

Study on the ratio and properties of the slurry of light insulation masonry with volcanic slag

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Abstract: Volcanic slag is a kind of natural high quality porous material, and it has a good thermal insulation effect, and it is an extremely rich natural resource. Therefore, this paper adopts the natural volcanic slag as the aggregate to build the insulation mortar mix design for the slag masonry, and tests the related performance of the mortar. The results show that adopts natural volcanic slag as the aggregate and the cement use fly ash to replace, and the appropriate uniform sealing pores were introduced into the mortar mix. The performance of the manufactured products can meet the requirements of JC/T890. The coefficient of thermal conductivity of lightweight masonry mortar is less than 0.14W/(m•K), and the frost resistance is greater than 100 times, and it is with a low price.

1. Introduction

With the building energy conservation requirements gradually improved, Including Jilin Province, which is located in the cold zone in China, Lightweight insulating blocks were applied in many areas, But the thermal conductivity of block (0.16W to 0.35W/(m•K)) is obviously smaller than the coefficient of thermal conductivity of ordinary mortar (0.8~1.0W/(m•K)), it is easy to produce a "cold bridge" at the masonry joint of masonry, causing greater heat loss, and the ordinary mortar has greater shrinkage, resulting in the wall through cracks or through the hole, resulting in masonry, joints and other parts of the ash appear serious dew (frost) phenomenon in the course of application of aerated concrete block^[1-4]. In order to solve such problems, this paper takes advantage of natural mineral resources and natural volcanic slag in Jilin Province as the main raw material, and carries out the research on the proportion and performance of cinder lightweight thermal insulation mortar.

2. Experimental process

2.1 Main raw materials

(1) volcano residue: 3.0-4.75mm particle size, physical properties are shown in Table 1, It is the origin of Huinan County, Jilin province;(2) cement: P•O42.5 cement;(3) fly ash: two stage fly ash;(4) other materials: Polycarboxylate superplasticizer; Poly methyl propyl ether; sodium dodecyl benzene sulfonate; Tap water.

Table 1. Volcanic slag performance.

Category	Heavy volcanic slag	light quality scoria
stacking density (g/cm ³)	0.810	0.438
water absorption (%)	13.5	37.2



2.2 Test method and testing equipment

The single variable method is used in the basic mixing ratio test, the main test items include: cellulose ether, sodium benzene sulfonate, water reducing agent, and the influence of cement and lightweight aggregate ratio on the physical properties of mortar. the mixture ratio optimization test adopts 4 factors and 3 levels orthogonal table (shown in Table 2), The main test items include: cellulose ether, sodium benzene sulfonate, water reducing agent, and the influence of cement and lightweight aggregate on the performance of mortar, and the influence of the amount of fly ash on the performance of mortar.

Table 2. Orthogonal test arrangement.

experiment \ column	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

First of all, taking the cellulose ether, sodium benzene sulfonate and water reducing agent added to the cement and mix evenly, then add the heavy scoria into the mixture, finally add the lightweight slag into the mixture. The micro morphology analysis by scanning electron microscopy of TM3030; Determination of thermal conductivity of thermal conductivity measuring instrument by using DRY-300F.

3. Test results and discussion

3.1 Basic mix ratio

The influence of cellulose ether and sodium benzene sulfonate on the final setting time of mortar is shown in Table 3. The effects of cellulose ether and sodium benzene sulfonate and cement and lightweight aggregate on mechanical properties of slag thermal insulation mortar are shown in Fig.1 and Fig.2.

Table 3. The effect of cellulose ether and sodium benzene sulfonate on the final time.

materials \ amount	0.0%	0.20%	0.40%	0.60%	0.80%
cellulose ether	3.5h	3.5h	4.2h	6.0h	12.0h
Sodium benzenesulfonate	3.3h	3.4h	3.8h	5.2h	6.5h

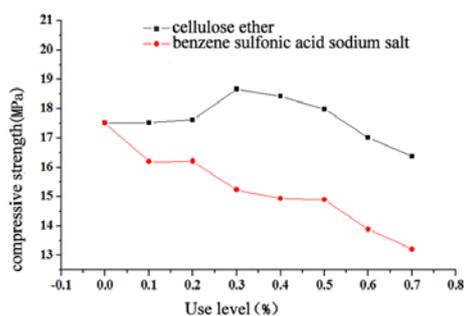


Figure 1. Effect of cellulose ether and benzene sulfonate.

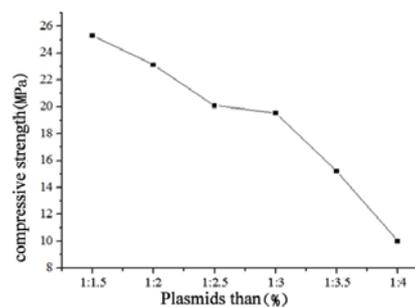


Figure 2. Influence of cement and aggregate quality.

According to the experimental results and analysis, we can see that the performance of the thermal insulation mortar mixture has been improved with the increase of the amount of cellulose ether or sodium benzene sulfonate. Moreover, the number of closed pores increased gradually, But the setting time of mortar is greatly prolonged when the amount of admixture was used too large. Therefore, the dosage of cellulose ether is 0.2-0.4%, and the dosage of sodium benzene sulfonate is 0.2-0.4% under the condition that the cementing material is only cement. And according to the test result of cement and aggregate dosage, the suitable proportion of “cement quality: aggregate volume” is 1:2-1:3.

3.2 Orthogonal experiment

According to the test results, the relationship between the orthogonal test factors and the horizontal variables is shown in table 4, the experimental results and the results are shown in table 5 and table 6 and Fig. 3 and Fig. 4.

According to the analysis: With the increasing of cellulose ether, the mechanical properties of thermal insulation mortar was increased and then decreased. Therefore, the optimum dosage of cellulose ether is 0.3% of the amount of cementitious material; With the increase of the amount of sodium benzene sulfonate, cement and heavy slag, the mechanical properties of thermal insulation mortar are obviously improved; And cement, poly methyl cellulose ether, light aggregate (heavy slag: light cinder), and twelve sodium benzene sulfonate have gradually diminishing impact on the strength.

Table 4. Relationship between factors and horizontal variables.

Sort	A cellulose ether (%)	B Sodium benzenesulfonate (%)	C cement (part)	D heavy slag: light cinder
1	0.20	0.2	170.0	1:3
2	0.30	0.3	185.0	1:1
3	0.40	0.4	200.0	3:1

Table 5. Mechanical test results.

Group	1	2	3	4	5	6	7	8	9
Compressive strength MPa	8.7	14.6	16.5	14.8	13.3	12.6	12.0	9.0	8.5

Table 6. Analysis of test results.

K(k) value	A	B	C	D
K ₁	39.8	35.5	30.3	30.5
K ₂	40.6	36.9	37.8	39.1
K ₃	29.6	37.6	41.9	40.3
k ₁	13.3	11.8	10.1	10.1
k ₂	13.6	12.3	12.6	13.1
k ₃	9.9	12.5	14.0	13.5
Range	10.3	2.5	11.5	9.8

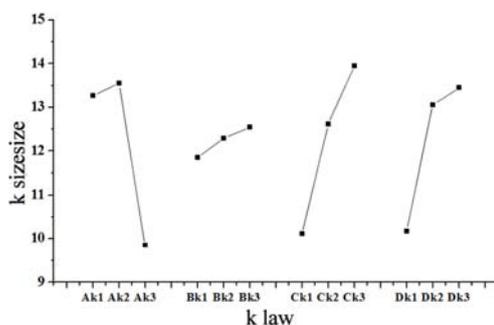


Figure 3. Variation of k value.

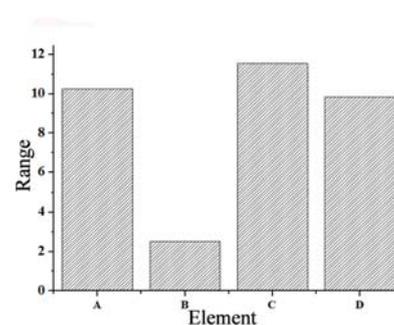


Figure 4. Comparison of the difference of factors.

3.3 Influence of fly ash on properties of insulating mortar

In order to reduce the cost of mortar, the cement was replaced by fly ash in this section; in order to reduce the apparent density of hardened mortar, we continue to increase the amount of lightweight scoria; And at the same time, according to the above experimental results, the amount of cellulose ether and water reducing agent in each experimental group are 0.3% of the cementing material, The arrangement of experiment and the result of experiment are shown in table 7, table 8 and table 9.

According to the analysis: The rate of substitution of fly ash was the most important factors of the performance of mortar, and the compressive strength of mortar increases greatly when the substitution rate of fly ash was 15%, According to Fig.5, we can see that the fly ash improved the interfacial layer in the hardened mortar, and the more dense hydration products increase the strength of the mortar at the interface. According to the mixture performance and experimental results analysis, the experimental group is E₂F₁G₂H₂, but compared with the economic and practical, we adjusted the E₂F₁G₃H₁ as a good experimental group.

Table 7. Relationship between factors and horizontal variables.

Sort	E cellulose ether (%)	F Sodium benzenesulfonate (%)	G cement (part)	H heavy slag: light cinder
1	0.30	160.0	0	1:8
2	0.35	170.0	15	1:6
3	0.40	180.0	30	1:4

Table 8. Mechanical test results.

Group	1	2	3	4	5	6	7	8	9
Compressive strength MPa	8.1	10.2	8.1	9.1	8.6	12.5	7.8	8.8	11.4

Table 9. Analysis of test results.

K(k) value	E	F	G	H
K ₁	K1	26.4	25.0	29.4
K ₂	K2	30.2	27.6	30.7
K ₃	K3	27.9	31.9	24.5
k ₁	k1	8.8	8.3	9.8
k ₂	k2	10.1	9.2	10.2
k ₃	k3	9.3	10.6	8.2
Range	3.7	6.9	6.2	4.6

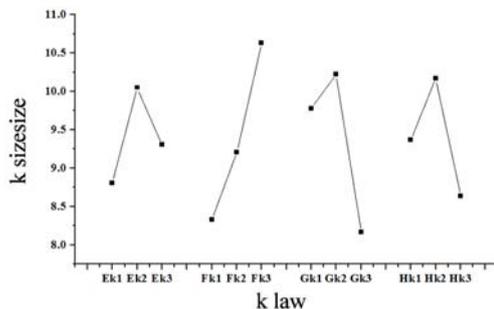


Figure 5. Variation of k value.

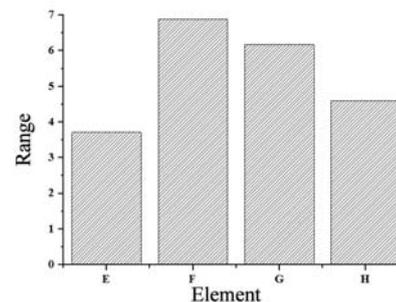


Figure 6. Comparison of the difference of factors.

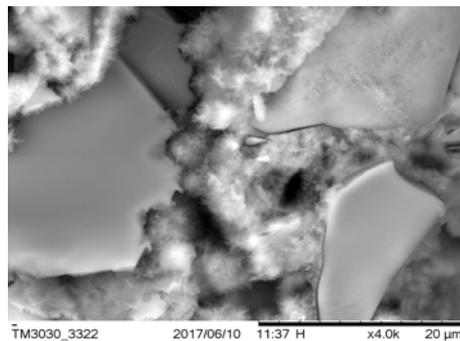


Figure 7. The SEM of the hydrating condition after replacing the cement with the fly ash.

3.4 Comprehensive performance of slag insulation mortar

According to the selected optimum experimental mixture ratio, we tested the mechanical properties and thermal conductivity of mortar, and the test results are shown in table 10, The results showed that the experimental group E₂F₁G₃H₁ meets the requirements, and all the performances meet the requirements of the JC/T890 standard, and it has high frost resistance. When used it with autoclaved aerated concrete blocks, the heat transfer coefficient of the wall is 0.419 (W/m•K), which achieved the requirement of 65% energy saving in the cold areas of North china, and meet the A level of fire protection requirements.

Table 10. The value of mortar performance for volcanic slag insulation.

Heat conductivity coefficient (W/m•K)	compressive strength (MPa)	dry density (kg/m ³)	frost-resistance (times)	bonding strength (MPa)	separation (mm)	Conductivity (mm/m)	setting time (h)
0.13578	5.82	1020.26	100	0.33	18	0.39	4.5

4. Conclusion

(1) The fiber ether can effectively improve the water retention performance of the mortar mix of volcanic slag and get a more suitable consistency, but the solidification time will be prolonged with too much mixing of mortar.

(2) Sodium benzenesulfonate has a good effect in heat preservation mortar.

(3) We can make all the indexes meet the requirements, and have excellent frost resistance, low cost and suitable for mortar used in the cold areas of North china with slag as aggregate. And when using it with autoclaved aerated concrete blocks, we can achieve the requirement of 65% energy by saving in the cold areas of North china, and meet the A level of fire protection requirements.

Acknowledgments

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