Experimental Study on the Bond Behavior of Corroded Rebar in Ultra-high Toughness Cementitious Composite

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ABSTRACT

Ultra-high toughness cementitious composite (UHTCC) shows prominent tensile strain-hardening and multiple-cracking characteristics, can serve as a new type of high performance material used for structure retrofitting and strengthening. The bond between corroded reinforcement and UHTCC has an apparent influence on the mechanical properties of retrofit fitted structural members. This paper presents an experimental investigation on the bond behavior of corroded rebar and UHTCC through central pullout tests. The experimental results revealed that for rebar with the corrosion ratio in the range of about 10%, the bond strength almost remain identical to that of original rebar whereas about 22% drop was shown for rebar with corrosion ratio of about 14%. At corrosion ratio around 10%, reinforcement with 3d bond length showed 1.5 times bond strength of that with 7d bond length. In addition with the increase in corrosion ratio, the rebar showed relatively high residual bond stress and relatively plump descending branch of bond-slip curve. Furthermore, in comparison with concrete companion samples failing in splitting, all the UHTCC samples failed in pullout due to the fine ductility of UHTCC. Based on experimental results, an empirical model of bond strength between UHTCC and corroded rebar is proposed.

KEY WORDS: UHTCC; corrosion; bond; slip.

INTRODUCTION

Ultra-high toughness cementitious composite (UHTCC) is a kind of high performance fiber reinforced cementitious composite (HPFRCC) developed recently, which is optimized based on the micromechanics model proposed by Li and Leung (Li and Leung, 1992). This material is comprised of a cement-based mortar matrix reinforced by 2% high performance polymeric fiber (such as high modulus polyvinyl fiber and polyethylene fiber etc.) in volume or less (Li et al., 1995, 2001; Van Zijl and Wittmann, 2010; Li et al., 2009 ). Compared with traditional concrete or fiber reinforced concrete (FRC) material, this UHTCC material showed steady-state multiple-cracking propagation (Li et al., 1995, 2001; Li 2002), excellent tensile strain-hardening behavior with ultimate tensile strain above 3% (Li et al., 2001; Li et al., 2009), outstanding crack control capability (Li, 2002; Xu and Zhang, 2009), as well as fine durability including permeability resistance, chloride diffusion, and self-healing capacity (Ahmed and Mihashi, 2007; Van Zijl and Wittmann, 2011).

The retrofitting and strengthening of existing and damaged structures using UHTCC have been investigated due to its fine mechanical properties and durability. Kim et al. (2014) carried out the study on the strengthening of reinforced concrete (RC) beams by use of UHTCC reinforced with high strength rebar. The experimental results indicated that the multiple cracking mode was shown in tension zone with the maximum crack width of 0.2 mm, and the load carrying capacity was enhanced markedly. The corrosion experimental study on the RC/UHTCC composite beams with UHTCC replacing the cover of RC beam (Xu and Cai, 2011) revealed that the corrosion process and cracking due to corrosion swelling was clearly delayed, which ensured a relatively high load bearing capacity and stiffness after corrosion. It needs to be pointed out that Kobayashi et al. (2010) carried out experimental investigation on the retrofitting of corroded RC beams with 10% corrosion ratio by use of UHTCC. Experimental results revealed that UHTCC layer may effectively decrease the penetration of chloride ions, and recover the initial load carrying capacity.

However, in the case of corroded structural members, the surface appearance is different from that of original reinforcement, showing local or continuous corrosion pit and heavy damage on ribs of rebar. This damage may result in the deterioration of the bond property between corroded rebar and retrofitting material UHTCC. The corroded reinforcement needs to be cleaned before the retrofit for the corroded members, and further works together with UHTCC for retrofitted members. Apparently, fine interface bond property between corroded rebar and UHTCC is a key to ensuring deformation compatibility, full exertion of tension capacity of UHTCC and reinforcement.

Currently, most of studies mainly concentrate on the effect of rebar corrosion swelling on bond deterioration (Coronelli, 2002; Fang et al., 2006). However, as for the corroded reinforcement that is cleaned and shows surface damage, the bond deterioration characteristic remains unclear up to now. Based on this, this paper presents an experimental investigation on the bond behavior between corroded reinforcement and UHTCC with the varying corrosion ratio and bond length. This can...