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A Study on the Distortion of Radiata Pine Plywood *1

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라디에타소나무 합판의 굽음에 관한 연구*1

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요 약

4군데의 임반에서 선발된 라디에타 소나무를 공시목으로 두께 2.6mm와 1.4mm의 단판을 제작 하였다. 단판을 조합하여 만들어진 합판의 크기는 1200×2400×12.5mm이었다. 12.5mm의 합판으로 단판의 성질에따른 합판의 굽음을 조사하였던 바 단판의 성질과 합판의 굽음과의 관계는 낮은 상관관계를 보였다.

Keywords : Plywood, radiata pine, veneer, distortion, pluse speed

1. INTRODUCTION

New Zealand radiata pine is easily peeled for plywood manufacture, the veneer grade depending on log quality. Clear butt logs provide highly decorative veneer, often with a characteristic sheen. Unpruned logs provide veneer for construction plywood.

New Zealand radiata pine plywood is used for exterior and interior sheathing and panels, box and web beam construction, treated lumber frame foundation, flooring pallets, bins. High-quality decorative veneers are also produced for panelling, doors etc(Ministry of Forestry, 1988). Radiata pine plywood is very easy to saw, shape and fabricate into a full range of structural components. Many mechanical studies on plywood of radiata pine have been carried out (Bier, 1983 ·1984; Hirashima, 1988). Okuma *et al*(1983 · 1984) has tested radiata pine, laun and Douglas-fir plywood. Radiata pine was found to have bending properties similar to the other species, but it had better shear properties. A general relationship between plywood distortion and veneer properties were not investigated. This publication examines the effect of distortion on properties of radiata pine plywood.

2. MATERIALS & METHODS

2. 1 Selection of trees

Four trees were obtained from Matahina forest as part of a study that was being done for Tasman Forestry in 1994. They came from stand 1 of compartment 392 which was planted in 1964 and has a site index value of 35. The management history of that stand is: First prune to 2m at age 6. Second prune to 4m at age 7. First extraction thinning to 347 stem per hectare at age 16. Mid rotation inventory at age 26

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showed total stocking 347 stem per hectare, pruned trees 247 stem per hectare, basal area 54.1 m^2/ha, mean crop height 37.9m, mean top height 38.4m, mean DBH 45.8 cm.

2. 2 Peeling

The logs were transported to HT plywood Ltd at Mt Maunganui and further crosscut to 2.7m bolts for peeling to 2.6mm thick veneer on the 2.4m lathe. Bolts were labelled 1 for the butt end and 2 for the top end. Bolts with a small end diameter less than mm were further cut in half(labelled A and B) for peeling to 1.5mm thick veneer on the 1.2 m lathe.

During peeling and immediately after the clipper, the sheets of veneer were each labelled with the tree/log/bolt number and numbered according to the sequence in which they came off the bolt.(eg. 114A1-1 for the first sheet off the butt-end bolt off the butt log tree 114). A continuous crayon mark was also drawn on the ribbon of veneer as it came off the lathe before clipping. After drying they were transported to FRI where they were resorted into correct sequence using the sequence numbers but checking these by means of the crayon mark, defect patterns, and the distance between repeating defects across the grain. This measurement gave the bolt circumference at that point. A total of 493 sheets of 2.6mm veneer and 274 sheets of 1.5mm veneer were obtained.

2. 3 Veneer MOE

Before testing, final sizing of the air dry specimens was done after had reached constant weight in a room with temperature and humidity control designed to give an equilibrium moisture content of 12%. The width and weight of each sheet was measured, also the parallel-to-grain modulus of elasticity using a "Pundit" device. This device has transmitting and receiving transducers which were placed against opposite end-grain edges of the veneer sheets. The Pundit device measured the time for an ultrasonic pulse to be transmitted through the sheet. Modulus of elasticity was calculated from the relationship:

$$E = \rho v^2 \ (N/m^2)$$

where = density (kg/m^3), and
= velocity of the sound wave (m/s)

Density was calculated using the weight and width of each sheet together with an average value for sheet length and thickness which was determined from measurements on 40 sheets, and length = 2.540m and thickness = 2.651mm for the large sheets, and length = 1.288m and thickness = 1.437mm for the small sheets. Velocity was calculated from the measured pulse times and the average length of the veneer sheets.

2. 4 Plywood manufacture

Five-ply sheets of plywood were made using the veneer sheets in the same sequence as they came off the bolts. Urea-formaldehyde adhesive ("sylvic" U-257T is made in ICI New Zealand Ltd.) was used and plywood was made at the HT Plywood plant at Mt. Maunganui. 98 sheets of 12.5mm × 1200mm × 2400 mm plywood and 43 sheets of 7.5mm × 1200mm × 1200mm plywood were made.

2. 5 Plywood distortion

The odd-numbered sheets of 12.5 mm plywood were fillet stacked in a shed where they were protected from direct sun and rain but were open to free air circulation. The average temperature and humidity was determined as 18℃ and 57% respectively. Four equally spaced fillers were used between the sheets, i.e. they were supported at 0.8m intervals along their length. After three months the sheets were measured for distortion by observing the maximum offset from a string line placed along each long edge, each short edge, and across each diagonal. Twist was also measured by supporting one end of a panel at two corners of a short side, supporting it at the centre of the opposite short side(the "free" end), and measuring the slope, from horizontal, of the panel at the free end. The requirments for flatness in AS/NZS 2269 : 1994 follow. Notice that the method of measurement in descrived in AS 2098.4. Table 1 gives distortion in 12.5mm plywood sheet.

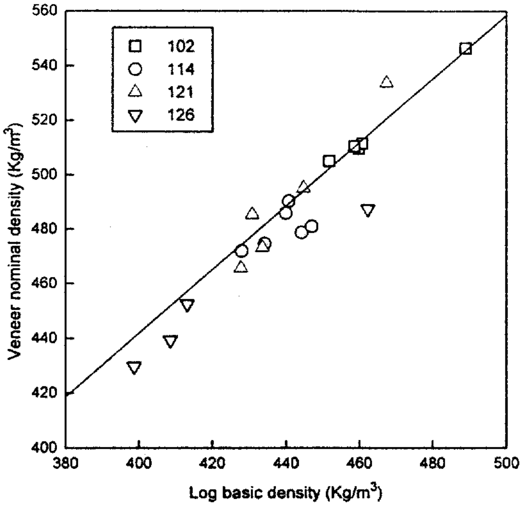

Fig. 1. Relationship of average veneer density to log density.

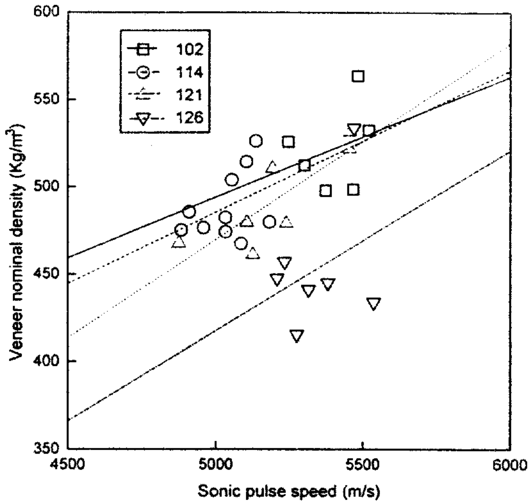

Fig. 2. Relationship of average veneer density to sonic pulse speed.

3. RESULTS & DISCUSSION

3. 1 Log to veneer density relationship

Fig. 1 compares the mean nominal density of the sheets of veneer from each log with the basic density of that log. The regression equation describing the relationship is

$$D_{n,v} = 1.288D_{b,l} - 82.7 \text{ kg/m}^3$$

where $D_{n,v}$: Nominal density of the veneer, and
$D_{b,l}$: Basic density of the log.

The standard error of the estimated veneer density is 9.15kg/m³.

Bier(1986) related the density of the plywood to that of the veneer by the following express;

$$5\text{ply}: D_{np} = 1.061D_{nv} + 26.7\text{kg/m}^3$$
$$7\text{ply}: D_{np} = 1.065D_{nv} + 28.6\text{kg/m}^3$$

where D_{np} : Nominal density of the plywood - M.C. at 10%
D_{nv} : Nominal density of the veneer - M.C. at 10%

3. 2 Relationship of pulse speed to density

The measured speed of the sonic pulse through the sheet can be used to sort sheets for density and/or modulus of elasticity. Such a device is marketed by Metriguard Inc. as their " Ultrasonic veneer tester model 2600" which used to grade veneer. Fig. 2 shows the relationships between nominal density of the veneer sheets and the average speed of the sonic pulse measured on them for each tree. The data for 2.6 mm veneer only have been plotted.

3. 3 Distortion behaviour of plywood

Fig. 3 to 6 show the distortion measured on each sheet, plotted against the average veneer density, MOE, pulse speed, and peeling circumference. The correlations are all low and nonsignificant but there is a consistent trend for decreasing distortion with an increase in each of the predictive parameters.

4. CONCLUSIONS

The research examines the effect of distortion on properties of radiata pine plywood. The major conclusions which could be drawn are as

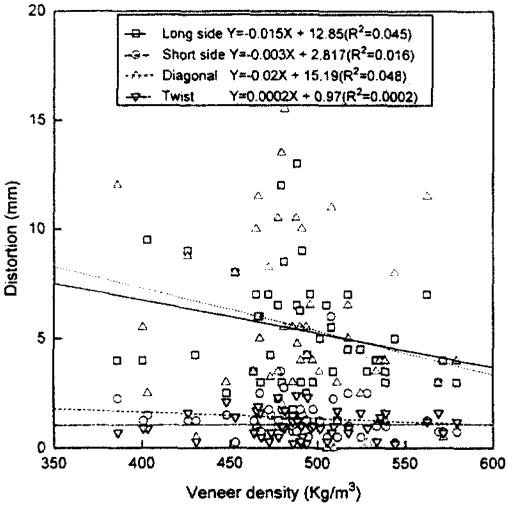

Fig. 3. Distortion in plywood sheets plotted against average veneer density.

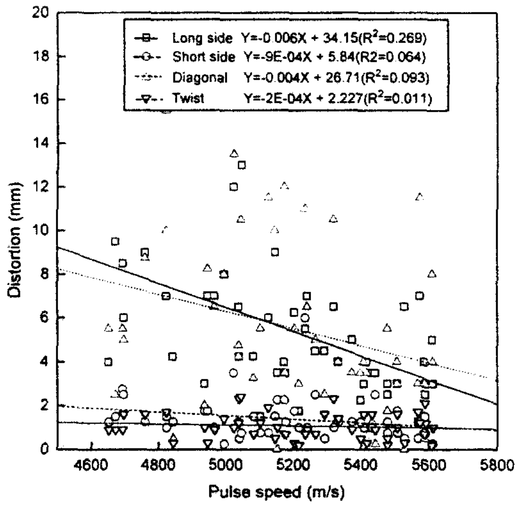

Fig. 4. Distortion in plywood sheets plotted against average pulse speed.

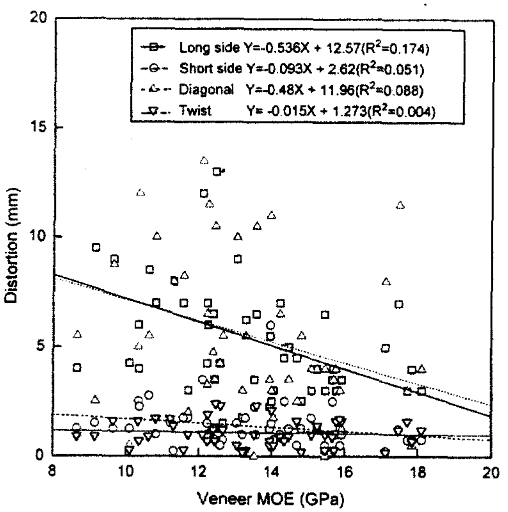

Fig. 5. Distortion in plywood sheets plotted against average veneer MOE.

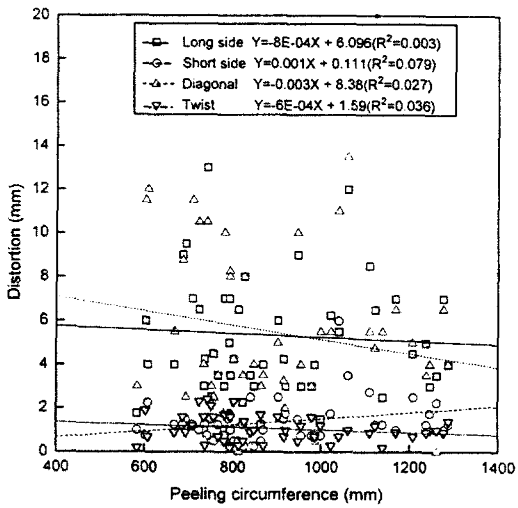

Fig. 6. Distortion in plywood sheets plotted against average peeling circumference.

1. Log density and veneer density together give a better prediction of plywood distortion than does either property alone.
2. There is a trend for distortion in plywood sheets to increase as the veneer from which it is made is taken from nearer the pith, but the trend is not strong.

ACKNOWLEDGEMENT

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Table 1. Distortion in 12.5mm plywood sheets.

Sheet No.	Nominal density (Kg/m³)	Speed (m/s)	MOE (Gpa)	Peel circ. (mm)	Distortion in plywood sheet: Long (mm)	Short (mm)	Diagonal (mm)	Twist slope (%)
1	536.1	5333	15.25	1288	4.1	1.2	4.0	1.4
3	517.7	5241	14.24	1277	7.0	1.1	6.5	0.9
5	496.2	4996	12.24	1170	7.0	1.0	6.5	0.9
7	485.9	5101	12.66	999	1.5	0.7	5.5	1.2
9	430.6	4843	10.11	737	4.3	1.2	0.5	0.3
11	497.5	5507	15.09	1246	3.0	1.7	4.0	1.0
13	488.4	5037	12.40	1123	6.5	1.3	4.8	1.2
15	491.4	5148	13.04	948	9.1	1.5	10.0	0.5
17	403.1	4762	9.16	693	9.5	1.5	2.5	0.9
19	509.2	5152	13.52	1261	3.5	2.3	0.2	1.0
21	481.0	4694	10.62	1110	8.5	2.8	5.5	0.9
23	467.1	4697	10.34	903	6.1	2.5	5.0	1.6
25	400.6	4652	8.66	667	4.1	1.3	5.5	0.9
27	501.5	5373	14.48	1238	5.0	1.3	3.5	0.9
29	479.3	5023	12.10	1061	12.0	3.5	13.5	1.0
31	453.0	4994	11.30	826	8.1	0.3	8.0	1.4
33	493.7	5478	14.82	1139	2.5	1.3	5.5	0.2
35	490.2	5203	13.29	1022	6.3	1.8	5.5	0.3
37	465.2	4823	10.82	782	7.0	1.0	10.0	1.7
39	517.6	5265	14.35	1208	4.5	2.5	5.0	0.7
41	473.3	5081	12.23	916	4.3	1.5	3.3	0.7
43	426.1	4760	9.66	686	9.1	1.3	8.8	1.6
45	479.9	4937	11.71	920	3.0	1.7	2.0	1.0
47	508.0	5235	13.96	1040	5.5	6.0	11.0	0.7
49	472.3	4946	11.58	793	7.0	1.8	8.3	0.3
51	481.5	4823	11.22	791	16.3	1.5	15.5	1.7
53	494.6	5039	12.59	802	4.3	0.5	4.3	2.3
55	579.4	5590	18.10	955	3.1	0.8	4.0	1.2
57	562.5	5573	17.48	709	7.0	1.3	11.5	1.2
59	544.2	5608	17.12	793	5.2	0.3	8.0	0.2
61	533.9	5417	15.70	869	4.0	1.0	3.5	0.3
63	505.4	5528	15.46	813	6.5	0.5	0.1	0.3
65	486.0	5216	13.19	583	1.7	1.0	3.0	0.2
67	466.1	5125	12.25	602	6.0	0.7	11.5	1.9
69	568.9	5580	17.72	979	3.0	0.7	3.0	1.6
71	539.0	5408	15.77	735	3.0	1.0	4.0	1.6
73	539.0	5433	15.92	795	3.5	1.0	1.3	1.6
75	528.6	5442	15.66	840	3.5	2.5	0.3	0.9
77	511.3	5568	15.87	864	1.2	0.5	3.0	1.7
79	488.1	5045	12.45	742	13.1	0.8	10.5	2.4
81	477.7	5319	13.58	724	6.5	1.0	10.5	2.3
83	571.5	5586	17.84	986	4.0	0.8	0.5	0.7
85	524.7	5292	14.70	757	4.5	0.5	2.5	1.6
87	490.8	5611	15.47	848	3.0	0.3	4.0	1.0
89	386.2	5173	10.36	607	4.0	2.2	12.0	0.7
91	463.6	5177	12.44	767	3.5	1.3	3.5	0.7
93	477.7	5398	13.95	823	2.2	1.3	3.5	0.5
95	467.7	5478	14.06	780	3.1	0.8	1.8	0.5
97	448.0	5588	14.01	752	2.5	3.0	3.0	2.1

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