"NOTCH ROUNDING APPROACH" APPLICATO A MODO I E III

POSSIBILE ESTENSIONE AL MODO II

UNIVERSITA' DI PADOVA

DIPARTIMENTO DI TECNICA E GESTIONE DEI SISTEMI INDUSTRIALI

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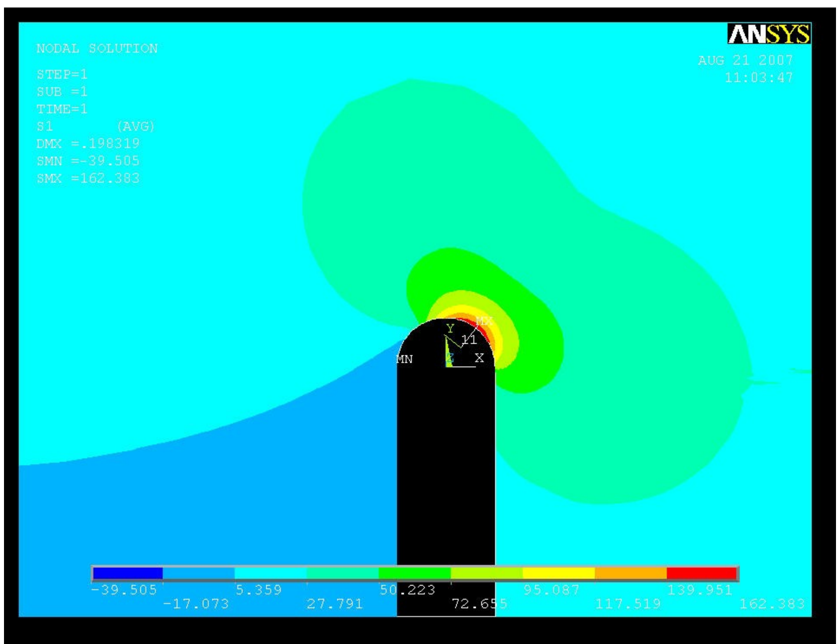
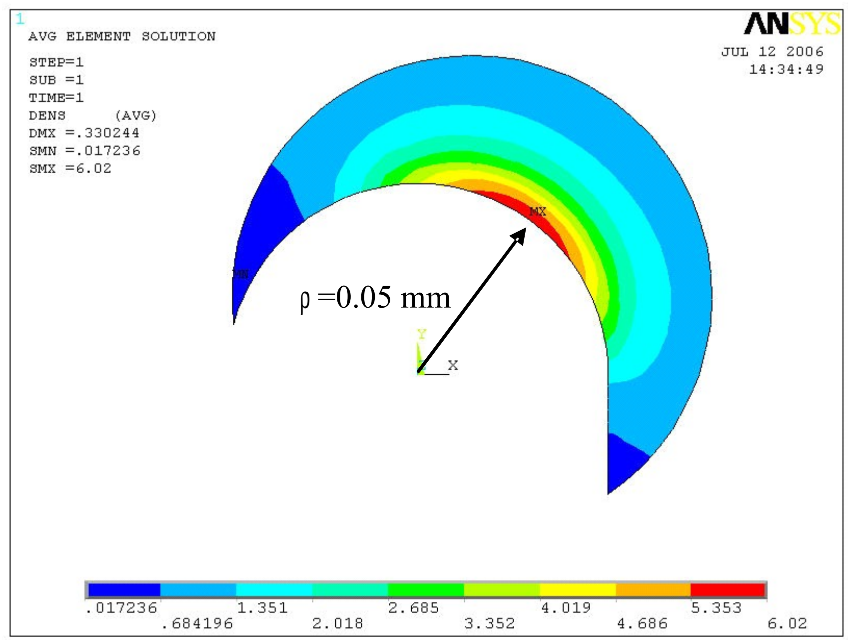




Criteri per giunti saldati

- **Criteri: tensioni nominali, tensioni di hot-spot, MFLE.**

Tra i criteri locali:

- **Criterio di Radaj (1969, 1990), *'Notch rounding approach'*, incluso nelle Raccomandazioni IIW (2007) e FKM (2003).**

$$\rho_f = \rho + s\,\rho^* = 1.0 \text{ mm}$$

- **(raggio reale $\rho = 0$, lunghezza microstrutturale $\rho^* = 0.4$ mm per '*cast iron*', fattore di multiassialità costante $s = 2.5$).**
- **Valori inferiori di ρ^* suggeriti per giunti di spessore ridotto saldati a punti o al laser.**

Criteri locali

- Giunti di spessore ridotto. Criterio basato sul '*Substitute notch radius*, ρ_s=0.05 mm

- Eibl, M., Sonsino, C.M., Kaufmann, H. and Zhang, G. (2003) Int J Fatigue **25**.
- Karakas Ö., Morghenstern C., Sonsino C. M. (2008) Int J Fatigue **30**, 2210-2219.

'Notch rounding approach' e *'SED approach'*

Messi a confronto in:

- Radaj D., Berto F., Lazzarin P. (2009). Engng Fract Mech, in press, available on line.
- Radaj D., Lazzarin P., Berto F. (2009). Submitted to Int J Fatigue.

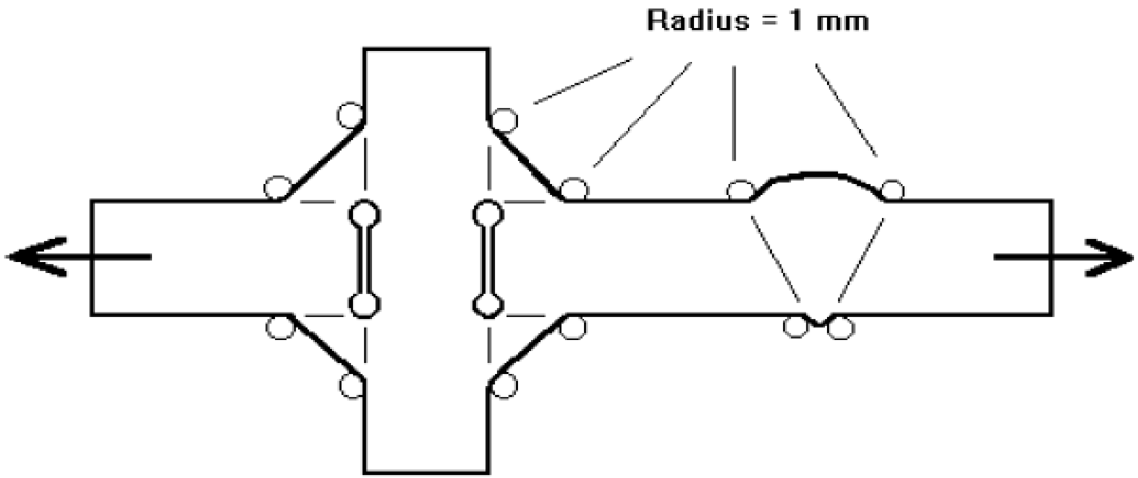
'…A local approach for the fatigue assessment of welded joints with potential to substitute the IIW notch rounding procedure is the strain energy density (SED) concept….'

RACCOMANDAZIONI IIW: METODO DI RADAJ

Hobbacher 2005, 2007

2.2.4.3 Measurement of Effective Notch Stress

Because the effective notch radius is an idealization, the effective notch stress cannot be measured directly in the welded component. In contrast, the simple definition of the effective notch can be used for photo-elastic stress measurements in resin models.



ρ_f=1 mm indipendentemente dall'angolo di apertura

"s" si riferisce al caso normal stress (plane stress)

$\rho_f = \rho + s\,\rho^* = 1.0$ mm   s=2.5, $\rho = 0$, $\rho^* = 0.4$ mm

Tabelle 4.4: Faktor s der Mikrostützwirkung an Kerben für unterschiedliche Mehrachsigkeitsgrade und Festigkeitshypothesen (mit Querkontraktionszahl ν); in Anlehnung an Neuber [587, 660], mit Korrektur nach Radaj u. Zhang [692]

Festigkeitshypothese	Mehrachsigkeitsgrad		
	ESZ Flachstab unter Zug-Druck oder Biegung	EDZ Rundstab unter Zug-Druck oder Biegung	NES Rundstab unter Torsion
	Faktor s	Faktor s	Faktor s*)
Normalspannungshypothese	2	2	0,5 bzw. 1,0
Schubspannungshypothese	2	$\frac{2-\nu}{1-\nu}$	0,5 bzw. 1,0
Oktaederschubspannungs- u. Gestaltänderungsenergiehypothese	2,5	$\frac{5-2\nu+2\nu^2}{2-2\nu+2\nu^2}$	0,5 bzw. 1,0
Dehnungshypothese	$2+\nu$	$\frac{2-\nu}{1-\nu}$	0,5 bzw. 1,0
Formänderungsenergiehypothese	$2+\nu$	$\frac{2-\nu}{1-\nu}$	0,5 bzw. 1,0

ESZ: ebener Spannungszustand, EDZ: ebener Dehnungszustand, NES: nichtebene Schubbeanspruchung

*) $s = 0{,}5$ nach Neuber [587] und Radaj u. Zhang [692] für rißartige Kerben,
$s = 1{,}0$ nach Neuber [660] für allgemeine Kerben, Widerspruch ungeklärt

Radaj e Vorwald 2007
Ermüdungsfestigkeit

s validi per il caso 2α=0°
(plane stress o plane strain)???

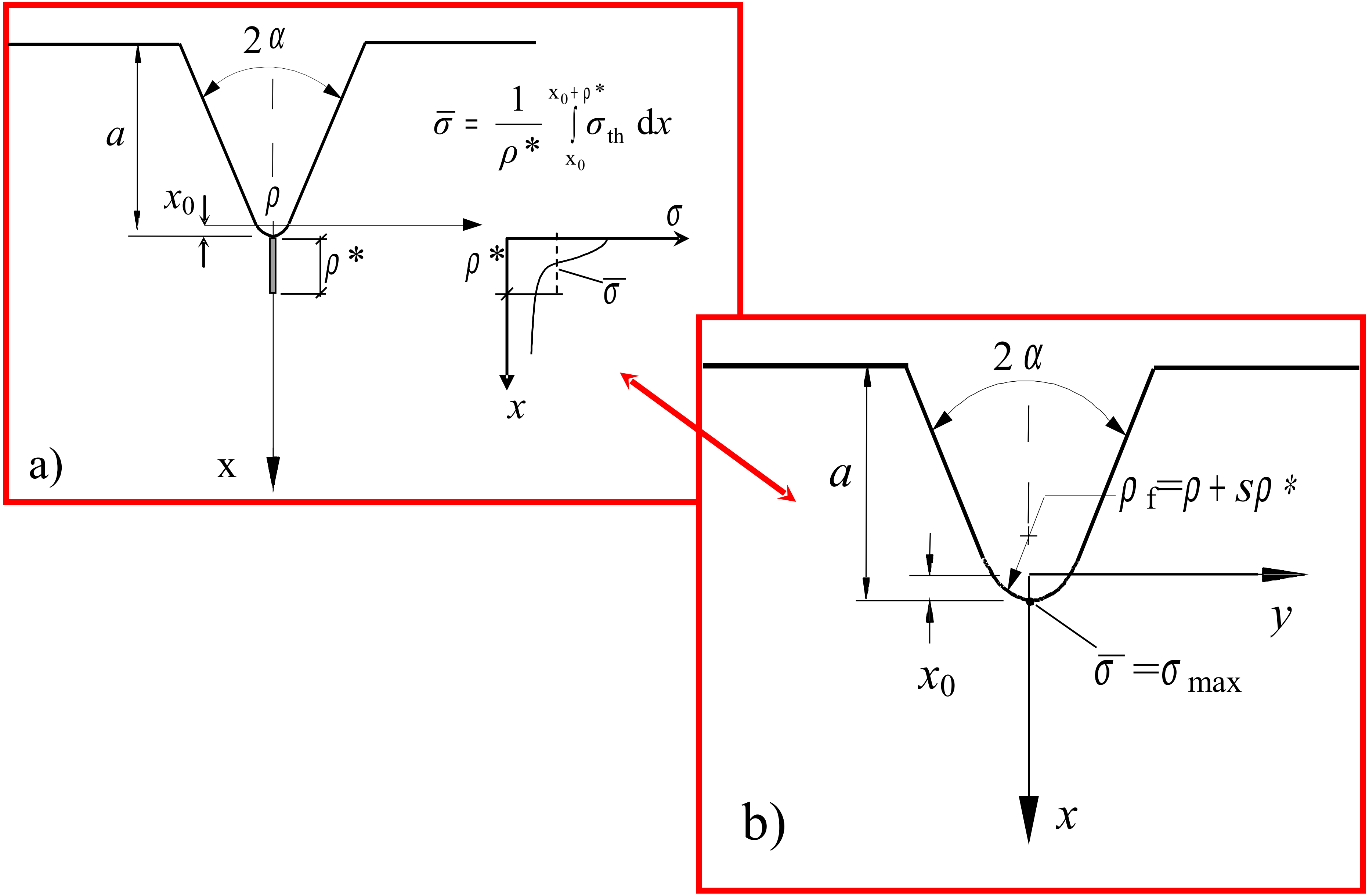
s per la torsione s=0.5 o 1.0 ???

RIFERIMENTI RECENTI

- F. Berto, P. Lazzarin, D. Radaj, "Fictitious notch rounding concept applied to sharp V-notches: evaluation of the microstructural support factor for different failure hypotheses. Part I: Basic stress equations", *Engineering Fracture Mechanics*, 75, 3060-3072, 2008.

- F. Berto, P. Lazzarin, D. Radaj, "Fictitious notch rounding concept applied to sharp V-notches: evaluation of the microstructural support factor for different failure hypotheses. Part II: Microstructural support analysis", E*ngineering Fracture Mechanics*, *in press* doi:10.1016/j.engfracmech.2008.01.015.

SCHEMA DI APPLICAZIONE DEL NOTCH ROUNDING APPROACH



STEPS PER APPLICAZIONE DEL METODO SEGUENDO LA TRATTAZIONE DI NEUBER

STEP 1

Scelta del criterio da adottare (normal stress, von Mises, Beltrami)

Esprimere la tensione equivalente σ (o τ) lungo la bisettrice dell'intaglio (percorso di probabile propagazione della cricca di fatica) utilizzando le espressioni per gli intagli a V

STEP 2

Determinare la tensione efficace che dipende da ρ e ρ*

$$\bar{\sigma}(\rho, \rho^*) = \frac{1}{\rho^*} \int_{x_0}^{x_0+\rho^*} \sigma_{th} \, dx$$

STEP 3

Risolvere il limite: $\bar{\sigma}\max(\rho_f) = \lim_{\rho^* \to 0} \bar{\sigma}$

STEP 4

Risolvere l'equazione:

$$\overline{\sigma}\max(\rho_f) = \overline{\sigma}(\rho^*, \rho)$$

STEP 5

Determinare $\rho_f(\rho, \rho^*)$:

$$\rho_f = f(\rho^*, \rho)$$

STEP 6

Calcolo di s:

$$s = (\rho_f - \rho)/\rho^*$$

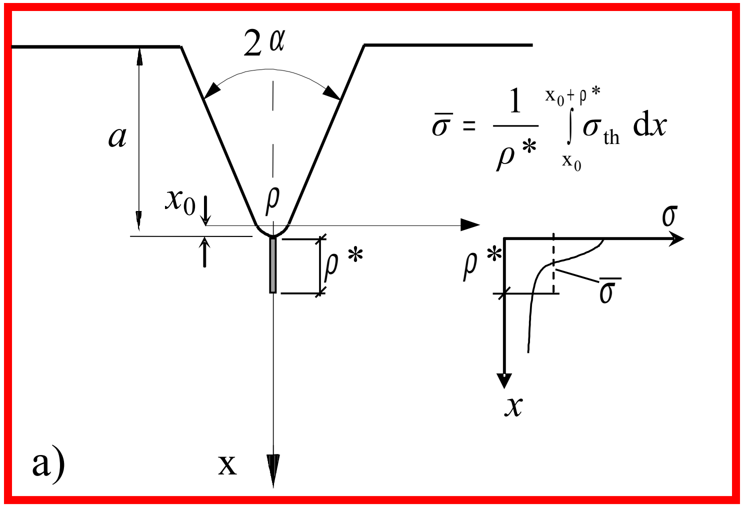
Beltrami criterion, plane strain (with Poisson's ratio)

Caso $2\alpha=135°$:

$$\bar{\sigma}^2 = \frac{1}{\rho^*}\int_{x_0}^{x_0+\rho^*}\sigma_B^2\,\mathrm{d}r = -\frac{K_1^2\rho^{-2\mu}(1+\nu)}{\rho^*}\left[\frac{r^{2\mu-1}\rho^{2\lambda}\left(B^2(\nu-1)+G^2(\nu-1)+2BG\nu\right)}{-1+2\mu}+\right.$$

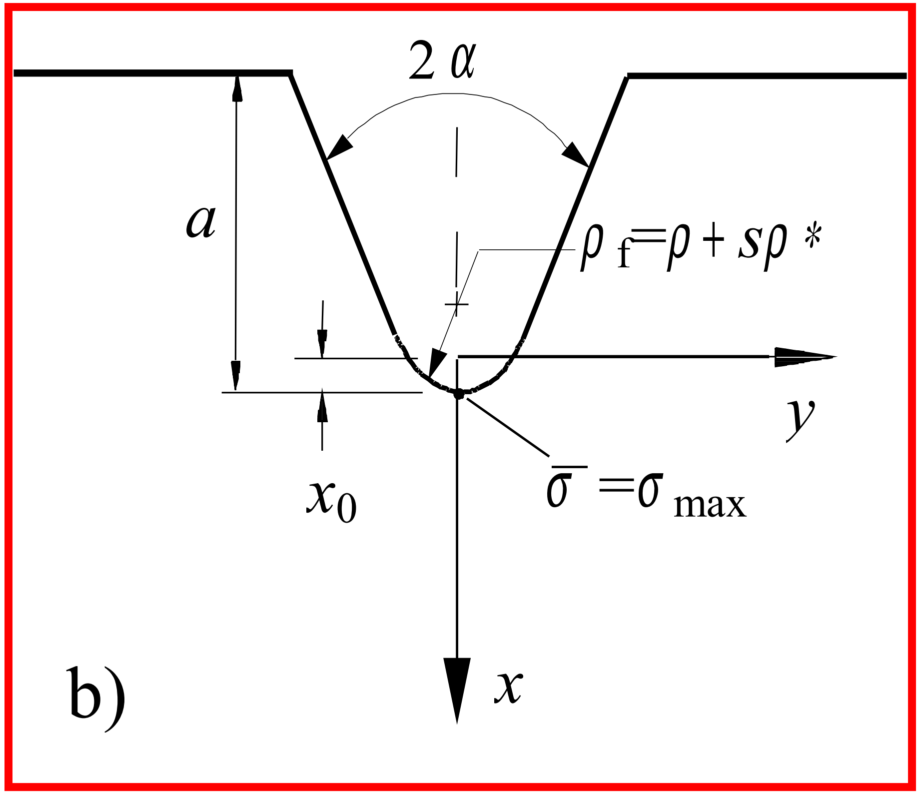
$$+\frac{r^{2\lambda-1}\rho^{2\mu}\left(A^2(\nu-1)+F^2(\nu-1)+2AF\nu\right)}{-1+2\lambda}+\frac{2Gr^{\lambda+\mu-1}\rho^{\lambda+\mu}\left(F(\nu-1)+\nu A\right)}{-1+\lambda+\mu}+$$

$$\left.+\frac{2Br^{\lambda+\mu-1}\rho^{\lambda+\mu}\left(A(\nu-1)+F\nu\right)}{-1+\lambda+\mu}\right]_{x_0}^{x_0+\rho^*}$$



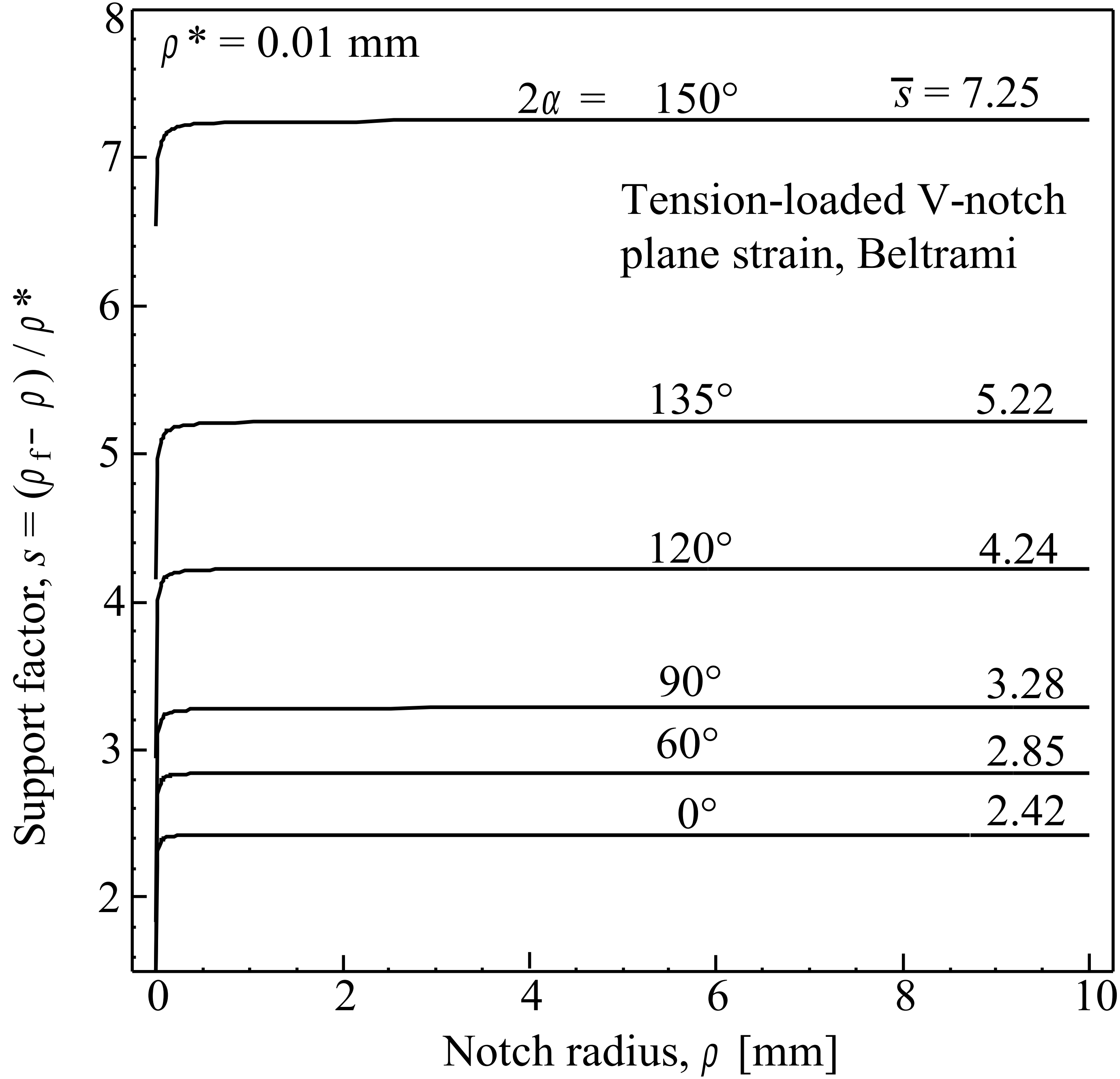
$$\bar{\sigma} = \frac{1}{\rho^*}\int_{x_0}^{x_0+\rho^*}\sigma_{th}\,\mathrm{d}x$$

$$
\begin{aligned}
\lim_{\substack{\rho^{*}\to 0\\ \nu=0.3}} \overline{\sigma}^{2} = {} & -1.3K_1^2\rho^{-2\mu}\Bigg(-\frac{1}{\left(\rho-\frac{\rho}{q}\right)^2}\Bigg(\frac{\left(-0.7A^2+0.6AF-0.7F^2\right)\rho^{2\mu}\left(\rho-\frac{\rho}{q}\right)^{2\lambda}}{2\lambda-1}+ \\
& +\frac{\left(-0.7B^2+0.6BG-0.7G^2\right)\rho^{2\lambda}\left(\rho-\frac{\rho}{q}\right)^{2\mu}}{-1+2\mu}+ \\
& +\frac{2B\left(-0.7A+0.3F\right)\rho^{\lambda+\mu}\left(\rho-\frac{\rho}{q}\right)^{\lambda+\mu}}{\lambda+\mu-1}+\frac{2G\left(0.3A-0.7F\right)\rho^{\lambda+\mu}\left(\rho-\frac{\rho}{q}\right)^{\lambda+\mu}}{\lambda+\mu-1}\Bigg)+ \\
& \frac{1}{\left(\rho-\frac{\rho}{q}\right)}\Bigg(\frac{2\left(-0.7A^2+0.6AF-0.7F^2\right)\lambda\rho^{2\mu}\left(\rho-\frac{\rho}{q}\right)^{2\lambda-1}}{2\lambda-1}+ \\
& +\frac{2B\left(-0.7A+0.3F\right)\left(\lambda+\mu\right)\rho^{\lambda+\mu}\left(\rho-\frac{\rho}{q}\right)^{\lambda+\mu-1}}{\lambda+\mu-1}+\frac{2G\left(0.3A-0.7F\right)\left(\lambda+\mu\right)\rho^{\lambda+\mu}\left(\rho-\frac{\rho}{q}\right)^{\lambda+\mu-1}}{\lambda+\mu-1} \\
& +\frac{2\left(-0.7B^2+0.6BG-0.7G^2\right)\mu\rho^{2\lambda}\left(\rho-\frac{\rho}{q}\right)^{2\mu-1}}{2\mu-1}\Bigg)\Bigg)
\end{aligned}
$$



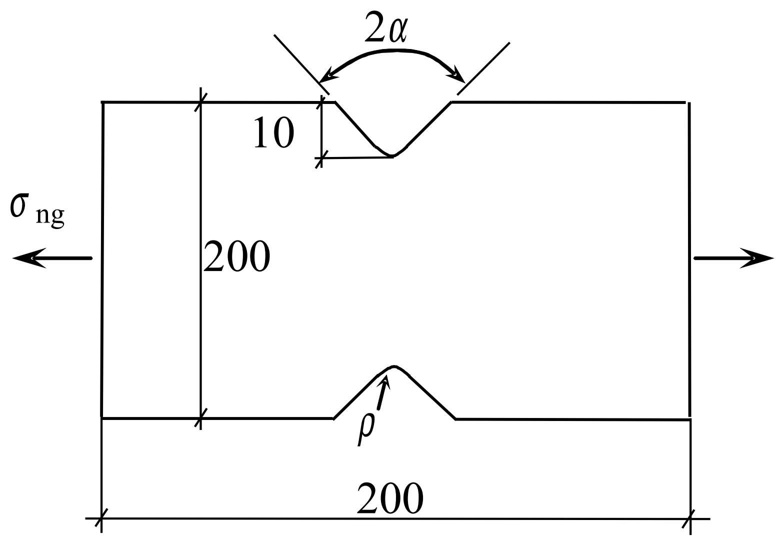
$$\rho_f(\rho,\rho^*) =$$

$$= \left(\frac{(\rho^* + 0.2\rho)^{0.3472}}{2.45723\rho^*} - \frac{\rho^{0.3472}}{16.74934\rho^*} - \frac{\rho^{0.8934}}{16.5645\rho^*(\rho^* + 0.2\rho)^{0.5462}} - \frac{\rho^{1.7868}}{367.22974\rho^*(\rho^* + 0.2\rho)^{1.4396}} \right)^{-1.5319}$$



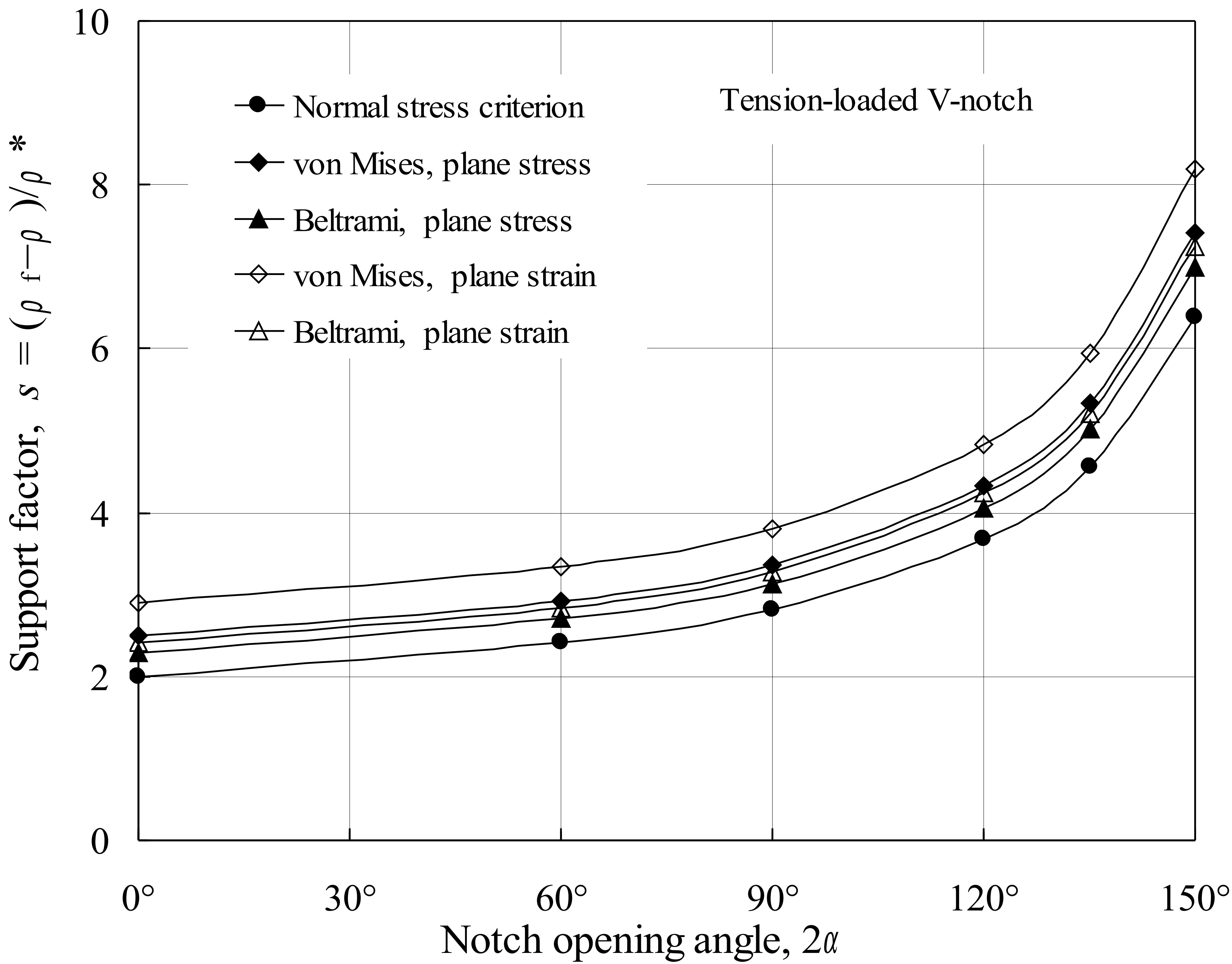
ρ* = 0.01 mm
2α = 150°
s̄ = 7.25
Tension-loaded V-notch
plane strain, Beltrami
135°
5.22
120°
4.24
90°
3.28
60°
2.85
0°
2.42
Support factor, s = (ρ_f − ρ) / ρ*
Notch radius, ρ [mm]
8
7
6
5
4
3
2
0
2
4
6
8
10

VALORI DI "s" PER DIVERSI ANGOLI DI APERTURA

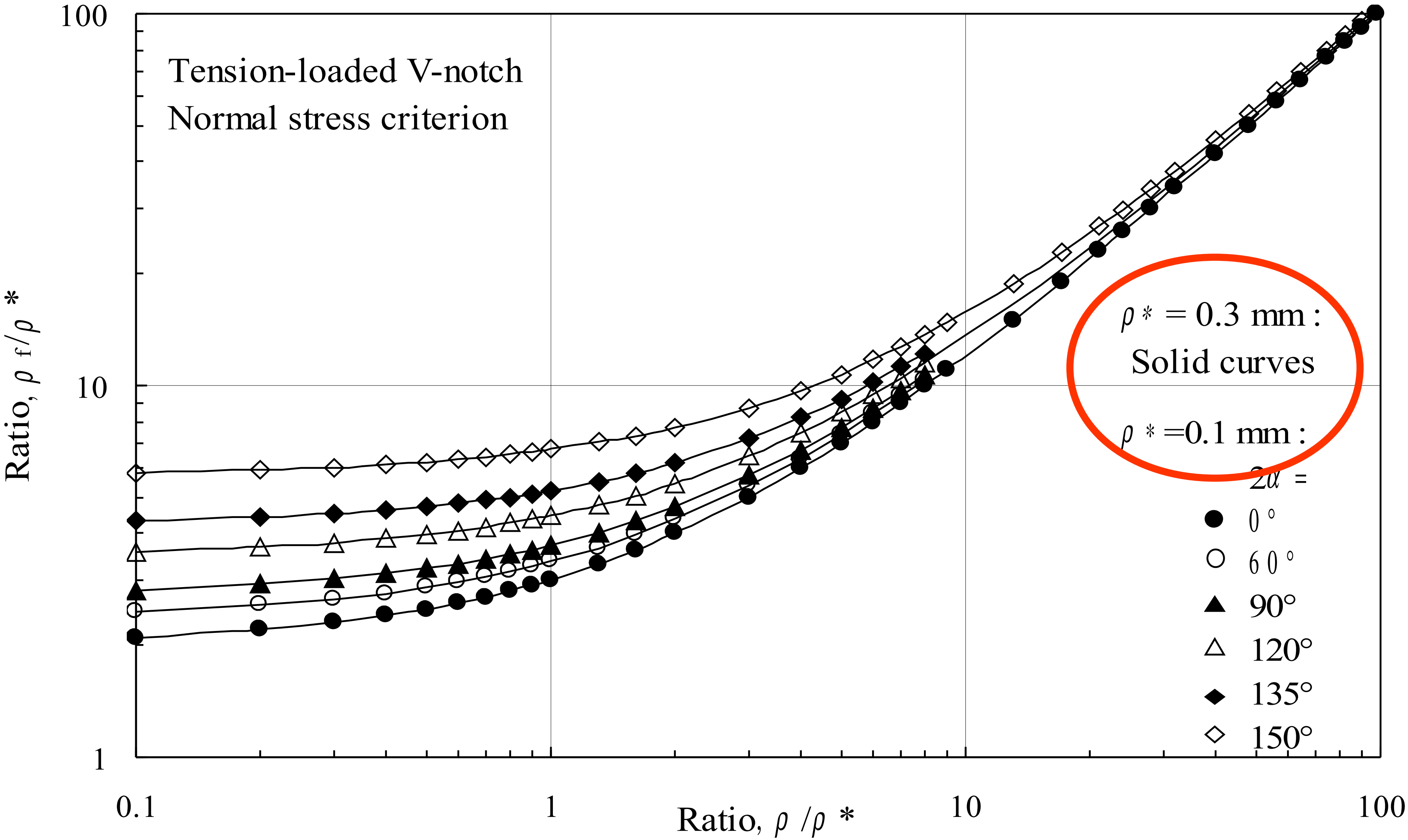


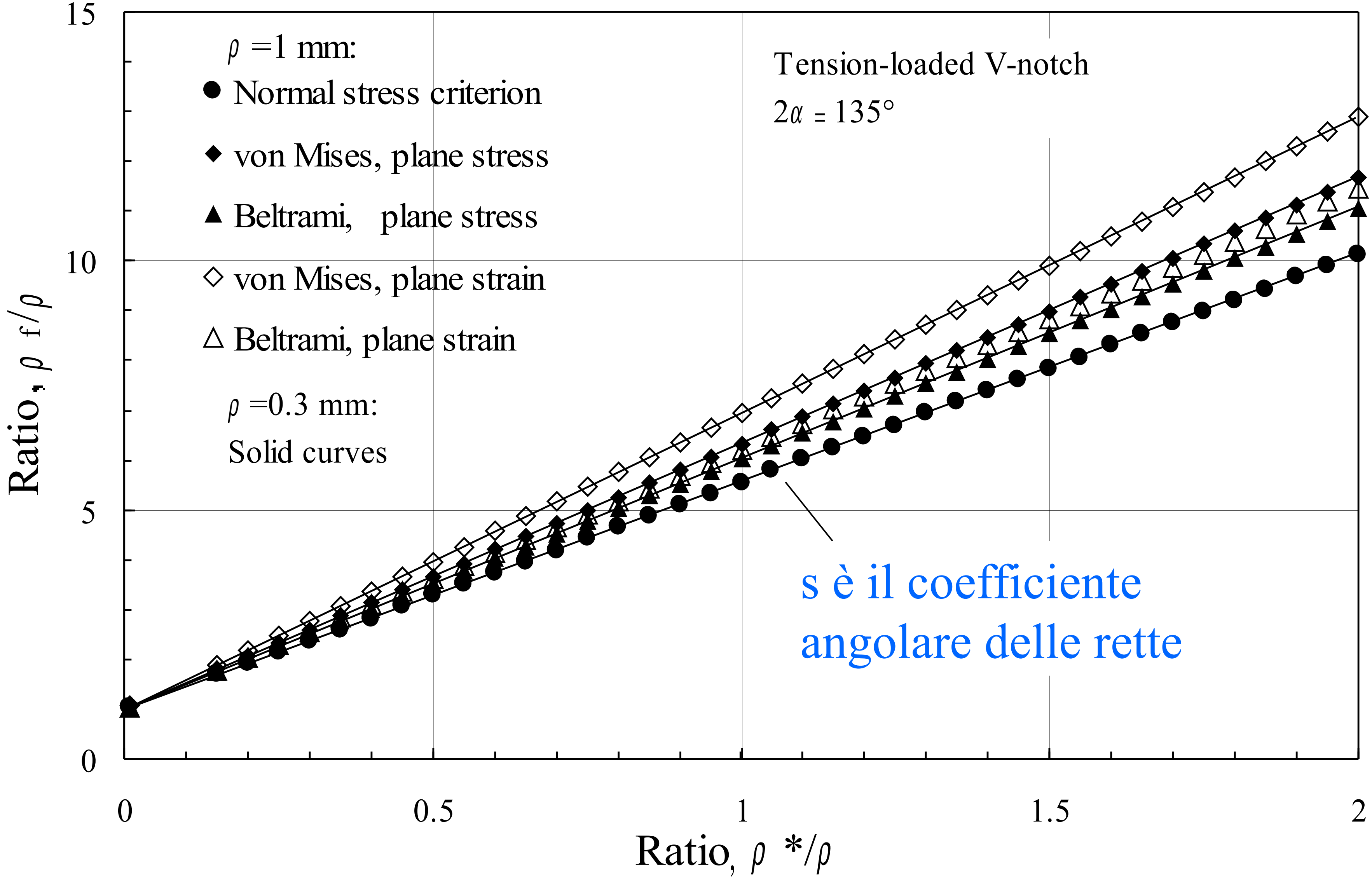
2α	Neuber Normal stress	Filippi, Lazzarin and Tovo Normal stress	von Mises plane stress	von Mises plane strain	Beltrami plane stress	Beltrami plane strain
0°	2.00	2.00	2.50	2.90	2.30	2.42
60°	2.36	2.41	2.90	3.33	2.72	2.85
90°	2.72	2.81	3.37	3.80	3.14	3.28
120°	3.47	3.67	4.32	4.84	4.06	4.24
135°	4.21	4.56	5.33	5.94	5.02	5.22
150°	5.73	6.38	7.41	8.20	6.99	7.25

$$\rho_f = 2.50 \times 0.4 = 1 \text{ mm}$$



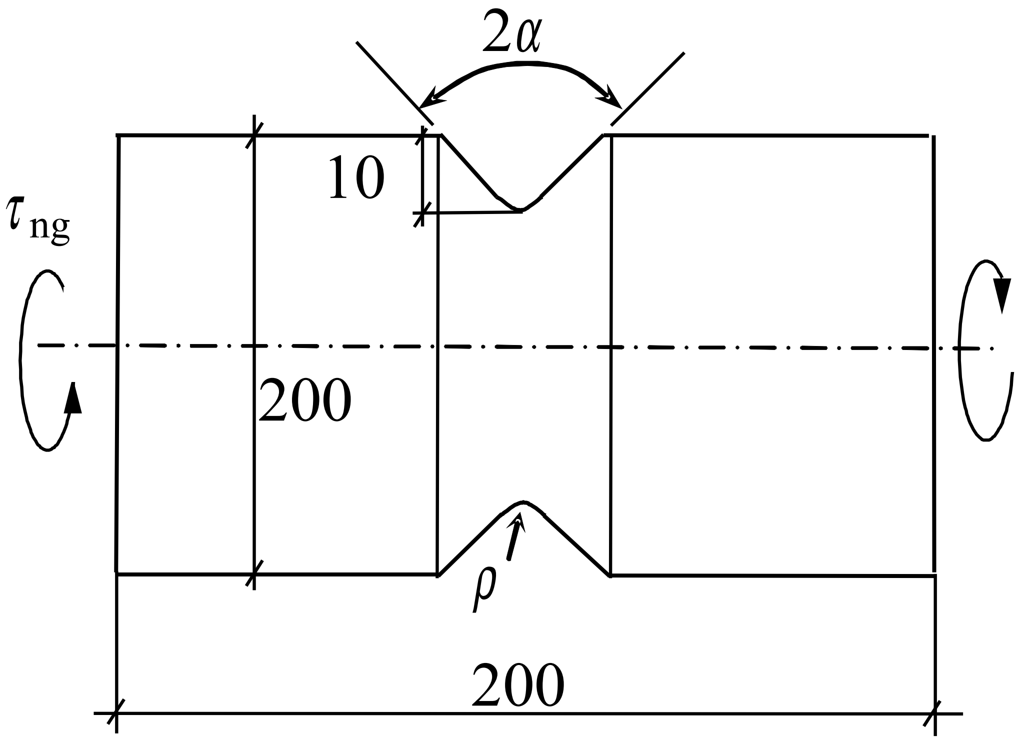
Normal stress criterion
von Mises, plane stress
Beltrami, plane stress
von Mises, plane strain
Beltrami, plane strain
Tension-loaded V-notch
Support factor, s = (ρ f−ρ)/ρ *
Notch opening angle, 2α
0
2
4
6
8
10
0°
30°
60°
90°
120°
150°


Tension-loaded V-notch
Normal stress criterion
ρ* = 0.3 mm :
Solid curves
ρ* =0.1 mm :
2α =
0°
60°
90°
120°
135°
150°
100
10
1
0.1
1
10
100
Ratio, ρ f/ρ*
Ratio, ρ/ρ*

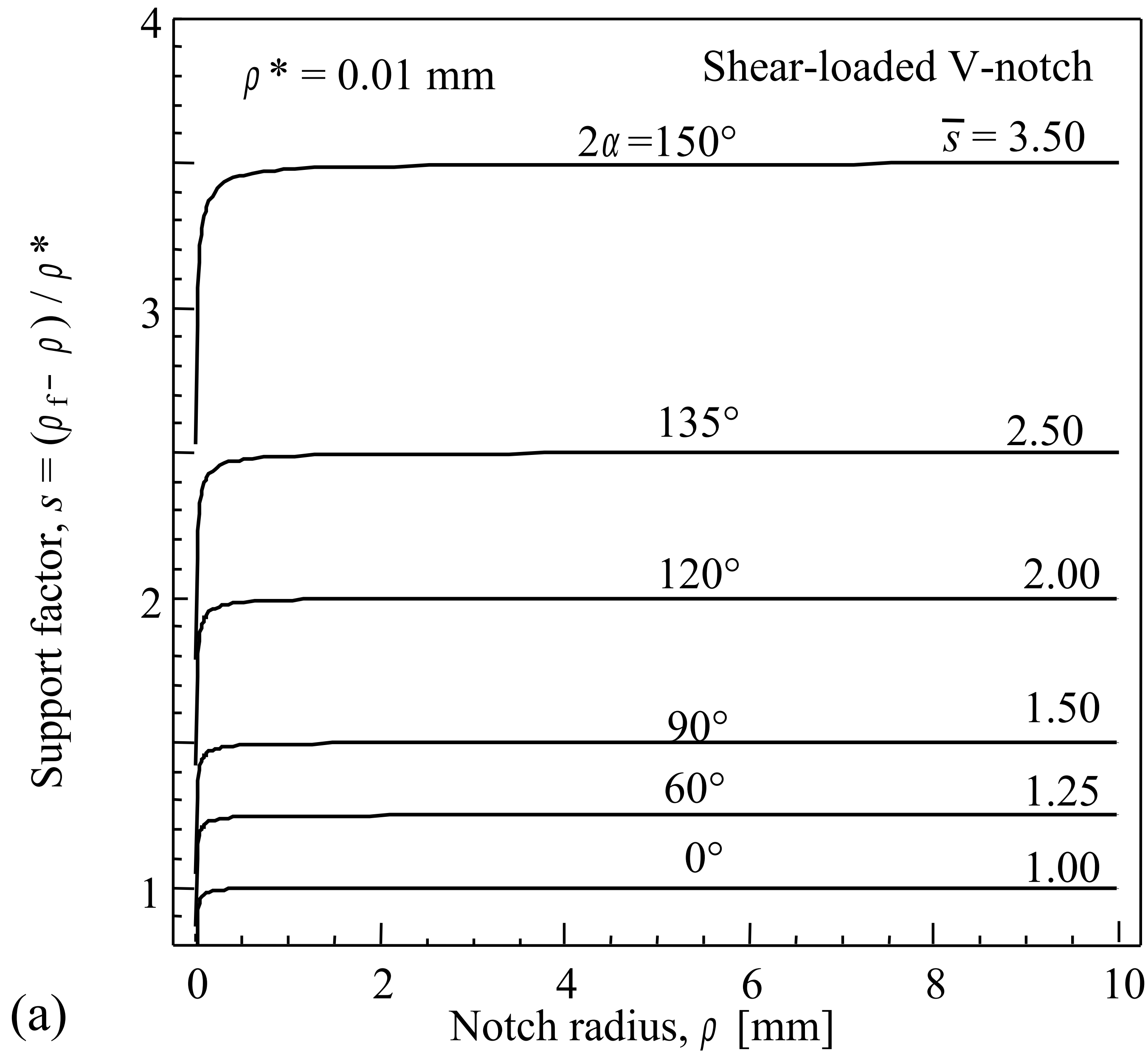


ρ =1 mm:
Normal stress criterion
von Mises, plane stress
Beltrami, plane stress
von Mises, plane strain
Beltrami, plane strain
ρ =0.3 mm:
Solid curves
Tension-loaded V-notch
2α = 135°
Ratio, ρ f/ρ
Ratio, ρ */ρ
0
5
10
15
0
0.5
1
1.5
2
s è il coefficiente angolare delle rette

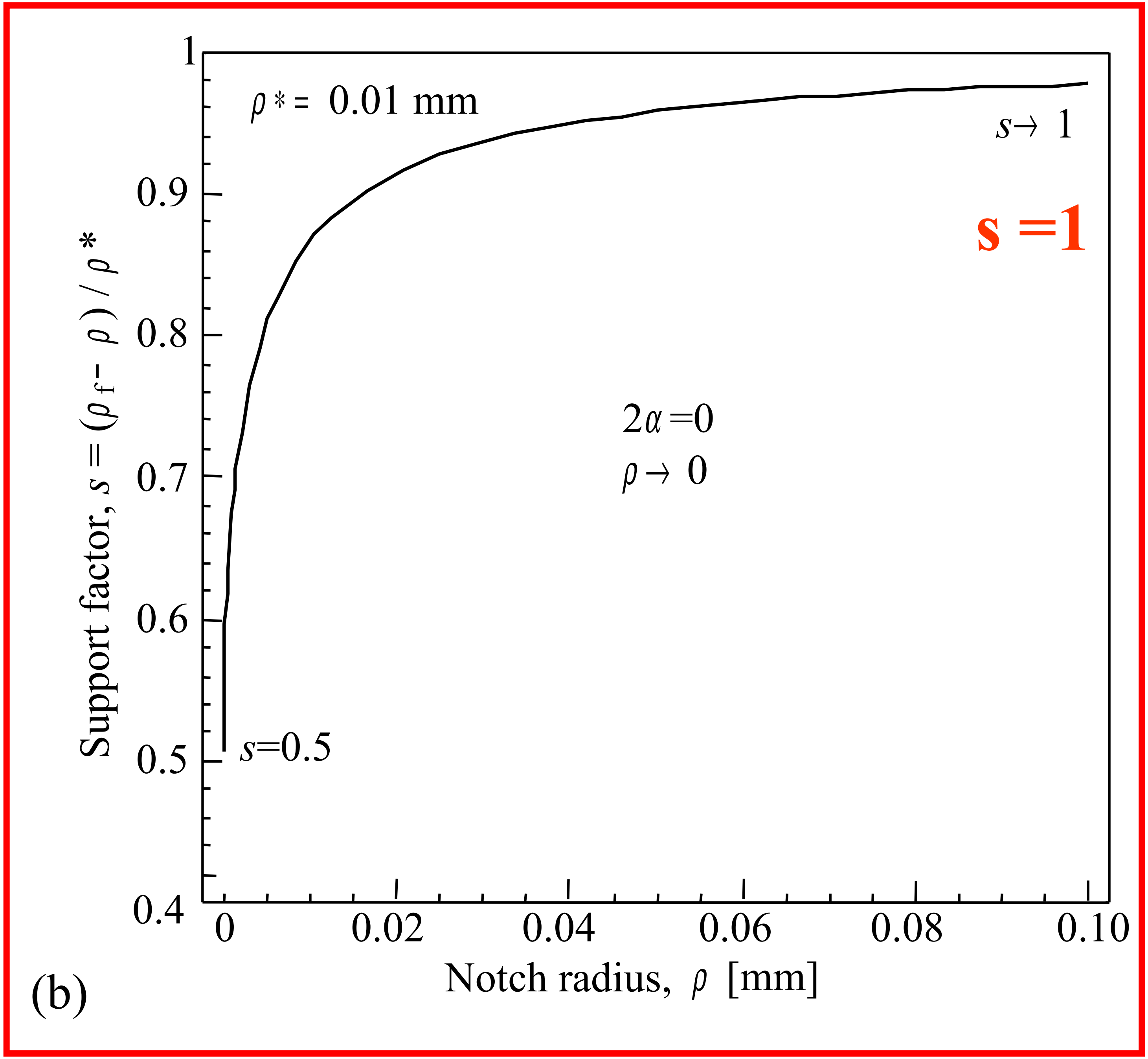
CASO DELLA TORSIONE



s=0.5 o s=1 ??

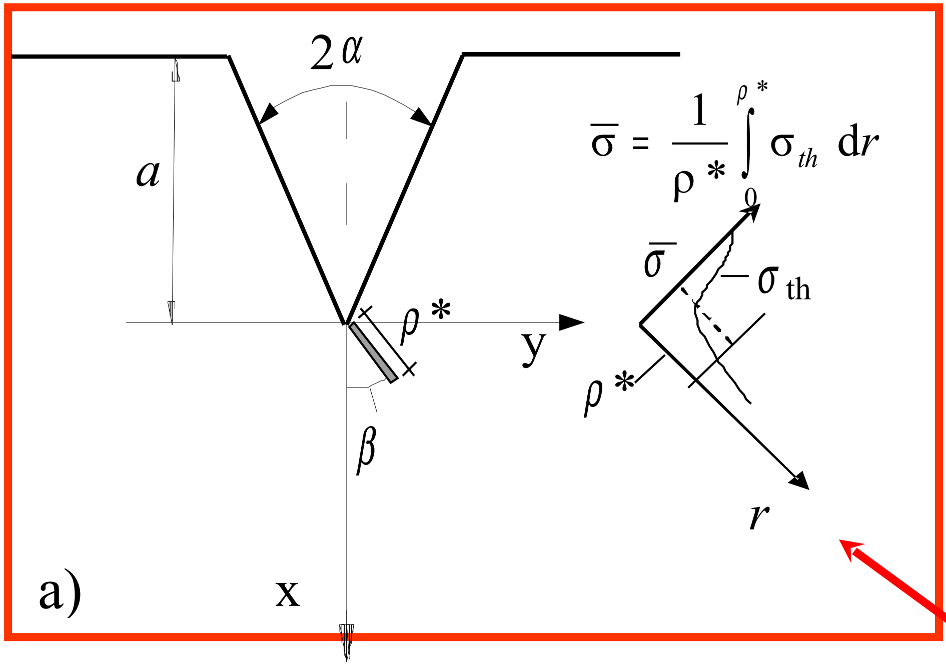


ρ* = 0.01 mm
Shear-loaded V-notch
2α =150°
s̄ = 3.50
135°
2.50
120°
2.00
90°
1.50
60°
1.25
0°
1.00
Support factor, s = (ρ f − ρ) / ρ*
Notch radius, ρ [mm]
4
3
2
1
0
2
4
6
8
10
(a)

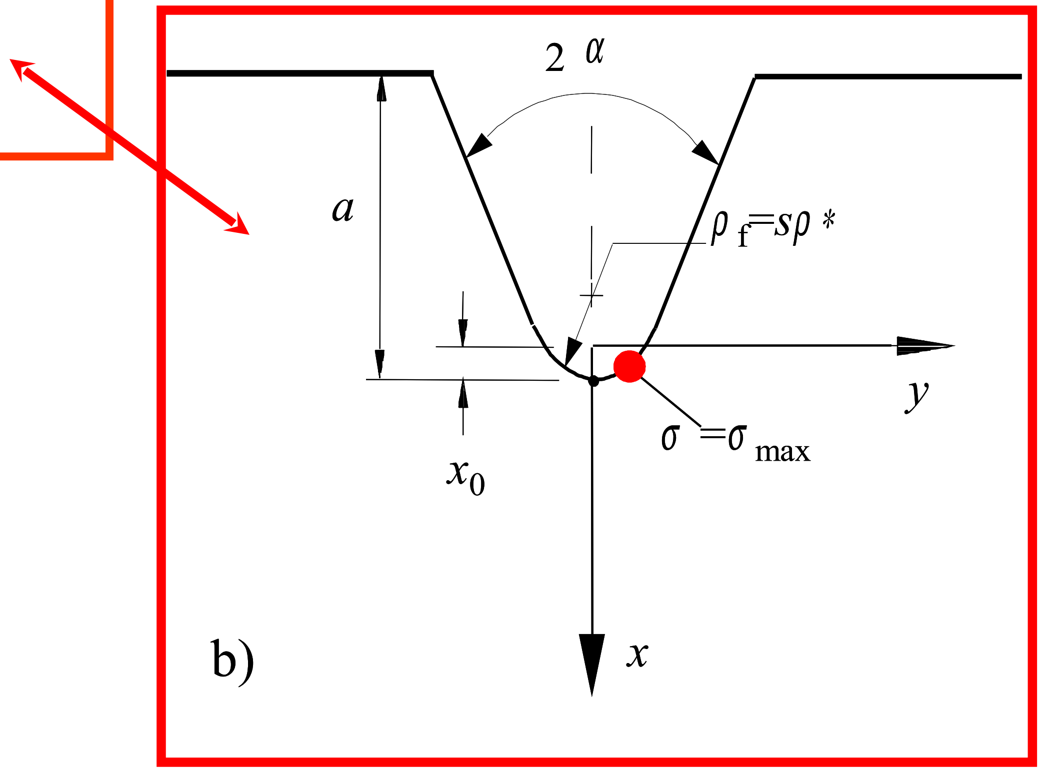


ρ* = 0.01 mm
s→ 1
s =1
2α =0
ρ → 0
s=0.5
Support factor, s = (ρ f − ρ) / ρ*
Notch radius, ρ [mm]
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.02
0.04
0.06
0.08
0.10
(b)

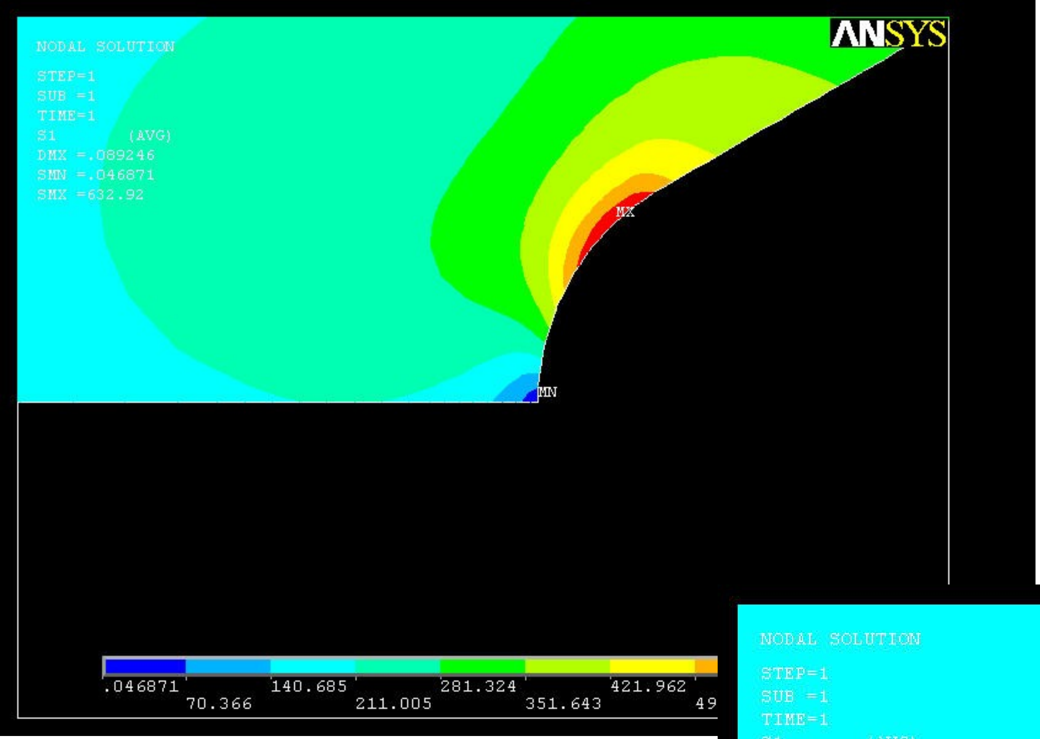
MODO II

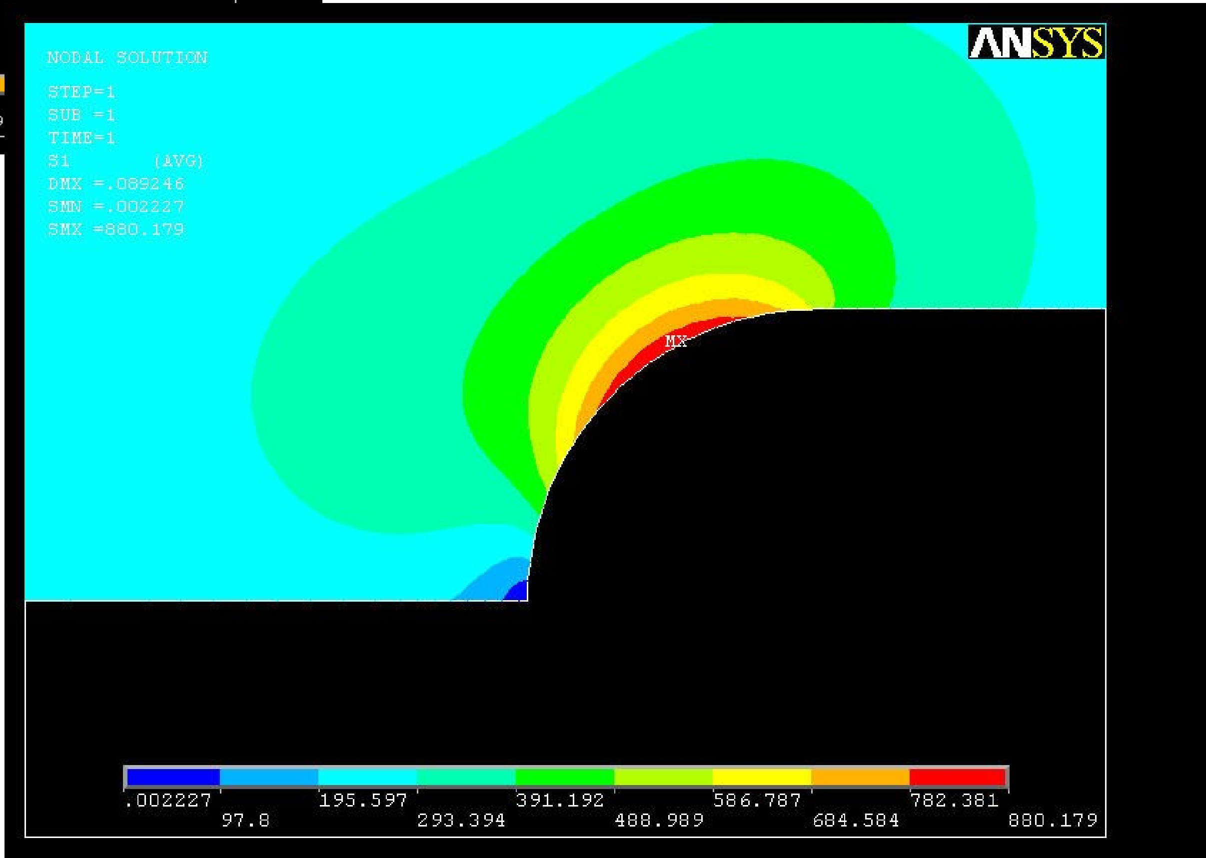


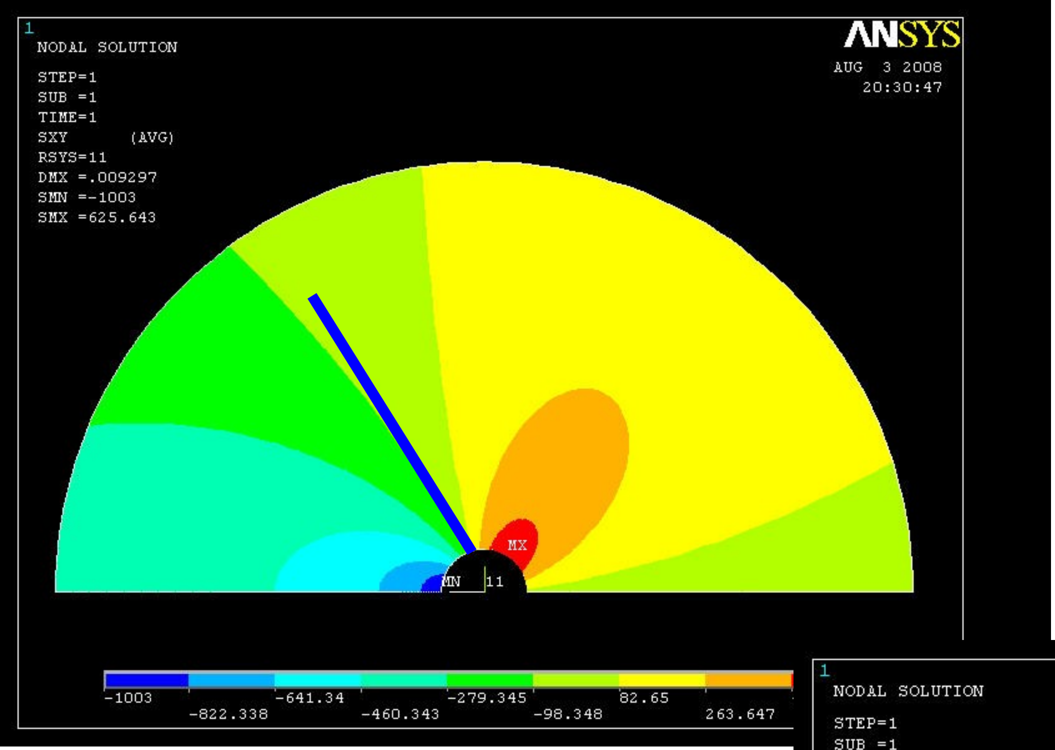
2α
a
$\bar{\sigma} = \frac{1}{\rho^*}\int_0^{\rho^*} \sigma_{th}\, dr$
$\bar{\sigma}$
σ_{th}
ρ*
y
ρ*
β
r
a)
x

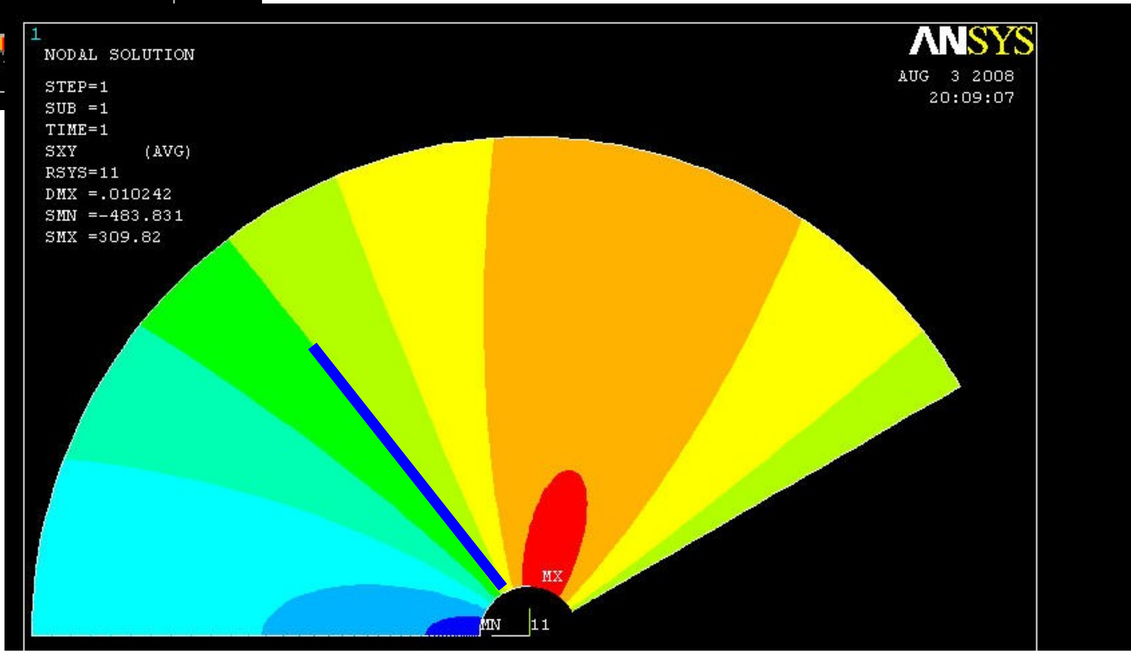


2 α
a
$\rho_f = s\rho^*$
y
x_0
$\sigma = \sigma_{max}$
b)
x


NODAL SOLUTION
STEP=1
SUB =1
TIME=1
S1 (AVG)
DMX =.089246
SMN =.046871
SMX =632.92
MX
MN
.046871
70.366
140.685
211.005
281.324
351.643
421.962


NODAL SOLUTION
STEP=1
SUB =1
TIME=1
S1 (AVG)
DMX =.089246
SMN =.002227
SMX =880.179
MX
.002227
97.8
195.597
293.394
391.192
488.989
586.787
684.584
782.381
880.179

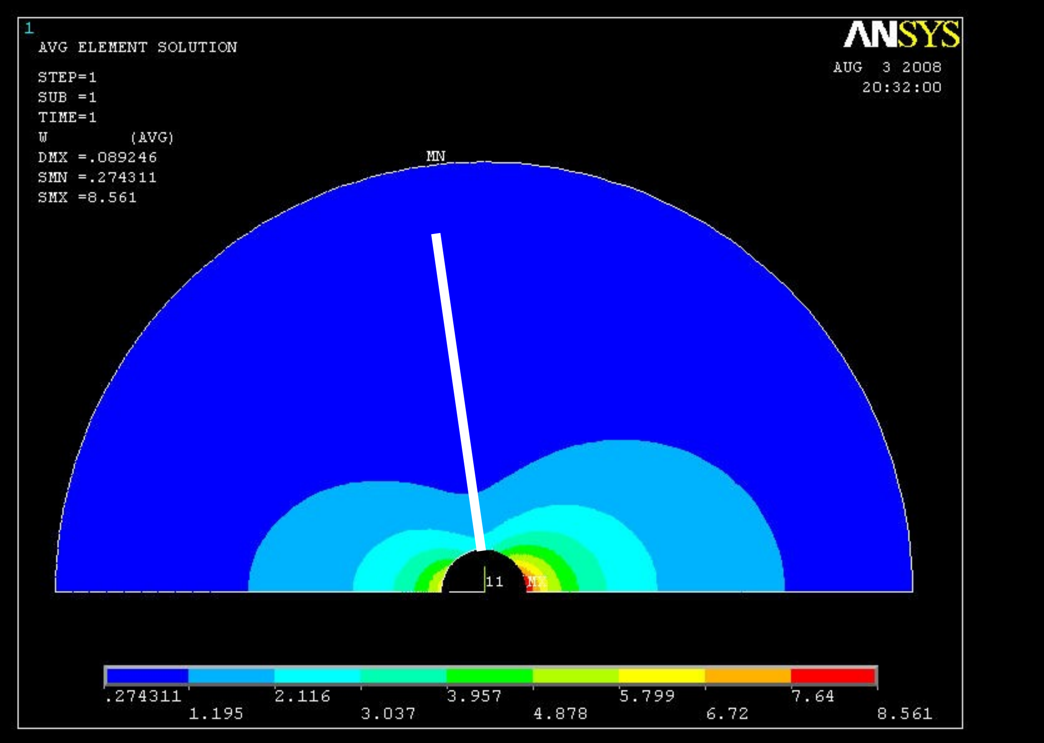




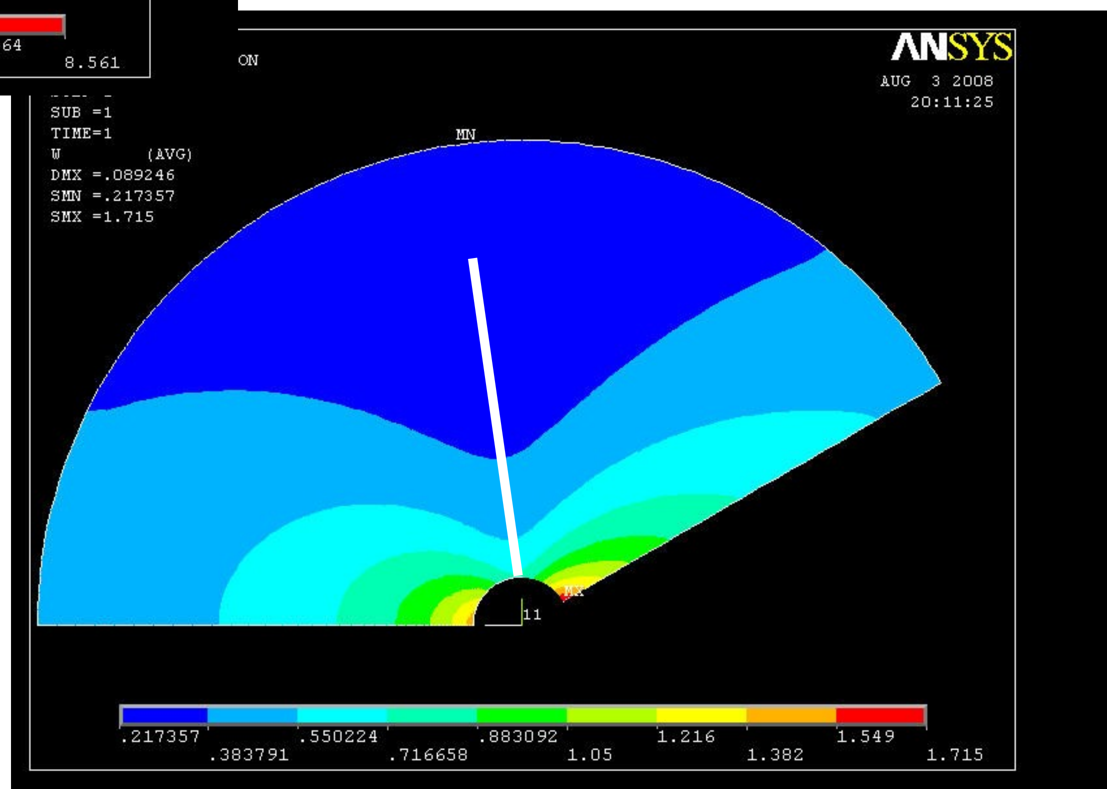
CRITERIO DI ERDOGAN-SIH

Fatigue cracks emanating from sharp notches in high-strength aluminium alloys: The effect of loading direction, kinking, notch geometry and microstructure

M. Benedetti , M. Beghini , V. Fontanari, B. Monelli, in press Int J Fatigue



CRITERIO DI SIH



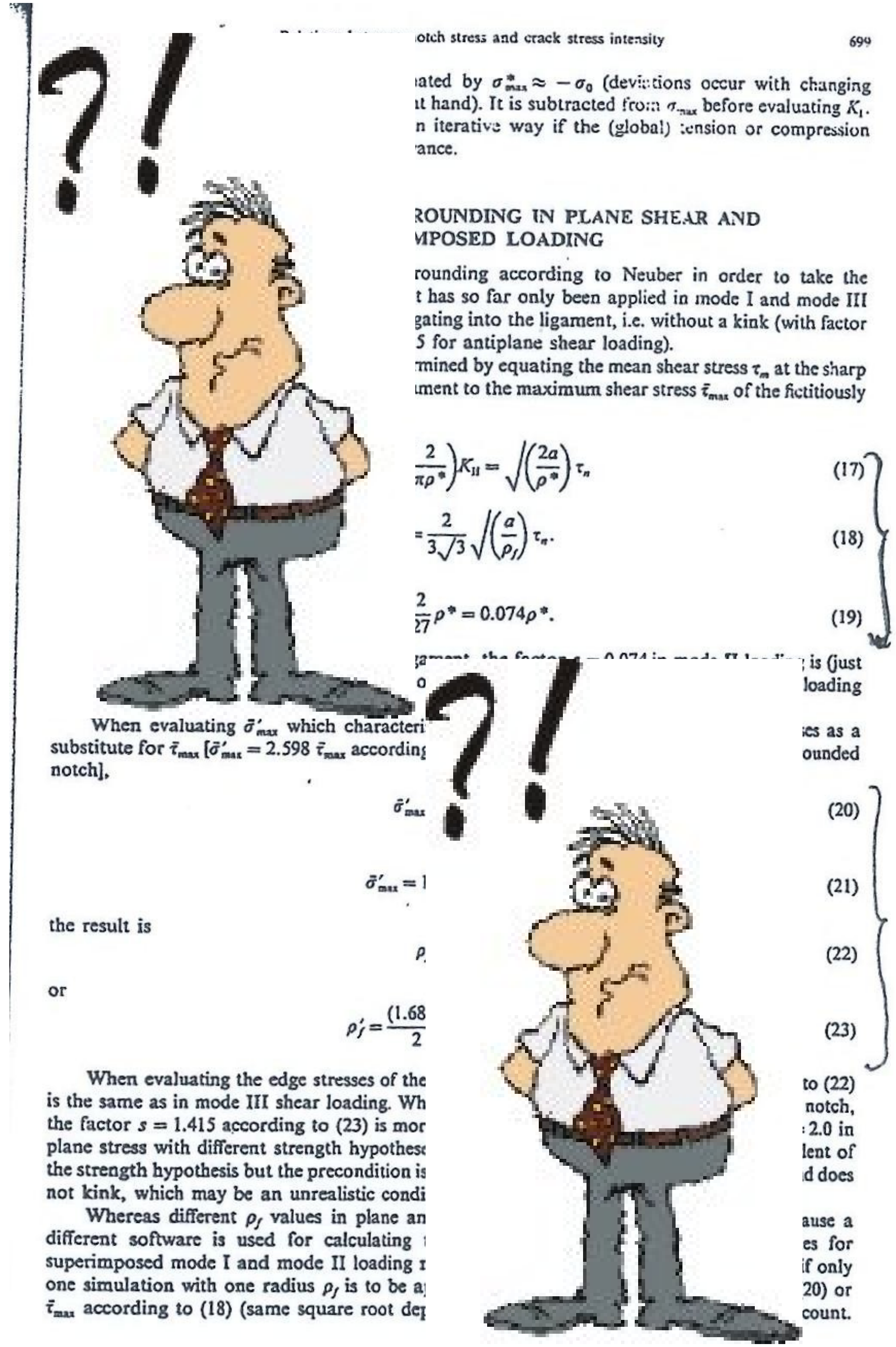
s=0.074 (caso dell’ellisse)

o s=0.5 (caso dell’ellisse)

o s= 1.415 (caso del “circular notch”) ???????

Radaj e Zhang 1993, Engineering Fracture Mechanics 44, 691-704

Radaj D., Sonsino C.M. and Fricke W. *Fatigue Assessment of Welded Joints by Local Approaches*. Woodhead Publishing, Cambridge, 2006 (2nd edn).



...otch stress and crack stress intensity 699

...ated by $\sigma^*_{max} \approx -\sigma_0$ (deviations occur with changing ...t hand). It is subtracted from σ_{max} before evaluating K_I. ...n iterative way if the (global) tension or compression ...ance.

...ROUNDING IN PLANE SHEAR AND ...MPOSED LOADING

...rounding according to Neuber in order to take the ...t has so far only been applied in mode I and mode III ...gating into the ligament, i.e. without a kink (with factor ...5 for antiplane shear loading).
...mined by equating the mean shear stress τ_m at the sharp ...ment to the maximum shear stress $\bar{\tau}_{max}$ of the fictitiously

$$\ldots \frac{2}{\pi\rho^*}\Big) K_{II} = \sqrt{\left(\frac{2a}{\rho^*}\right)}\,\tau_n \quad (17)$$

$$= \frac{2}{3\sqrt{3}}\sqrt{\left(\frac{a}{\rho_f}\right)}\,\tau_n. \quad (18)$$

$$\frac{2}{27}\rho^* = 0.074\rho^*. \quad (19)$$

... is (just ... loading

When evaluating $\bar{\sigma}'_{max}$ which characteri... substitute for $\bar{\tau}_{max}$ [$\bar{\sigma}'_{max} = 2.598\,\bar{\tau}_{max}$ according... notch].

...es as a ...ounded

$\bar{\sigma}'_{max}$ ... (20)

$\bar{\sigma}'_{max} = 1$... (21)

the result is

ρ... (22)

or

$\rho'_f = \frac{(1.68}{2}$... (23)

When evaluating the edge stresses of the... is the same as in mode III shear loading. Wh... the factor $s = 1.415$ according to (23) is mor... plane stress with different strength hypothes... the strength hypothesis but the precondition is... not kink, which may be an unrealistic condi...
Whereas different ρ_f values in plane an... different software is used for calculating ... superimposed mode I and mode II loading ... one simulation with one radius ρ_f is to be a... $\bar{\tau}_{max}$ according to (18) (same square root dep...

... to (22) ... notch, ... 2.0 in ... lent of ... d does ... ause a ... es for ... f only ... 20) or ... count.

MODO II

CRITERIO DI ERDOGAN-SIH

2α	Normal stress	von Mises plane stress	von Mises plane strain	Beltrami plane stress	Beltrami plane strain
0°	2.47	2.52	3.22	2.52	2.76
30°	4.00	3.20	3.77	3.45	3.72
45°	5.90	3.94	4.55	4.43	4.72
60°	10.90	5.60	6.48	6.68	7.15

CRITERIO DI SIH

2α	Normal Stress Plane stress	Normal stress Plane strain	von Mises plane stress	von Mises plane strain	Beltrami plane stress	Beltrami plane strain
0°	2.46	2.45	2.73	3.95	2.60	2.98
30°	3.90	3.85	3.80	5.20	3.83	4.33
45°	5.59	5.40	5.02	6.75	5.20	5.88
60°	10.00	9.46	8.05	11.55	8.62	9.95

	s	$\rho^* = 0.01$ mm				$\rho^* = 0.05$ mm				$\rho^* = 0.1$mm			
		ρ_f [mm]	$K_t(\rho_f)$	$\overline{K}_t$	Δ %	ρ_f [mm]	$K_t(\rho_f)$	$\overline{K}_t$	Δ %	ρ_f [mm]	$K_t(\rho_f)$	$\overline{K}_t$	Δ %
$2\alpha=0°$													
NS	2.47	0.02470	51.27	51.60	-0.64	0.12350	23.13	23.07	0.26	0.24700	16.4	16.31	0.55
vM, ps	2.52	0.02520	50.70	51.60	-1.74	0.12600	23.02	23.07	-0.22	0.25200	15.93	16.31	-2.33
vM, pn	3.22	0.03220	45.00	45.86	-1.88	0.16100	20.48	20.51	-0.15	0.32200	14.72	14.5	1.52
B, ps	2.52	0.02520	50.70	51.60	-1.74	0.12600	23.02	23.07	-0.22	0.25200	15.93	16.31	-2.33
B, pn	2.76	0.02760	48.45	49.21	-1.54	0.13800	22.04	22.01	0.14	0.27600	15.73	15.56	1.09
$2\alpha=30°$													
NS	4.00	0.04000	27.63	27.95	-1.14	0.20000	14.69	14.6337	0.38	0.40000	11.19	11.0749	1.04
vM, ps	3.20	0.03200	30.22	30.63	-1.33	0.16000	15.96	16.0378	-0.49	0.32000	12.11	12.1375	-0.23
vM, pn	3.77	0.03770	28.32	28.73	-1.44	0.18850	15.04	15.045	-0.03	0.37700	11.45	11.3862	0.56
B, ps	3.45	0.03450	29.40	29.74	-1.15	0.17250	15.51	15.5727	-0.40	0.34500	11.91	11.7855	1.06
B, pn	3.72	0.03720	28.49	28.92	-1.48	0.18600	15.11	15.1421	-0.21	0.37200	11.48	11.4597	0.18
$2\alpha=45°$													
NS	5.90	0.05900	18.48	18.66	-0.99	0.29500	10.79	10.7986	-0.08	0.59000	8.61	8.53132	0.92
vM, ps	3.94	0.03940	21.13	21.31	-0.84	0.19700	12.31	12.3284	-0.15	0.39400	9.8	9.73993	0.62
vM, pn	4.55	0.04550	20.13	20.30	-0.86	0.22750	11.73	11.7469	-0.14	0.45500	9.37	9.28055	0.96
B, ps	4.43	0.04430	20.31	20.50	-0.91	0.22150	11.84	11.858	-0.15	0.44300	9.45	9.36831	0.87
B, pn	4.72	0.04720	19.92	20.05	-0.67	0.23600	11.59	11.6023	-0.11	0.47200	9.26	9.16627	1.02
$2\alpha=60°$													
NS	10.90	0.10900	11.31	11.49	-1.57	0.54500	7.42	7.45	-0.40	1.09000	6.26	6.18	1.29
vM, ps	5.60	0.05600	13.50	13.58	-0.59	0.28000	8.82	8.81	0.11	0.56000	7.37	7.31	0.82
vM, pn	6.48	0.06480	13.02	13.07	-0.38	0.32400	8.48	8.48	0.00	0.64800	7.1	7.04	0.85
B, ps	6.68	0.06680	12.93	12.97	-0.31	0.33400	8.44	8.41314	0.32	0.66800	7.06	6.98	1.15
B, pn	7.15	0.07150	12.62	12.74	-0.94	0.35750	8.27	8.27	0.00	0.71500	6.9	6.86	0.58

		$\rho^* = 0.01$ mm				$\rho^* = 0.05$ mm				$\rho^* = 0.1$mm			
	s	ρ_f[mm]	$K_t(\rho_f)$	$\overline{K}_t$	Δ %	ρ_f[mm]	$K_t(\rho_f)$	$\overline{K}_t$	Δ %	ρ_f[mm]	$K_t(\rho_f)$	$\overline{K}_t$	Δ %
<u>2α=0°</u>													
NS, ps	2.46	0.02460	51.26	51.84	-1.12	0.123000	23.39	23.185	0.88	0.24600	16.37	16.34	0.18
NS, pn	2.45	0.02450	51.40	52.34	-1.80	0.122500	23.34	23.408	-0.29	0.24500	16.64	16.5519	0.53
vM, ps	2.73	0.02730	48.72	49.61	-1.79	0.136500	22.18	22.19	-0.05	0.27300	15.8	15.69	0.70
vM, pn	3.95	0.03950	40.23	41.42	-2.87	0.197500	18.57	18.5235	0.25	0.39500	13.32	13.0981	1.69
B, ps	2.60	0.02600	50.01	50.69	-1.35	0.130000	22.66	22.67	-0.04	0.26000	16.15	16.0305	0.75
B, pn	2.98	0.02980	46.75	47.61	-1.80	0.149000	21.26	21.2914	-0.15	0.29800	15.27	15.0553	1.43
<u>2α=30°</u>													
NS, ps	3.90	0.03900	27.93	28.31	-1.33	0.195000	14.84	14.82	0.12	0.39000	11.3	11.22	0.74
NS, pn	3.85	0.03850	28.07	28.63	-1.94	0.192500	14.91	14.99	-0.53	0.38500	11.36	11.34	0.14
vM, ps	3.80	0.03800	28.22	28.64	-1.45	0.190000	14.99	14.99	-0.03	0.38000	11.4	11.35	0.46
vM, pn	5.20	0.05200	24.93	25.34	-1.60	0.260000	13.18	13.27	-0.65	0.52000	10.16	10.04	1.19
B, ps	3.83	0.03830	28.13	28.55	-1.48	0.191500	14.94	14.95	-0.07	0.38300	11.37	11.31	0.49
B, pn	4.33	0.04330	26.87	27.25	-1.41	0.216500	14.25	14.27	-0.14	0.43300	10.86	10.80	0.56
<u>2α=45°</u>													
NS, ps	5.59	0.05590	18.82	18.97	-0.79	0.279500	10.98	10.98	0.04	0.55900	8.76	8.67	1.03
NS, pn	5.40	0.05400	18.98	19.20	-1.17	0.270000	11.06	11.11	-0.46	0.54000	8.85	8.78	0.82
vM, ps	5.02	0.05020	19.45	19.66	-1.05	0.251000	11.39	11.37	0.16	0.50200	9.08	8.98	1.07
vM, pn	6.75	0.06750	17.64	17.70	-0.34	0.337500	10.18	10.24	-0.60	0.67500	8.25	8.09	1.97
B, ps	5.20	0.05200	19.21	19.43	-1.15	0.260000	11.26	11.24	0.14	0.52000	8.96	8.88	0.86
B, pn	5.88	0.05880	18.50	18.65	-0.83	0.294000	10.8	10.79	0.07	0.58800	8.62	8.53	1.10
<u>2α=60°</u>													
NS, ps	10.00	0.10000	11.52	11.68	-1.40	0.500000	7.59	7.58	0.16	1.00000	6.32	6.29	0.49
NS, pn	9.46	0.09460	11.68	11.87	-1.60	0.473000	7.7	7.70	0.05	0.94600	6.48	6.39	1.46
vM, ps	8.05	0.08050	12.22	12.36	-1.11	0.402500	8.02	8.02	0.06	0.80500	6.74	6.65	1.33
vM, pn	11.55	0.11550	11.09	11.26	-1.49	0.577500	7.31	7.30	0.11	1.15500	6.16	6.06	1.66
B, ps	8.62	0.08620	12.01	12.15	-1.14	0.431000	7.86	7.88	-0.24	0.86200	6.62	6.54	1.24
B, pn	9.95	0.09950	11.57	11.71	-1.15	0.497500	7.6	7.59	0.11	0.99500	6.4	6.30	1.58

Tecniche di Giunzione

16-17 Aprile, Reggio Emilia

"NOTCH ROUNDING APPROACH" APPLICATO A MODO I E III

POSSIBILE ESTENSIONE AL MODO II

UNIVERSITA' DI PADOVA

DIPARTIMENTO DI TECNICA E GESTIONE DEI SISTEMI INDUSTRIALI

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