Project flow of JBlock

- Geotechnical Domain
- Excavation
- Keyblocks
- Support Scenario
- Hazard Analysis
- Results
Specify jointset:

- Orientation
  - Dip
  - Dip direction

- Strength
  - Cohesion
  - Friction

- Spacing
- Length
Joint Data 1

**Orientation**

<table>
<thead>
<tr>
<th>Set</th>
<th>Dip</th>
<th>Standard Dev.</th>
<th>Dip dir</th>
<th>Standard Dev.</th>
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<tbody>
<tr>
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</tbody>
</table>

Stress fractures: 0.0 N (Parallel to face)

**Strength**

<table>
<thead>
<tr>
<th>Cohesion kPa</th>
<th>Standard Dev.</th>
<th>Friction</th>
<th>Standard Dev.</th>
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<tbody>
<tr>
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<td>5.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>30.0</td>
<td>5.0</td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>30.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Random joints: 0.0 N 0.0 N 30.0 N 5.0 N

**Notes:**
- Dips: Stereographic Projection Analysis
- PEM: Point Estimate Method: Barton Bandis
Stereographic projections and discontinuity analysis
Friction Angle

Barton-Bandis model

This model is an improvement of the Patton’s approach by Barton (1973, 1976). In this case changes in shear strength with increasing normal stress are gradual rather than abrupt. Barton studied the behaviour of natural rock joints and proposed that Patton’s equation could be rewritten. In the Barton-Bandis model, simple measurements of joints were developed to have a practical way of evaluating the shear strength of joints (Barton, 1976; Barton and Choubey, 1977; Barton and Bandis, 1990). The joint shear strength for the Barton-Bandis model can be represented by the following equation:

\[ \tau = \sigma_n \tan[\varphi_b + JRC \log_{10}\left(\frac{JCS}{\sigma_n}\right)] \]

Where
- \( \tau \) = joint shear strength
- \( \sigma_n \) = effective normal stress
- \( \varphi_b \) = basic friction angle
- \( JRC \) = Joint Roughness Coefficient in the range 0(sMOOTH) to 20(ROUGH)
- \( JCS \) = Joint Wall Compressive Strength

The weakness of this model is that its focus is on expressing joint behaviour at peak shear strength. This therefore means that it cannot be relied upon when describing the pre-yield and post-yield behaviour of rock joints.
Friction Angle

Barton model

Barton (2002) provided a method of determining friction angles as follows:

$$\varphi = \tan^{-1} \frac{J_r}{J_a}$$

where:

- $\varphi$ is the joint friction angle
- $J_r$ is Joint roughness condition ($J_r$ = smooth for seepentinized joints and rough undulating for calcite filled joints and joints with no fill)
- $J_a$ is the joint alteration number ($J_a$ = unaltered for joints with no infill, non-softening sandy particles for calcite fill and clay mineral fillings of varying thicknesses for serpentinised joints)

This model has an underlying assumption that the joints are cohesionless. This is normally the case with sheared joints. This model provides an easy, cheap and intelligent field estimate of joint shear strength properties.

The other important joint properties are, thickness of filled joints, type of infill and water conditions. These properties contribute towards the joint shear strength. It should be noted here that joint set properties contributing toward the shear strength cannot be described by distributions and therefore mean values will be used.
Joint Data 2

Geotechnical Domain Data

Project: Projects
Domain Name: [Field]
Filename: DemoGeology.ged
Rock density (kg per m^3):

Joint Data 1
- Spacing
  - Set 1: Mean 0.0, Min 0.0, Max 0.0
  - Set 2: Mean 0.0, Min 0.0, Max 0.0
  - Set 3: Mean 0.0, Min 0.0, Max 0.0
  - Set 4: Mean 0.0, Min 0.0, Max 0.0
  - Set 5: Mean 0.0, Min 0.0, Max 0.0
  - Set 6: Mean 0.0, Min 0.0, Max 0.0
  - Set 7: Mean 0.0, Min 0.0, Max 0.0
  - Set 8: Mean 0.0, Min 0.0, Max 0.0
  - Stress fractures: Mean 0.0, Min 0.0, Max 0.0

Joint Data 2
- Length
  - Include?

Persistence: Applies
ends visible rules

Random joints: Mean 0.0, Min 0.0, Max 0.0
True Spacing: Hudson Priest

Scanline(Tape) →

Joint →

$\varepsilon$ → Apparent spacing → $d$

True spacing $\theta$
Persistence: Apply ends visible rules

E0: No ends visible: Length x 2.0
E1: One end visible: Length x 1.5
E2: Both ends visible: Length x 1.0
EXCAVATION

- Build excavation outline in clockwise direction
- Set excavation surface (orientation)
- Set mining direction
- Set face line
- Set face advance per blast
Setup Excavation
- Key block creation limits
- Generate 100,000 key blocks
Key block creation limits

• Block creation
  o Max aspect ratio considered

Aspect ratio = 1
High aspect ratio triangle

Aspect ratio = 1
High aspect ratio quad
FOG database

Aspect Ratio: Longest Edge

Aspect ratio = longest edge/volume$^{1/3}$

Max = 5.4
SUPPORT SCENARIO

- Simulation Tab
  - Set area of interest
  - Set Hazard Zones
  - Set Block release distance
  - Set External Loads

- Support Tab
  - Select support type
  - Set support properties
  - Place support in excavation
Setup Support Scenario: Simulation Tab
Simulation Tab: Block Release distance

- Block release during blast:
  - Percentage of blocks released during blast %: 80
  - Percentage of blocks released later %: 20

- Remaining blocks - release distance:
  - Percentage blocks released at face %: 75
  - Distance for 99% of blocks to be released (m): 40

Update graph
Compare different clamping stresses to get best correlation:
FOG database vs synthetic database:
- Correlation Coefficient
- Kolmogorov-Smirnov: Two Sample Test
Clamping Correlation

Clamping Correlation: Volume

Fallout: Volume

40% 80%
## Clamping Correlation

<table>
<thead>
<tr>
<th>Clamping Stress [kPa]</th>
<th>Correlation coefficient [%]</th>
<th>Max Error [%]</th>
<th>Avg Error [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>92%</td>
<td>38%</td>
<td>15%</td>
</tr>
<tr>
<td>4</td>
<td>92%</td>
<td>38%</td>
<td>17%</td>
</tr>
<tr>
<td>6</td>
<td>94%</td>
<td>32%</td>
<td>16%</td>
</tr>
<tr>
<td>8</td>
<td>96%</td>
<td>27%</td>
<td>9%</td>
</tr>
<tr>
<td>10</td>
<td>94%</td>
<td>30%</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Correlation coefficient**

\[
\text{Correl}(X,Y) = \frac{\sum (x-\overline{x})(y-\overline{y})}{\sqrt{\sum (x-\overline{x})^2 \sum (y-\overline{y})^2}}
\]

Kolmogorov-Smirnov: Two Sample Test
Setup Support Scenario: Support Tab
HAZARD ANALYSIS

- Analyse a support scenario
- Batch run several scenarios
- Block filtering
  - Mid height
  - Height to face area ratio
Analyse a support scenario

Filter blocks for clamping or extreme size...
Batch run several scenarios

Filter block sizes/clamping to use in analysis
Block filtering input parameters

- Block filtering
  - Tall thin block clamping
    - Mid height
    - Height to face area ratio

![Block filtering input parameters](image-url)
Block filtering: Mid height

Mid height = Max thickness / 2

Max = 3.5
Mid height = 1.75
Block filtering: Height to face area ratio

Height to face area ratio = $\text{thickness}/\text{face area}^{1/2}$

Max = 1.1
RESULTS

- Number of falls per 10 000m²
  - number of falls / (area exposed / 10 000)

- Mode of failure
  - Failed support
    - Too short
    - Too weak
  - Failed between support
  - Failed by rotation

- Size distributions of failed key blocks
  - Height
  - Volume
  - Face area
RESULTS EXPRESSED AS FALLS PER 10 000m²
What is driving the Mode of Failure?

Modes of Failure Analysis

Cumulative Frequency Normalised to 10000m²

Modes of Failure

- Failed Support
- Failed Between Support
- Failed by Rotation
What is driving the Support Failure?
Size distributions of failed key blocks?