Process Parameter Investigations on Poplar Wooden Brick for Indoor Partition Wall

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Abstract

Green building materials made from waste wood fiber have attracted worldwide attention. Poplar wood fiber can be molded into indoor partition wall brick with calcium hydroxide. The best process parameters are studied by single and multifactor methods. Compressive strength increases with the decreasing poplar wood fiber content and increasing calcium hydroxide content. The best process is 310 g of poplar wood fiber, 1,849 g of calcium hydroxide, and 10 minutes of cold press time. The mass proportion of poplar wood fiber and calcium hydroxide is 14:86. Compressive strength is affected extremely significantly by the interaction of poplar wood fiber mass, calcium hydroxide mass, and cold press time. It is affected significantly by the interaction between the calcium hydroxide mass and cold press time. The results are important to effectively use poplar wood fiber.

More and more renewable resources are manufactured into green building materials (Yuanhsiou et al. 2015, 2016; El-Gamal and Selim 2017) such as waste wood fiber and crop stalks (Arsenović et al. 2015, Jochem et al. 2016, Nidzam et al. 2016, Eliche-Quesada et al. 2017, Galán-Arboledas et al. 2017). The strength and intensity of biomass bricks are improved by adding straw (Donkor and Obonyo 2015, Masuka et al. 2018). Waste wood residues are used to make lightweight composites (Turgut 2007, Turgut and Algin 2007, Bories et al. 2015) such as poplar wood fiber (Shengnan and Xiaojun 2017). Structural composite lumber (Maleki et al. 2017), furniture, wood-based composites, paper (Wang et al. 2016), and biofuels (Gegu et al. 2018) are made from poplar wood. Fire resistance of poplar wood is improved by the boric acid compound phenolic resin (Kong et al. 2016); the antimildew property is achieved by the modification of phosphorous and chitosan silver (Yushuang et al. 2016). Properties of wood–plastic composites are affected by poplar powder, polyethylene, and molding temperature (Junfeng et al. 2016, Li et al. 2016, Min et al. 2016, Minghua 2016, Xiaoting et al. 2016, Oskouei et al. 2017, Xiaona et al. 2017).

Calcium hydroxide is the earliest used adhesive in history, and is used widely in building materials (Jerman et al. 2016, Nežerka et al. 2016, Xiaohong et al. 2016, Yu et al. 2016, Zhiyi et al. 2016, Masuka et al. 2018). The gelatinization of corn flour is affected significantly by calcium hydroxide (Peipei et al. 2016). Corn stalks are alkalized by calcium hydroxide to make biomass composites (Lin et at. 2016). There is a new way that calcium hydroxide can be used to make poplar fiber brick, and exploring its process is necessary.

Bricks are molded from poplar wood fiber and calcium hydroxide to investigate the process parameters with single-factor and multifactor methods. Poplar fiber content, calcium hydroxide content, and cold press time are studied, and the properties such as compressive strength, bending strength, and moisture content are analyzed. The relationships between process parameters and properties are shown.

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Forest Prod. J. 70(3):317–325.
doi:10.13073/FPJ-D-20-00003

The results are useful to promote the effective utilization of poplar wood fiber.

Material and Methods

Materials

Poplar wood fiber and calcium hydroxide were bought from market in Shandong Province, China. Their properties are shown in Tables 1 and 2.

Methods

Experimental schemes.—(1) Single-factor schemes of poplar fiber content: When calcium hydroxide mass is constant, poplar wood fiber is changed. The calcium hydroxide mass used was 1,769 g. Poplar wood fiber samples were 310, 320, 330, 340, 350, 360, 370, 380, 390, and 400 g, respectively. Therefore, poplar fiber content in brick ranged from 14.91 to 18.44 percent. Each scheme was repeated 20 times, and the total experiments are equal to 200. (2) Single-factor schemes of calcium hydroxide content: When poplar wood fiber mass is constant, calcium hydroxide is changed. The poplar wood fiber mass was 350 g. Calcium hydroxide mass was 1,669, 1,689, 1,709, 1,729, 1,749, 1,769, 1,789, 1,809, 1,829, and 1,849 g, respectively. Therefore, calcium hydroxide content in brick ranges from 82.66 to 84.08 percent. Each scheme was repeated 20 times, and the total experiments equaled 200. (3) Multifactor schemes of process parameters: Multifactor schemes of process parameters are designed according to orthogonal experimental design methods, which are shown in Table 3. Poplar fiber mass, calcium hydroxide mass, and cold press time are variable. Each scheme was repeated 20 times, and the total experiments equaled 180.

Process and test methods.—Experiments were accomplished according to Figure 1. Calcium hydroxide and poplar wood fiber were weighed with an electrical balance (Model JA21002; Jingtian Electronic Instrument Co., Ltd., Shanghai, China), mixed with a blender (Model JJ-5; Luda Test Instruments Co., Ltd., Taian, China), and put into a mold. The mold consisted of an indenter, a bucket, and a bottom board. The indenter was the loading body and the bucket and bottom board were the bodies to be pressed. The internal dimensions of the bucket were 235 mm in length, 110 mm in width, and 150 mm in thickness. The mixture was molded into brick with a cold press machine (Model MY 50B; Jilongchang Equipment Co., Ltd., Qingdao, China). The press was equal to 10 MPa; the temperature was room temperature. The pressing time was 10 minutes for the single-factor experiments, and it was the designed time for orthogonal experiments. The brick was dried for 48 hours in a hot-air drying room (3.0 by 4.5 by 2.8 m [length by height by width]) at 60°C, 30.1 percent relative humidity, and 0.20 m/s air velocity. Relative humidity and temperature were tested by an electronic thermohygrometer (Model 310 RS-232; Center Technology Co., Ltd., Taiwan, China) and wind speed was measured by a hot-bulb anemometer (Model QDF-3; Beijing Detecting Instrument Co., Ltd., Beijing). Dried brick was measured by an electronic balance (Model ACS-302; Huachao Electric Co., Ltd., Shanghai, China), size was measured with a vernier caliper, and the dry volume and density of the brick were calculated.

Compressive strength of dry brick was measured by a compressive strength tester (Model DTH-300B; Luda Test Instruments). The loading speed was 1.0 mm/min in the thickness direction. When the deformation reached 2.5 mm in thickness, the load was the compressive strength, which is the elastic recovery deformation strength, not the destroyed strength. Bending strength of the brick was tested in thickness by a universal mechanical testing machine (Model CMT4104; Meters Industrial System (China) Co., Ltd.,

Table 1.—Moisture content and density of raw materials.

	Poplar wood fiber, mean (range)	Calcium hydroxide, mean (range)
Moisture content (%)	7.17 (6.63–7.60)	49.63 (47.36–52.20)
Density (g/cm^3)	0.08 (0.074–0.087)	1.07 (1.015–1.115)

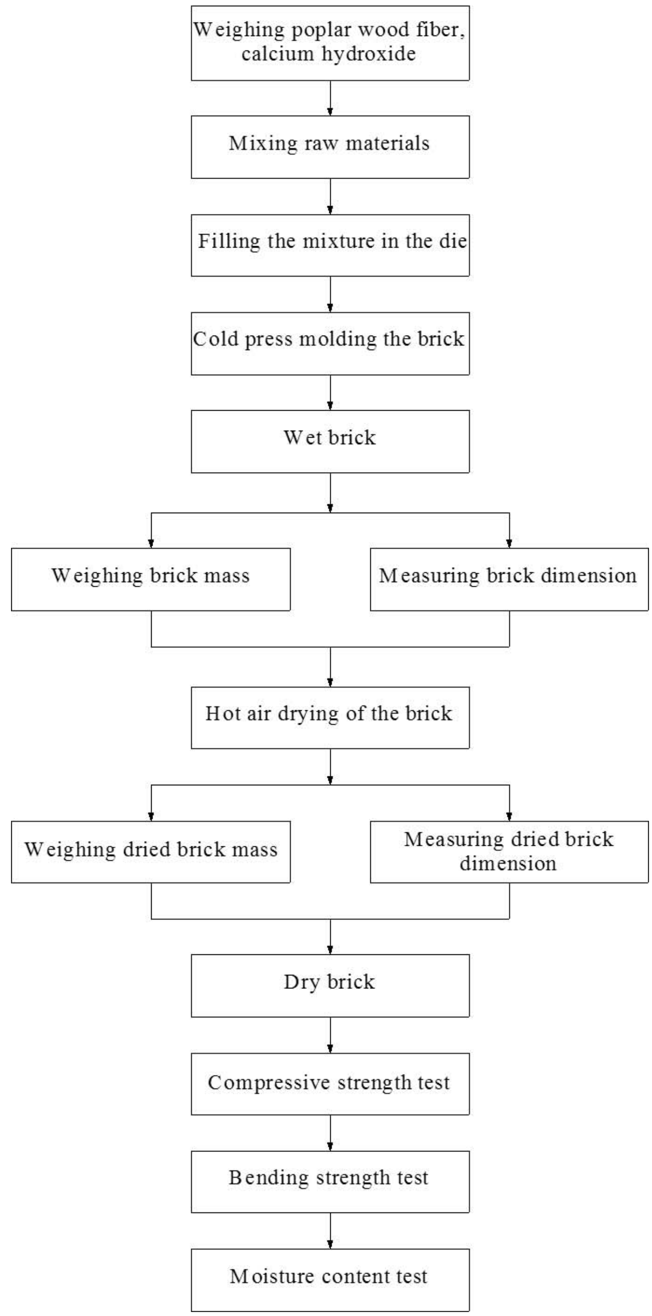

Figure 1.—Technical route.

Table 2.—Mesh ratio of poplar wood fiber.

	Mesh (No.)										
	10	20	30	40	50	60	70	80	90	100	>100
Mass percentage (%)	2.66	14.29	14.57	18.67	14.78	7.51	2.05	5.86	2.87	2.02	14.72

Shenzhen, China; Mao and Shi 2012, Wan et al. 2017). The brick sample was dried to the absolute dry state in an oven (Model DUG 9123A; Jinghong Experimental Equipment Co., Ltd., Shanghai, China) to test the moisture content.

Statistical analysis method.—SPSS statistics software was used to analyze the experimental data. For single-factor experiments, single-factor analysis of variance (ANOVA) and multiple comparisons were carried out to determine whether the final moisture content, size shrinkage rates, density, bending strength, and compressive strength were affected by poplar fiber content and calcium hydroxide content. The least significant ranges were calculated at the 0.05 level ($LSR_{0.05}$) and 0.01 level ($LSR_{0.01}$). For multifactor experiments, the data were analyzed by one-way ANOVA, two-factor interaction, and three-factor interaction to judge the effects of poplar fiber mass, calcium hydroxide mass, and cold pressing time as independent variables on the properties of brick.

Results and Discussion

Effects of poplar fiber contents on properties of brick

Moisture content of the brick increases with increasing poplar fiber content in general (Fig. 2). It is between 9.52 and 11.59 percent and averages 10.93 percent. The maximum value is the same as 1.22 times the minimum one. Moisture content is affected significantly by poplar fiber content (Table 4). The reason is that the initial moisture content of calcium hydroxide is the same as 6.92 times that of poplar fiber (Table 1). When calcium hydroxide mass is constant for different schemes, the compressive degree increases with increasing poplar wood fiber content, and more moisture coming from calcium hydroxide is squeezed into the poplar wood fiber. There is more contacting surface between poplar wood fiber and calcium hydroxide with the increasing poplar wood fiber content. Poplar wood fiber is more evenly mixed with the calcium hydroxide particles, and the particles are more dispersed, so more water is squeezed into fibers. As far as why the lowest moisture content appears at 17.30 percent poplar wood fiber content, the reason is that this is the best mixture ratio between calcium hydroxide and poplar wood fiber. The exact reason should be studied in further investigations.

Drying shrinkage rate in length ranges from –0.59 to –0.87 percent, and averages –0.74 percent (Fig. 3). The maximum value is the same as 1.46 times the minimum value. The rate in width ranges from –0.67 to –1.04 percent, and averages –0.87 percent. The maximum value is the same as 1.54 times the minimum value. The rate in thickness ranges from 0.74 to 2.89 percent and averages 1.72 percent. The maximum value is the same as 3.91 times the minimum value. The rates in width and thickness are affected significantly by the poplar fiber content (Table 4). The rate in thickness is the largest because the press in thickness is the greatest and the compressive ratio is the greatest in thickness. When the press is unloaded, the recovery degree of the brick in thickness is the greatest. When the brick is dried, the drying shrinkage amount in thickness is the greatest.

The density of brick ranges from 0.99 to 1.03 g/cm^3 and averages 1.02 g/cm^3 (Fig. 4). The maximum value is 1.04 times the minimum value. It is not affected significantly by poplar wood fiber. The reason is that density of calcium hydroxide is the same as 13.38 times that of poplar wood fiber. Calcium hydroxide mass is constant, and the mass difference of poplar wood fiber is little; the density of brick is determined by calcium hydroxide.

The bending strength of brick ranges from 0.31 to 0.38 MPa, and averages 0.34 MPa (Fig. 5). The maximum value is as same as 1.23 times the minimum value. It is not affected significantly by poplar wood fiber content (Table 4). The reason is that bending strength is determined by contacting surface area between calcium hydroxide and poplar wood fiber, which is determined by the poplar wood fiber mass. When the mass difference of poplar wood fiber is little, their contacting surface area is almost the same.

The compressive strength of brick is between 0.50 and 1.07 MPa, and averages 0.78 MPa (Fig. 6). The maximum is the same as 2.15 times the minimum. It decreases with increasing poplar wood fiber content. It is affected extremely significantly by poplar wood fiber content (Table 4). The reason is that compressive strength is determined by calcium hydroxide, which is not easy to compress. Calcium

Table 3.—Orthogonal experimental schemes.

Scheme No.	Calcium hydroxide mass (g)	Poplar wood fiber mass (g)	Cold press time (min)
1	1,769	310	2
2	1,769	330	6
3	1,769	350	10
4	1,809	310	6
5	1,809	330	10
6	1,809	350	2
7	1,849	310	10
8	1,849	330	2
9	1,849	350	6

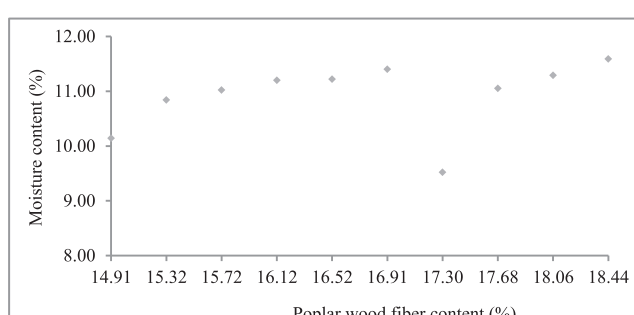

Figure 2.—Moisture content and poplar wood fiber content.

Table 4.—Variance analysis on the relationship between poplar wood fiber content and properties of brick.[a]

Sources	F value	P value	$LSR_{0.05}$	$LSR_{0.01}$
Moisture content (%)	1.974	0.044*	1.481	1.890
Drying shrinkage rate in length (%)	1.213	0.289	0.266	0.340
Drying shrinkage rate in width (%)	2.131	0.029*	0.296	0.378
Drying shrinkage rate in thickness (%)	2.138	0.028*	1.507	1.924
Density (g/cm^3)	1.610	0.115	0.033	0.042
Bending strength (MPa)	0.824	0.595	0.082	0.105
Compressive strength (MPa)	9.498	0.000**	0.217	0.277

* = Significantly different at $P < 0.05$; ** = significantly different at $P < 0.01$.

[a] LSR = least significant range.

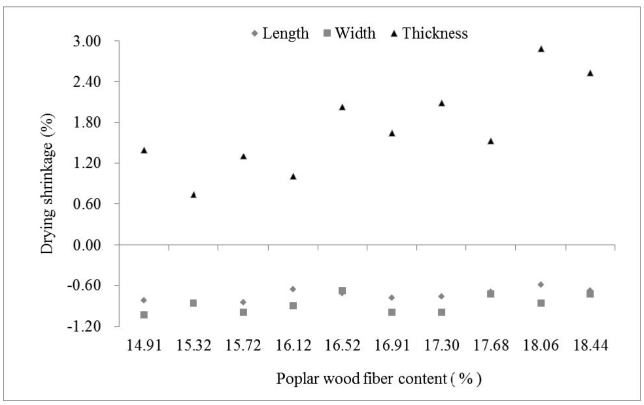

Figure 3.—Drying shrinkage rates and poplar wood fiber content.

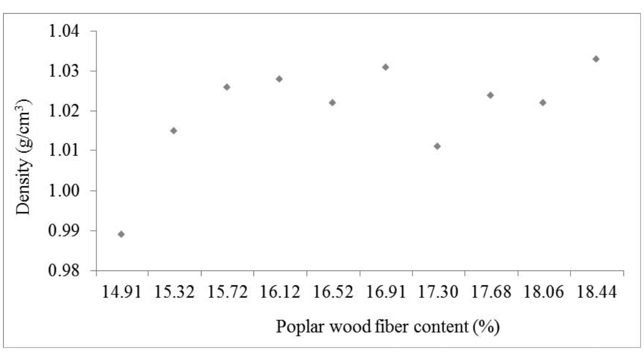

Figure 4.—Density and poplar wood fiber content.

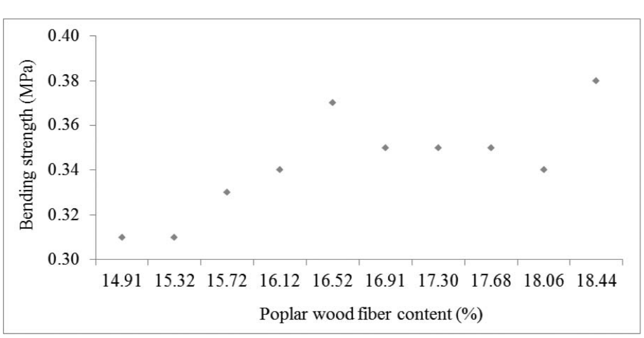

Figure 5.—Bending strength and poplar wood fiber content.

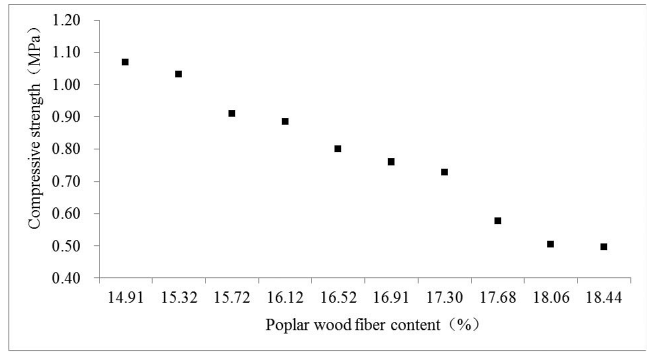

Figure 6.—Compressive strength and poplar wood fiber content.

hydroxide, an adhesive, has a constant mass. When poplar wood fiber mass increases, the adhesive surface between calcium hydroxide and poplar wood fiber increases, the unit surface adhesive amount decreases, and the interior adhesive strength becomes poor. When the brick is unloaded, the brick expands more. The dried brick has more pores and it is poorly anticompressed.

Effects of calcium hydroxide contents on properties of brick

The moisture content of brick ranges from 9.87 to 11.10 percent, and averages 10.72 percent (Fig. 7). The maximum value is the same as 1.12 times the minimum value. It is not affected significantly by calcium hydroxide content (Table 5). The reason is that the moisture content of calcium hydroxide is the same as 6.92 times that of poplar wood fiber. Moisture in brick comes mostly from calcium hydroxide. When poplar wood fiber mass is constant, the mass difference of calcium hydroxide is little, and the moisture content difference of brick is little.

The drying shrinkage rate of brick in length ranges from –0.61 to –0.76 percent and averages –0.69 percent, and the maximum value is the same as 1.24 times the minimum value (Fig. 8). The rate in width ranges from –0.68 to –1.04 percent, and averages –0.85 percent, and the maximum is the same as 1.53 times the minimum. The rate in thickness ranges from 0.46 to 1.93 percent, and averages 1.33 percent, and the maximum value is the same as 1.98 times the minimum value. The rate in thickness is affected significantly by calcium hydroxide content (Table 5). The reason is that the rate in thickness is determined by the drying

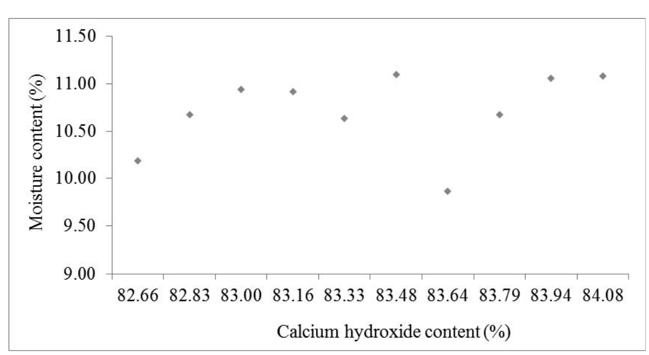

Figure 7.—Moisture content and calcium hydroxide content.

Table 5.—Variance analysis on the relationship between calcium hydroxide content and properties of brick.[a]

Sources	F value	*P* value	$LSR_{0.05}$	$LSR_{0.01}$
Moisture content (%)	0.633	0.768	1.688	2.155
Drying shrinkage rate in length (%)	0.191	0.995	0.293	0.374
Drying shrinkage rate in width (%)	1.505	0.148	0.306	0.391
Drying shrinkage rate in thickness (%)	1.937	0.049*	1.280	1.634
Density (g/cm^3)	4.272	0.000**	0.046	0.059
Bending strength (MPa)	0.650	0.753	0.099	0.126
Compressive strength (MPa)	3.737	0.000**	0.280	0.357

* = Significantly different at $P < 0.05$; ** = significantly different at $P < 0.01$.

[a] LSR = least significant range.

shrinkage degree when the brick is dried. Drying shrinkage degree is determined by the elastic volume and the interior adhesive strength. The elastic volume is determined by the pressing strength. The pressing strength is determined by the compressive ratio. The compressive ratio in thickness is equal to 3.0, and the ratios in length and width are equal to 1.0. The pressing strength in thickness is the greatest. The interior adhesive strength is different for different calcium hydroxide contents. When brick is dried, the drying shrinkage degree in thickness is the greatest.

The density of brick ranges from 0.98 to 1.07 g/cm^3, and averages 1.02 g/cm^3 (Fig. 9). The maximum value is the same as 1.10 times the minimum. It is affected extremely significantly by calcium hydroxide content (Table 5). The reason is that poplar wood fiber mass is constant, and the density of calcium hydroxide is 13.38 times greater than that of poplar fiber. Therefore, the density variance of brick is primarily decided by calcium hydroxide content.

The bending strength of brick ranges from 0.32 to 0.40 MPa, and averages 0.36 MPa (Fig. 10). The maximum value is the same as 1.25 times the minimum value. It changes little with increasing calcium hydroxide content (Table 5). The reason is that bending strength of brick is determined by the toughness among the fibers. The toughness is determined by antitearing ability. Antitearing ability is determined by the adhesive surface area. When poplar wood fiber mass is constant, the surface area of fiber is constant and the contacting adhesive surface area is constant.

The compressive strength of brick ranges from 0.60 to 1.10 MPa, and averages 0.80 MPa (Fig. 11). The maximum value is the same as 1.83 times the minimum value. It increases with increasing calcium hydroxide content. It is affected extremely significantly by calcium hydroxide content (Table 5). The reason is that compressive strength is determined by the interior adhesive strength. When poplar fiber mass is constant, the interior adhesive strength of brick increases with increasing calcium hydroxide content because the unit of surface adhesive mass increases when calcium hydroxide mass increases.

Effects of multifactor process parameters on properties of brick

The moisture content of brick ranges from 15.95 to 17.64 percent, and averages 16.95 percent. The maximum value is the same as 1.11 times the minimum value (Fig. 12). Calcium hydroxide mass, cold press time, and poplar wood fiber mass affect moisture content of brick in decreasing

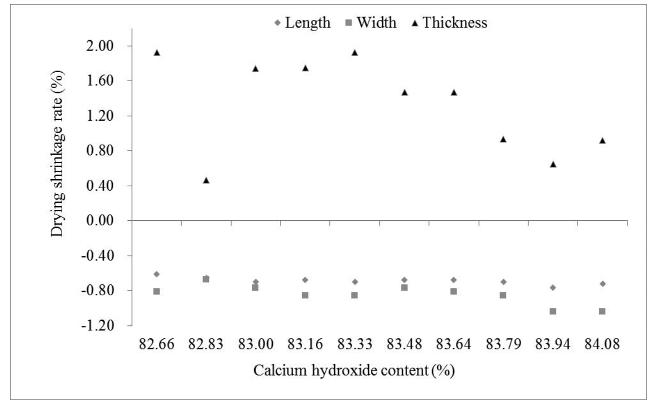

Figure 8.—Drying shrinkage rates and calcium hydroxide content.

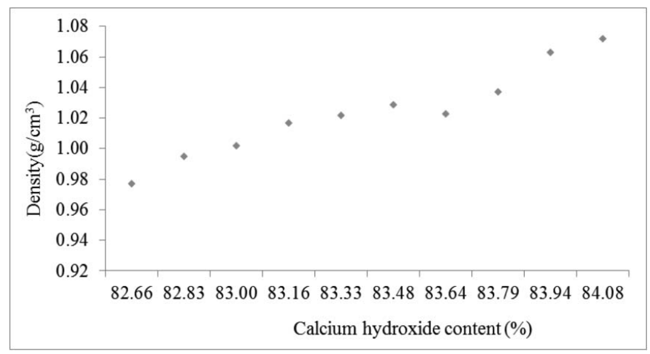

Figure 9.—Density and calcium hydroxide content.

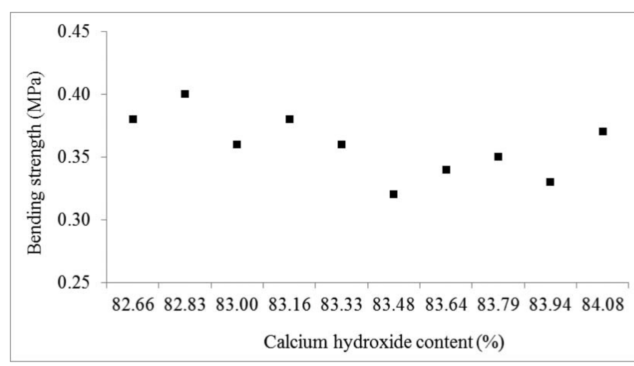

Figure 10.—Bending strength and calcium hydroxide content.

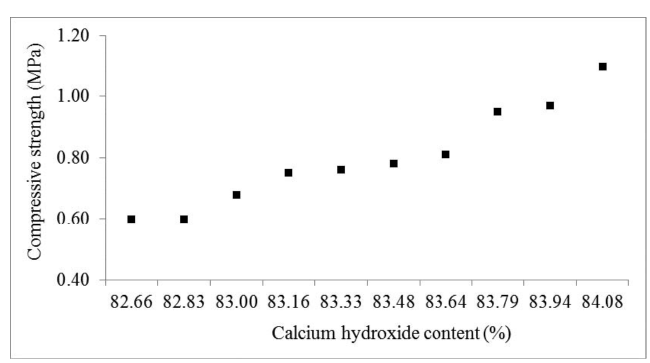

Figure 11.—Compressive strength and calcium hydroxide content.

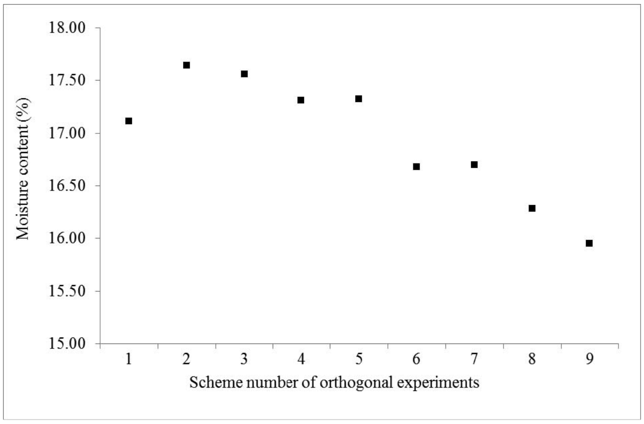

Figure 12.—Moisture content under different orthogonal experimental schemes.

order. Moisture content of brick is affected significantly by calcium hydroxide mass (Table 6) because the moisture content of calcium hydroxide is the same as 6.92 times that of poplar fiber, and the mass of calcium hydroxide is the same as 5.48 times that of poplar fiber.

The drying shrinkage rate of brick in length ranges from –1.01 to –1.31 percent, and averages –1.16 percent (Fig. 13). It is affected extremely significantly by the interaction between calcium hydroxide mass and cold press time. Poplar wood fiber mass, calcium hydroxide mass, and cold press time affect rate of brick shrinkage in decreasing order. The rate is affected extremely significantly by poplar fiber mass (Table 6). Because the volume of poplar fiber is the same as 2.44 times that of calcium hydroxide, the degree of compression of poplar fiber is higher than that of calcium hydroxide. When the mixture is molded, the compressed degree of poplar wood fiber is more than that of calcium hydroxide. After the brick is unloaded, poplar fibers have more obvious elastic deformation. Poplar wood fibers absorb the moisture from the calcium hydroxide. When the brick is dried, the shrinkage deformation of poplar fiber is higher than that of calcium hydroxide.

The rate in width ranges from –0.81 to –0.95 percent, and averages –0.90 percent. The maximum value is 1.17 times the minimum one (Fig. 13). Poplar wood mass, cold press time, and calcium hydroxide mass affect shrinkage rate in

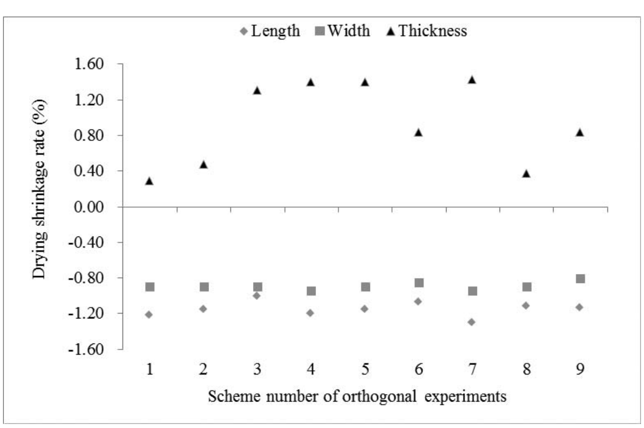

Figure 13.—Drying shrinkage rates under different orthogonal experimental schemes.

Table 6.—Variance analysis on the relationship among three factors and properties of brick.

Source and factor[a]	F value	P value
Moisture content (%)		
M_p	0.437	0.647
M_c	3.890	0.022*
T	0.752	0.473
$M_p \times M_c$	0.486	0.746
$M_p \times T$	2.055	0.089
$M_c \times T$	0.329	0.859
$M_p \times Mc \times T$	1.325	0.234
Drying shrinkage rate in length (%)		
M_p	5.741	0.004**
M_c	0.685	0.506
T	0.171	0.843
$M_p \times M_c$	0.685	0.603
$M_p \times T$	0.942	0.441
$M_c \times T$	3.469	0.009**
$M_p \times M_c \times T$	1.949	0.056
Drying shrinkage rate in width (%)		
M_p	2.714	0.069
M_c	0.143	0.867
T	0.571	0.566
$M_p \times M_c$	0.786	0.536
$M_p \times T$	0.571	0.684
$M_c \times T$	1.857	0.120
$M_p \times M_c \times T$	1.107	0.361
Drying shrinkage rate in thickness (%)		
M_p	0.617	0.541
M_c	1.802	0.168
T	4.955	0.008**
$M_p \times M_c$	2.590	0.039*
$M_p \times T$	1.013	0.402
$M_c \times T$	0.421	0.793
$M_p \times M_c \times T$	1.900	0.063
Density (g/cm^3)		
M_p	1.638	0.197
M_c	3.353	0.037*
T	1.267	0.284
$M_p \times M_c$	0.656	0.624
$M_p \times T$	1.699	0.152
$M_c \times T$	0.841	0.501
$M_p \times M_c \times T$	1.576	0.135
Bending strength (MPa)		
M_p	9.335	0.000**
M_c	2.594	0.078
T	0.093	0.911
$M_p \times M_c$	0.387	0.818
$M_p \times T$	1.637	0.167
$M_c \times T$	5.007	0.001**
$M_p \times M_c \times T$	3.175	0.002**
Compressive strength (MPa)		
M_p	10.905	0.000**
M_c	4.457	0.013*
T	3.625	0.029*
$M_p \times M_c$	2.741	0.030*
$M_p \times T$	3.157	0.016*
$M_c \times T$	6.381	0.000**
$M_p \times M_c \times T$	5.211	0.000**

* = Significantly different at $P < 0.05$; ** = significantly different at $P < 0.01$.

[a] M_p = mass of poplar wood fiber; M_c = mass of calcium hydroxide; T = cold press time.

width in decreasing order. The rate is not affected significantly by these process parameters (Table 6). The reason is that the press in width is little, and the compressive ratio is equal to 1.

The rate in thickness ranges from 0.28 to 1.42 percent, and averages 0.92 percent. The maximum value is the same as 5.01 times the minimum value (Fig. 13). Cold press time, calcium hydroxide mass, and poplar wood fiber mass affect shrinkage rate in thickness in decreasing order. The rate is affected extremely significantly by cold press time (Table 6). The rate is affected significantly by the interaction between poplar fiber mass and calcium hydroxide mass. The reason is that deformation in thickness is the result of a combination of elastic recovery deformation, thermal deformation, and shrinkage deformation. When cold press time increases, more moisture is squeezed out, and poplar wood fiber and calcium hydroxide molecules are decomposed and combined more tightly, which means that the internal bond strength of brick is greater. Moreover, the compressive ratio in thickness is equal to 3.0, and the press in thickness is the greatest.

Density ranges from 1.08 to 1.12 g/cm^3 and averages 1.10 g/cm^3. The maximum value is the same as 1.04 times the minimum one (Fig. 14). It is affected significantly by calcium hydroxide mass (Table 6). The reason is that the density of calcium hydroxide is 13.38 times more than that of poplar wood fiber, which plays a dominant role.

Bending strength of brick ranges from 0.26 to 0.38 MPa and averages 0.31 MPa (Fig. 15). The maximum value is the same as 1.46 times the minimum value. It is affected extremely significantly by the interaction of the three factors, and the interaction of calcium hydroxide mass and cold pressing time. Poplar fiber mass, calcium hydroxide mass, and cold pressing time affect bending strength in decreasing order. The strength is affected extremely significantly by poplar fiber mass (Table 6). The reason is that bending strength depends mainly on the toughness of poplar fibers. Scheme No. 9, with the best flexural strength, is significantly different from scheme Nos. 8, 4, 7, 2, and 1 (Table 7). Scheme No. 6 is significantly different from scheme Nos. 7, 2, and 1. Scheme No. 9 is very significantly different from Scheme Nos. 7, 2, and 1.

Compressive strength of brick ranges from 0.83 to 1.52 MPa and averages 1.03 MPa. The maximum value is the same as 1.83 times the minimum value (Fig. 16). Scheme No. 7 includes 1,849 g of calcium hydroxide, 310 g of poplar wood fiber, and 10 minutes of cold press time, which has the greatest compressive strength. Compressive strength is affected extremely significantly by the interaction of the three factors and the interaction of calcium hydroxide and cold press time. It is affected significantly by the interaction between poplar fiber mass and calcium hydroxide mass, and the interaction between poplar fiber mass and cold press time. Calcium hydroxide mass, poplar wood fiber mass, and cold press time affect compressive strength in decreasing order. The strength is affected extremely significantly by poplar fiber mass, and it is affected significantly by calcium hydroxide mass and cold press time (Table 6). The reason is that compressive strength mainly depends on the binding force of calcium hydroxide and poplar fibers. Poplar fiber is more compressible than calcium hydroxide, and its effect on compressive strength is stronger than that of calcium hydroxide. When poplar fiber mass difference is more than 20 g, the compression volume of the fiber is very large, so

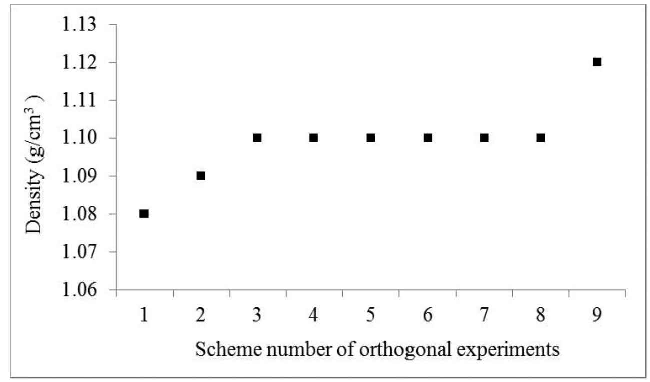

Figure 14.—Density under different orthogonal experimental schemes.

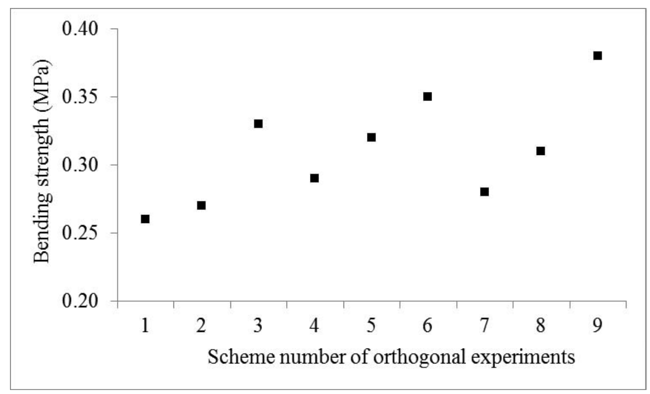

Figure 15.—Bending strength under different orthogonal experimental schemes.

Table 7.—Difference analysis of the influence of different schemes on properties of brick.[a]

Content	$LSR_{0.05}$	$LSR_{0.01}$
Moisture content (%)	1.649	2.110
Drying shrinkage rate in length (%)	0.199	0.254
Drying shrinkage rate in width (%)	0.130	0.167
Drying shrinkage rate in thickness (%)	1.112	1.422
Density (g/cm^3)	0.033	0.042
Bending strength (MPa)	0.075	0.096
Compressive strength (MPa)	0.303	0.388

[a] LSR = least significant range.

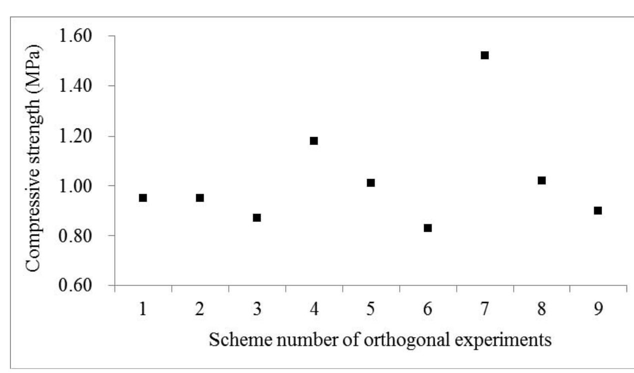

Figure 16.—Compressive strength under different orthogonal experimental schemes.

that compressive strength is affected significantly. When calcium hydroxide mass difference is more than 80 g, the difficult-to-compress material mass changes significantly, and thus compressive strength difference is also significant. Cold pressing time plays a vital role to compressive strength. The longer the compression time, the denser the bricks, the higher the bonding force between the material particles, and the higher the compressive strength. When compressive strength difference is more than 0.30 MPa, the difference is significant. If it is more than 0.39 MPa, the difference is extremely significant (Table 7). The difference between Scheme No. 7 and other schemes is extremely significant, and Scheme No. 4 is significantly different from Scheme Nos. 3 and 6.

Conclusions

Poplar wood fiber and calcium hydroxide are molded into wooden bricks for indoor partition walls to effectively use the waste poplar wood fiber in a new way. Process parameters including poplar wood fiber mass, calcium hydroxide mass, and cold press time were studied with single-factor and multifactor methods. Compressive strength is affected extremely significantly by the three-factor interaction of poplar wood fiber mass, calcium hydroxide mass, and cold press time; the pairwise interaction of calcium hydroxide mass and cold press time; and the single effect of poplar wood fiber mass. Compressive strength decreases with the increasing poplar fiber content from 14.91 to 18.44 percent, and increases with increasing calcium hydroxide content from 82.66 to 84.08 percent. Bending strength is affected extremely significantly by poplar wood fiber mass. Drying shrinkage rate of brick in thickness is extremely significantly affected by cold press time. The best process parameters include 310 g of poplar wood fiber, 1,849 g of calcium hydroxide, and 10 minutes of cold press time. The results show the importance of adjusting the process parameters to improve the properties of brick.

Acknowledgments

The research was funded by the Project of Special Fund for Forest Scientific Research in the Public Welfare, No. 201504506, China. MW performed the statistical analysis and wrote the paper; RD manufactured the brick and carried out the measurements; ZL designed the study and wrote the manuscript; WJ manufactured the samples. Chao Ma, Min Zhang, and Yufa Gao are thanked for their help in the experiments at Shandong Agricultural University.

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