### ROCK CLASSES

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<tr>
<td>Exceptionally poor</td>
<td>Extremely poor</td>
<td>Very poor</td>
<td>Poor</td>
<td>Fair</td>
<td>Good</td>
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#### REINFORCEMENT CATEGORIES:

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting, (and unreinforced shotcrete, 4 - 10 cm), B(+S)
5) Fibre reinforced shotcrete and bolting, 5 - 9 cm, Sfr + B
6) Fibre reinforced shotcrete and bolting, 9 - 12 cm, Sfr + B
7) Fibre reinforced shotcrete and bolting, 12 - 15 cm, Sfr + B
8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting, Sfr, RRS + B
9) Cast concrete lining, CCA
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**REINFORCEMENT CATEGORIES:**

1) Unsupported
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3) Systematic bolting
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5) Fibre reinforced shotcrete and bolting, 5 - 9 cm
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8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting
9) Cast concrete lining

**Rock mass quality**

\[
Q = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF}
\]
Exceptionally poor
Extremely poor
Very poor
Poor
Fair
Good
Very good
Ext. good
Exc. good

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Span or height in m

ESR

Bolt spacing in shotcreted area

Bolt spacing in unshotcreted area

RQD       Jr         Jw

Jn         Ja        SRF

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9) Cast concrete lining

Reinforced shotcrete ribs: 6 reinforcement bars in double layers in 55cm thick ribs with centre to centre (c/c) spacing 1.2m.

Each box corresponds to Q-values of the left side of the box, as indicated.

After Barton and Grimstad, 2006
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**Span or height in m**

**ESR**

**Bolt length in m for ESR = 1**

**Bolt spacing in shotcreted area**

**Bolt spacing in unshotcreted areas**

**REINFORCEMENT CATEGORIES:**

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9) Cast concrete lining

**Rock mass quality**

\[ Q = \frac{RQD}{J_n} \times \frac{J_r}{J_a} \times \frac{J_w}{SRF} \]