DCP Evaluation of EarthZyme Treated Road

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Executive Summary

In the fall of 2009, a 250m x 20m test section (one lane) of the Sulfur Block Road was treated with EarthZyme soil stabilization product to a depth of 25 cm. During June 8-9 2010, a test was carried out by Cypher using a Dynamic Cone Penetrometer (DCP). Using the DCP, the treated area was compared to the adjacent untreated lane, as well as a gravel haul road. The results of this study showed that the EarthZyme treated section was significantly more consistent in shear strength than the untreated section and the gravel road. Additionally, the average CBR was higher on the EarthZyme treated road than the untreated section and the gravel road. From these results, it is recommended that Syncrude continue with a full haul road construction using EarthZyme to evaluate the product in a real-world scenario.

Scope of Work

Using the DCP testing instrument, Cypher West compared the shear strength of a gravel haul road, the treated EarthZyme section, and the untreated section adjacent to the EarthZyme section. The test was intended for comparison purposes only; any estimated CBR values should be used with discretion and should not be used for engineering purposes.

Testing Method

The Dynamic Cone Penetrometer is a standardized instrument that is widely used for measuring the in-situ shear strength of granular materials and particularly subgrade soil for road construction. The apparatus consists of a steel rod fixed with a 20mm diameter 60 degree hardened steel cone tip and an 8 kilogram sliding hammer with a drop height of 575mm. The testing procedure is rapid compared with other procedures, it is relatively non-destructive, offers a strength-depth profile, and is cost-effective. The disadvantage of the DCP instrument is that accuracy decreases in high strength and coarse aggregate soils.

The results from the DCP test can be correlated to a California Bearing Ratio (CBR) value. There is considerable literature which has validated and improved the correlation between DPI (Dynamic Penetration Index, mm/blow) and CBR values. There are several widely accepted relationships between DPI and CBR; the following equations are used frequently around the world for estimating CBR values:

Kleyn1	LogCBR = 2.438 – 1.065*LogDPI	(1)
Livneh2	LogCBR = 2.14 – 0.69*(LogDPI)1.5	(2)
US Army3	LogCBR = 2.465 – 1.12LogDPI	(3)
South Africa4		
For DPI > 2	CBR = 410*(DPI)-1.27	(4a)
For DPI < 2	CBR = (66.66*DPI2) – (330*DPI) + 563.33	(4b)

In the following chart, these relationships are plotted for a range of DPI values. It can be seen that the relationships diverge for very small DPI values, but converge well at the DPI value of 3 mm/blow. The Livneh (2) relationship is the most conservative for smaller DPI values; therefore this relationship will be used in the data analysis.

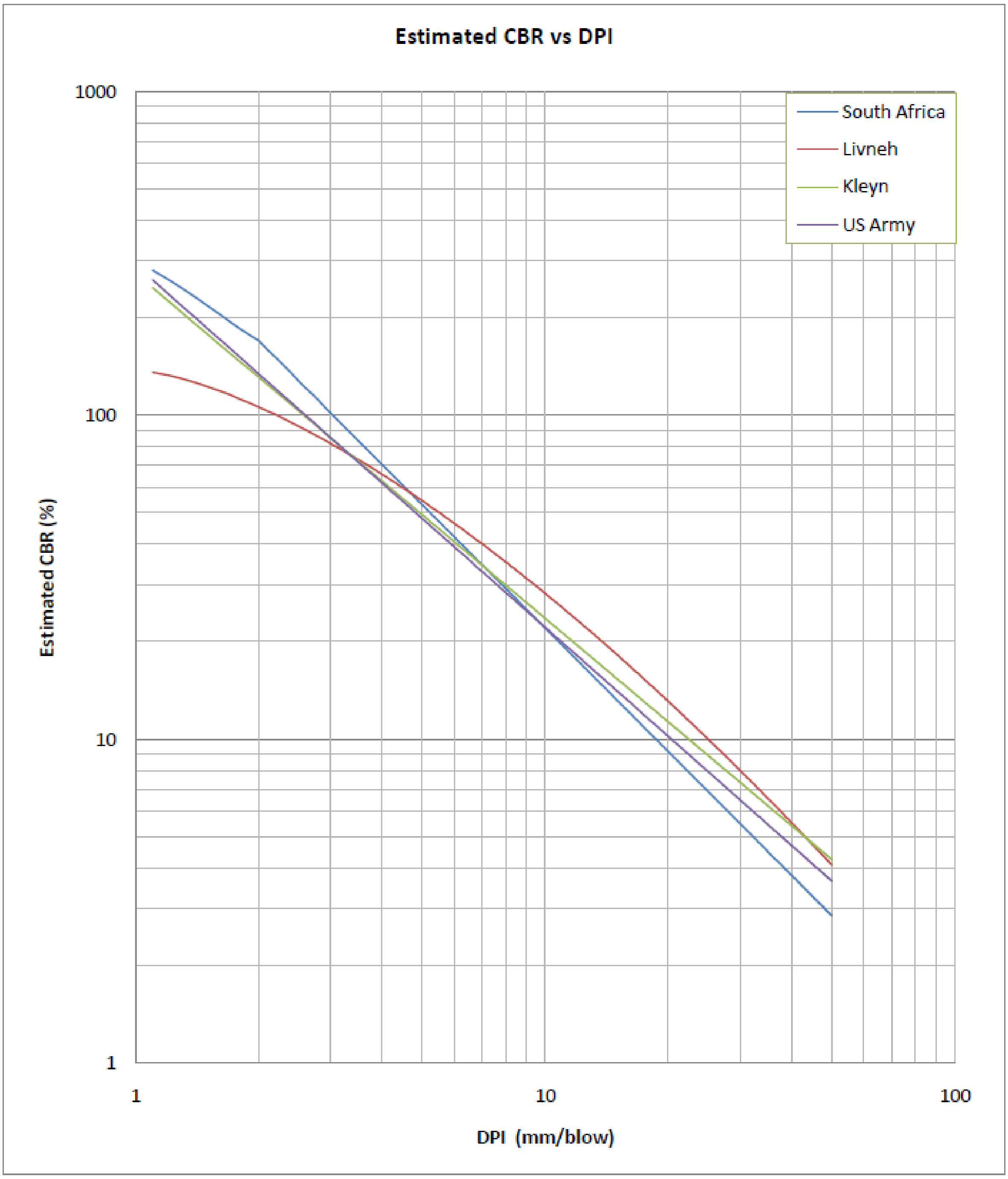

Figure 1: Comparison of accepted CBR - DPI relationships

Observations and Results

Some of the initial observations included:

EarthZyme Road:

- Consistently flat with no potholes, ruts, or water accumulation
- Smooth running surface
- Minimal deflection from haul trucks

Untreated road adjacent to EarthZyme section:

- Undulated road surface
- Settled water in low spots
- Deflection was noticeable from haul trucks
- Cracking in road surface

Gravel road (#702 & N. Mine Expressway):

- Undulated road surface
- Considerable amount of road gravel was scraped into berm
- Road had extremely hard spots, but also very soft spots with loose material
- Cracking in road surface

Testing procedure

DCP testing was carried out at least four meters from the berm towards the center of the road and the interval between each test was approximately 10-20 meters. Proper procedure for using DCP instrument was carried out to ensure consistency. Conditions were dry for duration of test.

Summary of test results

Results show that the EarthZyme treated section is significantly more consistent in shear strength than the untreated road and gravel roads. The following charts highlight the results of the DCP testing. It can be seen that the average strength of the EarthZyme treated road is higher than the untreated road and the gravel roads. The range of values is substantially lower for the EarthZyme tests when compared with the untreated section and the gravel roads.

Section	Average DPI (mm/blow)			
	Mean	Max	Min	Range
EarthZyme treated section	2.49	2.93	1.98	0.95
Untreated adjacent section	3.00	4.87	1.86	3.01
Gravel Road (#702 & N. Mine Express)	3.23	6.47	1.45	5.02

Section	Estimated CBR (%)			
	Mean	Max	Min	Range
EarthZyme treated section	95	109	84	25
Untreated adjacent section	80	111	57	54
Gravel Road (#702 & N. Mine Express)	87	125	45	80

Table 1: Comparison of test results

Consistency of test results

In Figure 2 the results of each test are compared. It can be seen that the estimated CBR values of the EarthZyme road remains relatively consistent compared to the untreated conventional road and gravel roads. The range of estimated CBR values for each road can be seen in Table 1.

Figures 3 and 4 show the DPI and CBR values at their recorded depths. These charts show that the data is not skewed from variations in shear strength with increasing depth. The EarthZyme treated road shows a consistent, narrow range of values for increasing depth. The untreated conventional road and the gravel roads show a consistently high range of values for increasing depth.

Limitations of test results

The tests were usually limited to a depth of 200 mm, due to the difficulty of removing the instrument and time limitations. During testing it was seen that shear strength remained relatively constant with increasing depth (this can be seen from Figures 3 and 4). Therefore, it was decided that a wider sample of test data was preferred over deeper tests.

The correlation of DPI to CBR decreases in accuracy for DPI values less than 3mm/blow. The conservative Livneh relationship was used in order to avoid over estimation of CBR, but the CBR values could be higher based on other accepted relationships.

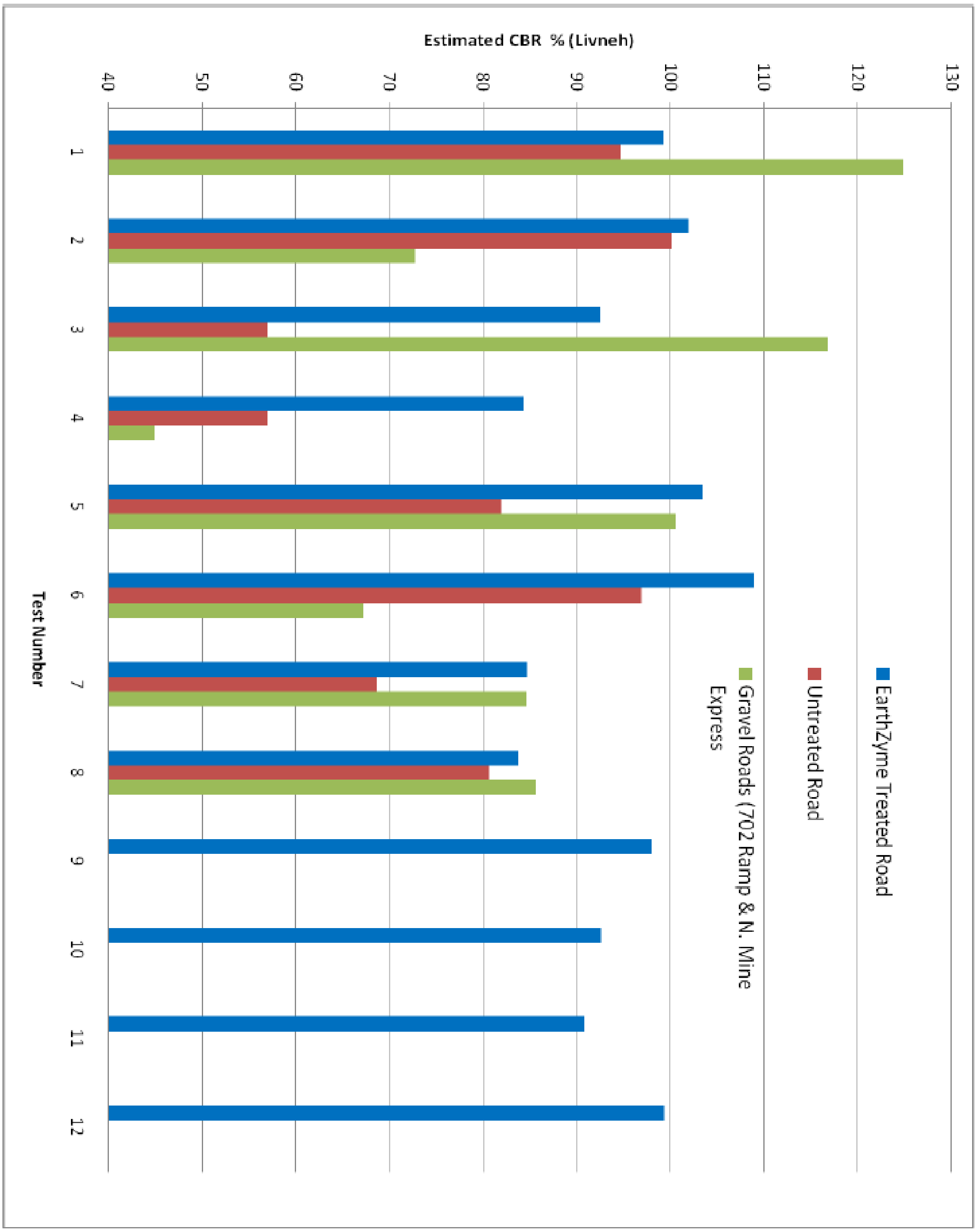

Figure 2: Comparison of estimated CBR values

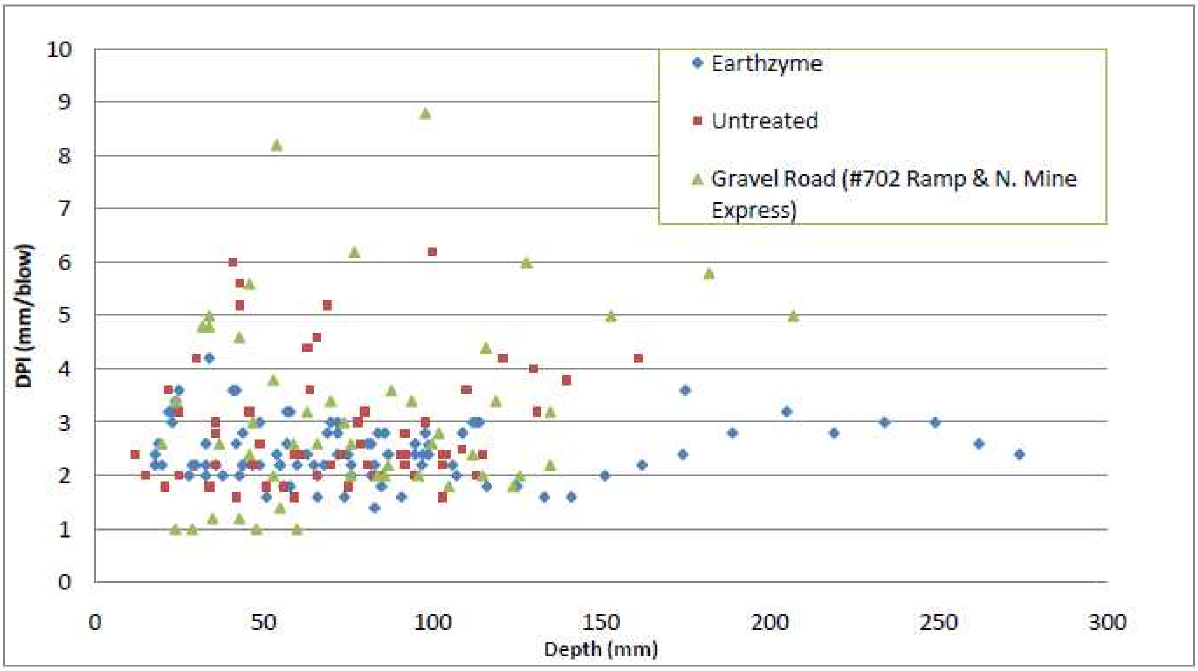

Figure 3: DPI (Dynamic Penetration Index, mm/blow) versus Depth

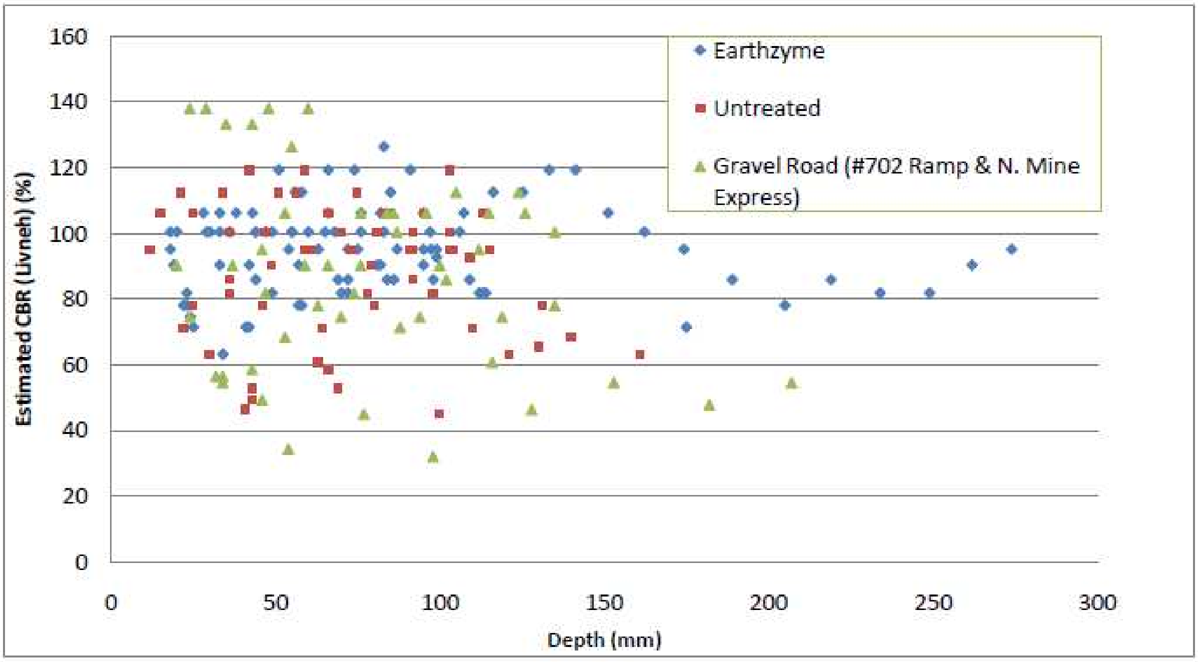

Figure 4: Estimated CBR (California Bearing Ratio) versus Depth

Conclusions and Recommendations

From the results, it can be concluded that the EarthZyme treated road is considerably more consistent in shear strength than the adjacent untreated road, as well as the tested gravel roads (#702 and North Mine Expressway). It is speculated that the inconsistencies in shear strength of the untreated section and the gravel roads contribute to the surface undulations of these roads. These same undulations were not observed on the EarthZyme treated section. It can be assumed from the test results that the consistency in shear strength achieved through arthzyme treatment has prevented undulations from forming.

These test results provide an explanation for the observable consistency of the EarthZyme road; however, construction and monitoring a full haul road will be the true test for determining if EarthZyme suits the needs of Syncrude.

References

[1] Kleyn, E.G. "The Use of the Dynamic Cone Penetrometer," Report L2/L4, Transvaal Roads Department, Pretoria, South Africa, 1975.

[2] Livneh, M. Ishai, I. And Livneh N. "Effect of Vertical Confinement on Dynamic Cone Penetrometer Strength Values in Pavement Subgrade Evaluation," Transportation Research Record 1473, 1995.

[3] Webster, S.L.,Grau, R.H. and Williams, R.P. "Description and Application of Dual Mass Dynamic Cone Penetrometer," U.S. Army Engineer Waterways Experiment Station, Report No. GL-92-3, 1992.

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