Study on improving properties of desulfurized gypsum based cementitious materials

Jianmei Zhou

School of Chemistry and Chemical Engineering,Inner Mongolia University of Science & Technology,Baotou 014010,China

zjmwjy@aliyun.com

Abstract. Two kinds of inorganic reinforcing materials, single Portland cement clinker, compound Portland cement clinker and mineral powder, were used to analyze the effects of desulfurized gypsum on the properties of desulfurized gypsum based cementation material. The results show that either single Portland cement clinker or compound Portland cement clinker and mineral powder can effectively improve the mechanical properties and softening coefficient of the material, and the effect of compound mixing is better. The optimum dosage of Portland cement clinker is 10%, the 7d and 28d bending strength of cementing material is 2.5MPa and 4.1MPa, the compressive strength is 4.6MPa and 9.8MPa, and the softening coefficient is 0.61. The appropriate composite content of Portland cement clinker and mineral powder is: Portland cement clinker 5%~10%, mineral powder 10%~15%, gelling material 7d, 28d bending strength of 3.0~3.5MPa, 6.3~7.4MPa, compressive strength of 5.4~6.7MPa, 12.1~13.6MPa, softening coefficient of 0.58~0.62.

Keywords: Desulfurized gypsum; Portland cement clinker; Mineral powder; Softening coefficient; property.

1. Introduction

Desulphurized gypsum is a by-product of the wet desulphurization process of thermal power stations, and its main component is calcium sulfate dihydrate [1]. The resource utilization of solid waste wet flue gas desulphurization gypsum is an urgent research difficulty. Desulphurized building gypsum with certain hydration activity and gelling property can be obtained after calcination and dehydration of desulphurized gypsum. The products have the advantages of lightweight thermal insulation, fire protection and heat insulation, etc. [2-4]. However, due to the generally low strength of gypsum products, the development and application in building materials are severely limited [5]. Therefore, it is necessary to improve it into a composite cementitious material with better performance and wider application prospect by modification.

Based on the existing literature [6-8], this paper first calcined desulphurized gypsum into desulphurized building gypsum, and studied the effects of Portland cement clinker and mineral powder, two inorganic reinforcing materials, on the properties of gypse-based cementation materials, to provide theoretical support for the resource utilization of desulphurized gypsum.

2. Experimental

2.1 Materials.

The desulfurized gypsum used in this experiment came from Baotou Thermal Power Plant, Portland cement clinker from Mengxi Cement Factory, and slag powder from Baotou Iron and Steel Group Co., LTD., whose chemical composition is shown in Table 1. The free water content of undisturbed desulfurized gypsum is 18.39%. The chemical pure sodium citrate was used as the retarder of the cementing material, and the dosage was 0.15% of the cementing material.

Table 1 Chemical composition of gelling materials wt%

constituent	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	MnO_2	TiO_2	Firing loss
slag powder	36.66	2.08	11.5	34.93	9.98	0.38	0.59	0.47
Portland cement clinker	20.1	3.96	4.57	63.45	2.04	0.04	0.24	2.1
Desulfurized building gypsum	2.23	0.04	31.96	40.76	0.77	-	-	-

2.2 Methods.

The sample was prepared according to the national standard GB/T 9776-2008 "Building Gypsum". Refer to GB /T 17671-999 "Cement mortar strength Test Method (ISO method)" to determine the 7d, 28d bending and compressive strength. The length × width × height of the specimen is 160 mm × 40 mm × 40 mm. The softening coefficient was determined according to JCT698-2010 Gypsum Block.

3. Results and discussion

3.1 Effect of Portland cement clinker on mechanical properties of desulfurized building gypsum

The results are shown in Fig. 1 and Fig. 2.

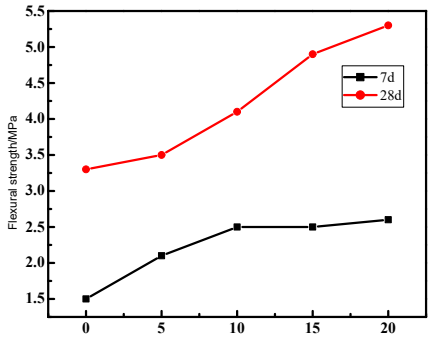

Fig. 1 Influence of Portland cement clinker content on flexural strength of desulfurized building gypsum

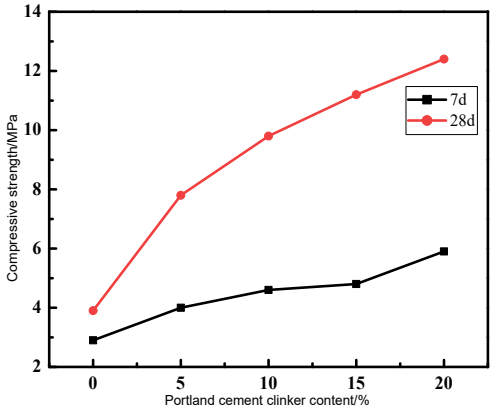

Fig. 2 Influence of Portland cement clinker content on compressive strength of desulfurized building gypsum

As can be seen from Fig.1 and Fig. 2, the strength of gypsum products has been increasing with the increase of Portland cement clinker content. Considering that the setting time of the products during molding will also shorten with the increase of Portland cement clinker content, 10% is appropriate, and the 7d and 28d bending strength of the cement-forming materials are 2.5MPa and 4.1MPa, respectively. The compressive strength is 4.6MPa and 9.8MPa respectively.

3.2 Effect of Portland cement clinker on softening coefficient of desulfurized building gypsum

Table 2 shows the effect of Portland cement clinker content on softening coefficient of desulfurized building gypsum (7d).

Table 2 Influence of Portland cement clinker content on softening coefficient of desulfurized building gypsum

Portland cement clinker content/%	Sodium citrate retarder/%	7d saturated water compressive strength/MPa	7d absolute dry compressive strength/MPa	Softening coefficient
0	0.15	2.5	6.2	0.4
5	0.15	4.0	6.9	0.58
10	0.15	4.4	7.2	0.61
15	0.15	4.5	8.2	0.55
20	0.15	4.9	8.7	0.56

As can be seen from Figure 3, with the increase of Portland cement clinker content, the softening coefficient presents a trend of first sharp increase and then slow increase. Considering comprehensively, the dosage of Portland cement clinker should be 10%, and the softening coefficient is 0.61.

3.3 Effect of Portland cement clinker on mechanical properties of desulfurized building gypsum and mineral powder composite cementation material

The influence of the content of Portland cement clinker on the mechanical properties of composite materials was analyzed by fixing 10% slag powder, and the results were shown in Fig. 3 and Fig. 4.

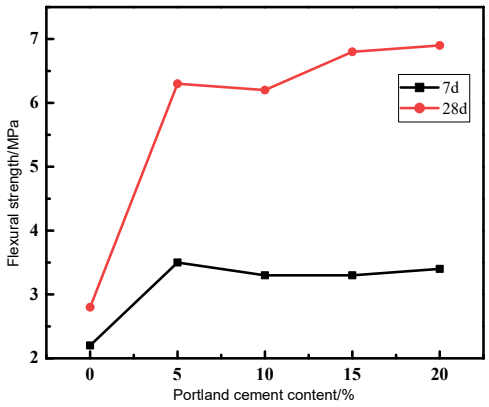

Fig. 3 Influence of Portland cement clinker content on flexural strength of desulfurized building gypsum and slag powder composite cementation material

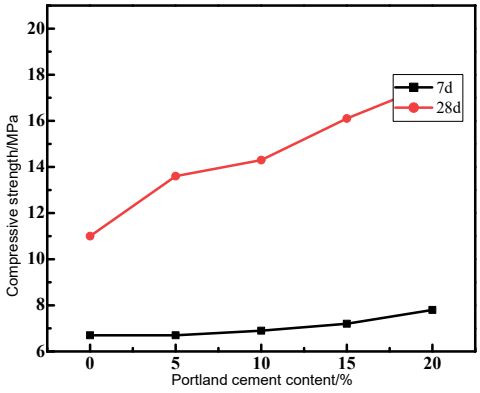

Fig. 4 Influence of Portland cement clinker content on compressive strength of desulfurized building gypsum and slag powder composite cementation material

As can be seen from Fig. 3 and Fig. 4, with the increase of Portland cement clinker content, the strength of desulfurized building gypsum and slag powder composite material is also significantly enhanced. Due to the addition of slag powder, the density of the material is improved, so the overall strength is higher than that of desulfurized building gypsum material without slag powder. Taking into consideration, the appropriate dosage of Portland cement clinker is 5%, and the 7d and 28d flexural strength of the composite cementative material is 3.5MPa and 6.3MPa, and the compressive strength is 5.7MPa and 13.6MPa, respectively.

3.4 Effect of Portland cement clinker on softening coefficient of desulfurized building gypsum and slag powder composite cementing material

The effect of the content of Portland cement clinker on the softening coefficient of the composite material (7d) was analyzed by fixing 10% slag powder. The results are shown in Table 3.

Table 3 Influence of Portland cement clinker content on softening coefficient of composite materials

slag powder/%	Portland cement clinker/%	7d saturated water compressive strength/MPa	7d absolute dry compressive strength/MPa	Softening coefficient
10	0	2.9	6.6	0.44
10	5	4.0	6.7	0.6
10	10	4.6	7.9	0.58
10	15	4.8	8.6	0.56
10	20	5.9	10.3	0.57

It can be seen from Table 3 that with the increase of Portland cement clinker content, the softening coefficient of the composite material shows an increasing trend. According to its influence on mechanical properties, the appropriate dosage of Portland cement clinker is 5% and the softening coefficient is 0.6.

3.5 Effect of slag powder content on mechanical properties of desulfurized building gypsum and Portland cement composite cementing material

The effect of the content of slag powder on the mechanical properties of the composite was analyzed by fixing 5% Portland cement clinker, and the results are shown in Fig. 5 and Fig. 6.

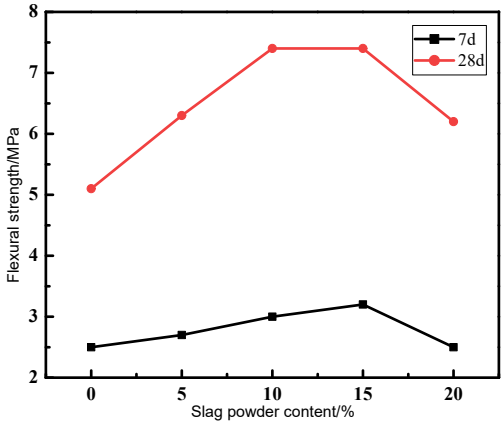

Fig. 5 Influence of slag powder content on flexural strength of desulfurized building gypsum and Portland cement composite cementation material

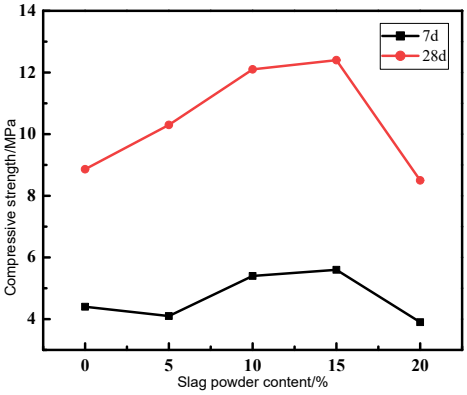

Fig. 6 Influence of slag powder content on compressive strength of desulfurized building gypsum and Portland cement composite cementing material

It can be seen from Fig. 5 and Fig. 6 that with the increase of slag powder content, the flexural and compressive strength of the composite cementing material increases first and then decreases, and the appropriate dosage is 10%. the 7d and 28d flexural strength of the composite cementing material is 3.0MPa and 7.4MPa, and the compressive strength is 5.4MPa and 12.1MPa, respectively.

3.6 Effect of slag powder content on softening coefficient of desulfurized building gypsum and Portland cement composite cementing material

The effect of the content of slag powder on the softening coefficient of the composite material (7d) was analyzed by adding 5% Portland cement clinker. The results are shown in Table 4.

Table 4 Influence of slag powder on softening coefficient of composite materials

Portland cement clinker/%	slag powder/%	7d saturated water compressive strength/MPa	7d absolute dry compressive strength/MPa	Softening coefficient
5	0	4.4	8.1	0.54
5	5	4.1	7.9	0.52
5	10	4.6	7.4	0.62
5	15	5.0	8.6	0.58
5	20	3.9	9.3	0.42

It can be seen from Table 4 that the influence of slag powder content on the softening coefficient of the composite material increases first and then decreases, and the appropriate dosage is 10%, at which time the softening coefficient of the composite material is 0.62.

4. Conclusions

The addition of Portland cement clinker to desulfurized building gypsum can effectively improve the mechanical properties and softening coefficient of the material, and the appropriate dosage is 10%. At this time, the 7d and 28d bending strength of the cementable material is 2.5MPa and 4.1MPa, the compressive strength is 4.6MPa and 9.8MPa, and the softening coefficient is 0.61.

The composite addition of Portland cement clinker and slag powder in desulphurized building gypsum has a more obvious improvement effect on the mechanical properties of the cementation material, and the appropriate composite dosage is: Portland cement clinker 5%~10%, slag powder 10%~15%, at this time, the 7d and 28d bending strength of the cementation material is 3.0~3.5MPa, 6.3~7.4MPa, the compressive strength is 5.4~6.7MPa, 12.1~13.6MPa, the softening coefficient is 0.58~0.62.

References

[1] ZhangYun Gao. Study on resource treatment of industrial by-product gypsum and its application in preparation of dry powder coatings [D]. Changsha: Hunan University,2010.

[2] WU S，WANG W L，REN C Z，et al． Calcination of calcium sulphoaluminate cement using flue gas desulfurization gypsum as whole calcium oxide source[J]．Construction and Building Materials，2019，228: 116676．

[3] Youjing Yan, He Zhang, Shifeng YU. Analysis of desulfurization gypsum calcination technology and calcination equipment[J]. New building materials,2018,45(2):100-102．

[4] Tingshu He, ZeQian Kang, Chang Chen. Effect of sodium methylsilicate on water resistance of desulfurized gypsum block [J]. Journal of building materials,2021,24(2):247-253,259．

[5] Xin Shi, Chuanxin Rong, Bin Wang, et al.Experimental Study on Physical and mechanical Properties of modified desulfurized gypsum concrete [J]. Science,Technology and Engineering ， 2018,18(21):288-293．

[6] Jian Fu . Effect of Portland Cement on strength and water resistance of building gypsum [J]. Non-Metallic Mines，2019，42(5):39-41．

[7] Hong Peng,Zhong LV,TaoJiang.Preparation and properties of desulfurized construction gypsum-cement composite cementitious material [J]. Journal of Civil Engineering and Management ， 2020 ， 37(6):38-43．

[8] Lei Yang,Min Jing,Haixia Song. Study on water resistance of desulfurized building gypsum [J]. Silicate bulletin，2016，35(9):2787- 2792．