Best practices for geotechnical planning and design in open pit mining operations: A sustainability approach

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Presentation outline:

Geotechnical Importance in Sustainable Mining

Geotechnical Best Practices in Open Pit Mining

Case Study of a lignite open pit mine in Greece

Conclusions
Geotechnical Importance in Sustainable Mining

**Sustainable Mining:**

- Cost effective mining
- Minimize Environmental Impact
- Produce added social and economic value

*How Geotechnical involvement affects sustainability?*
Geotechnical Importance in Sustainable Mining

Striping Ratio:

\[
\text{stripping ratio} = \frac{\text{overburden removed}}{\text{seam removed}}
\]
Geotechnical Importance in Sustainable Mining

Striping Ratio:

Too LOW can produce slope failures

Bingham Canyon Mine, 2013

known as the Kennecott Copper Mine

Kennecott slide moved more than 165M tons of dirt

Associated Press
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Striping Ratio:

Slope failures can result in loss of life

Tibet Gold Mine, 2013
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Striping Ratio:

Slope failures can result in operation disruption

Yallourn Coal mine, Victoria
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Striping Ratio:

Slope failures can result in Company loss of Credibility

Round Mountain gold mine, Nevada
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Striping Ratio:

Too **HIGH** can produce uneconomical operation
Geotechnical Importance in Sustainable Mining

Environmental and sociological impact

Mine tailings failures

Hungary Ajka alumina sludge spill 4 October 2010
Geotechnical Importance in Sustainable Mining

Why do such events occur?

Due to poor initial design?

Due to poor design implementation?

Due to climatic (weather) conditions?

Due to other events (i.e. seismic, poor blasting)?

Due to combination of factors?
Geotechnical Best Practices in Open Pit Mining

Can such occurrence be prevented?

“Best practice” approach:

Appropriate GEOTECHNICAL involvement in all mine stages

Starting during Reserve Investigation

During Feasibility Study

During Mine Planning

During Mine Production

During Mine Closure
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Reserve Investigation:

Involve as early as possible an Engineering Geologist

When drilling for reserves....

...use the opportunity for geotechnical data collection, and sampling
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Feasibility Study:

Execute preliminary geotechnical testing of all materials
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Feasibility Study:

Record geological - geotechnical information in consistent way
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Feasibility Study:

Install monitoring instruments in selected boreholes
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Mine Planning:

Detail evaluation of geological – geotechnical model
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Mine Planning:

Detail slope stability analysis and slope design
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Mine Planning:

Deterministic slope stability calculations (FS)

- Limit equilibrium analysis
- Best estimate of parameters

Probabilistic slope stability calculations (FS)

- Monte Carlo simulation
- FOSM method
- Point Estimate method

Figure 4: Concept of slope stability analysis

Probability Density Function

- Low Uncertainty
- High Uncertainty

Factor of Safety

F=1

F<1.2

F>1.4
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Mine Planning:

Execute risk hazard analysis
Implement risk management procedures

Risk management

- Decision-making on risk reduction
- Risk policies

Risk assessment

- Hazard identification
- Estimation of frequency of hazards
- Estimation of consequence of hazard

Risk evaluation

- Consideration of acceptability of risk
- Analysis of risk mitigation options (e.g. cost, etc.)
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Mine Planning:

Design monitoring program

Evaluate and design contingency plans
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Mine Operation:

Frequent re-evaluation of geological – geotechnical model

Routine monitoring of slopes

Store and analyze monitoring data (real time database?)

Implement warning and alarm limits

Implement contingency plan
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:

Excavation depth ~150m
Mine operation from 2002
328 bank Mm³
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:

Slope monitoring locations
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:

![Graph showing dY vs dX for different sections of a mine.](chart.png)
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:
Case Study of a lignite open pit mine in Greece

Mavropigi Mine Ptolemaida PPC:
Conclusions

Geotechnical best practices are tightly linked with the sustainability of mining operations (surface or underground)

An example was presented for best practices with respect to geotechnical planning and design

Yes, there are success stories
Thank you!

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Bingham Canyon Copper Mine