A new method for reinforcement design in concrete structures

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Summary

In different design codes, only stirrups and bent-up bars are designed as shear reinforcement. But for torsion design, both longitudinal reinforcement and stirrups are considered as torsion reinforcement, although in both cases, the reinforcements are actually designed to resist shear flow resulting from external loading. So there exists some inconsistency between reinforcement design for shear and torsion in popularly adopted design codes. In this paper, a new method to design orthogonal steel grids as shear reinforcement is proposed. The concept and formulations of this method is extended to the analysis of reinforced concrete beams subjected to combined shear and bending. Some tests on reinforced concrete beams with orthogonal grid reinforcement were undertaken to validate the accuracy of the method. Experimental results are compared with theoretical calculations, and it is found that the model predicts the experimental behaviour accurately.

Keywords: Concrete beams, Experiments, Shear reinforcement, Design, Shear strength.

1. Introduction

Qualitatively, most of researchers and codes [1,2,3] state that shear strength of a beam (V_R) is the sum of concrete contribution (V_c) and shear reinforcement contribution (V_s), if present. V_c depends on many factors, such as longitudinal tensile reinforcement ratio, concrete grade, size effect or shear span [4, 5, 6]. Its evaluation is very controversial and always relies on empirical methods. For evaluation of V_s, the model can be dated back to the truss analogy proposed by Mörsch [7] and Ritter [8]. It is assumed that no stress acts on the surface of concrete crack. Hence, the shear force is resisted by tensile stresses in vertical steel (referred as V_s) and only stirrups are designed as shear reinforcement in shear truss analogy. Hence, shear tests done in the past have been focused on concrete beams with or without stirrups [9, 10]; and no conceptual improvement has been made in the evaluation of V_s up to now. Regarding the contribution of longitudinal reinforcement, it is clearly stated that longitudinal reinforcement should be able to resist additional tensile force caused by shear in EC2 [11] and AASHTO LRFD [1]. However, there are no such special provisions in ACI318-05 [2]. On the other hand, both longitudinal and vertical reinforcements are considered as torsion reinforcement in different codes. It is found that different codes propose a different reinforcement pattern to resist shear stresses if they are produced by shear (stirrups) or by torque (longitudinal and vertical reinforcement).

In this paper, a new concept of shear reinforcement -orthogonal grid reinforcement- is proposed, and corresponding design method of such shear reinforcement for concrete beam is also deduced. Some experiments on concrete beams are undertaken to validate the accuracy of the proposed method.

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