308/C

A rational procedure to predict shear strength of beams without stirrups

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With the turn of the century, shear design of reinforced concrete beams has been a matter of debate. The design for shear has always been uncertain as the true nature of the shear carrying mechanism has not been understood clearly. For the past several decades researchers have developed several design techniques for the calculation of shear. Some of these techniques have also been adopted by various codes of practice. But the accuracy of shear design has not been improved when compared with flexural design. Most codes of practice use empirical formulae developed using test results. The proposed design procedure is a new step in the ongoing search for finding an improved representation of shear carrying mechanism.

The shear carrying mechanism of a beam is assumed to be similar to the load carrying mechanism of a truss. The shear force is carried by tension in stirrups and compression in concrete. For beams without stirrups, the shear strength is completely governed by compression in diagonal concrete members. The behaviour of concrete in compression is rather complex to model.

For this condition, the compression carrying member is idealised as a concrete cylinder applied with a uniaxial compressive stress. Sectional analysis can be carried out to calculate the variation of radial and circumferential stresses along the radius of the cylinder cross section. Isotropic analysis can be used because the uncracked concrete behaves like a homogeneous isotropic linear elastic material.

It is found that the cracks will propagate along the radius up to the outer surface with the increment of axial compression and with further increment; crack width at the outer surface will increase. Cohesive cracking technique can be used for finding the reduced tensile stress transferred in the crack concrete as the Isotropic analysis can not be used in cracked concrete. A failure stress can be defined at the outer surface and using cohesive cracking model and isotropic analysis, the axial compression responsible for failure of the selected cylinder can be calculated. This compressive force will be the shear carried by concrete.

This design procedure is applied for 214 beams without stirrups and compared with the tested shear strength and found 72.9% of the beams have test shear strengths between 0.9 and 1.5 time of calculated strength whereas BS, ACI, Australian and Canadian codes have only 67.04%, 52.96%, 67.78% and 56.3% respectively. So it is evident that the proposed model is giving better representation of shear carrying mechanism.

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