Bond-slip modeling in long anchorage condition

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Summary

In this article a new bond-slip relationship is proposed, which allows for numerical simulation of interaction phenomena between highly stressed reinforcement and surrounding concrete, keeping into account real anchorage conditions of rebars into concrete elements.

Most part of experimental tests performed through the years for investigating such aspect are characterized by limited anchorage length which allow both tested steel rebars to remain into elastic field and tangential stresses to be approximated as constant. On the contrary real anchorage conditions are often such to assure yielding before slippage: in such a condition the reduction of the section area of bar due to the Poisson's effect, plays a key role in drastically reducing maximum tangential stress which can be transferred, not only in the plastic field when the Poisson coefficient is maximum, but also when the rebar is still elastic, as shown by some reference experimental pull-out tests. The proposed bond-slip expression, alternative to classical "short length" bond relations, keep into account such phenomena.

Finite elements simulation of deep anchorage pull-out experimental tests have been used for testing the proposed relation. Results from experimental tests on squat beams and a beam-column joint highly affected from the bond behaviour of longitudinal reinforcement, have been compared for validation and the accuracy of the proposed relation have been demonstrated.

Keywords: Bond-slip relationship; bond-slip modelling; bond failure; long anchorage

1. Introduction

In problems dealing with modeling of reinforcement adherence phenomena, the formulation of simple expressions able to correlate the transferred bond stress to relative slip between materials (bond-slip relationships) is the crucial point. Such expressions must be able to synthesize complex phenomena that for being fully comprehended should be analyzed at a microscopic level in order to capture micro-cracking development around rebars. Starting from the end of the 70's several pull-out tests tried to define suitable formulation for such problems.

Different authors performed experimental tests characterized by limited anchorage length for which the assumption of constant stress field along anchorage are adequate. The bond-slip formulation obtained from this wide experimental campaign can be found in literature, for example in CEB Fib Model Code 90 [1] and CEB fib bulletin n°10 [2]. Experimental tests to whom such expression make reference are then characterized by permanency of the rebar in the elastic domain [3], where the role played by the Poisson's coefficient is limited in reducing the transverse area of rebar due to low tension stress.

Differently when anchorage length is deep enough, that is the usual condition in practice, rebar can be subject to high stress level and yielding before slippage and the effect played by the Poisson's coefficient can not be neglected anymore, deeply conditioning final test results. In such condition moreover the assumption of constant stress along anchorage length is not longer true.

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