Chalmers University of Technology, Thomas Concrete Group

Modelling of restraint cracking in hybrid reinforced concrete structures

Master program Structural Engineering and Building Technology

Background

Concrete has a low tensile strength and tensile strain capacity and cracking is initiated at a tensile strain of about 0.1 mm/m, which is comparable to the drying shrinkage of concrete of about 0.5 to 0.8 mm/m. Consequently, cracks are almost unavoidable and reinforcement is needed to control the behavior after cracking as well as to limit the crack widths. Cracking may be caused by external applied forces, imposed deformations, by shrinkage or thermal strains which are externally and/or internally restrained, or by a combination of these. When cracking is caused by an externally applied force, the crack width will depend on the applied force as long as sufficient reinforcement is added. However, when cracking is caused by an imposed deformation the force in the member depends on the actual stiffness of the member, hence on the number of cracks formed (see Fig. 1).

Today, most codes do not distinguish between load controlled and restraint cracking. Furthermore, for structures featuring a combination of both fibers and conventional reinforcement, often referred to as hybrid reinforcement systems, there exist almost no guidelines for structural engineers, which hinders their ability to utilize the advantages of this type of reinforcement in structural applications.

Aim and goal

The aim of this master proposal is to investigate, numerically, the cracking behavior, crack spacing and crack width of hybrid reinforced concrete elements subjected to restraint cracking. The ultimate goal is to generate relevant data that can be used to validate an analytical model for restraint cracking in hybrid reinforced concrete elements.

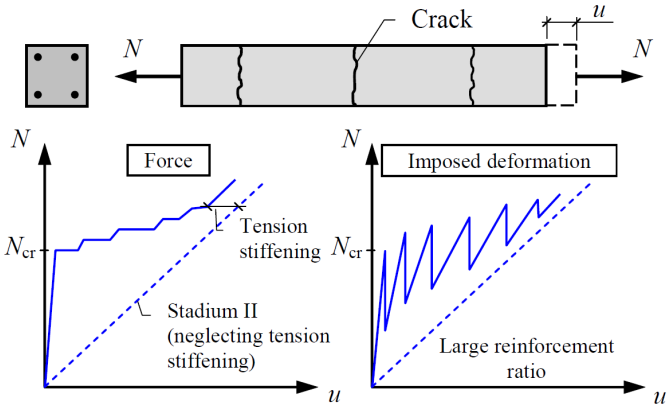

Fig 1. Structural behaviour of a reinforced concrete tie-element subjected to imposed load (left) and imposed deformation (right).

Approach

The project will focus on the generation of non-linear finite element models using a smeared crack approach to predict the crack pattern and crack width in concrete elements subjected to restraint forces (see Fig. 2). The project will be divided into two main task: (i) modelling of restraint shrinkage cracking in conventionally reinforced elements and validation with experimental tests results and (ii) a parametric study to assess the effect impact of fibre reinforcement on the crack spacing and crack width, taking into consideration aspects such as the residual tensile capacity of fibre reinforced concrete, the reinforcement ratio and the cover to bar diameter ratio to mention a few.

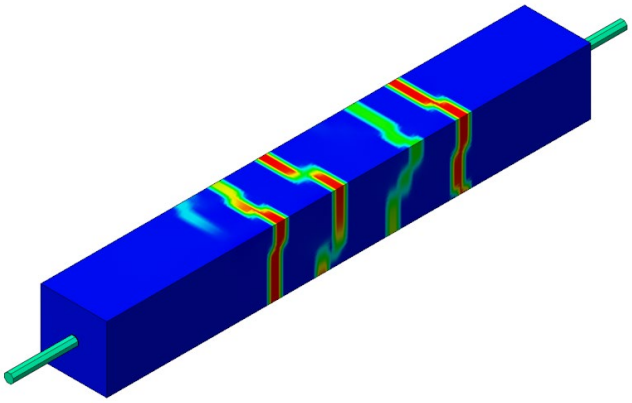

Fig 2. FE analysis of a concrete tie-element showing the crack pattern

Thesis setup

This work will be carried out at Chalmers University of Technology in collaboration with Thomas Concrete Group. The master thesis is suitable for students interested in FE modelling of concrete structures.

Impact

This thesis will provide valuable results to quantify the ability of hybrid reinforcement systems to limit the crack width in concrete structures subjected to restraint cracking, which will be of great support for the development of analytical tools for practitioners.

Supervision team

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