



Experimental and Numerical Study of Nano-Silica Additions on the Local Bond of Ultra-High Performance Concrete and Steel Reinforcing Bar

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Abstract

Micro-silica is widely used as an additive to cement in producing high performance concrete. This matter is used to enhance the strength and efficiency of concrete. Recently, due to the development of advanced nano-technology, nano-silica has been produced with particle sizes smaller than micro-silica and higher pozzolanic activity. Studies show that addition of nano-silica into cement-based materials improves their mechanical properties. Considering the unique characteristics of nano-silica, it seems that this material can be used in ultra-high performance concrete (UHPC). Therefore, further studies are needed on how the local bond and bond stress of steel reinforcing bar and UHPC containing nano-silica would be effected. In the present study, after preparing the mix designs and proposed specimens, the effects of various parameters on the local bond of steel reinforcing bars and UHPC containing nano-silica were examined by pullout experiments. In this research, we have numerically investigated the bond strength using numerical methods and calibration of the ABAQUS results in addition to its experimental study of ultra-high performance concrete and steel reinforcement. In numerical analysis, the concrete damage plasticity method was used to simulate the nonlinear behavior of concrete and its strain softness. Comparing between numerical and experimental analysis results shows that numerical analysis with high precision can predict the bond stress, bond load, and concrete specimen fracture mode.

Keywords: Ultra-High Performance Concrete; Nano-Silica; Local Bond; Bond Stress; Pullout Experiment.

1. Introduction

The ultra-high performance concrete (UHPC) has many advantages. Due to its better mechanical properties and low permeability, this type of concrete is gradually replacing conventional concrete. Because of its considerable properties, this type of concrete can either be used in structures to resist loads, or in large bridges and several constructions due to being affected by environmental conditions. Micro-silica is widely used as an additive to cement in producing high performance concrete. This matter is used to enhance the strength and efficiency of concrete. Several experiments have shown that replacing a part of cement with micro-silica, improves sulphate and acid resistance of concrete and reduces chlorine permeability. By addition of micro-silica to concrete or cement mortar, due to being fine grained, it fills the space between cement particles, so the existing pores will become smaller. Moreover, due to the reaction between silica and calcium hydroxide remained from cement hydration process, more C-S-H gels are produced and, as a result, more capillary cracks will be covered [1]. Recently, considering the unique characteristics of nano-silica, it seems that this material can be used in ultra-high performance concrete. Therefore, further research is needed on how to use it in concrete mix designs. To this end, the present study used Pullout test to assess the effect of nano-silica on the bond stress between steel reinforcement and ultra-high performance concrete. Pullout test is the oldest, simplest, cheapest and less time-consuming way to measure local bond stress of concrete. In this test, a reinforcement is placed into a cylindrical

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