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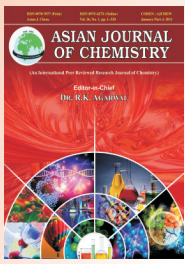

Experimental Study on Application of Anhydrous Plaster Gypsum†

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With natural anhydrite (type II anhydrous gypsum) from Hanshan Country of Anhui Province as major raw materials, the preparation and application of anhydrous plaster gypsum are investigated. The physical properties and mechanical properties, ventilation property and respiratory capability of anhydrous plaster gypsum with different properties are detected by using the method of orthogonal test. The results show that compress strength reaches to 8.20 MPa after 14 days, the flexural strength reaches to 3.80 MPa after 14 days, the bonding strength reaches to 0.37 MPa after 7 days, initial setting time is 150 min, final setting time is 386 min. Micro-structure analysis indicates that the plaster is a kind of cellular material which has enormous internal specific surface area, favorable ventilation property and respiratory capability and coarse grain occluding the wall in a close way with no blister phenomenon. This material is an ideal inorganic fireproofing materials of free calcining, high performance price ratio and green nontoxic for interior wall painting.

Keywords: Anhydrous plaster gypsum, Respiratory, Ventilation property, Setting time, Strength.

INTRODUCTION

The reserves of anhydrite in Hanshan County of Anhui Province is 5.8 billion tons, its benefits[1]. But poor activity and slow hydration reaction rate of the gypsum, seriously restrict its utilization. In recent years, anhydrite mines have begun to attract much attention with the continuous development of high product[2]. The research and development of anhydrite-based plastering materials without calcination have important economic and social benefits not only in the aspects of resource conservation and energy saving but also in the aspects of the development of new building materials[1,3].

In this study, the reaction activity of natural anhydrite (type II anhydrous gypsum) is stimulated by adding the reinforcing material and the active excitation agent to prepare the gypsum plaster with excellent performance[4].

Test preparation

Major raw materials: The gypsum plaster obtained from Hanshan County of Anhui Province, the density is 2.198 g/cm^3, the fineness is 180-200 mesh, chemical composition is shown in Table-1. Water requirement standard for consistency water is 23.375 %, initial setting time is 1050 min, final setting time is 1353 min, internal specific surface area is 3250 cm^2/g.

Cement: Xiangshan mountain, P·O42.5, apparent density is 3.1 g/cm^3. Building gypsum powder (market): apparent density is 2.73 g/cm^3. Lime powder (market): apparent density is 2.2 g/cm^3. Mineral powder: S95 powder, Yaqing in Hefei, apparent density is 2.9 g/cm^3. Glue powder: Hansen recycled rubber powder in the United States, apparent density is 0.6 g/cm^3. Thickener: made of corn starch, apparent density is 0.57 g/cm^3. Sand: the fineness is greater than 0.5 mm, apparent density is 2.63 g/cm^3. Compound salt excitation agent: calcined alum (at 650 ºC calcined 1 h), apparent density is 0.0083 g/cm^3.

Homemade tester (Fig. 1): The 100 mL syringe and infusion hoses are linked together, with iron clamp checking gas. The hoses is made into U-shaped tube injected with a certain amount of red ink. After making the specimen into a syringe shape, smear vaseline on and put it into the syringe. Then use a jack to control gas pressure. Firstly, push the piston of the syringe to a fixed value of a syringe scale and open metal trap. Secondly, record the liquid maximum level in the unit time to determine the permeability of specimens.

Test and analysis

Orthogonal experimental results: Gypsum plaster is made according to the ratio of orthogonal experiment [L8(2^5)], then,

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TABLE-1
CHEMICAL COMPOSITION OF GYPSUM PLASTER

Designation	CaO	SO_3	SiO_2	MgO	Fe_2O_3	Al_2O_3	TiO_2	Loss on ignition	Water of crystallization	Attached water
Content	40.32	51.68	1.17	2.25	0.19	0.24	0.02	0.83	0.42	0.04

Fig. 1. Homemade tester

respectively molded and painted on the surface of clay brick, hollow bricks and insulation block, to measure performances of 7 days and 14 days, the results are shown in Table-2. As is shown in Table-2 water, gypsum, lime have a great impact on respiratory capability and permeability of waterless molding gypsum plaster.

Analysis of orthogonal experimental results: From Table-2, the dosages of water, gypsum plaster, cement and lime powder have a greater influence on compressive strength, flexural strength, permeability and respiratory capability of molding gypsum plaster. In general, the more the dosages, the better permeability of stucco gypsum, but the worse respiratory capability of stucco gypsum.

Zhai and Zhang[1] find that Budde Kafelnikov complex salts reaction occurs and the activity of anhydrite is stimulated when the water powder ratio of anhydrite and calcined alum than 0.25. In this experiment, more water is used in test 1-4 than 5-8, to have a complete Budde Kafelnikov complex salts reaction, with more dehydrate gypsum and greater strength. The strength of stucco gypsum plaster can be increased by increasing water plaster ratio in a small range. After adding building gypsum, the hydration of anhydrite is accelerated, the crystallization rate is improved, the early strength is increased. Cement and lime plaster powder improve the gelling properties of stucco gypsum and play an active role in the hydration of anhydrite. Because of volume shrinkage phenomenon of lime powder after hardening, sand is added as aggregate to prevent cracking and increase the intensity of stucco gypsum.

The respiratory is composed by the moisture absorption and moisture releasing, the distance between all kinds of particles in stucco gypsum becomes greater with water consumption increasing,which leads to an increase of pores in stucco gypsum. After being hydrated by means of adding the amount of gypsum and lime make for the volume expansion, a large number of pores are produced and the internal specific surface area is increased. Similarly, the distance between particles and the pore size increase *via* mixing with sand. From the above, these factors have positive effects on the moisture absorption and moisture releasing. In addition, with boosting the hydration of cement by adding cement content, stucco gypsum will continue to absorb moisture, but moisture releasing is not obvious, therefore we should control the amount of cement.

From the foregoing results, the best ratio of anhydrite is: calcined alum: water: cement: building gypsum: lime: mineral powder: starch: glue powder: hydroxypropyl cellulose: sand = 1: 0.05: 0.5: 0.0325: 0.0043: 0.006: 0.08: 0.0134: 0.001: 0.004: 1.829, the performance density is 413.73 Kg/m^3.

Microanalysis

Molding gypsum plaster microstructure analysis: The main hydration products of anhydrous stucco gypsum are dihydrate gypsum in Figs. 2 and 3. Its growth is in-erratic and the space among crystals is relatively close, so that stucco gypsum has the high compressive and flexural strength and rough surface. The bonding strength between stucco gypsum and wall materials is good. Also there are a lot of pores between them with good permeability and respiratory.

Molding gypsum plaster and cement mortar: Fig. 4 shows that the permeability of stucco gypsum is nearly equal to that of cement mortar, but breathing performance is better than cement mortar just because there are a mass of pores among the stucco gypsum crystal grain. Its internal specific surface is large, causing a large surface free energy. Moreover, hydration level and hydration rate of anhydrite both depend on the degree of the exciting agent. Calcined alum contains a lot of active Al_2O_3 and SO_4^{2-} and adding cement, building plaster, lime and other materials in the stucco gypsum that can stimulate

TABLE-2
ORTHOGONAL EXPERIMENT RESULTS

Property		Setting time (min)		Compressive strength and flexural strength of 14 days (MPa)		Performance of 7 days		
						Adhesive strength (MPa)		
		Initial set	Final set	Flexural strength	Compression resistance	Clay brick	Hollow bricks	Insulation block
Test number	1	118	299	3.2	8.6	–	0.19	0.16
	2	154	401	2.7	7.7	–	0.07	0.14
	3	140	386	2.9	8.2	0.28	0.37	0.25
	4	167	418	3.1	8.3	0.06	0.18	0.16
	5	108	352	3.0	7.9	0.07	0.23	0.19
	6	116	367	2.6	7.8	0.07	0.17	0.16
	7	164	396	2.7	7.9	0.04	0.20	0.19
	8	150	394	3.1	8.4	0.15	0.16	0.20

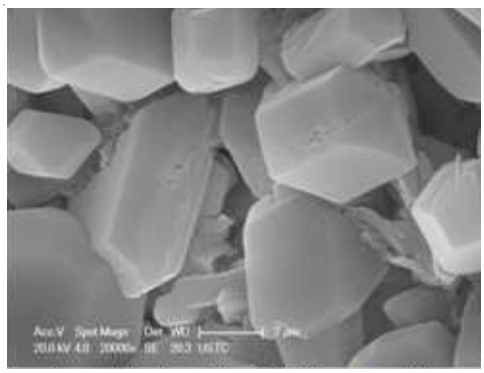

Fig. 2. Stucco gypsum scanning electron microscope(20000 times)

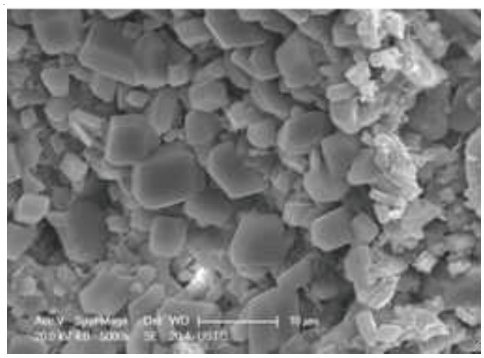

Fig. 3. Stucco gypsum scanning electron microscope (5000 times)

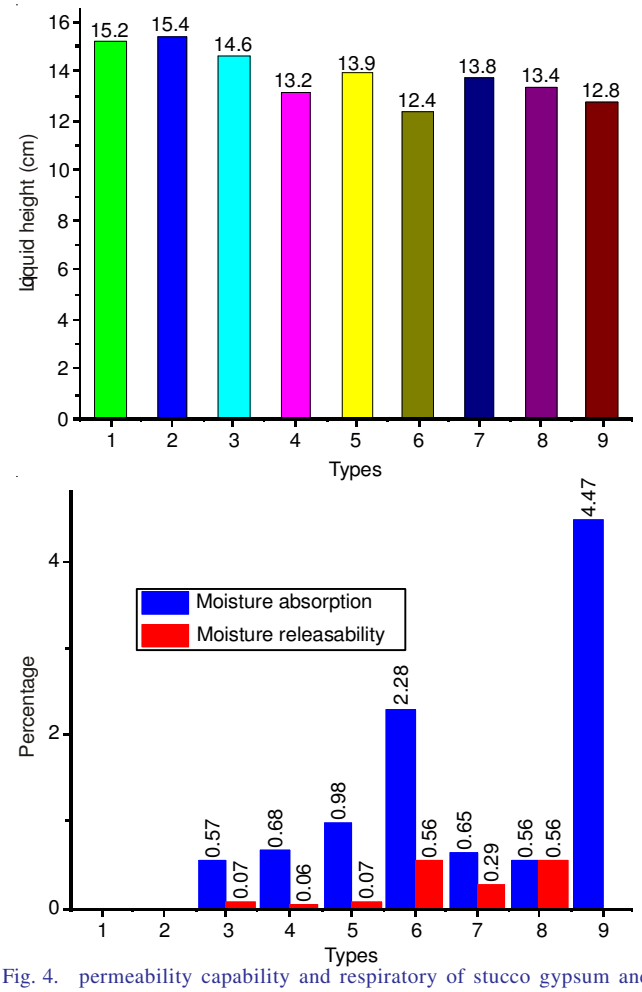

Fig. 4. permeability capability and respiratory of stucco gypsum and cement mortar (No. 1-8 represent stucco gypsum, No. 1-8 represent cement mortar)

multiple anhydrite activity, making plaster grain grow in rules. The research suggests that the hydration rate of 28 days stucco gypsum reaches to 72.43 %. Besides, hydration rate of stucco gypsum is faster than the cement hydration which can last several decades. Due to continuous water absorption and less water release, although moisture adsorption of cement mortar is better, the overall respiratory performance is inferior to stucco gypsum.

Environmental protection and economic benefit analysis

Environmental benefit analysis: The main raw material of stucco gypsum is natural anhydrite, most of the filler material is inorganic materials. Compared with cement, filler material and anhydrite's direct levigating without calcining is a better way in saving plenty of energy, reducing harmful gas emissions and improving the natural environment.

Economic benefit analysis: According to the matching calculation, the anhydrous stucco plaster is priced at 200.6 yuan/ton, the special plaster mortar is priced at 159.6 yuan/ton. The volume of one ton plaster is 2.4 m^3 which can paint an area of 800 m^2, one ton cement mortar is 0.36 m^3 which can paint an area of 120 m^2. The surface of cement mortar requires secondary processing and the stucco gypsum just needs a shape. All taken integrated into account, stucco gypsum can replace cement mortar as interior wall rendering materials.

Conclusion

All the indexes of physical and mechanical properties of stucco gypsum can meet the requirements of national standards and local standards. The respiratory capability and permeability of stucco gypsum is better than that of the cement mortar. The stucco gypsum does well in avoiding hollowing, preventing cracking phenomena, *etc*. The manufacturing process is simple with no calcination, environmental protection, energy saving and highly-cost-effective. The stucco gypsum can replace cement mortar as interior wall rending materials.

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