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GEOTECHNICAL SITE INVESTIGATION REPORT

FOR

LUCKHOFF WASTE DISPOSAL FACILITY, LETSEMENG LOCAL MUNICIPALITY, FREE STATE PROVINCE

FINAL REPORT

27th April, 2018

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Abbreviations

AASHTO	American Association of Highway and Transport Officials
CBR	California Bearing Ratio
GM	Grading Modulus
LL	Liquid Limit
LS	Linear Shrinkage
MDD	Maximum Dry Density
NP	Non Plastic
OMC	Optimum Moisture Content
PL	Plastic Limit
PI	Plasticity Index
SP	Soil Profile
TP	Test Pit

1. Introduction and Terms of Reference

On the 23rd November, 2017 Dipabala Civil Engineers requested a quotation for carrying out geotechnical site investigation at Luckhoff Waste Disposal. Geotechnical Engineering Laboratory (Pty) Ltd was appointed on the 18th January, 2018 to carry out the geotechnical site investigation for the proposed Luckhoff Waste Disposal Facility in Letsemeng Local Municipality, Free State Province.

2. Site Description

The proposed waste disposal facility is located in Luckhoff within Letsemeng Local Municipality, Free State Province and is easily accessible. The slope of the site is approximately 1 % and the climatic conditions of the site are very poor, very dry and no rainfall. Water pipelines, ponds and telephone cables are not available on this site. The site location and test pit layout is as shown in ***Appendix A*** of this report. Photos taken during site investigation are attached to this report as ***Appendix B***.

3. Method of Site Investigation

The site investigation was carried out on the 23rd January, 2018 and involved excavation of four (4) test pits by TLB to an approximate depth of 0.5 m to 2.1 m or refusal, whichever came first. The test pits were profiled using "Revised Guide to Soil Profiling for Civil Engineering Purposes in Southern Africa by Jennings JEB, Brink ABA and Williams AAB (1973)". Representative soil samples were taken and the following tests were carried out

- Sieve Analysis
- Atterberg Limits
- Mod AASHTO
- CBR
- Specific Gravity
- Hydrometer Analysis
- Shear Box test
- Moisture content test
- Permeability test

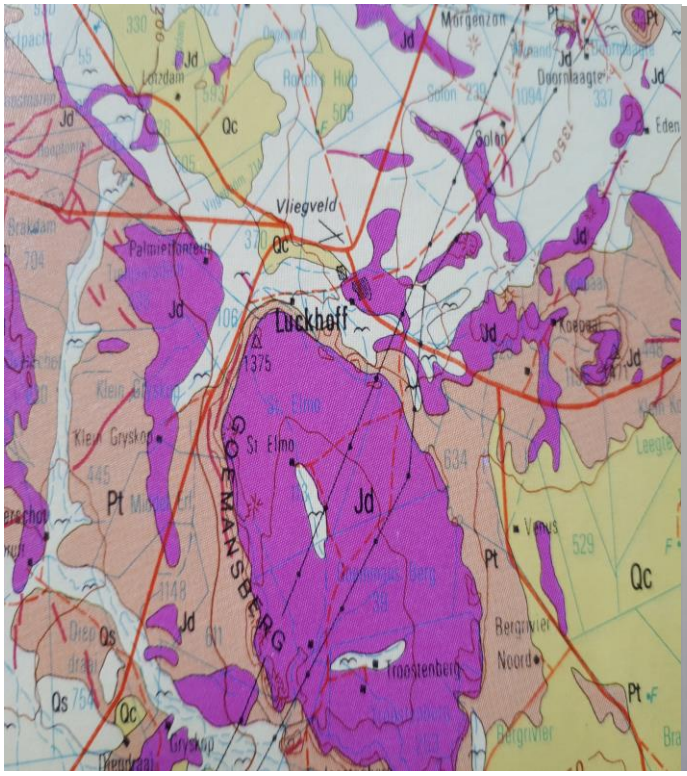
The main objectives of carrying out the testing were as follows:

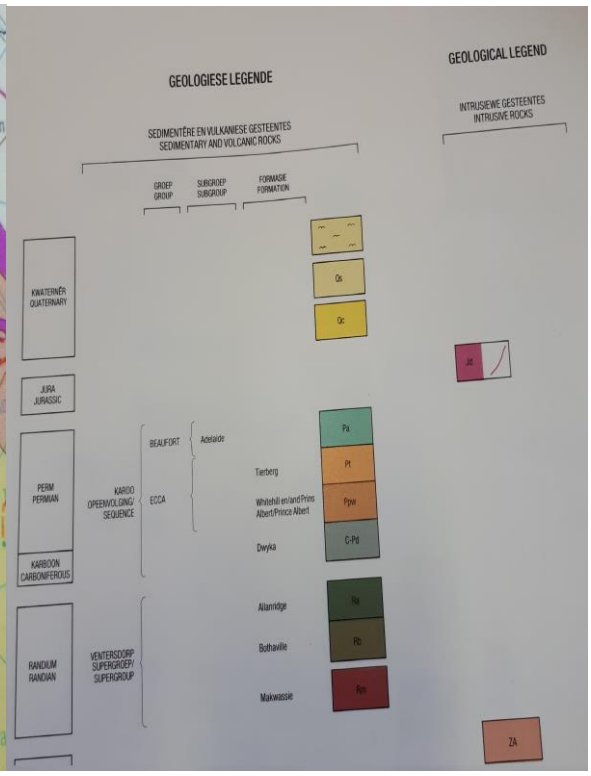
- To classify the in-situ soils and assess their suitability for use in constructional activities,
- To determine the type and depth of the soils found on site,
- To determine the potential heave and the bearing capacity, and
- To determine soil permeability

4. Site Geology and Groundwater Conditions

4.1. General

General geology of Luckhoff is shown on the Geological Map series of the Republic of South Africa, Sheet # 2924 for Koffiefontein, scale 1:250,000. According to this map dolerite intrusions (J-d) of Karoo Supergroup are dominant. Quarternary deposits (Qc) are also available. Tierberg Formation of Adelaide Subgroup of the Ecca Group that falls under Karoo Supergroup is also available on the project site. Rocks of this formation were formed during Permian period. During site investigation at Luckhoff, doleritic gravel was observed on TP 73 to TP 75. Lukhoff geology is shown below





4.2. Soil Profile

The soil layers found on the project site are attached as ***Appendix C*** of this report and show the following soils

TP 73

0 – 300 mm	Moist red loose silty sand
300 – 700 mm	Dry greyish white dense decomposed sugary gravel

TP 74

0 – 300 mm	Dry red loose silty sand
300 – 500 mm	Dry brown dense sugary gravel

TP 75

0 – 400 mm	Moist red loose silty sand
400 – 1000 mm	Dry grey dense sugary gravel

TP 76

0 – 700 mm	Dry brown loose silty sand
700 – 2100 mm	Dry yellowish brown silty sand

The soil profiles from the project site indicate that

- 300 mm to 700 mm thick red to brown silty is dominant on the project site. This is underlain by greyish white, brown to grey sugary gravel in TP 73 to TP 75. In TP 76 brown silty sand is underlain by yellowish brown silty sand. In essence TP 76 comprises mostly of silty sand up to about 2100 mm depth
- Refusal was encountered on sugary gravel at TP 73 to TP 75. No refusal was encountered on TP 76

4.3. Groundwater

No groundwater encountered during site investigation.

5. Geotechnical Evaluation

The relevant engineering characteristics were evaluated visually during site investigation and soil profiling. This evaluation was also done from laboratory testing as discussed below. Summary of test results is attached as ***Appendix D*** to this report.

5.1.Indicator Test Results

Indicator test results i.e. Sieve Analysis and Atterberg Limits test results are summarized in Table 5.1 below. The specific gravity test results are also shown in the table below. The in-situ moisture content was also determined as shown below.

Table 5.1 Indicator Test Results

TP #	Depth (mm)	Sieve Analysis				Atterberg Limits					Specific Gravity	W_n, %
		% < 2.00 mm	% < 0.425 mm	% < 75 µm	GM	LL (%)	PL (%)	PI (%)	LS (%)	AASHTO Class		
TP 73a	100-200	78.5	61.0	19.1	1.4	19	15	4	2	***A-2-4***		
TP 73b	400-600	45.1	32.1	10.8	2.1	25	19	6	3	***A-1-b***	***2.651***	***4.2***
TP 74a	100-300	92.2	76.6	33.5	1.0	21	16	5	2	***A-2-4***		
TP 74b	350-450	36.6	17.3	7.2	2.4	22	16	6	3	***A-1-a***	***2.882***	***3.1***
TP 75a	200-300	98.5	84.4	37.7	0.8	21	16	5	2	***A-4***		
TP 75b	700-900	51.7	17.6	7.5	2.2	26	19	7	3	***A-1-b***	***2.720***	***4.3***
TP 76a	500-600	99.7	89.8	39.8	0.7	22	16	6	3	***A-4***		
TP 76b	1800-2000	99.5	89.9	40.4	0.7	23	18	5	2	***A-4***	***2.595***	***5.2***

Note: W_n Natural In-situ moisture content

The results in Table 5.1 indicate that

- Soils from this project site are classified as A-2-4 (silts of low compressibility), A-4 (silts of low compressibility), A-1-a and A-1-b (stone fragments - gravel) according to AASHTO classification system.
- Specific gravities vary between 2.595 and 2.882
- Dry yellowish brown silty sand in TP 76 has the lowest specific gravity and the highest natural moisture content

5.2.Compaction and CBR Test Results

CBR and Compaction tests were carried out on four soil samples and the results are summarized in Table 5.2 below.

Table 5.2 Compaction and CBR Test Results

TP #	Depth (mm)	CBR @						TRH 14 Class
		100 %	98 %	97 %	95 %	93 %	90 %	
TP 73b	400-600	36.6	32.6	31.3	27.5	24.3	19.3	**G6**
TP 74b	350-450	29.8	26.5	24.8	21.8	18.5	13.8	**G7**
TP 75b	700-900	30.0	26.1	24.0	19.8	15.5	9.5	**G7**
TP 76b	1800-2000	14.0	12.5	12.0	10.8	9.5	7.8	**Nil**

***Note**: Nil refers to an unclassified soil in terms of CBR*

Test results in Table 5.2 indicate that

- Gravel in TP 73 to TP 75 is classified as G6 and G7 according to COLTO and TRH 14 classification system. This material is suitable for fills
- Dry yellowish brown silty sand in TP 76 is unclassified according to COLTO and TRH 14 classification system

5.3.Shear Strength Parameters

Shear box test was carried out on TP 74b (gravel). The shear strength parameters of this gravel are shown in Table 5.3 below.

Table 5.3 Shear Strength Parameters

TP #	Depth, mm	ϕ'	c'	ρ	γ	ρ_{dry}	γ_{dry}
TP 74b	350-450	39.7^{o}	17.1 kPa	2375 kg/m^3	23.3 kN/m^3	2211 kg/m^3	21.7 kN/m^3

5.4.Heave

Hydrometer test was carried out at TP 74b to determine the potential heave of the materials from these test pits. The test results are summarized in Table 5.4 below.

Table 5.4 Hydrometer Test Results

TP #	Depth (mm)	Atterberg Limits					Specific Gravity	W_n, %	% Clay	Potential Heave
		LL (%)	PL (%)	PI (%)	LS (%)	AASHTO Class				
TP 74b	350-450	22	16	6	3	***A-1-a***	***2.651***	***3.1***	***1.0***	***LOW***

The test results in Table 5.4 above indicate that the gravel from this site possess low potential heave.

5.5.Bearing Capacity

Bearing capacity determination for this project is done using the shear strength parameters stated above. The determination is done per square metre and assuming a factor of safety of 3. Founding depth is also assumed to be 1 m. The calculations are shown in Table 5.5 below.

Table 5.5 Bearing Capacity Determination

TP #	Depth, mm	ϕ'	c'	ρ	γ	ρ_{dry}	γ_{dry}	q_u	q_a
TP 74b	350-450	39.7^o	17.1 kPa	2375 kg/m^3	23.3 kN/m^3	2211 kg/m^3	21.7 kN/m^3	2213.3 kPa	737.7 kPa

Note: q_u = ultimate bearing capacity, q_a = allowable bearing capacity

5.6.Seepage

Falling head test was carried out on TP 74b to determine seepage properties of the soils found on the project site. The test results are summarized in Table 5.6 below.

Table 5.6 Falling Head Permeability

TP #	Depth (mm)	Specific Gravity	Permeability, k (cm/s)	Degree of Permeability
TP 74b	350-450	***2.770***	***8.45E-06***	***LOW***

Table 5.6 above indicates that the gravels on the proposed Luckhoff Waste Disposal site possess low degree of permeability.

5.7.Impact of geotechnical character on the site

The proposed Luckhoff Waste Disposal site is located on a doleritic intrusion and partly on sand. The material coming from this intrusion is porous and this property makes it easy for the water/leachate to

flow. During construction of the landfill the gravel from this area will have to be compacted to at least 95 % of Mod AASHTO in order to reduce its porosity.

All materials from this project were excavated using a TLB and as such the excavation can be classified as intermediate excavation as per SABS 1200 D-1988 (as amended 1990).

6. Conclusions and recommendations

The following geotechnical conditions will have an effect on the project and as a result they need to be considered during the design phase of the project

- In TP 73 to TP 75 red silty sand is underlain by gravel. TP 76 shows brown to yellowish brown silty sand through its entire depth
- Gravel in TP 74b possesses low potential heave
- Degree of permeability for gravels on this site is low. Since the gravel will be forming the base of the landfill, it is recommended that this material should be compacted to at least 95 % of Mod AASHTO in order to reduce its porosity
- TP 74b brown sugary gravel gives the ultimate and allowable bearing capacities of 2213.3 kPa and 737.7 kPa respectively
- Drainage of the leachate coming from the landfill should be provided

7. References

Jennings JEB, Brink ABA and Williams AAB (1973). *Revised Guide to Soil Profiling for Civil Engineering Purposes in Southern Africa*

Brink ABA and Bruin RMH (2002). *Guidelines for Soil and Rock Logging in South Africa*

Geological Map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland

Geological Map series of the Republic of South Africa, sheet number 2924 Koffiefontein, and scale 1:250,000

SABS 1200 D-1988 (as amended 1990). Standardized specification for Civil Engineering Construction. D : Earthworks.

8. Appendices

Appendix A Site Location and Layout

Appendix B Photos

Appendix C Soil Profile

Appendix D Summary of Test Results