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Full Length Research Paper

Physical and mechanical properties of raj koroi (*Albizia richardiana*) plywood

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This paper summarizes the results of a research aimed at assessing the uses of raj koroi (*Albizia richardiana*) an alternative raw material for plywood production. Five plies raj koroi plywood of 2400 mm×1200 mm×12 mm size was manufactured using urea formaldehyde adhesive. The physical and mechanical properties of the manufactured plywood were evaluated. The results of physical and mechanical properties of raj koroi plywood were compared; data was examined with the existing market available plywood manufactured by simul (*Bombax ceiba*). It was found that the density of rajkori plywood and simul plywood was 0.75 and 0.50 g/cm^3 respectively. The MOR was 62.79 N/mm^2 for raj koroi plywood and it was 32.52 N/mm^2 for simul plywood. The MOE of raj koroi plywood was found 6997.20 N/mm^2 and on the other hand it was 3224.15 N/mm^2 for simul plywood. All physical and mechanical properties except thickness, swelling (%) after 24 hours of water soaking of raj koroi plywood were higher than that of simul plywood and which satisfies the standard.

Key words: *Albizia richardiana,* physical properties, mechanical properties, MOR (Modulus of Rupture), MOE (Modulus of Elasticity).

INTRODUCTION

Plywood is a flat panel built up of sheets of veneer called plies, united under pressure by a bonding agent to create a panel with an adhesive bond between plies. Plywood can be made from either softwoods or hardwoods. It is always constructed with an odd number of layers with the grain direction of adjacent layers, oriented perpendicular to one another (Youngquist, 1988). Plywood is often named as the first from the group of products which are known as engineered wood at present (Hrázský and Král, 2007). Plied veneered materials overcome largely three crucial drawbacks of solid wood by their construction arrangement: Material anisotropy and heterogeneity, insufficient dimensional stability in the course of changes in the moisture content and problems in creating large areas and forms (Král and Hrázský, 2006).

Timber is the principle raw material for manufacture of plywood besides adhesives. But all timber species are not equally suitable for large scale manufacture of any type of plywood for reasons of physical character of timber, its availability in bulk quality and price factor. Large scale manufacture of plywood is dependent on rotary cut veneers which come from clean, fresh, cylindrical boles of soft hard or moderately hard wood species (Zaman, 1982).

There are about 150 tree species grown in the homestead and village groves of Bangladesh (Das, 1990). Only a few of them are being used by the plywood, tea chest and particleboard industries. Sixteen timber species are recommended for decorative veneer and decorative plywood, 17 for marine plywood, 46 for manufacturing of ply for general purposes, 36 for plywood and battens for tea chest (Sattar et al., 1995).

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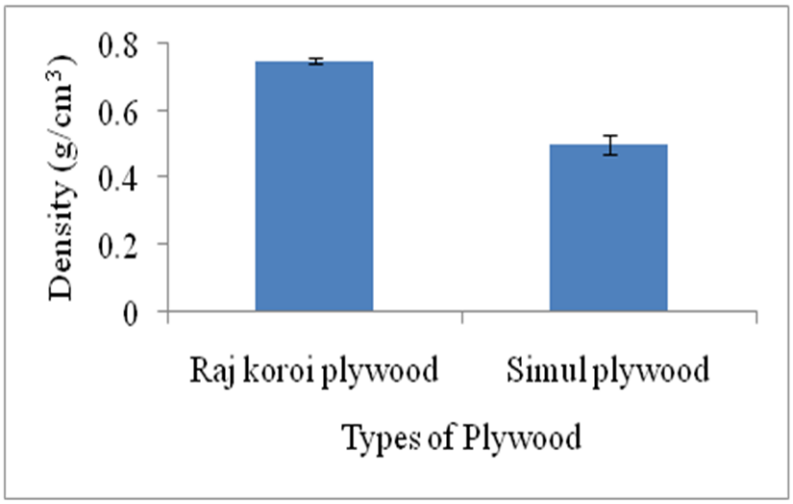

Figure 1. Density of Raj koroi plywood and simul plywood.

Raj koroi *(Albizia richardiana)* growth in Bangladesh is promising (Das and Alam, 2001). The species is pantropical, occurring in Asia, Africa, Madagascar, North America and Australia but mostly in the Old World tropics (Azad et al., 2010). In Bangladesh, this species occurs in the scrub forest of Sunamgonj. Also occurs in the forest of Chittagong Hill Tracts (Kaptai) and Chittagong are found in the village of northern districts. This species is an important component of the village and social forest in Bangladesh (BFD, 2011).Timber is used for construction purpose and as fuel for wood (Das and Alam, 2001).

The enlargement of raj koroi plantation and the quick growing characteristic are a great scope which uses it for healthier purposes. Deficiency of raw material is a critical problem for wood based industry in Bangladesh, it is thus, imperative to find out the fast growing species for wood based industry. In this Study we assessed the suitability of raj koroi as a raw material for manufacturing plywood determining the physical and mechanical properties of raj koroi plywood.

MATERIALS AND METHODS

Raj koroi plywood was manufactured in Akij Particle Boards Limited which is situated at Tora (23.86^0 N and 89.95^0 E), Ghior, Manikgonj, Bangladesh. Two Raj koroi trees of 7 years old were used in this study collected from Mohamad Pur, Botiaghata, Khulna (22° 48' 0" N and 89° 33' 0" E),Bangladesh.

The logs were cross cut lengthwise by hand saw to convert into bolt of 1.40 m. Then the bolt was ready to be conveyed into the plant for peeling. The veneers were produced from bolt in two veneer lathes and the thickness of core veneer was 2.50 mm.

Veneers were conveyed through a long chamber of Automatic Roller Track Veneer Drier for drying after clipping manually. It was dried for 45 minutes at 135ºC to 145ºC. The dried veneers were clipped by Jostling; veneer cutting machine was used to cut width to size and into smaller strips for removing defective material.

Urea -formaldehyde resin was used to glue the plies together making plywood and it was spread on alternative layers of ply manually. The glue coated veneers were allowed assembly time for 25 minutes between the spreading of adhesive and the application of pressure.

The glue-coated veneers were assembled in an appropriate order to ensure proper alignment of components and intimate contact between the veneer and the glue. A multi-plate hot press was used for making 1.2 cm thick plywood and the board was pressed at 8 MPa for 8 minutes. The press was performed by two steps. The pressure was applied for 3 minutes in order to remove air between veneer layers in first step. It was then applied for 5 minutes. The temperature of 120ºC was used for making this plywood.

The dimension of the trimmed plywood was 240.0 cm×120.0 cm. The trimmed plywood was sanded by sand paper number 1.50 inch. Some defects were appeared on the surface of the plywood after sanding and these were removed by sigel manually. The plywood was stored in the conditioning room for 12 hours.

Simul plywood was collected as market plywood was from Akij Particleboard Mills Ltd. which was produced using same procedure. The tests of physical properties were carried out according to ASTM D 1037-100 (ASTM 2006) standard procedures. Mechanical properties were performed according to DIN 52362 (DIN 1984). Universal Testing Machine (UTM) (model: UTN-100, serial-11/98-2443) was used to measure the mechanical properties. The sample size was 5.0 cm×5.0 cm ×1.2 cm for determining physical properties whether it was 24.0 cm×2.5 cm ×1.2 cm for mechanical properties. Physical properties of plywood were determined in the laboratory of Forestry & Wood Technology Discipline, Khulna University, Khulna. Mechanical properties of plywood were

Table 1. Summaries of analysis of Independent Sample t-test of physical properties.

Density	Water Absorption	Linear Expansion	Thickness swelling
t = 15.99, df = 8, P < 0.05*	t = -9.563, df = 8 P < 0.05*	t = 1.66, df = 8, P < 0.05*	t = -1.88, df = 8, P < 0.05*

Note: * = Significant at 95% probability level

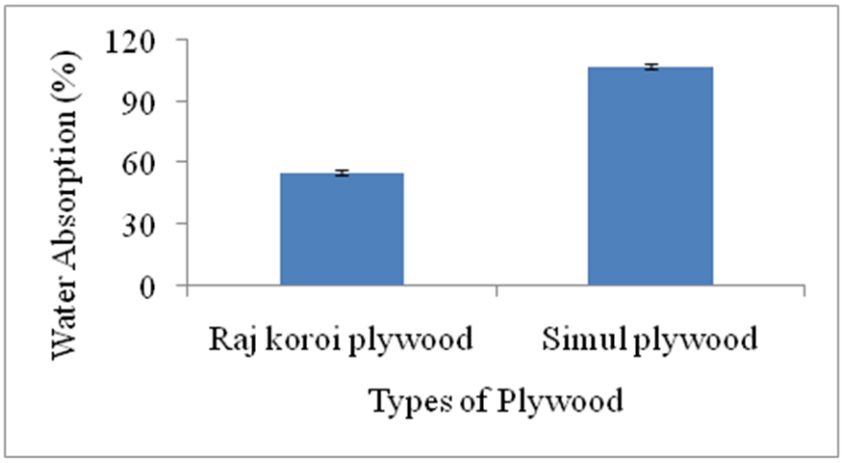

Figure 2. Water absorption of raj koroi plywood and simul plywood.

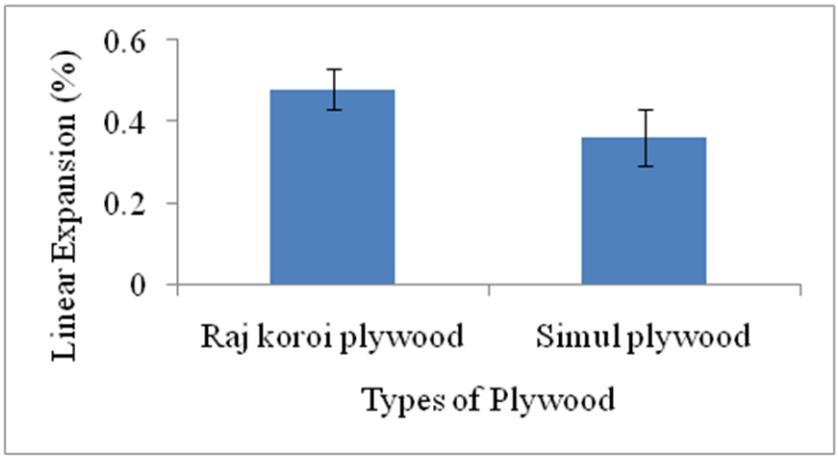

Figure 3. Linear expansion of raj koroi plywood and simul plywood.

examined in the laboratory of Akij Particleboard Mills Ltd. Five replications were used to determine the both types of properties.

Microsoft office excel 2007 and SPSS 12.0 were used for analyzing all data collected from various tests for determining the performance of raj koroi plywood.

RESULTS AND DISCUSSIONS

Physical Properties

The density of raj koroi plywood and simul plywood were 0.75 and 0.50 g/cm^3 respectively (Figure 1). The density of raj koroi plywood was higher than that of simul plywood. From the Independent Sample t-test, it was observed that there was a significant difference between the density of raj koroi plywood and simul plywood (Table 1). Franz *et al.* (1975) described that the density range of the standard plywood is 0.43 to 0.79 g/cm^3. Raj koroi plywood follows the standard.

After 24 hours, the value of water absorption by raj koroi plywood and simul plywood were 55.48 and 107.32% respectively (Figure 2). The water absorption was the highest for simul plywood. The Independent Sample t-test showed that there was significant difference of water

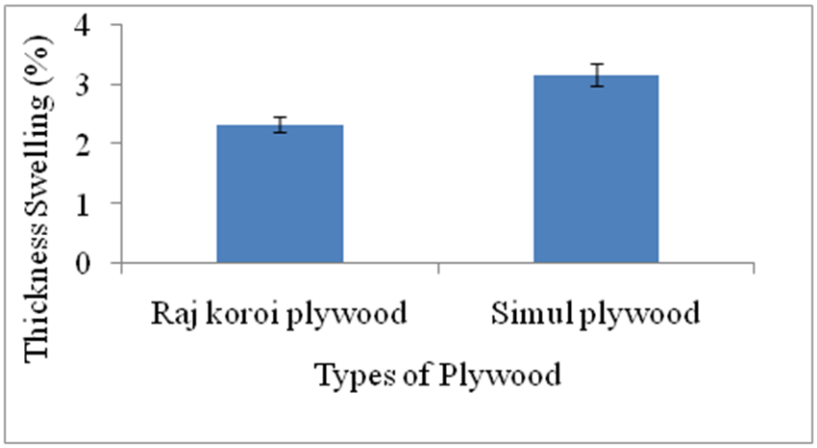

Figure 4. Thickness swelling raj koroi plywood and simul plywood.

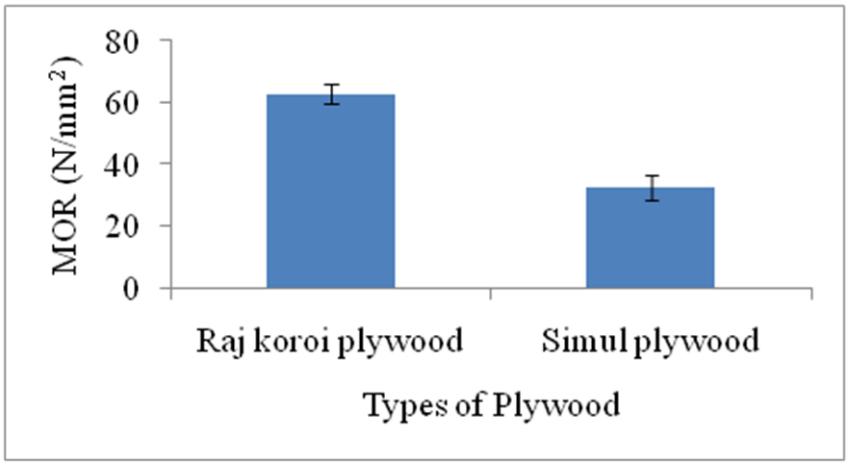

Figure 5. MOR of raj koroi plywood and simul plywood.

absorption of the two types of plywood (Table 1). Sulastiningsih et al. (1996) reported that water absorption decreased with increasing board density.

The linear expansion of raj koroi plywood and simul plywood was observed 0.48 and 0.36 respectively after submerging for 24 hours (Figure 3). Raj koroi plywood showed the highest value of linear expansion. Statistical analysis of Independent Sample t-test indicated the significant difference between these two types of plywood (Table 1).

It was found that after submerging 24 hours, the percentage of mean thickness swelling of raj koroi plywood and simul plywood were 2.32 and 3.16 respectively (Figure 4). The lowest value of thickness swelling was found for raj koroi plywood. In general, the thickness swelling has a tendency to increase with decreasing board density after a long duration of water immersion (Hermawan, 2001). Significant difference was found from the Independent Sample t-test between the two types of plywood (Table 1).

Mechanical Properties

The Modulus of Rupture (MOR) of raj koroi plywood was 62.79 N/mm^2 while it was 32.52 N/mm^2 for simul plywood (Figure 5). The highest value of MOR was for raj koroi plywood. Higher density influence is on MOR (Kwon and Geimer, 1998; Ajayi, 2002; Zheng et al., 2007; Das et al., 2012). The MOR of raj koroi plywood is significantly different from the MOR of simul plywood (Table 2). According to ASTM D3043-87, the standard range of MOR is 20.70 to 48.30 N/mm^2. The raj koroi plywood satisfies the standard.

The modulus of elasticity (MOE) of raj koroi plywood was found 6997.20 N/mm^2 but the MOE of simul plywood was observed at 3224.15 N/mm^2 respectively (Figure 6). In case of raj koroi plywood, it was the highest value. Higher density board shows the highest value of MOE (Kwon and Geimer, 1998; Ajayi, 2002; Zheng et al., 2007; Das et al., 2012). Significant difference was found between the two types of plywood after analyzing by

Table 2. Summaries of analysis of Independent Sample t-test of mechanical properties.

MOR	MOE	Tensile strength	Screw withdrawal
t =6.31, df = 8, P < 0.05*	t =4.42, df = 8, P < 0.05*	t =27.92, df = 8, P < 0.05*	t =22.44, df =8, P < 0.05*

Note: * = Significant at 95% probability level.

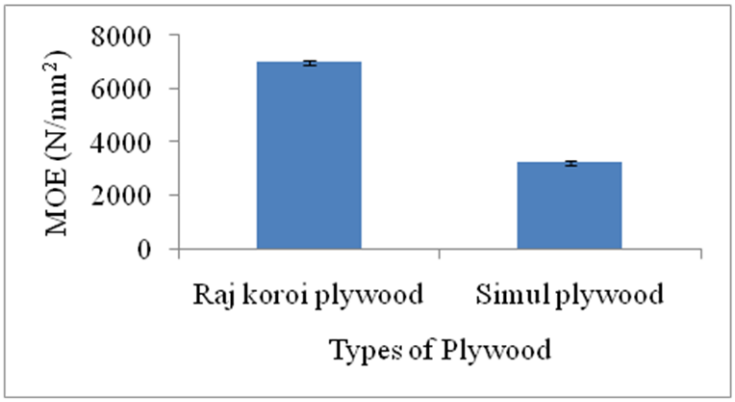

Figure 6. MOE of raj koroi plywood and simul plywood.

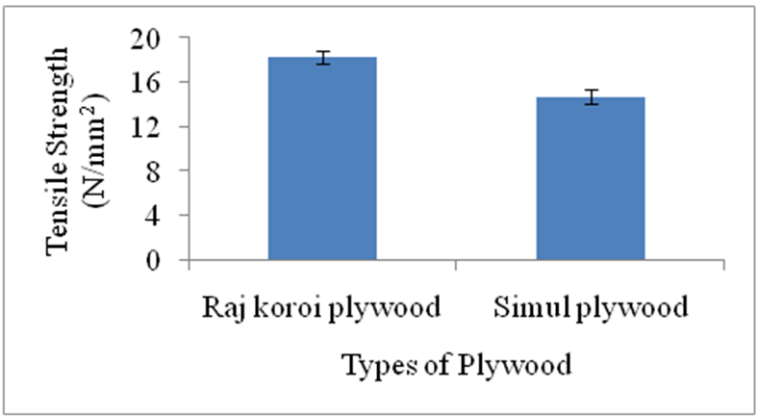

Figure 7. Tensile strength of raj koroi plywood and simul plywood.

Independent Sample t-test (Table 2). The standard value of MOE is 6890 to 1310 N/mm^2 (ASTM D3043-87). Raj koroi plywood follows the standard.

The tensile strength of raj koroi plywood was observed 18.24 N/mm^2 and simul plywood was observed 14.67 N/mm^2 (Figure 7). Observation of the tensile strength was the highest for raj koroi plywood. Analysis of Independent Sample t-test showed that the tensile strength of raj koroi plywood was significantly different from the tensile strength of simul plywood (Table 2). In ASTM D3500-90, the standard tensile strength range of plywood is 10.30 to 27.60N/mm^2. In this study, the tensile strength of raj koroi plywood is higher than that of standard of tensile strength.

Screw withdrawal was examined for the two types of plywood. It was 116.84 and 75.96 Kg respectively for raj koroi plywood and simul plywood (Figure 8). The value of screw withdrawal of raj koroi plywood was higher than that of simul plywood. The analysis of Independent Sample explored the significant difference between raj koroi plywood and simul plywood for screw withdrawal (Table 2).

CONCLUSION

All physical and mechanical properties except thickness swelling of raj koroi plywood were higher than that of simul

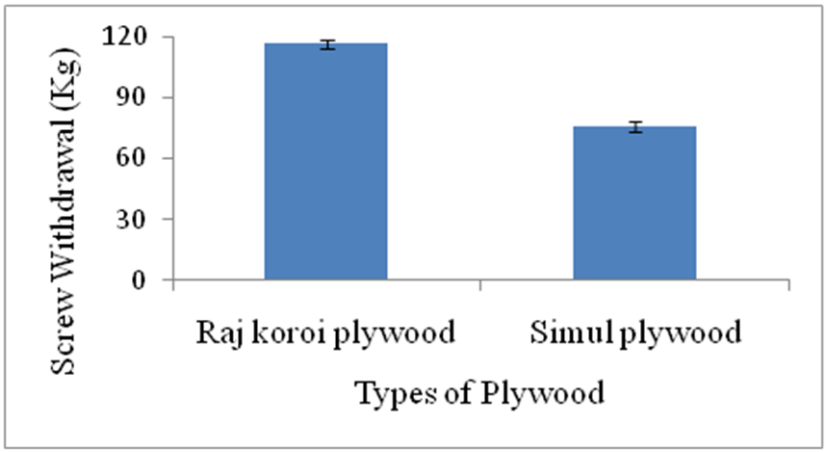

Figure 8. Screw withdrawal of raj koroi plywood and simul plywood.

plywood. Raj koroi plywood also maintains the standard. In this case, there is a possibility of using raj koroi for an alternative raw material for plywood industry. This will also help to use it for better economical purposes.

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