A Study on the Effects of Technical Parameters on the Tensile Strength of Bamboo Plywood

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Abstract. The application of bamboo by-products such as bamboo branches, chips to recycle and produce pressed bamboo pulp is an urgent task in Vietnam. It perfectly replaces natural wood with artificial wood embryos from bamboo powder, which has both economic benefits of reserving the source of raw materials, environmental protection.... The paper presents a study on the influence of technological parameters on the tensile strength of pressed bamboo plastic fiber that is a new product of a project of our laboratory.

1 GENERAL INTRODUCTION

Currently, in the world as well as in Vietnam, improving the quality of wood pulp press is a basic need in the development process of this industry. The use of different types of wood has also been studied, in which, bamboo wood stands out as a potential candidate. In the study [1], the authors presented the advantages and disadvantages of bamboo wood compared to other woods, as well as their potential for use in laminated wood technology. In the study [2], the authors presented the process of making plywood of bamboo wood pulp, the effect of particle size and pressing temperature on flexural strength, elastic module, and perpendicular tensile strength. Limitations of the study are incomplete technological parameters (particle size and temperature of pressing). This research will apply empirical and statistical methods to study the influence of technological parameters such as particle size; ratio of bamboo wood pulp / pressed mix; The ratio of additive / biosynthetic mixture to tensile strength of pressed wood pieces of bamboo pulp conforms to the standard of IS 3087-1985 wood pulp sheet material [3].

2 METHODS OF SAMPLING AND EXPERIMENTAL PRACTICE

2.1 The Process of Manufacturing Products from Pressed Bamboo Powder

Bamboo debris and its by-products are cleaned and put into a bamboo shredder to chop into bamboo chips before passing to the pulverized bamboo that uses impact kinetics to

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grind into bamboo powder. In the next step, the bamboo powder is conducted into the dryer at about 80 ℃ for 6 hours to evaporate the remaining steam. Blending bamboo powder with CU-3 bio-glue and CU-H adhesive in a logical proportion in the mixer is always an important session for enhancing the mechanical property of the material. The mixture is put into a cold hydraulic press machine where it is pressed and held for a certain period so that the colloidal molecule and additive bind to the wooden molecule to create a pressed wood pulp of bamboo pulp. After being kept in a certain time, the wood embryos is taken out, trimmed and grinded the surfaces and the edges to achieve a rectangular standard finished market product (Figure 1).

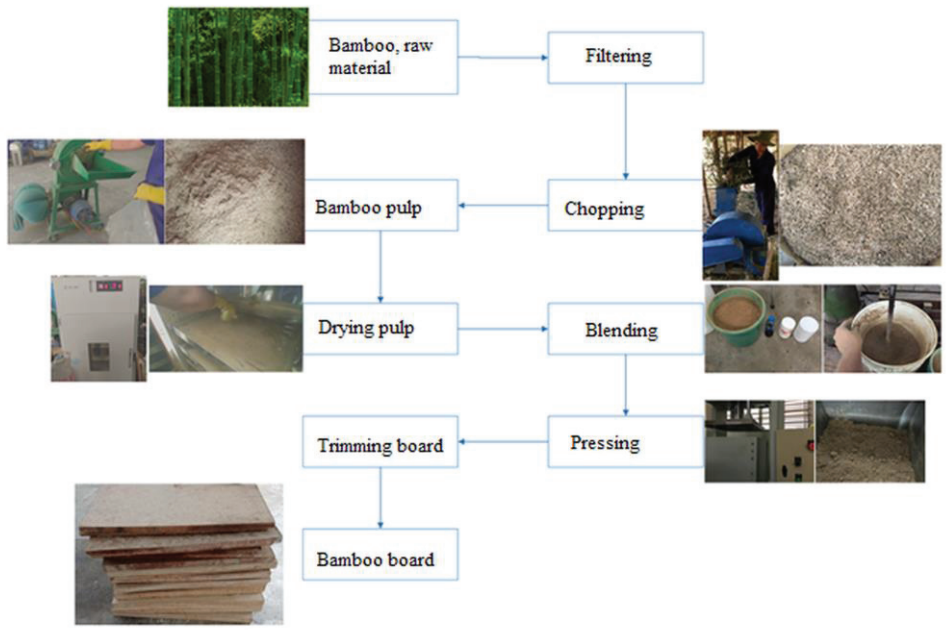

Fig. 1. Process of forming of bamboo plywood

2.2 Modeling for Tensile Measurement Experiments

After the Design of Experiment (DOE) process via Minitab software, 8 samples of pressed bamboo plastic fiber components 600x50xd wherein d is the thickness that is a selected value of 15mm÷25mm according to the type of the sample. The formation of a tensile test of samples is performed according to ASTM D 1037-99 (Figure 2).

Fig. 2. Specimen of bamboo plywood tensile testing

2.3 Selection of Experimental Planning Model (SIWRP)

After analyzing and testing many times, a DOE of 3 parameters is considered as the most effect on the durability of pressed wood pulp bamboo pulp:
Particle size (low: Fine; high: Coarse)
Ratio of bamboo powder in mixture (low level: 50%; high level: 65%)
Ratio of additive in glue mixture (low level: 20%; high level: 30%)
Other parameters are chosen to the results of the previous experiments [2]:
Hold time under pressure: 60 ~ 120 minutes;
Pressure: 250 bars;
Drying time: 15 minutes;
Temperature 1000 C
Pressed mixed volume: 10kg;
Mixing time: 20-30 minutes for one specimen.
Repetition number: 3 times to increase the accuracy of the result.

The multi-parameter experimental planning (planning 2n) of this study are 2 subtypes which are full empirical factors and partial empirical factors [4]. Full empirical factors are a standard experimental plan in which when each element has 2 levels, this plan will be of the form 2n. This scheme has high reliability, regression equations that often reflect the authentically effects of the parameters. However, the disadvantage of this method is the need of high number of experiments so it increases costs and time.
Partial empirical factors that is not applied in the paper is a form of experimental planning with the appearance of virtual parameters that is the product of the other real parameters in order to reduce the number of practical tasks of the full empirical factor, reducing time, cost, and level but the accuracy of the regression equation is worse than the full empirical factor that we only consider the combined effect of the two parameters, reducing implementation time and cost of experiment.

Since we only analyze the effects of the 3 most influential parameters and with the repetition of 3 times, we only need to perform $3 \times 23 = 24$ experiments. The number of experiments is completely satisfactory with our condition, so we will choose the full parameters DOE with 3 times of repetition.

2.4 Steps to implement the master plan 2

1) Selection of the number of influential parameters (input parameters), the level values of these parameters, the number of parameters to be surveyed (output parameters).

2) Performing the experimental run tables for experiments.
3) Testing samples and measuring the output values on each sample.
4) Processing the output data to establish the regression equations that express the relationship between input and output parameters. This task can be performed by many commercial specialized software for statistics and planning such as Minitab, SPSS, and R. In the scope of the study, Minitab software was applied.
5) Evaluation, analyzing and adjusting to get the suitable results and conclusions.

3 Achievements and discussion

3.1 Practice experiments

Tasks of experiments:

-Measuring the thickness and width of samples at traction critical point;

-Adjusting the distance between the clamps to match the set point of traction;

-Transferring of pull force onto the specimen through the specimen grips;

-Measuring the deformation at the midpoint of the test piece;

-Drafting the strain load relationship;

-Recording the maximum load (Figure 3).

Fig. 3. Tensile testing of bamboo plywood specimen in universal tensile test machine LLOYD LR 30K

3.2 Experimental results and regression equations

The results of tensile strength tests on the versatile LLOYD LR 30K tractor as shown in Table 1.

Table 1. Test results on tensile strength of pressed wood pieces of bamboo pulp.

No	Particle size	Ratio of bamboo powder in mixture	Ratio of additive in glue mixture	Measured Tensile Strength (MPa)		
1	Fine	50	20	6.493486	6.13291391	5.99682795
2	Coarse	50	20	10.9567095	10.5299679	10.9612826
3	Fine	65	20	1.54161735	2.80095658	3.13371333
4	Coarse	65	20	7.49107886	6.67446548	6.9441218
5	Fine	50	30	3.92746734	3.453889	3.97336791
6	Coarse	50	30	9.6204124	10.1663823	9.05958696
7	Fine	65	30	2.22284597	2.92453766	2.57099415
8	Coarse	65	30	5.1018655	5.19370624	3.85198257

Applying Minitab analysis software, we obtain a regression equation considering the effect of technological parameters (particle size, ratio of bamboo pulp in mixture, ratio of additive in mixture) on tensile strength of pressed bamboo pulp.

Tensile strength = 22.61 + 5.74 × Particle size - 0.2268 × Ratio of bamboo powder in mixture - 0.1466 × Ratio of additives in glue mixture - 0.0625 × Particle size × Ratio of bamboo powder in mixture.

The effect of technology parameters on tensile values as shown in Figure 4.

Compare the average tensile strength of pressed wood pulp of bamboo pulp with IS3087-1985 standard of PB wood (Particle Board) as shown in Table 2:

Table 2. Results of tensile strength testing of pressed bamboo pulp with IS3087-1985 standard.

Criterion	Unit	IS 3087-1985		Pressed bamboo pulp
		Type I	Type II	
Orthogonal Tensile Strength (IB)	MPa	0.4	0.3	*5.60*

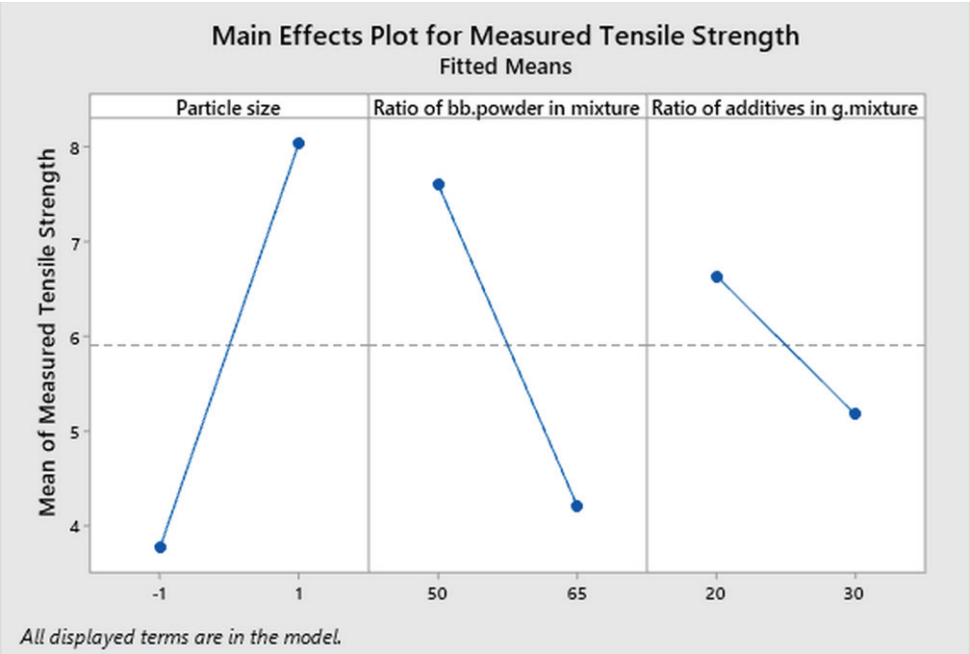

Fig. 4. Influence of input parameters on the tensile strength of bamboo plywood specimen.

4 Conclusion

The comparison results to IS3087-1985 standard of particle board shows that the pressed bamboo pulp in experiments could achieve type I in the tensile standard. The result shows that with a suitable set of blending parameters we can reach the type I of standard pressed bamboo. This research can be widely applied in a new version of bamboo plywood for construction material.

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