Predicting the Shear Capacity of Reinforced Concrete Slabs subjected to Concentrated Loads close to Supports with the Modified Bond Model

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Summary

The shear problem is typically studied by testing small, heavily reinforced, slender beams subjected to concentrated loads, resulting in a beam shear failure, or by testing slab-column connections, resulting in a punching shear failure. Slabs subjected to concentrated loads close to supports, as occurring when truck loads are placed on slab bridges, are much less studied. For this purpose, the Bond Model for concentric punching shear was studied at first. Then, modifications were made, resulting in the Modified Bond Model. The Modified Bond Model takes into account the enhanced capacity resulting from the direct strut that forms between the load and the support. Moreover, the Modified Bond Model is able to deal with moment changes between the support and the span, as occurs near continuous supports, and can take into account the reduction in capacity when the load is placed near to the edge. The resulting Modified Bond Model is compared to the results of experiments that were carried out at the Stevin laboratory. As compared to the Eurocodes (NEN-EN 1992-1-1:2005) and the ACI code (ACI 318-11), the Modified Bond Model leads to a better prediction.

Keywords: arching action; bond; compressive strut; continuous supports; edge loading; punching shear; shear; slabs; torsion.

1. Introduction

The shear problem is typically addressed by studying two well-defined cases: 1) the one-way shear capacity of beams (beam shear), and 2) the two-way shear capacity of slabs (punching shear). One-way shear in beams is most often studied on small, heavily reinforced, slender beams, tested in four point bending [1, 2], resulting in the semi-empirical expressions as given in NEN-EN 1992-1-1:2005 [3] and ACI 318-11 [4] for the beam shear capacity. Two-way shear in slabs is studied on slab-column specimens [5]. These experiments form the basis of the semi-empirical punching shear provisions as given in NEN-EN 1992-1-1:2005 and ACI 318-11.

Besides these two standard cases of the shear problem that have been widely studied over the past decades [6], other loading cases, often at the intersection of beam shear and punching shear, arise in practice. An example is the shear capacity of existing reinforced concrete solid slab bridges, subjected to concentrated live loads when located close to the support, resulting in large shear stresses at the support [7]. The available code provisions are not fully suitable to determine the shear capacity of slabs subjected to concentrated loads close to supports, a problem at the intersection between one-way and two-way shear.

To describe the behaviour of reinforced concrete slabs subjected to concentrated loads close to the support, a new model is proposed. This model is a combination of load-bearing quadrants and strips, and is based on the Bond Model [8, 9]. The resulting Modified Bond Model can be considered a mechanical model, in which the concept of a limiting one-way shear stress is incorporated. Where most beam shear and punching shear models make a strict distinction between these two modes of

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