REPORT ON THE SUITABILITY OF POLYMER ROADS FOR USE ON THE HAUL ROADS AT NKOMATI MINE

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Date: July 2010

1. INTRODUCTION

Modern road building technologies have developed to the extent that non-traditional additives such as polymers provide a cost effective solution to road construction. POLYROADS, which bonds the soil and gravel, is a tailor-made polymer product for road construction in all environments. This report considers the suitability of the polymer for use at the Nkomati mine based on a comparison of a trial section constructed with the polymer and the regular crushed slag surfaced road. Note that this report was compiled based on test results taken at the mine as well as photographs provided. The author did not visit the mine.

The objective of this report is to present a comparison of the two road construction types and to make recommendations regarding the benefits of using polymer to stabilize the wearing course. The available results as well as photographs are presented and conclusions and recommendations drawn regarding the results.

2. CONSIDERATION OF THE HAUL ROAD ENVIRONMENT

The operating performance of a haul road system can be subdivided into four distinct design categories as defined below;

- **Geometric design**. This refers to the layout and alignment of the road, in both the horizontal (curve radius, etc.) and vertical (incline, decline, ramp gradients, cross-fall, camber, super-elevation) plane, stopping distances, sight distances, junction layout, berm walls, provision of shoulders and road width variation and should accommodate optimal vehicle speeds, stability, road performance and safety.
- **Structural design**. This concerns the ability of a haul road to carry the imposed loads without excessive pavement deformation and consequently the need for excessive maintenance.
- **Functional design.** This refers to the ability of the haul road to perform its function, i.e. to provide an economic, safe and vehicle friendly ride. The selection and management of wearing course materials (or surfacing) primarily controls the functional performance.
- **Maintenance design.** The management and scheduling of maintenance (blading, watering and regravelling) of the wearing course according to the limits of the expected and actual road performance.

It is accepted that the geometric layout fulfills the requirements of safe and efficient movement of the haul trucks, and will thus not be considered in this report. Furthermore, the structural capacity of the haul road is accepted to be adequate for the existing haul trucks, and will not result in undue deformation requiring maintenance, or high deflections leading to unwarranted fuel consumption. The focus of this report is thus on the wearing course, which provides a vehicle-friendly environment.

3. FUNCTIONAL DESIGN OF WEARING COURSE

The main requirements for a wearing course material are to provide a vehicle-friendly ride, and no dust from a safety perspective. Generally material is selected based on the grading and plasticity requirements that have been developed (Thompson and Visser 2000). No information on the wearing course properties is available. However, Figure 1 shows that the existing material without polymer does show signs of surface deformation and particularly during the wet season may be prone to severe deformation and the resultant need for additional maintenance.

Figure 1. Deformation of the existing slag gravel wearing course.

With the Polymer stabilizer a hard surface is provided, as may be seen in Figure 2. The loose material on the surface is spillage. Such spillage should be removed by industrial vacuum cleaner, as a motor-grader will damage the hard crust and a rotary broom will create unwanted dust. When a stabilizer is used, appropriate wearing course material is required. One cannot use a poor wearing course material and then hope that the stabilizer will solve all the problems.

Figure 2. View of the Polymer stabilized trial section with spillage from trucks.

At Nkomati mine a trial section of haul road was constructed using Polymer as a stabilizer on the slag gravel. The adjacent section was untreated slag. Besides the visual performance, in terms of deformation and dust, the wearing course should also have the required bearing capacity. Bearing capacity is expressed in terms of the California Bearing Ratio (CBR), and is measured with the Dynamic Cone Penetrometer (DCP) in the field. Often the DCP CBR is measured on the dry road and the conclusion is then drawn that the stabilizer has shown an improvement. The most critical situation is, however, during the rainy season, and the DCP CBR should be measured to reflect this. It is recommended that the test be performed after 2 hours of soaking with 50 mm of water in the container. This is shown in Figure 3.

Ideally the soaked DCP CBR should be more than 60% (Thompson and Visser 2000).

Figure 3. Wearing course is soaked before performing DCP test.

The results obtained on the two sections are shown in Table 1. Note that two sets of results were taken. The first, in March 2010 only provided results on the stabilized sections, and no comparison with the untreated road.

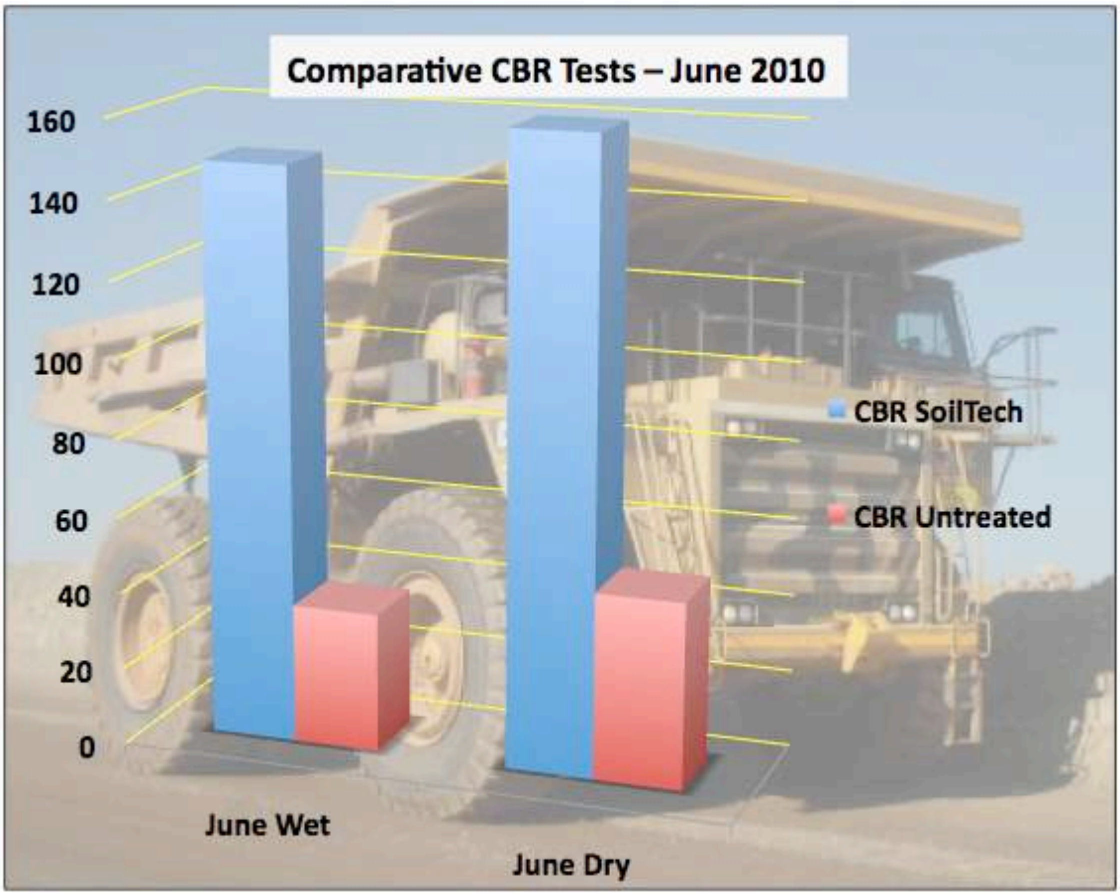
The repeated test in June 2010 provided results on both sections. Firstly, it is interesting to note that on the untreated slag road the DCP CBR is 48% dry and 36% wet, although only soaked for 40 minutes because of constraints.

The soaked CBR **should be more than 60%,** and the untreated road does not fulfill this criterion, and this low value also explains the deformation shown in Figure 1.

The **stabilized section** had a dry DCP CBR of 135% in March and 160% in June 2010. This shows that there was strength gain in the intervening period. Furthermore, the soaked DCP CBR was 102% in March (after 2 hours soaking) and 148% in June after 40 minutes soaking. These results show that the bearing capacity improved by stabilizing, and the bearing capacity is better than the minimum required. The UCS and modulus values are presented for future use in pavement design as these are derived from the DCP CBR.

Table 1. DCP CBR values on Polymer treated and untreated haul road at Nkomati

Dry Test (June 2010)	Wet Test (soaked for 40 mins)
Average Reading on Treated Dry Road CBR 160% UCS 1308 kPa E-Modulus 509 MPa	Average Reading on Treated Wet Road CBR 148% UCS 1217 kPa E-Modulus 475 MPa
Average Reading on Untreated Dry Slag Road CBR 48% UCS 453kPa E-Modulus 187 MPa	**Average Reading on Untreated Wet Slag Road** CBR 36% UCS 352 kPa E-Modulus 147 MPa
Dry Test (9 March 2010)	**Wet Test (soaked for 2 hours)**
Average Reading on Treated Dry Road CBR 135% UCS 1121 kPa E-Modulus 440 MPa	Average Reading on Treated Wet Road CBR 102% UCS 875 kPa E-Modulus 347 MPa



4. CONCLUSIONS AND RECOMMENDATIONS

The trial section with Polymer stabilizer has shown a significant improvement in the functional performance in that dust has been minimized. The bearing capacity of the stabilized section is substantially higher than the untreated slag gravel section, and this explains why the untreated section showed signs of deformation. Since the bearing capacity of the Polymer stabilized section is more than the requirements, maintenance will also be significantly reduced. In fact, it is recommended that a motor-grader should not be used to remove spillage, but that an industrial vacuum cleaner is employed. It is recommended that the wearing course slag gravel be stabilized with Polymer to ensure operational efficiency.

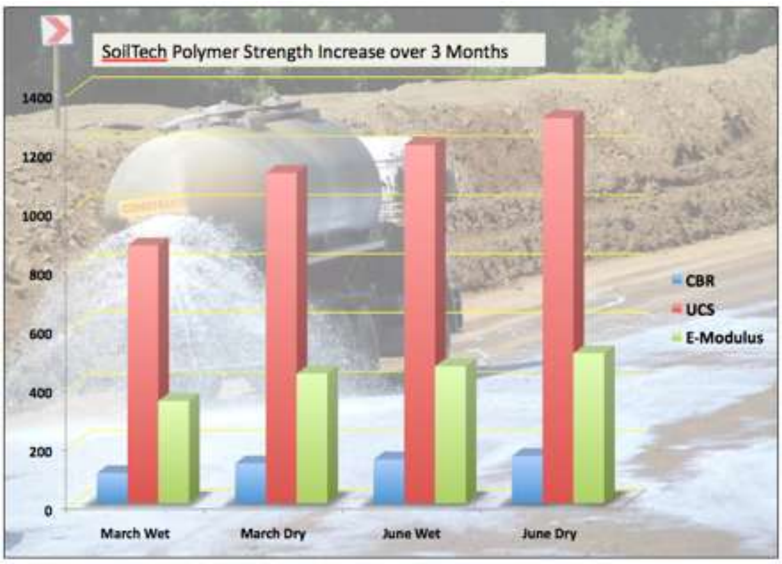
In terms of treatment on other sections of the haul road network, the process should consider the following:

- Ensure that the geometric layout is both satisfactory from an operational and a safety perspective;

- Evaluate the structural capacity of the pavement structure, and strengthen where appropriate (note that the wearing course cannot remedy structural defects);

- Evaluate the slag gravel wearing course (if it is the same as on the trial section this has been shown to be adequate when stabilized with Polymer), and stabilize as the untreated material has been shown to be substandard in terms of general structural guidelines;

- Adjust the maintenance regime to consider the hard wearing surface, and to avoid damage with a motor-grader. Ideally an industrial vacuum cleaner should be used to remove spillage and to reduce dust.



Explanation of California Bearing Ratio

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road subgrades and basecourses. It was developed by the California Department of Transportation before World War II.

The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The CBR test is described in ASTM Standards D1883-05 (for laboratory-prepared samples) and D4429 (for soils in place in field), and AASHTO T193.

The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads. The CBR can also be used for measuring the load-bearing capacity of unimproved airstrips or for soils under paved airstrips. The harder the surface, the higher the CBR rating. A CBR of 3 equates to tilled farmland, a CBR of 4.75 equates to turf or moist clay, while moist sand may have a CBR of 10. High quality crushed rock has a CBR over 80. The standard material for this test is crushed California limestone which has a value of 100.

= CBR [%]
= measured pressure for site soils [N/mm^2]
= pressure to achieve equal penetration on standard soil [N/mm^2]

REFERENCES

Thompson, RJ and Visser, AT. (2000). The functional design of surface mine haul roads. Jnl. of the South African Institute of Mining and Metallurgy, v100, no 3, Johannesburg, South Africa, pp169-180.