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Experimental Study of Bamboo Composite Materials Proposed for Application in Ship Superstructure

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Extended Abstract

A superstructure on board a ship refers to the extended construction above ship's main deck. The potential benefits of reducing the superstructure weight of marine vessels include higher fuel efficiency, improved stability, increased loading capacity, and reduced environmental impact. Using a composite system can result in lightweight superstructure that improves vessel stability and is not subject to corrosion. Bamboo provides sustainable structural material due to its rapid growth cycle, high strength, and lighter weight. We developed a bamboo-plastic composite material, and proposed to use it as an alternative material for ship superstructure. In this study, we conducted a testing program to investigate the mechanical properties of bending and compressive strengths of the new bamboo composite material.

The new material mainly envelopes with plastic sheet or pipe a bundle of bamboo culms, proposed to be used as beam, truss, post, wall, and so on. We conducted press and bend tests on two types of structure material: round columns and support plates. For columns, a bundle of eight bamboo culms were enveloped in a PVC pipe to become a specimen. For support plates, 12-14 bamboo culms were enveloped to become a specimen.

Maximum compressive strengths parallel to grain were 417-915 kgf for single bamboo culms tested in this study. The test results of single bamboo culms indicate that only inside diameter has a positive relationship with the maximum compressive strengths. No identifiable relationship exists between the dimensional factors and the maximum bending strengths for the studied culms.

For composite column specimens tested in this study, the maximum compressing strengths parallel to grain were 3772-5162 kgf. The results indicate positive linear relationships exist between the maximum compressive strengths and inside diameter (R^2=0.669), thickness (R^2=0.631), and density (R^2=0.882). For bending strengths, however, positive linear relationships exist with outside diameter (R^2=0.934), thickness (R^2=0.907), cross sectional area (R^2=0.936) and weight (R^2=0.907). To test the effect of temperature, the specimens were placed in enclosed spaces of temperatures of -15°C and 28°C for 24 hours before loading on the stress tester for testing. The results demonstrate higher strengths of pressing (28%) and bending (47%) under freezing condition in comparison to under room temperature.

In this study, we also compared the strengths for support plates of steel sheet, plywood, and bamboo composite. The new bamboo composite demonstrates highest compress strength, while plywood display highest bend strength. For compress strength, the bamboo composite is approximately 42% higher than plywood and 20 times that of the steel specimen. For bend strength, the bamboo composite is approximately 62% lower than plywood and 5 times that of the steel specimen.

The bamboo composite material presented in this study promises significant benefits, and has a great potential for low cost construction for both ships and structures on land. Further studies are needed to investigate if there are potential limitations on the use of proposed bamboo composite in design of ship superstructure. The data generated in this study may shed lights on further designs and tests for similar combinations of bamboo culms and other material.