FRACTURE TOUGHNESS OF MARBLE DETERMINED ON "EASY-TO-PREPARE" SPECIMENS

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Prismatic test pieces - generally used for testing metals - are not appropriate for rocks because of difficulties in machining and because of premature fracture as a consequence of local stresses.

To evaluate a more economic specimen-form we performed experiments on test pieces reccomended by Erismann and Prodan (1). These can be easily prepared from the circular rods, the usual form of samples taken from the rocks. However, because of the particular features of rocks some alterations had to be made compared to the original recommendations. So, e.g. instead of the load transmitting rolls wedges were applied to avoid local stress concentration (Fig. 1.). These changes were thought to be insignificant, but the first experiments provided unreasonable results.

Photoelastic stress measurements demonstrated that the friction between the test piece and the wedges cannot be neglected and the stress intensity factor should be calculated with the formula:

$$K_I = (\sigma_B + \sigma_T)\sqrt{a'}\ Y \tag{1}$$

σ_B, the bending stress and σ_T, the tensile stress at the tip of the crack are:

$$\sigma_B = \frac{6\,F}{2\,B}\left[d + \left(a' + \frac{w' - a'}{2}\right)\mathrm{tg}\Psi\right]\frac{1}{(w' - a')^2}$$
$$\sigma_T = \frac{F}{2\,B}\ \mathrm{tg}\Psi\ \frac{1}{(w' - a')} \tag{2}$$

with the notations seen in Fig.1., $Y=0{,}65 \pm 0{,}03$ in the range of the thickness and diameter tested. These experiments are described in details by Czoboly et al.(2) and Thamm et al.(3).

Further on the influence of the angle α has been investigated. The experiments were performed on marble, which is a rock of micro holocrystalline structure, having crystals of homogen grain size, without micro cracks. Test pieces of α = 0, 90, 120 and 180 deg. were tested (Fig.2.). Before the test the specimens were coated with photoelastic layer to determine the stress distribution. During the tests the fringe distribution figure was observed and recorded on a video recorder. At the moments of wedge openings the critical stress intensity factors (SIF crit) could be determined. The method of evaluation was similar to that of described in Refs. (2,3.). The results are given in Fig.3.

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It was interesting to observe that in the case of specimens with $\alpha = 0$ and 180 deg. the highest stress concentration was at the point of contact of the specimens and the flat tools, therefore the cracks started from that point. It was concluded that these type of specimens cannot be used, because the component of tensile stress at the crack tip is too small (or zero) to initiate a fracture.

Calculations of critical SIF-s using the formula (1) are in excellent agreement with those determined by photoelastic methods. The results are compared below.

K_I $(N.mm^{-3/2})$	= 90 deg. by Formula (1)	45,2
	by photoelastic method	50,4
	= 120 deg. by Formula (1)	44,7
	by photoelastic method	57,2

The effect of   in the tested range is insignificant.

SYMBOLS USED

a' = crack length (mm)
d = distance of wedges (mm)
F = load (N)
Y = shape factor (-)
B = thickness of specimen (mm)
w' = width of specimen (mm)
α = the angle of cut-off (deg.)
Ψ = the angle between load and vertical line (deg.)

K_I = stress intensity factor $(N.mm^{-3/2})$
K_{Ic} = fracture toughness $(N.mm^{-3/2})$
σ_B = bending stress at the crack tip (Nmm^{-2})
σ_T = tensile stress at the crack tip (Nmm^{-2})

REFERENCES

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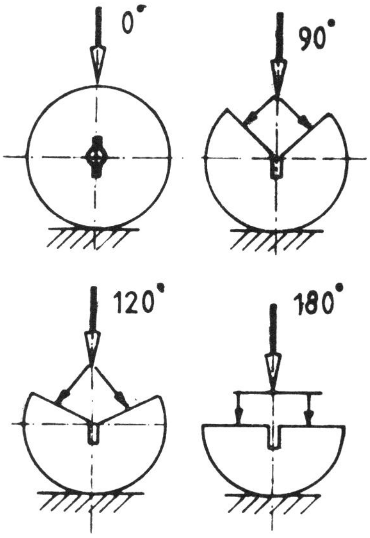

Fig.1. Shape and dimensions of the specimens

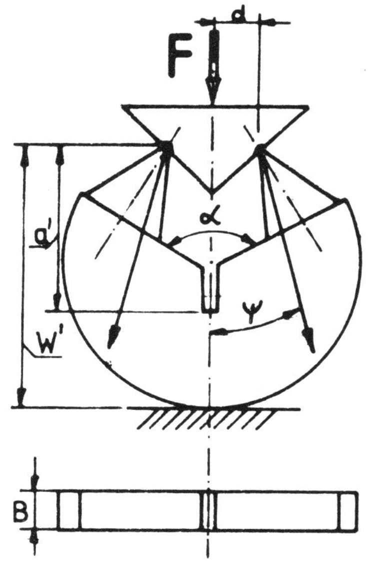

Fig.2. Specimens with different α cut-off angles

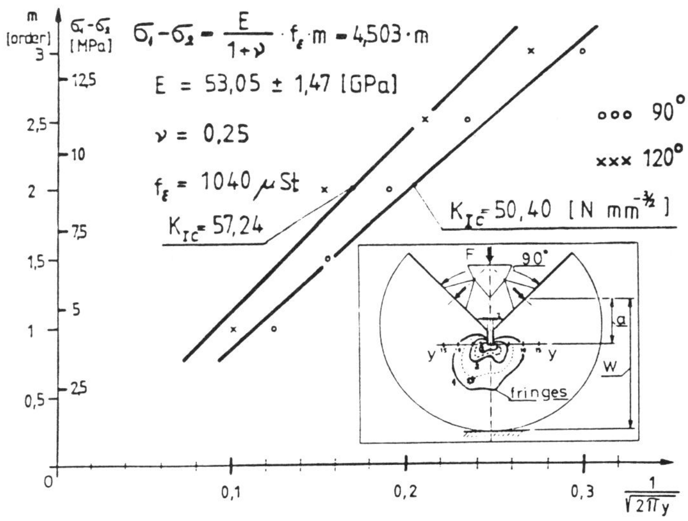

Fig.3. The evaluated critical stress intensity factors (SIF)