Heat-treatment of Sitka spruce, Japanese larch and lodgepole pine panelling

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Abstract

The results of the latest evaluation of test panels representing a cladding application and constructed using heat-treated Sitka spruce, lodgepole pine and Japanese larch, exposed in a field trial in Clonmel are reported and some earlier mechanical property results are summarised. Most timber had been subject to the Finnish Thermowood process with smaller amounts of timber treated in the Netherlands using the Platowood and Lignius processes. Control panels using un-treated spruce and western red cedar were also exposed and the trial is now concluding in its eleventh year. Application of the previously described scoring system using criteria such as colour retention, numbers of splits and defects, nail staining and overall appearance has also continued. Untreated spruce controls are showing significant decay, but no decay has been observed in the heat-treated materials, which also show higher dimensional stability. Although the heat-treated panels are much better than the spruce controls they do not equal the overall weathering behaviour of the cedar control panels. Timber from the Thermowood process continues to show the best performance of the heat-treated materials and this is considered to be substantially attributable to it being better quality selected timber.

1. Introduction and background

This project was commenced in 2004 when it was noted that the European timber industry was showing considerable scientific and commercial interest in heat-treatment as a method of wood modification to improve durability and stability. Consequently it was decided to evaluate the response of Irish timber to such processes, this being judged necessary as growth conditions in Ireland produce timber which is somewhat different in density and anatomy from superficially similar European species. The primary interest at the beginning was in the effectiveness of the treatments in increasing resistance to fungal decay and improving dimensional stability, and in assessing the effects of process conditions on timber mechanical properties. Subsequently the project was expanded to include the response to nail fixing and the assessment of long-term exterior durability in a field trial. The project was funded by COFORD, carried out under the supervision of Professor Colin Birkinshaw, at that time at the University of Limerick and more recently as a consultant to the Department of Agriculture, Food and Marine. Technical assistance was provided in the Netherlands by the wood research institute, SHR, and by the treatment companies Platowood and Lignius. In Ireland assistance and materials were provided by Coillte, Dundrum and Palfab, Macroom. Timber was also sourced from the Wicklow Rural Partnership project which had worked in cooperation with the Finnish Thermowood company. It is considered, from observation, that this latter timber was specially selected, whereas the timber used by the University of Limerick was not selected. The significance of this will be discussed later.

The process of heat-treatment causes changes to occur within the cellulose, hemicellulose and lignin components of the wood. The crystalline cellulose component is relatively resistant to treatment, but hemicelluloses being amorphous are more readily degraded and during thermal treatment carbonic acids, mainly acetic acid, are formed as a result of cleavage of the acetyl groups. This catalyses carbohydrates cleavage, causing a reduction of the degree of polymerisation and results in the formation of formaldehyde, furfural and other aldehydes. The decomposition of hemicelluloses results in the reduction of the number of available hydroxyl groups and a lower concentration of reactive sites will therefore decrease the equilibrium moisture content of heat-treated wood, and thus improve the dimensional stability. It also removes an important fungal food source.

Lignin changes are complex and difficult to characterise. It appears that bonds between phenylpropane units are partly broken but condensation reactions also occur and the longer the treatment period is, the more condensation reactions occur, presumably through the formation of methylene bridges connecting aromatic rings. This leads to an increase in cross-linking with consequent improvement in dimensional stability and decreased hygroscopicity.

Thus, heat-treated wood has reduced hygroscopicity and improved dimensional stability because the cellulose microfibrils are surrounded by a more firm and inelastic network due to the cross-linking within the lignin matrix. The microfibrils have decreased expansion possibility and less capacity to adsorb water between cellulose chains. This results in a lower fibre saturation point and a higher resistance to biological decay. The cell wall hemicellulose is transformed into a more hydrophobic network.

These microstructural changes have important consequences for mechanical properties. Wood is a composite material in which high strength high modulus cellulose fibrils are surrounded by an amorphous lignin matrix. In such a system the matrix acts as the stress transfer medium and overall mechanical behaviour will be sensitive to changes in the properties of the components. Many workers have noted loss of strength in heat-treated timber, for example Vernois (2001) reported strength losses up to 40% whilst Boonstra et al. (1998) and Militz (2002) report losses ranging from 5-18% under mild heat-treatment conditions.

However, despite the strength loss only moderate change in stiffness is to be expected, for example Rapp and Sailer (2000) and Militz (2002) report only small changes in modulus of elasticity for a number of species modified by different heat-treatment methods. Essentially the wood becomes more brittle.

In assessing the consequences of this for practical applications it is important to consider what aspects of mechanical property change are important to a chosen application. Although structural timbers may be used in situations where bending loads are significant relative to the ultimate strength of the timber, in many applications in-service stresses are well below the strength of the material, and stiffness is the major consideration. Cladding represents such an application, where the component has protection and appearance functions, but in general is not strength critical. There are many similar applications where reductions in ultimate strength can be tolerated providing stiffness is maintained.

Increased brittleness may impinge upon the timber’s ability to be fixed using conventional nailing technology. Whilst overall timber stiffness is likely to be satisfactory, the increased brittleness provoked concern regarding the suitability to nail fixing and also the long term performance of nail fixed materials. To consider all of this the project was extended and expanded from laboratory to large-scale field trials and ultimately looked at the following questions:

1. Effect of heat-treatment on in-process dimensional stability
2. Effect on laboratory assessed fungal durability
3. Change in mechanical and physical properties
4. Tolerance of and reaction to nail fixing
5. Long term exterior durability.

Items 1 to 3 have been reported on in detail previously (Dolan 2006) and so results will only be summarised here. The procedure and results of the initial nailing trials have also been reported in detail (Thornton et al. 2007), and a COFORD Connects Note [Processing/Products No. 44] has been published dealing with the scientific principles of heat-treatment. Interim reports on the continuing performance of the panels have been issued to COFORD in 2008 and in 2012. This final report describes and discusses the overall long-term performance of the various heat-treated materials used in the field trials. Some comments about the applicability and potential of the heat-treatment processes to fast grown Irish softwoods are also made.

2. Experimental

Timbers were Sitka spruce (*Picea sitchensis*), lodgepole pine (*Pinus contorta*) and Japanese larch (*Larix kaempferi*), treated using the Thermowood process, the Platowood process or the Lignius process. These processes have been described previously and are explained in the COFORD Connects Note. The Lignius process is considered to be the most thermally severe of the three. Untreated controls were also used along with western red cedar (*Thuja plicata*) controls.

Full details of the procedures for laboratory evaluation of mechanical and physical property changes have been given previously (Dolan 2006) and here only a summary of the strength and stiffness changes are given, using three-point bending results as examples. Electron micrographs are presented to explain these results.

Cladding test panels were manufactured from the heat-treated timbers using standard nail gun methods with both plated and stainless steel nails. Profiling, where used, was carried out after treatment and profiles were plane sawn, V edge and shiplap, and again details have been reported previously (Dolan 2006, Thornton et al. 2007). The panels were initially exposed at the Coillte Mill at Dundrum, County Tipperary on 26 December 2006, and were mounted vertically and faced towards the south and are shown in Figure 1.

Figure 1: *Panelling exposure, Dundrum, Co Tipperary*.

Most panels were one metre square, and were constructed as described in the previous nailing report. A small number were half this size. The Coillte mill closed in 2013 and consequently the panels were moved to an open field near Clonmel and exposure continued, as shown in Figure 2.

Figure 2: *Panelling exposure, Clonmel, Co Tipperary*.

Assessment was visual and a performance scoring system was devised based on the categories set out below. Each category was allowed five points for the best result and one point for the worst result. Results were consolidated as a percentage.

Colour and colour retention

All externally exposed wood, regardless of species, tends towards silver-grey as the lignin is selectively photodegraded, leaving a surface rich in cellulose fibres. Points were awarded here on the basis of retention of the original colour and general evenness of colouration.

Distortion

Assessed by appearance and by running the hand over the surface of the panel. Cupping and twisting etc. caused loss of points. Good panels showed a substantially flat surface.

Defects, knots and splits

Points were awarded on the basis of freedom from gross visual defects such as loose or missing knots, star knots, splits not associated with nails, and flaking.

Nail splitting
Points were lost if there was any evidence of significant splitting around nailing points.

Nail staining
Points were lost if noticeable staining was present around nail holes.

General appearance
Points were awarded on the overall appearance of the panel when viewed from a distance of approximately 2 m. To score highly a panel had to look as if it would be acceptable as part of a building system.

It is appreciated that there is a large degree of subjectivity in this scoring system, however it is considered that it provides a useful approach towards a quantitative assessment of performance and corresponds to practical in-service assessment.

3. Results and discussion

3.1 Mechanical property change

Figure 3 compares typical 3-point bending plots for a treated and untreated control Sitka spruce. Stress-strain curves for the heat-treated materials are linear up to the point of abrupt fracture, which occurs at small deformation relative to controls. Untreated control materials show a more progressive fracture involving much greater work, judged by the area under the curve.

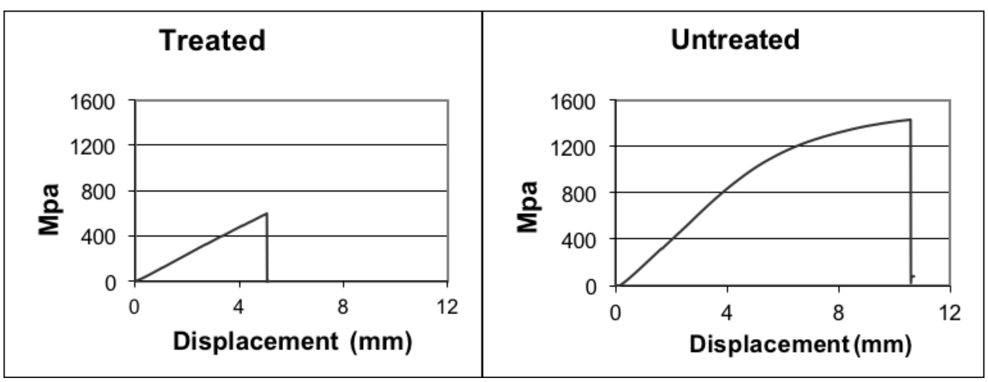

Figure 3: *Typical three-point bending plots for Sitka spruce, treated and untreated.*

Electron micrographs of fracture surfaces, shown as Figure 4, demonstrate that in the case of control materials, cell pullout had occurred with cell walls remaining largely intact. In comparison heat-treated materials clearly show cell wall cleavage and significant delamination of the cell wall layers, particularly following the more severe treatment. The micrographs show separation of the middle lamella and it is proposed that lignin degradation within the middle lamella and within the cell wall is removing one of the essential conditions for composite material behaviour, in that stress transfer and stress distribution are seriously compromised by matrix degradation. Dynamic mechanical analysis, previously reported (Dolan, 2006) shows that there is a small change in the relationships between timber stiffness and temperature, as assessed by the temperature coefficient of modulus. Timber stiffness under small strain is substantially determined by such factors as microfibril angle (Barnett and Bonham 2004, Hofstetter et al. 2006, Yang and Evans 2004) and this will be largely unchanged by heat-treatment, whereas timber toughness under large strain is a function of the ability to transfer and distribute stress between fibrils, and this is dependent upon matrix integrity, which is damaged by heat-treatment.

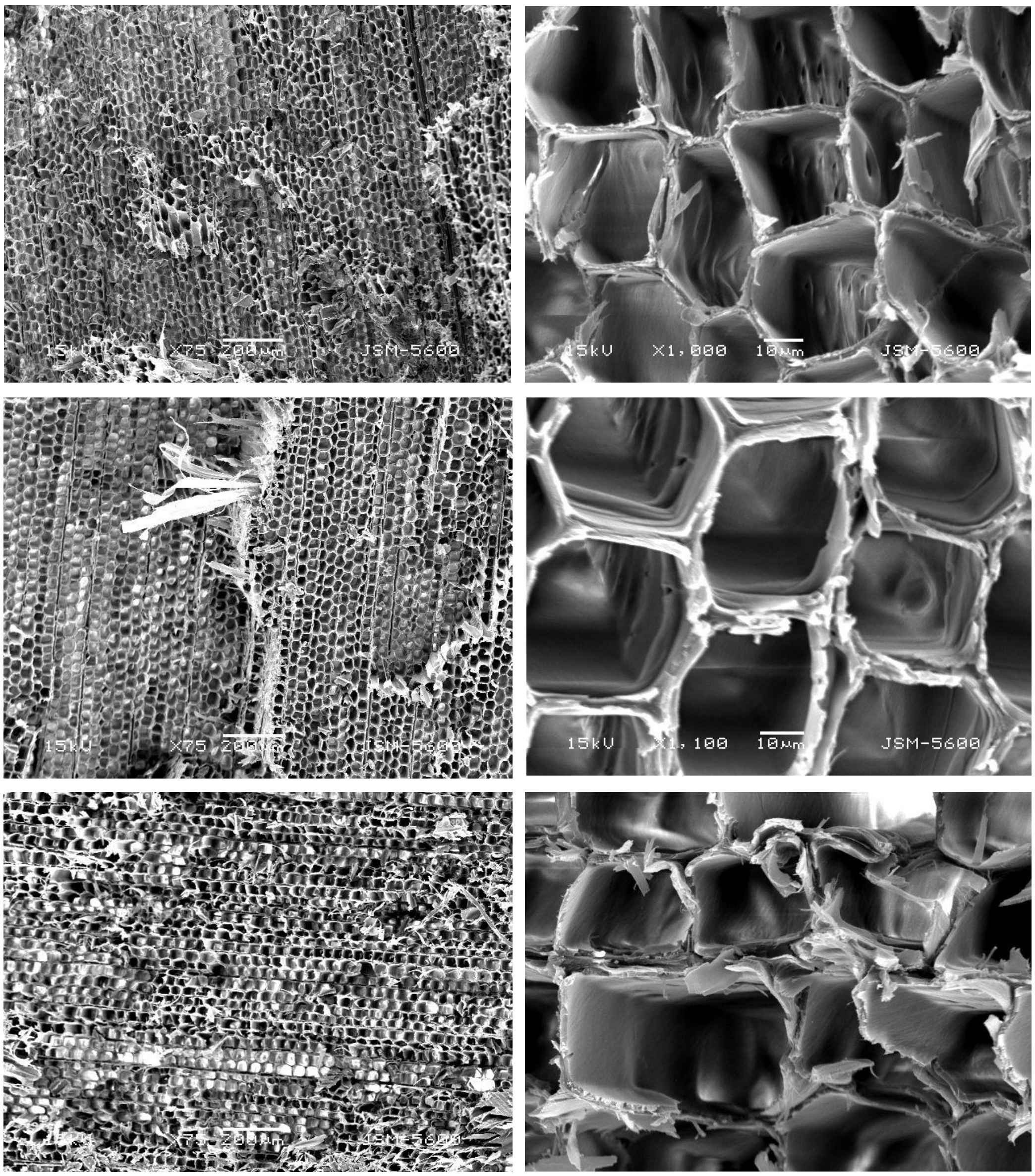

Figure 4: *Electron micrographs of the fracture surfaces of Sitka spruce broken in three-point bend, from top to bottom, untreated, Platowood treatment and Lignius treatment. Failure along the middle lamellae is apparent with increasing severity of treatment.*

3.2 Species comparison

The full score sheet is shown as an Appendix and considers results for different species, profiles and treatments. An extensive library of photographs is also available should it be required.

Although the trial looked at three species, spruce, pine and larch it was apparent from their initial response to heat-treatment that pine and larch, at least in the quality presented for the trial, had little to offer. As the hydrothermal stresses, inherent to the treatment process, exacerbate existing anatomical irregularities in the wood the knot whorls of the pine and the grain structure of the larch lead to immediate faults. Consequently this final report is primarily concerned with the response of Sitka spruce.

3.3 Decay resistance

The first visible signs of fungal decay occurred in the spruce controls at 4 years of exposure, and by six years exposure decay was established in three of the controls. Decay was extensive by eight years. Figure 5 shows an example of this and as can be seen fungal attack is associated with areas where water will be retained. Some slight decay was observed in one of the cedar controls at eight years, associated with a nail hole. At eleven years no decay was observable in any of the heat-treated timbers. The three timbers used are all low durability, falling in Durability Class 5, and so this has to be considered a good result.

Figure 5: *Decay in a spruce control, possibly a brown rot such as* Coniophera puteana.

There are two mechanisms by which decay is inhibited in heat-treated softwoods. First, heat-treatment reduces equilibrium moisture content to values below that at which fungi can thrive, and secondly, by altering the chemical structure of the lignin and degrading the hemicelluloses the usefulness of the timber as a nutrient source is reduced.

3.4 Distortion, stability and defects

It is clear that the heat-treated timbers show a much higher level of stability than the spruce controls and are approximately similar to cedar controls. Heat-treated boards exhibit much less cup and bow and less longitudinal splits. The Thermowood treated spruce from the Wicklow Rural Partnership trial is noteworthy as showing very high stability with very few loose or lost knots and very little splitting. Panels are flat and visually the most acceptable of the heat-treated timbers. Figure 6 shows an example. Again, it must be emphasised that this appears to be selected timber. Other heat-treated materials show a relatively higher incidence of knot loss, and this was remarked upon when the wood was being machined, with knots flying away at the cutter.

Figure 6 *Thermowood spruce panel after 10 years*.

Material from the Lignius trial showed transverse cracking, as illustrated in Figure 7. The cracking and extreme embrittlement imply that the wood has been over-treated. This process used higher temperature with the wood constrained between platens and although very effective at inhibiting decay it is clearly promoting unacceptable mechanical damage. The illustration shows a highly developed series of cracks but there were also examples of smaller cracks running perpendicular to the grain. It is considered that this represents a hydrolytically driven fatigue failure in which changes in surface moisture content and associated dimensional change promote fatigue cracks.

Figure 7: *Transverse cracking in Lignius treated larch.*

3.5 Nailing performance and nail staining

No significant problems were observed with any of the treated timbers. As already reported (Thornton et al. 2007) nailing was completed without any mechanical damage relative to controls and now the long-term evaluation shows that there was no significant evidence of nail induced splitting during weathering. Some staining occurred around the plated nails, especially in the larch, but with time most of this washed away. No loosening or gross corrosion of the nails was apparent, although the use of plated nails cannot be recommended.

3.6 Overall appearance and performance

Considering first of all the control materials scores, as compared in Figure 8, western red cedar is the industry standard against which alternative timbers can be judged, and as would be expected showed the best result, with excellent performance in all categories. Note that in Figures 8, 9 and 11 the vertical ordinate is similar to allow comparison between charts. Also as little change occurs in the early years of exposure the results in these figures are presented at two year intervals for the early years and then at six month intervals in the later period when more change is occurring. Comparing the performance of spruce controls with the cedar controls provides a check on the methodology being used, and as the spruce performed substantially less well it is considered that the overall experimental method is valid.

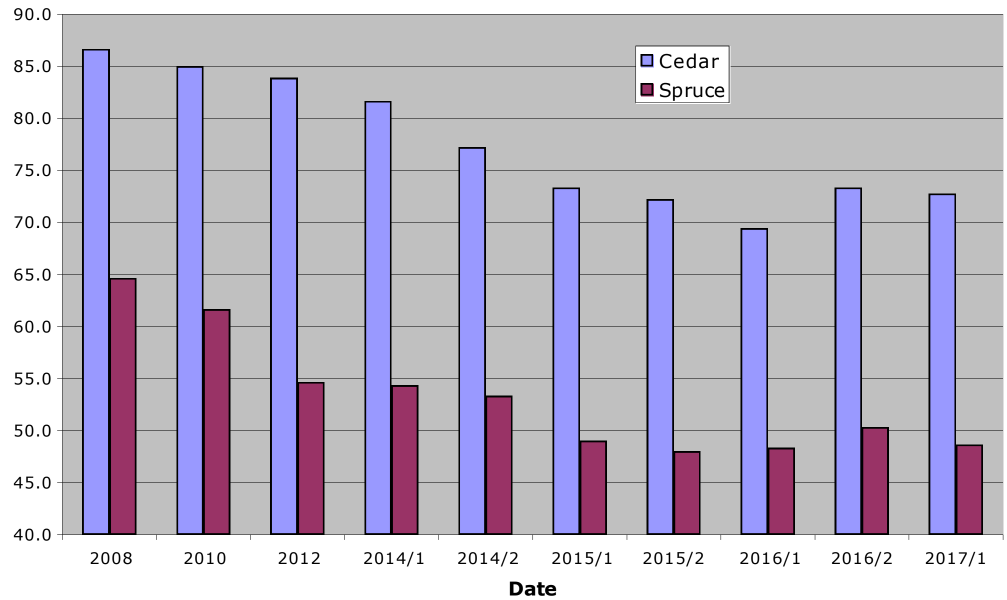

Figure 8: *Comparison of points scores for western red cedar and Sitka spruce controls*.

The results for the spruce panels with a shiplap profile from the different processes are compared in Figure 9, and it can be seen that the Thermowood material clearly performs the best, and again the panel shown in Figure 6 is a typical example.

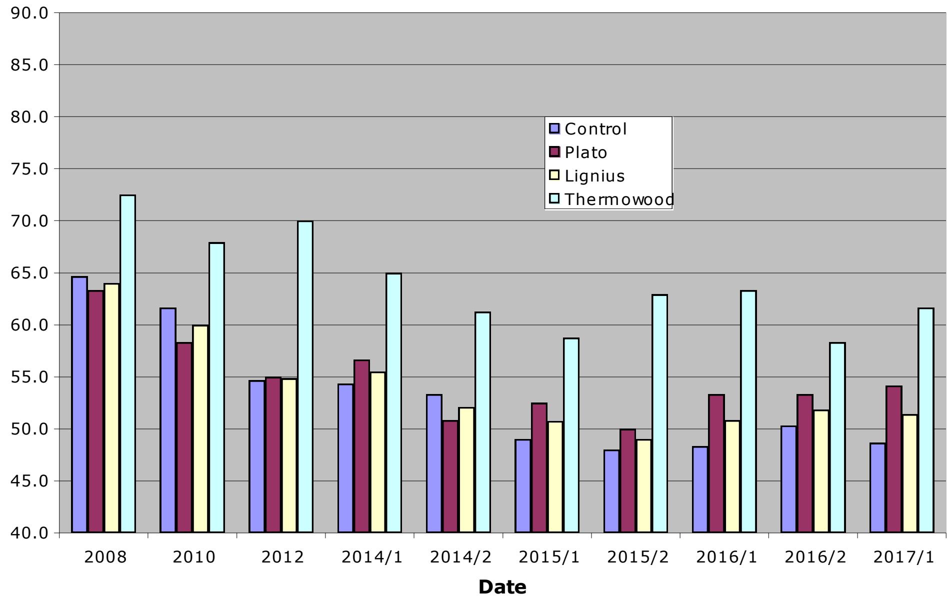

Figure 9: *Comparison of point scores of spruce, shiplap profile, from various processes with controls.*

The main area in which problems were apparent with the Thermowood treated material was in some lost knots and other small defects, and many of these defects pre-date the exposure trials. Loss of knots during machining was an identified problem with all heat-treated timber, however in the Thermowood spruce the knots are small, reducing the impact of the problem. In the unselected timbers used in the other processes loss of large knots was relatively common and would result in rejection of boards and panels in an industrial situation. Figure 10 illustrates the problem and these effects arise from the hydrothermal stresses in the process and the inhomogeneity of the material. Large knots will always be a problem and similar effects have been observed with chemical modification of fast grown softwoods.

Figure 10: *Example of knot damage in shiplap machined boards*.

Figure 11 compares the Thermowood spruce in the different profiles along with the average for the spruce control controls. The results suggest that the more extensively the wood is machined the lower the long-term performance and this is probably because of knot loss.

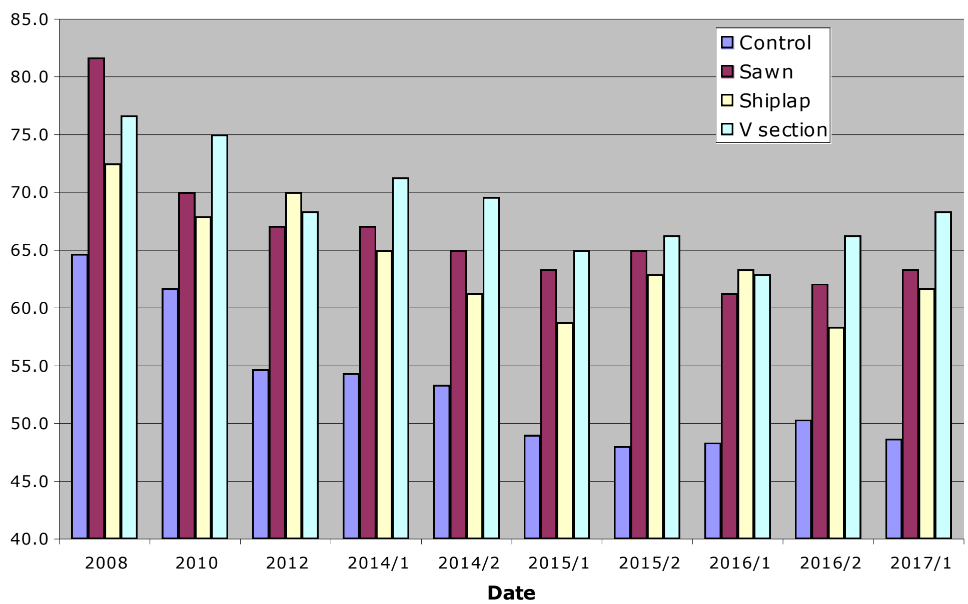

Figure 11: *Comparison of point scores of Thermowood treated spruce with controls, various profiles.*

The colour change during exposure is very considerable. Heat-treated timbers exit the treatment kiln as a rich chocolate brown, as shown in Figure 12, and it was hoped that some of this colour would be retained during weathering. It is the case that at least one treatment company claims better colour performance for heat-treated timber.

Figure 12: *Colour contrast between heat-treated and machined boards and controls.*

Figure 13, which shows the same sawn panel before and after six years exposure, demonstrates that this has not been observed here. Although heat-treated timbers retained their colour for slightly longer than untreated timber, ultimately all exposed material treated or not, attains the same grey colour. This suggests that although heat-treatment is effective at modifying lignin to reduce its attractiveness as fungal food source, it does not reduce the susceptibility of the lignin to photo-oxidative degradation.

Figure 13: *Colour change on weathering. The left hand illustration shows a panel in the workshop, immediately after fabrication, and the right hand illustration shows the same panel after six years exposure.*

Previous reports (Dolan 2006) have shown that in laboratory evaluation fast grown Irish timber responds to heat-treatment in the same manner as slower grown Northern European timbers. It has now been confirmed, in this large-scale field trial, that fungal

durability is considerably increased in a representative external environment. However an important point is that although this trial would approximate to Use Class 3, where continuous wetting is expected, it is an “out of ground contact” situation. It is generally accepted by the treatment industry that heat-treated timber is not suitable for ground contact applications and this is a limitation which potential users should be aware of.
Dimensional stability is improved with less cupping and distortion, consequent on the lower equilibrium moisture content at any particular relative humidity. Similarly, as less dimensional change occurs with change in humidity, treated timbers show less splitting with time.

Measurement of mechanical properties has shown substantial reductions in work to fracture and this has been explained in terms of composite theory. Matrix degradation is limiting stress transfer between the composite components allowing premature failure. Despite this, nail fixing is perfectly feasible and this trial shows that no long-term problems arise from nail splitting or nail staining. Stainless steel nails should always be used.
It is apparent that heat-treatment tends to exacerbate existing defects in the timber with loss of knots being an obvious problem. Many of the defects observed during the inspections were present before exposure of the panels. Timber quality is critical to the final result.

Heat-treatment offers a relatively low cost non-toxic method of substantially improving exterior durability and dimensional stability. In these respects applying the processes to Irish timber is no different to applying them to Northern European timber. However it is apparent that in order to obtain the full benefits of these processes pre-selection of the material is essential. Heat-treatment, like other modification processes, subjects the wood to considerable hydrothermally induced mechanical stresses, and structural imperfections, of any form, are likely to become much more apparent in the processed timber. In fast grown relatively young timber the inherent irregularities are potential problem sites.

Whilst the Finnish Thermowood process timber has given the best result in these trials, it is likely that considerable process development would still be needed to match particular grades of timber to processes and to applications. Potential end uses for this technology are cladding, as evaluated here, out of ground fencing components and timber framing. European treatment companies suggest that paint retention is good, but this would need further examination.

Production of heat-treated timber in Europe in 2016 was estimated at 300,000m^3 (Sandberg and Kutnar 2016) and so it can now be considered as mature technology. Only two countries in Europe do not use the technology on a large scale, Ireland and the UK. The critical questions for industry to consider are the availability of suitable selected timber, the costs of selection and the possible market demand compared with the cost of building and operating a heat-treatment plant. Energy use in heat-treatment is two to three times that of simple kiln drying, and kilns and ancillary equipment are more complex. However a significant advantage is the non-toxic nature of both the process and the end product.

Considering the merits of the trial overall it is considered that the primary objectives of evaluating the behaviour of fast grown Irish softwoods to heat-treatment has been achieved. The advantages have been identified, as have the potential problems arising with fast grown timber. The results obtained should allow industry and the appropriate state authorities to make an informed choice about the possible adoption of heat-treatment technology.

Acknowledgements

Technical and practical contributions were received during the course this work from Seamus Dolan and Daragh Thornton. Funding for the work reported was provided under the COFORD programme (HEATREAT project) and directly by the Department of Agriculture, Food and the Marine.

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Appendix

Page	Controls											
1	**Year**	**Panel no.**	**Species**	**Type**	**Colour retention**	**Distortion**	**Defect, knots, splits**	**Nail splitting**	**Nail staining**	**Overall appearance**	**Total ex 30**	%
	2008	25	Cedar	Shiplap	3.0	5.0	5.0	5.0	5.0	4.0	27.0	90.0
	2010				2.5	5.0	5.0	5.0	5.0	4.0	26.5	88.3
	2012				2.5	4.5	5.0	5.0	5.0	3.5	25.5	85.0
	2014/1				2.0	4.5	4.5	4.0	5.0	4.0	24.0	80.0
	2014/2				2.0	4.5	3.5	4.5	3.0	3.5	21.0	70.0
	2015/1				1.0	4.5	4.0	4.0	4.0	3.0	20.5	68.3
	2015/2				1.0	4.0	3.5	4.5	4.0	3.5	20.5	68.3
	2016/1				1.0	4.0	4.0	4.0	4.0	3.5	20.5	68.3
	2016/2				1.0	4.0	4.0	4.5	4.5	3.5	21.5	71.7
	2017/1				1.0	4.5	4.0	4.5	4.0	3.5	21.5	71.7
	2008	26	Cedar	Sawn	2.0	5.0	5.0	5.0	5.0	4.0	26.0	86.7
	2010				2.5	5.0	5.0	5.0	5.0	2.5	25.0	83.3
	2012				2.5	5.0	4.5	5.0	5.0	3.5	25.5	85.0
	2014				2.0	5.0	4.0	5.0	5.0	4.0	25.0	83.3
	2014/2				2.5	5.0	4.5	4.5	4.0	4.0	24.5	81.7
	2015/1				2.0	5.0	4.0	5.0	4.0	4.0	24.0	80.0
	2015/2				1.5	4.5	3.5	5.0	4.5	3.5	22.5	75.0
	2016/1				2.0	4.5	3.5	4.0	4.0	3.5	21.5	71.7
	2016/2				2.0	4.5	3.5	4.5	4.5	3.5	22.5	75.0
	2017/1				2.0	4.5	4.5	4.5	4.5	3.5	23.5	78.3
	2008	27	Cedar	V	2.0	4.0	5.0	5.0	5.0	4.0	25.0	83.3
	2010				1.5	4.5	5.0	5.0	5.0	4.0	25.0	83.3
	2012				2.0	4.5	4.5	5.0	5.0	3.5	24.5	81.7
	2014				2.5	4.5	4.5	4.5	5.0	3.5	24.5	81.7
	2014/2				2.5	4.5	4.0	4.5	5.0	3.5	24.0	80.0
	2015/1				2.0	4.5	3.0	4.5	4.5	3.0	21.5	71.7

2015/2				1.0	4.5	3.5	4.5	4.5	4.0	22.0	73.3
2016/1				1.5	4.0	3.5	4.0	4.0	3.5	20.5	68.3
2016/2				2.0	3.5	4.0	4.5	4.5	3.5	22.0	73.3
2017/1				1.5	4.5	3.5	4.5	3.0	3.5	20.5	68.3
2											
2008	Average			2.3	4.7	5.0	5.0	5.0	4.0	26.0	**86.7**
2010	Average			2.2	4.8	5.0	5.0	5.0	3.5	25.5	**85.0**
2012	Average			2.3	4.7	4.7	5.0	5.0	3.5	25.2	**83.9**
2014	Average			2.2	4.7	4.3	4.5	5.0	3.8	24.5	**81.7**
2014/2	Average			2.3	4.7	4.0	4.5	4.0	3.7	23.2	**77.2**
2015/1	Average			1.7	4.7	3.7	4.5	4.2	3.3	22.0	**73.3**
2015/2	Average			1.2	4.3	3.5	4.7	4.3	3.7	21.7	**72.2**
2016/1	Average			1.5	4.2	3.7	4.0	4.0	3.5	20.8	**69.4**
2016/2	Average			1.7	4.0	3.8	4.5	4.5	3.5	22.0	**73.3**
2017/1	Average			1.5	4.5	4.0	4.5	3.8	3.5	21.8	**72.8**

Controls											
Year	**Panel no.**	**Species**	**Type**	**Colour retention**	**Distortion**	**Defect, knots, splits**	**Nail splitting**	**Nail staining**	**Overall appearance**	**Total ex 30**	%
2008	1	Spruce	Shiplap	1.0	4.0	2.0	4.0	5.0	3.0	19.0	63.3
2010				2.0	2.5	3.0	4.0	5.0	2.5	19.0	63.3
2012				2.0	2.5	2.0	3.0	5.0	2.5	17.0	56.7
2014				1.0	4.0	1.5	4.0	5.0	1.0	16.5	55.0
2014/2				1.0	3.0	2.0	3.0	4.5	1.5	15.0	50.0
2015/1				0.5	4.0	1.5	4.0	4.0	1.0	15.0	50.0
2015/2				0.5	3.5	1.5	3.5	4.5	1.5	15.0	50.0
2016/1				0.5	3.0	1.5	4.0	4.0	1.0	14.0	46.7
2016/2				0.5	3.0	1.5	4.0	4.0	1.5	14.5	48.3
2017/1				0.5	2.5	1.5	4.0	4.0	1.0	13.5	45.0
2008	33	Spruce	Shiplap	2.0	4.0	2.0	4.0	5.0	3.0	20.0	66.7
2010				1.0	3.5	3.0	4.0	5.0	1.5	18.0	60.0
2012				1.0	4.0	2.0	2.5	5.0	1.5	16.0	53.3
2014				1.0	4.0	2.0	3.0	4.5	2.0	16.5	55.0
2014/2				1.0	3.0	2.0	4.0	4.0	2.0	16.0	53.3
2015/1				1.0	3.5	2.0	2.5	4.0	1.5	14.5	48.3

	2015/2				1.0	4.0	2.5	3.0	4.0	1.5	16.0	53.3
	2016/1				1.0	3.5	2.0	3.0	4.0	1.5	15.0	50.0
	2016/2				1.0	3.0	2.0	4.0	4.0	2.0	16.0	53.3
	2017/1				1.0	3.5	1.5	3.0	4.0	1.5	14.5	48.3
3	2008	34	Spruce	Shiplap	2.0	5.0	4.0	4.0	5.0	3.0	23.0	76.7
	2010				1.5	4.0	3.5	5.0	5.0	2.5	21.5	71.7
	2012				1.5	3.5	3.0	4.0	5.0	2.5	19.5	65.0
	2014				1.0	4.0	2.5	4.0	5.0	2.5	19.0	63.3
	2014/2				1.0	4.0	3.0	4.0	5.0	2.5	19.5	65.0
	2015/1				1.0	3.5	2.5	4.0	4.0	2.5	17.5	58.3
	2015/2				1.0	4.0	3.0	3.5	4.5	3.0	19.0	63.3
	2016/1				1.0	3.5	3.0	4.0	4.0	3.0	18.5	61.7
	2016/2				1.0	3.5	3.0	4.0	4.0	3.0	18.5	61.7
	2017/1				1.0	3.5	3.0	4.0	4.5	3.0	19.0	63.3
	2008	37	Spruce	V	2.0	1.0	2.0	5.0	5.0	1.0	16.0	53.3
	2010				2.0	2.0	2.0	4.0	5.0	2.5	17.5	58.3
	2012				1.5	1.5	1.5	2.5	5.0	1.0	13.0	43.3
	2014				1.0	1.5	2.5	4.0	4.0	1.5	14.5	48.3
	2014/2				1.0	3.0	1.5	4.0	4.0	1.0	14.5	48.3
	2015/1				0.5	2.0	1.0	4.0	4.0	0.5	12.0	40.0
	2015/2				1.0	2.5	1.5	2.5	4.0	0.5	12.0	40.0
	2016/1				0.5	3.0	0.5	3.0	4.0	0.5	11.5	38.3
	2016/2				1.0	2.5	0.5	3.0	4.0	0.5	11.5	38.3
	2017/1				1.0	2.5	1.0	4.0	4.0	0.5	13.0	43.3
	2008	38	Spruce	V	2.0	3.0	2.0	3.0	5.0	4.0	19.0	63.3
	2010				1.0	2.0	2.5	3.5	5.0	2.5	16.5	55.0
	2012				2.0	2.5	2.5	2.5	5.0	2.0	16.5	55.0
	2014				1.5	2.0	1.5	3.5	4.5	2.0	15.0	50.0
	2014/2				1.5	2.5	2.0	2.5	4.5	2.0	15.0	50.0
	2015/1				1.0	3.0	2.0	3.0	4.0	1.5	14.5	48.3
	2015/2				0.5	2.0	1.5	3.5	4.5	0.5	12.5	41.7
	2016/1				0.5	2.5	2.0	3.5	4.0	1.0	13.5	45.0
	2016/2				1.0	3.0	2.0	4.0	4.0	1.0	15.0	50.0
	2017/1				0.5	2.5	2.0	3.5	4.0	0.5	13.0	43.3

4											
2008	Average			1.8	3.4	2.4	4.0	5.0	2.8	19.4	**64.7**
2010	Average			1.5	2.8	2.8	4.1	5.0	2.3	18.5	**61.7**
2012	Average			1.6	2.8	2.2	2.9	5.0	1.9	16.4	**54.7**
2014	Average			1.1	3.1	2.0	3.7	4.6	1.8	16.3	**54.3**
2014/2	Average			1.1	3.1	2.1	3.5	4.4	1.8	16.0	**53.3**
2015/1	Average			0.8	3.2	1.8	3.5	4.0	1.4	14.7	**49.0**
2015/2	Average			0.8	3.0	1.9	3.2	4.2	1.3	14.4	**48.0**
2016/1	Average			0.8	2.6	1.5	2.9	3.4	1.5	12.7	**48.3**
2016/2	Average			1.2	3.5	2.5	3.8	4.4	1.8	17.2	**50.3**
2017/1	Average			1.0	3.3	2.3	3.8	4.5	1.6	16.5	**48.7**

Thermowood											
Year	**Panel no.**	**Species**	**Type**	**Colour retention**	**Distortion**	**Defect, knots, splits**	**Nail splitting**	**Nail staining**	**Overall appearance**	**Total ex 30**	%
2008	17	Spruce	Sawn	2.0	5.0	5.0	5.0	5.0	4.0	26.0	86.7
2010				2.5	4.0	4.0	5.0	5.0	2.5	23.0	76.7
2012				1.5	4.0	3.5	5.0	5.0	3.0	22.0	73.3
2014				1.0	4.0	4.0	4.5	5.0	3.5	21.0	70.0
2014/2				1.0	3.5	4.0	4.5	5.0	3.0	21.0	70.0
2015/1				1.0	3.5	4.0	4.0	4.0	3.0	19.5	65.0
2015/2				1.5	4.0	3.5	4.0	4.5	3.5	21.0	70.0
2016/1				1.0	3.5	3.5	4.0	4.0	3.0	19.0	63.3
2016/2				1.0	3.0	3.5	4.0	4.0	3.0	18.5	61.7
2017/1				1.5	0.5	3.5	4.0	4.5	3.5	17.5	58.3
2008	14	Spruce	Sawn	2.0	4.0	5.0	5.0	5.0	4.0	25.0	83.3
2010				1.5	4.0	4.5	5.0	5.0	3.0	23.0	76.7
2012				2.0	4.0	3.5	4.5	5.0	3.0	22.0	73.3
2014				1.0	4.0	4.0	4.5	5.0	3.0	21.5	71.7
2014/2				1.0	4.0	4.0	4.5	5.0	2.0	20.5	68.3
2015/1				1.0	4.0	4.0	4.0	4.0	3.5	20.5	68.3
2015/2				1.0	3.5	3.5	4.0	4.5	3.0	19.5	65.0
2016/1				1.0	3.5	3.5	4.0	4.0	3.5	19.5	65.0
2016/2				1.0	3.5	3.5	4.0	4.0	3.5	19.5	65.0
2017/1				1.0	4.0	3.0	4.0	4.0	3.0	19.0	63.3

5	2008	15	Spruce	Sawn	1.0	5.0	4.0	5.0	5.0	4.0	24.0	80.0
	2010				2.0	4.0	2.5	3.0	5.0	2.0	18.5	61.7
	2012				1.0	3.5	2.5	2.5	5.0	2.0	16.5	55.0
	2014				1.5	4.0	3.0	3.5	5.0	2.5	19.5	65.0
	2014/2				1.0	4.0	2.5	3.5	4.5	2.0	17.5	58.3
	2015/1				1.0	3.5	2.5	4.0	4.0	2.5	17.5	58.3
	2015/2				1.0	3.5	3.0	3.5	4.0	2.5	17.5	58.3
	2016/1				1.0	3.5	2.5	3.5	4.0	2.5	17.0	56.7
	2016/2				1.0	3.5	2.5	3.0	4.0	2.5	16.5	55.0
	2017/1				1.0	3.5	2.5	4.0	4.0	2.5	17.5	58.3
	2008	18	Spruce	Sawn	1.0	5.0	4.0	4.0	5.0	4.0	23.0	76.7
	2010				1.5	3.5	2.5	5.0	5.0	2.0	19.5	65.0
	2012				1.5	3.5	2.5	4.5	5.0	3.0	20.0	66.7
	2014				1.0	4.0	2.5	3.0	5.0	2.5	18.0	60.0
	2014/2				1.0	4.0	2.5	3.5	5.0	2.5	18.5	61.7
	2015/1				1.0	4.0	2.0	4.0	4.0	2.5	17.5	58.3
	2015/2				1.0	3.5	2.5	4.5	4.5	2.5	18.5	61.7
	2016/1				1.0	3.5	2.0	4.0	4.0	2.0	16.5	55.0
	2016/2				1.0	3.5	3.0	4.0	4.5	2.5	18.5	61.7
	2017/1				1.0	3.0	2.5	4.0	4.0	2.5	17.0	56.7
	2008	Average			1.5	4.8	4.5	4.8	5.0	4.0	24.5	**81.7**
	2010	Average			1.9	3.9	3.4	4.5	5.0	2.4	21.0	**70.0**
	2010	Average			1.5	3.8	3.0	4.1	5.0	2.8	20.1	**67.1**
	2014	Average			1.1	3.9	3.4	3.9	5.0	2.9	20.1	**67.1**
	2014/2	Average			1.0	4.0	3.3	4.0	4.9	2.4	19.5	**65.0**
	2015/1	Average			1.0	4.0	3.1	4.0	4.0	2.9	19.0	**63.3**
	2015/2	Average			1.1	4.0	3.1	4.0	4.4	2.9	19.5	**65.0**
	2016/1	Average			1.0	3.9	2.9	3.9	4.0	2.8	18.4	**61.3**
	2016/2	Average			1.0	3.8	3.1	3.8	4.1	2.9	18.6	**62.1**
	2017/1	Average			1.1	4.0	2.9	4.0	4.1	2.9	19.0	**63.3**

6 **Thermowood**

2008	12	Spruce	Shiplap	2.0	4.0	3.0	5.0	5.0	3.0	22.0	73.3
2010				1.5	4.0	2.5	4.0	5.0	3.0	20.0	66.7
2012				2.5	4.0	2.5	3.5	5.0	2.5	20.0	66.7

	2014				1.0	4.0	3.0	4.5	5.0	2.5	20.0	66.7
	2014/2				1.0	4.0	2.5	4.5	5.0	2.5	19.5	65.0
	2105/1				1.0	3.5	2.5	4.0	4.0	3.0	18.0	60.0
	2015/2				1.0	4.0	3.0	4.0	4.5	3.0	19.5	65.0
	2016/1				1.0	4.0	3.5	4.0	4.0	3.5	20.0	66.7
	2016/2				1.0	4.0	3.5	3.0	4.0	3.5	19.0	63.3
	2017/1				1.0	4.0	3.5	3.5	4.0	3.5	19.5	65.0
	2008	5	Spruce	Shiplap	3.0	4.0	4.0	4.0	5.0	4.0	24.0	80.0
	2010				1.5	4.0	3.5	5.0	5.0	2.5	21.5	71.7
	2012				1.5	4.0	3.0	3.5	5.0	2.0	19.0	63.3
	2014				1.5	4.0	4.0	4.0	3.0	3.0	19.5	65.0
	2014/2				1.0	4.0	3.5	4.0	3.0	2.5	18.0	60.0
	2105/1				1.0	4.0	3.5	4.0	4.0	3.0	19.5	65.0
	2015/2				1.0	4.0	3.5	4.0	3.5	3.0	19.0	63.3
	2016/1				1.0	4.0	3.5	4.0	4.0	3.5	20.0	66.7
	2016/2				0.5	3.5	3.5	4.0	4.0	3.0	18.5	61.7
	2017/1				1.0	4.0	3.5	4.0	3.5	3.5	19.5	65.0
	2008	13	Spruce	Shiplap	2.0	4.0	3.0	4.0	5.0	4.0	22.0	73.3
	2010				1.0	3.0	2.5	3.5	5.0	3.0	18.0	60.0
	2012				1.5	3.5	2.5	3.5	5.0	2.0	18.0	60.0
	2014				2.0	4.0	3.0	3.5	4.0	2.5	19.0	63.3
	2014/2				1.0	4.0	2.5	3.5	4.5	2.5	18.0	60.0
	2105/1				1.0	4.0	2.5	3.0	4.0	3.0	17.5	58.3
	2015/2				1.0	4.0	3.0	3.5	4.5	3.0	19.0	63.3
	2016/1				1.0	3.5	2.5	4.0	4.0	3.0	18.0	60.0
	2016/2				1.0	3.5	2.0	4.0	4.0	2.0	16.5	55.0
	2017/1				1.0	4.0	3.0	2.5	4.0	2.5	17.0	56.7
7	2008	4	Spruce	Shiplap	2.0	4.0	3.0	3.0	4.0	3.0	19.0	63.3
	2010				3.0	4.0	3.0	3.5	5.0	3.5	22.0	73.3
	2012				2.0	4.0	2.5	3.5	5.0	2.5	19.5	65.0
	2014				1.0	4.0	2.5	4.0	5.0	3.0	19.5	65.0
	2014/2				1.0	3.5	2.5	4.0	5.0	2.0	18.0	60.0
	2015/1				1.0	3.5	2.5	3.0	3.5	2.0	15.5	51.7
	2015/2				1.0	4.0	2.5	5.0	2.5	3.0	18.0	60.0
	2016/1				1.0	4.0	2.5	4.0	4.0	2.5	18.0	60.0

	2016/2				1.0	3.5	2.5	2.5	4.0	2.5	16.0	53.3
	2017/1				1.0	4.0	2.5	4.0	4.0	2.5	18.0	60.0
	2008	Average			2.3	4.0	3.3	4.0	4.8	3.5	21.8	**72.5**
	2010	Average			1.8	3.8	2.9	4.0	5.0	3.0	20.4	**67.9**
	2012	Average			1.9	3.9	3.4	4.5	5.0	2.4	21.0	**70.0**
	2014	Average			1.4	4.0	3.1	4.0	4.3	2.8	19.5	**65.0**
	2014/2	Average			1.0	3.9	2.8	4.0	4.4	2.4	18.4	**61.3**
	2015/1	Average			1.0	3.8	2.8	3.5	3.9	2.8	17.6	**58.8**
	2015/2	Average			1.0	4.0	3.0	4.1	3.8	3.0	18.9	**62.9**
	2016/1	Average			1.0	3.9	3.0	4.0	4.0	3.1	19.0	**63.3**
	2016/2	Average			0.9	3.6	2.9	3.4	4.0	2.8	17.5	**58.3**
	2017/1	Average			1.0	4.0	3.1	3.5	3.9	3.0	18.5	**61.7**

	Thermowood											
	2008	24	Spruce	V	1.0	5.0	4.0	5.0	5.0	4.0	24.0	80.0
	2010				1.0	4.0	3.5	5.0	5.0	3.5	22.0	73.3
	2012				1.5	4.0	3.5	5.0	5.0	3.0	22.0	73.3
	2014				1.5	4.0	3.5	4.5	5.0	3.5	22.0	73.3
	2014/2				1.0	4.0	3.5	4.5	5.0	3.0	21.0	70.0
	2015/1				1.0	4.0	3.5	4.0	4.0	3.0	19.5	65.0
	2015/2				1.0	4.0	3.5	4.5	4.0	3.0	20.0	66.7
	2016/1				1.0	4.0	3.5	4.0	4.0	3.0	19.5	65.0
	2016/2				1.0	4.0	3.5	4.0	4.0	3.5	20.0	66.7
	2017/1				1.0	4.0	4.0	4.5	4.5	3.5	21.5	71.7
8	2008	22	Spruce	V	2.0	4.0	3.0	5.0	5.0	4.0	23.0	76.7
	2010				3.5	2.0	4.0	3.5	5.0	3.5	21.5	71.7
	2012				2.0	4.0	2.5	3.0	3.5	3.0	18.0	60.0
	2014				1.5	4.0	3.5	4.0	4.5	3.5	21.0	70.1
	2014/2				1.0	4.0	3.5	4.0	4.5	3.0	20.0	66.7
	2015/1				1.0	4.0	3.5	4.0	4.0	3.0	19.5	65.0
	2015/2				0.5	4.0	3.5	4.0	4.5	3.0	19.5	65.0
	2016/1				1.0	3.5	3.0	4.0	4.0	3.0	18.5	61.7
	2016/2				1.0	3.5	3.5	4.0	4.0	3.5	19.5	65.0
	2017.1				1.0	4.0	3.0	4.5	4.0	3.0	19.5	65.0

	2008	23	Spruce	V	1.0	4.0	3.0	5.0	5.0	4.0	22.0	73.3
	2010				1.5	4.0	3.5	5.0	5.0	4.0	23.0	76.7
	2012				2.0	4.0	2.5	4.0	5.0	3.0	20.5	68.3
	2014				1.0	4.0	3.5	4.5	5.0	3.0	21.0	70.0
	2014/2				1.0	4.0	3.0	4.5	5.0	3.5	21.0	70.0
	2015/1				1.0	4.0	3.0	4.0	4.0	3.0	19.0	63.3
	2015/2				1.0	4.0	3.5	4.0	4.5	3.5	20.5	68.3
	2016/1				1.0	4.0	3.0	4.0	4.0	3.5	19.5	65.0
	2016/2				1.0	4.0	4.0	4.0	4.0	4.0	21.0	70.0
	2017/1				1.0	4.5	3.5	4.5	4.0	4.0	21.5	71.7
	2008	21	Spruce	V	2.0	4.0	3.0	5.0	5.0	4.0	23.0	76.7
	2010				2.0	4.0	4.0	5.0	5.0	3.5	23.5	78.3
	2012				2.5	4.0	3.0	4.0	5.0	3.0	21.5	71.7
	2014				2.0	4.0	3.0	4.0	5.0	3.5	21.5	71.7
	2014/2				1.5	4.0	3.5	4.0	5.0	3.5	21.5	71.7
	2015/1				1.0	4.0	3.0	4.5	4.0	3.5	20.0	66.7
	2015/2				1.0	4.0	3.0	5.0	3.5	3.0	19.5	65.0
	2016/1				1.0	3.5	2.5	4.0	4.0	3.0	18.0	60.0
	2016/2				1.0	4.0	3.0	4.0	4.0	3.0	19.0	63.3
	2017/1				1.0	3.5	3.5	4.0	4.0	3.5	19.5	65.0
9	2008	Average			1.5	4.3	3.3	5.0	5.0	4.0	23.0	**76.7**
	2010	Average			2.0	3.5	3.8	4.6	5.0	3.6	22.5	**75.0**
	2012	Average			2.0	4.0	2.9	4.0	4.6	3.0	20.5	**68.3**
	2014	Average			1.5	4.0	3.4	4.3	4.9	3.4	21.4	**71.3**
	2014/2	Average			1.1	4.0	3.4	4.3	4.9	3.3	20.9	**69.6**
	2015/1	Average			1.0	4.0	3.3	4.1	4.0	3.1	19.5	**65.0**
	2015/2	Average			0.9	4.0	3.4	4.4	4.1	3.1	19.9	**66.3**
	2016/1	Average			1.0	3.8	3.0	4.0	4.0	3.1	18.9	**62.9**
	2016/2	Average			1.0	3.9	3.5	4.0	4.0	3.5	19.9	**66.3**
	2017/1	Average			1.0	4.0	3.5	4.4	4.1	3.5	20.5	**68.3**

Plato											
Year	**Panel no.**	**Species**	**Type**	**Colour retention**	**Distortion**	**Defect, knots, splits**	**Nail splitting**	**Nail staining**	**Overall appearance**	**Total ex 30**	%

	2008	30	Spruce	Shiplap	2.0	4.0	2.0	5.0	5.0	2.0	20.0	66.7
	2010				1.0	4.0	2.5	4.0	5.0	2.0	18.5	61.7
	2012				1.0	4.0	2.0	4.0	5.0	1.5	17.5	58.3
	2014				1.0	4.0	2.0	3.0	4.5	2.0	16.5	55.0
	2014/2				1.0	4.0	2.0	3.0	4.0	2.0	16.0	53.3
	2015/1				1.0	4.0	1.5	4.0	4.0	1.5	16.0	53.3
	2015/2				1.0	4.0	1.5	2.5	4.0	1.5	14.5	48.3
	2016/1				0.5	3.5	2.0	4.0	4.0	2.0	16.0	53.3
	2016/2				1.0	3.5	2.0	4.0	4.0	1.5	16.0	53.3
	2017/1				1.0	4.0	2.0	3.5	4.0	2.0	16.5	55.0
	2008	9	Spruce	Shiplap	1.0	4.0	2.0	3.0	5.0	3.0	18.0	60.0
	2010				1.5	3.5	1.5	2.5	5.0	2.5	16.5	55.0
	2012				1.5	4.0	1.0	2.5	5.0	1.5	15.5	51.7
	2014				1.0	4.0	2.0	3.5	5.0	2.0	17.5	58.3
	2014/2				1.0	4.0	1.5	3.0	4.0	1.0	14.5	48.3
	2015/1				1.0	4.0	1.5	3.0	4.0	2.0	15.5	51.7
	2015/2				1.0	4.0	1.5	3.0	4.0	2.0	15.5	51.7
	2016/1				1.0	3.5	2.0	3.5	4.0	2.0	16.0	53.3
	2016/2				1.0	3.5	2.0	4.0	4.0	1.5	16.0	53.3
	2017/1				1.0	3.5	1.5	4.0	4.5	1.5	16.0	53.3
10	2008	Average			1.5	4.0	2.0	4.0	5.0	2.5	19.0	**63.3**
	2010	Average			1.3	3.8	2.0	3.3	5.0	2.3	17.5	**58.3**
	2012	Average			1.3	4.0	1.5	3.3	5.0	1.5	16.5	**55.0**
	2014	Average			1.0	4.0	2.0	3.3	4.8	2.0	17.0	**56.7**
	2014/2	Average			1.0	4.0	1.8	3.0	4.0	1.5	15.3	**50.8**
	2015/1	Average			1.0	4.0	1.5	3.5	4.0	1.8	15.8	**52.5**
	2015/2	Average			1.0	4.0	1.5	2.8	4.0	1.8	15.0	**50.0**
	2016/1	Average			0.8	3.5	2.0	3.8	4.0	2.0	16.0	**53.3**
	2016/2	Average			1.0	3.5	2.0	4.0	4.0	1.5	16.0	**53.3**
	2017/1	Average			1.0	3.8	1.8	3.8	4.3	1.8	16.3	**54.2**
	2008	31	Lodgepole	Shiplap	1.0	4.0	5.0	5.0	5.0	4.0	24.0	80.0
	2010				1.5	4.5	4.0	5.0	5.0	3.5	23.5	78.3
	2012				2.5	4.5	3.0	5.0	5.0	3.0	23.0	76.7
	2014				1	4.5	3.0	4.0	5.0	3.0	20.5	68.3

2014/2				1	4.5	3.0	4.0	4.5	3.0	20.0	66.7
2015/1				1	4.0	3.0	4.0	4.0	3.0	19.0	63.3
2015/2				1	4.0	3.0	4.0	4.5	3.5	20.0	66.7
2016/1				1	4.0	3.0	4.0	4.0	3.5	19.5	65.0
2016/2				1	4.0	3.5	4.0	4.0	3.5	20.0	66.7
2017/1				1	4.0	3.5	4.0	4.0	3.5	20.0	66.7
2008	10	Lodgepole	Shiplap	3.0	4.0	2.0	4.0	2.0	3.0	18.0	60.0
2010				1.5	4.0	2.0	2.0	4.0	3.0	16.5	55.0
2012				2.0	4.0	1.5	3.5	3.0	2.0	16.0	53.3
2014				1.0	4.0	1.5	3.5	5.0	2.0	17.0	56.7
2014/2				1.0	4.0	2.0	3.0	4.5	2.0	16.5	55.0
2015/1				1.0	3.5	2.0	3.0	4.0	2.5	16.0	53.3
2015/2				0.5	4.0	2.0	2.5	4.5	2.5	16.0	53.3
2016/1				1.0	4.0	3.0	4.0	4.0	2.5	18.5	61.7
2016/2				1.0	3.5	2.5	3.5	4.0	2.0	16.5	55.0
2017/1				1.0	3.0	3.5	3.5	4.0	3.0	18.0	60.0
11 2008	Average			2.0	4.0	3.5	4.5	3.5	3.5	21.0	**70.0**
2010	Average			1.5	4.3	3.0	3.5	4.5	3.3	20.0	**66.7**
2012	Average			2.3	4.3	2.3	4.3	4.0	2.5	19.5	**65.0**
2014	Average			1.0	4.3	2.3	3.8	5.0	2.5	18.8	**62.5**
2014/2	Average			1.0	4.3	2.5	3.5	4.5	2.5	18.3	**60.8**
2015/1	Average			1.0	3.8	2.5	3.5	4.0	2.8	17.5	**58.3**
2015/2	Average			0.8	4.0	2.5	3.3	4.5	3.0	18.0	**60.0**
2016/1	Average			1.0	4.0	3.0	4.0	4.0	3.0	19.0	**63.3**
2016/2	Average			1.0	3.8	3.0	3.8	4.0	2.8	18.3	**60.8**
2017/1	Average			1.0	3.5	3.5	3.8	4.0	3.3	19.0	**63.3**

Plato											
Year	**Panel no.**	**Species**	**Type**	**Colour retention**	**Distortion**	**Defect, knots, splits**	**Nail splitting**	**Nail staining**	**Overall appearance**	**Total ex 30**	%
2008	32	Larch	Shiplap	2.0	4.0	2.0	4.0	5.0	3.0	20.0	66.7
2010				1.5	4.0	2.0	4.0	5.0	2.5	19.0	63.3
2012				2.0	4.0	2.0	3.5	5.0	2.0	18.5	61.7
2014				1.0	4.0	2.0	3.5	4.5	2.0	17.0	56.7
2014/2				1.0	4.0	2.5	4.0	4.5	2.5	18.5	61.7

	2015/1				1.0	4.0	2.5	3.5	4.0	3.0	18.0	60.0
	2015/2				1.0	4.0	2.5	4.0	4.5	3.0	19.0	63.3
	2016/1				1.0	4.0	2.5	4.0	4.0	3.0	18.5	61.7
	2016/2				0.5	3.5	3.0	4.0	4.0	3.0	18.0	60.0
	2017/1				1.0	4.0	2.5	4.0	4.0	3.0	18.5	61.7
	2008	11	Larch	Shiplap	1.0	4.0	1.0	4.0	1.0	2.0	13.0	43.3
	2010				1.5	3.5	1.5	2.5	2.5	2.0	13.5	45.0
	2012				1.0	3.5	1.0	2.5	2.5	2.0	12.5	41.7
	2014				1.0	4.0	1.0	3.5	3.0	1.5	14.0	46.7
	2014/2				1.0	3.5	1.0	3.0	3.5	1.5	13.5	45.0
	2015/1				1.0	3.5	1.0	3.0	3.0	2.0	13.5	45.0
	2015/2				1.0	3.5	1.5	2.5	2.5	1.0	12.0	40.0
	2016/1				1.0	3.5	1.5	3.5	2.5	1.5	13.5	45.0
	2016/2				1.0	3.5	1.0	4.0	2.5	1.5	13.5	45.0
	2017/1				0.5	3.0	1.0	3.0	2.5	1.5	11.5	38.3
12	2008	Average			1.5	4.0	1.5	4.0	3.0	2.5	16.5	**55.0**
	2010	Average			1.5	3.8	1.8	3.3	3.8	2.3	16.3	**54.2**
	2012	Average			1.5	3.8	1.5	3.0	3.8	2.0	15.5	**51.7**
	2014	Average			1.0	4.0	1.5	3.5	3.8	1.8	15.5	**51.7**
	2014/2	Average			1.0	3.8	1.8	3.5	4.0	2.0	16.0	**53.3**
	2015/1	Average			1.0	3.8	1.8	3.3	3.5	2.5	15.8	**52.5**
	2015/2	Average			1.0	3.8	2.0	3.3	3.5	2.0	15.5	**51.7**
	2016/1	Average			1.0	3.8	2.0	3.8	3.3	2.3	16.0	**53.3**
	2016/2	Average			0.8	3.5	2.0	4.0	3.3	2.3	15.8	**52.5**
	2017/1	Average			0.8	3.5	1.8	3.5	3.3	2.3	15.0	**50.0**

Lignius											
Year	**Panel no.**	**Species**	**Type**	**Colour retention**	**Distortion**	**Defect, knots, splits**	**Nail splitting**	**Nail staining**	**Overall appearance**	**Total ex 30**	%
2008	6	Spruce	Shiplap	2.0	4.0	2.0	4.0	4.0	2.0	18.0	**60.0**
2010				2.0	3.5	1.0	4.0	5.0	2.0	17.5	**58.3**
2012				2.0	3.5	1.0	3.5	5.0	2.0	17.0	**56.7**
2014				1.5	3.5	1.0	3.5	5.0	1.0	15.5	**51.7**
2014/2				1.5	3.5	2.0	3.5	3.5	1.5	15.5	**51.7**

	2015/1				1.0	3.5	1.5	3.0	4.0	1.5	14.5	**48.3**
	2015/2				1.5	3.5	2.0	3.5	3.0	1.5	15.0	**50.0**
	2016/1				1.0	4.0	1.5	4.0	3.5	1.5	15.5	**51.7**
	2016/2				1.0	4.0	1.0	3.5	4.0	1.5	15.0	**50.0**
	2017/1				1.0	4.0	0.5	3.5	3.0	1.5	13.5	**45.0**
	2008	28	Spruce	Shiplap	2.0	4.0	3.0	5.0	5.0	3.0	22.0	**73.3**
	2010				1.5	4.0	3.0	4.5	4.0	2.5	19.5	**65.0**
	2012				1.5	4.0	2.5	4.0	5.0	2.0	19.0	**63.3**
	2014				1.0	3.5	2.0	4.0	4.5	2.0	17.0	**56.7**
	2014/2				1.0	3.5	1.5	4.0	3.5	1.5	15.0	**50.0**
	2015/1				1.0	4.0	2.0	4.0	4.0	1.5	16.5	**55.0**
	2015/2				1.0	4.0	2.5	4.0	4.0	2.0	17.5	**58.3**
	2016/1				1.0	3.5	2.0	4.0	4.0	2.0	16.5	**55.0**
	2016/2				1.0	4.0	2.0	4.0	4.0	1.5	16.5	**55.0**
	2017/1				1.0	4.0	2.5	4.0	4.0	2.0	17.5	**58.3**
13												
	2008	8	Larch	Shiplap	2.0	3.0	4.0	5.0	3.0	3.0	20.0	**66.7**
	2010				2.0	4.0	3.0	4.5	4.0	1.5	19.0	**63.3**
	2012				1.5	4.0	3.0	3.0	2.5	3.0	17.0	**56.7**
	2014				2.5	4.0	1.5	4.0	2.5	1.5	16.0	**53.3**
	2014/2				1.5	4.0	2.0	4.0	2.5	1.5	15.5	**51.7**
	2015/1				1.0	4.0	2.0	2.0	2.0	2.5	13.5	**45.0**
	2015/2				1.0	4.0	2.0	3.0	2.0	1.5	13.5	**45.0**
	2016/1				1.5	4.0	2.0	4.0	2.0	2.0	15.5	**51.7**
	2016/2				1.0	3.5	2.0	4.0	3.0	2.0	15.5	**51.7**
	2017/1				1.0	4.0	2.0	4.0	2.5	2.5	16.0	**53.3**
	2008	7	Lodgepole	Shiplap	2.0	5.0	3.0	3.0	2.0	3.0	18.0	**60.0**
	2010				2.0	4.0	2.5	4.0	4.5	3.0	20.0	**66.7**
	2012				2.0	4.0	2.5	4.0	3.5	3.0	19.0	**63.3**
	2014				1.5	3.5	1.5	3.0	5.0	1.5	16.0	**53.3**
	2014/2				1.0	3.5	1.5	2.5	5.0	1.5	15.0	**50.0**
	2015/1				1.0	4.0	1.0	2.0	4.0	1.0	13.0	**43.3**
	2015/2				0.5	4.0	1.0	2.5	4.0	1.0	13.0	**43.3**
	2016/1				0.5	3.5	1.0	3.5	4.0	1.5	14.0	**46.7**

2016/2				0.5	4.0	1.0	3.5	4.0	1.5	14.5	**48.3**
2017/1				1.0	4.0	1.5	3.5	4.0	2.0	16.0	**53.3**
2008	29	Larch	Shiplap	3.0	4.0	2.0	4.0	5.0	2.0	20.0	**66.7**
2010				2.0	4.0	3.5	5.0	5.0	2.0	21.5	**71.7**
2012				2.0	4.0	2.5	5.0	5.0	2.0	20.5	**68.3**
2014				1.0	4.0	2.0	3.5	5.0	2.0	17.5	**58.3**
2014/2				1.5	4.0	2.0	3.5	5.0	2.0	18.0	**60.0**
2015/1				1.5	4.0	2.5	4.0	4.0	2.5	18.5	**61.7**
2015/2				1.0	4.0	3.0	3.5	4.5	3.0	19.0	63.3
2016/1				1.0	4.0	3.0	3.5	4.5	3.0	19.0	63.3
2016/2				1.5	4.0	3.5	4.0	4.0	2.5	19.5	65.0
2017/1				1.0	4.0	3.5	4.5	4.5	3.0	20.5	68.3