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Effect Of Wetting - Drying Cycles On Physical, Mechanical And Failure Properties Of Sandstone

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Abstract: In many environments, rocks are usually exposed to continuous wetting and drying cycles. The number of wetting-drying cycles will exacerbate weathering and reduce the mechanical quality of the rock which results in geological disasters. The effects of alternating wetting and drying cycles on rocks degradation have a greater impact than long-time soaking, which is a critical issue in the sustainability of rock mass engineering. In this research, sandstone specimens of Lalun Formation in Lushan area were investigated and the effect of wetting-drying cycles (0, 1, 4, 16) was examined on the physical properties including effective porosity, P-wave velocity, dry and saturated specific weight, mechanical properties including indirect tensile strength, uniaxial compressive strength, elasticity modulus, triaxial compressive strength, cohesion, and internal friction angle. The results indicate that by increasing the wetting-drying cycles, the effective porosity increased while the dry and saturated specific weight, P-wave velocity, tensile strength, uniaxial compressive strength, triaxial compressive strength, elasticity modulus, cohesion, and internal friction angle decreased.

Keywords: Sandstone, Physical properties, Mechanical properties, wetting-drying cycle.

INTRODUCTION

Rock mechanics is applicable to tunnel construction, mining, slope stability analysis, rock drilling, and other applications. In such uses, continuous rock wetting-drying cycles affect the physical, mechanical and failure characteristic properties of sandstones that lead to destructive effects and deteriorate the stability of such engineering structures. The continuous wetting-drying cycles results in some problems including rock fatigue and wear and tear, rock weathering and degradation of the physical and mechanical properties of rocks [1].

The continuous rock wetting-drying cycles occur for the following reasons:

1. Water absorption and evaporation [1]
2. Groundwater flow [1]

3. Water level fluctuations in dams [2]

Most of the previous studies investigated the effect of wetting-drying cycles on uniaxial compressive strength, triaxial compressive strength, porosity, and longitudinal wave velocity. In addition to items mentioned above, this study also investigated the effect of drying-wetting cycles on the tensile strength (using the Brazilian test), rock internal friction angle, longitudinal wave velocity, porosity, and specific gravity.

The effect of continuous drying-wetting cycles on the physical, mechanical, and fracture properties of rocks highlights the significance of this investigation. This article studies the effect of continuous wetting-drying cycles on the uniaxial compressive strength, elasticity modulus, triaxial compressive strength, cohesion, internal friction angle, longitudinal wave velocity, tensile strength, porosity, and specific gravity.

METHODS

The sandstone sample used in this study was obtained from the Lalun formations of the Lushan region, which consists of 15 percent quartz, 7 percent feldspar, 15 percent calcite, 8 percent chert, 7 percent opaque minerals, and 48 percent of this rock were made of fine quartz and clay particles. Before all tests, the polished samples were placed inside the water basin for 48 hours (wet cycle); then the samples were taken from the basin and placed in the oven for 24 hours in a fixed 105° temperature (dry cycle). Then, the samples were left in the environment to cool down. This process includes a wet and dry cycle. The longitudinal wave velocity test, the Brazilian test, uniaxial and triaxial compression tests, and the effective porosity and specific gravity tests were performed on samples that were subjected to wetting-drying cycles.

FINDINGS AND ARGUMENT

In this study, effective porosity, specific gravity, longitudinal wave velocity, tensile strength test, and uniaxial and triaxial compressive strength tests in 3, 5, 7 and 10 MPa lateral pressures were performed on sandstone samples that were subjected to 0, 1, 4 and 16 wetting-drying cycles. The results are as follows:

1. Increased wetting-drying cycles increase porosity; decrease dry and saturated unit weight and increase porosity. These changes are compatible with the findings of Zhou et al. in 2017 [3] and Zhang et al. in 2014 [2].
2. Increasing drying-wetting cycles decreases sandstone tensile strength.
3. Initially, increasing wetting-drying cycles greatly reduces longitudinal wave velocity in the lower wetting-drying cycles, but in higher wetting-drying cycles, longitudinal wave velocity changes slightly. This is compatible with the findings of Zhang et al. in 2014 [2] and Zhou et al. in 2017 [3].
4. Increasing wetting-drying cycles decreases the uniaxial compressive strength (Figure 1) as well as the elasticity modulus. These changes are compatible with the findings of Zhou et al. in 2017 [3].

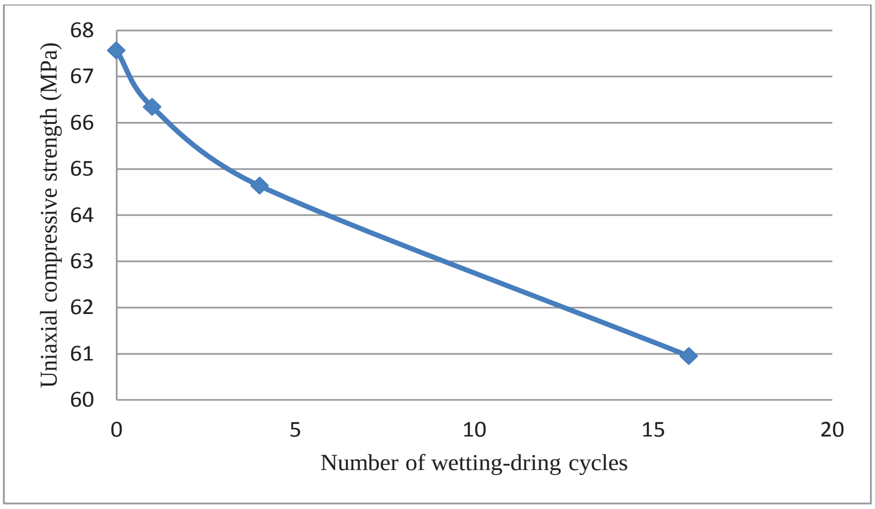

Figure 1. The variation of uniaxial compressive strength with the number of wetting-drying cycles

5. At the same lateral pressure, increasing wetting-drying cycles reduces triaxial compressive strength. The changes are compatible with the findings of Zhang et al. in 2014. Increasing lateral pressure reduces the strength rate of reduction, which means by increasing wetting-drying cycles in higher lateral pressures, the triaxial compressive strength is reduced less than the lower lateral pressure. In other words, increasing lateral pressure reduces the destruction tendency. Also, increasing wetting-drying cycles reduces internal friction angle and cohesion.

6. The studies showed that the results can be estimated using the Hoek and Brown criterion. Also, increased wetting-drying cycles decrease the Hoek and Brown criterion constant.

CONCLUSIONS

In this research, sandstone specimens of Lalun Formation in Lushan area were used and the effect of wetting-drying cycles (0, 1, 4, 16) was investigated on the physical properties including effective porosity, P-wave velocity, dry and saturated specific weight and mechanical properties including indirect tensile strength, uniaxial compressive strength, elasticity modulus, triaxial compressive strength, cohesion, and internal friction angle.

The results indicate that by increasing the wetting-drying cycles, effective porosity increased but dry and saturated specific weight, P-wave velocity, tensile strength, uniaxial compressive strength, triaxial compressive strength, elasticity modulus, cohesion, and internal friction angle decreased.

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