INTERACTIVE THERMAL STRESS PROFILES

PGE 383 Advanced Geomechanics Final Project

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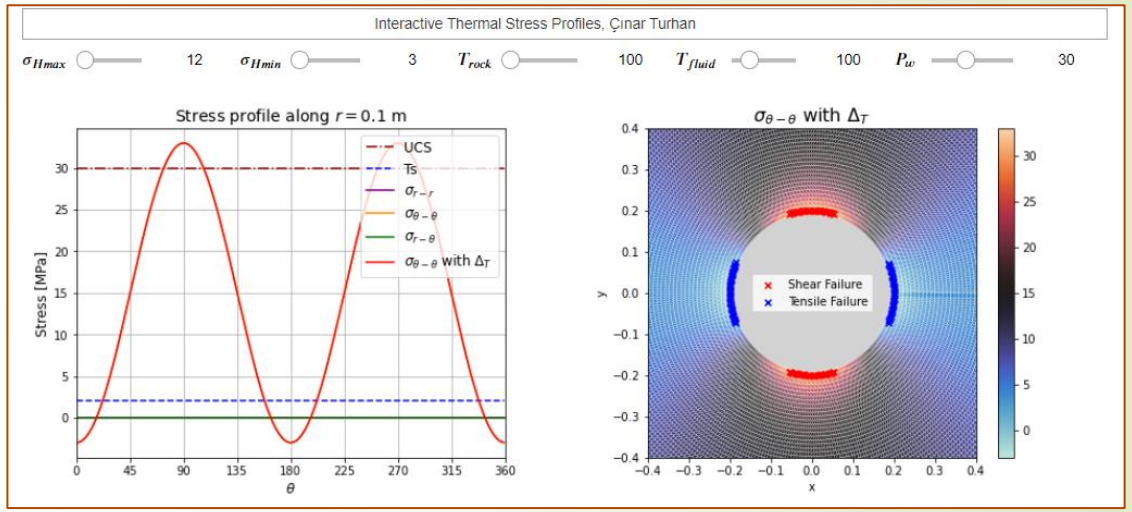
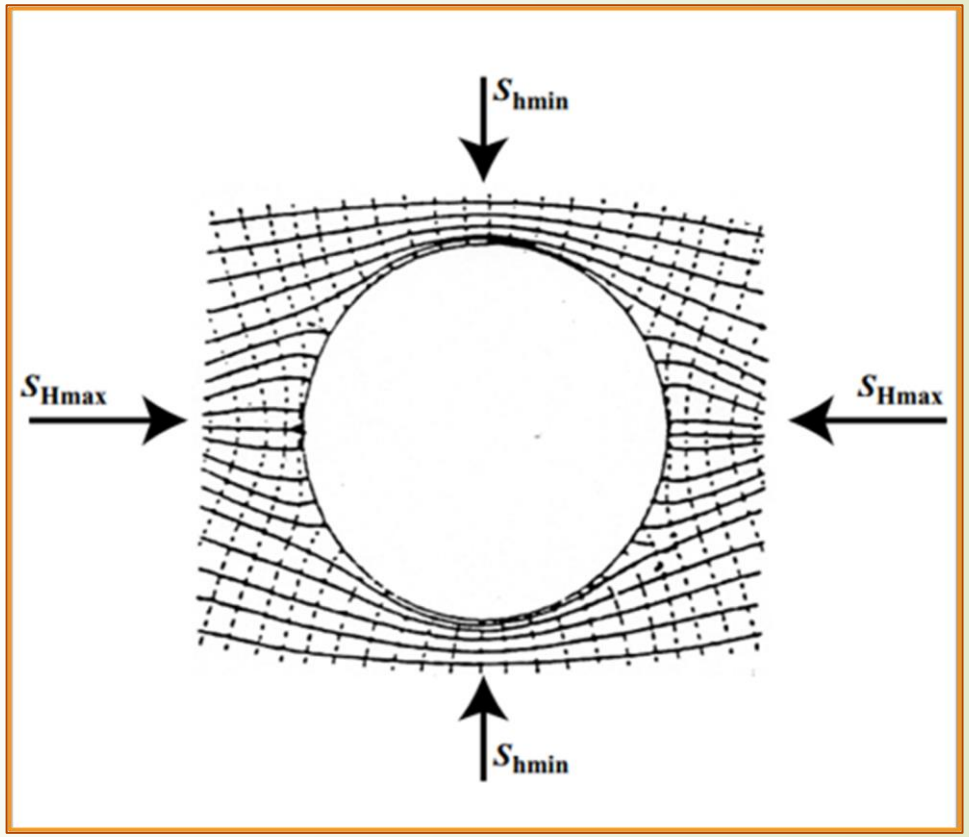
OUTLINE

- Background
- Equations
- Parameters and Implementation
- Features of the Interactive Plot
- Sample Results



BACKGROUND

Principal stress trajectories around a cylindrical opening based on the Kirsch equations.



Zoback, 2007, Ch.6

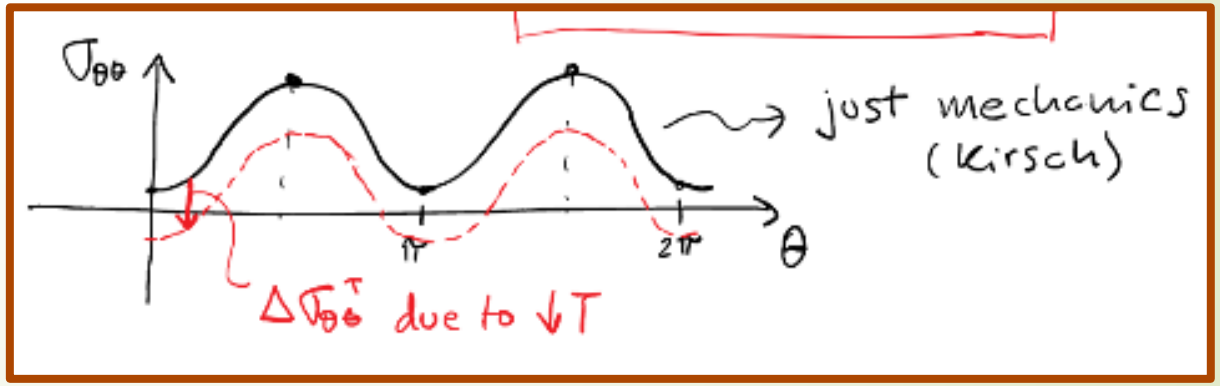
EQUATIONS

$$\begin{cases} \sigma_{rr} &= (P_W - P_p)\left(\frac{a^2}{r^2}\right) + \frac{\sigma_{Hmax}+\sigma_{hmin}}{2}\left(1 - \frac{a^2}{r^2}\right) + \frac{\sigma_{Hmax}-\sigma_{hmin}}{2}\left(1 - 4\frac{a^2}{r^2} + 3\frac{a^4}{r^4}\right)\cos(2\theta) \\ \sigma_{\theta\theta} &= -(P_W - P_p)\left(\frac{a^2}{r^2}\right) + \frac{\sigma_{Hmax}+\sigma_{hmin}}{2}\left(1 + \frac{a^2}{r^2}\right) - \frac{\sigma_{Hmax}-\sigma_{hmin}}{2}\left(1 + 3\frac{a^4}{r^4}\right)\cos(2\theta) \\ \sigma_{r\theta} &= \frac{\sigma_{Hmax}-\sigma_{hmin}}{2}\left(1 + 2\frac{a^2}{r^2} - 3\frac{a^4}{r^4}\right)\sin(2\theta) \\ \sigma_{zz} &= \sigma_v - 2\nu\left(\sigma_{Hmax} - \sigma_{hmin}\right)\left(\frac{a^2}{r^2}\right)\cos(2\theta) \end{cases} \quad (6.2)$$

Espinoza, 2021, Ch.6

$$\sigma_{\theta\theta}^{\Delta T} = \frac{\alpha_t E \Delta T}{1 - \nu}$$

Zoback, 2007, Ch.6



Espinoza, 2022. Lecture Notes.

PARAMETERS AND IMPLEMENTATION

Parameters;

- Wellbore Pressure, Pw
- Pore Pressure, Pp
- Effective Stresses, σHmax, σhmin
- Diameter of Interest, a
- Young's Modulus, E
- Poisson's Ratio, v

For Failure Criteria;

- Unconfined Compression Strength, UCS
- Tensile Strength, Ts

For Thermal Component;

- Linear Coefficient of Thermal Expansion, α

PARAMETERS AND IMPLEMENTATION

Interactive Thermal Stress Profiles

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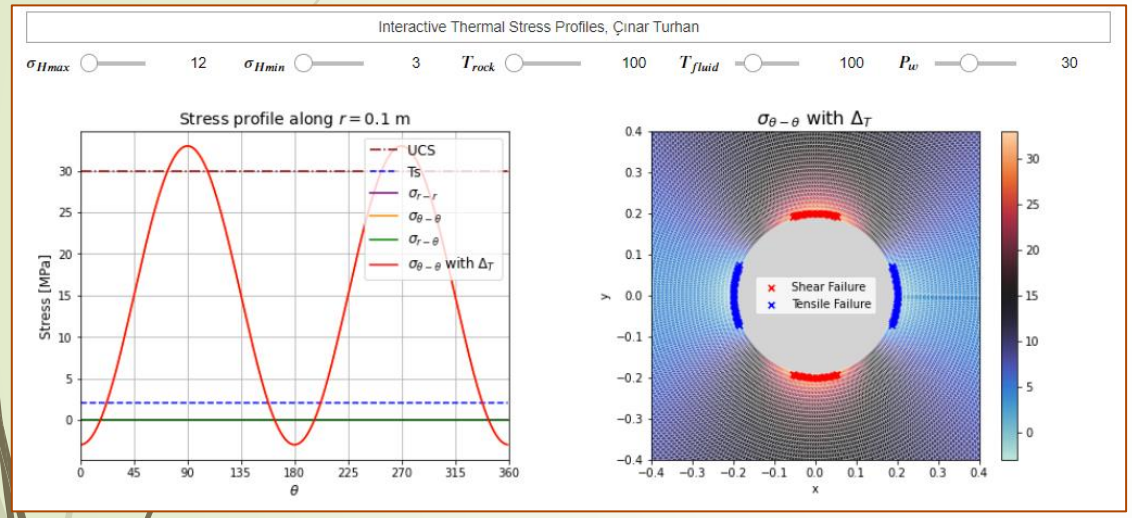
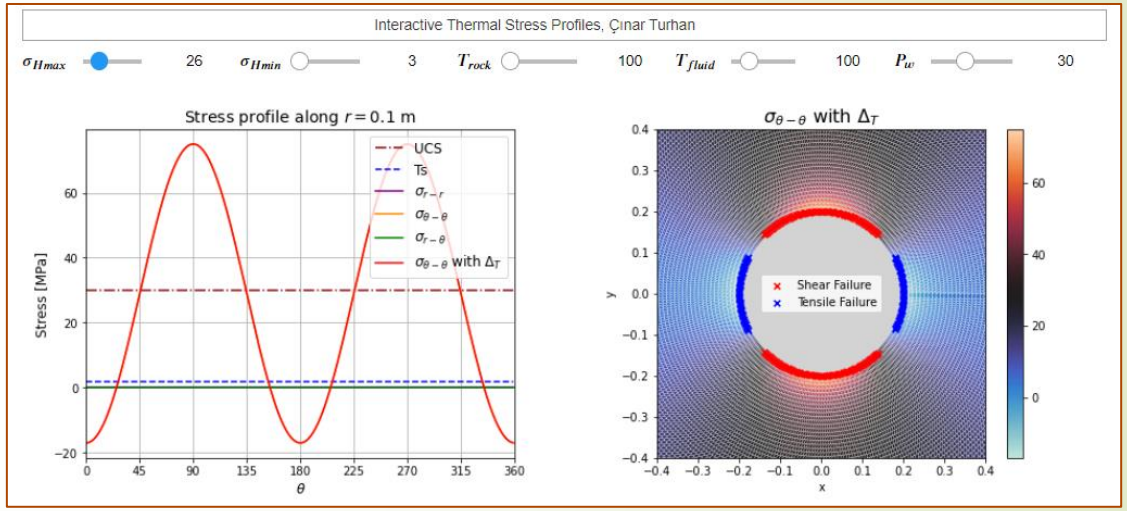
LinkedIn - GitHub

PGE 383 Advanced Geomechanics Final Project

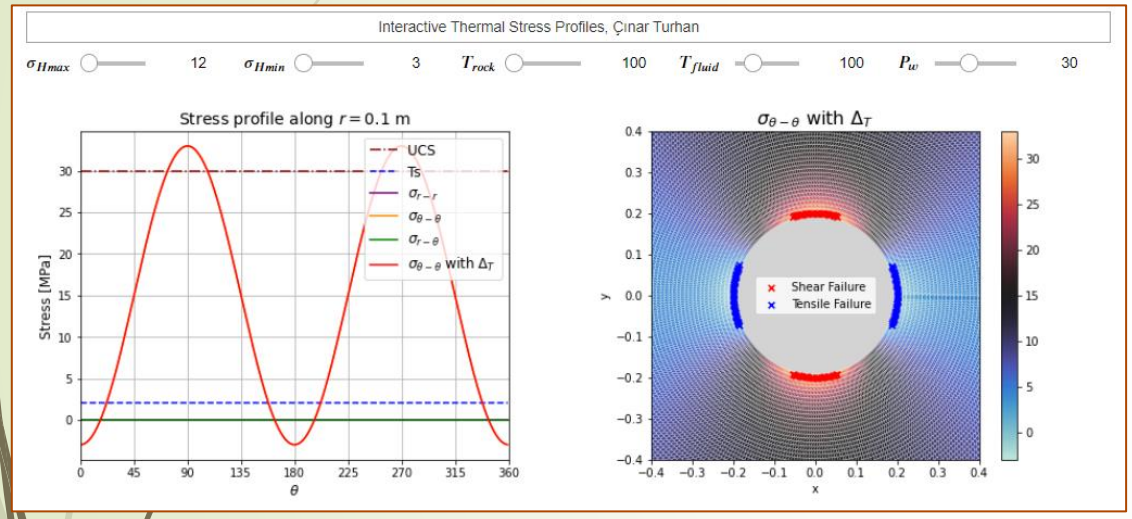
Instructor: Dr. Nicolas Espinoza

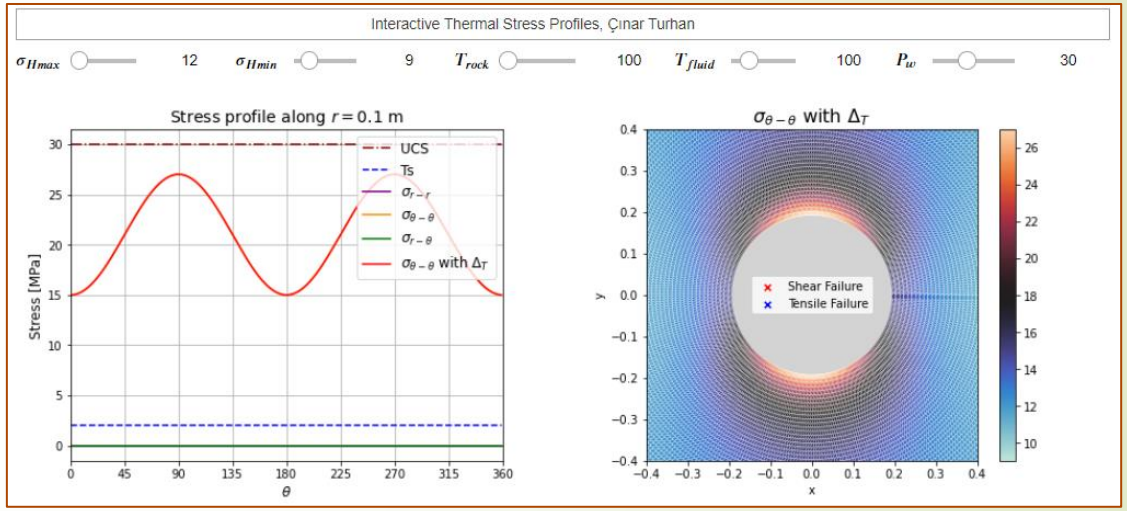
EXAMPLES – varying σHmax



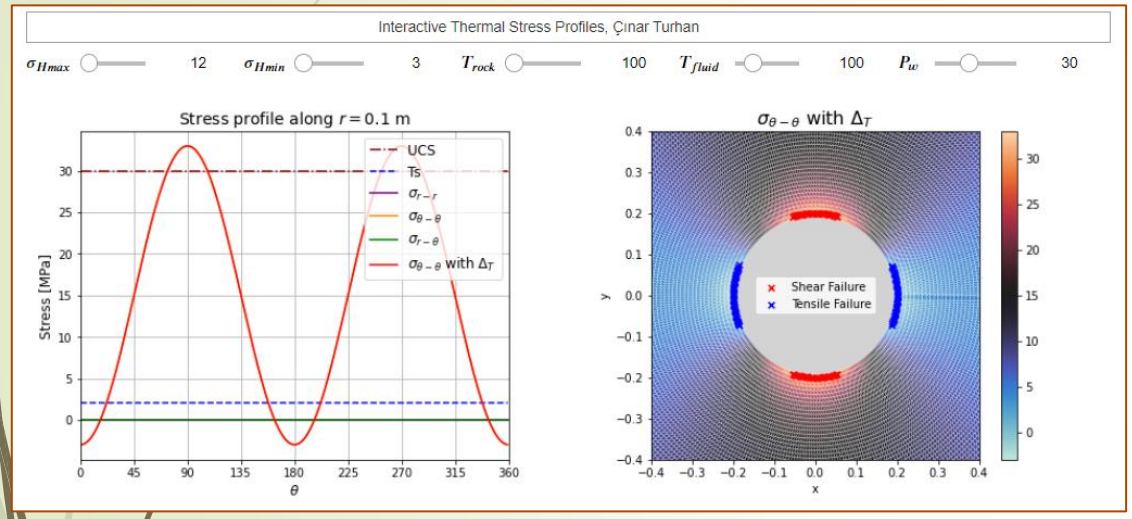


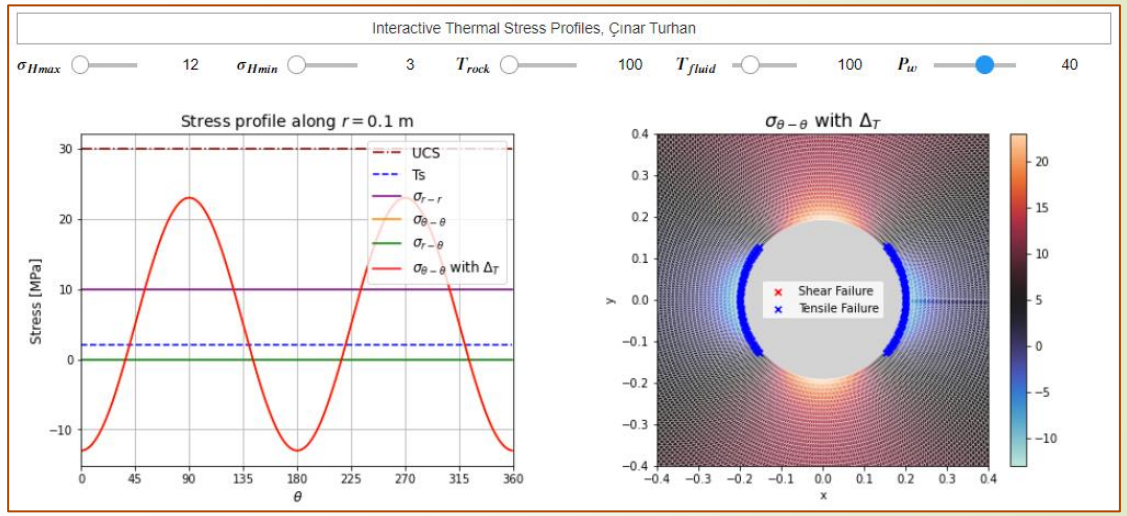
EXAMPLES – varying σhmin





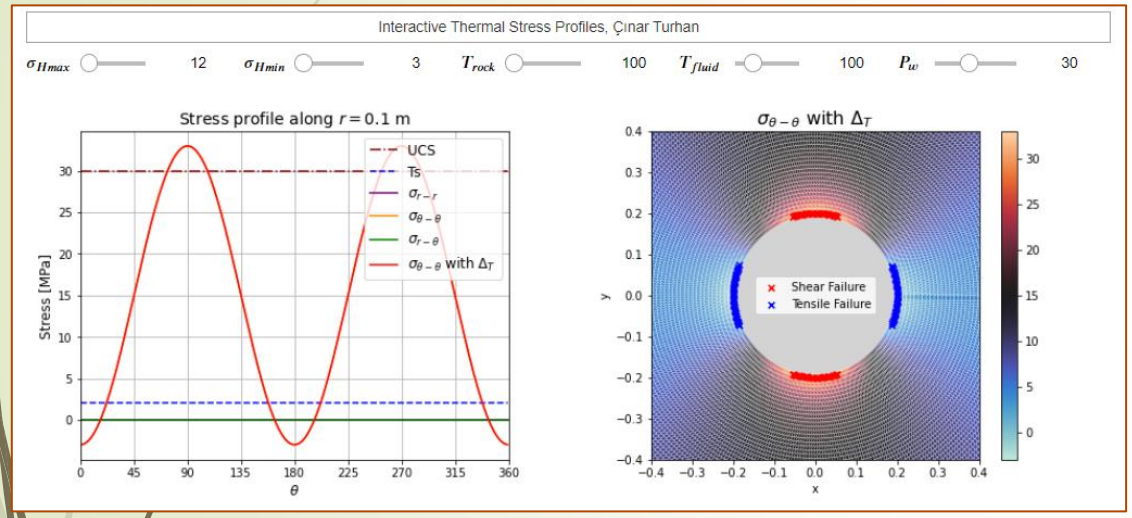
EXAMPLES – varying Pw

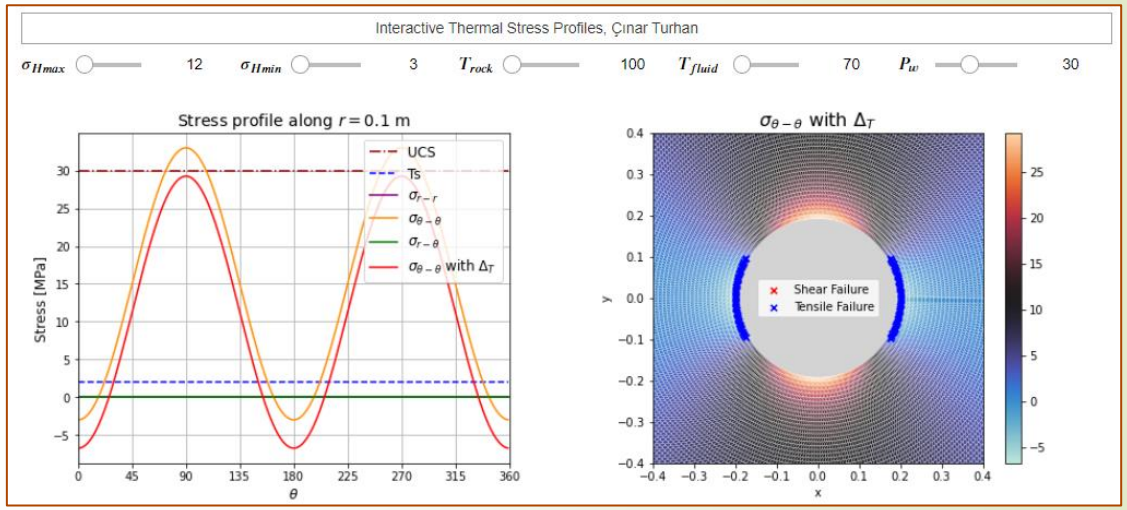




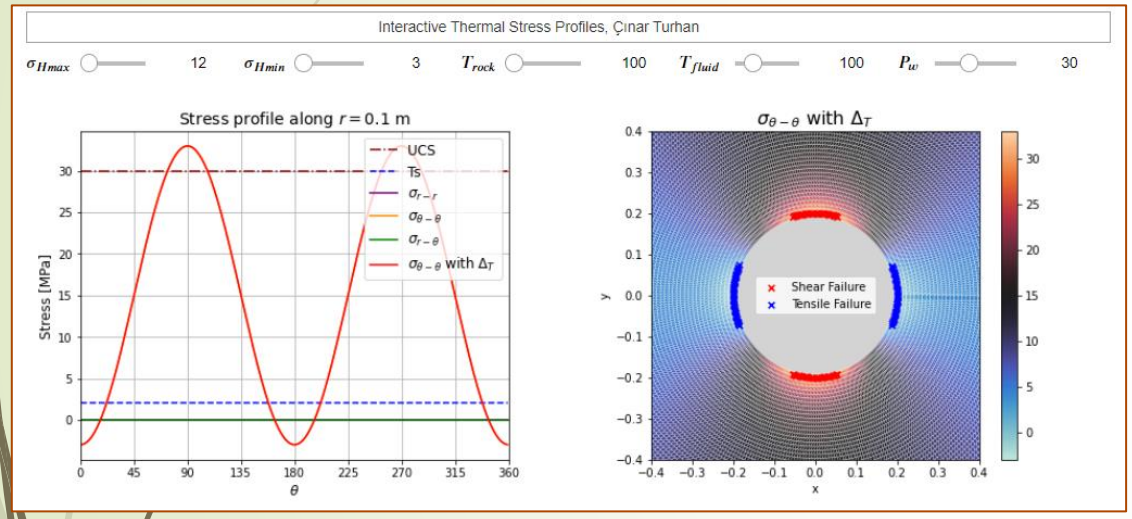
$$
\begin{cases}
\sigma_{rr} &= (P_W - P_p)\left(\frac{a^2}{r^2}\right) + \frac{\sigma_{Hmax}+\sigma_{hmin}}{2}\left(1 - \frac{a^2}{r^2}\right) + \frac{\sigma_{Hmax}-\sigma_{hmin}}{2}\left(1 - 4\frac{a^2}{r^2} + 3\frac{a^4}{r^4}\right)\cos(2\theta) \\
\sigma_{\theta\theta} &= -(P_W - P_p)\left(\frac{a^2}{r^2}\right) + \frac{\sigma_{Hmax}+\sigma_{hmin}}{2}\left(1 + \frac{a^2}{r^2}\right) - \frac{\sigma_{Hmax}-\sigma_{hmin}}{2}\left(1 + 3\frac{a^4}{r^4}\right)\cos(2\theta) \\
\sigma_{r\theta} &= \frac{\sigma_{Hmax}-\sigma_{hmin}}{2}\left(1 + 2\frac{a^2}{r^2} - 3\frac{a^4}{r^4}\right)\sin(2\theta) \\
\sigma_{zz} &= \sigma_v - 2\nu\left(\sigma_{Hmax} - \sigma_{hmin}\right)\left(\frac{a^2}{r^2}\right)\cos(2\theta)
\end{cases}
\tag{6.2}
$$

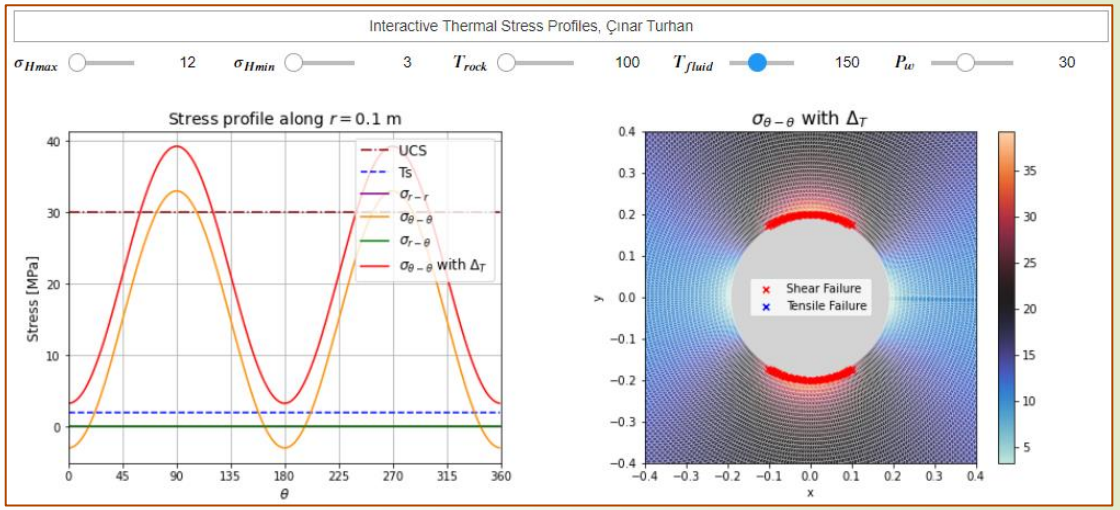
EXAMPLES – varying Tfluid





EXAMPLES – varying Tfluid





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REFERENCES

Espinoza, D. N. (2020). 1.4 WP4: Solution of Navier's Equation for the Stress Field. *Advanced Geomechanics - Class Notes*.

Espinoza, D. N. (2021). 6.2 Kirsch solution for stresses around a cylindrical cavity. *Introduction to Energy Geomechanics.*

Espinoza, D. N. (2022). Handwritten notes Advanced Geomechanics course.

Zoback, M. D. (2007). Chapter 6 - Compressive and tensile failures in vertical wells. In *Reservoir Geomechanics* (pp. 167–205). Cambridge University Press.