ZITHOLELE CONSULTING PTY LTD

Geotechnical Investigation of Rehabilitation of Mintek Steelpoort Asbestos Mine, Limpopo

Submitted to:
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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (Golder) was appointed by Zitholele Consulting Pty Ltd (Zitholele) to conduct a geotechnical investigation for the proposed Mintek Mine rehabilitation projects for Steelpoort Asbestos mine (abandoned) sites. The environmental risk and legal regulations associated with the status quo of abandoned mines necessitates rehabilitation which in turn requires a geotechnical investigation. The primary objectives for the geotechnical investigation were sourcing of material to be used for the rehabilitation of the abandoned mine.

The findings from the geotechnical investigation conducted at the abandoned Steelpoort asbestos mine are presented in this report, including both the field observations and laboratory test results. These findings are intended to locate and estimate a quantity of available construction material over the site for design of the rehabilitation measures which include capping of dumps, slope stabilization works at the Steelpoort mine and temporary road works. Recommendations are also made pertaining to the workability and engineering use of the encountered materials for the design of the rehabilitation measures.

2.0 SCOPE OF WORK

The geotechnical investigation comprised the following:

- Fieldwork including test pitting and general site assessment;
- Laboratory testing of the soil material for construction purposes; and
- Evaluation of the materials according to their geotechnical properties

3.0 SITE DESCRIPTION

3.1 Location and Access

The investigated area is located near the town of Steelpoort, approximately 120 km south-east of Polokwane, Limpopo Province (see Figure A1; Appendix A). The site is located at coordinates can be used; 223240.00 m E 7268150.00 m S (WGS84, UTM Zone 36J). Although the site is located on the south-eastern site of the R555 road, access is via the R37 road gained from an unnamed gravel road positioned approximately 2.7 km from the intersection of R555 and R37.

3.2 Topography and Surface Water Hydrology

The topography of the site is defined by hills with moderately steep (~25%) slopes and flat river banks on the south-eastern areas. The site is drained by the perennial river channel (Steelpoort River) that traverses through the site flowing towards the north direction.

3.3 Climate and Vegetation

The climatic conditions for the general area are characterised by very hot summers with moderately rainfall whilst the winter periods are characterised by cold and very dry conditions (Mucina and Rutherford, 2006). The climatic conditions influence the dominant form and degree of geological weathering. Based on the Weinert et al., (1980), the site has a Weinert N-value less than 5. It is however adjacent to the boundary of the Weinert curve which indicates a close balance between mechanical and chemical weathering, chemical weathering processes remains slightly prominent.

Thorn trees are the main vegetation type on site, even though these are sparse on account of the generally shallow rock and thin layers of overlying soils.

4.0 GEOLOGY

The regional geology at the Steelpoort Asbestos Mine site is characterised by the Vaalian aged Rustenburg Layered Suite, Bushveld Complex. This geological sequence comprises of Shelter Norite which is an assembly of norites, feldspathic pyroxenites and quartz norites. These rock sequences are conformably overlain by the Croydon Subsuite which is a sequence of pyroxenites and harzburgite rock formations. The
regional geology is also characterised by a younger Rossenekal Subsuite which is defined by pyroxenite rocks.

The field investigation and associated ground mapping proved that the regional geology map present inaccurate geological contact between the pyroxenites and quartz norites of the Shelter Norite, and the alluvium on site. Contrary to regional geological map showing that the northern western areas of the site comprised of the Shelter Norite rocks, test pitting conducted during the investigation proved that majority of the site is underlain by quartz norites and pyroxenites with alluvium only located over the south-eastern portions of the site. An updated geological map presenting the outcomes of the field mapping is presented on Figure A2; Appendix A.

5.0 FIELD INVESTIGATION AND TESTING PROCEDURES

5.1 Subsurface Field Investigation

The field investigation was conducted on the 8th of July 2017, for the purposes of soil profiling and soil sampling for laboratory testing. The subsurface investigation included excavation of five test pits (see Figure A3; Appendix A) which were located using Global positioning System (GPS, Etrex20 Garmin) that is accurate to approximate 5 m horizontally. Excavations for test pitting were conducted using a JCB 3CX Tractor Loader Backhoe (TLB) and to a maximum depth of 3 m or earlier practical refusal on hard rock. Profiling was in accordance with SANS 633 and are presented in Appendix C. The works were directed by Golder’s Engineering Geologist, who profiled the ground conditions and collected samples for laboratory testing.

5.2 Laboratory Testing

Soil samples were collected during the subsurface investigation for determination of engineering properties as follows:

- Dispersivity (by means of double hydrometer testing);
- Atterberg limits;
- Particle size distribution analysis including hydrometer;
- pH and electrical conductivity;
- Moisture content; and
- Maximum dry density determination using Standard Proctor compactive effort

A summary of the laboratory test results are provided in Table B2 Appendix B, whilst the laboratory test certificates are attached in Appendix D.

6.0 GROUND PROFILE

The majority of the site is characterised by pyroxenite and quartz norites from a very shallow depth (0.5 m). These are covered (over the north-west of the site) by very thin scree deposits or colluvium which has a thickness of less than 0.5 m. Along Steelpoort River (south-eastern portion of the site), the soil profile differs and is mainly defined by 0.8 m thick alluvium material which is underlain by thick soils of residual pyroxenite (see test pits STL004 and STL007, Appendix C). Based on the geology, aerial photography and geomorphology the geotechnical character of the planted areas north (fenced and inaccessible) of these test pits are anticipated to be similar to the areas over the aforementioned test pits.

A summary table presenting the ground conditions intersected in the test pits is presented in Table B1 of Appendix B. Typical ground profiles of the aforementioned areas on the study area are given in the tables below.

Table 1: Generalised Ground Profile of the North-Western Portion of the Site
GI FOR MATERIAL SOURCING: ABANDONED STEELPOORT ASBESTOS MINE

<table>
<thead>
<tr>
<th>Material Horizon</th>
<th>Average Depth Intersected (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular, very coarse, tightly packed GRAVELS with very fine slightly moist, dark red, intact, sandy silt. Very loose, <strong>COLLUVIUM</strong>.</td>
<td>0.0-0.4</td>
</tr>
<tr>
<td>Dark olive weathered reddish brown, highly to moderately weathered, soft to medium-hard, medium-hard to hard ROCK. <strong>PYROXENITE</strong> (or <strong>NORITES</strong>).</td>
<td>&gt;0.4</td>
</tr>
</tbody>
</table>

Table 2: Generalised Ground Profile of the South-Eastern Portion of the Site

<table>
<thead>
<tr>
<th>Material Horizon</th>
<th>Average Depth Intersected (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly moist, dark brown, soft to firm, intact, clayey SAND with silt. <strong>ALLUVIUM</strong>.</td>
<td>0.0-0.8</td>
</tr>
<tr>
<td>Slightly moist, yellow brown mottled whitish, intact, medium-dense to dense, clayey SAND with silt. <strong>RESIDUAL MATERIAL</strong>.</td>
<td>&gt;0.8</td>
</tr>
</tbody>
</table>

7.0 **GROUNDWATER CONDITIONS**

No groundwater seepage was observed in the excavated test pits and due to the lack of pedogenic soil horizons, no perched water-table could be inferred.

8.0 **LABORATORY TEST RESULTS AND ENGINEERING PROPERTIES**

8.1 **Transported Soils**

The transported alluvium sample tested classified as SC (sand-clay mixture with some silt particles) in accordance with Unified Soil Classification (USC) system. This material has a plasticity index of 19%, linear shrinkage of 8.3% and liquid limit 38%. The Casagrande Plasticity Chart shows that the fines component (<0.06mm) will behave as a clay since they material plot above the A-line, although the material is general is expected to behave as a non-cohesive sand.

According to the compaction test that was conducted, the transported soils have slightly low maximum dry density value of 1748 kg/m$^3$ and this may be attributed to lack of gravels. The material is also anticipated to be of poor quality, particularly for road construction and has very low grading modulus.

This material is slightly basic with a pH of 8.5 whilst its electrical conductivity is 0.0647 mS/sm. It also shows medium to relatively high dispersivity in the range of 55-70.

8.2 **Residual Pyroxenite Soils**

The residual pyroxenites show some similarities to the alluvium material. It classifies, according to USC, as a SC – silty sands with some silts. Whilst the material will generally behave as a non-cohesive sand, the fines component of the material will behave as a low to medium plasticity clay as it plot above the A-line on Casagrande Plasticity Chart.

It is also characterised by relatively low maximum dry density (1704 kg/m$^3$) which is be attributed to the ultramafic plutonic nature of the geological origin of the constituent minerals within the material. There is also no variation on textural composition of these soils. A grading modulus of 0.61 is indicative of poor suitability as road construction material.
9.0 GEOTECHNICAL INTERPRETATION AND EVALUATION

9.1 Material excavatability

The evaluation of the material excavatability has been made according to the field findings. The criteria used is based on the National Standard Construction Specification referenced from the SANS 1200D: Earthworks, (1998). A summary of this reference is give below:

- **Soft Excavation** is material that can be efficiently removed without prior ripping by 22t bulldozer (such as Cat D7) or front end loader
- **Intermediate Excavation** is material that can be efficiently ripped by a 35t bulldozer (such as Cat D8) with a single ripping tyne
- **Hard Rock Excavation** is material that cannot be efficiently ripped by 35t bulldozer (such as Cat D8), and requires blasting or splitting

Based on this classification, the materials found on site may be categorised as follows:

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Excavation Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colluvium</td>
<td>Soft Excavation</td>
</tr>
<tr>
<td>Alluvium</td>
<td>Soft Excavation</td>
</tr>
<tr>
<td>Pyroxenite</td>
<td>Hard (Medium) Rock Excavation</td>
</tr>
</tbody>
</table>

9.2 Potential Use of Material in Construction

The potential use of material on site has been evaluated, adapted from Wagner, 1957. According to the classification of all soils on site (transported and residual soils), which generally are found to classify as a SC – sandy clay mixtures with some silts, they are predicted to have:

- moderate shearing strength when compacted;
- good workability due to its textural composition;
- semi-pervious permeability when compacted;
- relatively low compressibility when compacted and saturated;
- fair degree of erodibility

The soil materials encountered on site are considered fair for use in construction as capping materials. This is based on their shear strength, permeability, compressibility and workability. The quantity of available construction material has been estimated to a maximum of 6x10⁴ m³, 2.1x10⁴ and 4x10⁴ m³ of alluvium and soils of residual pyroxenites respectively. Should the quantities be insufficient, materials would need to be imported as the surrounding areas showed shallow rocks on elevations above where alluvium and residual pyroxenite occurs.

10.0 CONCLUSIONS AND RECOMMENDATIONS

Approximately 6x10⁴ m³ of material is considered suitable for use as capping materials in the rehabilitation of the site. The engineering suitability of the clayey silty sands for its intended use (as a capping material) are considered to be fair. However with very little gravel, a low grading modulus and relatively low maximum dry density, it is expected to be relatively erodible and difficult to compact. They would be unsuitable for use as road construction materials.
We note that there is high probability that trace amounts of asbestiform minerals are present in the soils, including those with potential for use in rehabilitation process. Any work on site should be carried out using appropriate asbestos mineral controls. Mineralogical testing to confirm and quantify amounts of asbestiform minerals was outside the scope of works.

11.0 REFERENCES


Sandle Nkosi
Engineering Geologist

Simon Owens-Collins
Senior Engineering Geologist

SN/SOC/mbf
APPENDIX A

Figures
RUSTENBURG LAYERED SHELTER NORITE
CROYDON
Asbestos Mine
STL 004
STL001
STL003
STL007
30°16'0"E
30°15'0"E

Geology
Vsh: Norite, feldspathic pyroxenite, quartz norite
Q8: Alluvium and
Vr3: Pyroxenite
Vcr: Pyroxenite, harzburgite

FIGURE A2: REGIONAL GEOLOGY MAP - STEELPOORT

REFERENCE
Coordinate System: GCS WGS 1984
PROJECT MATERIAL SOURCING - STEELPOORT

PROJECT No. 1782072
REV 1
SCALE 1:10,000
GIS TS 26/7/2017
CHECK SN 26/7/2017
REVIEW NJ 26/7/2017
FIGURE A4: ZONATION MAP - STEELPOORT

- **Site Location Name**
- **Test Pit Locations**
- **Site Boundary**
- **Zone A**: Shallow (<0.5 m), highly weathered, soft, pyroxenite and quartz norite bedrocks.
- **Zone B**: Very thick (>2 m), loose becoming dense, clayey SAND with silt.

---

**Site Location Name**

- **Test Pit Locations**
- **Site Boundary**
- **Main road**
APPENDIX B
Tables
<table>
<thead>
<tr>
<th>Test Pit</th>
<th>Test Pit Depth</th>
<th>Alluvium (m)</th>
<th>Colluvium (m)</th>
<th>Residual (m)</th>
<th>Rock (m)</th>
<th>Alluvium (m)</th>
<th>Colluvium (m)</th>
<th>Residual (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL 001</td>
<td>0.60</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>STL 003</td>
<td>0.50</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>STL 004</td>
<td>2.00</td>
<td>0.7</td>
<td>-</td>
<td>2.0</td>
<td>-</td>
<td>0.7</td>
<td>-</td>
<td>1.3</td>
</tr>
<tr>
<td>STL 006</td>
<td>0.70</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
<td>0.7</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>STL 007</td>
<td>2.80</td>
<td>0.8</td>
<td>-</td>
<td>2.8</td>
<td>-</td>
<td>0.8</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>min</td>
<td>0.50</td>
<td>0.7</td>
<td>0.4</td>
<td>2.0</td>
<td>0.5</td>
<td>0.7</td>
<td>0.4</td>
<td>2.0</td>
</tr>
<tr>
<td>max</td>
<td>2.80</td>
<td>0.8</td>
<td>0.5</td>
<td>2.8</td>
<td>0.7</td>
<td>0.8</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>average</td>
<td>1.50</td>
<td>0.75</td>
<td>0.43</td>
<td>2.40</td>
<td>0.60</td>
<td>0.75</td>
<td>0.42</td>
<td>1.65</td>
</tr>
<tr>
<td>standard deviation</td>
<td>1.03</td>
<td>0.07</td>
<td>0.08</td>
<td>0.57</td>
<td>0.10</td>
<td>0.07</td>
<td>0.08</td>
<td>0.49</td>
</tr>
<tr>
<td>% Encountering</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>60%</td>
<td>40%</td>
</tr>
</tbody>
</table>
### Table B2: Summary of Laboratory Test Results

<table>
<thead>
<tr>
<th>Hole No</th>
<th>Sample No</th>
<th>Depth (m)</th>
<th>Horizon</th>
<th>LL (%)</th>
<th>IS (%)</th>
<th>GM (%)</th>
<th>MBC (%)</th>
<th>MDD (kg/m³)</th>
<th>OMC (%)</th>
<th>pH</th>
<th>Cond. (µS/m)</th>
<th>USC</th>
<th>TRB</th>
<th>Typical Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL004</td>
<td>STL004/1</td>
<td>0.0-0.6</td>
<td>ALLUVIUM</td>
<td>36</td>
<td>5.2</td>
<td>32.9</td>
<td>3.7</td>
<td>0.3-0.6</td>
<td>38</td>
<td>19</td>
<td>9.7</td>
<td>100</td>
<td>98</td>
<td>STY 401-1000 0.15  alluvial sand</td>
</tr>
<tr>
<td>STL007</td>
<td>STL007/1</td>
<td>0.0-0.5</td>
<td>RESIDUAL PIRROXYNITE</td>
<td>32</td>
<td>17.9</td>
<td>24.2</td>
<td>2.1</td>
<td>0.3-0.6</td>
<td>43</td>
<td>21</td>
<td>9.9</td>
<td>195</td>
<td>95</td>
<td>PIR 201-1000 0.15  pyroxenite</td>
</tr>
</tbody>
</table>
APPENDIX C

Test Pit Logs
<table>
<thead>
<tr>
<th>Scale</th>
<th>Legend</th>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.00</td>
<td>Angular, very coarse, tightly packed GRAVELS with very fine slightly moist, dark red, intact, sandy silt. <strong>Very loose, COLLUVIUM.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.40</td>
<td>Olive weathered reddish brown, highly becoming medium-weathered, <strong>soft becoming medium hard rock</strong>, massive, fine to medium grained, <strong>PYROXENITE.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.60</td>
<td><strong>End of hole at 0.6 m</strong></td>
</tr>
</tbody>
</table>

**NOTES:**
1: Refusal at 0.6 m  
2: No sample taken  
3: No water seepage  
4: End of log at 0.6 m
Test Pit STL001

Final Depth: 0.6 m

Zintholele Consulting

Steelpoort Mine Rehabilitation Geotechnical Study

STL001

A4
**TEST PIT PROFILE**

**CLIENT:** Zitholele Consulting  
**PROJECT:** Material Sourcing Steelpoort  
**LOCATION:** Steelpoort, Limpopo  
**PROJECT NO:** 1782072

**HOLE No:** STL 003  
**X COORD:** 223425.10  
**Y COORD:** 7268453.35  
**DATUM:** 36 J  
**ELEVATION:**

---

**Description**

0.00 m

Angular, very coarse, tightly packed GRAVELS with very fine slightly moist, dark red, intact, sandy silt. **Very loose, COLLUVIUM.**

0.38 m

Dark olive weathered white, highly to moderately weathered, soft to medium-hard, massive, medium-hard to hard ROCK. **QUARTZ NORITE.**

**End of hole at 0.5 m**

---

**NOTES:**  
1: Refusal at 0.5 m  
2: No sample taken  
3: No water seepage  
4: End of log at 0.5 m

---

**CONTRACTOR:** Coastal Hire Polokwane  
**DATE EXCAVATED:** 2017/08/07  
**MACHINE:** Bell 315 SJ  
**DATE PROFILED:** 2017/08/07  
**PIT LxB:** 1.5 X 2.0  
**FILE REF:** 1782072_STEELPOORT_FIELDLOGS.GPJ  
**PROFILED BY:** SN  
**CHECKED BY:** SOC
Test Pit STL003
Slightly moist, dark brown, loose to firm, intact, clayey SAND with silt. **ALLUVIUM.**

Slightly moist, yellow brown mottled whitish, intact, medium-dense to dense, clayey silty SAND. **RESIDUAL MATERIAL.**

End of hole at 2.0 m

End of log

**NOTES:**
1. Refusal at 2.0 m
2. Bulk sample taken at 0.3-0.6 m
3. No water seepage
4. End of log at 2.0 m

**CONTRACTOR:** Coastal Hire Polokwane
**DATE EXCAVATED:** 2017/08/07
**MACHINE:** Bell 315 SJ
**DATE PROFILED:** 2017/08/07
**PIT LxB:** 1.5 X 2.0
**FILE REF:** 1782072_STEEPLPOORT FIELD LOGS.GPJ
**CHECKED BY:** SOC

**HOLE No.:** STL 004
**X COORD:** 223214.07
**Y COORD:** 7267943.27
**DATUM:** 36 J
**ELEVATION:** 699.0
Test Pit STL004
### Description

<table>
<thead>
<tr>
<th>Depth</th>
<th>Legend</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Angular, very coarse, tightly packed GRAVELS with very fine slightly moist, dark red, intact, sandy silt. **Very loose, COLLUVIUM.**

Dark olive weathered white, highly to moderately weathered, soft to medium-hard, massive, medium-hard to hard ROCK. **QUARTZ NORITE.**

End of hole at 0.7 m

End of log

### NOTES:
1. Refusal at 0.7 m
2. No sample taken
3. No water seepage
4. End of log at 0.7 m

### CONTRACTOR:
Coastal Hire Polokwane

### DATE EXCAVATED:
2017/08/07

### MACHINE:
Bell 315 SJ

### DATE PROFILED:
2017/08/07

### PIT LxB:
1.5 X 2.0

### FILE REF:
1782072_STEELPOORT FIELD LOGS.GPJ

### CHECKED BY:
SOC
Test Pit STL006

Final Depth: 0.7m
TEST PIT PROFILE

CLIENT: Zitholele Consulting
PROJECT: Material Sourcing Steelpoort
LOCATION: Steelpoort, Limpopo
PROJECT NO: 1782072

HOLE No: STL 007
X COORD: 223299.36
Y COORD: 7268040.43
DATUM: 36 J
ELEVATION: 702.0

Description

0.00
Slightly moist, dark brown, loose to firm, intact, clayey SAND with silt. **ALLUVIUM**.

0.70
Slightly moist, yellow brown mottled whitish, intact, medium-dense to dense, clayey silty SAND. **RESIDUAL MATERIAL**.

End of hole at 2.8 m

NOTES:
1: No refusal
2: Ft sample taken at 0.3-0.7, Ft and bulk sample taken at 1.0-1.5 m
3: No water seepage
4: End of log at 2.8 m

CONTRACTOR: Coastal Hire Polokwane
DATE EXCAVATED: 2017/08/07
MACHINE: Bell 315 SJ
DATE PROFILED: 2017/08/07
PIT LxB: 1.5 X 2.0
PROFILED BY: SN
FILE REF: 1782072_STEELPOORT FIELD LOGS.GPJ
CHECKED BY: SOC
Test Pit STL007
APPENDIX D

Laboratory Test Results
**Client Name:** Golder Associates  
**Project Name:** Mintek Gl  
**Sample Number:** B/STL004/1 - 0.3 - 0.6m  
**Lab Number:** GOL-09-132  
**Job Number:** GOL-09  
**Date:** / /  
**Method:** ASTM D4221

---

**DOUBLE HYDROMETER**

**Dispersion:** 56%

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Although everything possible is done to ensure testing is performed accurately, neither Specialised Testing Laboratory (Pty) Ltd nor any of its directors, managers, employees or contractors can be held liable for any damages whatsoever arising from any error made in performing any tests, nor from any conclusions drawn therefrom. Test results are to be published in full. Samples will be kept for 1 month after the submission of test results due to limited storage space, unless other arrangements are in place.
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Client Name: Golder Associates
Project Name: Mintek GI
Job Number: GOL-09
Date: 2017-07-20
Method: SANS 3001 GR1, GR10 & ASTM D422

### FOUNDATION INDICATOR

<table>
<thead>
<tr>
<th>Sample</th>
<th>B/STL004/1</th>
<th>B/STL007/1</th>
<th>D/STL007/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (m)</td>
<td>0.3 - 0.6</td>
<td>1.0 - 1.5</td>
<td>1.0 - 1.5</td>
</tr>
<tr>
<td>Lab No</td>
<td>GOL-09-132</td>
<td>GOL-09-133</td>
<td>GOL-09-134</td>
</tr>
</tbody>
</table>

- **Liquid Limit (%):** 38
- **Plastic Limit (%):** 19
- **Plasticity Index (%):** 19
- **Linear Shrinkage (%):** 8.3
- **PI of whole sample:** 17

<table>
<thead>
<tr>
<th>Sample</th>
<th>B/STL004/1</th>
<th>B/STL007/1</th>
<th>D/STL007/1</th>
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<td>GOL-09-132</td>
<td>GOL-09-133</td>
<td>GOL-09-134</td>
</tr>
</tbody>
</table>

| % Gravel | 2 | 1 | 5 |
| % Sand | 62 | 67 | 76 |
| % Silt | 16 | 22 | 15 |
| % Clay | 20 | 10 | 4 |
| Activity | 1.0 | 2.1 | 1.3 |
| % Soil Mortar | 98 | 99 | 95 |

**Unified (ASTM D2487):**
- **Grading Modulus:** 0.65
- **Moisture Content (%):** 9.7
- **Relative Density (SG):** 2.65
- **Unified (ASTM D2487):** SC

**AASHTO (M145-91):**
- **Activity:** A - 6
- **Unified:** SC

**Remarks:**
- *: Assumed
- N / T: Not Tested

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Maximum Dry Density: 1719 kg/m³
Optimum Moisture Content: 18.5%

<table>
<thead>
<tr>
<th>Moisture Content (%)</th>
<th>15.5</th>
<th>16.5</th>
<th>17.5</th>
<th>18.5</th>
<th>19.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Density (kg/m³)</td>
<td>1676</td>
<td>1719</td>
<td>1748</td>
<td>1711</td>
<td>1664</td>
</tr>
</tbody>
</table>
**Client Name:** Golder Associates  
**Project Name:** Mintek GI  
**Sample:** B/STL007/1  
**Depth (m):** -

### MDD & OMC DETERMINATION (Std. Proctor)

<table>
<thead>
<tr>
<th>Moisture Content (%)</th>
<th>Dry Density (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Maximum Dry Density:** [ ] kg/m³  
- **Optimum Moisture Content:** [ ] %

**Job Number:** GOL-09  
**Lab Number:** GOL-09-133  
**Method:** BS 1377  
**Date:** 20-Jul-17

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APPENDIX E
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