TWP Timber and Wood Products Research Centre

DECK BOARDS

Stress Grading and Identification

For

Connell Wagner

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SUMMARY

In September 1991 Mr Al Austin of Connell Wagner contracted TWP to evaluate a sample of deck boards taken from a floating–pontoon–type helicopter pad.

Using in–grade techniques, the Modulus of Elasticity (MoE) and Modulus of Rupture (MoR) were determined. The density of the wood was determined both for air–dry Equilibrium Moisture Content (EMC) and oven dry (0%) moisture content.

The mean failure load for bearer–to–bearer span of 900 mm was calculated to be 7.4 kN (2P, 4 point loading). Other values of parameters were:

Number of specimens	= 8
Mean MoR	= 55.6 MPa
Mean MoE	= 10195 MPa
Mean EMC	= 12.3%
Mean Air–Dry Density	= 991 kg/m^3
Mean Oven Dry Density	= 935 kg/m^3

The timber was identified visually as Forest Red Gum (probably Structural Grade No. 2).

Based on density values the provisional classification would be SD4. Other data (MoR, MoE) indicate a provisional classification of SD6 to SD7.

With only 8 specimens in the sample, an inferential statistical analysis would not yield results which could be interpreted with any degree of confidence.

The conclusion is that the timber is in the stress grade range F11 to F17.

These results could be confirmed with a larger sample size ($n > 30$).

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1. INTRODUCTION

Toward the end of September 1991, Mr Al Austin of Connell Wagner, Mackay, contracted TWP to evaluate a sample of deck boards taken from a floating–pontoon–type helicopter pad from a North Queensland coastal island location. The boards had broken inservice.

Evaluations were to cover:

(a) species determination;

(b) condition:

- (i) rot;
- (ii) presence of sapwood;
- (iii) etc.

(c) mechanical stress grading; and

(d) breaking load in bending

The boards were identified by numbers marked on them.

All evaluations in bending were to be done with the marked face being loaded.

2. DESCRIPTION OF DECK BOARDS

The boards consisted of 5 pieces, labelled 2, 4 (two pieces), 8 and 9. They all had a nominal cross section of 110 mm by 33 mm. All were coated on the upper face with a "whitewash" type paint, incorporating traces of biological material resembling feathers, bird droppings and seaweed. They had an odour typical of dried seaweed.

The boards had rusty and split nail holes where they had been fixed to the bearers.

The 5 boards were docked at the nail holes to produce 8 in–grade length specimens for evaluation in bending. These are shown in Plate 1. A photocopy enlargement with bold numbers is shown in Plate 2.

3. INSPECTION AND IDENTIFICATION

Upon arrival, and after docking, the boards were carefully inspected by staff at TWP.

Preliminary inspection of ruptured grain, end–cut grain, gum veins, the state of faces generally, and weight suggested that the species might be ironbark or red gum. There was no prospect of detecting the wood odour because of the dominant "dried seaweed" odour.

The specimens were taken to a local hardwood sawmiller who identified them as Forest Red Gum (*Eucalyptus tereticornis*), to the best of his ability, given the "whitewash" covering and slight pitting of the rough sawn faces.

There appeared to be no rot.

There was no significant presence of sapwood.

There was degradation around nails and nail holes due to splitting during nail–driving and subsequent rust and chemical decomposition of wood fibre in the vicinity.

Plates 1 and 2

4. PREPARATION FOR TESTING

Each of the 900 mm docked test specimens were marked to locate the intersection of a vertical centre line and the neutral axis on the 33 mm side face. At this point, a flat sprig was tapped into the face to facilitate dial gauge contact for deflection readings.

Also datum lines were marked 300 mm either side of the centre line to locate specimens correctly on the test supports. It was ensured that the wide face which was "up" during service was also nominated as the "up" face for testing.

5. TESTING (MoR AND MoE)

The specimens were to be tested in bending for both MoR and MoE according to the Draft Standard for In–grade Testing, with the span of 18 h where h is the height of the specimen (18 x 33 = 600).

5.1 Test Set Up

The test set up was as shown in Plate 3. A four–point loading rig was arranged with the knife edge supports 600 mm apart and two curved hardwood blocks 300 mm apart. A steel I–section was used as a spreader–bar to transfer load from the hydraulic jack to the hardwood blocks. A shim of 1 mm steel plate was placed between each knife edge support and the specimen to prevent embedding of the support in the specimen.

The load cell in series with the 50 kN Ritch hydraulic jack was as follows:

Bongshin 5000 DSC (Serial No. 890013)

Excitation 12 volts

Maximum load 49.05 kN

Output 3 mV/V

The hydraulic jack was connected to a manual pump for purposes of load application. Because of the four–point loading system, the jack force is 2P, that is, twice the size of the end support reaction (P).

5.2 Test Procedure

The specimen which appeared to be the strongest (9.2) was placed in the rig.

It was preloaded to 4 kN for 2 minutes, then the load was removed. The specimen was allowed to "relax" for 5 minutes.

All gauges were then "zeroed".

Load was applied in increments of 1 kN and deflection dial gauge readings were recorded at each increment. The dial gauge was removed at a nominal load of 10 kN. Loading continued until failure and the failure load was noted. The failure mode is shown in plate 4.

This procedure was followed with all specimens, with the modification that the dial gauge was removed when the timber began to show signs of rupturing.

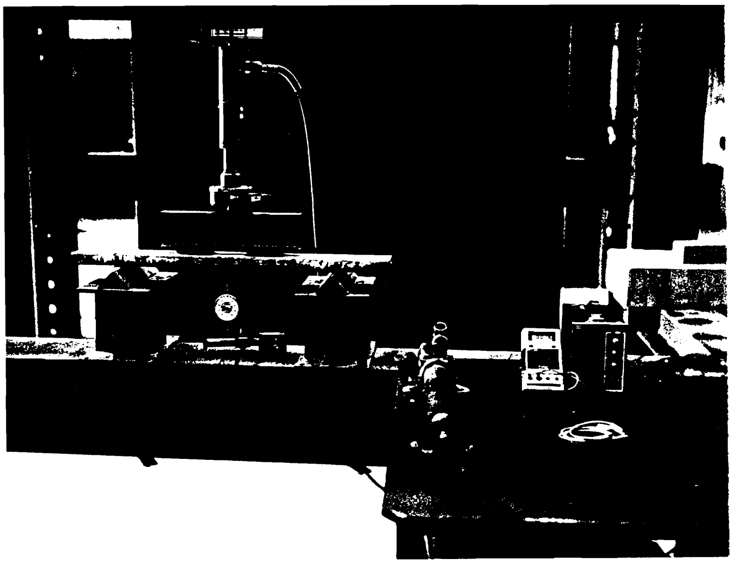

Plate 3
Test Set–up for Bending

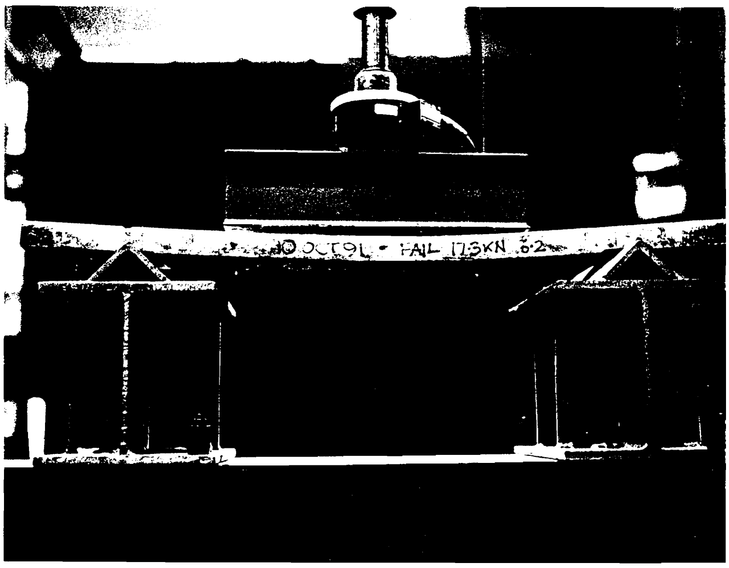

Plate 4
Failure Mode of Specimen 9.2

6. RESULTS (MoR and MoE)

Results for loading in bending are as shown in Table 1. It will be noted that the dial gauge was removed early for the specimens prefixed 2 and 4, as they showed signs of failing with loads as low as 6 kN.

The total failure load (2P) ranged from a maximum of 17.3 kN (specimen 9.2) to a minimum of 6.9 kN (specimen 4.2). It should be noted that these rupture loads were for the 600 mm span. The calculated equivalent rupture load in bending for a 900 mm span is equal to 2/3 or 0.67 times these values.

The range of elasticity, that is, where the increments in deflection were constant, differed from specimen to specimen, but generally was in the 3 kN to 7 kN range. These values are shown in bold in the table.

MoR for each specimen was calculated from:

$$\text{MoR} = \frac{M}{Z}$$

$$= \frac{2P}{2} \text{ x } \frac{L}{3} \text{ x } \frac{6}{bh^2}$$

$$= \frac{2PL}{bh^2}$$

$$= 2P \text{ x } 10^3 \text{ x } 600/(110 \text{ x } 33^2)$$

$$\text{MoR} = 2P\ [5.0088]\ \text{MPa}$$

MoE for each specimen was calculated from:

$$\text{MoE} = \frac{2P}{2} \text{ x } \frac{1}{\delta} \text{ x } \frac{L^3}{28.173I}$$

$$= \frac{2P}{2\delta} \text{ x } \frac{10^3 \text{ x } 600^3 \text{ x } 12}{28.173 \text{ x } bh^3}$$

$$= \frac{2P}{\delta} \text{ x } \frac{10^3 \text{ x } 600^3 \text{ x } 12}{2 \text{ x } 28.173 \text{ x } 110 \text{ x } 33^3}$$

$$\text{MoE} = \frac{2P}{\delta} \left[11{,}636\right] \text{ MPa}$$

The results of these calculations are shown in Table II.

Table I

Load Vs Deflection Data for Specimens in Bending

Specimen 9.2	
Load (2P) kN	Defl'n δ mm
0	0.00
1	0.74
2	1.43
3	2.12
4	2.82
5	3.51
6	4.10
7	4.75
8	5.41
9	6.07
10	6.73
17.3	Fail

Specimen 9.3	
Load (2P) kN	Defl'n δ mm
0	0.00
1	0.98
2	1.82
3	2.68
4	3.54
5	4.42
6	5.23
7	6.08
8	6.94
9	7.81
10	8.75
16.4	Fail

Specimen 2.1	
Load (2P) kN	Defl'n δ mm
0	0.00
1	2.29
2	4.00
3	5.54
4	6.98
5	8.40
6	10.03
7	11.54
8	13.58
–	–
–	–
8.6	Fail

Specimen 2.2	
Load (2P) kN	Defl'n δ mm
0	0.00
1	1.68
2	2.87
3	4.34
4	5.75
5	7.28
6	9.93
7	10.39
–	–
–	–
–	–
8.9	Fail

Specimen 4	
Load (2P) kN	Defl'n δ mm
0	0.00
1	1.31
2	2.59
3	3.94
4	5.24
5	6.60
6	8.05
7	9.43
8	10.89
–	–
–	–
11.6	Fail

Specimen 4.1	
Load (2P) kN	Defl'n δ mm
0	0.00
1	1.65
2	3.14
3	4.68
4	6.24
5	7.85
6	9.62
7	11.31
–	–
–	–
–	–
7.2	Fail

Specimen 4.2	
Load (2P) kN	Defl'n δ mm
0	0.00
1	1.82
2	3.60
3	5.08
4	6.69
5	8.30
6	10.08
–	–
–	–
–	–
–	–
6.9	Fail

Specimen 8	
Load (2P) kN	Defl'n δ mm
0	0.00
1	1.26
2	2.21
3	3.19
4	4.16
5	5.18
6	6.18
7	7.19
8	8.17
9	9.19
10	10.20
11.9	Fail

7. DENSITY AND MOISTURE CONTENT

Two blocks were cut from the undamaged ends of each specimen and were planed smooth such that their final dimensions were approximately 105 mm wide by 31 mm high by 50 mm long.

The blocks were weighed, and measured with a vernier caliper. From these data the air–dry density was determined. Values are shown in Table II, with an average air–dry–density of 991 kg/m³.

The blocks were then placed in an oven at 103° C for 24 hours. They were removed and immediately weighed and measured. From these data, the oven–dry density was determined. Values are shown in Table II. The average oven–dry density was 935 kg/m³.

Also the air–dry or equilibrium moisture content (EMC) was determined. It was 12.3%.

Table II

Specimen, Failure Load, Stiffness, MoR, MoE and Density

Specimen	Failure Load kN (600mm Span)	Calculated Failure Load kN (900mm Span)	Stiffness $2P/\delta$ kN/mm	MoR MPa (600mm Span)	MoE MPa (600mm Span)	Density (Air Dry) kg/m³	Density (Oven Dry) kg/m³
2.1	8.6	5.7	0.6666	43.08	7,750	994	937
2.2	8.9	5.9	0.6612	44.58	7,704	953	897
4	11.6	7.7	0.7310	58.10	8,519	997	934
4.1	7.2	4.8	0.6309	36.06	7,331	965	904
4.2	6.9	4.6	0.6383	34.56	7,424	957	896
8	11.9	7.9	0.9934	59.61	11,567	1027	966
9.2	17.3	11.5	1.5184	86.65	17,665	1042	1001
9.3	16.4	10.9	1.1686	82.15	13,592	994	949
Mean Values	11.1	7.4	0.8761	55.60	10,195	991	935
Standard Deviation	3.99	2.65	0.3251	21.46	3,772	32	36

8. OBSERVATIONS AND CONCLUSIONS

Taking into account the good state of the timber after exposure to a salt–water environment, its durability was assessed at Level 2, which is consistent with Forest Red Gum.

It is not known whether the specimens had been "proof–loaded" many times prior to failure by the wheel loads of landing helicopters.

Also it is not known whether the specimens were water–saturated when they were broken during service. Saturated timber can suffer a reduction in strength (MoR) of as much as 30%, and in stiffness (MoE) of as much as 15%.

Because of the small number of specimens (n = 8), an inferential statistical analysis of the loading data could not yield results which could be interpreted with any degree of confidence. Therefore such an analysis is not presented in this report.

Based on air–dry density values, the timber could be classified provisionally as an SD4 (Strength Group, Dry 4) class, with a minimum density of 840 kg/m^3 at 12% moisture content.

However, the MoR and MoE data indicate a provisional strength Group SD6 to SD7, with mean mechanical properties as follows:

	MoR	MoE
SD6	65 MPa	10500 MPa
SD7	55 MPa	9100 MPa

In conclusion, the timber is most probably Forest Red Gum, of Structural Grade 2, and Durability Class 2, with a stress grade in the range F11 to F17, but most likely F14.

9. ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance of Mr Kevin Hinz (J.B. Hinz and Sons) in identifying the timber species.

10. REFERENCES

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