A NEW PROCEDURE FOR CALCULATING COD FROM THE PLASTIC-CLIP-GAUGE DISPLACEMENT FOR CT-SPECIMENS

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INTRODUCTION

Usually a "plastic-hinge" model is used to calculate the crack-tip-opening displacement, COD, from the plastic component of the clip-gauge displacement, v_p. The location of the "plastic hinge" in front of the crack tip is defined (in terms of the ligament length, b) by the plastic rotational factor, r_p. The calculation of COD can only be successful when the size of r_p is accurately known.

Therefore in two preceding papers (Kolednik (1), Kolednik (2)) the size of r_p was estimated theoretically for different stages of loading. These estimates were made for bend- and CT-specimens. The most important results of the studies (1,2) are summarized in the following section.

APPARENT AND ACTUAL PLASTIC ROTATIONAL FACTORS

There must be defined two different kinds of the plastic rotational factor: The apparent (or integral) plastic rotational factor, r_p, relates the momentary measured value of v_p to COD at a given laod. The actual (or incremental) plastic rotational factor, $r_p^{(a)}$, determines the actual plastic rotational centre which is physically active during a considered load increment (see Fig. 1).

With increasing load, F, up to the general yield load, F_{GY}, both plastic rotational factors decrease. For plane strain conditions the size of r_p can be estimated by

$$r_p = 0.81 \frac{1}{L} \frac{(1 - 0.11 L^2)^2}{(1 - 0.055 L^2)} , \qquad (1)$$

with the variable L being

$$L = F/F_{GY} . \qquad (2)$$

For L = 1 we get $r_p = 0.68$ (and $r_p^{(a)} = 0.40$).

For loading beyond general yield the actual plastic rotational factor, $r_p^{(a)}$, remains constant. $r_p^{(a)}$ depends slightly on the crack length to specimen width ratio, a/w, but

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$$r_p^{(a)} = 0.37 \qquad (3)$$

will be a good approximation, if a/w is not too small (see Table 1).

TABLE 1 - The size of the actual plastic rotational factor in CT-specimens after general yielding.

a/w	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
$r_p^{(a)}$	0.28	0.33	0.35	0.37	0.37	0.37	0.37	0.37

The apparent plastic rotational factor can be estimated from $r_p^{(a)}$ introducing a variable

$$s = V_p / V_p^{(GY)} \quad , \qquad (4)$$

where $V_p^{(GY)}$ is the plastic component of clip-gauge displacement at the general yield load:

$$r_p = \frac{s\, r_p^{(a)}(a/b + 0.68) + a/b(0.68 - r_p^{(a)})}{s\,(a/b + 0.68) - (0.68 - r_p^{(a)})} \quad , \qquad \text{for } s \geqq 1 \qquad (5)$$

For large crack extension in Eq. 5 $r_p^{(a)}$ should be replaced by a correct value, $r_p^{(a)*}$ (see below).

Crack extension, Δa, enlarges the apparent plastic rotational factor according to a relationship

$$r_p^{(a)*} = r_p^{(a)} + (1 - r_p^{(a)})\, \Delta a/b \qquad (6)$$

CALCULATION PROCEDURE

From the estimates of the plastic rotational factors a procedure for calculating COD can be derived:

(1) Estimate the general yield load. F_{GY}, e.g. according to a relationship of Merkle and Corten (3). From the load-displacement record determine the corresponding value of $V_p^{(GY)}$.

(2) Measure the crack extension, Δa.

(3) For loads up to F_{GY} apply Eq. 1 to calculate r_p. (Usually the crack extension will be small up to F_{GY}, so no correction of r_p will be necessary.)

(4) For loads larger than F_{GY} or for V_p-values larger than $V_p^{(GY)}$, firstly calculate the Δa-corrected value of $r_p^{(a)}$ using Eq. 6 and, secondly determine r_p applying Eq. 5.

(5) Calculate COD from the estimated r_p and from the measured V_p using

$$\mathrm{COD} = \frac{r_p\, b}{r_p\, b + a}\, v_p \quad . \tag{7}$$

This procedure can be applied for 3- or 4-point bend specimens, too.

REFERENCES

(1) Kolednik, O., Engng. Fracture Mech., Vol. 29, 1988, pp. 173-188.

(2) Kolednik, O., submitted to Int. J. Fracture.

(3) Merkle, J.G., and Corten, H.T., Trans. ASME, J. Pres. Ves. Technol., 1974, pp. 286-292.

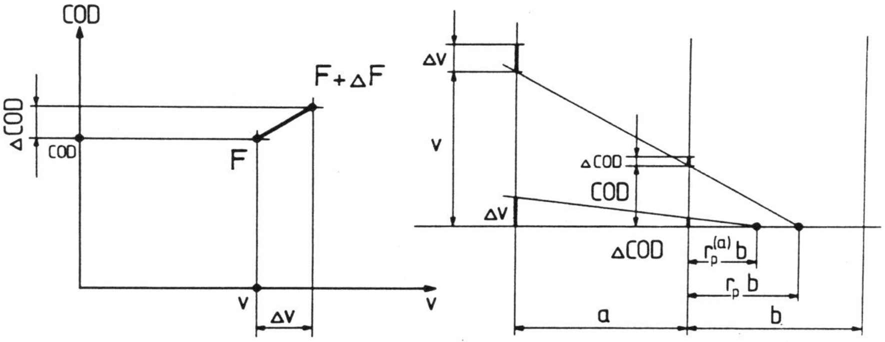

Figure 1 The actual rotational centre during a load increment ΔF