Effect of Activator on Alkali-Slag-Oil Shale Ash Cement under Thermal Excitation

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Abstract. By studying the influence of the content of activator on the strength of alkali-slag-oil shale ash cement under the condition of standard curing after 3 days of thermal excitation at 50℃, the problem that the cement's 28-day compressive strength is low under the standard curing conditions was solved. The results indicate that the strength of the cement can exceed 42.5MPa, when the amount of admixture of the water glass with 1.10 modulus is no more than 40 ml; or when the density of NaOH is no less than 3.15mol/L, the amount of admixture of NaOH is no less than 5%.

Keywords: Oil Shale Ash, Water Glass, NaOH, Cement Strength

1. Introduction
Oil shale and oil shale slag can be used as an admixture of cement [1-5]. The activity of oil shale ash produced by oil shale after combustion and power generation is less than oil shale slag. When oil shale ash content is high, the compressive strength of alkali-slag-oil shale ash cement cured at normal temperature for 28 days is low [6-8]. In this paper, the strength of oil shale cement is influenced by alkali activator under the condition of thermal excitation is studied [9], and the proportion of alkali-slag-oil shale ash cement which can meet the production requirements is sought.

2 Test Process
2.1 Raw Materials
Cement clinker: Jilin Yatai cement co. LTD; slag: Jilin Tonghua Iron and steel plant; oil shale ash: Huadian thermal power plant in Jilin Province; activator (NaOH, water glass): purchased from the market.

2.2 Preparation of Activator Solution
After the activator is accurately weighed, it is added into the measuring cylinder and fully stirred for later use.

2.3 Molding Method
After the cement mortar test specimen is manufactured[10], it is placed into curing box with the curing
temperature controlled at 50±2 °C for 3 days before the standard curing. The cement strength test was carried out in 24 hours, 48 hours, 3 days, 7 days and 28 days respectively.

3. The Influence of Activator on Alkali-Slag-Oil Shale Ash Cement Strength under the Condition Of 50°C Thermal Excitation

Oil shale ash content is fixed at 50%, cement clinker content is fixed at 8%, slag content is fixed at 42%, the water-cement ratio is 0.42, under the condition of 50°C thermal excitation, the influence of the type and content of activator on the cement is considered.

3.1 The Strength of Cement Is Affected By Water Glass Content

Cement strength is affected by water glass content which is shown in Fig.1.

![Fig 1 Effect of water glass content on compressive and bending strength](image)

The overall trend of the strength of cement and water glass content is proportional; the growth rate of cement strength and water glass content is also proportional. Adding 50ml of water glass with modulus of 1.10, the compressive strength of 3 days can reach 54.5MPa, and the compressive strength of 28 days later can reach 63.4MPa, that is to say, when the volume ratio of water glass to water is greater than 3:1, the cement strength is higher.

The setting time of cement is inversely proportional to the content of water glass, especially when the water glass content is large; at the same time, as the content of water glass increases, the viscosity of water solution increases and it is not easy to vibrate and compact, which makes the strength growth rate of samples with higher content of water glass slower. Therefore, the high content of water glass activator is not suitable for construction site application.

When the test sample is cured at 50°C for 3 days, adding 40 ml of water glass with modulus of 1.10 can meet the requirement of 425 cement strength in 28 days; adding 50 ml to 60 ml of water glass with modulus of 1.10 can meet the requirement of 525 cement strength in 3 days and 625 cement strength in 28 days.

Considering the experimental data and the properties of cement, it is better to add 40-50 ml water glass.

3.2 The Cement Strength Is Affected By The Water Glass Modulus

The cement strength is affected by the water glass modulus which is shown in Fig.2.
**3.3 Effect of NaOH Content on Cement Strength**

The influence of NaOH content on the strength of cement is shown in Fig. 3.

![Fig 3: Effect of NaOH content on compressive and bending strength](image)

When the content of NaOH is 3%-7%, the bending strength of cement increases with the increase of NaOH content, and the growth rate is large on the first day and the second day of curing, then the growth rate slows down; when NaOH content is 3%-6%, the compressive strength increases with the increase of NaOH content, and when NaOH content is 7%, the compressive strength decreases. From the aspect of cement strength, it can be considered that when NaOH content is 6%, the compressive strength is high. If it is expected to reach 425 cement standard in 28d, the content of NaOH can be 5%-7%; if it is expected to reach 325 cement standard in 28d, the content of NaOH can be 3% - 4%. 

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**3.2 Effect of modulus of water glass on compressive and bending strength**

Under the condition of curing at 50 °C, the data in Fig.2 show two aspects: first, the bending strength of cement decreases with the increase of water glass modules, and the bending strength of cement is higher when water glass modules is 1.05 and 1.10. Secondly, The compressive strength of cement is inversely proportional to the modulus of water glass. When the water glass modules is greater than 1.15, the rate of cement strength decrease decreases.

With the increase of viscosity and water glass modulus, the cement sample is not easy to be dense and porous, which results in the decrease of cement strength.

The test sample is cured at 50 °C for 3 days, and 40 ml of water glass with modulus of 1.10 can meet the strength requirements of 425 cement.

Considering the experimental data and the properties of cement, it is better that the modulus of water glass is 1.10 or less.

**Fig 2: Effect of modulus of water glass on compressive and bending strength**

| Water Glass Modulus | 1.05 | 1.10 | 1.15 | 1.20 | 1.25 |
|---------------------|------|------|------|------|------|
| Bending Strength    |      |      |      |      |      |
| Compressive Strength|      |      |      |      |      |

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The influence of NaOH content on the strength of cement is shown in Fig. 3.

![Fig 3: Effect of NaOH content on compressive and bending strength](image)
3.4 Effect of NaOH Density on Cement Strength

The influence of NaOH density on the cement strength is shown in Fig.4.

![Fig 4 Effect of NaOH density on compressive and bending strength](image)

The density of NaOH is directly proportional to the compressive and bending strength. When NaOH density is less than 3.15mol/l, the compressive and bending strength decrease relatively. Therefore: if it reaches 325 cement standard in advance, NaOH density shall be greater than 3.0mol/l; if it reaches 425 cement standard in advance, NaOH density shall be greater than 3.15mol/L. That is to say, when the NaOH density is less than 3.0mol/L, the excitation effect of NaOH decreases.

4 Conclusion

The 28d compressive strength of alkali-slag-oil shale ash cement cured at 50 °C for three days can meet the requirements of 42.5MPa-62.5MPa respectively.

The content of water glass is directly proportional to the strength of cement, and the content of water glass is inversely proportional to the growth rate of cement strength. Water glass content should be controlled at 40-60ml. With the decrease of water glass modules, cement strength increases, and the growth rate of cement strength increases.

When the content of NaOH is 3%-6%, with the increase of the content, the cement strength increases. However, when the content of NaOH is more than 6%, the cement strength decreases.

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