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Study on the structure and properties of autoclaved aerated concrete produced with the stone-sawing mud

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HIGHLIGHTS

- Norel autoclaved aerated concrete (AAC) was prepared by using the stone-sawing mud.
- Using the stone-sawing mud is helpful to form the C-S-H gel in the AAC.
- AAC with stone-sawing mud had good porosity and thermal-conductivity property.

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ABSTRACT

The mineral composition of the stone-sawing mud is mainly quartz, containing a small amount of sodium feldspar and potassium feldspar. It could be instead of river sand to be used for preparation of the autoclaved aerated concrete (AAC). The results showed that under the same condition, the porosity rate of the AAC with stone sawing mud and river sand was 73.3% and 74.6% respectively. The average pore size was 0.82 mm and 0.95 mm respectively. The AAC prepared with stone sawing mud and river sand have good thermal insulation performance with the thermal conductivity of 0.14 W/(m·K). As the amount of stone sawing mud replacing the river sand increased gradually, the bulk density and the compressive strength of the AAC were gradually increased. The X-ray diffraction (XRD) and scanning electron microscope (SEM) showed that the amount of hydrated products of the tobermorite and the calcium silicate hydrates (C-S-H) in the AAC with stone-sawing mud were more than that in the AAC with the river sand. The crystallization of tobermorite crystals in the AAC with the stone-sawing mud grew into a leaf shape, and interleaved with each other to form a dense structure net, which made the AAC with improved mechanical properties.

1. Introduction

Stone-sawing mud is the solid waste during processing of the stone in industry. A lot of stone is mined and transported to the factory for cutting, grinding or other processing. This can produce a lot of stone powder containing lots of water. After precipitation formation, it was called the stone-sawing mud. It was reported that the processing of each ton of rock produced about 0.1 m^3 of mud [1]. China has become the world's largest producer of stone products, what causes about 8 million cubic meters of sawing-mud every year. During the stone processing, a small amount of phosphate and organic matter is usually added to the cooling water to protect the sawing blade. It makes the sawing mud with weak acid, which could pollute the environment. Therefore, how to effective utilize stone-sawing mud is an issue what related to the protection of environment and groundwater.

The autoclaved aerated concrete (AAC) is a porous and lightweight concrete material, compared with traditional concrete materials. The AAC has the characteristics of the light quality, low density, low shrinkage and high porosity, etc [2,3]. It has been used to make the refractory materials and thermal insulation materials widely used in building engineering. The main raw materials of AAC include silica sand, lime powder and cement, with the aluminum powder as foaming agent [4]. The silica sand is mainly from the precious river sand, which consumes a lot of power when grinding. Over exploitation of river sand can destroy the riverbed and will also destroy the ecological balance of the river. Many studies showed that some other wastes can be used to replace the part proportion of raw material to produce AAC. Ma Bao-guo et al. studied the mechanical properties and microstructure of AAC with iron tailings, the results indicated that the ferric tailings

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can replace river sand to produce B05 grade AAC [5]. Huang Xiaoyan used other copper tailings and blast furnace slag to prepare B06 grade AAC [6]. QIAN J used copper tailings–silica -lime-cement system to prepare the AAC blocks [7]. Huang X et al. adopted the low silicon copper tailings-cement clinker-wind-accretion sand-slag powder system to prepare no-lime AAC [6]. Agnieszka Rzycka et al. reported that the production of AAC using 30% perlite instead of river sand can significantly reduce the bulk density of AAC and increase its thermal conductivity [8]. Wang Chang-long's study indicated that 20% of gangue and 40% of iron tailings can replace 60% river sand to produce high-quality AAC [9]. Kittipong Kunchariyakun's study indicated that replacing river sand with rice husk ash to produce AAC can greatly improve the preparation process of AAC [10]. Pawel Walczak et al. studied the production of low density and high strength of aerated concrete based on fly ash [11]. Marijonas Sinica et al. studied the effect of basalt fiber and SiO_2 dust on the strength and heat resistance of the AAC [12]. These indicate that some wastes contain SiO_2 and CaO can be used to replace the raw materials in the ACC produce progress. Stone–sawing mud also contain rich SiO_2, it is possible to be used in the AAC production. However, less report is found about using the stone-sawing mud to replace the river sand to produce the AAC.

This research studied the influence of the stone-sawing mud content on the AAC regarding bulk density, compressive strength and coefficient of thermal conductivity, and also analyzed its structure of porosity and the mechanism of hydrothermal reaction. All results were compared with the traditional AAC. The outcome of this study can be used to guide massively using the stone-sawing mud in the AAC production. It is meaningful to save the resources and protect the environment.

2. Experiments

2.1. Materials

2.1.1. River sand and stone-sawing mud

River sand used in this study has an apparent density of 2.63 g/cm^3, with a sieving residue of 12% above 80 μm. Its main chemical compositions were shown in Table 1, and the XRD analysis is shown in Fig. 1, the particle size of river sand is shown in Fig. 2. It was indicated that the main mineral composition were quartz, small amounts of mica, without sodium feldspar. Stone-sawing mud is mainly made from granite or marble. This study used the sawing mud produced during processing granite stone, with a content of SiO_2 as high as 70%.The water content of sawing mud was 22%, and sieving residue above 80 μm was 8%, with an apparent density of 2.72 g/cm^3. The main chemical compositions of sawing mud are given in Table 1, and the XRD analysis is shown in Fig. 1, the particle size of stone-sawing mud is shown in Fig. 2. The mineral compositions of sawing mud were quartz, sodium feldspar, potassium feldspar and mica. Obviously, the characteristic peaks of quartz in river sand and the characteristics of quartz in sawing mud are ever similar, indicating that quartz content in river sand is similar to that in sawing mud. In addition, the content of potassium feldspar and sodium feldspar in sawing mud is higher than that in river sand.

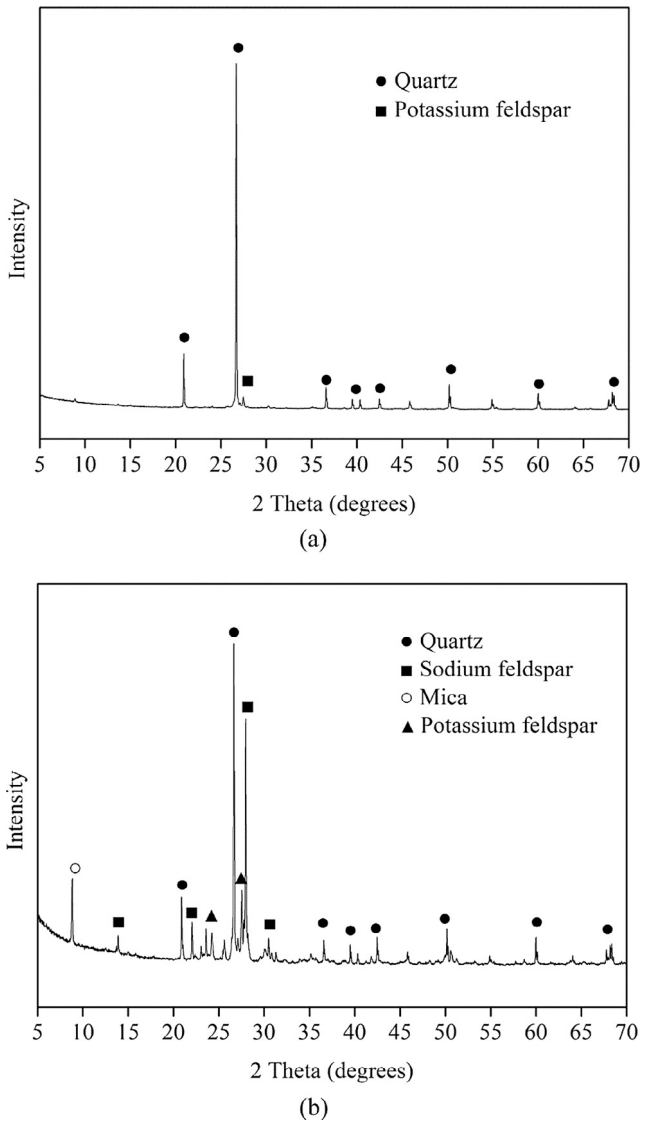

Fig. 1. XRD curves of (a) river sand and (b) stone-sawing mud.

2.1.2. Cement

The cement used was P.O42.5 ordinary Portland cement. Its chemical compositions and physical properties were shown in Tables 1 and 2 respectively.

2.1.3. Lime

The active CaO content in the lime used was more than 80%, with the content of MgO less than 5%. The digestion time was 14 min, with the sieve residue above 80 μm less than 10%. Lime

Table 1
Chemical composition of raw materials.

Chemical composition (%)	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	SO_3	K_2O	Na_2O	LOI*
River sand	72.27	4.98	10.90	3.25	2.06	–	1.20	0.75	2.46
Stone-sawing mud	72.66	1.56	15.09	1.15	0.38	–	3.58	4.54	0.42
P.O42.5 cement	20.49	61.02	5.01	3.50	2.23	2.58	0.64	0.15	3.07
Desulfurization gypsum	2.61	30.5	0.66	–	0.92	43.40	–	–	20.12

* LOI means loss on ignition (%).