The Flexural Strength and Ductility of Concrete Sections with Inadequately Anchored Reinforcement

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Introduction

The importance of bond was realised as soon as reinforcement was introduced in concrete. It was recognised early that the carrying capacity of concrete sections depends on the reinforcement and its bond with concrete. Much work has been conducted into bond in concrete. However, very little work has been done into residual bond strength that remains once the ultimate strength has been attained. The knowledge of such strength may prove critical in the event of assessing overloaded concrete structures.

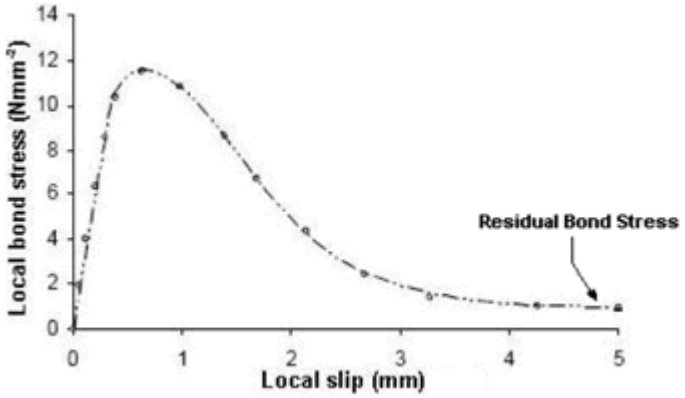

Figure 1 Typical relationship between local bond stress and local slip of an 8mm deformed bar (Baldwin 1995)

Problem Statement

A particular problem has arisen when assessing a number of three-span continuous beams as primary load carrying members, of a reinforced concrete frame of a sports stadium built in 1920's. At each internal support, the reinforcement bars, in the tension zone, were inadequately anchored according to current standards. The beams have, therefore, inadequate hogging bending resistance at the supports as required by the current code. At different applied loads, the tension bars, at the support, slip but still maintain a residual load. It is necessary to allow a plastic hinge to develop at the support, under ultimate load conditions, in order to carry the required ultimate load. The response of the beam to overloads is highly non-linear and difficult to model. It is not covered by the codes or an established method of how to calculate either the flexural capacity of such a hinge or its rotation capacity. (Clark 2000)

Aims and Objectives

Over the past several years an extensive program of bond research has been carried out at the University of Birmingham with a view to improving assessment criteria of concrete structures. It is the purpose of this research project, as part of the bond research program,

1. to understand residual bond strength of a group of reinforcing bars with a mix of full and inadequate anchorages

2. to develop a theoretical model incorporating findings from Objective (1) to predict the strength and ductility characteristics of a concrete section with a mix of fully and inadequately anchored reinforcement.

Methodology

In the project a mathematical prediction model will be developed based on the available test data on residual bond strength of a series of single bar pull out test. The model will then be used to estimate residual bond strength of a group of reinforcing bars with a mix of full and inadequate anchorages. The model will then be verified against a series of experimental pullout test data. At a later stage, a theoretical model will be derived from first principles, which will incorporate a reinforcement-slip relationship and will enable a section moment-rotation capacity relationship to be developed. In order to verify the model a test programme will be devised which will enable the strength and ductility characteristics of a section with a mix of anchored and inadequately reinforcement to be determined.

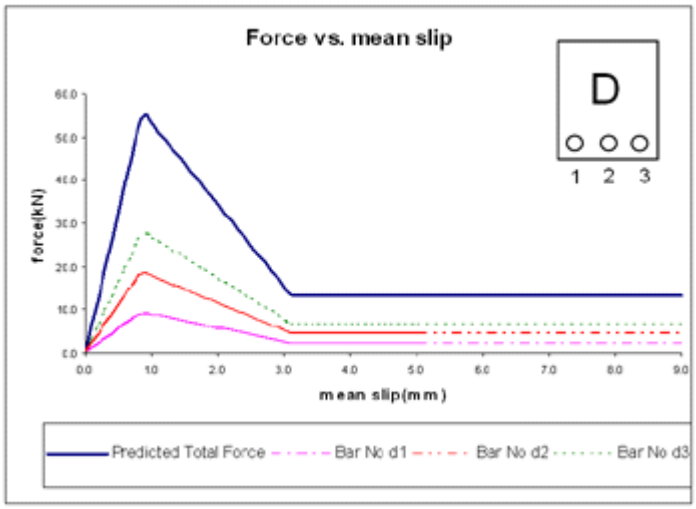

Figure 2 Example of mathematical prediction model of 3 numbers of 8mm deformed bars with different anchorage lengths, with concrete cover of 2 x diameter

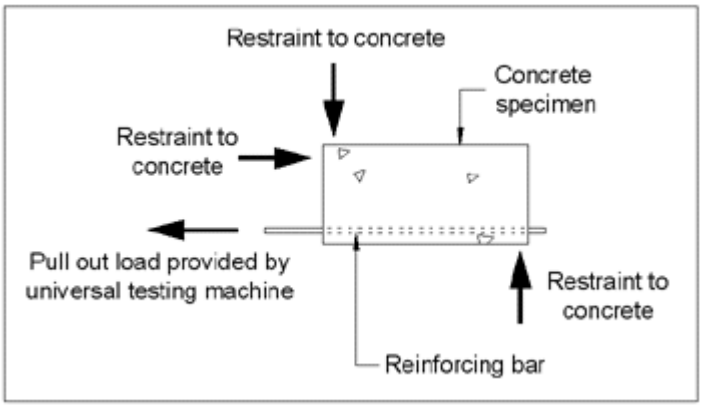

Figure 3 Bond pull out test experiment- Line Diagram

References

1. Baldwin, M. I. The Assessment of Inadequate Anchorage in Reinforced Concrete Structures, Ph. D. Thesis, the University of Birmingham, 1995

2. Clark, L. A. Developments in the Assessment of Concrete Structures, Sixth International Conference on Structural Failure, Durability and Retrofitting, Singapore, 2000, pp.74-85.