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Technical note

Evaluating of bonding strength of pine, oak and nyatoh wood species related to their surface roughness

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ABSTRACT

The objective of this study was to evaluate bonding strength of samples from three wood species, namely pine (*Pinus strobus*), white oak (*Quercus alba*) and nyatoh (*Palaquium balance*). Defect free samples were sanded with 80-, 100- and 240-grit sandpaper before their surface roughness was quantified employing a stylus type profilometer. Samples were bonded in the form of pairs to each other using polyvinyl acetate (PVAc) at a spread rate of 0.15 g/cm^2 by compressing for 24 h. The specimens of nyatoh sanded with 80-grit sand paper resulted in the highest average roughness value of 14.75 μm. The same samples also showed the highest bonding strength of 527.35 N among the others. It appears that stylus type equipment can be used to evaluate and differentiate roughness of such species due to grit size of sandpaper. Having rougher surfaces of the samples revealed that their higher bonding strength values can be achieved.

1. Introduction

Adhesive bonding strength of wood plays an important role for effective use of the final product for different applications. Species, density, grain orientations, surface quality, amount of pressure and press time applied are some of the parameters influencing overall bonding quality of the members. Several tropical wood species were used to evaluate their shear strength under wet and dry conditions [1,2]. Strength values of these specimens bonded using polyvinyl acetate (PVAc) were found to be affected by wood density [1]. Non-linear finite element analysis approach was also used to determine shear strength of wood in another study [3]. It was concluded that the type of the adhesive, grain orientations and density of the samples were the major factors affecting the results [3]. Chemicals and extractives of the species also are considered as important factors regarding of well-developed bonding quality of the specimens. In a previous work Sakura and Moredo determined that extracting of chemicals from the wood prior the bonding process enhanced their bonding strength characteristics [2]. It is a well-known fact that the natural roughness of wood surfaces plays an important role in terms of penetration of adhesive throughout the wood [4]. High polarity of wood surface results in formation of strong bond for a various types of adhesives [5]. Shear strength of four Japanese species, namely sugi, hinoki, hiba and karamatsu was studied in a past work [6]. Both radial and tangential surfaces of such species were sanded with the sandpapers ranging from 80- to 240-grit size, and their surface roughness was quantified using a stylus type profilometer [6]. It was determined that samples from all types of species with rougher surfaces showed higher bonding strength values than those with smooth surface quality [6].

Several studies also attempted to investigate bonding strength of different species treated with various chemicals. Beech samples treated with Tanalith CBC and Klebit 303 using dipping method showed enhanced bonding strength values of the samples with sanded surface [7].

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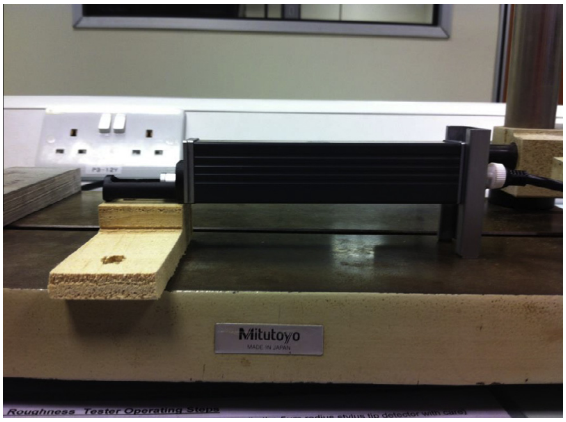

Fig. 1. L-shape test sample.

The influence of surface roughness of spruce veneer on shear strength of urea formaldehyde bonded plywood samples was also evaluated in a previous study [8]. Aydin tested of surface quality and bonding strength of Calabian pine along the radial and tangential grain orientation and found that those samples bonded with PVAc and having rough surface resulted in enhanced bonding values [8].

Currently there is very little or no information on bonding strength of these three species as function of their surface roughness measured by stylus method. Therefore the objective of this work was to determine bonding strength characteristics of pine, oak, nyatoh samples sanded with three different grit sizes of sandpaper. It is expected that findings of this work would provide some benefit for more effective and efficient use of these species in further manufacturing steps.

2. Materials and methods

Defect free L-shape samples in tangential grain orientation were planned to have a flat surface after they were cut from oak, pine, and nyatoh lumbers. Fig. 1 shows L-shape sample. A total of 24 pair specimens were prepared for each species and they were conditioned in a climate chamber with a temperature of 20 °C and a relative humidity of 65% until they reach equilibrium moisture content of 12%. Surface of each sample was sanded on 80-, 180-, and 240-grit sandpaper applying ten light strokes along the grain orientation. After sanding of the specimens was completed, their surface roughness was measured employing a stylus type profilometer, Mitutoyo Surftest-SJ-301 equipped with a skid type stylus having 90° tip angle and a radius of 5 μm [9]. Five measurements with 12.5 mm tracing length were taken from the surface of each sanded and control sample across the grain orientation. Typical roughness profiles of the samples are illustrated in Fig. 2.

Three commonly accepted roughness parameters, namely average roughness (R_a), mean peak-to-valley height (R_z) and maximum roughness (R_{max}) were used to quantify surface quality of the samples. Specifications of such parameters and application to various wood and wood products were discussed in past studies [10–12]. Each pair of samples was glued together using PVAc adhesive. Adhesive was applied to both surfaces at a spread rate of 0.15 g/cm^2 before they were clamped together for 30 min, and left in a room temperature for 24 h before the tests were carried out as illustrated in Fig. 3. An Instron Testing System Model 5569 was employed for determination of bonding strength of the specimens with a cross head speed of 5 mm/min. In addition to bonding samples, a total of 10 samples with dimensions of 66 mm by 80 mm by 20 mm were cut from each species and their

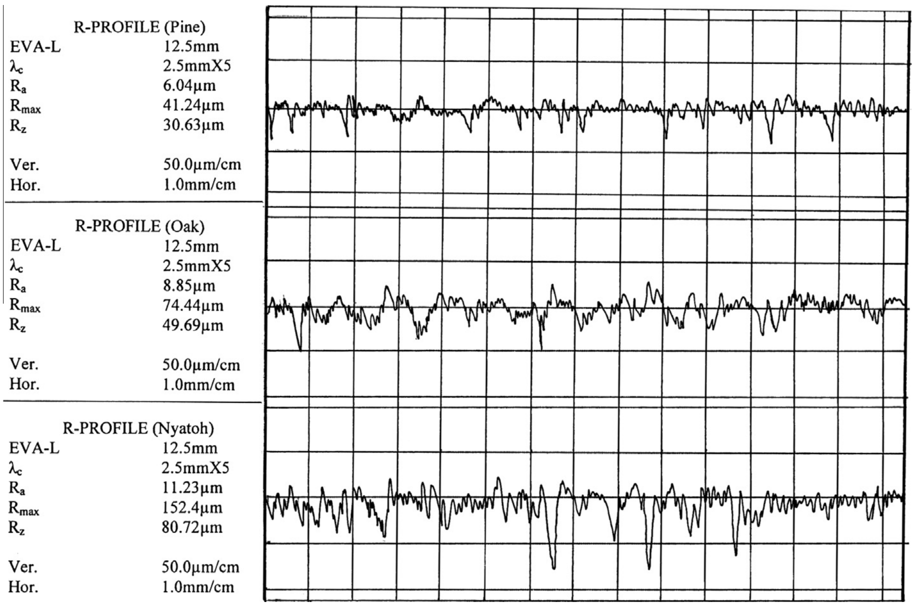

Fig. 2. Typical roughness profiles of the samples.