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Research Article

Study the Fire Resistance of Desert Sand Concrete (DSC) with Interface Phase through Uniaxial Compression Tests and Analyses

Qian Zhang,[1] **Haifeng Liu**,[1,2] **Qiang Liu**,[1] **Jialing Che**,[1] **Weiwu Yang**,[1] **Jurong Ma**,[2] **Shu Ing Doh**,[3] **and Kar Sing Lim**[3]

[1]*College of Civil and Hydraulic Engineering, Ningxia University, Yinchuan 750021, China*
[2]*Xinhuan College, Ningxia University, Yinchuan 750021, China*
[3]*College of Engineering, University Malaysia Pahang, Lebuhraya Tun Razak, Gambang 26300, Kuantan, Pahang, Malaysia*

Correspondence should be addressed to Haifeng Liu; liuhaifeng1557@163.com

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The shortage of sand resources and high-rise building fires are becoming increasingly prominent. Desert sand (DS) with smaller particles can effectively fill the concrete voids and further improve its working performance; it is used as a fine aggregate to produce concrete. This article studied the performance of desert sand concrete (DSC) against fire resistance by using mathematical modeling for simulation. The stress-strain curves of desert sand mortar (DSM) after elevated temperatures were tested, and the constitutive model was established. By comparing the experiment and simulation results, it was verified that the model is suitable to be adopted in this study. Data from experiment and past literature can serve as parameters for the subsequent simulation. The destruction process of DSC under uniaxial compression after elevated temperature was simulated by using ANSYS. The simulation results indicated that, after elevated temperature, compressive strength reduced with increase of interface thickness. The compressive strength of DSC had a substantially linear increase as the interface compressive strength increased. For two-grade coarse aggregate, the optimum volume content was 45%, and particle size of it showed a significant effect on the compressive strength of DSC. The DSM constitutive model and simulation results can provide a sound theoretical basis and technical support for DSC engineering applications.

1. Introduction

In recent years, the incidence of fires has soared in China. Fire disasters of high-rise buildings were recorded at alarming rates of 2499 cases in 2013 [1] (p. 329), 4989 in 2014 [2] (p. 365), and 5571 in 2015 [3] (p. 303). Compared to 2013, the fire growth rates in 2014 and 2015 were 99.64% and 122.93%, respectively. For high-rise buildings, due to the chimney effect, fire spreads rapidly, which may cause an increase in economic losses and casualties. Therefore, research on the fire resistance of concrete buildings after elevated temperature will help reduce unnecessary damage. Numerous researchers studied concrete after different elevated temperatures [4–7]. Pliya et al. [6] heated the recycled aggregate high-strength concrete to 550–600°C at different heating rates and observed a decline in compressive strength. Qiu [7] used a test to study C70 concrete failure behaviour after heating of 25–800°C. Initial crack toughness and instability toughness both decreased with temperature increase. In this paper, the target temperatures were set at 300°C, 500°C, and 700°C, while the room temperature (20°C) was used as a reference.

Due to rapid development of construction and infrastructure, the shortage of medium sand in construction has become a global problem. Many researchers in China and abroad have started to find alternatives to substitute construction sand [8–10]. To reduce the dependency on nonrenewable sources while curbing environmental pollutions, desert sand was used as a substitute for medium sand. Many researchers are working on DSC [11–13]. The fineness modulus of DS is only 0.292, which is finer than fine sand (0.7–1.5 mm). It is classified as ultrafine sand. Zhang and