

# Processing and material properties of Tasmanian yellow gum, *Eucalyptus johnstonii*

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## Summary

Boards of native forest Tasmanian yellow gum (*Eucalyptus johnstonii*) were processed using current commercial best practice. Boards were evaluated before and after processing to determine parameters such as board shrinkage, appearance grade and drying degrade. Bending strength and stiffness were determined by standard tests on thirty small clear sections, while Janka hardness was measured at two points on each of ten specimens. Yellow gum boards proved prone to collapse shrinkage and distortion on drying. The results showed that the species produces much denser, stronger and harder timber than the Tasmanian oak group of eucalypts, with seasoned strength rating according to Australian Standards of strength group SD2 (compared with SD4 for the species group) and mean Janka hardness 10.9 kN (compared to 6.1 kN).

*Keywords:* wood properties; quality; density; shrinkage; collapse (drying); checks; wood defects; moisture content; wood strength; *Eucalyptus johnstonii*

## Introduction

Naughton (1995) reported that Tasmanian yellow gum, *Eucalyptus johnstonii*, is 'a tall forest tree usually up to 40 m in height, with DBH up to 1.5 m ... exceptional trees may reach 60 m in height and 2 m DBH'. The species grows on mountains and plateaus in the south-east of Tasmania at altitudes of 450–900 m, usually with other eucalypts such as alpine ash (*E. delegatensis*) and messmate stringybark (*E. obliqua*), although there may be localised association with rainforest trees such as celery top pine (*Phyllocladus aspleniifolius*) and myrtle (*Nothofagus cunninghamii*).

No published data on the structural properties of Tasmanian yellow gum have been available, although quantitative knowledge of the properties of the timber is essential prior to its use in structural applications. Anecdotal evidence from a company that processed yellow gum until the mid-1970s (Peter Bennett, FFIC<sup>1</sup>, *pers. comm.* 2003) suggested that flooring produced from yellow gum was very hard, with few processing problems except for slow drying and rapid cutter wear when milling. This study was designed to assess the properties of the species.

## Methods

### Sampling

Forestry Tasmania supplied the Lindsay St, Launceston, sawmill of Gunns Ltd with 27 m<sup>3</sup> of construction grade Tasmanian yellow gum logs in June 2003. The logs had been cut from Denison coupe 10G, co-ordinates MGA94 477040/5246000, at an altitude of about 600 m. Log sizes are unavailable. Gunns sawed the logs, randomly selected 108 boards 29 mm thick, 80–150 mm wide and 3.0 m long, and supplied them as a wrapped pack to the laboratory.

### Sawing

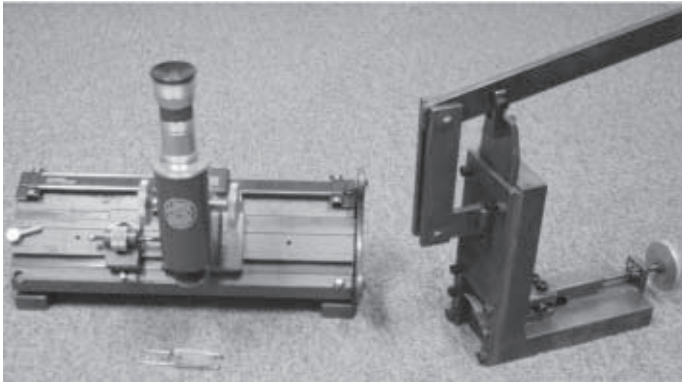
The boards were all quartersawn (i.e. milled with growth rings close to perpendicular to the wide faces of the board). Timber shrinks more in the tangential than in the radial direction, is weaker tangentially and dries faster radially. These factors combine to make backsawn boards (milled with growth rings tangential to the wide faces) more prone to degrade such as surface splitting ('checking') than are quartersawn boards. Most Tasmanian and Victorian eucalypts are quartersawn due to their high tangential shrinkage, and the timber then tends to dry slowly. In contrast, most other woods, including eucalypts from NSW, Queensland and Western Australia, are backsawn, as the boards dry faster and wider boards can be cut from small trees, and an attractive grain pattern is produced.

### Green timber properties

Basic density and initial moisture content (MC) were measured on 20 randomly selected samples, which were the entire board cross-section and about 50 mm long. The samples were weighed and green volume determined by water displacement before they were oven dried at 103±2°C to constant weight.

Unconfined shrinkage was measured on 10 samples. A cube of side about 29 mm was cut from the centre of the board width, about 400 mm clear of the board end. Slices about 0.8 mm thick were cut across the end grain of the sample (Fig. 1) to eliminate most collapse shrinkage, and two slices were retained from each cube. The slices were restrained from out-of-plane deformation by a wire bridle. Two marks were made on each slice, separated radially on one slice and tangentially on the other. As the slices dried in the laboratory, the distance between the marks was

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**Figure 1.** Apparatus to cut and monitor slices for measurement of unconfined shrinkage



**Figure 2.** Research kiln, Forests and Forest Industry Council of Tasmania

measured regularly along with the sample weight. Samples were then oven dried, remeasured and reweighed.

### Green evaluation and drying

Prior to drying, each board was assessed: length, width, thickness, end splits at each end, and board spring (edgewise distortion) if >10 mm over a 2.4 m length were measured. Boards were dried from green as part of a charge in an experimental timber kiln owned by the Tasmanian Forests and Forest Industry Council (Fig. 2). The kiln is built of light-weight concrete, steam heated, with six overhead fans and cold-water sprays for humidification. The drying schedules are shown in Table 1. Following predrying to about 18% average moisture content (MC), the timber was steam reconditioned to recover collapse before final drying in the kiln (Table 1). The kiln was not operated over weekends as steam was not available. Drying progress was monitored by regular weighing and measurement of thickness of six sample boards, each 300 mm long.

### Machining and dry evaluation

Following drying, the width and thickness of all boards were measured. They were then machined to 19 mm thickness by

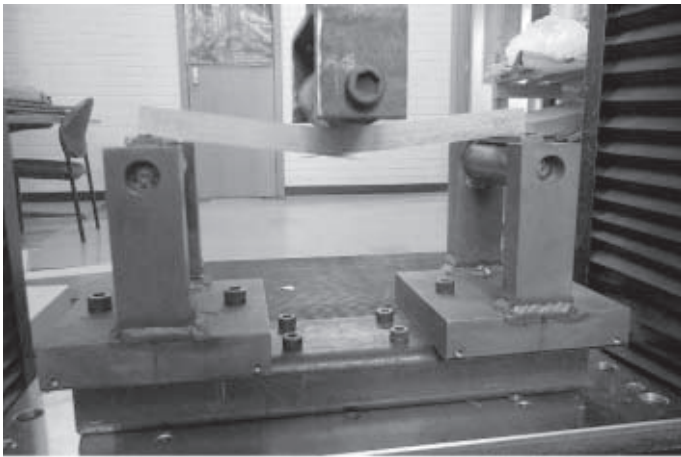
**Table 1.** Drying schedules used for Tasmanian yellow gum

Predrying schedule			
Time (d)	Dry bulb temperature (°C)	Wet bulb temperature (°C)	Air speed (m s <sup>-1</sup> )
0	23.0	21.5	0.5
7	23.0	21.0	0.5
14	24.0	21.5	0.5
21	24.0	21.0	0.5
28	24.0	21.0	0.5
35	25.0	20.5	0.5
42	25.0	20.0	0.5
49	25.0	20.0	0.5
54	25.0	20.0	0.5
Reconditioning schedule			
Time (h)	Temperature (°C)	Comments	
0–2	Ambient–98	Weights fitted, heat up	
2–6	98		
Doors opened, charge allowed to cool for 14 h			
Final drying schedule			
Time (h)	Dry bulb temperature (°C)	Wet bulb temperature (°C)	Air speed (m s <sup>-1</sup> )
0.0	19.0	17.0	1.3
0.5	31.0	28.0	1.5
1.0	33.0	29.0	1.8
1.5	39.0	34.0	2.0
2.0	43.0	38.0	2.0
2.5	45.0	40.0	2.0
3.0	48.0	41.0	2.0
3.5	55.0	45.5	2.0
4.0	59.0	50.0	2.0
4.5	61.0	51.0	2.0
5.0	66.0	54.0	2.0
6.0	65.0	52.0	2.0
7.0	65.0	50.5	2.0
8.0–49.0	65.0	50.0	2.0

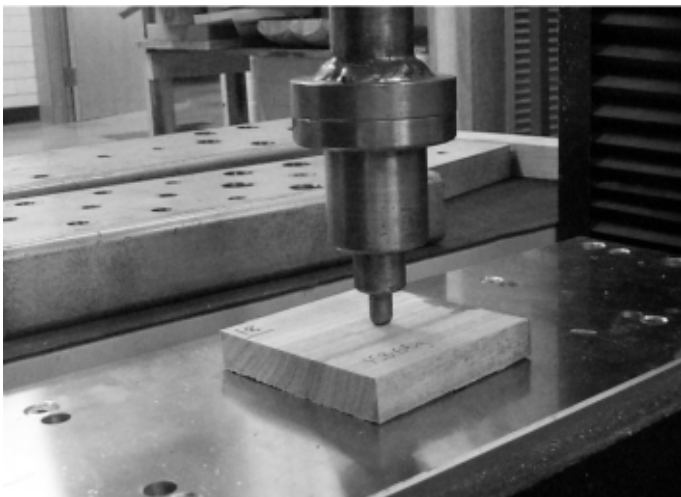
removing 2 mm from one side of each board and a variable amount from the other. A qualified grader at Neville Smith Timber, Launceston, graded the boards to that company's standard. This uses Australian Standard AS2796 (Standards Australia 1999) as a minimum, but as the Tasmanian market accepts significantly less natural feature than AS2796, such mills may apply their own (often unwritten, more stringent) grading standards. Boards were then assessed in the laboratory for total length of each side of the board degraded by surface check or machining skip, length of end splits at each end, and spring if >10 mm over a 2.4 m length. Ends of boards were docked by 300 mm and the clean end inspected for internal checking.

### Strength testing

Thirty boards including both inner and outer heartwood were randomly sampled for strength testing; samples with defect were rejected and replaced. Sections 300 mm long were cut 100 mm clear of any end splits, or at least 200 mm clear of the board end (whichever was greater). Sections 20 mm × 20 mm × 300 mm were cut for testing in three-point bending as detailed by Mack



**Figure 3.** Three-point bending test on 20 mm × 20 mm × 300 mm sample (Mack 1979)

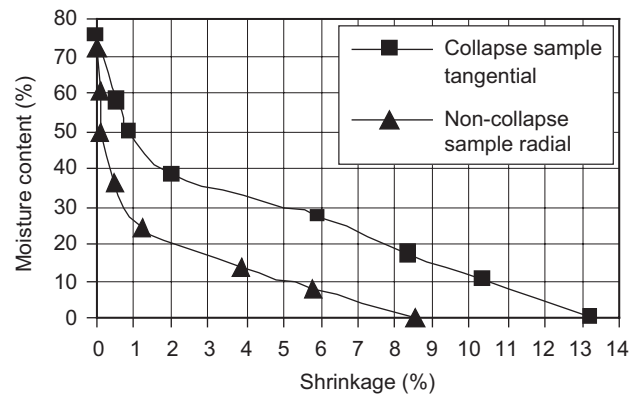


**Figure 4.** Janka hardness testing of Tasmanian yellow gum

(1979) and specified in Australian Standard AS/NZS 2878:2000 (Standards Australia 2000), using a calibrated Instron tensile testing machine (Fig. 3). Modulus of elasticity (MOE) was estimated using data from fitting a straight line by eye to the first part of the load-deflection curve, and Modulus of rupture (MOR) was also calculated. The results were corrected to values at 12% MC based on the measured (oven-dry) moisture content of each sample and the requirements of AS/NZS 2878:2000. The strength group was estimated from the overall mean values using that Standard.

### Hardness testing

Ten randomly selected samples were each tested twice for hardness, after specimens were cut adjacent to the strength samples, and tested using the Janka hardness test as detailed by Mack (1979) (Fig. 4). Oven-dry MC was measured for each sample, as was sawing orientation, i.e. whether the test face was a radial or tangential surface.



**Figure 5.** Typical shrinkage curves for collapse prone and non-collapse prone Tasmanian yellow gum timber

## Results

### Sawing

Mean sawn thickness of the 108 boards assessed was 29.1 mm, with a standard deviation (SD) of  $\pm 1.4$  mm. Twenty-six per cent of boards were sawn to a nominal width of 75 mm (nominal width is the intended dry dimension width, not including overcut for shrinkage), 30% to 100 mm and 44% to 125 mm. About 6% of boards were backsawn, 75% quartersawn and 19% transitional. Backsawn orientation was defined as all growth rings making an angle of  $< 45^\circ$  with the wide face, quartersawn was defined as this angle being  $> 45^\circ$ , and transitional was defined as having a mixture of backsawn and quartersawn orientation.

### Green timber properties

Mean basic density was  $633 \text{ kg m}^{-3}$  with SD of  $\pm 42 \text{ kg m}^{-3}$ , while mean initial MC was 85% with SD  $\pm 13\%$ .

Any sample slices prepared for the assessment of unconfined shrinkage which displayed significant collapse shrinkage were discarded. Collapse is abnormal shrinkage arising from physical crushing of fibres due to surface tension effects while the MC is above fibre saturation point, whereas normal shrinkage is a decrease in volume of fibre walls accompanying removal of moisture (generally at MCs below fibre saturation point). Collapse shrinkage is largely avoided if sample slices are cut thinly enough to sever most of the fibres, but some slices still collapse. Typical examples of the two types of shrinkage curves are shown in Figure 5.

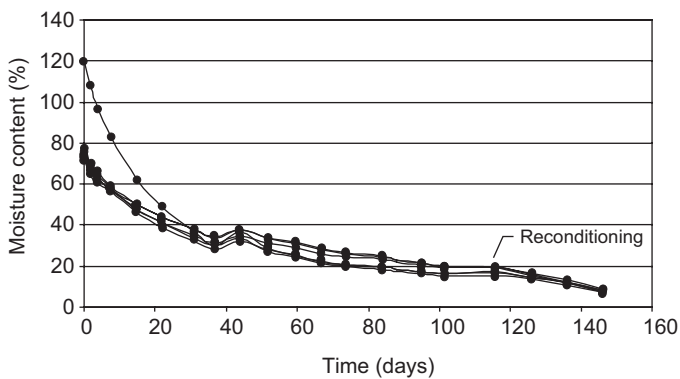
Three points were selected on each unconfined shrinkage curve: initial MC (zero shrinkage); fibre saturation point MC and shrinkage; and equilibrium MC and shrinkage. Means and SDs were calculated from the non-collapsed samples, after three of the ten tangential samples were discarded due to collapse. Results are shown in Table 2.

'Movement' or 'unit shrinkage' is defined as the percentage dimensional change in response to MC change over the maximum range of MC potentially encountered in service (typically between

**Table 2.** Unconfined shrinkage of Tasmanian yellow gum

Sample	Initial MC (%)	Radial shrinkage: fitted points				Tangential shrinkage: fitted points			
		Fibre saturation MC		Equilibrium MC		Fibre saturation MC		Equilibrium MC	
		MC (%)	Shrinkage (%)	MC (%)	Shrinkage (%)	MC (%)	Shrinkage (%)	MC (%)	Shrinkage (%)
10	85	40	0.4	11.4	6.3	45	0.7	8.2	8.4
18	90	50	0.5	11.5	5.8	35	0.8	13.1	6.6
21	75	30	0.5	7.8	5.8	38	1.0	8.9	8.7
24	100	40	0.5	10.5	8.4	45	1.0	9.1	10.7
31	85	40	0.5	11.4	6.3	<sup>a</sup> 47	<sup>a</sup> 1.2	<sup>a</sup> 9.1	<sup>a</sup> 11.1
37	80	30	0.5	11.0	4.2	50	0.9	11.3	7.6
45	80	40	1.0	12.7	7.0	<sup>a</sup> 45	<sup>a</sup> 0.7	<sup>a</sup> 11.9	<sup>a</sup> 10.5
58	88	30	0.2	8.8	4.5	40	0.4	10.8	6.0
82	115	45	0.4	8.8	6.1	45	1.5	9.1	12.0
91	75	35	0.7	9.0	7.2	<sup>a</sup> 50	<sup>a</sup> 0.9	<sup>a</sup> 10.2	<sup>a</sup> 10.4
<sup>b</sup> Mean	87	38	0.5	10.0	6.2	43	0.9	10.0	8.6
<sup>b</sup> SD	±12	±7	±0.2	±1.6	±1.2	±5	±0.3	±1.7	±2.2

<sup>a</sup>Discarded because of collapse; <sup>b</sup>Not including discarded samples

**Figure 6.** Drying progress of six Tasmanian yellow gum sample boards**Table 3.** Fraction (%) of Tasmanian yellow gum boards in each grade to AS2796 (ignoring skip) as modified by Neville Smith

Grade	Top surface	Bottom surface	Both sides
Select	80	81	74
Standard	16	14	
High feature	4	4	

5% and 20%). It was estimated by fitting a straight line by eye to each shrinkage curve between these two MCs. Radial movement was measured as 0.33% per 1% MC change, with a SD of  $\pm 0.08\%$ . Tangential movement was 0.32%, with a SD of  $\pm 0.06\%$ .

### Drying and dry evaluation

The drying progress of sample boards is shown in Figure 6. The rise in MC at around 40 days drying time was due to a kiln malfunction and subsequent increase in humidity. Mean shrinkage was 16.5% in thickness (SD  $\pm 6.2\%$ ) and 11.0% in width (SD  $\pm 2.7\%$ ). Substantial collapse shrinkage was observed, the maximum shrinkage in thickness being 33%. When the timber was machined, the standard set cutter depth of 2 mm was

unfortunately too shallow, resulting in 71% of overall board length on that surface displaying machining skip. About 17% of the length of the other face also had skip as a result of the high shrinkage.

There was very little surface checking, with 3% of the length on one surface affected and 1% on the other. Internal checks were observed on 4.6% of boards. When the boards were graded to the requirements of AS 2796 (Standards Australia 1999), machining skip was ignored. Grading results are shown in Table 3. None of the boards had spring exceeding the allowances of AS 2796 for flooring, but 6% of the boards exceeded the smaller spring allowance for lining. As the edges of boards were not machined, this spring would not cause a significant loss of recovery as it could be straightened by ripping wide boards or docking to shorter length.

End splits extended during drying from 1.2% of overall board length to 3.5%, which is significantly lower than the loss of about 7% reported for quartersawn regrowth Tasmanian *E. obliqua* (Innes *et al.* 2004).

### Strength testing

Two samples were rejected because of knots and were replaced. Mean MOE was 21.1 GPa (SD  $\pm 2.1$  GPa), and mean MOR 170 MPa (SD  $\pm 20$  MPa). These mean values indicate a strength grouping of SD2 under Australian Standard AS/NZS 2878:2000 (Standards Australia 2000) whereas the species with which *E. johnstonii* is commonly associated, Tasmanian oaks (*E. obliqua*, *E. delegatensis* and *E. regnans*), are ranked lower in SD4. Mean air-dry density corrected to 12% was 966 kg m<sup>-3</sup> (SD  $\pm 62$  kg m<sup>-3</sup>).

### Hardness testing

Janka hardness specimens were tested twice on a radial face (corresponding to the width of a quartersawn board). Mean hardness was 10.9 kN (SD  $\pm 1.7$  kN), which is about twice as hard as timber of the Tasmanian oak group (Bootle 1983). Mean MC of the specimens was 7.2%.

## Conclusions

Tasmanian yellow gum is a dense, hard and strong timber. Its tangential:radial unconfined shrinkage and movement ratios are 1.4:1 and 1:1 respectively, which suggests that the timber will be stable in service. There was little distortion, end splitting or surface checking in drying, although a high propensity for collapse shrinkage and some internal checking were observed. Recovery of boards graded as 'Select' to a minimum of Australian Standard 2796 on both sides was high at 74%. Strength properties were good, with a seasoned rating of SD2 based on Australian Standard AS/NZS 2878:2000 (Standards Australia 2000).

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