5-35 NORTON

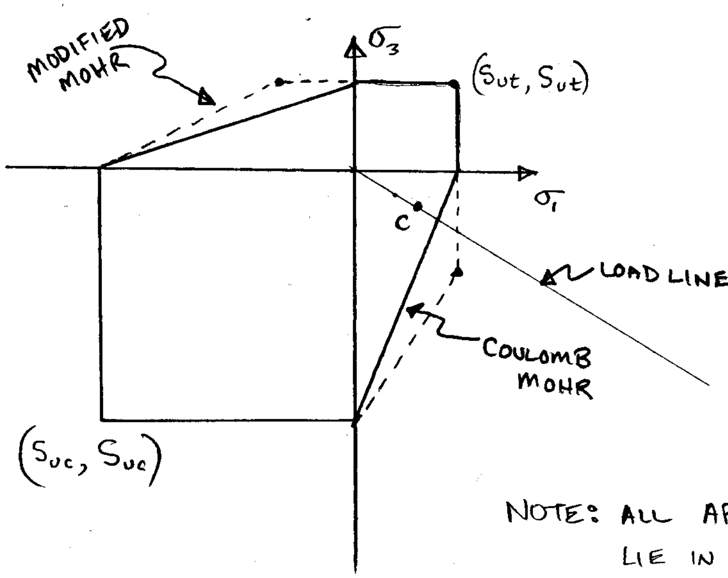
- USE STRESSES CALCULATED FROM 5-33
  COMPUTE PRINCIPLE STRESSES

$$\sigma_{1,3} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x + \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$\sigma_2 = 0$ (2-DIMENSIONAL STRESS STATE)

(CAN ALSO USE MOHR'S CIRCLE)

CONSIDER FAILURE ENVELOPES SHOWN BELOW... FIG 5-9 TEXT



POINT C IS APPLIED STATE OF STRESS.
THE FACTOR OF SAFETY IS FOUND AS FOLLOWS...

$$N = \frac{\left(\text{DISTANCE FROM ORIGIN TO FAILURE ENVELOPE ALONG LOAD LINE}\right)}{\left(\text{DISTANCE TO POINT C FROM ORIGIN ALONG LOAD LINE}\right)}$$

NOTE: ALL APPLIED STATES OF STRESS FOR POINTS A & B LIE IN 4TH QUADRANT AS SHOWN. (TORSION)

USING GEOMETRY,

LOAD LINE EQN IS $y = \frac{\sigma_3}{\sigma_1} x$

COULOMB-MOHR ENVELOPE LINE (FOURTH QUADRANT) IS $y = \frac{S_{uc}}{S_{ut}} x - S_{uc}$

X INTERSECTION AT $x = \frac{S_{uc}}{\left(\frac{S_{uc}}{S_{ut}} - \frac{\sigma_3}{\sigma_1}\right)}$

FOS IS THE RATIO OF X AT INTERSECTION AND σ_1

$$N = \frac{1}{\left(\frac{\sigma_1}{S_{ut}} - \frac{\sigma_3}{S_{uc}}\right)}$$

SIMILAR CALCULATIONS CAN BE MADE FOR THE MODIFIED MOHR CASE.
SEE ALSO p 305 EQN 5.12 a & b

5-35 NORTON <u>CONT'D</u>

- HAND CALCULATIONS FOR ROW A: (POINT A)

USE STRESSES CALCULATED FROM 5-33

$$\sigma_{1,3} = \frac{8.38+0}{2} \pm \sqrt{\left(\frac{8.38+0}{2}\right)^2 + 16.76^2} = 4.19 \pm 17.28$$

$\sigma_1 = 21.5$ MPa

$\sigma_3 = -13.1$ MPa

COULOMB-MOHR:

$$N = \frac{1}{\left(\frac{\sigma_1}{S_{ut}} - \frac{\sigma_3}{S_{uc}}\right)} = \frac{1}{\left(\frac{21.5}{350} + \frac{13.1}{1000}\right)} = 13.4$$

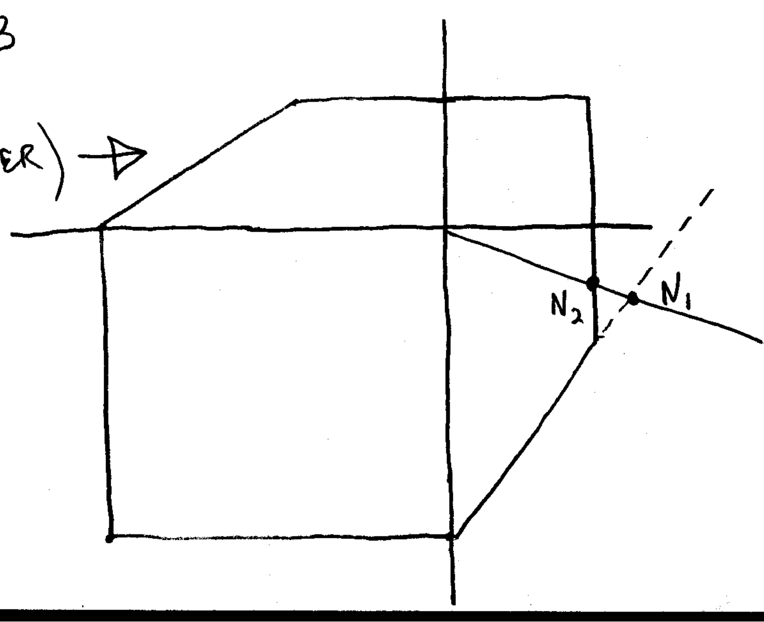
- MODIFIED-MOHR:

$$\cancel{N_1 = \frac{S_{ut} S_{uc}}{S_{uc}\sigma_1 - S_{ut}(\sigma_1 + \sigma_3)} = \frac{350(1000)}{1000(21.5) - 350(21.5-13.1)}}$$

$$\cancel{= 18.9}$$

$$N_2 = \frac{350}{21.5} = 16.3$$

(USE SMALLER) →



- SEE SPREADSHEET (PG3) FOR ADDITIONAL ROWS

	Data from Table P5-3					Prob. 5-33							
						Stresses at Point A (Mpa)				Stresses at Point B (Mpa)			
ROW	l (m)	a (m)	F (N)	od (m)	id (m)	Sigmā	Tau-torsion	Tau-bending	von mises	Sigma	Tau-torsion	Tau-bending	von mises
a	0.100	0.400	50	0.020	0.014	8.38	16.76	0	30.2	0	16.76	0.42	29.8
b	0.070	0.200	85	0.020	0.006	7.64	10.92	0	20.4	0	10.92	0.40	19.6
c	0.300	0.100	95	0.025	0.017	23.64	3.94	0	24.6	0	3.94	0.48	7.7
d	0.800	0.500	160	0.046	0.022	14.14	4.42	0	16.1	0	4.42	0.17	7.9
e	0.085	0.350	900	0.055	0.024	4.86	10.01	0	18.0	0	10.01	0.62	18.4
f	0.050	0.180	950	0.050	0.030	4.45	8.01	0	14.6	0	8.01	1.01	15.6
g	0.160	0.280	850	0.045	0.019	15.71	13.75	0	28.5	0	13.75	0.87	25.3
h	0.200	0.100	800	0.040	0.024	29.27	7.32	0	31.9	0	7.32	1.33	15.0
I	0.400	0.150	950	0.065	0.037	15.76	2.95	0	16.6	0	2.95	0.56	6.1
j	0.200	0.100	600	0.045	0.032	18.03	4.51	0	19.6	0	4.51	1.02	9.6
k	0.120	0.180	880	0.060	0.047	7.99	5.99	0	13.1	0	5.99	1.07	12.2
l	0.150	0.250	750	0.052	0.028	8.90	7.42	0	15.6	0	7.42	0.66	14.0
m	0.070	0.100	500	0.036	0.030	14.77	10.55	0	23.5	0	10.55	2.14	22.0
n	0.085	0.150	820	0.040	0.015	11.32	9.99	0	20.7	0	9.99	1.01	19.1

	Prob. 5-35									
	Principal Stresses at Point A (Mpa)			FOS at Point A		Principal Stresses at Point B (Mpa)			FOS at Point B	
Row	Sigma1	Sigma2	Sigma3	Coulomb-Mohr	Modified Mohr	Sigma1	Sigma2	Sigma3	Coulomb-Mohr	Modified Mohr
a	21.5	0	-13.1	13.4	16.3	17.2	0	-17.2	15.1	20.4
b	15.4	0	-7.7	19.3	22.7	11.3	0	-11.3	22.9	30.9
c	24.3	0	-0.6	14.3	14.4	4.4	0	-4.4	58.6	79.2
d	15.4	0	-1.3	22.1	22.7	4.6	0	-4.6	56.5	76.3
e	12.7	0	-7.9	22.6	27.5	10.6	0	-10.6	24.4	32.9
f	10.5	0	-6.1	27.6	33.2	9.0	0	-9.0	28.8	38.8
g	23.7	0	-8.0	13.2	14.8	14.6	0	-14.6	17.7	24.0
h	31.0	0	-1.7	11.1	11.3	8.6	0	-8.6	30.0	40.5
i	16.3	0	-0.5	21.2	21.5	3.5	0	-3.5	73.7	99.5
j	19.1	0	-1.1	18.0	18.3	5.5	0	-5.5	46.9	63.3
k	11.2	0	-3.2	28.4	31.3	7.1	0	-7.1	36.7	49.5
l	13.1	0	-4.2	24.0	26.7	8.1	0	-8.1	32.1	43.3
m	20.3	0	-5.5	15.8	17.3	12.7	0	-12.7	20.4	27.6
n	17.1	0	-5.8	18.2	20.4	11.0	0	-11.0	23.6	31.8