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Influences of Admixtures on Properties of Foam Concrete with Iron Tailings

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Abstract. Iron tailings are mineral wastes obtained from industrial processing and magnetic separation of iron ore. A type of superplasticizer with high water reducing rate and early strength gaining property was characterized in this study. The influence of admixtures, i.e. superplasticizer, early strength agent and accelerating agent, on the mechanical strength, setting and hardening time of foam concrete containing iron tailings has been investigated. Further, the microstructure of foam concrete was observed. This result demonstrates that high-strength foam concrete with excellent thermal insulation property can be made with iron tailings, cement, fly ash, silica fume, polypropylene fiber, superplasticizer, early strength agent, accelerating agent and foaming agent, which develops a new route for the comprehensive utilization of iron tailings.

Introduction

Iron tailings are generally obtained from industrial processing and magnetic separation of iron ore. The huge reserves of iron tailings can cause potential hazard. When the dam height of a large-scale tailings pond is greater than 100 meter, a mining accident could cause a substantial damage beyond earthquake [1]. Further, the finely ground tailings pollute water, soil property and air [2,3]. The dust cloud caused by tailings deteriorates the environment of surrounding area and living conditions [4,5]. Hence, it is significant to appropriately utilize the iron tailings. As a sort of secondary resource, iron tailings have attracted great attention all over the world.

Raw materials and properties

• The chemical compositions of iron tailings are as follows: SiO_2: 61.49 %, Al_2O_3: 5.84 %, Fe_2O_3: 12.78 %, CaO: 6.84 %, MgO: 2.96 %, SO_3: 1.41 %, and its particle size is less than 0.3 mm.
• Ordinary Portland cement (strength grade 42.5) was used.
• Mixing amount of polypropylene fiber with tensile strength of 400 MPa was 0.5 %, and density of polypropylene fiber of 15 mm in length and 300 μm in diameter is 900 kg/m^3. Modulus of elasticity of polypropylene fiber is less than 8 GPa which has stretch rate of 165%.
• Activity index (28d) of fly ash is more than 85 %. Bulk density and lgnition loss are separately less than 750 kg/m^3 and 8 %. The total content of SiO_2 and Al_2O_3 is more than 70 %.
• Homemade polycarboxylate superplasticizer was used as water reducing agent.
• Compound admixtures are composed by early strength agent and accelerating agent. Early strength agent is a mixture of triethanolamine and sodium sulfate with a mix proportion of 1:2 by weight. Accelerating agent mainly consists of carbonate and tiny particles of alumina clinker.
• Average particle size of silica fume with apparent density of 180 kg/m^3 and specific surface area of 25 m^2/g is less than 0.1 μm. Mixing amount is 6 % by weight of cement.

• Foaming agent is a composite of animal protein and plant protein. Foaming ratio is more than or equal to 20. Distance of sedimentation for an hour is less than or equal to 70 mm and bleeding rate for an hour is less than or equal to 70 %. It was used in amounts from 3.6 % to 4.8 %.

Experiment Procedure

Preparation of foam concrete with iron tailings. The prepared foam was added to the paste which consists of cement, iron tailings, fly ash, water and admixture. Further, the foam concrete containing iron tailings was prepared by processing above raw materials including mixing, stirring, pouring, curing et al.

Preparation of superplasticizer. The polymerization was performed in a reactor with a stirrer. A certain mount of TPEG and deionized water were poured into the reactor equipped with a stirrer. The reaction temperature was controlled by thermostat water bath. When all raw materials were dissolved and the mixture was heated to a certain temperature, crylic acid, SMAS and initiator solution were dropwise added into reactor respectively by constant flow pumps. The reaction was terminated at about 40 ℃, followed by neutralization of mixture with NaOH solution to pH 7. The superplasticizer was prepared after aforementioned experiment steps.

Results and Discussion

Structure characterization of superplasticizer. Infrared spectrum of superplasticizer is shown in Fig. 1.

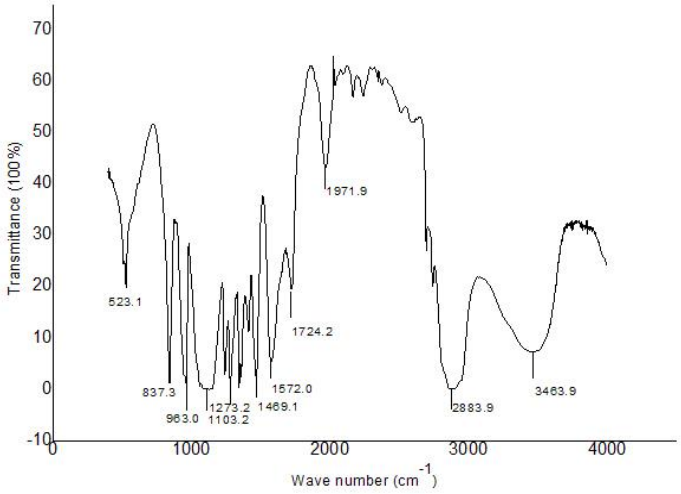

Fig. 1 Infrared spectrum of superplasticizer

Fig.1 shows the absorption vibration peaks of carboxyl (-COO-) at 1572 cm^{-1} and 1724.2 cm^{-1}, stretching vibration peak of sulfonic acid group (-SO_3-) at 1273.2 cm^{-1}, stretching vibration peaks of polyether base (-C-O-C-) at 2883.9 cm^{-1} and 3463.9 cm^{-1}, and characteristic absorption peak of polyether base (-C-O-C-) at 1103.2 cm^{-1}. The results shown in Fig.1 demonstrate the synthesized superplasticizer contains the functional groups of polyether base (-C-O-C-), carboxyl (-COO-), sulfonic acid group (-SO_3-) et al.

Influence of mixing amount of iron tailings on the strength of foam concrete. The effect of mixing amount of iron tailings on compressive strength of foam concrete is shown in Fig. 2.

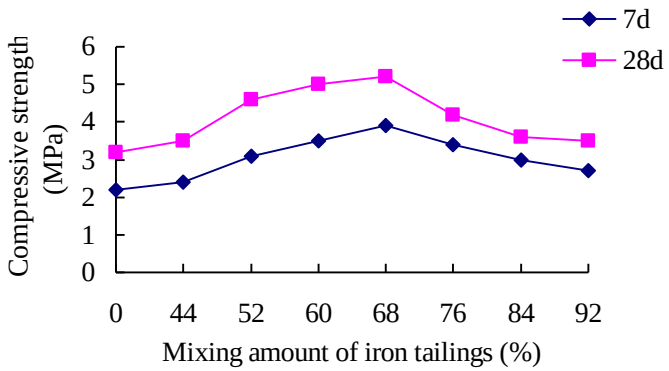

Fig.2 Effect of mixing amount of iron tailings on compressive strength of foam concrete

It is seen in Fig. 2, the compressive strength of foam concrete was hardly influenced at low mixing amount of iron tailings. When mixing amount of iron tailings reached 52 % (b.w.o.c), the compressive strength of foam concrete was found to increase distinctly. While the mixing amount was 68% (b.w.o.c), the compressive strength of foam concrete achieved maximum. However, it is noted a further increase in mixing amount of iron tailings resulted in a decrease in the strength of foam concrete. The above results suggest the compressive strength of foam concrete can be increased by appropriately mixing iron tailings in the foam concrete. This is attributed that the small iron tailings particles disperse adequately among the cement particles, thus improving the liquidity of paste and making the bubble distributed uniformly in the paste.

Influence of superplasticizer on compressive strength of foam concrete. The homemade polycarboxylic type superplasticizer in this study showed high water reducing rate and early strength gaining property. Specifically, the water reducing rate reached 40 % at a superplasticizer dosage of 0.4 %. The influence of superplasticizer dosage on the compressive strength of foam concrete with iron tailings is shown in Fig. 3.

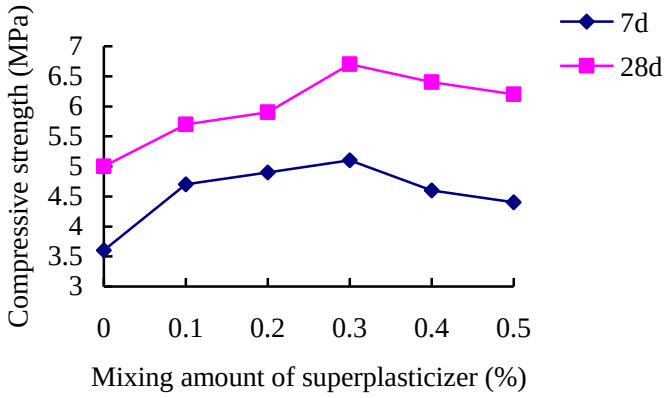

Fig. 3 Influence of mixing amount of superplasticizer on compressive strength of foam concrete with iron tailings

From Fig. 3, the compressive strength of foam concrete increased with increasing the dosage of superplasticizer. It is noted the compressive strength (7d and 28d) reached maximum at a mixing amount of 0.3 %, which is attributed to the optimum dosage of superplasticizer.

Influence of compound admixtures on foam concrete with iron tailings. The influence of compound admixtures (the mixture of early strength and accelerating agent was used as compound

admixture at a mixing proportion of 2:1 by weight; mixing amount of superplasticizer was fixed at 0.3 %) on compressive strength (3d, 7d and 28d), setting and hardening time of foam concrete is shown in Table 1.

Table 1 Influence of compound admixtures on foam concrete with iron tailings

Run	Mixing amount of admixtures [%]				Compressive strength [MPa]			Setting and hardening time[h]
	Accelerating agent	Superplasticizer	Early strength agent	Total mixing amount	3d	7d	28d	
0	0	0	0	0	0.8	2.7	4.9	30
1	0	0.3	0	0.3	1.0	2.9	5.0	28
2	0.7	0.3	1.4	2.4	1.7	3.7	5.3	24
3	0.8	0.3	1.6	2.7	2.0	4.0	5.5	21
4	0.9	0.3	1.8	3.0	2.4	4.2	5.7	20
5	1	0.3	2	3.3	2.6	4.4	5.8	18
6	1.1	0.3	2.2	3.6	2.3	4.1	5.6	16
7	1.2	0.3	2.4	3.9	2.1	3.9	5.5	15

From Table 1, setting and hardening time of foam concrete without any admixtures was 30 h. It was shortened greatly when superplasticizer was added together with early strength agent and accelerating agent. Meanwhile, 3d and 7d compressive strength of foam concrete was found to increase obviously. However, the long-term strength of foam concrete decreased with excessive amount of compound admixture.

Relationship of apparent density and thermal conductivity of foam concrete with iron tailings. The apparent density of foam concrete containing iron tailings varied with the mixing amount of the foaming agent. The relationship of apparent density and thermal conductivity is shown in Fig. 4.

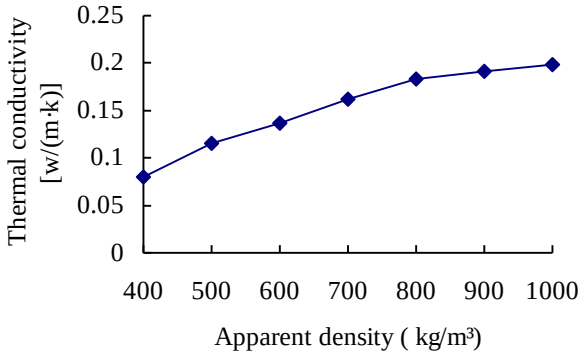

Fig. 4 Relationship of apparent density and thermal conductivity

From Fig. 4, the apparent density of foam concrete has significant influence on its thermal conductivity. The lower apparent density leads to smaller thermal conductivity of foam concrete and accordingly the better heat preservation and thermal insulation of concrete.

Microstructure characteristics of foam concrete with iron tailings. The microstructure of foam concrete containing iron tailings has been characterized with SEM and results are shown in Fig. 5. From Fig. 5, the majority of pores are small ones in the foam concrete. In addition, there are more closed pores than interconnected pores. Due to the uniformly distributed pores and rather complete pore wall, the mechanical properties and thermal properties of foam concrete are excellent.

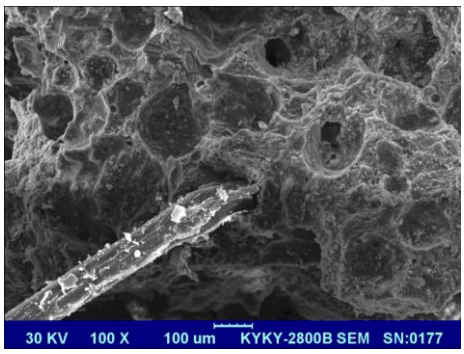

Fig. 5 Microstructure of foam concrete with iron tailings

Conclusions

The admixtures, including superplasticizer, early strength agent and accelerating agent, have significant effect on the mechanical strength, setting and hardening time of foam concrete containing iron tailings. The foam concrete prepared by adding iron tailings, cement, fly ash, silica fume, polypropylene fiber, superplasticizer, early strength agent, accelerating agent and foaming agent is characterized by its high strength and excellent thermal insulation property, which develops a new route for the comprehensive utilization of iron tailings.

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