Soilkraft cc

Reg no CK 96/08031/23

PO Box 73478
Lynnwood Ridge
0040
Tel : 012-9910426
Fax : 012-9912555
Email: soilkraf@iafrica.com

GEOTECHNICAL CONDITIONS ON A PORTION OF PORTION 19 OF THE FARM ZWARTKOPPIES 364-JR : A REPORT FOR THE ESTABLISHMENT OF THE PROPOSED TIJGERVALLEI EXTENSION 9 AND 10 RESIDENTIAL DEVELOPMENT

1 INTRODUCTION

- *Appointment* : It is envisaged to establish the new residential developments of Tijgervallei Extensions 9 and 10 on a portion of Portion 19 of the farm Zwartkoppies 364-JR. To this end Soilkraft cc was appointed by Ms Y Pelser on behalf of Tijgervallei 2 to undertake a geotechnical survey complying with the requirements of the Council for Geoscience[Reference 9.1] and other relevant authorities. The purpose of such an investigation is to:

  - identify possible relevant geotechnical constraints;
  - make certain recommendations regarding the founding of structures and
  - to identify other factors that could possibly influence the future development of the area.

- *Reporting* : Five printed and bound copies and the original of the report are supplied to the client. An electronic copy of the entire report is also supplied to enable the client to adjust the site plans to a scale convenient to him and to provide additional copies of the report, should it be required. All printed drawings in the hard copies are in A2 format, and serve for illustrative purposes only. *Scope of Investigation* : The report reflects the geotechnical conditions as determined for township development purposes. The report shall therefore under no circumstances be regarded as the results of a detailed geotechnical investigation as far as zoning of individual stands, materials utilization, depth of excavation or other related matters are concerned. These issues shall be determined by purpose specific investigations and the results there of be evaluated by a suitably qualified professional person.

2 AVAILABLE INFORMATION

The following sources of information were consulted :

- 1 : 50 000 scale topographical map, Rietvlei Dam 2528CD, published in 1995.
- 1 : 50 000 geological map, Rietvlei Dam 2528CD, published in 1973.
- The document *Report on the Reconnaissance Geotechnical Survey on Portions 5, 6, 8, 9, 17 and 45 ; and the Remainder of Portion 19 of the Farm Zwartkoppies 364-JR*, compiled and issued by Soilkraft cc in April 2004, and issued on behalf of Sable Homes.

3 SITE DESCRIPTION

3.1 Site Location

The land under discussion is situated in an area east of Hans Strijdom Road, north of Lynnwood Road and south of the N4 freeway linking Pretoria and Bronkhorstspruit. It is located east of the existing Silver Lakes and north of Silverwoods Security Estates. The area of the land investigated is approximately 114 hectare.

Refer to the attached Figure 1 : Locality Plan.

3.2 Topography

The surface of the land slopes regularly from south to north. Topographically, the southern part of the property is the highest at approximately 1360 meters above mean sea level, sloping northwards to approximately 1340 meters above mean sea level. There are no outstanding topographical features influencing the development of the property.

3.3 Flora

A dense stand of indigenous trees is present in the northern and western parts of the property. Such flora are mostly trees preferring argillaceous soils. Typically, specimens of *Acacia karoo, Acacia caffra* and *Ziziphus mucronata* are common. The southern parts of the land is virtually void of any trees, and at the time of investigation was covered by a dense stand of short grass and dryland agriculture.

3.4 Climate and Weather Conditions

The site is located in an area with an approximate Weinert N-value of 2,4 and a Thornthwaite Moisture Index between 0 and -20. Climatically the area may thus be described as subhumid. The importance of this is that chemical weathering of rock material will take place, rather than mechanical breakdown thereof, resulting in the formation of active clays if the suitable parent material is available. Minerals like amphiboles, pyroxenes and olivine are especially susceptible to such weathering.

The area receives summer rainfall at a mean annual precipitation of 664mm, generally in the form of thunderstorms. The average maximum summer temperature of approximately 29,0°C occurs in January. Winters are mild and frost is uncommon. The average minimum winter temperature of 4,0°C occurs in June.

4 EXISTING FACILITIES

At the time of investigation, the property formed part of a large diary farm. The land is thus used for grazing and crop cultivation, but the residence of one of the farm owners is also located within the area of investigation.

Electricity is available in the area for household purposes, but not sufficient for bulk utilization. Water is extracted from several boreholes. For infrastructure development, all services such as electricity, water, sewerage and telecommunication must be provided to the property.

5 SITE INVESTIGATION

5.1 Test Pitting

For the purposes of the survey 88 test pits were excavated with a John Deere 310-A TLB provided by SNALAB. The locations of the test pits are indicated on the site plans relevant to the survey as contained in this report. GPS grid references for the test pits are indicated on the profile sheets.

The test pits were profiled according to the guidelines of SAICE and SAIG[Reference 9.2]. For the benefit of the non-geotechnical reader, these guidelines are summarized in the attached Table 1 : Soil Profiling Parameters. The profiles of the test pits may be found in Addendum A to this report. The profile descriptions as per the test pits reflect the impressions created by the pedological conditions and may sometimes be in slight variance with the results of the soil testing.

5.2 Materials Testing

Soil testing was done by the laboratory facilities of SNALAB and Soillab. The following soil tests were done :

- California Bearing Ratio (CBR) and road indicator determinations to determine road building properties on samples of the residual and transported soils that may serve as sources for road construction material.
- Conductivity and pH determinations on samples of the various in-situ soils to determine the corrosivity of such soils.
- Foundation indicator testing to determine properties of heave of the in-situ argillaceous soils.

TABLE 1 : SOIL PROFILING PARAMETERS

CONSISTENCY : GRANULAR SOILS **CONSISTENCY : COHESIVE SOILS**

SPT N	GRAVELS & SANDS Generally free draining soils		DRY DENSITY (kg/m^3)	SPT N	SILTS & CLAYS and combinations with SANDS. Generally slow draining soils		UCS (kPa)
<4	Very loose	Crumbles very easily when scraped with geological pick. Requires power tools for	<1450	<2	Very soft	Pick point easlily pushed in 100mm. Easily moulded by fingers.	<50
4-10	Loose	Small resistance to penetration by sharp pick point. requires many blows by pick point	1450-1600	2-4	Soft	Pick point easlily pushed in 30mm to 40mm. Moulded by fingers with some pressure.	50-125
10-30	Medium dense	Considerable resistance to penetration by sharp pick point.	1600-1750	4-8	Firm	Pick point penetrates to 10mm. Very difficult to mould with fingers.	125-250
30-50	Dense	Very high resistance to penetration by sharp pick point. Requires many blows by pick point for excavation.	1750-1925	8-15	Stiff	Slight indentation by pick point. Cannot be moulded by fingers. Penetrated by thumb nail.	250-500
>50	Very dense	High resistance to repeated blows of geological pick. Requires power tools for excavation.	>1925	15-30	Very stiff	Slight indentation by blow of pick point. Requires power tools for excavation.	500-1000

SOIL TYPE

SOIL TYPE	PARTICLE SIZE(mm)
Clay	<0,002
Silt	0,002-0,06
Sand	0,06-2,0
Gravel	2,0-60,0
Cobbles	60,0-200,0
Boulders	>200,0

MOISTURE CONDITION

Dry	No water detectable
Slightly moist	Water just discernable
Moist	Water easily discernable
Very moist	Water can be squeezed out
Wet	Generally below water table

SOIL STRUCTURE

Intact	No structure present.
Fissured	Presence of discontinuities, possibly cemented.
Slickensided	Very smooth, glossy, often striated discontinuity planes.
Shattered	Presence of open fissures. Soil break into gravel size blocks.
Micro shattered	Small scale shattering, very closely spaced open fissures. Soil breaks into sand size crumbs.
Residual structures	Residual bedding, laminations, foliations etc.

COLOUR

Speckled	Very small patches of colour <2mm
Mottled	Irregular patches of colour 2-6mm
Blotched	Large irregular patches 6-20mm
Banded	Approximately parallel bands of varying colours
Streaked	Randomly orientated streaks of colour
Stained	Local colour variations : Associated with discontinuity surfaces

ORIGIN

Transported	Alluvium, hillwash, talus etc.
Residual	Weathered from parent rock, eg residual granite
Pedocretes	Ferricrete, silcrete, calcrete etc.

DEGREE OF CEMENTATION OF PEDOCRETES

TERM	DESCRIPTION	UCS (MPa)
Very weakly cemented	Some material can be crumbled between finger and thumb. Disintegrates under knife blade to a friable state.	0,1-0,5
Weakly cemented	Cannot be crumbled between strong fingers. Some material can be crumbled by strong pressure between thumb and hard surface. Under light hammer blows disintegrate to a friable state.	0,5-2,0
Cemented	Material crumbles under firm blows of sharp pick point. Grains can be dislodged with some difficulty by a knife blade.	2,0-5,0
Strongly cemented	Firm blows of sharp pick point on hand-held specimen show 1-3mm indentations. Grains cannot be dislodged by knife blade.	5,0-10,0
Very strongly cemented	Hand-held specimen can be broken by single firm blow of hammer head. Similar appearance to concrete.	10,0-25

- Double oedometer tests on samples of the reworked fine colluvium.
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The results of the soil testing may be found in Addendum B. However, for easy reference, the results are summarized in the attached Table 2 : Results of Soil Testing.

6 DISCUSSION

6.1 Geology

The regional geology of the area is indicated on the attached Figure 2 : Regional Geology. This is an extract of the official geology map of the area. This map shows the property to be located on sediments of the Silverton Formation, Pretoria Group, Transvaal Supergroup ; and post Transvaal intrusive diabase, associated with the Bushveld Complex. A major syenite dyke traverses the property. The presence of fault zones is not indicated in the area.

Closer inspection during the site investigation revealed the property to be located on the following :

- *Shale* : Shale associated with the Silverton Formation is present as bedrock over the southern and central parts of the property. The shale is usually highly weathered, consisting of light red brown, very closely fractured, slightly weathered, medium hard rock. Laminations are poorly developed in the shale matrix. In the contact aureole of the diabase sill, the shale is higly metamorphosed to hard rock, light grey hornfelsic shale. Some xenolites of shale are contained in the diabase, and were encountered in the southern parts of the property. Regionally the sequence of sediments dips to the northeast at approximately 20°.
- *Diabase* : Bedrock over the larger part of the property is present as diabase. Sub-outcrops, outcrops and corestones of diabase are visible on the boundary of Extension 9 and Extension 10. Diabase is regarded as a hypabyssal, intrusive, basic, igneous rock. The mineral assemblage consists predominantly of plagioclase and pyroxene. Under the given climatic conditions, diabase is therefore highly susceptible to chemical decomposition and the formation of highly expansive clays as indicated in section 3.4 of this report. In an unweathered form diabase can be described as a fine grained to very fine grained, light grey to dark grey, very hard rock. The diabase intrusions follow the same dip and strike as the surrounding shales.

As the investigation reveals certain flaws in the published geology map, Figure 3 : Site Geology is attached, providing a more correct lithological presentation than the official one.

6.2 Hydrology

- *Perched Water* : The investigation was conducted at the time of the year when soil moisture is at its highest level, but perched water was largely absent from the property. Perched water was encountered in only three of the test pits (no’s 68 to 70) in the lowlying area close to one of the spruits. The presence of limited ferruginization is indicative that perched water may not be regarded as widely distributed across the property. It must be stressed that the presence of perched water is a seasonal phenomenon and the extent thereof depends on precipitation, time of

the year etc. In other words, it is possible that in the middle of winter, much less perched water may be present in the area than in summer.

- *Permanent Water* : Vegter[Reference 9.3] indicates the probability of drilling successfully for water in the area to be less than 40%, and, should water be encountered, chances are between 10% and 20% that the yield of such a borehole will exceed $2ls^{-1}$. Such groundwater that is present in the area is usually encountered at depths between 20 and 30 meter, occurring in fractures restricted to a zone directly below groundwater level. Groundwater is usually found in the contact aureole of the shale and the diabase.
- *Surface Water* : Drainage takes place by means of surface sheetwash and becomes concentrated into two non-perennial spruits bisecting the land from south to north. These spruits feed into a dam on the property and forms a tributary of the Pienaars River, which feeds the Roodeplaat Dam to the northeast of the site. The extent of the drainage features is such that the affected areas can not be zoned as separate geotechnical areas. Such areas should be regarded as an urban lay out issue and addressed accordingly.

6.3 Pedology

Prior to discussing the geotechnical zoning of the land, it is important to distinguish between the different soil materials present on site. Eight different soil materials are encountered in the area, namely :

- *Black Colluvial Sandy Clay* : A surface horizon of black, colluvial sandy clay is present as the most important soil material over the larger part of the property. During the investigation it was encountered in test pits one to three, 11 to 13, 21 to 24, 33 to 34, 41 to 44, 50, 54 to 55, and 69 to 70. The vertical extent of the horizon varied between 500mm and 1700mm, the thicker deposits of clay being present in the low lying areas near the spruits. The matrix of the sandy clay is usually of loose consistency, desiccated and slickensided. The results of the soil testing indicate the plasticity index of the black sandy clay to vary between 36 and 45 ; and the grading modulus between 0,15 and 0,53. In terms of the TRB materials classification system, it is regarded as a A-7-6(18 to 20) type of soil. The black sandy clay can be regarded as potentially very highly expansive, containing between 43,4% and 48,4% active clay.
- *Dark Brown, Colluvial Clayey Sand* : A surface horizon of dark brown, colluvial clayey sand is present as the most important soil material in the northern parts of the property, extending in a narrow band towards the south. During the investigation it was encountered in test pits four, seven, 14, 16 to 19, 25 to 32, 37 to 39, 60, 67, 69, 73, 77, 79, and 81 to 88. The vertical extent of the horizon varied between 300mm and 1500mm. The matrix of the sandy clay is usually of loose consistency and desiccated. The results of the soil testing indicate the plasticity index of the dark brown clayey sand to vary between 19 and 30 ; and the grading modulus between 0,26 and 0,52. In terms of the TRB materials classification system, it is regarded as a A-7-6(11 to 20) type of soil.

The dark brown clayey sand can be regarded as potentially moderately to highly expansive, containing between 44,5% and 54,2% active clay.

- *Light Brown, Colluvial Clayey Sand* : A surface horizon of light brown to light red, colluvial clayey sand is present in the southern and central parts of the property. The sand can be associated with shallow gullies and is thought to be colluvial sand reworked by the presence of water through transportation. During the investigation it was encountered in test pits five to six, eight to ten, 40, 48 to 49, 56 to 59, 61 to 66 and 68. The vertical extent of the horizon varied between 200mm to more than 2000mm. The matrix of the clayey sand is usually of loose consistency and intact. The results of the soil testing indicate the plasticity index of the clayey sand to vary between 16 and 25; and the grading modulus between 0,39 and 1,04. In terms of the TRB materials classification system, it is regarded as a A-7-6(7 to 17) type of soil. The reworked clayey sand can be regarded as potentially moderately expansive, containing between 24,2% and 56,8% active clay. However, the results of the double oedometer testing indicate that in spite of its argillaceous composition, the reworked sand is subject to settlement too. Due to its reworked nature, it is in an unconsolidated condition, and settlement will take place with long term heave only.
- *Fill* : A surface horizon of fill material is present in the southwestern parts of Tijgervallei Extension 9. The fill consists of various clayey sands containing builder's rubble and foreign matter. The fill was encountered in test pits 51 to 53, 74 to 76, 78 and 80. The soil matrix of the fill is mostly of loose to very loose consistency. The vertical extent of the horizon of fill varied between 500mm to more than 3000mm. The fill can be regarded as potentially highly compressible.
- *Diabase Derived Sandy Clay* : Due to the combination of climatic conditions and the mineralogical assemblage of diabase, it ultimately weathers to a clay. Such clay is present underlying the colluvium in the area of diabase. It is present in the southern and northern parts of the property and was encountered in test pits three, nine, ten, 14, 23, 25, 33 to 35, 44, 49 and 70. It consists of dark yellow to olive sandy clay. The soil matrix of the residual clay is mostly slickensided. The vertical extent of the horizon of sandy clay varied between a minimum of 300mm to more than 2000mm in the test pits. The results of the soil testing indicate the plasticity index of the diabase derived sandy clay to vary between 37 and 53 ; and the grading modulus between 0,11 and 0,23. In terms of the TRB materials classification system, it is regarded as a A-7-5(20) to A-7-6(20) type of soil. The clay can be regarded as potentially very highly expansive, containing between 41,9% and 56,9% active clay.
- *Diabase Derived Sand* : A horizon of residual silty to coarse sand is present underneath the residual diabase derived clay or black, transported clay. It was encountered in test pits two to five, seven to eight, 10 to 11,13 to 21, 24 to 33, 37 to 43, 48 to 49, 54 to 55, 69 to 70, and 77 to 88. The sand is light yellow to dark yellow tending to grey in colour and speckled white. The soil matrix of the sand is relic jointed and stained black on such discontinuities. The consistency is medium dense improving to very dense with depth. Refusal of excavation most often took place in the sand, and the vertical extent of the horizon could not be determined. The results of the soil testing indicate the plasticity index of the diabase derived sand to vary between seven and 17 ; and the grading modulus between 1,17 and 1,63. In terms of the TRB materials classification

system, it is regarded as a A-2-4(0) to A-2-7(1) type of soil. The sand can be regarded as potentially non-expansive, containing between 2,7% and 7,7% active clay.

- *Shale Derived Sandy Clay* : Due to the combination of climatic conditions and the mineralogical assemblage of the shale, it ultimately weathers to a clay. The clay is dark yellow to dark olive in colour. Such clay is present underlying the colluvium in the area of shale, but is sometimes exposed at the surface and was encountered in test pits 22, 45 to 47, 60, and 62 to 68. The soil matrix of the residual clay is mostly slickensided and some ferruginization in the form of singular, black concretions may be present. The vertical extent of the horizon of sandy clay varied between a minimum of 500mm to more than 2000mm in the test pits. The results of the soil testing indicate the plasticity index of the shale derived sandy clay to vary between 24 and 47 ; and the grading modulus between 0,22 and 0,56. In terms of the TRB materials classification system, it is regarded as a A-7-5(16) to A-7-6(19) type of soil. The clay can be regarded as potentially moderately to highly expansive, containing between 45,3% and 51,9% active clay.
- *Shale Derived Sand* : A horizon of residual clayey sand tending to gravels of shale contained in a sandy matrix is present on top of bedrock, shale. It was encountered in test pits one, 12, 22, 53, 56 to 59, 61 and 71 to 72. The sand is light yellow to grey and brown in colour. The soil matrix of the sand tends to contain the characteristics of the shale, that is relic laminations and joint sets. The consistency is loose increasing to very dense. Refusal of excavation most often took place in the sand, and the vertical extent of the horizon could not be determined. The results of the soil testing indicate the plasticity index of the shale derived sand to vary between nine and 16 ; and the grading modulus between 1,34 and 2,05. In terms of the TRB materials classification system, it is regarded as a A-2-4(0) to A6(4) type of soil. The sand can be regarded as potentially non-expansive, containing between 10,2% and 12,7% active clay.

6.4 Geotechnical Zoning

When discussing the pedology of the area, it is important to bear the following issues in mind :

- *Properties of Heave* : Using the results of the soil testing in the parametric heave calculation method as proposed by Van der Merwe[Reference 9.4] as per the RAFT software compiled by the CSIR, free heave was calculated where required.
- *Properties of Settlement* : Only the reworked colluvial sand is regarded as potentially subject to settlement due to stresses brought about by foundation loads of single storey and double storey structures. Settlement was estimated according to the results of the double oedometer testing, and further extrapolated by means of the guidelines proposed by Partridge[Reference 9.5], according to which an arenaceous soil horizon with a thickness exceeding 700mm may require foundation precautionary measures.

The soil classification of the property is in accordance with the guidelines of the NHBRC[Reference 9.6]. Based on the principles as explained above, the following three geotechnical zones are distinguished :

- *Pedological Area I* : This is the southeastern part of Tijgervallei Extension 10. It covers approximately 4,3% of the site and is considered as being of favourable development potential. The soil profile of the area is characterized by a superficial combined horizon of colluvium and residual shale, prior to encountering bedrock, shale. Soil movements are determined by the potentially compressible characteristics of the residual shale and the overlying reworked colluvium, and consist of less than 5mm of time related consolidation and collapse settlement. The area is consequently zoned as C.
- *Pedological Area II* : This is the northwestern corner of Tijgervallei Extension 10 extending into Extension 9. It covers approximately 2,7% of the site and is considered as being of intermediate development potential. The soil profile of the area is characterized by a surface horizon of argillaceous colluvium overlying residual clayey sand derived from diabase and shale. Soil movements are determined by the potentially expansive characteristics of the transported soils, and consist of 15mm to 30mm of free heave. The area is consequently zoned as H2.
- *Pedological Area III* : This zonation consists of the southwestern corner of Tijgervallei Extension 10 and the northern central part of Tijgervallei Extension 10 extending into Extension 9. It covers approximately 16,9% of the site and is considered as being of intermediate development potential. The soil profile of the area is characterized by a surface horizon of reworked colluvium overlying residual clayey sand derived from diabase and shale. Soil movements are determined by the potentially expansive characteristics of the residual and transported soils and settlement of the transported soil, and consist of 15mm to 30mm of free heave and 5mm to 10mm collapse and consolidation settlement. The area is consequently zoned as (C1-H2).
- *Pedological Area IV(a)* : This zonation consists of the southern part of Tijgervallei Extension 10 and the northern central part of Tijgervallei Extension 9. It covers approximately 56,6% of the site and is considered as being of intermediate development potential. The soil profile consists of a surface horizon of colluvial sandy clay overlying residual sand, mostly from diabase. Soil movements are determined by the potentially expansive characteristics of the transported soil, and consist of 30mm to 60mm of free heave. The presence of surface water in gullies impede the development of this zone. The area is consequently zoned as H3.
- *Pedological Area IV(b)* : This zonation consists of a portion of land located centrally in Tijgervallei Extension 9. It covers approximately 5,7% of the site and is considered as being of intermediate development potential. The soil profile consists of a surface horizon of colluvial sandy clay overlying residual sandy clay, from diabase and shale. Soil movements are determined by the potentially expansive characteristics of the transported soil, and consist of 60mm to 90mm of free heave. The presence of surface water in gullies impede the development of this zone. The area is consequently zoned as H3.
- *Pedological Area V* : This zonation consists of a portion of land located centrally in Tijgervallei Extension 9. It covers approximately 7,7% of the site and is considered as being of intermediate

development potential. The soil profile consists of a surface horizon of reworked colluvial clayey sand overlying residual sandy clay, from diabase and shale. Soil movements are determined by the potentially expansive characteristics of the residual and transported soils and settlement of the transported soil, and consist of 30mm to 60mm of free heave and 5mm to 10mm collapse and consolidation settlement. The presence of surface water in gullies impede the development of this zone. The area is consequently zoned as (C1-H3).

- *Pedological Area VI* : This is the western part of Tijgervallei Extension 9. It covers approximately 6,1% of the site and is considered as being of poor development potential. The soil profile of the area is characterized by a surface horizon of fill, consisting of imported clayey sand containing builder's rubble. The material is in an uncompacted condition. It is not possible to predict anticipated soil movements in any sensible manner. It is sufficient to state that it will be determined by the vertical extent of the fill, state of density and material type. The area is consequently zoned as P(Fill).

Although areas of outcrops and sub outcrops of diabase do occur, the extent of such materials is not sufficient to zone them as separate geotechnical entities.

The attached Figure 4 : Geotechnical Zoning Map, based on the discussion above, indicates the pedological distribution.

6.5 Construction Material

- *Residual Shale* : The results of the soil testing indicate a mixture of the residual shale and excavated bedrock, shale, to vary from poorer than G10 to G6 quality. The quality of the material is totally dependent on the content of shale gravel. With selection the material is thus regarded as suitable for the construction of all layerworks up to selected layers in lightly trafficked roads.
- *Residual Diabase* : The residual diabase, silty sand to coarse sand, is widely used for construction purposes in the area. Although the upper extent of the material is usually fairly argillaceous, the quality there of improves with depth. The results of compaction tests on the residual sand proved the quality there of to vary from poorer than G10 to G6. The problem with the poorer quality material is not so much the compaction characteristics, but it has a fairly high plasticity index. It is thus fair to state that with selection the residual diabase sand may be used for the construction of all layerworks up to selected layer in lightly trafficked roads. It may be worthwhile to subject samples of the residual diabase sand to stabilization testing to determine whether it is suitable to be utilized as aggregate for the construction of subbase and base course layers.
- *Reworked Fine Colluvium* : The results of the soil testing indicate the reworked colluvium to be of poorer quality than G10 material. The problem can be found in both the plasticity index and the compaction characteristics of the material. The colluvial sand is thus regarded as suitable to be used only for the construction of non-structural earthfills only.

6.6 Conditions of Excavation

Conditions of soft excavation up to a depth of 1500mm generally prevail on site. When discussing the excavatibility of the in-situ materials, it must be kept in mind that it is normally possible to excavate to approximately 500mm with a light TLB into bedrock shale, prior to encountering refusal. This is mainly due to the discontinuous rock matrix. The same conditions apply to bedrock of diabase, although the matrix of the diabase is much harder than the shale. Only in isolated areas was it not possible to penetrate to a depth of 1500mm with a TLB. It is expected that it will be possible to do so across the entire property with an excavator.

The following is applicable :

- The residual diabase sand is more dense than the other soil materials, but can still be removed by mechanical excavation equipment.
- Conditions of clayey excavation prevail across the entire site.
- Conditions of wet excavation prevail close to the water courses.
- Conditions of collapse may occur in the wet argillaceous soils and especially in the fill.

6.7 Soil Corrosivity

When discussing soil corrosivity, it is important to consider the guidelines as proposed by Evans[Reference 9.7]. The corrosivity of a soil towards buried, exposed, metallic surfaces is dependent on the following properties of the soil :

- Electrical conductivity;
- Chemical properties of the soil;
- Ability of the soil to support sulphate reducing bacteria and
- Heterogeneity of the soil.

The tests carried out for the compilation of this report must be considered as indicative of the soil conditions only. The pH of a soil gives an indication of potential acid related problems. Should the soil pH be less than 6,0, corrosion may take place ; and should the pH be less than 4,50, the problem of corrosion may be serious. If the conductivity of the soil is less than 0,1mScm^{-1}, corrosivity is generally not a problem. However, the corrosion potential of the soil increases with an increase in conductivity. Should the conductivity of the soil exceed 0,5mScm^{-1}, the soil can be regarded as very corrosive. Should exposed metal pipes pass from argillaceous soils to arenaceous soils or vice versa, electrochemical cells are set up due to the different rates of oxygen diffusion of the soils. Sulphate

reducing bacteria is usually present under anaerobic conditions, that is, typically saturated or waterlogged clays.
The results of the chemical testing of the soil sampling indicate the following :

- *Soil Acidity* : The results of chemical testing indicate pH values of 6,10 to 7,31. The soil materials on site are thus not corrosive due to acidity.
- *Soil Conductivity* : The soil conductivity of the in-situ soils varies between 0,031Sm^{-1} and 0,126Sm^{-1} without a definite pattern that can be defined for the various materials. The soils are thus considered as corrosive due to the presence of soluble salts, as reflected by the soil conductivity, but not due to its acidity.
- *Heterogeneity of the Soil* : A definite transition in material properties can be identified on the boundary between the shale and the diabase ; as well as between the residual sand and clay derived from the weathering of diabase. Electrochemical cells can thus be set up due to the different rates of oxygen diffusion of the soils along this boundary, resulting in chemically corrosive soil conditions.
- *Ability of the Soil to Support Sulphate Reducing Bacteria* : Areas of potentially saturated soils may develop close to the water courses. Sulphate reducing bacteria may thus be present under these anaerobic conditions, resulting in corrosive soil conditions.

6.8 Cemetery Sites

There are no cemeteries or graves on the site. Taking the guidelines of Fischer[Reference 9.8] into account, the site is not suitable to be developed as a cemetery site.

6.9 Seismicity

Kijko[Reference 9.9] indicates the annual probability for an earthquake with intensity of 4,2 on the Modified Mercalli Scale to occur in the area to be less than 10^0 ; and with an intensity of 7,1 to occur the probability is 10^{-3}. A 10% probability exists that an earthquake with Peak Ground Acceleration of 0,12g to 0,16g may take place once in 50 years.

To put the above information into perspective, Table 3 : Earthquake and Magnitude and Intensity, is attached to this report.

6.10 Other Considerations

- *Historic Monuments* : There are no historic monuments on the site.
- *Dolomite Stability* : The site is not subject to instabilities due to the presence of dolomite.
- *Undermining* : The area is not subject to undermining, neither has material been removed for road building purposes.

7 CONCLUSIONS

Based on geotechnical considerations the area is suitable for urban development. Based on geotechnical conditions the development potential property varies from favourable to poor. The following must be taken into account :

- *Geology* : The area is located on Silverton shale of the Pretoria Group, Transvaal Supergroup. The shale is intruded by a major post-Transvaal diabase sill.
- *Pedology* : The pedology in on the property consists of a surface horizon of various transported clayey sands and sandy clays overlying residual diabase and shale. Some fill is present in the eastern parts of the property.
- *Groundwater* : Perched water may be present close to the water courses. The presence of the watercourses influences the land utilization.
- *Founding Conditions :* Founding conditions on the property vary from C, H2, C1-H2, H3, C1-H3 to P(Fill). Maximum free heave is limited to 90mm. The provision of foundation precautionary measures is thus required over the larger part of the property.
- *Excavation Potential* : All soils will be easy to excavate to a depth of approximately 1500mm. The clay will become tackey at conditions of high soil moisture. Some excavation penetration into bedrock will be possible with a TLB. Conditions of sidewall collapse may take in the fill and in very moist argillaceous soil.
- *Soil Corrosivity* : Soil corrosivity is a factor to consider in the area.
- *Historic Monuments :* There are no historic monuments on the site.
- *Cemetery Sites :* There are no cemeteries or graves on the site. The site is not suitable to be developed as a cemetery site.
- *Dolomite Stability* : The site is not subject to instabilities due to the presence of dolomite.
- *Undermining* : The area is not subject to undermining, neither has material been removed for road building purposes.
- *Seismicity* : The annual probability for an earthquake with intensity of 4,2 on the Modified Mercalli Scale to occur in the area is less than 10^{0} ; and with an intensity of 7,1 to occur the probability is less than 10^{-3}. A 10% probability exists that an earthquake with Peak Ground Acceleration of 0,12g to 0,16g may take place once in 50 years.

8 RECOMMENDATIONS

8.1 Construction Materials

The soft rock, weathered shale and residual sand derived from the weathering of diabase may be used for the construction of layerworks up to selected layer level. However, in terms of urban

evelopment, it is most probably not feasible to utilize the sand for this purpose. At most these materials may be exposed for in-situ selected layerworks or road bed.

The consulting engineer should carefully investigate the necessity of undercutting the road pavement prism in the areas of clay. The use of dynamic compaction in the area of fill may also be considered to ensure a stable pavement and future long term servicability of the road construction.

8.2 Preliminary Proposals for Founding and Construction

As this document serves as a broad guideline for the purposes of township development only, it is proposed that the site of each structure be investigated prior to construction regarding the conditions of founding. A competent person should evaluate the results of such an investigation and make proposals for the design of the foundations.

For the purposes of this document and township development the following preliminary alternatives are recommended regarding the founding of structures :

- *Geotechnical Zone C (Area I)* : Normal construction procedures of superstructures are proposed. Foundations may consist of either strip footings or slab-on-the-ground foundations. The excavated trenches shall be compacted lightly prior to casting concrete. It is recommended that the founding of structures take place directly on the granular horizon of residual shale, or soft rock, shale. *Geotechnical Zone H2 (Area II)* : Modified normal construction procedures of superstructures are proposed. Construction of the superstructure must include articulation joints at some internal and all external doors, light reinforcement in the masonry, site drainage and service/plumbing precautions. Foundations can consist of reinforced strip footings designed to handle 30mm of free heave. As an alternative, the options of reinforced concrete rafts or soil replacement rafts may be considered. The excavations for a soil replacement raft shall extend through the argillaceous soil into the residual sand, or to 2000mm deep maximum. Such excavation must be backfilled with compacted material of G5 quality. A reinforced concrete raft can be designed to accommodate 30mm of free heave. Some sub outcrops of diabase are present in this zone. Structures must be placed to avoid these sub outcrops as far as possible.
- *Geotechnical Zone C1-H2 (Area III)* : Modified normal construction procedures of superstructures are proposed. Construction of the superstructure must include articulation joints at some internal and all external doors, light reinforcement in the masonry, site drainage and service/plumbing precautions. Foundations can consist of reinforced strip footings designed to handle 30mm of free heave and total settlement of 10mm. As an alternative, the options of reinforced concrete rafts or soil replacement rafts may be considered. The excavations for a soil replacement raft shall extend through the argillaceous soil into the residual sand, or to 2000mm deep maximum. Such excavation must be backfilled with compacted material of G5 quality. A reinforced concrete raft can be designed to accommodate 30mm of free heave and 10mm settlement.

- *Geotechnical Zone H3 (Area IV(a))* : Modified normal construction procedures of superstructures are proposed. Construction of the superstructure must include articulation joints at some internal and all external doors, light reinforcement in the masonry, site drainage and service/plumbing precautions. Foundations can consist of reinforced concrete rafts designed to accommodate 60mm of free heave. As an alternative, the option of a soil raft combined with reinforced strip foundations may be considered. The excavations for a soil replacement raft shall extend through the argillaceous soil into competent residual soil or the weathered bedrock of shale or diabase, or up to a depth of 2000mm. Such excavation must be backfilled with compacted material of G5 quality.
- *Geotechnical Zone H3 (Area IV(b))* : Modified normal construction procedures of superstructures are proposed. Construction of the superstructure must include articulation joints at some internal and all external doors, light reinforcement in the masonry, site drainage and service/plumbing precautions. Foundations can consist of reinforced concrete rafts designed to accommodate 90mm of free heave. As an alternative, the option of a soil raft combined with reinforced strip foundations may be considered. The excavations for a soil replacement raft shall extend through the argillaceous soil into competent residual soil or the weathered bedrock of shale or diabase, or up to a depth of 2000mm. Such excavation must be backfilled with compacted material of G5 quality.
- *Geotechnical Zone C1-H3 (Area V)* : Modified normal construction procedures of superstructures are proposed. Construction of the superstructure must include articulation joints at some internal and all external doors, light reinforcement in the masonry, site drainage and service/plumbing precautions. Foundations can consist of reinforced concrete rafts designed to accommodate 60mm of free heave and 10mm of settlement. As an alternative, the option of a soil raft combined with reinforced strip foundations may be considered. The excavations for a soil replacement raft shall extend through the argillaceous soil into the competent residual soil or weathered bedrock of shale or diabase, or up to a depth of 2000mm. Such excavation must be backfilled with compacted material of G5 quality.
- *Geotechnical Zone P(Fill) (Area VI)* : Preference should be given to set this area aside as public open space. Should it not be possible, modified normal construction procedures of superstructures are proposed. Construction of the superstructure must include articulation joints at some internal and all external doors, light reinforcement in the masonry, site drainage and service/plumbing precautions. Foundations can consist of soil replacement rafts combined with reinforced strip foundations. The excavations for a soil replacement raft shall extend through the fill into the competent residual soil. Such excavation must be backfilled with compacted material of G5 quality. As an alternative the entire area may be treated to dynamic compaction by falling weight and the foundations designed according to the elastic modulii of the treated material. The third alternative is the founding of structures by means of end bearing piles. It must be noted that in some areas the vertical extent of the fill is limited. It is thus essential that the site for each structure be investigated separately and foundation design be optimized.

The decision of which founding system to use is the responsibility of the consulting engineer. The NHBRC allows other foundation alternatives as applicable to the soil conditions too. The above proposals are given in good faith, but the final decision must be made based on financial constraints and experience of similar conditions. The anticipated soil movements, soil zoning and proposed foundation precautions are summarized in the attached Table 4 : Foundation Design, Building Procedures and Precautionary Measures. Detailed proposals for foundation and superstructure construction as approved by the Joint Structural Division of SAECI and IstructE and published by the NHBRC, are attached as Addendum C.

8.3 Conditions of Excavation

Under the heading of "Conditions of Excavation", SABS 1200 allows, amongst others, the following :

- *Soil* : It is proposed that all soils be considered as soft to excavate.
- *Rock Excavation* : Provision must be made for excavation of hard rock in Geotechnical Zones I and II on the shale and diabase.
- *Sidewall Collapse* : Care must be taken with excavations close to the water courses and in the fill as collapse of sidewall excavations may take place.

8.4 Soil Corrosivity

Conditions of corrosive soil may develop across the entire property. It is therefore recommended that non-metallic subsurface materials be used for services, or, if the use of metallic materials cannot be avoided ; the materials must be coated or protected against corrosion.

8.5 Influence of Test Pits

Cognizance must be taken of the positions of the test pits excavated for this survey. Some of them are quite deep and the presence of such a test pit underneath a structure may result in damage to the structure. The geographical co-ordinates of each test pit are supplied on the soil profiles and the contractor must ensure that loose materials do not influence the stability of the future structures.

8.6 Seismicity

The guidelines of the National Housing Board[Reference 9.10] indicate the level of seismicity of the area to be within acceptable limits. In terms of seismicity the development potential of the area is regarded as favourable.

9 SOURCES OF REFERENCE

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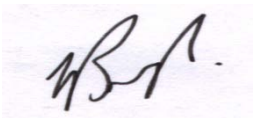
9.10 National Department of Housing : Geotechnical Site Investigations for Housing Developments – Generic Specifications GFSH-2, table 3 page 27, published in September 2002.



FJ Breytenbach, Pr Eng 10 June 2006
For Soilkraft cc