A Contribution to Sustainable Development in Vietnamese Hard Coal Mining by Mine Dust Mitigation and Waste Rock Dump Stabilization

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Waste Rock Dump Stabilization and Rehabilitation

Waste Water Treatment in Mining

Dust Mitigation and Monitoring

Plant based Technologies

Environmental Management, Capacity Building

Methods for Planning Land Use after Mining

Research Association Mining and Environment in Vietnam

Institute of Mining Engineering

RWTH Aachen University

CBM

Geotechnik im Bauwesen
Geotechnical Engineering

BS
Vietnam, Quang Ninh Province, Ha Long

- Ha Long Bay: UNESCO World Heritage Site

Conflicts of Interest between Tourism and Mining
Nui Beo Coal Company (NBCC)

- Coal Production (mill. t)
- Waste Rock (mill. m³)
- Stripping Ratio (m³/t)

~ 5 Mt/a

~ 20 Mm³/a
Structure

- RAME Subproject 2a: Waste Rock Dump (WRD) Stabilization and Rehabilitation
  - Focus on Mechanical WRD Stability
    - Slope Stability
    - Erosion
    - Subsidence

- RAME Subproject 4a: Dust Mitigation and Monitoring
  - Dust Sources
    - Source Measurements
    - Emission Factors
  - Mine Dust Control Approach
    - Mitigation Methods
    - Control Factors & Modelling
Part I: Dump Stability

■ Existing WRD
  ➔ Heights > 300 m
  ➔ Single Slope Heights > 150 m
  ➔ No Vegetation
    ➔ Stability Problems

■ Investigation
  ➔ Material Parameters
  ➔ Erosion Modelling
  ➔ Test Areas
    ➔ Erosion Assessment
    ➔ Subsidence Monitoring

■ Stabilization Measures
Dump Stability: Erosion Monitoring (I)
Dump Stability:
Erosion Monitoring (II)

October 2010: 1.17 m³
May 2011: 1.26 m³
November 2011: 2.80 m³
April 2012: 2.82 m³
November 2012: 4.63 m³
# Stabilization Measures

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Cost</th>
<th>Slope Stability</th>
<th>Erosion</th>
<th>Landscaping</th>
<th>Area required</th>
<th>Effects on Production</th>
<th>Applicability</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight</strong></td>
<td>25%</td>
<td>10%</td>
<td>15%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>1 Height Reduction</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>0</td>
<td>--</td>
<td>-0,55</td>
</tr>
<tr>
<td>2 Slope Angle Reduction</td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>0,25</td>
</tr>
<tr>
<td>3 Berm Construction</td>
<td>0</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>0,6</td>
</tr>
<tr>
<td>4 Vegetation</td>
<td>-</td>
<td>0</td>
<td>++</td>
<td>++</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0,35</td>
</tr>
<tr>
<td>5 Surface Water Control</td>
<td>-</td>
<td>+</td>
<td>++</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0,5</td>
</tr>
<tr>
<td>6 Seepage Water Control</td>
<td>--</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-0,6</td>
</tr>
<tr>
<td>7 Soil Nails</td>
<td>--</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>--</td>
<td>-0,5</td>
</tr>
<tr>
<td>8 Support Structures</td>
<td>--</td>
<td>+</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>--</td>
<td>-0,75</td>
</tr>
</tbody>
</table>
Ongoing Dump Stabilization at Cẩm Phả
Dump Stability - Slopes

Factor of Safety vs. Slope Height [m]

- FoS=1.55
- FoS=1.00

Berm Construction

Graph Showing the Effect of Berm Construction on Dump Stability

- without berm
- 1 berm
- 2 berms
- 3 berms
- 4 berms
Part II: Dust Mitigation

Dust Emission Sources at NBCC Mining Area

- **Coal Production**
  - Loosening (Ripping)
  - Loading
  - Coal Transport
  - Unloading
  - Processing
  - Loading
  - Transport

- **Overburden Handling**
  - Loosening (Ripping - Drilling and Blasting)
  - Loading
  - Overburden Transport
  - Dumping

**Wind Erosion**
Emission Factor Development

- **Real-time Emission Measurements**
  - Emission Concentration and Wind Condition Measurements
  - Measurements of Parameters influencing Dust Emission
  - Provide Dataset for Emission Factor Development
## Dust Emission Factors – Contribution to Dust Generation

<table>
<thead>
<tr>
<th>Mining Activity</th>
<th>Emission Factor</th>
<th>Contribution to the Dust Generation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coal Production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling (case 1)</td>
<td>28.17 (g/m)</td>
<td>0.32</td>
</tr>
<tr>
<td>Drilling (case 2)</td>
<td>320.67 (g/m)</td>
<td></td>
</tr>
<tr>
<td>Drilling (case 3)</td>
<td>1,279.80 (g/m)</td>
<td></td>
</tr>
<tr>
<td>Blasting</td>
<td>0.53 (g/t)</td>
<td>0.06</td>
</tr>
<tr>
<td>Loading (case 1)</td>
<td>3.93 (g/t)</td>
<td></td>
</tr>
<tr>
<td>Loading (case 2)</td>
<td>3.78 (g/t)</td>
<td>0.58</td>
</tr>
<tr>
<td>Loading (case 3)</td>
<td>4.70 (g/t)</td>
<td></td>
</tr>
<tr>
<td>Haulage (case 1)</td>
<td>880 (g/km*truck)</td>
<td></td>
</tr>
<tr>
<td>Haulage (case 2)</td>
<td>524 (g/km*truck)</td>
<td></td>
</tr>
<tr>
<td>Haulage (case 3)</td>
<td>1,124 (g/km*truck)</td>
<td><strong>53.87</strong></td>
</tr>
<tr>
<td>Haulage (case 4)</td>
<td>392 (g/km*truck)</td>
<td></td>
</tr>
<tr>
<td>Dumping</td>
<td>0.225 (g/t)</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Wind Erosion</strong></td>
<td>0.198 (g/m²*hr)</td>
<td><strong>33.80</strong></td>
</tr>
<tr>
<td><strong>Overburden Handling</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### NBCC Watering Rate and Reduction [%]

<table>
<thead>
<tr>
<th>NBCC Watering Rate [l/m²] in 45 min</th>
<th>NBCC Reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.38</td>
<td>27</td>
</tr>
</tbody>
</table>

### Optimized Watering Rate and Reduction [%]

<table>
<thead>
<tr>
<th>Optimized Watering Rate [l/m²] in 30 min</th>
<th>Optimized Reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>70</td>
</tr>
</tbody>
</table>
### Dust Mitigation Methods & Dust Dispersion Modelling

#### Overburden Handling

<table>
<thead>
<tr>
<th>Mining Activity</th>
<th>Suggested Dust Mitigation Method</th>
<th>Dust Reduction Potential [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling</td>
<td>Wet Drilling</td>
<td>79</td>
</tr>
<tr>
<td>Blasting</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Loading</td>
<td>Wetting Material</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Wetting working Surface</td>
<td>9</td>
</tr>
<tr>
<td>Haulage</td>
<td>Water Spraying</td>
<td>70</td>
</tr>
<tr>
<td>Dumping</td>
<td>Reducing Dumping Height</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Wetting Working Surface</td>
<td>11</td>
</tr>
</tbody>
</table>
Conclusions

■ Dump Stabilization
  ➔ Stabilization is important for all further Rehabilitation Measures
  ➔ Change of Morphology is the cheapest and most effective Measure
  ➔ Surface Drainage Measures and Vegetation help to increase Erosion

■ Dust Mitigation
  ➔ Site-specific Mine Dust Emission and Reduction Factors required for Identification of Mine Dust Problem and corresponding control Options
  ➔ Developed Mitigation Methods provide cost-effective Dust Control at NBCC Mine Site

Project Results are implemented by Vietnamese Project Partners!
Thank you for your Attention!

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