Mohr circles in geophysics

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We consider a fault block 5km thick which rests on a horizontal detachment as represented in figure 1. The block is subjected to gravity and a horizontal tensile stress and the friction on the bedrock. As we are in a geotechnic problem, we will use the geotechnic conventions for stresses (positive for compression and negative for tensile stress).

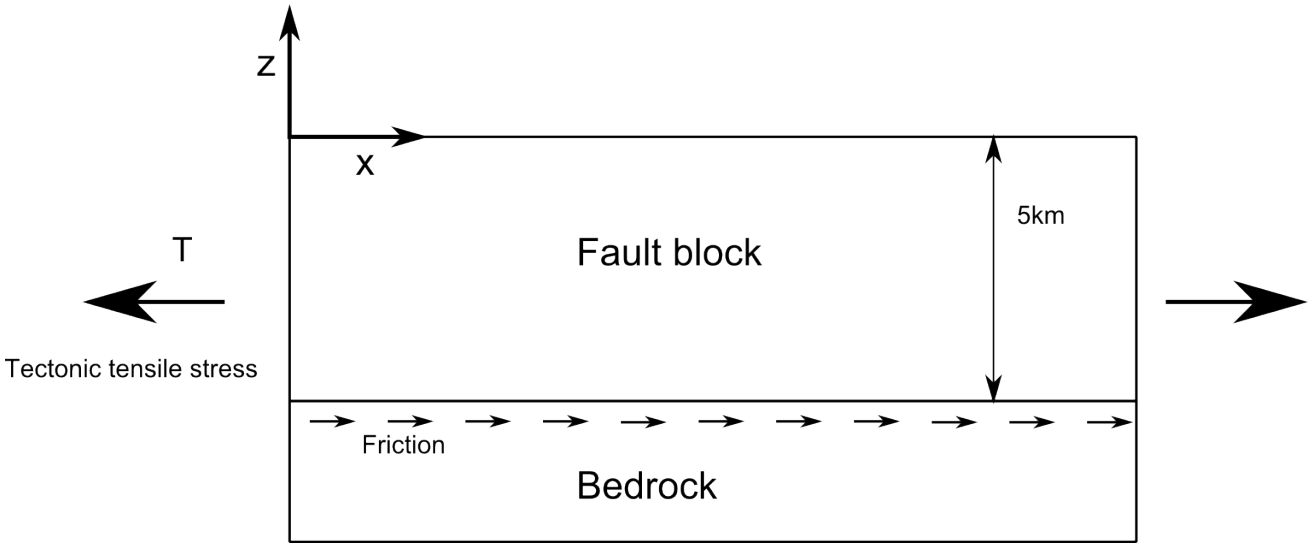

Figure 1: Model of the fault block and the different solicitations

The characteristic of the medium are listed below:

- $\rho = 2700$ kg.m^{-3}
- $g = 9.8$ m.s^{-2}
- $\nu = 0.3$
- $\mu = 0.5$
- $h = 5000$ m
- $T = 10$ MPa

1 - a Let us consider a point on the detachment surface at the depth h. Give the expression of the vertical normal stress (σ_{zz}) at that point.

b If we consider at first that $T = 0$, considering the Poisson effect, what is the horizontal stress (σ_H^{ν}) due to the gravity (reminder, Hooke's law in the general case is written $\varepsilon_{ij} = \frac{1}{E}\left[(1+\nu)\,\sigma_{ij} - \nu tr\left(\underline{\underline{\sigma}}\right)\delta_{ij}\right]$)?

c We consider that we can write the stresses as $\sigma_{xx} = \kappa\sigma_{zz} - T$ and $\sigma_{yy} = \kappa\sigma_{zz} - \nu T$. What is the expression of κ ?

d Amonton's second law of friction states that the friction between two solid bodies is proportional to the normal stress between both. Give then the magnitude of the shear stress σ_{xz}.

2 - Construct the Mohr circle for the two-dimensional stress that acts at this considered point. Give the radius and the coordinates of the center of the circle.

3 - What are the orientation and the magnitude of the principal stresses in the plane (x, z). Plot the axis in the physical space

4 - What are the orientation and the values of the maximal shear stress.

5 - What are the values of the normal and shear components on the following planes:

- perpendicular to (x, z), its normal at an angle of 35° from $\underline{x}$.
- perpendicular to (x, z), its normal at an angle of $-30°$ from the principal axis $\underline{e_3}$.