Acoustic emission properties of different mineral admixture concrete

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Abstract. To study the different mineral admixtures on the mechanical behavior of concrete, in this paper, three groups C20 concrete cubes made of different mineral admixtures were cast. The size of the cubes are all 150×150×150mm. Acoustic emission by uniaxial compressive test to study the different mineral admixtures on concrete mechanics performance and acoustic emission parameters (amplitude, energy, frequency) were studied. The results show that the addition of mineral powder to the concrete surface will increase the compressive strength of the early age (before 56d). Adding fly ash to the concrete will increase the compressive strength of the late age (after 90d). By combining fly ash and mineral powder, the compressive strength and durability can be better improved; and as the age goes by, the acoustic emission amplitude and dominant frequency of different mineral admixture concretes are increased. The dominant frequency of the compound concrete is greater than the dominant frequency of the single concrete.

1. Introduction

At present, most of the concrete is added with various chemical materials such as admixtures and high-performance fibers, which leads to an increase in the production cost of high performance concrete [1]. Therefore, it is of great research value to seek a low-cost and green sustainable improvement method for various properties of concrete. The instantaneous elastic wave generated by the rapid release of energy inside a material or structure is known as the acoustic emission (AE) [2-4]. Compared to other non-destructive techniques, acoustic emission enables real-time monitoring of concrete structures. Many studies have confirmed that mineral admixtures can improve the durability of concrete. Ramkrishnan [5] studied the compressive strength, sulfate resistance and wear resistance of porous concrete mixed with fly ash. Studies have shown that replacing some cement with fly ash will reduce the early strength of concrete and enhance the resistance of sulfate corrosion performance, reducing the wear resistance of concrete. Gu [6] conducted an experimental study on the tensile properties of high-performance concrete (HPC) containing mineral admixtures. The results showed that the addition of fly ash increased the early age of HPC at loading ages of 1d and 2d, respectively. Tensile properties, while the addition of blast furnace slag is the opposite. When the loading age is less than 3d, the early tensile properties of HPC are not significantly affected by the two. Bui [7] studied the effect of fly ash and silica fume on the mechanical properties of aggregate recycled concrete. The results show that the addition of mineral
admixture improves the high temperature resistance, elastic modulus and toughness of concrete. Alimohammad [8] proposed adding blast furnace slag, fly ash or silica fume to self-compacting concrete to improve its mechanical properties and workability. Spiesz [9] used fly ash, blast furnace slag and limestone powder instead of cement to analyze their effects on ultra-high performance concrete. The results show that the mechanical properties of concrete with fly ash added at 90 days are better, while slag is added. Concrete hydrates faster in the first 7 days.

2. Acoustic emission test

2.1. Experimental specimens
To determine the relationship between the inhomogeneity of concrete and velocity attenuation, a velocity test was conducted. It is necessary to extend the acoustic wave propagation path as far as possible in concrete. All of the concrete beams were 150×150×550 mm. In Figure 1, the water-cement ratio is 0.40, and the maximum aggregate size of the concrete beams is 25mm, 19mm, 12.5mm and 4.75mm respectively, the curing age is 28 days. In order to investigate the influence of different mineral admixtures (mine powder, fly ash, complex mineral powder and fly ash) on concrete compressive strength and acoustic emission properties, three sets of 150×150×150mm C20 concrete cubes were prepared.

2.2. Experimental procedure
By mixing cement, sand, stone, water and different minerals, mixing according to a certain mixing ratio, after stirring, injection molding, vibrating, in the humid air of 15-25 °C and relative humidity above 90%. After curing to the appropriate age, connect the acoustic emission equipment as required, as shown in Figure 1. The uniaxial compression test was started according to the national standard “Test Methods for Mechanical Properties of Ordinary Concrete” (GB/T50081-2002). The acoustic emission meter used in this test is DS5-8B, and the acoustic emission sensor model is RS-5A. The two sensors are placed on opposite sides of the concrete. The sensor is attached to the surface of the polished concrete specimen with a coupling agent. Check the coupling of the sensor. The threshold of the acoustic emission test was determined to be 40 dB by multiple lead-break tests.

3. Test results and analysis

3.1. Compressive strength
In order to study the influence of different mineral content on the mechanical properties of concrete, the uniaxial compressive strength test of four ages of C20 mineral admixture concrete was carried out. The results are shown in Figure 2.

With the increase of fly ash content, the early compressive strength of concrete 7d, 28d and 56d is gradually reduced, and the compressive strength of three ages is lower than that of concrete without fly
ash. For 90d concrete, when the dosage is 20% and 30%, the strength of coagulation is higher than that of concrete without fly ash. This is because the composition of fly ash has secondary hydration reaction, which can play a good auxiliary role in cement hydration reaction. With the continuous hardening of cement, the auxiliary effect of secondary hydration reaction can play a role. Therefore, with the increase of age, the concrete strength is higher and higher. When it exceeds 20%, the concrete strength begins to decrease. Therefore, the concrete strength (90d) reaches a maximum when the fly ash blending amount is 20%, which indicates that the later effect of the fly ash is more prominent for the concrete strength.

The strength of concrete with mineral powder is lower than that of concrete without adding mineral powder at all ages, and the compressive strength of concrete decreases with the increase of the content of mineral powder. The early compressive strength of the concrete (7d, 28d and 56d) mixed with ore powder is larger than the early strength of the fly ash, which indicates that the mineral powder has a positive effect on the early strength of concrete, and by 90 days, the compressive strength is not as good as that of concrete mixed with fly ash. This actually shows that the mineral powder has an effect on the strength of the concrete in the early stage (before 28d), and the fly ash has a positive effect on the late strength of the concrete (after 56d). When the amount of mineral powder is constant, the compressive strength of concrete increases with the increase of age, which indicates that the early effect of mineral powder is more prominent. The mixed mineral powder and fly ash have positive effects on improving the early and late strength of concrete.

![Graphs showing the effect of fly ash and mineral powder content on compressive strength of concrete](image-url)

**Figure 2.** Strength diagram of concrete of different ages with different mineral admixtures.
3.2. Acoustic emission frequency

It can be seen from Figure 3 that as the age increases, the dominant frequency of different admixture concretes is increasing. When the age is determined, the dominant frequencies of different admixtures are also different. For example, the dominant frequency value of 7d age: composite concrete (75KHz) is larger than mineral powder concrete (50KHz) than fly ash concrete (35KHz) is larger than ordinary concrete (15KHz). The dominant frequency value of 90d age: composite concrete (160KHz) is larger than fly ash concrete (85KHz) than mineral powder concrete (62KHz) is larger than ordinary concrete (25KHz). It can be seen that with the addition of the admixture, the dominant frequency of the concrete is increasing, and the dominant frequency of the complex doping is greater than the dominant frequency of any single doping.

![Dominant frequency diagram of concrete with different mineral admixtures](image)

**Figure 3.** Dominant frequency diagram of concrete with different ages and mineral admixtures

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