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Technical Report

Manufacture of three-layer wood–porcelain stone composite board reinforced with bamboo fiber

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ABSTRACT

The objective of this study was to improve bending strength properties of three-layer wood–porcelain stone composite board. The focus of this study was on the effects of orientations and weight ratios of bamboo fiber in face layer on physical and mechanical properties of the board. Three types of board with different orientation of bamboo fibers in the face layer were manufactured: one in which the fibers were oriented at random orientation (R board), another in which the fibers were oriented at unidirectional orientation (U board), and a third in which the fibers were oriented at cross orientation (C board). The physical and mechanical properties of the boards were evaluated based on the Japanese Industrial Standard for Particleboards. The main results obtained were as follows: Bending strength properties of the board were strongly affected by both orientation and weight ratio of bamboo fibers. Perpendicular specimen of C board has larger bending strength properties than U board and the value become larger with increased weight ratio of bamboo fibers. Internal bond strength value decreased with increasing weight ratio of bamboo fibers. The effect of orientation and weight ratios of bamboo fiber on thickness swelling of the board was not significant.

1. Introduction

Wood composites are defined as materials that have the commonality of being glued or bonded together. Composites include not only panels, but also molded products, lumber, large timbers, components, and products made with combinations of wood and other materials [1]. Recently, study on products made with combinations of wood and other materials has received considerable attention. Many authors reported the possibility to make boards with combinations of wood and plastic [2,3], wood and cement [4,5], and wood and mineral such as vermiculite [6].

In our previous study [7], we manufactured single-layer and three-layer wood–porcelain stone composite board made from pruned wood and porcelain stone scrap. As a result, we clarified that the three-layer composite board has excellent water proof and incombustibility properties as compared to the single-layer composite board and commercial wood-based composite board. However, the bending strength properties of these boards were inferior to the type 18 Particleboard (PB) standard of JIS A 5908. To improve the bending strength properties of the three-layer wood–porcelain stone composite board, we manufactured the board with several types and processing methods of raw material of the core layer. However, the bending strength properties of the board were still inferior to the type 18 PB standard [8].

Various methods can be applied to improve the bending strength properties of composite board such as reinforcing the board with natural fiber. Bamboo is an excellent candidate to be used as reinforcement material in composites board, because bamboo grows rapidly, and the fibers have good mechanical properties. Bamboo is abundantly available in many countries. Currently, the total bamboo forest area in the world has reached 22 million hectares. The worldwide availability of bamboo fiber is over 30 million tons per year [9].

Several papers on bamboo fiber reinforced composites have already been published. Jain et al. [10] evaluated the mechanical properties of bamboo fiber reinforced plastic (BFRP). Chen et al. [11] tested mechanical properties of bamboo fiber reinforced polypropylene (PP) composite. Deshpande et al. [12] used extracted bamboo fibers as reinforcement in polyester composites. And then, the properties of bamboo fibers extracted by a combination of chemical and mechanical methods were evaluated. Okubo et al. [13] reported an improvement in tensile strength and Young's modulus of composite made from bamboo fiber and polypropylene. Takagi and Ichihara [14] reported that both tensile and flexural strength of composite manufactured with a mixture of starch-based degradable resin and short bamboo fiber were strongly affected by fiber aspect ratio and fiber content.

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