Accepted Manuscript

Mechanical behavior of natural fiber-based isogrid lattice cylinder

Meirong Hao, Yingcheng Hu, Bing Wang, Shuo Liu

PII: S0263-8223(17)30973-X
DOI: http://dx.doi.org/10.1016/j.compstruct.2017.05.028
Reference: COST 8537

To appear in: *Composite Structures*

Received Date: 25 March 2017
Revised Date: 2 May 2017
Accepted Date: 11 May 2017

Please cite this article as: Hao, M., Hu, Y., Wang, B., Liu, S., Mechanical behavior of natural fiber-based isogrid lattice cylinder, *Composite Structures* (2017), doi: http://dx.doi.org/10.1016/j.compstruct.2017.05.028

Mechanical behavior of natural fiber-based isogrid lattice cylinder

Meirong Hao[a], Yingcheng Hu[a,*], Bing Wang[b], Shuo Liu[b]

[a] *Key Laboratory of Bio-based Material Science and Technology of Ministry of Education of China, College of Material Science and Engineering, Northeast Forestry University, Harbin 150040, China*
[b] *Science and Technology on Advanced Composites in Special Environments Key Laboratory, Harbin Institute of Technology, Harbin 150001, China*

[*] Corresponding author. Tel.: +86 451 82190394; fax: +86 451 82191748. E-mail address: yingchenghu@nefu.edu.cn (Y. Hu).

ABSTRACT This paper explores the compression behavior of eco-friendly natural fiber-based isogrid lattice cylinder made of pineapple leaf fibers and phenol formaldehyde resin matrix. The filament winding method and an appropriate curing system was used to prepare specimens. The mechanical behavior of the structure was determined by axial compressive test. The interfacial adhesions between pineapple leaf fibers and phenol formaldehyde resin contain physical and chemical bonding by analyzing fourier transform infrared spectroscopy. For the lattice cylinder, corresponding theoretical and finite element models were proposed to simulate the mechanical properties. Compared with the measured values, the predicted values for the theory and the finite element method were approximately 77-96% of the values of the experimental data. The failure forms of lattice cylinders focus on delamination and fracture of circular rib segments adjacent to the crossover, in agreement with the analytical position of shear failure based on the finite element method, indicating the validity of the predicted model. After that, an orthogonal test was designed to explore the impacts of structural parameters on the mechanical behavior of the lattice cylinder. The results indicated that the main influence factor of special load and stiffness is the number of equal divisions of the circumference. The lattice cylinder can be treated as a truss core combined with skins to manufacture a hierarchical sandwich structure, for use in the construction of some parts of buildings, like the floor.

Keywords Natural fibers composites; Isogrid lattice structure; Axial compression; Theoretical model; Finite element model

1. Introduction

Fiber reinforced composites have attracted people's attention compared with metal materials because of their high specific strength/stiffness, as well as their durability [1]. Traditional fibers used to reinforce composite structures are synthetic fibers, such as carbon, glass, or aramid fibers [2], which provide higher mechanical properties because of the regularity of arrangement, but the costs of these fibers are expensive. Increasing environmental awareness, resource depletion, and legislated requirement have stimulated efforts to seek new environmentally friendly sustainable resources, including natural fibers [3, 4].

Natural fibers are now used widely as reinforced materials. These materials are low cost, low density, easy access, and acceptable specific strength properties, also are abundant, degradable, recyclable, and renewable resources [2, 5]. If natural fibers can replace man-made fibers as reinforcing materials in some structures, they would be very important, essential materials in the future. Although the application of natural fibers is limited, and these materials are not able to take the place of carbon fibers in high technology areas such as aerospace, rocket, they can be used as substitutes for glass fibers in some polymer composites [6]. Common natural fibers as reinforced materials include sisal, ramie, flax, jute, bamboo, coir, hemp, pineapple leaf, and rice husk. Among these natural fibers, pineapple leaf fibers (PALF) offer good potential for use in the reinforcement of composites [3, 7, 8].

PALF are abundant in China, but they are typically considered agricultural waste. Reinforced fibers are expected to have a high cellulose content and a low microfibrillar angle [8]. PALF has a high cellulose content (70-82 wt%) and a low microfibrillar angle of 14º, and should result in excellent mechanical behavior [4]. PALF has high-tensile strength (413-1627 MPa), high elastic modulus (34.5-82.51 GPa), low density (1.44 g/cm^3) [9], and a high degree of crystallinity (76.63%) [10]. Moreover, the specific modulus and strength of PALF are close or even better than those of glass fibers [4].

Recently, lattice structures are extremely concerned because that they are lightweight, have good mechanical properties, and provide muti-functionalities [11-16]. The design of grid lattice structures