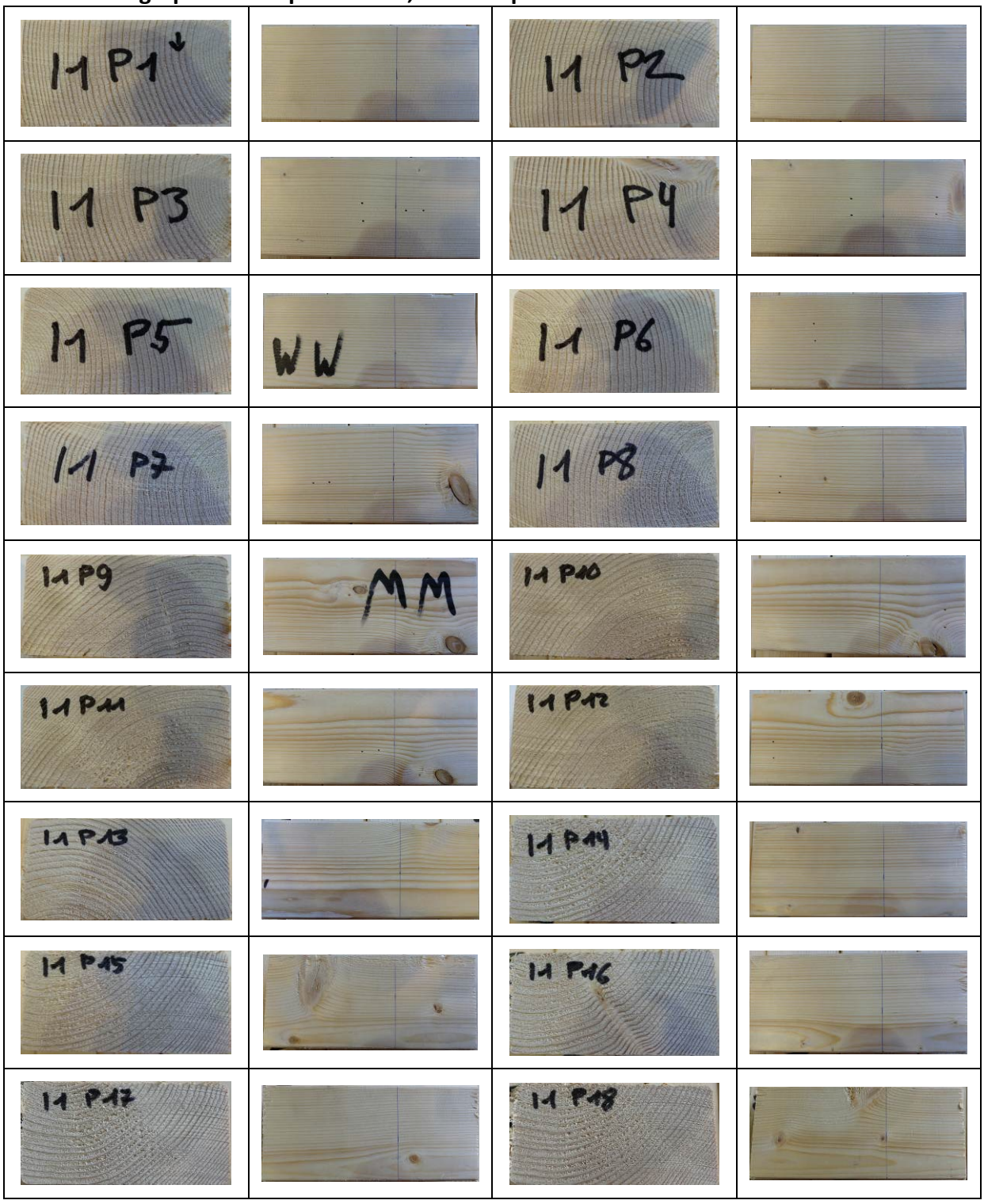
Table A99: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
H10 p33	9.3	0-45	12	-		no	333	199.5	91.4	41	445	-
H10 p34	9.3	0-45	12	-		no	311	199.75	91.6	41.3	412	-
mean:	9.3		12.0				322.0	199.6	91.5	41.2	428.5	
σ:	0.0		0.0				15.6	0.2	0.1	0.2	23.3	

European/Norwegian spruce – I1

Scientific name: Picea abies
Source location: Europe
Identification number: I1
Stress grade: MGP10

Table A100: Photographs of Samples Tested, end and plan view




11 P19
11 P20
11 P21
11 P22
11 P23
WW
11 P24
11 P25
11 P26
11 P27
11 P28
11 P29
11 P30
11 P31
11 P32
11 P33
MM
11 P34a
11 P35a
11 P36a
11 P37a
Picea abies
11 MM
Picea abies
Test 11
MM

Table A101: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	512	510	2.7
Bearing perpendicular to grain [MPa]	8.4	6.6	12.3
MOE perpendicular to grain [MPa]	367	358	19.8

Table A102: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I1 p1	503	8.34	324.61
I1 p2	498	7.62	300.23
I1 p3	496	8.38	341.74
I1 p4	497	8.78	341.59
I1 p5	498	7.53	257.46
I1 p6	519	8.24	262.24
I1 p7	513	7.54	321.54
I1 p8	511	8.02	276.76
I1 p9	533	8.61	534.00
I1 p10	540	7.58	467.96
I1 p11	520	7.60	367.98
I1 p12	504	10.09	413.85
I1 p13	506	7.67	340.30
I1 p14	504	7.88	350.61
I1 p15	529	8.33	382.46
I1 p16	499	7.43	492.51
I1 p17	503	7.51	319.60
I1 p18	513	8.42	406.81
I1 p19	519	6.92	339.31
I1 p20	513	9.35	350.59
I1 p21	541	11.93	535.44
I1 p22	529	7.75	318.76

I1 p23	503	9.52	485.64
I1 p24	524	8.03	301.86
I1 p25	524	8.19	300.07
I1 p26	509	7.27	456.62
I1 p27	513	7.88	460.56
I1 p28	505	8.46	355.09
I1 p29	532	11.70	352.57
I1 p30	494	8.83	336.71
I1 p31	505	8.69	333.96
I1 p32	490	8.64	322.42

Table A103: Individual Samples Density, Perpendicular to Grain Bearing and MOE, End of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I1 p33	488	6.75	238.34
I1 p34	511	8.27	352.04
I1 p35	512	7.74	295.50
I1 p36	523	7.51	255.14
I1 p37	505	7.44	287.82
I1 p38	469	6.70	249.28

Table A104: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I1 p1	12.9	90	2.2	0.5	23	-	407	199.25	89.9	44.8	507	-
I1 p2	13.2	90	2.2	0.5	23	-	404	199.75	90	44.7	503	-
I1 p3	13.4	90	2.2	0.5	23	-	404	199.75	90	44.8	502	Knot on the side, 4mm; knot in the middle/side, 4mm
I1 p4	13.4	90	2.2	0.5	23	-	408	199.75	90.1	45.1	503	2 knots on the side, 4mm and 9mm
I1 p5	12.6	90	2.2	0.5	23	-	399	199.5	89.5	44.6	501	Little damage on the side
I1 p6	13.4	90	2.2	0.5	23	-	424	199.5	89.9	45	525	Knot in the middle/side, 6mm
I1 p7	13.2	90	2.2	0.5	23	-	417	199.25	89.8	45	518	Knot in the middle, 9mm
I1 p8	13	90	2.2	0.5	23	-	414	199.5	89.7	44.8	516	Knot in the middle, 7mm
I1 p9	13.2	0-67.5	2.3	0.5	22	yes	440	199.5	90.3	45.3	539	2 knots in the middle, 7mm and 10mm; pitch pocket on the side, 20mm
I1 p10	13.5	0-67.5	2.3	0.5	22	yes	447	199.5	90.4	45.3	547	2 knots in the middle, 7mm and 10mm
I1 p11	13.5	0-67.5	2.3	0.5	22	yes	430	199.5	90.4	45.2	527	Knot in the middle/side, 7mm
I1 p12	13.1	0-67.5	2.3	0.5	22	yes	413	199.5	90.3	45	509	Knot in the middle, 10mm
I1 p13	13.1	0-67.5	2.3	0.5	22	yes	414	199.5	90.3	45	511	Knot in the middle/side, 10mm
I1 p14	12.7	0-67.5	1.7	0.4	24	no	409	199.5	90.1	44.9	507	-

I1 p15	12.7	0-67.5	1.7	0.4	24	no	431	199.5	90	45.1	532	Knot on the side, 25mm
I1 p16	13	0-67.5	1.7	0.4	24	no	407	199.5	90.2	45	503	-
I1 p17	13.1	0-67.5	1.7	0.4	24	no	412	199.75	90	45.1	508	Knot on the side, 15mm
I1 p18	13	0-67.5	1.7	0.4	24	no	420	199.5	90	45.2	518	2 knots in the middle/side, 15mm and 7mm
I1 p19	13.4	0-67.5	1.8	0.4	22	yes	426	199.5	90.3	45	525	Knot on the side, 25mm
I1 p20	13.4	0-67.5	1.8	0.4	22	yes	422	199.5	90.3	45.1	519	Knot in the middle/side, 12mm
I1 p21	12.7	0-67.5	1.8	0.4	22	no	439	199.5	89.9	45	544	Knot in the middle, 20mm
I1 p22	13	0-67.5	1.8	0.4	22	no	434	199.5	90.2	45.2	534	Knot on the side, 14mm
I1 p23	11.7	-67.5-67.5	1.8	0.4	22	yes	407	199.5	89.9	45.2	502	Knot in the middle/side, 7mm; knot in the middle, 10mm
I1 p24	11.6	-45-45	1.8	0.4	22	no	422	199.5	90	45	522	Knot in the middle/side, 7mm; knot in the middle, 10mm
I1 p25	11.9	-22.5-45	1.8	0.4	22	no	422	199.5	90.1	44.8	524	Knot in the middle, 10mm
I1 p26	13.1	-22.5-45	1.8	0.4	22	yes	415	199.5	90	45	514	-
I1 p27	12.5	-22.5-45	1.8	0.4	22	yes	416	199.25	90.1	45	515	-
I1 p28	13.2	90	1.6	0.4	25	-	413	199.5	90	45.1	510	Knot on the side, 7mm
I1 p29	13.4	90	1.6	0.4	25	-	436	199.5	90.1	45	539	2 knots in the middle, 7mm and 5mm
I1 p30	13.7	90	1.6	0.4	25	-	407	199.5	90.1	45.1	502	-
I1 p31	13.2	90	1.6	0.4	25	-	412	199.5	90	45	510	Knot in the middle, 10mm
I1 p32	13.3	90	1.6	0.4	25	-	402	199.5	90	45.1	496	-
mean:	13.0		1.9	0.4	22.9		417.9	199.5	90.1	45.0	516.6	

σ:	0.5		0.3	0.0	1.1		12.3	0.1	0.2	0.2	13.8	

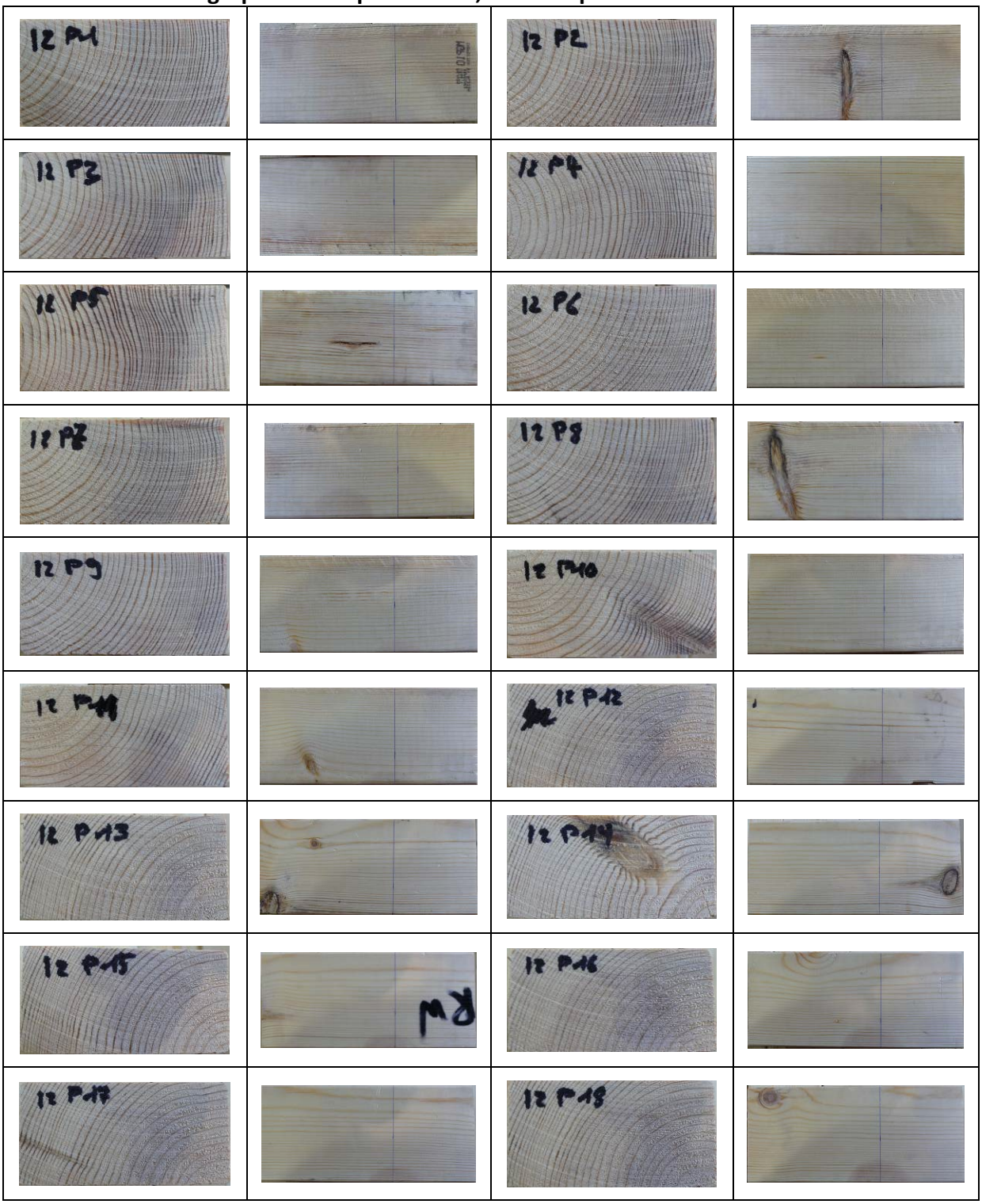
Table A105: Table of Sample Properties, End of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I1 p33	12.2	67.5	1.9	0.5	26	yes	391	199.5	90	44.5	489	Little damage on the bottom
I1 p34	12.6	90	1.9	0.5	26	-	410	199.25	90.1	44.4	514	3 knots in the middle, 2 x 5mm and 7mm
I1 p35	12.5	90	1.9	0.5	26	-	411	199.5	90	44.5	514	2 knots in the middle, 2 x 5mm
I1 p36	12.2	90	1.9	0.5	26	-	419	199.5	90	44.5	524	Knot in the middle, 5mm
I1 p37	12.2	90	1.9	0.5	26	-	406	199.5	90.1	44.6	506	Knot in the middle, 7mm
I1 p38	12.5	0-67.5	2.3	0.5	22	yes	404	194.5	98.5	44.8	471	2 knots on the side, 12mm and 23mm
mean:	12.4		2.0	0.5	25.6		406.8	198.6	91.5	44.6	503.0	
σ:	0.2		0.2	0.0	1.9		9.3	2.0	3.5	0.1	19.6	

Scots Pine – I2

Scientific name: Pinus sylvestris
Source location: Europe
Identification number: I2
Stress grade: MGP10

Table A106: Photographs of Samples Tested, end and plan view



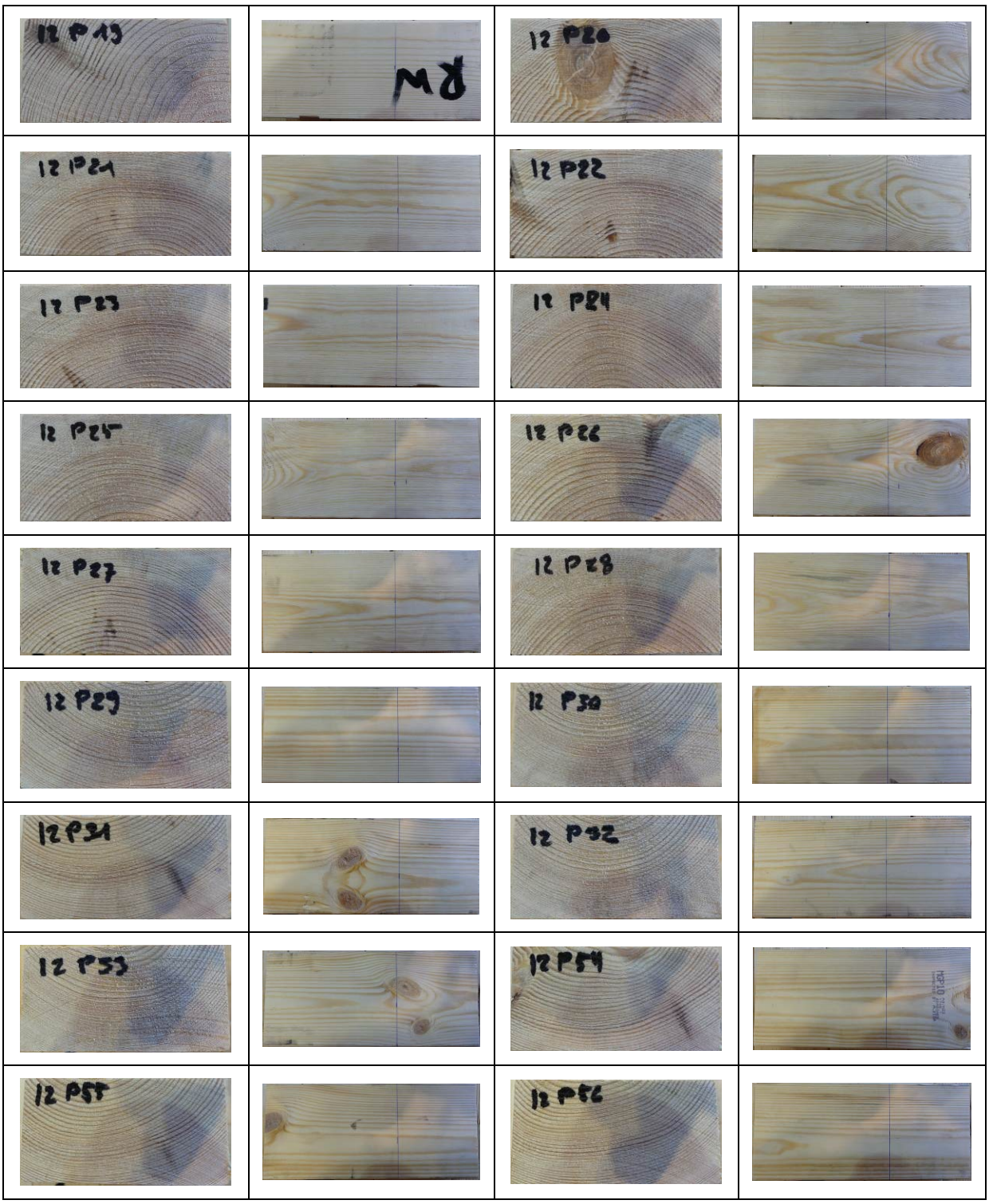


Table A107: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	521	516	8.1
Bearing perpendicular to grain [MPa]	8.6	6.1	17.7
MOE perpendicular to grain [MPa]	318	291	23.9

Table A108: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I2 p1	533	-	-
I2 p2	535	-	-
I2 p3	538	-	-
I2 p4	556	9.88	374.10
I2 p5	565	11.71	313.96
I2 p6	467	8.66	373.56
I2 p7	472	-	-
I2 p8	516	9.74	326.81
I2 p9	510	10.17	314.80
I2 p10	482	7.82	280.65
I2 p11	515	7.86	315.85
I2 p12	437	7.15	375.91
I2 p13	505	7.75	326.19
I2 p14	474	7.45	274.65
I2 p15	474	7.73	263.31
I2 p16	452	7.68	350.04
I2 p17	440	7.42	240.28
I2 p18	485	7.54	326.66
I2 p19	457	7.32	372.66
I2 p20	576	7.66	179.28
I2 p21	541	7.82	220.45
I2 p22	568	8.14	255.51
I2 p23	533	8.08	195.42
I2 p24	523	7.36	301.67
I2 p25	538	7.77	232.34

I2 p26	583	8.13	291.67
I2 p27	534	7.41	234.06
I2 p28	518	7.08	268.54
I2 p29	533	8.39	329.11
I2 p30	525	9.00	447.48
I2 p31	589	15.03	482.27
I2 p32	532	8.75	426.23
I2 p33	577	13.31	416.71
I2 p34	535	8.69	330.25
I2 p35	579	8.58	385.03
I2 p36	547	8.85	346.38

Table A109: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I2 p1	11.4	45-90	2.5	0.7	28	no	425	199.5	89.7	44.8	530	With roller; data is not used
I2 p2	11.4	45-90	2.5	0.7	28	no	429	199.75	89.7	45	532	Knot in the middle, 8mm; with roller; data is not used
I2 p3	11.5	90	2.5	0.7	28	-	430	199.75	89.8	44.7	536	With roller; data is not used
I2 p4	11.3	90	2.5	0.7	28	-	447	199.75	90	45	553	-
I2 p5	11.5	90	2.5	0.7	28	-	455	200	90	45	562	Pitch pocket on the side, 45mm
I2 p6	10.3	45-90	2.5	0.7	28	no	375	199.5	90.2	45.3	460	-
I2 p7	10.6	45-90	2.5	0.7	28	no	381	199.5	90.2	45.4	466	With roller; data is not used
I2 p8	10.9	45-90	2.5	0.7	28	no	414	199.5	90.2	45	511	Knot on the side, 10mm
I2 p9	11	45-90	2.5	0.7	28	no	409	199.5	90.2	45	505	Knot on the side, 6mm
I2 p10	10	45-90	2.5	0.7	28	no	382	199.5	90	45	473	-
I2 p11	10.2	45-90	2.5	0.7	28	no	410	199.5	90.1	45	507	Knot on the side, 10mm
I2 p12	10.5	45-90	2.5	0.7	28	yes	352	199.5	90.3	45.3	431	-
I2 p13	10.7	45-90	2.5	0.7	28	yes	406	199.5	90	45.3	499	Knot on the side, 10mm
I2 p14	10.6	45-90	2.5	0.7	28	yes	380	199.5	90	45.2	468	Knot on the side, 15mm
I2 p15	10.2	45-90	2.5	0.7	28	yes	377	199.5	89.9	45.1	466	Knot on the side, 10mm

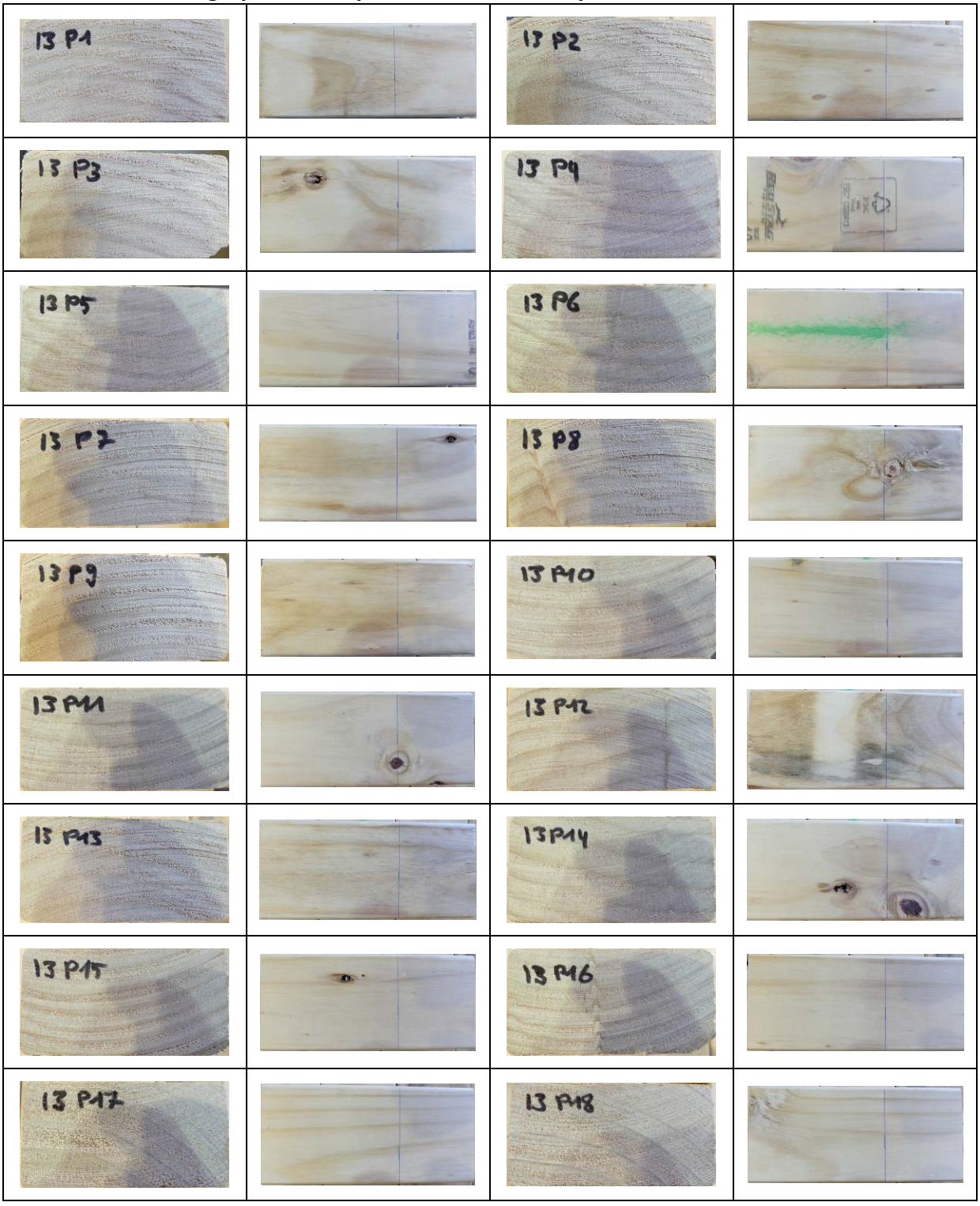
I2 p16	9.8	45-90	2.5	0.7	28	yes	360	199.5	90.3	45.1	443	-
I2 p17	9.9	45-90	2.5	0.7	28	yes	350	199.5	90.3	45	432	-
I2 p18	9.6	45-90	2.5	0.7	28	yes	386	199.5	90.2	45.2	475	2 knots on the side, 10mm and 9mm
I2 p19	9.8	45-90	2.5	0.7	28	yes	365	199.25	90.3	45.3	448	-
I2 p20	10.4	-45-45	1.5	0.3	20	yes	462	199.5	90.2	45.2	568	2 knots on the side, 17mm and 19mm
I2 p21	10.5	-45-45	1.5	0.3	20	yes	435	199.5	90.2	45.3	534	-
I2 p22	10.7	-45-45	1.5	0.3	20	yes	457	199.5	90.2	45.3	561	Knot on the side, 20mm; knot in the middle/side, 9mm
I2 p23	10.9	-45-45	1.5	0.3	20	yes	431	199.5	90.2	45.4	528	-
I2 p24	10.9	-45-45	1.5	0.3	20	yes	422	199.25	90.1	45.4	518	-
I2 p25	10.5	-45-45	1.5	0.3	20	yes	432	199.25	90	45.4	531	-
I2 p26	10.4	-45-45	1.5	0.3	20	yes	468	199.25	90.2	45.3	575	Knot in the middle/side, 25mm
I2 p27	10.7	-45-45	1.5	0.3	20	yes	430	199.25	90.1	45.4	528	-
I2 p28	11	-45-45	1.5	0.3	20	yes	416	199.25	90.1	45.2	513	-
I2 p29	10.4	-45-45	1.5	0.3	20	no	430	199.5	90.4	45.4	525	-
I2 p30	10.6	-45-45	1.5	0.3	20	no	423	199.5	90.3	45.3	518	-
I2 p31	10.8	-45-45	1.5	0.3	20	no	475	199.5	90.3	45.2	583	Knots in the middle, 16mm and 15mm
I2 p32	10.6	-45-45	1.5	0.3	20	no	429	199.5	90.4	45.3	525	-
I2 p33	10.5	-45-45	1.5	0.3	20	no	463	199.5	90.2	45.2	569	Knot in the middle, 16mm; knot in the middle/side, 12mm
I2 p34	10.1	-45-45	1.5	0.3	20	no	429	199.5	90.4	45.2	526	Knot on the side, 10mm
I2 p35	10	-45-45	1.5	0.3	20	no	463	199.5	90.3	45.2	569	Knot on the side, 16mm

I2 p36	10.3	-45-45	1.5	0.3	20	no	438	199.5	90.2	45.2	539	-
mean:	10.6		2.0	0.5	24.2		417.7	199.5	90.1	45.2	514.1	
σ:	0.5		0.5	0.2	4.1		34.4	0.2	0.2	0.2	42.4	

New Zealand Radiata – I3

Scientific name: Pinus radiata
Source location: New Zealand
Identification number: I3
Stress grade: MGP10

Table A110: Photographs of Samples Tested, end and plan view



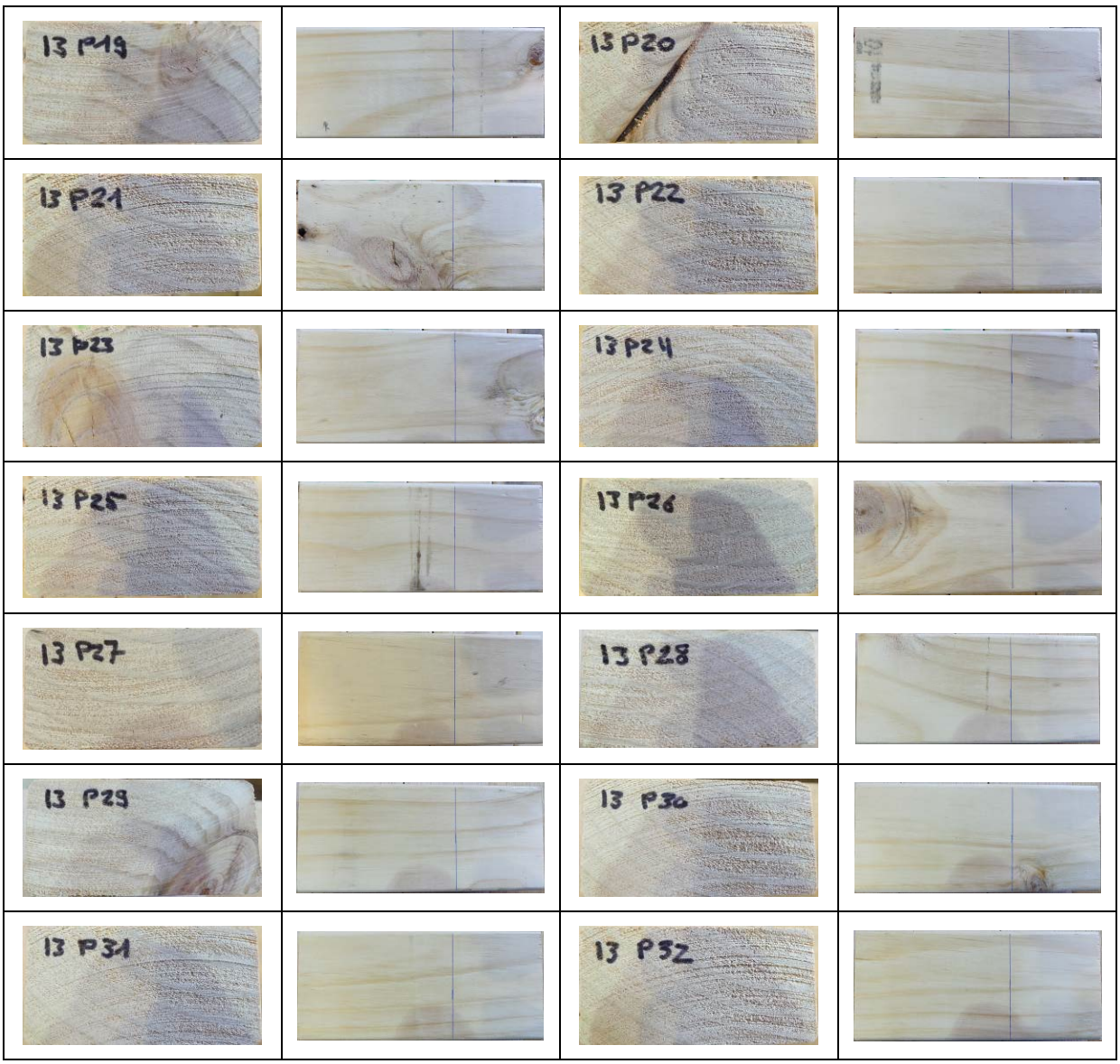


Table A111: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	454	449	9.1
Bearing perpendicular to grain [MPa]	10.8	6.9	23.4
MOE perpendicular to grain [MPa]	605	554	23.9

Table A112: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I3 p1	491	12.97	667.02
I3 p2	491	12.61	778.80

I3 p3	513	13.11	725.85
I3 p4	499	12.65	792.42
I3 p5	468	10.92	794.51
I3 p6	482	10.61	585.25
I3 p7	492	13.08	845.69
I3 p8	509	14.41	779.58
I3 p9	492	12.76	672.33
I3 p10	472	11.57	866.49
I3 p11	494	15.40	587.59
I3 p12	490	10.83	633.50
I3 p13	480	12.97	730.71
I3 p14	510	13.40	723.86
I3 p15	493	11.49	562.21
I3 p16	488	11.46	529.96
I3 p17	396	8.24	398.21
I3 p18	408	8.83	411.25
I3 p19	421	8.04	415.19
I3 p20	399	8.59	442.62
I3 p21	460	18.66	775.71
I3 p22	405	7.88	475.78
I3 p23	416	8.88	493.41
I3 p24	395	8.59	434.39
I3 p25	421	9.26	472.08
I3 p26	459	8.52	501.45
I3 p27	400	9.04	438.20
I3 p28	435	8.80	567.26
I3 p29	423	8.44	515.55
I3 p30	413	8.66	597.28
I3 p31	404	8.01	534.27
I3 p32	417	7.97	599.58

Table A113: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I3 p1	10.1	-22.5-22.5	9	4	44	yes	395	200	90.2	45.3	483	-
I3 p2	10	-22.5-22.5	9	4	44	yes	394	200	90.2	45.3	482	-
I3 p3	9.9	-22.5-22.5	9	4	44	yes	414	200	90.5	45.5	503	Knot in the middle, 10mm; knot in the middle/side, 12mm; damaged on the bottom at the edge, 50mm
I3 p4	10.3	-22.5-22.5	9	4	44	no	399	200	90.3	45	491	Knot in the middle/side, 14mm
I3 p5	11.9	-22.5-22.5	9	4	44	no	380	200	90.2	45	468	-
I3 p6	11.9	-22.5-22.5	9	4	44	no	390	200.25	90	44.9	482	-
I3 p7	10.5	-22.5-22.5	9	4	44	yes	393	200	90.3	44.9	485	Knot on the side, 6mm
I3 p8	10	-22.5-22.5	9	4	44	yes	407	200.5	90.5	44.9	500	Knot in the middle/side, 15mm
I3 p9	11.1	-22.5-22.5	9	4	44	yes	400	200.5	90.2	45.3	488	-
I3 p10	10.3	-22.5-22.5	9	4	44	no	381	200.5	90.3	45.3	465	-
I3 p11	10.6	-22.5-22.5	9	4	44	no	401	201	90.4	45.2	488	Knot in the middle/side, 23mm
I3 p12	11.4	-22.5-22.5	10	4	40	yes	402	200	91	45.4	487	-
I3 p13	10.2	-22.5-22.5	10	4	40	yes	386	200.5	90.5	45.1	472	-
I3 p14	10.5	-22.5-22.5	10	4	40	no	411	200.5	90.6	45	503	Knot in the middle, 9mm; knot on the side, 28mm
I3 p15	12.9	-22.5-22.5	9	4	44	no	409	200.5	90.6	45.3	497	Knot in the middle, 6mm; big chamber-bevel on

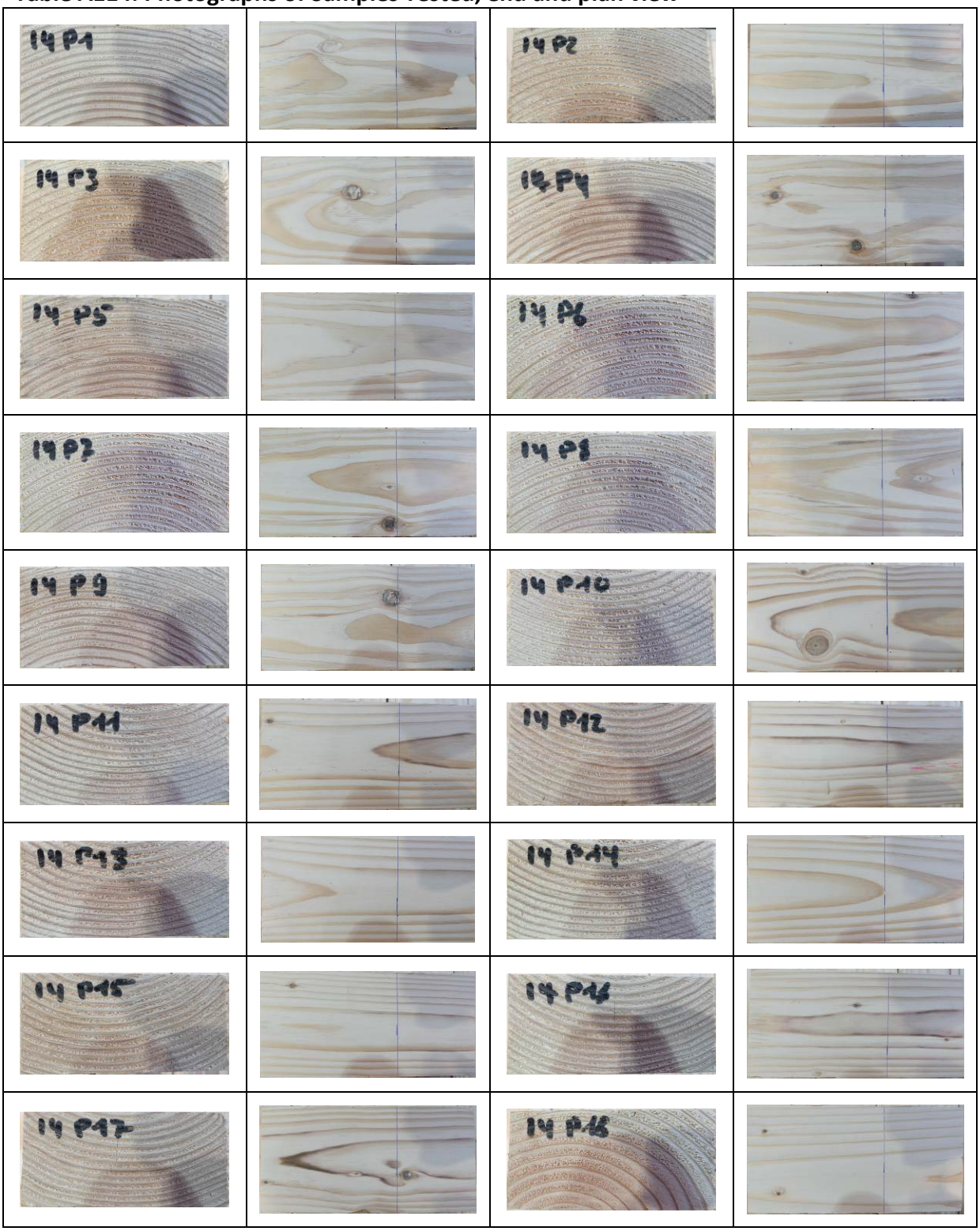
												the bottom 11mm bright
I3 p16	11.5	-22.5-22.5	9	4	44	no	399	200.5	90.6	45.2	486	Big chamber-bevel on the bottom side 11mm bright
I3 p17	12.1	0-45	12	2.5	21	yes	323	200.5	90.5	45	396	-
I3 p18	11.6	0-45	12	2.5	21	yes	331	200.5	90.2	45	407	-
I3 p19	11.7	0-45	12	2.5	21	yes	343	200.75	90.4	45	420	Knot on the side, 16mm
I3 p20	11.7	0-45	12	2.5	21	no	325	200.5	90.4	45.1	398	Knot on the side, 4mm
I3 p21	11	0-45	12	2.5	21	no	373	200.25	90.3	45.2	456	Missing knot on the side, 7mm; knot in the middle, 22mm
I3 p22	12.6	0-45	12	2.5	21	no	329	200.5	90.1	44.8	407	-
I3 p23	11.3	-22.5-22.5	12	2.5	21	yes	338	200.5	90.7	45	413	2 knots in the middle/side, 2 x 4mm; knot on the side, 20mm
I3 p24	11.6	-22.5-22.5	12	2.5	21	yes	323	200.5	90.6	45.1	394	-
I3 p25	10.9	-22.5-22.5	12	2.5	21	yes	341	200.5	90.4	45.1	417	-
I3 p26	11.9	-22.5-22.5	12	2.5	21	no	376	200.5	90.4	45.2	459	Knot on the side, 40mm; rough surface on the bottom
I3 p27	11.4	-22.5-22.5	12	2.5	21	no	327	200.5	90.8	45.1	398	-
I3 p28	12.7	0-45	10	2	20	yes	357	200	90.4	45.1	438	Knot on the side, 25mm
I3 p29	12.9	0-45	10	2	20	yes	346	200.25	90.1	45	426	Knot on the side, 25mm
I3 p30	11.9	0-45	10	2	20	no	335	200.25	90.1	45	413	Knot in the middle/side, 14mm
I3 p31	11.3	0-45	10	2	20	no	324	200.25	90.2	44.7	401	-
I3 p32	11.4	0-45	10	2	20	no	337	200.25	90.1	45	415	-
mean:	11.3		10.3	3.2	32.1		368.4	200.4	90.4	45.1	451.2	

σ:	0.9		1.3	0.9	11.8		32.6	0.3	0.2	0.2	39.0	

Douglas fir US (new) – I4

Scientific name: Pseudotsuga menziesii
Source location: North America
Identification number: I4
Stress grade: F7

Table A114: Photographs of Samples Tested, end and plan view



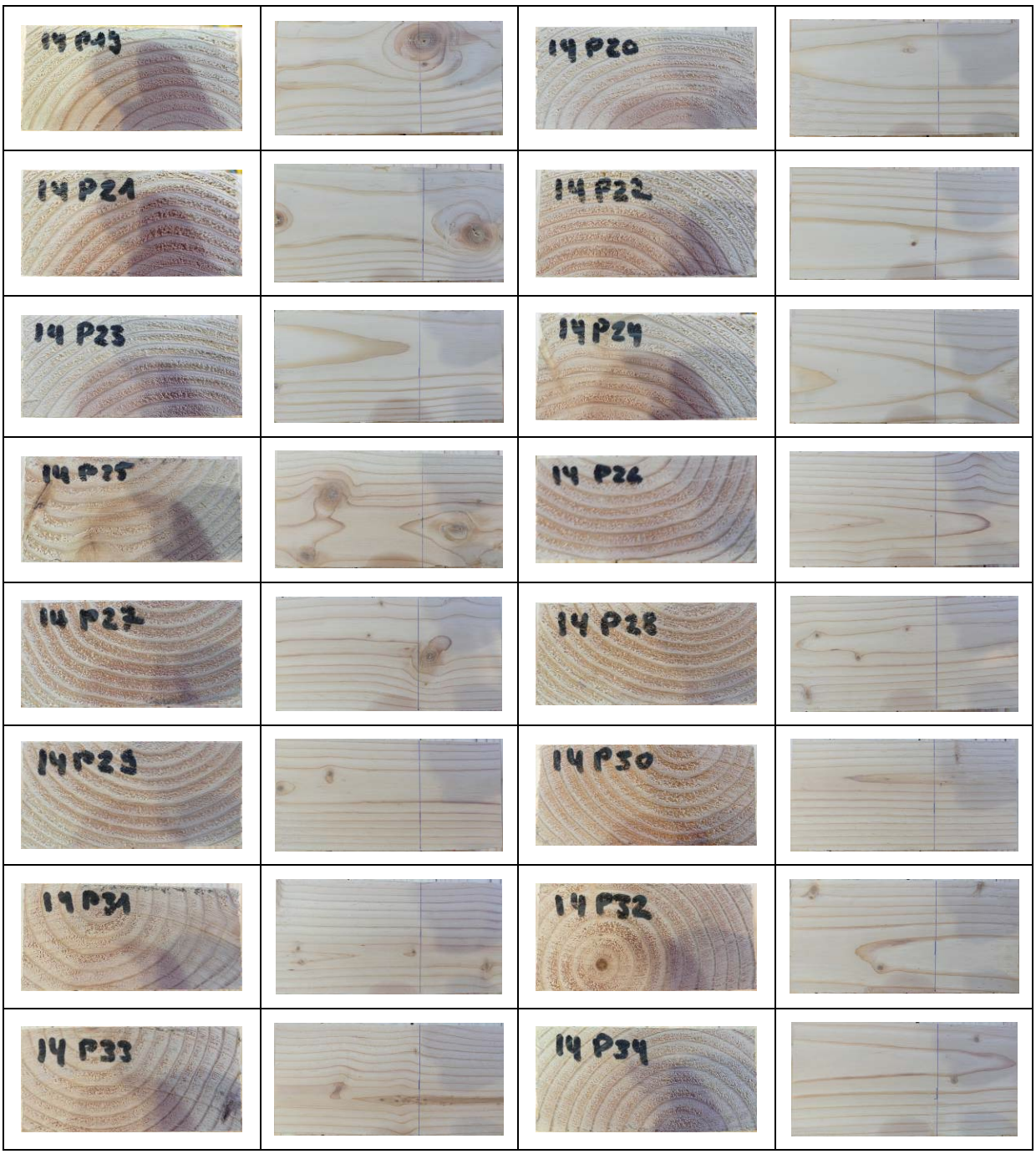


Table A115: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	482	476	11.1
Bearing perpendicular to grain [MPa]	7.6	5.1	21.0
MOE perpendicular to grain [MPa]	354	291	29.6

Table A116: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I4 p1	557	7.89	357.29
I4 p2	484	6.99	251.51
I4 p3	530	9.04	277.34
I4 p4	559	9.65	441.57
I4 p5	539	7.43	294.67
I4 p6	562	7.15	459.29
I4 p7	535	9.60	523.97
I4 p8	536	7.28	462.58
I4 p9	546	8.83	487.52
I4 p10	526	7.83	394.86
I4 p11	494	6.20	263.36
I4 p12	537	8.32	372.00
I4 p13	494	6.08	305.69
I4 p14	495	6.14	317.96
I4 p15	515	6.72	372.25
I4 p16	533	7.41	428.43
I4 p17	543	7.64	432.90
I4 p18	429	5.55	172.55
I4 p19	474	10.76	344.70
I4 p20	413	6.05	342.50
I4 p21	449	6.56	230.91
I4 p22	427	5.23	232.91
I4 p23	431	5.13	260.64
I4 p24	428	5.34	175.59
I4 p25	504	6.71	284.97
I4 p26	404	7.93	467.55
I4 p27	471	11.04	361.41

I4 p28	418	7.03	478.38
I4 p29	418	7.18	439.45
I4 p30	407	7.91	376.30
I4 p31	432	8.11	421.72
I4 p32	418	8.25	301.64
I4 p33	478	12.00	254.46
I4 p34	417	7.01	455.27

Table A117: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I4 p1	18.4	-22.5-22.5	4	2	50	yes	539	200	99.4	46	589	2 knots on the side, 12mm and 4mm; knot in the middle/side, 9 mm
I4 p2	18.5	-22.5-22.5	4	2	50	yes	468	200	99.1	46.1	512	-
I4 p3	17.6	-22.5-22.5	4	2	50	yes	511	200	99.6	46.1	556	Knot in the middle, 14mm
I4 p4	18.2	-22.5-22.5	4	2	50	yes	546	200.75	99.3	46.4	590	Knot in the middle, 10mm; knot on the side, 7mm
I4 p5	18.6	-22.5-22.5	4	2	50	yes	526	200.5	99.5	46.2	571	-
I4 p6	18.8	-22.5-22.5	4	2	50	yes	496	200	89.9	46.3	596	Knot on the side, 10mm
I4 p7	18.3	-22.5-22.5	4	2	50	yes	518	200	99	46.3	565	Knot in the middle, 12mm
I4 p8	17.4	-22.5-22.5	4	2	50	yes	523	200.25	99.5	46.7	562	Knot on the side, 3mm
I4 p9	16	-22.5-22.5	4	2	50	yes	518	200.25	99.1	46.1	566	Knot in the middle, 15mm
I4 p10	16	-22.5-22.5	4	2	50	no	491	200.25	98.8	45.5	545	2 knots on the side, 22mm and 3mm
I4 p11	16.8	-22.5-22.5	4	2	50	no	478	200	99.1	46.8	515	Knot on the side, 2mm
I4 p12	16.3	-22.5-22.5	4	2	50	no	517	200.25	99	46.7	558	-
I4 p13	18.3	-22.5-22.5	4	2	50	no	478	200	99.5	46	522	-
I4 p14	18.6	-22.5-22.5	4	2	50	no	480	200	99.2	46.2	524	-
I4 p15	18	-22.5-22.5	4	2	50	no	497	200	99.1	46.2	543	Knot on the side, 2mm

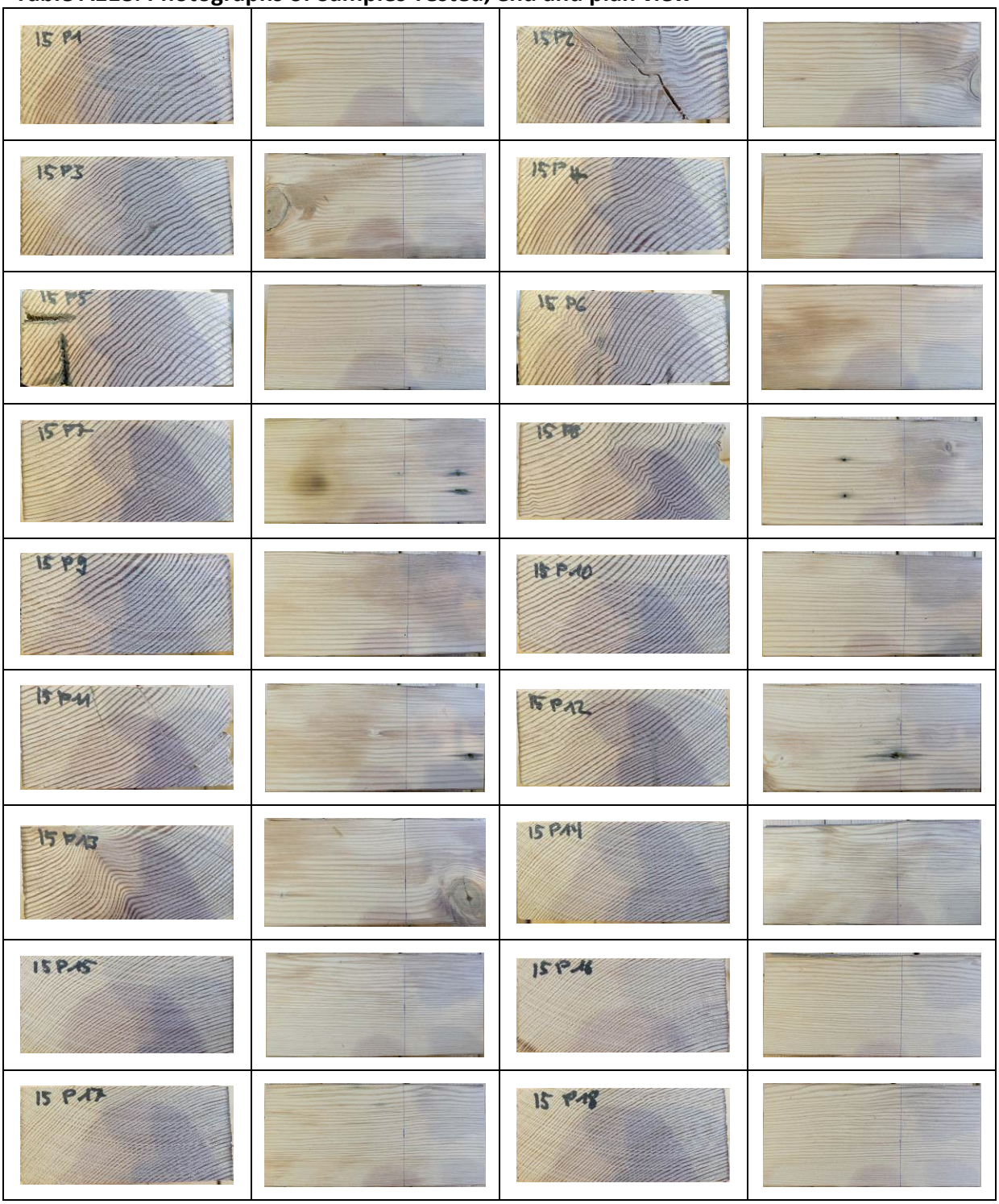
I4 p16	18.4	-22.5-22.5	4	2	50	no	519	200	99.8	46.2	563	Knot in the middle, 2mm
I4 p17	17.7	-22.5-22.5	4	2	50	no	527	200	99.7	46.3	571	Knot in the middle/side, 8mm; little damage on the edge
I4 p18	18.9	-22.5-22.5	6	2	33	yes	414	200.25	99.3	45.8	455	2 knots on the side, 2 x 2mm
I4 p19	17	-22.5-22.5	6	2	33	yes	447	200.25	98.9	45.6	495	Knot in the middle, 22mm
I4 p20	16.9	-22.5-22.5	6	2	33	yes	388	200.25	98.5	45.6	431	-
I4 p21	18.1	-22.5-22.5	6	2	33	yes	428	200.25	98.3	46	473	2 knots on the side, 25mm and 12mm; little damage on the surface on the edge
I4 p22	17.9	-22.5-22.5	6	2	33	yes	410	200.5	99.3	45.8	450	Knot in the middle, 3mm
I4 p23	18.2	-22.5-22.5	6	2	33	yes	415	200	99.2	46	455	Knot in the middle, 6mm; 2 knots on the side, 2 x 3mm
I4 p24	18.3	-22.5-22.5	6	2	33	yes	412	200.25	99.1	45.9	452	-
I4 p25	18.5	-22.5-22.5	6	2	33	no	487	200	99.5	45.9	533	3 knots on the side, 2 x 16mm and 13mm
I4 p26	18.4	-22.5-22.5	6	2	33	no	391	200	99	46.2	427	-
I4 p27	18.4	-22.5-22.5	6	2	33	no	452	200.25	99.4	45.6	498	Knot in the middle, 18mm
I4 p28	17.8	-22.5-22.5	6	2	33	no	405	200.25	99.5	46.2	440	3 knots on the side, 3 x 2mm; knot in the middle, 2mm
I4 p29	17.8	-22.5-22.5	6	2	33	no	406	200	99.6	46.3	440	2 knots on the side, 2 x 4mm
I4 p30	17.8	-22.5-22.5	6	2	33	no	390	200	99.4	45.8	428	Knot on the side, 3mm
I4 p31	18.4	-22.5-22.5	6	2	33	no	417	200	99	46.1	457	Knot in the middle, 12mm; 4 knots on the side, 3x 3mm and 12mm; with pith
I4 p32	16.8	-22.5-22.5	6	2	33	yes	400	200	99.1	46.3	436	Knot in the middle, 5mm; 3 knots on the side, 3 x 4mm; with pith
I4 p33	18.2	-22.5-22.5	6	2	33	no	447	200	98.4	45.1	504	2 knots in the middle, 2 x 15mm, cut through the

												pith; damage on the bottom
I4 p34	18.4	-22.5-22.5	6	2	33	yes	405	200	99.5	46.1	441	2 knots on the side,2 x 4mm; cut through the pith
mean:	17.9		5.0	2.0	41.7		463.1	200.1	98.9	46.1	507.7	
σ:	0.8		1.0	0.0	8.5		51.4	0.2	1.6	0.3	56.2	

Douglas fir US (old) – I5

Scientific name: Pseudotsuga menziesii
Source location: North America
Identification number: I5
Stress grade: F7

Table A118: Photographs of Samples Tested, end and plan view



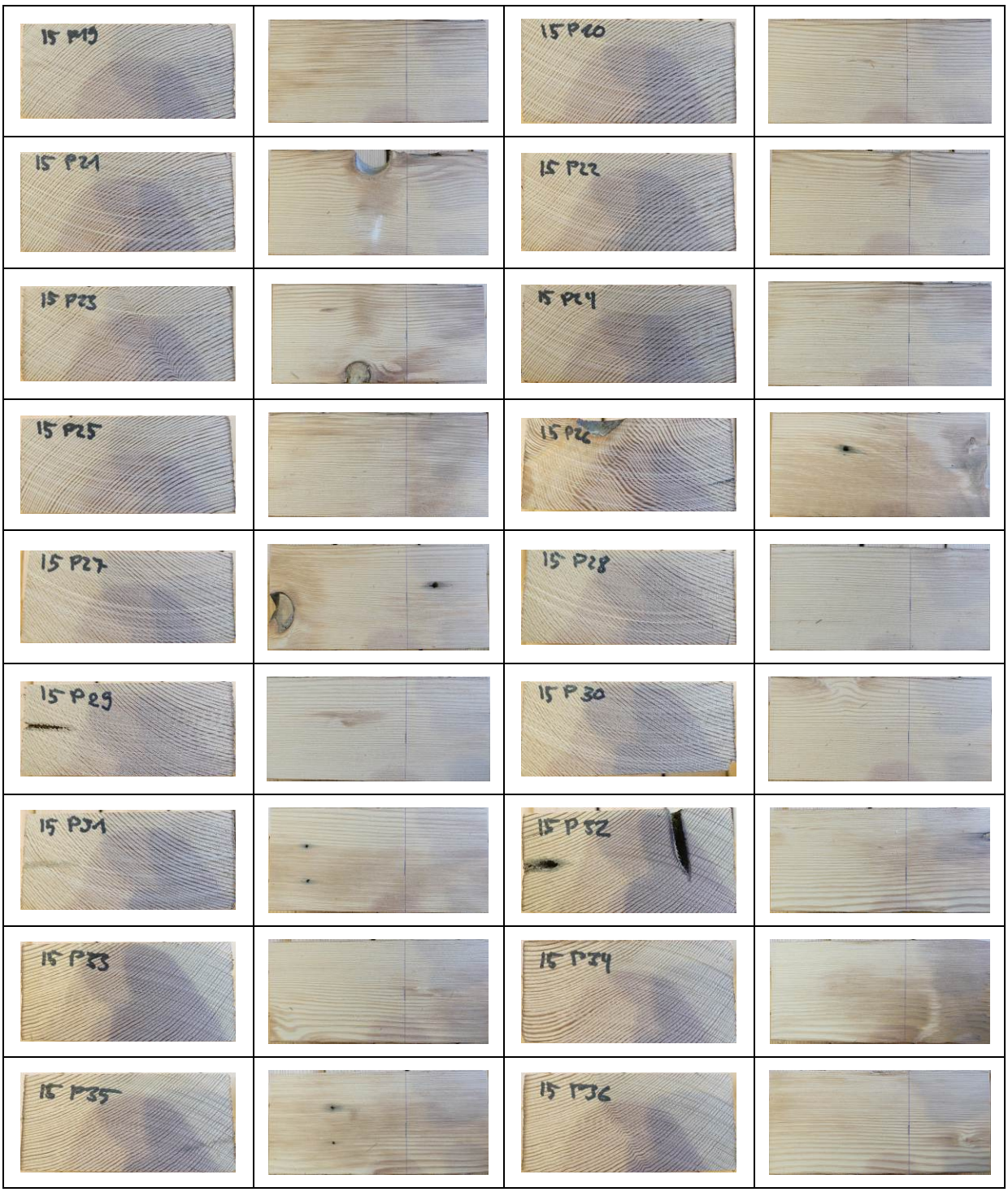


Table A119: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	599	596	3.6
Bearing perpendicular to grain [MPa]	10.7	8.8	10.1
MOE perpendicular to grain [MPa]	514	447	26.5

Table A120: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m³]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I5 p1	602	11.43	374.42
I5 p2	623	11.57	467.51
I5 p3	665	-	-
I5 p4	624	10.94	543.17
I5 p5	622	-	-
I5 p6	588	10.38	413.34
I5 p7	602	11.65	392.09
I5 p8	602	12.01	534.20
I5 p9	615	11.66	728.02
I5 p10	608	11.00	408.50
I5 p11	601	10.36	414.73
I5 p12	599	10.21	328.65
I5 p13	664	-	-
I5 p14	585	9.87	351.04
I5 p15	583	9.88	708.08
I5 p16	590	9.90	549.77
I5 p17	589	10.02	560.55
I5 p18	589	9.70	486.36
I5 p19	594	9.76	373.86
I5 p20	581	10.10	348.74
I5 p21	595	11.90	835.66
I5 p22	585	9.64	731.83
I5 p23	623	16.02	866.91
I5 p24	588	9.87	567.57
I5 p25	594	9.75	561.33

I5 p26	601	10.40	548.05
I5 p27	604	11.51	385.20
I5 p28	569	9.73	580.65
I5 p29	581	10.76	555.42
I5 p30	582	10.40	460.49
I5 p31	578	10.76	610.71
I5 p32	582	9.89	421.22
I5 p33	587	10.28	531.33
I5 p34	589	10.56	348.03
I5 p35	582	9.75	558.15
I5 p36	584	10.04	417.98

Table A121: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I5 p1	11.1	45-67.5	2.5	0.8	32	yes	483	200	94.8	42.7	597	-
I5 p2	11.2	45-67.5	2.5	0.8	32	yes	499	200	94.1	42.8	619	Knot on the side, 27mm
I5 p3	11.5	45-67.5	2.5	0.8	32	yes	538	200	94.1	43.2	662	Knot on the side, 27mm; strong coned-shaped; data is not used
I5 p4	10.5	45-67.5	2.5	0.8	32	yes	488	200.75	93.9	42	616	-
I5 p5	10.4	45-67.5	2.5	0.8	32	yes	478	200.5	93.7	41.5	613	Strong coned-shaped; data is not used
I5 p6	10.6	45-67.5	2.5	0.8	32	yes	470	200.25	95.5	42.3	581	-
I5 p7	11.2	45-67.5	2.5	0.8	32	no	494	200	94.9	43.5	598	-
I5 p8	11.1	45-67.5	2.5	0.8	32	no	492	200.25	94.4	43.6	597	Knot on the side, 5mm; damaged on the side
I5 p9	11.4	45-67.5	2.5	0.8	32	no	508	200	94.5	43.9	612	-
I5 p10	11	45-67.5	2.5	0.8	32	no	495	200.25	94.9	43.2	603	-
I5 p11	10.8	45-67.5	2.5	0.8	32	no	497	200	95.1	43.9	595	-
I5 p12	10.6	45-67.5	2.5	0.8	32	no	480	200.25	95.3	42.5	592	Old screw hole in the middle
I5 p13	10.8	45-67.5	2.5	0.8	32	no	527	200	94.6	42.4	657	Knot on the side, 25mm; strong coned-shaped; data is not used
I5 p14	11.9	22.5-45	1.5	0.5	33	yes	451	200	92.1	41.9	584	-
I5 p15	12.2	22.5-45	1.5	0.5	33	yes	454	200.25	92.2	42.1	584	-

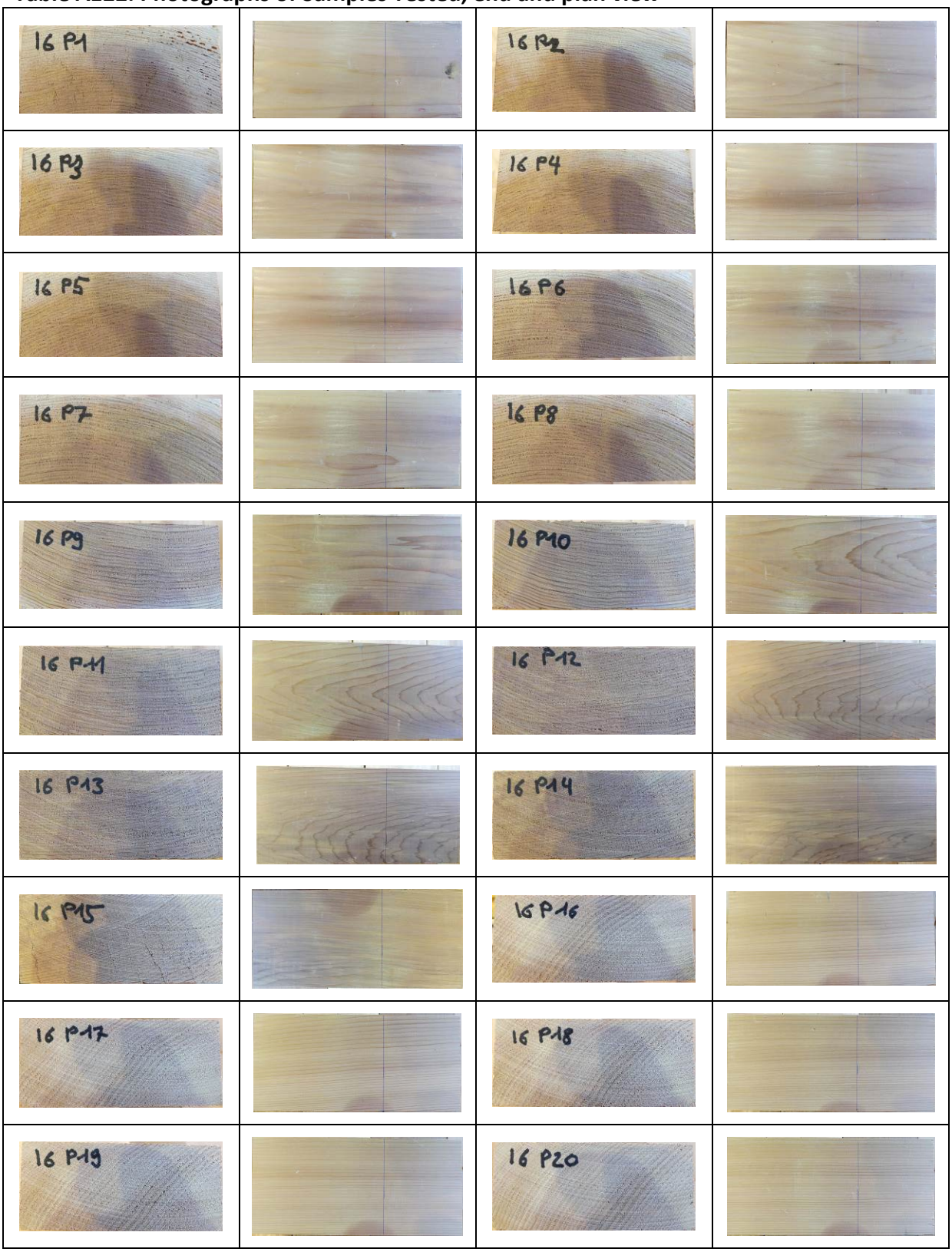
I5 p16	11.3	22.5-45	1.5	0.5	33	yes	444	200	91.8	41.3	586	-
I5 p17	11.4	22.5-45	1.5	0.5	33	yes	455	200.25	92.1	42.1	586	-
I5 p18	11.2	22.5-45	1.5	0.5	33	yes	449	200	92.5	41.5	585	-
I5 p19	11	22.5-45	1.5	0.5	33	yes	460	200	92.6	42.2	589	-
I5 p20	10.9	22.5-45	1.5	0.5	33	yes	452	200	92.5	42.5	575	-
I5 p21	10.6	22.5-45	1.5	0.5	33	yes	461	200	92.6	42.3	588	Missing knot in the middle, 34mm
I5 p22	11.1	22.5-45	1.5	0.5	33	yes	458	200	92.4	42.7	580	-
I5 p23	10.7	22.5-45	1.5	0.5	33	yes	474	200.25	93.1	41.3	616	Knot in the middle, 25mm
I5 p24	10.9	22.5-45	1.5	0.5	33	yes	455	200.25	92.7	42.1	582	-
I5 p25	10.9	22.5-45	1.5	0.5	33	yes	454	200	93.1	41.5	588	-
I5 p26	11	22.5-45	1.5	0.5	33	no	463	200	94.7	41	596	Knot on the side 5mm
I5 p27	11.1	22.5-45	1.5	0.5	33	no	455	199.75	94.2	40.4	599	Knot ion the side 32mm
I5 p28	11	22.5-45	1.5	0.5	33	no	430	200.5	93.5	40.7	564	-
I5 p29	11	22.5-45	1.5	0.5	33	no	431	200.25	93	40.2	576	-
I5 p30	11.1	22.5-45	1.5	0.5	33	no	433	200.25	93.3	40.2	577	-
I5 p31	11.1	22.5-45	1.5	0.5	33	no	449	200.25	93.2	42	573	-
I5 p32	11.7	22.5-45	1.5	0.5	33	no	456	200.5	92.2	42.5	580	-
I5 p33	11.1	22.5-45	1.5	0.5	33	no	454	200.5	91.8	42.4	582	-
I5 p34	11.6	22.5-45	1.5	0.5	33	no	459	200.5	92	42.4	587	Missing knot on the middle side, 10mm
I5 p35	11.5	22.5-45	1.5	0.5	33	no	453	200	92	42.5	579	-
I5 p36	11.2	22.5-45	1.5	0.5	33	no	447	200.25	91.9	41.9	580	-

mean:	11.1		1.9	0.6	32.9		467.9	200.2	93.4	42.1	593.8	
σ:	0.4		0.5	0.1	0.6		25.5	0.2	1.2	0.9	20.8	

Western Red Cedar – I6

Scientific name: Thuja plicata
Source location: Canada
Identification number: I6
Stress grade: -

Table A122: Photographs of Samples Tested, end and plan view



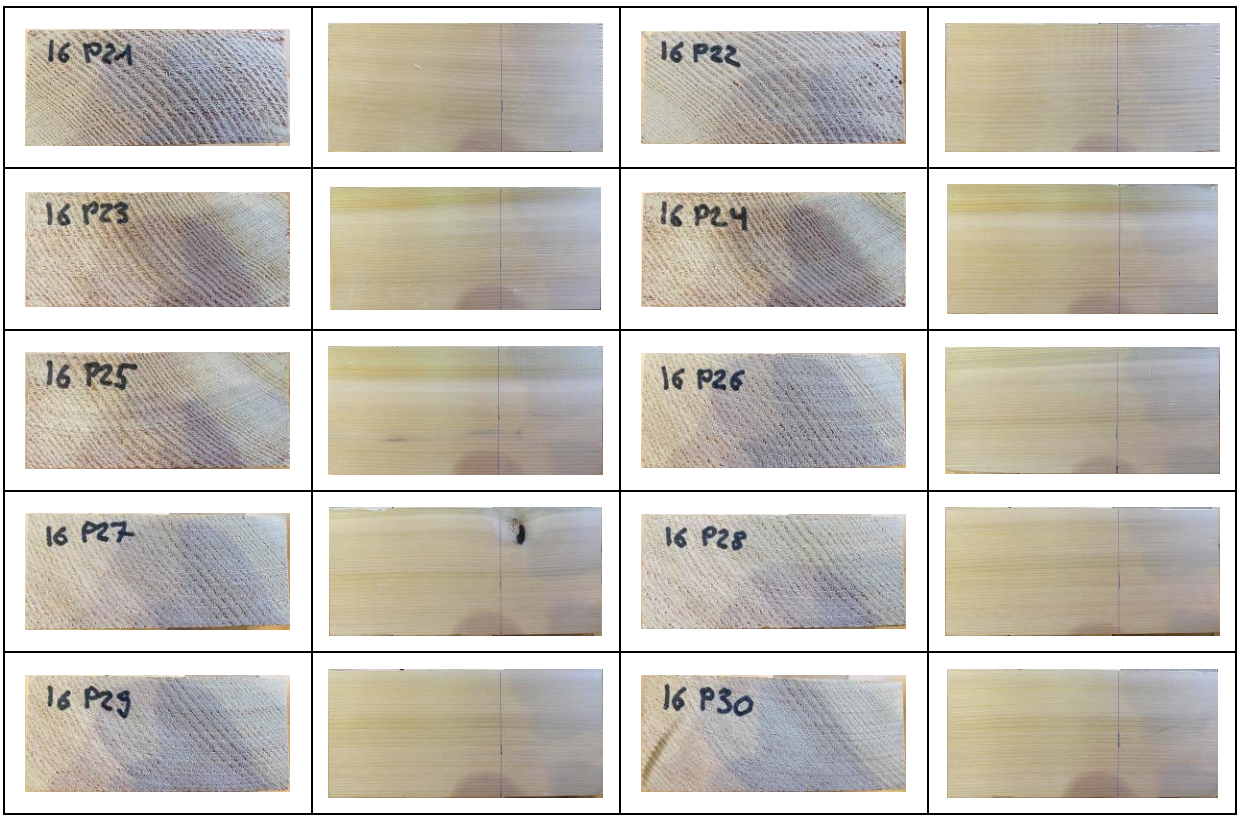


Table A123: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	383	381	4.5
Bearing perpendicular to grain [MPa]	7.6	4.9	22.9
MOE perpendicular to grain [MPa]	669	329	56.3

Table A124: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I6 p1	400	8.22	1100.43
I6 p2	400	8.20	1059.22
I6 p3	402	6.95	672.70
I6 p4	396	8.38	990.67
I6 p5	393	8.30	928.82
I6 p6	396	8.42	887.90
I6 p7	389	8.37	880.43
I6 p8	390	8.19	910.26
I6 p9	397	7.87	1002.47
I6 p10	393	8.21	1046.16

I6 p11	384	8.41	987.54
I6 p12	385	10.57	1141.73
I6 p13	401	11.71	1254.34
I6 p14	414	11.92	998.99
I6 p15	416	11.46	830.01
I6 p16	382	6.05	426.25
I6 p17	376	5.98	366.78
I6 p18	369	5.73	329.59
I6 p19	367	5.76	323.63
I6 p20	356	5.65	298.77
I6 p21	361	5.95	351.07
I6 p22	366	6.77	388.13
I6 p23	374	6.42	352.64
I6 p24	379	6.41	356.54
I6 p25	383	6.57	401.95
I6 p26	387	6.90	374.00
I6 p27	380	6.83	438.41
I6 p28	358	5.84	292.20
I6 p29	356	5.65	346.88
I6 p30	353	5.82	338.58

Table A125: Table of Sample Properties, Middle of Sample

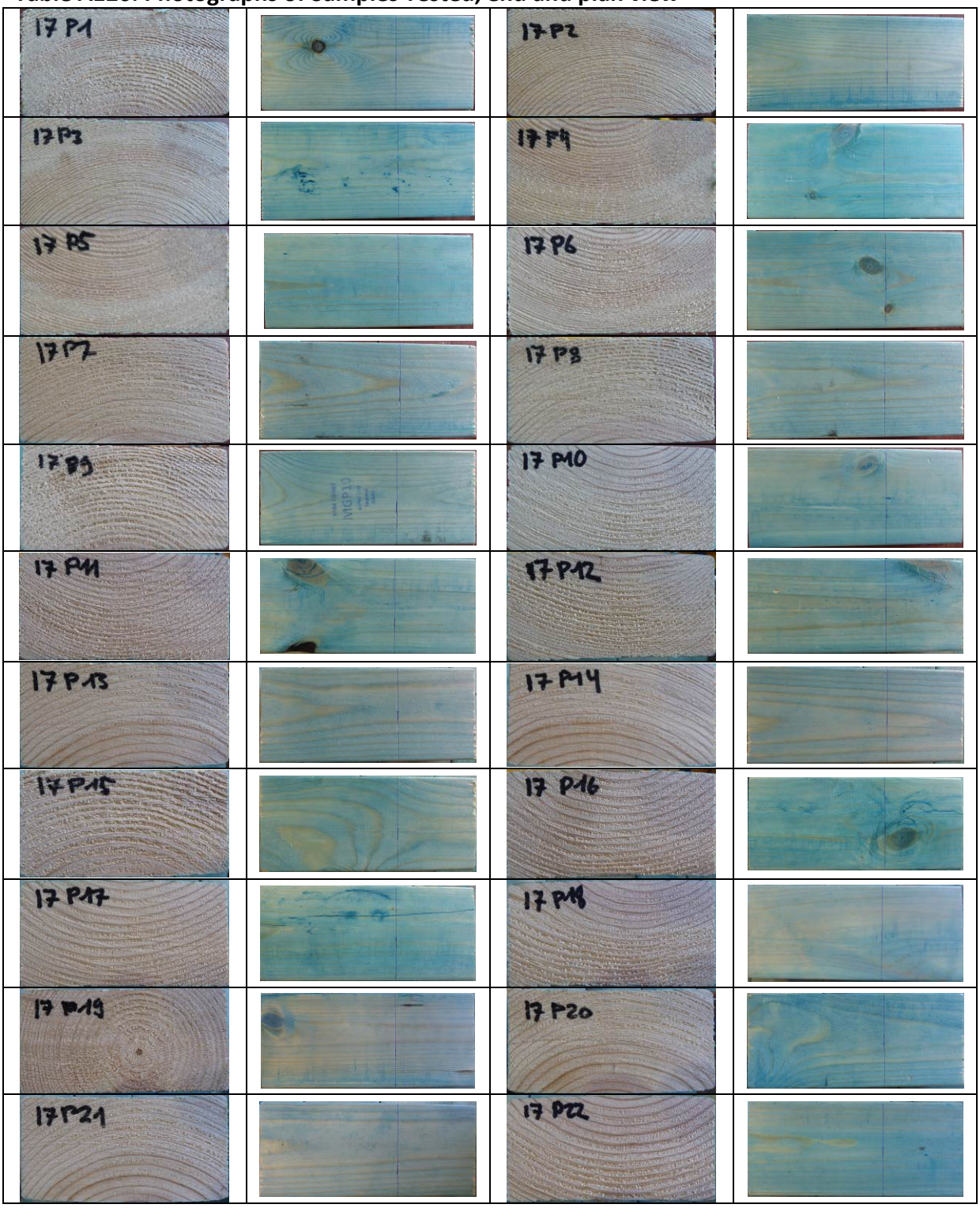
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I6 p1	10.3	-22.5-22.5	1.5	0.3	20	yes	279	200	90.9	39	394	-
I6 p2	10.5	-22.5-22.5	1.5	0.3	20	yes	280	200	90.9	39	395	-
I6 p3	10.4	-22.5-22.5	1.5	0.3	20	yes	281	200	90.9	39	396	-
I6 p4	10.9	-22.5-22.5	1.5	0.3	20	yes	278	200	90.9	39	392	-
I6 p5	10.9	-22.5-22.5	1.5	0.3	20	yes	276	200	90.9	39	389	-
I6 p6	10.5	-22.5-22.5	1.5	0.3	20	yes	277	200	90.9	39	391	-
I6 p7	11	-22.5-22.5	1.5	0.3	20	yes	274	200	90.9	39	386	-
I6 p8	10.5	-22.5-22.5	1.5	0.3	20	yes	273	200	90.9	39	385	-
I6 p9	10.2	-22.5-22.5	1.5	0.3	20	no	277	200	90.9	39	391	-
I6 p10	10.6	-22.5-22.5	1.5	0.3	20	no	275	200	90.9	39	388	-
I6 p11	10.2	-22.5-22.5	1.5	0.3	20	no	268	200	90.9	39	378	-
I6 p12	11.1	-22.5-22.5	1.5	0.3	20	no	271	200	90.9	39	382	-
I6 p13	10.4	-22.5-22.5	1.5	0.3	20	no	280	200	90.9	39	395	-
I6 p14	10.9	-22.5-22.5	1.5	0.3	20	no	291	200.25	90.9	39	410	-
I6 p15	10.5	-22.5-22.5	1.5	0.3	20	no	291	200.25	90.9	39	410	-
I6 p16	10.3	45-67.5	1.5	0.3	20	yes	267	200.5	90.9	39	376	-

I6 p17	10.2	45-67.5	1.5	0.3	20	yes	263	200.25	91	39	370	-
I6 p18	10.3	45-67.5	1.5	0.3	20	yes	258	200.25	90.9	39	363	-
I6 p19	9.9	45-67.5	1.5	0.3	20	yes	255	200	90.9	39	360	-
I6 p20	10.3	45-67.5	1.5	0.3	20	yes	249	200.25	90.9	39	351	-
I6 p21	10.6	45-67.5	1.5	0.3	20	yes	253	200.25	90.9	39	356	-
I6 p22	10.5	45-67.5	1.5	0.3	20	yes	256	200	90.9	39	361	-
I6 p23	10.3	45-67.5	1.5	0.3	20	no	261	200	90.9	39	368	-
I6 p24	10.2	45-67.5	1.5	0.3	20	no	264	200	90.9	38.9	373	-
I6 p25	10.5	45-67.5	1.5	0.3	20	no	268	200	90.9	39	378	-
I6 p26	10.1	45-67.5	1.5	0.3	20	no	269	200	90.8	39	380	missing knot in the middle/side, 6mm
I6 p27	10.3	45-67.5	1.5	0.3	20	no	265	200	90.9	39	374	-
I6 p28	10.4	45-67.5	1.5	0.3	20	no	250	200	90.9	39	353	-
I6 p29	10.2	45-67.5	1.5	0.3	20	no	248	200	90.9	39	350	-
I6 p30	10.5	45-67.5	1.5	0.3	20	no	247	200	90.9	39	348	-
mean:	10.5		1.5	0.3	20.0		268.1	200.1	90.9	39.0	378.1	
σ:	0.3		0.0	0.0	0.0		12.2	0.1	0.0	0.0	17.3	

Scots Pine (one stud, 48 mm) – I7

Scientific name: Pinus sylvestris
Source location: Europe
Identification number: I7
Stress grade: MGP10

Table A126: Photographs of Samples Tested, end and plan view



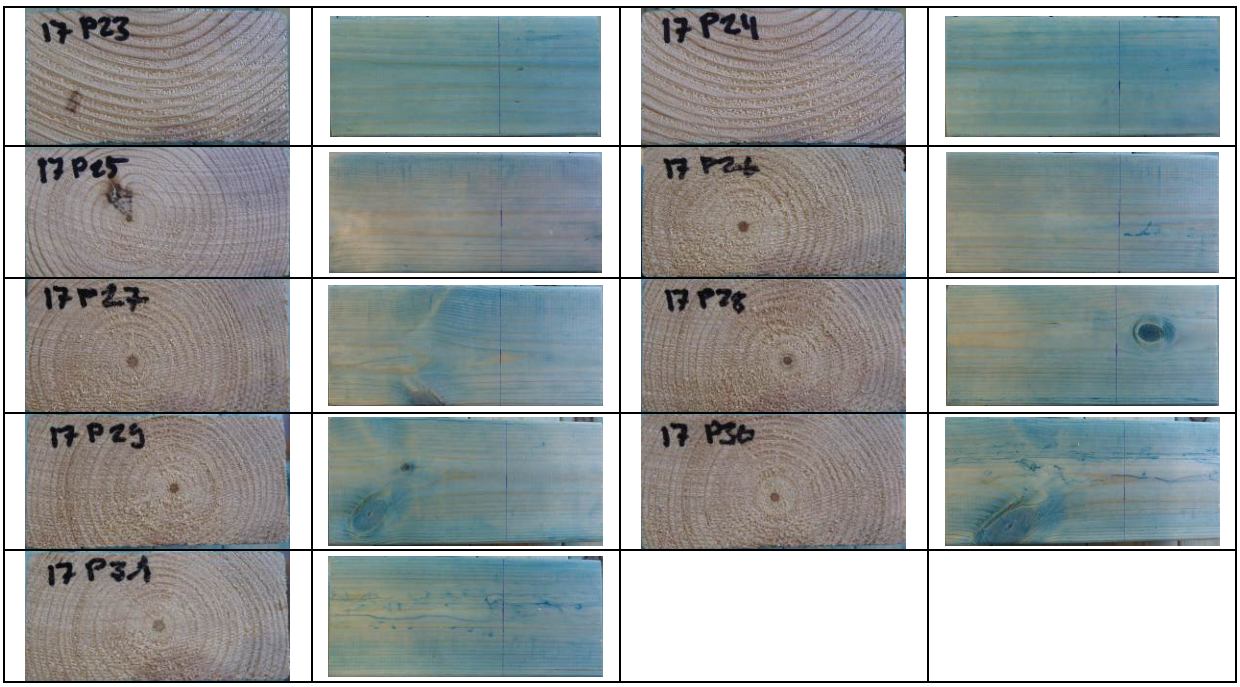


Table A127: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	428	424	7.3
Bearing perpendicular to grain [MPa]	6.1	4.4	16.6
MOE perpendicular to grain [MPa]	318	310	20.4

Table A128: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I7 p1	484	5.16	336.75
I7 p2	485	5.28	347.80
I7 p3	474	5.20	267.22
I7 p4	475	6.21	330.35
I7 p5	466	5.58	268.89
I7 p6	484	8.53	440.33
I7 p7	396	4.91	305.72
I7 p8	402	5.11	366.01
I7 p9	400	5.36	251.58
I7 p10	415	7.58	325.54

I7 p11	425	6.09	315.58
I7 p12	413	5.88	254.12
I7 p13	410	5.72	272.68
I7 p14	412	5.54	270.83
I7 p15	454	6.90	297.28
I7 p16	473	11.01	323.62
I7 p17	411	6.21	235.18
I7 p18	405	6.22	296.81
I7 p19	413	5.46	454.93
I7 p20	456	5.90	344.47
I7 p21	406	5.97	326.22
I7 p22	427	6.14	258.21
I7 p23	404	6.23	198.24
I7 p24	409	6.24	202.92
I7 p25	400	5.39	383.33
I7 p26	384	5.05	351.87
I7 p27	421	6.52	399.70
I7 p28	423	5.54	397.24
I7 p29	418	5.59	374.72
I7 p30	429	6.18	346.67
I7 p31	391	5.13	316.26

Table A129: Table of Sample Properties, Middle of Sample

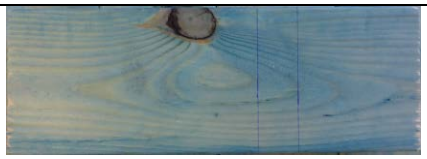
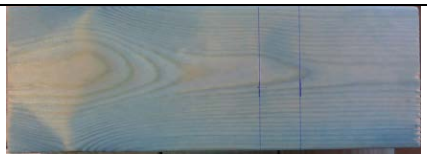
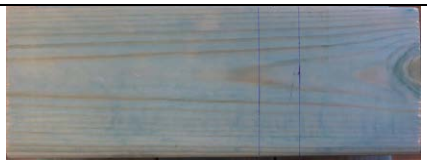
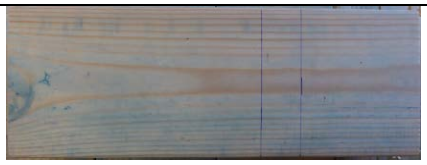
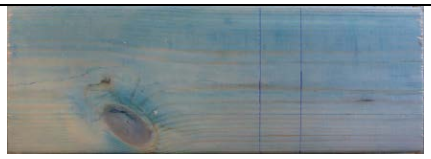
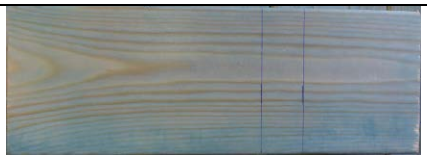
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I7 p1	12.3	-45-45	1.4	0.6	43	yes	387	200	89	44.8	485	Knot in the middle, 11mm
I7 p2	12.2	-45-45	1.4	0.6	43	yes	387	200	89	44.7	486	-
I7 p3	12.9	-45-45	1.4	0.6	43	yes	379	200	88.7	44.7	478	-
I7 p4	13.3	-45-45	1.4	0.6	43	no	382	200	88.9	44.7	481	Knot in the middle, 16mm
I7 p5	12.4	-45-45	1.4	0.6	43	no	371	200	88.9	44.6	468	-
I7 p6	13.5	-45-45	1.4	0.6	43	no	390	200	88.9	44.8	490	2 knots in the middle, 14mm and 6mm; pitch pocked on the side 40mm long 8mm wide
I7 p7	13	-45-45	2	0.8	40	yes	318	200.75	88.8	44.6	400	-
I7 p8	12.1	-45-45	2	0.8	40	yes	318	200.5	88.8	44.4	402	-
I7 p9	13.1	-45-45	2	0.8	40	yes	319	200.5	88.2	44.7	404	-
I7 p10	12.9	-45-45	2	0.8	40	no	332	200	88.9	44.7	418	Knot in the middle, 20mm
I7 p11	12.2	-45-45	2	0.8	40	no	334	200	88.2	44.4	426	Missing knot on the side, 18mm; knot on the side, 18mm
I7 p12	11.5	-45-45	2	0.8	40	no	323	200	88.1	44.6	411	Knot on the side, 18mm
I7 p13	12.7	-45-45	3.5	1	29	yes	323	200.5	87.8	44.4	413	-
I7 p14	12.5	-45-45	3.5	1	29	yes	325	200.75	88	44.4	414	-

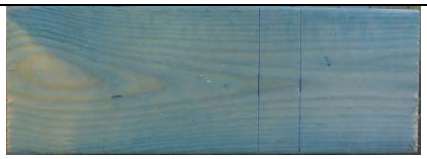
I7 p15	11.8	-45-45	3.5	1.5	43	yes	356	200	87.9	44.7	453	Knot in the middle/side, 28mm
I7 p16	13.4	-45-45	3.5	1.5	43	no	370	200	87.5	44.1	479	Knot in the middle, 20mm
I7 p17	12.3	-45-45	3.5	1	29	no	318	200.25	87.1	44.3	412	-
I7 p18	12.4	-45-45	3.5	1	29	no	322	200.5	88.6	44.6	406	-
I7 p19	13	90	3.5	0.8	23	-	337	200.25	89.7	45	417	2 knots on the side, 2 x 13mm
I7 p20	12.9	-45-45	4	1	25	yes	361	200.25	88	44.5	460	2 knots on the side, 2 x 18mm
I7 p21	12.8	-45-45	4	1	25	yes	319	200.5	87.9	44.3	409	-
I7 p22	13.4	-45-45	4	1	25	no	339	200.25	88.2	44.4	432	-
I7 p23	13.6	-45-45	4	1	25	no	318	200.25	87.6	44.2	410	-
I7 p24	12.7	-45-45	4	1	25	no	319	200.25	87.5	44.2	412	-
I7 p25	13.3	90	3.5	0.8	23	-	325	200.5	89.6	44.7	405	Knot on the side, 18mm
I7 p26	13.2	90	3.5	0.8	23	-	311	200	89.7	44.7	388	-
I7 p27	13.3	90	3.5	0.8	23	-	341	200	89.5	44.7	426	Knot in the middle/side, 13mm
I7 p28	13.4	90	3.5	0.8	23	-	343	200	89.6	44.7	428	Knot in the middle, 18mm; knot in the middle/side, 13mm
I7 p29	13.7	90	3.5	0.8	23	-	340	200	89.7	44.7	424	3 knots on the side, 2x 15mm and 12 mm
I7 p30	13.4	90	3.5	0.8	23	-	347	200	89.5	44.7	434	3 knots on the side, 12mm, 16mm and 22mm
I7 p31	13.3	90	3.5	0.8	23	-	317	200	89.5	44.7	396	-
mean:	12.9		2.9	0.9	32.4		341.0	200.2	88.6	44.6	431.2	
σ:	0.6		1.0	0.2	8.7		25.1	0.2	0.8	0.2	31.2	

Scots Pine (two studs, 100mm) – I7

Scientific name: Pinus sylvestris
Source location: Europe
Identification number: I7
Stress grade: -MGP10

Table A130: Photographs of Samples Tested, end and plan view

 17 P40	
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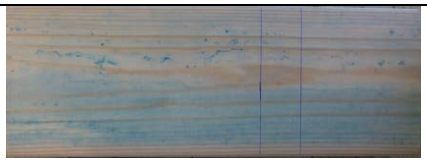
 17 P42	
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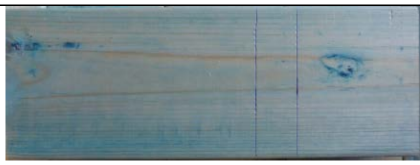
 17 P57	
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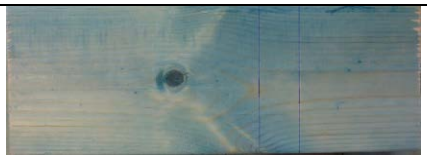
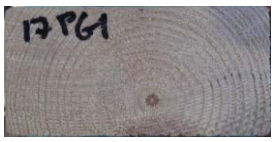
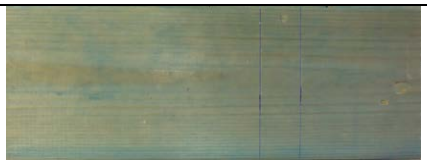
	
	

Table A131: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	445	441	7.6
Bearing perpendicular to grain [MPa]	4.7	3.4	16.5
MOE perpendicular to grain [MPa]	256	251	17.0

Table A132: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I7 p32	485	4.29	300.30
I7 p33	488	6.09	244.46
I7 p34	496	4.03	220.36
I7 p35	480	4.49	240.49
I7 p36	467	4.32	288.94
I7 p37	465	4.83	195.36
I7 p38	491	4.05	234.23
I7 p39	462	3.98	292.97
I7 p40	475	3.96	240.79
I7 p41	473	4.52	284.22
I7 p42	442	4.34	326.74
I7 p43	464	4.77	338.22
I7 p44	459	4.03	320.50
I7 p45	456	3.97	254.90
I7 p46	416	4.49	291.75

I7 p47	467	4.56	295.42
I7 p48	414	4.86	214.37
I7 p49	401	4.58	228.04
I7 p50	461	7.09	231.88
I7 p51	406	4.11	293.61
I7 p52	412	4.75	301.31
I7 p53	442	6.67	185.41
I7 p54	445	6.29	171.63
I7 p55	402	4.47	223.90
I7 p56	480	4.74	234.85
I7 p57	392	4.11	239.73
I7 p58	391	4.10	224.09
I7 p59	413	4.24	244.64
I7 p60	425	6.21	278.66
I7 p61	392	4.22	243.80

Table A133: Table of Sample Properties, Middle of Sample

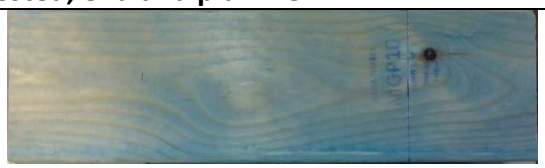
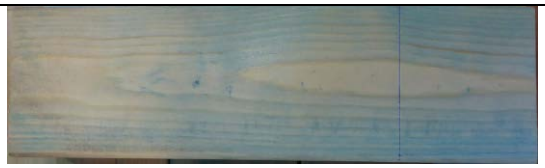
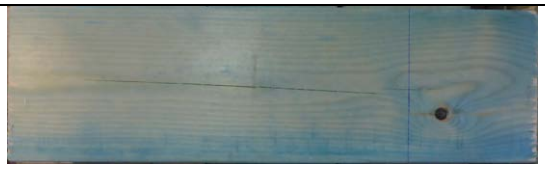
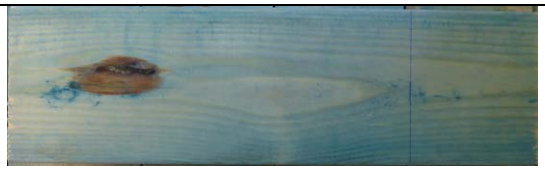
Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I7 p32	11.5	-22.5-22.5	1.4	0.5	36	yes	481	250.75	89	44.6	483	2 knots on the side, 21mm and 18mm
I7 p33	12.8	-22.5-22.5	1.4	0.5	36	yes	490	250.75	89.1	44.7	491	Knot in the middle, 20mm; knot on the side, 7mm
I7 p34	11.6	-22.5-22.5	1.4	0.5	36	yes	492	250.5	89	44.7	494	2 knots on the side, 2 x 16mm
I7 p35	13.7	-22.5-22.5	1.4	0.5	36	no	486	250.75	89.1	44.7	487	Knot on the side, 20mm
I7 p36	13	-22.5-22.5	1.4	0.5	36	no	470	250.75	89	44.7	471	Knot on the side, 20mm
I7 p37	11.8	-22.5-22.5	1.4	0.5	36	no	461	250.75	88.6	44.7	464	Knot in the middle, 19mm
I7 p38	12.8	-22.5-22.5	1.4	0.5	36	yes	493	250.75	89	44.6	495	Knot on the side, 17mm
I7 p39	11.6	-22.5-22.5	1.4	0.5	36	yes	457	250.75	89	44.5	460	-
I7 p40	12.7	-22.5-22.5	1.4	0.5	36	yes	475	250	89	44.7	478	2 knots on the side, 14mm and 21mm
I7 p41	13	-22.5-22.5	1.4	0.5	36	no	477	250.75	89.2	44.7	477	2 knots on the side, 2 x 17mm
I7 p42	13.7	-22.5-22.5	1.4	0.5	36	no	449	250.5	89.3	44.7	449	-
I7 p43	12.8	-22.5-22.5	1.4	0.5	36	no	467	250.75	89.2	44.7	467	3 knots in the middle/side, 3 x 13mm
I7 p44	11.8	-22.5-22.5	1.4	0.5	36	yes	456	251	89	44.6	458	Missing knot on the side, 18mm
I7 p45	13.2	-22.5-22.5	1.4	0.5	36	yes	460	250.5	89.1	44.7	461	-
I7 p46	12.2	-22.5-22.5	2	0.7	35	yes	410	250	87.9	44.7	417	-

I7 p47	12.3	-22.5-22.5	1.4	0.5	36	no	467	251	88.9	44.7	468	-
I7 p48	11.7	-22.5-22.5	2.5	0.8	32	no	405	250.75	88.1	44.4	413	2 knots on the side, 8mm and 15mm
I7 p49	12.7	-22.5-22.5	3	0.8	27	no	401	250.75	88.5	44.7	404	-
I7 p50	14.1	-22.5-22.5	3.5	1.2	34	yes	453	250.5	87.1	44.2	470	Knot in the middle side, 38mm
I7 p51	13.7	-22.5-22.5	3.5	1.2	34	yes	411	250.75	89	44.7	412	2 knots on the side, 2 x 19mm
I7 p52	14.5	-22.5-22.5	3.5	1.2	34	yes	405	250.5	86.9	44.2	421	Knot on the side, 14mm
I7 p53	13.6	-22.5-22.5	3.5	1.2	34	no	438	250.75	87.6	44.5	448	Knot in the middle/side, 22mm
I7 p54	13.5	-22.5-22.5	3.5	1.2	34	no	441	250	88	44.4	451	Knot in the middle, 20mm; knot on the side, 5mm
I7 p55	14.1	-22.5-22.5	3.5	1.2	34	no	396	250.25	87.3	44.2	410	-
I7 p56	12.6	-22.5-22.5	3.5	1.2	34	yes	481	250.5	88.9	44.7	483	2 knots in the middle, 19mm and 14mm
I7 p57	12.7	90	3.5	1	29	-	396	250	89.6	44.9	394	With pith; knot on the side, 10mm
I7 p58	13.1	90	3.5	1	29	-	396	250	89.5	44.8	395	With pith
I7 p59	13.8	90	3.5	1	29	-	422	250	89.5	44.9	420	With pith; 2 knots on the side, 17mm and 10mm
I7 p60	13.9	90	3.5	1	29	-	434	251	89.4	44.8	432	With pith, 2 knots in the middle, 2 x 15mm
I7 p61	12.5	90	3.5	1	29	-	396	250	89.6	44.9	394	With pith
mean:	12.9		2.4	0.8	33.7		445.5	250.5	88.7	44.6	448.9	
σ:	0.8		1.0	0.3	2.9		33.7	0.3	0.7	0.2	33.0	

Scots Pine (three studs, 150mm) – I7

Scientific name: Pinus sylvestris
Source location: Europe
Identification number: I7
Stress grade: MGP10

Table A134: Photographs of Samples Tested, end and plan view

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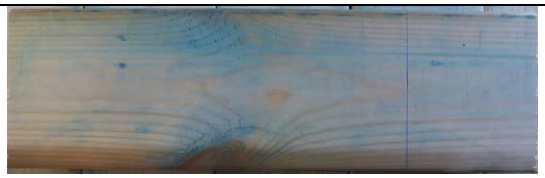
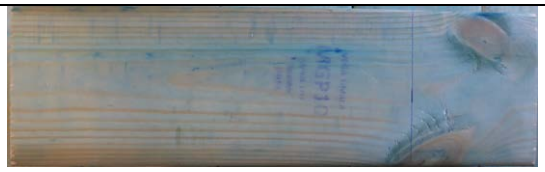
 17P72	
 17P73	
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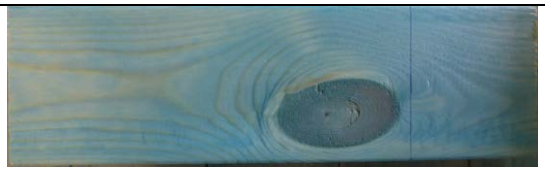
 17 P77	
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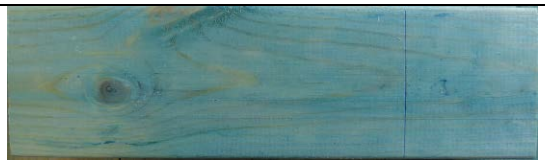
 17 P80	
 17 P81	
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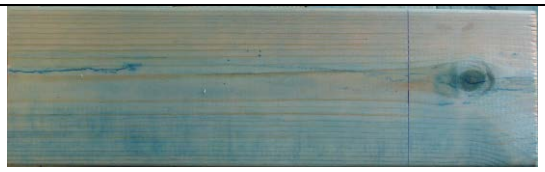
 17 P85	
 17 P86	
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	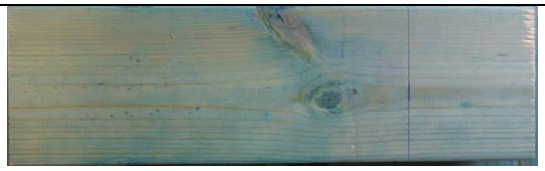
	

Table A135: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	432	429	6.0
Bearing perpendicular to grain [MPa]	4.3	3.2	14.0
MOE perpendicular to grain [MPa]	216	208	21.1

Table A136: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I7 p62	426	4.12	223.14
I7 p63	460	3.83	242.96
I7 p64	452	3.66	223.60
I7 p65	463	3.57	254.35
I7 p66	465	3.64	256.86
I7 p67	461	3.73	250.15
I7 p68	460	3.75	295.84
I7 p69	455	3.80	245.19

I7 p70	462	3.90	189.77
I7 p71	479	4.71	283.00
I7 p72	446	3.95	304.62
I7 p73	459	4.17	247.63
I7 p74	414	4.39	186.04
I7 p75	407	4.52	209.85
I7 p76	431	4.95	215.64
I7 p77	449	6.78	227.90
I7 p78	400	3.63	170.81
I7 p79	412	3.84	198.06
I7 p80	449	4.84	132.95
I7 p81	447	5.41	151.74
I7 p82	415	4.57	149.22
I7 p83	409	4.22	139.09
I7 p84	413	4.56	227.75
I7 p85	415	4.51	233.30
I7 p86	405	4.03	196.15
I7 p87	408	4.09	214.72
I7 p88	395	3.90	188.08
I7 p89	406	4.02	192.46
I7 p90	415	4.81	224.64
I7 p91	388	3.82	195.58

Table A137: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I7 p62	12.9	-22.5-22.5	1.4	0.5	36	yes	508	300.5	88.4	44.6	429	Knot on the side, 6mm
I7 p63	13.8	-22.5-22.5	1.4	0.5	36	yes	561	300.5	89.3	44.8	467	-
I7 p64	12.7	-22.5-22.5	1.4	0.5	36	yes	544	300.5	88.9	44.8	455	Knot in the middle, 17mm
I7 p65	13.7	-22.5-22.5	1.4	0.5	36	yes	563	300.5	89.1	44.7	470	3 knots on the side, 2 x 7mm and 14mm
I7 p66	14	-22.5-22.5	1.4	0.5	36	yes	567	301.25	89.3	44.6	473	3 knots on the side, 2 x 17mm and 7mm
I7 p67	14.1	-22.5-22.5	1.4	0.5	36	yes	564	301	89.2	44.7	470	Knot in the middle, 15mm; pitch pocket in the middle/side 5mm wide and 30mm long
I7 p68	12.9	-22.5-22.5	1.4	0.5	36	no	556	300.5	89.5	44.6	464	Knot on the side, 11mm
I7 p69	13.3	-22.5-22.5	1.4	0.5	36	no	548	301	88.7	44.6	460	-
I7 p70	12.6	-22.5-22.5	1.4	0.5	36	no	552	300.5	88.8	44.6	464	2 knots on the side, 2 x 12mm
I7 p71	13.8	-22.5-22.5	1.4	0.5	36	no	585	300	89.3	44.8	487	Knot in the middle, 20mm; knot on the side, 13mm
I7 p72	12.1	-22.5-22.5	1.4	0.5	36	no	538	300.75	89.3	44.9	446	Knot in the middle, 25mm
I7 p73	12.5	-22.5-22.5	1.4	0.5	36	no	552	300.5	89.1	44.7	461	2 knots on the side, 2 x 19mm
I7 p74	11.6	-22.5-22.5	2.2	0.9	41	yes	489	300	88.5	44.6	413	3 knots in the middle, 3 x 11mm
I7 p75	13.5	-22.5-22.5	2.2	0.9	41	yes	476	300.75	87.2	44.1	412	-
I7 p76	12.9	-22.5-22.5	2.2	0.9	41	yes	521	300.25	89.1	44.9	434	2 knots in the middle, 25mm and 18mm

I7 p77	14.2	-22.5-22.5	2.2	0.9	41	yes	549	300.5	89.2	44.7	458	Knot in the middle, 36mm
I7 p78	12.7	-22.5-22.5	2.2	0.9	41	yes	481	300.5	89	44.7	402	-
I7 p79	11	-22.5-22.5	2.2	0.9	41	yes	486	300.5	88.8	44.6	408	Knot on the side, 6mm
I7 p80	13.6	-22.5-22.5	3.5	1.2	34	no	531	301.5	87.8	44.1	455	Knot on the side, 30mm
I7 p81	14.2	-22.5-22.5	3.5	1.2	34	no	531	300.5	87.8	44.1	456	2 knots in the middle, 25mm and 16mm
I7 p82	12.3	-22.5-22.5	3.5	1.2	34	no	491	300.25	88.5	44.4	416	-
I7 p83	13.6	-22.5-22.5	3.5	1.2	34	no	486	300.25	88.1	44.3	415	-
I7 p84	13	-22.5-22.5	3.5	1.2	34	no	496	300.25	88.9	44.6	417	Knot in the middle, 19mm; knot on the side, 11mm
I7 p85	13.6	-22.5-22.5	3.5	1.2	34	no	488	300.5	87.2	44.2	421	Knot on the side, 26mm
I7 p86	13.9	90	3.5	1	29	-	498	301	89.5	44.9	412	With pith; 2 knots on the side, 17mm and 20mm
I7 p87	13.3	90	3.5	1	29	-	501	301	89.6	45	413	With pith; 5 knots on the middle side, 3 x 11mm, 14mm and18mm
I7 p88	12.2	90	3.5	1	29	-	478	300	89.5	44.9	396	With pith
I7 p89	13.5	90	3.5	1	29	-	498	301	89.5	45	411	With pith; 3 knots on the side, 3 x 15mm
I7 p90	12.1	90	3.5	1	29	-	502	300.5	89.7	44.9	415	With pith; 5 knots in the middle, 4x 11mm and 15mm
I7 p91	13.8	90	3.5	1	29	-	479	300.5	89.5	45.2	394	With pith
mean:	13.1		2.4	0.8	35.0		520.6	300.6	88.9	44.7	436.5	
σ:	0.8		1.0	0.3	4.0		33.4	0.4	0.7	0.3	27.4	

Scots Pine (four studs, 200mm) – I7

Scientific name: Pinus sylvestris
Source location: Europe
Identification number: I7
Stress grade: MGP10

Table A138: Photographs of Samples Tested, end and plan view

	
	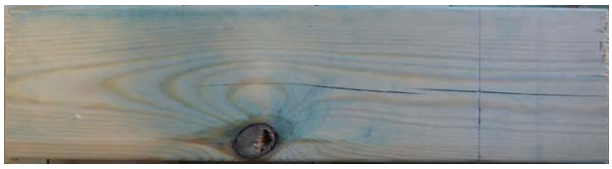
	
	
	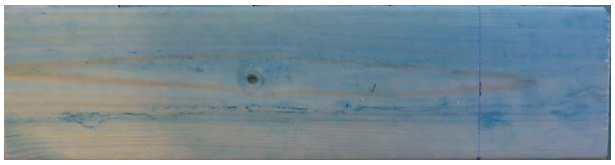
	
	
	

	
	
	
	
	
	
	

Table A139: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	436	430	6.7
Bearing perpendicular to grain [MPa]	3.9	3.1	12.5
MOE perpendicular to grain [MPa]	269	262	14.0

Table A140: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I7 p92	465	3.51	282.97
I7 p93	480	4.70	276.75
I7 p94	438	3.24	310.62
I7 p95	464	3.32	220.03
I7 p96	455	3.81	284.24
I7 p97	464	3.87	251.97
I7 p98	465	3.87	236.91
I7 p99	402	3.86	216.56
I7 p100	402	3.65	237.48
I7 p101	430	5.07	345.35
I7 p102	412	4.12	303.25
I7 p103	396	3.88	234.45
I7 p104	416	3.88	267.50
I7 p105	414	4.47	294.06

Table A141: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I7 p92	13	-22.5-22.5	1.4	0.6	43	yes	653	350.5	89.1	44.6	469	Knot on the side, 17mm
I7 p93	13.4	-22.5-22.5	1.4	0.6	43	yes	679	350.5	89.2	44.7	486	Knot in the middle, 18mm
I7 p94	13.5	-22.5-22.5	1.4	0.6	43	yes	621	350	89.3	44.7	444	-
I7 p95	13.5	-22.5-22.5	1.4	0.6	43	yes	658	350	89.3	44.8	470	2 knots on the side, 24mm and 18mm
I7 p96	13.5	-22.5-22.5	1.4	0.6	43	no	644	350.5	89.2	44.7	461	Knot in the middle, 5mm
I7 p97	13	-22.5-22.5	1.4	0.6	43	no	648	350.5	88.6	44.6	468	Knot in the middle/side, 15mm
I7 p98	13.7	-22.5-22.5	1.4	0.6	43	no	657	350.5	88.9	44.7	472	Knot in the middle/side, 23mm
I7 p99	12.9	-22.5-22.5	3	1	33	yes	555	350.5	87.8	44.5	405	Knot on the side 3mm
I7 p100	13.6	-22.5-22.5	3	1	33	yes	566	350.25	88.5	44.7	408	-
I7 p101	11.6	-22.5-22.5	3	1	33	no	579	350.5	87.1	44.3	428	2 knots in the middle/side, 22mm
I7 p102	12.1	-22.5-22.5	3	1	33	no	566	350.5	88	44.5	412	-
I7 p103	12.7	90	3	1	33	-	560	350.5	89.5	44.8	398	With pith
I7 p104	12.1	90	3	1	33	-	588	351	89.6	44.9	416	With pith; 2 knots on the side, 20mm and 16mm
I7 p105	11.8	90	3	1	33	-	580	350.5	89.5	44.8	413	With pith; 4 knots in the middle, 2 x 10mm and 2 x 20mm
mean:	12.9		2.2	0.8	38.1		611.0	350.4	88.8	44.7	439.3	

σ:	0.7		0.8	0.2	4.9		44.4	0.2	0.7	0.2	30.8	

Scots Pine (half studs, 30mm) – I7

Scientific name: Pinus sylvestris
Source location: Europe
Identification number: I7
Stress grade: MGP10

Table A142: Photographs of Samples Tested, end and plan view

	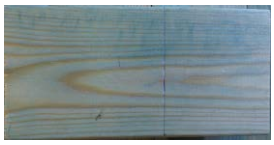		
			

Table A143: Summary of Characteristic Values

Properties	Average test result	Characteristic values	Coefficient of variation [%]
Density p12 [kg/m^3]	477	468	4.6
Bearing perpendicular to grain [MPa]	7.4	6.3	6.3
MOE perpendicular to grain [MPa]	409	384	15.9

Table A144: Individual Samples Density, Perpendicular to Grain Bearing and MOE, Middle of Sample

Identification	Density p12 [kg/m^3]	Test values perpendicular to grain bearing [MPa]	MOE Perpendicular to Grain [MPa]
I7 p106	456	7.05	388.88
I7 p107	474	7.12	482.74
I7 p108	500	7.90	355.16

Table A145: Table of Sample Properties, Middle of Sample

Identification	Moisture content [%]	Angle of the tree rings [°]	Size of the annual tree rings mean [mm]	Late wood [mm]	Late wood portion [%]	Test direction form sap to heart wood	Weight [g]	Length [mm]	Wide [mm]	Depth [mm]	Density [kg/m³]	Comment: (knots, pitch pockets…)
I7 p106	11.6	-22.5-22.5	1.4	0.6	43	yes	325	180.5	88.7	44.7	454	-
I7 p107	11.5	-22.5-22.5	1.4	0.6	43	yes	339	180.75	88.8	44.7	472	Knot on the side, 18mm
I7 p108	11.3	-22.5-22.5	2.5	0.9	36	no	356	181	88.7	44.6	497	3 knots on the side, 2 x 16mm and 11mm
mean:	11.5		1.8	0.7	40.6		340.0	180.8	88.7	44.7	474.3	
σ:	0.2		0.6	0.2	4.0		15.5	0.3	0.1	0.1	21.6	

Appendix B – Example Calculation

This appendix demonstrates the procedures of calculating the density, characteristic bearing strength perpendicular to grain and the perpendicular to grain modulus of elasticity for the timber specie light red Meranti.

Density

Table B1 contains the moisture content, weight, samples dimensions of all the samples for the species “Meranti” used in the test program.

Table B1: Properties for Light red Meranti

Identification	Moisture content [%]	Weight [g]	Length [mm]	Breath [mm]	Depth [mm]
H10 p1	8	329	199.75	91.4	41.1
H10 p2	8	300	199.75	91.6	41.2
H10 p3	8.1	302	199.5	91.7	41.2
H10 p4	7.9	290	199.5	91.6	41.2
H10 p5	7.8	294	199.75	91.7	41.2
H10 p6	8.2	334	199.75	91.1	41
H10 p7	7.6	336	199.75	91.1	40.9
H10 p8	7.4	346	199.75	91.1	41
H10 p9	8.6	284	199.75	91.1	41.1
H10 p10	8.6	320	200	91.1	41.1
H10 p11	9.4	336	199.5	91.1	41
H10 p12	9.2	353	199.5	91.2	40.8
H10 p13	9.2	341	199.75	91.2	40.9
H10 p14	10	335	199.5	90.6	40.9
H10 p15	9.7	348	199.5	91.2	41
H10 p16	8.7	326	199.75	91.1	41
H10 p17	8.4	329	199.75	91.1	41
H10 p18	8.5	352	199.75	91.1	41
H10 p19	8.3	303	199.75	91.5	41.3
H10 p20	8.1	306	199.75	91.6	41.2
H10 p21	8.9	310	200	91.6	41.1

H10 p22	9.1	312	200	91.7	41.2
H10 p23	8.9	312	200	91.4	41.3
H10 p24	9.3	339	199.5	91.5	41
H10 p25	9.5	359	199.75	91.5	41
H10 p26	9.4	294	199.75	91.6	41.2
H10 p27	9.3	315	200	91.5	41
H10 p28	9.6	339	200	91.4	41.1
H10 p29	9	327	199.5	91.5	41.1
H10 p30	9.6	349	199.5	91.4	41.1
H10 p31	9.2	344	199.5	91.4	41.3
H10 p32	9.6	344	200	91.3	41

The calculation for the density used is the following:

$$\rho_{test} = \frac{m * 10^9}{L * b * d} = \frac{0.329[kg] * 10^9}{199.75[mm] * 91.4[mm] * 41.1[mm]} = 438[kg/m^3] \quad \text{(B1)}$$

ρ_{test} = density of sample kg/m^3
m = weight in grams
L = length of sample in mm
b = the breath of the sample in mm
d = the depth of the sample in mm

As the measurement of density was not done at 12% moisture content, a correction was undertaken. First the density by 0 % moisture content was calculated.

$$\rho_o = \frac{\rho_u * 100\%}{u + 100\%} = \frac{438[kg/m^3] * 100\%}{8\% + 100\%} = 406[kg/m^3] \quad \text{(B2)}$$

p_0 = density of sample at 0 % moisture content kg/m^3
u = measure moisture content of sample

Now the density by 12% moisture content can be calculated.

$$\rho_{12} = \frac{u + 100\% * \rho_o}{100\%} = \frac{12\% + 100\% * 406[kg/m^3]}{100\%} = 454[kg/m^3] \quad \text{(B3)}$$

p_{12} = density of sample at 12 % moisture content kg/m^3

Table B2: Density results

Identification	Density [kg/m^3]	Density p_0 [kg/m^3]	Density p_{12} [kg/m^3]	$(pi-\acute{p})^2$
H10 p1	438	406	454	49.9
H10 p2	398	369	413	1151.8
H10 p3	401	371	415	1020.0
H10 p4	385	357	400	2203.1
H10 p5	390	362	405	1758.8
H10 p6	448	414	464	291.1
H10 p7	451	419	469	486.8
H10 p8	464	432	484	1373.6
H10 p9	380	350	392	3018.1
H10 p10	427	393	440	48.1
H10 p11	451	412	462	226.9
H10 p12	476	436	488	1686.1
H10 p13	458	419	470	531.9
H10 p14	453	412	461	197.8
H10 p15	467	426	477	903.8
H10 p16	437	402	450	9.4
H10 p17	441	407	456	82.1
H10 p18	472	435	487	1605.0
H10 p19	401	370	415	1020.0
H10 p20	406	376	421	672.8
H10 p21	412	378	424	526.1
H10 p22	413	379	424	526.1
H10 p23	413	379	425	481.3
H10 p24	453	414	464	291.1
H10 p25	479	437	490	1854.4
H10 p26	390	356	399	2298.0
H10 p27	420	384	430	286.9

H10 p28	451	411	461	197.8
H10 p29	436	400	448	1.1
H10 p30	466	425	476	844.6
H10 p31	457	418	469	486.8
H10 p32	459	419	469	486.8

After the calculation of all samples, results are shown in Table 2, the mean value can be calculated.

$$\rho_{12} = \frac{u + 100\% * \rho_o}{100\%} = \frac{12\% + 100\% * 406[kg/m^3]}{100\%} = 454[kg/m^3] \quad \text{(B4)}$$

For the calculation of the standard deviation S, the equation (pi-ṕ)^2 is needed.

$$(\rho_i - \bar{\rho})^2 = (454[kg/m^3] - 446.9[kg/m^3])^2 = 50 \quad \text{(B5)}$$

The standard deviation S:

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\rho_i - \bar{\rho})^2} = \sqrt{\frac{50 + 1152 + 1020 + \cdots + 487}{32 - 1}} = 29.3 \quad \text{(B6)}$$

The coefficient of variation [%] is calculated with:

$$V_p = \frac{S}{\bar{\rho}} = \frac{29.3}{446.9[kg/m^3]} = 6.6[\%] \quad \text{(B7)}$$

With the sampling factor k_s:

$$k_s = 1 - \frac{0.7V_p}{\sqrt{n}} = 1 - \frac{0.7 * 0.066}{\sqrt{32}} = 0.9918 \quad \text{(B8)}$$

The characteristic value $f_{k,mean}$ is calculated:

$$f_{k,mean} = k_s * \bar{\rho} = 0.9918 * 446.9[kg/m^3] = 443.2[kg/m^3] \quad \text{(B9)}$$

Determining the Maximum Compression Force at 2.0 mm off set Deformation

The section of Statistical Evaluation procedure illustrates the determination of the 2 mm off set value is done in the following steps. The following steps are referred to Figure B1.

Step 1: The estimated value for the Fc,90,max,est has to be found. The orange line is drawn to describe the elastic deformation of the graph.

Step 2: A 2 mm offset line (grey) is drawn parallel to the orange line. The point the grey line intersects with the stress/deformation outcomes (blue line) is Fc,90,max,est = 42.6 kN.

Step 3: From the estimated value 42.6 kN, two values are determined, the 10% value, 0.1Fc,90,max,est = 4.26 kN, and the 40% value, 0.4Fc,90,max,est = 17 kN.

Step 4: A straight line is drawn through the 10% and 40% value (yellow line).

Step 5: The green line is drawn 2 mm off set, parallel to the yellow line. At the point where green line cross the stress/deformation outcomes (blue line) is the Fc,90,max = 42.5 kN value. The difference of the Fc,90,max to the original Fc,90,max,est is calculated with:

$$\frac{F_{c,90,max}}{F_{c,90,max\,,est}} * 100 = \frac{42.5[kN]}{42.6[kN]} * 100 = 99.8[\%] \qquad \text{(B10)}$$

With the following equation:

$$95[\%] \leq \Delta[\%] \leq 105[\%] = 95[\%] \leq 99.8[\%] \leq 105[\%] \qquad \text{(B11)}$$

Is correct.

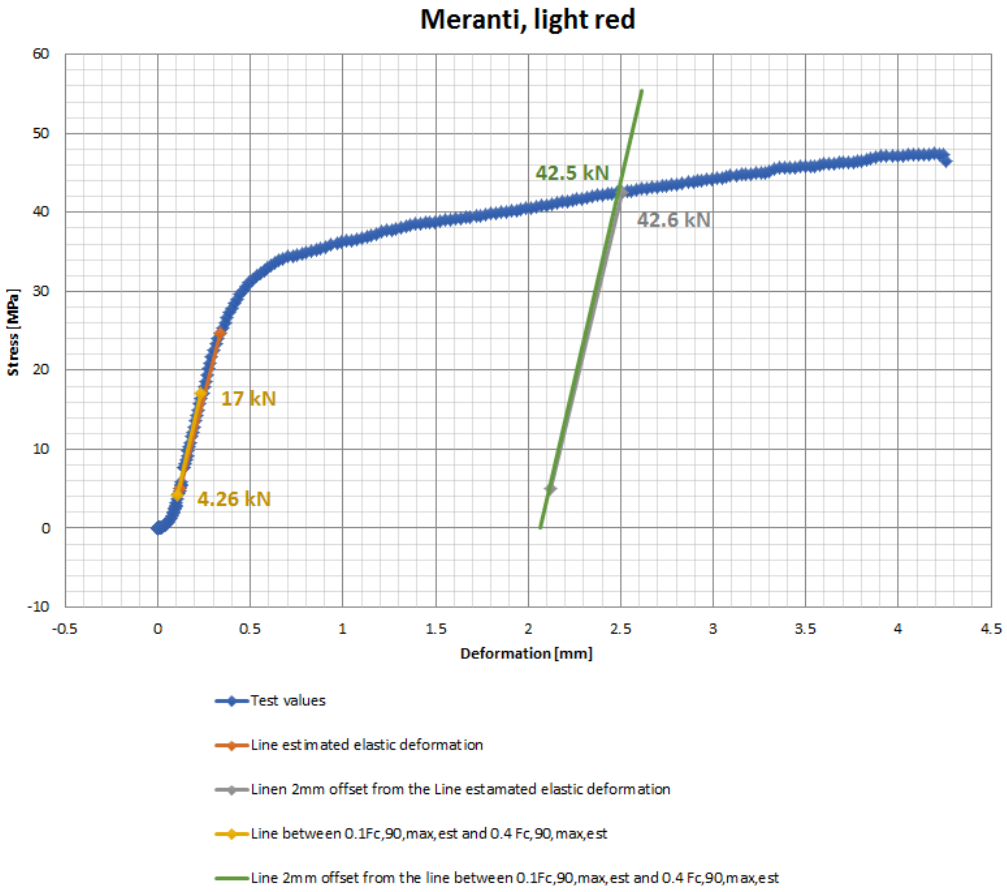

Figure 1B: Load-deformation curve for compression perpendicular to the grain for Meranti

Bearing strength perpendicular to the grain

The characteristic value perpendicular to grain is based on the 5th percentile fractile strength. Table B3 contains the Fp corresponding to a deformation of 2 mm off set, and the standard deviation of the result for all the samples tested.

Table B3: Bearing strength perpendicular to grain

Identification	Fp corresponding to a deformation of 2 mm off set [kN]	fp [N/mm^2]	ln(fp)	(ln(fp)-ȳ)^2
H10 p1	47.5033	10.8277	2.3821	0.0146
H10 p2	39.0722	8.8865	2.1845	0.0059
H10 p3	43.0967	9.7912	2.2815	0.0004
H10 p4	42.5474	9.6769	2.2697	0.0001
H10 p5	42.4491	9.6440	2.2663	0.0000
H10 p6	45.5499	10.4166	2.3434	0.0067
H10 p7	47.8877	10.9513	2.3935	0.0174
H10 p8	48.7079	11.1388	2.4104	0.0222
H10 p9	38.8405	8.8823	2.1841	0.0060
H10 p10	42.5800	9.7375	2.2760	0.0002
H10 p11	44.7318	10.2296	2.3253	0.0041
H10 p12	52.8547	12.0739	2.4910	0.0527
H10 p13	44.3128	10.1226	2.3148	0.0028
H10 p14	44.9289	10.3313	2.3352	0.0054
H10 p15	49.6969	11.3525	2.4294	0.0282
H10 p16	41.2275	9.4282	2.2437	0.0003
H10 p17	41.9120	9.5847	2.2602	0.0000
H10 p18	47.7164	10.9121	2.3899	0.0165
H10 p19	38.3932	8.7416	2.1681	0.0087
H10 p20	38.2800	8.7063	2.1641	0.0095
H10 p21	40.0929	9.1187	2.2103	0.0026
H10 p22	35.6588	8.1013	2.0920	0.0287
H10 p23	31.8557	7.2610	1.9825	0.0778
H10 p24	38.5752	8.7831	2.1728	0.0079

H10 p25	39.1273	8.9088	2.1870	0.0055
H10 p26	31.5436	7.1742	1.9705	0.0847
H10 p27	45.2882	10.3115	2.3333	0.0052
H10 p28	47.6003	10.8498	2.3841	0.0150
H10 p29	38.4668	8.7584	2.1700	0.0084
H10 p30	39.3598	8.9715	2.1941	0.0045
H10 p31	45.1100	10.2822	2.3304	0.0048
H10 p32	40.6415	9.2738	2.2272	0.0012

Form these values and equation B12 the f_p value, value of applied load corresponding to a 2.0 mm off set deformation per mm^2, is calculated.

$$f_p = \frac{F_p}{b_m * b_w} = \frac{47.5[kN]}{48[mm] * 91.4[mm]} = 10.8[N/mm^2] \quad \text{(B12)}$$

The breath of the metal plate is given is 48 mm the breath of the sample is in Table B1.

The next step is the natural logarithm is found. After the calculation of the logarithm for all samples, results are shown in Table B3, the mean value can be calculated.

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} \ln(f_i) = \frac{2.38 + 2.18 + 2.28 + \cdots + 2.23}{32} = 2.26 \quad \text{(B13)}$$

The calculation of the standard deviation S_y the equation $(\ln(f_i) - \bar{y})^2$ is needed.

$$(\ln(f_i) - \bar{y})^2 = (2.38 - 2.26)^2 = 0.0144 \quad \text{(B14)}$$

The standard deviation S_y:

$$S_y = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\ln(f_i) - \bar{y})^2} = \sqrt{\frac{0.0146 + 0.0059 + \cdots + 0.0012}{32 - 1}} = 0.121 \quad \text{(B15)}$$

The coefficient of variation V_R is calculated with:

$$V_R = \sqrt{\exp(S_y^2) - 1} = \sqrt{\exp(0.121^2) - 1} = 0.121[\%] \quad \text{(B16)}$$

With the sampling factor k_s:

$$k_s = 1 - \frac{1.15V_R}{\sqrt{n}} = 1 - \frac{1.15 * 0.121}{\sqrt{32}} = 0.9754 \quad \text{(B17)}$$

The 5th percentile fractile strength is given as:

$$f_{05} = \exp(\bar{y} - 1.645 * S_y) = \exp(2.26 - 1.645 * 0.121) = 7.85[N/mm^2] \quad \text{(B18)}$$

The characteristic value f_k is calculated with the education:

$$f_k = k_s * f_{05} = 0.9754 * 7.85[N/mm^2] = 7.66[N/mm^2] \quad \text{(B19)}$$

Modulus of Elasticity Perpendicular to Grain

The calculation of the modulus of elasticity E_k is found from the slope of the load/deformation curve within the elastic deformation phase of the test. Table B4 contains the slope of the elastic stress/deformation, the estimated MoE perpendicular to grain and the standard deviation. The sample properties are contained in Table B1, and the metal plate properties given in section titled Methodology.

Table B4: Results Modulus of Elasticity

Identification	Slope [kN/mm]	MoE [N/mm²]	ln(Ei)	(ln(Ei)-ȳ)²
H10 p1	78.5771	736.1232	6.6014	0.0402
H10 p2	49.6275	465.0325	6.1421	0.0670
H10 p3	63.8640	597.7815	6.3932	0.0001
H10 p4	76.4838	716.6875	6.5746	0.0302
H10 p5	52.8520	494.7068	6.2040	0.0388
H10 p6	71.3615	669.0958	6.5059	0.0110
H10 p7	64.4529	602.8456	6.4017	0.0000
H10 p8	76.1726	714.2056	6.5712	0.0290
H10 p9	82.6234	776.5786	6.6549	0.0645
H10 p10	91.5905	860.8598	6.7579	0.1275
H10 p11	73.8446	692.3775	6.5401	0.0194
H10 p12	64.5939	602.0262	6.4003	0.0000
H10 p13	90.1495	842.2684	6.7361	0.1124
H10 p14	86.7034	815.4364	6.7037	0.0917
H10 p15	75.0754	703.1457	6.5556	0.0239

H10 p16	70.8884	664.6602	6.4993	0.0097
H10 p17	57.3117	537.3626	6.2867	0.0130
H10 p18	88.1073	826.1069	6.7167	0.0998
H10 p19	65.0462	611.6594	6.4162	0.0002
H10 p20	62.1202	582.0939	6.3666	0.0012
H10 p21	71.7825	671.0020	6.5088	0.0116
H10 p22	55.3054	517.6716	6.2493	0.0230
H10 p23	51.8897	488.4765	6.1913	0.0439
H10 p24	50.0323	467.0589	6.1465	0.0647
H10 p25	54.7991	511.5583	6.2375	0.0267
H10 p26	39.4869	370.0101	5.9135	0.2375
H10 p27	63.9890	597.3477	6.3925	0.0001
H10 p28	47.0820	441.0721	6.0892	0.0971
H10 p29	73.9535	692.0508	6.5397	0.0193
H10 p30	47.5411	445.3725	6.0989	0.0912
H10 p31	53.3145	501.8894	6.2184	0.0333
H10 p32	53.4205	499.7814	6.2142	0.0349

$$E = \frac{\frac{F}{A}}{\frac{\Delta l}{l}} = \frac{\frac{78577[N]}{48[mm] * 91.4[mm]}}{\frac{1[mm]}{41.1[mm]}} = 728.9[N/mm^2] \quad \text{(B20)}$$

In a next step is the natural logarithm is taken. After the calculation of the logarithm for all samples, results are shown in Table B4, the mean value can be calculated.

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} \ln(E_i) = \frac{6.601 + 6.142 + \cdots + 6.214}{32} = 6.401 \quad \text{(B21)}$$

For the calculation of the standard deviation S_y the equation $(\ln(f_i) - \bar{y})^2$ is needed.

$$(\ln(E_i) - \bar{y})^2 = (6.601 - 6.401)^2 = 0.04 \quad \text{(B22)}$$

The standard deviation S_y:

$$S_y = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\ln(E_i) - \bar{y})^2} = \sqrt{\frac{0.040 + 0.067 + \cdots + 0.035}{32 - 1}} = 0.217 \quad \text{(B23)}$$

The coefficient of variation V_E is calculated with:

$$V_E = \sqrt{\exp(S_y^2) - 1} = \sqrt{\exp(0.217^2) - 1} = 0.220[\%] \quad \text{(B24)}$$

With the sampling factor k_s:

$$k_s = 1 - \frac{0.7V_E}{\sqrt{n}} = 1 - \frac{0.7 * 0.217}{\sqrt{32}} = 0.973 \quad \text{(B25)}$$

The 5th percentile fractile strength is given as:

$$E_{05} = \exp(\bar{y} - 1.645 * S_y) = \exp(6.401 - 1.645 * 0.217) = 421.59[N/mm^2] \quad \text{(B26)}$$

The mean modulus of elasticity is given as:

$$\bar{E} = \exp\left(\bar{y} + \frac{S_y^2}{2}\right) = \exp\left(6.401 + \frac{0.217^2}{2}\right) = 616.8[N/mm^2] \quad \text{(B27)}$$

The **characteristic value** E_k is taken as the lesser of $E_{k,mean,1}$ and $E_{k,mean,2}$ calculated with:

$$E_{k,mean,1} = k_s\bar{E} = 0.973 * 616.8[N/mm^2] = 600.15[N/mm^2] \quad \text{(B28)}$$

$$E_{k,mean,2} = \frac{k_s E_{05}}{0.7} = \frac{0.973 * 421.59[N/mm^2]}{0.7} = 586.01[N/mm^2] \quad \text{(B29)}$$

Appendix C - Suggested Wording to WoodSolutions Guide 50

The following is the suggested word change to the WoodSolutions Guide 50 Mid-rise Timber Building Structural Engineering Design Guide. New words are marked in red while deleted words are ~~double strikethrough~~.

6.3.1 Perpendicular to grain deformation and creep of beams and wall plates

The compression load in studs differs from floor to floor, and these loads are transferred to the wall plates and floor joists or trusses that resist the loads by compression perpendicular to grain.

The axial shortening of the building caused by deformation and creep of elements loaded perpendicular to grain will be different from floor to floor. Axial shortening of these elements must be evaluated at each floor level for any elements in the vertical load path and summed over the height of the building using Equation 6.5.

$$\delta_{c,p} = \sum_{floors} \frac{j_2 N_{c,i} d_{2,i}}{E_{p,i} A_{p,i}} \qquad \text{Equation 6.5}$$

where:

$\delta_{c,p}$ = *Total compression shortening perpendicular to grain (mm)*
j_2 = *Duration of load factor for long-term loads = 2*
$N_{c,i}$ = *Long-term compression forces in a stud in storey i (kN)*
$d_{2,i}$ = *Height of elements perpendicular to grain in storey i (mm)*
$E_{p,i}$ = *Modulus of elasticity perpendicular to grain in storey i (MPa)*
$A_{p,i}$ = *Loaded cross-sectional area of elements perpendicular to grain in storey i (mm^2)*

The deformation perpendicular to grain is caused by stresses throughout the depth of the loaded section. Because of lateral dispersion of the load, the area changes throughout the depth as shown by the red shading in Figures 6.2 and 6.3. An average cross-sectional area is used and is shaded in these figures.

For long duration loads, the load in each stud ($N_{c,i}$) is given by G + 0.4Q and j_2 =2, and this load is transferred to the elements perpendicular to grain.

~~*The MoE perpendicular to grain ($E_{p,i}$) is j_e x MoE parallel to grain given in design properties.*~~

~~*Typically, for clear wood, j_e = 1/30. However, if knots are present in the loaded area, the MoE perpendicular to grain can be close to the MoE parallel to grain. Current research is investigating the value of j_e that applies for different Australian species of timber and engineered wood products. Until the results are released, it is recommended that designers use j_e = 1/25, which allows for the presence of knots in some of the elements in the height of the building.*~~

For values of average MoE Perpendicular to Grain, a recently completed project Characteristic Perpendicular to Grain Bearing Test on Common Australian and Imported Timber Species, TDA, 2019 found a relationship between AS 1720.1 Joint Groups and average MoE Perpendicular to Grain, refer to Table ??.

Minimum Joint Groups can be specified to critically loaded timber elements, or where timber species usage is not known or specified, deformation checks could assume a Joint Group of JD5.

Table ??: Average MoE Perpendicular to Grain by Joint Group

Joint Group	Average MoE Perpendicular to Grain (MPa)
JD1	1,025
JD2	840
JD3	720
JD4	575
JD5	535
JD6	470

The dimensions of the loaded cross-sectional area vary through the thickness of the elements as the bearing stresses are distributed. Examples are shown in Figures 6.2 and 6.3. A realistic bearing area in these elements is larger than the cross-section of the stud. Different expressions are used for each element in the vertical load path:

- *platform framing involves top and bottom plates and floor joists;*
- *semi-balloon framing involves only top and bottom plates. (Balloon framing has top and bottom plates that are not in the vertical load path, leaving no elements loaded perpendicular to the grain.)*

Solid floor joists and beams (for example)

Where solid timber joists or beams are parallel to the wall plates (as with the use of rim-beams or blocking), there are no stress concentrations under studs, and the compression of the joists or beams is very small and can be ignored. However, where solid timber joists or beams are perpendicular to the wall plates as shown in Figure 6.2 (a), there are high bearing stresses under the studs and the deformation needs to be calculated using Equation 6.5 with the dimensions shown in Figure 6.2 (a), and $A_{p,i}$ as determined using Equation 6.6. Where the wall is at the end of a joist, Figure 6.2 (a) applies and a quarter of the beam or plate depth can be used for the calculation of A_{pi}.

If the wall bears within the length of the joist or beam, then Figure 6.2 (b) applies, but the calculation for the wall at the end of the joist or beam gives a conservative estimate.

$$A_{p,i} = max\left(b_2 + \frac{d_3}{2}, k_7 b_2\right) \times b_3 \qquad \text{Equation 6.6}$$

where:

k_7 = *Length of bearing factor defined in Table 2.6 in AS 1720.1 for length of bearing =* b_2

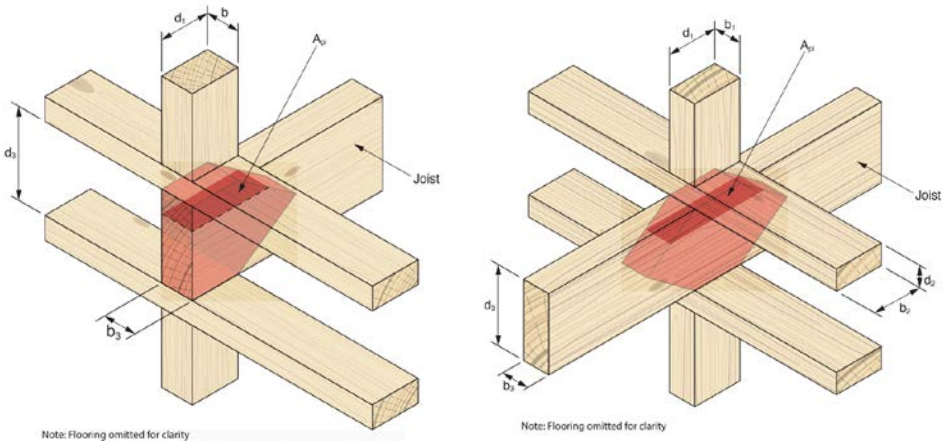

Figure 6.2a Bearing perpendicular to grain in solid floor joists (left image: load at edge, right image: load at centre)

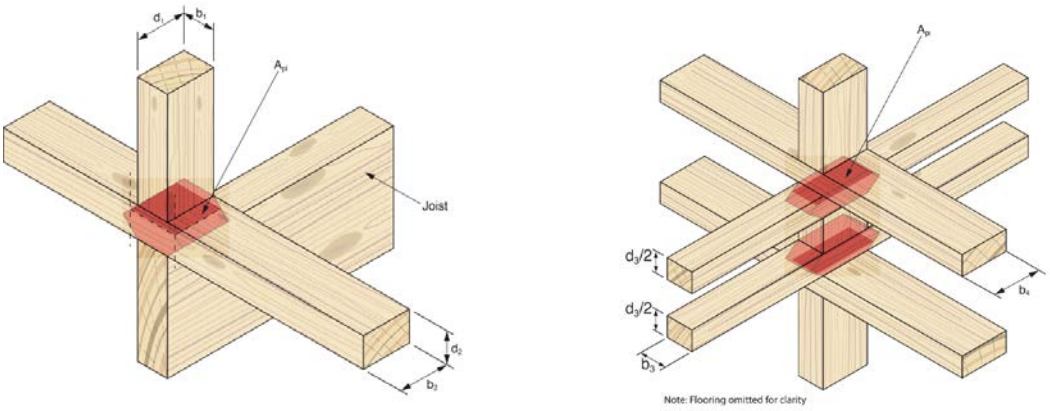

Figure 6.2b – Bearing in top plate (left) and top and bottom floor truss (right)

Examples of bearing area calculations for different scenarios can be found in Timber Design Handbook: in accordance with the Australian Limit State Timber Design Code AS 1720.1-2010: timber structures, Part 1: Geoffrey N. Boughton, Keith I. Crews.