Crack Mechanism In Thick Concrete Structures During Hydration

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Summary

According to the existing design codes reinforced concrete structures have to be dimensioned with a minimum reinforcement, which avoids big cracks at the time when first cracks appear. For thick concrete structures this leads to an uneconomic amount of reinforcement. To avoid separate reduction factors it is easier to remember that restraint is a problem of deformation compatibility. Nonlinear finite element analysis were performed to study the crack mechanism. If the restrained deformation due to the discharge of the heat of hydration is known, deformation compatibility can be reached with primary and secondary cracks. The amount of reinforcement has to ensure that the needed number of secondary cracks can occur and that the crack width is limited as wanted. A simplified, robust and mechanical consistent algorithm can be achieved. It leads to an economic reinforcement percentage, which is confirmed to reach the goal of crack width control from the experience.

Keywords: temperature restraint, young concrete, hydration, minimum reinforcement, cracking, limitation of crack width, deformation compatibility

1. Introduction

When dimensioning the minimum reinforcement for control of crack width, it is presumed in national and international standards for concrete constructions that the cracking force has to be covered with reinforcement to limit the appearing crack width. As the cracking force increases with the thickness of the cross section, the amount of reinforcement increases at the same time. Factors are needed to reduce the cracking force.

The influence of nonlinear stress distribution (self-equilibrating effects) is given as the reason for significant reduction of the stresses which occur before the first crack. However, test results of different authors, e. g. [1] and [2], do not support this reasoning.

Another factor reduces the concrete strength in tension because cracking is expected to appear at an early age of the concrete when the strength is still developing.

Nonlinear finite element analysis were performed to analyse the process in detail. It was tried to check the above mentioned effects. The final goal was to find a mechanical consistent model to dimension the minimum reinforcement

2. Cracking in young hardening concrete

2.1 Actual normative regulations

CEB/FIP Model Code 90 [3] suggests to calculate a minimum reinforcement $A_{s,min}$ for the tensioned concrete zone A_{ct} with the following equation

$$A_{s,\min} = \frac{k_c \cdot k \cdot f_{ct,\max} \cdot A_{ct}}{\sigma_{s2}} \qquad (1)$$

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