Scots pine projects –

Laminated falling boards (FG10/05)

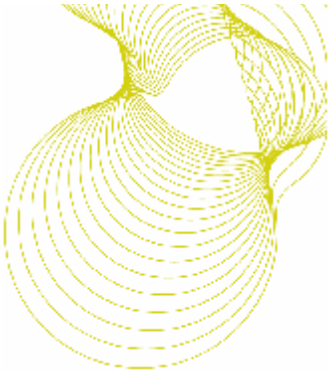
and

Higher machine settings (FG11/05)

Prepared for: Mr Dewar
Industry Advisor
Forestry Commission

6 March 2006

Client report numbers 225 -819, 225 - 800



Prepared by

Name Chris Holland & Geoff Cooper

Position Seniors Consultants

Signature

Approved on behalf of BRE

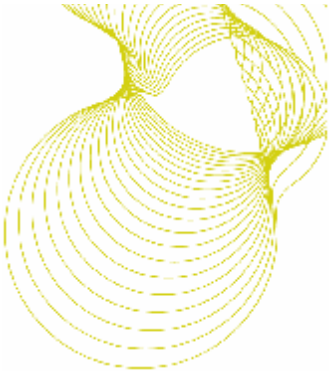
Name Dr E Suttie

Position Director Timber

Date

Signature

Construction Division
BRE
Garston
WD25 9XX
T + 44 (0) 1923 664200
F + 44 (0) 1923 664096
E construction@bre.co.uk
www.bre.co.uk



Executive Summary

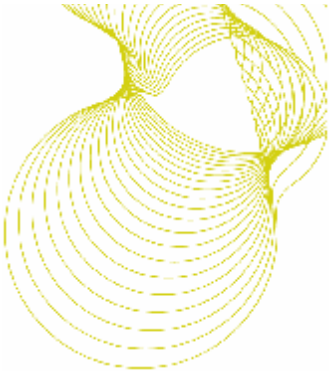
This report represents the first progress report of the two research contracts FG10/05 and FG11/05 on the re-engineering and laminating of Scots pine falling boards and the derivation of strength grading machine settings to yield higher strength classes for Scots pine.

The Identification, collection and most of the processing of the Scots pine from Scotland has been completed with material drawn from seven sites as identified by either BRE or the Northern Research Station of the Forestry Commission. Material from an eighth site (Deeside) was supplied by James Jones to increase the size range of the specimens as the material identified by BRE and the FC yielded material of only small to medium cross sectional size. The total number of battens produced is of the order of 800, excluding possible material from England.

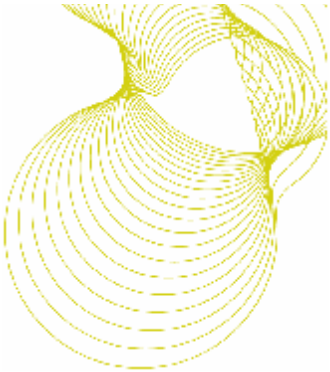
All the material that has been, or is in the final stages of processing has been individually tagged for future identification and is currently waiting to be passed through the GoldenEye strength grading machine.

An initial investigation of the quality of falling boards from Scots pine has been carried out. This was based on material already at BRE from a previous project and indicated that the majority of the material will meet the requirements of the C22 strength class before re-engineering. This offers great potential for the final strength of the re-engineered products.

A trial grading exercise has been carried out on data from the current data base and this demonstrated that acceptable yields of the higher strength classes (C24 to C35) can be achieved. The yields are based on the theoretical maximum that can be achieved although in practice the actual attainable yields will be slightly lower.



Contents



Introduction

This report covers the progress made in the first six month period for the following two projects:

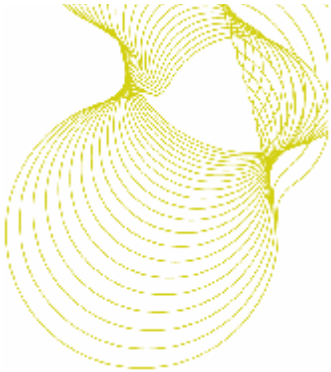
- Laminating Scots pine falling boards (FG10/05).
- Higher machine settings for Scots pine. (FG11/05).

For this reporting period the two projects have been combined into one report because much of the activity that has been carried out is common to both projects; as they are intimately linked, with regard to common sourcing of the raw material and the early processing activities.

Both projects are designed to increase the potential for Scots pine, identifying new markets and processes and improving the competitiveness of the UK sawmilling industry, and producers of the raw material.

The laminating of Scots pine falling boards stems from work carried out by BRE on the quality of Scots pine from the Cairngorms and Grampian regions of Scotland and builds on work undertaken by BRE to demonstrate the potential of laminating Sitka spruce falling boards. The work on laminating Sitka spruce clearly demonstrated that the strength of the raw material could be significantly improved by re-engineering and there is potential to add value to the resource. Scots pine has significant advantages over Sitka spruce for laminating as innately it is a stronger timber. More importantly Scots pine has a distribution of stiffness and density that is more appropriate to the timbers measured strength; unlike Sitka, where stiffness and density are invariably the limiting factors to the materials overall performance. Therefore, there is real potential to re-engineer Scots pine falling boards to meet specific high strength end uses that currently this material cannot achieve.

The derivation of machine settings for the higher strength classes for Scots pine results from a clearly identified need for more UK timber to be produced to meet the C24 strength class to counter competitive threats. Additionally higher strength classes (C27 to C35) are required to meet the increasing demand for laminating stock for products such as glulam. The machine settings for higher strength classes are required to keep the species competitive in an ever changing market place and open new added value markets for the material.



Description of the project

The two projects are intended to maximising the full potential of UK grown Scots pine across a range of possible products previously thought out of the scope of the UK grown resource. The aims are to demonstrate that not only are new markets possible but UK grown Scots pine can be shown to meet the new market demands either by re-engineering the material or through the derivation of machine settings that will result in higher strength classes for the timber.

Falling boards frequently represent the best quality timber produced from the log though due to the dimensions they are sold for low value end uses, either pallet wood or fencing. This low value offers potential to re-engineer the resource to make products for new markets that can add value to the original material and thereby attain higher prices. It has been clearly demonstrated that Sitka spruce falling boards can be re-engineered to produce simple laminated sections equal in strength to the C24 strength class. Scots pine offers greater potential as the material is stronger than Sitka spruce with a better distribution of stiffness and density both more in line with the strength characteristics. This offers the potential to produce high strength re-engineered products with minimal re-engineering input. One of the main aims of the project is to determine the mechanical and structural properties of the falling boards so that future products can be designed to meet specific end used

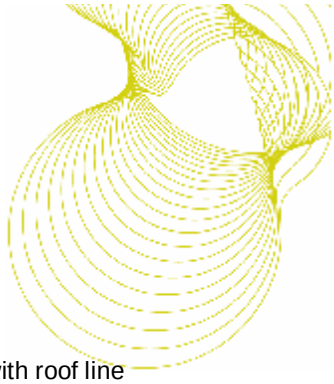
Structural applications for the material is one possible new market area but the use of re-engineered material for joinery applications will not be ignored, markets that will attract a premium for visually appealing yet dimensionally stable timber will be explored.

The second project to derive strength grading machine settings for the higher strength classes is aimed at better utilisation of the timber suitable for construction purposes. A data base will be generated as part of the project from which the machine settings for the GoldenEye will be derived. These settings will be for all current strength classes for UK grown Scots pine and the proposed higher strength classes as well. For bending type machines only the machine settings for the proposed higher strength class will be derived as the settings for the lower strength classes already exist. The derivation of the machine settings for the higher strength classes has a two fold objective and these are:

- To open new markets such as glulam where timber graded to the higher strength classes should be at a premium.
- To attempt to maintain the competitiveness of the UK sawmilling industry in response to the new machine settings for European redwood / whitewood in EN14081: Part 4[1].

For glulam use the higher strength classes (C30 / C35) would result in less timber being needed for a beam with the same structural performance as one made from C24 or lower strength class timber. This would reduce the size of the beam, particularly depth, reduce self weight and make the beam more economical to produce and use. The current drive within Europe is toward the use of such higher strength class timbers.

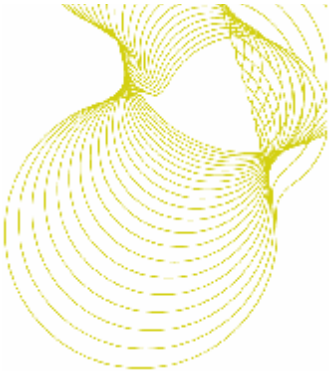
The growth in the use of attic trusses for both new build and loft conversions, which increases the usable internal space on a small building footprint is increasing but the bottom chord of these trusses tend to be disproportionately deep, needed to meet the floor loading requirements. This can lead to difficulties with roof line detailing. Therefore, to replace the current strength class used for the bottom chord with a C30 or



C35 strength class chord would reduce the depth requirement and ease the difficulties with roof line detailing.

Another possible market where a higher strength class would be beneficial for UK timber is in truss rafter manufacture. Currently there are no machine settings for UK timbers that produce TR26, predominantly the strength class for truss manufacture. Scots pine has the potential of being graded to meet the requirements of the TR26 strength class so opening the market to UK timber.

Evidence in BS EN 14081: Part 4 indicates that the Scandinavian's (including Estonia, Latvia and Russia) have a resource with an innate strength around the C24 strength class. This could, in the future, put pressure on the UK resource if methods are not found to increase the yields of C24 from the UK timber supply. Therefore, settings for the higher strength classes will make Scots pine more competitive in response to this threat.



Findings

Resource location and acquisition

The resource is common to both projects. After conversion of the logs the falling boards produced will be used for the re-engineering and laminating project and the structural timber produced will be used for the derivation of settings for the higher strength classes.

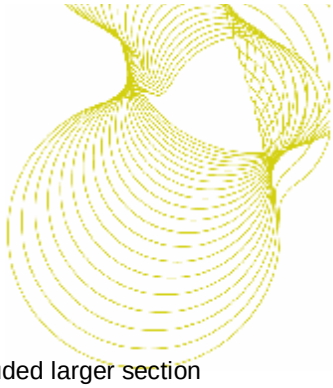
Great effort has gone in to obtaining material representative of the resource in its entirety from within Scotland and England. To date material has been sourced from 8 sites across Scotland some identified by BRE contacts and some via co-operation with Elspeth MacDonald of the Forestry Commission's Northern Research Station. Additional timber was supplied by James Jones to increase the sectional size of the timber being studied. The locations of the sources are as follows:

- Balmoral Estate – Aberdeenshire
- Alvie & Dalraddy Estate – Aberdeenshire
- Cawdor Estate – Moray
- Seafield - Strathspey
- Strath Carron – An FC site 40 miles north of Inverness
- North Strome – An FC site 60 miles west of Inverness
- Black Isle – FC site north of Inverness
- Deeside (supplied by James Jones large section 200mm and 225mm).

The logs from Balmoral, Alvie and Cawdor estates were provided for roadside collection. A local haulier was hired to collect and transportation the logs to either James Jones saw mill at Aboyne or Gordons saw mill at Nairne. Whilst the logs were at the roadside awaiting collection, staff from BRE colour coded the logs to identify the site of origin. However, due to seasonal weather conditions the collection process was delayed and collection was not commenced until the second week of March.

Once the logs were at the Aboyne saw mill and before conversion, staff from the Northern Research Station carried out stress-wave testing on the logs from Balmoral and Alvie estates to determine the characteristic stiffness of the timber in the in-log condition. Adding to the data collected by the Northern Research Station as part of their pine quality project. The appropriate grading data for this material will later be supplied to the Northern Research Station so they can carry out their evaluation of the stress-wave equipment. Timber from the Cawdor estate was delivered to Gordons at Nairne for sawing. On the 30th of March staff from BRE visited Gordons and tagged the battens produced so that they could be individually identified through the various stages of grading and testing.

On the 31st of March the material at James Jones was sawn and BRE staff marked the individual battens for later tracking through the grading process. Staff from the Northern Research Station was present to record the information they need for their future work.



Whilst at James Jones extra material from Royal Deeside was offered; this material included larger section sizes than were possible from the logs provided for the project, and relates to section depths of 200mm and 225mm.

The total number of battens produced by this exercise is of the order of 800, though a precise tally has not been made. All this material will be passed through the Microtech GoldenEye to collect the grading data needed to derive settings for that grading machine.

Additional progress on the re-engineering of falling boards project

BRE already held a supply of Scots pine falling boards from a previous project (Pine Quality project from the Cairngorms and Grampian region). This resource has been inspected to give some indication of the likely strength characteristics of the material as a whole. The majority of the material is below the minimum thickness (20mm) for carrying out an effective visual strength grading to BS 4978[2], as the knot area ratio (KAR) becomes increasing difficult to calculate the thinner the boards are. However, based on the size and location of knots it is possible to determine that this material is at the upper end of the quality range and could be attributed to the SS visual grade, which for Scots pine derived for structural use would meet the requirements of the C22 strength class. However, timber from falling board is known to be of better quality than the bulk of the timber converted for normal structural use, being generally slower grown with a straighter microfibril angle and therefore stiffer. This suggests that in reality the falling boards may well exceed the performance of the C22 strength class. However, due to the difficulty of accurately strength grading these boards the intention is to map structural performance to a visual appearance grade rather than a KAR in BS4978, which will make selection by scanning practical and effective.

Additional progress on the derivation of higher machine settings for Scots pine.

Settings for bending type machine

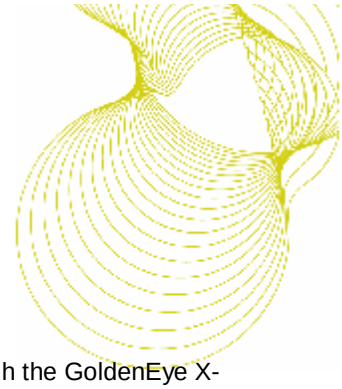
The machine settings for the higher strength classes for the bending type machines have been discussed with Mr A Fewell and he is currently working at producing these settings. He was responsible for the derivation of the machine settings for the EN338 strength classes for UK timber.

During the course of the project the settings for the higher strength classes will be used to evaluate the data from the Scots pine being tested. If the settings yield acceptable results, approval will be sought for their inclusion in BS EN 14081: Part 4. However, if it is thought there is potential to improve the yields by deriving settings based on a combined data base of the new and current data then this will be done and these new settings will be put forward for approval and inclusion in BS EN14081: Part 4. At this stage it cannot be guaranteed that the machine settings for higher strength classes will be accepted for inclusion in BS EN 14081: Part 4. That is a decision for CEN WG2.

The derivation of these trial settings is currently underway and it is expected that they will available for use by the time the material is cut and testing has commenced.

Settings for the GoldenEye X-ray machines

Discussions with Mr F Wilber of James Jones regarding the collection of data for the derivation of settings for the GoldenEye and the subsequent breaking of the test samples have taken place and the following arrangements are agreed.



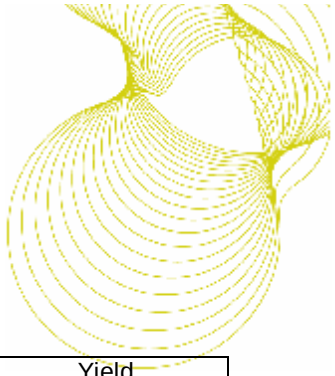
- All the material, both that sawn at Aboyne and other mills, will be passed through the GoldenEye X-ray strength grading machine. When this is done a technical representative of Microtech will be present to supervise the collection of the grading data from the X-ray machine.
- The grading data will be identified by individual piece number based on the unique identification code attached to every specimen by BRE.
- On completion of the X-ray grading the timber will be sent to BRE where it will be passed through a Cook-Bolinder bending type grading machine and the grading data collected. The material will then be destructively tested to determine strength, stiffness and density at an identified point appropriate to both BRE and the technical representative of Microtech. This will provided the matching strength, stiffness and density data to the appropriate grading data.
- Microtech will derive settings appropriate to the requirements of the sawmilling industry for the GoldenEye grading machine.

Theoretical grading

An exercise has been carried out to establish how well a trial sample of Scots pine would grade to the requirements of the strength classes C24, C27, C30 and TR26. This exercise is based not on derived settings but the actual strength requirements of the strength classes with regard to the test data. Such exercises usually result in slightly higher yields than are attainable in practice as the exercise maximises the yield by repeated iteration of the data to give the full theoretical potential: this is never actually attainable in practice but the exercise gives a good approximation of yield.

The sample was 175 pieces of section size 47mm x 150mm: the depth of 150mm was chosen as this conforms to the reference depth for EN338 strength classes and therefore the results needed no adjustment for depth. This data is actual test data derived from an exercise carried out to derive machine settings for the EN338 strength classes back in 1995 and was tested in full compliance with the requirements of the CEN strength classes.

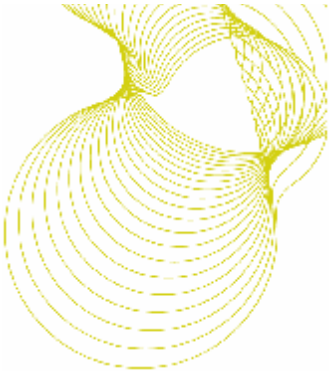
The aim of the exercise was to grade the sample to the requirements for each strength class such that the results met the target requirements for that strength class. The results of the exercise are shown in Table 1, along with the maximum possible yields.



Strength class	Characteristic strength (N/mm^2)	Mean MoE (N/mm^2)	Mean Density (kg/m^3)	Yield (%)
C24 strength class	32.49	13172	456	94
C24 target values	21.43	10450	420	
C27 strength class	24.1	13463	458	86
C27 target values	24.1	10925	450	
C30 strength class	27.29	13791	461	76
C30 target values	26.78	11400	460	
TR26 strength class	25.26	13587	459	84
TR26 target values	25.26	10450	450	

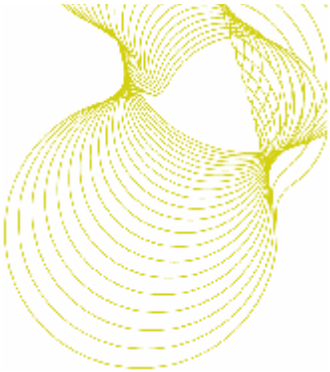
Table 1. Results for the trial grading of the 47mm x 150mm Scots pine

The results in Table 1 shows that there is potential to achieve high yields for these strength classes, though in practice they will be a little lower when derived by machine settings. The encouraging feature of these results is that stiffness and density was appropriate for the measured strength, and whilst this had been assumed it is encouraging to have this confirmed. The mean stiffness in all cases was well above the target values for the respective strength class and density was in line with strength. These results compare well with those for European redwood / whitewood, which is a demonstration of the potential of the UK grown Scots pine.



Conclusion and recommendations

1. The material so far collected and supplied from Scotland is believed to accurately reflect the supply of Scots pine in that geographical area.
2. Material from England still needs to be acquired and this is underway.
3. The material should provide sufficient falling boards for the study into mechanical and structural properties and the initial manufacture of demonstration products but more may need to be sought later when the full range of products are being manufactured.
4. The 800 battens, when combined with the data from England, will form a sufficiently robust data base for the derivations of machine settings for both the GoldenEye X-ray and bending type strength grading machines.
5. The data collected will also give a very clear indication of the yields that can be expected for the higher strength classes based on the new settings.
6. Within Scotland the quality range is well covered from the high quality represented by material from the Balmoral estate to what is believed to be poorer material from the Black Isle. The size range of the pieces is also sufficient to cover the range of sizes needed for the derivation of structural properties.
7. The initial grading of Scots pine falling boards that were already held at BRE indicates that a high percentage will meet the SS visual grade and this for Scots pine can be attributed to the C22 strength class. However, it is believed that when the mechanical and structural properties of the falling boards are tested they will exceed the C22 strength class. Re-engineering will further enhance their structural properties.
8. To make best use of the material and make automated sorting of the boards possible the mechanical and structural properties will be determined based on an appropriate appearance grading rather than the KAR method in BS 4978. This will allow high speed optical scanning for board selection for re-engineering purposes.
9. The trial grading carried out on current data for the Scots pine supply as a whole indicates that acceptable yields of the higher strength classes can be achieved and these may be comparable with the yields achieved by the Scandinavian's grading European redwood / whitewood combinations.



References

1. British Standards Institution 2005: Timber structures – Strength graded structural timber with rectangular cross section, BS EN 14081: Parts 1 to 4: 2005, London.

2. British Standards Institution 1996: Visual strength grading of softwoods, BS4978:1996, London.