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Anisotropic mechanical properties of coal in water-immersed pillar dam: An insight from acoustic emission characterization

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Abstract: The safe and stable operation of underground reservoirs in coal mines is crucial for solving the coordinated exploitation of coal and water resources in western China. The infiltration of mine water significantly influences the stability of coal pillar dams. Therefore, based on the working environment of unidirectional compression and immersion of coal in the dam body, a series of laboratory tests were carried out systematically using coal from the Daliuta Coal Mine in Northwest China. The samples were taken from vertical and parallel bedding directions and soaked for 0 d, 2 d, 4 d, and 16 d. The variations in water absorption characteristics and internal structure of coal over water-soaking time were studied through atomic absorption spectroscopy, X-ray diffraction, and scanning electron microscopy. In addition, the uniaxial compression tests and synchronous acoustic emission monitoring obtained the failure process and mechanical properties of the samples. Finally, the time-domain and frequency-domain characteristics of acoustic emission signals were comprehensively analyzed through fractal dimension, fast Fourier transform, and cluster analysis. The results showed that the average strength of samples increased after soaked for 2 days; after soaked for 16 days, the strength and elastic modulus of the vertical bedding sample decreased by 29% and 37.4%, respectively, while those of the parallel bedding sample decreased by 45.7% and 38.9%, respectively. The mechanical properties of coal demonstrate significant anisotropy and a certain degree of water content can slightly enhance them; however, prolonged immersion significantly will diminish them by a large margin. Under uniaxial compression load, the coal samples mainly produce shear cracks, while parallel layered loading and immersion can increase the proportion of tensile cracks. In addition, the reduction of fractal dimensions in time and space characterizes the progressive failure process of coal samples; this process mainly produces high-frequency and low-amplitude acoustic emission signals.

Keywords: coal; underground reservoir; anisotropy; moisture content; fractal dimension; cluster analysis;