Copper mine in the DRC
innovative piling, MSEW and basal reinforcement

This short article details a unique solution whereby low fines concrete drainage piles are used to facilitate a predicted one-month consolidation period. In addition, basal reinforcement spanning over pile caps was used to ensure sufficient load capacity at the base of the high tip wall with the piles additionally utilised in shear to ensure localised slope stability.

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INTRODUCTION

A copper mine, located in the south-east of the Democratic Republic of the Congo, is at present being upgraded via the installation of a crusher and screening plant, complete with an 18.3 m high mechanically stabilised earth wall (MSEW) to process extracted ore. The installation of 5.8 m of new fill over the existing 15 m of imported silty material, complicates the situation, with settlements of approximately 105 mm predicted to take some four years to be 90% complete. The down drag from the additional 5.8 m of fill on the as-designed 600 mm φ piles will be significant. This short article details a unique solution whereby low fines concrete drainage piles are used to facilitate a predicted one-month consolidation period. In addition, basal reinforcement spanning over pile caps was used to ensure sufficient load capacity at the base of the high tip wall with the piles additionally utilised in shear to ensure localised slope stability.

Figure 1: Site location

INVESTIGATION

The field investigation involved profiling excavator dug test pits complemented by four percussion boreholes drilled to a maximum depth of 40 m and profiled according to Brink and Bruin's standardised procedures.

GEOLOGY AND TYPICAL SOIL PROFILE

According to various sources, the site is underlain by sandstone, siltstone and shale of the Roan Series, Katanga System.

SITE-SPECIFIC GEOLOGY

At the site, the fill of some 15 m deep is described as clayey, gravelly and pebbly silt. With depth, the material comprises alternating layers of siltstone, sandstone and shale. The siltstone is generally more weathered and is less competent, while the sandstone layers are less common, but of better strength. Figure 2 shows a cut in the pit sidewall which provides a better understanding of the in-situ material. Clearly seen in the side wall are the inter-layered grey siltstone layers and the prominent light-brown sandstone layers.

MSEW, BASAL REINFORCEMENT AND SHEAR RESISTING PILES

The 18.3 m high MSEW, basal reinforcement and 900 mm pile foundation layout were input to the finite element analysis (FEA) program Phase II Version 8 as shown schematically in Figure 3.

Figure 4 shows the output, once loaded, in the form of the zones of maximum shear strain plus the predicted deflections of the system in the ultimate condition. Note that the deflections are magnified by many times for effect.

As is evident in Figure 4, a strength reduction factor SRF = 1.6 was obtained for this serviceability case. This is satisfactory. Acceptable forces in the geosynthetic reinforcement were calculated.

PILED FOUNDATIONS

Due to the high deflections which would result from the 15 m thick compressible silt layer underlying the site, various solutions were attempted before deciding on a piled raft layout using 600 mm and 900 mm ϕ auger installed variants to 10 m and some 15/18 m deep as shown in Figures 5.

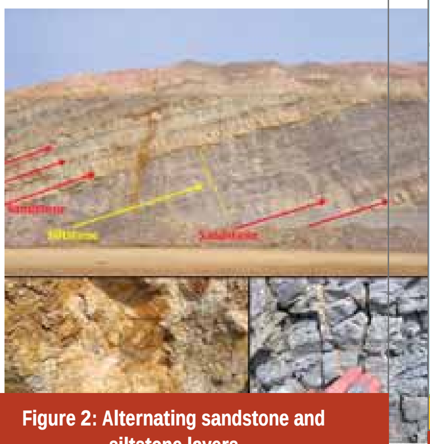

Figure 2: Alternating sandstone and siltstone layers

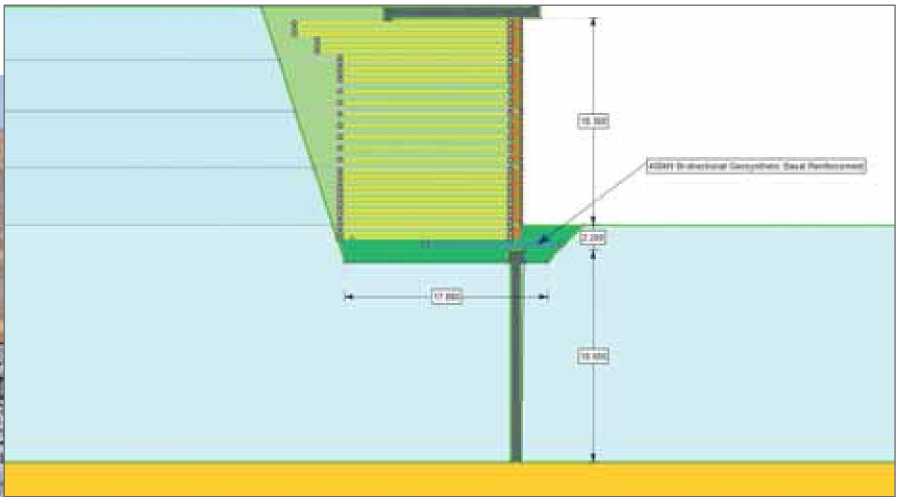

Figure 3: Details of FEA mesh and layout

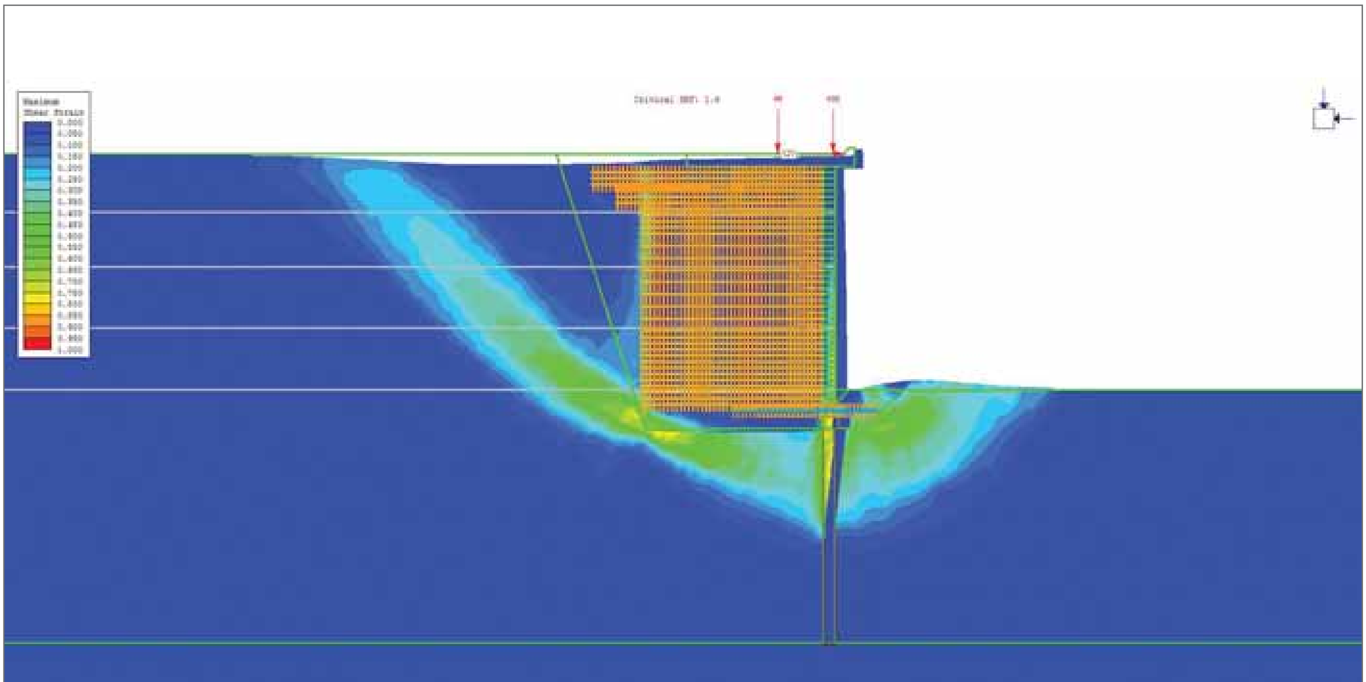

Figure 4: Shear strains and deflected shape

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By tweaking the number and layout of piles, the deflections of the various components of the system were reduced to acceptable limits such that the *differential* settlements between elements were minimal. The situation was, however, later complicated when it was decided to increase the fill thickness at the site by 5.8 m to facilitate better vertical conveyor alignments. The resulting downdrag on piles, and the additional approximately 100 mm of settlement, which was calculated would occur over a four-year period, complicated the matter. A solution was advanced whereby 15 m long drainage piles, constructed of unreinforced low fines concrete (LFC), and installed between the load carrying piles, would reduce time of consolidation to one month and not affect the piled raft carrying capacity.

All 600 mm diameter auger piles were detailed as 10 m long, except over very lightly loaded structures where they were nominally assigned a length of 5 m. The 900 mm diameter piles over the Pecker area were made 15 m long, while those utilised as support to the face of the tip wall were assigned a length of 18 m. This was done in light of the fact that the investigation at the site revealed sloping bedrock, with the possibility that sliding failure on the interface between fill and bedrock may occur. In order to obviate this possibility these piles were designed as shear resistors as well.

CONCLUSION

This multi-discipline design approach, is believed will enable a cost-effective and mine-suitable structure, to be completed within a tight construction schedule imposed by the constraint of mainly low-quality fill materials available locally.

Permission to publish this article, is acknowledged with thanks.

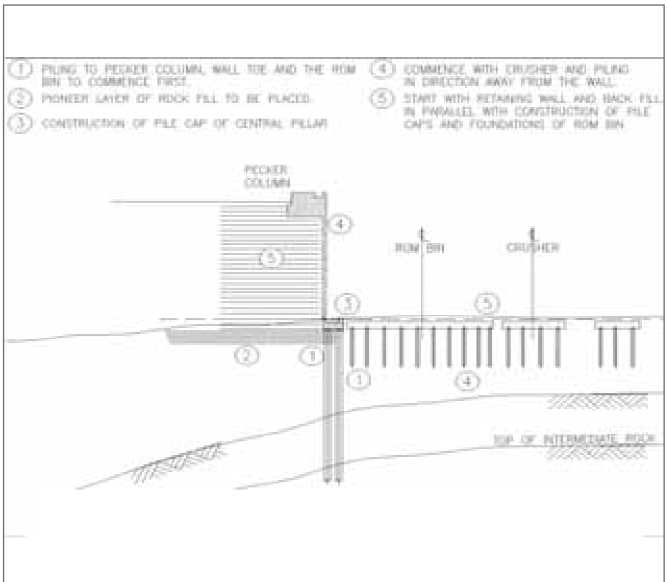

Figure 5: Section through MSEW and piles

Source:
http://www.saice.org.za/downloads/monthly_publications/2013/2013-Civil-Engineering-July/#/0