Why is SHmax Different in FEM CDF and Geomechanics?

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1 Sign Convention Differences

- **FEM (Engineering Convention)**: Tension is positive, compression is negative [1].
- **Geomechanics (Rock Mechanics)**: Compression is positive, tension is negative [2].
- This difference can cause a 90-degree rotation in SHmax if not corrected.

2 Why Does This Affect Principal Strain Directions?

- In **FEM (tension-positive convention)**:
  - The largest strain direction aligns with maximum tension.
  - The smallest strain direction aligns with maximum compression.
- In **Geomechanics (compression-positive convention)**:
  - The largest strain direction aligns with maximum compression.
  - The smallest strain direction aligns with maximum tension.

3 Example: How This Rotates SHmax

- If FEM results give principal strain directions as:

$$\varepsilon_1 = [0.9, 0.4, 0], \quad \varepsilon_2 = [-0.4, 0.9, 0], \quad \varepsilon_3 = [0, 0, 1]$$

- Geomechanics convention inverts this due to the opposite sign rule.
- SHmax appears rotated relative to FEM results [3].

4 How to Correct This?

- **Flip Stress Sign Convention:**

$$\sigma_{\text{geo}} = -\sigma_{\text{fem}}$$

- **Adjust Strain Interpretation:** Ensure proper principal strain comparison.
- **Compare SHmax After Sign Correction:** SHmax should align after sign correction.

5 Summary

After correcting for this difference, SHmax from FEM and geomechanics should align.

Factor	FEM CDF (Engineering)	Geomechanics	Effect on SHmax
Stress Sign Convention	Tension = Positive	Compression = Positive	SHmax may appear rotated
Strain Sign Convention	Tension = Positive	Compression = Positive	Principal strain directions may flip
Principal Stress	σ_1 = Max Tensile Stress	σ_1 = Max Compressive Stress	SHmax directions may differ
Correction Needed?	Flip stress sign	No correction needed	Corrects SHmax

Table 1: Comparison of SHmax Differences between FEM and Geomechanics

6 References

References

[1] Bathe, K. J. (2006). *Finite Element Procedures*. Prentice Hall.

[2] Zoback, M. D. (2010). *Reservoir Geomechanics*. Cambridge University Press.

[3] Jaeger, J. C., Cook, N. G., Zimmerman, R. W. (2007). *Fundamentals of Rock Mechanics*. Blackwell Publishing.