First Crack Strength Criterion of Ferrocement at Combined Tension and Shear

A.M.Skudra, A.A.Skudra
Department of Structural Mechanics
Riga Technical University
1 Kalku Street, Riga, LV PDP 1658
Latvia

Introduction

Constructions made of ferrocement are thin-walled and under conditions of explotation they usually are under plane state of stresses. For the given state of stresses the first crack formation criterion has not been yet investigated. The aim of this paper is to investigate such criterion for one special case of combined loading - proportional biaxial tension and shear.

Results and Discusion

It is characteristic to ferrocement that it has low volume fraction of reinforcement. Thus to determine the stresses in the cement-sand matrix, using the methods of mechanics of composite materials, it is possible to neglect the influence of stress concentrations caused by the reinforcement. When the load is acting in the directions of the axis of elastic simmetry of composite (Figure 1) the stresses in the cement-sand matrix can be determined by the following relationships:

$$\sigma_1 = \left(\langle\langle \sigma_1 \rangle\rangle \frac{\bar{A}_{22} - \nu_m \bar{A}_{12}}{\bar{A}_{11}\bar{A}_{22} - \bar{A}_{12}^2} + \langle\langle \sigma_2 \rangle\rangle \frac{\nu_m \bar{A}_{11} - \bar{A}_{12}}{\bar{A}_{11}\bar{A}_{22} - \bar{A}_{12}^2} \right) \frac{E_m}{1-\nu_m^2}$$

$$\sigma_2 = \left(\langle\langle \sigma_1 \rangle\rangle \frac{\nu_m \bar{A}_{22} - \bar{A}_{12}}{\bar{A}_{11}\bar{A}_{22} - \bar{A}_{12}^2} + \langle\langle \sigma_2 \rangle\rangle \frac{\bar{A}_{11} - \nu_m \bar{A}_{12}}{\bar{A}_{11}\bar{A}_{22} - \bar{A}_{12}^2} \right) \frac{E_m}{1-\nu_m^2}$$

$$\tau_{12} = \langle\langle \tau_{12} \rangle\rangle \frac{G_m}{\bar{A}_{66}}$$

where E_m, G_m and ν_m are elastic characteristics of matrix.

The extensional stiffnesses $\bar{A}_{ij}$ of the laminate depend of its structure, volume fraction, geometry and orientation of reinforcement, mechanical properties of matrix and reinforcement.

In order to forecast the strength of cement-sand matrix under biaxial tension and shear experimentally proved energetic strength criterion may be used:

$$\frac{\sigma_1^2 + \sigma_2^2}{(R_m^+)^2} + \left(\frac{\tau_{12}}{T_m} \right)^2 = 1$$

where R_m^+ and T_m are the strength of the matrix under tension and shear. This criterion is compared (Figure 2) to reinforced panel tests of Bhide and Collins.

Crack orientation angle α can be calculated from the equation

$$\alpha = 90^\circ - \frac{1}{2} \operatorname{arctg} \frac{2\tau_{12}}{\sigma_1}$$

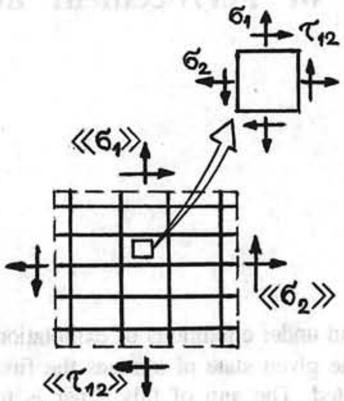

Figure 1 A calculation scheme

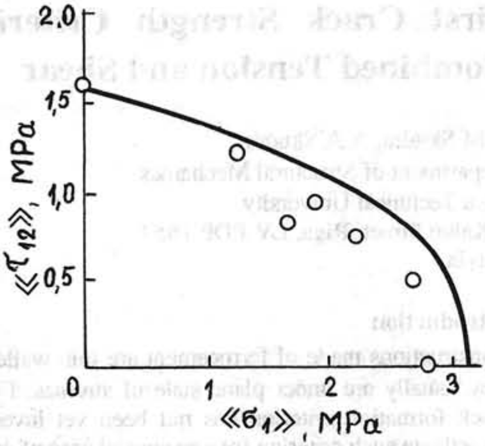

Figure 2 Comparison of theoretical and test results

Theoretical values of α also are compared to test results of Bhide and Collins. The coincidence of theoretical and experimental values of α is satisfactory.
In the case of bond failure the strength criterion has the form

$$\frac{\sigma_1}{R_b} + \left(\frac{\tau_{12}}{T_b}\right)^2 = 1$$

where R_b and T_b are the rupture and shear strength of the bond.

Conclusions

The obtained results make it possible to forecast the moment of crack formation as well as their orientation under various regimes of combined tension and shear loading.

References

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