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Study on the mechanical properties and pore structure of desert sand concrete (DSC) after high temperature

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ABSTRACT

To study the mechanical properties and pore structure of desert sand concrete (DSC), the ultrasonic testing, mechanical properties and mercury intrusion experiments of DSC after high temperature were carried out with different temperatures and desert sand replacement rate (DSRR). The ultrasonic wave velocity, mechanical properties and pore structure parameters after high temperature were measured. The mechanical properties degradation model was established. The relationship between the mechanical properties of DSC after high temperature and pore structure parameters was discussed. The results showed that the relative compressive strength, flexural strength and splitting tensile strength of DSC decreased gradually with temperature and arrived at the maximum with DSRR of 40%. The specific pore volume, average pore diameter, porosity ratio and threshold diameter of DSC after various temperatures were positively correlated with temperature. The porosity volume percentage of DSC with the diameter less than 100 nm decreased with temperature. However, the porosity volume percentage with the diameter ranging from 100 nm to 1000 nm increased with temperature. The porosity volume percentage of DSC with the diameter larger than 1000 nm had no significant change with temperature.

1. Introduction

Desert sand (DS) can be used to substitute medium sand in a certain proportion to produce desert sand concrete (DSC), which has good workability and strength after being mixed with water-reducing agent (Zhang et al., 2006; Seif, 2013; Luo et al., 2013). Thus, DSC had been successfully applied to many engineering constructions (Gao et al., 2013; Wang et al., 2011). Many researches had been focused on the mechanical properties of DSC (Benabed et al., 2014; Liu et al., 2016, 2017, 2020, 2021; Shen et al., 2022). The deterioration of the mechanical performance of DSC after high temperature would weaken the safety performance of DSC structure. Compared with room temperature, the axial compressive strength and static compression modulus of elasticity of DSC increased at 100 °C, decreased significantly after 300 °C and reached the maximum with DSRR of 40% (Liu and Liu, 2018). Zhang (Zhang et al., 2019) carried out the dynamic mechanical performance test of DSC after high temperature and analyzed the effect of temperature and DSRR on the dynamic strength. Due to the difference between chemical composition and particle gradation of desert sand, ordinary fine sand, medium sand and coarse sand, the fineness modulus and particle diameter of the desert sand are smaller than others. Therefore, there is a great difference between DSC and ordinary concrete (Zhang et al., 2006; Seif, 2013; Luo et al., 2013; Gao et al., 2013; Wang et al., 2011; Benabed et al., 2014).

The decomposition of cement hydration products in concrete after high temperatures caused crack growth along the bond interface between aggregate and cement mortar (Jin and Huo, 2016), which increased the diameter of pores in concrete (Chan et al., 1999). It was imperative to explore the deterioration mechanism of mechanical performance after high temperature by studying the pore structure of concrete. Ju (Ju et al., 2013) analyzed the pore structure and vapour pressure mechanism of reactive powder concrete after high temperature and found that the specific pore volume, threshold pore diameter, most probable aperture and other pore structure parameters of reactive

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