GEOTECHNICAL ANALYSIS OF A STOPE AS PART OF THE STOPE EXTRACTION NOTE

Case study of an underground hard rock mine

Contents

Introduction of stope extraction note

- Stope extraction note or stope note is a document used by most mines to define the strategy before mining the stope
- The following are considered as part of the stope extraction note;
  - Stopes economics
  - Stope planning – Gantt chart of all activities required for mining the stope
  - Stope geology
  - Development requirement to access the stope
  - **Geotechnical or ground control consideration**
  - Extraction sequence (Drill and Blast)
  - Hydrogeology
  - Ventilation consideration
  - Backfill consideration
  - Operational consideration
- This document solely focuses on the geotechnical consideration

Basis of stope geotechnical review

- The following should be checked as part of the ground control review before mining a stope:
  - Historical performance of the surrounding stopes (i.e. block)
  - Lithology and major geotechnical structures interacting with the stope
  - Stope stability analysis
  - Stress analysis and seismicity
  - Impact of adjacent stopes on the stope to be mined
  - Support and rehab requirements
- Other important aspects to be considered:
  - Support and rehabilitation requirements
  - Stope sequencing
  - Other important questions to ask as part of the analysis
  - Action plan from the analysis to be closed prior to mining the stope

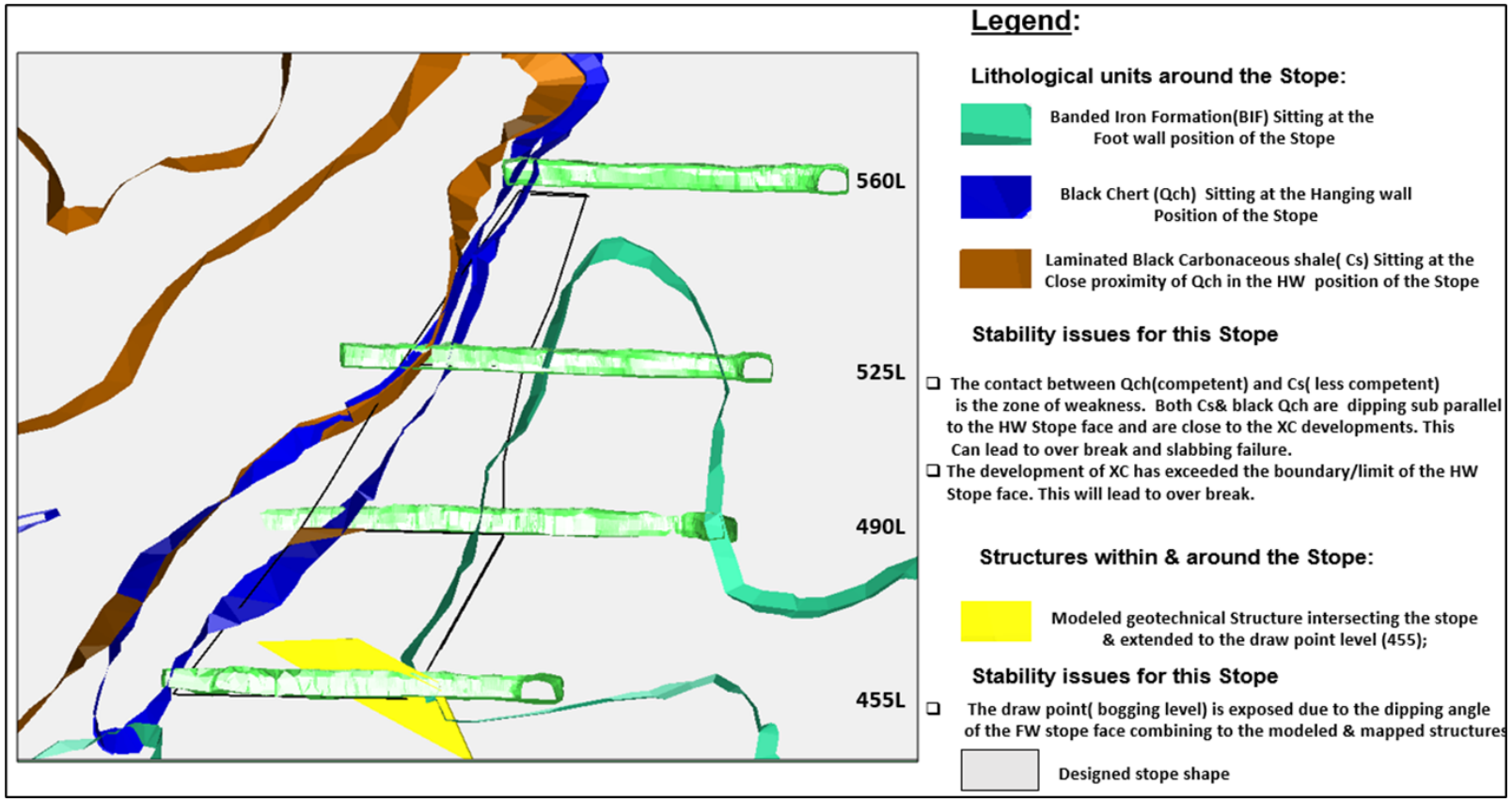
Block historical performance

- Historical performance of the block to be mined and surrounding stopes are critical especially when accessing previously mined stopes

- These basic questions should be asked when assessing these areas;
  - How did the stopes performed in that area (hanging wall, footwall, crown, side walls)?
  - Are there signs of overbreak or underbreak in the surroundings stopes and what caused those?
  - Is the block mined according to the recommended mining sequence?
  - Are there major issues related to seismicity?
  - Is it safe to access the block based on the recorded history of the area?
  - What are the major structures in the area that need to be considered for future stopes?

Lithology and geotechnical structures

- The lithology and major geotechnical structures should be defined from the block model and should also be confirmed on site after inspecting the stope underground
- The following is an example of a lithology of a stope and Geotech structures



Stope stability analysis

- One of the common methodology used to determine the stope stability analysis is done using the research work conducted by Nickson S.D.(1992) and Potvin (1988).
- The rock mass quality (Qindex) is first determined (Barton *et al*, 1974) after conducting a geotechnical core logging.

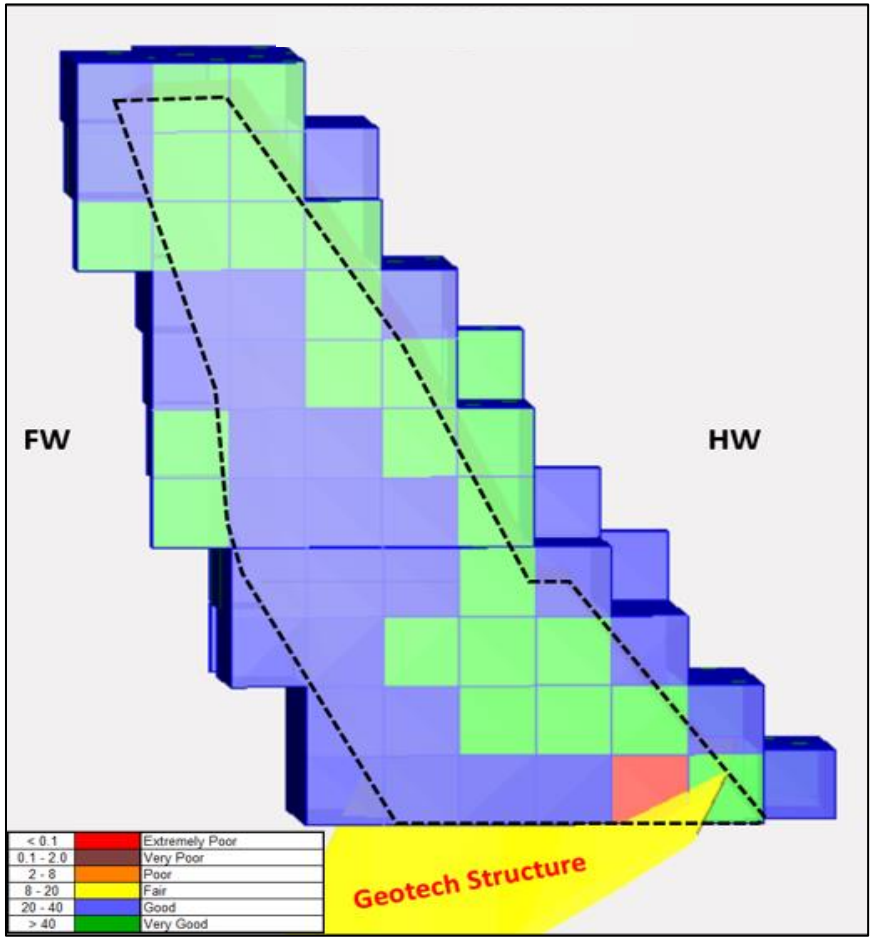
$$Q = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF}$$

RQD% = Rock Quality Designation
Jn = Joint set number
Jr = Joint roughness number
Ja = Joint alteration number
Jw = Joint water reduction factor
SRF = Stress reduction factor

- A mining rock mass model (MRMM) could be modelled using the data from the core after logging
- Inspecting the stope would be necessary to confirm the model and the structures
- The stopes could then be displayed in the MRMM during evaluation

Stope stability analysis

- The rock mass classification could be rated to define areas of good and poor ground within the stopes as illustrated in the example below.

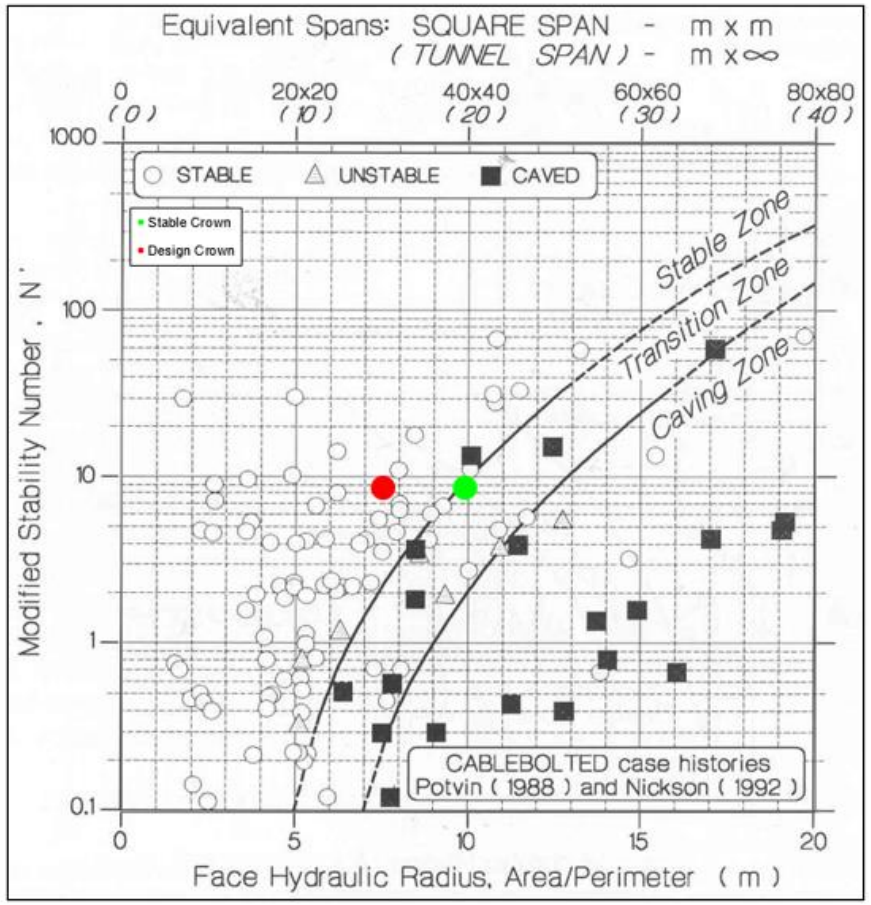


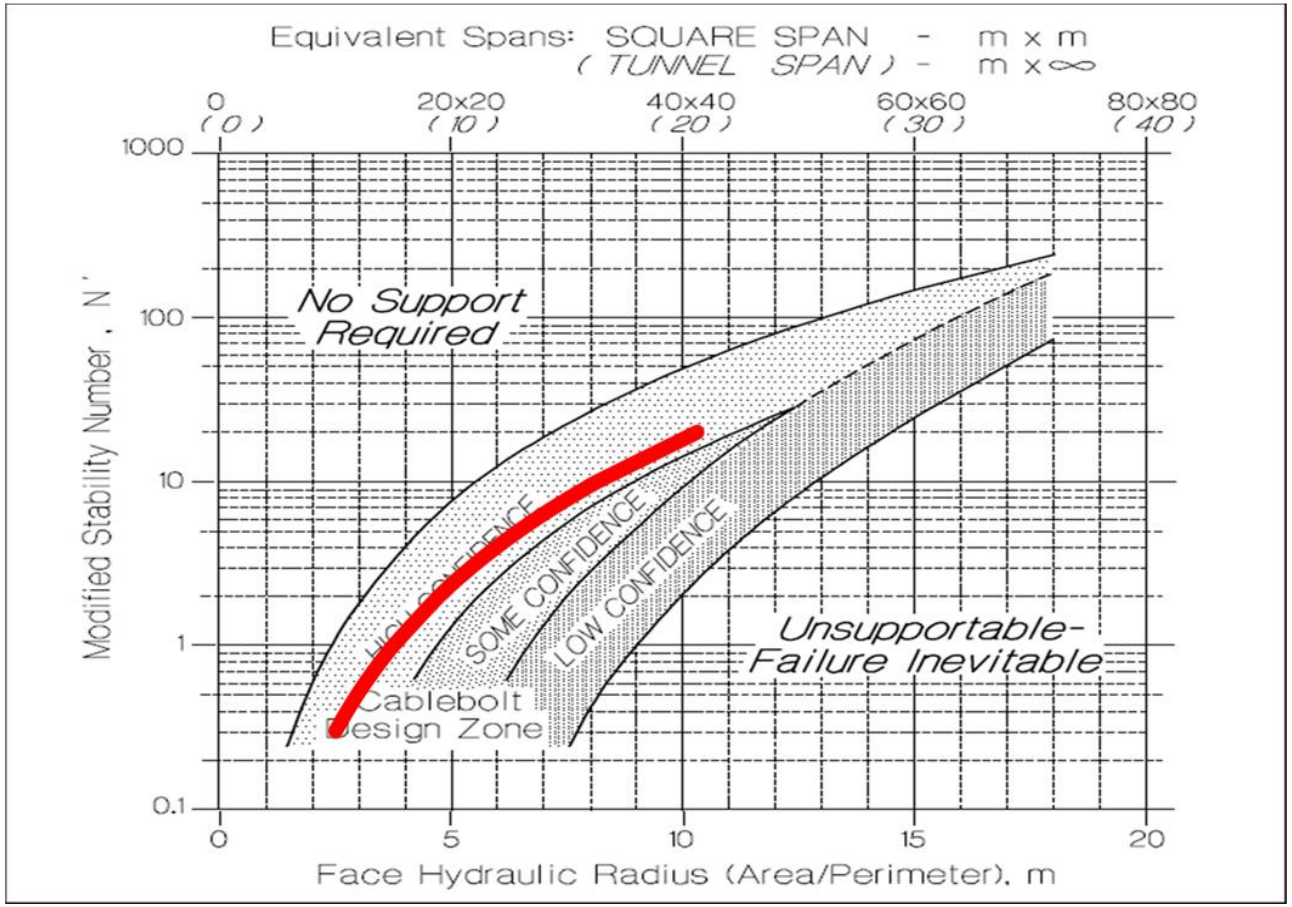
Stope stability analysis

- Using the modified stability number (N') and the hydraulic radius (HR), the stope faces (crown, side walls, hanging wall, footwall) could be plotted in the curve generated from various case studies by Nickson S.D.(1992) and Potvin (1988).
- N' is a function of rock mass quality, stress, joint orientation and block failure mode.
- Hydraulic radius (area of face divided by the perimeter of a stope).
- This will determine whether the designed stope is stable, transition or caving zone.
- The same approach is followed to determine the support requirement of the stope.
- Note: These are empirical design curves based on various case studies. It is strongly recommended to update these curves based on the actual stope's performance experienced in the mine.

Stope stability analysis

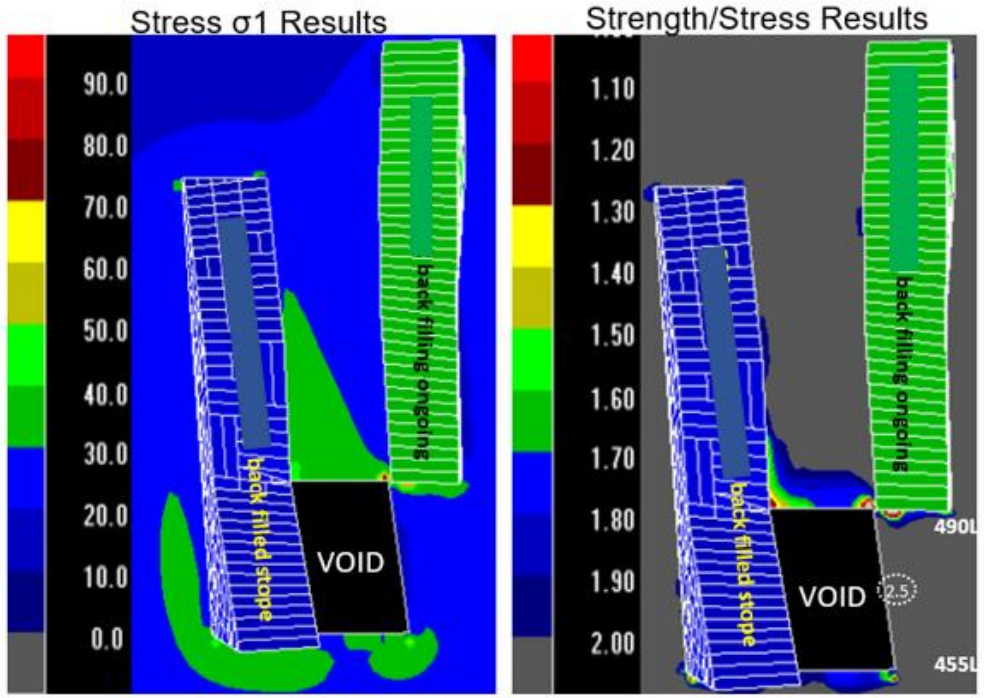
- The example below shows a stope crown being plotted in the stability curve (left) and cable bolt design zones (right)





Stress and Seismicity consideration

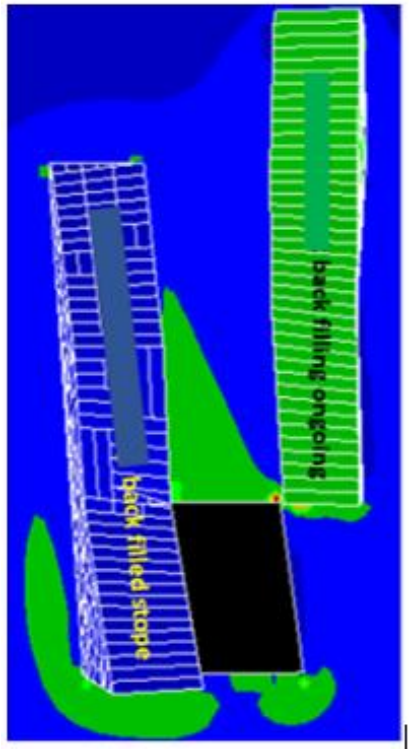
- A numerical modelling is conducted around a stope based on its sequence to understand the mining induced stress and potential seismicity after mining the stope.
- Previous seismic events in the area should be considered as part of the analysis.
- The figure below shows an example of a stress analysis around a stope after mining.



Stress results (left) and safety factor (right) around the stope

Impact of adjacent stopes

- The face exposed to the adjacent stope, which is previously mined should be analyzed.
- The number of faces exposed depends on the mining method.
- As per the previous example, there is only one face exposed to the backfill. It will be required to understand the backfill strength before mining the stope.
- This is to ensure that the adjacent stope has reached the required strength before blasting the current stope. Lower backfill strength means that after blasting the current stope, the backfill material would dilute the ore, possibly making the stope uneconomical.



Other important aspects

- Support requirements should comply to the ground control management plan (GCMP)of the mine site. The following are examples of types of supports.
  - Brow support: supporting the mucking level where the scoop operator will be working (always required)
  - Crown support: supporting the crown of the stope to prevent failure (might not always be required)
  - Hanging wall support: to prevent overbreak from the hanging wall (might not always be required)
- Rehabilitation might be required when accessing old workings to ensure that the area is accessible and safe to operate.
- Stope sequencing should be considered to ensure that stope is mined as per the recommended sequence.
- Other important questions;
  - Is ground water considered to be an issue to the stability of the stope?
  - Are they potential structures influencing blasting that may result into overbreak?
  - Have ground conditions for the stope brow been inspected ?
  - Are there any potential issues with the integrity of the brow?
  - If pillars are required between stopes, have they been assessed appropriately?
- Action plan from geotechnical analysis is required to ensure that the findings from the analysis is implemented before production drilling starts.

Conclusion

- The case study provided key aspects to be considered as part of the geotechnical review.
- Historical performance of the block to be mined and surrounding stopes should be considered.
- The lithology and geotechnical structures impacting the stope should be analysed.
- The N’ and HR value consideration as part of the stability analysis should be considered.
- The empirical design curve can be used as a starting point and then adapted to site later.
- Stress analysis and seismicity should be considered in the numerical modelling.
- The impact of adjacent stopes should be considered in the analysis (e.g. backfilled stope).
- Other important aspects to be considered are discussed in the case study.
  - Support requirement as per the GCMP
  - Rehabilitation requirement
  - Stope sequencing
  - Impact of water ingress in the stope stability
  - Important structures to be considered that will impact blasting
  - Pillar analysis between stopes if required
- Inspecting the stope to confirm MRMM and to inspect brow prior to mining the stope.

References

- Barton, N.R., Lein, R., and J. Lunde (1974). Engineering Classification of Rock Masses for the Design of Tunnel Support. Rock Mechanics, No. 6.
- Nickson S.D., 1992. Cable support guidelines for underground hard rock mine operations. MASc. Thesis, Dept. Mining and Mineral Processing, University of British Columbia.
- Potvin, Yves. 1988. Empirical open stope design in Canada. Ph.D. dissertation, University of British Columbia.

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