Final sealing of Huntly West Mine: A geosynthetic solution to long term stability.

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Use of Geosynthetics

- Civil construction industry
- Active or historic mining areas
- Ground likely to develop voids
Huntly West Mine History
West Mine Tunnels
Voids

(a) Caving arrested by more competent strata

(b) Caving arrested by bulking of roof debris

(c) Formation of a trough at surface

(d) Formation of a chimney at the surface
Voids
Closure Planning

• The standard for sealing of underground coal mines is legislated by the Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016.

• The New South Wales Department of Primary Industries Mining Design Guideline – MDG 6001 - Guideline for the Permanent Filling and Capping of Surface Entries to Coal Seams.

• The guidelines aim to prevent the propagation of an open void to the surface (cracks, sink holes) allowing access and the mine to “breathe”, exposing the general public to unexpected hazards.

• Seal drifts at a location where there has at least 15m of solid cover and backfilling the drift to the surface and installing another surface bulkhead seal.
Closure Planning

Several constraints that influenced the ability to install mine seals as described by the MDG 6001 guideline, including:

- The mine is filled with water;
- M&M tunnel contains a significant fall of ground close to the surface;
- 15m of solid strata cover is not available;
- Not feasible to dewater the mine to establish an inbye bulkhead.
Closure Planning: Sealing Options

- Excavation of an open pit with seal installed at the base;
- Install seals at a higher level;
- Conventional sealing via tunnel entrances;
Geotechnical Investigations

- Four cored drillholes; insitu strength tests and installation of standpipe piezometers.
Geotechnical Investigations

BH BHT, Box 4 of 4, 10m - 16.5m E0H
WEST MINE

1/3/2018

Start Box 4

Geotechnical Investigations
Design Strategy

• Mitigate the risk of voids opening to the surface and retain long-term stability

• Catastrophic failure is the primary concern for the design as surface settlements in pastural land of up to 1m could be adequately accommodated.

• The design of reinforced fill overlying a void is a variation of the ‘trapdoor’ experiment originally described by Terzaghi (1936)
Design Calculations

Key
1. Reduced depression at surface
2. Zone of deformation
3. Reinforcement
4. Depression at reinforcement
5. Void
6. Subterranean cavern
7. Collapsed rock
8. Depression at surface
9. Depression at reinforcement

United Kingdom Code of Practice (BS 8006-1 (2010))

\[ \varepsilon_{\text{max}} = \frac{8 \left( \frac{d_s}{D_s} \right)^2 \left( D + \frac{2H}{\tan \theta_d} \right)^4}{3D^4} \]

\[ T_{rs(BS)} = 0.5\lambda (f_s \gamma H + f_q w_s) D \sqrt{1 + \frac{1}{6\varepsilon}} \]

Formulation of Giroud et al (1990)

\[ T_{rs(Giroud)} = \frac{2\gamma D^2 \left( 1 - e^{-\frac{0.5H}{D}} \right) + W_s D e^{-0.5H/D}}{\Omega} \]
Design Calculations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s$: length of surface deformation</td>
<td>30m – 60m</td>
</tr>
<tr>
<td>$H$: height of fill above reinforcement</td>
<td>4m</td>
</tr>
<tr>
<td>$D$: design diameter of void</td>
<td>2.5m</td>
</tr>
<tr>
<td>$d_s$: depression at surface</td>
<td>0.75m</td>
</tr>
<tr>
<td>$d$: depression at reinforcement</td>
<td>0.5m</td>
</tr>
<tr>
<td>$\theta_d$: angle of draw / peak friction angle</td>
<td>30°</td>
</tr>
<tr>
<td>$W_s$: surcharge load</td>
<td>18 kN/m³</td>
</tr>
<tr>
<td>$\gamma$: unit weight of fill</td>
<td>18 kN/m³</td>
</tr>
<tr>
<td>$f_{fs}$: soil unit weight partial load factor</td>
<td>1.0 (SLS) 1.3 (ULS)</td>
</tr>
<tr>
<td>$f_q$: external applied load partial load factor</td>
<td>1.0 (SLS) 1.3 (ULS)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>Serviceability Limit State</th>
<th>Ultimate Limit State</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS 8006 (2010)</td>
<td>124 kN/m²</td>
<td>161 kN/m²</td>
</tr>
<tr>
<td>Giroud et al. (1990)</td>
<td>103 kN/m²</td>
<td>135 kN/m²</td>
</tr>
</tbody>
</table>
Geo-reinforcement Layout