Advancements in Shear Resistance Prediction for Concrete Beams: A New Shear Model

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Abstract

The shear resistance of concrete beams has been a challenge. This study introduces an innovative shear model based on the critical crack model. By incorporating the concept of a local compression zone, the shear contribution from the upper edge of the concrete is effectively enhanced. An expression for the shear capacity of a concrete beam is derived by assuming an inclination angle for a critical crack. The optimal crack inclination angle is determined through an analysis of extreme values. To assess the reliability of the proposed methodology, the widely recognized ACI-DAfStb database was used. Comparative analyses were conducted between the calculation results obtained by the new model and those derived from the Strut-and-Tie model for deep beams and the truss model for slender beams. The positive results of these comparisons affirm the efficacy of the developed approach in enhancing the accuracy of shear behavior predictions in concrete beams.

Keywords: shear resistance; concrete beams; critical crack; ACI-DAfStb;

1 Introduction

The challenge of addressing shear resistance in reinforced concrete girders has been a persistent concern in the realm of bridge design [1-3]. When subjected to the combined effects of bending moment and shear force, concrete girders undergo the development of diagonal principal tensile and principal compressive stresses. The occurrence of critical cracks ensues when the principal tensile stress is larger than the material's tensile ultimate strength. The formation of diagonal cracks induces force redistribution, leading the structure into intricate nonlinearities.

In the early 1900s, truss models emerged as conceptual tools for analyzing and designing reinforced concrete beams. The earliest truss models assumed a parallel chord truss with compression diagonals inclined at 45 degrees with respect to the longitudinal axis of the beam, neglecting the contribution of concrete in tension [4]. Subsequently, the Strut-and-Tie Model (STM) for deep beams and the truss model for slender beams were developed based on these foundational approaches [5]. Both methods are written into the relevant codes in various countries and have become the main design methods nowadays.

Experimental observations have revealed that critical cracks occur in concrete beams experiencing shear damage. This paper adopts the assumption of a single main crack, allowing for the

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