Brown Coal Open Pit
Mechanisms of Failure
Geo-Technical or Administrative...?

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Outline

- Setting the Scene – Geo-Technical Mechanism of Failure
- Historical Failures
- Known Knowns
- Tools to identify the known unknowns
- 3D & 2D Structural Geological Models
- Kinematic Analysis
- Administrative mechanisms of mine slope failures
A number of significant historic ground failure incidents have occurred in the Latrobe Valley some of which have prompt changes to operating arrangements and legislation. The historic incidents varies between overburden clearance, coal mining activities and overburden waste dumping activities.

One of the most recent and famous failures associated with coal mining activities occurred at the Yallourn Open Cut Mine in November 2007. The allege failure mechanism associated with this batter failure was that it was structurally controlled.
Setting the Scene – Geo-Technical Mechanism of Failure

(Yallourn Mine Batter Failure, Courtesy of Australian Mining)
The principal cause of this failure was concluded to have been hydrostatic pressure that had increased in a persistent joint located to the rear of the failure. This joint extended through to the Latrobe River. The other main cause was apparent excess hydrostatic pressure in the inter-seam clays underlying the block of coal which reduced the normal stresses acting perpendicular to the seam and hence reduced the shear strength of the interface.

“This failure mechanism was found to involve block sliding in which a large block of coal slid across the pit floor.” (Mining Wardens Report – Yallourn Mine Batter Failure Inquiry – Victorian Government Printer – No 156 Session 2006-08.)
HISTORICAL FAILURES

Block slippage of coal batter instigated by drainage entry into existing joint and opened crack pattern.

Image: Block failures - History of Morwell Open Cut, J.A. Vines
HISTORICAL FAILURES

Other historic failures highlight the importance of structural geological modelling for mine designs at all Brown Coal Operations and open pit mines in general.
KNOWN KNOWNS

There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know (Donald Romsfeld).

It is a known known that geological structures within the brown coal is one of the underlying factors associated with failures within the batters of the brown coal operations !!!

What should be not unknown to us is that there should be an obligation to allocate the necessary resources (budget and technical competent staff) to confirm the unknown knowns.
KNOWN KNOWNS

• The importance to identify the known unknowns is crucial in minimising geotechnical risk to any mining operation.

• The process of identifying geological structures as known hazards is crucial for long-term mine planning.

• What is more crucial is the development of 3D structural geological models to fit in with mining schedules.

• The lack in allocating the required budget and experienced resources to this important task forms the basis of an *administrative mechanism of failure*. 

(Yallourn Mine Batter Failure, Courtesy of Australian Mining)
TOOLS TO IDENTIFY THE KNOWN UNKNOWNS

- We have found that the MAPTEK I-Site scanning tool is a reasonable reliable and safe method of efficient structural mapping.
TOOLS TO IDENTIFY THE KNOWN UNKNOWNS

- Extraction of joints using MAPTEK – I-Site scanning and data processing

Joints are to be extracted
TOOLS TO IDENTIFY THE KNOWN UNKNOWNS

• The Geotechnical module of I-Site studio enables us to extract and measured all the joints captured in a scan.
TOOLS TO IDENTIFY THE KNOWN UNKNOWNS

Orientation of the mapped joints is presented in the form of strike/dip direction and can be exported in the form of text files.
3D & 2D STRUCTURAL GEOLOGICAL MODEL DEVELOPMENT
KINEMATIC ANALYSIS

For carrying out kinematic analysis, joint data must be categorised into different joint sets.

E.g. Joint sets can be identified in the following manner:

- J1 (Low angle set)
- J2 (Sub-vertical set)
- J3 (Steeply dipping set)
KINEMATIC ANALYSIS

DIPS and 2D & 3D Swedge software packages can be used to analyse all the major joints set and their sub-sets for the following modes of failure:

- Plane Failure
- Toppling
- Wedge Failure
KINEMATIC ANALYSIS

Potential Plane Failure
KINEMATIC ANALYSIS

Toppling Failure
KINEMATIC and Wedge Analysis

Potential Wedge
ADMINISTRATIVE MECHANISMS OF MINE SLOPE FAILURES

- Mine management fails to understand the geotechnical risk environment
- Budgets are not allocated to identify the known unknowns
- In-experienced resources are allocated to analyse the apparent Geo-Technical mechanism of potential failure
- Technical services fails to design an appropriate drainage network
- Mine production fails to implement much needed remediation e.g. fixing leaking pipes / unblocking blocked drains
ACKNOWLEDGEMENTS

I would like to thank the “organisers” of this event for the opportunity to highlight the *known unknowns.*

*If you leave water to seep into the batters at a rate of 1L / min how many standard pools full with water would be in the batters after 24 hours / days / weeks / months...?*

- 1 L / min (slow)
- 24 hours
- 1440 Litres
Thank You!