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Simplified Interactive Flexure-Shear Design Method for Concrete Beams Based on Plastic Stress Field

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Abstract: Rational design approach for reinforced concrete beam under combined bending and shear needs to be developed, since they always occur simultaneously. Based on the Thurlimann's fully-plastic stress field model, a parabolic envelope and an additional limitation for intensive shear capacity is derived. Then, a simplified flexural-shear design method for concrete beams is proposed suitable for different reinforcement layout, which is illustrated by a working example. It has to be admitted that the parallel cracked model is more applicable to shallow beam, for cracking pattern in small shear-to-span ratio regions is quite different. In addition, the ductility of reinforcement must be ensured to prevent possible brittle premature failure.

Keywords: reinforced concrete beam; reinforcement design; flexure-shear interaction; plastic stress field

1 Introduction

Ultimate limit state is set for structural safety verification under certain failure patterns. For reinforced concrete beam, the flexural failure pattern is depicted by concrete cracking and steel yielding on tensile side, and crushing of the compression zone over the crack tip. In contrast, shear failure patterns are more complex and controversial [1]. The reasons mainly come from three aspects:

(1) The combined flexure and shear interaction, which may be indexed by shear to span ratio;

(2) The arrangement of longitudinal rebar and stirrups at the disposal of designer;

(3) The effective concrete compressive strength at failure.

Although bending and shear always coexist in everywhere of beam in consideration of moving load, most codes still check the flexure and shear separately [2], and give shear design expression in the format of

$$V_{Rd} = V_c + V_s \quad (1)$$

Where V_c is the contribution of concrete, and V_s is the part of steel for shear capacity.

AASHTO LRFD Bridge Design Specifications provide three procedures for determining shear resistance[3]. The first one is similar to Eq.(1). The second method provides shear-moment interaction diagram, which allows for the influence of longitudinal strains ε_x that occurs within the web of the member when the section is subjected the combination of moment and shear. And the last procedure for shear design adds an item about moment reduction factor[4]. Nevertheless, it is not easy to calculate the value of strain and the inclination of stress field and effective strength of concrete.

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