Shear design in concrete beams without transverse reinforcement - A comparative study

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Abstract

In reinforced concrete structures without transverse reinforcement, the shear resistance relies on different internal resisting mechanisms and their interaction. The dependence of the overall load-bearing capacity upon different geometrical and mechanical parameters is complex. There is no unified theory that is universally accepted and certain aspects are still subject to scientific debate. The lack of agreement between theories has led to the development of different formulations and design provisions. The results of predictive models can vary significantly. In some instances, the limited accuracy can lead to safety risks. In other cases, it can lead to overly conservative design with increased economic and environmental costs. In this study on the shear resistance of reinforced concrete beams without transverse reinforcement, a comparison was carried out between analytical and experimental results. The data from laboratory tests were compared with the predictions from different formulations including those from the ACI 318, Eurocode 2, Simplified Modified Compression Field Theory, simplified Critical Shear Crack Theory, and Strut-and-Tie method. The findings of this study contribute to the development of safer and more sustainable infrastructure.

Keywords: Arch; compression; crack; tooth; optimisation; strut.

1 Introduction

The efficiency of our infrastructure network depends on the accuracy and precision of the models that are used to estimate its performance. Where the load bearing resistance can be predicted adequately, design and assessment can lead to structures that are fully utilised and safe. In cases where predictive models are unable to give satisfactory predictions, decisions must be made on the conservative side, increasing the cost and environmental footprint of infrastructure. Conversely, in rare cases where the level of conservatism is not sufficient, structural collapses can occur with serious societal consequences. Although structural failures are to be prevented, the type of failure associated with each limit state is a critical aspect that affects design and assessment decisions. Structures are typically designed to behave – and only theoretically fail – in a safe manner. This means that the attainment of the ultimate resistance of a structure should occur gradually, with clear signs of distress and visible deformations. Nevertheless, there are instances where failures can occur suddenly, without prior indication that a structure is in a critical state. This is typically the case of brittle failures. These considerations can help identify structural aspects that constitute a priority for the industry. The 'riddle of shear failure' is, among others, a critical example [1].

The behaviour of reinforced concrete structures subjected to shear is notoriously complex and depends on numerous factors. It is commonly