Calculation of Infiltration-cracks in the edge zone of Gas Storage Caverns with FLAC3D

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Gas storage in salt caverns

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\[ |p_i| > |\sigma_3| + \beta_{eff}^T \]

infiltration-cracks

\[ \beta_{eff}^T = 2 - 4 \text{ MPa} \]

(1 MPa = 145 Psi)
Calculation model

-600 m depth
(1 m = 3.28 ft)

-900 m

-1,300 m

-1,600 m

140 m

Cavern

Rock salt
Discrete crack modelling

1. Determination of the stress state
2. Query for the zone at the cavern edge or at the crack front
   - Criterion is not fulfilled
   - Criterion is fulfilled
   - Zone will be eliminated / Creation of discrete crack planes
   - Applying of gas pressure in the crack plane
Calculation examples

Internal pressure curve

\[ (1 \text{ MPa} = 145 \text{ Psi}) \]

\[
\begin{array}{c|c|c|c|c|c|c|c|c|c|c}
\hline
\text{time, days} & 730 & 830 & 930 & 1030 & 1130 & 1230 & 1330 & 1430 & 1530 & 1630 \\
\hline
\text{stresses, MPa} & -30.0 & -25.0 & -20.0 & -15.0 & -10.0 & -5.0 & 0.0 & 5.0 & 10.0 & 15.0 \\
\hline
\end{array}
\]

\[ \text{--- Internal pressure } p_i \]
Calculation examples

Calculation without discrete crack modelling

\[
\Delta \sigma = 8 \text{ MPa}
\]

\[
\beta_{\text{eff.}} = 2 - 4 \text{ MPa}
\]

(1 MPa = 145 Psi)
Calculation examples

criterion for crack formation: $|p_i| > |\sigma_{zz}|$

with discrete cracks
(five horizontal cracks)

without discrete cracks

vertical stress $\sigma_{zz}$, MPa

$\sigma_{zz}$, MPa

$|p_i| > |\sigma_{zz}|$

evaluation area

Appr. 1.6 m
Calculation examples

criteria for crack formation:
horizontal: $|p_i| > |\sigma_{zz}|$ / vertical: $|p_i| > |\sigma_{yy}|$

d = 1.566 d

five horizontal cracks

one horizontal crack

one vertical crack
Conclusion

- formation of infiltration-cracks in the gas cavern surrounding rock salt
- considering in rock mechanical design of gas storage caverns
- suitable models and methods are needed
- method of discrete crack modelling
  - considering of the internal pressure in the crack
  - stress state in the vicinity of infiltration-cracks.