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Research Paper

Effects of hot air drying time on properties of biomass brick

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HIGHLIGHTS

- Moisture content and drying density of biomass brick are decreasing with the increasing hot air drying time from 0 to 96 h.
- Compression strength is increasing with the increasing drying time and decreasing moisture content and drying density.
- Elastic recovery deformation rate in thickness is greater than ones in width and length.

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ABSTRACT

Biomass brick is made from poplar wood and corn stalk fibers and calcium hydroxide, and dried in the hot air drying environment where it is 50 °C in temperature and 32.1% in relative humidity and 0.12 m/s in air velocity. Moisture content and drying density are decreasing with the increasing drying time from 0 to 96 h. Compression strength is increasing with the increasing drying time and decreasing moisture content and drying density. Drying shrinkage deformation rate in length is greater than ones in width and thickness, and it is greater than the permanent and elastic recovery deformation ones. Elastic recovery and permanent deformation rates in width and thickness are greater than drying shrinkage deformation rate. When the brick is dried for 96 h, it is 9.10% in moisture content, 1.04 g/cm^3 in drying density, 1.28 MPa in compression strength, 1.23 N m/kg in the ratio of strength and density.

1. Introduction

There is 0.549 billion m^3 poplar wood stock volume and 0.25 billion tons corn stalk in China, therefore, it is important to study the effective utilization of poplar and corn stalk [1]. Poplar wood and veneer and particle and fiber can be manufactured into laminated wood [2], compressed wood [3], modified wood [4], plywood [5], veneer-laminated wood [6], particleboard [7], pallet [8], micro/nano fibril [9], fiberboard [10], wood plastic composite [11], wooden ceramics [12], and so forth. The whole corn stalk and fiber and particle can be manufactured into floor [13], corrugated paper [14], oil absorbing material [15], packaging material [16], foamed material [17], straw-cement composite material, straw-plastic composite material, straw-wood composite material [18], and heat insulating material [19]. The introduction of stalk into the architecture industry can accomplish the merger of the two industries development, which solves the problem about the severe resources and energy and environmental pressure in architecture industry and explores a new way for agricultural economy [20].

There are about 40 billion m^2 in building area in China now [21], and the area will be 68.8 billion m^2 by 2020 [22]. Lightweight is the trend of building wall material development in the world, because that it can save resources and energy, reduce traffic volume, increase the useful area and decrease labor intensity [22]. Calcium hydroxide is an inorganic binder as the earliest adhesive in history, which can be manufactured into calcium hydroxide slurry [23], cement mortar [24], tung oil mortar [25], sticky rice mortar [26], concrete [27], and other products. In order to increase the value of poplar wood and corn stalk, it is an effective way that the mixture of poplar wood and corn stalk fibers and calcium hydroxide can be molded into the lightweight biomass brick for building indoor partition.

Drying method is important to the properties and manufacture efficiency and cost, and hot air can be used to dry the brick. Drying speed and quality can be affected by the temperature and relative humidity and velocity of hot air and drying time. When the temperature and relative humidity and velocity of hot air are same,

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drying time is vital to the properties of brick. Moisture is evaporated and the physical and mechanical properties of brick are changed in the drying process. So that it is necessary to explore the effects of hot air drying time on the moisture content and strength and deformation of brick, which will provide a basic theory for manufacture and application of biomass brick.

2. Materials and methods

2.1. Materials

Properties about poplar wood and corn stalk fibers and calcium hydroxide are shown in Fig. 1 and Tables 1 and 2.

2.2. Methods

Mass of poplar wood and corn stalk fibers and calcium hydroxide are balanced using an electrical balance (Model JA21002, Shanghai Jingtian Electrical Instrument Co., Shanghai, China) with a precision of 0.01 g. Moisture content of raw materials are tested using a halogen moisture detector (Model JT-K6, Jingtai Co., Taizhou, China). They are mixed completely with the mixing machine (Model JJ-5, Shandong Luda Test Measurement Machine Co., Taian, China) and put into the squeeze die, shown in Figs. 2 and 3.

The squeeze die is customized (Model custom, Shandong Luda Test Measurement Machine Co., Taian, China). There are squeeze head and bucket and backing board, shown in Fig. 3. The head is the loading body. The bucket is the square shape, which interior dimensions are 235 mm in length and 110 mm in width and 150 mm in thickness. The backing board is the loaded body. Mixed materials are molded into biomass brick with the press machine (Model MY 50B, Qingdao Jilongchang Equipment Machine Co., Qingdao, China), in which the press is equal to the load when the head is pressed into the bucket completely at room temperature.

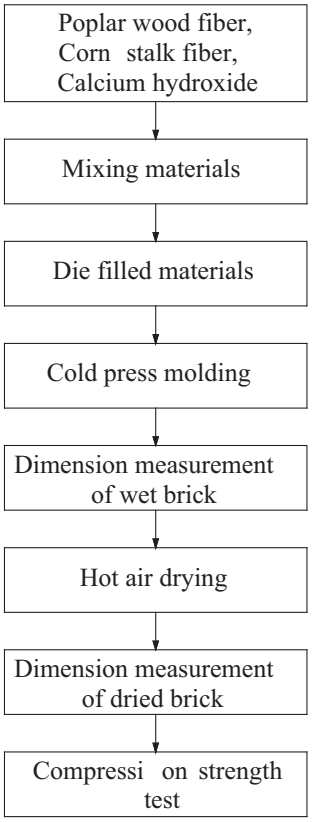
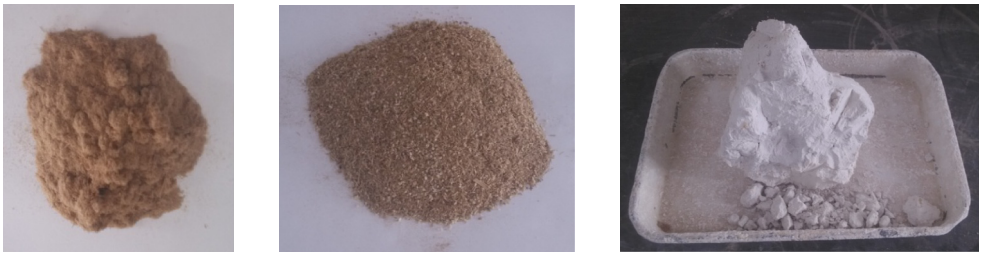


Fig. 2. Process flow chart.

Dimensions of wet brick in length and width and thickness are measured with the plastic ruler (Model 30 CM, Deli Group Co., Zhejiang, China), shown in Fig. 4. It is balanced on an electrical balance (Model ACS-302, Shanghai Huachao Electrical Instrument Co.,



(a) Poplar wood fiber (a) Corn stalk fiber (c) Calcium Hydroxide

Fig. 1. Raw materials.

Table 1
Moisture content and density of raw materials.

Raw materials	Corn stalk fiber		Poplar wood fiber		Calcium hydroxide	
	Range	Mean	Range	Mean	Range	Mean
Moisture content (%)	5.40–8.15	6.55	11.33–12.94	11.60	46.01–53.53	48.69
Density (g/cm^3)	0.066–0.107	0.077	0.097–0.138	0.104	1.173–1.317	1.246

Table 2
Mesh ratio of poplar wood and corn stalk fibers.

Mesh (number)	Mass percent (%)										
	10	20	30	40	50	60	70	80	90	100	⩾100
Poplar wood fiber	0.63	26.23	20.08	13.88	11.32	5.56	3.54	4.07	1.66	2.38	10.65
Corn stalk fiber	3.18	6.99	6.35	14.24	13.93	2.94	5.42	4.26	4.49	5.17	33.02