

## Activated temperature of coal gangue and its effect on mechanical properties of cement mortar

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**Abstract.** The phase and composition of Liupanshui gangue are tested by XRD and XRF respectively. The activation properties of coal gangue as cement admixture at different calcination temperatures are investigated. The results show that: Liupanshui coal gangue as a binder to join the cement cementing material, its optimum calcination temperature is 600°C and the best dosage of coal gangue calcined is 30%. When the coal gangue activation temperature at 600 °C, the incorporation amount is 30%, the 28d compressive strength of cement mortar is 59.2MPa, and the maximum flexural strength is 10MPa.

### Introduction

Coal gangue is the waste produced during the coal mining process, Liupanshui is known as "Jiangnan Sea of Coal," is the largest coal base resources in Southern China, where the annual emissions of hundreds of millions of tons of coal gangue, the stacking become a waste rock take up a lot of arable land, the local soil, water and other pollution [1-4]. If the coal gangue is not burned will cause serious pollution to the atmosphere, and undermine the healthy development of the ecological environment. It has become one of the important research directions of coal measures solid waste for the comprehensive utilization of coal gangue in the process of turning waste into treasure.

In this paper, according to the current research progress of coal gangue utilization, coal gangue used in cement concrete, must be activated, otherwise it will affect the performance of the cement material caused by adverse effects. There are many ways to activate coal gangue, there are three kinds of mechanical activation, heat activation and chemical activation of three kinds of heat activation of coal gangue calcined, the coal gangue calcined with the nature of volcanic ash and have a certain degree of gelatin, can be part of the alternative Cement is used as a binder for cementations materials [5]. So the heat activation of coal gangue is three kinds of activation which is more effective and commonly used method. Each place of coal gangue composition and physical and chemical properties are different. Therefore, the heat treatment technology of cement gangue in Liupanshui mining area is studied systematically[6], which fully stimulates the activity of coal gangue, and makes full use of local coal gangue to solve the problem of coal gangue application and Pollution has a guiding significance.

### Experiment

The cement was made of ordinary Portland cement on the local market, labeled P• O32.5 R grade cement; sand was a local common stone sand over 5 mm sieve. The coal gangue from Liupanshui Eagle Hill mining area. The water used to place more than 24 h of tap water.

The X-ray diffract meter and XRF spectrometer are used to detect the phase and composition of coal gangue. Coal gangue after self medium separator separates the poor mechanical property of coal gangue, better mechanical property of coal gangue after washing for standby, the sediment after drying and poor mechanical properties of coal gangue in XL-1 furnace in calcination, the range of calcination temperature is 400 °C ~ 800 °C, coal gangue calcined after ball mill grinding, grinding into fineness of 200 mesh powder, according to a certain proportion of cement cementing material.

Mixed with heat activated coal gangue cement mortar strength determination, after heat activated coal gangue with different content (mass fraction) into the cement mortar, and in accordance with GB / T 17617-1999 "cement mortar strength test Method (ISO method) "to carry out the formation and maintenance of the specimen, the use of WAW-600C universal testing machine to test the mechanical properties of cement mortar specimens.

## Results and discussion

**Composition and phase analysis of coal gangue.** Table.1 shows the results of XRF of raw coal gangue. The results show that the main components of coal gangue are quartz, iron and aluminum oxide, which account for nearly 80% of coal gangue. In addition, that Liupanshui coal gangue also contains a few amount of titanium.

Table.1 Analysis of main elements of coal gangue by XRF

Name	SiO <sub>2</sub>	CaO	MgO	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	MnO	TiO <sub>2</sub>	LOI
%	46.82	1.01	1.86	19.36	12.34	1.09	0.11	5.71	11.67

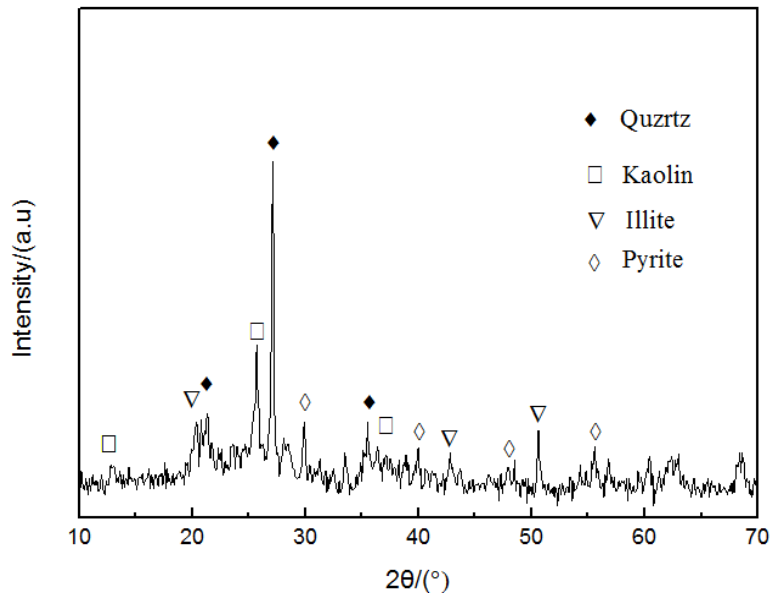


Fig.1 XRD patterns of raw coal gangue powder

Fig.1 showed the gangue XRD test pattern, the scanning step is 0.1, the scanning angle range is 10 ° ~ 70 °. The analysis of the mineralogical phase shows that the main components of coal gangue are quartz, kaolinite, and a small amount of illite and pyrite and some organic matter. Gangue at high temperatures, will make kaolinite, pyrite and organic matter decomposition, thereby changing the original mineral composition of coal gangue, and improve the activity of coal gangue [7].

**The effect of calcination temperature on the activity of coal gangue.** In the calcination process, the kaolinite where content in the coal gangue at about 500 °C, will be occurrence of inter-layer hydroxyl dehydration in the conversion into amorphous met kaolin. In the stage of 500 °C ~ 744.4 °C, the exothermic reaction of organic matter, the exothermic reaction of pyrite and the decomposition endotherm of kaolinite are studied[7,8]. Therefore, the calcination temperature range of this study is 400 °C ~ 800 °C.

Under the conditions of water-cement ratio of 0.36 and coal gangue content accounting for 30% (weight ratio) of cement, the effects of the heat activation temperature of 400 °C, 500 °C, 600 °C and 800 °C on the cement Effect of mechanical properties of cementitious materials. The test of compressive strength and bending resistance of the specimen is shown in Table 2 and Table 3. It can be seen from Table 2 that with the increase of activation temperature, the compressive strength of coal gangue cement samples decreased at 3d and 7d, and the compressive strength of 28 days is improved

to some extent. At the activation temperature of 800 °C, the compressive strength of 28d reached the maximum, the maximum value is 65.4MPa.

Table 2. Compressive strength of coal gangue cement mortar at different activation temperatures

Activation temperature (°C)	400	500	600	800
3d(MPa)	43.0	41.0	39.5	41.0
7d(MPa)	46.0	44.2	43.5	51.0
28d(MPa)	57.1	57.0	59.2	65.4

When the amount of heat activated coal gangue is 30%, the flexural strength of coal gangue cement sample is shown in Table 3. It can be seen from the data in the table that the addition of heat activated coal gangue to the pre-bending strength Almost no effect, with the extension of time, 7d and 28d flexural strength with the activation temperature fluctuations have fluctuated, the overall increase in the trend. When the activation temperature of the coal gangue cement is above 600 °C, the flexural strength of the coal gangue cement reaches 10MPa.

Table 3 different activation temperature of coal gangue cement mortar flexural strength

Activation temperature(°C)	400	500	600	800
3d(MPa)	7.0	7.0	7.0	7.0
7d(MPa)	8.0	7.0	8.0	9.0
28d(MPa)	9.0	7.0	10.0	10.0

Through the above analysis, coal gangue activation temperature above 600 °C, which can better stimulate the activity of coal gangue. Although the activation temperature is favorable to further improve the mechanical properties of the sample, considering the high activation temperature of coal gangue will cause the cost increase, so the best activation temperature of heat activated coal gangue is 600 °C.

Table 4. Compressive strength test of cement mortar with different coal gangue content

Amount of coal gangue (%)	20	25	30	50	70	90
3d(MPa)	34.5	31.5	39.5	3.7	4.9	5.4
7d(MPa)	36.5	32.5	43.5	7.46	7.0	7.5
28d(MPa)	38.1	38.6	59.2	21.2	16.4	13.1

Table 5. Test results of flexural strength of cement mortar with different coal gangue content

Amount of coal gangue (%)	20	25	30	50	70	90
3d(MPa)	5.0	7.0	7.0	2.3	2.0	2.0
7d(MPa)	7.0	7.0	8.0	3.8	3.0	3.4
28d(MPa)	8.0	7.0	10.0	7.2	6.5	5.2

**The best amount of heat activated coal gangue in cement mortar.** In the case of water - cement ratio of 0.36, the activation temperature of coal gangue is 600 °C, and the influence of coal gangue content on the mechanical properties of cement cementing material is examined. The results of the test are shown in Table 4 and Table 5, respectively. After the standard curing, the compressive and flexural properties of the coal gangue cement are tested. From the test results, it can be seen that the compressive strength of the sample increases with the increase of the amount of coal gangue before

30%. When the amount of coal gangue incorporation is 30%, the maximum compressive strength and flexural strength of the sample are the largest at 28 days, which are 59.2MPa and 10MPa respectively. When the amount of calcined coal gangue is more than 50%, the compressive strength of the specimen decreases sharply, and the mechanical properties of the sample are significantly worse. Through the comprehensive analysis of the experimental results, the optimum dosage of gangue activation temperature is 600 °C.

## **Conclusions**

The coal gangue in Liupanshui mining area is sorted by different mechanical properties, the optimum temperature of thermal activation is 600°C and the holding time is 2h. The calcined coal gangue are milled for 200 purpose powder, can be used as admixture of cement cementitious materials. When the incorporation amount is less than 30%, the mechanical properties of cement mortar had a little affected, the compressive strength is slightly decreased in the early stage, and the compressive strength at the later stage is slightly increased. The mechanical properties of cement bonded sand samples rapidly became worse after the addition of more than 30%. When the activation temperature of coal gangue is 600 °C and the content is 30%, the compressive strength of cement mortar is 59.2MPa and the flexural strength reaches 10MPa.

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