JP LIMIT STATE CRITERION FOR BRITTLE MATERIALS

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1. Limit state conditions

The three failure criteria (Fig. 1) had been considered to analysis:

- author's (*PJ)* criterion, proposed in 1986 [1], which limit state depends on three tensor invariants (I_1, J_2, J_3)
- well known Drucker-Prager criterion, (I_1, J_2)
- classical Huber-Mises criterion (J_2)
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Limit curves described by eqs. (1), (2), (3) in biaxial stress state are shown in Fig. 1. Fig. 2 shows "tension meridian" and "compression meridian" of the ***PJ*** and Drucker-Prager limit surface in $\tau_0 - \sigma_0$ plane and Fig. 3 shows isometric view of this surfaces.

1.1 PJ criterion

The ***PJ*** criterion was proposed by one of the author's (J.P.) in 1986 [1] in the form:

$$\sigma_0 - C_0 + C_1 P(J)\tau_0 + C_2\tau_0^2 = 0, \qquad (1)$$

where:

$P(J) = \cos\left(\frac{1}{3}\arccos(\alpha J) - \beta\right)$ - function describing the shape of limit surface in deviatoric plane,

$\sigma_0 = \frac{1}{3} I_1$ - mean stress,

$\tau_0 = \sqrt{\frac{2}{3} J_2}$ - octahedral shear stress,

I_1 - first invariant of the stress tensor,

$J_2,\ J_3$ - second and third invariant of the stress deviator,

$J = \dfrac{3\sqrt{3}\,J_3}{2\,J_2^{3/2}}$ - alternative invariant of the stress deviator,

$\alpha, \beta, C_0, C_1, C_2$ - material constants.

Classical failure criteria, like Huber-Mises, Tresca, Drucker-Prager, Coulomb-Mohr as well as some new ones proposed by Lade, Matsuoka Ottosen, are particular cases [cf. 1,2] of the general form (1) ***PJ*** criterion.

Material constants can be evaluated on the basis of some simple material test results like:

- f_c - failure stress in uniaxial compression,
- f_t - failure stress in uniaxial tension,
- f_{cc} - failure stress in biaxial compression at $\sigma_1/\sigma_2 = 1$,
- f_{0c} - failure stress in biaxial compression at $\sigma_1/\sigma_2 = 2$,
- f_v - failure stress in triaxial tension at $\sigma_1/\sigma_2/\sigma_3 = 1/1/1$,

For concrete or rock-like materials some simplifications can be taken on the basis of test results in biaxial stress state and R. M. Haythornthwaite "tension cutoff" hypotesis:

$$f_{cc}=1.1\, f_c\,, \qquad f_{0c}=1.25\, f_c\,, \qquad f_v= f_t.$$

1.2 Drucker – Prager criterion

With notation used in eq. (1) well-known Drucker–Prager criterion can be written:

$$\sigma_0 - C_0 + C_1\tau_0 = 0\,. \qquad (2)$$

Two material constants C_0 and C_1 can be evaluated on the basis of uniaxial test results like f_t and f_c .

1.3 Huber – Mises criterion

Classical criterion proposed by T. Huber and R. von Mises can be obtained by simplification of the general form (1):

$$\tau_0 - C_0 = 0. \qquad (3)$$

Material constant C_0 , in this analysis, is evaluated with uniaxial tension failure stress f_t.

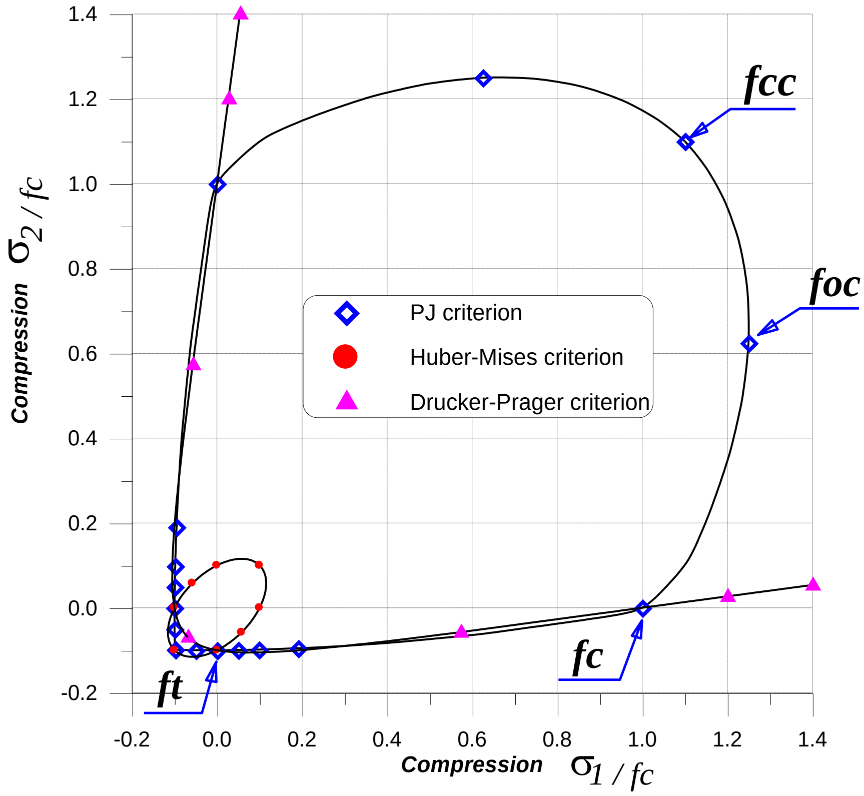

Fig. 1. Limit curves in biaxial state of stress

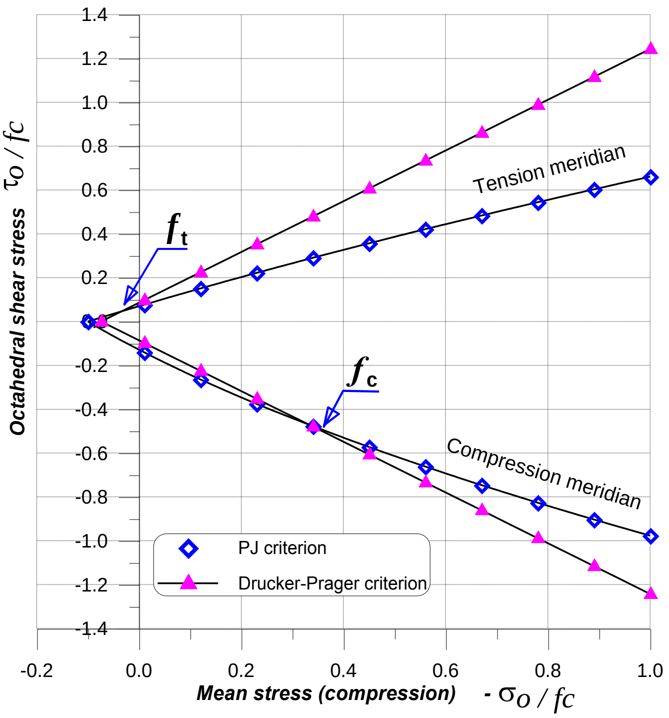

Fig. 2. ***PJ*** and Drucker-Prager limit surface cross section by $\tau_0 - \sigma_0$ plane.

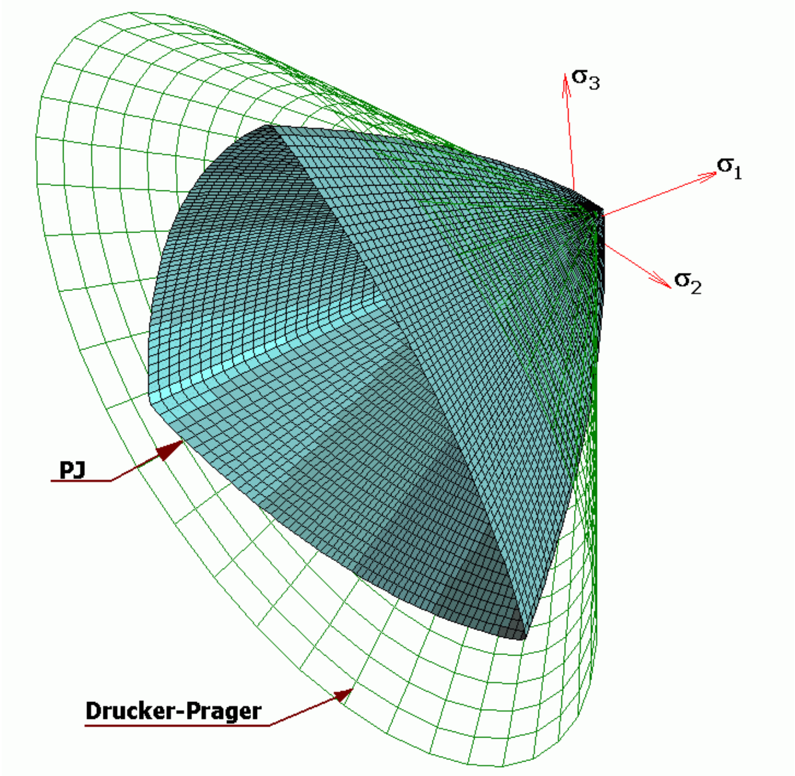

Fig. 3. ***PJ*** and Drucker-Prager limit surface – isometric view.

2. References

[1] J. Podgórski (1985). General Failure Criterion for Isotropic Media. *Journal of Engineering Mechanics ASCE*, **111,** 2, *188-201*.

[2] Podgórski J.: Limit state condition and the dissipation function for isotropic materials. *Archives of Mechanics*, 36(1984) 3, *323-342*.