Text: **Fernando Pequenino**
Vela VKE
PequeninoF@velavke.co.za

Construction starts on geotechnically challenging N17 freeway link for 2010

CONSTRUCTION HAS RECENTLY STARTED on the new N17 freeway link in Soweto, with site establishment and enabling works under way. The 5,8 km freeway link will provide much-needed access from the N1 to Soweto and the Soccer City and Orlando stadiums.

The approximately R400 million design-and-build contract is a contractor-consultant joint venture between Group Five and Vela VKE. Funding is provided by Sanral and is programmed to be completed before the 2010 FIFA World Cup.

The project presents numerous geotechnical challenges along the relatively short link road; besides several large bridges over challenging geological terrain, there is a deep cutting through an existing tailings dam, a large fill constructed with tailings, and some shallow undermining. In addition, a significant portion of the route is being constructed on an existing tailings dam and in close proximity to two other large tailings dams.

All of this is not forgetting the challenges in constructing a road pavement structure on tailings, the aggressive nature of the soils and water in the area towards concrete and cement, together with the regular challenges of delivering such a project to a tight design and construction programme.

ROUTE AND PROJECT DESCRIPTION

Figure 1 shows the N17 Link Road alignment. The two-lane dual carriageway (four lanes in total) tees onto the Soweto Highway at Klipspruit Valley Road (near Orlando Stadium) and for the first 1,5 km is aligned in the floodplain of the Klipspruit whilst dipping below the existing New Canada Railway and later New Canada Road. Here four bridges are provided, one of which will be a large twin portal bridge with spans of 11 m which is to be jacked below the railway line.

The remainder of the route is aligned west-east towards Nasrec Road, through a derelict mining area; crossing shallow undermined land and cutting through an existing tailings dam in which two substantial cuts are located. It is here, between the two cuttings, that the N17 crosses over the existing N1 (Western Bypass) and a partial interchange is provided with north-facing access to the N1 only. It is also here that the route approaches the currently operational Mooifontein and Diepkloof tailings dams. Finally, the road tees in the east with Nasrec Road with a large at grade roundabout provided and with some upgrading and widening of Nasrec Road to improve access to the nearby Soccer City.

HISTORICAL BACKGROUND

The proposed N17 link is part of a future through route linking the current end of the existing N17 Toll Freeway at Wemmer Pan through the Witwatersrand mining belt in Johannesburg to

Mogale City (Krugersdorp) in the west.

Extensive planning and design of the N17 was undertaken in the 1980s and early 1990s by various consultants for the then South African Roads Board, with most of the current link road section corresponding to the section designed by BKS and a small section by Vela VKE.

Although there are benefits to implementing the full N17, in particular that it would provide an important east-west link south of the M2 Motorway, the route's location through a built-up area makes this expensive.

GEOTECHNICAL CHALLENGES

The current project presents several geotechnical challenges over the relatively short section of road being constructed. This in itself also highlights the limitations which could be extended to the full route. Some of these challenges are the following:

- **Shallow undermining over part of the route** Fortunately for the link road, this only occurs over a small section of the route, less than 50 m. The stopes have been dewatered and are currently being backfilled using sand/cement slurry
- **Materials balances** The shortage of adequate quantities of suitable road-building materials has required several iterative adjustments to the vertical alignment and to the cut-and-fill side slopes implemented, in order to optimise the materials usage. One such example is where the N17 cuts under New Canada Road; hard rock quartzite is encountered at shallow depth and the cut is designed deeper, wider and with shallower side slopes in order to generate additional good quality materials. The shortage of suitable road building materials has also necessitated the use of tailings for the construction of some of the fills
- **Shallow rock and outcrop** It is seldom that shallow rock – in this instance hard rock quartzite – presents a problem for foundations and indeed, two of the six bridges on the route are founded on conventional spread footings at shallow depth. However, when the shallow rock is dipping steeply and a large bridge is to be constructed and then jacked across the dip on strike, it results in significant excavations being required and also affects the height of the bridge. Normal bridge clearance

1 Aerial photograph showing N17 Link Road alignment
2 Showing typical terrain through which the N17 Link Road will be built. In the background is the tailings dam through which the road will cut

heights are in the order 5,2 m, but the dipping rock has added an extra 3 m to the bridge height, at the southern abutment where rock levels are much deeper. This makes the bridge to be jacked under the railway a significantly larger structure and one of the largest bridge jackings yet to be undertaken in the country. Shallow rock is also encountered at the site of the fourth bridge at New Canada Road and spread foundations will mostly be used. However, because of the presence of a 10 m wide, near-vertical diabase dyke, which presents as a weak compressible soil an innovative arched spread foundation (arching over the weak dyke and transferring most load to the quartzite) is proposed

- **Bridges on weak compressible soils** A much more significant diabase dyke is also encountered at the site of the N1/N17 bridge and interchange. Here weak compressible soils are encountered to depths of up to 30 m where rock is encountered. The design has also needed to account for the negative skin friction forces resulting from the approach fills placed on the highly compressible soils. A driven precast pile solution is proposed at this bridge and at the sixth bridge, where compressible soils are also encountered, but to shallower depths
- **High fills on compressible soils** The compressible soils also result in challenges where high fills (of up to 14 m) are constructed. In one instance settlements of up to 250 mm are predicted with most of the settlements taking in excess of a year to occur. The construction of these particular fills will be prioritised so that the settlements occur during construction and prior to the construction of the road pavement
- **Existing tailings dams** For much of the route the N17 is in close proximity to the operational Mooifontein and Diepkloof tailings dams. The dams' current heights are in the order of 30–40 m and their proposed final heights will be up to 60 m. The link road comes as close as 150 m to the toes of these dams and falls within the 'zone of influence' of the dams. A detailed analysis has been undertaken and the design of the dams gives no cause for concern, provided of course that the dams continue to be managed and operated to accepted norms and standards
- **Contaminated soils and water** Testing on tailings, ground water and surface water show that all of these will be highly aggressive towards steel, concrete and cement (for example when used in stabilised layers) and several mitigating measures will be implemented. These include the use of high durability concrete for 'very severe' environmental exposure conditions as well as increased cover and smaller design crack widths. In addition, bituminous coatings will be applied to concrete exposed directly to tailings and a buffer layer will be provided between any tailings and stabilised pavement layers

The N17 Link Road project has been selected as the part of the N17 that will best serve the demands of the 2010 FIFA World Cup, while improving access to Soweto. It presents numerous geotechnical and materials challenges which are rarely encountered on a single project over such a short length. The variability of geotechnical conditions and materials used has required a relatively flexible design which can be reviewed and adjusted as conditions present themselves during ongoing investigations and construction. □

Source:
http://www.saice.org.za/downloads/monthly_publications/2008/CivilApri08/#/0