CORE GEOTECHNICAL CONSULTANTS
Engineering Geology and Geohydrology

23 April 2015

Bergstan SA
P O Box 4733
Cape Town
8000

**ATTENTION: Mr G Honeyman**

Dear Glenn

**PROJECT 044-15 STELLENBOSCH PARADYSKLOOF – PORTION 1 FARM 372 – GEOTECHNICAL INVESTIGATION FOR RESIDENTIAL UNITS**

At your request, we have carried out a geotechnical investigation for the proposed single and double storey units on Portion 1 Farm 372 in Paradyskloof, Stellenbosch.

The objectives of this investigation were to determine site geotechnical conditions and to give recommendations for the design of foundations and surface beds. Related geotechnical aspects to be addressed included excavation conditions, materials usage, subgrade and pavement design aspects and drainage.

Site layout plans, contour plans and sections were provided to assist in planning the field investigation.

Our findings and recommendations are outlined in this report.

## 1. Nature of the investigation

The investigation comprised:-

a) A walkover survey of the site to assess broad site topographic and ground surface conditions

b) Excavation of six test pits, using a digger-loader, coupled with inspection, formal soil profiling and selective sampling

c) Laboratory indicator testing (moisture content, grading and Atterberg Limits analyses to assess basic soils engineering properties of the in-situ soils

Test positions are shown on the enclosed site plan. Copies of the recorded test pit soil profiles, and laboratory test results are also attached.

## 2. Site geology and geohydrology

The site is underlain from surface by Recent unconsolidated sandy silts, silty clays and gravelly sandy silts of colluvial (transported) origin, which occur to depths of between 0.6 m and 2.0 m. The colluvial deposits essentially comprise soft or firm to stiff clayey soils with variable sand, clay and silt contents and thickness. These soils extend to greater depths over the north eastern portion of the site and decrease in depth towards the south west. Alluvial soils underly the colluvial horizons in all test pits except for TP 5 and TP 6. These alluvial soils are most likely associated with the stream/drainage line that intersects the site to the north.

Residual shales of the Malmesbury Group consist of clayey silts and underlie the colluvium and alluvium as observed in all test pits except for TP 1 and TP 2. In the remaining test pits these

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**CC no.** CK96/62430/23 **VAT no:** 4180186159 Ad Libertum CC t/a Core Geotechnical Consultants
**Members:** JRC Yates – MSc.(Eng.Geol.),DIC,BSc(Geol.),MSAIEG,Pr.Sci.Nat., RL Yates – Dip. Coaching & Communication (SACAP), CEA

residual soils were intersected at depths of between 1.3 m to 1.6 m. Weathered shale of rock consistency is expected to occur at depth below the residual soils, but was not encountered in this investigation.

Detailed descriptions of the soils underlying the site and encountered in test pits, may be found in the recorded test pit soils profiles.

Perched groundwater was intersected towards the north eastern portion of the site. The perched water levels are possibly hydraulically linked to the adjacent stream and may rise during wet winters or after intensive rainfall events and direct infiltration and recharge.

The main water table is expected to occur at depth in the shale rock aquifers. As such, it should not influence the proposed development directly.

## 3. Geotechnical evaluation

On the basis of the field investigation and the laboratory test results, summarised in Table 3.1, the following points relating to site geotechnical conditions and constraints, may be made:-

a) The colluvial and alluvial soils are variable in composition and consistency. Due to these variations the transported soils are moderately to highly compressible and therefore not suitable for use as a founding horizon unless special foundations are utilized.
b) The residual shale soils underlying the transported soils, are moderately compressible but exhibit a potentially expansive soil fabric. Whilst these soils can be used as a load-bearing founding horizon, structural design will have to accommodate potential heave movements (as seen in Table 3.1).

**Table 3.1 Summary of Soils Engineering Properties**

| Test Pit | Depth (m) | Material Description | LL | PI | GM | TRH14 classification | Estimated total heave (mm) |
|---|---|---|---|---|---|---|---|
| 3 | 1.7 | Residual clayey silt | 22 | 6 | 0.42 | G10 | 5 -10 |

Key: LL – liquid limit. PI – plasticity index. S-P – slightly plastic. GM – grading modulus.

c) In terms of material properties, the colluvial and alluvial soils are fine grained and will have a low post-compaction strength with CBR values in the range 1-3 forming a poor construction material. The underlying residual shale soils are also fine grained, plastic and expected to exhibit low recompacted strength (CBR1-2). Broad engineering characteristics of soils are outlined in Table 3.2.
d) The nature of the silty soils at surface indicates that they may well be fairly susceptible to erosion by water. Safe slope angles in cuts will be of the order of 30-35° to the horizontal. Appropriate design precautions will therefore be necessary.

In terms of the NHBRC GFSH-2 specification, the broad Site Classifications are **S1/S2** and **S1/H1**. The extent of these areas is shown on the site plan (enclosed).

**Table 3.2 Engineering Properties of Compacted Materials**

| Material | Potential usage | Shear strength when compacted | Drainage character -istics | Workability as a construction material | TRH 14 classifi-cation |
|---|---|---|---|---|---|
| Colluvium/ Alluvium | Subgrade once recompacted/landscaping | Low | Poor | Poor | G9 - G10 |
| Residual shale | Spoil or landscaping | Very low | Very poor | Poor | G10 |

## 4. Recommendations for design and construction

In summary of the geotechnical evaluation the following recommendations are pertinent for the single storey and double storey structures envisaged:

In the area with the classification of S1/H1 (see site plan):-

- Structures may be founded conventionally using deep strip or spread footings (see Table 4.1) founded through any transported soils into stiff residual shales at depths of between 1.3 m to 1.6 m below present ground surface. A maximum allowable bearing pressure of 120 kPa is applicable under these conditions and structures should be designed for total heave movements of 5 mm to 10 mm. Differential movement should be taken as being 50% of total settlement.

In areas with the classification of S1/S2 (see site plan):-

- It is recommended that this area be avoided if possible. It could possibly form a green belt/recreational area. Alternatively if construction in this area is required then the following should be considered:
- Structures may be founded using stiffened raft or piled foundations (see Table 4.1). Additional investigations will be required if these options are considered.

**Table 4.1 Summary of founding options and allowable bearing capacity with depth and soil type**

| Site class classification | Founding option | Founding horizon | Expected range of founding depths (m bgl) | Maximum allowable bearing pressure (kPa) | Preliminary prediceted total settlements (mm) | Comment |
|---|---|---|---|---|---|---|
| S1/H1 | Conventional strip or spread foundations | Stiff residual shales | ±1.3 – 1.6 | 120 | 5 - 10 (Single and double storey) | Bearing pressures may be higher if less weathered shale rock is intersected |
| S1/S2 | Piled foundations. Suitable pile types include driven displacement, forum bored or CFA piles | Stiff to very stiff residual shale or very soft rock to soft rock shale | 8.0 – 10.0 | Design dependent | >5 (Single and double storey) | DPSH deep probe testing or rotary core drilling will be required to determine founding depths and for pile design parameters |
| S1/S2 | Stiffened raft foundations | In very dense colluvial soils | 0.3 | 30 (Single storey)<br>60 (Double storey) | 10 - 15 (Single storey)<br>15 – 20 (Double storey) | This method assumes that the upper colluvium is very dense/stiff to 1.8m throughout. DPSH deep probe testing will be required |

All structures that are not founded using piles will require formal modified normal construction techniques to be applied. It is recommended that long wall panels are articulated using full construction joints in order to minimize the risk of cracking in brickwork. Guidelines contained in the NHBRC Home Building Manual should also be applied. Structures founded on piles can be constructed using normal construction techniques.

Preliminary settlement calculations have been based on soil profiles descriptions. To better define the magnitude of settlement in the S1/S2 areas, DPSH deep probe testing would be required. Another factor to consider is potential differential settlements in these areas – these could be exacerbated by the possible presence of underlying palaeo-channels, in which the alluvial soils are deposited by fluvial action. These channels can be sporadically placed and often have near vertical sidewalls, creating a rapid change from shallow underlying residual shales to much softer and more compressible transported soils, as one moves towards the drainage line. The interpolated boundary between the two site classifications should therefore be considered as an approximation based on available information. The soil conditions could vary between the two extremes for a distance of up to approximately 20 m on either side of the interpolated line (see site plan).

It is recommended that a geotechnical engineer inspect foundation excavations prior to casting concrete in order to confirm that founding conditions are compatible with the foundation design, and some allowance should be made for this.

As regards bulk earthworks, soils taken from cut are expected to be fairly silty/clayey and, as such, relatively difficult to compact, even to 93 % of Mod AASHTO maximum dry density. Close compaction control will be necessary to achieve any reasonable densities in area where surface beds will be founded on compacted colluvial and alluvial soils. It may be necessary to bring in a selected granular material where better-quality material is required. Surface beds should be designed to cater for minor heave movements and any backfill below surface beds should comprise a selected granular material and be compacted to at least 93 % of Mod AASHTO maximum dry density. Alternatively in the S1/S2 area, one may wish to consider designing surface beds as suspended slabs. This is due to the added risk of long term settlement within the colluvial and alluvial soils.

Close attention to drainage and the effective collection and disposal of storm water run-off is required throughout the site as part of surface erosion management. Roads should also be constructed with adequate drainage to minimize the possible effects of seasonal shallow perched ground water and surface water run-off and to prevent deterioration of the upper layer works (base course and sub-base layers).

Measures to prevent water ingress into soils below foundations are also required. These would include grading of slopes to promote run-off and prevent ponding close to houses, effective collection and removal off site of storm water and water from downpipes and regular checking of wet services for leaks.

We trust that this report meets your present requirements and would be pleased to discuss any aspects with you.

Kind regards

**JOHN YATES**

**MATTHEW JONES**

encl.

Site plan Test pit soil profiles (6) Laboratory test results (1)


**KEY**

TP - Test Pit

CORE GEOTECHNICAL CONSULTANTS
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**Physical address:** Unitb1, Clareview Business Park, 236 Imam Haron Road, Claremont, 7708

| | | | | | |
|---|---|---|---|---|---|
| **CLIENT:** BERGSTAN SA | | | | | |
| **PROJECT:** STELLENBOSCH PARADYSKLOOF | | | | | |
| **TITLE:** SITE PLAN SHOWING TEST PIT POSITIONS | | | | | |
| **DATE:** | Apr-15 | **TRACED BY:** | SS | | |
| **SCALE:** | NTS | **FIG.NO.** | 1 | **JOB NO.** | 044-15 |

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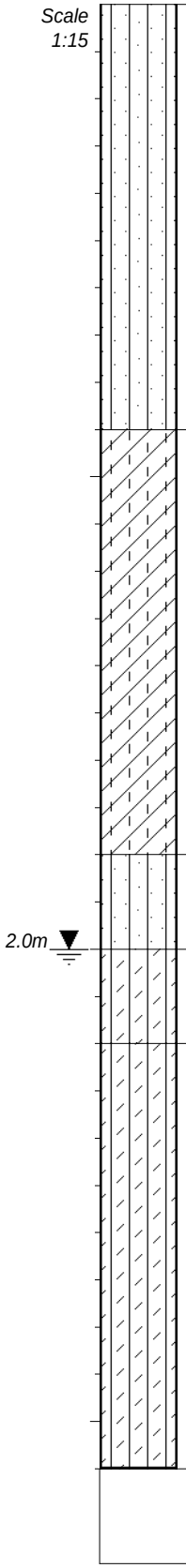
**Stellenbosch - Paradyskloof development**

TEST PIT SOIL PROFILES

*HOLE No:* TP01
*Sheet 1 of 1*

*JOB NUMBER:* 044-15




*0.00* Dry light grey very dense intact sandy silt.
Colluvial

*0.90* Moist dark grey stiff intact silty clay.
Colluvial

*1.80* Wet light grey loose intact sandy silt.
Colluvial

*2.00* Moist orange brown soft intact clayey silt.
Alluvial

*2.20* Moist orange brown firm intact clayey silt.
Alluvial

*3.10*

NOTES

1) Water pours from water table at 2.0m.

2) No refusal of TLB.

3) No sample

*CONTRACTOR :*
*MACHINE :* TLB
*DRILLED BY :*
*PROFILED BY :* Matthew Jones

*LOCATION* MALMESBURY
*DIAM :*
*DATE :*
*DATE :* 27 March 2015

*COLLAR LEVEL :* gl
*X COORD :* 33 57 38.8 S
*Y COORD :* 18 51 27.6 E

*HOLE No:* TP01

*TYPE SET BY :* Matthew Jones
*SETUP FILE :* STANDARD.SET

*DATE :* 15/04/2015 13:22
*TEXT :* ..of04415\Paradyskloof.txt

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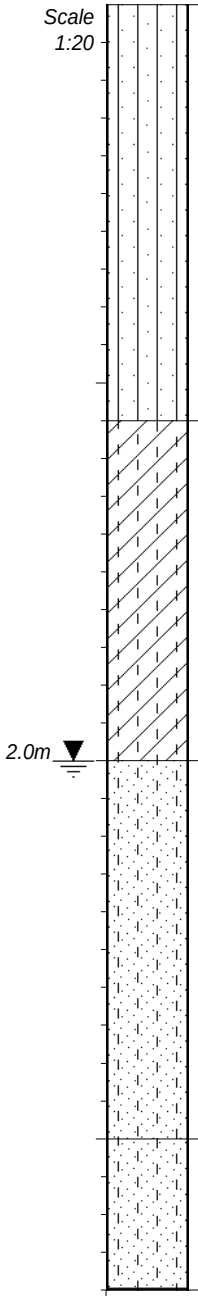
**Stellenbosch - Paradyskloof development**

TEST PIT SOIL PROFILES

*HOLE No:* TP02
*Sheet 1 of 1*

*JOB NUMBER:* 044-15




*0.00*
Dry light grey very dense intact sandy silt.
Colluvial

*1.10*
Moist dark grey stiff intact silty clay.
Colluvial

*2.00*
Wet dark grey medium dense intact silty sand.
Alluvial

*3.00*
Wet light grey brown loose intact silty sand.
Alluvial

*3.40*

NOTES

1) Water pours from water table at 2.0m.

2) No refusal of tlb.

3) No sample

*CONTRACTOR :*
*MACHINE :* TLB
*DRILLED BY :*
*PROFILED BY :* Matthew Jones

*TYPE SET BY :* Matthew Jones
*SETUP FILE :* STANDARD.SET

*LOCATION:*
*DIAM :*
*DATE :*
*DATE :* 27 March 2015

*DATE :* 15/04/2015 13:22
*TEXT :* ..of04415\Paradyskloof.txt

*COLLAR LEVEL :*
*X COORD :* 33 57 37.0 S
*Y COORD :* 18 51 25.4 E

*HOLE No:* TP02

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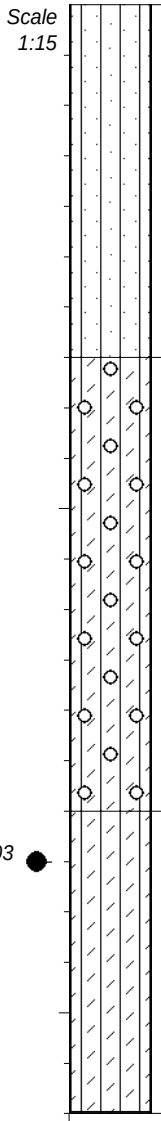
**Stellenbosch - Paradyskloof development**

TEST PIT SOIL PROFILES

*HOLE No:* TP03
*Sheet 1 of 1*

*JOB NUMBER:* 044-15




*0.00*

Dry light brown very dense intact gravelly sandy silt.
Colluvial.

*0.70*

Slightly moist orange brown dense intact gravelly clayey silt.
Alluvial

*1.60*

Moist orange brown stiff intact clayey silt.
Residual shale.

*2.20*

NOTES

1) No water table

2) TLB stopped.

3) BULK03 sample at 1.7m.

*CONTRACTOR :*
*MACHINE :* TLB
*DRILLED BY :*
*PROFILED BY :* Matthew Jones

*TYPE SET BY :* Matthew Jones
*SETUP FILE :* STANDARD.SET

*LOCATION:*
*DIAM :*
*DATE :*
*DATE :* 27 March 2015

*DATE :* 15/04/2015 13:22
*TEXT :* ..of04415\Paradyskloof.txt

*COLLAR LEVEL :* gl
*X COORD :* 33 57 39.1 S
*Y COORD :* 18 51 25.1 E

*HOLE No:* TP03

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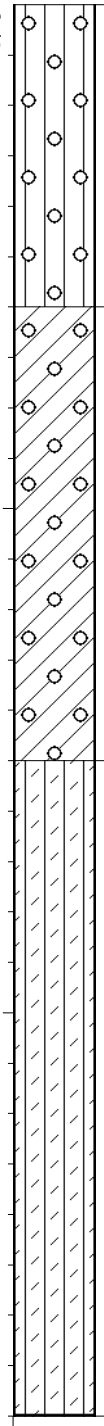
**Stellenbosch - Paradyskloof development**

TEST PIT SOIL PROFILES

*HOLE No:* TP04
*Sheet 1 of 1*

*JOB NUMBER:* 044-15

*Scale 1:15*



*0.00* Dry light grey brown very dense intact gravelly silt.
Colluvial.

*0.60* Slightly moist orange brown dense intact gravelly clay.
Alluvial

*1.50* Slightly moist orange brown streaked maroon stiff intact clayey silt.
Residual shale.

*2.80*

NOTES

1) No seepage.

2) TLB stopped.

*CONTRACTOR :*
*MACHINE :* TLB
*DRILLED BY :*
*PROFILED BY :* Matthew Jones

*TYPE SET BY :* Matthew Jones
*SETUP FILE :* STANDARD.SET

*LOCATION:*
*DIAM :*
*DATE :*
*DATE :* 27 March 2015

*DATE :* 15/04/2015 13:22
*TEXT :* ..of04415\Paradyskloof.txt

*COLLAR LEVEL :* gl
*X COORD :* 33 57 40.8 S
*Y COORD :* 18 51 24.7 E

*HOLE No:* TP04

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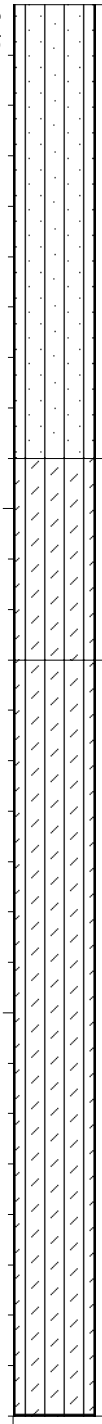
**Stellenbosch - Paradyskloof development**

TEST PIT SOIL PROFILES

*HOLE No:* TP05
*Sheet 1 of 1*

*JOB NUMBER:* 044-15

*Scale 1:15*



*0.00* Dry light brown dense intact gravelly sandy silt.
Colluvial.

*0.90* Slightly moist orange brown streaked maroon firm intact clayey silt.
Residual shale

*1.30* Slightly moist orange brown streaked maroon stiff intact clayey silt.
Residual shale.

*2.80*

NOTES

1) No seepage.

2) TLB stopped

*CONTRACTOR :*
*MACHINE :* TLB
*DRILLED BY :*
*PROFILED BY :* Matthew Jones

*TYPE SET BY :* Matthew Jones
*SETUP FILE :* STANDARD.SET

*LOCATION:*
*DIAM :*
*DATE :*
*DATE :* 27 March 2015

*DATE :* 15/04/2015 13:22
*TEXT :* ..of04415\Paradyskloof.txt

*COLLAR LEVEL :* gl
*X COORD :* 33 57 41.5 S
*Y COORD :* 18 51 23.4 E

*HOLE No:* TP05

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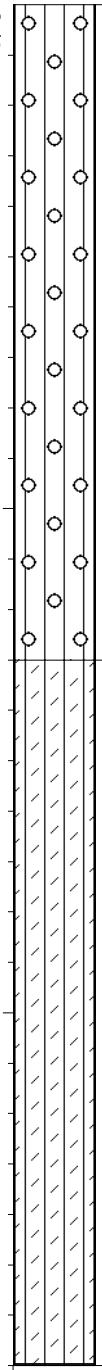
**Stellenbosch - Paradyskloof development**

TEST PIT SOIL PROFILES

*HOLE No:* TP06
*Sheet 1 of 1*

*JOB NUMBER:* 044-15

*Scale 1:15*



*0.00* Dry light brown dense intact gravelly silt.
Colluvial.

*1.30* Slightly moist orange brown streaked maroon stiff intact clayey silt.
Residual shale.

*2.70*

NOTES

1) No seepage.

2) Not refusal.

*CONTRACTOR :*
*MACHINE :* TLB
*DRILLED BY :*
*PROFILED BY :* Matthew Jones

*TYPE SET BY :* Matthew Jones
*SETUP FILE :* STANDARD.SET

*LOCATION:*
*DIAM :*
*DATE :*
*DATE :* 27 March 2015

*DATE :* 15/04/2015 13:22
*TEXT :* ..of04415\Paradyskloof.txt

*COLLAR LEVEL :* gl
*X COORD :* 33 57 39.2 S
*Y COORD :* 18 51 22.5 E

*HOLE No:* TP06

GEOSCIENCE LABORATORIES (PTY) LTD

| | | | |
|---|---|---|---|
| **CLIENT:** | Core Geotechnical<br>Postnet Suite 177<br>Private Bag X3<br>Plumstead 7801 | **PROJECT:** | Stellenbosch Paradyskloof |
| | | **DATE:** | 07-04-2015 |
| **ATT:** | John Yates | **REF:** | L150347 |

# *ASTM D422 SIEVE ANALYSIS*

| | | | |
|---|---|---|---|
| **DESCRIPTION :** | olive yellow silty clay | **SAMPLE NO. :** | 24699 |
| **POSITION :** | TH 3 @ 1.7m | **CLIENT SAMPLE NO. :** | |

| Sieve Analysis | | Percent Passing |
|---|---|---|
| SIEVE SIZE (mm) | 75.00 | |
| | 63.00 | |
| | 53.00 | |
| | 37.50 | |
| | 26.50 | |
| | 19.00 | |
| | 13.20 | |
| | 9.50 | 100 |
| | 6.70 | 99 |
| | 4.75 | 98 |
| | 2.36 | 96 |
| | 2.00 | 96 |
| | 1.18 | 95 |
| | 0.600 | 94 |
| | 0.425 | 92 |
| | 0.300 | 89 |
| | 0.150 | 80 |
| | 0.0750 | 70 |

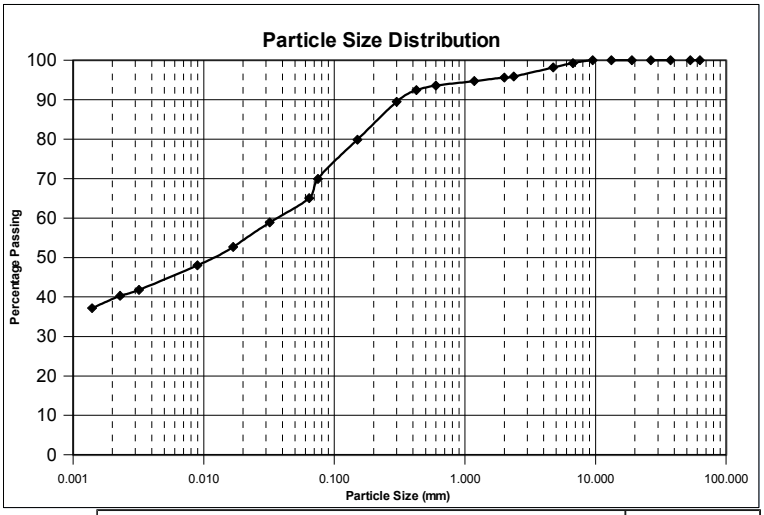
| Hydrometer Analysis | |
|---|---|
| Diameter of particle (mm) | Percentage of soil suspension (%) |
| 0.0640 | 65 |
| 0.0324 | 59 |
| 0.0166 | 53 |
| 0.0087 | 48 |
| 0.0031 | 42 |
| 0.0022 | 40 |
| 0.0013 | 37 |

| SCS Dispersion Test | |
|---|---|
| Diameter of particle (mm) | Percentage of soil suspension (%) |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

| | |
|---|---|
| **% SCS Dispersion:** | |
| **Initial Moisture Content (%) :** | |
| **pH:** | |
| **Conductivity mS/m:** | |

| *Atterberg Limits :* | |
|---|---|
| Liquid Limit | 22 |
| Plastic Index | 6 |
| Linear Shrinkage | 3.0 |

| *MOD AASHTO ; C.B.R. :* | |
|---|---|
| MOD AASHTO (Kg/m³) | |
| O.M.C. (%) | |
| C.B.R. @ 100% Comp. | |
| C.B.R. @ 98 % Comp. | |
| C.B.R. @ 95 % Comp. | |
| C.B.R. @ 93 % Comp. | |
| C.B.R. @ 90 % Comp. | |
| Swell ( max ) % | |




| Tabulated Summary | Percentage |
|---|---|
| **Gravel** : Percentage - 4.75 mm | 2 |
| **Sand** : Percentage - 4.75mm and + 0.075mm | 28 |
| **Silt** : Percentage - 0.075mm and + 0.002mm | 29 |
| **Clay** : Percentage - 0.002mm | 41 |



For Geoscience: