RAPID INSTALLATION OF SUPPORT IN A PARTIALLY RAISE BORED SHAFT USING SKY JACKS.

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Synopsis
Installation of support in known poor ground intersections during reaming operations requires rapid access to stabilize the shaft wall and thus to prevent the loss of the shaft through scaling. This is especially relevant to shafts of long dimension where the duration from time of exposure to time of support installation is lengthy.

This paper deals with the innovative methodology employed at Harmony’s No. 8 Shaft 17/24 level sub ventilation shaft to rapidly support a shale intersection between 23 and 24 Level by employing a single deck stage suspended from the reamer head by means of Skyjack winches.

Introduction
Murray & Roberts Cementation (Pty) Limited was contracted to drill a raise bore ventilation shaft of 4.5m diameter at Harmony’s Evander Gold Mine No. 8 shaft from 17 level to 24 level to serve as a downcast ventilation shaft to serve the expanding operations below the 24 level horizon. The shaft is of approximately 520 metre length. A known intersection of shales in the lower portion of the shaft from 24 level to approximately 60 metres from shaft bottom posed a potential failure of the shaft side wall as support of this portion of shaft would conventionally only be accessed following completion of the remaining and installation of shaft access equipment.

The risk of shaft wall failure due to the conventional methodology prompted Harmony Engineers to approach Murray and Roberts Cementation (Pty) Ltd Mining Division to propose a solution to the problem.

Rock mechanic recommendations required installation of 1.5m x 20mm resin grouted rock dowels on a 1.6m horizontal lx 1.5m vertical spacing covered with a layer of polypropylene fibre reinforced shotcrete 100mm thick.

Initial Planning
Several meetings took place to devise a suitable safe method to support the shale intersection as soon as it practically possible following traversing this section of shaft by the reamer head.

At first a method of “blind supporting” the shaft was considered. This entailed attaching a stage to the reamer head on 24 level and raising the reamer head and stage in 3 metre lifts.
to allow the crew to support the shaft wall from the protection of the reamer head and stage. The idea was discarded due to perceived difficulty in providing ventilation to the stage and the possibility of the shaft collapsing above the reamer head position with the potential of the whole support system falling back to the level below.

**The Solution**

It was noted that a tunnel excavation on 23 level some 90 metres above 24 level passed approximately 100 metres from the shaft position. It was decided to develop this tunnel to intersect the shaft and to serve as a top access during the support phase.

To negate the necessity to excavate a catwalk and winder chambers for the access equipment it was decided to employ Skyjack winches to suspend a stage below the reamer head. A risk assessment revealed no extraordinary risks and this methodology was chosen and further refined.

**Scope of Work to be carried out**

**Methodology**

In order to allow the placing of the 100mm layer of shotcrete and to allow the reamer head to be lowered for future cutter changes it was determined that the lower section of
shaft had to reamed to a diameter of 4.8m. This would allow a clearance of 100mm either side of the reamer once the shaft was supported. The stage dimension was designed to be 4.2m diameter.

The sequence would be to ream to 10m above 23 level elevation, develop the 23 level access into the shaft, lower the reamer to 24 level and then to attach the stage ropes to a ring fitted to the reamer head. The stage ropes would be threaded through 6 Skyjack winches installed on the stage. Once attached the raise bore will be employed to raise the reamer and stage up to 23 level for the system to be commissioned for support to commence from the top down.

**Safety Considerations**

Due to the novelty of the methodology every aspect of safety risk was considered and mitigated. These included;

- The covering of the raise bore head with a protective cover to prevent any loose material in the 1m exposed shaft area above the reamer from falling through the reamer head.
- The lockout of the raise bore machine during support operations.
- Emergency procedures for lowering of the stage during power failures.
- A procedure for accessing the stage by men due to the stage being 4.2m and the shaft 4.8m leaving a gap of 300mm between stage and shaft wall.
- Training of the crew in maintenance of the access system.
- A telephone communication system between 23 level bank and the stage.
- Crew selection with suitable shaft experience.
- Designs signed off by professional Engineers.
- Test certificates of Skyjack winches and stage suspension ropes.

**Hazard identification**

**EVANDER 8 SHAFT VENTILATION SHAFT SUPPORT HAZARD IDENTIFICATION**

The following Actions need to be taken on Hazard Identification by the crew and The Shift Supervisor.

All Items to be inspected on every Shift before using the Sky Jack Stage Arrangement.

**Responsible persons:**

- **Mine Overseer** – Nico de Lange
- **Shaft Foreman** – Inspection day Shift & Checklist
- **Fitter** – Daily Inspection & Checklist
- **Mine Overseer** – Planned Inspection once Weekly – Record.
<table>
<thead>
<tr>
<th>Hazard</th>
<th>Immediate Action</th>
<th>Remedial Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sky Jack Rope damage</td>
<td>Stop all Work</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td>Stage Bolts suspension bolts loose</td>
<td>Fitter to tighten</td>
<td>Record</td>
</tr>
<tr>
<td>Electrical feeder cable damage</td>
<td>Stop all work</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td>Stage assembly bolts loose</td>
<td>Fitter to tighten</td>
<td>Record</td>
</tr>
<tr>
<td>Sky Jack Winch failure on Bank</td>
<td>Stop all work</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td>Sky Jack Winch failure below Bank</td>
<td>Release Clutch on failed unit, raise stage to bank.</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td></td>
<td>Stop all work</td>
<td></td>
</tr>
<tr>
<td>Power failure</td>
<td>Release Clutches on all Sky Jack Winches. Lower stage to 24 level.</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td>Loose Rocks/material on bank area</td>
<td>Remove to safe place</td>
<td></td>
</tr>
<tr>
<td>Shot crete Build up on Stage</td>
<td>Clean Stage at end of every shift</td>
<td></td>
</tr>
<tr>
<td>Overloading of Stage</td>
<td>Shift boss to Oversee and sign off</td>
<td></td>
</tr>
<tr>
<td>Lighting failure on Stage</td>
<td>Repair at end of Shift</td>
<td>Record</td>
</tr>
<tr>
<td>Fire on Stage</td>
<td>Extinguish with Fire Extinguisher provided</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td>WB Temp above 31,5 C</td>
<td>Raise Stage to bank, Withdraw</td>
<td>Record, Report to Mine Overseer</td>
</tr>
<tr>
<td>No Compressed air</td>
<td>Raise Stage to bank</td>
<td>Record</td>
</tr>
<tr>
<td>Bad Ground conditions in Shaft</td>
<td>Raise Stage to above position, Bar down</td>
<td>Record</td>
</tr>
<tr>
<td>Loose Pipe suspension Clamps</td>
<td>Inspect every shift.</td>
<td>Tighten</td>
</tr>
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<td>-----------------------------</td>
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</tbody>
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**MAXIMUM STAGE EQUIPMENT ALLOWED**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x S21 Rock drills, Air legs</td>
<td>216 kg’s</td>
</tr>
<tr>
<td>6 men</td>
<td>480 kg</td>
</tr>
<tr>
<td>10 x 1,8m Drill Stems</td>
<td>45kg</td>
</tr>
<tr>
<td>45 x 1,8m Rock bolts</td>
<td>113kg</td>
</tr>
<tr>
<td>1 x Shotcrete Nozzle</td>
<td>15kg</td>
</tr>
<tr>
<td>Hoses, Fittings &amp; Tools</td>
<td>75kg</td>
</tr>
<tr>
<td>Grout pump</td>
<td>66kg</td>
</tr>
<tr>
<td>Grout</td>
<td>150kg</td>
</tr>
<tr>
<td>Total Mass Allowed</td>
<td>1160kg</td>
</tr>
</tbody>
</table>

Skyjack manuals
Stage Design

The stage was designed to be a lightweight structure 4.2m diameter. Stage mass was 1060.2 kg with maximum permissible load of 2000kg.

Procedures were established to limit the stage mass to below this capacity.

Reamer Suspension Ring Design
Working hours and Schedule

Two x 10 hours shifts were worked 23 days per month. During the latter stage of the project the project schedule was changed to 24 hours per day to make up lost time due to material delivery constraints initially.
Programme of work

Crew Size

The crew comprised of the following shaft sinking personnel

Master Sinker        1
Shaft Foreman        2
Stage Hand/Miner     2
Electrician          1
Skyjack Technicians  2
Stage Team Leader    2
Rock drill Operators 4
Shot crete Nozzle men 2
Bank Labourers       4

Equipment

A wet/dry crete machine of 2m3/hour capability feeding via an 80mm HDPE flanged pipe attached to the shaft wall was employed for shotcreting. The rigid pipe fed directly into the placing hose on the stage.

Rock bolt holes were drilled pneumatically with s21 rockdrills powered by compressed air via a 50mm compressed air pipe. Water was delivered via a 2\textsuperscript{nd} 50mm column.

Holes were drilled to 28mm to maximize the strength of the resin capsules around the 20mm rock bolts.
Actual Performance

Shotcrete placed  1350 m² in 34 days at average 39 m²/day
Bolts installed    565 in 34 days @ average 16 per day
Agreed Scope changes  11 days
Contractors delays   4 days
Total Support days    49 days

Safety Statistics

The project was executed with no accidents or safety related incidents.

Acknowledgements

Marius Pelser       Harmony
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Cassie Wesolowski   Harmony
Nico de Lange       M & R Cementation
The support crew    M & R Cementation