UBC

Ainsworth

Conversion of MPB Sawmill Residuals to Flakes for OSB

by

Kenneth Lau, Ritch MacDonald, Robert Loth, Kim Marshall, Peter Woodbridge and Frank Lam

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Abstract

The project investigated the five principal areas where materials suitable for OSB flake production are generated within a typical BC Interior spruce-pine-fir (SPF) sawmill.

These materials are referred to (for convenience, in this report) as *sawmill intermediate residual materials* (SIRMs). They comprise (1) green log end trims (2) the initial breakdown of the green log into slabs (3) green rough lumber edgings (4) green rough lumber trim ends and (5) kiln dried planed lumber trim ends. ‘Green’ refers to materials prior to kiln drying.

For sawmillers, SIRMs are vital to their overall processing economics and net wood costs. Revenues derived from SIRMs, along with other residuals such as sawdust, shavings and hog fuel, contribute substantially to sawmills’ profitability. In 2004, further processed SIRMs and other residuals contributed around 40% of BC Interior region lumber producers’ net earnings. SIRMs involve stumpage costs per m3 at the full rate charged for the sawlog. Thus, optimizing revenues from these materials is vital to sawmills.

In the BC Interior region, most SIRMs traditionally have been further processed by sawmills into by-product pulp chips. Recent wide fluctuations in demand as well as contract and spot prices for residual pulp chips have motivated independent sawmillers to seek alternative products and/or markets for these materials. Kiln dried, planed trim blocks are already pulled by many sawmills and provide a valuable revenue stream, while enabling higher aggregate lumber recovery factors to be achieved (i.e. via finger joint lumber production).

The economic rationale for the study anticipated that some parts of the sawmills’ SIRM volume could provide a mutually beneficial alternative income stream to the SIRM seller and provide a lower cost raw material for a new group of buyers. More specifically, for OSB producers, SIRMs may be able to offer a potentially lower cost alternative wood source to whole log chipping. Bio-fuel chip buyers may be another.

Samples of Mountain Pine Beetle (MPB) affected SIRMs were collected from a representative group of random length and stud sawmills which agreed to take part in the experiment.

Two technology options were used to convert the materials into OSB flakes. Two equipment suppliers cooperated independently and at arm’s length from each other in the experiment. They were Carmanah Design and Manufacturing Inc., located in Vancouver, British Columbia, Canada, and B. Maier Zerkleinerungstechnik GmbH, located in Bielefeld, Germany. In order to produce laboratory-scale samples of OSB flakes, the former utilized traditional flaking technology and the latter utilized a new, two-step “maxi chip” technology.

Both technologies were successful in producing commercial quality OSB flakes from the MPB impacted timber five sample groups. In addition, both equipment suppliers immediately noted the low (15-30%) moisture content of the green/unconditioned MPB impacted SIRM samples. This was due, in part, to the time of year (summer) chosen for the experiments and also to transportation time involved in sending the samples to the testing laboratories. However, another contributory cause was the nature of MPB killed timber wood quality itself. Three to five year old standing dead MPB timber has experienced a significant loss of moisture. Dry wood produces a higher percentage of pan and slivers, which ultimately has negative economic implications.

Carmanah and Maier each modified their equipment settings (knife angles and machine speeds) to best suit the samples before commencing their trial runs. Maier water-conditioned or soaked a portion of the samples to reduce the proportion of pan and slivers in the samples tested.

The final results showed that green rough lumber end trims processed through a one-step modified disc flaker produced the highest quality OSB flakes results – and, in fact, produced an ideal OSB strand in a laboratory setting. These results, along with preliminary research into the economics of extracting, handling and transporting green rough lumber end trims to an OSB mill equipped with a modified disc flaker, lead to the conclusion that this opportunity holds potential for further steps in commercialization.

Acknowledgments

The project sponsors wish to thank the various people and organizations who participated in this study.

Sawmill participants provided the project with MPB-killed timber lumber samples for testing. They allowed the extraction process of these samples to be monitored at their sawmills and they provided estimates of in-process costs and materials transportation. Financially they, along with Ainsworth Engineered Canada LP, contributed towards the project budget. Without the cooperation of these firms this study would not have been possible, and their participation is acknowledged with sincere thanks.

They include Apollo Forest Lumber Products, Carrier Lumber, Dunkley Lumber, Lakeland Mills, L & M / Nechako Lumber, Stuart Lake Lumber and Winton Global. All are located in the Quesnel-Prince George-Vanderhoof region of the BC Interior.

The wood samples were consolidated and readied for shipment to Germany and Vancouver, respectively, at the Wood Enterprise Centre warehouse in Quesnel, BC. The staff at the Centre did an outstanding job of packaging the samples.

OSB industry participation comprised a significant contribution of time and technical advice from Ainsworth Engineered Canada LP, which is located in BC. The firm’s cooperation and strategic and technical guidance throughout the project is very much appreciated.

Woodbridge Associates Inc. was sub-contracted by UBC to carry out project management, the collection of test samples from the participating sawmills, liaison with the two testing laboratories, economic analyses and report writing.

The project sponsors would also like to acknowledge the work of two globally recognized OSB flake equipment manufacturers which operate independent fibre sample testing laboratories and which were contracted to carry out the fibre tests – and to thank them for their cooperation and project results. They are Mr. Robert Loth and the team at B. Maier Zerkleinerungstechnik GmbH located in Bielefeld, Germany and Mr. Ritch McDonald, and his team comprising Mr. Todd Macey, Mr. Carlos Vieira, Mr. Alvaro Urrutia and Ms. Monica Alvarez, at Carmanah Design and Manufacturing Inc., located in Vancouver, BC.

The project team owes its thanks to the project team leader, Dr. Frank Lam of the University of British Columbia and to the UBC Timber Engineering and Applied Mechanics Group.

Finally, thanks are due to the project sponsor – Forestry Innovation Investment Ltd. (FII).

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1.0 Introduction

The Mountain Pine Beetle (MPB) epidemic in British Columbia is having a wide range of environmental, social and economic impacts. New products and new market solutions are being sought for the very substantial volumes of standing dead MPB-killed timber that now exist. In addition, where MPB-killed timber can help reduce costs in already existing products, technologies and/or processes, these opportunities will become important to maintaining their competitiveness.

When used for processing into lumber, the economic shelf-life of standing dead, dry MPB-killed lodgepole pine timber is as yet unknown. Several studies are currently underway on this vital subject. For the purposes of this report, the economic interests of the BC Interior sawmilling industry are being addressed through the evaluation of the technical and economic suitability of MPB-killed timber residual by-products to reduce the net wood costs of SPF sawmills, and to provide a lower cost fibre supply base to the province's OSB industry.

More specifically, the principal fibre by-product of the region's sawmills in the past has been pulp chips. This study looks at the technical and economic suitability of creating new and alternative markets for sawmillers' residual fibre. The opportunity exists in concept to divert some portion of the rapidly expanding stream of sawmill residual fibre into OSB flakes.

This report evaluates the logistics of separating this stream of residual fibre for the OSB industry. It provides some preliminary economics of doing so. Importantly, the principal focus of the study is the laboratory test results of converting the fibre to OSB flakes.

1.1 Definitions

Sawlogs are converted partly into lumber and partly into sawmill residuals. Lumber recovery factors (LRFs) refer to the volume of solid sawn lumber recovered from the log. Chip recovery factors (CRFs) refer to the volume of residuals (specifically, in this case, pulp chips) recovered. The two vary in inverse relationship with each other. Historically, in BC at least, the highest economic return to sawlogs has been derived by maximizing the volume of lumber recovered.

Lower valued sawmill residuals include *bark and hog fuel*, which have generally rising economic values (depending on mill location and other factors) in end-use applications such landscaping and – importantly – in bio-fuel and energy production, often via cogeneration.

Intermediate and higher valued residuals range from *sawdust* (used for pulp making and, in some regions, for MDF and particleboard) to *planer shavings* (used, in BC, for wood pellet production and heating kilns in several regions for high and medium density fibreboards – MDF/HDF). In BC, at least, the top position on the residual fibre price hierarchy traditionally has been held by pulp chips. Positions within this hierarchy appear to be changing.

Within BC Interior SPF sawmills, the flow of lumber and residuals output from the sawlog is illustrated in Chart 1. The high level of global competitiveness of the BC Interior sawmilling industry is achieved, in part, through constant attention to increasing LRF values – and reducing net wood costs through sales of by-product residuals to end-sues which are capable of accepting and using (a) the high volumes produced by the region's very productive sawmills and (b) high prices for these residuals.

As illustrated in the the chart, the primary breakdown process seeks to maximize LRFs. Subsequent diversion of trim blocks (after the planer) achieves a secondary recovery for lumber – which may occur either in-mill or at third party plants producing finger-joint lumber.

Material for chipping into pulp chips occurs at every stage from the primary breakdown to green and dry end trimming. Chip n'Saw technology, for example, produces this material directly from the log. Depending on the sawing technology being used (head rig band saws are typical for the region), other mills may produce pulp chips (along with sawdust and shavings) at various other stages in the process.

The potential to divert material such as green log end trims, slabs, edgings and trim ends for OSB flakes is shown conceptually in the flowchart.

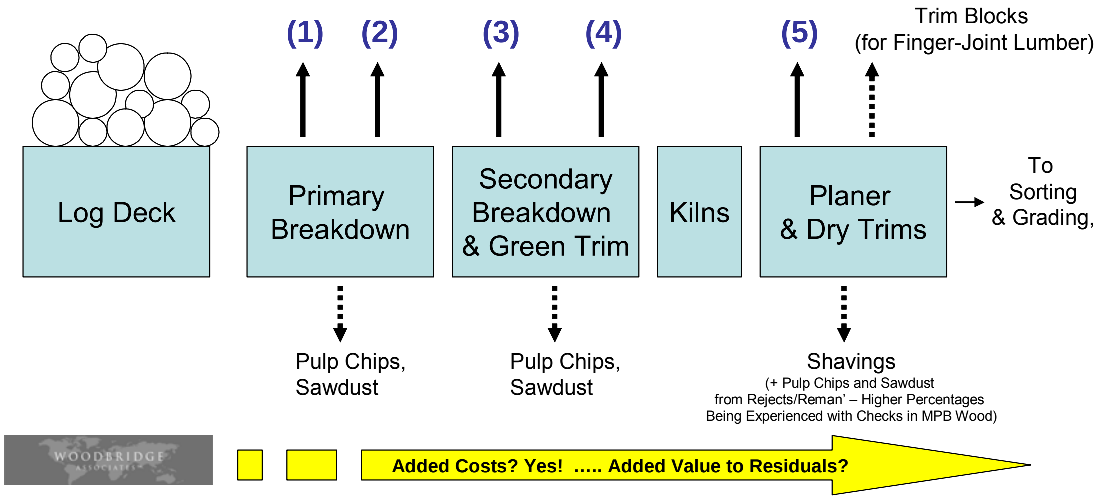
Chart 1

Flow Chart for Extracting Sawmill Intermediate Residual Materials (SIRMs)

BC Interior Region

Samples of SIRMs Collected for Testing

(1) Green log end trims
(2) Slabs
(3) Green lumber edgings
(4) Green lumber trim ends
(5) Kiln dried lumber trim ends.



1.1.1 Targeted Residual Materials – SIRMs

The project investigated the five principal areas where materials suitable for either pulp chip or OSB flake production are generated within a typical BC Interior spruce-pine-fir (SPF) sawmill.

These materials are referred to (for convenience, in this report) as *sawmill intermediate residual materials* (SIRMs). They comprise:

(1) green log end trims

(2) the initial breakdown of the green log into slabs

(3) green lumber edgings

(4) green rough lumber trim ends and

(5) kiln dried planed lumber trim ends.

'Green' refers to materials prior to kiln drying.

1.1.2 MPB-Killed Timber

Throughout this report, references are made to *MPB-killed timber* and *MPB sawmill residues*. The Mountain Pine Beetle (MPB) attacks pine stands in the region – and predominantly affects Lodgepole Pine (LPP). This is part of the spruce-pine-fir commercial grading definition. References to MPB-killed timber may refer to SPF logs processed by the industry.

1.2 Economic Perspective on the BC Interior SPF Sawmilling Industry

For decades, BC Interior and BC Coast market pulp and paper mills have purchased the bulk of residual pulp chips produced by BC Interior spruce-pine-fir (SPF) sawmills. This has been a key public policy platform in the utilization of Crown timber to develop a balanced and inter-dependent forest economy in the region.

Surpluses of pulp chips to the province's needs typically have been exported to US and offshore markets. Historically, the BC market pulp and papermaking sector has provided some of the highest available prices for the BC Interior region's various sawmill residual fibre by-products (pulp chips, sawdust, shavings and hog fuel).

One of the impacts of the current Mountain Pine Beetle (MPB) epidemic in the BC Interior region has been a surge in the volume of MPB infected salvage-timber harvested – and it has created the opportunity for local sawmills to increase their lumber capacity. The subsequent increase in lumber production has been significant. Residual fibre by-product output also has increased dramatically.

In early 2006, the MPB timber driven surge in BC Interior sawmill residual production initially caused a significant imbalance in the region's historical fibre supply-demand equilibrium. Pulp chip prices declined sharply. Sawmill operating incomes dropped sharply. Pulp chip buyers initiated new contractual relationships with SPF pulp chip sellers.

Later in 2006, however, buoyant softwood market pulp (NSBKP) demand globally led to rapidly rising market pulp prices. Simultaneously, BC sawmills reduced their lumber and residual fibre production in response to a cyclical downturn in US housing markets. BC Interior pulp chip markets swung rapidly from a surplus of chips to a shortage. In late 2006/07, whole log chipping became necessary to meet the increased needs of BC Interior market pulp mills as they operated close to capacity.

Against this economic backdrop, and rapid changes pulp chip demand, prices and income, BC Interior sawmillers in 2006 began to search for alternative markets for their sawmill fibre residuals. One of the opportunities identified was the potential for sawmills to supply MPB affected log trim ends, slabs, edgings and other material for the production of OSB flakes.

The economic rationale was that OSB mills, which currently utilize a whole log chipping process, could instead use a portion of OSB flakes produced at lower cost from these sawmill intermediate residual materials (SIRMs). Technically, OSB mills appear able to use these residual materials. But there were various technical and economic unknowns on the sawmilling supply-side. These were the focus of this study.

1.3 Economic Perspective on BC's Pulp and Paper Industry

BC's pulp and paper sector is comparatively large. It is focused mainly on market pulp production in the BC Interior and market pulp and paper-making on the Coast. The sector is highly dependent on virgin fibre sources for its feedstock – the vast bulk of which is supplied by the province's wood products manufacturing industry.

BC's pulp and paper sector obtains only a small part of its wood fibre needs from roundwood chipping. It is highly dependent on residual fibre sources obtained from the province's lumber, plywood and other wood product mills. As already noted, this interdependence is mutual. Sawmills need the pulp and paper industry for residual fibre sales revenues. The two sectors have grown hand-in-hand over many generations.

Today, fibre supply to the province's pulp mills is meeting increased competition from alternative uses. These are small in volume compared with the pulp and paper sector's needs – but are growing. Potentially they include fibre used for bio-fuels and a variety of wood-based structural products, such as OSB.

Experience in other countries has shown that, as aggregate fibre demand grows, the domestic pulp and paper sector's dominant and principal position on the fibre-use hierarchy can be down-graded. In Germany and Scotland, for example, sectors consuming fibre who have long been used to having the primary call on these supplies are now having to compete with other buyers – some of which can pay higher prices.

Closer to BC, the pricing of the full hierarchy of fibre sources in Washington State and Oregon is much higher on average than in the BC Interior where the opportunity cost of this fibre traditionally has been low – and the market pulp sector has been the dominant and often only user.

The temporary surge in MPB-timber availability is expected to be followed by sharply declining annual harvest levels in BC's SPF forests. This almost certainly will create a significant level of competition for wood fibre in the region, at some date in the future.

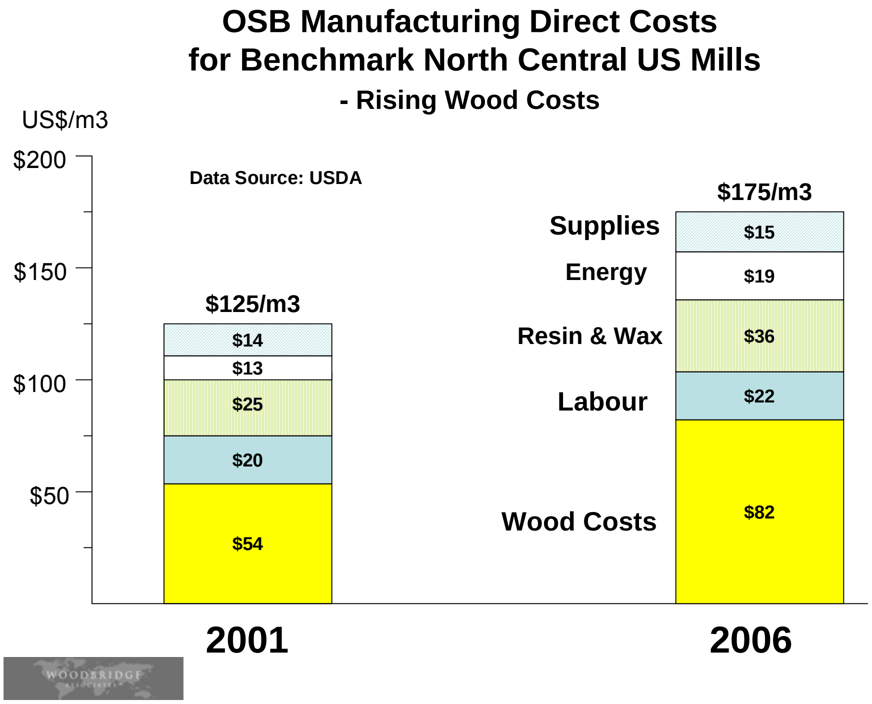
1.4 Economic Perspective on the BC Interior OSB Industry

BC-based and/or BC located oriented strand board (OSB) producers and mills, such as Ainsworth, Canfor, Canfor-LP and Tolko are among the world's leading producers. The industry is an important successor to plywood production in the structural panels manufacturing sector.

It is able to use both hardwoods (the dominant feedstock to date) and softwoods (which are the target for announced future capacity expansions). Wood costs are a high proportion of total OSB costs – representing around 47% of direct costs in 2006 for benchmark North American mills, based on USDA data.

Chart 2 shows that wood costs, in absolute terms and as a proportion of direct costs, are gradually rising for benchmark mills. Principally because of rising wood costs, and higher costs for resin and energy, total manufacturing costs for OSB in North America have risen sharply. Larger scale mills have contributed significantly to lower fixed costs per unit of output, but excess capacity in the current market down-cycle has led to sharply lower mill net prices. It is clear that market cycles will continue to influence OSB prices.

Chart 2



This suggests that the global competitiveness of BC's export focused OSB capacity very much depends on (a) the elimination of excess North American marginal capacity and (b) the ability to reduce wood and energy costs. Conceptually, OSB flakes produced from SIRMs may be able to contribute to the sector's cost competitiveness. Strand thickness and orientation can help reduce resin costs.

Currently there are a few mills where sawmill residues are converted to OSB flakes. However, as noted in this report, existing technology is available and new technology is being developed that potentially could make it economically viable to convert sawmill residues into OSB flakes. This could also assist in reducing wood costs.

1.5 MPB Fibre –The Opportunity

From the perspective of the OSB industry, the increasing volumes of MPB fibre available for processing are a potential capacity growth opportunity. With considerable excess OSB manufacturing capacity at the present time in North America, and cyclically very low OSB market prices, the timing of any further capacity expansions would be a critical investment decision.

Compared with dimensional SPF lumber, however, OSB suffers none of the product quality problems (e.g. checking) associated with the production of SPF lumber from MPB-killed timber. Moreover, the dryness and brittle nature of the aged, standing dead MPB-killed timber are not a major disadvantage to the OSB manufacturing process.

In the aftermath of the MPB epidemic, the full extent of the economically accessible future timber supply in the BC Interior is unknown at this time. The annual allowable cut (AAC) and financially feasible harvest outlook are uncertain.

It is estimated that 80% of BC Interior's vast Lodgepole Pine (LPP) forests will be either dead or killed by the Mountain Pine Beetle (MPB) over the next several years. During the last five years significant volumes of MPB-killed timber well above the AAC have been made available to the forest industry. While the commercial shelf life of MPB-killed timber is uncertain, it is expected that for the next 5-10 years higher than normal volumes of timber will be available to the BC Interior SPF sawmills and other wood users.

2. Material and Methods

2.1 Material

This study utilized samples from four random length and several stud sawmills in the Quesnel-Prince George-Vanderhoof corridor. The samples were gathered at random during June 2006, at which time the winter log decks were very heavy to 3-5 year old grey-attack MPB-killed lodgepole pine timber.

The samples were collected at five machine centers where SPF random length and stud sawmills convert logs and lumber into residual wood chips. These five centers were:

1. Log deck trim saws which generate green/unconditioned log trims.
2. The initial/primary breakdown of the log within the sawmill which generates green/unconditioned slabs or wood chips, if a chipper header is utilized.
3. Sawmill lumber edgers which generate green/unconditioned lumber edgings.
4. Lumber trim saws before the sawmill J bar sorter which generates green/unconditioned rough lumber end trims.
5. Lumber trim saws before the planer J bar sorter which generates kiln dried/conditioned planed lumber end trims.

While the kiln dried lumber trim ends have a relatively consistent moisture content (MC) of around 16-19%, the other sample groups had a considerable variation in MC. Before the MPB epidemic occurred, green live timber typically would vary from 50-80% MC. However, today the timber delivered to the log deck can vary from green (i.e. alive), through MPB red kill/dead < 1 year, or MPB grey kill/2 plus years standing dead. The MC in green/unconditioned MPB timber can now vary from 15% to 80%. The volume of each sample was approximately 100 kilos (5 sample groups X 100 kilos = 500 kilos).

The samples were consolidated at the Wood Enterprise Centre warehouse in Quesnel. The samples were sorted, cut to length to fit a 42"x 38" pallet, weighed then loaded on to pallets, labeled and then strapped/shrink wrapped. The samples for Maier were also checked for any external bark, which not permitted for shipments to the European Union (EU).

The shipment to Maier required methyl bromide fumigation and Canadian Food Inspection Agency (CFIA) inspection and documentation (phytosanitary certificate). Samples were delivered to Carmanah in early July 2006, while Maier's samples were air freighted in late July.

2.2 Test Methods

The goal was to test the MPB timber-killed materials (SIRMs) supplied, under two alternative stranding technologies, to ascertain if these materials are suited for producing OSB flakes, and to maximize the proportion of wide width (0.5" and wider) flakes keeping pan and slivers to a minimum.

2.2.1 Carmanah Design and Manufacturing Inc.

Scope of Testing

The initial plan proposed the following procedures:

1. Samples will be stranded as is, without conditioning.
2. Will use a 40 degree counter-knife angle.
3. Target strand thickness will be 0.028" (0.7mm).
4. Target strand length will be 4" (100mm).
    - Will take a 12" (300mm) cut and use scoring knives to create 3 separate strands.
5. Samples will be cut with the following orientation:
    - Trim ends which will be stacked parallel to knife edge.
    - Rounds will be placed parallel to knife edge.
    - Edgings and slabs will be stacked as grabbed rather than placed and ordered within the cutting chamber
6. Will be simulating the inner and outer knife speeds of the 37/118 SmartDisc strander
    - Average knife speed of 40m/s

Procedure Adjustments

In the event, the following adjustments were made.

- Carmanah modified the infeed to its laboratory disc flaker and experimented with different machine speeds. It found the best results by running the test using two speeds [73' & 127'/sec.] to mimic the inside and outside speeds of a disc flaker. Carmanah used 12" long knives. Normally a commercial disc flaker would run at about 100'/sec. inside and 150'/sec. outside and use 36" long knives.

- Carmanah used a 40 degree "gentle" knife angle. The objective remained to generate flakes 4" long and .028" thick.

- A portion of the samples were sprinkled with water as the summer weather was hot and dry. This was done as an attempt to maintain the current MC, not to condition the samples (Table 1).

Table 1

MC Information	Avg.
Trim Ends Dry	13% (Min 11, Max 15)
Trim Ends Green	76% (Min 42, Max 108)
Edgings	12% (Min 11, Max 13)
Slabs	85% (Min 80, Max 104)
Rounds	68% (Min 58, Max 78)

Source: Carmanah

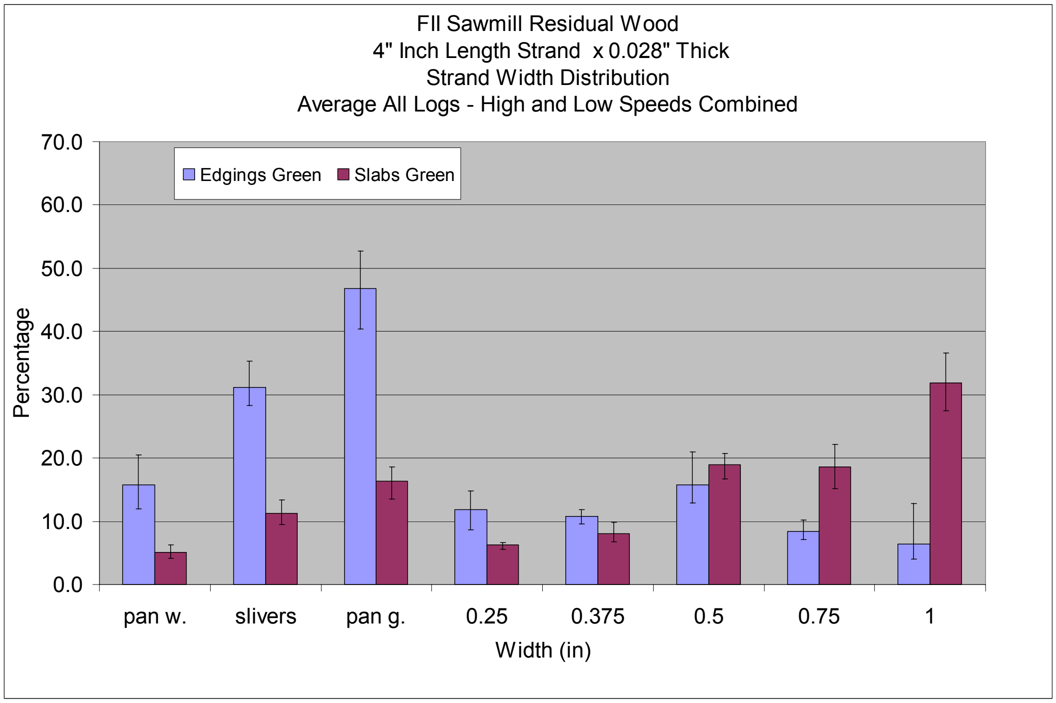
Carmanah looked at two separate speeds on the lab disk strander and used 5 separate samples for each of the residual wood groups. Although there were often strong differences between the samples of the same group, the average of the samples was very consistent between the two speeds.

- Stacking the in feed to the laboratory disk flaker was under ideal conditions.
  - The trims [green and dry] were the easiest to handle and run.
  - The edgings were difficult to align. The log ends were easy to align.
  - The slabs were a bit of a challenge to align. Also it was noted that the samples appeared to be fairly uniform [48", little/no taper] which might not be representative.

2.2.2 Carmanah Results

The results of the Carmanah tests are summarized below, with test parameters inset.

Chart 3



In Chart 3, Carmanah lab tests show that green edgings had a very high percentage (47%) of pan and slivers, while green slabs had a significant portion of desirable wide strands ~70% > 0.5".

Chart 4

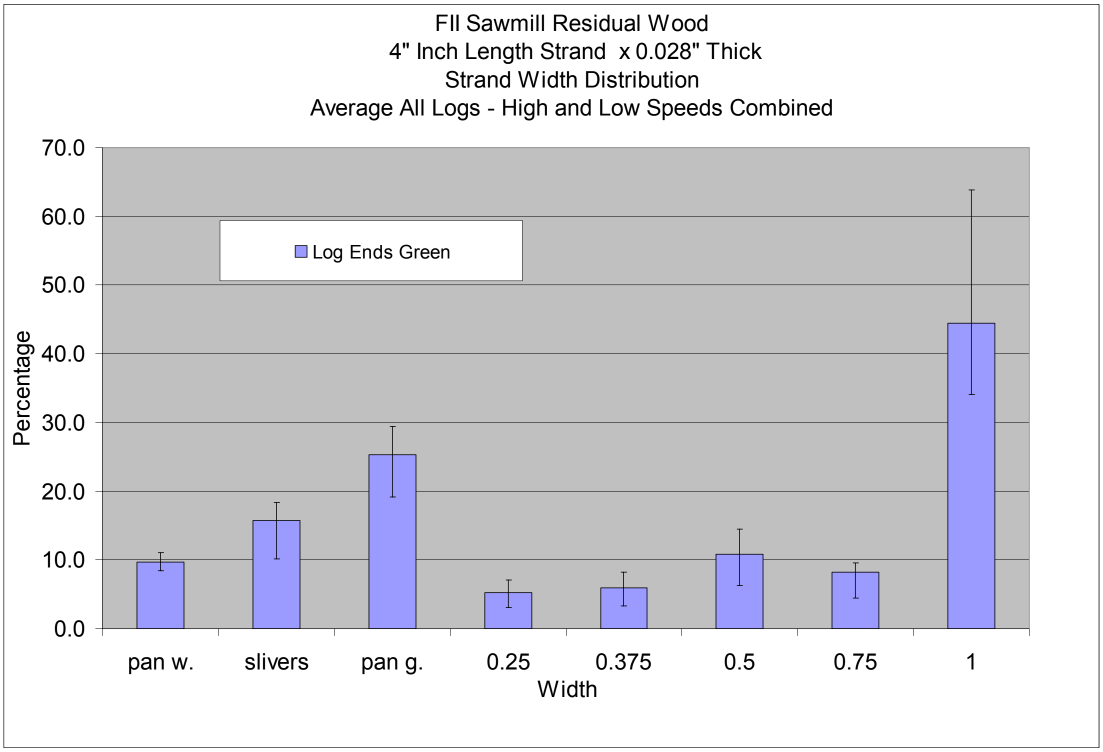
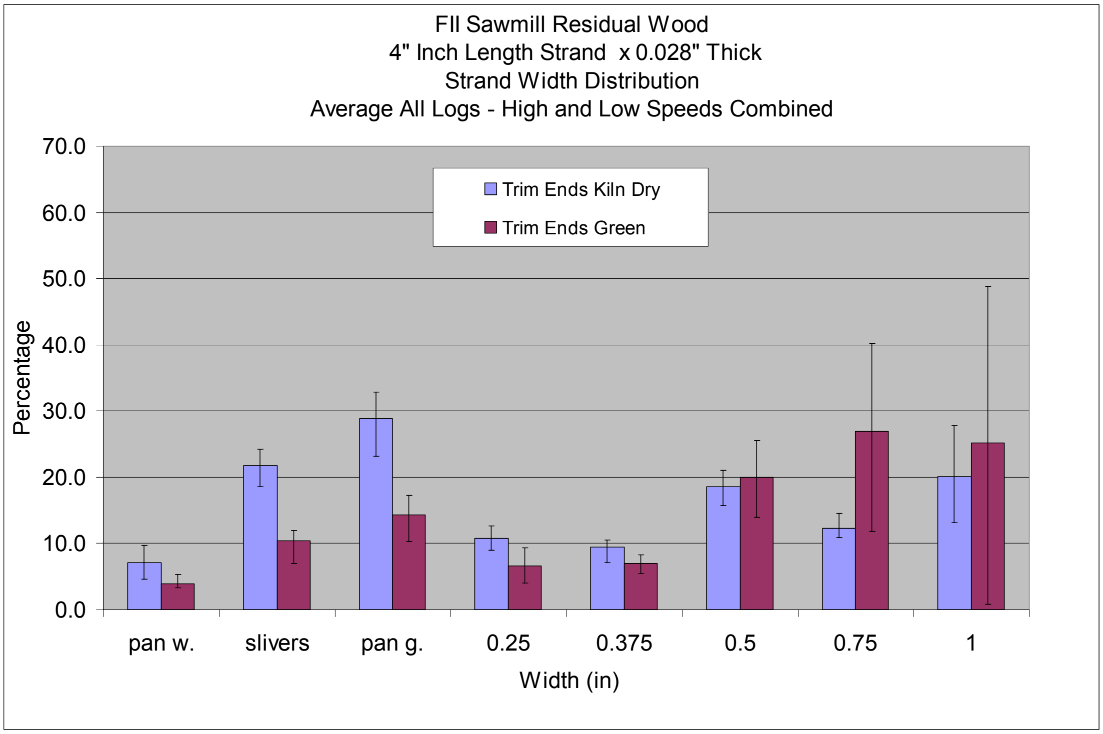


Chart 4 shows that green log ends produced 25% pan and slivers, and 64% of > 0.5"strands.

Chart 5



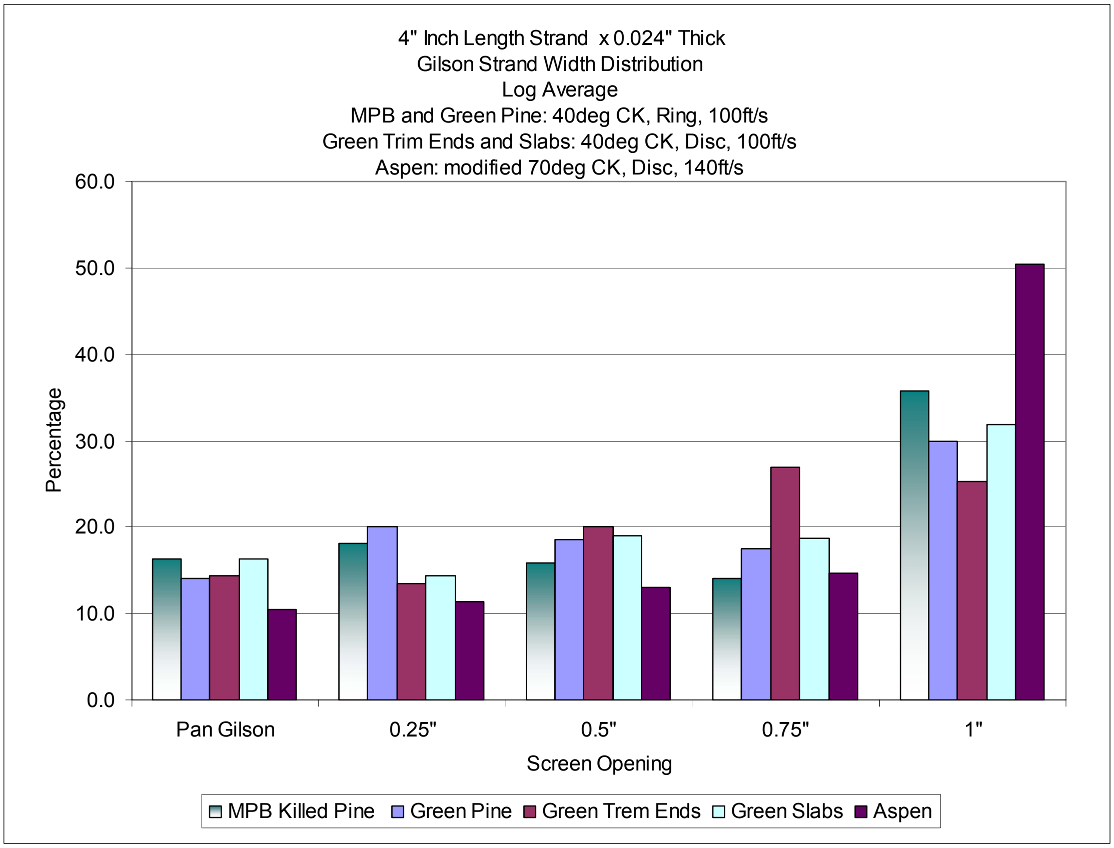
In Chart 5, Carmanah lab tests showed that green rough lumber trim ends produced a lower percentage of pan and slivers compared with kiln dry trim ends (13% v. 29%) and a higher percentage of >0.5” material (72% v. 60%).

Taking the two best lab results; namely,

- Green lumber trim ends and slabs

and comparing these, in Chart 6, with aspen (from a previous test) shown for comparison, it is apparent that green lumber trim ends had the second best result.

Chart 6



source: Carmanah

Both aspen and MPB-killed pine provided the highest proportion of wides – notably 1” strands.

Other test results and supporting data from Carmanah are shown in the Appendices.

<u>Cautionary Note About the Transfer of Laboratory Results to the Field</u>

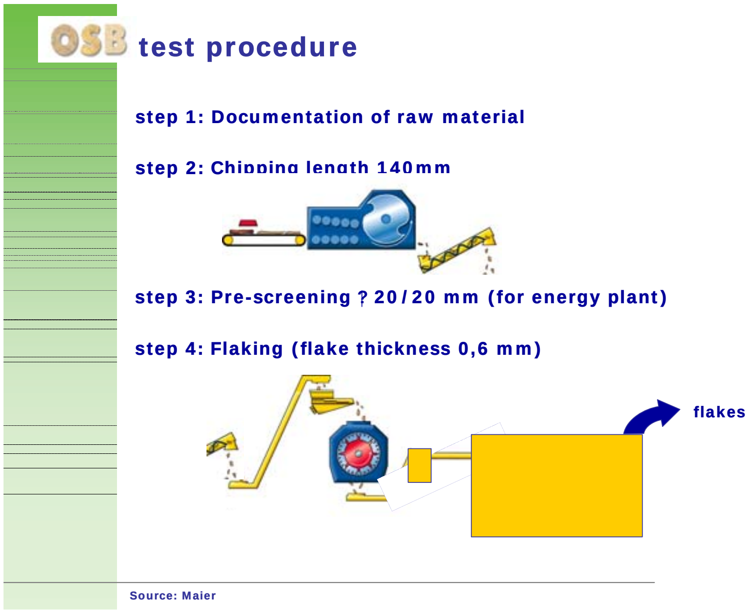
These results are generated in a laboratory situation. Users of this report should note that these results may not necessarily be replicated in the field.

2.2.3 Maier Zerkleinerungstechnik GmbH

Scope of Testing – Two Step Process (Maxi Chip, OSB Flake)

Maier's test procedure is illustrated in Chart 7.

Chart 7



test procedure

step 1: Documentation of raw material

step 2: Chipping length 140mm

step 3: Pre-screening ? 20/20 mm (for energy plant)

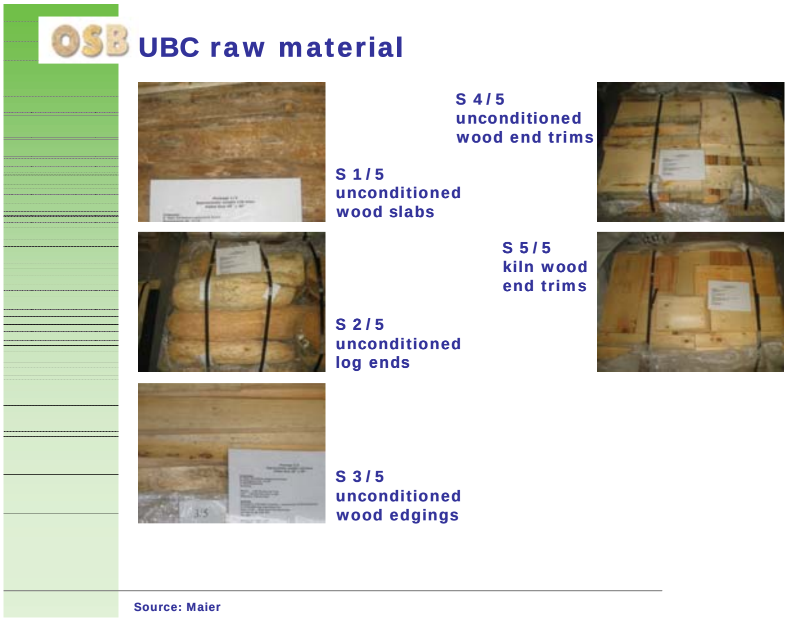
step 4: Flaking (flake thickness 0,6 mm)

Source: Maier

The initial plan proposed the following procedures:

1. Measure raw materials: Dimensions, weight and moisture content.
2. Process raw material through laboratory drum chipper to make 20mm x 20mm "maxi chips". Target maxi chip length 140mm. Target drum cutting speed 9.03 m/s.
3. Hand screen for 20mm x 20mm maxi chips. Separate out the "small fraction (bark, minerals, fines) material" after drum chipper.
4. Process "maxi chips" through Maier strand flaker. Maxi chips are pressed to the knives by centrifugal forces. These forces align the maxi chips in a way that the fibre becomes parallel to the knives. Knife angles 35 degrees. Target cutting speed is 42m/s. Target flake thickness is .05 to .07mm.

Chart 8



UBC raw material

S 1/5 unconditioned wood slabs

S 2/5 unconditioned log ends

S 3/5 unconditioned wood edgings

S 4/5 unconditioned wood end trims

S 5/5 kiln wood end trims

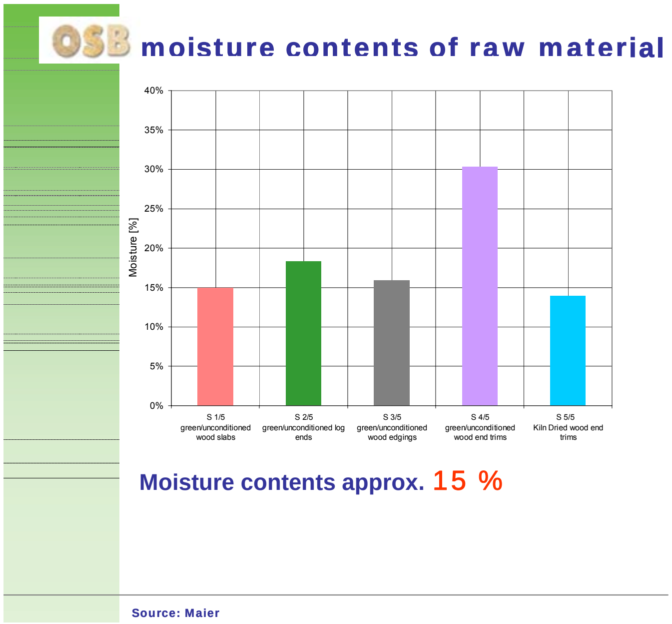
Source: Maier

The raw material received by Maier is shown in Chart 8.

Procedure Adjustments

When Maier measured the raw material, it found the average moisture content ranged from 13.9% (kiln dried lumber trim ends) to 15.0 - 30.3 % for the green/unconditioned samples (Chart 9).

Chart 9

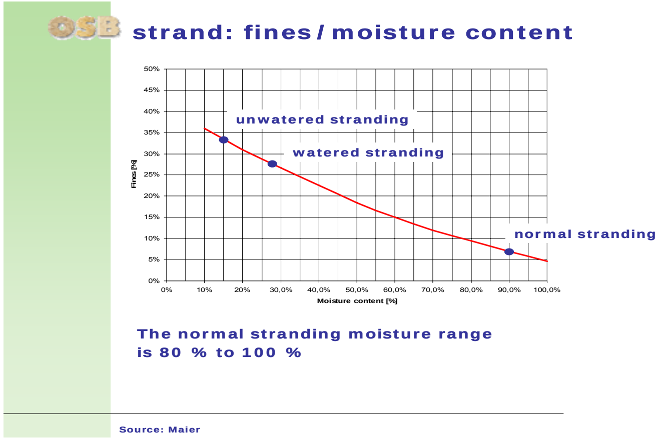

moisture contents of raw material

Moisture contents approx. 15 %

Source: Maier

- The normal MC for green live fibre is 60-100%. Wood this dry will generate a much higher percentage of fines.

Chart 10


strand: fines / moisture content

The normal stranding moisture range is 80 % to 100 %

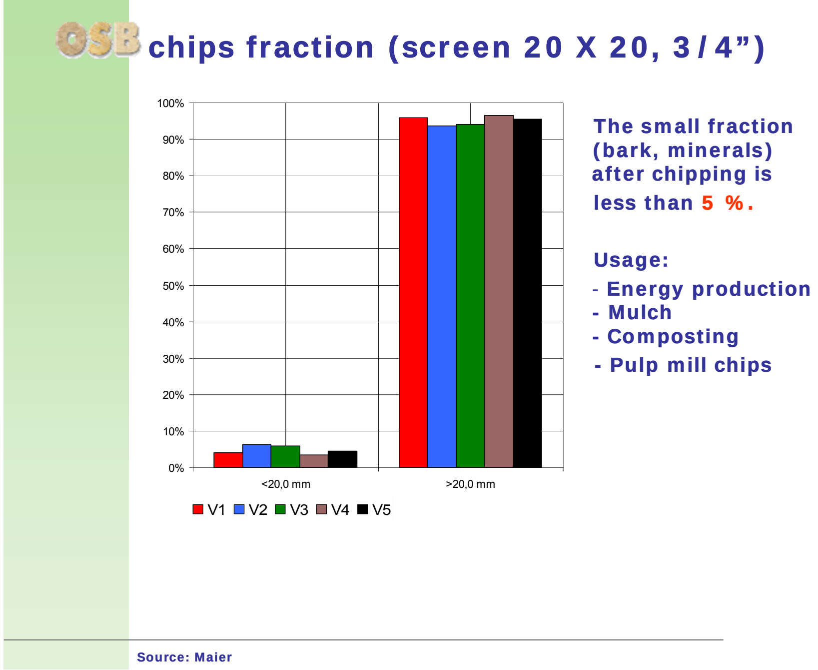
Source: Maier

- To simulate a much higher MC the samples (Chart 10) were divided into to parts *after* the drum chipper. One portion was watered in a box for approximately 1 hour. The water *does not* penetrate to the inner part of the maxi chips; it is only on the surface. The water works as a surface lubricant.

- The lab drum chipper and Maier strand flaker targets were maintained as above.

- The screening process for “small fraction material” after the drum chipper came to about 5% (Chart 11).

Chart 11



OSB chips fraction (screen 20 X 20, 3/4”)

The small fraction (bark, minerals) after chipping is less than 5 %.

Usage:
- Energy production
- Mulch
- Composting
- Pulp mill chips

Source: Maier

2.2.4 Maier Results

All samples were labeled as follows (Table 2).

Table 2

Labeling of Samples

1) V1.1 - Green Slabs Unconditioned Unwatered
2) V1.2 - Green Slabs Unconditioned Watered

3) V2.1 - Green Log Ends Unconditioned Unwatered
4) V2.2 - Green Log Ends Unconditioned Watered

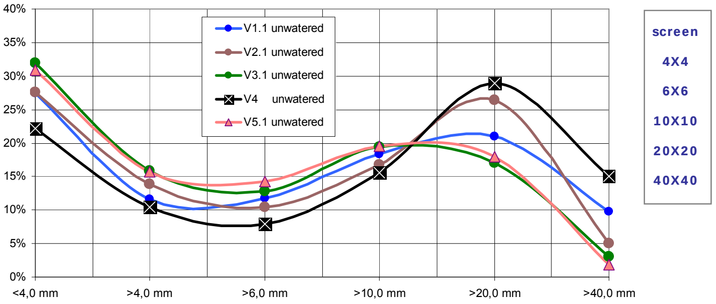
5) V3.1 - Green Edgings Unconditioned Unwatered
6) V3.2 - Green Edgings Unconditioned Watered

7) V4 - Green Trim Ends Unconditioned Unwatered

8) V5.1 - Dry Trim Ends Unconditioned Unwatered
9) V5.2 - Dry Trim Ends Unconditioned Watered

Chart 12

strand fraction

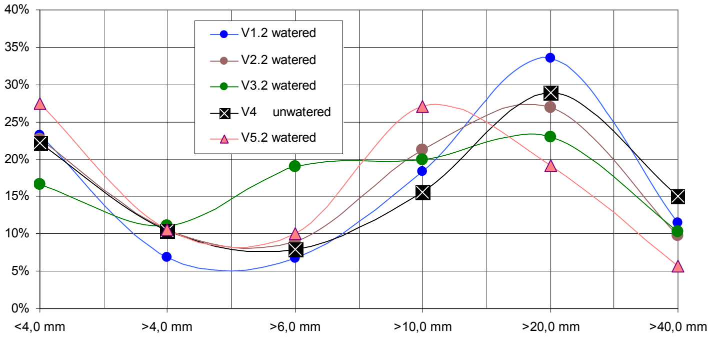


Result:
Because of the relativly low moisture content of approx. 15 % the fines < 4mm are relativly high

Source: Maier

Chart 13

influence on fines by watering the chips



Result:
Fines are up to 10% less

Source: Maier

Other test results and process steps used by Maier are shown in the Appendices.

Cautionary Note About the Transfer of Laboratory Results to the Field

These results are generated in a laboratory situation. Users of this report should note that these results may not necessarily be replicated in the field.

2.3 Material Measurement (at UBC)

2.3.1 Comparability

Screening studies of strands generated from the Maier and Carmanah processes were conducted by Maier and Carmanah, respectively. The results are reported in their respective reports, as noted above.

An important issue for the study was exact comparability of the test results.

One of the challenges in comparing the results of various OSB flake equipment manufacturers worldwide is that there are no established international standards for OSB flakes. There is no "right" system or "wrong system" as such, but simply differences in approach and equipment.

Since it was important to be able to compare the (UBC) FII test sample results using the same measuring equipment (Gilson Sieve Classifier and a Williams Classifier – used to process the Gilson Pan material) the Maier strands were returned to Canada to be processed through the Carmanah Gilson/Williams Classifier.

Like many European firms, Maier measures its flakes with another process which uses metric screen sizes which are slightly different from the Gilson/Williams imperial sizes. There are other equipment differences. The North American system, for example, vibrates up/down while the European system rotates.

In fact, each OSB manufacturer may have its own internal flake parameters based on issues, such as the raw material (flake dimensions -length, width and thickness), flake alignment/orientation, resin, wax, density, species and so on. It is the OSB panel itself which has to meet a set of national/international standards and these can be reached by a variety of variables.

Equipment manufacturers cater to the OSB manufacturers' requirements/instructions while at the same time trying to add value by improving flake dimensions and so on.

UBC Procedures

The strands obtained by the Maier stranding process were shipped back to Canada and re-screened by UBC personnel using the Carmanah equipment.

Differences can be noted in the various test results which can be affected by a number of factors, such as: the raw material stranded by Maier was much dryer because of significant moisture loss during transportation between Canada and Germany in summer time, breakage of strands during transportation back to Canada, differences in screening equipment (rotation based versus up-and down vibration based system), differences in stranding process etc.

The Carmanah's stranding results would be representative of the laboratory setting while the Maier's results would be more representative of a mill prototype setting. One should use caution and exercise judgment in the interpretation of the results.

The UBC re-screening procedure involved the following steps:

1) Thoroughly mix strands to ensure even distribution of strands and fines.

2) 3 x Ten litre samples were collected from the strand pile and then screened using the Gilson Sieve Classifier.

3) The weight (g) of the material retained by each screen size was recorded.

4) The material collected in the Gilson Pan was then reclassified using the Williams Classifier to get slivers (material retained by the 3/16" screen) and true fines (material retained by the Williams pan).

5) The weight (g) of the material retained on the Williams 3/16" screen (slivers) and the pan (fines) was recorded.

All samples were labeled as shown previously.

Lab Raw Data: Maier Flakes Screening by UBC

Chart 14

Figure 1- V1.2 Mixed pile of strands obtained from slabs watered sample

Figure 2 - William's Classifier 3/16" screen

Figure 3- William's Classifier pan

Gilson Sieve Screener (sample picture).
Screens used in this study are:

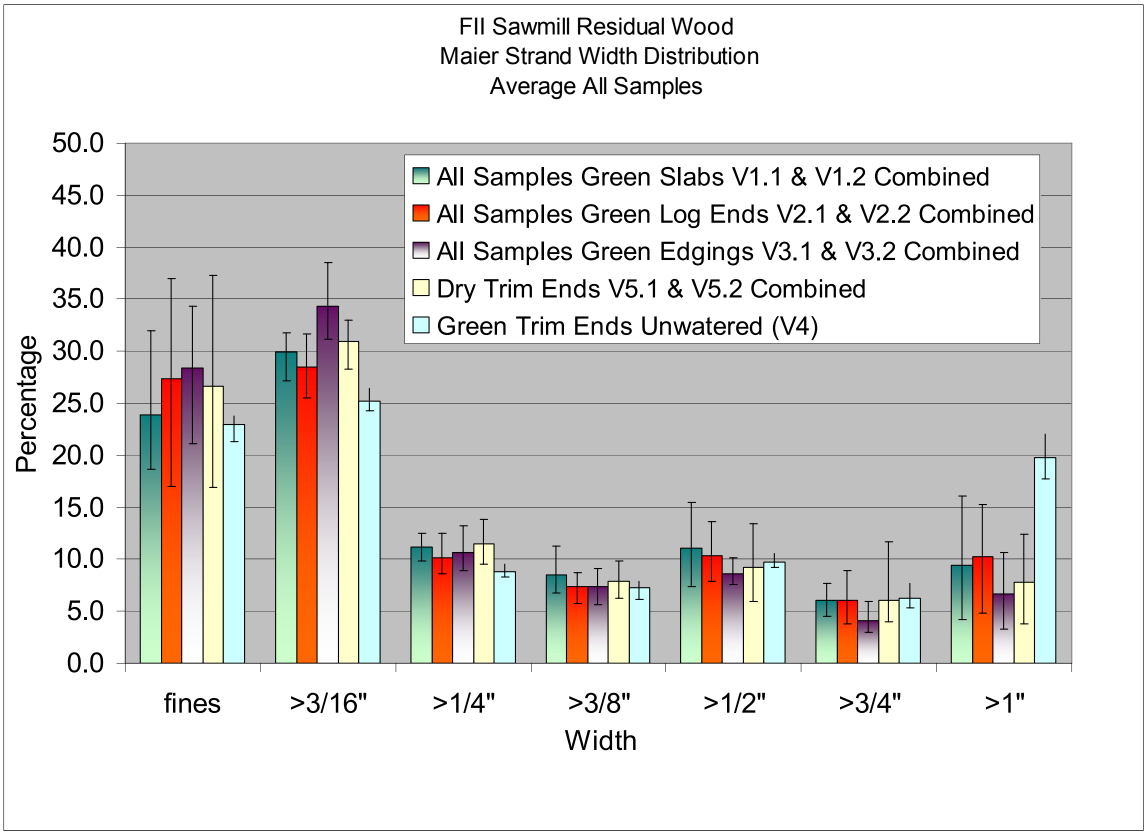
1", 3/4", 1/2", 3/8", 1/4", pan

William's Classifier (sample picture)
Screens used in this study are:

3/16", pan

Note : Additional data are shown in the Appendices

Chart 15



Carmanah and Maier's sample flakes were both measured using the Gilson Sieve Classifier. The material collected in the Gilson Pan was then reclassified using a Williams Classifier. This produced directly comparable results, but subject to the above comments and caution.

The outcome is that this test produced a comparatively high proportion of pan and slivers (fines and >3/16") and a lower proportion of wide strands (Chart 15).

Furthermore, Carmanah results were also compared to similar measurements for aspen logs, green LPP logs and MPB LPP logs.

The initial measurements had been focused on flake width. However other flake dimensions such as thickness, and length to be considered. UBC conducted a thickness, width and length variation measure survey of Carmanah and Maier's test strands.

Note again the difference in target lengths: Carmanah 100mm and Maier 140mm. A direct comparison is a challenge.

Cautionary Note About the Transfer of Laboratory Results to the Field

These results are generated in a laboratory situation. Users of this report should note that these results may not necessarily be replicated in the field.

Strand Geometry Measurement Procedures and Analyses

See Appendix.

3.0 Results and Discussion

3.1 Fibre Samples

While the log ends produced the highest percentage in 1” strands it was noted that many of these strands were over 1” wide and not ideal for OSB flakes. With the current SPF log trimming methods there is not a large volume of material available. There are also issues of debarking and handling. It was decided that log ends should be dropped from the priority list.

Dry trim ends produced a higher percentage of pan and slivers and a lower percentage of 0 .5” 0.75” and 1” strands when compared to green trim ends and slabs. It was also noted that while many or most of the interior SPF sawmills have already set up systems to pull dry trim ends they are currently sold to finger joint stud mills. Therefore it was decided that this should not be a primary focus item.

Edgings produced the highest percentage of pan and slivers, plus the lowest percentage combined total of 0.375” 0.5” 0.75” and 1” strands. This material is difficult to handle and to align to the disc face. The initial indications from the sawmills was that there are significant volumes of edgings, but the challenges of how to effectively handle and transport is a concern. It was decided that this material should not be a primary focus item.

Slabs produced relatively good results [pan/slivers vs. flakes]. The SPF sawmills indicated that this is by far their biggest source of residual fibre. However, in almost all random length [RL] sawmills, profile chippers instantly convert slabs to wood chips. This is done at high speeds at the initial breakdown of the log. To modify an RL sawmill to produce slabs and then remove them from the mill would involve significant engineering and capital.

However it was noted that stud mills and a few RL sawmills do produce slabs that go through the mill and could be separated. Handling and transportation of slabs would take present some challenges but not insurmountable ones. It was decided that slabs at selective sawmills [mainly stud] could have some potential and should be part of the primary focus.

Green trims ends generated the best overall results.

Green end trims generated the best overall results. There is a significant volume in the RL sawmills (not stud mills). Green trim blocks are mainly generated just before the J-bar sorter in the sawmill therefore they are relatively easy to access.

Furthermore BC SPF sawmills have been through the process of collecting, handling and transporting their dry trim blocks. It is relatively easy step to use this experience for green trim blocks. It was decided that green trim blocks should be the primary focus for the next steps.

3.2 Test Conclusions

An important overall conclusion is that these are test results and caution should be exercised in interpreting the comparisons.

Both technologies were successful in producing commercial quality OSB flakes from the MPB impacted timber five sample groups.

In addition, both equipment suppliers immediately noted the low (15-30%) moisture content of the green/unconditioned MPB impacted SIRM samples. Dry wood produces a higher percentage of pan and slivers, which ultimately has negative economic implications.

Carmanah and Maier each modified their equipment settings (knife angles and machine speeds) to best suit the samples before commencing their trial runs. Maier water-conditioned or soaked a portion of the samples to reduce the proportion of pan and slivers in the samples tested.

The final results showed that green rough lumber end trims processed through a one-step modified disc flaker produced the highest quality OSB flakes results – and, in fact, produced an ideal OSB strand in a laboratory setting. These results, along with preliminary research into the economics of extracting, handling and transporting green rough lumber end trims to an OSB mill equipped with a modified disc flaker, lead to the conclusion that this opportunity holds strong potential for further steps in commercialization.

4.0 Economics

4.1 Caveat to Cost, Price and Investment Estimates

The study goal was a pre-assessment of the economic viability of the concept. It should be recognized that, at best, this can only be preliminary in nature. No markets currently exist for the targeted materials at OSB plants so, as a result, no actual market prices or indicators are available. No mills in Canada currently are separating the targeted materials specifically for OSB flakes production, so no capital costs or operating cost benchmarks are available that might provide indications of the likely costs, or the investment payback.

Moreover, any market prices that might develop for the targeted materials, and any operating costs involved in producing them, are expected to be highly localized and site-specific. They could vary widely, even within the same region due to variations in factors such as fibre availability, fibre quality, mill layout/configuration issues, operating costs of individual mills, opportunity costs of the fibre at the sawmill, transportation costs to the OSB plant, the opportunity costs at the OSB mill, incremental capital costs for additional equipment at the sawmill and OSB plant and various factors, including operating risks (e.g. fibre security).

Correspondingly, all estimates provided in this section should be viewed in the above context. Interested firms should carry out their own assessments based on site-specific empirical data. The following estimates are broad order-of-magnitude data only, and should be used with caution.

4.2 Fibre Supply Availability & Assumptions

The first critical issue to be addressed is this*: "Is there enough raw material of the desired type available?"* Clearly, the answer is site-specific. For the purpose of this study, the study team selected the heavily MPB-impacted region of Vanderhoof-Prince George-Quesnel in the BC north central Interior region. This is appropriate based on a number of factors, including a current proposal to locate a new state-of-the-art OSB mill in the region at a site that, so far, has not been announced.

For simplification of the study economics, and in order to have a defined point of reference for delivery of the targeted materials, a hypothetical OSB mill site was chosen located midway between Quesnel and Prince George. Within the targeted fibre supply region for the hypothetical OSB mill, several lumber manufacturing firms which operate sawmills locally, collaborated in the study.

4.2.1 Confidentiality

Although the lumber producing firms involved in this study have been identified in the *Acknowledgements*, (see front of this report), all proprietary and/or confidential data provided to the study team has been aggregated as a group total – in order to protect the identity and competitiveness of each firm.

4.2.2 Matching Fibre Supply to Disk Flaker

A useful starting point in the economic evaluation was to match the scale of a disk flaker to the available fibre. The ideal would be to operate the equipment on the same basis as the remainder of the OSB mill.

The flaker could be run on a one-shift or two-shift basis. However, this would affect the comparative importance of the SIRM OSB flakes supply within the whole mix of fibre available to the OSB mill, and the financial payback to the investment would take longer. On a one-shift or two-shift basis, SIRM OSB flakes most likely would be regarded by the OSB mill as a supplementary supply, produced on a batch basis versus the continuous flow basis used for roundwood flaking.

Assuming continuous flow operation, SIRM OSB flakes potentially could provide a more significant proportion of the typical fibre requirements of a state-of-the-art OSB mill. It has been estimated that a disc flaker will produce approximately 20 oven-dry tons (ODTs) of OSB flakes per hour. Based on 24 hour day and 340 operating days, the flaker would consume about 87.6 million FBM equivalent of SIRMs per year, at full efficiency (source: Carmanah Engineering).

The three random length mills in the sample group produce the following aggregate volume of rough green trim end (Table 3), based on projected 2008 data and sampling of SIRM volumes.

Table 3

Estimation of Green Trim Ends Production for Selected Group of Three RL Sawmills

	Lumber Production Million FBM/y	**Chip Output** Thousand ODTs/y	**Estimated 12" L Green End Trim Production** Mfbm/y		**Total Annual Green Trim Volume** NET '000 FBM/y	Scenario B **Total Annual Green Trim Volume** NET '000 FBM/y	Scenario C **Total Annual Green Trim Volume** NET '000 FBM/y
			2"	1"			
Total	1,021	541	32,012	1,940	**24,087**	**33,952**	**~35,853**
Number of "Typical" Participating Mills Required to Meet OSB Flaker Requirements at Capacity [87.6 Million FBM/y]					**10-11**	**7-8**	**7**

Source: Woodbridge Associates Mill Survey (and Carmanah Engineering fibre requirement estimates)

The table shows that these three representative random length lumber mills typically expect to produce a total of 24,087 MFBM/y *net* of rough green trim SIRM volume – or 27.5% of the annual needs of a single line disk flaker. On this basis, the output of ten or eleven typical sized RL sawmills would be required to produce enough volume to keep the disk flaker operating at full capacity. In the Vanderhoof – Prince George – Quesnel region, there are a significant number of random length mills able to meet this requirement. Conceptually, the necessary volume could be met from the area.

A sample of three (3) random length sawmills produce sufficient volume of green end trims annually to meet 27.5% of the needs of a single line disk flaker operating at full capacity.

This volume assumes, however, that the sawmills are not optimizing at the green trim for OSB flake production. If they did, more volume could be produced but it would require a significant commitment of capital and changes in operating procedures.

The sawmill survey estimated the typical *existing* volume of various types of SIRMs produced at the sawmills involved in the sample. If OSB flakes become a commercially attractive residual by-product alternative to pulp chips, it is quite possible that these and other sawmills in the region would be able to produce additional volumes of green rough trim ends, above the volumes indicated in the sample. In the post-MPB-attack era, this is quite plausible scenario.

The opportunities to increase this volume are:

1. Sawmills could convert to a much heavier trimming program at the J-bar.

   A preliminary assessment of lumber trim end volumes at one of the mills indicated that, in the light of MPB associated quality problems and consequent lower grade recovery, the mill potentially could trim at 6% of the throughput volume. In this case, there could be a 50% increase in volume, or a total of 33,952 MFBM/y from these three representative mills in the sample (Scenario B, Table 3). Seven to eight "typical" sized mills in the region would be required as suppliers to the OSB flaker.

   In the content of the volume of MPB wood available, and the associated within-mill processing and LRF problems being experienced with the pine beetle, an even higher volume scenario could become possible. More specifically, instead of dropping all the broken lumber pieces directly onto belts and into the chipper, operatives could move them back through the sawmill to the J Bar trim saw.

   In addition, when dealing with MPB wood, many of the planer trim blocks don't make finger-joint (FJ) grade for numerous reasons. These include knots, split, heavy wane and so on. This volume also could be directed to the OSB plant.

   The material involved is dry and there would be more fines. But this material could blend in well with other OSM flake material. In most mills within the region the appropriate equipment for handling the volume already exists. The equipment could catch the FJ rejects and drop them into a separate bin. Contractors could pick up the bins and deliver them to the OSB mill.

2. If the price for rough green trim blocks is higher for OSB flakes than for pulp chips, an additional incremental volume could be come available. This is shown as Scenario C in Table 3. The full annual participation of around seven "typical" sawmills in the area would be required.

3. More sawmills could be added to the program. Based on current lumber production levels, for example, there is an estimated additional volume 1billion plus FBM/y of suitable material conceptually available in the immediate region, from existing sawmills.

4.2.3 Economic Evaluation of Fibre Supply

Without an established and diversified market (such as exists with pulp chips) for SIRM volumes dedicated to OSB flake customers, it can be expected that not all sawmills would necessarily be interested in changing their operating procedures to produce this material. In this respect, based on the estimates shown in Table 3, diversion of SIRMs for OSB flake production likely would not involve a substantial incremental revenue item if priced at today's market price for pulp chips. However, there are other issues.

From the perspective of an OSB mill seeking to procure this fibre, it seems potentially problematic to expect that the buyer would want to commit (in the conservative case shown in Table 3) to around ten to eleven mill contracts in order to obtain what essentially is a *customized sawmill residual by-product.* Moreover, ultimately this supply would represent only a portion of the OSB mill's total fibre requirements.

However, as already noted, much depends on the opportunity costs involved. For the sawmills, the opportunity cost to them would be the price that could be obtained from the same fibre sold to the next best alternative use, after adjustments are made for any other direct costs and capital and overhead costs involved for the sawmill. This could be pulp chips. Or, if future economics work out favourably in energy generation applications, bio-fuel chips could be a possible high revenue end-use for SIRMs.

For the OSB mill, the opportunity cost of SIRM OSB material delivered to the OSB mill would be the cost of fibre obtained from whole log chipping on the same delivery basis, after adjustments are made for any other direct costs and capital and overhead costs for the OSB mill.

Pulp Chip Prices

Pulp chip prices in the BC Interior have fluctuated quite widely over the past two years in particular. Also, at various times in the past (e.g. 1995) there have been very sharp spikes in market prices followed by significant price declines. From the viewpoint of sawmill owners, pulp chip *prices* are only one aspect of their significant existing commitment to market pulp mills and to their exports of chips to other regions, such as customers on the BC Coast and offshore. An additional vital issue is the *level of contractual commitments* for this residual by-product by the buyer.

Pulp chip buyers have the capability to absorb the most, but not all, of the very large volumes of SIRMs produced annually by the BC Interior sawmilling industry. These buyers are large volume customers for sawmills and, as already noted (see *Introduction*), chip revenues are an important source of income. But exports to the BC Coast and offshore are important markets for the surplus volume not further processed by the BC Interior market pulp (and paper) industry.

BC Interior sawmillers' interest in alternative markets for their SIRM volumes increased rapidly during early 2006. At that time, many independent sawmillers were informed of a new relationship by their traditional market pulp mill buyers in the BC Interior. Due to a rising surplus of wood chip availability associated with the MPB epidemic timber harvest and lumber expansion, several market pulp mills re-wrote long established chip-purchase contracts.

Chip prices, which had been around C$75 per ODT in early 2006, declined very suddenly to around C$35-C$40 per ODT by mid-year. Worse still, many independent sawmills were left without a market for their pulp chip volumes.

By late-2006, the situation surprisingly had reversed itself. Rapidly rising market pulp prices globally (NBSKP) created a shortage of pulp chips – and prices rose to around their current quarterly level of C$65-$80 per ODT. Strong offshore demand, as well as domestic demand growth, resulted in the early 2006 "pulp chip surplus" turning quickly into "pulp chip shortage" by year-end. It continues today because many sawmills are taking significant downtime, and some are closing permanently.

Pulp chip contracts no longer represent the automatic 'security blanket' that they once were for independent or captive (i.e. integrated) BC Interior sawmills. Production of pulp chips carries more risk for most sawmillers than it did historically.

Our interviews indicate that sawmillers in the region are reasonably content with current prices and demand for pulp chips, but still have a significant interest in seeking longer term alternative markets for some part of their SIRM volumes. Along with bio-fuel options (woodlands "biomass waste" and reject sawlog material), SIRMS re-directed to end-uses such as OSB flake producers are of considerable interest to them.

A preliminary supply proposition for OSB flakes can be deduced from this situation:

$$Sf = f[(Pf - Pp) + (Df - Dp) + (Cf - Cp) + \Delta R]$$

Where Sf = supply of OSB flakes
Pf = price of OSB flakes
Pp = price of pulp chips
Df = demand for OSB flakes
Dp = demand for pulp chips
Cf = costs of producing OSB flakes
Cp = costs of producing pulp chips
ΔR = differentials in financial and operating risks

Of these factors, each has already been discussed above. In view of recent history, one of the most significant decision factors for sawmills is likely to involve the differential that they perceive in financial and operating risks (ΔR).

4.2.4 Operating Costs

Sawmill: Fibre Costs

As already noted, revenue from the sale of sawmill residual fibre is critical to the income and viability of sawmills. In 2004, further processed SIRMs and other residuals contributed around 40% of BC Interior region lumber producers' net earnings (source: PricewaterhouseCoopers 2004 cost study for the Council of Forest Industries [COFI]). With the very low North American lumber prices that prevailed in Q1 2007, chip revenue income was the only item that kept many mills in business. Sawmillers have long memories, and do not want to give up this income easily without some reliable commercial assurances.

Based on the most likely opportunity cost for sawmills, the assumption used in this report is that the NET FOB sawmill price for SIRMs sold for OSB flakes would approximate the NET FOB sawmill price for pulp chips. These can vary widely at any point in time, depending on supply and demand.

OSB Mill: Fibre Costs

As noted in Chart 2 in Section 1, wood costs also are critical to the economics of OSB manufacturing. The cost of logs delivered for whole log flaking at any specific existing or planned OSB mill clearly is unknown at this stage. For the purposes of this study, the following estimates are provided:

Assumed long term average price for whole logs for flaking (debarked)	= $35/m3
Current prices (month of March 2007) for SPF chips	= $34/ m3 (~$85/BTU)
SPF (this region) chip price 1 year ago (March 2006)	= $16/m3 (~$40/BTU)

Source: Trade estimates

Current Prices

At current pulp chip prices, there appears to be no financial incentive for the OSB mill to seek supplies of sawmills SIRMs, for the purpose of flaking them for OSB. At $34 to$35/m3, both "prices" are about the same, even before any incremental operating and capital costs (sawmill and OSB mill) are taken into account. In addition, the price of heavily infested MPB logs for whole log flaking is reported as likely to be decline in 2007.

However, a year ago, the picture was very different. Pulp chip prices varied throughout the BC Interior, but generally were around $16/m3 in the target area. After adding $5/m3 for transporting SIRMS to the OSB mill, the estimated price of $21/m3 would have provided a gross $14/m3 financial incentive for the OSB mill to purchase them. Net of any incremental capital cost amortization and any incremental operating cost increases, it would seem that a financial incentive would exist a year ago.

Clearly, SIRM transaction prices will vary widely and would be subject to negotiation. The actual price could be substantially lower, or it could be much higher depending on a variety of factors.

From the perspective of an OSB mill which is purchasing sawmill SIRMS at the chip-price-equivalent, there would be few additional direct costs because the cost of flaking would be the same in both cases. However, because some incremental capital equipment would be required at the OSB mill, depreciation costs would have to be deducted from the price paid to the sawmill for the fibre.

These data indicate a broad gross differential of around C$10-$15/m3 in favor of SIRMs, prior to the additional deprecation costs as noted. However, based on the assumption that the buyer would be responsible for transportation costs to the OSB mill, these costs would also have to be deducted from the estimated purchase price of fibre. Costs of C$9-14 per mfbm have been estimated for shipment from representative sawmills to a hypothetical OSB mill located between Prince George and Quesnel.

4.2.6 Capital Costs

Capital costs are a complicated area, because there are so many variables to consider. Several simplifying assumptions have been made.

Sawmills

Green Trim End Collection:
Some capital costs would be involved in collecting green trim ends and separating these from other SIRMs destined for the chipper (i.e. pulp chips). These costs will vary widely, depending on mill configuration and proximity to the green trim end storage bin. A capital cost of around C$500,000 per line has been assumed. For a two-line sawmill, this would represent a capital commitment of around C$1 million.

It should be noted that several independent finger joint lumber operators, which collect kiln dried trim blocks from random length sawmills, have supplied bins and loading equipment – at no capital cost to the sawmill. This could be a negotiation option for the OSB mills. But, within the sawmill, there are additional capital (and operating) costs for separating out this material and delivering it to the storage bin. These incremental capital costs would have to be recovered in the selling price.

KD Trim End Collection:
Most mills in the region already have this type of system in place – as part of their finger joint trim blocks business. Correspondingly, no additional capital costs are assumed for this option.

Loading Equipment:
The current loading and transporting system used for kiln dried trim blocks is assumed likely to be suitable for loading the SIRMs for shipment to the OSB mill.

Per Unit Capital Costs:
Amortization per unit depends on throughput volume. This can vary widely, and likely would be lowest for larger scale mills. For the purposes of this study, a capital cost $1,000,000 for every 300 million board feet of production and 12,000 ODT's of trim blocks has been assumed to adapt existing fibre flows and install an OSB flake SIRM system.

OSB Mills

Stranding Equipment:
A system of trim end stranding would have to be devised, for the purpose of inviting price quotations from equipments suppliers. It may be possible to reduce capital expenditures by using existing block flakers. Trade sources indicate that there are quite a few used machines available in the market, and some OSB producers may already have them, but not in use.

Other Systems:
Trade sources indicate a very preliminary estimate of the cost of the system, excluding the flaker (new or used), at around C$250,000 per line. Total costs for all modifications are unknown, and would be site-specific. As a working assumption, they could be similar in aggregate to those for the sawmills.

4.3 Economic Evaluation – Conclusions

The process and product being considered are new to the region. Little or no empirical data can be obtained. As a result, the estimates and commercial findings provided are very broad in nature. However, the following general conclusions can be provided.

1. Adequate SIRM fibre appears to exist in the target region to supply a significant proportion of the needs of a state-of-the-art OSB mill. But it is likely that OSB mills would regard SIRM fibre as a potentially lower cost supplementary source of fibre, not an exclusive source.

   The principal reason is commercial, not technical. The three RL mills surveyed as part of this study have been used as an example only. However, they are representative of other sawmills in the region. They would provide only 27.5% of the annual fibre needs of a single line disk flaker – if the most ideal material (green end trims) is considered alone.

   If other potentially available fibre, such as dry trim ends, is included (but which currently is purchased by finger joint lumber producers) these three mills (as the example) could provide up to 41% of the needs of a single line disk flaker.

   In contrast to full self-sufficiency in captive fibre sources – assuming 100% whole log flaking – an OSB mill relying heavily on SIRMs would have to enter into a significant number of contracts with a large number of firms, in order to be able to secure adequate supplies.

   On a risk assessment basis, this would depend on the differentials which prevail in fibre costs.

2. The SIRM fibre targeted as potential material for OSB flakes has fairly high opportunity cost for the sawmills. In most instances, market pulp mills traditionally have offered the highest prices for this fibre (pulp chips). This situation has been changing recently, and BC Interior market pulp mills are no longer an assured outlet for sawmill’s residual by-products. At least some sawmillers are very interested in seeking diversified markets for their SIRMs.

3. Only broad generalizations can be provided as to the capital and operating costs that would be involved in producing SIRMs for OSB flakes. Actual costs would depend on a wide range of factors – and transaction prices for this fibre are most likely to become established through commercial negotiations between the parties.

Appendix 1

Carmanah Additional Results

Chart 16

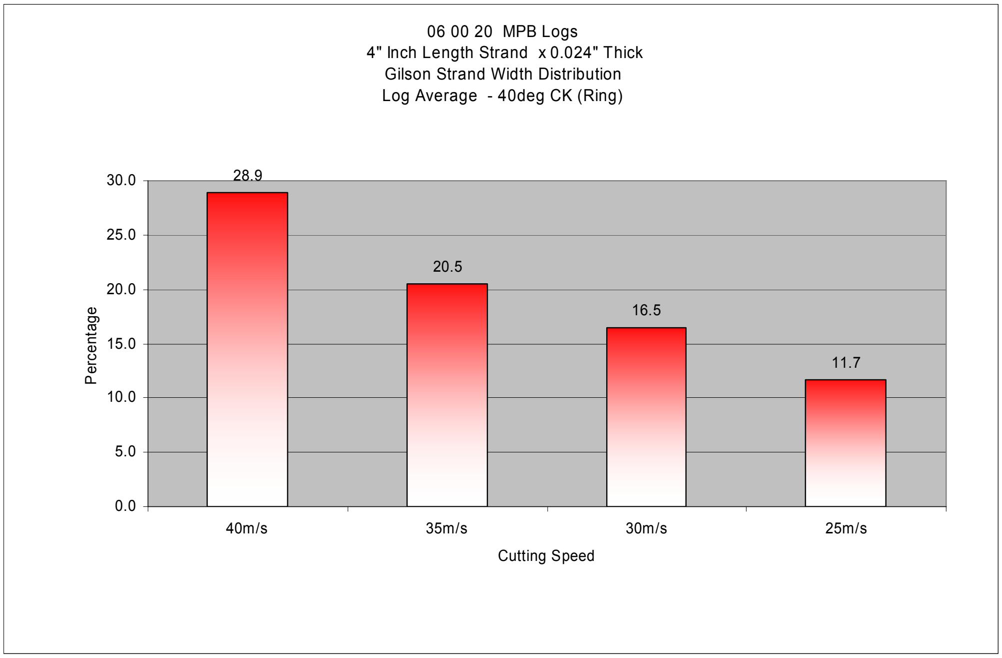


Chart 17

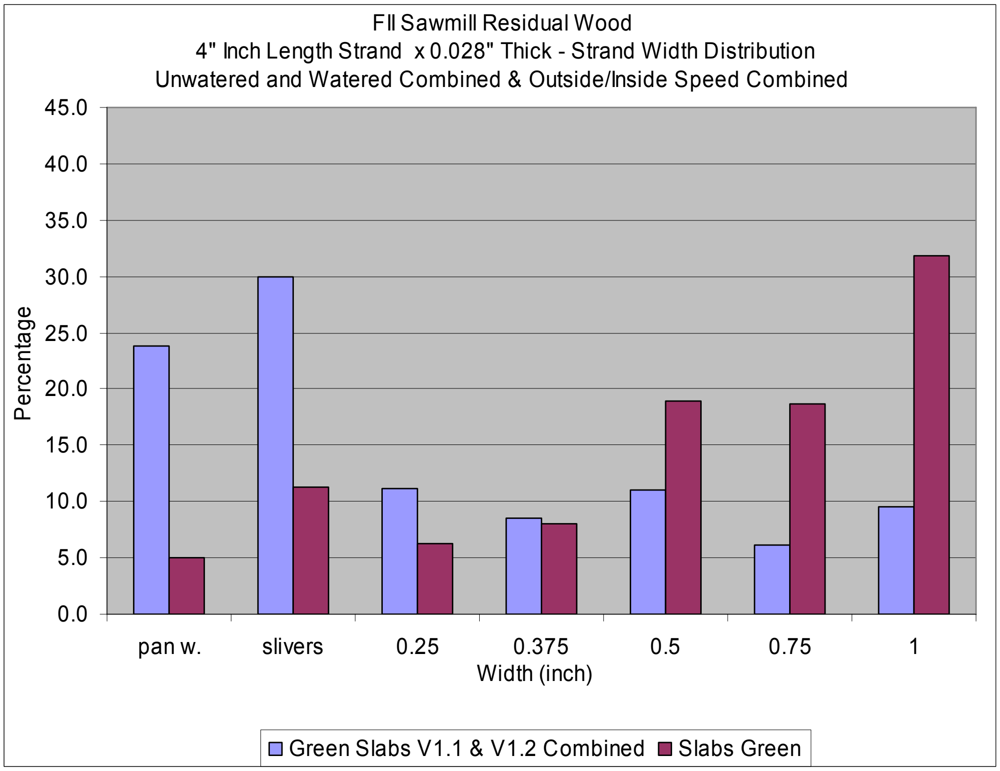


Chart 18

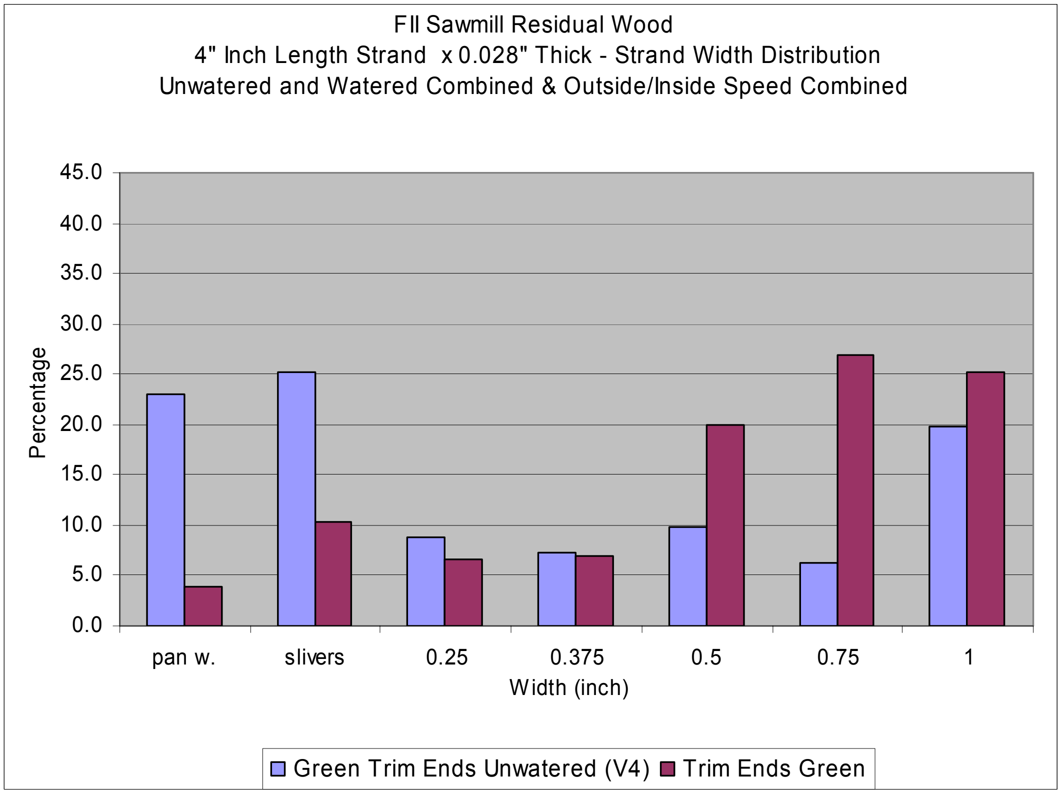


Chart 19

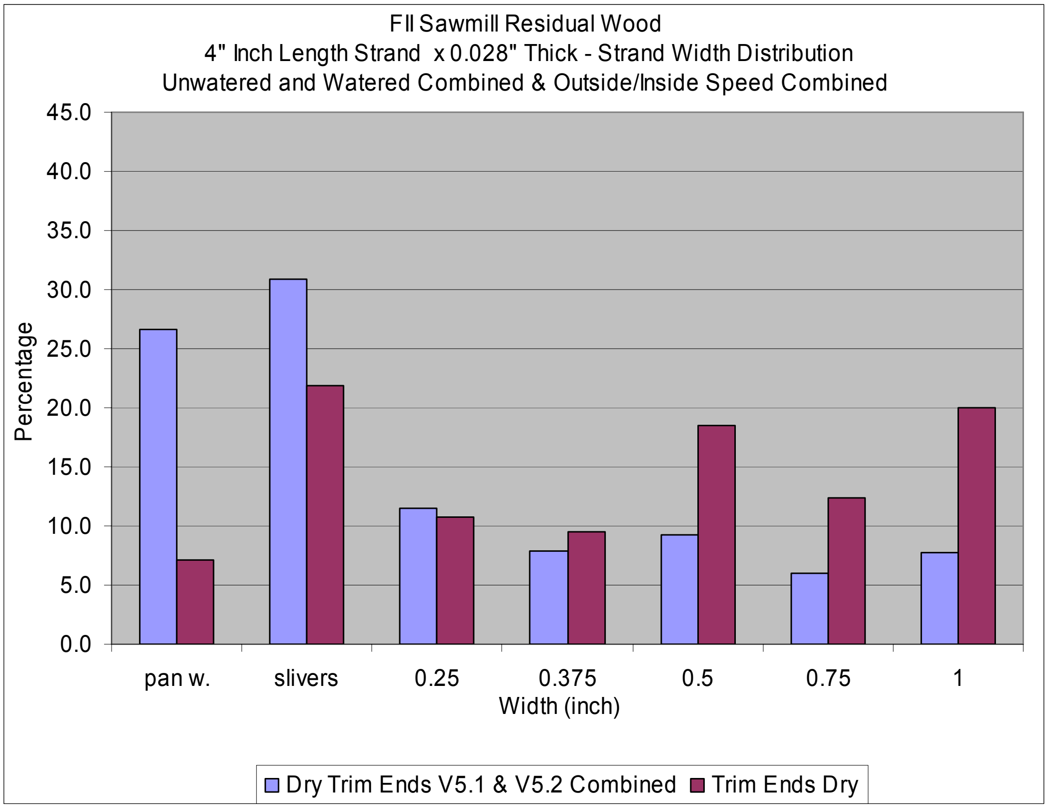
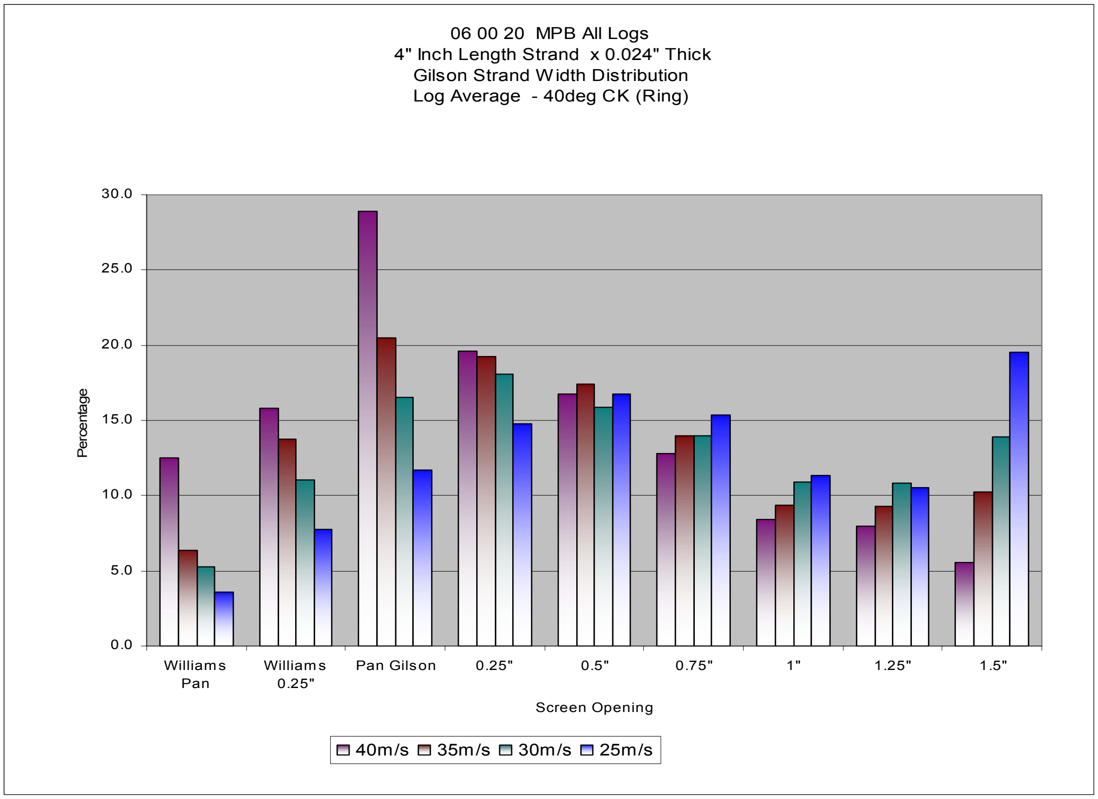


Chart 20

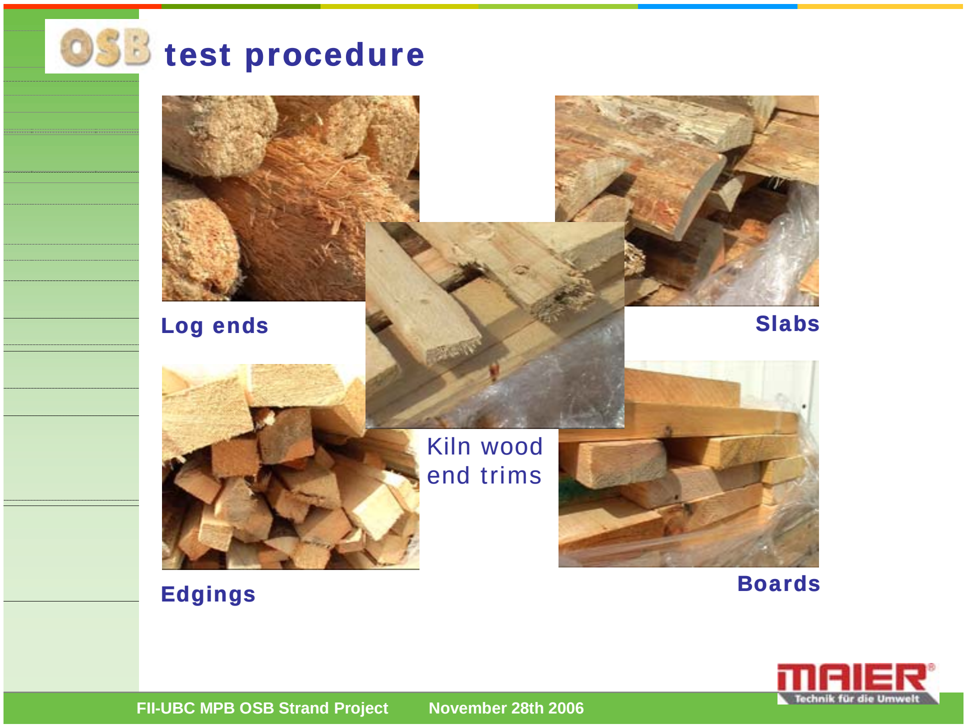

06 00 20 MPB All Logs
4" Inch Length Strand x 0.024" Thick
Gilson Strand Width Distribution
Log Average - 40deg CK (Ring)
Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Williams Pan
Williams 0.25"
Pan Gilson
0.25"
0.5"
0.75"
1"
1.25"
1.5"
Screen Opening
40m/s
35m/s
30m/s
25m/s

Appendix 2

Laboratory Raw Data: Maier Test Procedures and Results

and

UBC Test Results of Maier Strands (Tested on Carmanah Equipment)



OSB test procedure

Log ends

Slabs

Kiln wood end trims

Edgings

Boards

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OSB test procedure

Dimensions, weight, moisture contents of raw material

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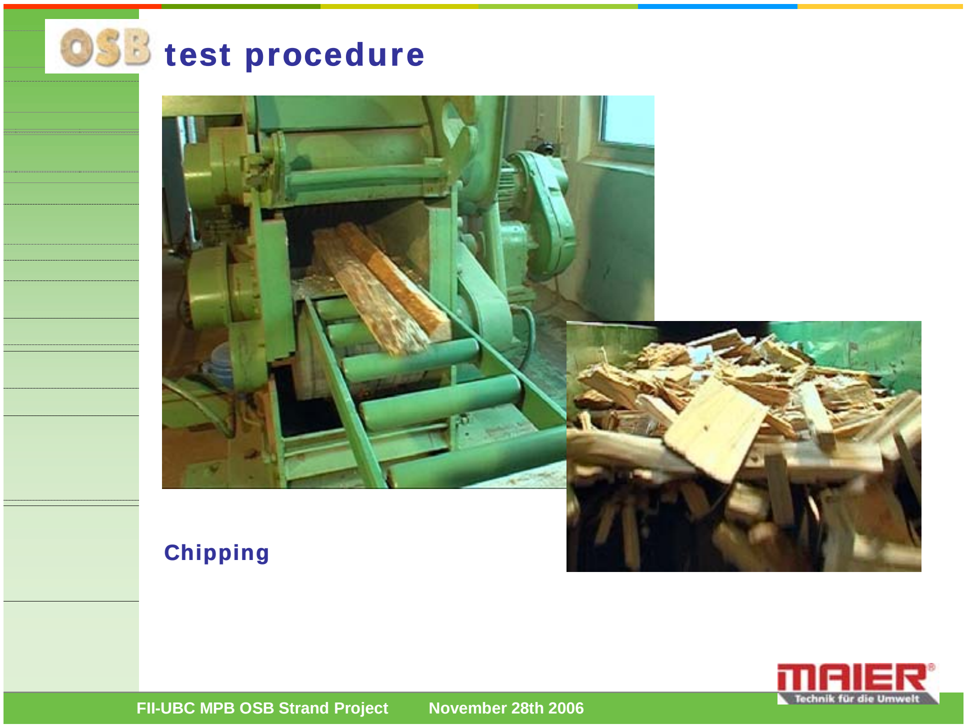

test procedure

Chipping

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chips 140 mm

S 1 / 5 Unconditioned wood slabs

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chips 140 mm

S 2/5 Unconditioned log ends

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chips 140 mm

S 3/5 Unconditioned wood edgings

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OSB chips 140 mm

S 4 / 5 Unconditioned wood end trims

MAIER® Technik für die Umwelt

FII-UBC MPB OSB Strand Project November 28th 2006

OSB chips 140 mm

S 5 / 5 Kiln wood end trims

MAIER® Technik für die Umwelt

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OSB test procedure

Hand screening
20 x 20 mm, ¾”

Chips ready
for stranding

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OSB test procedure

Flaking / Stranding

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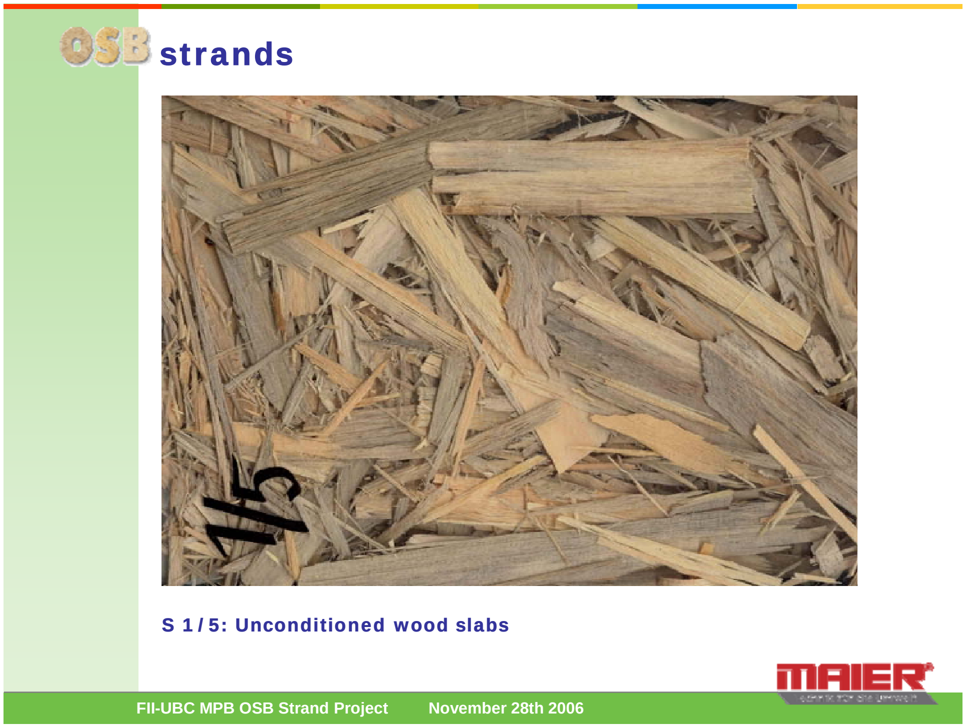

OSB strands

S 1 / 5: Unconditioned wood slabs

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OSB strands

S 2 / 5: Unconditioned log ends

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OSB strands

S 3 / 5: Unconditioned wood edgings

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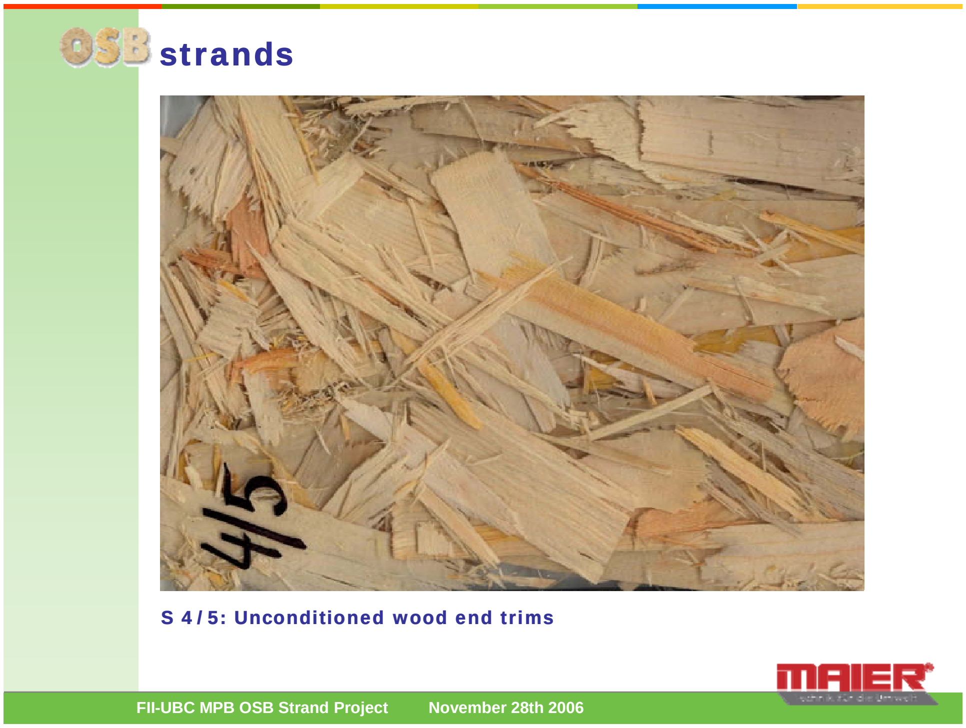

OSB strands

S 4 / 5: Unconditioned wood end trims

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strands

S 5 / 5: Kiln wood end trims

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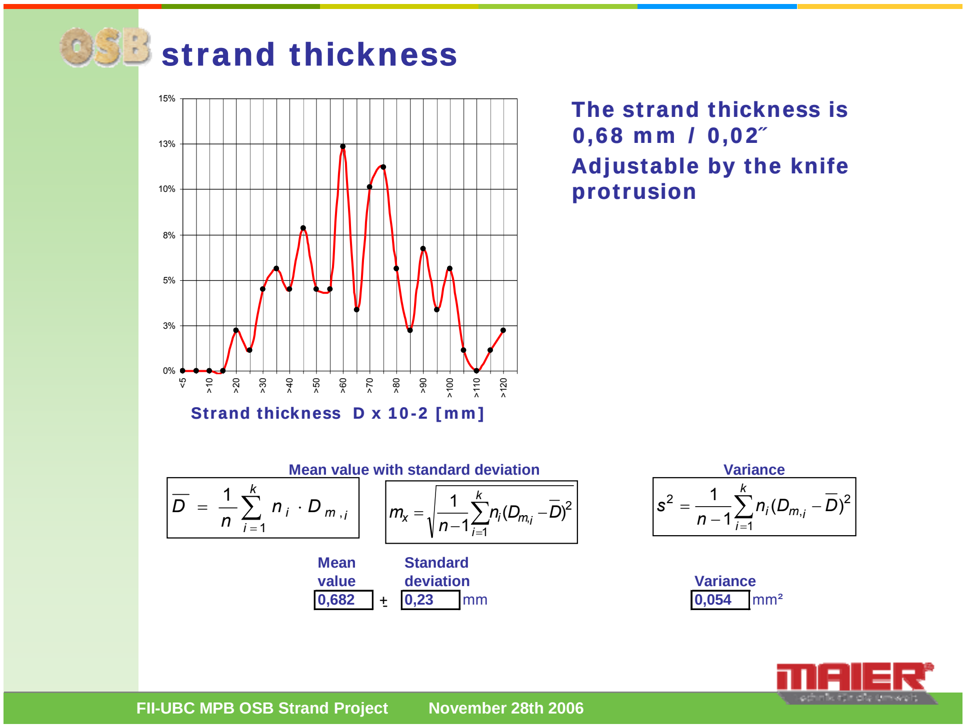
Chart 21



strand thickness

Strand thickness D x 10-2 [mm]

The strand thickness is 0,68 mm / 0,02˝

Adjustable by the knife protrusion

Mean value with standard deviation

$$\overline{D} = \frac{1}{n}\sum_{i=1}^{k} n_i \cdot D_{m,i}$$

$$m_x = \sqrt{\frac{1}{n-1}\sum_{i=1}^{k} n_i (D_{m,i} - \overline{D})^2}$$

Variance

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{k} n_i (D_{m,i} - \overline{D})^2$$

Mean value		Standard deviation		Variance	
0,682	±	0,23	mm	0,054	mm²

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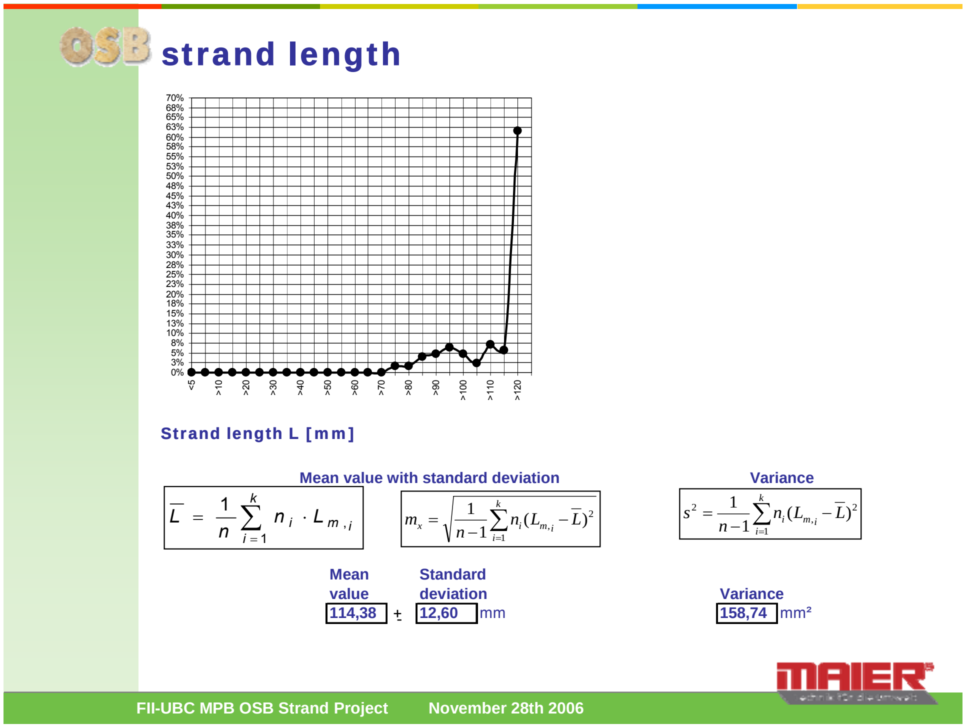
Chart 22



strand length

Strand length L [mm]

Mean value with standard deviation

$$\bar{L} = \frac{1}{n}\sum_{i=1}^{k} n_i \cdot L_{m,i}$$

$$m_x = \sqrt{\frac{1}{n-1}\sum_{i=1}^{k} n_i (L_{m,i} - \bar{L})^2}$$

Variance

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{k} n_i (L_{m,i} - \bar{L})^2$$

Mean value 114,38 ± Standard deviation 12,60 mm

Variance 158,74 mm²

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Table 4

UBC Test Results of Maier Strands

			12/68 Carmanah Lab Disc Strander			
Sample:	**V1.1**		Green Slabs Unwatered (V1.1)			
Gilson	**Screen# 1**	**Screen# 2**	**Screen# 3**	**Screen# 4**	**Total**	**%**
fines	173	149	130	164	616	26.7
>3/16"	172	182	182	170	706	30.5
>1/4"	60	74	67	59	260	11.3
>3/8"	37	57	39	50	183	7.9
>1/2"	40	61	71	64	236	10.2
>3/4"	37	34	33	39	143	6.2
>1"	23	33	58	53	167	7.2
Total	542	590	580	599	2311	100

Sample: V1.2 **12/68 Carmanah Lab Disc Strander**
Green Slabs Watered (V1.2)

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	99	115	130	129	473	21.1
>3/16"	155	164	185	152	656	29.2
>1/4"	60	67	59	61	247	11.0
>3/8"	60	45	50	47	202	9.0
>1/2"	54	67	92	55	268	11.9
>3/4"	41	35	33	25	134	6.0
>1"	63	63	47	90	263	11.7
Total	532	556	596	559	2243	100

Sample: V2.1 **12/68 Carmanah Lab Disc Strander**
Green Log Ends Unwatered (V2.1)

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	213	230	210	158	811	32.2
>3/16"	199	191	173	176	739	29.4
>1/4"	61	55	54	72	242	9.6
>3/8"	50	41	42	54	187	7.4
>1/2"	64	49	51	69	233	9.3
>3/4"	31	26	22	47	126	5.0
>1"	57	30	35	57	179	7.1
Total	675	622	587	633	2517	100

Sample: V2.2 **12/68 Carmanah Lab Disc Strander**
Green Log Ends Watered (2.2)

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	97	136	189	96	518	22.4
>3/16"	157	159	152	172	640	27.7
>1/4"	57	72	51	68	248	10.7
>3/8"	50	39	34	44	167	7.2
>1/2"	72	61	58	74	265	11.5
>3/4"	51	52	33	27	163	7.1
>1"	87	83	78	63	311	13.5
Total	571	602	595	544	2312	100.0

Sample: V3.1 **12/68 Carmanah Lab Disc Strander**
Green Edgings Unwatered (V3.1)

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	158	164	173	156	651	31.8
>3/16"	155	188	201	192	736	36.0
>1/4"	41	52	62	47	202	9.9
>3/8"	35	36	39	28	138	6.7
>1/2"	35	45	47	38	165	8.1
>3/4"	20	17	24	15	76	3.7
>1"	16	17	24	22	79	3.9
Total	460	519	570	498	2047	100

12/68 Carmanah Lab Disc Strander

Sample: V3.2 **Green Edgings Watered (V3.2)**

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	117	143	163	145	568	24.9
>3/16"	201	178	176	189	744	32.7
>1/4"	73	67	53	66	259	11.4
>3/8"	34	50	44	54	182	8.0
>1/2"	54	45	48	60	207	9.1
>3/4"	33	25	21	25	104	4.6
>1"	42	58	60	54	214	9.4
Total	554	566	565	593	2278	100

12/68 Carmanah Lab Disc Strander

Sample: V4 **Green Trim Ends Unwatered (V4)**

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	139	139	137	138	553	23.0
>3/16"	155	143	147	161	606	25.2
>1/4"	49	56	53	54	212	8.8
>3/8"	46	45	43	40	174	7.2
>1/2"	54	57	61	63	235	9.8
>3/4"	31	33	36	50	150	6.2
>1"	112	117	103	143	475	19.8
Total	586	590	580	649	2405	100

12/68 Carmanah Lab Disc Strander

Sample: V5.1 **Dry Trim Ends Unwatered (V5.1)**

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	225	199	226	203	853	35.6
>3/16"	199	191	196	180	766	32.0
>1/4"	59	61	58	61	239	10.0
>3/8"	38	42	38	42	160	6.7
>1/2"	36	42	40	53	171	7.1
>3/4"	24	28	25	24	101	4.2
>1"	23	29	23	30	105	4.4
Total	604	592	606	593	2395	100

12/68 Carmanah Lab Disc Strander

Sample: V5.2 **Dry Trim Ends Watered (V5.2)**

Gilson	Screen# 1	Screen# 2	Screen# 3	Screen# 4	Total	%
fines	93	94	98	101	386	17.7
>3/16"	155	159	166	171	651	29.9
>1/4"	71	77	69	67	284	13.0
>3/8"	50	47	52	50	199	9.1
>1/2"	50	75	55	65	245	11.2
>3/4"	64	36	32	38	170	7.8
>1"	66	69	58	51	244	11.2
Total	549	557	530	543	2179	100

Chart 23

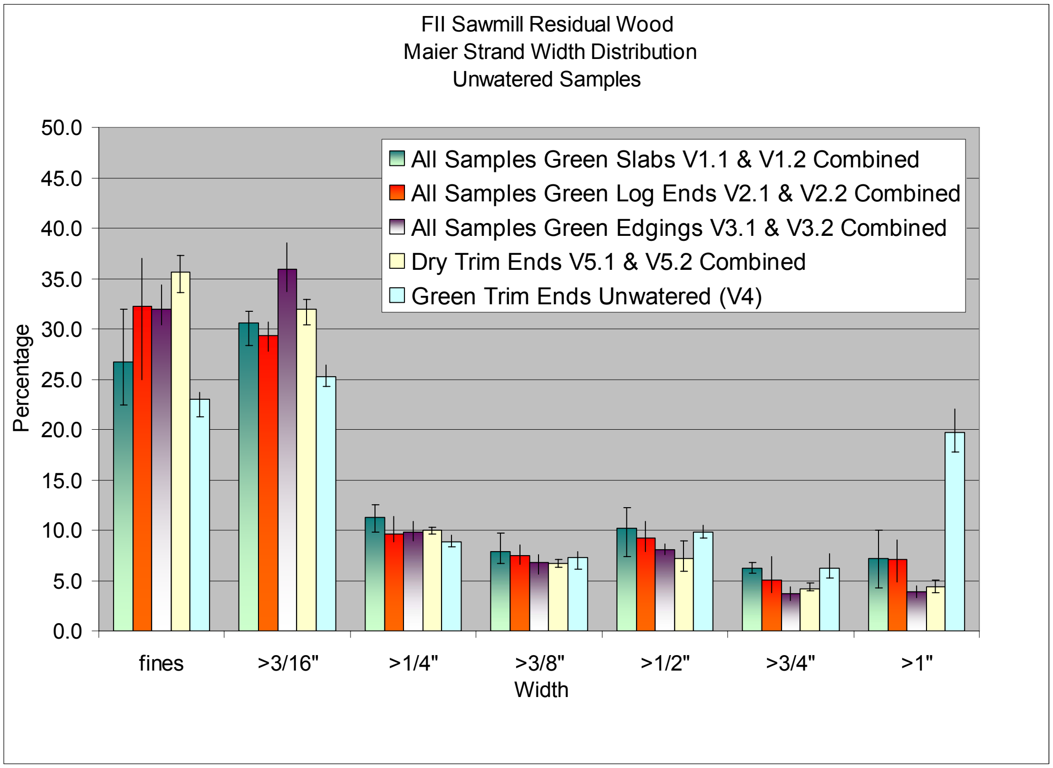
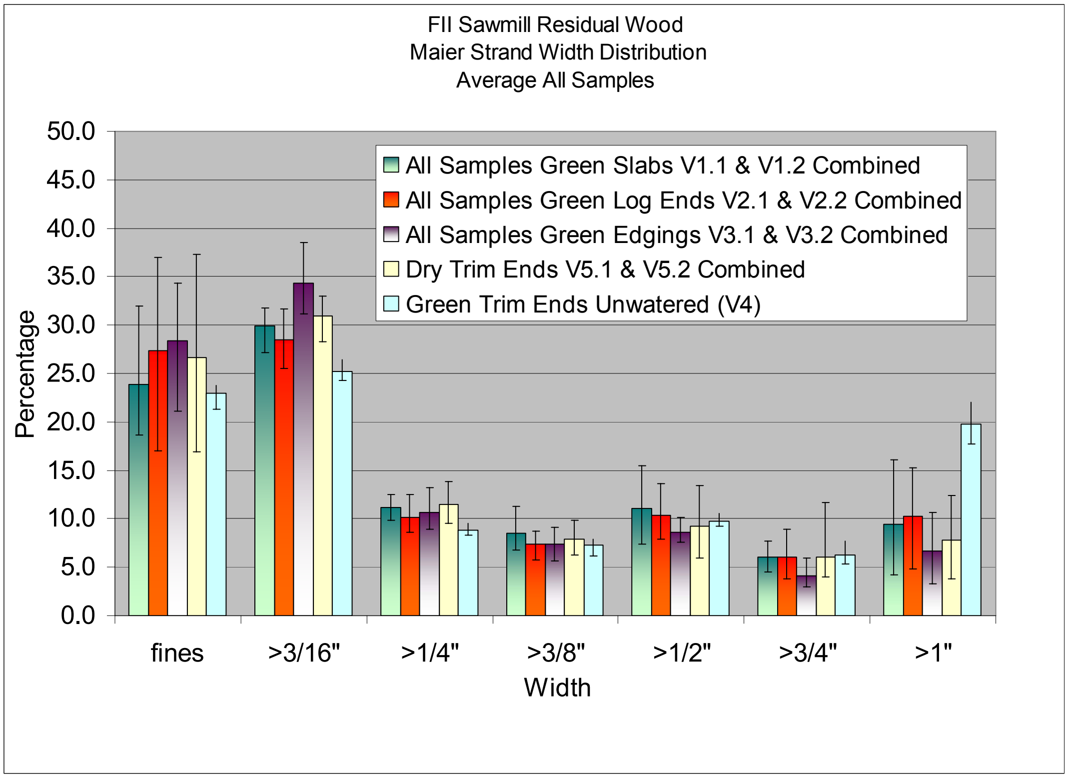


Chart 24



Appendix 3

Strand Geometry Analysis

Carmanah and Maier Results Comparison

Table 5

Strand Geometry Analysis

	Mean (mm)			Area weighted Mean (mm)		
Sample	Length	Thickness	Width	Length	Width	
Slabs	100.31	0.83	31.16	102.17	39.14	**Carmanah**
Log Ends	90.01	0.95	61.72	99.67	101.73	
Edgings	95.60	1.03	19.17	97.73	23.14	
Trim Ends Green	94.94	0.81	25.64	98.95	29.74	
Trim Ends Dry	98.66	0.87	25.88	101.48	30.61	
V1.1 Strands from green/unconditioned wood slabs (S 1/5) Unwatered	120.15	1.03	24.64	130.82	30.28	**Maier**
V1.2 Strands from green/unconditioned wood slabs (S 1/5) Watered	116.02	0.97	20.94	125.75	26.38	
V2.1 Strands from green/unconditioned log ends (S 2/5) Unwatered	114.44	1.03	22.84	128.20	29.64	
V2.2 Strands from green/unconditioned log ends (S 2/5) Watered	123.19	1.05	25.07	132.49	31.12	
V3.1 Strands from green/unconditioned wood edgings (S 3/5) Unwatered	115.57	0.92	19.48	122.28	23.25	
V3.2 Strands from green/unconditioned wood edgings (S 3/5) Watered	119.54	0.97	19.29	135.49	26.54	
V4 Strands from green/unconditioned wood end trims (S 4/5) Unwatered	111.32	1.02	32.60	128.32	42.20	
V5.1 Kiln Dried wood end trims (S 5/5) Unwatered	112.95	0.98	21.01	124.65	28.68	
V5.2 Kiln Dried wood end trims (S 5/5) Watered	117.58	0.97	23.10	124.96	29.08	

	Standard Deviation (mm)			**Coefficient of Variation (%)**			
Sample	Length	Thickness	Width	Length	Thickness	Width	
Slabs	11.45	0.16	15.47	11	19	50	**Carmanah**
Log Ends	23.96	0.20	46.61	27	22	76	
Edgings	14.84	0.30	8.84	16	29	46	
Trim Ends Green	19.07	0.11	10.16	20	14	40	
Trim Ends Dry	14.02	0.17	10.68	14	19	41	
V1.1 Strands from green/unconditioned wood slabs (S 1/5) Unwatered	31.92	0.24	11.53	27	23	47	**Maier**
V1.2 Strands from green/unconditioned wood slabs (S 1/5) Watered	32.01	0.20	10.61	28	21	51	
V2.1 Strands from green/unconditioned log ends (S 2/5) Unwatered	34.05	0.25	11.50	30	25	50	
V2.2 Strands from green/unconditioned log ends (S 2/5) Watered	33.02	0.24	11.92	27	23	48	
V3.1 Strands from green/unconditioned wood edgings (S 3/5) Unwatered	27.94	0.20	9.18	24	22	47	
V3.2 Strands from green/unconditioned wood edgings (S 3/5) Watered	38.18	0.23	11.34	32	24	59	
V4 Strands from green/unconditioned wood end trims (S 4/5) Unwatered	38.07	0.29	16.28	34	28	50	
V5.1 Kiln Dried wood end trims (S 5/5) Unwatered	34.49	0.23	12.48	31	24	59	
V5.2 Kiln Dried wood end trims (S 5/5) Watered	33.44	0.21	12.73	28	21	55	

Strand Geometry Measurement Procedures

Strand geometry measurements conducted on the strand samples from Carmanah and Maier were based the following procedures:

- Empty the strands of each sample from the plastic bag into a plastic pail.
- Obtain a hand full of strands from about 1/3 to ½ of the way down.
- Place the strands on a flat surface in a cone shape.
- Mold the pile into a line approximately 610 mm long.
- Divide the line in half.
- Take one of the halves and divide it in half,
- Continue dividing the sample until a pile of strands is approximately about 100 strands required for the analysis.
- Care must be taken to ensure that the final sample is representative of the whole. It is best to have a sample that is too small and measure all the strands and then go through the process of selection again.
- Measure thickness using a caliper with proper envils.
- Measure length at the longest point but not diagonally.
- Estimate and measure the average width.

Strand Geometry Analysis

Table 5 shows results of the strand geometry analysis. The strands from Maier were cut to a longer length; therefore direct comparisons of strand geometry information from Carmanah and Maier is not appropriate. Area-weighted mean strand length and width information and variability of strand geometry information are also shown in the tables.

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