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An assessment of rubber wood *(Hevea brasiliensis)* from Liberia for particle board manufacture

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SUMMARY

An assessment of rubber wood from Liberia for particle board manufacture

In laboratory trials to assess the suitability of rubber wood (*Hevea brasiliensis*) for particle board manufacture, it was found that the extractives in the raw material interfered with the glue bond with a resulting loss of strength and water resistance. This can be overcome to produce a board which meets the relevant British Standard specification, if the moisture content of the board mat is carefully controlled, a high proportion of wax is incorporated and the surfaces of the board mat are sprayed with water before pressing. Rubber wood cannot be considered as a first choice of raw material for particle board manufacture but its shortcomings might be reduced by admixture with another more promising raw material.

SOMMAIRE

Une évaluation du bois de l'arbre à gomme provenant du Libéria pour la fabrication des panneaux de particules

Au cours des essais de laboratoire en vue d'évaluer le bois de l'arbre à gomme (*Hevea brasiliensis*) pour la fabrication des panneaux de particules, on a trouvé que les extractifs dans le matériau ont interféré avec la liaison de colle avec le résultat d'une perte de force et de résistance a l'eau. On peut supprimer celle-ci et produire un panneau qui remplit les exigences des spécifications du norme britannique à condition que l'humidité du matelas de fibres soit controlée avec précision, une proportion élevée de cire soit incorporée et les superficies du matelas du panneau soient pulverisées avec l'eau avant de l'application de pression. Le bois de l'arbre à gomme ne peut pas être consideré comme une choix par excellence de matière première pour la fabrication de panneaux agglomérés, mais on peut réduire ses imperfections par l'addition d'une autre plus convenable matière première.

RESUMEN

Una valuación de la madera de cauchera proveniente de Liberia para la fabricación de madera aglomerada

En ensayos de laboratorio para evaluar la utilidad de la madera de cauchera (*Hevea brasiliensis*) para la fabricación de madera aglomerada, fué descubierto que los extractivos en la materia prima han perjudicado la adherencia de la cola, de este

manera produciendo una pérdida de fuerze y de resistencia al agua. Esto puede ser vencido y fabricado un tablero que satisfaga los requerimientos de las especificaciones de las normas británicas, si el contenido de agua en el material antes de ser prensado es regulado con cuidado, una proporción elevada de cera es incorporada y las superficies de los tableros son pulverizadas con agua antes de la prensadura. La madera de cauchera no se puede considerar como la más adecuada materia prima para la fabricación de madera aglomerada pero se puede reducir sus deficiencias en mezclándola con alguna otra materia más promisoria.

An assessment of rubber wood *(Hevea brasiliensis)* from Liberia for particle board manufacture

Following a request from the West African Explosives and Chemicals Ltd, in Liberia, a sample of rubber wood, *Hevea brasiliensis* Muell.-Arg., was dispatched to the Tropical Products Institute to enable particle boards to be made in the laboratory. The boards were tested according to British Standard specification BS 1811: 1969, Part 2 *Methods of test for wood chipboards and other particle boards* and the results compared with BS 2604: 1970, Part 2 *Resin bonded wood chipboard.*

1. DESCRIPTION AND PREPARATION OF SAMPLES

The sample weighed a total of 1330kg, consisting of debarked logs, 1100mm to 1300mm in length and between 120mm and 250mm in diameter. They were prepared for board making by cutting into 250mm lengths and then submerging in water for seven days to ensure the minimum production of fines during flaking. At the end of this period, the billets were removed from the tank and flaked on a machine with radial knives and scorers housed in a rotating disc. These were arranged to produce flakes 30mm long and 0.6mm thick. The flakes were dried from a moisture content of 40 per cent to about 5 per cent and were then passed through a hammermill fitted with a 13mm screen to reduce the width of the flakes to between 1.5 and 3.0mm. The amount of fines (ie material which would pass a 22 British Standard sieve) produced during the preparation of these particles was approximately 10 per cent. After removal of these fines, a proportion was added to the particles to give a fines content of 5 per cent in the final board making material.

2. BOARD MAKING

Commercial grade urea formaldehyde resin was sprayed onto a weighed quantity of particles in a rotary mixer using a multiple head spray housing. The resin contained 68 per cent solids and a hardener solution was added amounting to 10 per cent based on the weight of the resin solution. The hardener solution contained 25 grams of hexamine and 15 grams of ammonium chloride in 1 litre of solution. The amount of resin used was varied and ranged between 4 and 8 per cent resin solids. The final moisture content of the sprayed particles was adjusted to 10, 11 and 12 per cent by adding water to the resin/hardener mix before spraying. The sprayed particles were placed in a rectangular mould to form a loose mat which after cold prepressing was sufficiently compacted to be transferred to a heated hydraulic press. The boards were pressed to a thickness of 19mm at a temperature of 140°C for a period of 15 minutes. A variation in the amount of sprayed material used produced particle boards with a density range of 400 to 800kg/m^3 and 736mm square. For the resin content variation trials, where the board density remains constant, a density of 640kg/m^3 ± 20kg/m^3 was maintained.

With a few noted exceptions, 1.0 per cent of wax emulsion (expressed as wax solids based on the weight of wood particles) was used to improve the water resistance of the board.

The results of the tests are given in Tables 1 to 5.

3. DISCUSSION OF RESULTS

A sprayed material moisture content of 12 per cent (Tables 1 and 2)

The poor strength characteristics (especially the Tensile Stress) of boards made with a 12 per cent sprayed particle moisture content indicate a weakness in the glue bond. In some cases there is evidence of delamination when the boards are released from the press. It may be that the residual latex in the material interferes in some way with the curing of the resin binder and the resulting reduced strength of the bond may be insufficient to cope with the internal pressure caused by the generation of steam inside the board during the pressing operation. The water absorption and thickness swelling values are satisfactory and come well below the limit specified in the British Standard BS 2604:1970, Part 2. When the density of the board is increased, there is as expected a corresponding increase in the strength values but the thickness swelling values are only marginally reduced. There is however a marked decrease in the amount of water absorbed. The test results of boards made with an increased resin solids content between 4 and 8 per cent show a corresponding increase in strength values. The only exception being the tensile strength and surface soundness values which remain substantially unchanged. An increase in resin solids content also shows a corresponding improvement in the thickness swelling results.

A sprayed material moisture content of 10 per cent (Tables 3 and 4)

When the sprayed chip moisture content is adjusted to 10 per cent instead of 12 per cent, there is an overall increase in the strength properties of the boards produced. However, there is a marked decrease in the water resistant properties of the boards and the thickness swelling values are generally in excess of the limit laid down in the British Standard. It seems that the reduction in the amount of water present in the raw material prevents the formation of a proper glue bond and at the same time yields boards which absorb water rather readily as the results indicate. When the density of the board is increased, there is a corresponding and expected increase in the strength values. The thickness swelling values are substantially unchanged but there is a marked decrease in the amount of water absorbed. The test results of boards made with an increase in resin solids content between 4 and 8 per cent show a corresponding increase in strength values. Although the results of the water resistance tests are poor, there is some improvement with an increase in the amount of resin used.

A sprayed material moisture content of 11 per cent (Table 5)

The test results of a board made with a sprayed chip moisture content of 11 per cent showed a slight increase in thickness swelling when compared with the 12 per cent moisture content boards. This value however is still below the accepted BS limit. The strength properties of this board are considerably increased, bringing them well in excess of the BS specification.

An increase in wax content to 2 per cent (Table 5)

The thickness swelling values of boards made with a 10 per cent sprayed chip moisture content is considerably improved when the amount of wax present is increased from 1 to 2 per cent. The relatively high strength values of the board are maintained.

Surface spraying of board mat with water before pressing (Table 5)

If the board mat is prepared from material with a moisture content of 10 per cent, and water is sprayed onto both sides before loading into the heated press, there is also a great improvement in the water resistance of the boards produced. The two boards made by spraying 1.0 per cent and 1.5 per cent of water respectively onto each surface, gave similar results. These amounts of water are expressed as a percentage of the weight of the board.

4. SUMMARY AND CONCLUSIONS

The interference caused by extractives in rubber wood on the strength of the glue bond indicated in the results, must be taken into account if the material is to be used for the commercial manufacture of particle boards. This can be partially overcome by keeping the moisture content of the sprayed material at a maximum of 10 per cent. On the other hand, to ensure that the water resistant properties of the boards meet the British Standard specification BS 2604:1970, Part 2, provision should be made for the spraying of water onto the surfaces of the board mat before pressing. About 1.0 to 1.5 per cent of water, based on the weight of the board, should be used on each surface. The water resistant properties of boards made with a reduced sprayed chip moisture content, can also be improved by the increased use of wax. Two per cent of wax, added to the resin as an emulsion, will produce particle boards with a water resistance above the limit quoted in BS 2604:1970, Part 2, but it has to be borne in mind that 1 per cent of wax is considered to be the normal commercial maximum.

Because of these shortcomings, rubber wood cannot be considered to be the first choice of a raw material on which to base a commercially viable particle board plant. It is just possible that the interference of the extractives on the glue bond could be substantially reduced or eliminated by admixture with another and more promising raw material.

Table 1: Variation of resin content
Timber density: 483kg/m³
Flake dimensions = 30 x 0.6mm milled through a 13mm screen. Nominal board density 640kg/m³
Moisture content of sprayed particles 12 per cent

Resin content per cent	Wax content per cent	Board density kg/m³	Modulus of rupture MN/m²	Tensile stress perpendicular MN/m²	Screw holding (edge) N	Water absorption 1 hour per cent	Thickness swelling per cent	Impact height mm	Surface soundness N	Dimensional change per cent from 65% RH at 25°C			
										40% RH at 25°C		90% RH at 25°C	
										Length	Thickness	Length	Thickness
8	0	627	18.3	0.65	640	38.4	13.6	432	1275	−0.08	−1.15	0.05	4.08
8	1	613	18.1	0.44	475	14.5	7.7	381	957	−0.05	−0.52	0.12	4.77
6	1	637	17.8	0.37	512	13.8	9.0	305	1018	−0.38	−0.73	0.22	5.02
4	1	629	13.9	0.40	350	17.6	15.1	254	1085	−0.13	−0.87	0.19	5.88
BS 2604:1970. Part 2		Min 480	Min 13.8	Min 0.34	Min 360	—[1]	Max 12	—[2]	Min 1100			Max 0.35	Max 7.0

Footnotes: [1] No limit set in BS 2604:1970. Part 2, but a maximum of 75% set in BS 2604:1955
[2] No limit set in BS 2604:1970. Part 2, but a minimum of 380mm set in BS 2604:1955

Table 2: Variation of board density
Timber density: 483kg/m^3
Resin content 8 per cent. Wax content 1 per cent
Flake dimensions = 30 x 0.6mm milled through a 13mm screen
Moisture content of sprayed particles 12 per cent

Board density kg/m^3	Modulus of rupture MN/m^2	Tensile stress Perpendicular MN/m^2	Screw holding (edge) N	Water absorption 1 hour per cent	Thickness swelling per cent	Impact height mm	Surface soundness N	Dimensional change per cent from 65% RH at 25°C			
								40% RH at 25°C		90% RH at 25°C	
								Length	Thickness	Length	Thickness
613	18.1	0.44	475	14.5	7.7	381	957	−0.05	−0.52	0.12	4.77
561	14.6	0.63	486	15.7	8.3	279	1313	−0.08	−0.41	0.17	3.93
479	8.5	0.32	329	46.6	10.0	229	780	−0.07	−0.49	0.09	3.72
BS 2604: 1970. Part 2											
Min	Min	Min	Min		Max		Min			Max	Max
480	13.8	0.34	360	—[1]	12	—[2]	1100			0.35	7.0

Footnotes: [1] No limit set in BS 2604: 1970. Part 2, but a maximum of 75% set in BS 2604: 1955
[2] No limit set in BS 2604: 1970. Part 2, but a minimum of 380mm set in BS 2604: 1955

Table 3: Variation of resin and wax content
Timber density: 483kg/m^3
Flake dimensions = 30 x 0.6mm milled through a 13mm screen. Nominal board density 640kg/m^3
Moisture content of sprayed particles 10 per cent

Resin content per cent	Wax content per cent	Board density kg/m^3	Modulus of rupture MN/m^2	Tensile stress perpen-dicular MN/m^2	Screw holding (edge) N	Water absorption 1 hour per cent	Thickness swelling per cent	Impact height mm	Surface soundness N	Dimensional change per cent from 65% RH at 25°C			
										40% RH at 25°C		90% RH at 25°C	
										Length	Thickness	Length	Thickness
8	0	645	18.8	1.16	880	40.0	16.7	241	1706	-0.12	-2.14	0.19	10.0
8	0.5	655	19.6	1.18	845	18.9	12.0	305	1521	-0.11	-1.37	0.19	10.14
8	1	652	20.3	1.07	794	18.6	15.2	330	2017	-0.11	-0.28	0.24	8.50
7	1	649	18.4	1.00	737	12.9	11.3	394	1886	-0.09	-1.27	0.26	11.86
6	1	638	16.6	0.68	622	20.8	20.5	368	1489	-0.12	-0.28	0.16	5.30
5	1	638	16.3	0.46	532	19.6	18.2	356	1136	-0.10	-1.58	0.16	5.66
4	1	641	14.1	0.46	581	33.0	26.4	279	871	-0.16	-6.11	0.11	0.14
BS 2604:1970. Part 2		Min	Min	Min	Min		Max		Min			Max	Max
		480	13.8	0.34	360	–[1]	12	–[2]	1100			0.35	7.0

Footnotes: [1] No limit set in BS 2604:1970. Part 2, but a maximum of 75% set in BS 2604:1955
[2] No limit set in BS 2604:1970. Part 2, but a minimum of 380mm set in BS 2604:1955

Table 4: Variation of board density

Timber density: 483kg/m^3

Resin content 8 per cent. Wax content 1 per cent

Flake dimensions = 30 x 0.6mm milled through a 13mm screen

Moisture content of sprayed particles 10 per cent

Board density kg/m^3	Modulus of rupture MN/m^2	Tensile stress perpen-dicular MN/m^2	Screw holding (edge) N	Water absorption 1 hour per cent	Thickness swelling per cent	Impact height mm	Surface soundness N	Dimensional change per cent from 65% RH at 25°C			
								40% RH at 25°C		90% RH at 25°C	
								Length	Thickness	Length	Thickness
652	20.3	1.07	794	18.6	15.2	330	2017	-0.11	-0.28	0.24	8.50
574	14.9	0.65	617	31.0	14.9	254	1785	-0.11	-0.03	0.13	4.12
492	9.6	0.50	383	53.6	14.5	203	1122	0.00	-1.20	0.09	4.01
BS 2604: 1970. Part 2											
Min	Min	Min	Min		Max		Min			Max	Max
480	13.8	0.34	360	—[1]	12	—[2]	1100			0.35	7.00

Footnotes: [1] No limit set in BS 2604: 1970. Part 2, but a maximum of 75% set in BS 2604: 1955

[2] No limit set in BS 2604: 1970. Part 2, but a minimum of 380mm set in BS 2604: 1955

Table 5: Variation of wax and moisture content
Timber density: 483kg/m³
Resin content 8 per cent
Flake dimensions = 30 x 0.6mm milled through a 13mm screen. Nominal board density 640kg/m³

Wax content per cent	Moisture content of sprayed particles per cent	Board density kg/m³	Modulus of rupture MN/m²	Tensile stress perpendicular MN/m²	Screw holding (edge) N	Water absorption 1 hour per cent	Thickness swelling per cent	Impact height mm	Surface soundness N	Dimensional change per cent from 65% RH at 25°C			
										40% RH at 25°C		90% RH at 25°C	
										Length	Thickness	Length	Thickness
1	12	613	18.1	0.44	475	14.5	7.7	381	957	-0.05	-0.52	0.12	4.77
1	11	646	17.9	0.80	674	12.7	9.7	457	1795	-0.11	-2.77	0.10	6.93
1	10	652	20.3	1.07	794	18.6	15.2	330	2017	-0.11	-0.28	0.24	8.50
2	10	644	18.6	1.05	741	5.3	5.3	419	1990	-0.14	-2.52	0.08	7.36
1	10[3]	653	18.2	0.97	626	10.3	8.9	406	1397	-0.20	-2.51	0.20	6.56
1	10[4]	654	18.8	0.77	637	10.9	8.9	406	1668	-0.10	-2.84	0.12	7.54
BS 2604: 1970. Part 2		Min	Min	Min	Min		Max		Min			Max	Max
		480	13.8	0.34	360	–[1]	12	–[2]	1100			0.35	7.00

Footnotes:
[1] No limit set in BS 2604: 1970. Part 2, but a maximum of 75% was set in BS 2604: 1955
[2] No limit set in BS 2604: 1970. Part 2, but a minimum of 380mm was set in BS 2604: 1955
[3] 75cm³ of water (1% of board weight) was sprayed onto each surface of the board before pressing
[4] 112cm³ of water (1½% of board weight) was sprayed onto each surface of the board before pressing