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Kiln drying of sawn boards of young *Eucalyptus globulus* Labill. and *Eucalyptus camaldulensis* Dehnh. grown on the Ethiopian Highlands

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Two drying schedules, a higher-and a lower temperature drying schedule, were tried on sawn boards from young *Eucalyptus globulus* and *Eucalyptus camaldulensis* grown in Ethiopia.The aim of the study was to investigate the effect of the two schedules on seasoning degradation and to develop recommendations concerning drying schedules for the examined timbers. Both seasoning schedules gave satisfactory degradation results for 32 mm thick juvenile *E.globulus* and *E camaldulensis* boards, even though the degradation obtained using the low temperature drying in most cases was slightly lower than using the high temperature drying. The boards of *E. camaldulensis* generally proved to have less degradation than the boards of *E.globulus* in this study.The conditioning of kiln dried materials in the conditioning room has reduced the extent of seasoning degradation in most cases. Kiln conditioning has also reduced deformation values to a certain extent, but often not checking values. In evaluating the differences between the upper- and butt logs, it is found that there were no consistent differences between them, except that the 2m long *E. camaldulensis* boards from butt logs had more deformation than those from upper logs. End sealing with silicon paste gave generally better results than unsealed boards with both drying schedules.

Künstliche Trocknung von Schnittholz aus jungen E. globulus und E. camaldulensis, gewachsen in Äthiopien

Mit je einem Trocknungsplan bei hoher und niedriger Temperatur wurde Schnittholz von *E. globulus* und *E. camaldulensis* (Äthiopien) getrocknet. Anhand der Versuche sollten Trocknungsschäden bestimmt und günstige Bedingungen für die Trocknung dieser Schnitthölzer erarbeitet werden. Beide Verfahren lieferten befriedigende Ergebnisse für 32 mm dicke Bretter, wenn auch die Trocknungsschäden bei niedriger Temperatur etwas geringer ausfielen. Bretter aus *E. camaldulensis* neigten im Allgemeinen weniger zu Trocknungsschäden. Durch Konditionieren konnte das Ausmaß der Schäden reduziert werden. Auch die Verformung wurde dadurch bis zu einem gewissen Grad unterdrückt, nicht aber die Rißbildung. Zwischen den Brettern aus oberen und unteren Stammteilen gab es keine durchgängigen Unterschiede, außer daß 2 m lange Bretter von *E. camaldulensis* aus den unteren Stammteilen Verformungen aufwiesen als aus der oberen Stammteilen. Endversiegelung mit Silikonpaste verbesserte die Ergebnisse beider Trocknungsverfahren.

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1 Introduction

As the natural forests of Ethiopia became dwindled, *Eucalyptus* became the most planted genus of exotic trees around Addis Abeba, other towns and villages of the highlands of Ethiopia (Davidson 1989). Among those in 1895 introduced seed materials, *Eucalyptus globulus* Labill. and *Eucalyptus camaldulensis* Dehnh. were and are the widely planted ones.

During the last few decades *Eucalyptus* species have provided a great part of the Ethiopian population with large quantities of wood, such as fuel wood, construction timber, transmission poles, and other uses. *Eucalyptus* is grown as wood lots, boundaries of fields, shelters, single trees in the fields or around homesteads and along road sides. Because of their fast growth and their utility value for the population, *Eucalyptus spp* are planted almost all over the country.

Therefore, it is important to develop efficient utilisation procedures for sawn boards of such exotic tree species like *E. globulus* and *E. camaldulensis* which are fast growing and found in a relative abundant amount in Ethiopia.

Several investigators have found that one of the biggest problems with the utilisation of young fast-grown *Eucalyptus* trees is the excessive shrinkage and drying defects resulting in check formation and other seasoning defects (Hillis and Brown 1987, Alexiou 1990). The use of commercial drying and its importance for timber utilisation of Ethiopia is in its very young stage. The information gained from this study will be a bench mark for the future activities to be done in this field.

The main aim of this study is to develop recommendations concerning drying schemes for young plantation material from *E. globulus* and *E. camaldulensis.* Drying is a very important problem in processing of wood products and its solution will help to establish economic value (Simpson 1992). The influence of two drying schedules on checking and the development and extent of deformation will be analysed and reported in this paper.

2 Materials and methods

The material for this study was obtained from Ethiopia (Menagesha State Forest, 40 km from Addis Abeba) at altitude of 2400m, with annual rain fall of 1100 mm, mean temperature of 15–17°C, and the length of growing period being 211–240 days. This site together along with two other sites, was planted in July, 1975 consisting of 24 species of *Eucalyptus* in unreplicated plots (Davidson 1989; Pohjonen 1989).

Table 1. Defects and conditions measured on 114 logs of E. globulus (4m) and 68 logs of E. camaldulensis (2m) with standard deviations in parentheses.

Condition and defects of logs	Mean	
	E. globulus	*E. camaldulensis*
Top diameter under bark (cm)	12.9 (2.0)	15.6 (3.1)
Butt diameter under bark (cm)	15.2 (2.3)	17.8 (3.5)
Heartwood diameter on top-end (cm)	8.3 (1.9)	9.6 (3.0)
Heartwood diameter on the butt-end (cm)	10.8 (2.3)	11.9 (3.6)
Number of knots on the log /m	10.8 (3.1)	7.7 (2.6)
Spiral grain angle (°)	6.7 (3.7)	5.3 (2.6)
Max. crook (cm)	3.6 (2.1)	2.8 (1.0)
Shake length on the top-end (cm)	9.1 (3.3)	13 (3.2)
Shake length on the butt-end (cm)	10.4 (2.9)	15.7 (3.3)
Shake width on the top-end (cm)	0.28 (1.0)	0.38 (0.2)
Shake width on the butt-end (cm)	0.26 (0.2)	0.43 (0.3)

Table 2. Higher Temperature Drying (Schedule)

DBT (°C)	WBT (°C)	WBD (°C)	TIME hours*
40	37.5	2.5	0–34.7
40	36.5	3.5	69.0–104.1
45	40 5	4.5	138.8–173.5
45	39.5	5.5	208.2–242.9
45	38.5	6.5	277.6–3 12.3
50	42.0	8.0	347.0–381.7
60	47.5	12.5	416.4–451.1
65	48.5	16.5	485.8–520.5

DBT=Dry bulb temperature, WBT=Wet bulb temperature, WBD=Wet bulb depression.
* The interval between two succeeding drying stages is about 34 hours.

Table 3. Lower Temperature Drying (Schedule 2)

DBT (°C)	WBT (°C)	WBD (°C)	TIME hours*
22.5	20	2.5	0–240
23.5	20	3.5	264–312
24.5	20	4	336–384
25	20	5	408–504
27.5	20	7.5	528–600
32	21	11	624–720
35	21	14.0	744–840

DBT=Dry bulb temperature, WBT=Wet bulb temperature, WBD=Wet bulb depression.
* The interval between two succeeding drying stages is 24 hours.

At the end of November 1991 43 and 31 trees of *E. globulus* and *E. camaldulensis* respectively were felled. From these trees 182 logs were obtained and transported to Addis. Before shipping both ends of the logs were treated with a preservative. Approximately 16 m^3 of *E. globulus* and about 6 m^3 of *E. camaldulensis* were shipped to Sweden in the middle of January 1992 and arrived at the end of February. The delay in transporting the material to Sweden was partly due to the existing situation of Ethiopia at that time. After the arrival of the logs in Sweden, the defects and conditions of the logs for both *Eucalyptus* species were registered before the actual sawing started.

Data concerning the condition of the logs before sawing are given in Table 1. When considering the data, especially concerning crook of the two *Eucalyptus* species, the reader should be aware that their logs have different lengths (4 and 2m respectively). The sawing of the logs was carried out in April, 1992. The logs were sawn through-and-through into 32 mm thick boards by using a circular saw. The first cut was made through the centre of the log. During sawing, the logs were positioned in such a way that the effect of checks were minimized as far as possible.

The heartwood of *E. camaldulensis*, especially that of the larger sizes (more than 20 cm in diameter), was prone to heart shakes from top to butt end following the previous shakes on both ends of the logs.

According to Bariska (1992) the development of heart shakes is often connected to collapse phenomena in the living tree and in the log few days directly after felling (the term shake is here only used for logs).

Directly after sawing the extent of splits was higher in the case of *E. camaldulensis* than *E. globulus*. On the other hand the sawing of *E. globulus* was more difficult, especially of crooked logs, which were cross cut in to two parts so that the sawing became somewhat easier. Immediately after sawing the lumber was stacked using stickers and stored under cover.

After about a week from the date of sawing, more surface checks had been developed and the end splits existing were enlarged, in some cases to the central part of the piece. On the basis of a seasoning schedule (C-schedule for refractory timbers) as described by Pratt (1986), two schedules were devised, a higher and a lower temperature schedule. In the continuation of this paper schedule 1 (see Table 2) is called higher temperature drying schedule and schedule 2(see Table 3) is called lower temperature drying schedule, because the term high temperature drying usually refers to temperatures higher than those used in this paper.

For the seasoning trials 180 boards (90 for each drying experiment) of *E. globulus* were shortened to 2.5 m length in order to have the boards as straight as possible and to reduce the amount of end splits, checks and warp. The width of the boards was in the range of 10–21 cm. All boards, except 8 were end sealed with a silicon paste for each drying experiment to see whether there is any effect of end sealing on the level of degradation during seasoning.

The average initial moisture content of the material for both experiments was about 54% for *E. camaldulensis* and 58% for *E. globulus* and average density 770 kg/m^3 and 680 kg/m^3 respectively based on dry weight and volume at 15% moisture content. The thickness of the boards was about 32 mm for both species. The moisture content of the boards at the start and at the end of drying period was determined by taking cross sections of 15–20 cm from both ends of the sample boards.

In the case of *E. camaldulensis* 69 boards were tested of which 27 were 2m long and 42 shortened to 1 m length with varying width(10–28 cm). The shortening of the boards was necessary in order to eliminate materials which were already severely degraded before the drying experiment started. All, except five 1 m long boards for each seasoning experiment were end sealed. Thereafter the sample boards were put in a freezing chamber in order to reduce further drying before the actual kiln drying.

Both drying experiments were carried out in the mobile experimental kiln of the Swedish Institute for Wood Technology Research, which is computer controlled for regulation and follow-up of the seasoning processes. Both wood species were dried together in the same kiln. The air circulation during drying was 1.5 m/s for both drying schedules. The second schedule had a drying period of 36 days, low temperature and low wet-bulb depression, whereas the drying time for the first schedule was only 21 days. The calculated programmes for the drying conditions in both cases are presented in the Tables 2 and 3.

At the end of both drying schedules the weight of the seasoned boards and the degradation (bow, twist, cup, depth and length of checks and relative check area of the boards on both sides of each board) were registered. In the case of the low temperature drying (schedule 2) the stack was weighted with an extra load of 400 kg (80kg/m^2) on the top of the stack and deformation was recorded before drying and directly after drying. In the case of the low temperature drying, 47 boards most of them of *E.globulus* were selected and conditioned in the kiln for about 4 hours at 70°C and 72% relative humidity. The stickers used for stacking were 1m long and 2.5 cm thick in both experiments.

The relative check area was calculated according to the formula below, the check length being the total of all check lengths and check depth being the average of the maximum check depths on each face of the board.

relative check area =

$$\frac{\text{average maximum check depth} \times \sum \text{check length}}{\text{board length} \times \text{board thickness}} \times 100$$

The formula is derived in modified form from the one originally given by Malmquist (1984). Bow and cup were measured from sapwood side of each board. Values for bow, twist and check lengths are based on 2 m length board, except the measurements on 1 m long boards which are not corrected to 2m lengths. The twist deformation was measured by placing the board so that three of its corners are in contact with a plane surface and measuring the perpendicular distance from the forth corner to the plane surface (Standard Association of Australia 1979).

After each kiln drying experiment the boards were conditioned in a conditioning room to an equilibrium moisture content of about 13%. After conditioning, the weight and deformation of each sample was again recorded and evaluated.

The general linear models were used for the statistical analysis of the data.

3
Results

The drying condition of both schedules are shown in Figs. 1 and 2. The scheduled and real values of the temperature and the wet bulb depression were in a good agreement according to the calculated program for the whole drying time for schedule 1 and there were only small deviations at the very beginning of schedule 2.

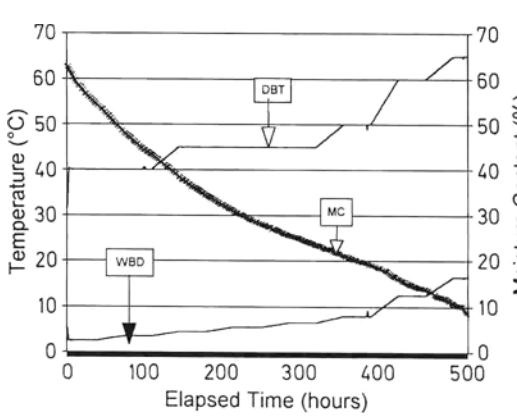

Fig. 1. Higher temperature drying (schedule 1). The scheduled and actually obtained conditions are nearly identical. WBD = wet bulb depression, DBT = dry bulb temperature, MC = moisture content
Bild 1. Trocknung bei erhöhter Temperatur (Schema 1). Angestrebte und tatsächliche Bedingungen sind nahezu identisch. WBT: Feuchttemperatur, DBT: Trockentemperatur, MC: Holzfeuchte

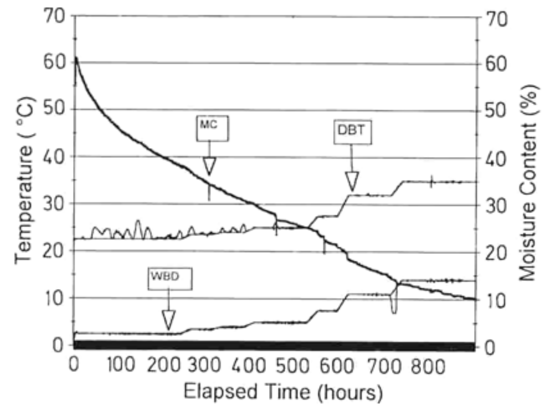

Fig.2. Lower temperature drying (schedule 2). Small differences between scheduled and actually obtained results. WBT = wet: bulb depression, DBT = dry bulb temperature, MC = moisture content
Bild 2.Trocknung bei niedriger Temperatur (Schema 2). Geringfugige Unterschiede zwischen Soll- und Ist- Werten WBT: Feucht-temperatur, DBT: Trockentemperatur, MC: Holzfeuchte

The final average moisture content obtained from schedule 1 and 2 was 8.9 and 9.9% respectively.

The data concerning checking and other deformation values obtained from both drying experiments (schedule 1 and schedule 2) are presented in Table 4. Significant differences between the schedules are indicated in the table mentioned. Deformation, especially bow and cup, obtained with the low temperature schedule is often significantly lower than with the high temperature schedule. The checking results are more varying in this respect. When corresponding values are compared for the two *Eucalyptus* species they differ significantly for most investigated degradation variables.

Deformation values obtained directly after drying are usually greater than after conditioning in the conditioning room, but check depth and check lengths were in some cases larger after conditioning. The increase of the check length after conditioning was mainly caused by development of checks within and around the knots, which was not observed directly after drying. (See checking values in Table 4 for *E. camaldulensis*).

The extent of variation in check lengths was very high varying from 0 to 200 cm on both heartwood and sapwood side, some times covering the whole length of the board.

In the case of *E. globulus*, the average check depth on the side of the heartwood (HCD) was found to be less than the average check depth on the sapwood side (SCD), though check length was higher on the heartwood side (HCL) than on the sapwood side (SCL).

Checking of *E. camaldulensis* is significantly lower than that of *E. globulus* on both sides of the boards. No check formation was observed for 1m long *E. camaldulensis* boards on the sapwood side directly after drying and after conditioning. Deformation (bow and twist) was significantly higher for *E. globulus* than for *E. camaldulensis* boards before and after conditioning. Cup values are similar for both species. Especially twist deformation in *E. globulus* is much larger than *E. camaldulensis* before and after conditioning (See also values for spiral grain values for logs of both species in Table 1).

The statistical tests indicate that there is no significant difference in check formation between the boards of upper logs (all log types other than butt logs) and butt logs (see Table 4). The effect of the two drying schedules on deformation before and after conditioning is also shown for upper and butt logs. No consistent differences between the two types of logs could be shown, though the deformation values of 2m *E. camaldulensis* often were larger for the boards from butt logs than those from the upper logs.

Table 4. Degradation of upper-and butt log boards (32 mm thick) of *E. globulus* and *E. camaldulensis*, using higher temperature (Hi) and lower temperature (Lo) drying schedule respectively, directly after drying (a)and after conditioning (b). Bow, twist and check length are based on 2m length, except the measurements on 1m long boards which are not corrected to 2m lengths. Standard deviations in parentheses.

		E. globulus (2.5m)				*E. camaldulensis* (2m)				*E. camaldulensis* (1m)			
		Upper logs		Butt logs		Upper logs		Butt logs		Upper logs		Butt logs	
Number	Hi	59		31		8		5		15		6	
	Lo	42		45		7		7		17		4	
		a	b	a	b	a	b	a	b	a	b	a	b
Bow (mm)	Hi	7.1(4.3)	5.9(3.8)	6.2(5.4)	4.9(5.3)	4.3(1.7)	2.9(2.2)	6.0(4.4)	4.8(2.8)	3.4(2.6)	2.0(1.6)	2.8(0.7)	1.8(1.0)
	Lo	4.8(4.6)*	5.8(3.8)	5.8(4.1)	5.4(2.9)	3.1(3.1)	1.0(1.4)	3.3(2.1)	2.6(2.1)	1.6(1.3)*	1.2(1.3)	3.0(3.5)	2.8(2.2)
Twist (mm)	Hi	31.1(11.9)	21.7(10.3)	28.3(12.3)	19.6(13.1)	3.9(4.7)	5.6(5..0)	6.8(7.0)	2.6(4.2)	6.6(4.8)	4.1(3.6)	2.6(2.9)	2.8(3.7)
	Lo	27.9(14.9)	19.6(7.7)	30.7(15.5)	22.3(10.1)	3.1(2.4)	1.3(1.6)*	7.6(7.5)	3.1(4.7)	2.7(2.8)*	1.4(2.5)*	4.5(3.1)	2.3(2.1)
Cup (mm)	Hi	3.5(1.9)	2.2(1.7)	3.4(1.8)	1.6(1.8)	3.8(2.5)	2.8(2.4)	4.4(1.3)	2.6(1.1)	3.5(1.9)	1.9(2.1)	3.2(2.6)	2.2(2.5)
	Lo	1.9(1.2)*	1.9(1.1)	2.0(1.4)*	1.8(1.3)	1.4(1.3)*	1.7(1.4)	2.7(1.6)	2.7(1.6)	2.2(1.8)*	1.9(1.8)	1.2(1.3)	1.3(1.3)
HCD (mm)	Hi	3.5(3.6)	3.7(3.3)	2.2(3.3)	2.3(3.5)	1.0(2.1)	0.4(1.1)	0.8(1.8)	0	3.5(8.1)	0.5(1.4)	2.2(5.3)	0
	Lo	2.6(3.7)	2.6(3.5)	2.7(3.7)	2.9(3.8)	0.8(2.3)	0	1.0(2.6)	1.7(2.4)	0.6(1.1)	1.1(2.2)	0	0
HCL (cm)	Hi	34.1(36.1)	32.1(35.8)	29.6(43.6)	23.6(42.6)	11.8(26.4)	0.4(1.1)	1.6(3.6)	0	4.5(11.6)	0.3(0.9)	0.8(2.0)	0.2(0.4)
	Lo	24.5(38.9)	26.4(44.7)	30.9(50.5)	28.9(49.3)	1.1(3.0)	0	6.4(17.0)	13.4(22.9)	2.3(4.1)	3.8(7.6)	0	0
HCA (%)	Hi	3.3(4.9)	3.1(4.6)	2.6(5.5)	2.3(5.9)	0.4(0.7)	0	0	0	0.6(1.4)	0	0	0
	Lo	2.7(6.1)	2.8(5.4)	3.3(6.1)	3.4(6.9)	0.1(0.4)	0	0.6(1.5)	0.9(1.9)	0	0.2(3.9)	0	0
SCD	Hi	5.2(4.9)	5.4(4.7)	4.6(4.9)	5.4(5.1)	0	0.5(1.4)	0	0	0	0	0	0
	Lo	4.2(4.1)	3.9(4.1)*	3.9(3.8)	3.4(3.5)	1.9(3.1)	1.1(1.1)	4.6(8.5)	2.9(5.0)	02.2(5.0)*	0.4(1.1)	0.5(1.0)	0
SCL (cm)	Hi	24.7(32.1)	24.4(28.6)	17.0(24.2)	18.4 (28.2)	0	10 (28.3)	0	0	0	0	0	0
	Lo	20.3(30.4)	17.1(33.7)	24.2(33.6)	21.3(34.2)	8.1(10.6)*	5.9(10.3)	11.0(19.3)	13.1(23.9)	3.3(9.2)	1.7(4.8)	1.5(30)	0
SCA (%)	Hi	3.8(5.9)	3.3(4.3)	2.3(3.3)	2.6(4.7)	0	0.5(1.4)	0	0	0	0	0	0
	Lo	2.4(3.9)	2.3(6.2)	2.8(4.3)	2.2(4.5)	0.3(0.5)	0.3(0.5)	2.1(3.7)	1.7(3.4)	0.1(0.3)	0.1(0.2)	0	0

*$p \leq 0.05$ significant differences between higher-and lower temperature drying shedule.

HCD = check depth on the heartwood side, HCD = check length on the heartwood side, HCA = relative check area on the heartwood side, SCD = check depth on the sapwood side,SCL = check length on the sapwood side, SCA = relative check area on the sapwood side, Hi = higher temperature drying,

Lo = lower temperature drying.

Table 5. Degradation of Eucalyptus boards, directly after kiln drying (schedule 2) and after conditioning in the kiln and in the conditioning room respectively. (The abbreviations with letters HCD, HCL and HCA denote check depth, check length and relative check area on the heartwood side; SCD, SCD and SCA denote check depth length and relative check area on the sapwood side)

	MC (%)	BOW (mm)	TWIST (mm)	CUP (mm)	HCD (mm)	HCL (cm)	HCA (%)	SCD (mm)	SCL (mm)	SCA (%)
Kiln dried	9.9	5.1	29.0	2.4	3.8	53.6	4.9	5.3	39.7	3.6
Kiln cond.	10.7	4.5	25.0	2.3	4.0	56.0	5.4	5.4	50.1	4.8
Cond. room	13.0	4.7	20.9	2.8	4.3	55.8	5.2	5.0	37.9	3.8

In *E. globulus*, the deformation values noted in the low temperature schedule were also often slightly higher in boards from butt logs as compared to those from upper logs, in contrary to the results obtained from the high temperature schedule. The results above may partly be due to the wider width of the boards from butt logs.

Generally, those materials that were not end sealed proved to have more check deformation than sealed boards in both experiments. No "washboarding" (a type of collapse) effect and fungal development were noted during the drying period.

The conditioning in the kiln was accomplished after registering all deformation and checks for the whole stack and after selecting 47 boards most of them from *E. globulus*. The moisture content after conditioning in the kiln was 10.7%. The conditioning in the kiln was carried out in order to see whether this may effect in reduction of degradation. The results are presented in Table 5. There was slight decrease of deformation during this short time of kiln conditioning in the case of bow, twist and cup which indicates the importance of the decrease of stress during kiln conditioning. However, the check values have slightly increased instead of being reduced.

4
Discussions and conclusions

The results generally show that both schedules provide an acceptable drying condition for 32 mm boards of *E. globulus* and *E.camaldulensis* regarding degradation, except for some extremely checked and twisted boards. There were significant differences between the two schedules in cup deformation directly after drying, but after conditioning these differences decreased to a large extent. In the case of *E. globulus* also the difference in bow between the two drying schedules has disappeared after conditioning.

The above effect is caused by the fact that deformation decreased considerably during conditioning, but the decrease was more pronounced for the boards dried with the higher temperature drying schedule than for those dried with lower temperature drying schedule. In this connection it should be mentioned that the moisture content was increased ca 4% for the former schedule compared with 3% for the latter during conditioning. As compared to the long conditioning time in the conditioning room the conditioning in the kiln has a reasonable effect on recovery from deformation. As far as checking is concerned such a clear favourable effect of conditioning was not observed . Not seldom checking increased as compared to the results found directly after drying. As mentioned before, checks developed in and around knots under conditioning. Another contributing factor to the increased checking after conditioning might be the extreme low moisture content directly after drying. Closed checks might open during conditioning. Neumann (1992) has summarised that the higher the temperature and wet-bulb depression the more checks were formed and extended inside the boards. No such clear tendency was found in this investigation.

Differences in degradation between upper and butt logs were generally not significant and not consistent.

There was a marked difference between the two species in developing degradation. *E. camaldulensis* showed much less degradation when dried than *E. globulus*, except cup formation, which indicates the suitability of the former species as a sawing timber. Generally, shorter boards showed lower deformation values than the longer ones, which is logical since they are based on 1m length.

Taking into account the shortage of sawn timber in Ethiopia, the observed deformation can be tolerable and categorized well within permissible norms for dried boards (Pandey, 1988). According to Pandey, the bow and twist of kiln dried 40 mm thick and 210 cm long boards of *Albizia odoratissima* (moderately refractory to seasoning) were 5.5 mm and 10 mm respectively. According to CSIRO Exchange N° 4 "Laboratory rating of seasoning degrade", 8 mm and 63 mm bow and twist respectively are acceptable based on 210 cm length (cited by Pandey). The value of 63 mm for twist seems remarkably high but it could not be checked in the original Australian CSIRO source since it was not available. In this study the average bow and twist values based on 2m length are 6.9 and 30.2 mm in the case of schedule 1 and 5.3 and 29.4 mm in the case of schedule 2 directly after drying for *E. globulus*, the species with the higher deformation tendency. Moreover, after conditioning the deformation and checking values are mostly lower and a large part of the boards, especially of *E. camaldulensis*, would be acceptable to Australian Standard (AS) 2082-1979 for structural timber. The degradation values observed would also often be acceptable according to the Australian Standard (AS) 2796-1985 for seasoned hardwood-milled products "Utility Grade". Furthermore, Alexiou (1991) in his study on drying regrowth *Eucalyptus pilularis* Sm (50 mm thick boards), has compared the extent of face checking in conventional and accelerated schedules. The results of his study for average check depth for accelerated schedules were 9.5 mm and for conventional schedules 10.5 mm respectively. These values are much larger than those obtained in this study for both *Eucalyptus* species. Check depths in this study were found to be between 0 and 5 mm. Moreover, the observed seasoning degradation would have been less if more mature materials had been used instead of juvenile wood which is prone to checking and twisting. The variation and extent of degradation obtained for sawn wood from butt-and upper logs during drying should be further investigated on mature material of both species. It would also be useful to compare sawn wood from several young *Eucalyptus* plantations of the same age from different sites.

Generally, high temperature drying is advantageous compared with low temperature drying in respect of stress relaxation (Kubler 1987; Morén 1993). In this study the deformation obtained using the lower temperature drying schedule was slightly less than that obtained with the higher temperature drying schedule. This can be explained by the fact that the former schedule was a milder one with a longer drying time and that a load was placed on the charge. The load might have suppressed deformation in general but not necessarily checking. The amount of deformation registered in the lower temperature schedule would probably have been higher, if no weight was put on the top of the stack. Those pieces that were not under direct influence of the weight of the charge and the extra load were more deformed during the kiln drying than the other material.

Thus, both schedules could be suitable as drying schedule for seasoning of young *Eucalyptus* materials of different species at the same time. Moreover, the higher temperature drying schedule could give better results, if a heavy load was placed on the top of the stack and was easier to run. Furthermore, the duration is shorter and cost of seasoning lower in the higher temperature drying schedule as compared to the other schedule.

5
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