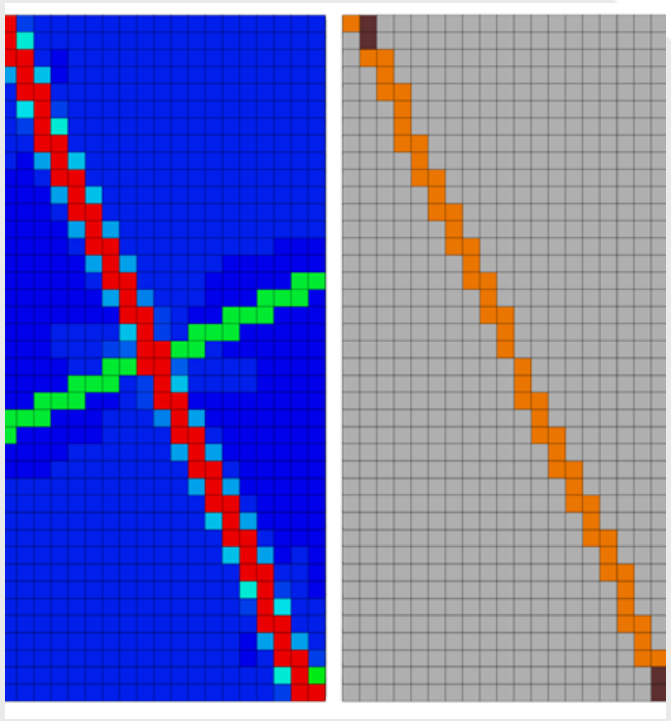

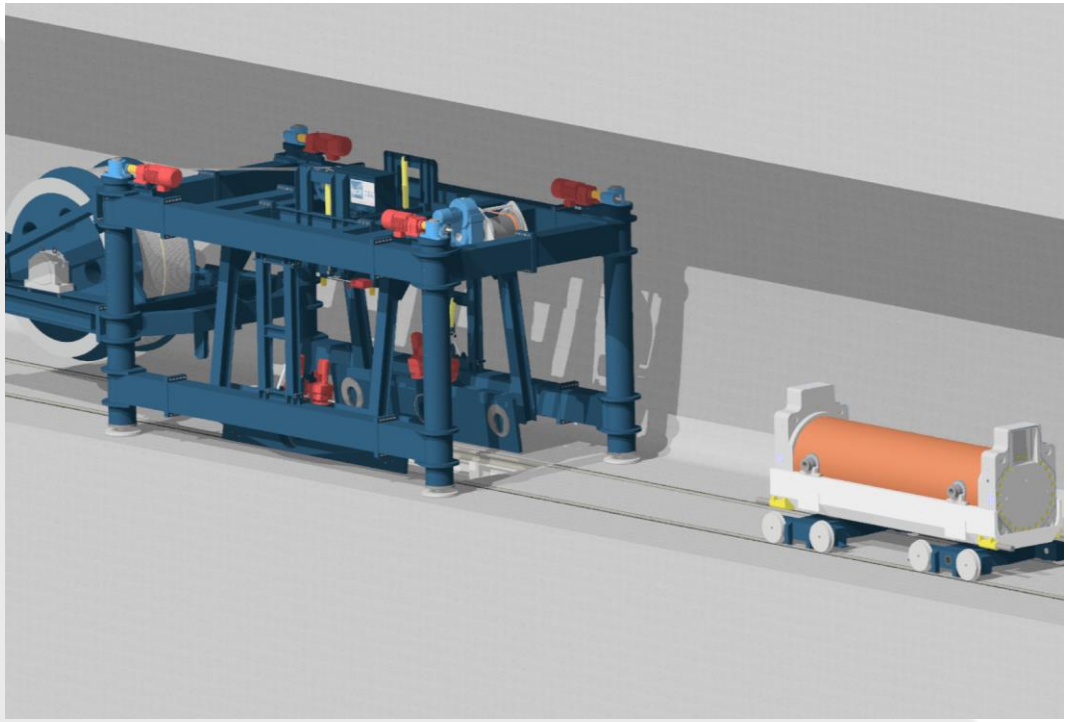

Application of Ubiquitous-Joint Model for Modelling Fractures in Crystalline Rock Formations: Preliminary Studies

Ajmal Gafoor, Christian Müller, Philipp Herold

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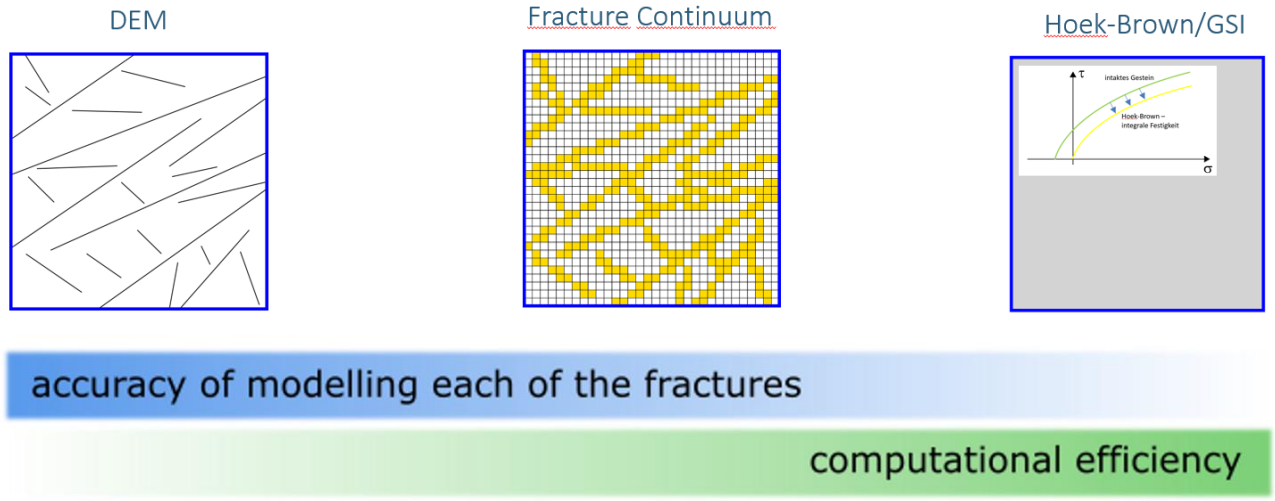
Motivation

- Project PRECODE – Various numerical modelling approaches
    - Integrity Analyses (Quantification of Dilatancy und Fluid pressure)
- Small-scale and Benchmark calculations
    - To verify influence of fractures on crystalline rock mechanical deformation behaviour
- Fracture-Continuum approach – Unique material behaviours (Fracture+Matrix) in numerical models



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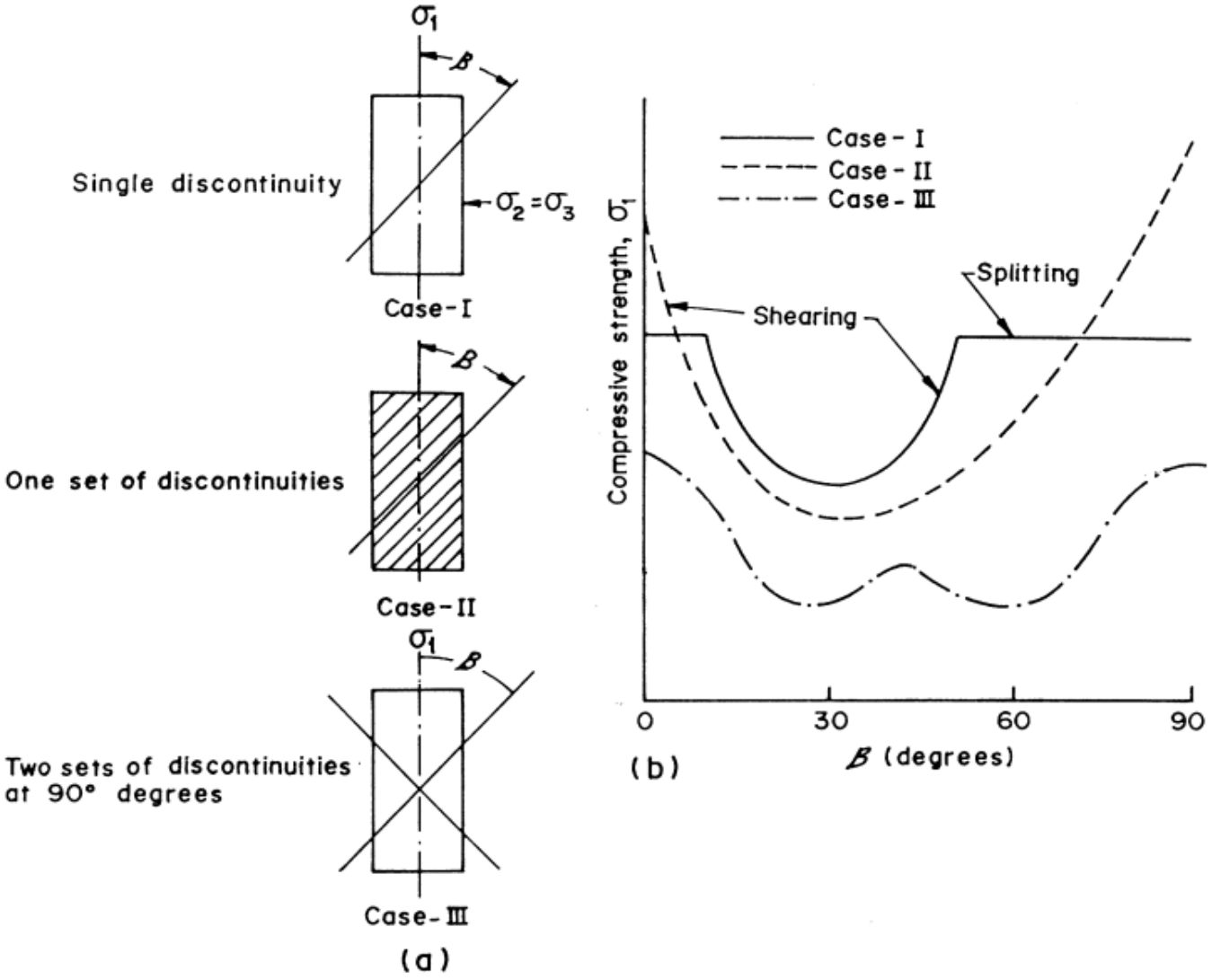
Typical Strength Anisotropy Curves of Crystalline-type Rocks



- → Aim: Qualitative reproduction of strength anisotropy curves for shown fracture discontinuities
- → Typical strength anisotropy curves for samples with single, one set and two discontinuities
- → Observations according to Hoek-Brown (1980)
  (Al-Harthi, 1998)

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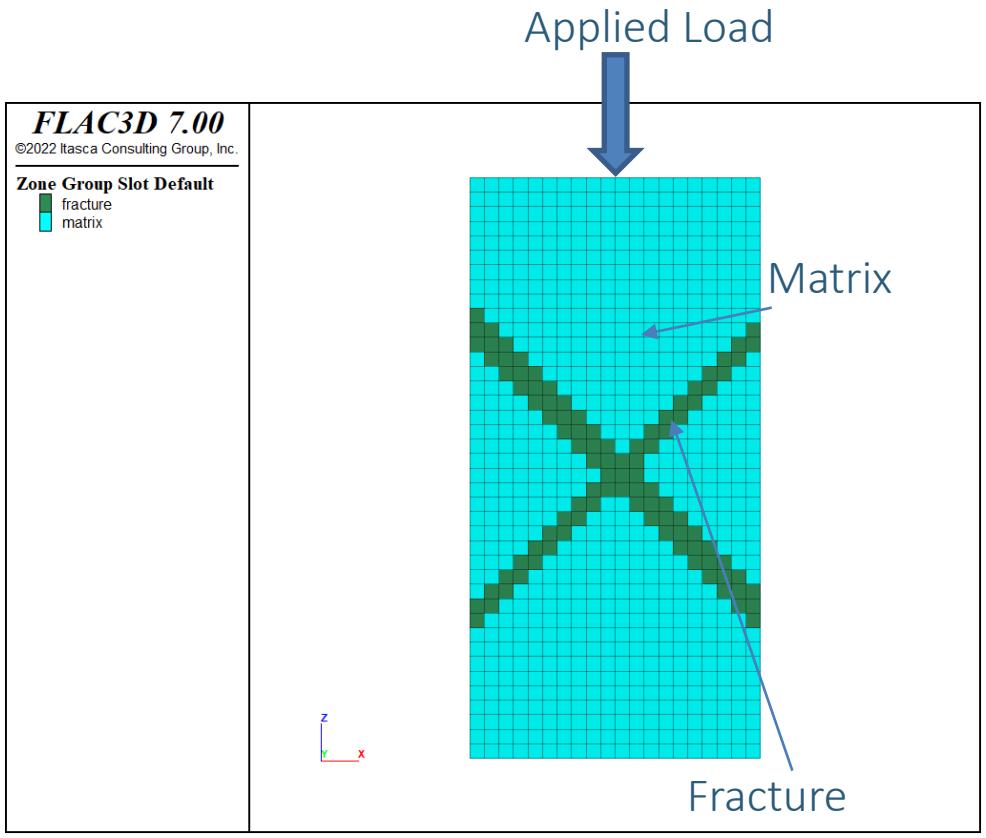
Small-scale Model – Plate-like Model, Parameters



Model with two orthogonal fractures

Materialparameter	Fracture	Matrix
Elastic parameters		E = 10 GPa ν = 0.20
Friction	35°	45°
Dilation	20°	30°
Cohesion (MPa)	0.2	3
Tension (MPa)	0.2	3

- Axial loading
- Mohr-Coloumb Model : Matrix
- Ubiquitous-Joint Model : Fracture
- Model size: 100 x 5 x 200 [m]
- Zone size: 20 x 1 x 40
- Fracture orientation : $0° \leq \beta \leq 90°$

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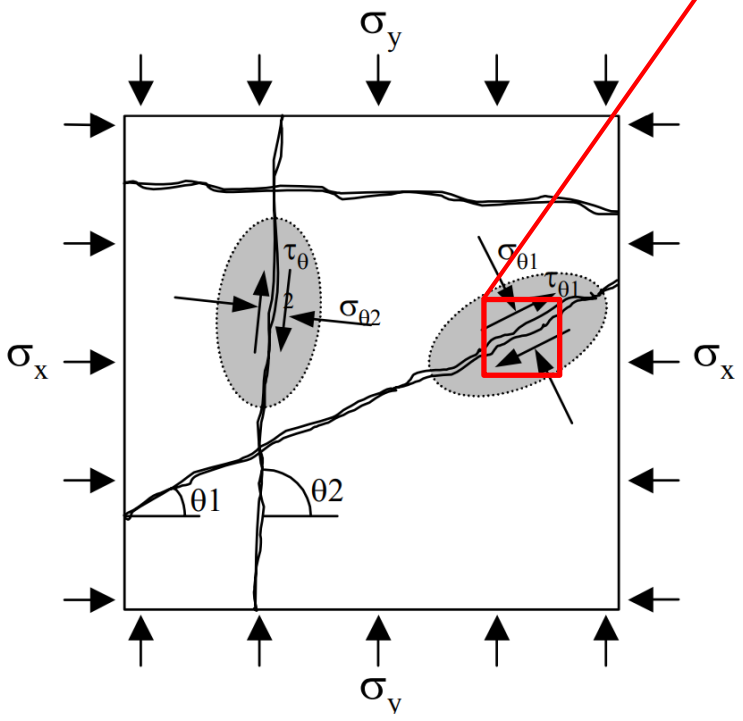
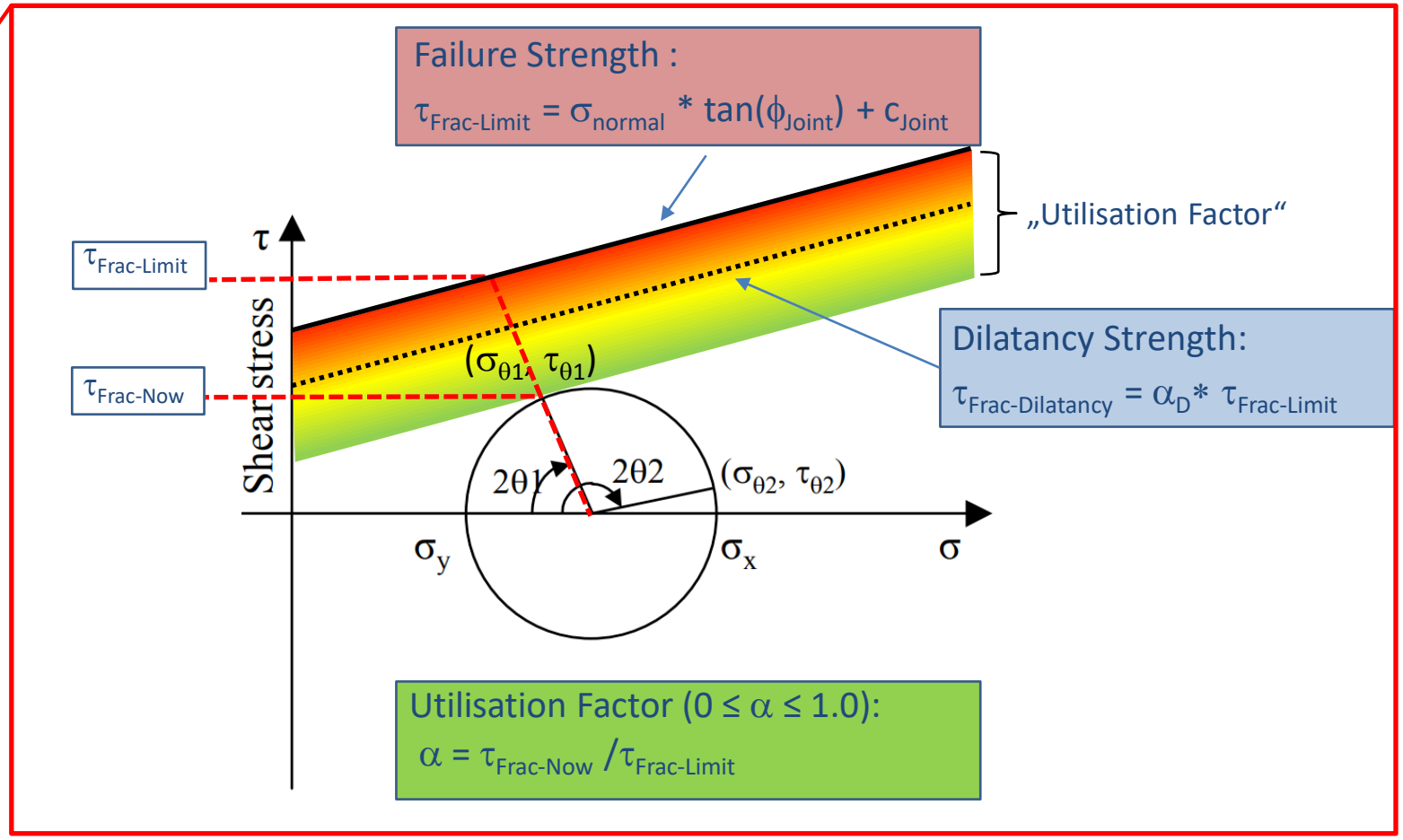
Failure/Dilatancy Envelopes in Mohr-Circle-Diagram → Joints





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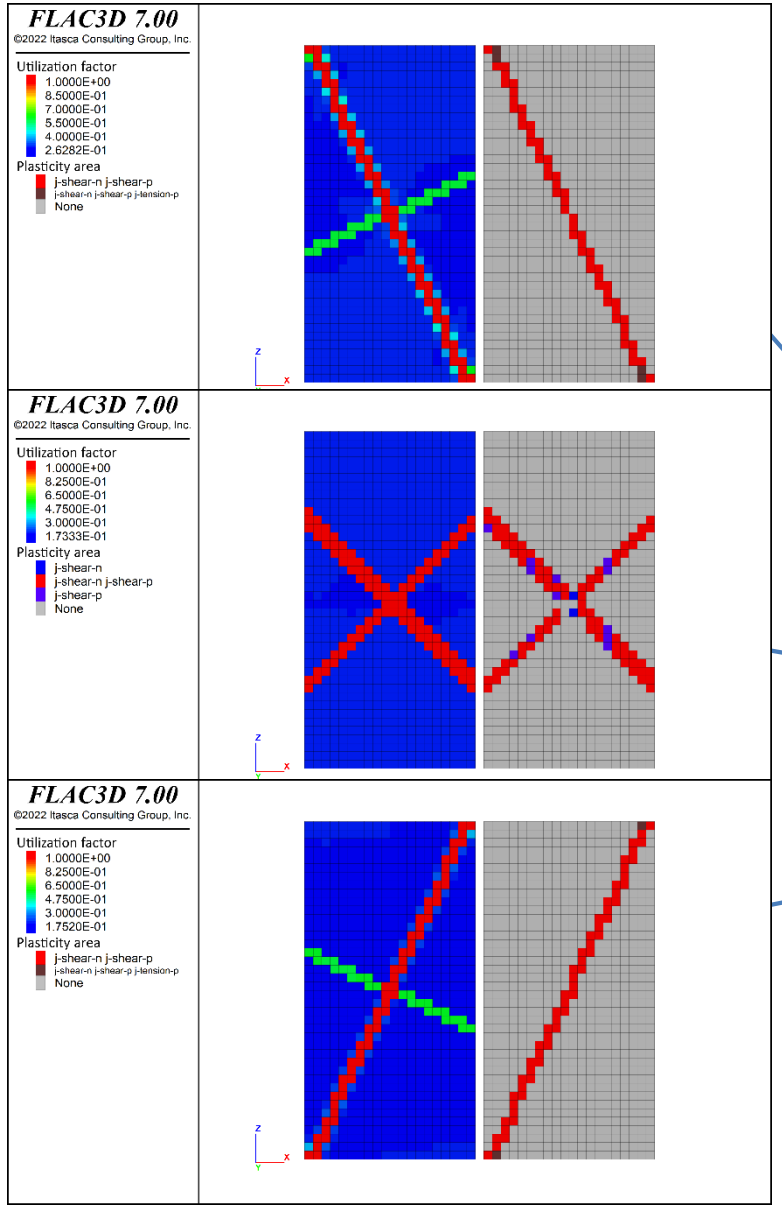
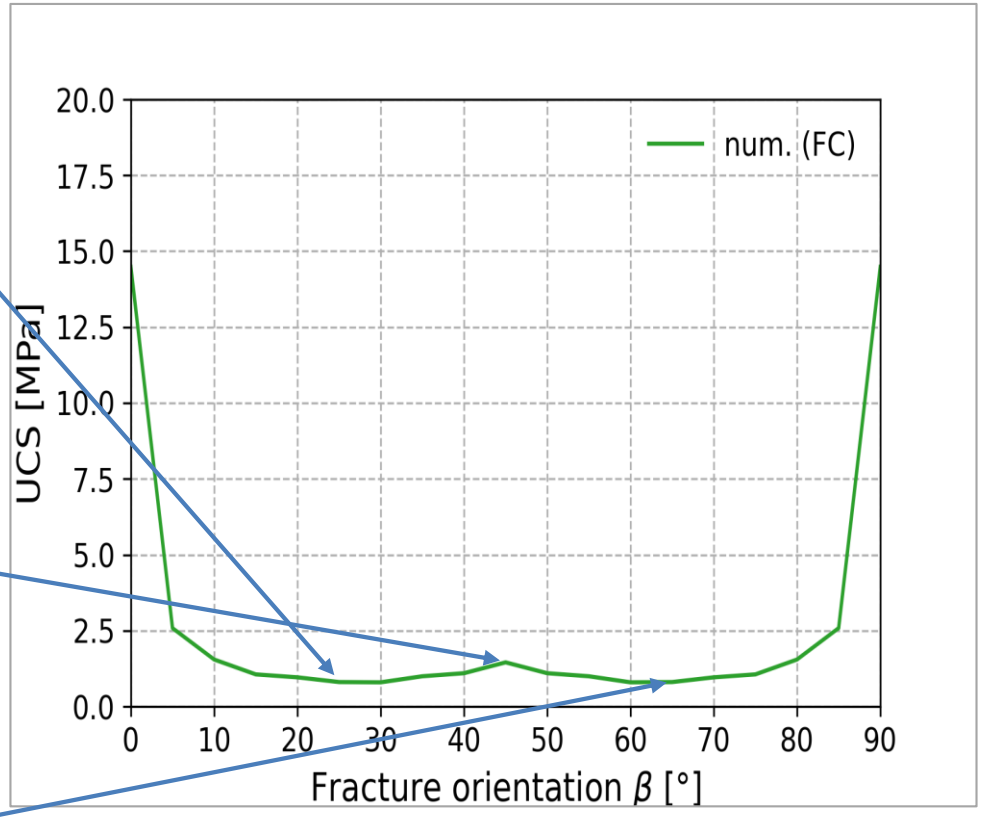
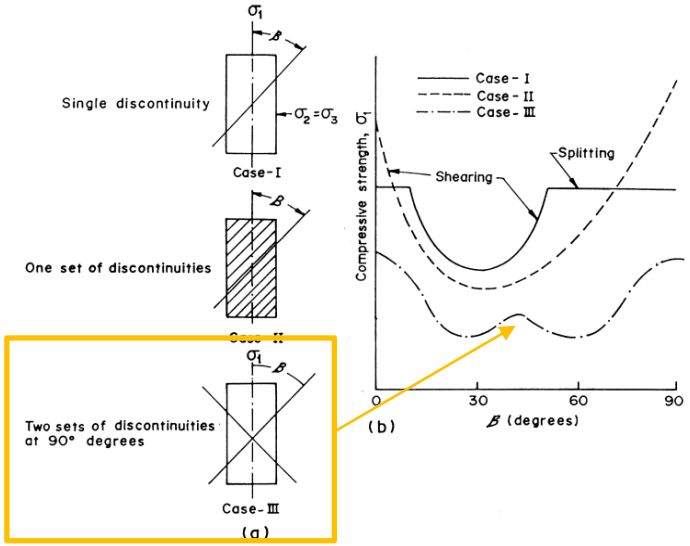
Fracture-Continuum: Two Orthogonal Fractures (Case III)







Left: Orthogonal fractures of different orientation. The colours represent utilisation factor (left) and the (shear) failure modes (right). Depending on the orientation, only one of the two fractures fails under shear. At 45°, both fractures fail.

Middle: Numerical strength anisotropy curve (qualitative)

Right: Observed curves according to literature

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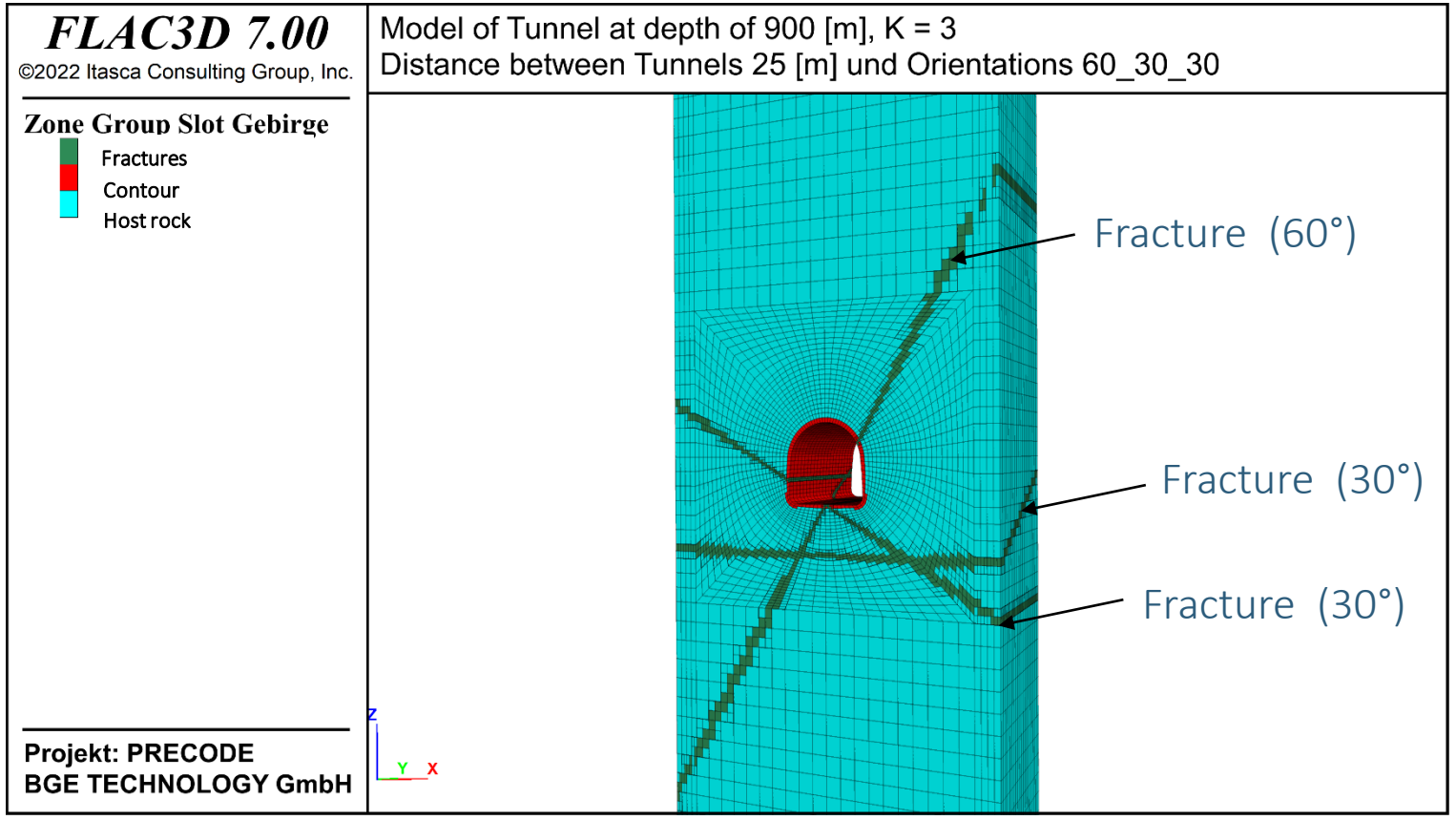
Benchmark – Tunnel



- Generalised model of size
  50 m x 10 m x 100 m
- Fractures of three different orientations
- Mechanical deformation processes

Material parameters	Fracture	Matrix
E (GPa) ν	7.85 0.27	73 0.27
Friction	35°	49°
Dilation	20°	10°
Cohesion (MPa)	0	31
Tension (MPa)	0	14.8

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Benchmark – Tunnel under different lateral initial stresses

FLAC3D 7.00
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Utilization-Factor-Matrix [-]
7.6007E-01
6.0000E-01
4.0000E-01
2.0000E-01
2.0768E-02
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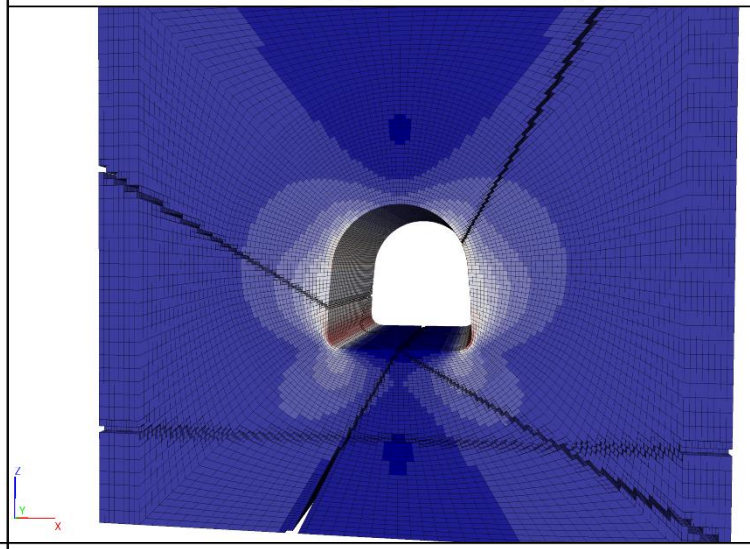
Model of Tunnel at depth of 900 [m], K = 0.5
Distance between Tunnels 25 [m] und Orientations 60_30_30



FLAC3D 7.00
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Utilization-Factor-Joint [-]
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8.0000E-01
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1.3770E-04
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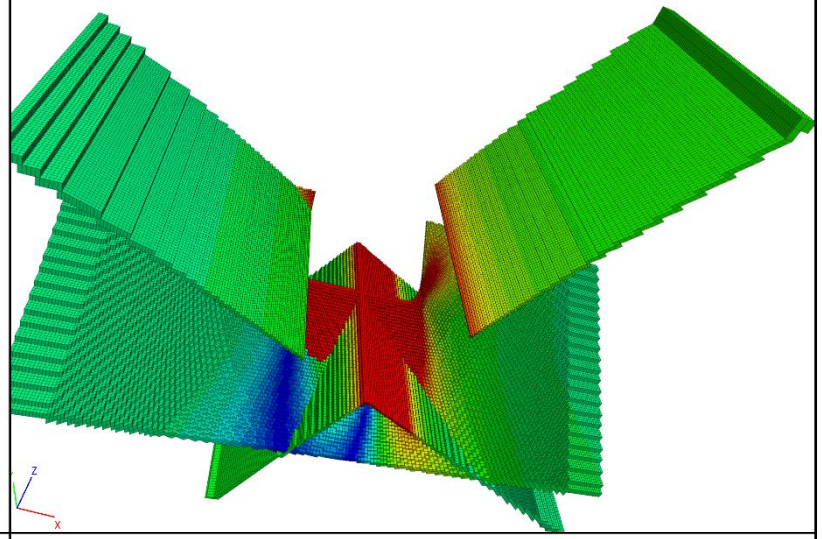
BGE TECHNOLOGY GmbH

Model of Tunnel at depth of 900 [m], K = 0.5
Distance between Tunnels 25 [m] und Orientations 60_30_30



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Projekt: PRECODE
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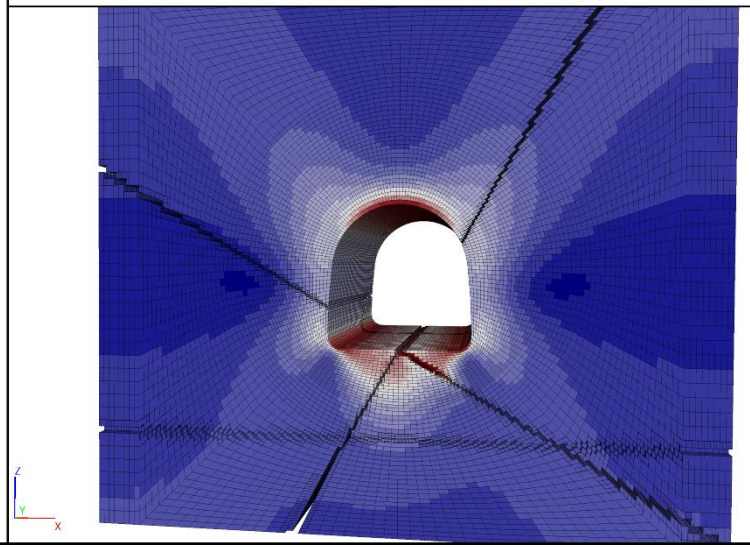
Model of Tunnel at depth of 900 [m], K = 3
Distance between Tunnels 25 [m] und Orientations 60_30_30



FLAC3D 7.00
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Utilization-Factor-Joint [-]
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2.0000E-01
3.2054E-04
Projekt: PRECODE
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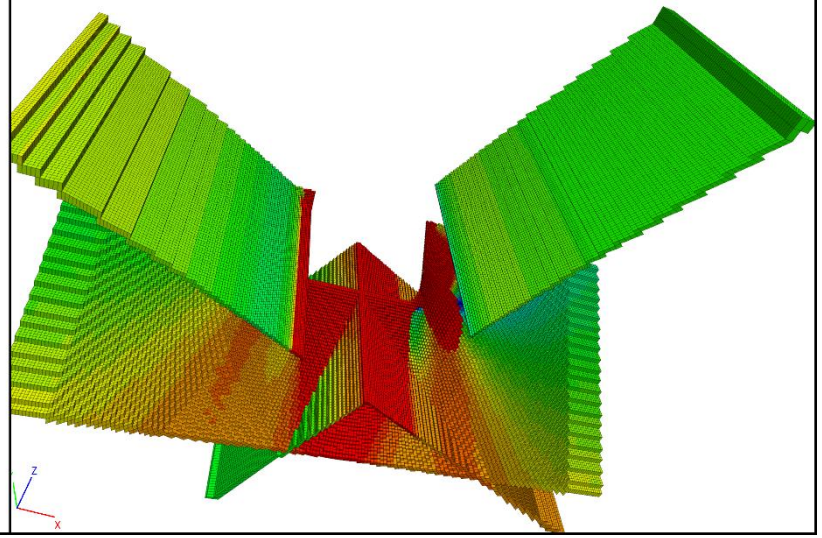
Model of Tunnel at depth of 900 [m], K = 3
Distance between Tunnels 25 [m] und Orientations 60_30_30



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Conclusions & Outlook

- Evaluation of the dilatancy criterion in a fractured crystalline host rock
    - Small-scale – Model with single/multi fractures
    - Benchmark – Case I – Medium-scale model with a tunnel
- To demonstrate the dilatant strength/the fluid pressure criteria of geological barrier
    - Benchmark – Case II – Medium-scale model with a borehole
    - Benchmark – Case III – Large-scale model with a repository