Homework 1

Eric Gallimore

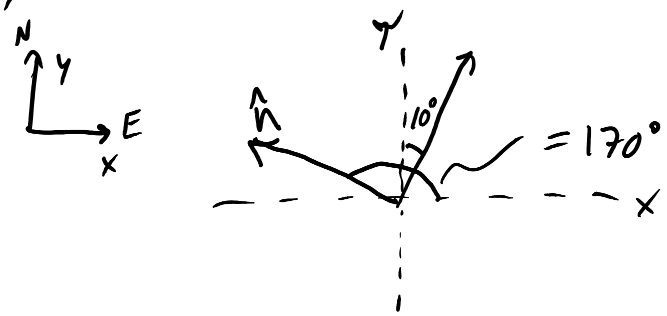
Friday, January 17, 2014 11:58

2.1

Wednesday, January 15, 2014 09:34

$$\underline{\underline{\tau}} = \begin{bmatrix} -30 & -20 \\ -20 & -40 \end{bmatrix} \text{MPa} \qquad \text{in } x, y$$

a) NORMAL STRESS ON FAULT 10°E OF NORTH



$$\hat{n} = \begin{bmatrix} \cos(170°) \\ \sin(170°) \end{bmatrix} = \begin{bmatrix} -0.985 \\ 0.173 \end{bmatrix} \qquad \underline{t}(\hat{n}) = \underline{\underline{\tau}}\,\hat{n}$$

$$\underline{t}(\hat{n}) = \begin{bmatrix} -30 & -20 \\ -20 & -40 \end{bmatrix} \begin{bmatrix} -0.985 \\ 0.173 \end{bmatrix} = \begin{bmatrix} 26.07 \\ 12.75 \end{bmatrix} \text{MPa}$$

NORMAL STRESS: $t(\hat{n}) \cdot \hat{n}$

$$\begin{bmatrix} 26.07 & 12.75 \end{bmatrix} \begin{bmatrix} -0.985 \\ 0.173 \end{bmatrix} = \boxed{-23.46 \text{ MPa}}$$

SHEAR STRESS JUST HAS FLIPPED TRANSFORM

$$t_s = \begin{bmatrix} 26.07 & 12.75 \end{bmatrix} \begin{bmatrix} 0.173 \\ 0.985 \end{bmatrix} = \boxed{17.08 \text{ MPa}}$$

B)

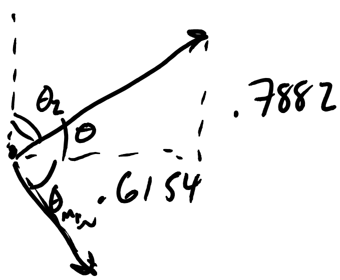
USE MATLAB EIG

EIGENVALUES

$$\boxed{\underline{\underline{T}}^R = \begin{bmatrix} -55.6 & \text{MPa} \\ -10.4 & -14.4 \end{bmatrix}}$$

EIGENVECTORS

$$N = \begin{bmatrix} 0.6154 & -.7882 \\ .7882 & .6154 \end{bmatrix}$$



$$\frac{.7882}{.6154} = \tan(\theta)$$

$$\theta = 0.9079 = 52.02°$$

MAXIMUM AXIS:

37.98° E of N

MINIMUM AXIS:

127.98° E of N

2.3

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DISPLACEMENT AMPLITUDE = 300 μm

$c = 3.9$ km/s

$$f = \frac{40 \text{ cycles}}{1000 \text{ s}} = 0.04 \text{ Hz}$$

$$\left(\frac{\partial u_z}{\partial x}\right)_{max} = \frac{2\pi f A}{c} = \frac{2\pi (0.04)(300E-6)}{3.9E3} = \boxed{1.93E-8}$$

2.8

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$\alpha = 5.5 km/s$

$\rho = 2.6 Mg/m^3$

LAME?

YOUNGS MODULUS?

BULK MODULUS?

$$\alpha = \sqrt{\frac{\lambda + 2\mu}{\rho}}$$

POISSON SOLID: $\lambda = \mu$

SO

$$\alpha^2 = \frac{3\mu}{\rho} \qquad \frac{\alpha^2 \rho}{3} = \mu$$

$$\frac{(5.5E3)^2 (2.6E3)}{3} = \mu = \lambda$$

$$\boxed{\mu = \lambda = 2.62E10 \ Pa}$$

$$E = \frac{(3\lambda + 2\mu)\mu}{\lambda + \mu}$$

$$= \frac{5\mu^2}{} = \frac{5\mu}{}$$

$$= \frac{5\mu^2}{2\mu} = \frac{5\mu}{2}$$

$$E = \frac{5(2.62E10)}{2} = \boxed{6.55E10 \text{ Pa}}$$

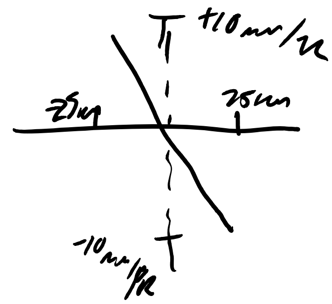
$$K = \lambda + \frac{2}{3}\mu = \frac{5}{3}\lambda$$

$$K = \frac{5}{3}(2.62E10) = \boxed{4.37E10 \text{ Pa}}$$

2.10

Thursday, January 16, 2014 21:41

a) ESTIMATE SLOPE ON FAULT



LOOKS LINE

$$\frac{du_y}{dx} = -\left(\frac{10}{25}\right)\frac{\text{mm/yr}}{\text{km}}$$

$$= -0.4\,\frac{\text{mm/yr}}{\text{km}} \simeq -4\text{E-}7\ \frac{\text{m}}{\text{yr}}$$

$$\underline{\underline{e}} = \begin{bmatrix} \frac{\partial u_x}{\partial x} & \frac{1}{2}\left(\frac{\partial u_x}{\partial y} + \frac{\partial u_y}{\partial x}\right) \\ \frac{1}{2}\left(\frac{\partial u_y}{\partial x} + \frac{\partial u_x}{\partial y}\right) & \frac{\partial u_y}{\partial y} \end{bmatrix}$$

$$= \begin{bmatrix} 0 & \frac{1}{2}(-4\text{E-}7) \\ \frac{1}{2}(-4\text{E-}7) & 0 \end{bmatrix} = \boxed{\begin{bmatrix} 0 & -2\text{E-}7 \\ -2\text{E-}7 & 0 \end{bmatrix}}$$

$$\underline{\underline{\Omega}} = \begin{bmatrix} 0 & \frac{1}{2}\left(\frac{\partial u_x}{\partial y} - \frac{\partial u_y}{\partial x}\right) \\ -\frac{1}{2}\left(\frac{\partial u_x}{\partial y} - \frac{\partial u_y}{\partial x}\right) & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & \frac{1}{2}(+4\text{E}-7) \\ -\frac{1}{2}(+4\text{E}-7) & 0 \end{bmatrix} = \boxed{\begin{bmatrix} 0 & 2\text{E}-7 \\ -2\text{E}-7 & 0 \end{bmatrix}}$$

b) $\mu = 27$ GPa

ASSUME ISOTROPIC

CRUSTAL, SO ASSUME POISSON RATIO OF 0.25

ASSUME $\lambda = \mu$

SO:

$$\underline{\underline{\tau}} = \begin{bmatrix} \lambda \, \text{TR}[\underline{\underline{e}}] + 2\mu e_{11} & 2\mu e_{12} \\ 2\mu e_{21} & \lambda \, \text{TR}[\underline{\underline{e}}] + 2\mu e_{22} \end{bmatrix}$$

$$\underline{\underline{\tau}} = \begin{bmatrix} 27\text{E}9\,(0) + 2(27\text{E}9)(0) & 2(27\text{E}9)(-2\text{E}-7) \\ 2(27\text{E}9)(-2\text{E}-7) & 0 \end{bmatrix}$$

$$\boxed{\underline{\underline{\tau}} = \begin{bmatrix} 0 & -10800 \\ -10800 & 0 \end{bmatrix} \text{ Pa}}$$

c) $\underline{\underline{\tau}} \cdot 200 = \boxed{\begin{bmatrix} 0 & -2.16\text{E}6 \\ -2.16\text{E}6 & 0 \end{bmatrix} \text{ Pa}}$

d)

If large earthquakes occur every 200 years and release all of the accumulated strain, we can still infer that our estimate of shear stress represents a lower limit of the absolute shear stress. In other words, the slope of the velocity/distance curve will continue to get steeper until the earthquake occurs.

e)

The width of the zone of deformation is related to the shear modulus of the material. A higher shear modulus would result in a wider zone of deformation.

I conceptualize this in what is probably an imperfect way… I think of the continuous solid like a fluid, and think of the shear modulus as viscosity (which it is, after all, in a fluid). The more viscous the substance, the further the stress signal will travel in the continuum.