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Shear strain in *B*-regions of beams in service

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ABSTRACT

The effect of shear deformation is not negligible in particular for r.c. beams with thin webs and low span-to-depth ratios. In order to calculate the contribution of shear on the deflection of a r.c. beam, a theoretical model, called the mixed model, was carried out which considers the web as a smeared model subjected to tensile and compressive principal stresses and its interaction with the tensile and compressed chords. The principal direction of compressive stresses acting on the web is calculated as a function of the acting load effects and assuming, as far as the mean strains are concerned, that the sections remain plane. The constitutive laws of the cracked web are obtained from the Modified Compressive Field Theory proposed by Collins, and are supported by an experimental campaign conducted on 24 zones of 6 r.c. beams with thin webs. The difficulties in the calculations, due to the necessity of performing two iterative procedures to obtain the solution, led the authors to prepare a simplified model. In the paper the simplified model is performed and the results are compared with that obtained with the mixed method and the experimental data.

1. Introduction

In some cases, for beams with thin webs and low span-to-depth ratios, the effect of shear deformation is not negligible and should be taken into account in the calculations. In this context, the tests carried out by Leonhardt on r.c. beams with span-to-depth ratios ranging from 12 to 5 showed that the shear deformations were from 0.2 to 3 times that of the deformation due to bending [1–3].

On the other hand, shear deformation in cracked sections, at service conditions, is often neglected because there are no suitable models for everyday applications. Traditionally, the problem is dealt with in two different ways: one method is based on the analysis of lattice-like behaviour, a concept that was first introduced by Mörsch, where the inclination of the concrete compression struts in the web can be obtained from the theory of plasticity [4]. This model was implemented, through the so-called "concrete contribution" [3,5,6], considering the favourable effects due to aggregate interlock, dowel effect and the contribution of the compressed concrete's flange. Even though it provides an adequate safety level, it is less accurate for the study of the behaviour of r.c. members under serviceability conditions. A second way of analysing shear deformation is to use "smeared models". They were first proposed by Vecchio and Collins in the Modified Compression Field Theory (MCFT) [7,8] and then further developed by other authors [6,9,10]. In this case, a reinforced concrete cracked element is considered as a new material whose strength and deformability properties are represented by the mean values. An extensive experimental work was carried out on reinforced concrete panels with bars in the two directions and subjected to shear and axial forces. The application of these models to reinforced concrete beams, however, is not easy. In fact, it is necessary to subdivide the section into horizontal strips, each of which is considered as a finite element that has to respect equilibrium of forces and congruency of strain conditions [11].

In the present paper, a mixed model is considered. This model takes the tensile and compressed chords into consideration; they interact with the web, which is considered as a smeared model subjected to tensile and compressive principal stresses. The principal direction of compressive stresses is calculated as a function of the acting load effects and assuming, as far as the mean strains are concerned, that the sections remain plane. The constitutive laws of the cracked web are obtained from MCFT, and are supported by an experimental campaign conducted on 24 zones of 6 reinforced concrete beams with thin webs [12,13]. This permitted a mixed calculation model [14] to be performed whose theoretical results are in good agreement with the experimental ones. The difficulties in the calculations, due to the necessity of performing two iterative procedures to obtain the solution, led the authors to prepare a simplified model. The determination of the unknowns of the problem, such as the θ-angle and the concrete contribution V_c, is therefore performed directly, taking into account the more significant parameters, to avoid any iterative procedure. This allows the solution to be obtained in closed form.

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