Contribution of Geotechnical and Rock Mechanics design to vertical shaft sinking and design
CONTENTS

- Geological and Geotechnical investigations
- Pre-sink
- Examples of Pre-sinking in soft soils
- Ancillary excavations
- Conclusions
GEOLOGICAL INVESTIGATIONS

- Surface mapping of outcrops
- Seismic survey/aeromagnetic survey
- Borehole drilling in area of interest (mine boundary)
- Output is a stratigraphic representation of borehole logs, including weathering profiles in relation to rock layers
- Surface and underground structural plans can be produced
AEROMAGNETIC SURVEY RESULTS
3-D SEISMIC SURVEY PLOT
PLANNED BOREHOLES
EXAMPLE OF A WEATHERING PROFILE AND ROCK LAYERS
GEOLOGICAL AND GEOTECHNICAL CORE LOGGING

- Geological logging: structures, stratigraphy, Rock Quality Designation (RQD) and grade values

- Geotechnical logging: RQD, Rock Mass Ratings, condition of joints, faults, hangingwall, footwall and signs of stress effects (e.g. core discing)

- Critical to drill a mother hole where the shaft is to be positioned – gives an indication as to the ground conditions to be expected during sinking operations
GEOTECHNICAL INVESTIGATION OF THE MOTHER HOLE

- Down-the-hole surveys - measure joint frequency and orientation
  - measure water inflow and position of aquifers
  - detect major geological structures
  - measure borehole breakout (indication of orientation and magnitudes of stress)

- Classification of rock for sinking operations

- Geotechnical testing of rock, particularly hangingwall/roof, reef and footwall/floor

- Ideal to have an indication of the stress regime
EXAMPLE OF A PLOT FROM A DOWN-THE-HOLE SURVEY

RNF 63 Televiewer Survey
Joints Pole plot True North

RNF 63 Televiewer Survey
Joints Dip Direction True North

RNF 63 Televiewer Survey
Joints Strike Direction True North
EXAMPLE OF CORE DISCING
EXAMPLE OF BOREHOLE BREAKOUT
TYPICAL EXAMPLES OF CLASSES OF ROCK IN BOREHOLE
### Diagnostic Features of Weathering Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Discolouration</th>
<th>Discontinuities</th>
<th>Fabric</th>
<th>Texture</th>
<th>Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Severe throughout</td>
<td>Individual fractures may be unclear</td>
<td>Weak and friable</td>
<td>Mostly destroyed</td>
<td>Friable or loose</td>
</tr>
<tr>
<td>2</td>
<td>Moderate to severe throughout, severe along fractures</td>
<td>Discoloured and clearly weathered, may contain thick clay</td>
<td>Moderately friable, only slightly abrasive and usually weak</td>
<td>Visible, but only partly preserved</td>
<td>Partial opening</td>
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<tr>
<td>3</td>
<td>Moderate in fabric, moderate to severe along fractures</td>
<td>Most minerals present, joints may contain clay and/or oxides</td>
<td>Recognisable, but rock only moderately strong</td>
<td>Mostly preserved and intact</td>
<td>Intact</td>
</tr>
<tr>
<td>4</td>
<td>None in rock, slight to moderate along fractures</td>
<td>All minerals present, some clay and/or oxide staining</td>
<td>Fresh</td>
<td>Preserved</td>
<td>Intact</td>
</tr>
<tr>
<td>5</td>
<td>None</td>
<td>Fresh</td>
<td>Fresh</td>
<td>Preserved</td>
<td>Intact</td>
</tr>
</tbody>
</table>
INDICATION OF STRESS REGIME AT STATION LAYOUT
TYPICAL RESULT FROM CORE TEST (UCS)
PRE-SINKING ASPECTS

- Soil tests for toeing in the collar
- Depth of weathering
- Mass of the headgear and surface structures
- Design of foundations for surface infrastructure
- Equipment selection
SOIL CONSISTENCY TESTS

- Diamond drill borehole cores using triple tube techniques
- Standard Penetrometer Tests, including Raymond Spoon sampling
- Core logging – material type, moisture content and in-situ consistency
- Dynamic Probe Super Heavy tests – limited to 15 meter depth
- Piezo-cone (CPT) testing – can measure pore pressure which can be used to calculate 3-D stress at depth
- Laboratory tests – including triaxial (drained and undrained) and Atterburg limits (particle size analysis)
EXAMPLE OF A PLOT TO INDICATE THE COLLAR MATERIAL
HAZARDS THAT CAN INFLUENCE CONDITIONS

- Loose and running sands
- Active clays – squeezing and contracting conditions
- Collapsing soils
- Liquefaction
- Influence of water and piping
- Strength of residual materials
- Weathering/slaking of exposed material
- Depth of weathering
EXAMPLES OF PRE-SINKING IN WEAK MATERIAL
EXAMPLE OF WEATHERED DOLERITE
EXAMPLE OF PRE-SINK IN SOFT MATERIAL
PILING USING OLD PIPES
GROUND CONDITIONS BELOW THE PILES
EXAMPLE WHERE NO PRE-SINK WAS REQUIRED
EXAMPLE WHERE NO PRE-SINK WAS REQUIRED
EXAMPLE OF PILING TO CATER FOR SOFT SOIL
EXAMPLE OF PILING TO GO THROUGH SOFT SOIL
EXAMPLE OF PROBLEMATIC GROUND CONDITIONS NOT DETECTED IN DRILLED CORE
ANCILLARY EXCAVATIONS

- Shaft reef intersections
- Station breakaways
- Station layouts
- Silos/orepasses
- Pump chambers
- Dams
- Loading boxes
EXAMPLE OF SHAFT LAYOUT – SECTION VIEW
MAXIMUM STRESS ORIENTATION

- Maximum horizontal stress (MPa)
- Depth (m)

- Shallow mines
- Platinum mines

Graph showing the relationship between depth and maximum horizontal stress for shallow mines and platinum mines.
CONCLUSIONS

- Geological and Geotechnical programme critical
- Drilling of a Mother Hole is critical – spend the money on a down-the-hole survey
- Important to do the soil consistency tests
- Different methods available to do the pre-sink to toe in the collar
- Ancillary excavation orientations, sizes and shapes to be planned carefully
QUESTIONS / COMMENTS ?