FRACTAL SIMULATION OF THE STRESS-STRAIN CURVE OF FROZEN SOIL

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The stress-strain relationship of frozen soil is important to indicate the strength of frozen soils in use. According to traditional mechanics, the stress-strain relationship in geomaterials is a smooth curve. However, some studies have shown that the real stress-strain curves of geomaterials, such as concrete, rock and frozen soil, are step-like and that they have fractal characteristics. Therefore, the traditional mathematical and mechanical methods used to describe the stress-strain curves of frozen soil are not accurate. Mandelbrot's fractal geometry theory is a new mathematical branch whose primary object is to describe natural structures that are irregular, rough or fragmented. It can also describe the degree of variation of a curve, a surface or a volume by using a fractal dimension. Therefore, fractal geometry theory can be used to analyze the stress-strain curve of frozen soil more accurately and in greater detail.

In this paper, a fractal method to simulate the stress-strain curve of frozen soil is presented, based on the fact that the stress-strain curve of frozen soil has fractal properties. First, a linear hyperbolic iterated function system (LHIFS), in which the perpendicular contraction factors are regarded as parameters, is established. Second, a method to calculate the best point which makes the attractor of the LHIFS an optimal approximation of the stress-strain curve of frozen soil is presented. Then, a method for calculating the fractal dimension of a stress-strain curve is obtained. Finally, a stress-strain relationship of clayey soil from the Qidong mine shaft, China, from uniaxial testing at -7°C is investigated.

Several conclusions can be drawn from this paper:

1) The fractal simulated method presented in this paper can be used to simulate stress-strain curves of geomaterial that have fractal features. Since the fractal features have been considered, this simulated method will describe the stress-strain curve of geomaterial more accurately than traditional mathematics and mechanics.

2) Since the method to calculate the fractal dimension is based on the optimal point, the calculated result is a good approximation.

3) The method presented in this paper provides a theoretical foundation for analyzing the stress-strain relationship of frozen soil using fractal geometry theories, and presents a new general method for simulating the stress-strain curve of frozen soil and calculating its fractal dimension by using a computer.

Fractal theory is a new effective method to solve complicated problems. Applications for the research of fractal theories in frozen soil are only at the initial stage. What a fractal dimension tells us about the mechanical properties of frozen soil, what are the physical implications of a fractal stress-strain curve, etc., are still open questions.