GEOTECHNICAL INVESTIGATION FOR ROADS AT THE COVES - HARTEBEESPOORTDAM

Undertaken for

HC PIETERSEN & ASSOCIATES

REPORT NO: 5135/2979/1/G

OCTOBER 2002

GEOTECHNICAL INVESTIGATION FOR ROADS AT THE COVES - HARTEBEESPOORTDAM

1 INTRODUCTION AND TERMS OF REFERENCE

Golder Associates was appointed to carry out a geotechnical investigation for the proposed internal roads and access roads for the Coves Development, near Hartebeespoortdam.

The objectives of the investigation are summarised as follows:

i. To determine the geology and relevant engineering properties of the soil and rock horizons present along the route(s);

ii. To give general foundation recommendations for the proposed roads;

iii. To comment on the excavation characteristics and possible uses of the materials underlying the site for the construction of roads;

iv. To comment on site water management aspects, particularly pertaining to shallow groundwater or seepage.

This report summarises the findings of the investigation taking into account inter alia the following:

- Active soils.
- Shallow groundwater or seepage.
- Difficulty of excavation to 1,5m depth.

The positions of the test pits as well as the different geotechnical zones are indicated on the accompanying map, **Figure 1**.

Samples of the soils were taken to assess the engineering properties of the materials. This testing included grading, Atterberg limits and moisture density relationships as well as strength (MOD-CBR).

2 GEOLOGY

Rocks of the Pretoria Group of the Transvaal Supergroup underlie the site and the observed rocks were shales as well as intrusive diabase.

The bedrock is overlain sequentially by residual, pedogenic and transported soils.

3 FINDINGS & RECOMMENDATIONS

3.1 Route Zones

The route has been divided into two geotechnical zones in accordance to the geotechnical conditions encountered:

Zone 1: Silty gravelly hillwash/talus overlying weathered diabase

Zone 2: Clayey Alluvial soils

The geotechnical zones are indicated on **Figures 1**.

3.2 Founding Conditions

The founding conditions for the road pavement are generally poor. The transported and upper residual soil profile exhibits, almost without exception, a low to medium expansiveness. All the laboratory tests results are tabled in **Table 1**. Estimates of swell and heave are presented in **Tables 2 and 3**.

In all the considerations presented below, a Class E1 (UTG 2) segmental block road design is assumed for the internal roads, i.e. the Promenade and Boulevard. A lightly trafficked black top road design for the access road is assumed.

In **Zone 1**, Transported soils (hillwash/talus) are overlying weathered shale. The transported soil comprises intact, slightly clayey silt and sand with variable quantities of gravel to cobble sized clasts and roots. The residual soil is a completely weathered shale comprising stiff slightly clayey silt with gravel and larger clasts of harder weathered shale. PI ranges between 11 and 24. The grading modulus is variable, ranging from 0.3 to 1.16. The maximum dry density was found to be 1 773 kg/m^3, but the CBR is relatively low, i.e. 9 at 93 per cent MOD AASHTO. The latter is the reason for the TRH 14 classification of G7, despite how good the material looks visually. It appears that the material breaks down under compaction to form a fine soil (silt) with low strength characteristics. However, the soil is good for selected layers. Apart from stripping the biotic topsoil, no problem is anticipated with the pavement foundation. The average lime consumption percentage is 1,9%.

In **Zone 2**, the clayey soils extend to a depth in excess of 1.5m. They exhibit a plasticity index greater than 12, and even the plasticity of the whole sample exceeds 12, indicating a fine, medium to high expansive soil condition. The observed moisture condition is high and seems to be at or just below optimum moisture content. The observed shattered soil structure is indicative of the activity confirmed by the laboratory testing.

The material encountered is unsuitable for inclusion in the road pavement. The high plasticity of the soil suggests that the subgrade layer should be treated with lime as minimum to reduce the soil activity in subgrade layers. The other alternative is to import material of lower plasticity. In either case, at least 3x150mm layers should be considered. The balance of the road pavement should be imported. The average lime consumption percentage is 2,3%.

Table 1: Laboratory test results

Test Pit No.	Zone	Description	Depth (m)	PI (%)	PI of the whole sample (%)	Grading Modulus	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Unified Class.	% Lime Consumption	CBR@ 93% Mod AASHTO	CBR@ 93% Mod AASHTO	Maximum Mod AASHTO dry density (kg/m^3)	In Situ Moisture Content (%)	Optimum Moisture Content (%)
TP 5	1	Silty gravelly hillwash/Talus overlying weathered diabase	***0.50-1.30m***	20.2	7.8	1.86	45.4	34.2	7.7	12.7	SM					12.9	
TP 8	1		***0.50-1.10m***	18.8	12.8	0.93	21.1	22.7	43.0	13.2	ML/OL					16.4	
TP 10	1		***0.40-1.50m***	17.3	10.1	1.16	23.2	36.8	29.7	10.3	SM	1.60				15.2	
TP 11	1		***0.50-1.50m***	24.9	19	0.69	12.4	24.8	39.6	23.2	MH/OH		9	9	1 773	18.3	19.1
TP 13	1		***0.0- 0.80m***	16.1	14.1	0.43	2.1	38.7	43.2	16.0	CL	1.40				18.3	
TP 14	1		***0.50-1.70m***	14.4	10.1	0.89	15.5	36.0	37.4	11.0	ML/OL					19.6	
TP 16	1		***0.0 -1.2m***	11.1	9.9	0.37	5.5	19.5	63.4	11.7	ML/OL	2.80				20.8	
			Averages :	***17.5***	***12***	***0.9***	***17.9***	***30.4***	***37.7***	***14.0***		***1.9***	***9.0***	***9.0***	***1773***	***17.4***	***19.1***
TP 3	2	Clayey Alluvial Soils	***0.40-1.30m***	23.1	18.3	0.61	11.5	22.0	38.8	27.6	MH/OH		6	8	1 701	22.1	21.3
TP 4	2		***0.40-0.70m***	23.8	21.7	0.30	3.1	23.5	38.6	34.8	CH	2.80				24.1	
TP 6	2		***0.20-0.60m***	37.2	30.5	0.60	15.7	17.3	35.2	31.8	CH	2.80	4	4	1 776	10.4	18.0
			Averages :	***21.7***	***23.5***	***0.7***	***14.8***	***26.6***	***37.6***	***21.0***		***2.3***	***6.7***	***4***	***1753***	***18.0***	***19.4***
Dam Site			-	11.9	3.7	2.16	65.7	17.3	12.5	4.5	GM	25	22		1 983	7.8	12.4

MC = Moisture Content, PI = Plasticity Index, GM =Silty Gravels, OL = Organic Silts and Organic Silty clays of low plasticity, OH = Organic Clays of high plasticity, SM = Silty Sands, CL = Inorganic clays, silty clays, sandy clays of low plasticity, GC = Clayey gravels, clayey sandy gravels, ML = Inorganic silts, silty or clayey fine sands, with slight plasticity

Table 2: Heave Calculations: Weston Method

Test Position	Depth	Description	Liquid Limit [%]	$P_{0.425}$	WLL	Vert. Pres. [kPa]	NMC [%]	Swell [%]	Swell [mm]
TP 5	***0.50-1.30m***	Clayey sandy silt in a 80% matrix of fine to coarse diabase gravel	47.4	38	18	7.4	12.9	0.08	0.42
TP 8	***0.50-1.10m***	Ferruginised fine gravel nodules in a matrix of sandy, clayey fine silt	47.2	68	32	7.4	16.4	0.54	2.7
TP 10	***0.40-1.50m***	Fine to medium rounded gravel in a matrix of ferruginised sandy clayey silt.	50.2	59	30	5.9	15.2	0.50	2.0
TP 11	***0.50-1.50m***	Slickensided sandy clayey silt	56.2	76	43	7.4	18.3	1.37	6.9
TP 13	***0.0- 0.80m***	Sandy clayey silt	35.9	88	32	2	18.3	0.64	3.2
TP 14	***0.50-1.70m***	Sandy clayey silt	41.8	70	29	7.4	19.6	0.24	1.2
TP 16	***0.0 -1.2m***	Sandy clayey silt	40.7	89	36	2	20.8	0.85	4.2
								Average	3
TP 3	***0.40-1.30m***	Shattered clayey sandy silt	52.3	79	41	5.9	22.1	0.84	3
TP 4	***0.40-0.70m***	Shattered clayey sandy silt	50.2	91	46	5.9	24.1	1.04	4
TP 6	***0.20-0.60m***	Clayey sandy silt in a matrix of fine to medium diabase gravel	64.3	82	53	3	10.4	17.54	35
								Average	8

Swell % = 0.000411 * (WLL)^+4.17 * (p)^-0.386 * (NMC)^-2.33

WLL = Weighted Liquid Limit = liquid limit * P0.425

p = vertical pressure in kPa under which swell takes place

NMC = initial or natural moisture content

Table 3: Heave Calculations: Van Der Merwe-Savage Method

Test Position	Depth	Description	Pot. Expansiveness	F	T	D	Heave [mm]
TP 5	***0.50-1.30m***	Clayey sandy silt in a 80% matrix of fine to coarse diabase gravel	Low	0	0.5	0	0
TP 8	***0.50-1.10m***	Ferruginised fine gravel nodules in a matrix of sandy, clayey fine silt	High	0.11	0.5	0	91
TP 10	***0.40-1.50m***	Fine to medium rounded gravel in a matrix of ferruginised sandy clayey silt.	Low	0	0.4	0	0
TP 11	***0.50-1.50m***	Slick and sided sandy clayey silt	Medium	0.055	0.5	0	46
TP 13	***0.0- 0.80m***	Sandy clayey silt	Medium	0.055	0.5	0	46
TP 14	***0.50-1.70m***	Sandy clayey silt	Low	0	0.5	0	0
TP 16	***0.0 -1.2m***	Sandy clayey silt	Low	0	0.5	0	0
						Average	26
TP 3	***0.40-1.30m***	Shattered clayey sandy silt	Medium	0.005	0.4	0	4
TP 4	***0.40-0.70m***	Shattered clayey sandy silt	Medium	0.005	0.4	0	4
TP 6	***0.20-0.60m***	Clayey sandy silt in a matrix of fine to medium diabase gravel	High	0.11	0.2	0	102
						Average	31

Heave (m) = F * (e^-0.377D) * (1-(e^-0.377T))

D = Thickness of non swelling layer

T = Thickness of swelling layer

F = 0 for low expansiveness

F = 0.055 for medium expansiveness

F = 0.11 for high expansiveness

F = 0.221 for very high expansiveness

The talus soil appears to be suitable for use as sub grade, although the addition of lime would be required to ensure a uniformly low plasticity index.

3.3 Excavation Characteristics

The excavation characteristics of the different soil horizons encountered have been evaluated according to the South African Bureau of Standards standardised excavation classification for earthworks (SABS 1200D), earthworks (small works – SABS 1200DA) and earthwork (pipe trenches – 1200DB). In terms of this classification and the in-situ soil/rock consistencies as profiled, the relationships given below are generally applicable.

“soft excavation” - very loose/very soft through to dense or stiff.

“intermediate excavation” - very dense/very stiff through to very soft rock.

“hard rock excavation” - soft rock or better.

The excavation characteristics is summed up in **Table 4**.

Table 4: Excavation Characteristics

Zone	Excavation Characteristic
Zone 1	Soft to > 1.5m
Zone 2	Soft to > 1.5m

For specific excavation characteristics refer to the soil profiles attached.

3.4 Materials Usage

The results of the laboratory tests, the field observations and interpretations have been used to evaluate the suitability of the various on site materials for construction purposes. The test results are summarised in **Table 1** and the results are attached in **Appendix B**. The material usage is summarised up in **Table 5**.

Table 5: Material Usage

Material	Potential Use
Silty gravelly hilwash/tallus overlying weathered diabase (Zone 1)	Subgrade and selected layers, material has small, but variable plasticity, strength (CBR) also low though higher than the weathered shale and has a G7/G8 classification
Clayey soils	Spoil, material too plastic for use in pavement structure

Potential borrow area at damsite:

This material forms part of a nearby dam basin. It is found along the dam perimeter. The material comprises mostly gravels consisting of 65% gravel, 17% sand, 12% silt and 5% clay.

This material will act as good quality sub-base and base material since its high grading modulus and CBR values. It is classified as a G6 material in terms of TRH 14.

The mod. AASHTO maximum dry density is 1983kg/m^3 with an optimum moisture content of 12.4%. The in situ moisture content is approximately 4.6% below optimum moisture content.

It is expected that this material is suitable for use in road layers up to selected if lime stabilised (+/- 2%) and marginally suitable as a subbase if cement stabilised.

3.5 Seepage

No seepage associated with the presence of a perched water table was encountered in any of the test pits excavated, apart from TP's 13-15.

The water table can be regarded as being below the influence of civil works for the most part. However, the soil structure and moisture condition in Zone 1 is indicative of a propensity to develop a seasonal, perched water table at the interface of transported and residual soil, or within the weakly developed pedogenic horizon (ferricrete/ferruginous soil).

4 INVESTIGATION PROCEDURE

4.1 Fieldwork

The field investigation was carried out on the 10th of September 2002 and comprised the excavation of 15 test pits with an excavator.

A Geotechnical Engineer inspected the test pits and soil profiles recorded using standard procedures. The positions of the test pits are indicated on **Figure 1** and the soil profiles are included in **Appendix A**.

4.2 Laboratory Testing

Bulk as well as small disturbed soil samples, representative of the materials encountered were retrieved from the test pits and submitted to a commercial soils laboratory for testing. The following tests were performed in order to determine the engineering properties of the various soil horizons.

Indicator Tests

These tests were carried out to determine the particle distribution and plasticity of the soils. The material was fine grained and therefore the grading was done to 0,002mm.

MOD AASHTO Density

On the material tested for earthwork purposes the proctor density moisture relationship was conducted to determine the materials compaction characteristics.

CBR Tests

The remoulded strength of soil samples was conducted to obtain an indication of the material strength (CBR).

The depth of each of the samples is indicated on the relevant profile sheets that are in **Appendix A** and the test results are included in **Appendix B**.

A. Strauss **DG Walker**

for **Wates Meiring & Barnard**

GEOTECHNICAL INVESTIGATION FOR ROADS AT THE COVES - HARTEBEESPOORTDAM

TABLE OF CONTENTS

List of Tables

APPENDIX A

SOIL PROFILES

APPENDIX B

LABORATORY TEST RESULTS