Study on Firing Method of Composite Clay Ceramsite

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Abstract. In the process of burning clay ceramsite, the quality of products had large difference when the constituent of added composite material, the mix proportion， and the temperature of burning were different . To seek the optimum scheme of clay ceramsite constituted by composite material， such composite materials as coal ash， sawdust，large white powder，and high calcium powder were added into clay. Different development schemes were acquired via changing the constituent of composite material， the mix proportion， and the temperature of burning . The performances of clay ceramsites which were obtained from different development schemes under the same burning temperature were compared . The results indicate that the scheme constituted by clay, large white powder，and sawdust is the optimum scheme .

Introduction

Clay ceramsite is a kind of artificial light aggregate made from clay or silty clay, which is processed and fired and expanded under the high temperature of 1050 ~ 1350℃[1]。The lightweight aggregate concrete made by replacing the coarse aggregate in concrete with clay ceramsite has the advantages of light weight, good heat preservation and insulation, significant energy saving effect, obvious anti-cracking effect, high durability, high fire resistance and low engineering comprehensive cost [2,3]，At the same time, the seismic performance of the structure can be improved, the material consumption can be saved, and the transportation and hoisting efficiency of the components can be improved [4,5]，Therefore, it has great application space and development prospect in the field of architecture.

Clay ceramsite quality by the composition of raw materials, mixing ratio, firing temperature, the influence of firing time and so on many aspects, and any conditions of the change could lead to a clay ceramsite larger change in quality, therefore developed the clay ceramsite the best materials, mixture ratio, firing temperature and fire time is crucial.In this paper, the quality of clay and fly ash, sawdust, large white powder, high calcium powder and other materials fired under different mixing ratios and different temperatures are compared and analyzed, so as to finally get the best development plan.

Raw Materials and Development Plan

Raw Material. Clay.The clay came from somewhere in Inner Mongolia.The impurities in the clay were screened out, and then dried at 105 ° c for 12h. After drying, part of the clay was sealed and kept for later use, and part of the clay was used for physical and chemical analysis.

The particle analysis results are shown in table 1, and the related physical performance analysis results are shown in table 2.According to the data in table 1 and table 2, the particle size distribution of this clay is relatively uniform, with good gradation and good physical properties.

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Table 1 Clay particle analysis results

Soil sample number	＞0.25 [mm]	0.25～0.075 [mm]	0.075～0.050 [mm]	0.050～0.010 [mm]	0.010～0.005 [mm]	＜0.005 [mm]
Powdered clay	0.1	3.2	2.1	36.9	15.2	42.5

Table 2 Analysis results of physical properties of clay

mean grain size D_{50}	water content W[%]	liquidity line W_L[%]	the plastic limit W_P[%]	plasticity index I_P	liquidity index I_L
0.01	14.0	37.7	20.7	17.0	－0.39

Different chemical composition and ignition loss in clay were analyzed, and the analysis results were shown in table 3.

Table 3 Chemical composition and ignition loss of clay (%)

project	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	loss on ignition
proportion	38.8	16.5	15.3	15.8	2.57	0.39	1.5	5.68

Saw dust. Sawdust was firstly dried at a constant temperature of 80℃ for 12h, and then sealed for later use.

Coal ash. Bake at a constant temperature of 105℃ for 12h. After drying, some parts are sealed and kept for later use, and some are used for chemical analysis. The analysis results are shown in table 4.

Table 4 Chemical composition and ignition loss of fly ash (%)

project	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	loss on ignition
proportion	56.3	14.7	3.5	2.8	1.3	2.4	1.9	2.1	2.4

Large white powder and high calcium powder. Use the large white powder and high calcium powder bought in the market.

Development Scheme. In this study, 5 raw materials including clay, fly ash, sawdust, large white powder and high calcium powder were developed according to different combination modes and different quality mixing ratios.The development process is divided into three batches, and 48 firing schemes are made in total, each of which takes 10 minutes.The specific programmes are shown in tables 5, 6 and 7.

Table 5 The first batch development plan of clay ceramsite

serial number	constitute	mass ratio [%]	sintering temperature 1 [℃]	sintering temperature 2 [℃]	sintering temperature 3 [℃]	sintering temperature 4 [℃]	fire time [min]
1	pure clay	100	1100	1150	1180	1200	10
2	clay: sawdust	95：5	1100	1150	1180	1200	10
3	clay: fly ash	90：10	1100	1150	1180	1200	10
4	clay: fly ash	80：20	1100	1150	1180	1200	10
5	clay: fly ash: sawdust	85：10：5	1100	1150	1180	1200	10

Table 6 Development plan of the second batch of clay ceramsite

serial number	constitute	mass ratio [%]	sintering temperature 1 [℃]	sintering temperature 2 [℃]	sintering temperature 3 [℃]	sintering temperature 4 [℃]	fire time [min]
6	clay: high calcium powder	97：3	1100	1150	1180	1200	10
7	clay: high calcium powder	95：5	1100	1150	1180	1200	10
8	clay: large white powder	97：3	1100	1150	1180	1200	10
9	clay: large white powder	95：5	1100	1150	1180	1200	10

Table 7 Development plan of the third batch of clay ceramsite

serial number	constitute	mass ratio [%]	sintering temperature 1 [℃]	sintering temperature 2 [℃]	sintering temperature 3 [℃]	sintering temperature 4 [℃]	fire time [min]
10	clay: large white powder: sawdust	94：3：3	1100	1150	1180	1200	10
11	clay: large white powder: sawdust	92：3：5	1100	1150	1180	1200	10
12	clay: sawdust	95：5	1100	1150	1180	1200	10

Experimental Results and Analysis

Under the firing condition of 1100℃: under the conditions of various schemes, clay particles do not appear to expand and melt, and only some clay particles show light brown surface.

Under the firing condition of 1150℃: under the conditions of scheme 1, 3 and 4, the clay particles showed grayish brown color and local shrinkage occurred. The clay particles in schemes 2 and 5 are light brown in color, with partial melting and larger volume. In schemes 6, 7, 8 and 9, the clay particles were dark brown in color, partially inflated, but there were a few pores on the surface. The clay particles in schemes 10, 11 and 12 were brown in color and slightly increased in volume, but a few pores appeared on the surface of the clay particles in schemes 11 and 12.

Under the firing condition of 1180℃ : under the conditions of scheme 1, 3 and 4, the color of clay particles turns to dark brown, and there is melting phenomenon, but the volume does not increase. In schemes 2, 5, 6, 7, 8, 9, the color of clay particles changed to dark brown, melting occurred and the volume increased slightly, but there were more pores on the surface. The color of clay particles in schemes 10, 11 and 12 turns to brown, and the melting volume increases significantly. However, there are more pores on the surface of clay particles in schemes 11 and 12, while the surface of clay particles in schemes 10 is smooth.

Under the firing condition of 1200℃, the clay particles in schemes 1, 3, 4, 6, 7, 8 and 9 become dark brown in color, with melting phenomenon but no increase in volume. In scheme 2, 5, 10, 11 and 12, the color of clay particles changed to dark brown, and the molten volume increased, but there were more pores on the surface.

Clay particles will have chemical reactions under high temperature. Firstly, the color changes. Brown is the normal reaction color. Second, melting is accompanied by changes in volume, volume contraction means that all the gas produced by the reaction is lost, a slight increase in volume means that the amount of gas produced is small, and an obvious increase in volume means that the amount of gas produced is sufficient; The volume increases, but the surface is not smooth and there are pores, indicating that the tension on the surface of ceramsite after reaction melting is too small to prevent gas overflow [6].The volume increased but the surface was smooth, indicating that the surface tension could completely wrap up the gas after the melting of the reaction and form high-quality ceramsite.

To sum up, the quality of ceramsite produced by firing clay particles at 1180℃ in plan 10 is

brown in color, with obvious increase in volume and smooth surface, and the quality is the best. The volume expansion rate of clay ceramsite was 60%, the apparent density was 990Kg/m3, the water absorption rate was 1.6%, and the grain shape coefficient was 1.3.Judging from various parameters, the quality of the developed clay ceramsite is very good and can be used in engineering.

Conclusion

（1）The clay in a certain place in Inner Mongolia can be combined with fly ash, sawdust, large white powder and high calcium powder to produce clay ceramics.however, the quality of ceramicite obtained under different material combinations, mixing ratios and temperatures is not the same.

（2）The mixture ratio of clay, large white powder and sawdust at 1180℃ is 94:3:3.

References

[1] Huang Gang. Application examples of ultra-light clay ceramsite products ,J. Building energy conservation, Vol. 28 (2000) No.5, p.10-11. (In Chinese)

[2] Gan Yonghui, Ding Jiantong, Li Xin-cheng, Zhong Yang, Fang Taisheng, GuoYushun.Design and construction of lightweight aggregate concrete in housing construction ,J. Construction technology, Vol. 34 (2005) No.8, p.56-58. (In Chinese)

[3] Jia xiaozhao, lei guo-yuan, song jun-ping, xiang rui, MAO shao-bo, xu yan. Preparation of ceramicite foam concrete using lightweight red clay ceramicite [J]. Metal mine, 2018 "" (7) : 192-196. (In Chinese)

[4] Liu Lixin. Performance study and engineering application of lightweight aggregate concrete (clay ceramsite) ,J. Science and technology information, Vol. 29 (2010), p.20-22.

[5] Liu xi, lu beibei, liu jian-zheng. Experimental study on the factors influencing the proportion and strength of high-strength lightweight aggregate ceramicite concrete [J]. Silicate bulletin, 2014,33 (4) : 847-852. (In Chinese)

[6] (In Chinese) Shi Zhiyuan, Yang Zhiguang, Meng Guangcai. Experimental research and application prospect of sintering ceramicite from clay (loess) in changchun area ,J. Jilin geology, , Vol. 24 (2005) No.2, p.62-65.(In Chinese)