Numerical Modelling and Experimental Verification of Pullout Loading of Anchor Bolts in Reinforced Concrete Structures

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Abstract

The aim of this study is to provide a numerical model which can realistically present the failure load and failure mechanism of pullout loaded anchor bolts (headed studs) in reinforced concrete structures. The numerical analysis is carried out through a three-dimensional finite element (FE) code based on the Microplane constitutive law. The intension is to calibrate the FE model and to verify the numerical results against available test results. The calibrated FE model is intended to be used for an ongoing study to evaluate the influence of member thickness, surface reinforcement and size of anchor head on the tensile capacity and performance of anchor bolts.

The simulation results showed very good agreements with the available test results. The objectivity of numerical modelling in respect to the size of finite elements as well as the defined boundary conditions was confirmed by additional numerical analyses.

Keywords: fastening system; anchor bolt; pullout load; surface reinforcement; member thickness.

1 Introduction

Various kinds of fastening systems including cast-in-place and post-installed anchors are often used to transfer external loads to concrete structures. The cast-in-place anchors have been used ever since reinforced concrete was introduced around 1900. The post-installed anchors started to be used in the 1960ies with the advances in drilling technology of concrete structures. An overview of the technology is given in Eligehausen et al. [1].

As shown in Figure 1, fastening systems transfers applied external loads to concrete base material in various ways, which are typically identified as mechanical interlock, frictional interlock and chemical bond [1]. Mechanical interlock is the load transfer mechanism for most of the cast-in-place anchors (e.g. headed studs, anchor bolts and anchor channels) as well as some of the post-installed anchors (e.g. undercut anchors). Mechanical interlock transfers external load by means of a bearing interlock between the anchor and the concrete base material.

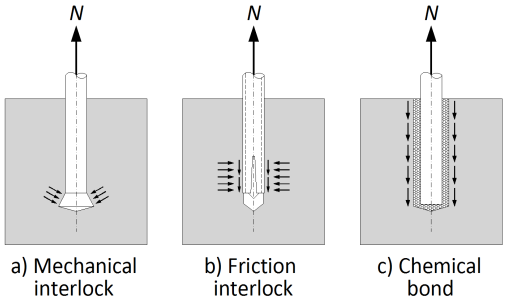

Figure 1. Anchor load-transfer mechanisms [1]

Frictional interlock and chemical bond are typical load transfer mechanisms for the post-installed anchors (e.g. expansion anchors, bonded anchors and plastic anchors). The load transfer mechanism through the frictional interlock is attained by

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