

Hoek-Brown and equivalent Mohr Coulomb failure criteria

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|-----------------|---|---|---------------------------------------|
| Input: | sigci = 85 MPa | mi = 10 | GSI = 45 |
| Output: | mb = 1.40 sigtm = -0.13 MPa k = 3.01 sigcm = 11.36 MPa | s = 0.0022 A = 0.50 phi = 30.12 degrees E = 6913.7 MPa | a = 0.5 B = 0.70 coh = 3.27 MPa |
| Tangent: | signt = 15.97 MPa | phit = 30.12 degrees | coht = 4.12 MPa |

Calculation:

| | | | | | | | | | |
|-------------|----------|----------|----------|----------|---------|---------|----------|----------|--------|
| | | | | | | | | | Sums |
| sig3 | 1E-10 | 3.04 | 6.07 | 9.1 | 12.14 | 15.18 | 18.21 | 21.25 | 85.00 |
| sig1 | 4.00 | 22.48 | 33.27 | 42.30 | 50.40 | 57.91 | 64.98 | 71.74 | 347.08 |
| ds1ds3 | 15.89 | 4.07 | 3.19 | 2.80 | 2.56 | 2.40 | 2.27 | 2.18 | 35.35 |
| sign | 0.24 | 6.87 | 12.56 | 17.85 | 22.90 | 27.76 | 32.50 | 37.13 | 157.80 |
| tau | 0.94 | 7.74 | 11.59 | 14.62 | 17.20 | 19.48 | 21.54 | 23.44 | 116.55 |
| x | -2.36 | -1.08 | -0.83 | -0.67 | -0.57 | -0.48 | -0.42 | -0.36 | -6.77 |
| y | -1.95 | -1.04 | -0.87 | -0.76 | -0.69 | -0.64 | -0.60 | -0.56 | -7.11 |
| xy | 4.61 | 1.13 | 0.71 | 0.52 | 0.39 | 0.31 | 0.25 | 0.20 | 8.12 |
| xsq | 5.57 | 1.17 | 0.68 | 0.45 | 0.32 | 0.23 | 0.17 | 0.13 | 8.74 |
| sig3sig1 | 0.00 | 68.23 | 202.01 | 385.23 | 612.01 | 878.92 | 1183.65 | 1524.51 | 4855 |
| sig3sq | 0.00 | 9.22 | 36.86 | 82.94 | 147.45 | 230.39 | 331.76 | 451.56 | 1290 |
| taucalc | 0.96 | 7.48 | 11.33 | 14.45 | 17.18 | 19.64 | 21.91 | 24.04 | |
| sig1sig3fit | 11.36 | 20.51 | 29.66 | 38.81 | 47.96 | 57.11 | 66.26 | 75.42 | |
| signtaufit | 3.41 | 7.26 | 10.56 | 13.63 | 16.55 | 19.38 | 22.12 | 24.81 | |
| tangent | 4.253087 | 8.103211 | 11.40318 | 14.47286 | 17.3991 | 20.2235 | 22.97025 | 25.65501 | |

Cell formulae:

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mb = mi*EXP((GSI-100)/28)
s = IF(GSI>25,EXP((GSI-100)/9),0)
a = IF(GSI>25,0.5,0.65-GSI/200)
sigtm = 0.5*sigci*(mb-SQRT(mb^2+4*s))
A = acalc = 10^(sumy/8 - bcalc*sumx/8)
B = bcalc = (sumxy - (sumx*sumy)/8)/(sumxsq - (sumx^2)/8)
k = (sumsig3sig1 - (sumsig3*sumsig1)/8)/(sumsig3sq-(sumsig3^2)/8)
phi = ASIN((k-1)/(k+1))*180/PI()
coh = sigcm/(2*SQRT(k))
sigcm = sumsig1/8 - k*sumsig3/8
E = IF(sigci>100,1000*10^((GSI-10)/40),SQRT(sigci/100)*1000*10^((GSI-10)/40))
phit = (ATAN(acalc*bcalc*((signt-sigtm)/sigci)^(bcalc-1)))*180/PI()
coht = acalc*sigci*((signt-sigtm)/sigci)^bcalc-signt*TAN(phit*PI()/180)
sig3 = Start at 1E-10 (to avoid zero errors) and increment in 7 steps of sigci/28 to 0.25*sigci
sig1 = sig3+sigci*(((mb*sig3)/sigci)+s)^a
ds1ds3 = IF(GSI>25,(1+(mb*sigci)/(2*(sig1-sig3))),1+(a*mb^a)*(sig3/sigci)^(a-1))
sign = sig3+(sig1-sig3)/(1+ds1ds3)
tau = (sign-sig3)*SQRT(ds1ds3)
x = LOG((sign-sigtm)/sigci)
y = LOG(tau/sigci)
xy = x*y      x sq = x^2      sig3sig1 = sig3*sig1      sig3sq = sig3^2
taucalc = acalc*sigci*((sign-sigtm)/sigci)^bcalc
s3sifit = sigcm+k*sig3
sntaufit = coh+sign*TAN(phi*PI()/180)
tangent = coht+sign*TAN(phit*PI()/180)
    
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Fig. C1. Spreadsheet for calculation of Hoek-Brown and equivalent Mohr-Coulomb parameters.

The equivalent Mohr envelope, defined by equation (4), may be written in the form:

$$Y = \log A + BX \tag{C6}$$

where

$$Y = \log\left(\frac{\tau}{\sigma_{ci}}\right), \quad X = \log\left(\frac{\sigma'_n - \sigma_{tm}}{\sigma_{ci}}\right) \tag{C7}$$

of A and B are determined by linear regression where:

$$B = \frac{\sum XY - (\sum X \sum Y)/T}{\sum X^2 - (\sum X)^2/T} \tag{C8}$$

$$A = 10^{(\sum Y/T - B(\sum X/T))} \tag{C9}$$

Using the value of σ_{tm} calculated from equation (C5) and a range of values of τ and σ'_n calculated from equations (C1) and (C2), the values

and T is the total number of data pairs included in the regression analysis.