GEOTECHNICAL CONDITIONS ON PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48: A REPORT FOR THE EXPANSION AND FORMALISATION OF OPWAG COMMUNITY

2020/J09/MCP_01

ON BEHALF OF : MACROPLAN

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EXECUTIVE SUMMARY

1 INTRODUCTION

It is envisaged to develop some 50 hectare of land on Plot 2642 of Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement 48 as an expansion and formalization of the existing Opwag community. For this purpose Cedar Land Geotechnical Consult (Pty) Ltd was appointed as subconsultant to Macroplan to conduct a geotechnical investigation on the property.

2 SITE DESCRIPTION

2.1 Site Location

The village of Opwag is located directly to the west of the Orange River and the local access road to the irrigation canal. It is some 6 km north of Groblershoop. The area of investigation consisting of Plot 2642 of Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement 48, is located on the perimeter of the village, on the western, eastern and southern sides thereof. The size of the property is 50 hectare.

2.2 Topography and Drainage

The land investigated is located between 903,0mamsl and 869,0mamsl. Topographical it can be described as the foot slope and plain of a ridge striking virtually due south-east to north-west, with the ridge present on the north eastern perimeter of the site. The slope of the south western flank of the ridge is approximately 10,3%, reducing to 2,2% on the low-lying area.

Drainage takes place by means of surface sheetwash. The sheetwash is disposed of into three small, non-perennial water courses. The drainage courses are contained in narrow, shallow sloping and well defined gullies.

2.3 Vegetation and Landscape

The area of investigation is referred to as Bushmanland Arid Grassland. The landscape features are described as consisting of extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses giving this vegetation type the character of semi-desert steppe. In places low shrubs change the vegetation structure. On site it was found that in the areas where natural vegetation is present it consists of a sparse stand of Acacia melliflora and prosopis glandulosa. Large stands of aloe claviflora are present and a few examples of aloe gariepensis.

2.4 Climatic Conditions

The area is located in a summer-rainfall region with mean annual precipitation between 70mm to 200mm ; mean maximum summer temperature of 38°C and mean minimum winter temperature of -0,6°C. Frost incidence varies between 10 and 35 days per year. The development of whirl winds are common on hot summer days. The Thornthwaithe moisture index is less than -40 ; and the Weinert N value approximately 35. The climate can thus be described as arid.

2.5 Existing Facilities

2.5.1 Informal Housing

Informal housing consisting of galvanized iron structures and some reed structures is present in the northern parts of the site, forming the existing village. Electricity is provided by overhead power lines. Water is provided by a pipeline originating at a reservoir located on the northern most part of the ridge.

2.5.2 Vacant Land

Vacant, undeveloped land extends from the existing village to the limits of the area of investigation in all directions.

3 NATURE OF INVESTIGATION

3.1 Test Pitting

Test pitting was conducted to provide applicable geotechnical information. On 8 and 9 July 2020 33 test pits were excavated with a Bell 315SK TLB on hire from ALS Plant Rentals. The TLB was equipped with a 600mm wide bucket. All test pits were excavated to refusal. The test pits were profiled by a professionally registered geotechnical engineer.

3.2 Materials Testing

Soil testing was undertaken by Roadlab in Upington. Due to general limited vertical extent of the soil profile and coarse nature thereof, it was not feasible to retrieved undisturbed samples to determine properties of settlement or collapse fairly accurately.

Soil testing consisted of the following :

- Conductivity and pH determinations on five samples of the in-situ materials to determine the corrosivity thereof.

- *Foundation indicator testing on ten samples of the in-situ materials to determine possible conditions of heave or settlement.*
- *CBR and road indicator testing on three samples to determine the suitability of the in-situ materials to be utilized as road layerworks.*

4 GEOLOGY, PEDOLOGY AND GROUNDWATER

4.1 Stratigraphy

The available information shows that the area of investigation is located on a subduction zone dating approximately 1000 million years old. The zone is located between the lithology of the Kaapvaal Craton and the Namaqua-Natal mobile belt. The remains of the original geology in the area are referred to as the Kaaien Terrane and the site is located on the Groblershoop Formation of the Brulpan Group. Bedrock on site occurs as grey brown quartzite becoming light grey quartzite of the Groblershoop Formation, Brulpan Group. Occasionally the quartzite tends to be muscovite-rich. The possibility that bedrock in western low-lying part of the site may consist of quartz-muscovite schist cannot not be excluded. However, it could not be confirmed due to the very dense, impenetrable barrier formed by the hardpan calcrete.

4.2 Soil Profile

4.2.1 Alluvium

Alluvium in the form of alluvial sand and minor deposits of river terrace gravels were encountered close to the southwestern and southeastern perimeters of the area of investigation. These deposits vary from dark brown and light red, loose, fine sand to medium dense, gravels of quartz and lesser content of banded ironstone contained in a sandy matrix. The presence of banded ironstone shows that these deposits can by associated with an earlier course of the Orange River. The thickness of the horizon varied between 200mm and 300mm in the test pits.

4.2.2 Colluvium

4.2.2(i) Gravelly Colluvium

Gravelly colluvium as surface deposit was found in the intermediate land between the low-lying area close to the water courses and the quartzite ridge. The colluvium is a homogenous material, consisting light brown fine sand and clasts of gravels and cobbles of quartz and some calcrete. The consistency of the gravelly colluvium is medium dense and the soil matrix intact. The horizon of colluvium was between 100mm and 200mm thick in the test pits.

4.2.2(ii) Coarse Colluvium

The coarse colluvium is present in the high-lying land on site, associated with transported material originating from bedrock of quartzite. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of light red brown fine sand. The consistency of the coarse colluvium varies from medium dense to very dense. The horizon of colluvium was between 300mm and 700mm thick in the test pits.

4.2.3 Residual Quartzite

On site residual quartzite was encountered as surface material or underlying the gravelly colluvium. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of dirty white, calcareous cemented sand. The soil matrix is very dense. The horizon of residual quartzite extended to a depth of 600mm in the test pits.

4.2.4 Mokalanen Formation

Calcrete was encountered as the dominant lithic material on site, in virtually a continuous cover over the quartzite, with the latter outcropping only in the high-lying ridge of outcrops. The calcrete is present as very dense hardpan calcrete. The calcrete is present as outcrops ; or underlies the transported materials, occurring from depths between 100mm and 300mm minimum, extending to 100mm to 600mm maximum, at which stage refusal of excavation occurred or bedrock of quartzite was encountered. It is described as dirty white to dirty light yellow white, very fine grained, very dense calcrete. Some fine sand may occasionally be contained in voids in the matrix of the calcrete.

4.3 Groundwater

4.3.1 Perched Water

Perched groundwater was not encountered in any of the test pits excavated for this investigation.

4.3.2 Permanent Groundwater

The probability for drilling successfully for water in the area is between 40% and 60%, and the probability that such a borehole will yield more than 2l/s is between 10% and 20%. Groundwater is expected to occur at depths less than 15 meters in compact, argillaceous strata.

5 SITE CLASS DESIGNATION

5.1 Geotechnical Zone I

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 65% of the proposed area for development. Slope across the land is approximately between 2% and 6%. The use of slab-on-the-ground foundations will require additional works in the form of the construction of an engineered fill or cutting to establish a level platform for construction. The more viable foundation alternative therefore remains founding by conventional strip foundations.

5.2 Geotechnical Zone II

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 4% of the proposed area for development. Slope across the land is less than 2%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on bedrock or very dense pedocrete. The latter option is regarded as the better solution of the two alternatives.

5.3 Geotechnical Zone III

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 22% of the proposed area for development. Slope across the land is between 2% and 6%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on medium dense terrace gravels. The more viable foundation alternative therefore remains founding by conventional strip foundations.

5.4 Geotechnical Zone IV

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 7% of the proposed area for development. Slope across the land is between 6% and 10%. Considering the slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or landscaping by cut-to-fill operations to prepare level surfaces for slab-on-the-ground foundations. The construction of a cut-and-fill terrace and foundation design associated with such an operation shall be done according to a professional design.

5.5 Geotechnical Zone V

Slope across this zone exceeds 10% and the presence of outcrops of hard rock dominates the land surface. It is thus zoned as P(Slope/rock outcrops). The distribution thereof encompasses 2% of the proposed area for development. The combination of these conditions reduces the suitability of the zone for low cost and affordable housing. The area is better suited to be set aside as public open space.

6 CONDITIONS OF EXCAVATION

On average over the entire site bedrock or refusal of excavation on very dense hardpan calcrete, boulders or bedrock quartzite was encountered at depths between 100mm minimum and 800mm maximum, averaging 410mm deep. The implication of this is that should trenches require excavated depths to 1000mm, 59% of the excavation may be classified as hard, requiring drilling and blasting. Should the required depth of excavation increase to 1500mm, 73% of the excavation may be classified as hard.

Conditions of Boulder Class A excavation are limited to the slopes and the quartzite ridge on the northeastern boundary of the area of investigation. Such conditions were encountered in TP's 16, 20, 21, 26, 30 and 33. It was possible to penetrate between 300mm and 800mm into the boulder layers, averaging 530mm, prior to encountering hard rock excavation or very tightly packed boulders that could not be removed by the TLB. The implication of this is that should trenches require excavated depths to 1000mm, 53% of the excavation may be classified as Boulder Class A excavation. Should the required depth of excavation increase to 1500mm, 35% of the excavation may be classified as Boulder Class A excavation.

7 LAND SLOPE

The average slope across 87% of the land is between 2% and 6% ; over 4% it is less than 2% ; over 7% it is between 6% and 10% ; and over 2% of the land the slope exceeds 10%.

The slope of less than 2% has a detrimental influence on especially the design of a stormwater disposal system depending on gravity to dissipate of the surface water due to downpours. The land slope also affects the design of the sewerage disposal but to a lesser extent as the gradient of the pipes can be adjusted according to design requirements. The land surface of the area subject to the slope exceeding 10% is covered by rock outcrops and do not represent conditions of unstable faces subject to slip failures. However, the slope reduces the potential of the land for the development of affordable and low cost housing.

8 AREAS SUBJECT TO FLOODING

The non-perennial water courses on site are contained in well-defined, narrow gullies and may be regarded as being of lesser importance, requiring no additional precautionary measures to ensure the safety of the population against flooding.

9 MATERIALS UTILIZATION

- *Trench Backfilling : None of the materials are suitable for selected fill or pipe bedding. With exception of the hardpan calcrete all materials can be used for normal backfill.*
- *Layerworks for Paved or Segmental Block Paving : The hardpan calcrete is of G6 quality and hence suitable for the construction of layerworks up to subbase and base course level for lightly trafficked roads.*
- *Wearing Course for Gravel Roads in Urban Areas : None of the soil materials are 100% suitable for this purpose. The use of these materials will generally result in a road surface subject to raveling and corrugations.*

10 OTHER CONSIDERATIONS

- *Undermining : The area is not subject to undermining.*
- *Seismic Activity : The Peak Ground Acceleration expected in 50 years is 0,05g. A low risk for the development of earth tremors therefore exist.*
- *Soil Corrosivity : The in-situ soils and pedocretes are not corrosive due to acidic properties. All soil materials can be regarded as corrosive due to high soluble salt contents.*
- *Dolomite : The area of investigation is not subject to any restrictions due to the presence of dolomite. Bedrock of dolomite does not occur in the area of investigation.*

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GEOTECHNICAL CONDITIONS ON PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48 : A REPORT FOR THE EXPANSION AND FORMALISATION OF OPWAG COMMUNITY

1 INTRODUCTION

It is envisaged to develop some 50 hectare of land on Plot 2642 of Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement 48 as an expansion and formalization of the existing Opwag community. For this purpose Cedar Land Geotechnical Consult (Pty) Ltd was appointed as subconsultant to Macroplan as per the minutes of the start-up meeting of the project held in the offices of Macroplan on 20 May 2020 to conduct a geotechnical investigation on the property.

2 TERMS OF REFERENCE

The requirements of the following documents were adhered to in the conduct of the investigation and reporting of the project :

- The document *Geotechnical Site Investigations for Housing Developments (Generic Specification GFSH-2)*, issued by the National Department of Housing in September 2002.
- The document *SANS 634-1 : Geotechnical Investigations for Township Development*, issued by SABS in February 2012.

3 AVAILABLE INFORMATION

The following source of available information recording available data obtained in the larger Upington to Groblershoop area have been consulted for background information :

- *Breytenbach FJ* : Contract NRA N010-110-2012/1F : Geotechnical Investigation for Four Bridge Widenings on the National Route 10 Section 11 between Groblershoop (km 0,0) and Lambrechtsdrift (km 61,1), issued by Soilkraft cc on behalf of Bvi Engineers on 8 March 2012.

4 SITE DESCRIPTION

4.1 Site Location

The village of Opwag is located directly to the west of the Orange River and the local access road to the irrigation canal. It is some 6 km north of Groblershoop. The area of investigation consisting of Plot 2642 of Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement 48, is located on the perimeter of the village, on the western, eastern and southern sides thereof. The size of the property is 50 hectare.

Refer to the attached Figure 1 : Locality Plan.

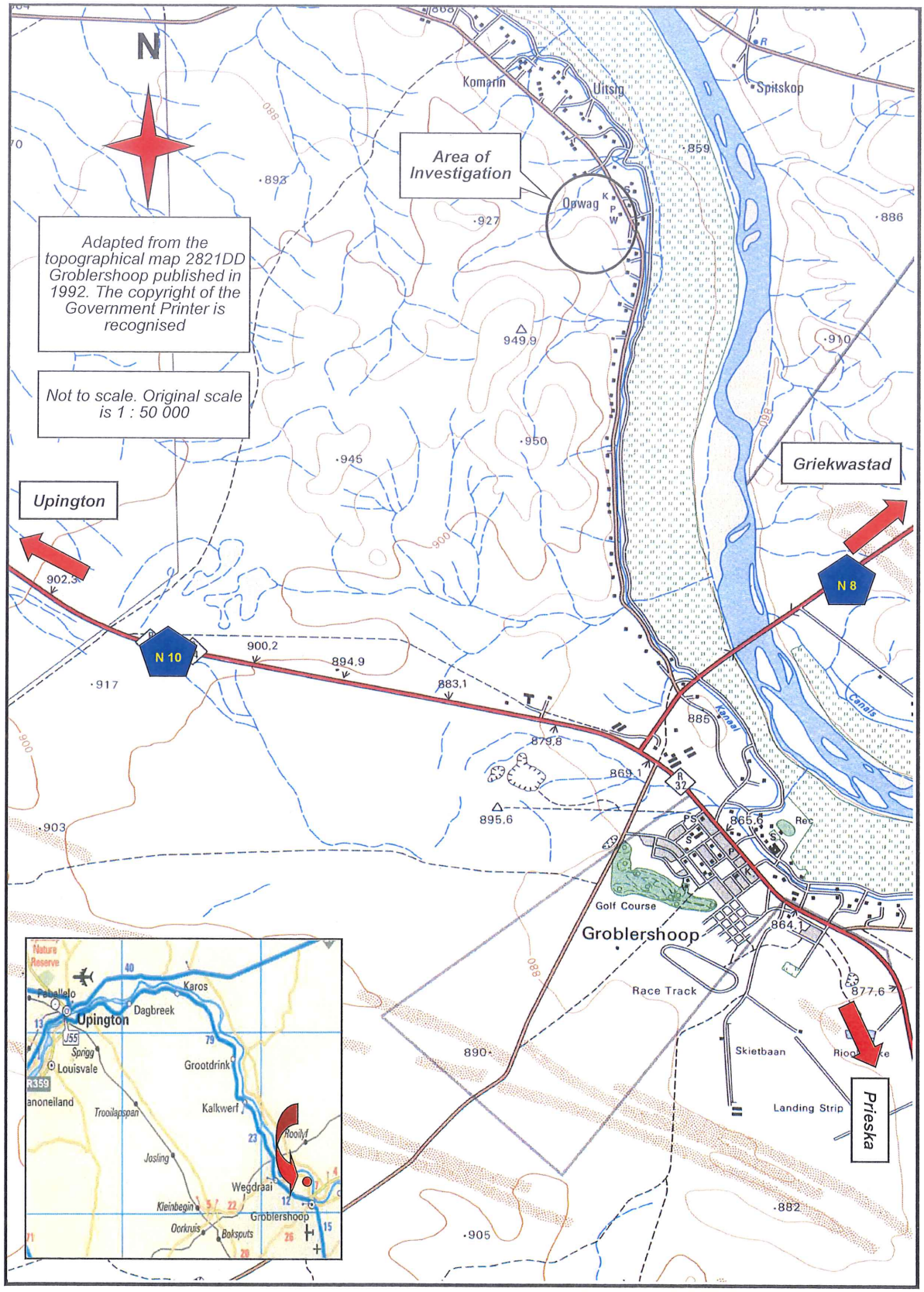
4.2 Topography and Drainage

The land investigated is located between 903,0mamsl and 869,0mamsl. Topographical it can be described as the foot slope and plain of a ridge striking virtually due south-east to north-west, with the ridge present on the north eastern perimeter of the site. The slope of the south western flank of the ridge is approximately 10,3%, reducing to 2,2% on the low-lying area.

Drainage takes place by means of surface sheetwash. The sheetwash is disposed of into three small, non-perennial water courses. The drainage courses are contained in narrow, shallow sloping and well defined gullies.

4.3 Vegetation and Landscape

Based on the work done by Mucina[Reference 14.1] the area of investigation is referred to as Bushmanland Arid Grassland. The landscape features are described as consisting of extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses giving this vegetation type the character of semi-desert steppe. In places low shrubs change the vegetation structure. In years of abundant rainfall rich displays of annual herbs can be expected. On site it was found that in the areas where natural vegetation is present it consists of a sparse stand of Acacia melliflora and prosopis glandulosa. Large stands of aloe claviflora are present and a few examples of aloe gariepensis.



C.L.G.C.

LOCALITY PLAN

FIGURE 1

4.4 Climatic Conditions

The area is located in a summer-rainfall region with mean annual precipitation between 70mm to 200mm ; mean maximum summer temperature of 38°C and mean minimum winter temperature of -0,6°C. Frost incidence varies between 10 and 35 days per year. The development of whirl winds are common on hot summer days. The Thornthwaithe moisture index is less than -40 ; and the Weinert N value approximately 35. The climate can thus be described as arid. The importance of this is that mechanical breakdown of bedrock will take place rather than chemical decomposition, limiting the formation of secondary minerals such as expansive montmorillonite clay.

4.5 Existing Facilities

Site conditions are illustrated on Photo 1 : Site Conditions.

The area can be divided into two zones as follows :

4.5.1 Informal Housing

Informal housing consisting of galvanized iron structures and some reed structures is present in the northern parts of the site, forming the existing village. Electricity is provided by overhead power lines. Water is provided by a pipeline originating at a reservoir located on the northern most part of the ridge. Some residents have created small vegetable and flower gardens on the stands.

4.5.2 Vacant Land

Vacant, undeveloped land extends from the existing village to the limits of the area of investigation in all directions.

5 NATURE OF INVESTIGATION

5.1 Test Pitting

In compliance with the requirements of SANS 634 and GFSH-2 test pitting was conducted to provide applicable geotechnical information. On 8 and 9 July 2020 33 test pits were excavated with a Bell 315SK TLB on hire from ALS Plant Rentals. The TLB was equipped with a 600mm wide bucket. All test pits were excavated to refusal.

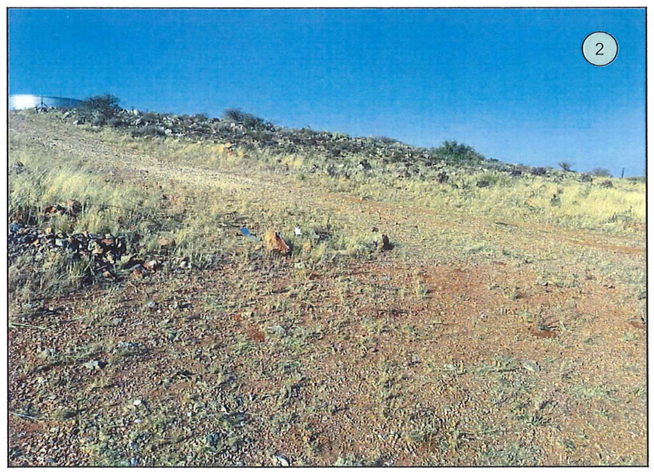


PHOTO 1: VIEW OF AREA BETWEEN VILLAGE AND QUARTZITE RIDGE TO THE NORTH EAST THEREOF. SURFACE SOILS OF COLLUVIAL SANDS.

PHOTO 2: VIEW OF AREA BETWEEN VILLAGE AND QUARTZITE RIDGE TO THE NORTH EAST THEREOF. SURFACE DEPOSITS OF QUARTZITE BOULDERS AND OUTCROPS OF QUARTZITE

PHOTO 3 : VIEW IN LOW-LYING AREA TO THE SOUTH AND SOUTH WEST OF THE VILLAGE. NOTE VEGETATED NON -PERENNIAL STREAM ON SOUTHERN PERIMETER OF THE SITE.

PHOTO 4 : VIEW IN LOW-LYING AREA TO THE SOUTH AND SOUTH WEST OF THE VILLAGE FACING NORTH. NOTE COLLUVIAL GRAVELS OF WHITE QUARTZ.

PHOTO 5 : CONDITIONS IN THE VILLAGE OF OPWAG

C.L.G.C.

CONDITIONS IN OPWAG VILLAGE

PHOTO 1

The test pits were profiled by a professionally registered geotechnical engineer. For the benefit of the non-geotechnical reader of this document, the guidelines for test pit profiling 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 positions of the test pits are indicated on the attached Figure 2 : Site Plan. Provisional co-ordinates for property beacons A to L are indicated on this figure.

5.2 Materials Testing

Soil testing was undertaken by Roadlab in Upington. As a matter of quality control duplicate samples were sent to the Roadlab branch in Germiston for independent testing to verify the results. Due to general limited vertical extent of the soil profile and coarse nature thereof, it was not feasible to retrieved undisturbed samples to determine properties of settlement or collapse fairly accurately.

Soil testing consisted of the following :

- Conductivity and pH determinations on five samples of the in-situ materials to determine the corrosivity thereof.
- Foundation indicator testing on ten samples of the in-situ materials to determine possible conditions of heave or settlement.
- CBR and road indicator testing on three samples to determine the suitability of the in-situ materials to be utilized as road layerworks.

The results of the soil testing may be found in Addendum B. However, for easy reference, these results are summarized in the attached Table 2 : Summary of Soil Testing. The data sheets contained in Addendum B are copies of the originals, which are available from Roadlab.

6 SITE GEOLOGY AND GEOHYDROLOGY

The geology of the area between Upington and Groblershoop appears to consist of granitoid rock in the north, grading into metamoprphic rocks towards Groblershoop, but it is in fact highly complex and from a stratigraphical viewpoint provides complicated formation. As a background to the site geology an effort is made in this subparagraph to provide a simplified explanation of the regional geology of the area. For this purpose publications by McCarthy[Reference 14.2], Cornell[Reference 14.3] and Moen[Reference 14.4] were consulted. Of these three references, the latter two can be regarded as site specific. However, there is disagreement between the two sources regarding the stratigraphic classification of the major subdivisions of

TABLE 1 : SOIL PROFILING PARAMETERS

CONSISTENCY : GRANULAR SOILS

SPT N	GRAVELS & SANDS Generally free draining soils		DRY DENSITY (kg/m^3)
<4	Very loose	Crumbles very easily when scraped with geological pick. Requires power tools for	<1450
4-10	Loose	Small resistance to penetration by sharp pick point. requires many blows by pick point	1450-1600
10-30	Medium dense	Considerable resistance to penetration by sharp pick point.	1600-1750
30-50	Dense	Very high resistance to penetration by sharp pick point. Requires many blows by pick point for excavation.	1750-1925
>50	Very dense	High resistance to repeated blows of geological pick. Requires power tools for excavation.	>1925

CONSISTENCY : COHESIVE SOILS

SPT N	SILTS & CLAYS and combinations with SANDS Generally slow draining soils		UCS (kPa)
<2	Very soft	Pick point easlily pushed in 100mm. Easily moulded by fingers.	<50
2-4	Soft	Pick point easlily pushed in 30mm to 40mm. Moulded by fingers with some pressure.	50-125
4-8	Firm	Pick point penetrates to 10mm. Very difficult to mould with fingers.	125-250
8-15	Stiff	Slight indentation by pick point. Cannot be moulded by fingers. Penetrated by thumb nail.	250-500
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

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

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.

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

the Namaqua-Natal province. As the work produced by Cornell is regarded as the reference document, his approach is adopted for this report.

Some concepts must be identified :

- *Craton* : A craton is a block of ancient crust, formed 3000 million years ago and its rocks have essentially remained unchanged. Cratons form the larger parts of the land-building mass.
- *Province* : A tectono-stratigraphic province is defined as a large area of contiguous structural fabric with well-defined boundaries which formed during a particular, geochronologically defined, tectono-metamorphic event. A province is further subdivided in sub-provinces and sub-provinces into terranes.

Adapted from Project : Opwag, Dated June 2020.
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60m 180m 300m
0m 120m 240m

N

Access to Canal Road

TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP18 TP19 TP20 TP21 TP22 TP23 TP24 TP25 TP26 TP27 TP28 TP29 TP30 TP31 TP32 TP33

VERY ROCKY

BOSCIA ALBITRUNCA (TO BE CONSERVED)

27/48 26/48 25/48 24/48 23/48 22/48 28/48 14/48

REMAINDER 48

COORDINATES – OPWAG		
System: WGS84 WG21		
Point	Y	X
A	-92933.796	3191431.553
B	-93437.665	3192213.387
C	-93721.563	3192101.399
D	-93903.815	3191804.059
E	-93839.048	3191745.192
F	-93762.602	3191666.075
G	-93731.138	3191632.727
H	-93615.278	3191513.705
J	-93514.409	3191409.532
K	-93358.006	3191247.802
L	-93196.700	3191313.417

FIGURE 2 :
SITE PLAN

LEGEND

TP1 TEST PIT POSITION

BOSCIA ALBITRUNCA (TO BE CONSERVED)

VERY ROCKY

Cedar Land Geotechnical Consult (Pty) Ltd

POSBUS 607
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SEL : 082 570-2767 (Frans)
082 373-2146 (Mariette)

P O BOX 607
CERES
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082 373-2146 (Mariette)

EPOS/E-MAIL: cedarland.frans@breede.co.za (Frans)
cedarland.mariette@breede.co.za (Mariette)

TAAK: JOB NAME: Expansion and Formalisation of Opwag Community

LIGGING: SITE: Plot 2642 Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement No 48

KLIËNT: CLIENT: !Kheis Municipality

TEKENING NO: DRAWING NO: Figure 2 : Site Plan

DATUM: DATE: 14 September 2020

TABLE 2 : SUMMARY OF SOIL TESTING

TEST PIT NO	SAMPLE NO (CLG)	DEPTH (mm)	SOIL ORIGIN	SOIL TYPE	GM	PI	LL	ACTIVITY	pH	CONDUCTIVITY (Sm^{-1})	% < 0,002mm	OMC	MDD	SOIL CLASS		
														COLTO	PRA	UNIFIED
1	U9277	200-600	Hardpan calcrete	Sandy gravel	2,40	2,0	28	Low			0,8	10,9	1906	G6	A-1-a(0)	GW-GM
5	U9278	0-300	Hardpan calcrete	Sandy gravel	2,30	2,0	19	Low	8,49	0,10	1,1				A-1-a(0)	GC
11	U9279	0-200	Hardpan calcrete	Sandy gravel	2,20	3,0	27	Low			0,6				A-1-a(0)	GM
12	U9280	0-300	Colluvium	Fine sand	1,00	5,0	29	Low	7,75	0,06	1,2				A-4(0)	SM
15	U9280	0-300	Hardpan calcrete	Sandy gravel	2,30	3,0	21	Low			0,8	7,4	1895	G6	A-1-a(0)	GW-GC
18	U9288	100-300	Hardpan calcrete	Sandy gravel	2,30	2,0	20	Low	7,83	0,13	0,5				A-1-a(0)	GW-GC
21	U9289	0-400	Coarse Colluvium	Cobbles and gravels	2,10	2,0	17	Low	7,69	0,09	0,7				A-1-b(0)	GC
22	U9290	100-300	Hardpan calcrete	Sandy gravel	2,00	3,0	22	Low	7,83	0,10	0,6				A-1-b(0)	GC
28	U9291	0-500	Hardpan calcrete	Sandy gravel	2,00	2,0	20	Low			0,8	5,8	2160	G6	A-1-b(0)	GC
33	U9292	0-400	Residual quartzite	Sandy gravel	2,00	2,0	19	Low	7,21	0,10	0,4				A-1-b(0)	GC

- *Terrane* : A terrane is a term for a tectonostratigraphic unit, which is a fragment of crustal material formed on, or broken off from, one tectonic plate and accreted or "sutured" to crust lying on another plate. The crustal block or fragment preserves its own distinctive geologic history, which is different from that of the surrounding areas.

6.1 Regional Geology

The geological processes by which the area under consideration was shaped, initiated some 1000 million years ago with the formation of the supercontinent Rodinia. A mountain chain of global extent formed along the boundaries, underlain by metamorphic rocks that have since then been exposed due to erosion. Metamorphic rocks of this age formed across South Africa to the south and west of the Kaapvaal Craton, known as the Namaqua-Natal Province. The Namaqua-Natal Province can be divided into five tectonostratigraphic subprovinces and terranes, based on marked changes in the lithostratigraphy across structural discontinuities. The five domains so recognized are the Richtersveld Subprovince, the Bushmanland Terrane, Kakamas Terrane, Areachap Terrane and Kaaien Terrane. The tectonic subdivision as proposed on Figure 2 (Cornell) is reproduced in this document as Figure 3.

The process of landforming can be described as compatible to the modern concept of plate tectonics. In this case the Namaqua plate became buried beneath the Kaapvaal Craton in a subduction zone. Considering the forces involved it can be regarded as a violent process, resulting in the breaking up of the landmass into the five domains as described above, associated with the intrusion of recycled rock material from the subduction zone. What is important for this report is that in the case of the Kaaien terrane, the formation of metaquartzites, deformed early Namaquan volcano-sedimentary rocks and deformed, but thermally metamorphosed bimodal volcanic rocks resulted, amongst others. These rocks are at present referred to amongst others as the Brulpan Group, on which Opwag is located. There is controversy about the age of the Brulpan Group, but is estimated between 1710Ma to 1780Ma, underlying the Wilgenhoutsdrif Group.

The regional geology is indicated on Figure 4 : Regional Geology.

6.2 Site Geology

The site geology is illustrated on Figure 5. The soil and pedocretes form an ubiquitous cover over bedrock with only localized exposures in areas of thin and less dense pedocretic cover, thus hampering field investigations. The inferred material boundaries must be accepted as indicative of the actual conditions only.

Bedrock on site occurs as grey brown quartzite becoming light grey quartzite of the Groblershoop Formation, Brulpan Group. In TP's 30 and 33 the quartzite tended to be muscovite-rich. The possibility that bedrock in western low-lying part of the site may consist of quartz-muscovite schist cannot not be excluded. However, it could not be confirmed due to the very dense, impenetrable barrier formed by the hardpan calcrete. It is accepted that the presence of the non-perennial stream may induce seasonal weathering of the calcrete, thus reducing the strength thereof. The strata of the Groblershoop Formation dip at 50° to the east-northeast in the area of investigation.

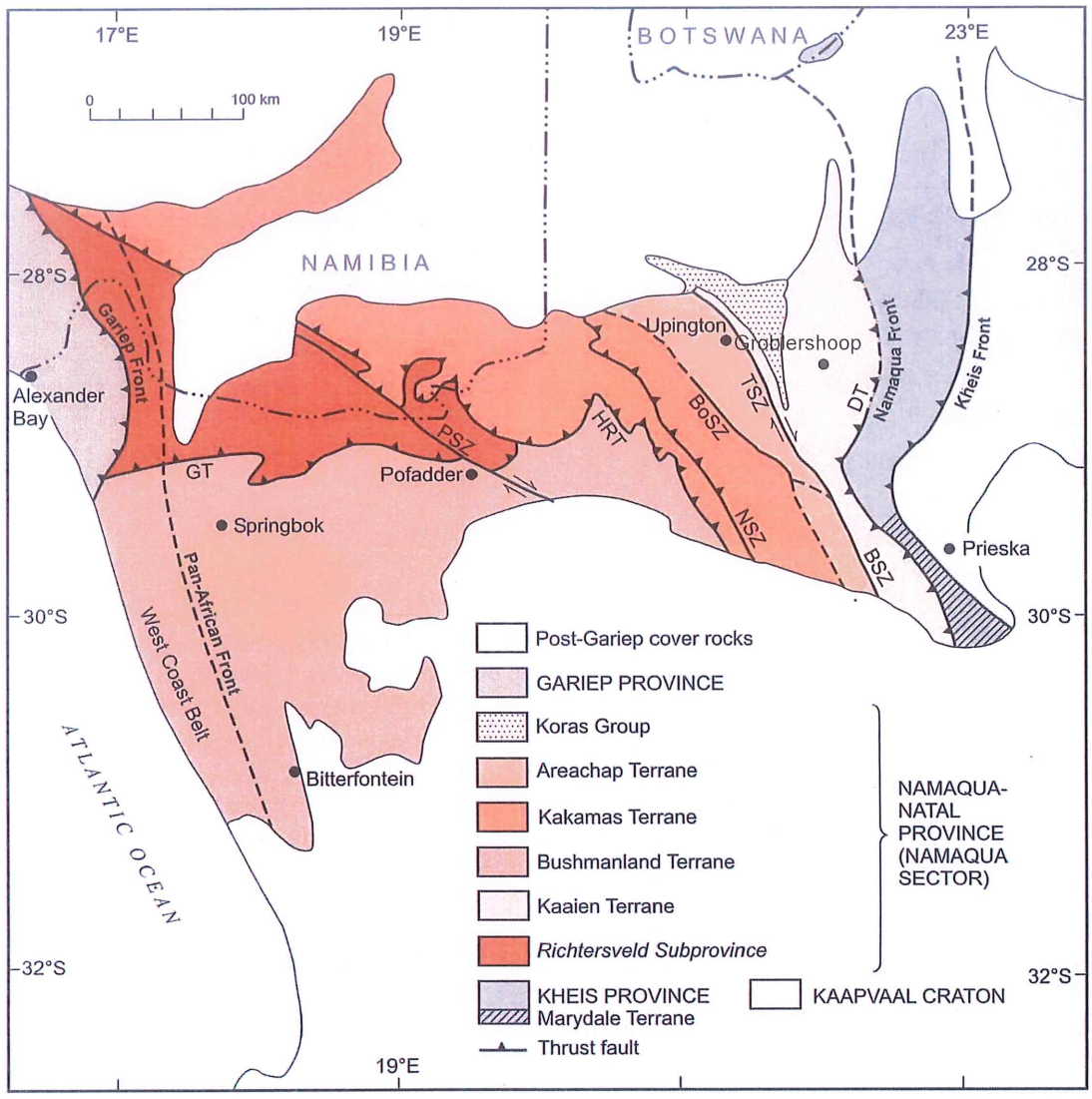
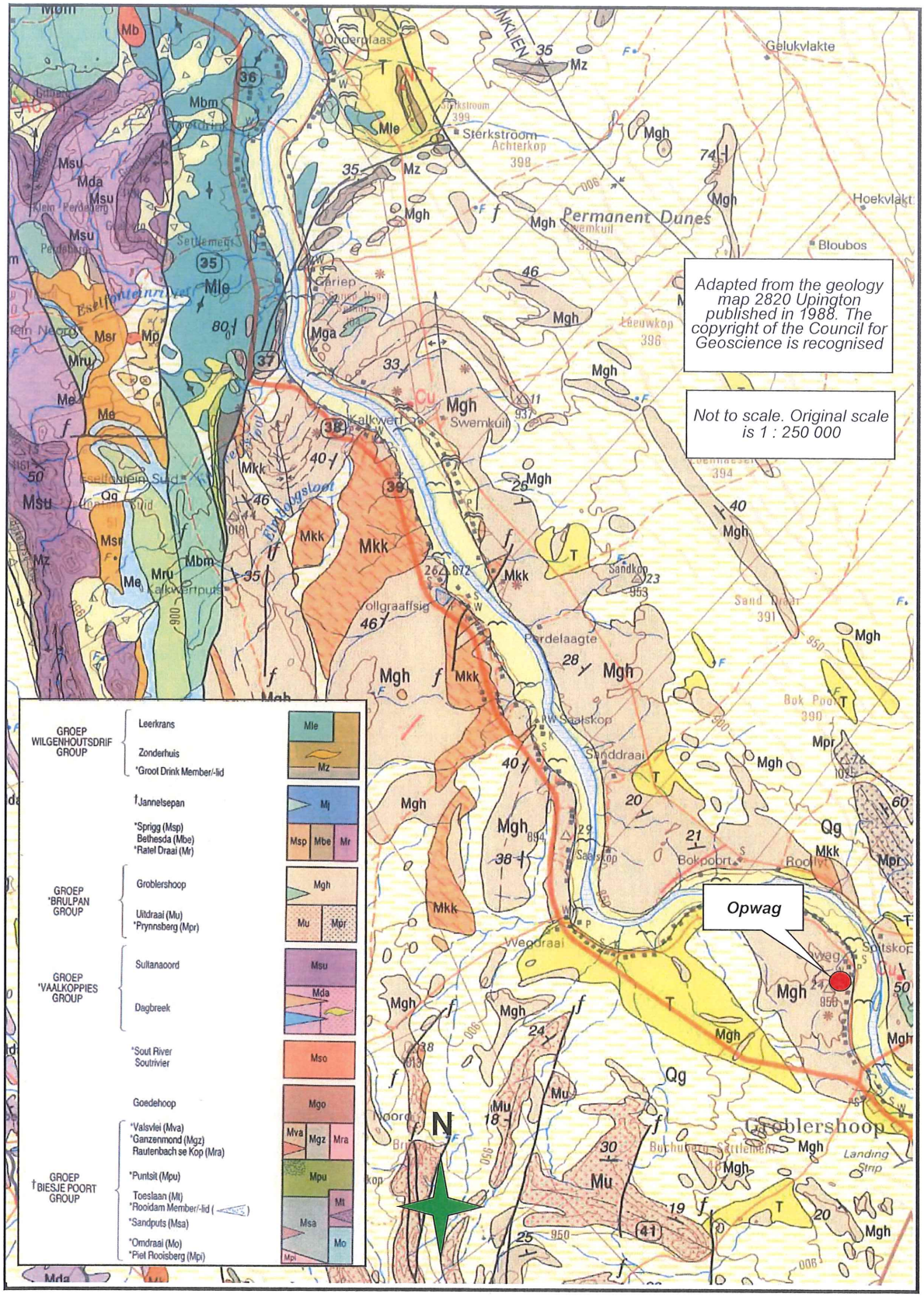


FIGURE 3 : TECTONIC SUBDIVISION OF THE NAMAQUA SECTOR

The pedocrete cover terminates in the eastern part of the site as the slope of the land becomes steeper, exposing the quartzite. On the eastern perimeter of the site the quartzite is present as outcrops of light grey, very hard rock, forming three very distinct hills.



C.L.G.C.

OPWAG : REGIONAL GEOLOGY

FIGURE 4

FIGURE 5 :
SITE GEOLOGY

Adapted from Project : Opwag, Dated June 2020.
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60m 180m 300m
0m 120m 240m

N

LEGEND

- TP1 — TEST PIT POSITION
- BOSCIA ALBITRUNCA (TO BE CONSERVED)
- VERY ROCKY
- INFERRED MATERIAL BOUNDARY

Access to Canal Road

TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP18 TP19 TP20 TP21 TP22 TP23 TP24 TP25 TP26 TP27 TP28 TP29 TP30 TP31 TP32 TP33

A B C D E F G H J K L

C Q

27/48 26/48 25/48 24/48 23/48 22/48 28/48 14/48 REMAINDER 48

VERY ROCKY

Lithology		Formation	Group
C	Calcrete	Mokolanen	Kalahari
Q	Quartzite	Groblershoop	Brulpan

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TAAK: JOB NAME: Expansion and Formalisation of Opwag Community

LIGGING: SITE: Plot 2642 Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement No 48

KLIËNT: CLIENT: !Kheis Municipality

TEKENING NO: DRAWING NO: Figure 5 : Site Geology

DATUM: DATE: 14 September 2020

6.3 Soil Profile

6.3.1 Alluvium

Alluvium in the form of alluvial sand and minor deposits of river terrace gravels were encountered close to the southwestern and southeastern perimeters of the area of investigation in TP's 12, 17, 28, 31 and 32. These deposits vary from dark brown and light red, loose, fine sand to medium dense, gravels of quartz and lesser content of banded ironstone contained in a sandy matrix. The thickness of the horizon varied between 200mm and 300mm in the test pits. The presence of banded ironstone shows that these deposits can by associated with an earlier course of the Orange River.

6.3.2 Colluvium

On site colluvium was encountered in all the test pits except TP's 1, 7, 10, 11, 12, 15, 17, 28, 31 and 32. Distinction must be made between two types of colluvial deposits :

6.3.2(i) Gravelly Colluvium

Gravelly colluvium as surface deposit was found in TP's 2 to 6, 8, 9, 13, 14, 18, 19, 22 to 25 and 27. The colluvium is a homogenous material, consisting light brown fine sand and clasts of gravels and cobbles of quartz and some calcrete. The consistency of the gravelly colluvium is medium dense and the soil matrix intact. The horizon of colluvium was between 100mm and 200mm thick in the test pits.

6.3.2(ii) Coarse Colluvium

Coarse colluvium as surface deposit was found in TP's 16, 20, 21, 26, 29, 30 and 33. The coarse colluvium is present in the high-lying land on site, associated with transported material originating from bedrock of quartzite. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of light red brown fine sand. The consistency of the coarse colluvium varies from medium dense to very dense. The horizon of colluvium was between 300mm and 700mm thick in the test pits.

6.3.3 Residual Quartzite

On site residual quartzite was encountered in TP's 3 and 7 as surface material or underlying the gravelly colluvium. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of dirty white, calcareous cemented sand. The soil matrix is very dense. The horizon of residual quartzite extended to a depth of 600mm in the test pits,

prior to encountering very dense, very tightly packed quartzite boulders and refusal of excavation.

6.3.4 Mokalanen Formation

Calcrete of the Mokalanen Formation, Kalahari Group, is present as an ubiquitous surface duricrust on site. Again there is a difference in opinion between Moen (Reference 14.4 page147) and Partridge[Reference 14.5] regarding the origin of the calcrete. Moen regards the calcrete as being of Tertiary age, but some doubt whether the outcrops are of the same age and in some localities it may still be in the process of forming. Partridge describes the age of the calcrete as straddling the boundary between the Pliocene and Quaternary, making it some 2,6 to 2,8 million years old. It was deposited under arid conditions and possibly reflects a climatic interval of global aridification.

The engineering properties of calcrete may differ widely for samples taken from the same locality. It is therefore important to provide some background in this regard to aid in the understanding of these conditions.

Brink[Reference 14.6] states that during pedocrete development, clay and silt become flocculated and cemented into larger silt to gravel-sized complexes of varying strength and porosity. These particles and aggregations may or may not break down during laboratory testing and under compaction. The mineralogy of the cementing material and of the clay fraction is different from those of normal, temperate zone soils on which current specifications for soil testing and classification is based. Calcrete can therefore be expected to exhibit differences in behaviour from those of traditional soil materials.

Whereas in traditional soil mechanics it is assumed that all the water is outside the particles, calcrete aggregates retain moisture and this affects conventional moisture content and Atterberg limit determinations. Palygorskite which is the dominant clay in calcrete has approximately the same plasticity index as some smectites, which can be regarded as highly expansive. However, the palygorskite has a non-expansive lattice and a hollow, needle-like shape instead of the usual flaky particle shape of most other clays. It has the lowest shrinkage limit and dry density and the highest optimum moisture content and shear strength of all clays.

Be it as it may, calcrete was encountered as the dominant lithic material on site, in virtually a continuous cover over the quartzite, with the latter outcropping only in the high-lying ridge of outcrops. The calcrete is present as very dense hardpan calcrete and was encountered in TP's 1, 2, 4 to 6, 8 to 15, 17 to 19, 22 to 28, 31 and 32. Only in TP 1 was a minor layer of nodular calcrete encountered as nodular calcrete overlying the hardpan calcrete. The calcrete

is present as outcrops ; or underlies the transported materials, occurring from depths between 100mm and 300mm minimum, extending to 100mm to 600mm maximum, at which stage refusal of excavation occurred or bedrock of quartzite was encountered. Moen reports the calcrete to be up to five meters thick in the area. Minor outcrops of calcrete are present randomly across the site. It is described as dirty white to dirty light yellow white, very fine grained, very dense calcrete. Some fine sand may occasionally be contained in voids in the matrix of the calcrete.

6.4 Groundwater

6.4.1 Perched Water

Perched groundwater was not encountered in any of the test pits excavated for this investigation. Considering the climate of the area and the nature of in situ materials, it is anticipated that perched water will generally not prove problematic on the site, except in the lesser drainage courses of the site after events of inundation. Even if it did occur, the grading of in-situ materials is such that dispersal will take place fairly rapidly. Furthermore, it is expected that perched water and/or surface seepage may occur shortly after precipitation events and in years of excessive rain only.

6.4.2 Permanent Groundwater

Vegter[Reference 14.7] indicates the probability for drilling successfully for water in the area to be between 40% and 60%, and the probability that such a borehole will yield more than 2l/s is between 10% and 20%. Groundwater is expected to occur at depths less than 15 meters in compact, argillaceous strata.

7 GEOTECHNICAL EVALUATION

The engineering properties of the in-situ materials are summarized in Table 3 : Summary of Engineering Properties. The characterizations have been derived based on the Unified materials classifications as reported by literature studies.

7.1 Engineering and Material Characteristics

7.1.1 Properties of Heave

The results of the materials testing as reported in Table 2 indicate the in-situ materials are not expansive. Any future structures will thus not be subject to heave. The content of active clay,

TABLE 3 : SUMMARY OF ENGINEERING PROPERTIES

TEST PIT NO	SAMPLE NO	DEPTH (mm)	SOIL ORIGIN	SOIL TYPE	SOIL CLASS		COHESION[1] (kNm^{-2})	FRICTION ANGLE (°)[1]	COMPRESSIBILITY[2]	EROSION RESISTANCE[2+5]	PERMEABILITY[2] k (cms^{-1})	SPECIFICATIONS FOR UNPAVED ROADS[3]					SUITABILITY FOR ROAD CONSTRUCTION[4]	
					PRA	UNIFIED						MAXIMUM SIZE	OVERSIZE INDEX (I_o)	GRADING COEFFICIENT(G_c)	SHRINKAGE PRODUCT(S_p)	CBR @ 95% MOD	PAVED	UNPAVED
1	U9277	200-600	Hardpan calcrete	Sandy gravel	A-1-a(0)	GW-GM	<5	30° to 40°	Negligible	1 to 4	$(2,7\pm1,3)X10^{-2}$	50,0	8	16,5	33,0	27		Corrugates and ravels
5	U9278	0-300	Hardpan calcrete	Sandy gravel	A-1-a(0)	GC	<5	28° to 35°	Very low	3	$>3X10^{-7}$	37,5	12	15,2	27,0			Corrugates and ravels
11	U9279	0-200	Hardpan calcrete	Sandy gravel	A-1-a(0)	GM	<5	30° to 40°	Negligible	4	$>3X10^{-7}$	37,5	15	15,6	60,0			Corrugates and ravels
12	U9280	0-300	Colluvium	Fine sand	A-4(0)	SM	20 to 22	32° to 35°	Low	8	$(7,5\pm4,8)X10^{-6}$	14,0	0	10,4	154,0			Erodible
15	U9280	0-300	Hardpan calcrete	Sandy gravel	A-1-a(0)	GW-GC	0 to 20	28° to 40°	Negligible to very low	1 to 3	Highly variable	63,0	10	16,4	42,0	43		Corrugates and ravels
18	U9288	100-300	Hardpan calcrete	Sandy gravel	A-1-a(0)	GW-GC	0 to 20	28° to 40°	Negligible to very low	1 to 3	Highly variable	37,5	6	16,0	39,0			Corrugates and ravels
21	U9289	0-400	Coarse Colluvium	Cobbles and gravels	A-1-b(0)	GC	<5	28° to 35°	Very low	3	$>3X10^{-7}$	37,5	11	23,5	35,0			Corrugates and ravels
22	U9290	100-300	Hardpan calcrete	Sandy gravel	A-1-b(0)	GC	<5	28° to 35°	Very low	3	$>3X10^{-7}$	50,0	6	17,4	76,0			Corrugates and ravels
28	U9291	0-500	Hardpan calcrete	Sandy gravel	A-1-b(0)	GC	<5	28° to 35°	Very low	3	$>3X10^{-7}$	75,0	6	10,1	39,0	28		Corrugates and ravels
33	U9292	0-400	Residual quartzite	Sandy gravel	A-1-b(0)	GC	<5	28° to 35°	Very low	3	$>3X10^{-7}$	37,5	11	15,8	64,5			Corrugates and ravels

1 Obrzud RF and Truty A : The Hardening Soil Model - A Practical Guidebook, 2018 edition, revised 21 October 2018.

2 Brink ABA et al : Soil Survey for Engineering, published in 1982.

3 The Structural Design, Construction and Maintenance of Unpaved Roads (Draft TRH 20), Committee of State Road Authorities 1990.

4 Structural Design of Flexible Pavements for Interurban and Rural Roads (Draft TRH 4), Committee of State Road Authorities 1996.

5 Erosion resistance : 1 is best 10 is poor.

that is the material smaller than 0,002mm in diameter, was less than 1,5% for all the samples tested.

7.1.2 Properties of Settlement

7.1.2(i) Colluvium

Gravelly colluvium was found in TP's 2 to 6, 8, 9, 13, 14, 18, 19, 22 to 25 and 27. It consists of light brown fine sand and clasts of gravels and cobbles of quartz and some calcrete. The consistency of the gravelly colluvium is medium dense and the soil matrix intact. The horizon of colluvium was between 100mm and 200mm thick in the test pits. The properties of the gravelly colluvium are thus such that it does not tend to excessive settlement.

Coarse colluvium was found in TP's 16, 20, 21, 26, 29, 30 and 33. The coarse colluvium consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of light red brown fine sand. The consistency of the coarse colluvium varies from medium dense to very dense. The horizon of colluvium was between 300mm and 700mm thick in the test pits. The properties of the gravelly colluvium are thus such that it does not tend to excessive settlement. However, foundations spanning a boulder of quartzite may be subject to stress concentrations and/or differential settlement. .

7.1.2(ii) Alluvium

Alluvium in the form of alluvial sand and minor deposits of river terrace gravels were encountered in TP's 12, 17, 28, 31 and 32. These deposits vary from dark brown and light red, loose, fine sand to medium dense, gravels of quartz and banded ironstone contained in a sandy matrix. The thickness of the horizon varied between 200mm and 300mm in the test pits. The properties of the alluvium are thus such that it does not tend to excessive settlement.

7.1.2(iii) Pedocretes

Very dense hardpan calcrete was encountered in TP's 1, 2, 4 to 6, 8 to 15, 17 to 19, 22 to 28, 31 and 32. Only in TP 1 was a minor layer of nodular calcrete encountered as nodular calcrete overlying the hardpan calcrete. The calcrete is present as outcrops ; or underlies the transported materials, occurring from depths between 100mm and 300mm minimum, extending to 100mm to 600mm maximum, at which stage refusal of excavation occurred or bedrock of quartzite was encountered. It can thus accommodate stresses imposed by conventional housing structures without undue settlement. Only limited – if any –settlement can thus be expected for structures such as single storey units of masonry construction.

7.1.2(iv) Residual Quartzite

Residual quartzite was encountered in TP's 3 and 7 as surface material or underlying the gravelly colluvium. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of dirty white, calcareous cemented sand. The soil matrix is very dense. The horizon of residual quartzite extended to a depth of 600mm in the test pit, prior to encountering very dense, very tightly packed quartzite boulders and refusal of excavation. The properties of the residual quartzite are thus such that it does not tend to excessive settlement.

7.1.3 Corrosivity

When discussing soil corrosivity, it is applicable to consider the guidelines as proposed by EvansReference [14.8]. 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.
- Heterogeneity of the soil.

The tests carried out for the compilation of this report must be considered as indicative of the corrosivity of the soils 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 $0,01Sm^{-1}$, corrosiveness is generally not a problem. However, the potential for corrosivity of the soil increases with an increase in conductivity. Should the conductivity of the soil exceed $0,05Sm^{-1}$, 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 carried out for this report indicate the following :

- *Acidity* : The pH of the samples of material tested varied between 7,58 and 7,87. The soils are thus regarded as not corrosive due to the acidity there of.
- *Water Soluble Salts Content* : The conductivity of the samples of material tested varied between $0,06Sm^{-1}$ for the colluvium to $0,13Sm^{-1}$ for the calcrete. All soils can therefore be regarded as corrosive due to their high soluble salt contents.

Other considerations are :

- *Heterogeneity of the Soil* : Conditions of corrosive soils due to a heterogeneous soil profile do not occur on the property.
- *Water Logged Soils* : Conditions of water logged soils were encountered in TP's 3 and 35 in the unlined stormwater course.

7.1.4 Materials Utilisation

7.1.4(i) Backfilling of Service Trenches

The hardpan calcrete and coarse colluvium are not suitable to be used for any type of backfill due to its tendency to break into boulder and cobble sized fragments on excavation. Such fragments cannot be compacted properly on backfilling.

The gravelly colluvium can be used for normal backfilling of services trenches. However, due to the coarse granular composition thereof, these materials are not suitable for pipe bedding or selected backfill around pipes.

7.1.4(ii) Construction of Paved or Segmental Block Streets

Only provisional indicators for future guidance of development are provided as far as material quality for road construction is concerned, complying with the requirements applicable to the level of investigation.

The results of the compaction testing on soil samples show the in-situ materials to be generally of G6 quality. These materials are thus suitable for purposes of paved road or segmental block paving construction. This type of construction is applicable to access roads to townships. The soil materials are therefore suitable for the construction of base and subbase course construction of lightly trafficked roads.

7.1.4(iii) Wearing Course for Urban Gravel Roads

The properties to provide guidance for the use of soil materials for the structural design of a wearing course for urban gravel roads are contained in the various sub-columns of the column "Specifications for Unpaved Roads" in Table 3. The various parameters are colour-coded : Green = suitable ; red = unsuitable. The two sub-columns with a light yellow-brown background contain the parameters on which the physical behaviour of the wearing is course is determined.

From the table it is clear that none of the in-situ materials comply in all aspects to the requirements for a gravel wearing course. In most cases the use of these materials will result in a wearing course subject to raveling and corrugations. This can be attributed the non-cohesive character of most of the materials. In contradiction to the construction of paved roads, calcrete appears to be the material more suitable for gravel wearing course construction, although experience has taught that if a calcrete with a high PI is used for this purpose, the road surface can become slippery in wet conditions.

7.1.5 Other Considerations

The properties discussed in this subsection of the report were obtained from literature reported values based on studies done by the US Army Corps of Engineers as reported by Brink[Reference 14.9] for compacted material. This approach is followed as the arenaceous character of the in-situ materials that did not allow the retrieval of undisturbed sampling. The typical soil properties associated with the Unified classifications of the materials are thus reported.

7.1.5(i) Compressibility

The compressibility of the material can be regarded as a necessary input to pavement design as well as lesser important supporting information for geotechnical classification for site class designation.

- *Colluvium* : The colluvium is regarded as very low to low compressible with cohesion (c_0) of less than 5,0kNm^{-2} to 22Nm^{-2} and the effective stress envelope approximately 28° to 35°.
- *Hardpan Calcrete* : The hardpan calcrete is regarded as negligible to very low compressible with cohesion (c_0) of less than 5,0kNm^{-2} to 20Nm^{-2} and the effective stress envelope approximately 28° to 40°.
- *Residual Quartzite* : The residual quartzite is regarded as very low compressible with cohesion (c_0) of less than 5,0kNm^{-2} and the effective stress envelope approximately 28° to 35°.

7.1.5(ii) Permeability

Permeability is an important parameter in the design of surface drainage and seepage drains. As such indicators in this regard are provided.

- *Colluvium* : The colluvium is regarded as semi-pervious to impervious. The soil permeability coefficient varies between 2,7X10^{-6}cms^{-1} to >3,0X10^{-7}cms^{-1}.

- *Hardpan Calcrete* : The permeability of the hardpan calcrete is highly variable depending on the mode of deposition and regarded as pervious to impervious. The soil permeability coefficient varies between more permeable than $1,5X10^{-2}cms^{-1}$ to $>3,0X10^{-7}cms^{-1}$.
- *Residual Quartzite* : The residual quartzite is regarded as impervious. The soil permeability coefficient exceeds $3X10^{-7}cms^{-1}$.

7.1.5(iii) Erosion Potential

All soil materials encountered during the investigation can be regarded as moderately to highly resistant against erosion. The net result of these properties is favourable founding conditions on the horizons of calcrete.

7.2 Properties of Bedrock

The TLB used to excavate the test pits did not penetrate hardpan calcrete or bedrock of quartzite to any significant extent and refusal of excavation occurred within millimeters after encountering these materials. It is not customary to penetrate bedrock in the case of a geotechnical investigation for purposes of a residential development. Refusal of excavation on hard rock is accepted as suitable. One can thus accept bedrock to be hard tending to very hard once refusal of excavation was encountered.

7.2.1 Calcrete

Voided matrices were not encountered in the hardpan calcrete during the investigation. The results of the materials testing on samples of the hardpan calcrete approach that of sandy gravel. However, it must be borne in mind that in in-situ conditions the properties of hardpan calcrete approaches that of hard rock rather than a gravelly sand. The grading modulus of the sample of hardpan calcrete fragments tested as 2,0 to 2,4 ; plasticity index as two to three ; and clay content less than 1,1%. The activity of the hardpan calcrete is described as low. The PRA classification of the calcrete is A-1-a(0) to A-1-b(0) ; and the Unified classification is GW to GC. Based on these properties and material classification the hardpan calcrete is regarded as non-expansive and no consolidation settlement and no collapse settlement can thus be expected for structures such as single storey units of masonry construction.

The test results of the samples of the hardpan calcrete reflect the properties of excavated fragments of material and not the intact mass of hardpan calcrete. It is therefore accepted that the properties of the very dense calcrete can be considered as tending towards soft rock to hard rock, limestone.

Brink (Reference 14.6) reports an average UCS of 32MPa for intact samples of hardpan calcrete from the Kalahari region. Using this as input to parametric calculations with Roclab software results for very dense calcrete tending to widely jointed, slightly weathered, medium hard rock, limestone result in the following properties :

- Cohesion : 1,08MPa
- Friction Angle : 24°
- Tensile Strength : 0,018MPa
- Uni-axle Compressive Strength : 550kPa
- Young's Modulus : 2340MPa

All which show a sound pedocrete, not compressible, not permeable nor subject to erosion.

7.2.2 Quartzite

Parametric calculations with Roclab software results for unweathered, jointed, very hard rock result in the following properties :

- Cohesion : 11,0MPa
- Friction Angle : 36,6°
- Tensile Strength : 0,35MPa
- Uni-axle Compressive Strength : 14,1MPa
- Young's Modulus : 21435MPa

All which show a sound, very hard and durable rock.

7.3 Excavation Classification with Respect to Services

7.3.1 Hand Excavation

7.3.1(i) Alluvium

The alluvium can be considered as suitable to be excavated by swing tools.

7.3.1(ii) Gravelly Colluvium

The gravelly colluvium can be considered as suitable to be excavated by swing tools.

7.3.1(iii) Coarse Colluvium

The coarse colluvium is of dense to very dense consistency containing boulders of quartzite. Such material cannot be considered as suitable to be manually excavated and may as minimum require the use of a 55kW TLB, but preferably a 30 ton excavator to remove it on an economical basis.

7.3.1(iv) Pedogenic Deposits

The nodular and hardpan calcrete are of dense to very dense consistency. Such material cannot be considered as suitable to be manually excavated and may as minimum require the use of a 55kW TLB, but preferably a 30 ton excavator to remove it on an economical basis.

7.3.1(v) Residual Quartzite

The residual quartzite is of dense to very dense consistency containing boulders of quartzite. Such material cannot be considered as suitable to be manually excavated and may as minimum require the use of a 55kW TLB, but preferably a 30 ton excavator to remove it on an economical basis.

7.3.1(vi) Bedrock

Bedrock of quartzite cannot be excavated manually successfully.

7.3.2 Classification of Material for Machine Excavation

In terms of Table 5 of SANS 634 : 2012 the following is applicable :

7.3.2(i) Restricted Excavation

- *Soft Excavation* : The alluvium, terrace gravels and gravelly colluvium can be regarded as soft excavation. The thickness of these strata varied between 100mm and 400mm in the test pits, averaging 180mm prior to encountering conditions of intermediate or hard rock excavation.
- *Intermediate Excavation* : Refusal of excavation with a TLB occurred in most cases once very dense, hardpan calcrete or slightly weathered to unweathered rock was encountered. However, some penetration into the hardpan calcrete or quartzite was possible and can be regarded as intermediate excavation. It was possible to penetrate between 100mm and 700mm into the hardpan calcrete and quartzite, averaging 160mm thick, prior to encountering hard rock excavation.

- *Boulder Class A Excavation* : Conditions of Boulder Class A excavation are limited to the slopes and the quartzite ridge on the northeastern boundary of the area of investigation. Such conditions were encountered in TP's 16, 20, 21, 26, 30 and 33. As a guideline in this regard the area of quartzite indicated on Figure 5 must be regarded as subject to Boulder Class A excavation. Such boulders that do occur originate from coarse colluvium and residual quartzite. It was possible to penetrate between 300mm and 800mm into the boulder layers, averaging 530mm thick, prior to encountering hard rock excavation or very tightly packed boulders that could not be removed by the TLB.
- *Hard Rock Excavation :* Refusal of excavation occurred on conditions of hard rock excavation in all the test pits at depths varying between 100mm and 800mm, averaging 410mm.

From the above it is clear that the transition of conditions of excavation occurs over a 250mm and can be regarded as rapid.

7.3.2(ii) Non-restricted Excavation

The classification as per subparagraph 7.3.2(i) : Restricted Excavation as above is also applicable for non-restricted excavation.

7.4 Seismicity

A 10% probability of an event with magnitude less than 100cms^{-2} to take place once in 50 years is regarded as favourable ; and a natural seismic activity with magnitude exceeding 100cms^{-2} is regarded as unfavourable. Based on a report compiled by Kijko[Reference 14.10] a 10% probability exists that an earthquake with Peak Ground Acceleration exceeding of 0,05g may take place once in 50 years in Opwag.

The closest source of seismic measurements to Opwag under control of the Council for Geoscience is Tontelbos at 31° 10' 12"S and 20' 30' 00"E.

- The annual probability for an earthquake with intensity of 4,5 on the Modified Mercalli Scale to occur in the area is less than $10^{-0,7}$; and with an intensity of 8,5 to occur the probability is $10^{-3,8}$.
- The annual probability for an earthquake with an acceleration of $10^{-1,9}$g to occur in the area is less than $10^{-0,7}$; and with an acceleration of $10^{-0,75}$g to occur in the area is less than $10^{-3,8}$.

To put the above information into perspective, Table 4 : Earthquake and Magnitude and Intensity, is attached to this report.

TABLE 4 : EARTHQUAKE MAGNITUDE AND INTENSITY

MODIFIED MERCALLI INTENSITY SCALE	INTENSITY	DESCRIPTION	RICHTER SCALE MAGNITUDE	RADIUS OF PERCEPTIBILITY (km)
I	Instrumental	Detected only by seismography		
II	Feeble	Noted only by sensitive people	3.5 to 4.2	3 to 24
III	Slight	Like the vibrations due to a passing lorry. Felt by people at rest, especially on upper floors		
IV	Moderate	Felt by people while walking. Rocking of loose objects, including vehicles	4.3 to 4.8	24 to 48
V	Rather strong	Felt generally ; most sleepers are awakened and bells ring		
VI	Strong	Trees sway and suspended objects swing ; damage by overturning and filing of loose objects	4.9 to 5.4	48 to 112
VII	Very strong	General public alarm ; walls crack ; plaster falls	5.5 to 6.1	110 to 200
VIII	Destructive	Car drivers seriously disturbed; masonry fissured ; buildings damaged	6.2 to 6.9	200 to 400
IX	Ruinous	Houses collapse ; pipes break		
X	Disasterous	Ground cracks badly ; buildings destroyed ; railway lines bent ; landslides on steep slopes	7.0 to 7.3	400 to 700
XI	Very disasterous	Few buildings remain standing; bridges destroyed ; all services out of action ; great landslides and floods	7.4 to 8.1	400 to 700
XII	Catastrophic	Total destruction ; objects thrown into the air; ground rises and falls in waves	>8.1	400 to 700

7.5 Undermining

The area of investigation is not undermined.

7.6 Dolomite Stability

The area of investigation is not subject to dolomite related instabilities.

8 SITE CLASS DESIGNATIONS

Based on the above discussions the property can be divided into five zones as per the guidelines posted by SANS 10400 : Section H[Reference 14.11] . The zonation is indicated on Figure 6 : Site Class Designation.

8.1 Geotechnical Zone I

This zone comprises 65% of the area investigated. It is characterized by the materials profiles of TP's 2, 5, 6, 9 to 11, 13 to 15, 17 to 19, 22 to 25, 27, 28 and 31 to 33. It covers the larger part of the area of investigation on a continuous basis. It consists of a superficial horizon less than 400mm thick comprising of colluvium, alluvium, terrace gravels and very dense calcrete overlying bedrock of quartzite. Several outcrops of calcrete occur in the area. Slope across the land is approximately between 2% and 6%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in almost negligible settlement if founded directly on the slightly weathered and unweathered hard rock to very hard rock, or on the very dense calcrete. The area is thus zoned as "R" and regarded as stable.

8.2 Geotechnical Zone II

This zone comprises 4% of the area investigated. It is characterized by the materials profiles of TP's 8 and 12. It is present along the western boundary of the site between the two drainage courses. It consists of a superficial horizon less than 400mm thick comprising of colluvium less than 400mm thick overlying very dense hardpan calcrete and bedrock of quartzite. Slope across the land is less than 2%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in almost negligible settlement if founded directly on the slightly weathered and unweathered hard rock to very hard rock, or on the very dense calcrete. The area is thus zoned as "R" and regarded as stable.

8.3 Geotechnical Zone III

This zone comprises 22% of the area investigated. The zone is present in two separate areas on the property as follows :

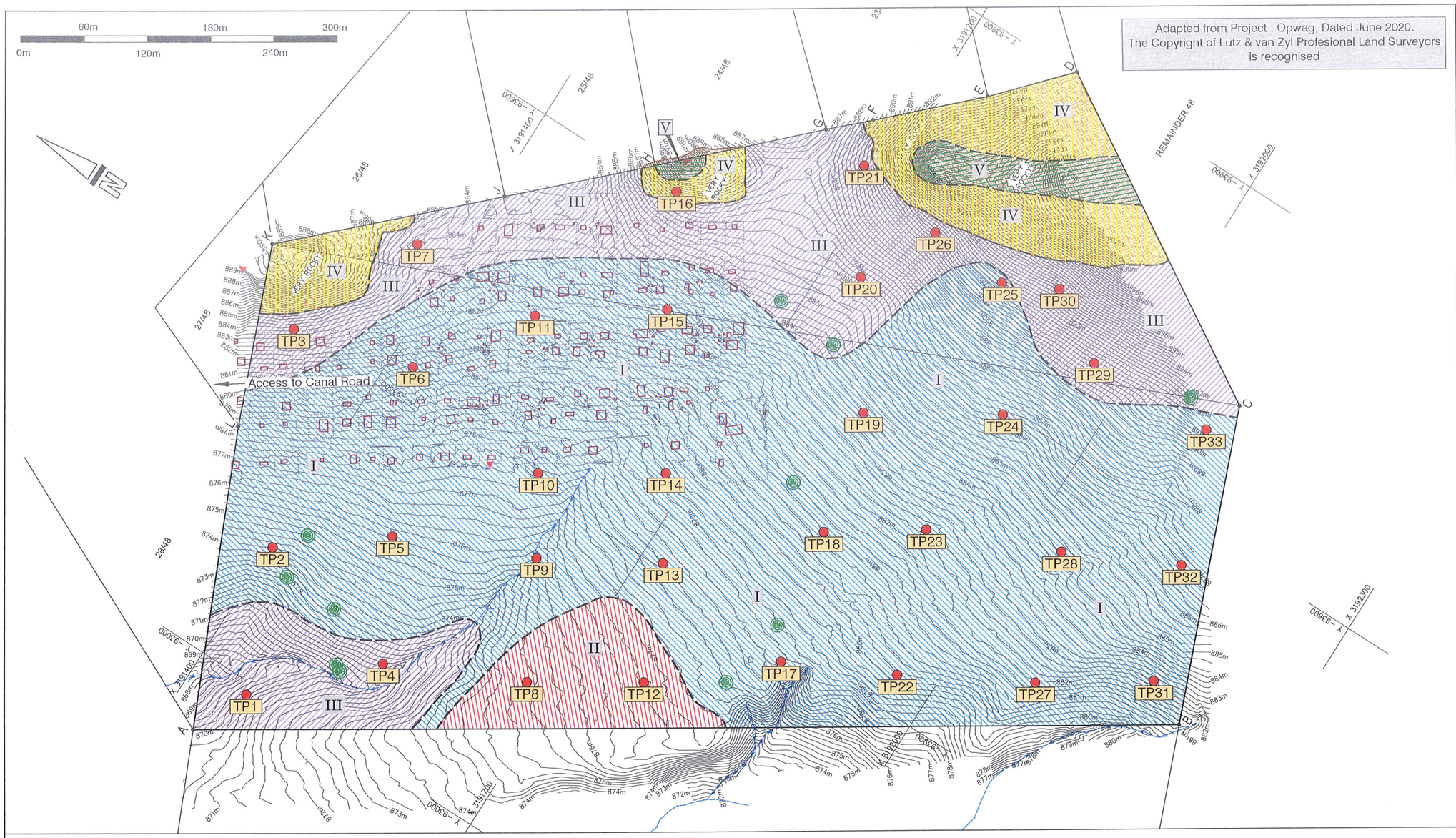

FIGURE 6 :
SITE CLASS DESIGNATION

LEGEND

- TP1 — TEST PIT POSITION
- BOSCIA ALBITRUNCA (TO BE CONSERVED)
- VERY ROCKY
- INFERRED MATERIAL BOUNDARY

FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES

AREA	AREA OF PROPERTY (%)	GEOTECHNICAL CLASS	ESTIMATED SOIL MOVEMENT(mm)	SOIL PROFILE	CONSTRUCTION TYPE	FOUNDATION DESIGN	ASSOCIATED PROBLEMS	DEVELOPMENT POTENTIAL
I	64,83	R	Negligible	Less than 400mm of colluvium, terrace gravels and alluvium overlying bedrock and very dense pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation. Landslope less than 2% and 6% favours strip footing foundations.	Intermediate
II	4,12	R	Negligible	Less than 400mm of colluvium and dense pedocretes overlying bedrock and very dense pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation. Landslope less than 2% favours slab-on-the-ground foundations.	Intermediate
III	22,09	S	0mm to 10mm compression settlement	More than 400mm of colluvial cobbles and boulders overlying bedrock of quartzite	Modified normal	Deep strip foundations placed directly on bedrock of quartzite Floorslabs to be mesh reinforced. Good site drainage	Conditions of boulder class A excavation Landslope between 2% and 6%	Intermediate
IV	7,29	S	0mm to 10mm compression settlement	More than 400mm of colluvial cobbles and boulders overlying bedrock of quartzite	Modified normal	Deep strip foundations placed directly on bedrock of quartzite Floorslabs to be mesh reinforced. or Strip footings or slab-on-the-ground foundations placed on engineered fill. Foundation system to be designed by engineer.	Conditions of boulder class A excavation Landslope between 6% and 10%	Intermediate
V	1,67	P (Slope/ Rock outcrops)	N/A	Outcrops of very hard rock, quartzite	N/A	Steep topography and outcrops of rock reduced the suitability of the land for low cost residential development. Set aside for public open space	Conditions of hard rock excavation. Landslope exceeds 10%	Poor

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TAAK: JOB NAME: Expansion and Formalisation of Opwag Community

LIGGING: SITE: Plot 2642 Boegoeberg Settlement and Portion 14 of the farm Boegoeberg Settlement No 48

KLIËNT: CLIENT: !Kheis Municipality

TEKENING NO: DRAWING NO: Figure 6 : Site Class Designation

DATUM: DATE: 14 September 2020

8.3.1 Northwestern Section

This area is characterized by the materials profiles of TP's 1 and 4. It consists of a horizon of calcrete that is less dense than over the remainder of the site. This deterioration in the quality may possibly be due to the action of surface water from the water course in the area. Isolated surface deposits of colluvial gavel may cover the calcrete. The thickness of the overburden exceeds 400mm and it overlies very dense calcrete and bedrock of quartzite at depth. Slope across the land is between 2% and 6%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in limited compression settlement less than 10mm if founded directly on the calcrete. As per the materials profile encountered in the test pits the thickness of the horizon of calcrete soil is sufficient to dissipate the stresses induced by the foundations effectively. The area is thus zoned as "S" and the materials strata can be regarded as compressible to a maximum of 10mm.

8.3.2 Eastern Section

This area is characterized by the materials profiles of TP's 3, 7, 20, 21, 26, 29 and 30. It consists of a horizon of medium dense to very dense coarse colluvium prior to encountering bedrock of quartzite. The coarse colluvium consists almost exclusively of boulders and cobbles of quartzite in a sandy matrix. The thickness of the overburden exceeds 400mm. Slope across the land is between 2% and 6%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in limited compression settlement less than 10mm if founded on the coarse overburden. As per the materials profile encountered in the test pits the thickness of the horizon of coarse colluvium is sufficient to dissipate the stresses induced by the foundations effectively. The area is thus zoned as "S" and the materials strata can be regarded as compressible to a maximum of 10mm.

8.4 Geotechnical Zone IV

This zone comprises 7% of the area investigated. Due to the steep slope and abundant presence of surface boulders of quartzite, health and safety precautions indicated test pitting in this area to be an unacceptable risk in terms of stability of the excavation equipment. TP 16 only was thus excavated in the area. A thorough walkover survey was conducted to supplement the information obtained from the test pit.

The soil profile consists of a horizon of dense coarse colluvium prior to encountering bedrock of quartzite. The coarse colluvium consists almost exclusively of boulders and cobbles of quartzite in a sandy matrix. The thickness of the overburden was 600mm in the test pit. Slope across the land is between 6% and 10%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in limited compression

settlement less than 10mm if founded on the coarse overburden. As per the materials profile encountered in the test pits the thickness of the horizon of coarse colluvium is sufficient to dissipate the stresses induced by the foundations effectively. The area is thus zoned as "S" and the materials strata can be regarded as compressible to a maximum of 10mm.

8.5 Geotechnical Zone V

This zone comprises 2% of the area investigated. Two small areas complying to the properties of this zonation are present enclaved by the Geotechnical IV zonation. There is virtually no soil profile in these two areas as they consist almost exclusively of quartzite outcrops. Slope across the land exceeds 10%. While constructing residential units on such land may be a viable proposition if costs are not a factor, financial constraints may dictate construction of low cost and affordable housing not to be viable in this zone. The area is thus zoned P(Slope/Rock outcrops).

9 FOUNDATION RECOMMENDATIONS AND SOLUTIONS

The foundation design alternatives and ancillary issues as discussed in subparagraphs 9.1 and 9.5 below are summarized in Table 5 : Foundation Design, Building Procedures and Precautionary Measures. In some cases more than one foundation solution is offered in the discussion below. Whichever option is used, the design must adhere strictly on the proposals of SANS 10400H. As geotechnical conditions favour the use of both alternatives, the decision of which option to use must be based on financial and practical considerations. In all cases service trenches shall not be excavated parallel to buildings within 1500mm of the building perimeter.

9.1 Geotechnical Zone I

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The slope across the land varies between approximately 2% and 6%. Two founding alternatives can be considered :

9.1.1 Strip Foundations

The preferable founding alternative is foundations of 400mm wide strip footings placed directly on very dense hardpan calcrete or bedrock of quartzite. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs. Should this option be adopted the floorslabs shall be reinforced steel mesh.

TABLE 5 : FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES

AREA	AREA OF PROPERTY (%)	GEOTECH NICAL CLASS	ESTIMATED SOIL MOVEMENT (mm)	SOIL PROFILE	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES	ASSOCIATED PROBLEMS	DEVELOPMENT POTENTIAL
I	65	R	Negligible	Less than 400mm of colluvium, terrace gravels and alluvium overlying bedrock and very dense pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation Landslope between 2% and 6% favours strip footing foundations	Intermediate
II	4	R	Negligible	Less than 400mm of colluvium and dense pedocretes overlying bedrock of andvery dense pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation. Landslope less than 2% favours slab-on-the-ground foundations.	Intermediate
III	22	S	0mm to 10mm compression settlement	More than 400mm of colluvial cobbles and boulders overlying bedrock of quartzite.	Modified normal	Deep strip foundations placed directly on bedrock of quartzite Floorslabs to be mesh reinforced. Good site drainage	Conditions of boulder class A excavation Landslope between 2% and 6%	Intermediate
IV	7	S	0mm to 10mm compression settlement	More than 400mm of colluvial cobbles and boulders overlying bedrock of quartzite.	Modified normal	Deep strip foundations placed directly on bedrock of quartzite Floorslabs to be mesh reinforced. or Strip footings or slab-on-the-ground foundations placed on engineered fill. Foundation system to be designed by engineer.	Conditions of boulder class A excavation Landslope between 6% and 10%	Intermediate
V	2	P(Slope/ Rock outcrops)	N/A	Outcrops of very hard rock, quartzite	N/A	Steep topography and outcrops of rock reduce the suitability of the land for low cost residential development. Set aside for public open space.	Conditions of hard rock excavation. Landslope exceeds 10%	Poor

9.1.2 Slab-on-the-ground Foundations

Considering the slope across the land of approximately 2% to 6% the use of slab-on-the-ground foundations may require additional works in the form of the construction of an engineered fill or cutting to establish a level platform for construction, but it still remains a viable alternative. This latter option of additional earthworks may be costly and hence is regarded as less attractive than conventional strip footings.

9.2 Geotechnical Zone II

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. Considering the limited slope across the land of less than 2% only and the favourable geotechnical site classification as per Section 8 above, two foundation design alternatives are applicable to the zone.

The two options can be discussed as follows :

9.2.1 Strip Foundations

Foundations of 400mm wide placed directly on the very dense hardpan calcrete may be used. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs. Should this option be adopted the floorslabs shall be reinforced steel mesh.

9.2.2 Slab-on-the-ground Foundations

This is the preferred method of founding. The solution of slab-on-the-ground foundations may only be used for dwellings less than 200m^2 in area. Edge beams shall be placed directly on the very dense hardpan calcrete.

Foundations for internal non-loadbearing walls shall consist of thickened floorslabs. The foundations shall not contain any changes in surface levels with steps exceeding 400mm and do not support any chimneys or walls which support concrete roofs.

9.3 Geotechnical Zone III

The zone is classed as S, meaning that less than 10mm of compression settlement may occur. Considering the slope across the land of approximately 2% to 6% and the presence of boulders and cobbles of quartzite in the soil matrix, it is proposed that structures be founded by deep strip foundations.

Foundations of 400mm wide can be placed directly on bedrock of quartzite. The founding of structures on the cobbles and boulders of quartzite is not advised as this may lead to tension concentrations in the foundations, resulting in structural damage. Floorslabs shall be reinforced with steel mesh. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs.

9.4 Geotechnical Zone IV

The zone is classed as S, meaning that less than 10mm of compression settlement may occur. The land slopes at approximately 6% to 10% and boulders and cobbles of quartzite are present in the soil matrix. The combination of these two properties, that is the fairly steep slope and very coarse soil overburden presents some issues that need to be addressed by foundation design and construction. Two options for foundation design may therefore be considered :

9.4.1 Deep Strip Foundations

The implementation of deep strip foundations, will require foundations of 400mm wide placed directly on bedrock of quartzite. The founding of structures on the cobbles and boulders of quartzite is not advised as this may lead to tension concentrations in the foundations, resulting in structural damage. Floorslabs shall be reinforced with steel mesh. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs.

However, the use of strip foundations need to be seen against the dimensions of the proposed housing units. Should the length of a load bearing wall placed directly parallel with the slope of the land be 5000mm, the maximum height of the plinth will be three courses of brick plus 300mm for landslope of 6% ; increasing to three bricks plus 500mm for landslope of 10%. At some stage the combination of the height of the plinth, land slope and dimension of the house will require an additional skin of bricks to be used for plinth construction.

Should the length of a load bearing wall placed directly parallel with the slope of the land be increased to 6000mm, the maximum height of the plinth will be three courses of brick plus 360mm for landslope of 6% ; increasing to three bricks plus 600mm for landslope of 10% - that is a total of approximately 850mm. At some stage the combination of the height of the plinth, land slope and dimension of the house will require an additional skin of bricks to be used for plinth construction, increasing the costs of the foundations. Under such conditions it may be more economical to consider another method of founding, as discussed in the following subparagraph.

9.4.2 Founding on an Engineered Fill

The site shall be cut and filled (terraced) with engineered fill to receive a slab-on-the-ground foundation or strip footing. The fill shall continue past the edge of the foundation wall/edge beam by at least 1000mm and have a batter of not more than 1(V) : 2(H). The interior of the slab shall be founded on natural soil or engineered fill and the edge beam or strip footing shall be founded on natural soil or engineered fill. If the interior of the slab or the footing are placed on natural soil, the slab shall be fabric reinforced and the strip footing steel reinforced.

9.5 Geotechnical Zone V

The zone is classed as P(Slope/Rock outcrops). The slope of the land exceeds 10% and large, very prominent rock outcrops are present. Surface deposits are typical coarse colluvium consisting of cobbles and boulders of quartzite. Due to these conditions the estimation of soil settlement is meaningless. It is possible to engineer structural and geotechnical designs suitable for conditions like these. However, such designs are costly and only suitable for high cost exclusive residential development, usually individual houses. It is therefore recommended that this area be set aside as public open space.

10 DRAINAGE

The water courses on site are contained in narrow and well-defined gullies of such extent that they do not influence the various geotechnical site class designations. They are therefore not zoned separately. However, the presence of these water courses must be taken into account and infrastructure established only in a safe distance from these features.

The slope of less than 2% in certain areas of the land is regarded as marginal and may result in problems with the design of stormwater and sewerage disposal systems depending on dissipation by gravity.

11 SPECIAL PRECAUTIONARY MEASURES

No extraordinary features requiring special precautionary measures to decrease the impact thereof are present on site.

12 CONCLUSIONS

Excluding Geotechnical Zone V, the property is regarded as being of intermediate suitability for residential development. Founding conditions can be defined as R and S. The factors that reduce the suitability of the land for development are :

- The presence of hard rock and very dense hardpan calcrete close to the surface. The presence thereof will result in conditions of hard excavation. On the other hand it provides conditions favouring conventional methods of founding.
- The limited slope of less than 2% in Geotechnical Zones II and IV will have a detrimental influence on the design of stormwater disposal systems and sewerage reticulation.
- Conditions of Boulder Class A excavation in Geotechnical Zone IV.
- Land slope exceeding 6% in Geotechnical Zones IV and V reduces the availability of land available for residential development and increases the costs of construction.
- The presence of waste material need to be addressed.

The conclusions as based on the site conditions are summarized in Table 6 : Influence of Constraints per Geotechnical Zoning. This classification is based on the proposals of the document *Geotechnical Site Investigations for Housing Developments (Generic Specification GFSH-2)*, issued by the National Department of Housing in September 2002.

12.1 Stratigraphy

The available information shows that the area of investigation is located on a subduction zone dating approximately 1000 million years old. The zone is located between the lithology of the Kaapvaal Craton and the Namaqua-Natal mobile belt. The remains of the original geology in the area are referred to as the Kaaien Terrane and the site is located on the Groblershoop Formation of the Brulpan Group. Bedrock on site occurs as grey brown quartzite becoming light grey quartzite of the Groblershoop Formation, Brulpan Group. Occasionally the quartzite tends to be muscovite-rich. The possibility that bedrock in western low-lying part of the site may consist of quartz-muscovite schist cannot not be excluded. However, it could not be confirmed due to the very dense, impenetrable barrier formed by the hardpan calcrete.

12.2 Soil Profile

12.2.1 Alluvium

Alluvium in the form of alluvial sand and minor deposits of river terrace gravels were encountered close to the southwestern and southeastern perimeters of the area of investigation. These deposits vary from dark brown and light red, loose, fine sand to medium dense, gravels of quartz and lesser content of banded ironstone contained in a sandy matrix. The presence of banded ironstone shows that these deposits can by associated with an earlier course of the Orange River. The thickness of the horizon varied between 200mm and 300mm in the test pits.

TABLE 6 : INFLUENCE OF CONSTRAINTS PER GEOTECHNICAL ZONING

CONSTRAINT	KEY TO CLASSIFICATION			CLASSIFICATION PER GEOTECHNICAL ZONE				
	MOST FAVOURABLE (1)	INTERMEDIATE (2)	LEAST FAVOURABLE (3)	I	II	III	IV	V
Collapsible soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750mm in thickness	Any collapsible horizon or consecutive horizons with a depth of more than 750mm in thickness	A least favourable situation for this constraint does not occur					
Seepage	Permanent or perched water table more than 1,5m below ground surface	Permanent or perched water table less than 1,5m below ground surface	Swamps and marshes					
Active soil	Low soil heave potential anticipated	Moderate soil heave potential anticipated	High soil heave potential anticipated					
Highly compressible soil	Low soil compressibility anticipated	Moderate soil compressibility anticipated	High soil compressibility anticipated					
Erodibility of Soil	Low	Intermediate	High					
Difficulty of excavation to 1,5m depth	Scattered or occasional boulders less than 10% of the total volume	Rock or hardpan pedocretes between 10% and 40% of the total volume	Rock or hardpan pedocretes more than 40% of the total volume					
Undermined ground	Undermining at a depth greater than 240m below surface, except where total extraction mining has not occurred	Old undermined areas to a depth of 90m to 240m below surface where stope closure has ceased	Mining within less than 90m to 240m of surface or where total extraction mining has taken place					
Dolomite and limestone stability	Possibly stable. Areas of dolomite overlain by Karroo rocks or intruded by sills. Areas of Black Reef rocks. Anticipated Inherent Risk Class 1	Potentially characterised by instability. Anticipated Inherent Risk Classes 2 to 5	Known sinkholes and dolines Anticipated Inherent Risk Classes 6 to 8					
Steep slopes*	Between 2° and 6° in all regions	Slopes between 6° and 18° and less than 2° (Natal and Western Cape) Slopes between 6° and12° and less than 2° (all other regions)	More than 18° (Natal and Western Cape). More than 12° (all other regions)					
Areas of unstable natural slopes*	Low risk	Intermediate risk	High risk (Especially in areas subject to seismic activity)					
Areas subject to seismic activity	10% probability of an event less than $100cms^{-2}$ within 50 years	Mining induced seismic activity more than $100cms^{-2}$	Natural seismic activity more than $100cms^{-2}$					
Areas subject to flooding	A "most favourable" situation for this constraint does not occur	Areas adjacent to a known drainage channel or floodplain with slope less than 1%	Areas with a known drainage channel or floodplain					

12.2.2 Colluvium

Distinction must be made between two types of colluvial deposits :

12.2.2(i) Gravelly Colluvium

Gravelly colluvium as surface deposit was found in the intermediate land between the low-lying area close to the water courses and the quartzite ridge. The colluvium is a homogenous material, consisting light brown fine sand and clasts of gravels and cobbles of quartz and some calcrete. The consistency of the gravelly colluvium is medium dense and the soil matrix intact. The horizon of colluvium was between 100mm and 200mm thick in the test pits.

12.2.2(ii) Coarse Colluvium

The coarse colluvium is present in the high-lying land on site, associated with transported material originating from bedrock of quartzite. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of light red brown fine sand. The consistency of the coarse colluvium varies from medium dense to very dense. The horizon of colluvium was between 300mm and 700mm thick in the test pits.

12.2.3 Residual Quartzite

On site residual quartzite was encountered as surface material or underlying the gravelly colluvium. It consists of cobbles and boulders of quartzite with diameter larger than 300mm contained a matrix of dirty white, calcareous cemented sand. The soil matrix is very dense. The horizon of residual quartzite extended to a depth of 600mm in the test pits.

12.2.2 Mokalanen Formation

Calcrete was encountered as the dominant lithic material on site, in virtually a continuous cover over the quartzite, with the latter outcropping only in the high-lying ridge of outcrops. The calcrete is present as very dense hardpan calcrete. The calcrete is present as outcrops ; or underlies the transported materials, occurring from depths between 100mm and 300mm minimum, extending to 100mm to 600mm maximum, at which stage refusal of excavation occurred or bedrock of quartzite was encountered. It is described as dirty white to dirty light yellow white, very fine grained, very dense calcrete. Some fine sand may occasionally be contained in voids in the matrix of the calcrete.

12.3 Groundwater

12.3.1 Perched Water

Perched groundwater was not encountered in any of the test pits excavated for this investigation. It is anticipated that perched water will generally not prove problematic on the site.

12.3.2 Permanent Groundwater

The probability for drilling successfully for water in the area is between 40% and 60%, and the probability that such a borehole will yield more than 2l/s is between 10% and 20%. Groundwater is expected to occur at depths less than 15 meters in compact, argillaceous strata.

12.4 Conditions of Excavation

On average over the entire site bedrock or refusal of excavation on very dense hardpan calcrete, boulders or bedrock quartzite was encountered at depths between 100mm minimum and 800mm maximum, averaging 410mm deep. The implication of this is that should trenches require excavated depths to 1000mm, 59% of the excavation may be classified as hard, requiring drilling and blasting. Should the required depth of excavation increase to 1500mm, 73% of the excavation may be classified as hard.

Irrespective of which method of excavation is considered, the most important issue is that across the entire site the depth to bedrock and hardpan calcrete that can be regarded as hard rock excavation is highly variable as follows :

12.4.1 Geotechnical Zones I and II

These zones are classified as R. The average depth to bedrock or very dense pedocrete is 170mm. Refusal of excavation occurred at an average depth of 310mm. The implication of this is that should trenches require excavated depths to 1000mm, 69% of the excavation may be classified as hard, requiring drilling and blasting. Should the required depth of excavation increase to 1500mm, 79% of the excavation may be classified as hard.

12.4.2 Geotechnical Zone III and IV

These zones are classified as S. Differentiation must be made between conditions of Boulder Class A excavation and hard rock excavation.

12.4.2(i) Boulder Class A Excavation

Conditions of Boulder Class A excavation are limited to the slopes and the quartzite ridge on the northeastern boundary of the area of investigation. Such conditions were encountered in TP's 16, 20, 21, 26, 30 and 33. It was possible to penetrate between 300mm and 800mm into the boulder layers, averaging 530mm, prior to encountering hard rock excavation or very tightly packed boulders that could not be removed by the TLB. The implication of this is that should trenches require excavated depths to 1000mm, 53% of the excavation may be classified as Boulder Class A excavation. Should the required depth of excavation increase to 1500mm, 35% of the excavation may be classified as Boulder Class A excavation.

12.4.2(ii) Hard Rock Excavation

The average depth to bedrock is 520mm. Refusal of excavation occurred at an average depth of 650mm. The implication of this is that should trenches require excavated depths to 1000mm, 65% of the excavation may be classified as soft, suitable for TLB excavation. Should the required depth of excavation increase to 1500mm, 57% of the excavation may be classified as hard, requiring drilling and blasting.

12.5 Site Class Designation

It is concluded that the area is regarded as suitable for residential development as follows :

12.5.1 Geotechnical Zone I

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 65% of the proposed area for development. Slope across the land is approximately between 2% and 6%. The use of slab-on-the-ground foundations will require additional works in the form of the construction of an engineered fill or cutting to establish a level platform for construction. The more viable foundation alternative therefore remains founding by conventional strip foundations.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface detracts from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.2 Geotechnical Zone II

The zone is classed as R, meaning that the proposed horizon for founding is stable and

negligible soil movement is expected. The distribution thereof encompasses 4% of the proposed area for development. Slope across the land is less than 2%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on bedrock or very dense pedocrete. The latter option is regarded as the better solution of the two alternatives.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface and slope less than 2% detract from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.3 Geotechnical Zone III

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 22% of the proposed area for development. Slope across the land is between 2% and 6%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on medium dense terrace gravels. The more viable foundation alternative therefore remains founding by conventional strip foundations.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface detracts from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.4 Geotechnical Zone IV

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 7% of the proposed area for development. Slope across the land is between 6% and 10%. Considering the slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or landscaping by cut-to-fill operations to prepare level surfaces for slab-on-the-ground foundations. The construction of a cut-and-fill terrace and foundation design associated with such an operation shall be done according to a professional design.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface and slope between 6% and 10%

detract from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.5 Geotechnical Zone V

Slope across this zone exceeds 10% and the presence of outcrops of hard rock dominates the land surface. It is thus zoned as P(Slope/rock outcrops). The distribution thereof encompasses 2% of the proposed area for development. The combination of these conditions reduces the suitability of the zone for low cost and affordable housing. The area is better suited to be set aside as public open space.

12.6 Land Slope

The average slope across 87% of the land is between 2% and 6% ; over 4% it is less than 2% ; over 7% it is between 6% and 10% ; and over 2% of the land the slope exceeds 10%.

The slope of less than 2% has a detrimental influence on especially the design of a stormwater disposal system depending on gravity to dissipate of the surface water due to downpours. The land slope also affects the design of the sewerage disposal but to a lesser extent as the gradient of the pipes can be adjusted according to design requirements. The land surface of the area subject to the slope exceeding 10% is covered by rock outcrops and do not represent conditions of unstable faces subject to slip failures. However, the slope reduces the potential of the land for the development of affordable and low cost housing.

12.7 Areas Subject to Flooding

The non-perennial water courses on site are contained in well-defined, narrow gullies and may be regarded as being of lesser importance, requiring no additional precautionary measures to ensure the safety of the population against flooding.

12.8 Materials Utilization

- *Trench Backfilling* : None of the materials are suitable for selected fill or pipe bedding. With exception of the hardpan calcrete all materials can be used for normal backfill.
- *Layerworks for Paved or Segmental Block Paving* : The hardpan calcrete is of G6 quality and hence suitable for the construction of layerworks up to subbase and base course level for lightly trafficked roads.
- *Wearing Course for Gravel Roads in Urban Areas* : None of the soil materials are 100% suitable for this purpose. The use of these materials will generally result in a road surface subject to raveling and corrugations.

12.9 Other Considerations

- *Undermining* : The area is not subject to undermining.
- *Seismic Activity* : The Peak Ground Acceleration expected in 50 years is 0,05g. A low risk for the development of earth tremors therefore exist.
- *Soil Corrosivity* : The in-situ soils and pedocretes are not corrosive due to acidic properties. All soil materials can be regarded as corrosive due to high soluble salt contents.
- *Dolomite* : The area of investigation is not subject to any restrictions due to the presence of dolomite. Bedrock of dolomite does not occur in the area of investigation.

13 RECOMMENDATIONS

13.1 Foundation and Structural Design

Section 9 of this document provides guidelines for foundation and structural design. These guidelines are based strictly on the contents of SANS 10400H and the NHBRC Home Owners Manual published in 2015. It is recommended that development take place strictly according to these guidelines. More than one founding solution is applicable on the site, and the property developer can base his choice on financial constraints.

13.2 Materials Utilization

- *Trench Backfill* : With exception of the hardpan calcrete, the in-situ materials may be used for normal backfill of trenches. The hardpan calcrete shall be spoilt and not used at all for this purpose. Material for pipe bedding and selected backfill shall be obtained from commercial sources.
- *Layerworks for Paved or Segmental Block Paving* : The hardpan calcrete is of G6 quality and hence suitable for the construction of layerworks up to subbase and base course level for lightly trafficked roads. It is recommended that a centerline investigation consisting of test pitting and soil sampling be conducted to allow the consulting engineer to produce suitable pavement designs for the project.
- *Wearing Course for Gravel Roads in Urban Areas* : Material for the construction of a gravel wearing course shall be obtained from stockpiled or calcrete from a licensed borrow pit.

13.4 Conditions of Excavation

Although manual excavation is possible through the colluvium, residual soil and to some extent through the calcrete, it is considered as not an economic proposition, mostly due to the consistency and composition of the soil. Excavation through these soils shall require the use of a TLB rated at 55kW minimum, or preferably a 30 ton excavator of the very dense

pedocretes need to be removed. It is recommended that adequate provision be made for hard rock excavation.

13.5 Land Slope

The average slope across 87% of the land is between 2% and 6%, which is regarded as favourable for residential development. Over 4% it is less than 2%, which will require careful consideration of the design of wet services due to possible reduced flow rates of liquids. Over 7% of the land the slope is between 6% and 10% which will require careful consideration of the design of wet services due to possible accelerated flow rates of liquids and increase the difficulty of founding and hence increase the costs of building houses. Over 2% of the land the slope exceeds 10%. This slope is regarded as not desirable for low cost housing.

14 SOURCES OF REFERENCE

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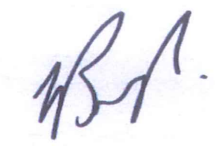

FJ Breytenbach, Pr Eng 15 September 2020
For Cedar Land Geotechnical Consult (Pty) Ltd

GEOTECHNICAL CONDITIONS ON PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48: A REPORT FOR THE EXPANSION AND FORMALISATION OF OPWAG COMMUNITY

2020/J09/MCP_01

ADDENDUM A: TEST PIT PROFILES

TRIAL HOLE: 1

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'09,3" S 21°57'10,1" E*

Cedar Land Geotechnical Consult (Pty) Ltd
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Ceres
6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				
		Abundant, clast supported, fine, rounded *CALCRETE* nodules in a matrix of dry, light grey brown, fine sand. Pedogenic deposits.				
0.20		Lenses (± 10 mm wide) of dirty white, very fine grained, very dense, hardpan *CALCRETE.* Joints between lenses are open, smooth and filled with light brown, fine sand. Pedogenic deposits.				
0.40			U9277	0,2-0,6	●	
0.60						
0.80						
1.00						
1.20						

NOTES:

1 Refusal of excavation at 600 mm on very dense hardpan calcrete.

- Water encountered
- Water level
- Bottom of hole
- Approximate material change
- Disturbed sample
- Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 1

FIGURE: A1

TRIAL HOLE: 2

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'07,5" S 21°57'14,9" E*

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cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty yellow white, fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						Water encountered Water level Bottom of hole Approximate material change Disturbed sample Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 2

FIGURE: A2

TRIAL HOLE: 3

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'04,4" S 21°57'21,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Colluvium.				1 Refusal of excavation at 600 mm on tightly packed quartzite boulders.
0.20		Abundant, clast supported, angular *COBBLES* and *BOULDERS* (> 300 mm) of quartzite contained in a matrix of dirty white, calcareous and cemented sand. Overall consistency is very dense. Residual quartzite.				
0.40						
0.60						
0.80						
1.00						Water encountered Water level Bottom of hole Approximate material change Disturbed sample Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 3

FIGURE: A3

TRIAL HOLE: 4

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'12,3" S 21°57'13,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Colluvium.				1 Refusal of excavation at 800 mm on very hard rock, quartzite.
0.20		Dirty yellow white, fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60		Light grey brown, medium jointed, fine grained, unweathered, very hard rock, *QUARTZITE.* Discontinuities are open, smooth and filled with light red sand.				
0.80						
1.00						Water encountered Water level Bottom of hole Approximate material change Disturbed sample Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 4

FIGURE: A4

TRIAL HOLE: 5

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'10,4" S 21°57'17,5" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
			U9278	0-0,3	●	
0.20		Dirty yellow white, fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						

▽ Water encountered
▼ Water level
⊓ Bottom of hole
---- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 5

FIGURE: A5

TRIAL HOLE: 6

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'08,1" S 21°57'22,8" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Colluvium.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20		Dirty yellow white, fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 6

FIGURE: A6

TRIAL HOLE: 7

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'06,2" S 21°57'26,4" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, angular *COBBLES* and *BOULDERS* (> 300 mm) of quartzite contained in a matrix of dirty white, calcareous and cemented sand. Overall consistency is very dense. Residual quartzite.				1 Refusal of excavation at 600 mm on very hard rock, quartzite.
0.20						
0.40						
0.60		Light grey brown, medium jointed, fine grained, unweathered, very hard rock, *QUARTZITE*. Discontinuities are open, smooth and filled with light red sand.				
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 7

FIGURE: A7

TRIAL HOLE: 8

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'07,5" S 21°57'14,9" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white mottled light pink, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						Water encountered Water level Bottom of hole Approximate material change Disturbed sample Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 8

FIGURE: A8

TRIAL HOLE: 9

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'14,5" S 21°57'19,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, subrounded and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Colluvium.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty yellow white, fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						

▽ Water encountered
▼ Water level
⊥ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 9

FIGURE: A9

TRIAL HOLE: 10

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'13,1" S 21°57'22,1" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				
		Dirty yellow white, fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				NOTES: 1 Refusal of excavation at 100 mm on very dense hardpan calcrete.
0.20						
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐r Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 10

FIGURE: A10

TRIAL HOLE: 11

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *8/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'10,4" S 21°57'26,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dirty yellow white, fine grained, very dense, voided hardpan *CALCRETE* containing fine, light brown sand in the voids. Pedogenic deposits.	U9279	0-0,2	●	1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20						
0.40						
0.60						
0.80						
1.00						
1.20						

▽ Water encountered
▼ Water level
Bottom of hole
--- Approximate material change
▪ Disturbed sample
■ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 8/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 11

FIGURE: A11

TRIAL HOLE: 12

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'19,3" S 21°57'18,0" E*

Cedar Land Geotechnical Consult (Pty) Ltd
P O Box 607
Ceres
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Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dry, dark brown, loose, intact, fine *SAND*. Alluvium.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
			U9287	0-0,3	●	
0.20						
		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 12

FIGURE: A12

TRIAL HOLE: 13

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'17,8" S 21°57'21,8" E*

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Email:
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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, angular and subangular, *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 13

FIGURE: A13

TRIAL HOLE: 14

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'16,4" S 21°57'24,5" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, angular and subangular, *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 14

FIGURE: A14

TRIAL HOLE: 15

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'13,7" S 21°57'29,3" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dirty yellow white, fine grained, very dense, voided hardpan *CALCRETE* containing fine, light brown sand in the voids. Pedogenic deposits.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20			U9280	0-0,3	●	
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 15

FIGURE: A15

TRIAL HOLE: 16

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'12,0" S 21°57'32,9" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, angular and subangular *COBBLES* and *BOULDERS* (300 mm - 500 mm in diameter) of quartzite in a matrix of dry, light red brown, fine sand. Overall consistency is dense. Colluvium.				1 Refusal of excavation at 700 mm on hard rock, quartzite.
0.20						
0.40						
0.60		Light yellow brown, medium jointed, fine grained, hard rock, *QUARTZITE.* Discontinuities are closed, smooth and clean.				
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ■ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 16

FIGURE: A16

TRIAL HOLE: 17

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'22,5" S 21°57'21,2" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dry, dark brown, loose, intact, fine *SAND* and matrix supported, medium coarse, angular gravels of calcrete. Alluvium.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20						
		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposit.				
0.40						
0.60						
0.80						
1.00						
1.20						

Water encountered
Water level
Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 17

FIGURE: A17

TRIAL HOLE: 18

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'21,4" S 21°57'25,8" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, angular and subangular, *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposit.	U9288	0,1-0,3	●	
0.40						
0.60						
0.80						
1.00						
1.20						

▽ Water encountered
▼ Water level
⌐ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 18

FIGURE: A18

TRIAL HOLE: 19

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'20,5" S 21°57'30,0" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse, angular and subangular, *GRAVELS* of quartz in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposit.				
0.40						
0.60						
0.80						
1.00						
1.20						

Water encountered
Water level
Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 19

FIGURE: A19

TRIAL HOLE: 20

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'18,2" S 21°57'33,9" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, angular and subangular *COBBLES* and *BOULDERS* (< 500 mm in diameter) of quartzite in a matrix of dry, light red brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 800 mm on very hard rock, quartzite.
0.80		Light blue grey, medium jointed, fine grained, unweathered, very hard rock, *QUARTZITE*. Joints are closed, smooth and clean.				
1.20						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 20

FIGURE: A20

TRIAL HOLE: 21

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'16,4" S 21°57'37,2" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES: 1 Refusal of excavation at 500 mm on very hard rock, quartzite.
		Abundant, clast supported, angular and subangular *COBBLES* and *BOULDERS* (< 500 mm in diameter) of quartzite in a matrix of dry, light red brown, fine sand. Overall consistency is medium dense. Colluvium.				
0.20			U9289	0-0,4	●	
0.40		Light blue grey, medium jointed, fine grained, unweathered, very hard rock, *QUARTZITE*. Joints are closed, smooth and clean.				
0.60						
0.80						
1.00						
1.20						

▽ Water encountered
▼ Water level
⌐ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 21

FIGURE: A21

TRIAL HOLE: 22

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'25,7" S 21°57'23,0" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse angular and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE.* Pedogenic deposits.	U9290	0,1-0,3	●	
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 22

FIGURE: A22

TRIAL HOLE: 23

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'24,0" S 21°57'27,8" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse angular and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						Water encountered Water level Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 23

FIGURE: A23

TRIAL HOLE: 24

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'24,1" S 21°57'32,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse angular and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 24

FIGURE: A24

TRIAL HOLE: 25

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'21,9" S 21°57'36,4" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse angular and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE.* Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⊥ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 25

FIGURE: A25

TRIAL HOLE: 26

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'19,3" S 21°57'36,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, angular *COBBLES* and *BOULDERS* (< 500 mm in diameter) of quartzite contained in a matrix of dry, light red brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 800 mm on very hard rock, quartzite.
0.20						
0.40						
0.60						
0.80		Light blue grey, medium jointed, fine grained, unweathered, very hard rock, *QUARTZITE*. Joints are closed, smooth and clean.				
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 26

FIGURE: A26

TRIAL HOLE: 27

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'29,4" S 21°57'25,4" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse angular and subangular *GRAVELS* of quartz in a matrix of dry, light brown fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 27

FIGURE: A27

TRIAL HOLE: 28

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'27,9" S 21°57'29,7" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dry, light red brown, loose, fine *SAND*. Alluvium.				1 Refusal of excavation at 500 mm on very dense hardpan calcrete.
0.20			U9291	0-0,5	●	
0.40		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.60						
0.80						
1.00						
1.20						

▽ Water encountered
▼ Water level
⌐ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 28

FIGURE: A28

TRIAL HOLE: 29

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'25,6" S 21°57'35,8" E*

Cedar Land Geotechnical Consult (Pty) Ltd
P O Box 607
Ceres
6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, angular and subangular *COBBLES* of quartzite in a matrix of dry, light red brown fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 500 mm on very hard rock, quartzite.
0.20						
0.40		Light blue grey, medium jointed, fine grained, unweathered, very hard rock, *QUARTZITE*. Joints are closed, smooth and clean.				
0.60						
0.80						
1.00						Water encountered Water level Bottom of hole Approximate material change Disturbed sample Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 29

FIGURE: A29

TRIAL HOLE: 30

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'23,5" S 21°57'37,3" E*

Cedar Land Geotechnical Consult (Pty) Ltd
P O Box 607
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6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, angular and subangular *COBBLES* and *BOULDERS* (< 500 mm in diameter) of quartzite in a matrix of dry, light red brown, fine sand. Overall consistency is medium dense. Colluvium.				1 Refusal of excavation at 600 mm on hard rock, quartzite.
0.20						
0.40						
0.60		Light grey, very closely jointed, fine grained, slightly weathered, hard rock, micaceous *QUARTZITE*. Joints are closed, smooth and clean.				
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 30

FIGURE: A30

TRIAL HOLE: 31

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'32,4" S 21°57'27,7" E*

Cedar Land Geotechnical Consult (Pty) Ltd
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6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dry, light red brown, medium dense, intact, fine *SAND* and matrix supported, subrounded, medium coarse gravels of quartz and banded ironstone. Terrace gravels.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20						
		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 31

FIGURE: A31

TRIAL HOLE: 32

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'31,2" S 21°57'31,6" E*

Cedar Land Geotechnical Consult (Pty) Ltd
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6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dry, light red brown, medium dense, intact, fine *SAND* and matrix supported, subrounded, medium coarse gravels of quartz and banded ironstone. Terrace gravels.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						▽ Water encountered ▼ Water level ⌐ Bottom of hole --- Approximate material change • Disturbed sample ▪ Undisturbed sample
1.20						

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 32

FIGURE: A32

TRIAL HOLE: 33

PROJECT: *EXPANSION AND FORMALISATION OF THE OPWAG COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48*

DATE LOGGED: *9/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°50'29,6" S 21°57'36,0" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				
		Abundant, clast supported, angular and subangular *COBBLES* and *BOULDERS* (< 500 mm in diameter) of quartzite in a matrix of dry, light red brown, fine sand. Overall consistency is medium dense. Colluvium.				
0.20			U9292	0-0,4	●	
		Light grey, very closely jointed, fine grained, slightly weathered, hard rock, micaceous *QUARTZITE*. Joints are closed, smooth and clean.				
0.40						
0.60						
0.80						
1.00						
1.20						

NOTES:

1 Refusal of excavation at 400 mm on hard rock, quartzite.

- Water encountered
- Water level
- Bottom of hole
- Approximate material change
- Disturbed sample
- Undisturbed sample

Contractor: ALS Plant Hire
Date Drilled: 9/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 33

FIGURE: A33

GEOTECHNICAL CONDITIONS ON PLOT 2642 BOEGOEBERG SETTLEMENT AND PORTION 14 OF THE FARM BOEGOEBERG SETTLEMENT 48: A REPORT FOR THE EXPANSION AND FORMALISATION OF OPWAG COMMUNITY

2020/J09/MCP_01

ADDENDUM B: RESULTS OF MATERIALS TESTING

ROADLAB

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207 Rietfontein Road Germiston
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Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835

Attention : Frans Breytenbach

Date Reported : 2020-07-17

Project : Opwag Infrastructure Upgrade

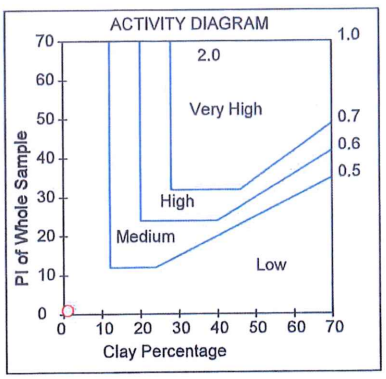
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

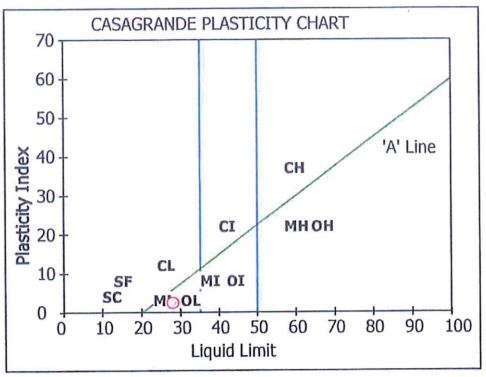
Sample No.	: U9277
Position	: TP 1
Layer Type	: 200-600mm
Sample Colour	: Light Brown Gravel
Sample Type	: Mix Calcrete+Quartz

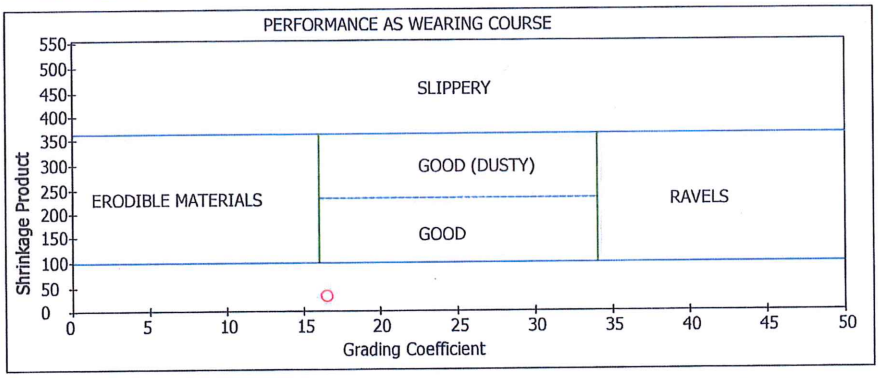
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	97
37.50	89
28.00	76
20.00	67
14.00	57
5.000	33
2.000	26
0.425	22
0.250	20
0.150	16
0.075	11
0.060	3,1
0.050	2,9
0.020	1,8
0.005	1,1
0.002	0,8

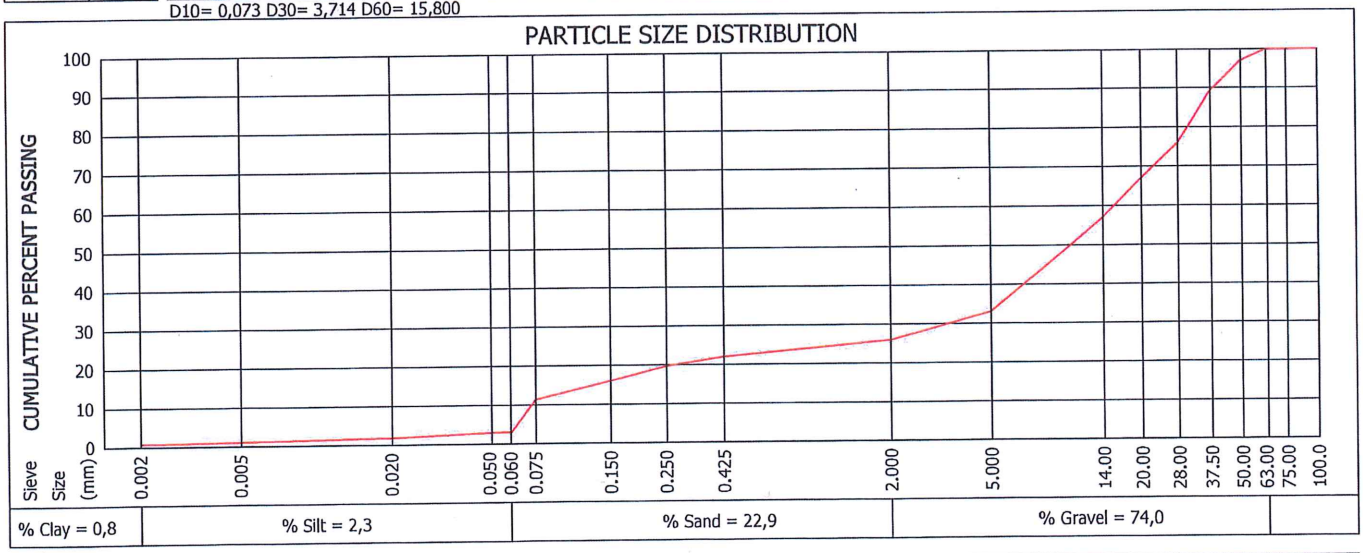
Soil Mortar	2.000 - 0.425	18
	0.425 - 0.250	7
	0.250 - 0.150	14
	0.150 - 0.075	20
	< 0.075	42
Effective Size		0,073
Uniformity Coefficient		216,4
Curvature Coefficient		12,0
Oversize Index		8,0
Shrinkage Product		33,0
Grading Coefficient		16,5
Grading Modulus		2,40
Atterberg Limits	Liquid Limit	28
	Plasticity Index	2,0
	Linear Shrinkage	1,5
	PI < 0.075	
Unified Soil Classification		GW-GM
US Highway Classification		A-1-a(0)

D10= 0,073 D30= 3,714 D60= 15,800









% Clay = 0,8	% Silt = 2,3	% Sand = 22,9	% Gravel = 74,0

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

sanas Testing Laboratory
Accreditation No. T0296
Prog.ver 10.7 (2019/11/07)

D Juckers
Technical Signatory

ROADLAB

Roadlab Germiston
207 Rietfontein Road Germiston
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Web: www.roadlab.co.za

Date Reported : 2020-07-24

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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Project : Opwag Infrastructure Upgrade

Attention : Frans Breytenbach

Determination of the California Bearing Ratio Test Report SANS 3001 - GR1 / GR2 / GR10 / GR20 / GR30 / GR40 / PR5

SAMPLE INFORMATION AND PROPERTIES

SAMPLE NO.	U9277			
HOLE NO./ Km / CHAINAGE	TP1			
ROAD NO./ NAME Line 1 ROAD NO./ NAME Line 2	S28° 50' 09,3" E21° 57' 10,1"			
LAYER TESTED/SAMPLED	200-600mm			
SAMPLE DEPTH	200-600mm			
DATE SAMPLED	2020-07-09			
COLOUR OF SAMPLE	Light Brown			
TYPE OF SAMPLE	Mix Calcretestone			

SIEVE ANALYSIS - % PASSING SIEVES *(SANS 3001-GR1:2010, SANS 3001-GR2:2010)

SIEVE ANALYSIS (GR 1) % PASSING	100.0 mm				
	75.0 mm				
	63.0 mm	100			
	50.0 mm	97			
	37.5 mm	89			
	28.0 mm	76			
	20.0 mm	67			
	14.0 mm	57			
	5.0 mm	33			
	2.0 mm	26			
	0.425 mm	22			
	0.075 mm	11			
GM %		2,4			

SOIL MORTAR ANALYSIS (SANS 3001-PR5:2011)

COARSE SAND	2.000 - 0.425	18			
COARSE FINE SAND	0.425 - 0.250	7			
MEDIUM FINE SAND	0.250 - 0.150	14			
FINE FINE SAND	0.150 - 0.075	20			
SILT CLAY	0.075	42			

ATTERBERG LIMITS ANALYSIS - *(SANS 3001-GR10:2010)

ATTERBERG LIMITS (%) SANS GR10,GR11	LIQUID LIMIT	28			
	PLASTICITY INDEX	2.4			
	LINEAR SHRINKAGE	1.5			
CLASSIFICATION	H.R.B.	A-1-a(0)			
	COLTO	G6			
	TRH 14	G7			

CALIFORNIA BEARING RATIO - *(SANS 3001-GR30:2010, SANS 3001-GR40:2010)

SANS GR30 MAX. DRY DENSITY	OMC %	10,9			
	MDD (kg/m³)	1906			
	COMP MC %	10,8			
SWELL % @	MOD | NRB | PRO	0,01 | 0,03 | 0,05			
C.B.R. SANS GR40	100 %	75			
	98 %	50			
	97 %	41			
	95 %	27			
	93 %	18			
	90 %	10			

STABILISER IN LAB	Not Applicable			
TEST TYPE	CBR			
SAMPLING METHOD	TMH 5			
WEATHER WHEN SAMPLED	Cold			

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

sanas Testing Laboratory
Accreditation No. T0296
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3/16

ROADLAB

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Web: www.roadlab.co.za

Job Request No.: RU3525

Date Reported : 2020-07-23

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835

Project : Opwag Infrastructure Upgrade

Attention : Frans Breytenbach

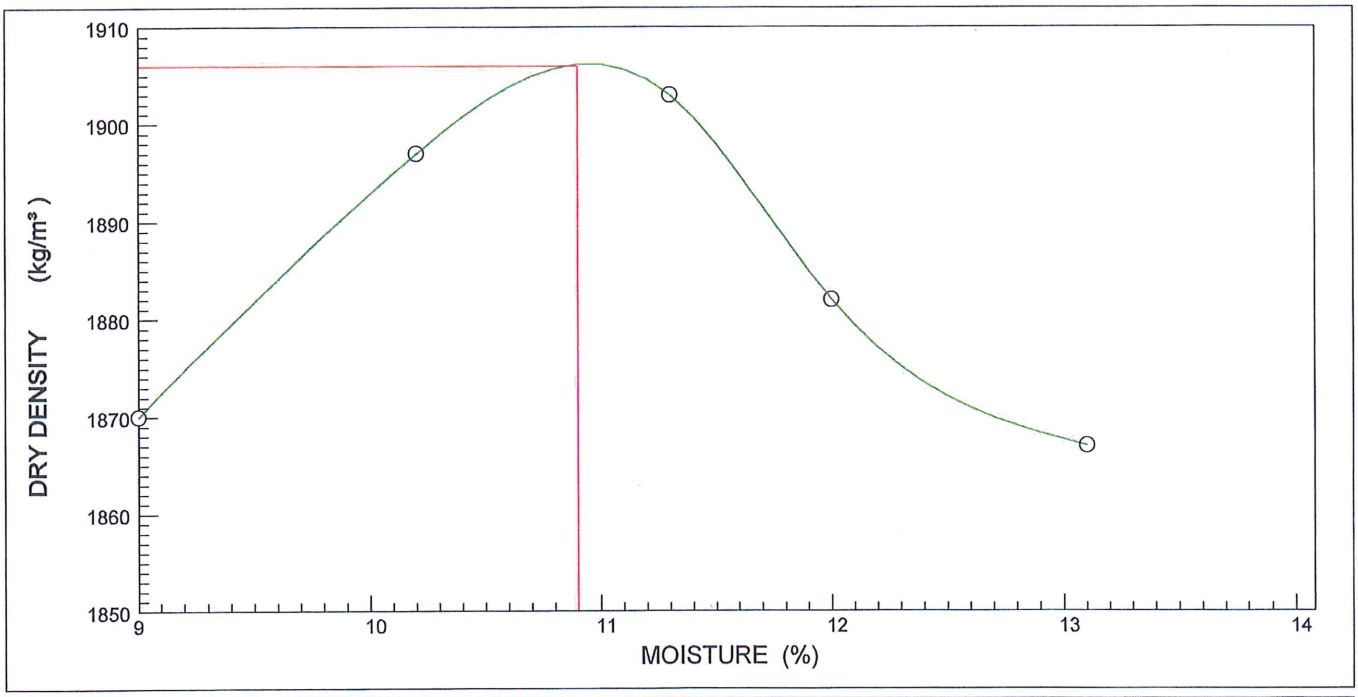
Determination Maximum Dry Density & Optimum Moisture Content Test Report

SANS 3001 - GR20/GR30

SAMPLE NO.	U9277
CONTAINER FOR SAMPLING	Black Bags
SIZE / APPROX. MASS OF SAMPLE	98kg
MOISTURE CONDITION OF SAMPLE	Moist
LAYER TESTED / SAMPLED FROM	200-600mm
MATERIAL DESCRIPTION	Mix Calcrete
HOLE NO./ km / CHAINAGE	TP1
ROAD NO.	Not Specified
DATE RECEIVED	2020-07-09
DATE SAMPLED	2020-07-09
CLIENT MARKING	S28° 50' 09,3"; E21° 57' 10,1"
COLOUR AND TYPE	Light Brown Gravel

POINT NO.	1	2	3	4	5			
DRY DENSITY (kg/m³)	1870	1897	1903	1882	1867			
MOISTURE (%)	9,0	10,2	11,3	12,0	13,1			

MAXIMUM DRY DENSITY (kg/m³) : 1906	OPTIMUM MOISTURE CONTENT (%) : 10,9



Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

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Accreditation No. T0296
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207 Rietfontein Road Germiston
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Web: www.roadlab.co.za

Date Reported : 2020-08-05

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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6835
Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

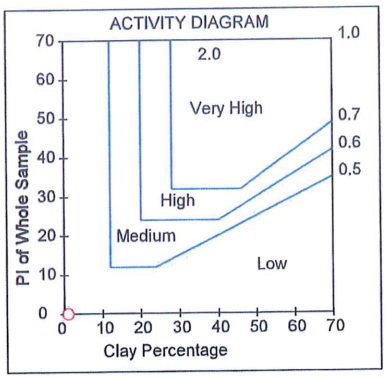
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

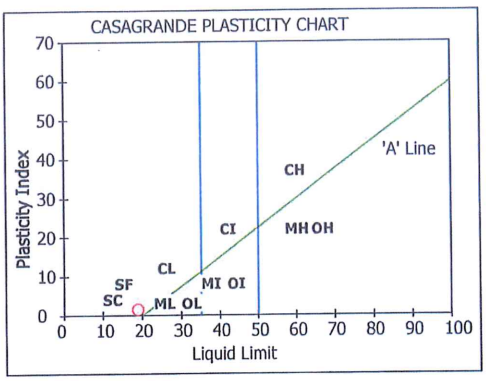
Sample No.	: U9278
Position	: TP 5
Layer Type	: 0-300mm
Sample Colour	: Dark Brown Gravel
Sample Type	: Mix Calcerete+Quartz

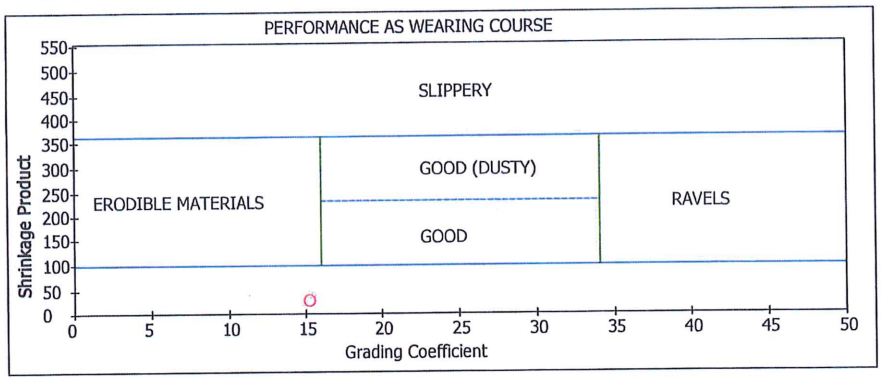
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	88
28.00	78
20.00	66
14.00	55
5.000	31
2.000	29
0.425	27
0.250	27
0.150	22
0.075	14
0.060	4,5
0.050	4,2
0.020	2,7
0.005	1,6
0.002	1,1

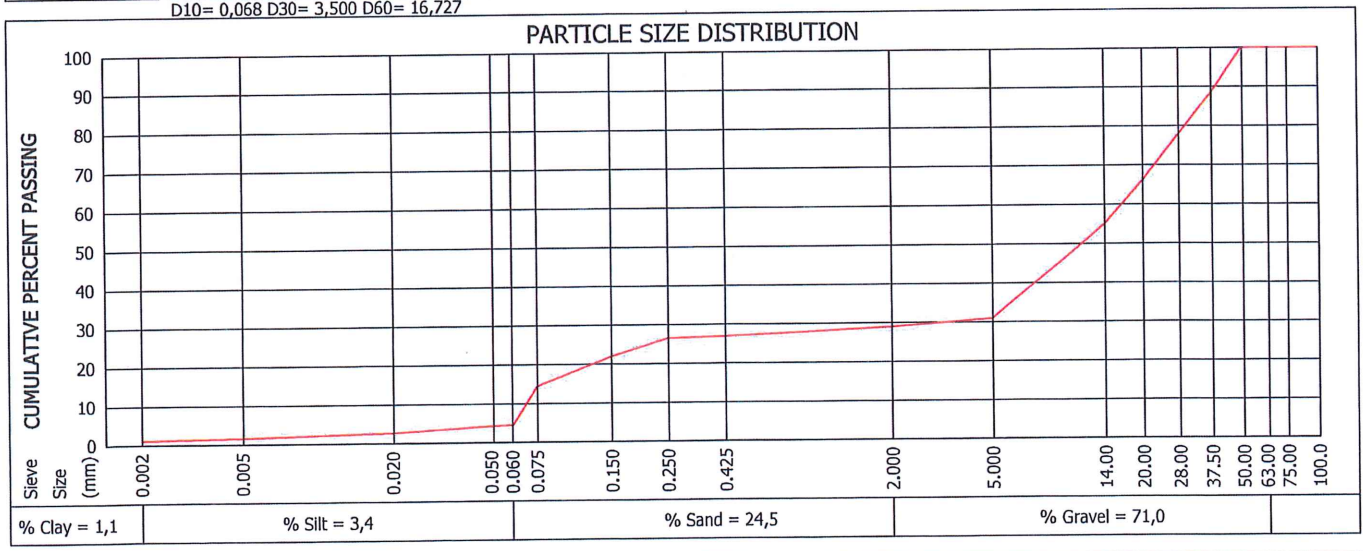
Soil Mortar	2.000 - 0.425	4
	0.425 - 0.250	3
	0.250 - 0.150	16
	0.150 - 0.075	28
	< 0.075	49
Effective Size		0,068
Uniformity Coefficient		246,0
Curvature Coefficient		10,8
Oversize Index		12,0
Shrinkage Product		27,0
Grading Coefficient		15,2
Grading Modulus		2,30
Atterberg Limits	Liquid Limit	19
	Plasticity Index	2,0
	Linear Shrinkage	1,0
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-a(0)

D10= 0,068 D30= 3,500 D60= 16,727









% Clay = 1,1	% Silt = 3,4	% Sand = 24,5	% Gravel = 71,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 8.49 [SANS 5854] & Conductivity = 0.10 S/m [SANS 6240]

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

sanas Testing Laboratory
Accreditation No. T0296
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ROADLAB

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Job Request No.: RU3525

Date Reported : 2020-08-06

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

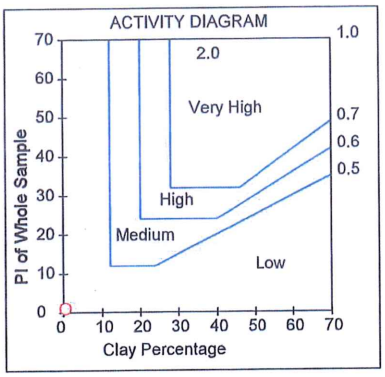
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

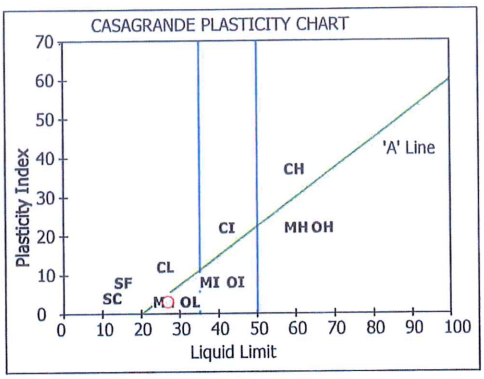
Sample No.	: U9279
Position	: TP 11
Layer Type	: 0-200mm
Sample Colour	: Brown Gravel
Sample Type	: Mix Calcretestone

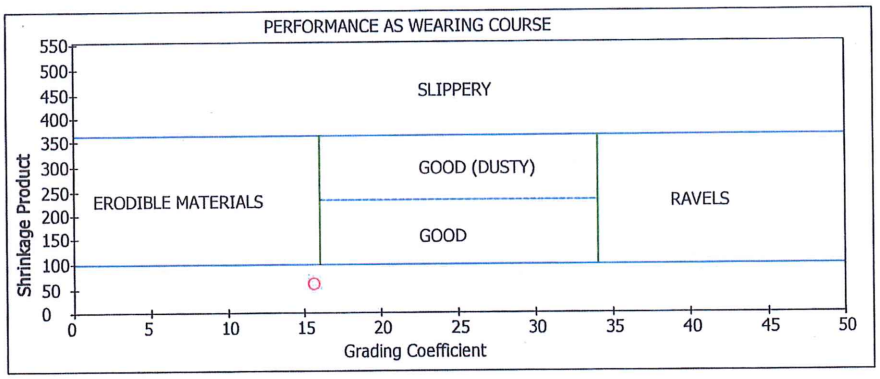
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	85
28.00	74
20.00	62
14.00	56
5.000	39
2.000	34
0.425	30
0.250	28
0.150	21
0.075	13
0.060	3,9
0.050	3,5
0.020	2,2
0.005	1,8
0.002	0,6

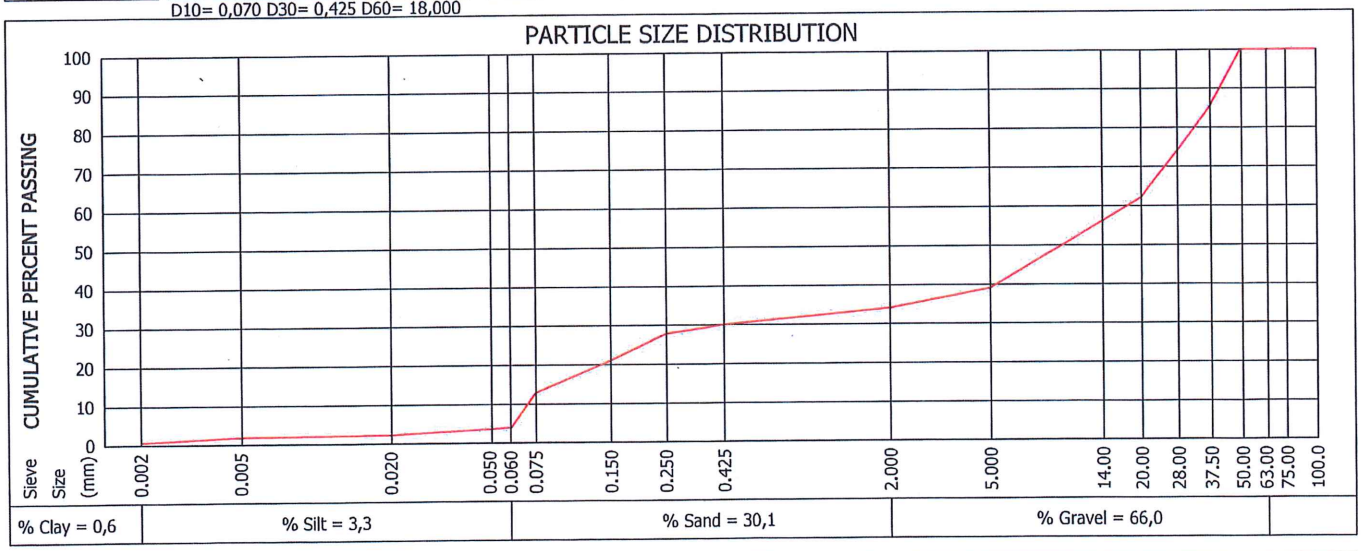
Soil Mortar	2.000 - 0.425	12
	0.425 - 0.250	6
	0.250 - 0.150	20
	0.150 - 0.075	24
	< 0.075	39
Effective Size		0,070
Uniformity Coefficient		257,1
Curvature Coefficient		0,1
Oversize Index		15,0
Shrinkage Product		60,0
Grading Coefficient		15,6
Grading Modulus		2,20
Atterberg Limits	Liquid Limit	27
	Plasticity Index	3,0
	Linear Shrinkage	2,0
	PI < 0.075	
Unified Soil Classification		GM
US Highway Classification		A-1-a(0)

D10= 0,070 D30= 0,425 D60= 18,000









% Clay = 0,6	% Silt = 3,3	% Sand = 30,1	% Gravel = 66,0

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

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Accreditation No. T0296
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Date Reported : 2020-08-12

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835
Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

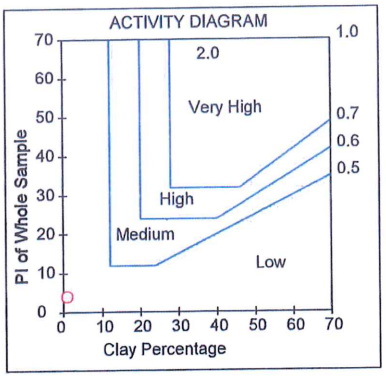
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

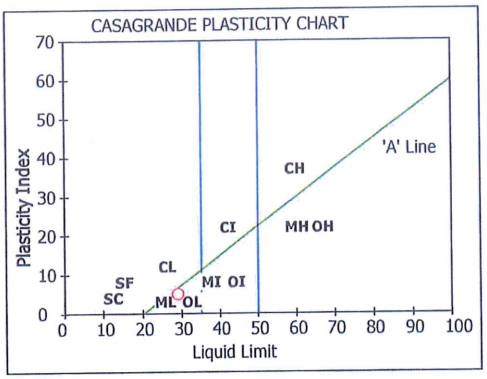
Sample No.	: U9287
Position	: TP 12
Layer Type	: 0-300mm
Sample Colour	: Orange Brown Sand
Sample Type	: Mix Quartzstone

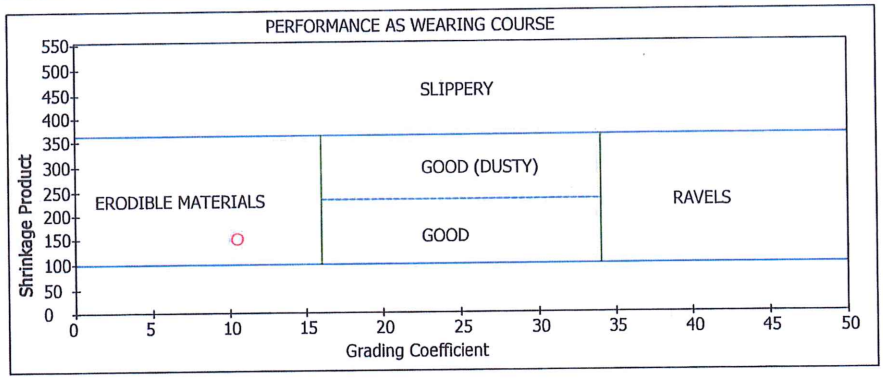
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	100
28.00	100
20.00	100
14.00	99
5.000	95
2.000	89
0.425	77
0.250	71
0.150	57
0.075	36
0.060	9,3
0.050	8,2
0.020	5,4
0.005	3,4
0.002	1,2

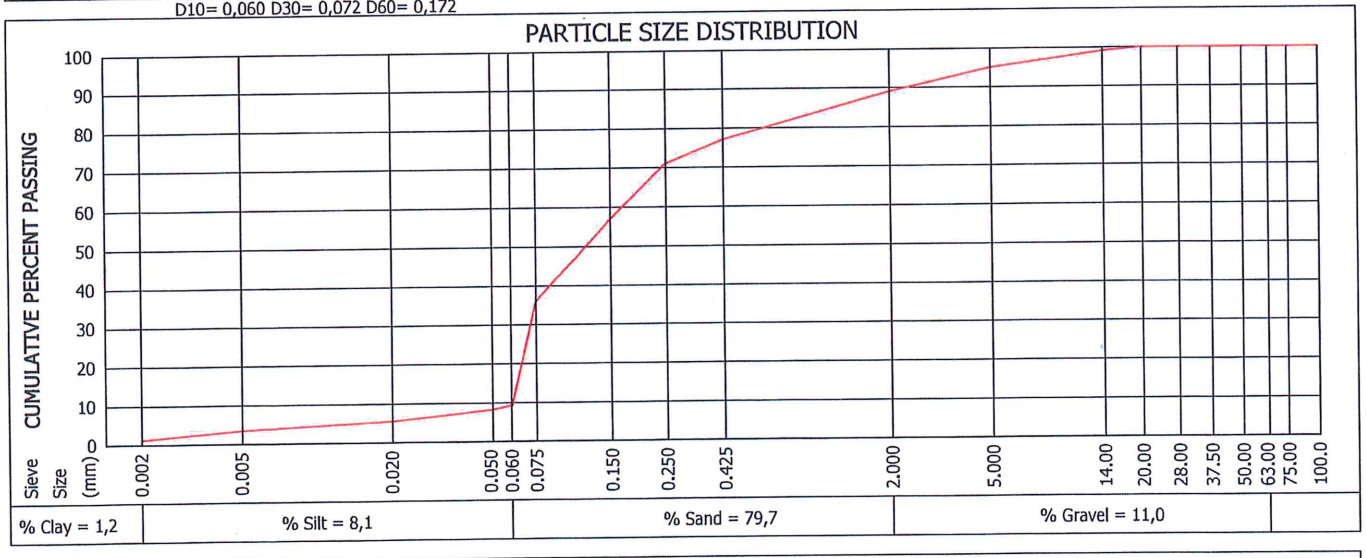
Soil Mortar	2.000 - 0.425	14
	0.425 - 0.250	7
	0.250 - 0.150	16
	0.150 - 0.075	24
	< 0.075	40
Effective Size		0,060
Uniformity Coefficient		2,9
Curvature Coefficient		0,5
Oversize Index		0,0
Shrinkage Product		154,0
Grading Coefficient		10,4
Grading Modulus		1,00
Atterberg Limits	Liquid Limit	29
	Plasticity Index	5
	Linear Shrinkage	2.0
	PI < 0.075	
Unified Soil Classification		SM
US Highway Classification		A-4(0)

D10= 0,060 D30= 0,072 D60= 0,172









% Clay = 1,2	% Silt = 8,1	% Sand = 79,7	% Gravel = 11,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.75 [SANS 5854] & Conductivity = 0.06 S/m [SANS 6240]

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

sanas Testing Laboratory
Accreditation No. T0296
Prog.ver 10.7 (2019/11/07)

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Job Request No.: RU3525

Date Reported : 2020-07-17

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

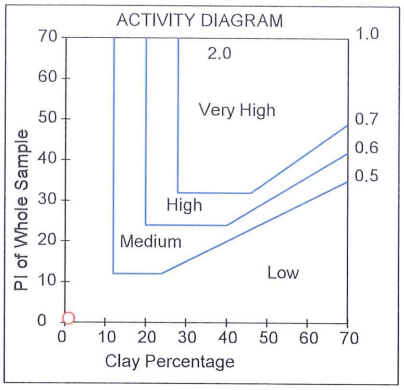
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

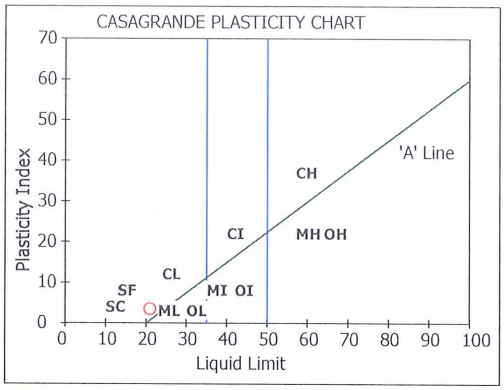
Sample No.	: U9280
Position	: TP 15
Layer Type	: 0-300mm
Sample Colour	: Brown Gravel
Sample Type	: Mix Calcretestone

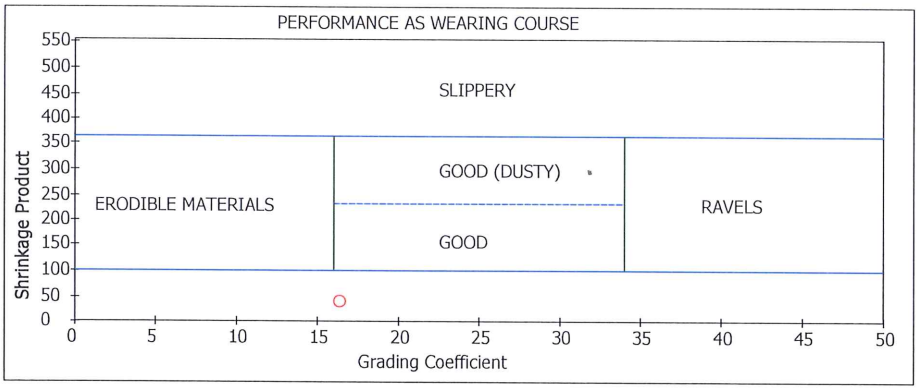
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	98
50.00	96
37.50	86
28.00	76
20.00	65
14.00	57
5.000	39
2.000	34
0.425	28
0.250	26
0.150	19
0.075	11
0.060	3,5
0.050	3,3
0.020	2,1
0.005	1,4
0.002	0,8

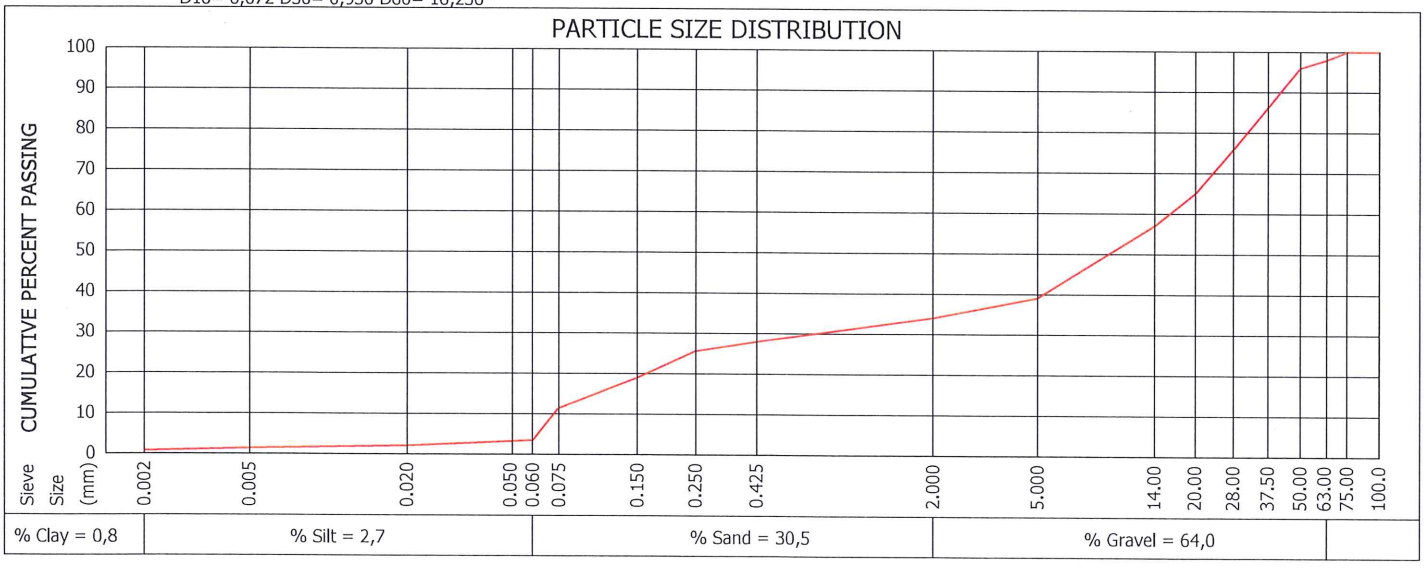
Soil Mortar	2.000 - 0.425	16
	0.425 - 0.250	8
	0.250 - 0.150	20
	0.150 - 0.075	24
	< 0.075	33
Effective Size		0,072
Uniformity Coefficient		225,7
Curvature Coefficient		0,8
Oversize Index		10,0
Shrinkage Product		42,0
Grading Coefficient		16,4
Grading Modulus		2,30
Atterberg Limits	Liquid Limit	21
	Plasticity Index	3.0
	Linear Shrinkage	1.5
	PI < 0.075	
Unified Soil Classification		GW-GC
US Highway Classification		A-1-a(0)

D10= 0,072 D30= 0,950 D60= 16,250









% Clay = 0,8	% Silt = 2,7	% Sand = 30,5	% Gravel = 64,0

Deviation from Test Method :
Remarks and Notes :

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Job Request No.: RU3525

Date Reported : 2020-07-24

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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Project : Opwag Infrastructure Upgrade

Attention : Frans Breytenbach

Determination of the California Bearing Ratio Test Report SANS 3001 - GR1 / GR2 / GR10 / GR20 / GR30 / GR40 / PR5

SAMPLE INFORMATION AND PROPERTIES

SAMPLE NO.	U9280			
HOLE NO./ Km / CHAINAGE	TP15			
ROAD NO./ NAME Line 1 ROAD NO./ NAME Line 2	S28° 50' 13,7" E21° 57' 29,3"			
LAYER TESTED/SAMPLED	0-300mm			
SAMPLE DEPTH	0-300mm			
DATE SAMPLED	2020-07-08			
COLOUR OF SAMPLE	Brown			
TYPE OF SAMPLE	Mix Calcretestone			

SIEVE ANALYSIS - % PASSING SIEVES *(SANS 3001-GR1:2010, SANS 3001-GR2:2010)

SIEVE ANALYSIS (GR 1) % PASSING	100.0 mm				
	75.0 mm	100			
	63.0 mm	98			
	50.0 mm	96			
	37.5 mm	86			
	28.0 mm	76			
	20.0 mm	65			
	14.0 mm	57			
	5.0 mm	39			
	2.0 mm	34			
	0.425 mm	28			
	0.075 mm	11			
GM %		2,3			

SOIL MORTAR ANALYSIS (SANS 3001-PR5:2011)

COARSE SAND	2.000 - 0.425	16			
COARSE FINE SAND	0.425 - 0.250	8			
MEDIUM FINE SAND	0.250 - 0.150	20			
FINE FINE SAND	0.150 - 0.075	24			
SILT CLAY	0.075	33			

ATTERBERG LIMITS ANALYSIS - *(SANS 3001-GR10:2010)

ATTERBERG LIMITS (%) SANS GR10,GR11	LIQUID LIMIT	21			
	PLASTICITY INDEX	3.3			
	LINEAR SHRINKAGE	1.5			
CLASSIFICATION	H.R.B.	A-1-a(0)			
	COLTO	G6			
	TRH 14	G6			

CALIFORNIA BEARING RATIO - *(SANS 3001-GR30:2010, SANS 3001-GR40:2010)

SANS GR30 MAX. DRY DENSITY	OMC %	7,4			
	MDD (kg/m³)	1895			
	COMP MC %	7,2			
SWELL % @	MOD | NRB | PRO	0,00 | 0,02 | 0,04			
C.B.R. SANS GR40	100 %	103			
	98 %	72			
	97 %	61			
	95 %	43			
	93 %	30			
	90 %	18			

STABILISER IN LAB	Not Applicable				
TEST TYPE	CBR				
SAMPLING METHOD	TMH 5				
WEATHER WHEN SAMPLED	Cold				

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
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Prog.ver 10.7 (2019/11/07)

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Job Request No.: RU3525

Date Reported : 2020-07-17

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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Project : Opwag Infrastructure Upgrade

Attention : Frans Breytenbach

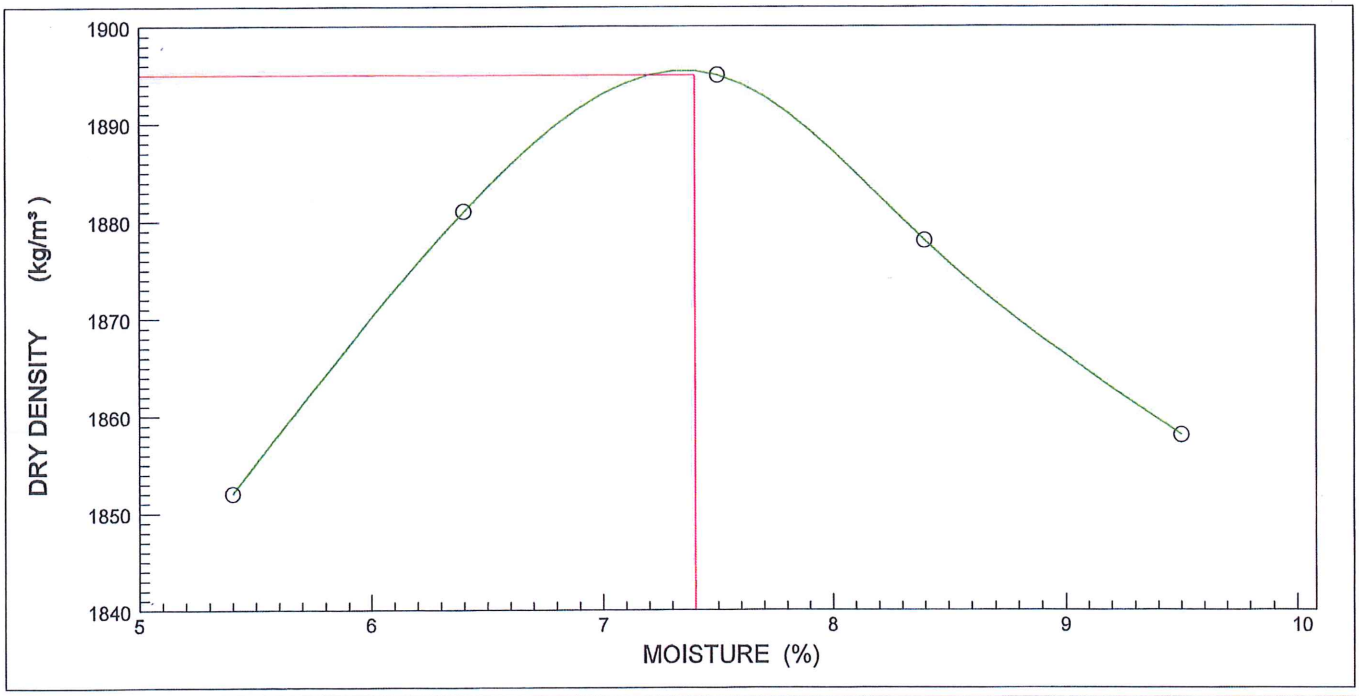
Determination Maximum Dry Density & Optimum Moisture Content Test Report

SANS 3001 - GR20/GR30

SAMPLE NO.	U9280
CONTAINER FOR SAMPLING	Black Bags
SIZE / APPROX. MASS OF SAMPLE	96kg
MOISTURE CONDITION OF SAMPLE	Moist
LAYER TESTED / SAMPLED FROM	0-300mm
MATERIAL DESCRIPTION	Mix Calcretestone
HOLE NO./ km / CHAINAGE	TP15
ROAD NO.	Not Specified
DATE RECEIVED	2020-07-09
DATE SAMPLED	2020-07-08
CLIENT MARKING	S28° 50' 13,7"; E21° 57' 29,3"
COLOUR AND TYPE	Brown Gravel

POINT NO.	1	2	3	4	5			
DRY DENSITY (kg/m³)	1852	1881	1895	1878	1858			
MOISTURE (%)	5,4	6,4	7,5	8,4	9,5			

MAXIMUM DRY DENSITY (kg/m³) : 1895	OPTIMUM MOISTURE CONTENT (%) : 7,4



Deviation from Test Method :
Remarks and Notes :

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The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
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Job Request No.: RU3525

Date Reported : 2020-08-06

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

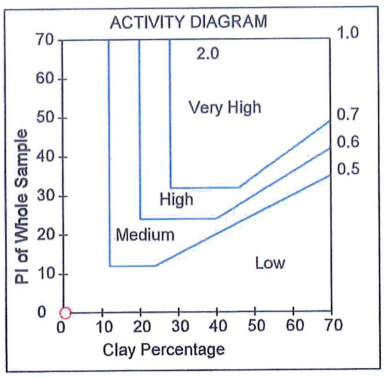
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

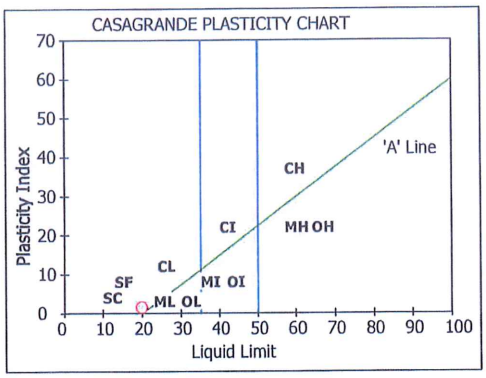
Sample No.	: U9288
Position	: TP 18
Layer Type	: 100-300mm
Sample Colour	: Brown Gravel
Sample Type	: Mix Calcrete+ OCC Qu

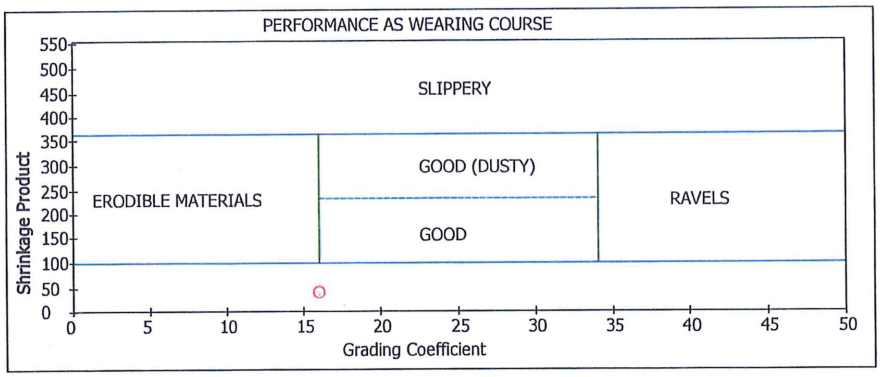
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	94
28.00	78
20.00	64
14.00	50
5.000	32
2.000	28
0.425	26
0.250	24
0.150	19
0.075	11
0.060	3,8
0.050	3,4
0.020	2,0
0.005	1,4
0.002	0,5

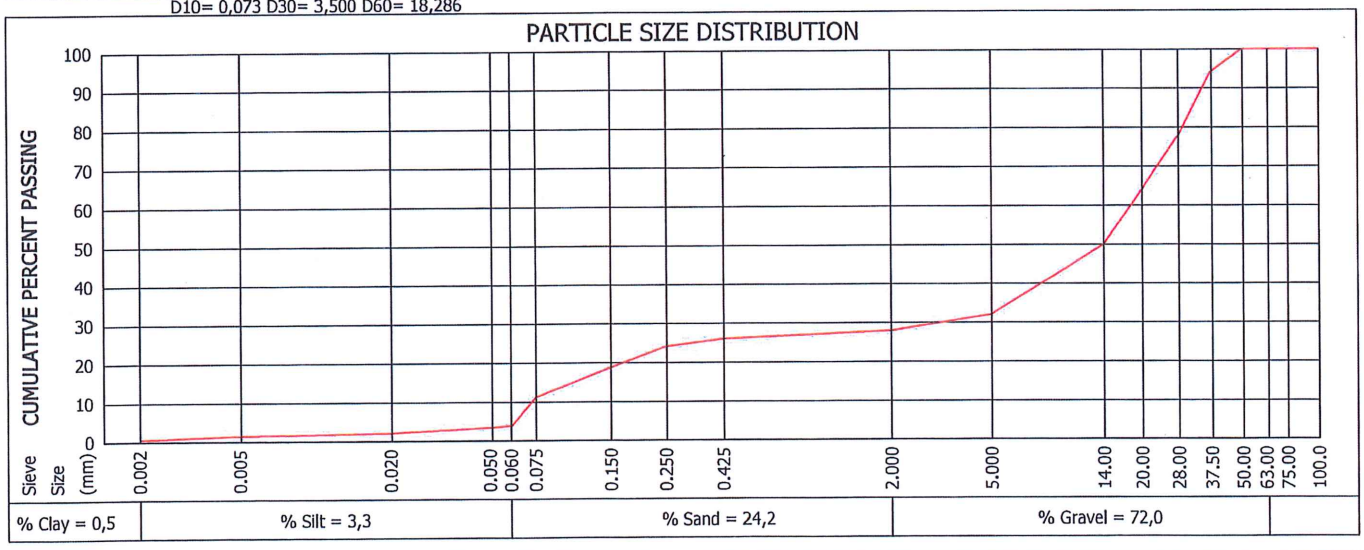
Soil Mortar	2.000 - 0.425	9
	0.425 - 0.250	7
	0.250 - 0.150	19
	0.150 - 0.075	27
	< 0.075	39
Effective Size		0,073
Uniformity Coefficient		250,5
Curvature Coefficient		9,2
Oversize Index		6,0
Shrinkage Product		39,0
Grading Coefficient		16,0
Grading Modulus		2,30
Atterberg Limits	Liquid Limit	20
	Plasticity Index	2.0
	Linear Shrinkage	1.5
	PI < 0.075	
Unified Soil Classification		GW-GC
US Highway Classification		A-1-a(0)

D10= 0,073 D30= 3,500 D60= 18,286









% Clay = 0,5	% Silt = 3,3	% Sand = 24,2	% Gravel = 72,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.83 [SANS 5854] & Conductivity = 0.13 S/m [SANS 6240]

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Job Request No.: RU3525

Date Reported : 2020-08-06

Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835

Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

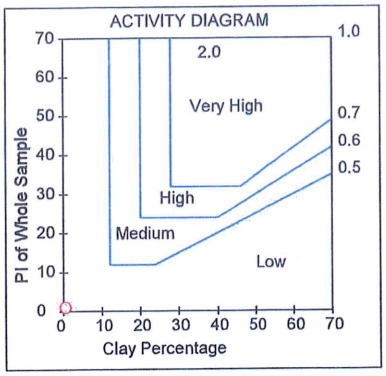
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

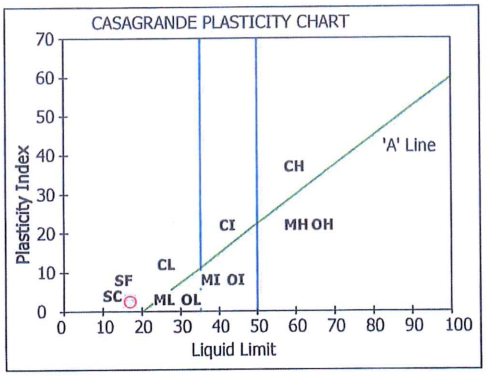
Sample No.	: U9289
Position	: TP 21
Layer Type	: 0-400mm
Sample Colour	: Reddish Brown Gravel
Sample Type	: Mix Calcrete+Quartzs

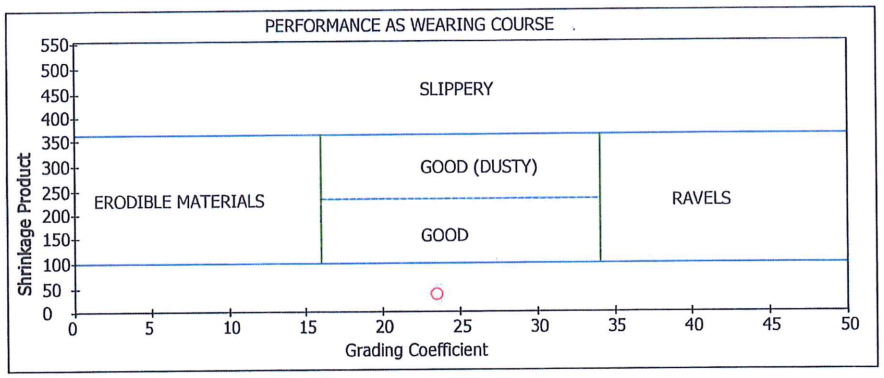
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	89
28.00	88
20.00	83
14.00	76
5.000	49
2.000	40
0.425	35
0.250	32
0.150	23
0.075	13
0.060	3,1
0.050	2,8
0.020	2,1
0.005	1,5
0.002	0,7

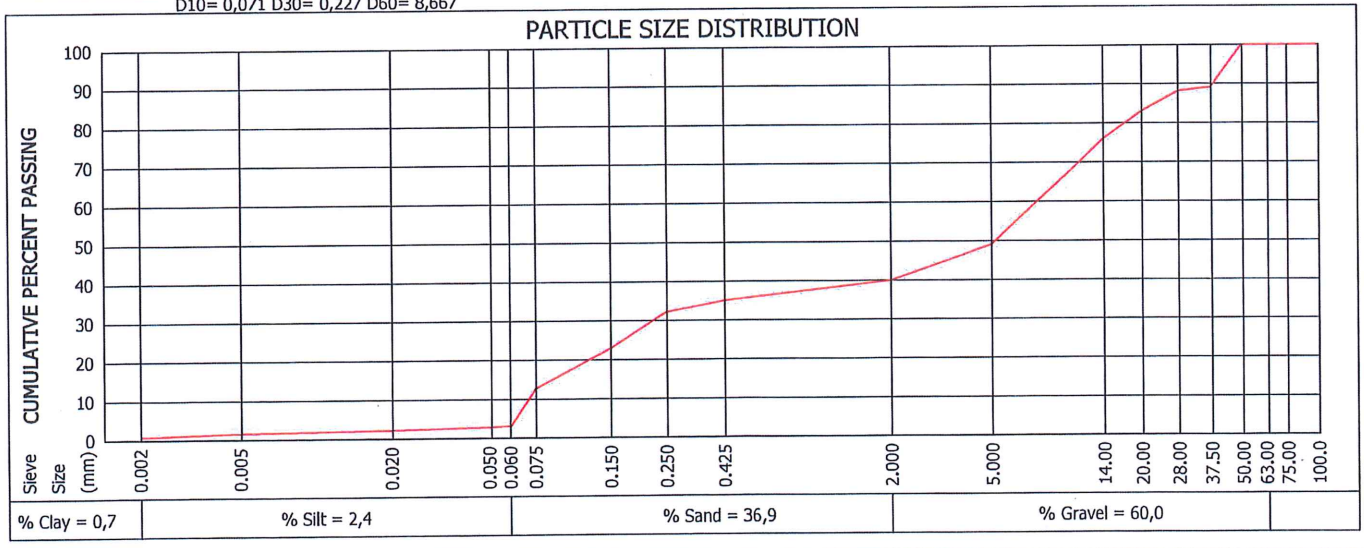
Soil Mortar	2.000 - 0.425	14
	0.425 - 0.250	6
	0.250 - 0.150	23
	0.150 - 0.075	25
	< 0.075	32
Effective Size		0,071
Uniformity Coefficient		122,1
Curvature Coefficient		0,1
Oversize Index		11,0
Shrinkage Product		35,0
Grading Coefficient		23,5
Grading Modulus		2,10
Atterberg Limits	Liquid Limit	17
	Plasticity Index	2,0
	Linear Shrinkage	1,0
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-b(0)

D10= 0,071 D30= 0,227 D60= 8,667









% Clay = 0,7	% Silt = 2,4	% Sand = 36,9	% Gravel = 60,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.69 [SANS 5854] & Conductivity = 0.09 S/m [SANS 6240]

Opinions and interpretations are not included in our scope of works. (T0296)
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Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

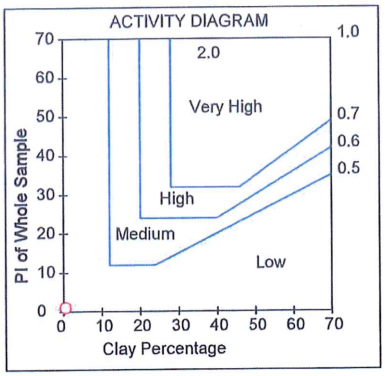
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

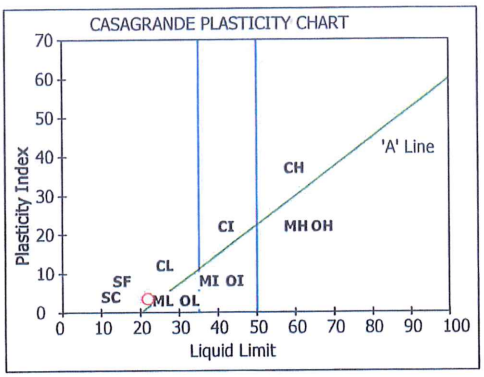
Sample No.	: U9290
Position	: TP 22
Layer Type	: 100-300mm
Sample Colour	: Brown Gravel
Sample Type	: Mix Calcretestone

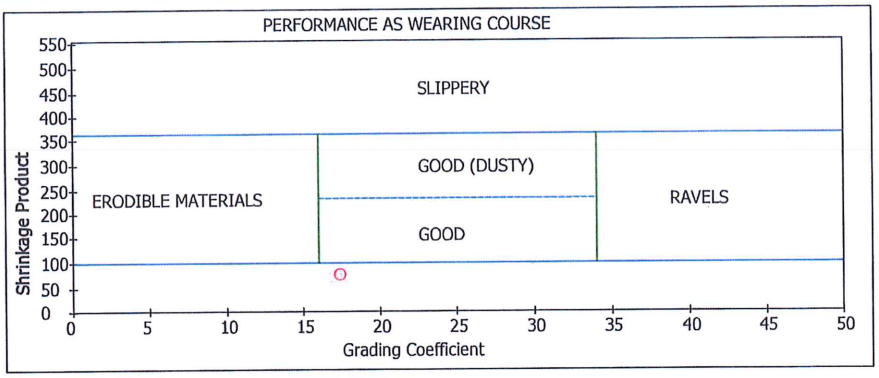
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	93
37.50	87
28.00	78
20.00	71
14.00	64
5.000	47
2.000	41
0.425	38
0.250	36
0.150	30
0.075	19
0.060	6,5
0.050	5,6
0.020	3,3
0.005	1,7
0.002	0,6

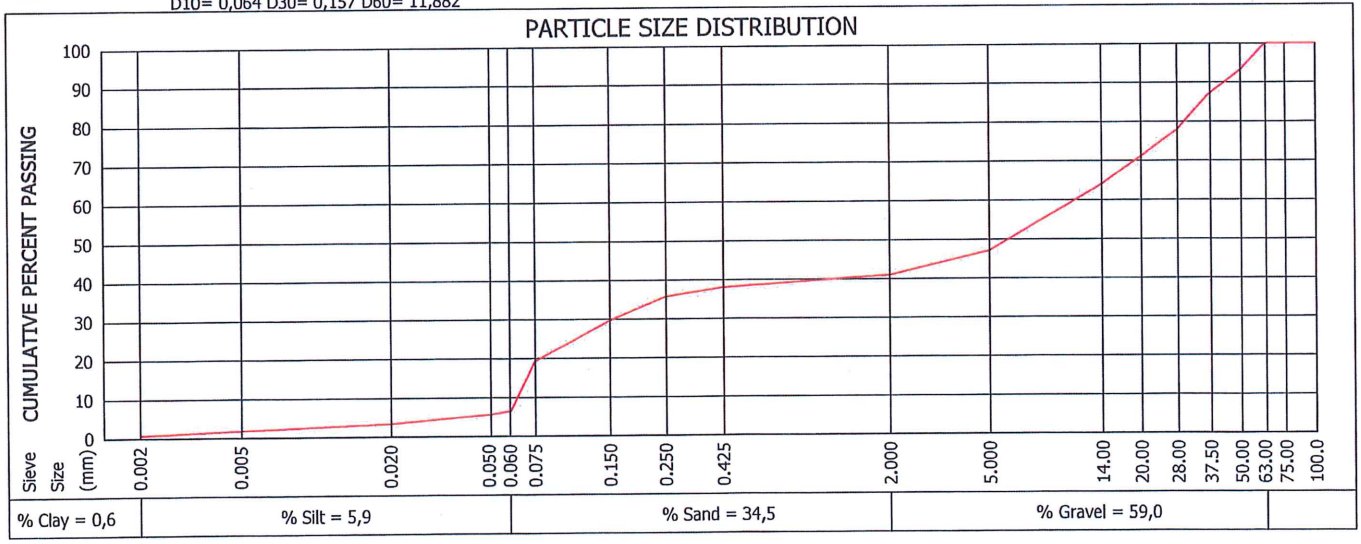
Soil Mortar	2.000 - 0.425	9
	0.425 - 0.250	4
	0.250 - 0.150	15
	0.150 - 0.075	26
	< 0.075	46
Effective Size		0,064
Uniformity Coefficient		185,7
Curvature Coefficient		0,0
Oversize Index		6,0
Shrinkage Product		76,0
Grading Coefficient		17,4
Grading Modulus		2,00
Atterberg Limits	Liquid Limit	22
	Plasticity Index	3.0
	Linear Shrinkage	2.0
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-b(0)

D10= 0,064 D30= 0,157 D60= 11,882









% Clay = 0,6	% Silt = 5,9	% Sand = 34,5	% Gravel = 59,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.83 [SANS 5854] & Conductivity = 0.10 S/m [SANS 6240]

Opinions and interpretations are not included in our scope of works. (T0296)
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sanas Testing Laboratory
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Prog.ver 10.7 (2019/11/07)

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Date Reported : 2020-08-06

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835
Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

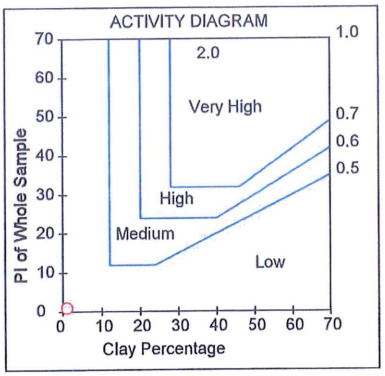
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

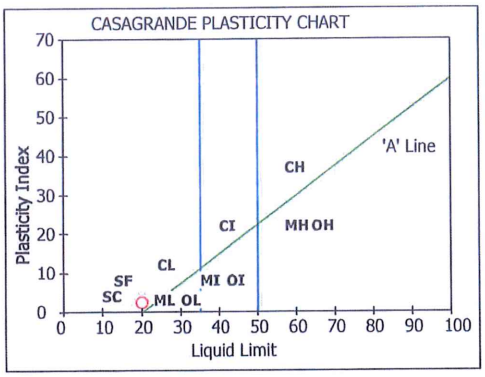
Sample No.	: U9291
Position	: TP 28
Layer Type	: 0-500mm
Sample Colour	: Orange Brown Gravel
Sample Type	: Mix Quartz

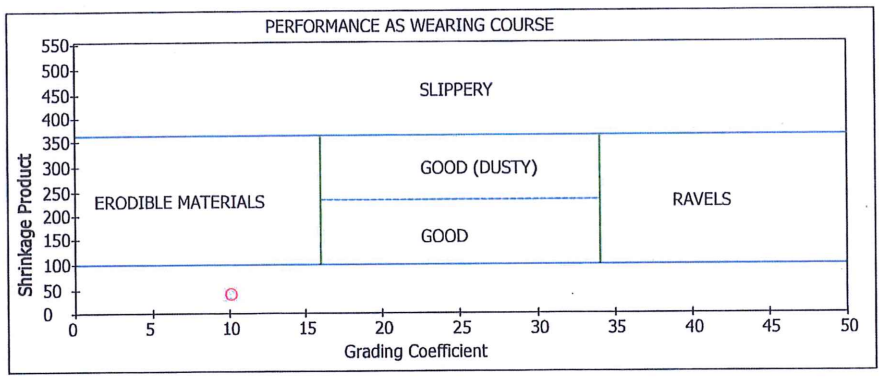
Sieve Size(mm)	% Passing
100.0	100
75.00	94
63.00	88
50.00	80
37.50	74
28.00	66
20.00	61
14.00	56
5.000	48
2.000	45
0.425	39
0.250	35
0.150	25
0.075	15
0.060	3,9
0.050	3,3
0.020	1,9
0.005	1,2
0.002	0,8

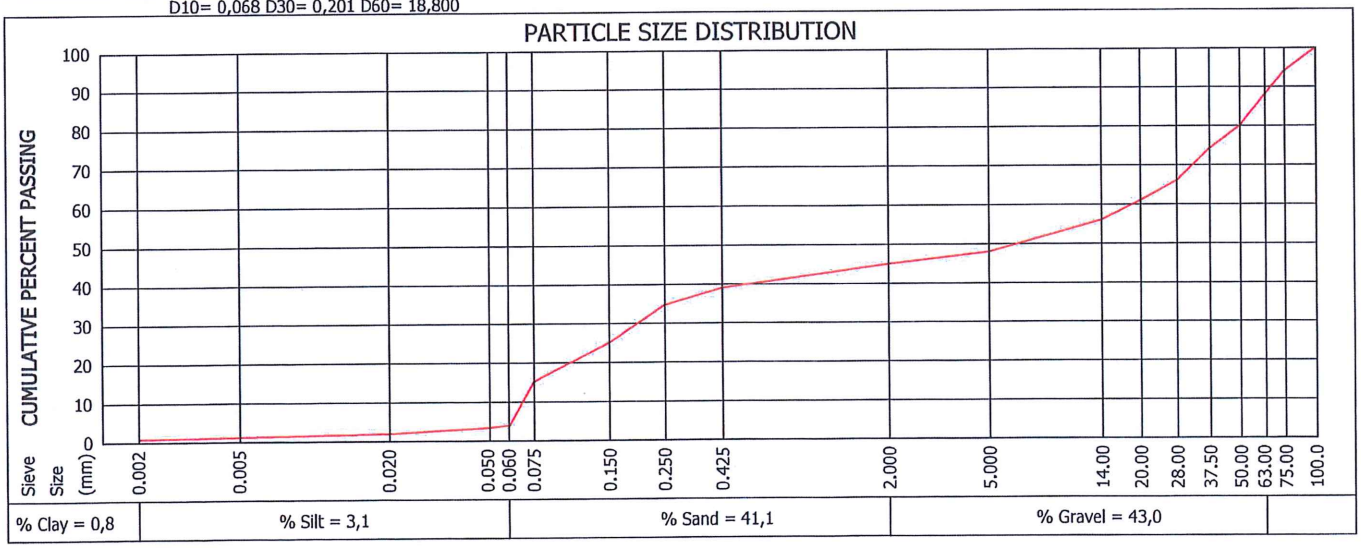
Soil Mortar	2.000 - 0.425	13
	0.425 - 0.250	10
	0.250 - 0.150	21
	0.150 - 0.075	23
	< 0.075	33
Effective Size		0,068
Uniformity Coefficient		276,5
Curvature Coefficient		0,0
Oversize Index		6,0
Shrinkage Product		39,0
Grading Coefficient		10,1
Grading Modulus		2,00
Atterberg Limits	Liquid Limit	20
	Plasticity Index	2.0
	Linear Shrinkage	1.0
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-b(0)

D10= 0,068 D30= 0,201 D60= 18,800









% Clay = 0,8	% Silt = 3,1	% Sand = 41,1	% Gravel = 43,0

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
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Job Request No.: RU3525

Date Reported : 2020-08-06

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Project : Opwag Infrastructure Upgrade

Attention : Frans Breytenbach

Determination of the California Bearing Ratio Test Report SANS 3001 - GR1 / GR2 / GR10 / GR20 / GR30 / GR40 / PR5

SAMPLE INFORMATION AND PROPERTIES

SAMPLE NO.	U9291			
HOLE NO./ Km / CHAINAGE	TP28			
ROAD NO./ NAME Line 1 ROAD NO./ NAME Line 2	S28° 50' 27,9" E21° 57' 29,7"			
LAYER TESTED/SAMPLED	0-500mm			
SAMPLE DEPTH	0-500mm			
DATE SAMPLED	2020-07-09			
COLOUR OF SAMPLE	Orange Brown			
TYPE OF SAMPLE	Mix Quartz			

SIEVE ANALYSIS - % PASSING SIEVES *(SANS 3001-GR1:2010, SANS 3001-GR2:2010)

SIEVE ANALYSIS (GR 1) % PASSING	100.0 mm	100			
	75.0 mm	99			
	63.0 mm	98			
	50.0 mm	97			
	37.5 mm	96			
	28.0 mm	95			
	20.0 mm	94			
	14.0 mm	89			
	5.0 mm	82			
	2.0 mm	79			
	0.425 mm	73			
	0.075 mm	28			
GM %		1,2			

SOIL MORTAR ANALYSIS (SANS 3001-PR5:2011)

COARSE SAND	2.000 - 0.425	7			
COARSE FINE SAND	0.425 - 0.250	11			
MEDIUM FINE SAND	0.250 - 0.150	22			
FINE FINE SAND	0.150 - 0.075	24			
SILT CLAY	0.075	36			

ATTERBERG LIMITS ANALYSIS - *(SANS 3001-GR10:2010)

ATTERBERG LIMITS (%) SANS GR10,GR11	LIQUID LIMIT	20			
	PLASTICITY INDEX	2.3			
	LINEAR SHRINKAGE	1.0			
CLASSIFICATION	H.R.B.	A-2-4(0)			
	COLTO	G6			
	TRH 14	G7			

CALIFORNIA BEARING RATIO - *(SANS 3001-GR30:2010, SANS 3001-GR40:2010)

SANS GR30 MAX. DRY DENSITY	OMC %	5,8			
	MDD (kg/m³)	2160			
	COMP MC %	6,2			
SWELL % @	MOD | NRB | PRO	0,01 | 0,04 | 0,06			
C.B.R. SANS GR40	100 %	54			
	98 %	41			
	97 %	36			
	95 %	28			
	93 %	21			
	90 %	14			

STABILISER IN LAB	Not Applicable			
TEST TYPE	CBR			
SAMPLING METHOD	TMH 5			
WEATHER WHEN SAMPLED	Cold			

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
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Job Request No.: RU3525

Date Reported : 2020-07-28

Ceder Land Geotechnical Consult (Pty) Ltd
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Project : Opwag Infrastructure Upgrade

Attention : Frans Breytenbach

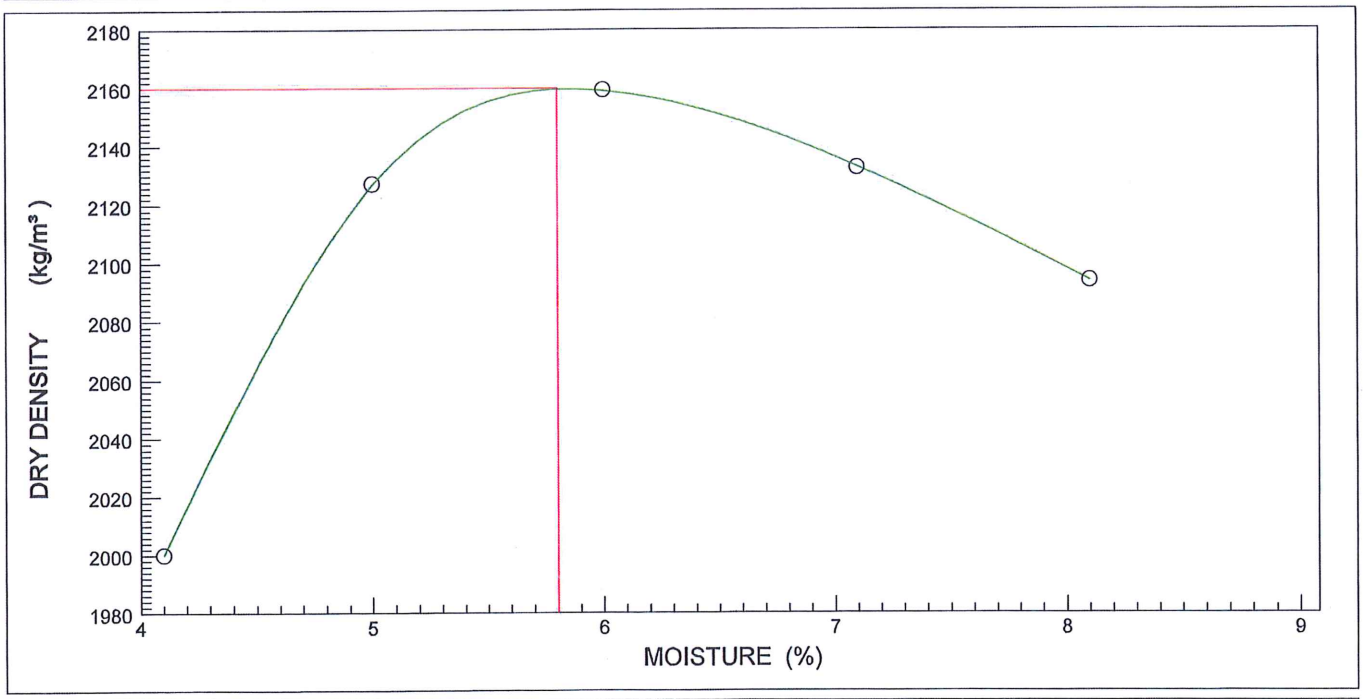
Determination Maximum Dry Density & Optimum Moisture Content Test Report

SANS 3001 - GR20/GR30

SAMPLE NO.	U9291
CONTAINER FOR SAMPLING	Black Bags
SIZE / APPROX. MASS OF SAMPLE	101kg
MOISTURE CONDITION OF SAMPLE	Moist
LAYER TESTED / SAMPLED FROM	0-500mm
MATERIAL DESCRIPTION	Mix Quartz
HOLE NO./ km / CHAINAGE	TP28
ROAD NO.	Not Specified
DATE RECEIVED	2020-07-10
DATE SAMPLED	2020-07-09
CLIENT MARKING	S28° 50' 27,9"; E21° 57' 29,7"
COLOUR AND TYPE	Orange Brown Gravel

POINT NO.	1	2	3	4	5			
DRY DENSITY (kg/m³)	2000	2127	2159	2133	2094			
MOISTURE (%)	4,1	5,0	6,0	7,1	8,1			

MAXIMUM DRY DENSITY (kg/m³) : 2160	OPTIMUM MOISTURE CONTENT (%) : 5,8



Deviation from Test Method :
Remarks and Notes :

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Job Request No.: RU3525
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Attention : Frans Breytenbach

Project : Opwag Infrastructure Upgrade

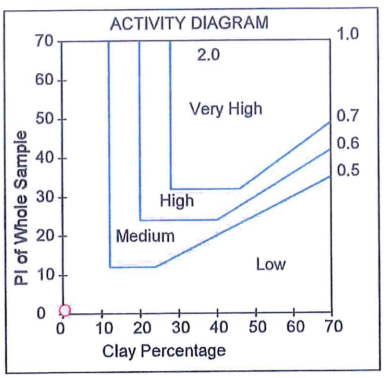
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

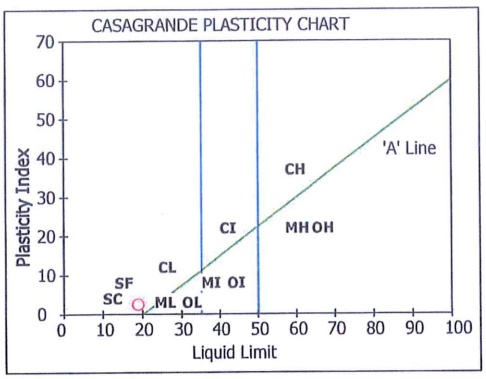
Sample No.	: U9292
Position	: TP 33
Layer Type	: 0-400mm
Sample Colour	: Reddish Brown Gravel
Sample Type	: Mix Calcrete+Quartz

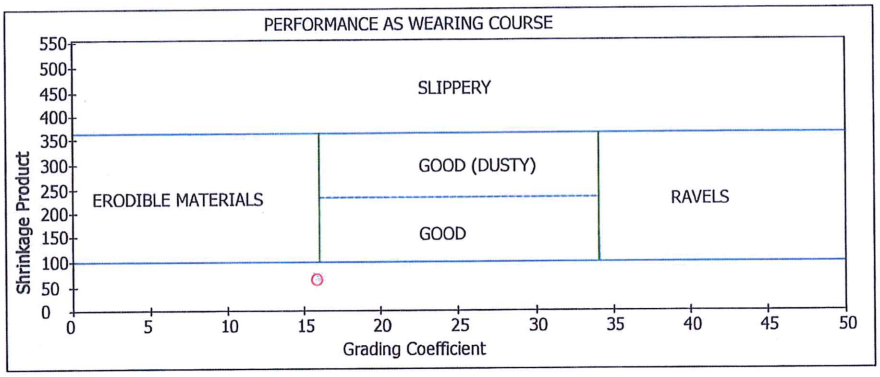
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	89
28.00	78
20.00	72
14.00	66
5.000	48
2.000	45
0.425	43
0.250	40
0.150	27
0.075	14
0.060	4,8
0.050	4,1
0.020	2,3
0.005	1,5
0.002	0,4

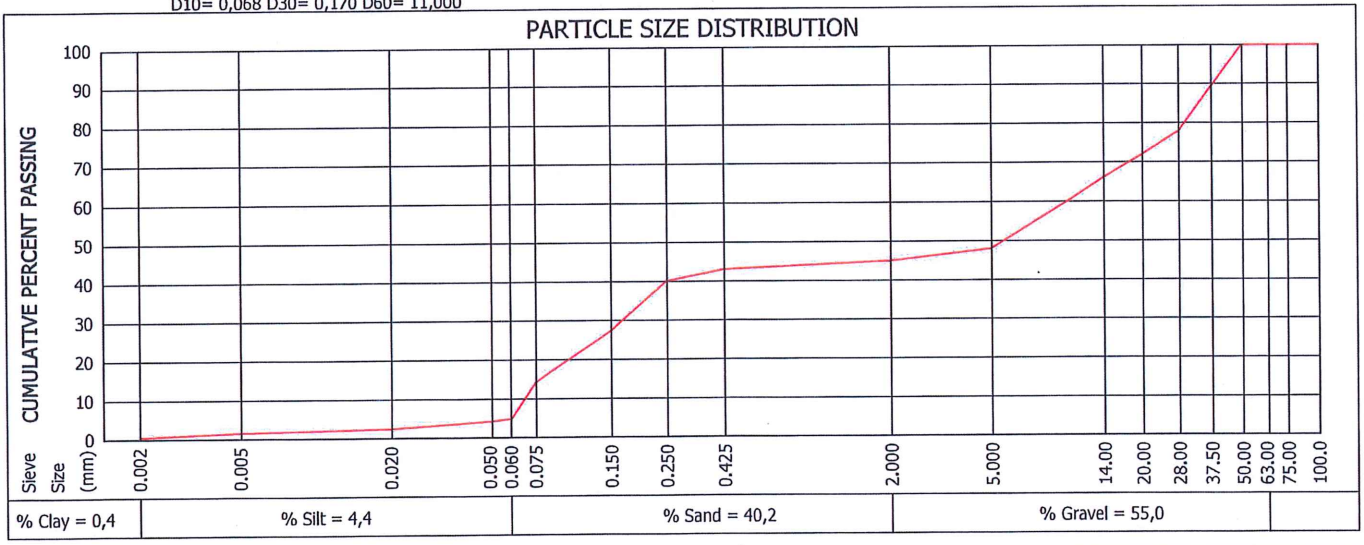
Soil Mortar	2.000 - 0.425	4
	0.425 - 0.250	7
	0.250 - 0.150	28
	0.150 - 0.075	30
	< 0.075	31
Effective Size		0,068
Uniformity Coefficient		161,8
Curvature Coefficient		0,0
Oversize Index		11,0
Shrinkage Product		64,5
Grading Coefficient		15,8
Grading Modulus		2,00
Atterberg Limits	Liquid Limit	19
	Plasticity Index	2.0
	Linear Shrinkage	1.5
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-b(0)

D10= 0,068 D30= 0,170 D60= 11,000









% Clay = 0,4	% Silt = 4,4	% Sand = 40,2	% Gravel = 55,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.21 [SANS 5854] & Conductivity = 0.10 S/m [SANS 6240]

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