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Influences of freezing and thermal cyclic loading on physical and mechanical properties of marble

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Abstract

In this study, marble specimens were used to investigate the effects of freezing and thermal cyclic loading on physical and mechanical properties. For this purpose, four types of loading were considered, including freezing-cooling (F–C), heating–cooling (H-C), freezing-cooling-heating (F–C-H) and heating–cooling-freezing (H-C-F). The changes observed in physical and mechanical properties of the marble were analyzed in temperature extend shifting from – 30 °C to 160 °C. To achieve this goal, two marble blocks with a dimension of $30 \times 30 \times 30$ cm^3 were selected. Then, compressive and shear wave velocities, uniaxial compressive strength (UCS), Young's modulus (*E*) and Brazilian tensile strength (BTS) were measured and compared in different loading conditions. Results showed that the number of freezing-cooling cycles influenced the mechanical properties of the marble. With an increase in the loading cycles, both compressional and shear wave velocities of the marble decreased. The highest reduction in tensile strength was observed in heating–cooling cycles. That is to say, the thermal loading of rock specimens caused weakening, thereby increasing the micro-crack density in the marble specimens by means of thermally shocks. It was observed that the increase in the number of loading cycles, brings about a huge decline in the marble dynamic modulus. The damage index (*D*) is introduced to reflect the variation of the mechanical properties and ultrasonic wave velocities of the samples before and after the thermal cyclic loading. In all freezing and thermal cyclic loading conditions, the main and predominant failure mechanism was shear failure.

Keywords: Freezing and thermal cyclic loading, Physical and mechanical properties, Wave velocities, Micro-cracks, Damage index, Failure mechanism

Introduction

The effects thermal loading exert on physical and mechanical properties of rocks have wide applications in rock mechanics and rock engineering. Two perspectives can generally be adapted to elaborate on the effects of thermal loading on rock properties. The first view involves all the necessary actions that must be taken to decrease the effects of thermal loading on rock characteristics in civil, mining, and nuclear activities, while, the second view considers all the necessary actions that must be carried out to increase the