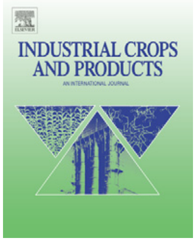
INDUSTRIAL CROPS AND PRODUCTS 28 (2008) 107–111

available at www.sciencedirect.com

journal homepage: www.elsevier.com/locate/indcrop



Short communication

Overlaying properties of fiberboard manufactured from bamboo and rice straw

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ARTICLE INFO

Article history:
Received 10 October 2007
Received in revised form
3 January 2008
Accepted 4 January 2008

Keywords:
Medium density fiberboard (MDF)
Overlays
Roughness
Bamboo
Rice straw

ABSTRACT

In this study, surface characteristics of overlaid medium density fiberboard (MDF) panels manufactured from bamboo (*Dendrocalamus asper*) and rice straw (*Oryza sativa*) were evaluated. Experimental panels were manufactured from two types of raw materials. Samples with dimensions of 15 cm × 15 cm both types of panels were overlaid with decorative paper with a density of 0.75 g/cm^3 using urea formaldehyde resin as a binder. Roughness measurements were randomly taken from the surface of overlaid samples using a fine stylus profilometer. Three roughness parameters, average roughness (R_a), mean peak-to-valley height (R_z), and maximum roughness (R_{max}) were used to evaluate surface characteristics of overlaid samples conditioned at 55% and 92% relative humidity levels. Statistical analysis revealed that no significant difference was found between roughness values of panels made from two types of raw materials. When the samples were exposed to 92% relative humidity both types of specimens had significantly higher values of R_a, R_z, and R_{max} than those of measurements taken at 55% relative humidity. The stylus method is able to detect differences in surface roughness of overlaid panels that can occur due to changes in environmental conditions. Initial findings of this study suggest that both non-wood under-utilized species can be considered as raw material to manufacture value-added MDF panels as substrate for overlaying without having any adverse influence on their surface quality.

1. Introduction

Non-wood based resources such as agricultural fibers including wheat straw, kenaf, bamboo, rice husk, and rice straw are getting more important as raw material to manufacture composite panels. Thailand has rich natural biological resources and diverse ecosystems that contain many non-wood forest products. Unfortunately similar to many developing Asian countries deforestation and over harvesting in Thailand also created environmental awareness which focused exploratory

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0926-6690/$ – see front matter © 2008 Published by Elsevier B.V.
doi:10.1016/j.indcrop.2008.01.002

research using above non-wood renewable resources in composite panel production (Chew et al., 1994; Chow et al., 1993; Chen and Hua, 1991; Hiziroglu et al., 2007).

Bamboo is one of the most diverse group of plants in the grass family which belongs to the sub-family of Bambusoidae. Its fast growth rate and better mechanical properties than many other wood species make this resource an alternative raw material for various types of composite panel production. (Fuyuan and Jianmin, 1988; Midmore, 1998; Ganapathy et al., 1996). Currently, bamboo is still one of the under-utilized non-wood species although it has limited use as scaffolding, furniture units, plywood, and flooring in Thai wood products industry (Ye, 1991).

It has been estimated that Thailand shares around 4% of the world rice production. Unfortunately, rice straw which is the inedible remains of the rice crop is not used as efficiently as it should be. Chemical composition and heterogeneous structure of rice straw make it an ideal raw material for composite panel manufacture (Inglesby et al., 2004; Yang et al., 2003).

Roughness of substrate panels is a latent property until it is exposed to high humidity exposure. Therefore, it is important to quantify surface roughness of the panel to have a better overlaying of the substrate. Fig. 1 is schematic illustration of effect of humidity exposure on overlaid substrate. The surface roughness of fiberboard could readily be determined in technical terms, given a representative graphical or numerical reading of the surface topography. Several meth-

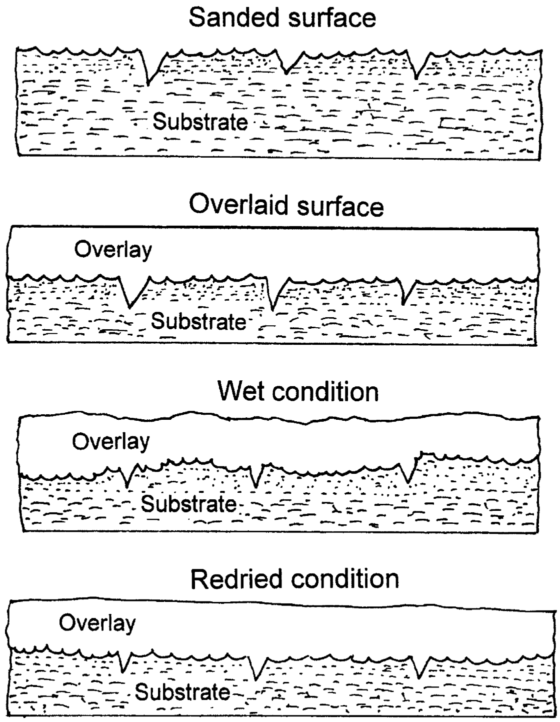

Fig. 1 – Influence of humidity on roughness of overlaid substrate.

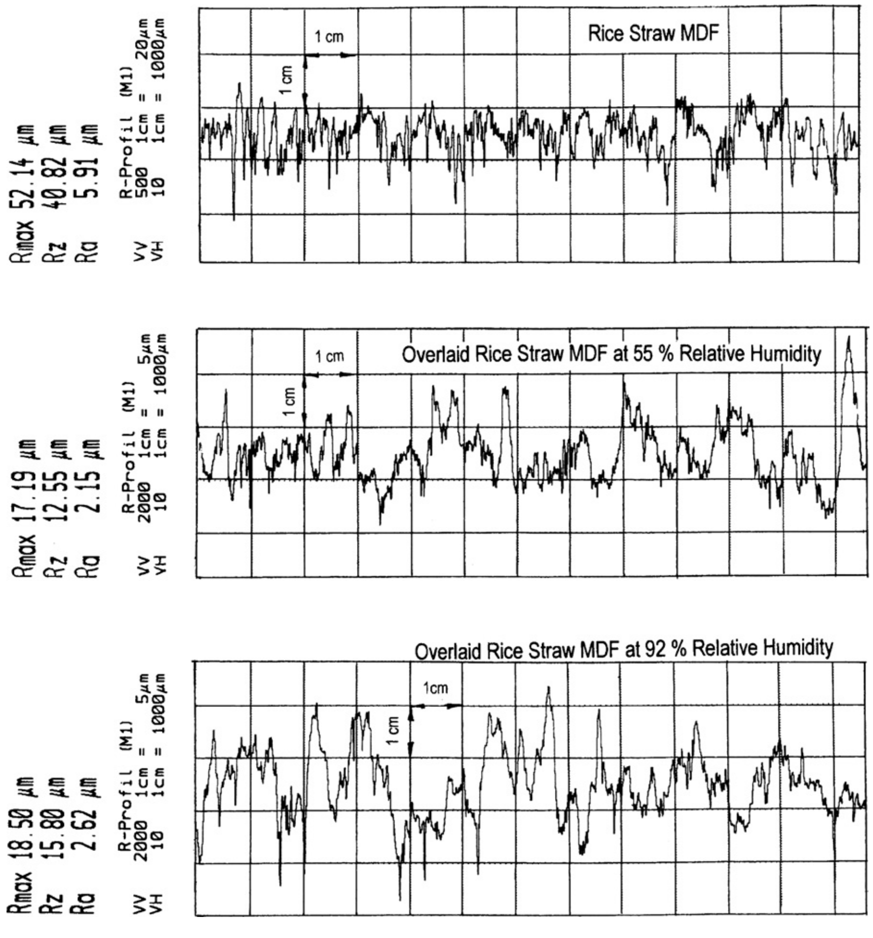

Fig. 2 – Typical roughness profiles of panels made from bamboo.

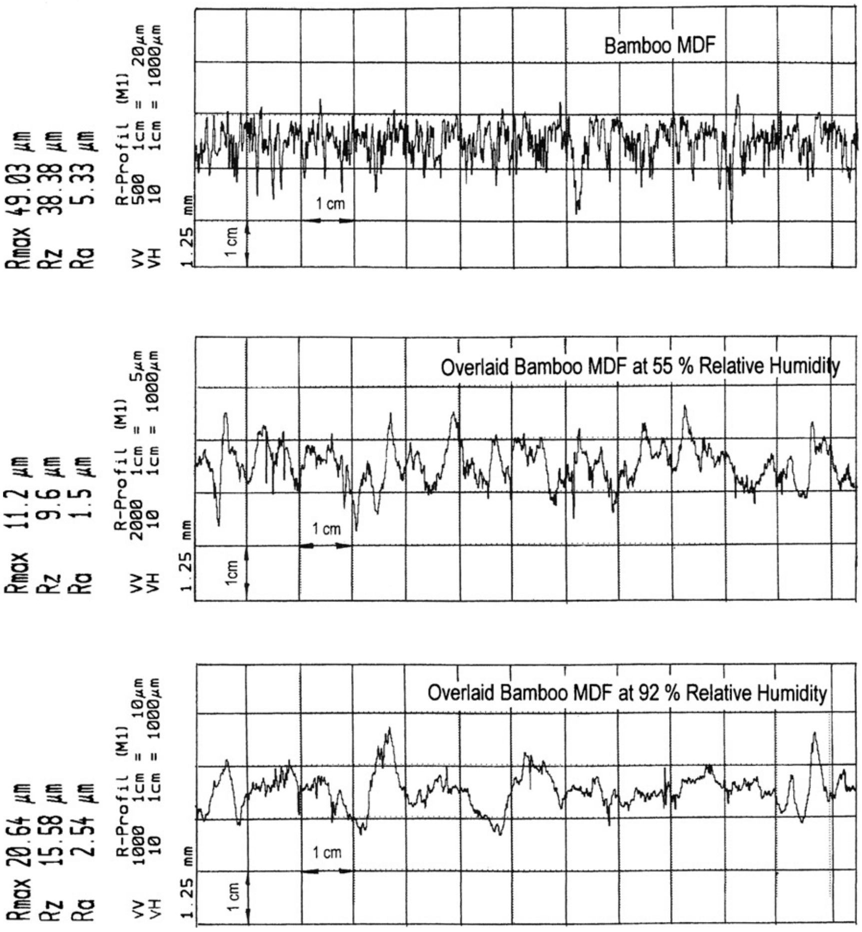

Fig. 3 – Typical roughness profiles of rice made from straw panels.

ods are available but have not found wide spread use in the industry. Also any practical standards to evaluate of surface quality of wood composites have not been developed (Hiziroglu et al., 2004; Ho, 1993; Hoag, 1992). Standard contact measuring devices employing a stylus tracer, such as used in the metal and plastic industry was successfully employed to evaluate roughness characteristics of various wood composites (Hiziroglu and Graham, 1998; Hiziroglu, 1996). One of the main advantages of the stylus method is to have an actual profile of the surface and standard numerical roughness parameters which can be calculated from the profile. Any kind of irregularities and magnitude of show-trough on the overlaid substrate can be objectively quantified. Therefore, in this study fiberboard panels manufactured from bamboo and rice straw were overlaid and their roughness properties were evaluated using a stylus method to have a better understanding overlaying quality of the samples.

2. Material and methods

Bamboo (*Dendrocalamus asper*), and rice straw (*Oryza sativa*) were harvested in Khon Khen, Prachin Buri bamboo plantation, and in the central region of Thailand, respectively. Bamboo was reduced into chips using a commercial chipper. The rice straw was reduced into smaller pieces by a laboratory shredder. Both types of particles were then “defibrated” in a laboratory type defibrator using a pressure of 0.75 MPa, at a temperature of 165 °C for 2.0 min. The defibrated fiber was dried in a kiln at a temperature of 85 °C until the furnish reach to 5% moisture content. Dried fibers were mixed with 9% urea-formaldehyde resin and 0.5% wax in rotating drum type of mixer fitted with a pneumatic spray gun for 4 min.

A total of ten, five for each type of panel with dimensions of 35 cm × 35 cm were manually formed in a plexiglass box. Mats on the aluminum cauls were compressed in a hot press at a temperature of 160 °C and using a pressure of 5 MPa for 6 min. All panels were pressed to a nominal thickness of 1.0 cm at their target density of 0.74 g/cm^3.

Later panels with dimensions of 15 cm × 15 cm were overlaid with melamine based decorative paper having weight of 0.74 g/m^2. Urea formaldehyde resin was spread on the surface of panels at the rate of 110 g/m^2 using a roller prior they were compressed using a pressure of 10 kg/cm^2 at a temperature of 110 °C for 1 min. The test samples were conditioned in a chamber with a temperature of 20 °C and a relative humidity of 65% until they reach to the equilibrium moisture content before any roughness measurements were taken from

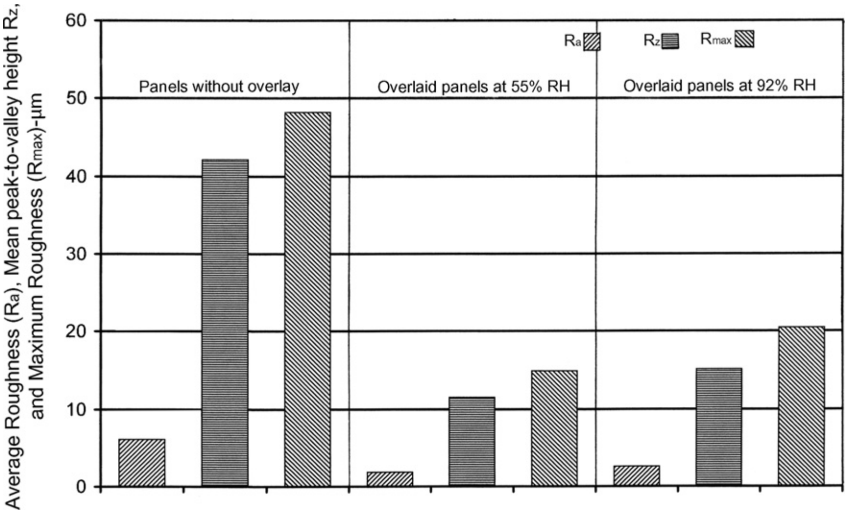

Fig. 4 – Average roughness values of bamboo panels.

their surface. Eight specimens with a size of 15 cm × 15 cm were used from each type of panels for roughness measurements. The profilometer used for the measurements consisted of main unit and a pick-up which has a skid-type diamond stylus with 5 µm tip radius and 90° tip angle. The stylus traverses the surface at a constant speed of 1 mm/s over 12.0 mm tracing length. The vertical displacement of the stylus is converted into electrical signals by linear displacement detector before the signal is amplified and converted into digital information. Various roughness parameters such as average roughness (R_a), mean peak-to-valley height (R_z), and maximum roughness (R_{max}) can be calculated from the digital information. Typical roughness profiles of the samples are shown in Figs. 2 and 3. Definition of these parameters is discussed in detail in previous studies (ANSI, 1985; Hiziroglu et al., 2004; Mummery, 1991; Peter and Cumming, 1970). Ten random measurements were taken from each side of the samples before and after overlaying at two humidity exposures. *T*-test was used to evaluate difference between treatments of the samples.

3. Results and discussion

Based on the findings of this study surface quality of samples made from two raw material before and after overlaying did not show any significant difference from each other at 95% confidence level. Average R_a values of 5.15 and 6.13 µm were determined for the samples manufactured from rice straw and bamboo, respectively. In a previous study R_a, R_z, and R_{max} values of commercially produced MDF panels in Thailand were determined as 4.90, 35.23, and 40.01 µm (Hiziroglu et al., 2004). In a typical commercial fiberboard manufacture surface of the panels is sanded to have a uniform thickness and enhance their surface quality for further processes. In our experimental study no sanding was applied to the panels. If the samples were sanded it would be expected that their surface quality would have been better than commercially produced panels. Surface quality of the samples evaluated in this work is comparable to the findings of above study. Once panels were overlaid with decorative paper bamboo samples

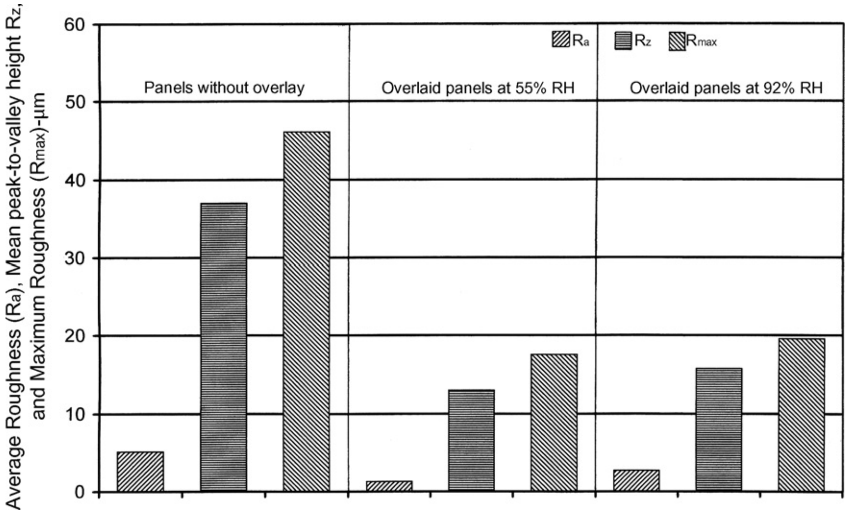

Fig. 5 – Average roughness values of rice straw panels.

had an average R_a value of 1.86 μm which is 3.29 times lower than its original surface. Overlaid rice straw samples also followed that similar trend having 4.05 times smoother R_a value than that of panels without overlays. Figs. 4 and 5 illustrate roughness values of the panels. Other two parameters, R_z and R_{max} also had similar trends. When bamboo samples were exposed to 92% relative humidity their surface quality reduced having R_a of 2.6 μm which is 1.39 times higher than those exposed to 55%. Rice straw samples also showed increase in their roughness characteristics as 2.13 times of R_a parameter. It appears that bamboo samples showed better stability as they are exposed to high humidity than that of rice straw panels. Although both types of panels were produced at same density higher hygroscopicity and less compaction ratio of rice straw would be responsible for less stability of the samples. Based on previous works yield of hemicellulose and lignin of rice straw were found as 18.6% and 7.2%, respectively (Sun et al., 2000; Eroglu and Deniz, 1993; Gould, 1985). Silica content which is concentrated in the outer parts of straw and overall chemical composition of rice straw would also contribute a possible factor resulting lower stability of panels made from than that of bamboo panels (He and Terashima, 1989). Roughness values of both types overlaid samples did not exhibit noticeable deterioration due to high humidity exposure. Also overlay papers neither delaminated nor separated from the surface of substrates as a result of high humidity exposure.

4. Conclusions

In this study fibers from two non-wood resources, namely bamboo and rice straw were used to manufacture experimental MDF panels, their surface quality and overlaying properties were evaluated. Based on the preliminary findings of this study low quality bamboo and rice straw can be used to produce vaule-added panels. It appears that manufacturing MDF from bamboo and rice straw which are non-wood species would provide a profitable and marketable panel products in Thailand. Such panels are not only environmentally friendly but also an alternative way convert under-utilized species into substrate panel products for furniture manufacture. In further studies, experimental panels produced from treated and non-treated fibers of bamboo and rice straw could give a better understanding of dimensional stability of MDF samples.

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