(FRONT COVER)

A COMPARATIVE STUDY OF NEW ZEALAND PINE AND SELECTED SOUTH EAST ASIAN SPECIES

(INSIDE FRONT COVER)

NEW ZEALAND PINE

- A RENEWABLE RESOURCE

NZ pine (*Pinus radiata* D. Don) was introduced to New Zealand (NZ) from the USA about 150 years ago and has gained a dominant position in the New Zealand forest industry - gradually replacing timber from natural forests and establishing a reputation in international trade.

The current log production from New Zealand forests (1998) is 17 million m^3, of which a very significant proportion (40%) is exported as wood products of some kind. Estimates of future production indicate that by the year 2015 the total forest harvest could be about 35 million m^3.

NZ pine is therefore likely to be a major source of wood for Asian wood manufacturers.

This brochure has been produced to give prospective wood users an appreciation of the most important woodworking characteristics for high value uses.

Sponsored by: Wood New Zealand Ltd.

Funded by: New Zealand Ministry of Foreign Affairs and Trade

Written by: New Zealand Forest Research Institute Ltd.

(Front page - First sheet))

NEW ZEALAND PINE - A VERSATILE TIMBER

NZ pine (*Pinus radiata* D.Don) from New Zealand is one of the world's most versatile softwoods - an ideal material for a wide range of commercial applications. Not only is the supply from sustainable plantations increasing, but the status of the lumber as a high quality resource has been endorsed by a recent comparison with six selected timber species from South East Asia. These species were chosen because they have similar end uses to NZ pine.

A comprehensive series of standard tests were used to evaluate the timbers in terms of their machining and related mechanical properties and demonstrated that NZ pine of a suitable grade is a suitable alternative. (See back cover for summary information).

NZ pine is already widely used for packaging and temporary construction throughout Asia, but its performance in the comparative study also confirms its suitability for a broad range of high value uses - including plywood production, general joinery and the manufacture of furniture.

The reports in this folder provide detailed results of each timber's performance in a variety of specific tests.

THE TIMBERS

NZ pine was compared with six selected timber species currently familiar to South East Asian wood processors and widely used in the higher value areas of the construction and manufacturing industries. The future supplies of many of these species are in doubt, whereas the prediction for NZ pine is for a significant increase in available volume.

Common Name	Botanical Name
Ramin	(*Gonystylus* spp.)
Jelutong	(*Dyera* spp.)
Nyatoh	(*Palaquium* spp.)
White Seraya	(*Parashorea malaanonan*)
Rubberwood	(*Hevea brasiliensis* Muel Arg)
Merkus Pine (Tenasserim pine)	(*Pinus Merkusii* Jungh & de Vries)

THE TESTS

The study was undertaken by the New Zealand Forest Research Institute Limited (***Forest Research***).

The testing used techniques specified by the American Society for Testing and Materials (ASTM 1666: 1987). No attempt was made to optimise machine conditions for individual species.

Machining Tests	**Related Mechanical Tests**
Cross-cutting Planing Moulding Shaping Turning (x2) Boring (x2) Mortising Sanding	Gluing Hardness Nail-withdrawal Nail-splitting Dimensional Stability (x2) Distortion

The tests were specifically selected to assess the timbers suitability for panelling, mouldings, joinery and furniture manufacture and included planning, shaping, turning, sanding and gluing.

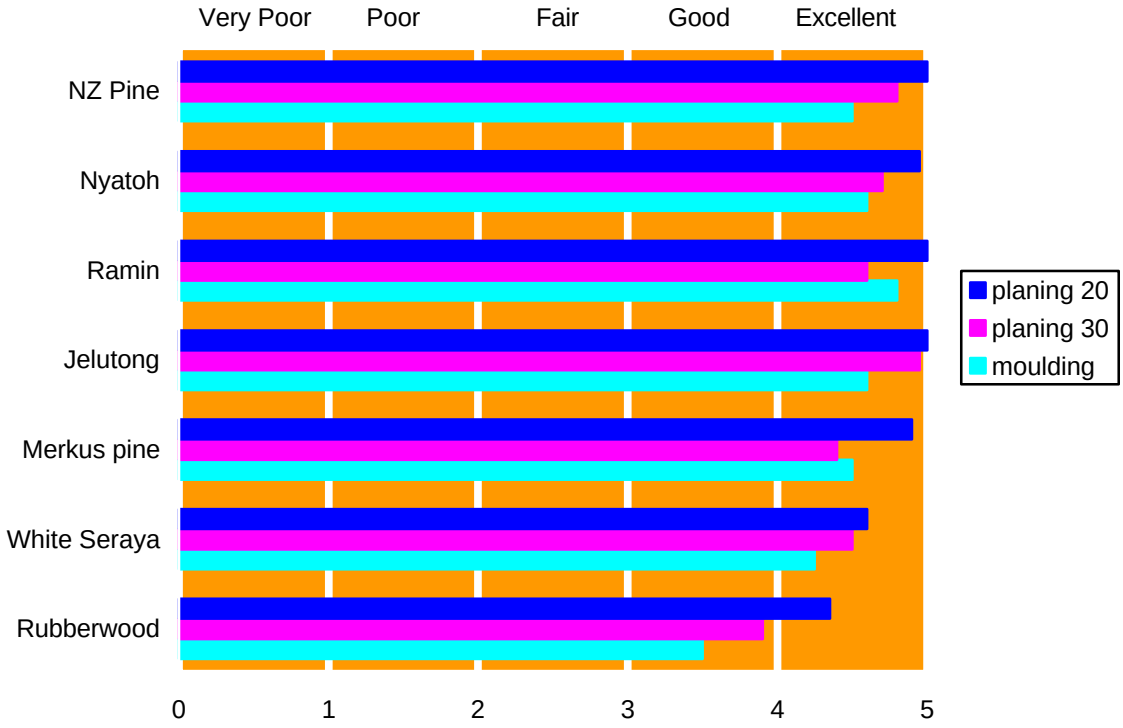
Each species was represented by a batch of 10 lengths of 50 x 25 mm thick timber, obtained from lumber merchants in South East Asia, and together with the NZ pine samples, the timber was conditioned to 12% equilibrium moisture content before testing commenced.

The NZ pine came from the Central North Island plantations and was selected as representing average quality and forest management history. Trees were 30 to 35 years old and had been thinned to maintain diameter growth rate and pruned to a height of 6m (a technique designed to promote the recovery of clear grades of lumber).

PLANING AND MOULDING

Planing is one of the most common machining applications in industries using timber for high-end value products (panelling, joinery and furniture), and the quality of finish is critical.

While most finishes require some sanding, the severity and type of defect resulting from machining will affect the cost (time, effort and materials) required to bring the product to an acceptable finish.



THE RESULTS

All species performed well in both the planing and moulding. In all cases the lower cutting angle of 20^0 gave the best result at the moisture content (12%) used in the tests.

For White Seraya and rubberwood the main defect was fuzzy grain and for all other species chipout was the dominate degrading defect.

Of importance to manufacturers, is that all species performed well in these tests with minimal instances of defects being assessed as poor or reject. Most samples were rated as Excellent or Good. These test results confirm the suitability of all these species for joinery, panelling and for many types of furniture manufacture.

THE TEST

The samples from all species were selected at random for machining through a modern computerised planer/moulder to prevent possible bias. A standard profile was used to allow assessment of planing on the flat surfaces and moulding on the edge. The machine settings were as follows:

Machine feed speed:	12 metres/minutes	
Cutter mark pitch:	2.0 mm	
Depth of cut:	1-2 mm	
Knife cutting angles:	Top head	30 degrees
	Bottom head	20 degrees

Assessments were made on both top and bottom surfaces to compare the effects of differing cutting angles (30^0 versus 20^0). The quality of finish was determined by visually grading each sample on a five-point scale:

5 = Excellent
4 = Good
3 = Fair
2 = Poor
1 = Very Poor

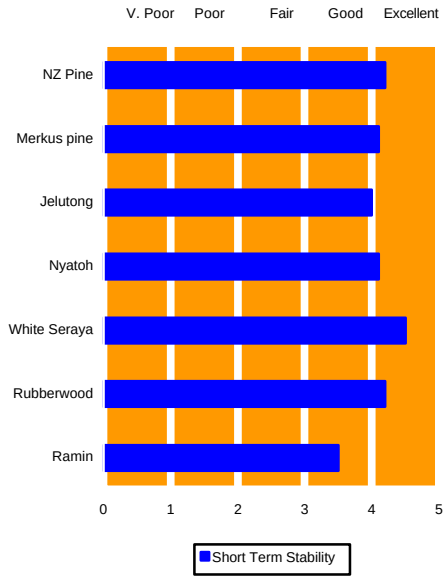
The kind of defects noted included chipping, torn grain, fuzziness of finish and raised grain.

DIMENSIONAL STABILITY

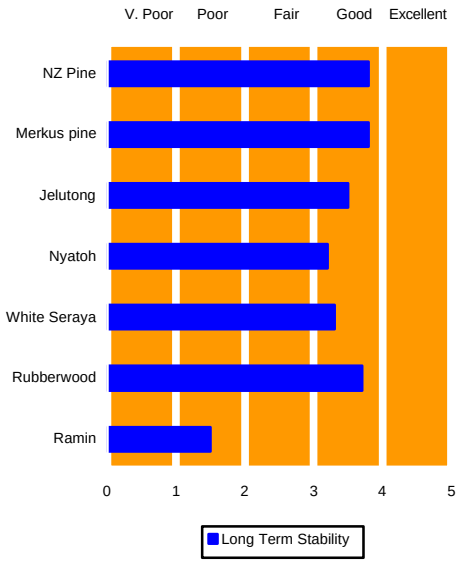
Stability is related to moisture movement - either entering or leaving the timber. This causes the wood to swell or shrink. It can also cause the timber to warp - a defect measured as bow, crook, cup or twist.

Timbers prone to these instability or warp are less desirable for joinery.

Short-term



Long-term



THE RESULTS

NZ pine, Merkus pine and Rubberwood recorded the best results in all stability tests, while Ramin proved to be the least stable of the seven timbers.

In the international range of values for all timber species, the test species recorded average results for stability. NZ pine performed well in the stability tests, slightly above the average results, demonstrating its suitability as an alternative timber to many of the others tested.

THE TESTS (DIMENSIONAL STABILITY)

There are few published methods to determine wood stability and this test was designed to measure both the short-term and long-term stability.

Short-term Stability
Short-term stability measures the **rate** of response to humidity changes. Samples (100 x 32 x 8 mm) were conditioned at 65% relative humidity (RH), measured, exposed to 95% RH for 24 hours and measured again. Differences in tangential swelling were used to rank stability in five grades:

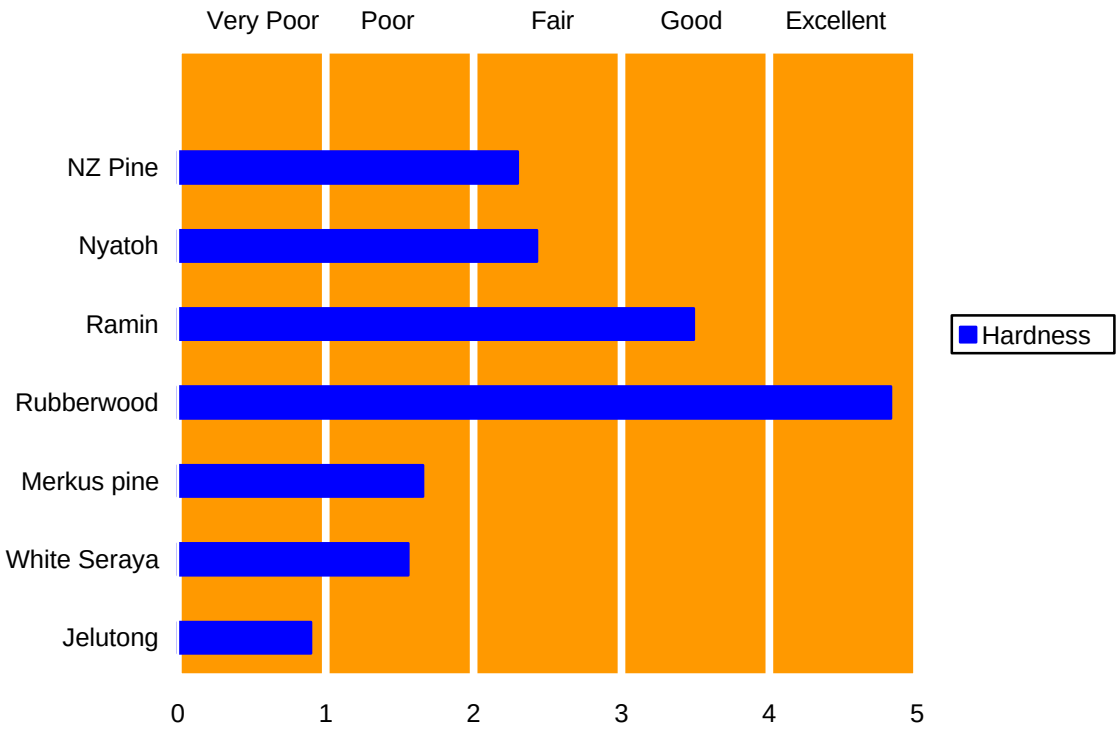
Excellent:	less than 1.4% tangential swelling
Good:	1.4% to 1.8%
Fair:	1.9% to 2.1%
Poor:	2.2% to 2.6% and
Very poor:	greater than 2.6%

Long-term Stability
For long-term stability samples (50 x 90 x 8 mm) were conditioned at 90% RH, measured, conditioned to equilibrium at a lower humidity (60% RH) and then re-measured. The sum of the tangential and radial shrinkages was used to describe long term stability. Results were graded as follows:

Excellent:	2.5% shrinkage or less
Good:	2.6% to 3.5%
Fair:	3.6% to 4.5%
Poor:	4.6% to 6.0% and
Very poor:	greater than 6.0% total shrinkage

SURFACE HARDNESS

Surface hardness is an important characteristic which indicates the ability of the timber to withstand the knocks in everyday use - often a requirement in applications such as furniture, joinery and flooring.



THE RESULTS

Higher density generally resulted in higher hardness. Average hardness for NZ pine was 3.3 kN at a test density of 500 kg/m^3 ranking in the middle of the species tested and shows that NZ pine is a satisfactory alternative to many of the timbers where surface hardness is a key consideration.

THE TESTS

The Janka Hardness Test measures the resistance to indentation.

By way of comparison, Janka Ball Tests record a force of less the 0.5 kN for Balsa wood and about 20 kN for Lignum Vitae - one of the world's densest timbers.

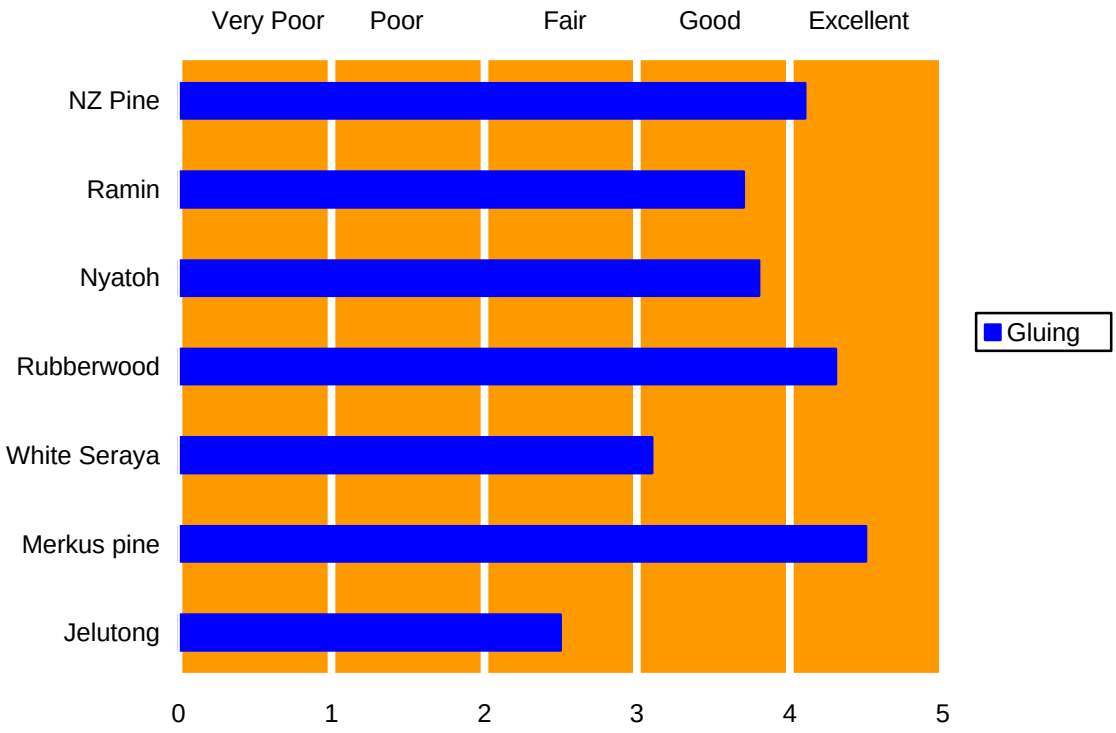
For the purpose of practical comparison, the results from the current study were allocated to five broad categories:

Excellent:	greater than 10 kN
Good:	5.1 - 10 kN
Fair:	3.1 - 5.0 kN
Poor:	1.6 - 3.0 kN
Very poor:	1.5 kN and less

Each species was represented by 10 samples and tests were carried out on two faces of each sample after conditioning to 12% equilibrium moisture content.

GLUING

The ability to provide a strong joint is critical for many high value uses - furniture, joinery and a range of engineered wood products.



THE RESULTS

NZ pine, Rubberwood and Merkus pine showed the best results in the gluing tests. Their combination of shear strength and high wood failure properties gave them consistently superior results to the other timbers.

Jelutong had the lowest shear strength in the PVA bonds. This was attributed to its lower density and wood strength. NZ pine performed particularly well. This is attributable to its medium wood density, evenness of grain within growth rings, good permeability and low extractives content, all of which make NZ pine highly suitable for glue jointing.

THE TEST

There are a wide range of commercial glue types available, however for this test one of the more common glue types used by industry was chosen a **Cross-linked polyvinyl acetate** (PVA) which also provides some water resistance.

The glue was prepared and applied to manufacturers' specifications and complied with the ASTM D 905 requirements. Each species was tested on 30 glued joints in a "shear block" test. As with all the other tests, the wood was conditioned to 12% equilibrium moisture content before testing.

Performance was based on a combination of:

- The force required to break the joint, and
- The percentage of wood failure in the separated faces of the broken joint

Grading was based on the following scale:

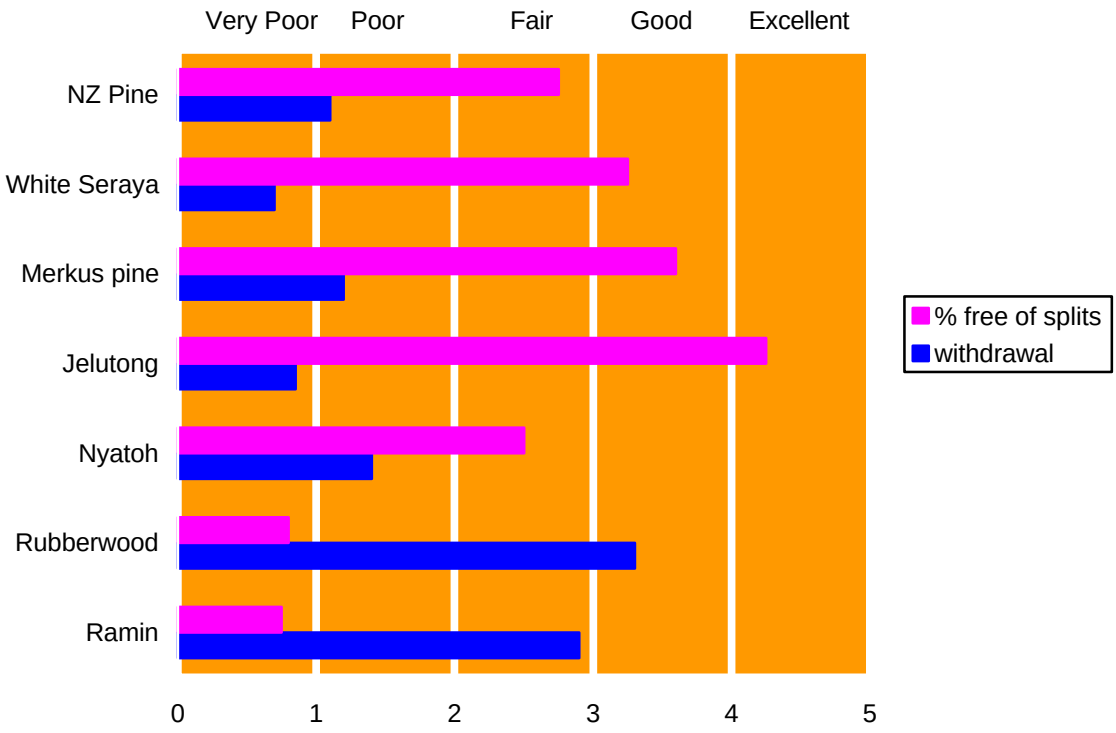
Excellent:	greater than 14,000 kPa
Good:	10,001 to 14,000 kPa
Fair:	6,001 to 10,000 kPa
Poor:	2,001 to 6,000 kPa
Very poor:	2,000 kPa and less

These measurements represent the shear strength of each species and the quality of the bond between the glue and the wood surface. The better the bond, the higher the percentage of wood failure when the faces are separated.

The strength of the glue bond is affected both by the texture and permeability of the wood and the chemicals in the wood commonly referred to as extractives.

NAILING

With the wide use of mechanical fastening methods in the manufacturing industry, an indication of the nailing properties of a species is important. A tendency to split is an undesirable property.



THE RESULTS

NZ pine, Jelutong, Merkus pine, White Seraya and Nyaton showed the greatest resistance to splitting, but had lower nail holding properties, Ramin and Rubberwood had the greatest resistance to nail withdrawal but were the worst for splitting. These results are a function of wood density, higher-density timbers have a higher likelihood of splitting, but greater nail-holding strength.

THE TESTS

The tests were carried out on 10 samples per species - all conditioned to 12% equilibrium moisture content.

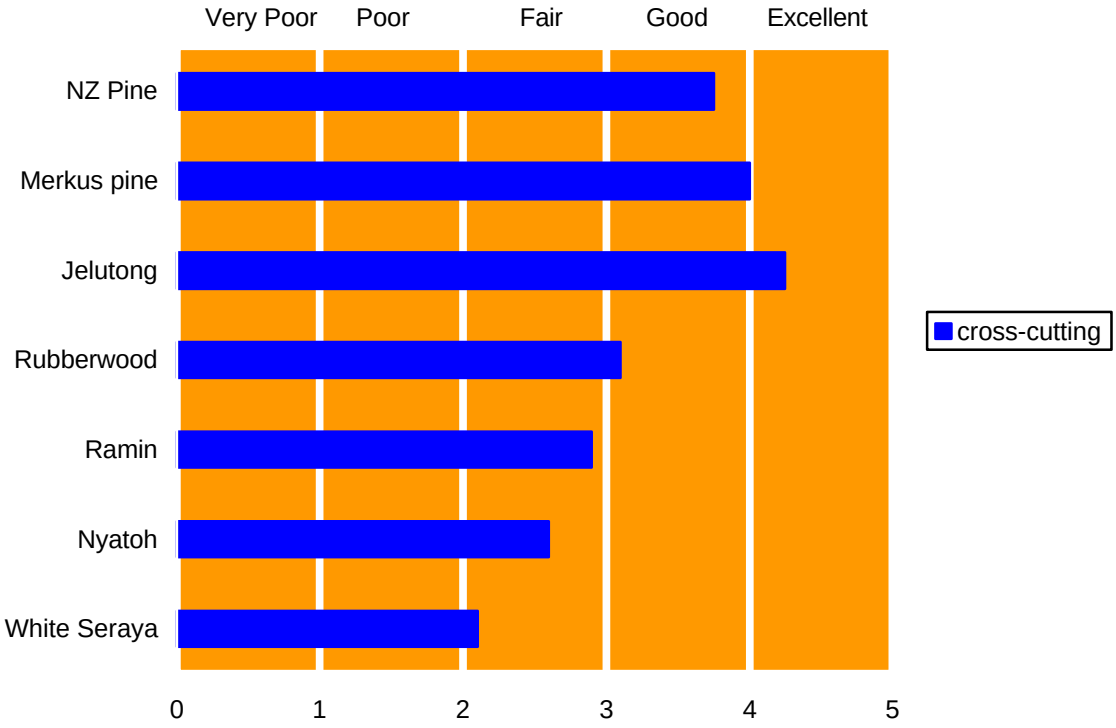
There is no accepted international standard for a nail splitting test however ***Forest Research*** has adopted a procedure whereby bright steel, jointed head nails, 3.15mm diameter were driven 40mm into the wood samples within 10mm of the board end. The performance of the timber is assessed on the number and the size of any resulting splits.

For nail withdrawal tests ASTM standards were available. Such tests were chosen to reflect the strength requirement of mechanical fasteners. The grades for resistance to nail withdrawal were rated as follows:

Excellent:	60.1 N/mm and greater
Good:	45.1 - 60.0 N/mm
Fair:	30.1 - 45.0 N/mm
Poor:	15.1 - 30.0 N/mm
Very poor:	15.0 N/mm and less

CROSS-CUTTING

Cross-cutting is one of the most basic applications in preparing lumber for any end use. It is used in all areas of production - for the basic elimination of blemishes or defects to the finer cuts required for cabinetry and furniture manufacture. Important criteria in cross-cutting are a smooth, clean cut with a minimum of crushing or splintering at the cut surface or face.



THE RESULTS

Jelutong and Merkus pine achieved the highest overall results in the comparative cross-cutting tests, with NZ pine following closely. NZ pine's overall cross-cutting performance was rated 'Good' along with Rubberwood. Ramin, Nyatoh and White Seraya, showed progressively poorer cross cut end surface quality.

The results indicated that all species tested can be cut cleanly with properly sharpened saws, and a correct feed speed.

THE TESTS

The cross-cutting test was carried out using a panel saw, to more closely relate to the finer cutting requirements for furniture and joinery manufacturing.

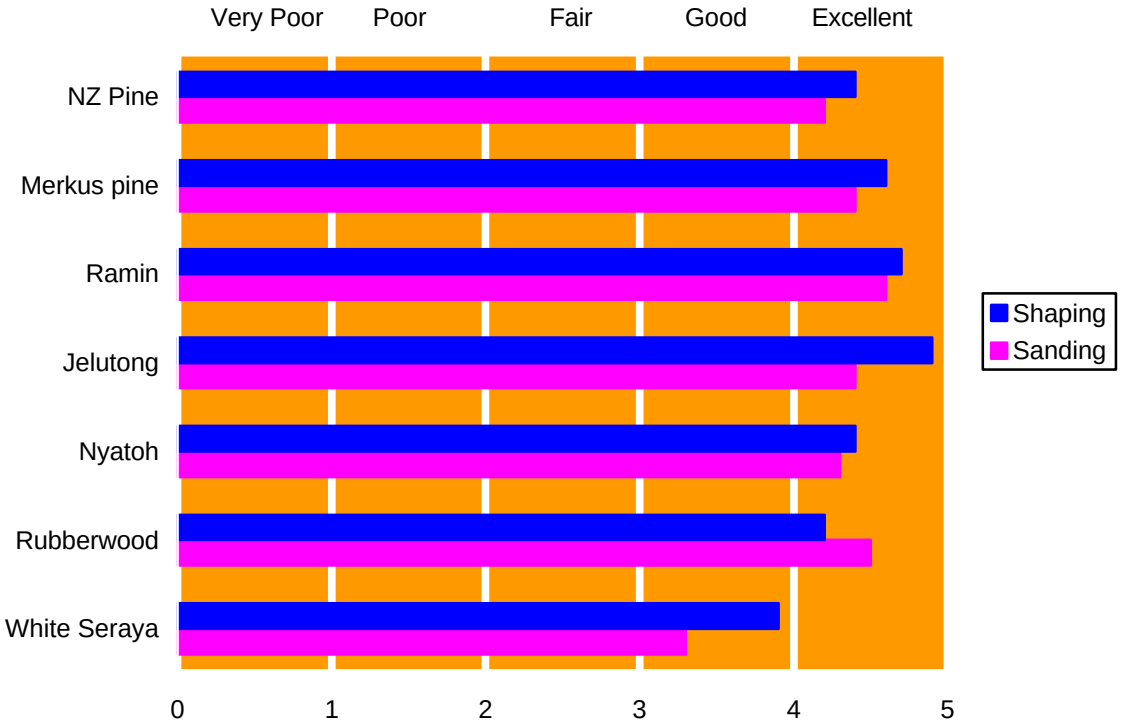
The results were assessed visually using a five-step scale of quality:

5 = Excellent
4 = Good
3 = Fair
2 = Poor
1 = Very Poor

SHAPING AND SANDING

Shaping is a widely used procedure in furniture manufacture. The process is usually carried out on hand-fed spindle moulders, but Computer Numerical Control (CNC) routers are being used increasingly due to their ability to be programmed to reproduce a variety of complex shapes.

Sanding is almost always required to produce an acceptable ‘quality finish’ for furniture and joinery.



THE RESULTS

Shaping

All species performed well in the shaping tests, with little difference between them. All achieved the top rating, with the exception of White Seraya, which was only marginally lower.

Sanding

All species sanded well with no sign of clogging. Scratching was not visible under normal lighting, the main cause of degrade was slight fuzziness, mainly in the White Seraya with its coarser grain. Jelutong produced the best finish in the sanding test, however overall the levels of fuzziness encountered in this study for all species would easily be removed with a sanding sealer followed by fine sanding.

THE TESTS

The ASTM standard requires the use of a commercial size, hand fed spindle shaper, but in view of today's developing industry, it was deemed more applicable to carry out these tests using a router head on a CNC machine centre.

The quality of finish was determined by visually grading each sample on a five-point scale and then calculating the percentage of 'acceptable' quality finishes for each species.

5 = Excellent
4 = Good
3 = Fair
2 = Poor
1 = Very Poor

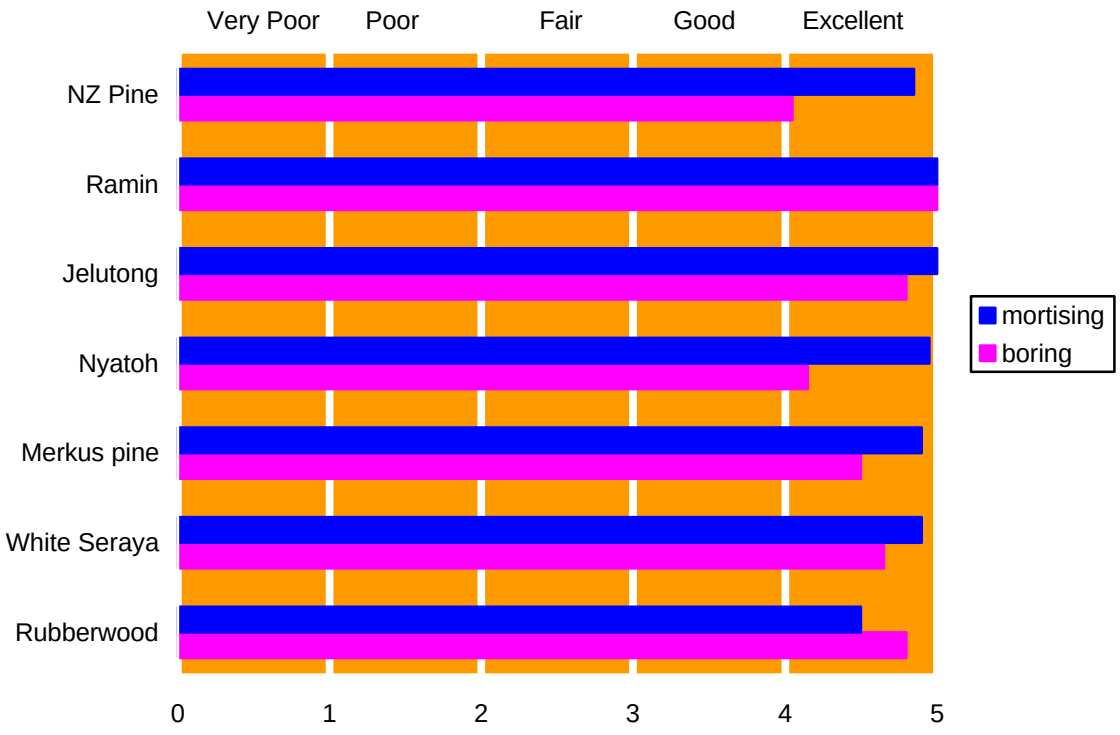
In the shaping trial, defects which were noted included fuzziness of finished surface, raised grain and tearout.

The sanding trial used a single head belt sander. Samples were first subjected to a treatment using 80-grit sandpaper then followed by 120-grit sandpaper (7m/min; 0.5mm removed). Quality was determined from the incidence of scratches, fuzziness of the surface and the tendency to clog the sandpaper.

BORING AND MORTISING

Both boring and mortising are commonly used to form joints between wood components. Boring is typically used in dowel joints or to attach legs to chairs. A mortise and tenon joint is customarily used to join top rails or lock rails to stiles in doors.

As woodworking characteristics, the machining process of boring and mortising may not rate as highly as planing or shaping, but they are still important considerations in the general use of lumber.



THE RESULTS

All species attained a Good/Excellent grade in the CNC boring and mortising tests, with slightly lower ratings for the manual operations. Using the manual mortiser, all species showed greater crushing and tearout, with the performance of NZ pine dropping to Fair.

Overall, however all species were rated Good to Excellent. All species met the requirements for mortising with both the router bit and hollow chisel and the timbers achieved superior results with CNC.

THE TESTS

To comply as closely as possible with the ASTM standard, the test used manual boring (a 24 mm auger at 2000 rpm) and hollow chisel mortising.

Since much of this type of work is now performed by automatic machines; a second test was undertaken using a router bit in a CNC machine to drill as 10 mm hole and to create a ‘square’ mortise hole 22 x 22 mm.

A third hole was made using a 10 mm double-twist, brad-point drill in a hand-fed electrical drill press.

Each of these five holes was graded according to the ASTM standards on smoothness of internal faces and cleanness of the entrance hole.

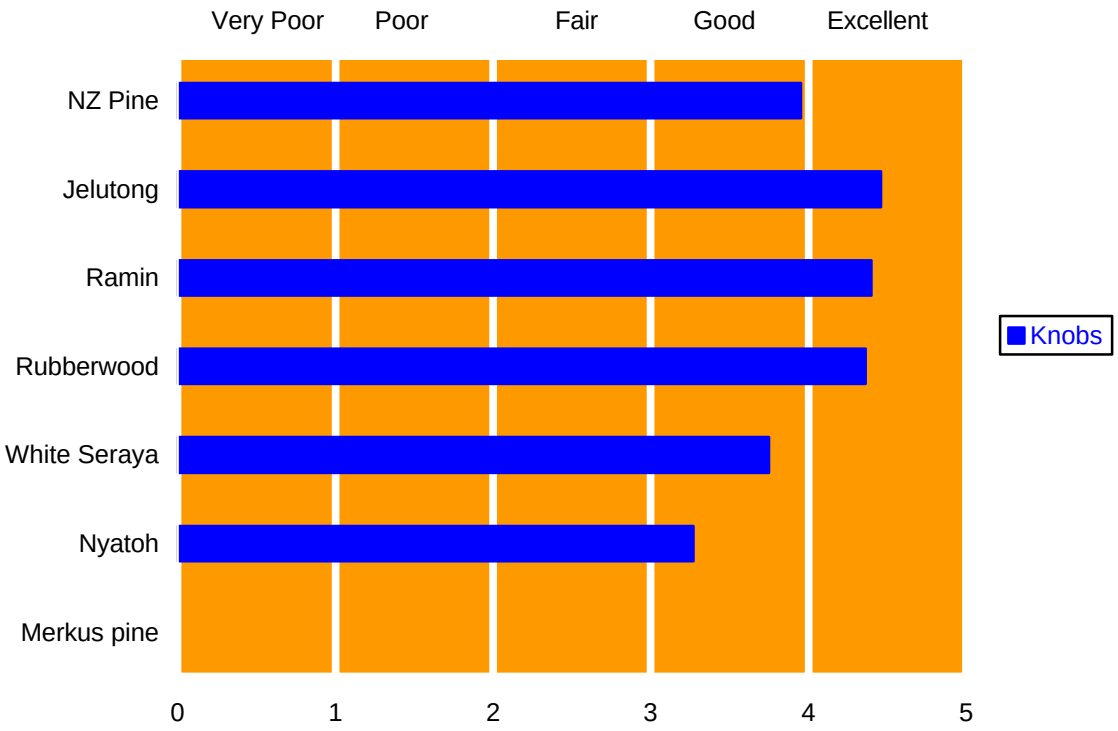
The quality of finish was determined by visually grading each sample on a five-point scale and then calculating the percentage of ‘acceptable’ quality finishes for each species.

5 = Excellent
4 = Good
3 = Fair
2 = Poor
1 = Very Poor

The defect types assessed were crushing, tearout and fuzzy grain.

TURNING

Turning is used extensively in the timber industry today to manufacture a wide variety of products, including furniture components, stair balustrades, wooden bowls, sporting goods, handles and toys.



Note: At the time of testing, the Merkus pine samples were not available.

THE RESULTS

In comparative woodturning tests, Jelutong, Ramin and a Rubberwood achieved the best results, with NZ pine following closely. Chipping (torn grain) was the most common defect causing downgrading, although picking-out on the end grain surfaces was also evident in many cases. The lower spindle speeds showed a tendency to increase the severity of the defect.

NZ pine has little density variation within the growth rings. Its overall moderate density and medium texture make turning an appropriate processing application.

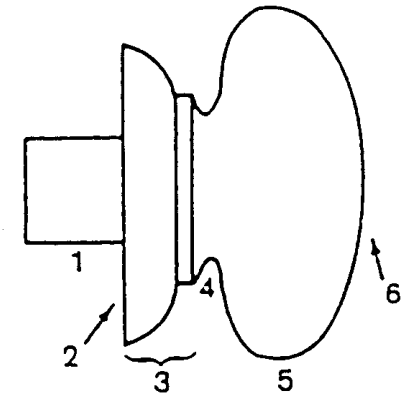
THE TESTS

Turning was assessed by the ***Forest Research*** "drawer knob" test.

The ***Forest Research*** "drawer knob" test was developed to assess a range of surfaces using a small but complex design pattern. Samples (49 x 49mm) of each species were used to provide test pieces for the turning tests. A single profiled knife was used in a lathe to produce turnings of considerable detail (see diagram). Four different turning speeds were used (1800, 2350, 4700, 5600 rpm) to give an estimate of the optimum turning conditions. Feed speed of finishing knife 0.6 m/min.

The quality of finish was determined by visually grading the six separate surfaces of each piece. Defects included severity of chipping, fuzziness of finish and tearout of the end grain. An average score was determined for each species by averaging all the observations (surface x turning speed) for all samples.

5 = Excellent
4 = Good
3 = Fair
2 = Poor
1 = Very Poor



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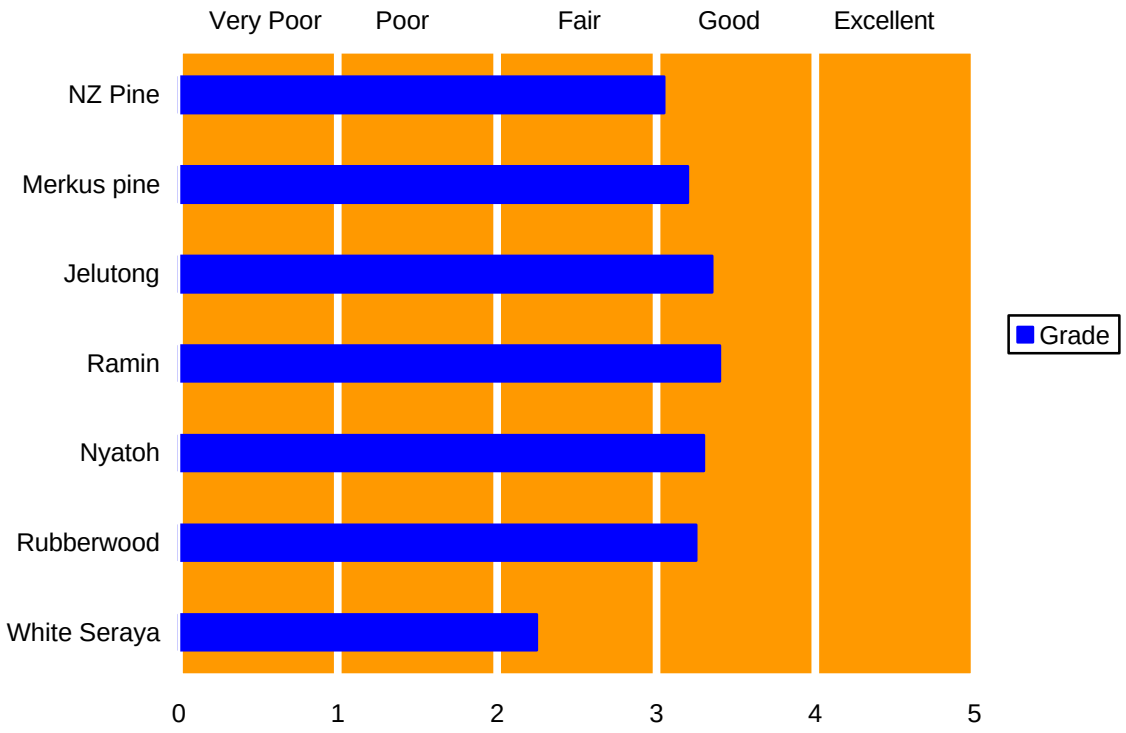
RELATIVE QUALITY RATING - ALL TESTS COMBINED



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Acknowledgments

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