Full Length Research Paper

Trial processing and lamination of balsa wood as an insulation board for ceiling construction in buildings

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The balsa sawn boards were tried for manufacturing an insulation board. A total of 32 rough sawn balsa boards, 100 × 25 × 1.5 mm length, were air-dried to 15% moisture content, dressed and machined into tongue and groove (T and G) product. The T and G boards were joined side by side (lamination), bonded with polyvinyl acetate (PVA) liquid wood adhesive to form an insulation board of 4.8 m² wide surface area. After curing of adhesives, the surfaces of the boards were lightly sanded and coated with paints and varnish. Laminated board surfaces exhibited a fine texture due to the use of sharp tools. The application of adhesive and surface coatings enhanced strong bonding and coated fairly well respectively. It was noticed that natural grayish brown colour of balsa appeared orange to yellowish brown after it was polished. The finish laminated products were suggested as suitable insulation board materials for utilization in interior lining purpose with a particular reference to ceiling construction in buildings.

Key words: Balsa wood, wood machining, tongue-and-groove, lamination, lining, insulation board, polyvinyl acetate liquid adhesive, surface coatings.

INTRODUCTION

The processing, utilization and marketing of balsa (Ochroma lagopus Sw.) wood for various end uses on domestic scale is limited or nil in Papua New Guinea (PNG). Balsa, a tropical hardwood native to South America, was introduced in PNG in the late 1940s and naturalized well in New Guinea islands region particularly at Kerevat, East New Britain Province (ENBP). Balsa is fast growing with short rotation age of 7 to 8 years for harvest. However, balsa has not been seriously adopted as commercial stock for plantation development in PNG. This may probably be due to lack of awareness on basic wood characteristics and end uses. On the other hand, Howcroft (2002) working on an ITTO balsa project at Kerevat(ENBP) has comprehensively provided information on plantation silviculture and management of balsa in PNG. Presently, small trial plantations are established in ENBP and a local industry processes about 2,500 to 4,500 m³ balsa sawn boards annually for export market in Europe. In 2004, a total of 4,709 m³ balsa lumber was traded (Libitino, 2006). An urgent research work is required to provide update information on basic wood properties, processing/utilization and marketability based on PNG grown material in order to promote its end use domestically. Basic wood properties of balsa vary between sapwood and heartwood, however, wood is lightweight with a density 90 to 310 kg/m³ at 12% moisture content (Wiselius, 1998). Also, Eddowes (1977) described balsa wood as being extremely soft and light in

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weight/density and hardness respectively. In addition, balsa dries easily (preferably by kiln drying) and has good dimensional stability (Tsoumis, 1991). Thus, the general end uses are mainly light constructions (e.g. buoys, aircraft manufacture, surgical splints, packaging fragile items, mounting boards, quality pulp and paper, etc), and an excellent insulation of heat/cold, and absorption of sound and vibrations (Wiselius, 1998). Further, balsa wood has satisfactory working properties that is, easy to work with sharp cutting tools, glues, paints, and finishes well. However, balsa does not hold nails and screws or other metal fasteners (Tsoumis, 1991).

Wood panel/composite boards e.g. soft-boards or medium density fibre-boards (MDF) are widely used for internal lining/paneling (walling and ceiling) constructions in buildings. Low density wood composites are specifically utilized as insulation boards for internal lining purposes. Haygreen and Bowyer (1989) provided specific gravity range 0.25 to 0.45 for insulation boards. Anon (1970) defined lining as covering of inner surfaces or framework of a building. Internal lining materials, apart from aesthetic appeal, should provide insulation against heat, cold and sound. In tropical warm environment (PNG) where modern buildings use metal roofing sheets, insulation board used in lining purpose (ceiling) must poses insulation characteristic from severe heat penetrations. As required by PNG Building Code, most modern building constructions in PNG use expensive engineered composites (e.g. plywood, mesonite, particle boards or MDF) as internal lining materials for ceilings which are often coated with paints. There is a need for developing an affordable new insulation (lining) board for ceilings as a substitute to expensive engineered composites.

In any side-by-side laminated panel products, adhesive is necessarily applied to achieve effective adhesion and bonding (Desch and Dinwoodie, 1996). In this case, synthetic adhesives in the form of liquid/emulsion are preferred. Rivers (1987) added that adhesive bonding is essentially a key factor in efficient utilization of wood.

Presently, there is no information available on utilization of balsa for insulation boards in PNG. This trial experiment aimed to machine balsa wood into tongue-and-groove (T and G) boards, laminate side-by-side into board and bond with synthetic polystyrene (PVA) liquid adhesive in order to find if it is suitable for end use as lining (insulation) material for ceiling construction. Also, the trial assessed the finish end product’s glulability and paintability characteristics. An examination of thermal conductivity and diffusivity as insulating properties were not aimed in this case study.

Study site

The study was conducted at Timber and Forestry Training College (TFTC) Lae and Bulolo University College (BUC) Bulolo. TFTC is within the vicinity of Lae city at sea level to 10 m altitude whilst BUC is located South-West of Lae at 750 to 800 m altitude above sea level. Daily temperatures are 34 and 40°C in Bulolo and Lae respectively.

EXPERIMENTAL

Materials used and machining of balsa boards

The materials used were rough sawn balsa boards as test samples, moisture meter, brush, polystyrene (PVA) liquid wood adhesive, bench top, cloth tissue, bar clamps, planer molder, sand paper, under-coat and finish primer paints (oil-base), and transparent coats (Clear Polyurethane Gloss).

At Kerevat (ENBP), balsa logs were extracted from a 6 year old plantation and milled into rough sawn boards (100 mm x 25 mm x 1.5 m length of 32 pieces), pre-dried and shipped to TFTC, Lae. The samples were stacked under a shed for further air-seasoning and were conditioned to 15% moisture content (MC). The samples were then dressed on all sides and machined into tongue and groove (T and G) boards using a planer molder. The T and G samples were taken to BUC carpentry shop for lamination into a board product.

Lamination for insulation board formation and coating process

A total of 32 T and G machined balsa boards were assembled on a bench top. The profiled T and G surface ends were thoroughly cleansed with cloth tissues from dust and other particles. A PVA liquid adhesive was applied lightly with a thin brush onto the tongue ends of the boards only. After applying adhesive, boards were laminated side by side i.e. a board of adhesive coated tongue was inserted gently into a groove of other adhesive-free board. There were 10 to 11 T and G samples laminated at a time (depending on a span of bar clamp) to form a wide board resembling to a wood composite. The two ends of the clamps were placed perpendicular to long axis of the laminated boards to compress the boards together. The amount of pressure exerted for compression was just enough that there was a good contact in the glued T and G joints. The setting and curing time of adhesives was 20 to 30 min and 2 hrs were allowed for compression. Eventually, two separate wide laminated boards were produced as finish products simulating insulation boards. One finish laminated board composed 16 T&G samples and two laminated boards contained 32 samples with a surface area of 4.8 m² (0.1 m x 1.5 m x 32 pieces) altogether. The finish laminated board simulating an insulation board is shown in Figure 1. Finally, surfaces of two laminated boards were lightly sanded and coated (1x under-coat and 1x primer finish paint). Apart from painting, transparent varnish was applied twice on the other faces of the laminated boards. Insulation properties (thermal conductivity and diffusivity) as variables were not measured as the aim of this work is to construct an insulation material from sawn balsa boards and laminated boards were not used in actual ceiling construction.

RESULTS AND DISCUSSION

Air-drying and machining characteristics

The pre-dried rough sawn boards dried fairly well during seasoning in a shed. It was observed that sawn boards did not develop severe drying defects like warping,
surface checks or end splits. However, top layers of the stack indicated slight bowing. Additionally, there were no stains on board surfaces by staining fungi under ambient atmospheric conditions at TFTC, Lae. This was suggested to be due to good stacking technique with the use of even-sized fillets and good wind ventilation at the seasoning site.

In the machining process, the individual boards were dressed well without difficulty and machined into tongue-and-groove (T and G) satisfactorily. It was observed that surfaces of machined boards as well as tongue and groove ends revealed smooth and even textures without fibre disintegration or conspicuous surface checking. This was attributed to the sharp tools e.g. cutting profiles used in the planer molder. This reflected the balsa wood's machining characteristic as been excellent as long as wood was dried properly and sharp tools were used.

**Lamination, gluing and surface-coating characteristics**

It was noticed in the lamination and board formation processes that setting/curing of PVA adhesive and compression took 20 to 30 min and 2 h respectively for effective bonding. In compression, clamps were slowly tightened with care until individual boards were in close contact and allowed adhesives to set and cure/harden. Theoretically, this was to allow setting/tagging of liquid adhesive with no air pockets within the joints. The lamination of 32 T and G boards was satisfactory with no gaps created during curing by uneven distribution of adhesive/tagging or air pockets. This can be seen in Figure 2 where laminated board showed no gaps in the initial jointing.

Also, light application of adhesive on one edge (tongue) was sufficient for adhesion and bonding provided groove surface was clean with no dust particles. Due to heavy adhesive applied in few joints in the board, exudations were evident on those joints when compressed. Heavy application of adhesive was unnecessary as noted from this experiment. The finish products as insulation boards with a surface area of 4.8 m² were composed. The insulation boards resembled many engineered wood composites e.g. plywood or MDF used as internal lining materials as the finish products were light. This was in agreement with Haygreen and Bowyer (1989) where insulation products must be light weight and low density materials.

Further, the balsa board surfaces indicated excellent characteristic to accept coatings when applied. This was due to fine (smooth) surface textures. The board surfaces were painted well with under-coat and then oil-base finish primer paints. In addition, transparent coat (varnish) 'Clear Polyurethane Gloss' was applied fairly well to expose the natural colour (grayish-brown) of balsa wood and then turning orange to yellowish brown after coats were cured. Figure 2 shows orange to yellowish brown
CONCLUSION AND RECOMMENDATIONS

This experiment highlights the possibility of utilizing balsa wood as insulation boards for interior lining in building constructions in PNG. According to this work, the physical property (seasoning) and working properties (machinability, lamination, gluability and paintability) of balsa and the appearance of the insulation board made were satisfactory. Insulation board manufactured from balsa is ideal for insulation purposes with reference to ceiling construction as the product is light in weight and resembles engineered materials e.g. MDF. Such an end product provides an opportunity for product diversification, utilization and marketing. Also such a new product provides an alternative for highly engineered wood composites presently utilized as internal lining boards. Due to fast growth and short rotation age, and market demand, balsa cultivation could be expanded in PNG given the appropriate environmental conditions (e.g. soil type, rainfall and temperature) for plantation developments.

Following recommendations are suggested in future research studies into processing and utilization of balsa wood as lining material for interior purposes: (1) thermal conductivity and diffusivity test be conducted to prove that balsa has insulation property, (2) cyclic humidity test be conducted on insulation board bonded with PVA adhesive intended for ceiling construction, (3) heat/thermal resistance type of adhesive could be ideal for jointing balsa boards intended for ceiling construction, (4) large dimension boards in the form of chip lap could be profiled into vertical joint (VJ) or other joint types and tried as a wall cladding material, (5) flame retardant treatment could be given to the insulation board to intumesce fire incident and (6) dissemination of information on wood and working properties is necessary for domestic processing, utilization and promotion of the finish product.

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REFERENCES


