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Development of Gypsum Block of Energy Conservation and Waste Utilization

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Abstract. Waste, parings and scraps (WPS) in shoemaking industry are difficult to deal with by traditional approaches, which will pollute the environment and results in waste of resources if not handled properly. In this paper, WPS, after modification, is used as reinforcing material in gypsum block, in which livestock-waste based retarder is used to control setting time. The result showed that the proper mass ratio of hemi-hydrate gypsum to WPS is 95:5. The optimal dosage of retarder is 0.23% (on the basis of total solid). The addition of modified WPS remarkably improved the characteristics of anti-cracking, water absorption, dry shrinkage and thermal conductivity of the gypsum block, with little decrease in mechanical strength values.

1 Introduction

The acceleration of urbanization has promoted the vigorous development of the construction and building industry, and the corresponding building energy consumption is also increasing. According to statistics, 99 % of existing 40 billion square meters of buildings and more than 95 % of new buildings in China belong to high energy consumption buildings. In recent years, as a lightweight material, gypsum block gradually replace the traditional clay brick as non-load bearing interior walls, partition walls, cavity walls, skin walls and pillar casing indoors, which not only can utilize waste gypsum, but also has the advantages of heat preservation, comfortable, and fire-resistant, etc.

In order to further improve the performance of gypsum, some admixtures were added [1,2]. Considering the cost, solid waste is the first choice. At present, a large number of shoe-making plants produce large amount of waste, parings and scraps which will pollute the environment and results in waste of resources if not handled properly. Analysis shows that the main components of them are rubber, adhesives and fiber etc. The combined use of these wastes with gypsum to produce construction block may be a possible approach considering the properties.

The aim of this work is to use WPS in gypsum block, giving full play the synergistic effects between different materials[3,4]. In order to reduce water requirement and increase the compatibility with gypsum, WPS is modified beforehand[5].

2 Experimental

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2.1 Raw materials

The construction gypsum was provided by shijiazhuang changan jiayi building materials Co. Ltd, which is obtained by the desulfurization gypsum calcined at 150-170℃. See Fig. 1. Table 1 gives the composition. Shoe-making industry waste is from the Xiong'an District, see Fig. 2. Gypsum retarder was prepared from livestock-waste [6]. Citric acid, sodium hexametaphosphate and other chemical reagents were bought on the market.

Table 1 Principal composition of desulfurization gypsum, wt%

Composition	CaO	SiO_2	FeO	Fe_2O_3	MgO	Al_2O_3	MnO	f-CaO	SO_3
Desulfurization gypsum	37.76	1.38	-	0.32	0.16	0.27	-	-	50.34

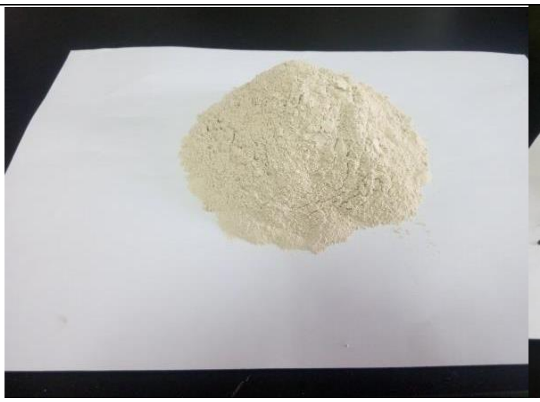

Figure 1. Construction gypsum

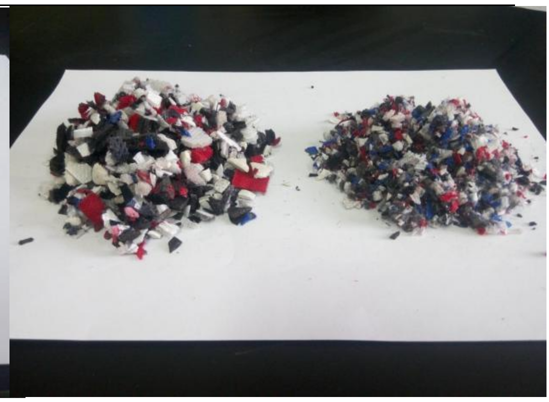

Figure 2. WPS in shoe-making industry

2.2 Methods

(1)Modification of WPS. Potassium methyl silicate, VAE emulsion and water are mixed to form modification liquid, in which small WPS fragments are soaked, air dried.

(2)Preparation of gypsum block sample[7]. Construction gypsum, modified WPS fragment, retarder and water are mixed to form gypsum slurry. The slurry is put into mold, then de-mold, curried and air dried to obtain the final product. Fig. 3 gives the flow-sheet of the preparation of gypsum block.

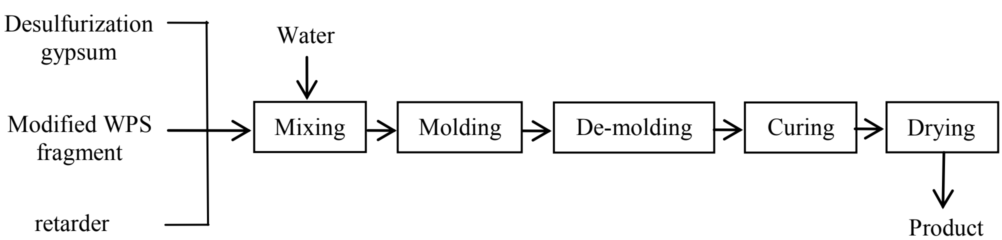

Figure. 3 Preparation of gypsum block

(3)Performance test. Specimens with dimension of 40 mm×40 mm×160 mm were molded in lab to test the performance of the product. The specimen is cured under standard curing conditions and then dried in thermostatic oven at (40±5)°C to constant weight. The standard consistency, setting time and mechanical strength of the gypsum were tested according to GB/T17669.4-1999. The flexural strength value was the average of every three tests, whereas the compressive strength value was the average of every six tests. The dry shrinkage and water absorption of the specimen is tested according to GB/

T2542-2512. The thermal conductivity of the specimen was determined on DRM thermal conductivity tester[8,9].

3 Results and discussion

3.1 Effect of retarder on setting time and mechanical strength

In this work, gypsum retarder was prepared using slaughter plant waste, by hydrolysis and neutralization process [1]. Based on the same initial setting time, the effects of four retarders on the bending and compressive strength of desulphurization gypsum were observed, See table 2.

Table 2 Effects of different retarders on the strength of construction gypsum

Retarder	Construction gypsum/%	Retarder /%	Initial setting time/min	Absolute dry strength/MPa	
				Bending	Compression
Blank	100	0	6	11.5	24.1
Citric acid	100	0.03	23	7.6	12.4
Sodium citrate	100	0.16	25	8.2	13.2
Sodium hexametaphosphate	100	0.16	20	7.1	12.0
Slaughter plant waste based retarder	100	0.11	23	12.5	17.3

It can be seen from table 2 that, the slaughter plant waste based retarder has less negative effect on the mechanical strength of gypsum, compared to the other three retarders.

3.2 Effect of modified WPS on the properties of gypsum block

The first choice is the larger size of the scraps, through the exploration of different dosage, testing the density, water absorption, bending and compressive strength.

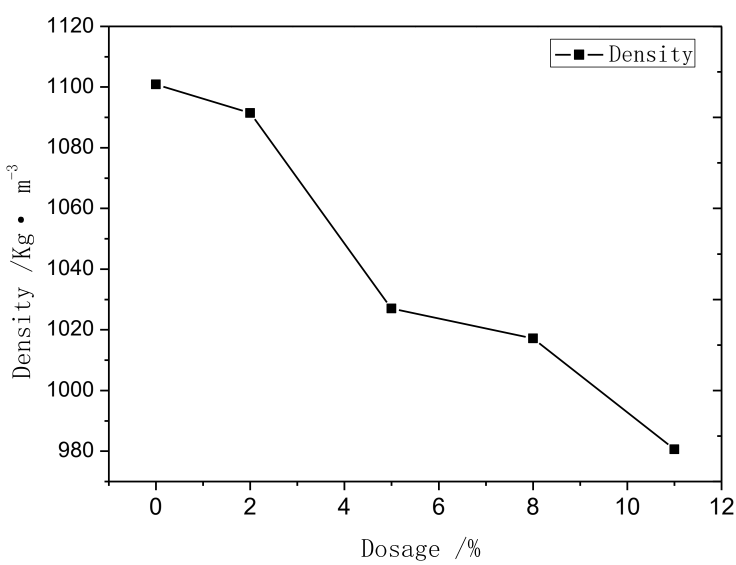

Figure. 4 Effect of different dosage on the density of gypsum

As we can see from Figure 4, with the increasing in WPS scraps content, the density of the block shows a downward trend.

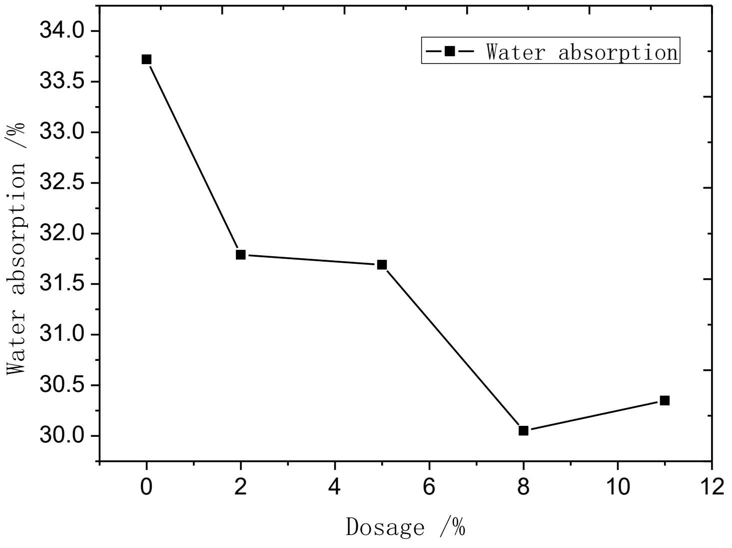

Figure. 5 Effect of different dosage on the water absorption of gypsum

As can be seen from Fig. 5, with the increase in WPS scraps content, the water absorption of block gradually decreased, indicating that WPS has a significant effect on gypsum system after modification, and the water absorption rate is reduced by 10% compared with the blank experiment.

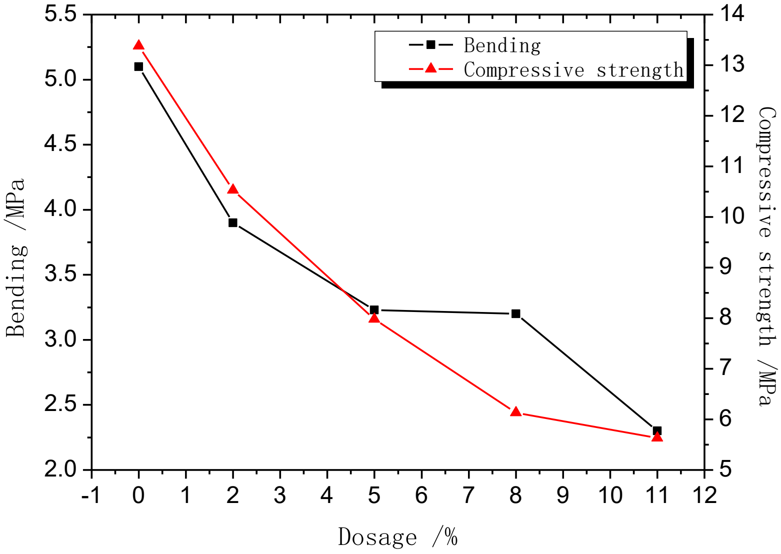

Figure. 6 Effect of different dosage on the bending and compression strength of gypsum

Fig 6 shows that the mechanical strength decreases with the increase of the dosage WPS. The flexural strength decreases sharply with the increase of the content of the WPS, and the compressive strength is slower.

Figure 7 and Figure 8 show the cross section morphology and profile of the block. It can be predicted that the addition of WPS can improve the crack resistance of the test block.

Figure 7 Distribution of WPS scraps in gypsum

Figure 8 Broken test block

3.3 Effect of scraps on dry shrinkage value and thermal conductivity

The dry shrinkage value and thermal conductivity were tested for addition of WPS scraps in the gypsum. See table 3.

Table 3 Effect of the scraps on the thermal insulation and deformation of gypsum

Dosage/%	Dry shrinkage value	Thermal conductivity
0	0.69	0.1864
5	0.39	0.1688

As can be seen from table 3, compared with the blank, the dry shrinkage and thermal conductivity of the gypsum system decrease by 43 % and 9.4 % respectively.

That is to say, the addition of WPS scraps can effectively improve the thermal insulation effect of gypsum blocks and reduce the dry shrinkage value[10, 11].

4 Summary

(1)A kind of environment-friendly gypsum insulation block of energy conservation is prepared by using desulphurization gypsum, WPS in shoemaking industry and slaughter plant waste based retarder, realizing solid waste utilization.
(2)The slaughter plant waste based retarder has good retarding effect on construction gypsum and has less negative effect on the mechanical strength of gypsum, compared to the other three retarders.
(3)The addition of modified WPS improved the characteristics of anti-cracking, water absorption, dry shrinkage and thermal conductivity of the gypsum block. In this case, the mechanical strength values of the block decrease[12-14].

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