Geotechnical Investigation on part of stand 3360, Nelspruit

(Mbombela Local Municipality)

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Report no: K7597-01
Project no: 7597-GB

June 2011

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GEOTECHNICAL INVESTIGATION ON PART OF STAND 3360, NELSPRUIT

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Date: June 2011

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APPENDICES

1. Introduction

This firm was appointed by the Unisa Creditors Section to conduct a geotechnical investigation on a part of stand 3360 in Nelspruit (Mbombela local Municipality). The aim of the investigation was to study the available geotechnical information, do in situ inspection and field work and to compile a report on the geotechnical conditions of the site. The investigation was carried out by S P Kok Pr Sci Nat (Engineering Geologist).

The purpose of the investigation is to:

- Determine the geological origin of the material on site.
- Determine the engineering properties of the different material layers.
- Give recommendations regarding the founding of the proposed structures.

2. Site location and description

The site locality is indicated on drawing number *7597-01: Locality Plan*. The site is situated in Jerepico Street, directly west of the Orchards Village Shopping centre and south of the Protea Hotel.

The site is approximately 1,4 hectares. At present the site is undeveloped, but is fairly disturbed with some ground terraces present.

3. General geology

The regional geology is indicated on drawing number *7597-02: Geology Map*. The available map and the test pits excavated on site showed that the site is underlain by granites of the basement Complex. Granites and granite-gneisses of the basement Complex are exposed over extensive parts of southern Africa. The term "granites" is slightly misleading as it in fact constitutes a complex suite, ranging in mineralogical composition from true granite, through granodiorites to quartz diorites and tonalites.

4. Groundwater conditions

Water seepage was recorded in four of the eight test pits excavated on site i.e. in test pits 2, 3, 4 and 5. Test pit TP1, may show water seepage at a greater depth if the test pit as excavated deeper. From the distribution of where groundwater was encountered it is evident that water seepage can be expected across the entire site at depths ranging from 2,1m to 4,2m below ground surface.

5. Available information

Maps

- The published geology map of South Africa (Government Printer) at a scale of 1 : 1 000 000.

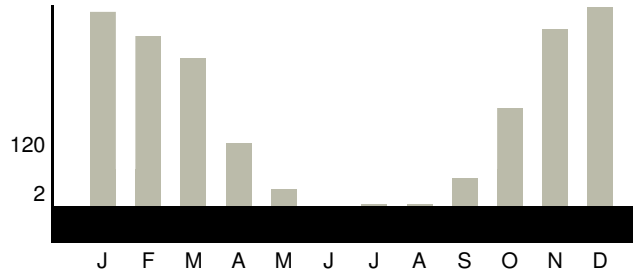
Publications

- SACS (Statigraphy of South Africa) Handbook 8, Part 1 Geological Survey (now the Council for Geoscience).
- Brink, A B A (1985). Engineering geology of Southern Africa (Volume 1). Building Publications.

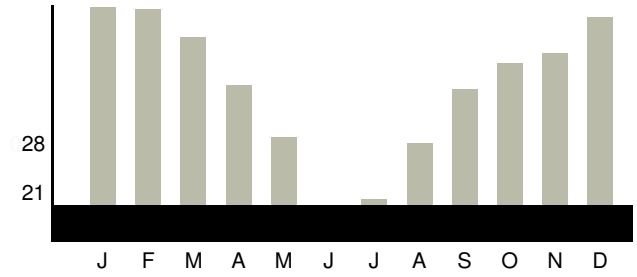
6. Climate

Nelspruit normally receives about 667mm of rain per year, with most rainfall occurring during summer. The chart below (top) shows the average rainfall values for Nelspruit per month. It receives the lowest rainfall (2mm) in June and the highest (119mm) in December. The monthly distribution of average daily maximum temperatures (centre chart below) shows that the average midday temperatures for Nelspruit range from 21.4°C in June to 27.9°C in January. The region is the coldest during July when the mercury drops to 6.2°C on average during the night. Consult the chart below (bottom chart) for an indication of the monthly variation of average minimum daily temperatures.

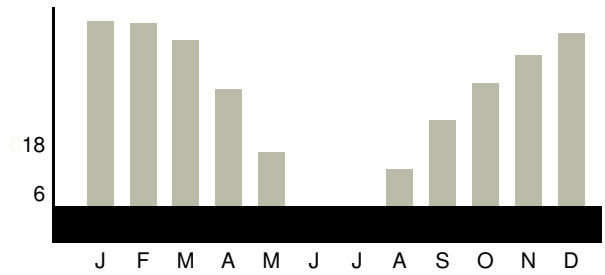
Average rainfall (mm)



Average midday temperature (°C)



Average night-time temperature (°C)



The Weinert N-value is in the region of 2,2 which indicates that predominantly chemical decomposition of the underlying rock has taken place.

7. Investigation methods

The available information such as the geology map at 1: 1000 000 was studied. Eight test pits were excavated by means of a JCB 3CX TLB with an extended boom. The soil profiles were described by an engineering geologist. Disturbed and undisturbed soil samples were taken and submitted to a commercial laboratory for testing. Foundation indicator tests and a CBR (Californian Bearing Ratio) test were done on the disturbed samples and two consolidation tests were done on the undisturbed samples.

The soil profile descriptions are attached in Appendix A (soil profiles) and the laboratory test results are included in Appendix B (laboratory test results). A table summarizing the laboratory test results is also included in Appendix B.

All the available data was used to evaluate the site and to classify the area according to the system proposed by the NHBRC (National Home Builders Registration Council).

7.1 Soil Profile

The site generally shows similar geotechnical conditions. A generalized soil profile can be described as follows:

0,0 – 0,5m *Moist, light sandy brown, very loose, voided sand with silt; Residual.*

0,5 – 2,0m *Moist, orange brown to grey brown with black mottling, firm, intact clayey sand; residual, slightly ferruginised granite.*

2,0 – 4,3m *Wet, light yellow brown to khaki brown, medium dense, intact clayey or silty sand; Residual.*

Generally no refusal of TLB with water seepage at around 3,5m.

7.2 Laboratory test results

General

Eight material samples were taken from the eight test pits excavated. Five foundation indicator tests were conducted and one CBR (Californian Bearing Ratio) test was done on the disturbed samples. Two collapse potential tests were done on the undisturbed samples.

Indicator tests

According to the Unified Classification System the samples will mostly classify as silty sand. Only one sample classified as a clayey sand (TP3/1,0). Some minor pockets of clay and sand layers are also present.

From the grading analysis it is evident that the material show very similar properties. In general it is evident that the samples are medium grained with a sand fraction varying between 72 and 95 percent with an average of 84 per cent. The silt fraction varies from 19 to 29 per cent with an average of 23 percent and the clay fraction varies from 2 to 11 percent with an average of 5,6 per cent. The clay content is therefore low. This is also evident from the Atterberg Limits, as most of the materials were either slightly plastic (SP) or non-plastic (NP). Only one sample showed some plasticity and that is sample TP3/1. Even this sample has a low heave potential and classifies low on the Activity chart.

For all the samples (except sample TP3/1), the linear shrinkage varies from 0 to 1 percent – sample TP3/1 is 5,5 per cent. This verifies the low activity of the materials on site.

CBR (Californian Bearing Ratio)

The CBR sample was taken in test pit 7 on the southern part of the site. The results show that this material will probably classify as a G5 according to the TRH 14. The material is therefore suitable for use in layer works of roads and in the construction of earth mattresses for foundations.

Heave potential

Using van der Merwe's method to determine the heave potential of material, it is evident that most of the materials classify as having a potentially low expansiveness potential. However, pockets of lay are present, but limited and therefore no heave related problems are foreseen on site.

Collapse potential

Two undisturbed samples were taken and collapse potential tests conducted on them. Most of the material present on site seemed collapsible from a visual inspection, but the materials were too loose to take a sample for testing purposes. The samples actually taken is believed to have a lower collapse potential than most of the materials present on site Sample TP3/2,2 show a collapse potential of 0,27 percent, which is not significant. However, sample TP6/0,9 indicate a collapse potential of 2,46 per cent indicating that the amount of movement due to collapse of the soil grain structure will be significantly more than 10mm.

7.3 Excavatibility

The material is generally easily excavatible and on this site it is soft excavation to a depth of 3,5m and probably deeper if an excavator is used. No excavation problems are foreseen.

7.4 Sidewall stability of excavations

In six of the eight test pits excavated, sidewall collapse occurred. All excavations deeper than 1,5m must be shored according to Health and Safety requirements.

7.5 Slope stability

The area is fairly flat and disturbed and no natural slope stability problems are foreseen. However, if excavations are made, it is likely that slope instabilities will occur as there is also some water seepage on adjacent properties.

7.6 Construction materials

The materials tested on site and inspected in the test pits seem suitable for use as construction materials for roads and fill where loads are placed on. Materials in the southern part of the site seem more suitable than the materials in the northern part of the site. It is proposed that the in situ materials be further tested to ensure that the materials are suitable.

7.7 Zonation

The entire site is classified according to the NHBRC as **C2/P (seepage).**

8. Foundation design and precautionary measures

The site classification is C2/P (seepage) according to the NHBRC soil classification system.

For single and double storey structures the following founding options can be considered:

Soil Raft	• Remove in situ material to 1,0m beyond perimeter of the building to a depth of 1,5 times the width of the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content • Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.
Stiffened strip footings, stiffened or cellular raft	• Stiffened strip footings or stiffened or cellular raft with lightly reinforced or articulated masonry. • Bearing pressure not to exceed 50 kPa • Fabric reinforcement in floor slabs • Site drainage and service/plumbing precautions.

Piled construction	• Piled foundations with suspended floor slabs with or without ground beams • Site drainage and plumbing / services precautions
Split construction	• Combination of reinforced masonry and full movement joints • Suspended floors or fabric reinforced ground slabs acting independently from the building • Site drainage and plumbing / services precautions

In this area the use of an earth mattress with a concrete raft type foundation for a three storey structure is recommended.

No wet services should be installed below the structures. Due to the risk of heave it is recommended that the following precautionary measures be implemented as far as is practically possible:

- Water pipe entries into the building shall be above ground level.
- All sewer and water pipes and fittings shall be provided with flexible, watertight joints.
- No plumbing and drainage pipes shall be placed under floor slabs, as far as is practicable.
- The fall of the trenches shall be away from the buildings.
- The selection of piping materials shall take cognisance of corrosion (both external and internal).
- Water pipes shall have a minimum cover of 500mm.
- Wherever practical, service trenches shall not be excavated along the length of structures within the first 3,0m beyond the perimeter of structures.
- Down pipes, if provided, shall discharge into concrete lined drainage channels or onto an apron slab, which discharge the water at least 1,5 m away from buildings.

- Where guttering is not provided, a 1,5 m wide apron slab shall be provided.

- The ground immediately against the buildings shall be shaped to fall in excess of 75 mm over the first 1,0 m beyond the perimeter of the building, from where it shall drain freely away from the structures. Apron slabs, where provided shall have the same fall.

It is recommended that the excavations (for foundations and underground services) be inspected on the site during construction. This should ensure that conditions at variance to that described can be noted and the necessary adjustments made.

9. Conclusions and recommendations

The regional geology is indicated on drawing number *7597-02: Geology Map.* The available map and the test pits excavated on site showed that the site is underlain by granites of the basement Complex.

The site is undeveloped and the site is fairly disturbed with no noticeable drainage features.

It is calculated that the maximum amount of movement due to collapse is in excess of 10mm if a foundation is placed at approximately 0,5m below ground level.

According to the NHBRC the site is classified as **C2/P (seepage).**

For single and double storey structures the following founding options can be considered:

Soil Raft	• Remove in situ material to 1,0m beyond perimeter of the building to a depth of 1,5 times the width of the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content • Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.

Stiffened strip footings, stiffened or cellular raft	• Stiffened strip footings or stiffened or cellular raft with lightly reinforced or articulated masonry. • Bearing pressure not to exceed 50 kPa • Fabric reinforcement in floor slabs • Site drainage and service/plumbing precautions.
Piled construction	• Piled foundations with suspended floor slabs with or without ground beams • Site drainage and plumbing / services precautions
Split construction	• Combination of reinforced masonry and full movement joints • Suspended floors or fabric reinforced ground slabs acting independently from the building • Site drainage and plumbing / services precautions

Due to the disturbed nature of the site and the collapsible grain structure of the residual granites it is recommended that a concrete raft type foundation placed on an engineered earth mattress be considered.

The precautionary measures to reduce water ingress must be implemented as changes in moisture content can cause ground movement.

Excavations (for foundations and underground services) must be inspected on the site during construction.

The materials present in the southern part of the site seem suitable for use in layer works (see drawing number 7597-03). It is recommended that additional tests be done if in situ materials are to be used in construction.

No excavation problems are foreseen, but sidewall instability is likely to be problematic. All excavations deeper than 1,5m must be shored.

10. Report provisions

The aim of the investigation was to estimate through site investigation; professional judgment and past experience the geotechnical conditions of the site, different soil horizons with their different geotechnical properties, areas subject to a perched water table, and areas of poor drainage, areas underlain by hard rock and to estimate their distribution. However, it is impossible to guarantee that isolated zones of different geotechnical conditions, foundation materials, blanketing layers or any other geotechnical problems have not been missed.

For this reason detailed foundation inspections should be carried out at the time of construction to identify such variances and adjust foundation designs accordingly if need be.

11. References

11.1 GEOLOGICAL MAP

Number and title: South Africa

Scale: 1:1 000 000

Date of publication: 1973

Source: Government Printer

11.2 Jennings, JE, Brink, ABA and Williams, AAB (1973). **Revised guide to soil profiling for Civil Engineering Purposes in SA.** Trans SAICE, Vol 5, No 1, pp 3-12.

11.3 Van der Merwe, DH (1964). **The prediction of heave from the plasticity index and the percentage clay fraction.** Trans SAIC Vol 6, No 6, pp 103-7.

11.4 Brink, ABA, (1979). **Engineering Geology of South Africa.** Vol. 1 published Building Publications, Silverton.

11.5 Burland, JB (1961), **A simplified colour chart for soil identification.** Trans SAICE Vol.3, No.8.

11.6 Jennings, JE & Kerrich, JE (1962). **The heaving of buildings and the associated Economic consequences, with particular reference to the Orange/Free State Gold Fields.** The Civil Engineer in SA. Vol4, No. 11.

11.7 Jennings, DE and Robertson, A Mac G (1974). **Settlement and collapse potential.** Reply to ABA Brink in SAICE Div. Soil Mech. And Found Eng. Newsletter No.2 pp 1-5.

11.8 South African Institute of Civil Engineers/Institution of Structural Engineers (1995). **Code of Practice P: Foundation and Superstructures for Single Storey Residential Buildings of Masonry Construction.** Joint Structural Division, Johannesburg.

11.9 Partridge, TC Wood, KC and Brink, ABA (1993). **Priorities for urban expansion within The PWV metropolitan region. The primacy of geotechnical constraints.** South African Geographical Journal, Vol 75, pp 9-13.

11.10 National Home Builders Registration Council (1999). **Home builders manual Parts 1 and 2.** Revision no. 1 February 1999.

11.11 SAIEG/SAICE (1996). **Guidelines for Urban Engineering Geological Investigations.**

Appendix A: Soil Profile Descriptions

Appendix B: Laboratory Test Results

Appendix C: Drawings