Everest Conquered

Thomas O'Brien
Geotechnical Engineer
ARQ Consulting Engineers (Pty) Ltd
thomas@arq.co.za

INTRODUCTION

Aquarius Platinum South Africa (AQPSA) is planning the expansion of their Everest Platinum Mine located approximately 30 km west of Lydenburg in Mpumalanga. The proposed expansion will include the addition of two new decline box-cuts, a tailings storage facility and a new road connecting this infrastructure. This extension of the infrastructure will provide access to additional ore-body that will increase the life of the mine.

ARQ Consulting was responsible for conducting and supervising the geotechnical fieldwork, the interpretation of results and several analyses, including finite element analyses, in order to produce detailed designs for certain components of the proposed surface infrastructure.

GEOLOGY AND TOPOGRAPHY

The Everest Platinum Mine is located between Lydenburg and Dullstroom in some of the most picturesque and steep landscapes in the country. The Groot Dwars River, near which the box-cuts are located, is in a valley approximately 850 m below the adjacent mountains.

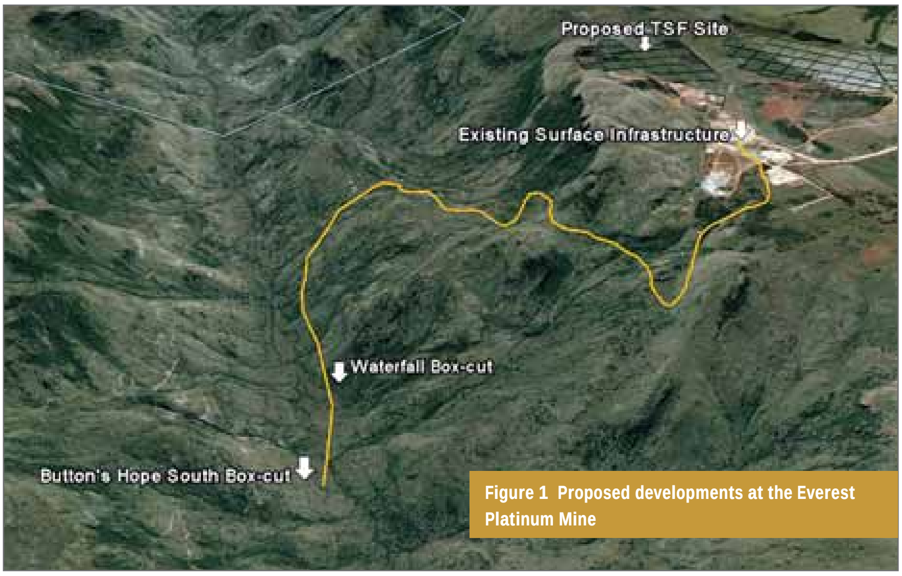

Figure 1 Proposed developments at the Everest Platinum Mine

The steep site terrain made the field investigation challenging, particularly the road centreline (RCL) investigation, with a change in elevation of approximately 450 m between the existing surface infrastructure and the proposed box-cut sites.

According to published geological maps, the mine is underlain by rocks of the Rustenburg Layered Suite, including norite. This is consistent with the soil conditions encountered during the test pit and drilling investigations. In some areas of the site, residual norite soils were found to have particularly poor engineering properties, which caused some difficulties during design.

In Figure 1 the various components of the proposed surface infrastructure can be seen on an inclined Google Earth image with the proposed RCL shown by the yellow line.

PROPOSED TAILINGS STORAGE FACILITY

The Everest Platinum Mine is currently utilising a tailings storage facility (TSF) to house the waste material produced by the processing plant. The capacity of the existing TSF will not be able to accommodate the additional volume of tailings which will be produced when the proposed infrastructure is brought into operation. For this reason an area of approximately 80 ha has been earmarked for the new TSF site. The geotechnical investigation for this area comprised excavator test pits and both disturbed and undisturbed soil sampling. Consolidated drained triaxial testing was undertaken on the undisturbed samples at carefully selected confining stresses to gather information that would allow for an accurate design. The proposed TSF footprint can be seen in Figure 2 with the test pit locations overlain. The TSF is to be placed on top of a disused portion of the Transvaal Kiwi Orchard which can also be seen in the figure.

Detailed test pit profiles and soil test results were provided to specialist tailings dam design consultants who will be responsible for further feasibility studies and designs.

Figure 2 Proposed TSF site at the Everest Platinum Mine

Figure 3 Typical test pit on road centreline

Figure 4 Waterfall box-cut centreline

The proposed TSF will require a large quantity of cohesive soil material for the construction of the starter wall. In an attempt to minimise environmental impact and construction cost, the option of sourcing this material from within the footprint of the TSF site is being considered. This proposal is subject to on-going EIAs (Environmental Impact Assessments) and other studies, and has not yet been finalised. The new tailings storage facility will have enough capacity for the extension phase of the mine.

ROAD CENTRELINE

The expansion of the mine will require the construction of a new road which will link the proposed box-cut developments down in the valley with the existing mining infrastructure 450 m higher up. The distance between these points is approximately 3.5 km in a straight line. However, due to the steep and uneven nature of this region, 8.6 km of road will be required. This rather indirect route is necessary as vehicles responsible for personnel transport and general deliveries will not be able to safely negotiate steep slopes and sharp bends.

It was initially envisaged that the 8.6 km of road centreline would be investigated by the excavation of test pits at regular intervals of 500 m, utilising a 30 ton excavator. Subsequent to ARQ's first inspection of the proposed RCL it soon became apparent that this method of investigation would not be possible. The steep slopes and rocky outcrops would not allow machine access to test positions. The investigation method was revised to include hand-excavated test pits and dynamic cone penetrometer (DCP) tests where access was not possible with the excavator.

As can be seen in Figure 3, a cream-coloured residual norite layer was often encountered near the surface. The properties of this material were found to be highly variable. Residual norite may manifest as a gravelly soil, in which case good shear strength and CBR values can be expected. On the other hand, when the residual norite manifests as a silty or clayey material, low CBR values and high PIs are to be expected. The gravelly residual norites make for good road building materials, whereas the silty or clayey materials do not. The RCL will be vertically aligned to accommodate the adverse soil conditions.

The possibility of utilising rock produced from blasting operations during the construction of the box-cuts has also been considered as a source of high quality construction material for the road. This rock, once blasted, can be passed through a multiple-stage crushing and screening plant. After this process, it is surmised that material with a quality very close to that required for G1 will be generated. In addition, the same procedure may be used to generate the aggregate source for the asphalt surfacing.

In devoting substantial attention to material balance studies, the need to either import construction material or stockpile excess material produced on the mine, will be minimised.

BOX-CUTS

Two decline box-cuts have been proposed to provide access to further ore. The proposed box-cuts will be excavated on the mountain slopes on either side of the Groot Dwars River. The natural slopes on

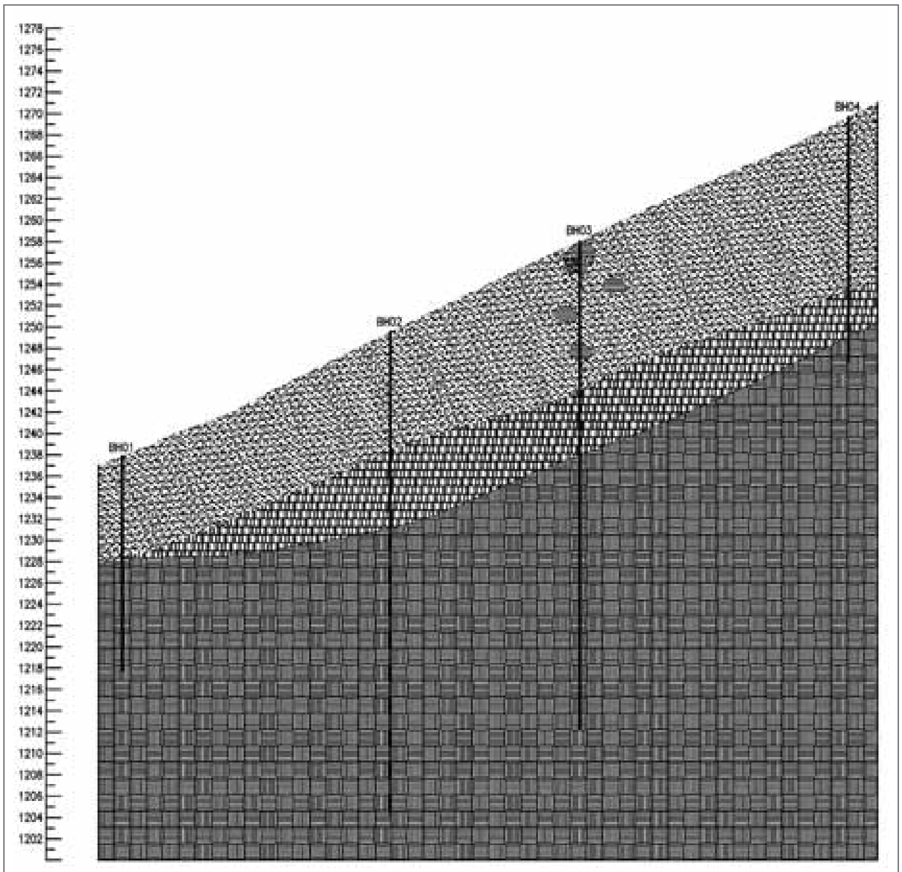

Figure 5 Soil and rock profile generated for Waterfall box-cut

which the box-cuts will be excavated can be described as steep, with average slopes in the order of 25°, and localised areas where the slopes are steeper.

The drilling rigs, which were used to drill four boreholes on each box-cut site, were established by helicopter as no other means of establishment was feasible. Figure 4 shows the approximate centreline of the Waterfall box-cut on the steep natural slope, and Figure 5 demonstrates the soil and rock profile generated from the core drilling.

The cores drilled on the proposed box-cut sites provided a good indication of the soil and rock profiles that could be expected. The upper layer, consisting of completely weathered norite-containing boulders and core stones, was the main concern when considering lateral support. This layer was found to be up to 14 m thick on the Waterfall box-cut site.

When considering a slope angle for the upper residual norite layer, it is important to note that the natural slope of the mountain is approximately 25°, and that the footprint of the box-cut becomes excessively large if a near vertical lateral support design is not implemented. This large footprint is undesirable from both a financial and environmental point of view and was thus avoided.

The lateral support technique of choice was determined to be soil nails, shotcrete and mesh. Soldier piling and mechanically stabilised earth walls (MSEW) were considered but found to be unfavourable. The soldier piling option was not well suited to this site, due to the presence of rock. The MSEW option would not be well suited because pre-excavation would be required, as the wall cannot be constructed from the top down. This pre-excavation would, in turn, require lateral support.

The analysis was completed on, amongst others, Rocscience's Phase 2 finite element analysis software. The final design entailed the use of 25 mm Threadbar 500 soil nails up to 26 m in length, 100 mm polypropylene fibre-reinforced shotcrete and Ref 395 steel mesh on an 85° slope with 2 m benches every vertical 7 m for the upper soil layer.

Rock bolts, mesh and anchors will be specified for the underlying rock layers. These stability measures will be specified during construction, as potential wedge failures and the like are identified and assessed. It is believed that this design will provide the optimal solution in terms of economic viability, practicality and safety.

CONCLUSION

Through a well planned and executed geotechnical investigation it was possible to accurately assess the conditions present on site. The certainty with which parameters could be estimated allowed for the generation of an optimal and cost-effective design solution.

It is for this reason that a thorough geotechnical investigation is encouraged for mining projects during the feasibility phase, which could result in major cost savings for the construction phase of the project. ◻

When considering a slope angle for the upper residual norite layer, it is important to note that the natural slope of the mountain is approximately 25°, and that the footprint of the box-cut becomes excessively large if a near vertical lateral support design is not implemented. This large footprint is undesirable from both a financial and environmental point of view and was thus avoided. The lateral support technique of choice was determined to be soil nails, shotcrete and mesh. Soldier piling and mechanically stabilised earth walls (MSEW) were considered but found to be unfavourable. The soldier piling option was not well suited to this site, due to the presence of rock

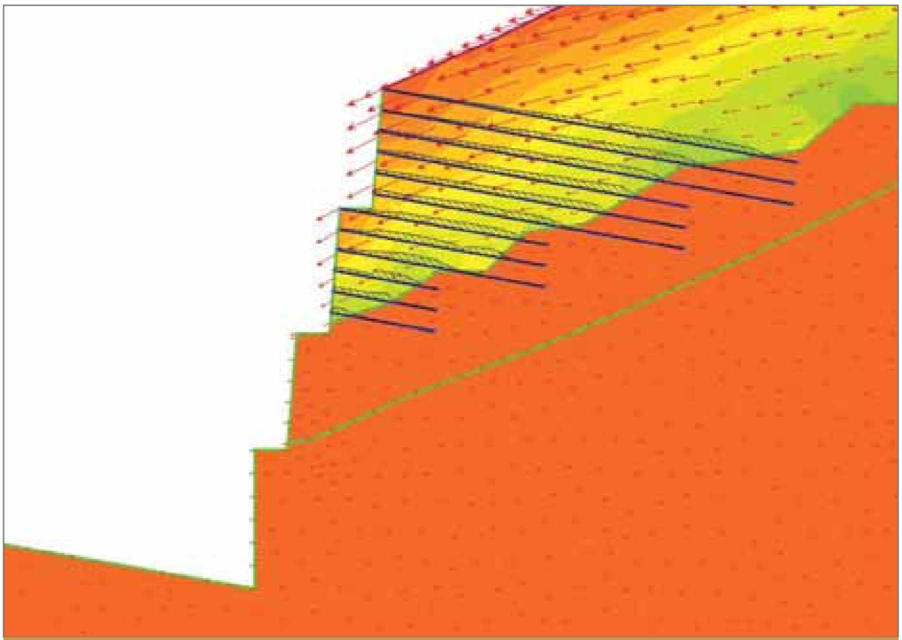

Figure 6 Example of an FEA model (finite element analysis)

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-April/#/0