Filling of strand corrosion products in cracked concrete based on accelerating corrosion method

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Abstract

An experimental study is proposed to investigate the filling extent of strand corrosion products during concrete cracking. A prediction model of crack width is developed incorporating the filling of corrosion products and geometric properties of strand. The relationship between the rust filling ratio and crack width is addressed. The restraint effects of stirrups on the rust filling ratio also are discussed. Twelve concrete beams were designed and accelerated toward corrosion-induced cracking. The proposed model is verified with the experimental results. Results show that the rust filling ratio increases with increasing crack widths before a critical value. After crack beyond the critical width, the rust filling ratio varies around the constant. The critical widths of maximum rust filling ratio in specimens with stirrups and without stirrups are 0.48 mm and 0.56 mm, respectively. The critical crack width of maximum rust filling ratio decreases 14.3% by using stirrups. Stirrups can restrict the corrosion-induced crack propagation and reduce the rust filling ratio.

Keywords: concrete beam; strand corrosion; stirrups; corrosion products; concrete cracking.

1 Introduction

Steel corrosion has been identified as one of the most deterioration factors in the concrete structures [1, 2]. During the corrosion process, the metallic iron is transformed to corrosion products [3, 4]. This would create an expansive pressure on the surrounding concrete and lead to concrete cracking [5]. The corrosion medium is easy diffuse to the steel surface with cover cracking, which would accelerate the corrosion process [6]. These coupling effects decrease the durability and safety of concrete structures. Cover cracking has been considered as an indicator of the service life end for the existing concrete structures [7].

A number of studies have been undertaken on corrosion-induced cracking of reinforced concrete (RC) structures. In the early studies, the researchers assumed corrosion products full fill cracks during concrete cracking process [8-9]. The filling extent of corrosion products in cracks varies with increasing corrosion degree. This assumption may overestimate the filling effect of corrosion products. Zhao et al. [6, 10] found corrosion products exhibited the non-uniform spatial distribution and did not fill cracks before cover cracking. The reduction coefficients were introduced to describe the filling extent of corrosion products [11]. How to quantitate the rust filling ratio is very difficult [12, 13]. The above studies mainly focus on the inner cover cracking. The distribution of corrosion products after cover cracking has not been reported yet.

The empirical relationship between crack width and reinforcement radius loss was established based on the experimental data [14-16]. Zhao et al. [6] described the shape of corrosion-induced crack in the radial direction using a linear function.

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