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Thermal Degradation of Chemically Treated *Shorea Parvifolia* Plywood

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Abstract

Thermal degradation of chemically treated plywood of *Shorea parvifolia* as the facing material in timber stud partition was investigated. The plywoods were treated with Dricon, Monoammonium Phosphate, Diammonium Phosphate and mixture of Borax and Boric Acid at 20% concentration. The cavity of the partition was filled with fibre insulating material. The fire resistance of the partitions was evaluated using 1.5 m by 1.5 m gas-fired furnace following the standard temperature-time curve set by the British Standard, BS 476 : Part 22:1987. The rating measures the integrity-ability to withstand collapse or sustained flaming and the insulation-ability to prevent excessive increase of temperature. In this study the best fire resistance rating time based on integrity failure was the partition using *Shorea parvifolia* plywood treated with Dricon (118 min.) followed by Diammonium Phosphate (116 min.), Monoammonium Phosphate (109 min.) and Borax and Boric Acid (97 min.) respectively. The untreated *Shorea parvifolia* plywood partition shows the weakest fire resistance rating of 95 min.

Keywords: Chemically treated plywood, *Shorea parvifolia*, Timber stud partition, Fire Resistance Test, Integrity Tests

Introduction

Plywood, chipboard, block-board, cement-board and wood-wool slab are widely used as the non-structural components in the building industry (Rashid, 1987; Lebow & Winandy, 1999; Winandy, 2001; Green 2004). These materials are commonly used as wall partition, flooring system and ceilings. Being combustible in nature, they do not comply with the fire safety requirements. Plywood include the most common and popular among wood composite performs more or less identical to solid wood, i.e it carbonizes at the rate of 0.6 mm per minute and has a spread of flame rating of class 3 (Rashid, 1986). Sometimes wood is treated with chemicals to extend its utility into new markets. Fire retardant treated

plywood is sometimes permitted as an alternative to noncombustible materials in structure that require increased fire safety (Winandy, 2001).

Surface treatment of wood with intumescent or other flame retardant finish can also be employed (Levan, 1984; Levan & Winandy, 1990). The incorporation of fire retardants chemicals such as mono-ammonium phosphate, boric acid and borax enhanced the fire retardants properties of chipboard (Rashid, 1982 & 1987). The strengths of the fire retardant treated plywood were found to decrease slightly compare to those of the untreated plywood (Wang, 1999)

In Malaysia the used fire rated building components of non-combustible material in multi-storey residential and commercial building is common since the introduction of the building regulation, the Uniform Building By Laws (UBBL) (Anonymous, 1984). At the moment the most common materials used in the fabrications of light weight partition system in multi-storey and modern high-rise building are steel and gypsum plasterboard. Wood farmed walls lined with wood-based material are not very popular except when used as separating walls in the two to three storey timber chalets. Beings combustible, timber and wood-based panel product are not used widely in the building industry unless they comply with the requirement specified in the UBBL. The clause on the non-combustibility criteria in the UBBL for some building component has limited the use of timber and wood-based panel product.

In this study "the effects of chemicals on treated *Shorea parvifolia* plywood as timber stud partition were investigated in relation to the flame properties". The chemicals chosen have the fire retardants ability (Rashid, 1986 & 182; Green 2004).

Material & Method

Treatment of plywood

Shorea parvifolia plywood of 18mm thickness were treated with chemicals of Monoammonium phosphate (MAP), Diammonium phosphate (DAP), Dricon and Borax:Boric Acid (BBA) respectively at 20% concentration. Treatments were conducted in a commercial vacuum impregnation chamber using full cell process with an initial vacuum of 1 bar for 30 min. followed by 14 bar of pressure for 2 hours and a final vacuum of 1 bar for 10 min. Treated samples were weighed before and after treatments to determine the chemical loading by weight difference. After treatment, the samples were labelled with stickers and stored outdoors under cover for fifthteen days to allow for chemical fixation to proceed. The chemical loading of each of the veneer were calculated based on differential in weight before and after treatments.

Timber stud partition system preparation

A timber stud partition system was constructed within a brick wall bonded together by cement and mortar. The overall size of the *Shorea parvifolia* plywood partition was 900 mm high by 810 mm wide by 106 mm thick built within a masonry brick wall inclusive of a 40 mm wide vertical gap along one edge to provide no lateral restraint to the specimen. Each *Shorea parvifolia* plywood panel was fixed on both sides to a vertical hardwood timber stud. The cavity of the partition was filled with 40mm thick Rockwool known as Fibertex with density of 100 kg m^{-3}. The size of the plywood was 900mm x 270 mm x 18 mm. Three samples of *Shorea parvifolia* plywood panels were fixed vertically to the masonry brickwall. The *Shorea parvifolia* plywoods were predrilled and fixed to the frame with nominal nails at 300 mm centre to centre. Figure 1 shows the detailed drawings of the *Shorea parvifolia* plywood partition system.

Fire Resistance Test

The fire resistance test was conducted in accordance with the procedure specified in BS 476: Part 22:1987. The ambient air temp., as measured by the ambient temperature specified as in standard, in the general vicinity of the test construction shall be within 5°C to 35°C immediately prior to the heating period. The complete partition sample has been installed to the frame of 120 mm thick cement wall within R.S.J. steel frame. The partition was exposed to fire following the temp.-time relationship specified in British Standard in the following manner. The steel frame containing the construction was mounted to form the vertical face of a gas-fired furnace provided with three probe thermocouples and controlled to conform the following temperature-time relationship:

$$T = 345 \log (8t+1) + T_0 \quad \text{----------} \quad (1)$$

Where,

T = furnace temp. at time, t

t = time of test (min.)

T_0 = ambient temperature

Throughout the heating process, the pressure within the furnace and over the upper two-thirds of the specimen was maintained slightly positive in relation to the pressure within the laboratory. The pressure conditions were controlled to be within the range of 8 to 12 Pa at the point located at the top edge of the test specimen. The mean temperature of the unexposed face of the partition was measured using five thermocouples in which one had to be fixed at the centre of

each of the quarters of the wall with thermocouples (type K) in which one had to be fixed approximately at the centre of each of the four quarters of the partition. Throughout the test, observations were made on the general behavior of the specimen on the exposed and unexposed faces. The partition system was judged on their ability to comply integrity and insulation criteria.

Insulation

In the insulation criteria, failure were recorded:

a. When the unexposed face temperature increases by more than 140 ^{0}C above its initial value;

b. When the temperature recorded at any position on the unexposed face, either by a fixed thermocouple or by the roving thermocouple were in excess of 180ºC above the initial mean unexposed face temp.

Integrity

In general, a failure of the test construction to maintain integrity occurred when the tested object collapses or sustained flaming occured for more than 10 seconds on the unexposed face. Under criteria for impermeability, failure is deemed to have occurred when one or either of the following conditions prevail:

a. Where the cotton pad test is performed, flames and/or hot gases cause flaming of the cotton pad.

b. Where the use of cotton pad is not suitable, failure shall be deemed to have occurred when either:

- the 6 mm diameter gap gauge can penetrate a through gap such that the end of the gauge projects into the furnace and the gauge can be moved in the gap for a distance of at least 150 mm ; or
- the 25 mm diameter gap gauge can penetrate a through gap such that the end of the gauge projects into the furnace.

Results & Discussions

Actual Furnace Temperature according to Standard Temp. Time Curve

Table1 shows the overall percentage deviation of each different sample following their time interval specified as in the BS standard. Supposedly, as in the standard, stated that any deviation calculated shall be within the specified percentage tolerance as in the table above. The percentage deviation is within the specified percentage tolerance for all tests. For the first 10 min. the percentage deviation for control, MAP, DAP, BBA and Dricon are -1.7%, 2.0%, 4.8%, 2.27% and11.9% respectively. Although Dricon has the highest percentage it still is within the tolerance. Between 10 to 30 min. the percentage deviation for control, MAP, DAP, BBA and Dricon are -1.5%, 0.5%, 0.7%, -0.07% and 1.5% respectively. It shows that the actual furnace start to burn accordingly. Between 30 to 120 min. the percentage deviation for control, MAP, DAP, BBA and Dricon are 0.03%, - 0.03%, - 0.2%, - 0.04% and - 4.1% respectively.

Unexposed Face Temperature of the Partition System

The temp. rise recorded on the unexposed face of the samples as determined by the surface thermocouples is shown in Table 2. Fire retardants treated plywood performed much better than the untreated samples. The recorded temperature shows MAP treated samples having the lowest mean temperature followed by BBA, Dricon, DAP and untreated samples respectively. In BS standard the failure point is above 180°C while for the mean temperature is above 140°C and all the plywood stills below the failure point.

Observation in failure of integrity during testing

Observations on the general behaviour of the test specimen taken during the test at the failure of integrity are tabulated in Table 3. The best fire resistance rating time was the partition using *Shorea parvifolia* plywood treated with commercial fire retardant chemical namely Dricon (118 min.) followed by DAP (116 min.), MAP (109 min.) and BBA (97 min.) respectively based on their integrity failure.

Conclusions & Recommendations

The best fire resistance rating time based on integrity failure obtained from the studies conducted was the partition using *Shorea parvifolia* plywood treated with commercial fire retardant chemical namely Dricon (118 min.) followed by DAP (116 min.), MAP (109 min.), BBA (98 min.) and control (95 min.) respectively. Based on the observation and in the sense of integrity, all the four partition samples that were made from treated plywood have failed before they can reach the final 120 min.. Dricon has showed the longest period which is only 2 min. away from the standard. On the other hand, untreated plywood showed the shortest period which was failed in the 95 min. In the insulation criteria, the treated *Shorea parvifolia* plywood performed slightly below the optimum or failure temperature and the insulation rating.

Further study needs to be undertaken in improving the tests design, increasing the effectiveness of the chemical treatment and uptakes, and the material used.

References

Anonymous. (1984). Malaysian Uniform Building By Laws 1984.

Green, J. (2004). An overview of the fire retardant chemicals industry, past, present, future. *Journal of Fire and Materials*. Vol. 19, Issue 5, 2004. Pp 197-204.

Lebow, S.T. and Winandy, J. E. (1999). Effect Of Fire Retardant Treatment On Plywood pH And The Relationship Of To Strength Propeties. *Wood Science and Technology.* 33 (1999) 285-298.

Levan, S.,L. and Winandy, J. E. (1990). Effect of fire retardant treatment on wood strength. *A review: Wood and Fiber Sciences*, 22 (1), 113-131

Levan, S.L. (1984). *Chemistry of fire retardancy*. P.p.531-574 in Rowell, R (ed.) The chemistry of solid wood. American Chemical Society Pub. Washington, D.C.614pp

Rashid, A.M. (1986). Fire Retardency And Fungal Decay Of Malaysians Timbers Treated With Phosphorus And Borax Compounds. M.Sc. Thesis, University Of London.

Rashid. A.M. (1982). Early Burning Properties of Malaysian Timber By Inclined Panel Test. *The Malaysian Timbers By Inclined Panel Test*. The Malaysian Forester. 45 (3).

Rashid. A.M. (1987). *Fire Retardant Study On Commercial Chipboard*-part 1 Fire Propagation performance. FRIM occasional paper. Forest Research Institute of Malaysia. Kepong.

Wang, S. Y. and Yu-Chen, R. (1999). Structure Performance of Fire-Retardant Treated Plywood:

Table 1. The percentage deviation of each sample following time interval

Time (min.)	Specified Percentage Tolerance (+ or -)	Percentage Deviation (%)				
		Dricon	BBA	DAP	MAP	Control
0-10	15	11.9	2.27	4.8	2.0	-1.7
10-30	10	1.5	-0.07	0.7	0.5	-1.5
30-120	5	-4.1	-0.04	-0.2	-0.03	0.03

Table 2. Unexposed face temp. of the partition system

Plywood Treatment	Mean temp. (°C)	Maximum temp. (°C)	Remarks
Untreated (Control)	122	154	Temp. at 95 min shows no failure in insulation
DAP	116	166	Temp. at 115 min shows no failure in insulation
MAP	76	92	Temp. at 100 min shows no failure in insulation
BBA	80	99	Temp. at 95 min shows no failure in insulation
Dricon	98	178	Temp. at 110 min shows no failure in insulation

Table 3. Observations noted on the samples that fail the integrity tests

Treatment	Failure in Integrity Tests (min.)	Observations
Untreated (Control)	95	At 86 min plywood panel at the bottom side started to char. The charring area starts to create a gap and at 95 min a flame flashing through the plywood panel for more than ten second.
DAP	116	At 110 min plywood panel at the bottom side started to char. At 118 min a flame flashing through the surface for more than ten second.
MAP	109	At 105 min surface of plywood started to char. It builds a gap within the plywood and at 109 min a flaming flashing through the surface for more than ten second.
BBA	98	At 96 min surface of plywood started to char. The charred area increased. At 98 min a flaming flashing through the surface more than ten second.
Dricon	118	At 110 min surface of plywood started to char. It builds a gap within the plywood and at 118 min a flaming flashing through the surface for more than ten second.

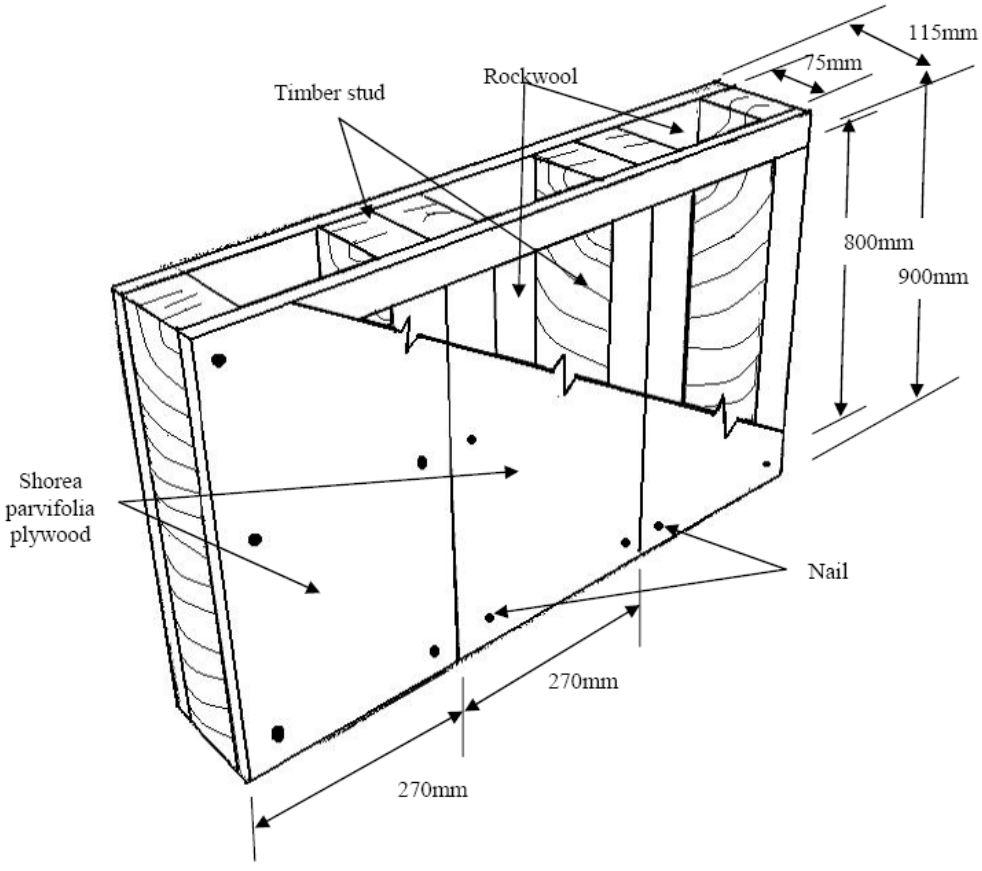

Figure 1. Isometric drawing view of the wall assembly