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Crack Spacing Model for FRP Reinforced Concrete Beams based on Stress-Transfer Approach

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Abstract

The present study develops a mean crack spacing model for fibre-reinforced polymer (FRP) reinforced concrete (FRP-RC) beams. The proposed model is based on stress-transfer approach and compatibility of mean strain in the FRP reinforcing bars, in order to predict the mean spacing of primary cracks in the stabilised cracking stage upon flexure. Typical concrete block element between adjacent cracks is demarcated into the debonding zone, the effective zone, and the central zone. The interactions between concrete and FRP reinforcement is reflected in the model by taking into account the stress-transfer, and the mean reinforcement strain along the concrete block element is evaluated from the principle of compatibility. Multiple FRP-RC beams specimens reported in the literature are analysed using the proposed model. The predicted mean crack spacing results agree closely with the experimental results, with root-mean-square error of approximately 10%. Hence, the developed mean crack spacing model is of satisfactory accuracy.

Keywords: Crack spacing model; fibre-reinforced polymer; stabilised cracking; stress-transfer; strain compliance.

1. Introduction

In the tension zone of reinforced concrete beams, the transfer of tension force between reinforcement and concrete is through the bond action. When a beam is loaded up to cracking, the flexural cracks represent locations that the entirety of tension force is resisted by the reinforcement and there is absence of force transferral through bond. Shifting away from the cracks along the longitudinal direction of the beam member, the sharing of tension force among reinforcement and concrete would vary gradually. The tension force resisted by concrete would increase with the distance from the nearest crack until the capacity of concrete, i.e. the tensile strength, is attained [1]. Consider a concrete block element between two primary cracks. By definition, the length of block element is the crack spacing, and the average length of block elements represents the mean crack spacing. As the basis of stress-transfer approach, the distributions of stresses in tension reinforcement and tensile concrete are dependent on the sharing of tension force described above [2]. The zone of the block in which the concrete attains its tensile strength would be susceptible to cracking.

When the external loading on a beam increases, more flexural cracks occur, and the mean crack spacing reduces. On the occasion a new primary crack is formed within a concrete block element, the block element is split into two and the stresses in reinforcement and concrete in the proximity of primary cracks along the block