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Studies on Particleboard (XII)

On the Evaluation of Adaptable Qualities for Furniture or Building Materials (1)

The influence of overlay on creep properties of particleboard

By

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Synopsis : The effects of overlay on creep deflection at constant and cyclic condition of moisture content have been studied in loaded beams of particleboard. The long term creep deflection at constant condition of moisture content in loaded beam (900 mm×300 mm×20 mm) of particleboard was also predicted.

By means of overlaying beech veneer (1 mm in thickness) on both sides of particleboard, the modulus of elasticity increased by 80 per cent and the creep deflection was reduced by 50 per cent.

The prediction of the creep deflection of the full-sized specimen, by using the result of creep test in small-sized specimen, brought a considerable error, since the relationship between the modulus of elasticity and the creep compliance was unstable. Therefore, it is desirable for predicting the long term creep deflection more accurately to use the basic data of the short term creep test of the actual full-sized specimen.

The creep deflection of the particleboard at the cyclic condition of moisture content was lowered considerably by overlaying a thin resin sheet on both sides of the particleboard, since the moisture sorption or desorption from the board surface was sufficiently restrained by the resin sheet, while the resin sheet overlaid board showed the same mechanical property as the original board.

Introduction

When particleboard is used as a material of the wall furniture in house building, the board material comes to be used as a shelf in many instances. Therefore, it is very important to improve creep deflection of particleboard which is bigger than that of solid wood, and to predict creep behavior.

The improvement of creep behavior in loaded beam of particleboard under constant bending stress has been investigated by many researchers [4)5)6)7)8)]. Poo Chow[7)] showed that creep deflection in veneer overlaid particleboard decreased with the increase of shelling ratio which is indicated as the ratio of thickness in overlaid veneer to that in core particleboard. Wu Tsai Perng[8)] also reported that it was effective for the reduction of creep deflection in particleboard to overlay 1～1.5 mm thick lauan veneer, but it was not useful to overlay more than 1.5 mm thick veneer.

The effects of cyclic change in the humidity of the surrounding air on creep of solid

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wood have been investigated by ARMSTRONG and KINGSTON[1]. The reduction of creep in wood occurred at the gaining moisture condition and ARMSTORONG and GROSSMAN[2] also reported the same creep behavior in particleboard beam. On the other hand, BRYAN and SCHNIEWIND[3] found that in tests on beams of particleboard, creep deflection increased while the particleboard was gaining moisture, and decreased during loss of moisture. These results were contrary to those of ARMSTRONG.

Particleboard is often overlaid with resin impregnated sheet in cases of being used as a material of furniture. As the resin sheet restrains the moisture sorption or desorption from the board, overlaying the resin sheet seems to have an effect on creep behavior of particleboard.

From this viewpoint, to investigate the effects of the overlay on creep behavior of particleboard under constant and cyclic humidity condition, this study was conducted. In addition, the prediction of creep behavior in full-sized shelf material under constant bending stress and humidity condition was attempted.

Experimental methods

The materials used in this study were obtained from commercial stocks in the market. The full-sized shelf specimens were three-layer particleboard (S. G. 0.77) overlaid with DAP resin impregnated sheet (without crossband) sized 300 mm×900 mm×20 mm, and also three-layer particleboard (S. G. 0.71) overlaid with DAP resin impregnated sheet (with beech-rotary 1 mm thick crossband veneer) sized 300 mm×900 mm×18 mm. Three specimens of humidity cyclic test were sized 50 mm×600 mm from the specimens which were the same materials as above-mentioned full-sized shelf, other three-layer particleboard overlaid with rotary 1 mm thick beech veneer, and also each non-overlaid original particleboard. Edge of the specimens in humidity cyclic test were filled with oil filler and then sealed with aluminium varnish. Three replications were used for each experimental condition.

The full-sized specimens in creep test under constant bending stress were maintained at 20°C, 65% RH air condition. The beams were supported at the ends over a span of 840 mm and loaded at 10 per cent of the ultimate bending load, 18 kg in center loading. The deflection of each beam at the center of its span was measured at certain intervals. The specimen in humidity cyclic creep test was first exposed at 65% RH for five days and subsequently exposed at 80% RH, followed by 40% RH (each for ten days). Three cycles of humidity change were subjected to each specimen. The beams were supported at the ends over a span of 600 mm and loaded at 10 per cent of the ultimate bending load, 5 kg in center loading. To investigate the moisture change in creep specimens, the moisture specimen in the same condition as each creep specimen was placed close by each creep specimen and the weight change measured.

Results and discussion

Effect of veneer overlay on creep behavior of particleboard

Creep deflections in the veneer overlaid particleboard and the original board (non-veneer overlaid) were measured under constant bending stress and humidy condition. The results are shown in Tables 1 and 2. By means of overlaying 1 mm thick beech veneer on particleboard, the

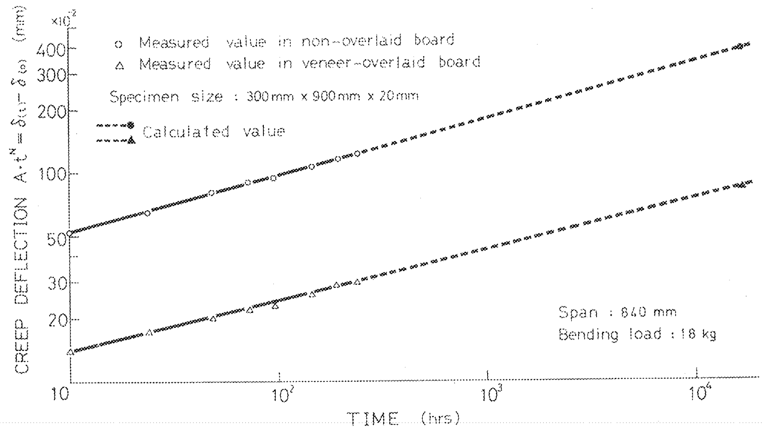

Fig. 1 Some examples of the creep deflection line in the veneer overlaid particleboard and original board.

modulus of elasticity increased by 80 per cent and consequently the creep deflection decreased by 50 per cent (Fig. 1). This means that it is necessary at first for reducing creep deflection of shelf materials mechanically to improve the modulus of elasticity of the materials.

Prediction of creep deflection in full-sized specimen

Y. MIWA *et al.*[5] reported that the logarithmic curve between creep deflection of beam material under constant bending stress and time was approximately linear and gave the following equations:

$$\delta_{(t)} = At^N + \delta_{(0)} \quad \cdots\cdots (1)$$

$$A = J_A Pl^3 / 4bh^3 \quad \cdots\cdots (2)$$

$$\delta_{(0)} = J_0 Pl^3 / 4bh^3 \quad \cdots\cdots (3)$$

where $\delta_{(t)}$: creep deflection in t minutes after loading (mm),

$\delta_{(0)}$: instantaneous deflection at zero minutes after loading (mm),

A, N : constant,

J_A : creep compliance (cm²/kg),

J_0 : instantaneous compliance (cm²/kg),

P : load in bending (kg),

l, b, h : span, width and thickness in creep specimen respectively (cm).

According to Y. MIWA *et al.* A

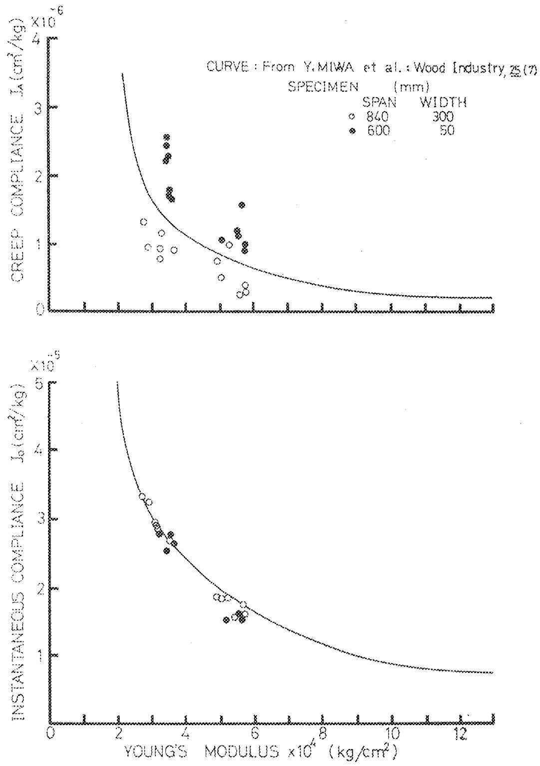

Fig. 2 Relationship between modulus of elasticity and J_A, J_0 in particleboards.

Table 1. Calculation of basic data on creep deflection of two kinds of overlaid particleboard

Specimen	No.	Thickness (mm)	S. G.	M. O. E. ×10⁴ (kg/cm²)	*A* (mm)	*N*	J_A ×10⁻⁶ (cm²/kg)	J_0 ×10⁻⁵ (cm²/kg)
DAP resin sheet overlaid particleboard								
Full size	1	20.70	0.78	3.4	0.092	0.27	0.92	2.76
	2	20.50	0.77	3.7	0.090	0.25	0.87	2.61
	3	20.90	0.76	3.3	0.072	0.27	0.74	2.82
	Mean		0.77	3.5	0.085	0.26	0.84	2.73
Small size	1	20.43	0.80	3.6	0.138	0.21	2.19	2.74
	2	20.40	0.79	3.5	0.144	0.21	2.27	2.65
	3	20.50	0.80	3.6	0.130	0.21	2.07	2.63
	Mean		0.80	3.6	0.137	0.21	2.18	2.67
DAP resin sheet & veneer overlaid particleboard								
Full size	1	20.65	0.71	5.8	0.030	0.24	0.30	1.61
	2	20.60	0.72	5.7	0.028	0.25	0.28	1.69
	3	20.65	0.72	5.8	0.039	0.25	0.40	1.75
	Mean		0.72	5.8	0.032	0.25	0.33	1.68
Small size	1	20.48	0.73	5.7	0.088	0.17	1.39	1.58
	2	20.55	0.74	5.8	0.061	0.20	0.99	1.52
	3	20.53	0.73	5.3	0.071	0.21	1.16	1.51
	Mean		0.73	5.6	0.073	0.19	1.18	1.54

Table 2. Effect of veneer overlay on the creep deflection and effect of basic data obtained from different size specimens on the prediction of creep deflection

Specimen	No.	Creep deflection in 240 hours (mm)		Creep deflection in 10⁶ minutes (mm)	Note
		Calculated	Measured	Calculated	
DAP resin sheet overlaid particleboard					
Full-sized specimen	1	3.98	3.98	6.60	Specimen size
	2	3.68	3.69	5.54	900×300×20 mm
	3	3.70	3.72	5.74	Load 18 kg
	Mean	3.79	3.80	5.69	
Based on small-sized specimen's value	1	4.38	—	6.73	
	2	4.48	—	6.99	Do
	3	4.06	—	6.22	
	Mean	4.31	—	6.65	
DAP resin sheet & veneer overlaid particleboard					
Full-sized specimen	1	1.91	1.91	2.44	
	2	2.01	2.01	2.59	Do
	3	2.16	2.15	2.96	
	Mean	2.03	2.02	2.66	
Based on small-sized specimen's value	1	2.09	—	3.05	
	2	2.21	—	3.12	Do
	3	2.41	—	3.70	
	Mean	2.30	—	3.29	

decreased linearly with the increase in modulus of elasticity and increased exponentially with the increase in bending load. N showed the value which was little changed by modulus of elasticity and bending load. Since A and N were values obtained from the results of a short term creep test, the long term creep deflection in the same specimen as that in the short term test could be predicted from the equation (1). Miwa also described that the relationship between J_A or J_0 and modulus of elasticity in each kind of material was shown with a solid line in Fig. 2. and if the modulus of elasticity in the material was given, the creep deflection could be predicted approximately.

But the plots between the modulus of elasticity and J_A or J_0 showed remarkable deviation depending on the difference between dimensions of specimen, as can be seen in the plots in Fig. 2 and the creep deflection of full-sized shelf material, which was predicted by using the basic creep data from small-sized specimen, caused a considerable error as shown in Tables 1 and 2. Consequently, as shown in the full-sized specimen in Table 2, it seems that if the long term creep deflection can be predicted by using the basic data of the short term creep test of the actual full-sized specimen to be predicted, the accurate prediction could be obtained, as shown with dotted lines in Fig. 1.

Effect of overlay of particleboard on creep behavior in humidity cyclic test

Fig. 3 shows the creep deflection curve and the moisture change in DAP resin sheet overlaid particleboard and the original particleboard in humidity cyclic test.

The range of moisture change was about 1 per cent for DAP resin sheet overlaid particleboard, whereas that for the original particleboard was about 4 per cent, and the big difference in creep deflection occurred in spite of no difference mechanically between both boards. This meant that since the thin film of DAP resin sheet restrained the moisture delivery to the board, the creep deflection of DAP resine sheet overlaid particleboard was decreased. According to Armstrong[1)2)], generally the creep behavior of wood or non-overlaid particleboard increased in

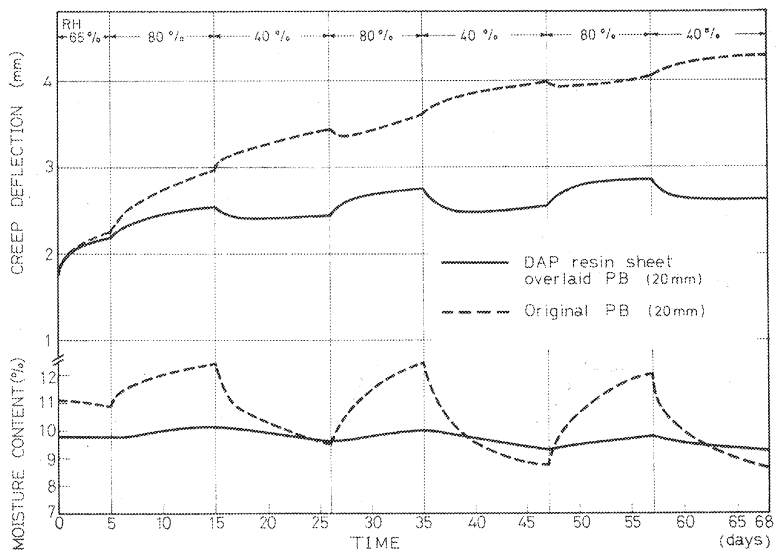

Fig. 3 The effect of DAP resin sheet overlay on the creep deflection of particleboard during cyclic humidity condition.

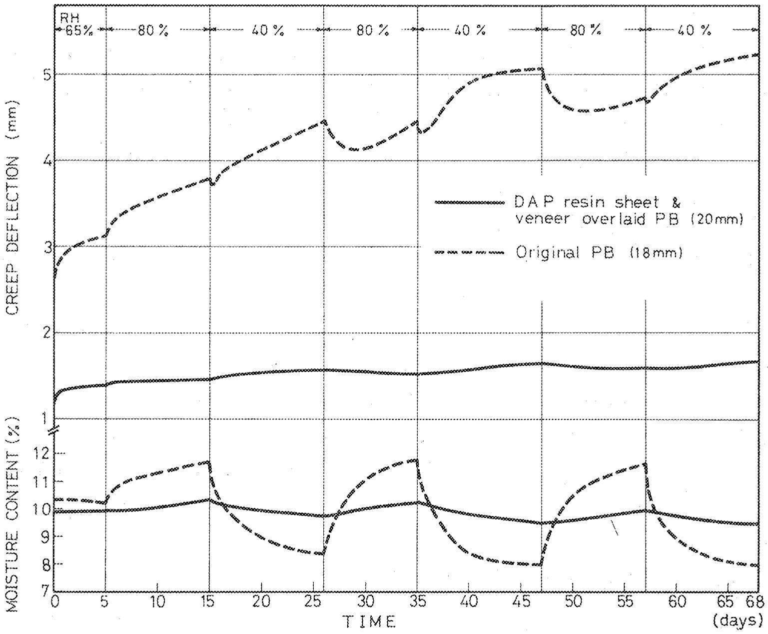

Fig. 4 The effect of DAP resin sheet and veneer overlay on the creep deflection of particleboard during cyclic humidity condition.

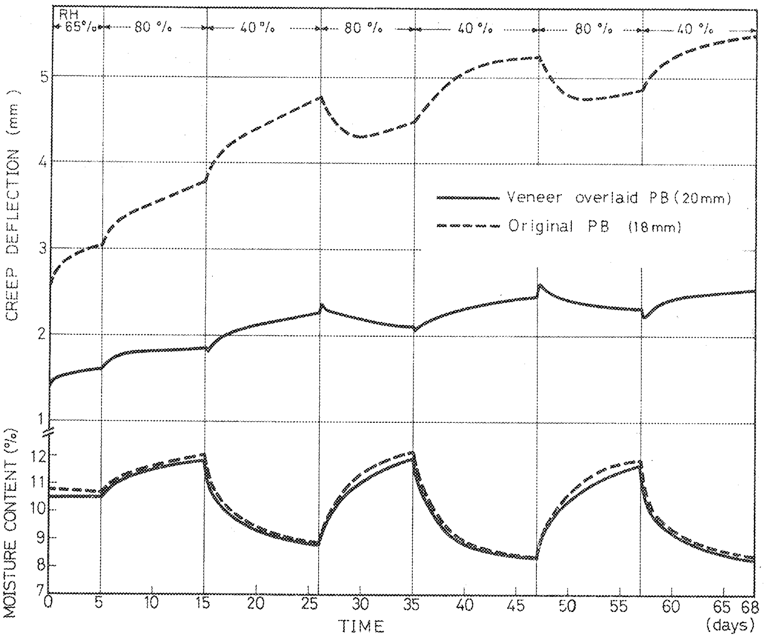

Fig. 5 The effect of veneer overlay on the creep deflection of particleboard during cyclic humidity condition.

desorption process and decresed in absorption process. However, the creep behavior of DAP resin overlaid particleboard shown in Fig. 3 is contrary to the results of Armstrong, whereas it coincides with the results of Bryan[3].

Fig. 4 shows the creep deflection curve and the moisture chage in DAP resin sheet overlaid (with beech crossband veneer) particleboard and the original particleboard in the humidity cyclic test. In this case, as in Fig. 3, since the moisture delivery was also restrained by the resin sheet layer on the resin sheet overlaid board and moreover, the mechanical effect of the veneer overlay was added, increase of the creep deflection was very little.

Fig. 5 shows the creep deflection curve and the moisture change in veneer overlaid particleboard (without DAP resin sheet) and the original particleboard in the humidity cyclic test. In this case, since DAP resin sheet was not overlaid but only veneer was laminated on the particleboard, although the range of moisture change was as large as that of the original board, the mechanical effect of veneer overlay on the creep behavior was evident.

Except for DAP resin sheet overlaid board as mentioned in Fig. 3, all creep behaviors under the cyclic humidity surrounding condition were the same as those shown by Armstrong. Namely, the creep deflections increased in desorption process and decreased in absorption process during the cyclic humidity. In additon, the non-overlaid board in Fig. 4 and the veneer overlaid board in Fig. 5 showed peculiar deflection behaviors, as after the deflections once moved to reverse direction for a while at the time when the surrounding air condition was changed, they returned to normal direction. This shows that the deflection is affected delicately by the most superficial moisture change on the board material.

Conclusion

Consequently, it is necessary for reducing creep deflection of particleboard which is bigger than that of solid wood to improve creep behavior mechanically by laminating the crossband veneer on particleboard, and moreover, to restrain the moisture sorption or desorption from particleboard physically by overlaying the resin impregnated sheet.

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パーティクルボードに関する研究（XII）

パーティクルボードの材質評価（1）

パーティクルボードのクリープに及ぼすオーバーレイの影響

岩　下　睦[1]

要　旨

一定温湿度条件および乾湿繰返し条件下におけるパーティクルボードの，棚材料のクリープにおよぼすオーバーレイの効果について検討した。また，一定温湿度条件下における900 mm×300 mm×20 mmのパーティクルボードのクリープの予測についても，あわせて調査した。

3層パーティクルボードにブナ1mm単板を両面にオーバーレイすることにより，曲げヤング率は約80%増大し，クリープ撓みは約50%減らすことができた。小試片のクリープ試験の結果から実大試料のクリープを予測する場合は，曲げヤング率とクリープ・コンプライアンスの間に一定の関係が得られないため，誤差が大きい。したがって，精度をあげるためには，実験に使用する実大試料自身の短期間のクリープ試験を行ない，その結果を使って長期のクリープを予測する必要がある。

乾湿の繰返しのばくろ条件のもとでのパーティクルボードのクリープは，薄いレジンシートをオーバーレイすることによって，力学的にはあまり変化がないにもかかわらず，ボード表面からの吸脱湿が押えられ，その結果かなりのクリープを減少することができることがわかった。

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(1) 木　材　部