Experimental Study on Bending Property of Bamboo-Reinforced Solid Wood Composite Board

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Abstract. Bamboo and wood structures are restricted by material characteristics because of its span, bearing capacity and structural size. In order to reveal the relationship between the bearing capacity of the bamboo-wood composite structure, this paper proposes a bamboo-reinforced solid wood composite board with bamboo-reinforced board and solid wood as the skeleton, which is spliced with any length of wood bar, and is subjected to mid-span bending test. The failure form, the relationship between load and deflection, and the relationship between load and strain are obtained. The experimental results show that the strain along the middle cross section of the original wood board and the bamboo-reinforced solid wood composite board is still basically in accordance with the assumption of flat section, which indicates that the bamboo and wood can work together, and that the bamboo-reinforced solid wood composite board give full play to its tensile properties.

1. Introduction
According to the Eighth World Forest Resources Survey, China's bamboo resources are the largest in the world. In particular, the planting area of artificial bamboo forest is increased by 15 hectares per year. At present, China already has more than 600 hectares of artificial bamboo planting area, which also ranks first in the world. According to the relevant statistics, the forest resources of our country not only show the trend of increasing year by year in area, but also show a good trend of sustainable development in quality and economic benefit. China has a long history of using bamboo and wood, and the research on bamboo and wood composites is also in the leading position in the world. Although China has made many achievements in this area, it has failed to carry out effective experiments to improve the utilization rate of bamboo and wood resources and reduce the waste of resources. Bamboo and wood as environmental protection, available new materials, for the world's scholars to study and develop, which provides favorable conditions for the processing and utilization of bamboo and wood materials in China. Bamboo and wood composites usually refer to all kinds of plywood, particleboard, laminated material, fiberboard and so on, which are made by certain structural combination or cementation[1]. This kind of composite material is widely used. It is mainly used in the interior floor of home decoration, the formwork of building concrete, the floor plate of carriage on vehicle manufacture and so on. In addition, the application of the bottom plate of the container is the most representative successful application case. In order to improve the utilization rate of bamboo and wood resources, reduce the waste of resources and reduce the cost. In this paper, a new type of bamboo-wood composite structure made of small size wood and bamboo-reinforced board is put forward. Bamboo and wood composite materials have been widely concerned and studied, Yan Wei, Zhu Yixin, Guan Mingjie, Cui Haixing[2]According to the application patent application of bamboo and wood composite
materials has been increasing exponentially since 1996. The research on bamboo and wood composite materials has also increased abroad, and the most representative of Japan's Kawai Yixiu, it has carried out in-depth research on high performance composite bamboo and wood materials[3]. C.S.Verma, Naresh kr Sharma, V.M.Chariar, S.Maheshwari, M.K.Hada[4]. Then further research on bamboo in bamboo wood composite, the strength of bamboo wood functional stratification, better use of bamboo wood composite. Wu Zhichao and Yang Yuan in China[5] In the study of MDF, it is proposed to obtain better fiberboard material by adjusting the ratio of different bamboo and wood fibers. Cold to ice, Xu Qingfeng, Wang Mingqian[6] In the study of bending resistance of bamboo-wood gluing materials, it is proposed to use engineering bamboo instead of the original wood material of upper and lower layers, so that the bending effect can be multiplied. Huang Zhiwei, Wang Yu, Xing Honggang[7] The bonding strength and failure mode of bamboo-wood composites are affected by temperature and humidity, which affects the strength of the composites. In Xiao Bo, Chen Qiang, Liu Shengxian, Zhang Hui, Shi Xintao, Liu Sunkun[8] In this paper, we propose the setting of flat section for the bending performance of solid wood composite board, and the curve increases linearly. Therefore, we boldly assume that there is a linear relationship between strain and uniform load when the deformation increases, which accords with the assumption of flat section.

In this paper, the mechanical properties of bamboo-wood composite board are studied, including the mechanical properties of bamboo-wood composite board and bamboo-wood composite board. In order to verify the rationality of bamboo bars and small size solid wood composite materials, and the synergistic deformation ability of bamboo and wood in bamboo bars solid wood board, the bending test of bamboo bars in the middle span is carried out. It is assumed that the tensile force of the composite structure is borne by bamboo bars and the wood side is under pressure.

2. General Situation

2.1. Specimen Design
Specimen design a set of 60 mm×600 mm×2000 mm bamboo-reinforced solid wood plywood, numbered A1mmmm×A3. A bamboo-reinforced solid wood composite board is composed of several small-sized solid wood blocks of varying length, and one layer of bamboo-reinforced board with a thickness of 5 mm is pasted on the upper and lower surfaces of the board, as shown in Fig. 1, Fig. 2.

2.2. Test Material
The test wood uses southern Chinese fir, small wooden square specification is high × width is 50 mm×50 mm, the length is between 10 and 80 cm, we choose the bamboo reinforcement board is the bamboo growing for more than four years, the manufacturer is the Taohua River in Hunan Province. The water content is 17%, the density is 820kg per cubic meter, the selected specification is 5 mm, width is 600 mm, length is 2000 mm. Elastic modulus MPa.10150 A bamboo board is composed of several solid wood blocks of different lengths, each of which is pasted with a bamboo board with a thickness of 5 mm. The test adhesive was made of two-component water agent adhesive. 3 h Initial curing, 24 h complete curing. Steel-steel tensile strength greater than 40 MPa, steel-steel shear strength greater than 18 MPa, compressive strength greater than 50 MPa.
2.3. Material Strength Experiments

2.3.1. Timber
On the basis of the relevant pressure test standard, 14 groups of cube specimens of 90 mm×90 mm×270 mm were selected. At room temperature 20°C, the measured compressive load and compressive strength of wooden square are shown in Table 1 through universal testing machine test.

| specimen | A1   | A2   | A3   | A4   | A5   | A6   | A7   |
|----------|------|------|------|------|------|------|------|
| Damage load (KN) | 159.9 | 165.92 | 161.45 | 157.82 | 159.72 | 156.64 | 153.31 |
| Compressive strength (MPa) | 19.741 | 20.484 | 19.932 | 19.483 | 19.719 | 19.338 | 18.927 |

| specimen | A8   | A9   | A10  | A11  | A12  | A13  | A14  |
|----------|------|------|------|------|------|------|------|
| Damage load (KN) | 150.46 | 163.56 | 157.25 | 186.09 | 140.77 | 166.51 | 131.64 |
| Compressive strength (MPa) | 18.575 | 20.193 | 19.414 | 20.233 | 17.379 | 20.557 | 16.252 |

Average compressive strength MPa 19.445 Because the inside of the bamboo-reinforced solid wood composite board is made of solid wood with different sizes bonded by glue, reference is made to the Code for Design of Masonry Structures[9] $f_c = k_1 f_1^c (1 + 0.07 f_2) k_2$ Make a reduction conversion. Solid wood combination reference concrete block, lightweight aggregate concrete block masonry value., $k_1 = 0.46, \bar{\sigma} = 0.9, k_2 = 1 \ f_1 = 19.445, f_2 = 50 \ (1.1 - 0.01 f_2) \ f_c = 17.95$ So the result is multiplied by the coefficient. As a result MPa, the strength of solid wood combination is determined by this strength.

2.3.2. Bamboo bars
According to the Test Method of Physical and Mechanical Properties of Bamboo[10], The material properties of bamboo composite made of 4–6 years old bamboo were 820 kg/m, the average moisture content was 10.7%, and the tensile strength of bamboo tendons was:$f_i = \frac{\sum X_i}{n} = 128.5Mpa$.

2.4. Loading and Test Point Arrangement
Six displacement meters were arranged at the L/4, 3 L/4 and middle span of the composite plate, and 12 strain gauges were arranged at the bottom, 3 L/4, and the bottom and top of the middle span to record the vertical displacement and strain of the specimen during loading. The DH3818 static strain tester is used to collect the data, and the schematic diagram of the test loading device is shown in figure 3 a. A schematic diagram of the preloading device is shown b. Figure 3.
3. Test Results and Analysis

3.1. Destruction Patterns
The composite board of the solid wood bamboo bars is shown in figure A1 to the A3, loading period, which shows that there is a gap between the solid wood contact surfaces. During the load increase, cracks appear in the tensile part of the board, the noise frequency increases and the sound increases, indicating that the structure of the solid wood board has begun to be destroyed, and the solid wood contact surface and bamboo bars have produced large deformation before reaching the limit load, so that part is damaged. Because this should be the solid wood block and bamboo bars to bear the pressure, become by the bamboo bars alone to bear the pressure, resulting in the block did not fully play its role, its test site picture see a.4.

3.2. Load-Span Deflection Curves
Centralized loading test was carried out on the bamboo-reinforced solid wood composite board. the mid-span deflection of each specimen was tested. the load-span deflection curves of 3 plates are shown in figure 5.
According to the above figure, we can see that the load-deflection has been in the process of elastic deformation with the experiment. However, with the increase of load to near the load pole, the curve of bamboo-reinforced solid wood composite plate specimen is flat compared with the previous part, the slope of the curve decreases, and the load and deflection increase nonlinearly, which enters the stage of elastic-plastic deformation.

3.3. Changes of Strain Along Height of Mid-Span Section
Typical specimens were selected from the specimens to verify the flat section assumption, the variation of cross section along height strain of bamboo-reinforced solid wood composite plate specimens is shown in figure 6.

It can be seen from Fig. 6 that the strain of the specimen of bamboo-reinforced solid wood composite plate increases with the increase of load, and basically meets the assumption of flat section. In the later period, due to the failure of the composite board, there is the possibility of cracking of glue between the solid wood and the failure of the strain gauge.

4. Conclusions
It can be seen that, in view of the shortcomings of the existing research, the composite wood structure has been improved. Considering that the strength of bamboo is higher than that of steel, bamboo can be used instead of steel to improve the mechanical properties of wood structure. Bending test failure type of

1) Bamboo-reinforced solid wood composite board is brittle failure.
2) During the bending test, the cross-section strain of the bamboo-reinforced solid wood composite plate is in accordance with the assumption of flat section height.
3) Considering that the bamboo-reinforced solid wood composite board is composed of broken wood square and bamboo-reinforced board, it has better applicability and universality, and effectively
reduces the requirement of age and size of wood, improves the utilization rate of bamboo, has higher performance-price ratio and applicability, and provides a test basis for the subsequent study of bamboo-wood composite structure, which has certain reference value.

5. References

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