

Study on the Pavement Brick of Alkali Cementitious Material

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Abstract. With the gradual depletion of natural resources, sustainable energy shortage and environmental pollution worsening. The green new building materials have gradually tended to be less or less natural resources and develop in the direction of energy conservation and pollution in the production process^[1]. With the development of industry, the production of industrial solid waste slag has increased dramatically, and the discharge of waste residue not only occupies land, aggravates the economic burden, but also causes a great pollution to the environment. Rational use of resources, reduce waste discharge, reduce environmental pollution, and clean the road of production. Slag, iron tailings, such industrial waste residue as silicate or aluminum silicate minerals, all have potential activity^[2]. However, at present, the waste residue is used as cement mixing material or concrete mixing material, further increasing the amount of waste residue is restricted. In order to make full use of the slag, the mineral slag is mainly studied as the main raw material, the iron tailings is the auxiliary material, and the inorganic alkali cementitious material pavement brick is prepared under alkali excitation conditions.

Introduction

The quality coefficient, alkalinity coefficient and activity coefficient of granulated blast furnace slag were 1.6, 1.1 and 0.3 respectively. Water quenching slag belongs to alkaline slag. And the mass coefficient and the activity coefficient are also satisfied. The modulus of the activated water glass was adjusted by industrial caustic soda. The modulus of water glass in the experiment was 1.0. In this experiment, the slag was ground to the surface area about 350m²/ kg, the iron tailings were auxiliary raw materials, and a small amount of admixture was used to prepare the pavement bricks of inorganic alkali gel materials.

Experiment Material

Experiment with the quality coefficient of blast furnace slag, basicity coefficient and activity coefficient were 1.6, 1.1 and 0.3, belong to alkaline slag water quenching slag, and quality coefficient and activity coefficient also meet the requirements, higher activity. The modulus of the activated water glass was adjusted by industrial soda. The modulus of Sodium silicate in the experiment was 1.0. In this experiment, the slag was ground to the surface area about 350m²/ kg, the iron tailings were auxiliary raw materials, and a small amount of admixture was used to prepare the pavement bricks of inorganic alkali gel materials.

Table 1 Chemical composition of main raw materials

Sample Name	Ignition loss	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Moisture
slag	0.97	31.86	9.38	2.81	38.15	10.03	0.23
Iron tailings	7.09	68.63	6.72	11.99	2.76	3.82	0.42

The two kinds of primary slag powder and iron tailings are arranged in proportion to the predetermined ratio and mixing evenly. Sodium silicate, sodium hydroxide and nitrate are used in a certain proportion to join a blender, try these materials after fully mixing into the joint mold molding, measure its flexural and compressive strength, to select optimal proportion is the highest intensity, pavement bricks made from alkali cement materials, reference GB28635-2012 standard for concrete pavement brick for the determination of main parameters.

Test results and analysis

Determination of additive admixture of alkali gel materials. According to the experimental design, the experiment was carried out under the same conditions of slag powder, respectively, and the coagulation time and strength were determined respectively, as shown in table 2:

Table 2 Setting time and strength determination results

No	Slag/g	Sodium hydroxide/%	Sodium silicate/%	nitrate/%	water/ml	Initial setting time/min	final setting time/min	3 days flexural strength/MPa	3 day compressive strength/MPa
1	500	4.0	4.0	4.0	160	189	309	23.41	38.54
2	500	4.0	4.0	3.5	160	163	273	21.19	40.96
3	500	5.0	5.0	4.0	160	138	270	22.68	43.54
4	500	5.0	5.0	4.5	160	125	259	23.57	44.44
5	500	5.0	5.0	5.0	160	176	311	21.31	34.83

By the experimental results in table 2, the suitable ratio for: sodium silicate account for 5% of the raw material, sodium hydroxide accounted for 5% of the raw materials, and nitrate accounted for 4.5% of raw material, normal setting time, relatively high comprehensive strength.

Alkali cementitious materials slag and admixture mixed alone, raw material proportioning design and strength test, the preparation of 40 * 40 * 160 mm body, and then into the standard constant temperature and humidity curing cement box, the temperature is 20±1°C, relative humidity is more than 90% under the conditions of curing. The strength results of the test subjects are shown in table3:

Table 3 Test results of the micropowder strength of the slurry of alkali cementitious materials

No	slag/g	Sodium silicate/%	Sodium hydroxide/%	nitrate/%	water/ml	3 days compressive strength/MPa	28 days compressive strength/MPa
1	500	3.0	3.0	3.5	160	20.46	46.86
2	500	4.0	4.0	4.0	160	41.78	61.16
3	500	5.0	5.0	4.5	160	44.42	64.33
4	500	6.0	6.0	5.0	160	39.89	60.94

By the experimental results can be seen in table 3, suitable ratio for: sodium silicate accounts for 4% ~ 5% of raw material, sodium hydroxide accounts for 4% ~ 5% of raw materials, nitrate accounts for

4.0% ~ 4.5% of raw materials, alkali cementitious material strength at this time there is a optimal value.

Study on hydration mechanism of alkali cementitious materials

In the slag and excitation agent sodium silicate, sodium hydroxide slurry, slag under the effect of OH^- , the surface of slag vitreous structure destruction, Ca^{2+} on the surface quickly dissolved in the liquid phase, Ca^{2+} concentration in the liquid phase increases, the concentration of the CaO in liquid phase depends on the surface of slag vitreous the dissolution rate of Ca^{2+} and the formation of calcium hydration products. The rate of formation of calcium hydrated products is much higher than that of Ca^{2+} in slag glass.

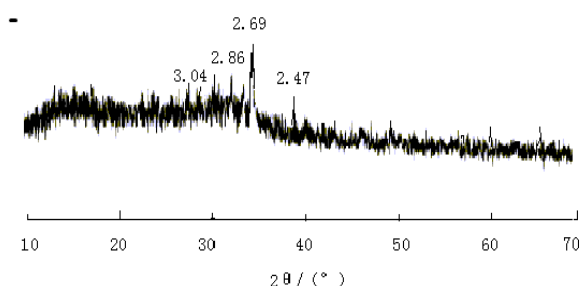


Fig .1 XRD of alkali-slag cement paste hydrated

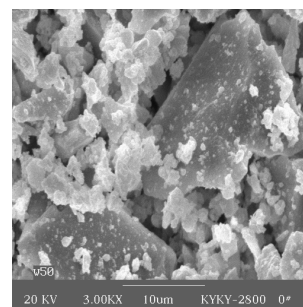


Fig .2 SEM photograph of alkali slag cement paste hydrated

Figure 1 is alkaline slag cement hydration map of initial setting sample X-ray diffraction analysis and curve at 3.04, 2.86, 2.69, 2.86 (Å) are a diffraction peak, the diffraction peaks are C - S - H cementitious characteristic peaks, it seems that alkali slag cement early hydration is C - S - H gel formation. From figure 2 samples of alkali slag cement hydration electron microscope photos, showed that between particles in slurry structure there is a lot of flocculating substance, and a small amount of flocculation of the material covered in not on the hydration of slag particles, energy spectrum analysis showed that the flocculating substance is C - S - H gel^[3]. According to the above analysis of the test results can think, C - S - H gel formation cause of alkali - slag cement fast setting, especially in the slag particles between the formation of hydrated calcium silicate gel particles of alkali - slag cement coagulation plays a main role.

The preparation of pavement brick

Iron tailings can be used to improve the ability of the specimen to be waterborne, cohesive and easy, and to prevent the shrinkage and deformation of specimens. It can save alkali gel and reduce the cost. Therefore, the amount of iron tailings in the experiment was conducted in a large proportion of the mixture ratio between 0% and 20%, and the compressive strength and the anti-bending strength were measured according to the test results. According to the experimental design, slag powder, alkali excitant and calcium nitrate were used as the benchmark ratio. The content of iron tailing was respectively 0 %, 10 %, 15% and 20 %, respectively. The content of different iron tailings is shown in table 4:

Table 4 Compressive and flexural strength of the pavement brick

No	slag/%	iron tailings/%	Sodium hydroxide/%	Sodium silicate/%	nitrate/%	water/mL	28days flexural strength/MPa	28days compressive strength/MPa
1	100	0	5.0	5.0	4.5	160	27.81	49.28
2	90	10	5.0	5.0	4.5	150	29.03	66.18
3	85	15	5.0	5.0	4.5	150	38.34	63.21
4	80	20	5.0	5.0	4.5	150	27.62	59.53

Table 4 shows that in the case of slag and admixture, with iron tail, an increase in the amount of iron tailings, the compressive strength and flexural strength of the specimens are promoted, peak value and then decreased, compared with not adding iron tailings specimen, maximum can improve the strength of 37.88%. Because the incorporation of iron tailings affected the volume of specimen, the grading of aggregate, shape, water cement ratio and porosity, etc. The iron tailing sand makes the specimen more resistant to contractility. In addition, the incorporation of iron tailing ore reduces the continuity of the water flow channel in the substrate, and the decrease of water content can be reduced by the decrease of the consistency. The compressive strength of the specimen increases, and when the content of iron tailing ore is within a certain range, the strength of the specimen is a better value, and the range of iron tailing ore is 10% ~ 15%. The C_c60 standard pavement tile was prepared.

Microscopic analysis of pavement brick

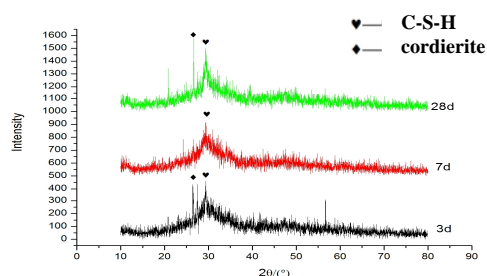


Fig. 3 XRD atlas of hydration products of pavement brick material

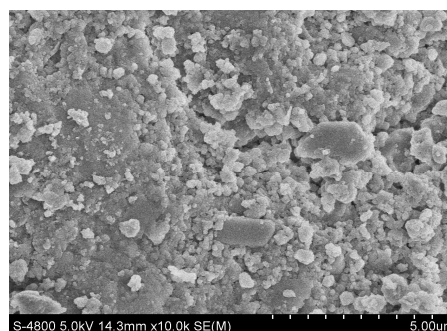


Fig. 4 SEM images of hydrate 3 day ages sample

As shown in figure 3, C-S-H gel and cordierite were formed when the alkali activated the gelation material in 3d, ad the content of C-S-H gel and cordierite increased in 28 days.

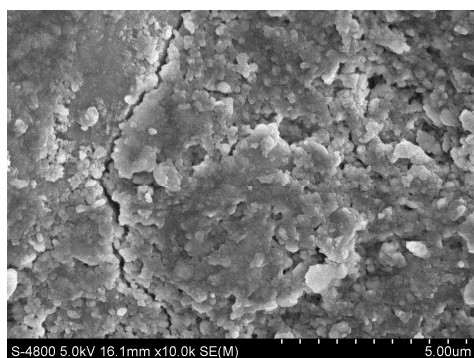


Fig. 5 SEM images of hydrate 7 day ages sample

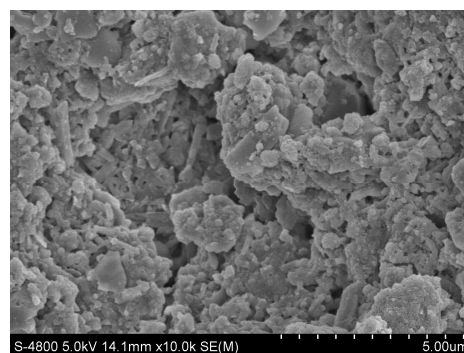


Fig. 6 SEM images of hydrate 28 day ages sample

Figure 4, figure 5 figure 6 respectively hydration ages of 3 d, 7 d, 28 d SEM figure, FIG4 shows a 3 d sample had formed the C - S - H gel particles, hydration, sodium silicate hydrolysis precipitation colloidal silicate, enters the adsorption layer of Ca^{2+} ion of hydration with colloidal SiO_2 particles between reaction occurred^[4], leading to the C - S - H gel between the slag particles generated in large quantities. FIG. 5 of 7d and FIG. 6, the number of gel particles formed by the SEM chart hydration was increased, but the changes were not significant, corresponding to the macro strength test, and the later hydration intensity was improved.

Conclusions

Using slag powder as the main raw material, the paving brick was prepared with iron tailings as auxiliary materials and additives. Preparation plan is: the ratio of raw material is 85% slag, iron tailings 15%, water/cement ratio is 0.3, sodium silicate, sodium hydroxide, nitrate in 5% of the gelled material dosage, 5%, 4.5%, accord with the standard C₆₀ pavement brick is prepared. The paving brick removed the sintering process, simplified the preparation process, and reduced the cost and environmental protection.

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