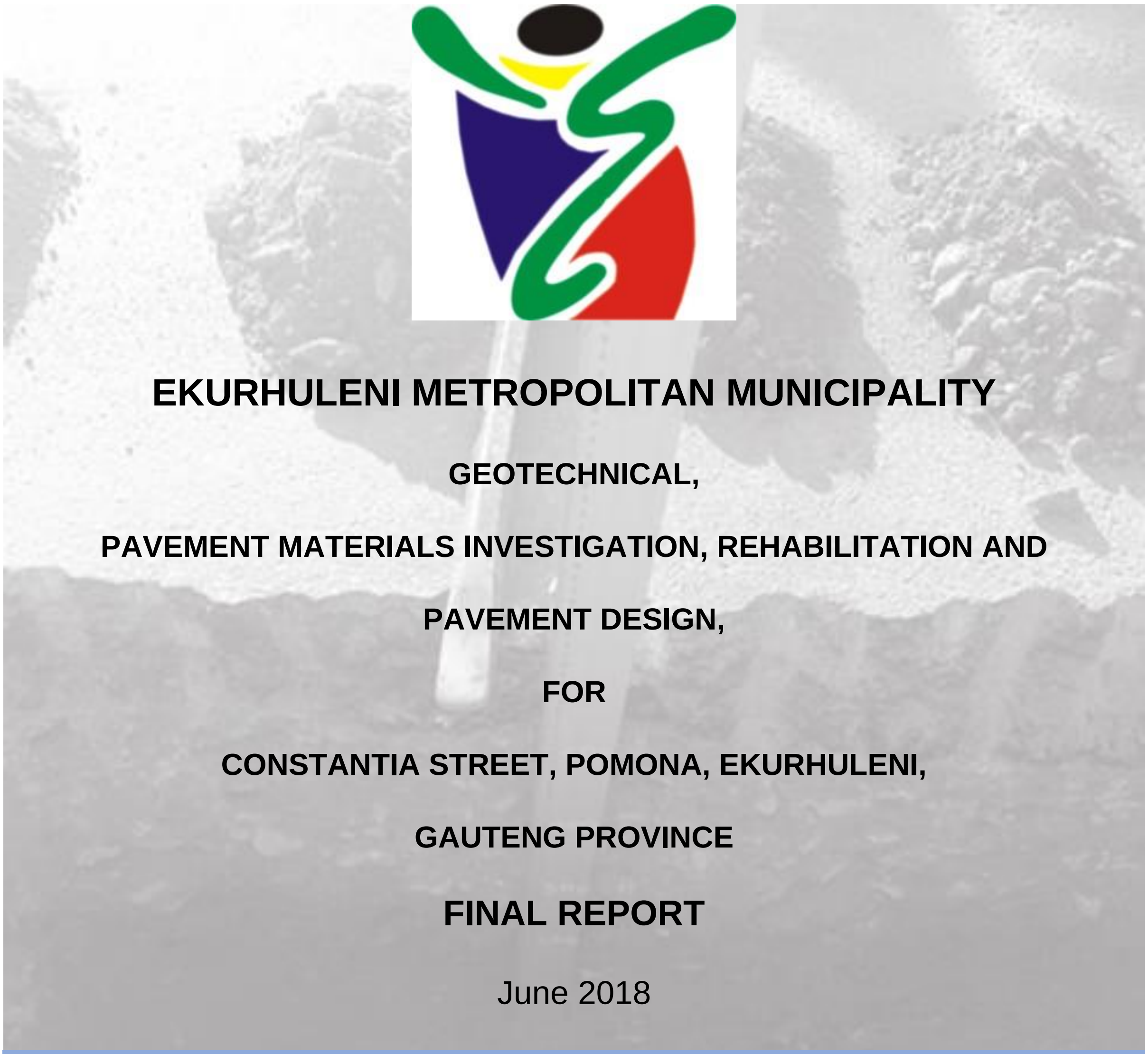

EKURHULENI METROPOLITAN MUNICIPALITY

GEOTECHNICAL,

PAVEMENT MATERIALS INVESTIGATION, REHABILITATION AND PAVEMENT DESIGN,

FOR

CONSTANTIA STREET, POMONA, EKURHULENI, GAUTENG PROVINCE

FINAL REPORT

June 2018

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FUNCTION OF REPORT	PREPARED BY:	DATE	SIGNATURE
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Revision Grid

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00	12/06/2018	Final report	First submission

EXECUTIVE SUMMARY

The report forms a final geotechnical and materials investigation that has been carried out with Roadlab laboratory who undertook the testing of materials under the supervision of Ndlovu Engineering Techniks on behalf of Calliper Consulting Engineers. The project is in the province of Gauteng, Ekurhuleni Metropolitan Municipality, Constantia Street between Pomona Road and West Street in Pomona. About six intersections are located along the road.

The road carries significant numbers of trucks and it is therefore also an objective to provide an adequate surfaced width for these trucks in terms of safety and to minimise road edge maintenance requirements. The objectives of the upgrade are to implement remedial works through widening, strengthening, pre-treat the road and to prepare improvements to drainage elements.

The report explores founding conditions for possible rehabilitation and widening. According to the trial pit data, the pavement material encountered varies for each segment of the road as defined by the intersections. The existing road for all the segments under investigation consists of asphalt surfacing with an average thickness of 40mm. This is supported by moderate to very dense base and subbase consisting of either asphalt base, slurry bound mecadam, stabilised gravel material and crushed stone base material of moderate to high shear strength.

The proposed upgrade is underlain by sediments of the Karoo Sequence and Witwatersrand Supergroup as well as by andesitic lava of the Ventersdorp Supergroup with granite of the Basement Complex emerging in the south. The road reserve is covered by an average 800mm thick layer of sandy and silty colluvium. Diamictite residuals were encountered that overlain the bedrock, which is a matrix supported gravel, that is, gravel of mixed origin within clayey, silty and sandy matrix. Sandstone and shale underlain the site. In general, the bedrock is overlain by residual and transported soils and present potentially slightly collapsible and highly compressible colluvium.

Perched underground water table was encountered during trial pit excavations. Following heavy or sustained rainfall periods, water levels may rise substantially from the small stream and overlying the underlying rock that may occur on the site.

The existing storm water drainage structures are generally in a poor state and are affecting the performance of the existing pavement.

A detailed pavement analysis was conducted to ascertain the current condition of the road. The investigation included a visual assessment which aided in the identification of distinct sections along the road with similar distress types. From the visual assessment, the road can be said to be in a poor to fairly good condition with surface defects ranging from transverse, block, crocodile and longitudinal cracks to bleeding, pumping and surface deformation.

From the traffic information provided, various pavement design alternatives have been provided at varying loading conditions and contact tyre pressures and the pavement solutions can be summarised as follows:

- Section 1 between Pomona Road and Maple Street can be said to be in a good condition and would require rehabilitation in the form of surfacing along the roadway. The two intersections would require re-working of the base layer and resurfacing.
- Section 2 to 4 between Maple Street and Deodar Street can be said to be in a poor state and would require rehabilitation in the form of reworking the base layer and resurfacing.
- Section 5 between Deodar Street and West Street have defects manifesting in the form of block cracking which requires crack seal and rejuvenation, however we recommend that this section undergo proper rehabilitation due to ageing base layer (slurry bound mecadam) in the form of reworking the base layer and resurfacing.

From a geotechnical and pavement engineering point of view, the proposed upgrade is feasible with no geotechnical hazards identified. Beside constraints that may be identified by other disciplines, the upgrade is supported from an engineering perspective posit by this report scope, context and domain.

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1 INTRODUCTION

1.1 Scope of Investigation

An upgrade to the Constantia Street between Pomona Road and West Street in Pomona, Ekurhuleni is being proposed. As part of this upgrade the approach and exit to the existing intersections of the road way might be widened, and the roadway strengthened to meet expected traffic conditions.

In collaboration with the proposed upgrades, an investigation evaluating the geological and existing pavement materials and founding conditions has been undertaken forming the subject of this report.

The objectives of this geotechnical and pavement materials investigation may be summarised as follows:

- To characterize the underlying subgrade soils and rock that may be influenced by the proposed upgrade and storm water management.
- To establish the nature and engineering properties of the existing pavement materials.
- To evaluate excavation conditions that may be expected.
- To determine the likelihood of subsurface water at the depth of the subgrade.
- To present appropriate usage of insitu materials based on the laboratory results and evaluation.
- To present appropriate pavement and rehabilitation design options that may be adopted during construction

The report forms a final geotechnical and materials investigation that has been carried out with Roadlab laboratory who undertook the testing of materials under the supervision of Ndlovu Engineering Techniks on behalf of Calliper Consulting Engineers.

1.2 Scope limits and exclusions

The geotechnical and materials investigation report is only concerned about founding conditions for the purposes of upgrading existing road and laying of pipes for storm water. The following critical geotechnical factors were not considered and are beyond the scope of this report.

1.2.1 *Inundation (flooding)*

The implications of the proposed construction on flooding is not considered in this report. Floods are natural events that have to be taken into account where development encroaches on or close to stream channels.

Upgrading roads may have significant effects on the flood behaviour of a river system. Factors such as changed hydrology, sediment loads and river diversions can have significant impacts to the extent that areas before development with a low risk of flooding can become high risk areas after development.

1.2.2 *Erodible soils*

Normally, erosion is exacerbated with road upgrades on erosion prone soils for example by storm water discharge from roads, and the use of erodible soils as fill material around culverts. This investigation did not cover the erodibility of the soils that will be used in the permanent works.

1.2.3 Foundation indicators for superstructures

The investigation did not make detailed studies and exploration to establish the founding condition and design parameters of any superstructure that might be widened such as bridges.

1.3 Locality

The investigation was conducted in the month of May 2018 in Pomona, Ekurhuleni, Gauteng Province along Constantia Street, Figure 1 (26° 5'44.54"S, 28°15'35.99"E). The project starts at an intersection between Pomona Road and ends at West Street along Constantia Street. The streets encountered along Constantia Street are Pomona Road, Maple Street, EP Malani Street, Elgin Street, and Deodar Street.

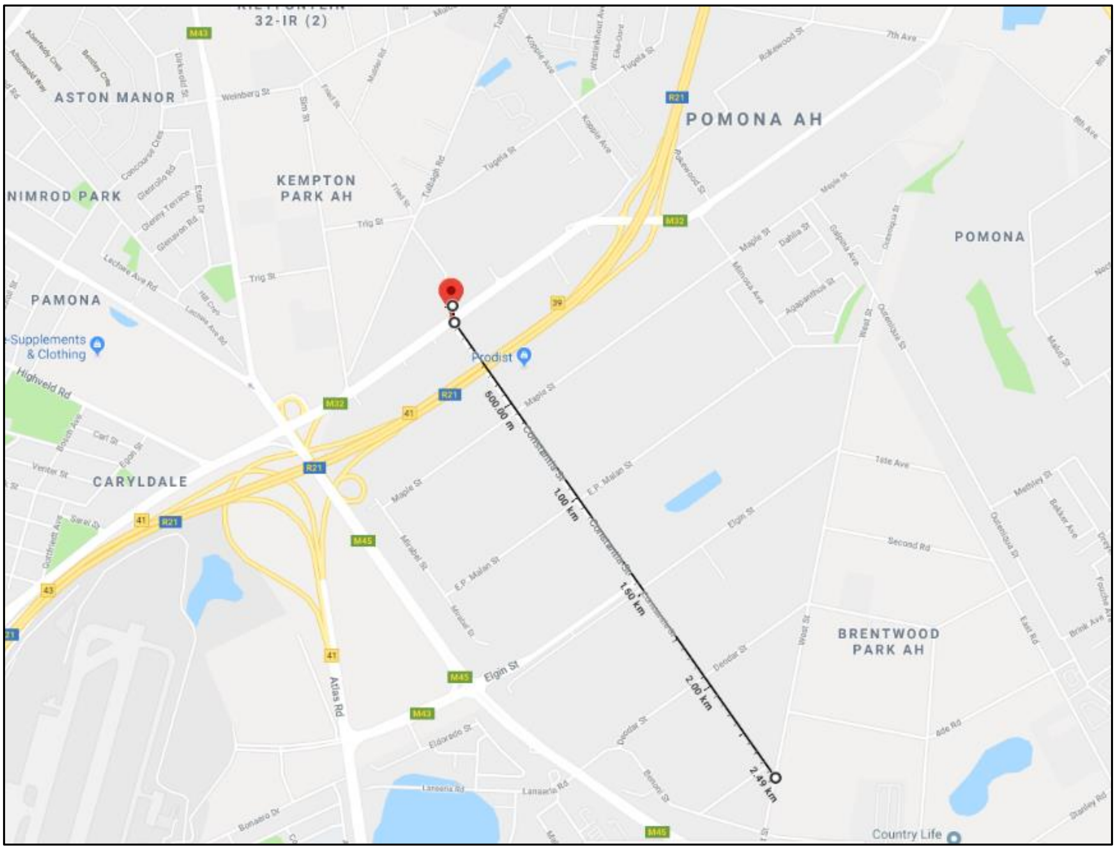

Figure 1: Project locality

1.4 General Description

This report places attention to geotechnical and materials investigation for the purposes of rehabilitation and pavement designs, roadway and storm water upgrades. Climate, and proposed scope of upgrades and detailed site-specific information are covered in detail elsewhere in relevant project design reports available from Calliper Consulting Engineers.

1.4.1 Climate

The rainfall of the region is known to be typical to the Highveld summer rainfall, which occurs from October to April. The average annual rainfall varies from 650 mm to 750 mm. Frost does occur frequently from mid-May to mid-August, which makes temperatures below freezing common during winter times.

The site is home to mild summers with temperatures seldom above 30°C. During spring and winter, northerly and north-westerly winds occur and during summer north-easterly to north-north-easterly winds occur.

The climate would affect the selection of materials for road construction and the design of buried pipes (storm water) as the performance of road infrastructure is greatly influenced by temperature, moisture regimes, weathering and the water table.

1.4.2 *Topography*

In general, the topography of the site is significantly influenced by resistance to weathering of the sandstone and shale bedrock that underlain the site. As can be seen from the topography, the site is shaped by a small stream that does not seem perennial and flows North Easterly and is crossed by the road under investigation. The elevation has an average slope varying between 0.5% to 2%, Figure 2, and the site may be considered to exist in environment where chemical weathering may dominate over mechanical weathering.

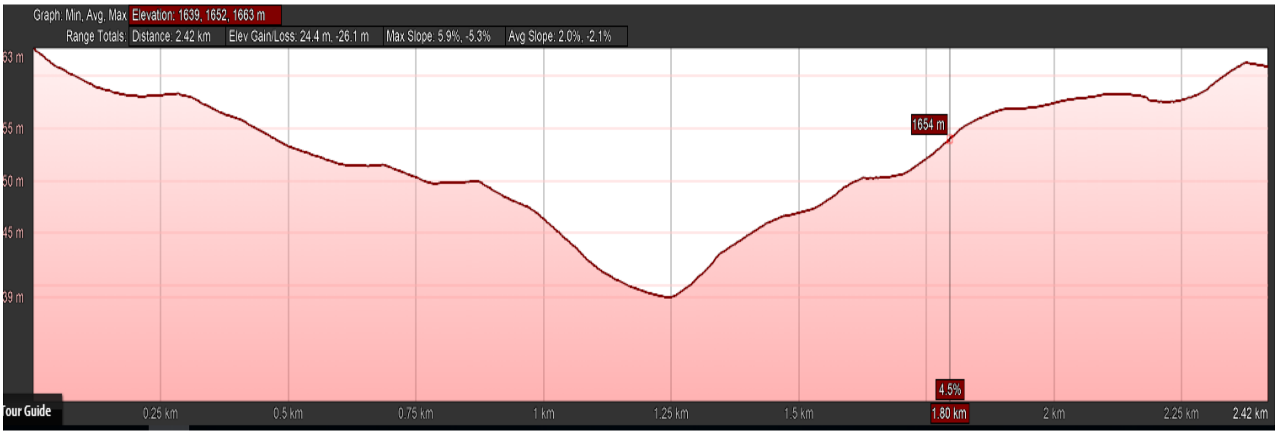

Figure 2: Site topography

1.4.3 *General geology*

According to the 1:250 000 Map obtained from the Council of Geoscience, the site is underlain by several geological formations:

- Sandstone and shale with coal beds of the Vryheid Formation, Karoo Sequence
- Tillite and shale of the Dwyka Formation, Karoo Sequence
- Breccia, andesitic lava, shale, conglomerate and greywacke, Ventersdorp Supergroup
- Quartzite and shale of the West Rand Group, Witwatersrand Supergroup
- Granite and gneiss of the Basement Complex

Sandstone and shale underlain the site. The bedrock is overlain by residual and transported soils and present potentially slightly collapsible and highly compressible colluvium.

2 INVESTIGATION PROCEDURE

2.1 Introduction

A desktop study was conducted in the month of May 2018, to assess the extent of investigation required during fieldwork. This included work conducted by Geoscience that describes the risk associated with geotechnical work for the area under investigation. The desktop study was focused on Dolomitic presences that cause surface movements manifesting as collapse, (sink hole) and slow compaction settlement.

Based on the desktop study, the presence of dolomitic conditions was improbable, and the extent of the investigation was limited to the pavement material properties, mass earthworks, bedrock formation, ground water and slope stability.

2.2 Site Walkabout

Initially a walk over of the site was undertaken in May 2018. The visit was undertaken to provide more detailed information on the surface conditions and characteristics of the project and the approach to the upgrade.

2.3 Visual Assessment

Following a walk over of the site, a detailed visual condition assessment was done according to the requirement of TMH9, and TRH12 in appendix C. The distress on the road was documented together with the most probable cause and mechanism of failure as well as gathering valuable information pertaining to the site:

- Shear strength of the existing base layer and moisture situation
- Determination of the type of surfacing and material re-utilisation
- Visual demarcation of uniform sections according to type and severity of distress and associate with probable causes
- Assessment of lanes and shoulders
- Assessment of subgrade materials according to the adjacent erosion
- Road prism and drainage

2.4 Field Work Undertaken

Fieldwork consisted of Dynamic Cone Penetration to determine uniform sections and position of test pits followed by the excavation by hand and re-instatement of test pits. On existing roads, test pits were excavated to a maximum depth varying between 600mm to 1000mm and excavation up to 2000mm or TLB refusal was the maximum depth on the road reserve. The test pit excavations were then profiled, representative, disturbed soil samples were collected to Roadlab for testing.

3 CONDITION VISUAL ASSESSMENT

3.1 Introduction

A condition visual assessment was conducted in the month of May 2018 to ascertain the level of road distress and advance developments towards the logical steps required as a point of departure to facilitate rehabilitation of designs, Appendix C.

The visual assessment of the road was assessed in terms of TH12 through subjective reflection and interpretation of observed distress and TMH9 uniform section in Appendix C.

Visual Condition Indices (VCI's) were determined based on the criteria in Table 1 below, (TMH 9: 1992) and details are in Appendix C, *Table 1*.

Condition	**VCI Range**	**Condition Description**
V Good	85 - 100	Road is well constructed and maintained. It will have a residual life of around 15 years with no further maintenance, or an indefinite life with proper maintenance
Good	70 - 85	Road is well constructed and maintained. It will have a life of around 8 years with no further maintenance, or an indefinite life with proper maintenance
Fair	50 - 70	Road shows some signs of deterioration but can be returned to a "Good" condition if proper maintenance is done immediately
Poor	35 - 50	Road has failed and extensive maintenance is immediately necessary to salvage a road in this state, Road will deteriorate to "Very Poor" quickly if maintenance is delayed
V Poor	0 - 35	This group of roads can no longer be maintained, but will require major reconstruction to return them to a "Good" state

Table 1: Road Condition in terms of Visual Condition Index (VCI) as described in TMH9 (1992) Visual Assessment Manual for Flexible Pavements

The road can be said to be in a poor to fairly good condition with surface defects ranging from transverse, block, crocodile and longitudinal cracks to bleeding, pumping and surface deformation, Figure 3. The general visual observations of the entire section from km 0.00 to km 2.49 indicates that the upper layers require rehabilitation in terms of base repairs and patching or a reworking of the base.

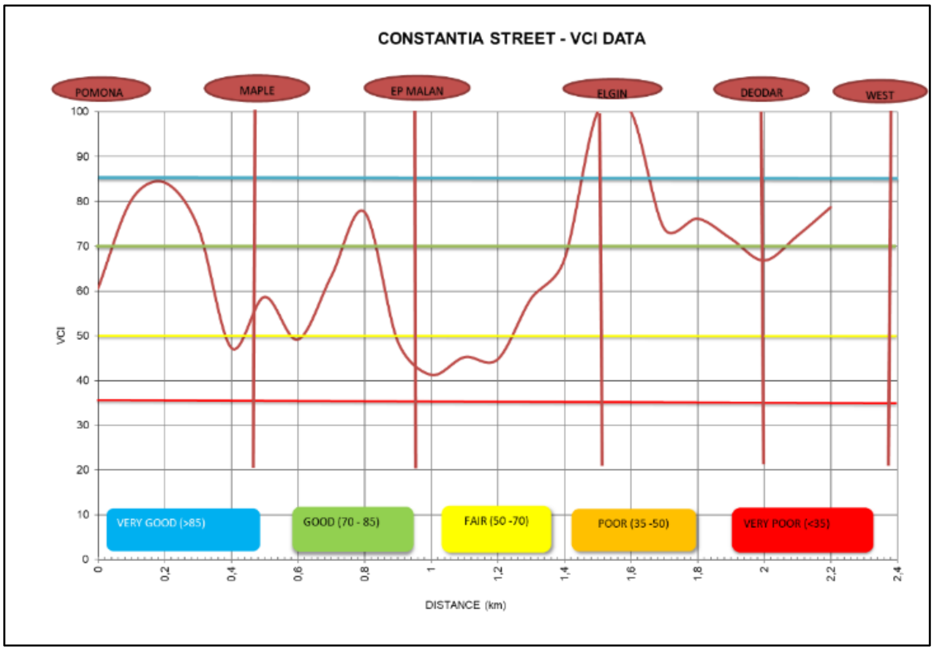

Figure 3: Visual Condition Index for constantia street according to draft TMH9

The narrative of the visual assessment presented in the succeeding section articulates a detailed response to the principal body of evidence that is required to action a rehabilitation design and upgrade of a road.

3.2 Pavement Assessment

3.2.1 Transverse cracking

These cracks occur sporadically along most of the Constantia Street and are early indications of forming block cracks, Photo 1.

Photo 1: Transverse crack between Deodar Street and West Street

3.2.2 Block cracks

Block cracks occur sporadically throughout the entire section of the street but most notably from km 2.00 to km 2.24 (Deodar Street and West Street), Photo 2.

Photo 2: Block cracks between Deodar Street and West Street

3.2.3 Crocodile cracks

Crocodile cracks occur frequently throughout this section of Constantia Street. This is an indication of structural problems, Photo 3 and Photo 4.

Photo 3: Crocodile cracking between Pomona Road - Maple Street

Photo 4: Advanced crocodile cracking between EP Malan Street - Elgin Street

3.2.4 Longitudinal cracks

Longitudinal cracks predominate the section between Deodar Street and West Street, Photo 5.

Photo 5: Longitudinal cracks between Deodar Street and West Street

3.2.5 Pumping

Pumping is present intermittently mostly in the wheel tracks where crocodile and block cracking occurs and this is frequent between Maple Street and EP Malan Street, Photo 6.

Photo 6: Pumping on the wheel path between Maple Street - EP Malan Street

3.2.6 Surface failure (roadway)

Surface failures are predominantly located in the wheel tracks and mostly due to the severity of crocodile cracking combined with rutting allowing water ingress into the base, Photo 7 and Photo 8. At intersections, surface defects manifests as shoving of an overlay due to turning heavy vehicles, Photo 9.

Photo 7: Surface failure between EP Malan Street and Elgin Street

Photo 8: Potholing between Maple Street - EP Malan Street

Photo 9: Shoving of surfacing at Maple Street

3.2.7 Rutting

Rutting is prevalent over most of the road, but notably from Maple Street and just before Elgin Street in the outer wheel track of both westbound and eastbound directions Photo 10. Photo 11.

Photo 10: Rutting at the approach to EP Malan Street

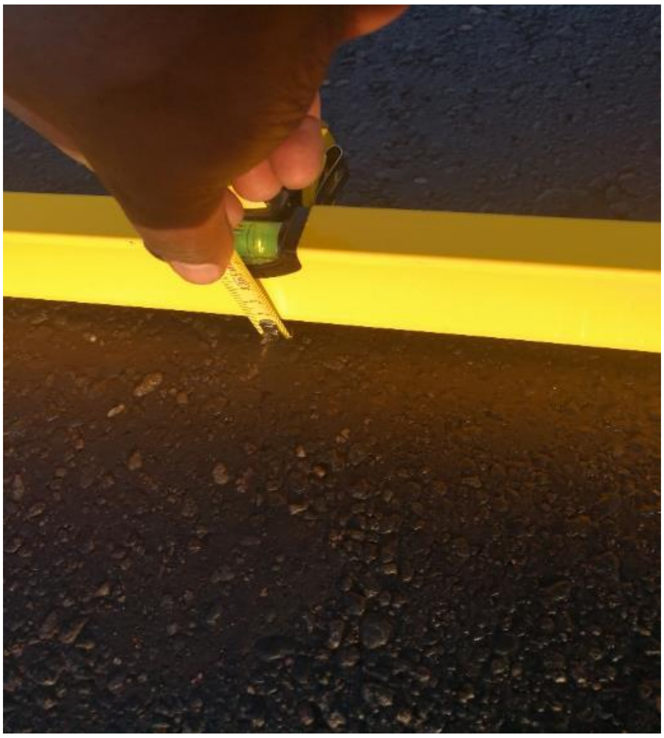

Photo 11: Rut measurement between Maple Street and EP Malani

3.2.8 Bleeding

The bleeding is not severe but will have to be taken into consideration when designing a subsequent resurfacing overlay especially between Pomona Road and Maple Street, Photo 12.

Photo 12: Slight bleeding on the wheel path

3.2.9 Patching

The current condition of the patches varies from fair to very poor, with some patches already failing, Photo 13. Almost the entire Constantia Street has underwent an asphalt overlay in some form on the full roadway.

Photo 13: Patchwork on the wheel path where rutting and crocodile cracking have advanced between Maple Street - EP Malan Street

3.2.10 Edge break

Isolated occurrences of edge breaks are present along the road, most notably from Maple Street to West Street, Photo 14. This is also the case at certain accesses along the street. Edge beams or kerbs will be required during the upgrade to minimise future damage and consideration be made for the access at the informal settlement.

Photo 14: Edge breaks between Maple Street - EP Malan Street

3.2.11 Edge drops

Edge drops were noticed where drainage was not properly done resulting in the scouring of the gravel shoulder during a storm, Photo 15.

Photo 15: Edge drops between Maple Street - EP Malan Street

Photo 16: Edge drop resulting from scouring of the gravel shoulder

3.3 Drainage Aspects

Pavement behaviour is influenced by storm water drainage. Proper drainage is important to ensure a high quality long lived pavement. Moisture accumulation in any pavement structural layer can cause problems. Moisture in the subgrade and aggregate base layer can weaken these materials by increasing pore pressure and reducing the materials' resistance to shear. Additionally, potentially collapsible soils encountered on site expand when moist, causing differential heaving. Moisture in the hot mix asphalt layers can cause stripping.

3.3.1 Drainage inlets

The existing storm water drainage structures are generally in a poor state with blocked kerb inlets and damaged covers, Photo 17 and Photo 18.

Photo 17: Blocked kerb inlet between Pomona Road - Maple Street

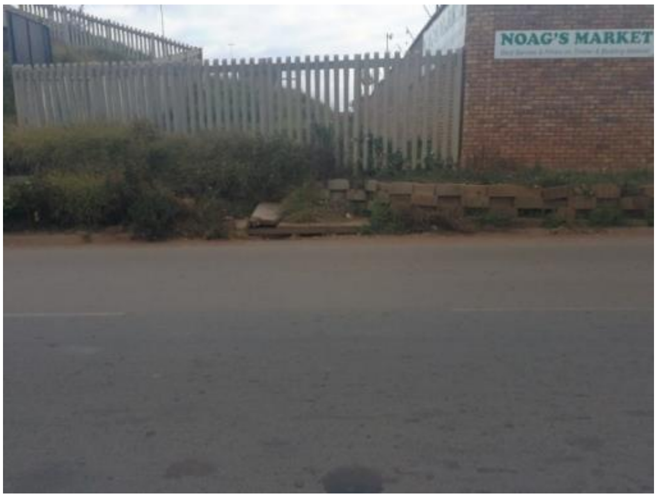

Photo 18: Blocked kerb inlet between Pomona Road - Maple Street

3.3.2 Culverts

At the small stream, the pipe culverts were blocked which could result in flooding during flush rainy periods, Photo 19.

Photo 19: blocked culvert pipes at the small stream

3.3.3 Road prism drainage

Road prism drainage along Constantia Street seem problematic especially after EP Malan Street due absence of proper channelling of storm water and to the topography of the area. The road reserve vertical grade varies between 0,5% to 2.0% This result in storm water ponding along the road reserve or scouring the shoulder towards the stream.

Special attention should be given to the drainage in this area and it is proposed that the possibility be investigated to construct proper storm water drainage or gravel side drains on grade and levels separate from the road to try and resolve standing water in road prism and erosion of the shoulder. The road prisms are shown in the photos that follow.

Photo 20: Road prism between Pomona Road - Maple Street

Photo 21: Road prism between Maple Street and EP Malan Street

Photo 22: Road prism between EP Malan Street and Elgin Street

Photo 23: Road prism between Elgin Street and Deodar Street

Photo 24: Road prism between Deodar Street - West Street

4 TRIAL PITS INFORMATION

A total of 15 test pits were done for the entire project with 5 test pits on the roadway and 10 test pits on the road reserve to assess the condition and quality of the existing pavement and subgrade materials. On the roadway, the test pits were generally excavated in the outer wheel path in either the east or westbound direction. Full details of the test pits information and test are in Appendix F and G.

4.1 Road Reserve

The road reserve is covered by an average 800mm thick layer of sandy and silty colluvium. No rock outcrop was observed, Photo 25. Diamictite residuals were encountered that overlain the bedrock, which is a matrix supported gravel, that is, gravel of mixed origin within clayey, silty or sandy matrix, Photo 26. From the TLB excavations, the lower portion of diamictite is cemented and would present intermediate to hard excavation.

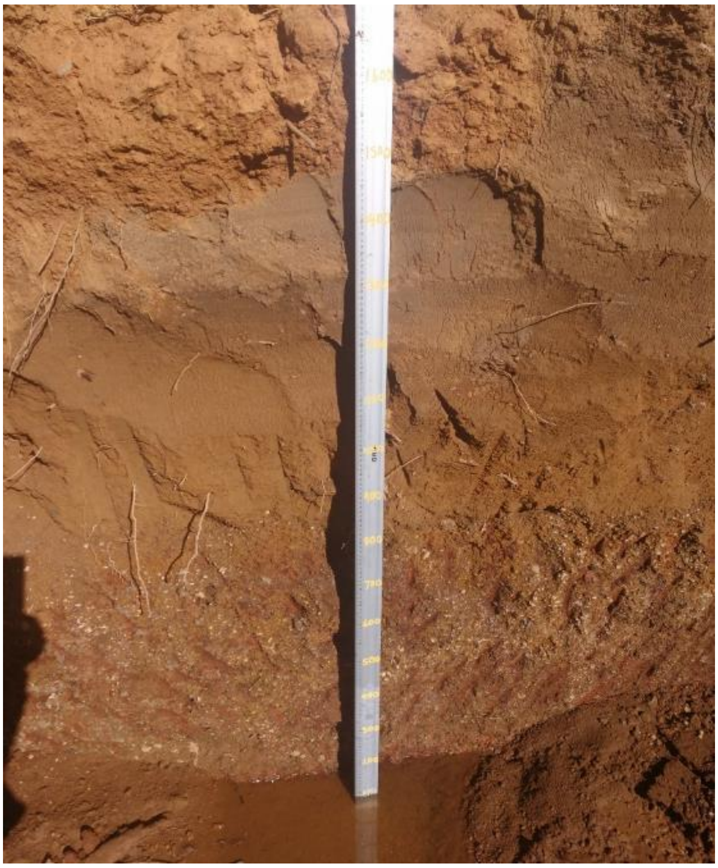

Photo 25: Typical road reserve material encountered during hand and TLB excavations

Photo 26: Residual material consisting of diamictite , nodules of a matrix supported gravel

Photo 27: Cemented Diamictite encountered at a depth of 1500mm

The position of test pits done on the road reserve are shown in Figure 4 and Appendix A. The summary of test pit information is in Table 2.

Figure 4: Position of test pit on the road reserve

Test Pit	**Position**	**Description**
TP06	26° 5'54.58"S 28°15'43.41"E	Between Pomona Road and Maple Street. TLB refusal at 1700mm. Underground water encountered on the bedrock.
TP07	26° 5'58.49"S 28°15'47.33"E	Intersection at Maple Street. No underground water. TLB refusal at 1300mm.
TP08	26° 6'9.27"S 28°15'54.75"E	Intersection at EP Malan at the West Bound reserve. TLB refusal at 1200mm. Very moist conditions and no underground water encountered.
TP09	26° 6'8.50"S 28°15'55.26"E	Intersection at EP Malan at the East Bound reserve. TLB refusal at 1000mm. Moist conditions and no underground water encountered.
TP10	26° 6'11.19"S 28°15'56.48"E	Intersection at EP Malan at the West Bound reserve. TLB refusal at 1300mm. Perched water encountered. Roots and building rumble.
TP11	26° 6'13.41"S 28°15'58.97"E	Between EP Malan and Elgin Street. TLB refusal at 900mm. Perched water encountered. Roots and building rumble.
TP12	26° 6'18.35"S 28°16'2.84"E	Between EP Malan and Elgin Street. TLB refusal at 900mm. No underground water encountered.
TP13	26° 6'30.49"S 28°16'11.60"E	Between Elgin Street and Deodar Street. TLB refusal at 500mm. No underground water encountered. Building rumble encountered.
TP 14	26° 6'37.64"S 28°16'17.25"E	Between Deodar Street and West Street. TLB refusal at 1600mm. No underground water.
TP 15	26° 6'46.26"S 28°16'24.29"E	Between Deodar Street and West Street. Hand refusal at 100mm.TLB refusal at 1600mm. No underground water.
TP16	26° 6'45.63"S 28°16'25.22"E	Excavation inside private property done by owner of the property along West Street. Excavation depth of 1300mm and not TLB refusal. No underground water encountered.

Table 2: Summary of test pit information on the road reserve.

4.2 Pavement Materials and Uniform Sections

A total of 5 tests pits were done along Constantia Street on the roadway, Table 3.

Test Pit	Position	Position Description
TP01	26° 5'48.49"S 28°15'39.09"E	Between Pomona Road and Maple Street.
TP02	26° 6'4.63"S 28°15'51.82"E	Between Maple Street and EP Malan Street
TP03	26° 6'12.52"S 28°15'57.89"E	Between EP Malan Street and Elgin Street.
TP04	26° 6'27.14"S 28°16'9.37"E	Between Elgin Street and Deodar Street
TP05	26° 6'38.24"S 28°16'18.27"E	Between Deodar Street and West Street

Table 3: Test pit information on the roadway

The pavement structure in the test pits was profiled, photographed and representative samples taken for laboratory testing. Laboratory tests included moisture content, particle size distribution, Atterberg Limits and California Bearing Ratio (CBR). The laboratory test results would be provided in the detailed final report. The material encountered together with the surfacing made is varying along Constantia Street as defined by the crossing streets resulting in the following uniform sections.

The test pit geotechnical information can be summarised in Table 4:

Test Pit No.	Layer			Layer Thickness	Material Classification					Moisture	
	mm			mm	COLTO	TRH14	PI	CBR @97%	MDD	OMC	Field Moisture
1	0	-	40	40	Asphalt Surfacing						
	40	-	110	70	Asphalt Surfacing						
	110	-	360	250	G5	G5	SP	111	2392	6,1	4,1
	360	-	610	250	G7	G7	NP	39	2191	7,2	8,8
	660	-	800	140	G6	G6	SP	57	2286	8,3	7,3
2	0	-	40	40	Asphalt surfacing						
	40	-	190	150	G6	G6	SP	49	2221	8,1	5,4
	190	-	320	130	G8	G8	15	14	2011	13,7	14,9
	320	-	550	230	G8	G8	3	25	2103	11,2	11,3
3	0	-	40	40	Asphalt surfacing						
	40	-	100	60	Asphalt surfacing						
	100	-	220	120	G8	G8	15	14	2011	13,7	14,9
	220	-	520	300	G8	G8	3	25	2103	11,2	11,3
4	0	-	50	50	Asphalt overlay						
	50	-	100	50	Asphalt surfacing						
	100	-	250	150	G7	G7	NP	39	2191	7,2	8,8
	250	-	500	250	G8	G8	15	14	2011	13,7	14,9
	500	-	650	150	<G9	<G10	25	10	1621	23,5	
5	0	-	60	60	Asphalt surfacing						
	60	-	160	100	Slurry bound mecadam						
	160	-	310	150	G7	G7	NP	39	2191	7,2	8,8
	310	-	460	150	<G9	G10	15	9	2062	10	15,9
	460	-	760	300	<G9	<G10	25	10	1621	23,5	

Table 4: Summary of laboratory results for roadway test pits

4.2.1 Uniform Section 1: Pomona Road - Maple Street

The section consists of 30 to 40mm surfacing and 70mm BTB as upper layer. The BTB is supported by a 200mm to 250mm crusher run subbase, grey olive silty sandy gravel with the following properties:

- PI: SP
- CBR @ 97%: 111
- GM: 2.48
- Classification (COLTO): G5
- MDD: 2392 kg/m^3
- DN layer: 2.18mm/blow

An upper selected layer of 200mm to 250mm G7 yellow orange brown silty sandy gravel, non-plastic supports the subbase, and has a CBR at 97% compaction of 39 and a GM 2.38 and an MDD of 2191 kg/m^3. The layer is supported by 50mm crusher run of 26mm stone size possible used to provide a stable founding horizon during construction. Subgrade materials were obtained at a depth of 700mm below surfacing and it’s a G8 natural soil with a P.I of 7 and a CBR at 97% of 19 and a GM of 2.53. The Maximum Dry Density is 2126kg/m^3. The materials recovered between Pomona Road and Maple Street are shown in Photo 28.

The section between Pomona Road and Maple Street can be said to be in a good condition and would require rehabilitation in the form of base repair, milling and re-surfacing along the roadway. The two intersections would require re-working of the base layer and resurfacing.

Photo 28: Pavement materials: Test Pit 1 between Pomona Road and Maple Street

4.2.2   Uniform Section 2: Maple Street - EP Malan Street

The section of the road consists mainly of 30mm asphalt overlay over a 13.2mm single seal with slurry making a 40mm surfacing. The base material consists of 150mm light Brown Sandy Gravel with the following properties:

- P.I : SP
- CBR at 97%: 49
- GM: 2.51

- Classification (COLTO): G6
- MDD: 2221kg/m3
- DN layer: 2.36mm/blow

The subbase is dark drown clayey sandy gravel with a P.I of 15 and CBR at 97% of 14 and a grading modulus 2.13. In terms of the COLTO classification, the material is a G8 natural soil with a maximum density of 2011 kg/m^3. The subgrade material is supported by residual material encountered at a depth of 650mm beneath the surfacing and consist of dark red orange clayey sandy gravel (diamictite) .

The materials recovered between Maple Street and EP Malan Street are shown in Photo 29. This section would require rehabilitation in the form of reworking the base layer and resurfacing.

Photo 29: Pavement materials: Test Pit 2 between Maple Street and EP Malan Street

4.2.3 Uniform Section 3: EP Malan Street - Elgin Street

The surfacing consists of an old asphalt and failed asphalt overlay. The combined thicknesses of the two layers is 100mm. Supporting the surfacing is a 120mm base, dark drown clayey sandy gravel with a P.I of 15 and CBR at 97% of 14 and a grading modulus 2.13. In terms of the COLTO classification, the material is a G8 natural soil with a maximum density of 2011 kg/m^3.

Residual subgrade material consisting of dark red orange clayey sandy gravel (diamictite) were encountered at 520mm below the top of surfacing. The subgrade material is similar to the material encountered in Test Pit 2 subgrade material. The materials recovered between EP Malan Street and Elgin Street are shown in Photo 30.

This section would require rehabilitation in the form of reworking the base layer and resurfacing.

Photo 30: Pavement materials: Test Pit 3 between EP Malan Street and Elgin Street

4.2.4 Uniform Section 4: Elgin Street - Deodar Street

Like section 3 above, the combined thickness of surfacing is 100mm indicating that an overlay was done to the existing surfacing as a repair method. The base later consists material that is non-plastic with a CBR at 97% of 39 and a grading modulus 2.39. In terms of the COLTO classification, the material is a G7 natural soil with a maximum density of 2191kg/m^3.

Subgrade material is reached at a depth of 650mm from top of surfacing. The profile of test pit 4 and material recovered is shown in Photo 31 .

This section would require rehabilitation in the form of reworking the base layer and resurfacing.

Photo 31: Test Pit 4 profile and pavement materials

4.2.5 Uniform Section 5: Deodar Street - West Street

The section from Deodar Street to West Street consists of 30mm medium asphalt surfacing and 100mm slurry bound mecadam , Photo 33. Subgrade material is reached at a depth of 650mm from top of surfacing. Material recovered in Test pit 5 is shown in Photo 32.

The defects in this section manifest in the form of block cracking which requires crack seal and rejuvination with fogspray, howver, this section would require proper rehabilitation in the form of reworking the base layer and surfacing.

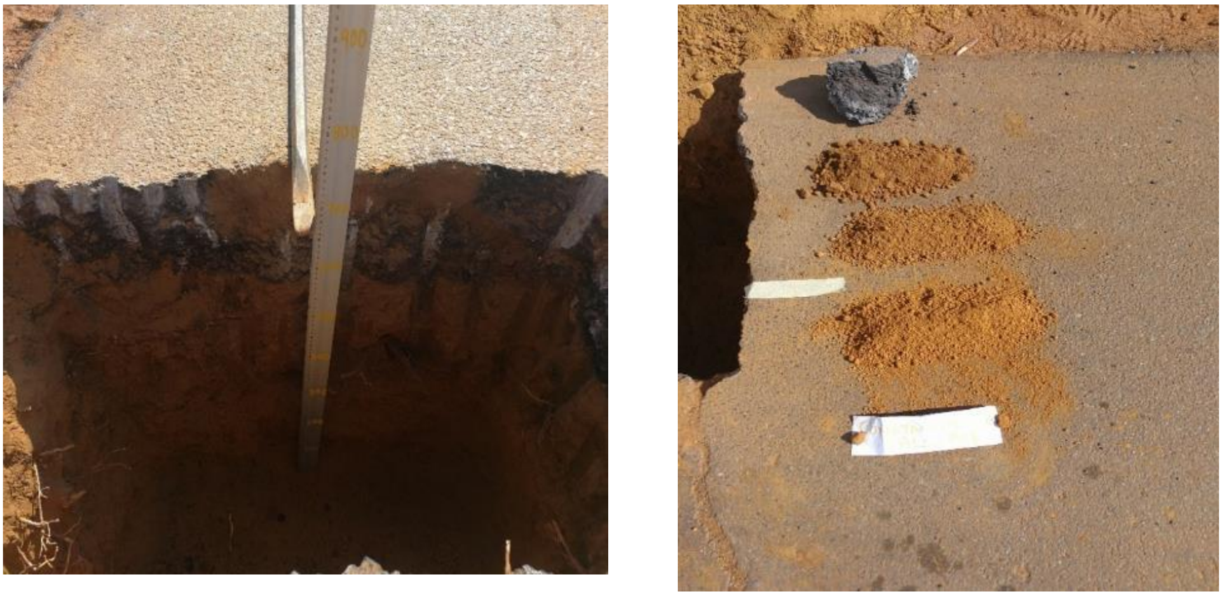

Photo 32: Test Pit 05 profile and pavement materials

Photo 33: 100mm slurry bound mecadam base

4.3 Groundwater

The material obtained on the road shoulder was generally wet from the topsoil possibly due to recent rains during excavations. At some point in the study, there was light rainfall that took place during excavation and sampling of materials were to be abandoned and test pits reprofiled after the rainfall subsided.

Perched underground water table was encountered at Test Pit 06, 10 and 11 at a depth of 1700mm, 1300mm and 900mm respectively, for example Photo 32. Underground water is expected to correlate directly with the water level in the small stream and correspond congruently with the surrounding topography.

Groundwater and moisture conditions may change from each season and time and these perched water tables may readily increase (or decrease) over short periods of time. Following heavy or sustained rainfall periods, water levels may rise substantially from the small stream and overlying the underlying rock that may occur on the site.

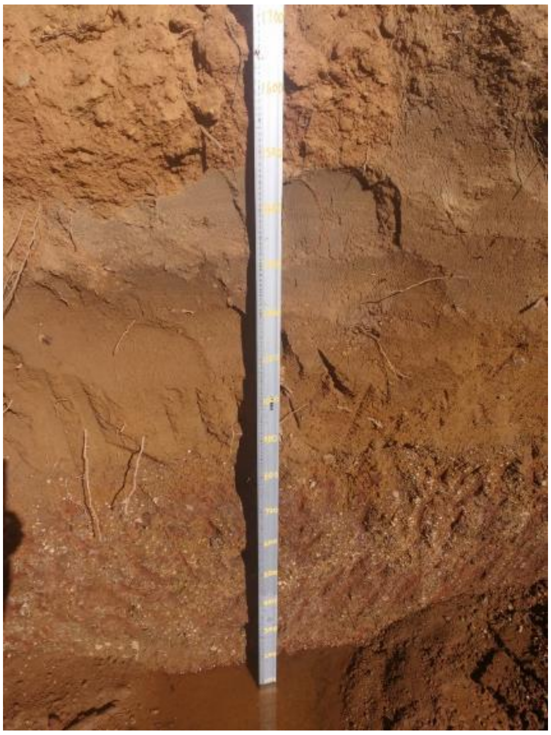

Photo 34: Underground water

5 GEOTECHNICAL, MATERIALS EVALUATION, PAVEMENT DESIGN AND RECOMMENDATIONS

5.1 Road Widenings and Mass Earthworks

The road reserve is covered by an average 500mm to 1700 thick layer of sandy and silty colluvium with properties varying between a G8 to less than G10 and this material will not be suitable as road construction materials for the upper layers but can be used for fills and storm water bedding and blanket material . Generally, the transported and residual soils were observed and may also be unconsolidated and owing to this potential loose state and their limited extent should also be disregarded as a direct founding horizon without treatment or compaction.

Any fill encountered on the reserve, may be expected to impact negatively on founding conditions as it may be expected to be variable, unconsolidated and loose in nature and should therefore be disregarded as a founding medium where encountered. The presence of building rumble on the shoulder adds to the variability of the founding materials which requires a competent person for selection and stockpiling for re-utilisation of material in the pavement layers for road widening. Table 5 contains a descriptive summary of the materials encountered.

Test Pit No.	**Profile**	**Material description**
TP06	0-900	Yellow orange brown, silty sandy gravel
TP06	900-1700	Dark red speckled black, silty clayey gravel (diamictite)
TP7	0-600	Yellow orange brown silty sandy gravel
TP7	600-1300	Dark red orange speckled white, clayey sandy gravel with weathered sandstone
TP8	0-500	Yellow orange brown silty sandy gravel
TP8	500-1300	Dark red orange speckled white, clayey sandy gravel with weathered sandstone.
TP9	0-1000	Dark red speckled black, silty clayey gravel (diamictite)
TP10	0-1300	Slightly moist, reddish brown, loose, intact, silty sand with roots. Topsoil.
TP11	0-300	Slightly moist, reddish brown, loose, intact, silty sand with roots. Topsoil.
TP11	300-900	Moist, brownish blue, stiff to very stiff, intact, sandy clay. Reworked residual.
TP12	0-300	Slightly moist, dark brown, loose, intact, silty sand with minor gravels and roots. Topsoil.
TP12	300-900	Slightly moist, dark brown, stiff to very stiff, intact, sandy clay. Reworked residual.
TP13	0-500	Dark red orange speckled white, clayey sandy gravel with weathered sandstone.
TP14	0-1600	Yellow orange brown, silty sandy gravel
TP15	0-1000	Slightly moist, reddish brown, loose, intact, silty sand. Topsoil.
TP16	0-300	Yellow orange brown silty sandy gravel
TP16	300-1300	Dark red speckled black, silty clayey gravel (diamictite)

Table 5: Description of material encountered on the road reserve

Conventional earthmoving equipment may be utilized for excavating in the transported and upper residual soils. Intermediate to hard excavation conditions will be encountered on the diamictite residual layer. Hard excavation would present itself in the sandstone rock and pneumatic tools will be required in those instances as well as the possibility of limited blasting.

Depending on construction levels, all loose and unconsolidated soil must be removed, and appropriate founding material utilized. The possibility of encountering boulders exist especially from EP Malan Street to Deodar Street and difficult excavating conditions will be presented where encountered.

When construction starts, site preparation should include the stripping and removal of existing vegetation, organic topsoil trees, existing foundations, abandoned underground utilities, debris and other deleterious materials from the areas to be excavated.

In general, the near surface soils encountered on site have a significant amount of silt and slightly collapsible in nature are therefore anticipated to be moisture sensitive. These conditions could hamper equipment manoeuvrability and efforts to compact site soils to the recommended densities during rainy season. In these instances, dump rock would have to be utilised to achieve insitu compaction of layer works as a pioneer layer.

5.2 Pavement Layer Works Foundation for the Widenings

The proposed foundation of pavement layer works for road widening are as follows:

- Selected layers and fill consisting of at least G7 gravel compacted to 93% MOD AASHTO
- Roadbed compacted to 90% MOD AASHTO

It is expected that the widening would be constructed with similar structural layers (surfacing, base and subbase) like the upgrade layer works of the existing roadway.

5.3 Upgrade and Construction of Structural Layer Works

The test pits indicate that the existing road for all the streets under investigation consists of asphalt surfacing with an average thickness of 40mm. This is supported by moderate to very dense base and subbase consisting of either asphalt base, slurry bound mecadam, stabilised gravel material and crushed stone base material of moderate to high shear strength.

Appropriate plant would be required in the rehabilitation of these roads. Any upgrade should consider the re-use of asphalt surfacing, base and subbase materials of which either chemical and mechanical stabilization should be done to modify insitu material for re-use in pavement layers.

5.3.1 Pavement design for the structural layers

The first objective of the pavement and rehabilitation design would be to provide a pavement structure that can sustain the structural and functional requirements for a period required by the Client. In this report, a period of 20 years is used for the selection of pavement materials and pavement layer works for capacity analysis. In terms of functional requirements, it is essential that a bituminous surfaced road be provided.

The second objective is to utilise local material as far as possible. This would require mechanical blending of existing pavement layers and surfacing, selection and stockpiling of suitable insitu material for re-use.

The pavement design for the structural layers utilised the South African Mechanistic Design Method (SAMDM) which uses linear elastic theory to determine theoretical stresses and strains at different positions in the pavement layers.

The Mechanistic design method starts with the load and material characterization. The standard design load for South Africa is a 40 kN dual wheel load at 350 mm spacing between centres and a uniform contact pressure of 520 kPa to 900kPa due to the legal axle load of 80 kN allowed on public roads. The material characterization includes layer thickness and elastic material properties for each layer in the pavement structure under consideration. The structural analysis involves a linear elastic, static analysis of the multi-layer system, resulting in the pavement response to the loading condition expressed in terms of stresses and strains at critical positions in the pavement structure determined by the material type used in each layer of the pavement structure.

5.3.2 Traffic loading

The 20-year traffic loading in terms if million E80s is shown in Table 6 and Table 7 for single carriageway and dual carriageway respectively as obtained from the Traffic loading analysis provided by Calliper Consulting Engineers.

Section No.	**Design Horizon (Years)**	**20**		
	Million E80s	**Low**	**Medium**	**High**
	Growth Rate per Annum	**1.51%**	**3.02%**	**5.56%**
1	Pomona Road - Maple Street	27.48	32.46	43.35
2	Maple Street - EP Malan Street	21.26	25.12	33.54
3	EP Malan Street - Elgin Street	19.85	23.45	31.31
4	Elgin Street - Deodar Street	18.55	21.92	29.27
5	Deodar Street - West Street	8.99	10.62	14.18

Table 6: 20-year traffic loading for single carriage way of Constantia Road

Section No.	**Design Horizon (Years)**	**20**		
	Million E80s	**Low**	**Medium**	**High**
	Growth Rate	**1.51%**	**3.02%**	**5.56%**
1	Pomona Road - Maple Street	19.24	22.72	30.34
2	Maple Street - EP Malan Street	14.88	17.58	23.48
3	EP Malan Street - Elgin Street	13.90	16.41	21.92
4	Elgin Street - Deodar Street	12.99	15.34	20.49
5	Deodar Street - West Street	6.29	7.43	9.92

Table 7: 20-year traffic loading with dualization of Constantia Road

5.3.3 *Recommended design traffic*

The recommended design traffic for the medium growth rate for a 20 year design scenario is presented in the tables that follow. The presentation indicates a situation where the upgrades results in single carriageway or a dual carriageway.

Section No.	**Design Horizon (Years)**	**20**			**Design Traffic (Million E80s)**
	Million E80s	**Low**	**Medium**	**High**	
	Growth Rate per Annum	**1.51%**	**3.02%**	**5.56%**	
1	Pomona Road - Maple Street	27.48	32.46	43.35	30
2	Maple Street - EP Malan Street	21.26	25.12	33.54	25
3	EP Malan Street - Elgin Street	19.85	23.45	31.31	25
4	Elgin Street - Deodar Street	18.55	21.92	29.27	20
5	Deodar Street - West Street	8.99	10.62	14.18	10

Table 8: Recommended design traffic for the single carriageway scenario

Section No.	**Design Horizon (Years)**	**20**			**Design Traffic (Million E80s)**
	Million E80s	**Low**	**Medium**	**High**	
	Growth Rate	**1.51%**	**3.02%**	**5.56%**	
1	Pomona Road - Maple Street	19.24	22.72	30.34	25
2	Maple Street - EP Malan Street	14.88	17.58	23.48	20
3	EP Malan Street - Elgin Street	13.90	16.41	21.92	20
4	Elgin Street - Deodar Street	12.99	15.34	20.49	15
5	Deodar Street - West Street	6.29	7.43	9.92	10

5.3.4 Recommended pavement layer works for reconstruction

Pavement options are presented in Table 9. The options were derived from a design philosophy that aims at utilising insitu materials as far as possible in the reconstruction of the stabilised subbase layers. The insitu material to be utilised for stabilised subbase shall consists of a mechanical blended asphalt surfacing millings and existing base and subbase depending on the final finished road levels.

Table 10 and Table 11 presents two options for pavement layer works for each section of Constantia Street. Table 10 indicates two options in a situation where the road remains as a single carriageway while Table 11 presents proposed options in case of a dual carriageway.

Option	Surfacing (mm)	Base (mm)	Subbase (mm)
1	40	150	400
	AC A-E2	G1	C3
2	40	100	400
	AC A-E2	BTB A-P1	C3
3	40	150	350
	AC A-E2	G1	C3
4	40	90	350
	AC A-E2	BTB A-P1	C3
5	40	150	300
	AC A-E2	G1	C3
6	40	90	300
	AC A-E2	BTB A-P1	C3
7	40	150	200
	AC 50/70	G1	C3
8	40	80	200
	AC 50/70	BTB A-P1	C3

Table 9: Proposed pavement options

Section		**Design Traffic (million E80s)**	**Selected Pavement Options See** Table 9	
1	Pomona Road - Maple Street (EB)	25	1	2
2	Maple Street - EP Malan Street (EB)	20	3	4
3	EP Malan Street - Elgin Street (EB)	20	3	4
4	Elgin Street - Deodar Street (EB)	15	5	6
5	Deodar Street - West Street (EB)	10	7	8

Table 10: Pavement options for the single carriage way for the section along Constantia Street (refer to Table 9 for selected options)

Section No.		Design Traffic (million E80s)	Selected Pavement Options See Table 9	
1	Pomona Road - Maple Street (EB)	25	3	4
2	Maple Street - EP Malan Street (EB)	20	5	6
3	EP Malan Street - Elgin Street (EB)	20	5	6
4	Elgin Street - Deodar Street (EB)	15	7	8
5	Deodar Street - West Street (EB)	10	7	8

Table 11: Pavement options for the dual carriage way for the section along Constantia Street with reference to Table 9 for selected options

5.3.5 Recommended pavement layer works for rehabilitation

The reconstruction of pavement described in the preceding section may be considered expensive and an alternative option would be a rehabilitation of the existing structural layers. Rehabilitation design are normally informed by stiffness measurements in the form of Falling Weight Deflectometer (FWDs) to establish the remaining life of the pavement and provide measures to meet futuristic traffic loading spectrum. This can be done at a detailed design stage of the project.

Based on subsurface materials observation and condition visual assessment, the following are the proposed rehabilitation measures:

- Section 1 between Pomona Road and Maple Street can be said to be in a good condition and would require rehabilitation in the form of surfacing along the roadway. The two intersections would require re-working of the base layer and resurfacing.
- Section 2 to 4 between Maple Street and Deodar Street can be said to be in a poor state and would require rehabilitation in the form of reworking the base layer and resurfacing.
- Section 5 between Deodar Street and West Street have defects manifesting in the form of block cracking which requires crack seal and rejuvenation, however we recommend that this section undergo proper rehabilitation due to ageing base layer (slurry bound mecadam) in the form of reworking the base layer and resurfacing.

5.4 Storm Water Upgrade

5.4.1 Founding conditions.

The topsoil and upper residual have been described in Section 5.1. Excavating for storm water pipes might encounter sandstone and shale bedrock rock beneath the cemented diamictite and is expected from 2 000mm to 3 000mm below original ground surface. This material has weathered to a degree insitu into a highly fractured rock but remains as a medium hard rock presenting a good founding material, especially for any structural work that might be done.

Perched waters occur, and will dominate if construction is done during rainy season requiring excavations to be dewatered. Allowance be made for dump rock fill as a pioneer layer. Obviously, any excavations within the stream itself will be problematic should the river be flowing.

Excavations were done at the small stream and the existing culverts are founded on mass concrete. Detailed geotechnical drilling will have to be undertaken should any superstructure be designed at stream.

Special precautions such as shoring and battering back excavations will be required to keep the working areas dry whilst construction is in progress.

5.4.2 Soil loading

The soil in which drainage structures such as pipes are installed has its own stiffness or resistance to vertical deflection under a surface load. The designer should assume that the soil surrounding the pipe has a density and therefore stiffness at least as great as the undisturbed adjacent soil. The most important factors for establishing earth loads on buried conduits are:

- the installation method
- fill height over conduit
- backfill density
- trench or external conduit width

In the determination of soil loading, the geostatic load has a value between the trench and embankment load. It is calculated from the equation below, which is the basis of earth loading equations.

$$W_E = \gamma H B$$

Where:

W_E - load of fill material in kN per meter.

γ – maximum density (=MDD) unit load of fill material in kN/m^3, provided in Appendix F.

B - trench width on top of conduit, or the outside diameter of pipe in m (trench or embankment condition respectively)

H - is fill height over pipe in m

When the fill height over a pipe exceeds 10 times its outside diameter full arching will take place and any further increases in fill will not increase the load. This maximum load can be calculated from:

$W_E = 2.63\gamma B$ for sandy conditions

$W_E = 3.84\gamma B$ in clayey conditions

Design parameters such as unit weights have been provided in Appendix F.

Various pipes are available in the market to be used in storm water. These include flexible pipe and rigid pipes. Flexible pipes are ordinarily less stiff (more flexible) than the soil in which it is embedded. Thus, the tendency is for the pipe to be deflected vertically (i.e. top and bottom flattened), more than the adjacent soil. This, in turn, tends to cause an increase in horizontal diameter of the pipe, which can only occur through compression of the soil beside the pipe. Good compaction beside the pipe during installation will minimize the effect.

Flexible pipe, while easily deformed by bending, is quite rigid with respect to retaining the length of its circumference. Given good side support, it is capable of sustaining great vertical loads. Rigid pipes are ordinarily stiffer than the soil in which it is embedded. The tendency is for the pipe to be deflected vertically less than the adjacent soil. This, in severe cases, leads to a hump over the pipe or low places on either side of it, and also results in the pipe carrying more than its proper share of the load from above. A good compaction beside the pipe during installation will minimize the effect.

Rigid pipe, while capable of carrying larger loads without side support, it is limited by its inherent strength. The addition of side support increases its vertical load-carrying capacity. The need for side support, while more obvious and extremely important for flexible pipe, can be quite important for rigid pipe.

5.4.3 Trench stability for storm water excavations

Trenches not exceeding 1300mm depth can remain open for periods of up to 2 days without significant collapse provided no significant rainfall and associated rise in groundwater seepage occurs during this period. If saturation of the trench occurs, sidewalls of trenches deeper than 1500mm should either be battered to a safe angle of 1V:2H (cohesionless) or supported laterally. In this respect it is recommended that the length of trenches likely to be left open for any sustained period be limited to prevent deterioration in the trench stability.

For excavation greater than 1500mm, all surface run-off or overland flows should be diverted by earth berms or other methods to prevent water entering the excavations. All runoff water and /or ground water entered within the excavation should be collected and disposed outside the construction limits.

Construction equipment, construction material, excavated soil, and vehicular traffic should not be allowed within 1/3 the slope height from the top of the excavation. Where the stability of adjoining buildings, walls, pavements, or other improvements is endangered by excavations operations, support systems, such as shoring, bracing, or underpinning may be required to provide structural stability and to protect personnel working within the excavation.

6 CONCLUSION

The proposed upgrade is underlain by sediments of the Karoo Sequence and Witwatersrand Supergroup as well as by andesitic lava of the Ventersdorp Supergroup with granite of the Basement Complex emerging in the south. From the geotechnical investigation, sandstone and probably shale rock predominately underlain the site and the proposed establishment is therefore supported from a geotechnical and perspective.

Owing to their consolidated state, residual soils should be classified as intermediate excavation. Excavations deeper than 2000mm may be classified as hard requiring pneumatic tools.

Various pavement options have been presented for each section of the road. These would be confirmed in detailed design of the project. Due to heavy trucks utilising the route, stiffness measurements shall be undertaken to produce an informed pavement design. For the road to perform optimally, drainage would require to be addressed and upgraded.

From a geotechnical and pavement engineering point of view, the proposed upgrade is feasible with no geotechnical hazards identified. Beside constraints that may be identified by other disciplines, the upgrade is supported from an engineering perspective posit by this report scope, context and domain.

7 LIMITATIONS

The recommendations contained in this report are based on our views, field observations, sub surface explorations, and our present knowledge of the proposed construction and laboratory results. It is possible that ground conditions could vary between or beyond the points explored. If soil conditions are encountered during construction that differ from those described herein, we should be notified immediately in order that a review may be made, and any supplementary recommendations be provided. If the scope of the proposed construction changes from that described in this report, our recommendation should be reviewed.

We have prepared this report in substantial accordance with the generally accepted geotechnical and pavement engineering practise as it exists in the site at the time of our study. The recommendations are based on the assumptions that the Design Engineer will apply his mind and incorporate adequate supervision during construction phase to evaluate compliance with our recommendations.

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9 APPENDICES

9.1 Appendix A: Test Pits Location

9.2 Appendix B: Design Parameters

1.1 Action

a) set of forces (loads) applied to the structure (direct actions);

b) set of imposed deformations or accelerations caused for example, by temperature changes, moisture variation, uneven settlement or earthquakes (indirect actions).

1.2 Active earth pressure

Minimum value of earth pressure exerted on a structure where the movement of the structure away from the retained earth is sufficient to fully mobilise the shear strength of the retained earth

1.3 Bulk weight density

Density of ground including the weight of moisture in the voids and pores

1.4 Design value

Value obtained by multiplying or dividing the representative value of an action or material property by a partial factor

1.5 Earth

Ground all earth materials (soil, gravel, rock, etc.) including fill or natural ground

1.6 Earth pressure

Lateral pressure exerted by earth and ground water on the structure

1.7 Earth pressure at rest

Pressure exerted by earth on an un-yielding structure where there is no movement of the structure relative to the ground

1.8 Effect of action

Effect of actions (or action effect) on structural members, (for example internal force, moment, stress, strain) or on the whole structure (for example deflection, rotation)

1.9 Fill

Imported soil or rock material placed on site with or without compaction

1.10 Geotechnical action

Action exerted on the structure by the ground or ground water

1.11 Irreversible serviceability limit states

Serviceability limit states where some consequences of actions exceeding the specified service requirements will remain when the actions are removed

1.12 Load case

Compatible arrangement of loads, sets of deformations and imperfections considered simultaneously with fixed variable actions and permanent actions for a particular verification

1.13 Limit states

States beyond which the structure no longer fulfils the relevant design criteria

1.14 Natural ground

In situ soil or rock in its natural undisturbed state

1.15 Nominal value

Value fixed on non-statistical bases, for instance on acquired experience or on physical conditions

1.16 Passive earth pressure

Maximum value of earth pressure exerted on a structure where the movement of the structure towards the retained earth is sufficient to fully mobilise the strength of the retained earth

1.17 Ultimate limit states

States associated with collapse or with other similar forms of structural failure

1.18 Unfavourable actions

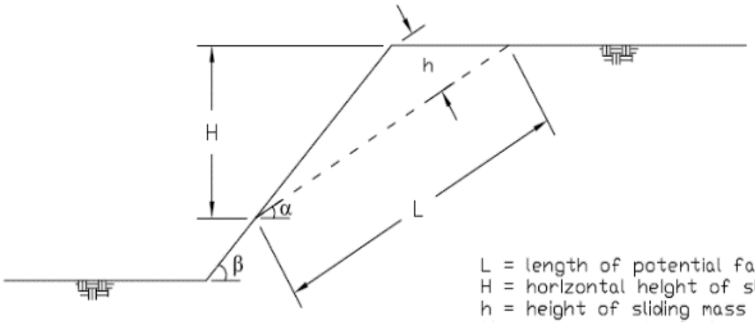
Actions that have a destabilizing effect

Recommended Angle of Friction Range

Description	**Soil friction angle [°]**		
	min	**max**	**Specific value**
Well graded gravel, sandy gravel, with little or no fines	33	40	
Poorly graded gravel, sandy gravel, with little or no fines	32	44	
Sandy gravels - Loose			35
Sandy gravels - Dense			50
Silty gravels, silty sandy gravels	30	40	
Clayey gravels, clayey sandy gravels	28	35	
Well graded sands, gravelly sands, with little or no fines	33	43	
Well-graded clean sand, gravelly sands - Compacted	-	-	38
Well-graded sand, angular grains - Loose			33
Well-graded sand, angular grains - Dense			45
Poorly graded sands, gravelly sands, with little or no fines	30	39	
Poorly-graded clean sand - Compacted	-	-	37
Uniform sand, round grains - Loose			27
Uniform sand, round grains - Dense			34
Sand	37	38	
Loose sand	29	30	
Medium sand	30	36	
Dense sand	36	41	
Silty sands	32	35	
Silty clays, sand-silt mix - Compacted	-	-	34
Silty sand - Loose	27	33	
Silty sand - Dense	30	34	
Clayey sands	30	40	
Calyey sands, sandy-clay mix - compacted			31
Loamy sand, sandy clay Loam	31	34	

Inorganic silts, silty or clayey fine sands, with slight plasticity	27	41	
Inorganic silt - Loose	27	30	
Inorganic silt - Dense	30	35	
Inorganic clays, silty clays, sandy clays of low plasticity	27	35	
Clays of low plasticity - compacted			28
Organic silts and organic silty clays of low plasticity	22	32	
Inorganic silts of high plasticity	23	33	
Clayey silts - compacted			25
Silts and clayey silts - compacted			32
Inorganic clays of high plasticity	17	31	
Clays of high plasticity - compacted			19
Organic clays of high plasticity	17	35	
Loam	28	32	
Silt Loam	25	32	
Clay Loam, Silty Clay Loam	18	32	
Silty clay	18	32	
Clay	18	28	
Peat and other highly organic soils	0	10	

Slope Stability Analysis for Excavations



SLIDING FORCES

$F_s = W \sin\alpha$

SLIDING RESISTANCE

$R_s = cL + W\cos\alpha\tan\phi$

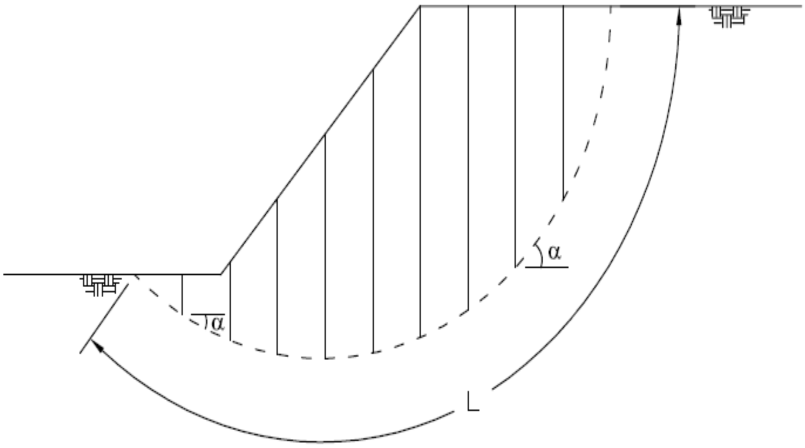
FACTOR OF SAFETY

$$FS = \frac{cL + W\cos\alpha\tan\phi}{W\sin\alpha}$$

L = length of potential failure plane
H = horizontal height of sliding mass
h = height of sliding mass
W = $\frac{Lh\gamma}{2}$ = weight of sliding mass
c = cohesion along failure plane
ϕ = angle of internal friction along failure plane
α = angle of potential failure surface
β = angle of slope
γ = unit weight of soil within sliding mass

ANALYSIS

Calculate factor of safety (FS) for multiple slip planes by using various horizontal heights of sliding mass (H) and angles of potential failure surface (α) until the lowest factor of safety is determined. Acceptable factor of safety for static slope conditions is usually equal to or greater than 1.5.



SLIDING FORCES

$F_s = \Sigma(W_i \sin\alpha_i)$

SLIDING RESISTANCE

$R_s = cL + [\Sigma(W_i\cos\alpha_i)]\tan\phi$

FACTOR OF SAFETY

$$FS = \frac{cL + [\Sigma(W_i\cos\alpha_i)]\tan\phi}{\Sigma(W_i\sin\alpha_i)}$$

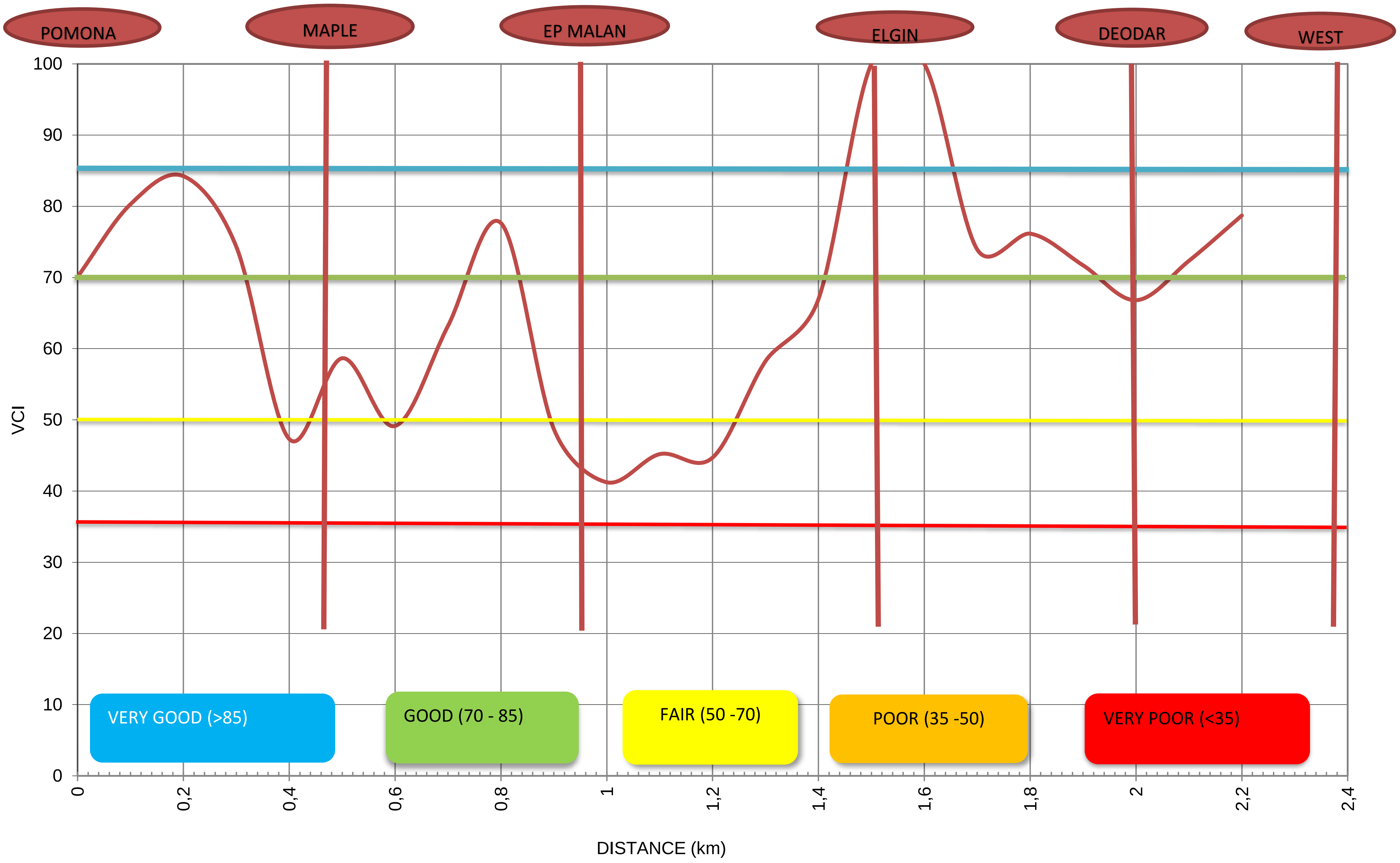
L = length of potential failure surface
W = γA = weight of individual soil slice
c = cohesion along failure surface
ϕ = angle of internal friction along failure surface
α = angle between horizontal plane and failure surface of individual slice. If horizontal plane is above the failure plane of the slice (i.e. left side of the circle) then α is a negative value.
γ = unit weight of soil within sliding mass
A = area of individual slice

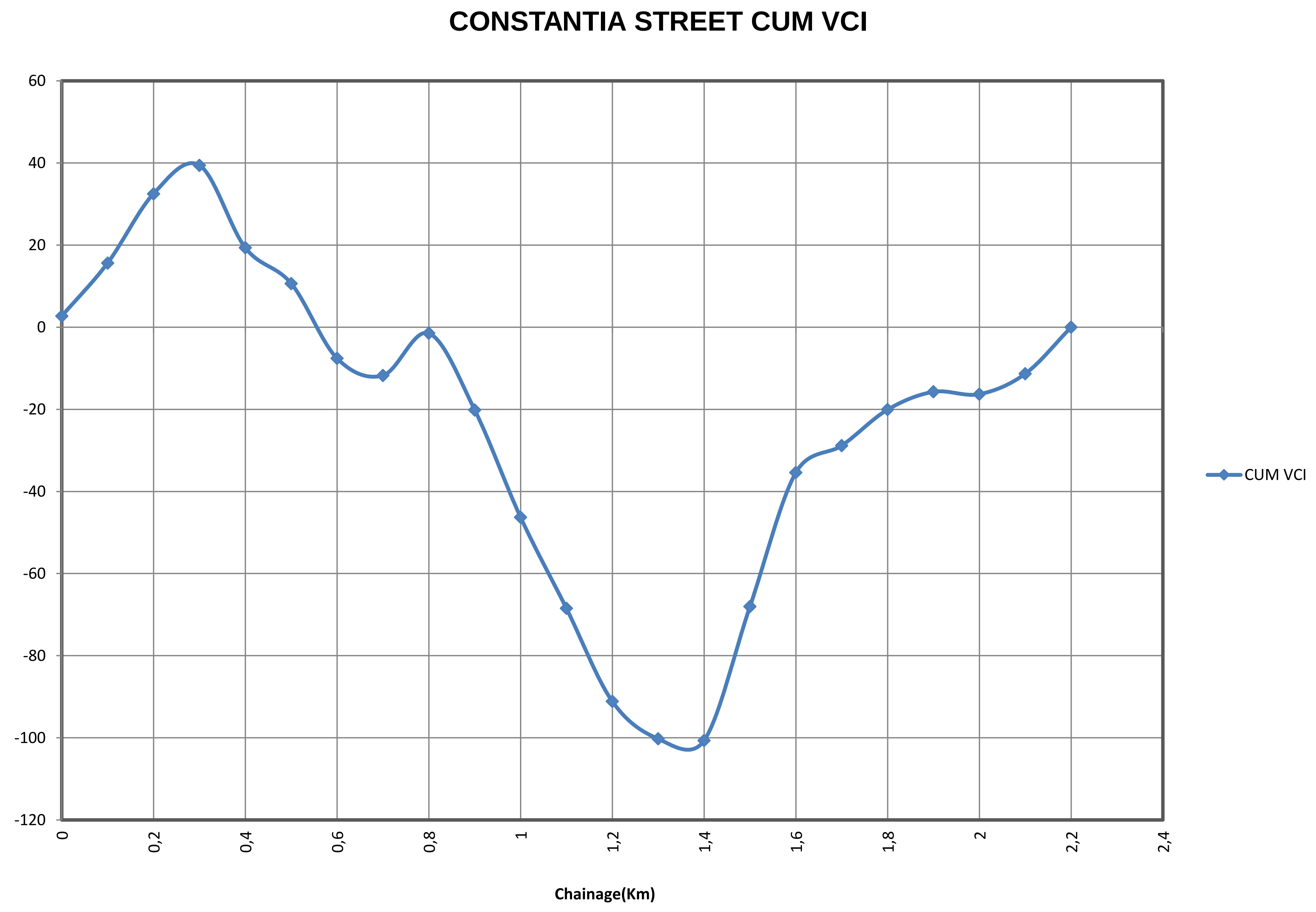
ANALYSIS

Calculate factor of safety (FS) for multiple slip surfaces by using various circle locations and radii until the lowest factor of safety is determined. The potential sliding mass is divided into slices, usually 10 slices. The above equations account for the summation (Σ) of all individual slice weights and slice angles (α). Acceptable factor of safety for static slope conditions is usually equal to or greater than 1.5.

9.3 Appendix C: Visual Assessment

CONSTANTIA STREET - VCI DATA




CONSTANTIA STREET CUM VCI
60
40
20
0
-20
-40
-60
-80
-100
-120
0
0,2
0,4
0,6
0,8
1
1,2
1,4
1,6
1,8
2
2,2
2,4
Chainage(Km)
CUM VCI

ANALYSIS OF VCI

From	to	VCI	Ave VCI	CUM VCI	Average	Stdev	CoV
0,00	0,10	70	70	3			
0,10	0,20	80	75	16			
0,20	0,30	84	82	33			
0,30	0,40	74	79	39			
0,40	0,50	47	61	19			
0,50	0,60	59	53	11			
0,60	0,70	49	54	-8			
0,70	0,80	63	56	-12			
0,80	0,90	78	70	-1			
0,90	1,00	49	63	-20			
1,00	1,10	41	45	-46			
1,10	1,20	45	43	-68			
1,20	1,30	45	45	-91			
1,30	1,40	58	51	-100			
1,40	1,50	67	63	-101			
1,50	1,60	100	83	-68			
1,60	1,70	100	100	-35			
1,70	1,80	74	87	-29			
1,80	1,90	76	75	-20			
1,90	2,00	72	74	-16			
2,00	2,10	67	69	-16			
2,10	2,20	72	70	-11			
2,20	2,30	79	76	0			
	Sum	1550					
	Average	67					

Constantia Street

Lane: L&R

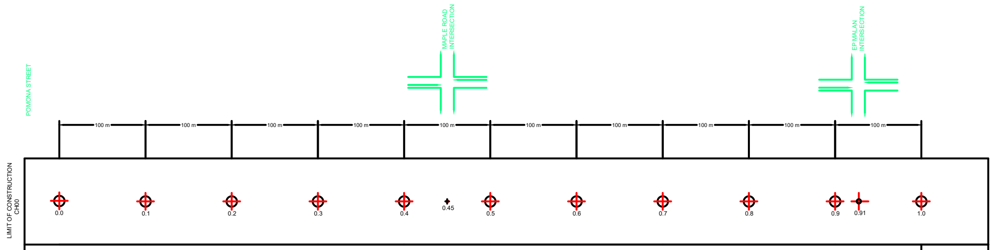
SECTION		SURFACE ASSESSMENT										STRUCTURAL ASSESSMENT																		FUNCTIONAL										
												CRACKS								Pumping		Rutting		Undulation		Patching		Potholes												
START	END	Surf Fail		Surf Crack		Aggr Loss		Binder Cond		Bleed/Flush		Block		Croc		Long		Trans												Drainage		Edge Drop		Shoulders		Edge Break		Overall	VCI (%)	Condition categories
km	km	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	Deg	Cause	Deg	Ext	Type	Cond	Deg	Ext	Condition		
0,00	0,10									3	3			4	2									4	3	1	3												70	Good
0,10	0,20	4	1							3	3															4	1												80	Good
0,20	0,30									3	3															1	3												84	Good
0,30	0,40									3	3											4	2			3	2												74	Good
0,40	0,50			4	3					3	3			5	3							4	2									5	3			5	5		47	Poor
0,50	0,60							3	5					3	3																	5	5			5	5		59	Fair
0,60	0,70			1	3			3	5					5	3	3	5															3	5			5	5		49	Poor
0,70	0,80			3	1			3	5	3	4			5	2																					5	3		63	Fair
0,80	0,90	3	1					3	5															5	1	3	1												78	Good
0,90	1,00	4	1					3	5			4	3	4	3									5	1							5	3			5	5		49	Poor
1,00	1,10							3	5			4	3	4	3	3	4	3	4							3	1					5	4			5	5		41	Poor
1,10	1,20	5	2					3	5					5	4											5	3									3	3		45	Poor
1,20	1,30	3	5					3	5					5	3											3	2					5	5			5	3		45	Poor
1,30	1,40	3	5					3	5																	4	1					5	5			5	3		58	Fair
1,40	1,50	3	5					3	5	3	3					3	3																						67	Fair
1,50	1,60																																						100	Very Good
1,60	1,70																																						100	Very Good
1,70	1,80							3	5																							5	3			5	3		74	Good
1,80	1,90	4	1					3	5																							5	2			3	2		76	Good
1,90	2,00							3	5							3	2	5	3							3	1												72	Good
2,00	2,10							3	5			4	3			3	2	5	3																				67	Fair
2,10	2,20							3	5							3	2	5	3													3	2						72	Good
2,20	2,30							3	5							3	4																						79	Good
								3	5																															
Average VCI																																							67	Fair

Comments:

LEGENDS:

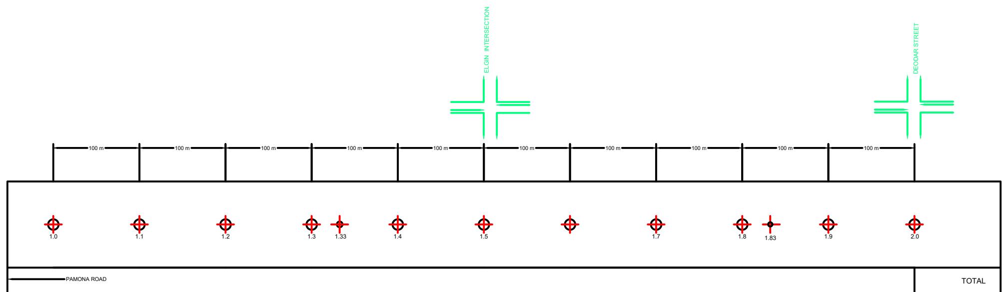
SHOULDER TYPE:		DRAINAGE	
G	Gravel	S	Sandy
K+G	Kerb + Grav	B	Blocked
G/G	**Grass+Gravel**	O	Overgrown

Legend: A = adequate; I = inadequate; Up = unpaved; U = unsafe; S = safe; W = warning; P = poor; F = fair; HR = heavy rehab; LR = light rehab; RS = reseal.



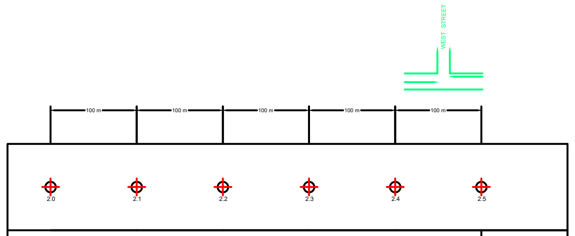
	SURFACE AREA OF SURFACING(m^2)	600	600	600	600	600	600	600	600	600	600	6000m^2
CRACKING	LC (m / 100m)	0	0	0	0	0	0	5	10	4	0	19m
	TC (m / 100m)	0	0	0	0	0	0	0	3	0	1,6000	4.6m
	BC (m^2 / 100m)	0	0	0	0	0	0	0	0	0	0	0m^2
	CC (m^2 / 100m)	8	0	0	0	1,5000	0	0,2400	8	0,4500	12	30.19m^2
	SURFACE TEXTURE (BLEEDING)(m / 100m)	80	65	75	80	75	0	0	70	0	0	445m
EDGE REPAIRS	EB (m / 100m)	0	0	0	0	90	90	90	90	0	90	450m
	ED (Depth / m)	0	0	0	0,2000	0,2000	0,1000	0	0	0	0,2000	0,7m
	POTHOLES (Number)	0	0	0	0	0	0	0	0	0	0	0
	PATCHING (m^2 / 100m)	2	3	3	0	0	0	0	0	3	0	11m^2
	NUMBER OF HYDRAULIC DRAINAGE FACILITIES	1	1	0	2	1	0	0	0	1	0	6

DEFECTS LIST: KM 0.000 TO KM 1.000



											TOTAL
	SURFACE AREA OF SURFACING(m^2)	600	600	600	600	600	600	600	600	600	600	6000m^2
CRACKING	LC (m / 100m)	0	4	0	0	0	0	0	0	0	60	64m
	TC (m / 100m)	6	3	0	0	10	0	0	0	0	0	9m
	BC (m^2/ 100m)	0	0	0	0	0	0	0	0	0	0	0m^2
	CC (m^2 / 100m)	3,3000	24	21	23	0	0	3	4	2	0	80,3m^2
	SURFACE (BLEEDING) (m / 100m)	0	0	0	0	60	76	0	0	0	0	136m
EDGE REPAIRS	EB (m / 100m)	73	64	0	0	61	60	61	55	61	54	490m
	ED (Depth / m)	0,2000	0	0	0	0,2000	0,3000	0,2000	0,2000	0,1000	0,2000	1,4m
	POTHOLES (Number)	0	0	0	0	0	0	0	0	0	0	0
	PATCHING (m^2 / 100m)	0,5000	6	11	16	6	0	0	0	0	3	42,5m^2
	NUMBER OF HYDRAULIC DRAINAGE FACILITIES	0	0	0	0	0	0	0	0	0	0	0

DEFECTS LIST: KM 1.000 TO KM 2.000



							TOTAL
	SURFACE AREA OF SURFACING(m2)	600	600	600	600	600	3000m^2
CRACKING	LC (m / 100m)	100	100	100	90	9	399m
	TC (m / 100m)	0	15	5,0000	0	0	3,1m
	BC (m2 / 100m)	0	2	0,2000	0	0	2,2m^2
	CC (m2 / 100m)	0	0	0	0	0	0m^2
	SURFACE TEXTURE (BLEEDING)(m / 100m)	0	0	0	0	0	0m
EDGE REPAIRS	EB (m / 100m)	0	0	0	0	0	0m
	ED (Depth / m)	0	0	0	0,1000	0,1000	0,2m
	POTHOLES (Number)	0	0	0	0	0	0
	PATCHING (m2 / 100m)	2	0	0	0	0	2m^2
	NUMBER OF HYDRAULIC DRAINAGE FACILITIES	0	0	0	0	0	0

DEFECTS LIST: KM 2.000 TO KM 2.5

No	DATE	AMENDMENTS	for HEAD OF DEPT.	DATE
01	06/2018	DETAILED DESIGN		

SURVEYED BY

SIGNTR.
DATE

DEP DIR:
TECH. SERVICES
DATE

DESIGNED BY

NDLOVU ENGINEERING TECHNIKS
25 MESOLITE CRESCENT
ENNERDALE EXT 5
ENNERDALE
1830

Tel.: (011) 211 0149

DESIGNED BY: J CHIKOMBA
CHECKED BY: S. NDLOVU
DRAWN BY: X MCUBE
CHECKED BY: S. NDLOVU

S. NDLOVU
DESIGN APPROVED
for CONSULTING ENGINEER
DATE:

APPROVED BY
for HEAD OF DEPARTMENT
DATE:

PROJECT
CONSTANTIA ROAD UPGRADE

DESCRIPTION
DEFECTS LIST: TRH12

CLIENT
EKURHULENI METROPOLITAN MUNICIPALITY
ROADS AND STORM WATER

SCALE	REVISION No	STAGE	TYPE OF DESIGN
N.T.S	00	DETAILED DESIGN (DD)	DD
DATE	**AGREEMENT No**		**DRG. No**
JUNE 2018			NET0044-RT-DD-01-00

DWG.No. NET0044-RT-DD-01-00

SHEET 1 OF 1

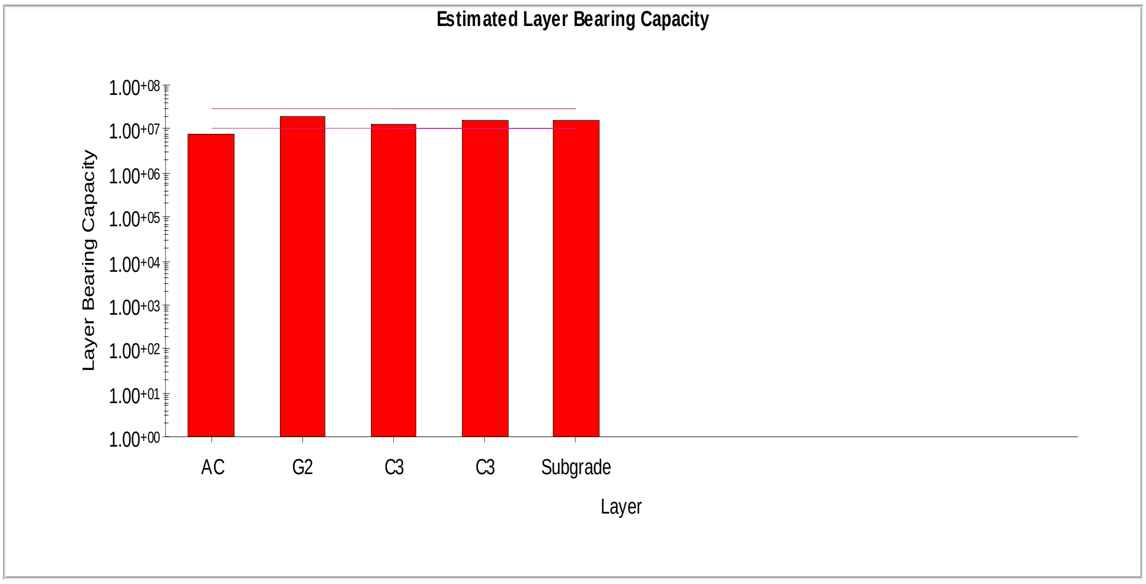
9.4 Appendix D: Pavement Design Calculations- Granular Base

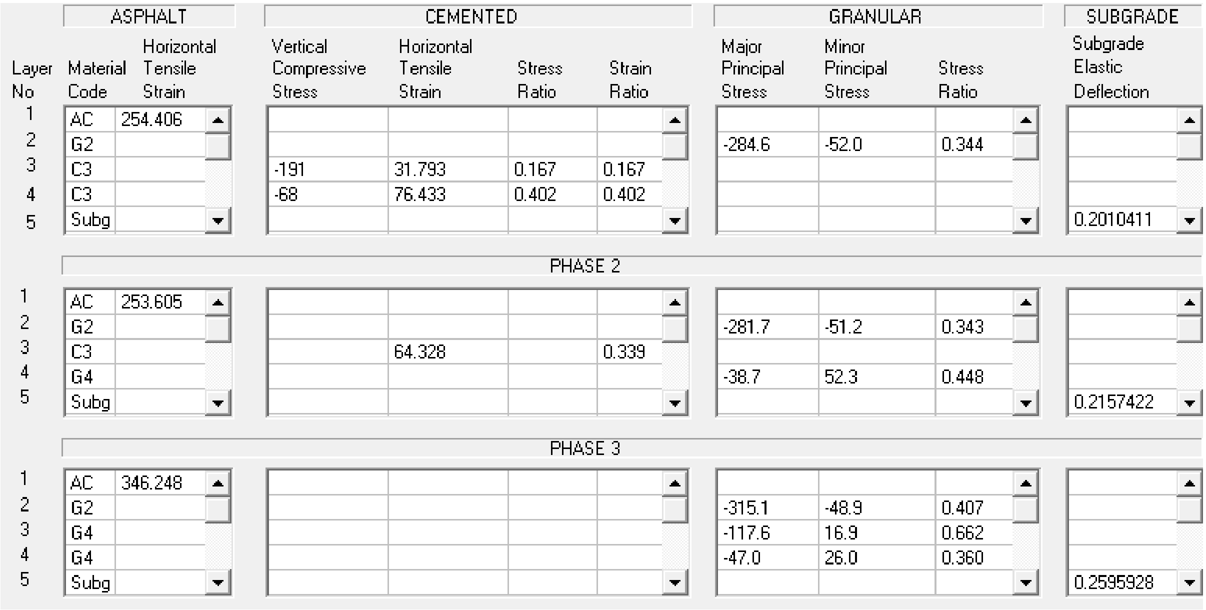
For Granual Base Under Heavy Traffic Loading (from Pomona Road to Elgin Street)

Pavement Structure A:

- 40mm Asphalt (AC)
- 150mm G2 (import)
- 150mm C3 upper subbase
- 150mm C3 lower subbase
- The layers beneath the existing subbase will remain untouched.

- **Inflation pressure = 520 kPa.**

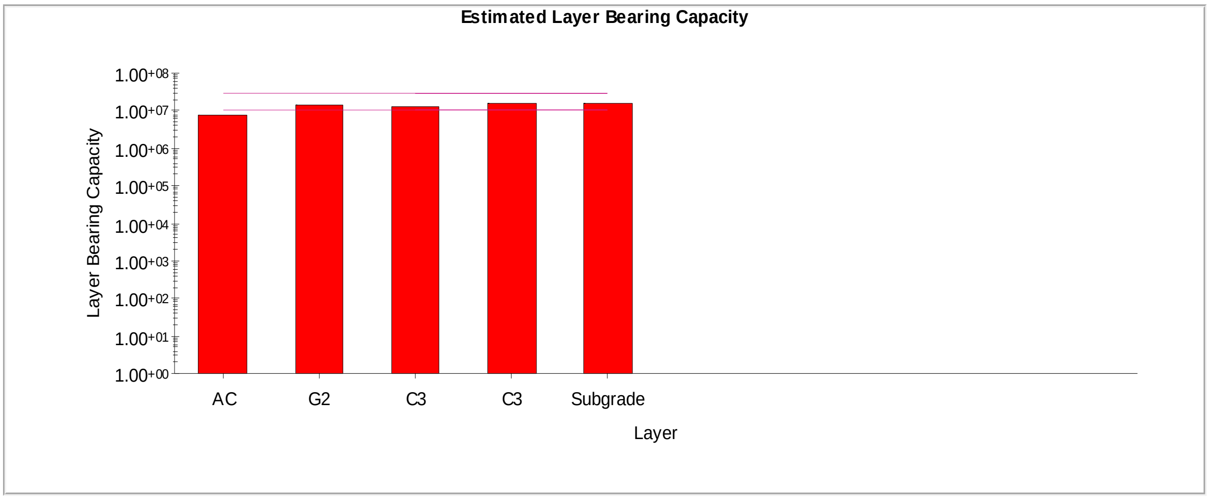


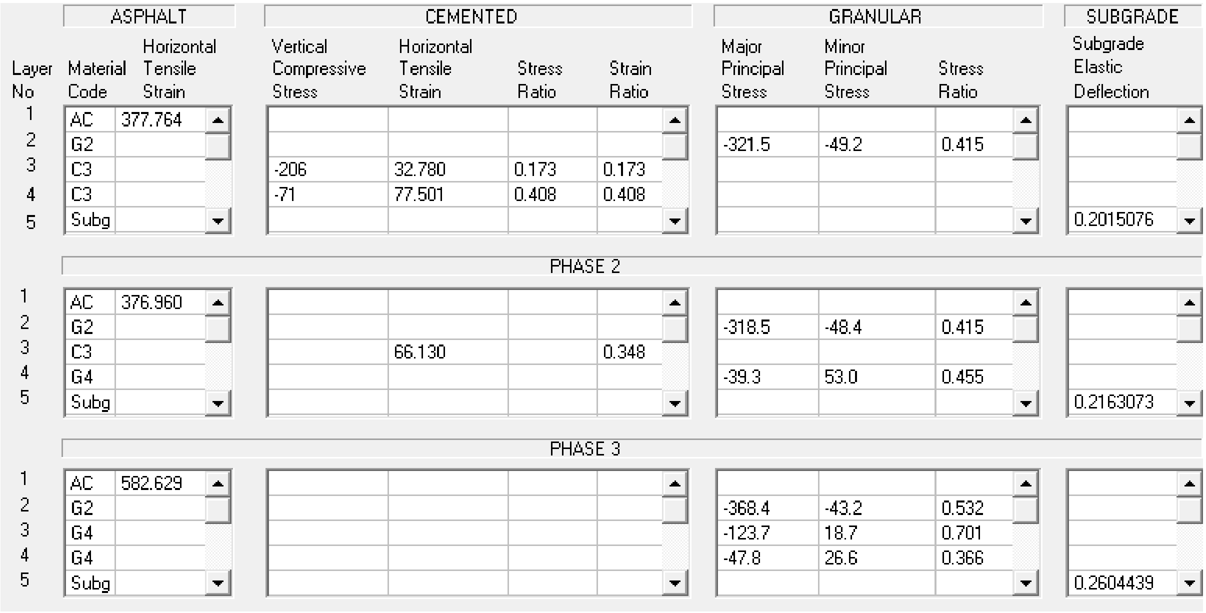


	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	254.406								
2	G2						-284.6	-52.0	0.344	
3	C3		-191	31.793	0.167	0.167				
4	C3		-68	76.433	0.402	0.402				
5	Subg									0.2010411
	PHASE 2									
1	AC	253.605								
2	G2						-281.7	-51.2	0.343	
3	C3			64.328		0.339				
4	G4						-38.7	52.3	0.448	
5	Subg									0.2157422
	PHASE 3									
1	AC	346.248								
2	G2						-315.1	-48.9	0.407	
3	G4						-117.6	16.9	0.662	
4	G4						-47.0	26.0	0.360	
5	Subg									0.2595928

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	356191	0	362073	1	0	0	71826.2	1	0	7.48E+06
G2	2.09E+07	1.56E+07	2.09E+07	1	1.56E+07	1.34E+07	1.78E+07	1.17448	1.14E+07	1.89E+07
C3	8.38E+06	3.12E+06	5.96E+06	1.40532	2.22E+06	0	5.85E+06	1	5.85E+06	1.33E+07
C3	5.25E+06	0	1.09E+07	1	1.09E+07	8.69E+06	1.41E+07	1	8.69E+06	1.62E+07
Subgrade	2.31E+07	1.78E+07	2.06E+07	1.12191	1.59E+07	1.37E+07	1.52E+07	1.51685	9.02E+06	1.65E+07

- **Inflation pressure = 750 kPa**

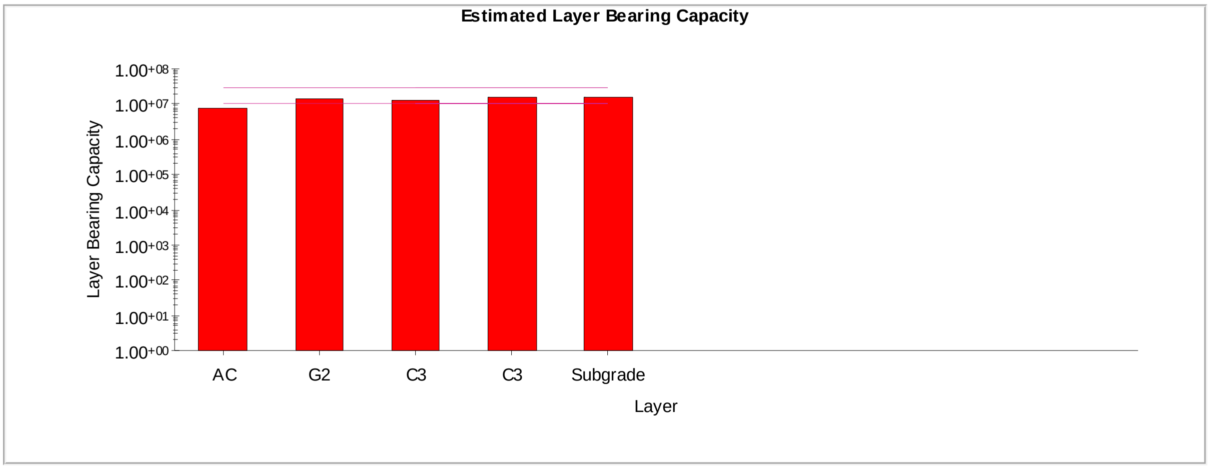


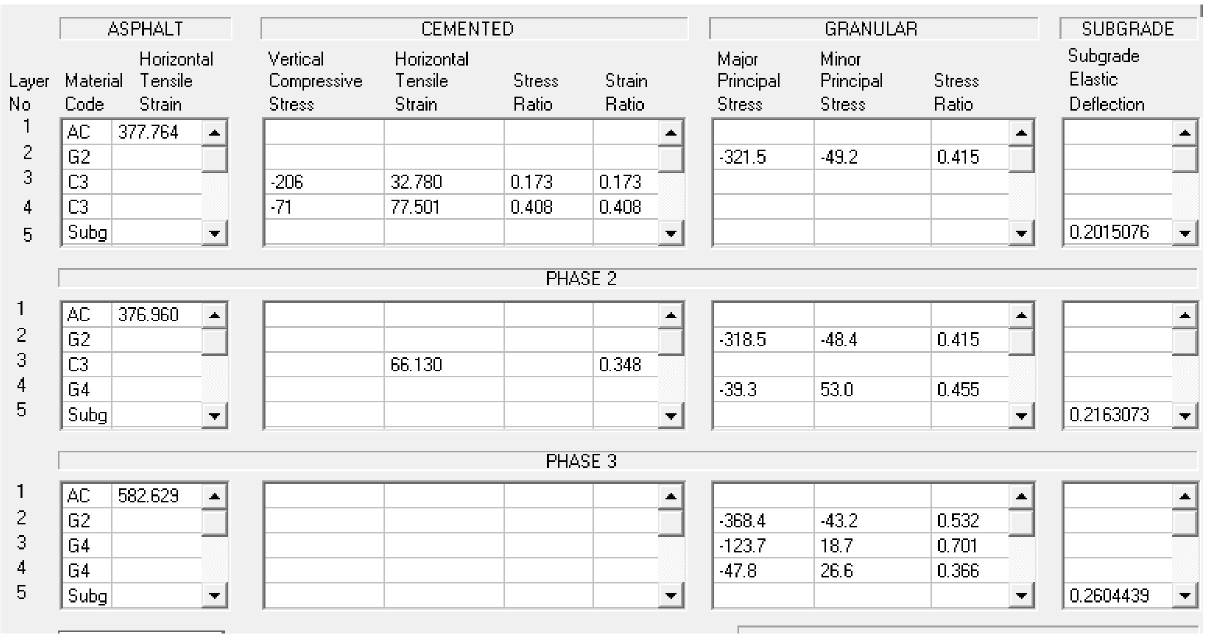


	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	377.764								
2	G2						-321.5	-49.2	0.415	
3	C3		-206	32.780	0.173	0.173				
4	C3		-71	77.501	0.408	0.408				
5	Subg									0.2015076
	PHASE 2									
1	AC	376.960								
2	G2						-318.5	-48.4	0.415	
3	C3			66.130		0.348				
4	G4						-39.3	53.0	0.455	
5	Subg									0.2163073
	PHASE 3									
1	AC	582.629								
2	G2						-368.4	-43.2	0.532	
3	G4						-123.7	18.7	0.701	
4	G4						-47.8	26.6	0.366	
5	Subg									0.2604439

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	45681.7	0	46189.7	1	0	0	4810.48	1	0	7.38E+06
G2	1.74E+07	1.22E+07	1.74E+07	1.00038	1.22E+07	1.01E+07	1.30E+07	1.34319	7.48E+06	1.49E+07
C3	8.29E+06	3.10E+06	5.85E+06	1.41736	2.19E+06	0	5.23E+06	1	5.23E+06	1.26E+07
C3	5.19E+06	0	1.07E+07	1	1.07E+07	8.51E+06	1.38E+07	1	8.51E+06	1.59E+07
Subgrade	2.30E+07	1.78E+07	2.05E+07	1.12246	1.59E+07	1.37E+07	1.51E+07	1.51921	9.01E+06	1.64E+07

- **Inflation pressure = 900 kPa.**

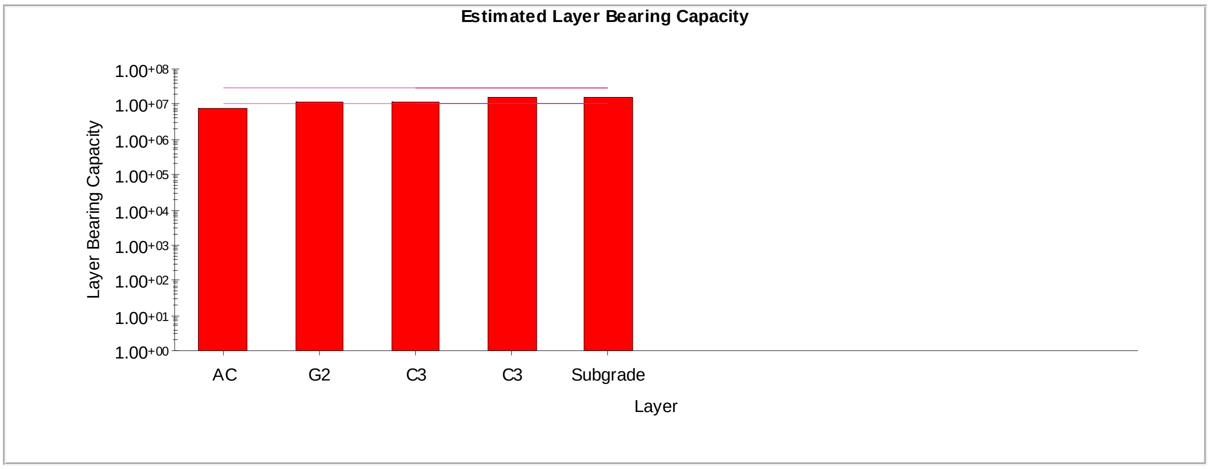


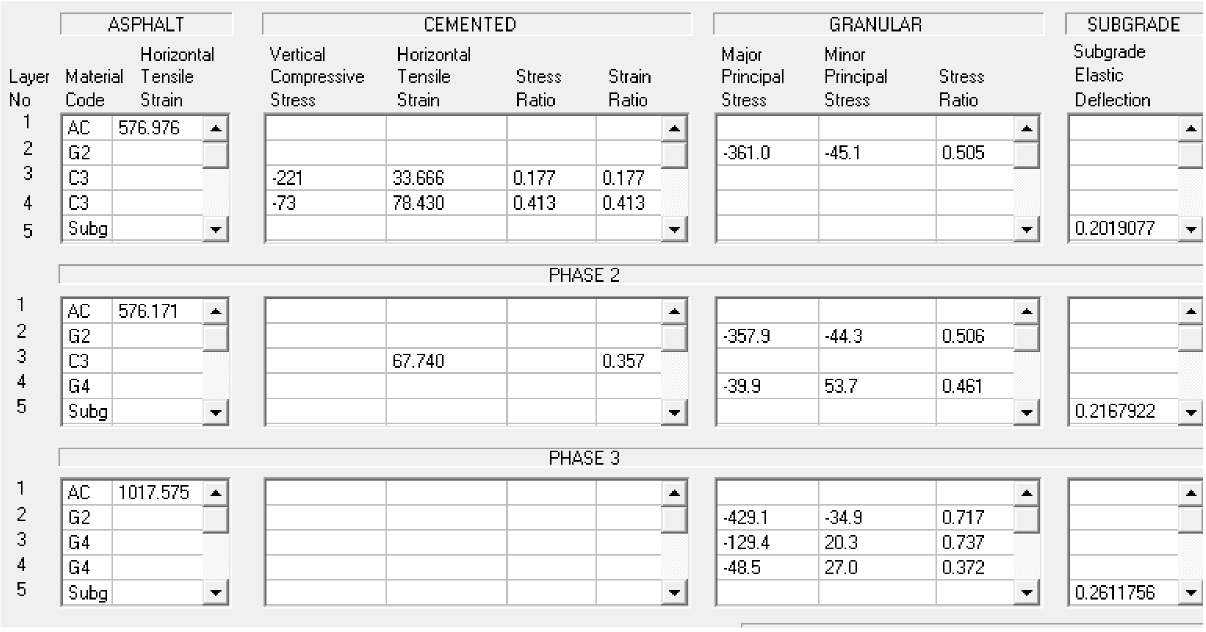


	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	377.764								
2	G2						-321.5	-49.2	0.415	
3	C3		-206	32.780	0.173	0.173				
4	C3		-71	77.501	0.408	0.408				
5	Subg									0.2015076
	PHASE 2									
1	AC	376.960								
2	G2						-318.5	-48.4	0.415	
3	C3			66.130		0.348				
4	G4						-39.3	53.0	0.455	
5	Subg									0.2163073
	PHASE 3									
1	AC	582.629								
2	G2						-368.4	-43.2	0.532	
3	G4						-123.7	18.7	0.701	
4	G4						-47.8	26.6	0.366	
5	Subg									0.2604439

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	45681.7	0	46189.7	1	0	0	4810.48	1	0	7.38E+06
G2	1.74E+07	1.22E+07	1.74E+07	1.00038	1.22E+07	1.01E+07	1.30E+07	1.34319	7.48E+06	1.49E+07
C3	8.29E+06	3.10E+06	5.85E+06	1.41736	2.19E+06	0	5.23E+06	1	5.23E+06	1.26E+07
C3	5.19E+06	0	1.07E+07	1	1.07E+07	8.51E+06	1.38E+07	1	8.51E+06	1.59E+07
Subgrade	2.30E+07	1.78E+07	2.05E+07	1.12246	1.59E+07	1.37E+07	1.51E+07	1.51921	9.01E+06	1.64E+07

- **Inflation pressure = 1200kPa**



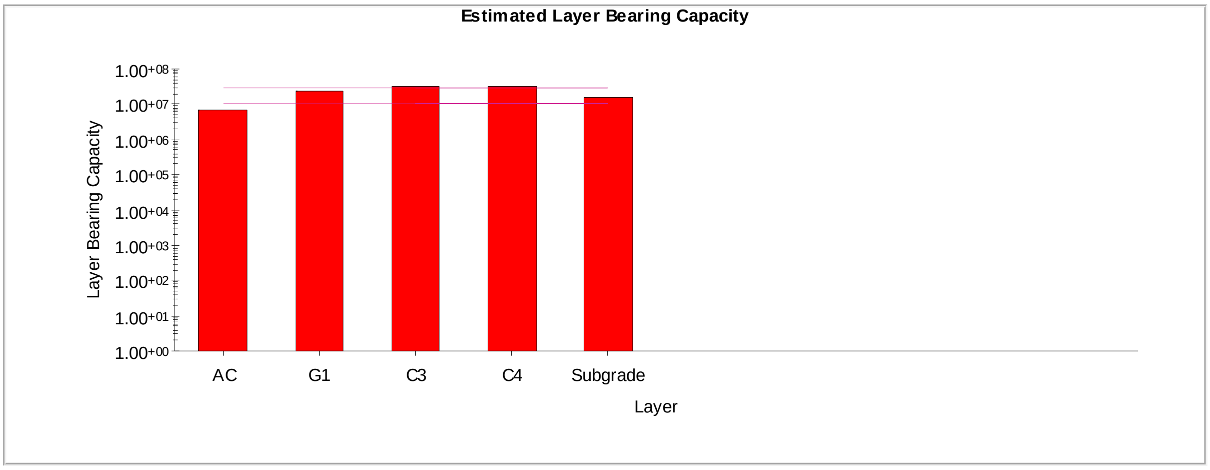


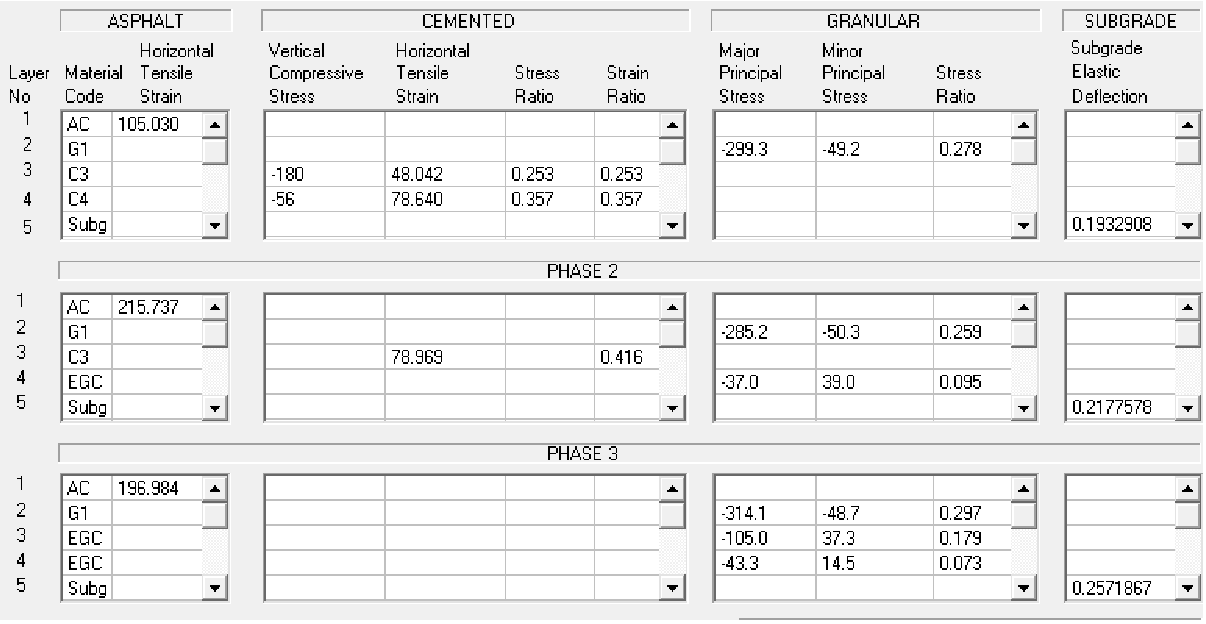
		ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain		Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	576.976									
2	G2							-361.0	-45.1	0.505	
3	C3			-221	33.666	0.177	0.177				
4	C3			-73	78.430	0.413	0.413				
5	Subg										0.2019077
		PHASE 2									
1	AC	576.171									
2	G2							-357.9	-44.3	0.506	
3	C3				67.740		0.357				
4	G4							-39.9	53.7	0.461	
5	Subg										0.2167922
		PHASE 3									
1	AC	1017.575									
2	G2							-429.1	-34.9	0.717	
3	G4							-129.4	20.3	0.737	
4	G4							-48.5	27.0	0.372	
5	Subg										0.2611756

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	5060.4	0	5097.25	1	0	0	265.518	1	0	7.29E+06
G2	1.39E+07	8.74E+06	1.39E+07	1.00191	8.72E+06	6.57E+06	8.11E+06	1.71037	3.84E+06	1.11E+07
C3	8.21E+06	3.07E+06	5.75E+06	1.42813	2.15E+06	0	4.71E+06	1	4.71E+06	1.20E+07
C3	5.14E+06	0	1.05E+07	1	1.05E+07	8.35E+06	1.36E+07	1	8.35E+06	1.56E+07
Subgrade	2.29E+07	1.78E+07	2.04E+07	1.12293	1.58E+07	1.37E+07	1.51E+07	1.52125	9.00E+06	1.63E+07

Pavement Structure B

- 40mm Asphalt (AC)
- 150mm G1 (import)
- 150mm C3,
- 150mm C4
- The layers beneath the existing subbase will remain untouched
- **520 kPa**





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	105.030								
2	G1						-299.3	-49.2	0.278	
3	C3		-180	48.042	0.253	0.253				
4	C4		-56	78.640	0.357	0.357				
5	Subg									0.1932908

PHASE 2

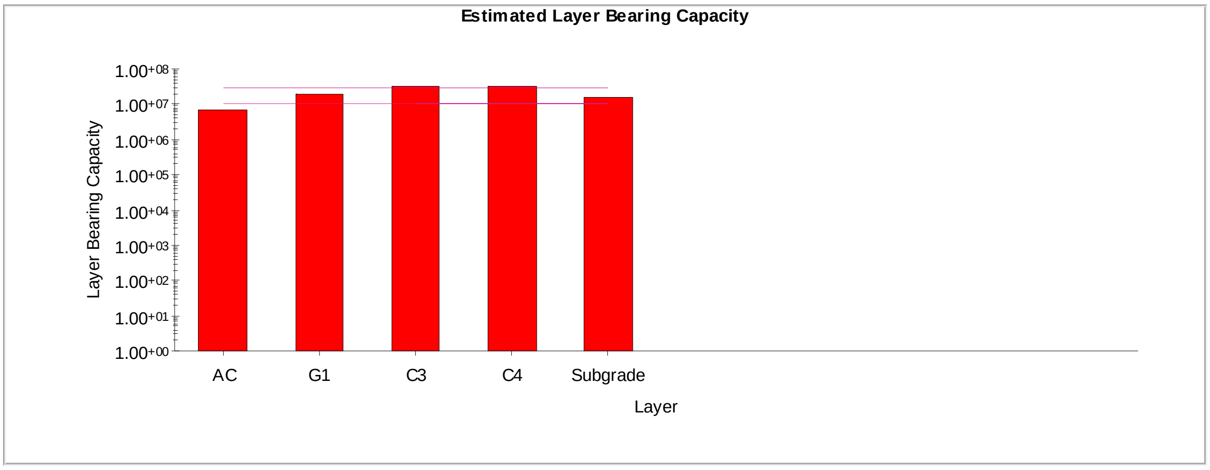
1	AC	215.737								
2	G1						-285.2	-50.3	0.259	
3	C3			78.969		0.416				
4	EGC						-37.0	39.0	0.095	
5	Subg									0.2177578

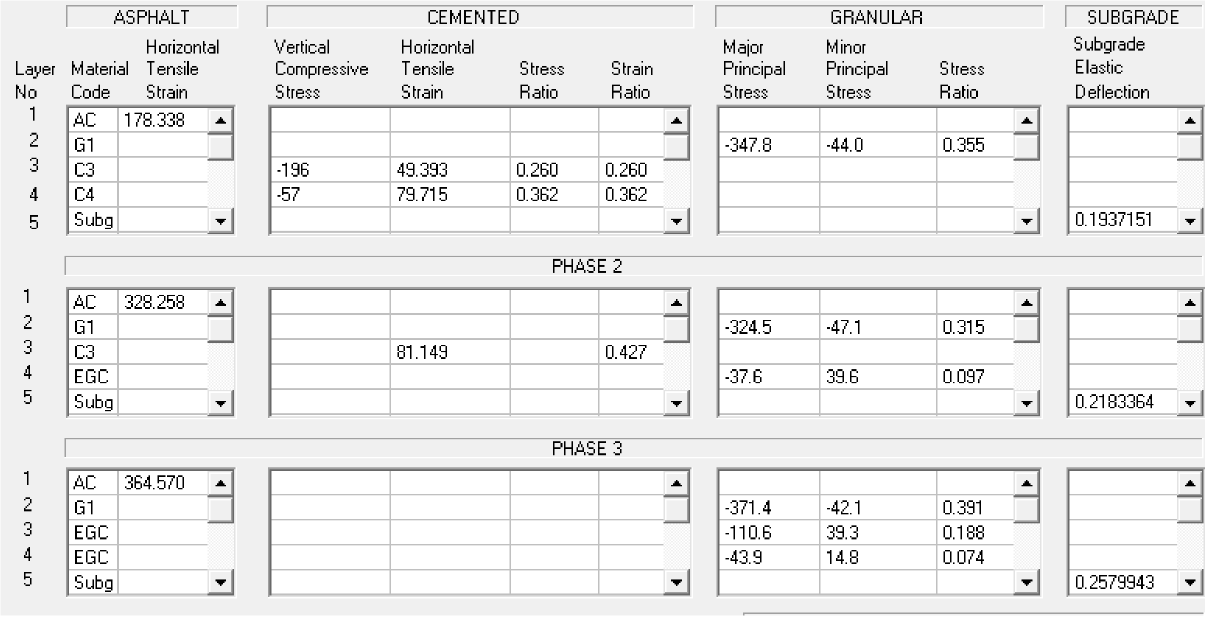
PHASE 3

1	AC	196.984								
2	G1						-314.1	-48.7	0.297	
3	EGC						-105.0	37.3	0.179	
4	EGC						-43.3	14.5	0.073	
5	Subg									0.2571867

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	3.53E+07	2.96E+07	838806	42.0738	702346	0	1.35E+06	1	0	6.70E+06
G1	2.46E+07	1.89E+07	2.59E+07	1	1.89E+07	1.79E+07	2.35E+07	1.04701	1.71E+07	2.38E+07
C3	7.07E+06	1.33E+06	5.11E+06	1.38188	959871	0	2.43E+07	1	2.43E+07	3.10E+07
C4	5.74E+06	0	2.49E+07	1	2.49E+07	2.40E+07	2.50E+07	1	2.40E+07	3.07E+07
Subgrade	2.46E+07	1.89E+07	2.03E+07	1.21443	1.56E+07	1.46E+07	1.55E+07	1.59287	9.16E+06	1.59E+07

- **750 kPa**





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	178.338								
2	G1						-347.8	-44.0	0.355	
3	C3		-196	49.393	0.260	0.260				
4	C4		-57	79.715	0.362	0.362				
5	Subg									0.1937151

PHASE 2

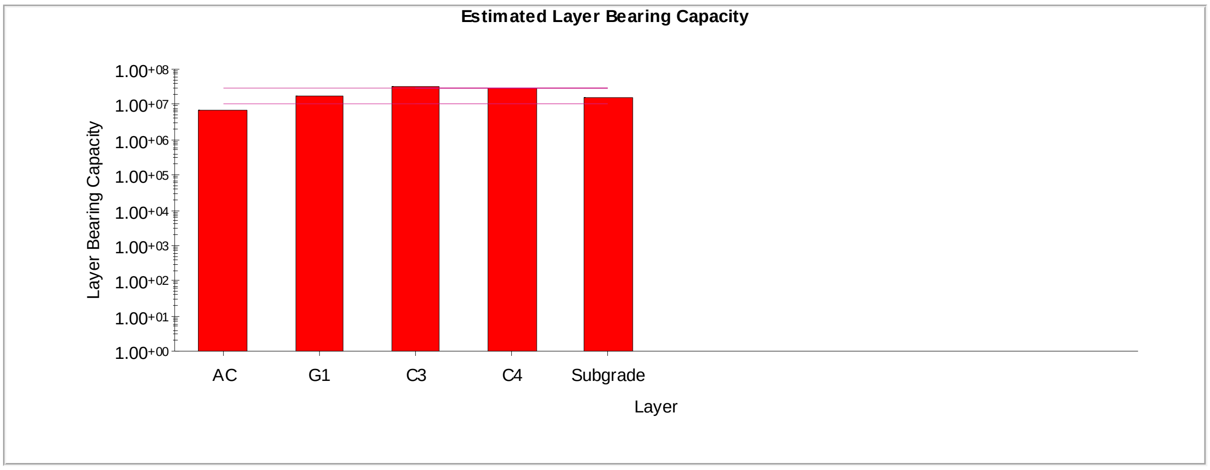
1	AC	328.258								
2	G1						-324.5	-47.1	0.315	
3	C3			81.149		0.427				
4	EGC						-37.6	39.6	0.097	
5	Subg									0.2183364

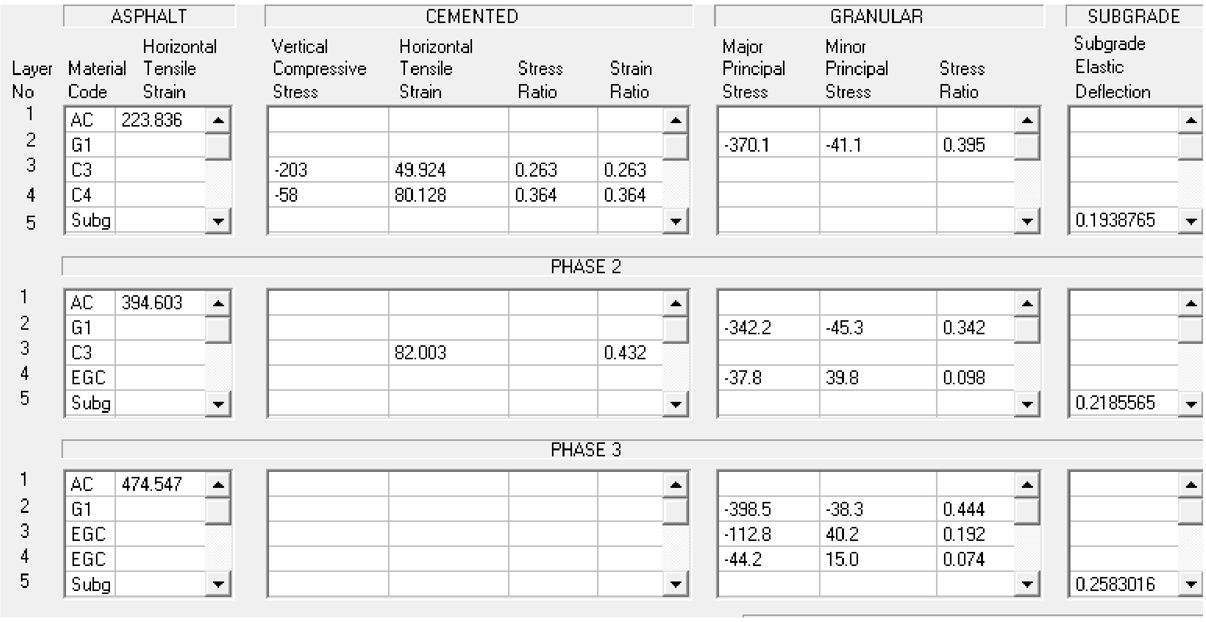
PHASE 3

1	AC	364.570								
2	G1						-371.4	-42.1	0.391	
3	EGC						-110.6	39.3	0.188	
4	EGC						-43.9	14.8	0.074	
5	Subg									0.2579943

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	2.26E+06	0	94767.9	1	0	0	54947.7	1	0	6.61E+06
G1	2.03E+07	1.46E+07	2.25E+07	1	1.46E+07	1.37E+07	1.85E+07	1.09731	1.25E+07	1.91E+07
C3	6.97E+06	1.28E+06	5.00E+06	1.39393	920282	0	2.42E+07	1	2.42E+07	3.08E+07
C4	5.69E+06	0	2.49E+07	1	2.49E+07	2.40E+07	2.50E+07	1	2.40E+07	3.06E+07
Subgrade	2.45E+07	1.89E+07	2.02E+07	1.21534	1.55E+07	1.46E+07	1.54E+07	1.59532	9.15E+06	1.58E+07

- **900kPa**





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	223.836								
2	G1						-370.1	-41.1	0.395	
3	C3		-203	49.924	0.263	0.263				
4	C4		-58	80.128	0.364	0.364				
5	Subg									0.1938765

PHASE 2

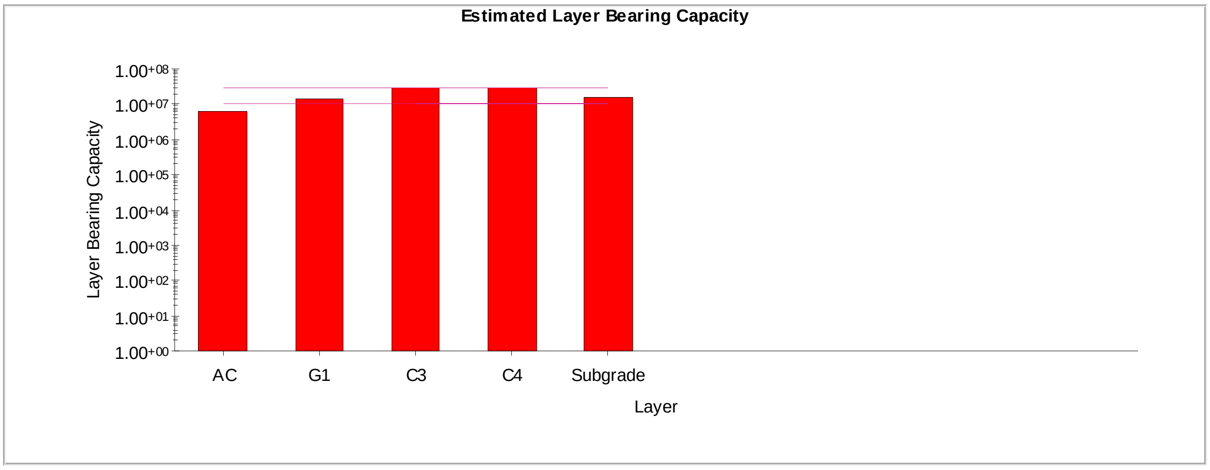
1	AC	394.603								
2	G1						-342.2	-45.3	0.342	
3	C3			82.003		0.432				
4	EGC						-37.8	39.8	0.098	
5	Subg									0.2185565

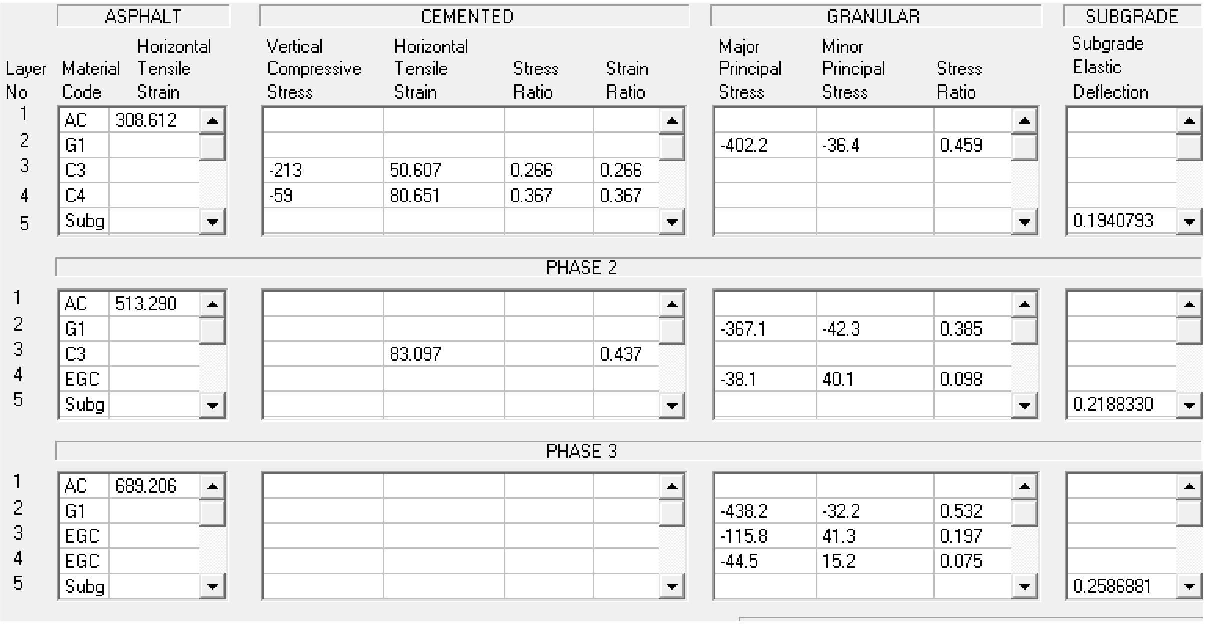
PHASE 3

1	AC	474.547								
2	G1						-398.5	-38.3	0.444	
3	EGC						-112.8	40.2	0.192	
4	EGC						-44.2	15.0	0.074	
5	Subg									0.2583016

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	692646	0	36420.7	1	0	0	13967.9	1	0	6.57E+06
G1	1.84E+07	1.27E+07	2.10E+07	1	1.27E+07	1.18E+07	1.62E+07	1.13239	1.04E+07	1.70E+07
C3	6.93E+06	1.27E+06	4.95E+06	1.39864	904709	0	2.41E+07	1	2.41E+07	3.07E+07
C4	5.66E+06	0	2.49E+07	1	2.49E+07	2.40E+07	2.50E+07	1	2.40E+07	3.06E+07
Subgrade	2.45E+07	1.88E+07	2.02E+07	1.21569	1.55E+07	1.46E+07	1.54E+07	1.59625	9.14E+06	1.57E+07

- <u>1200kPa</u>





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	308.612								
2	G1						-402.2	-36.4	0.459	
3	C3		-213	50.607	0.266	0.266				
4	C4		-59	80.651	0.367	0.367				
5	Subg									0.1940793

PHASE 2

1	AC	513.290								
2	G1						-367.1	-42.3	0.385	
3	C3			83.097		0.437				
4	EGC						-38.1	40.1	0.098	
5	Subg									0.2188330

PHASE 3

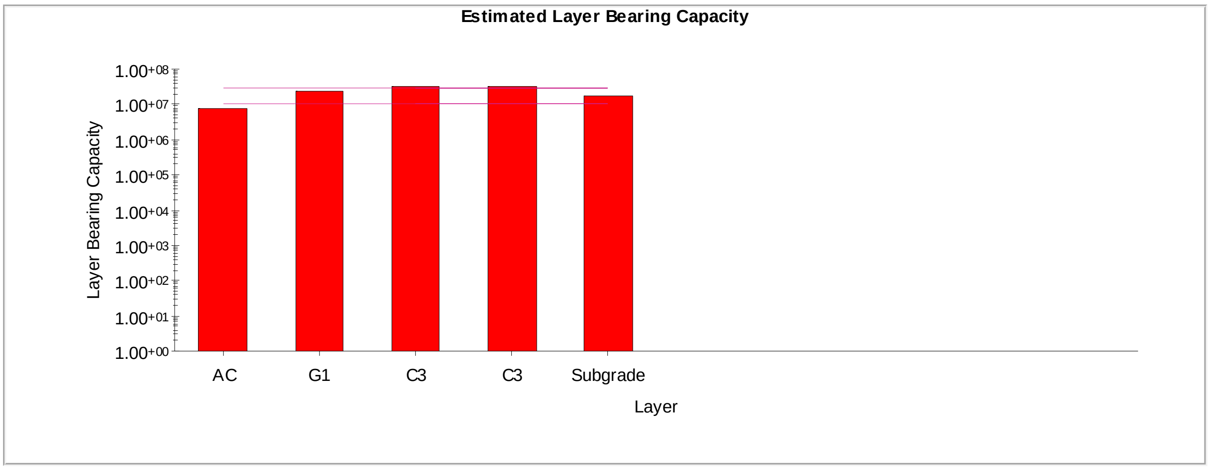
1	AC	689.206								
2	G1						-438.2	-32.2	0.532	
3	EGC						-115.8	41.3	0.197	
4	EGC						-44.5	15.2	0.075	
5	Subg									0.2586881

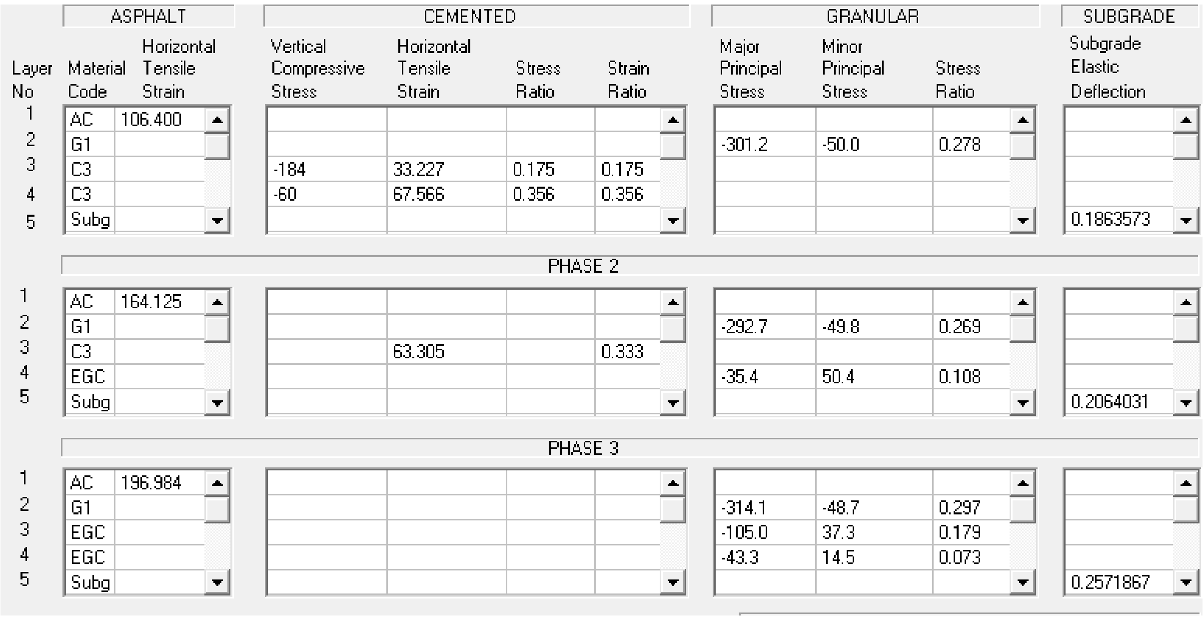
Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	130587	0	9291.07	1	0	0	2009.91	1	0	6.52E+06
G1	1.56E+07	9.97E+06	1.88E+07	1	9.97E+06	9.08E+06	1.30E+07	1.20365	7.55E+06	1.41E+07
C3	6.88E+06	1.24E+06	4.90E+06	1.40466	884722	0	2.40E+07	1	2.40E+07	3.06E+07
C4	5.64E+06	0	2.49E+07	1	2.49E+07	2.40E+07	2.50E+07	1	2.40E+07	3.06E+07
Subgrade	2.45E+07	1.88E+07	2.01E+07	1.21612	1.55E+07	1.46E+07	1.53E+07	1.59742	9.14E+06	1.57E+07

Pavement Structure C

- 40mm Asphalt (AC)
- 150mm G1 (import)
- 150mm C3
- 150mm C3
- The layers beneath the existing subbase will remain untouched

- **520 kPa**





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	106.400								
2	G1						-301.2	-50.0	0.278	
3	C3		-184	33.227	0.175	0.175				
4	C3		-60	67.566	0.356	0.356				
5	Subg									0.1863573

PHASE 2

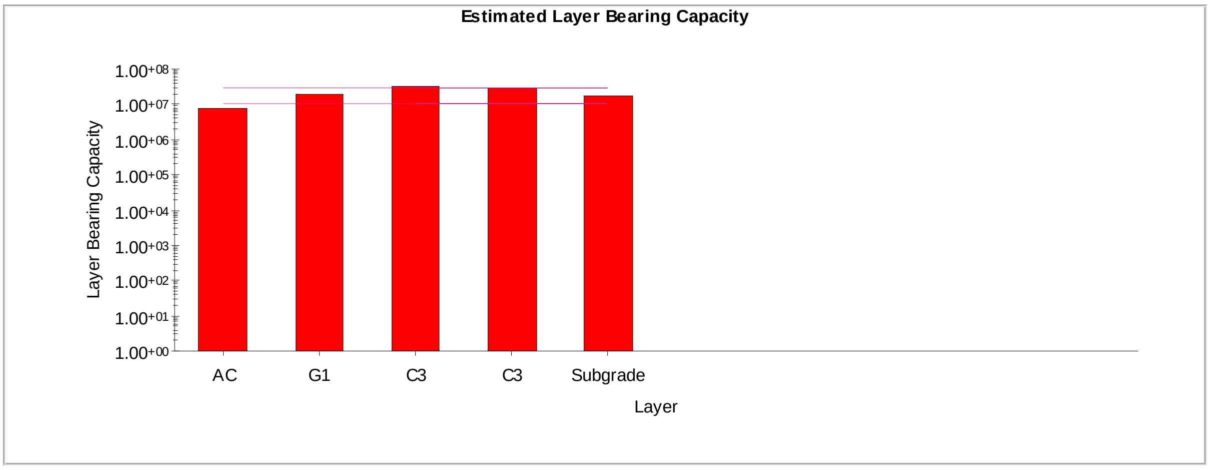
1	AC	164.125								
2	G1						-292.7	-49.8	0.269	
3	C3			63.305		0.333				
4	EGC						-35.4	50.4	0.108	
5	Subg									0.2064031

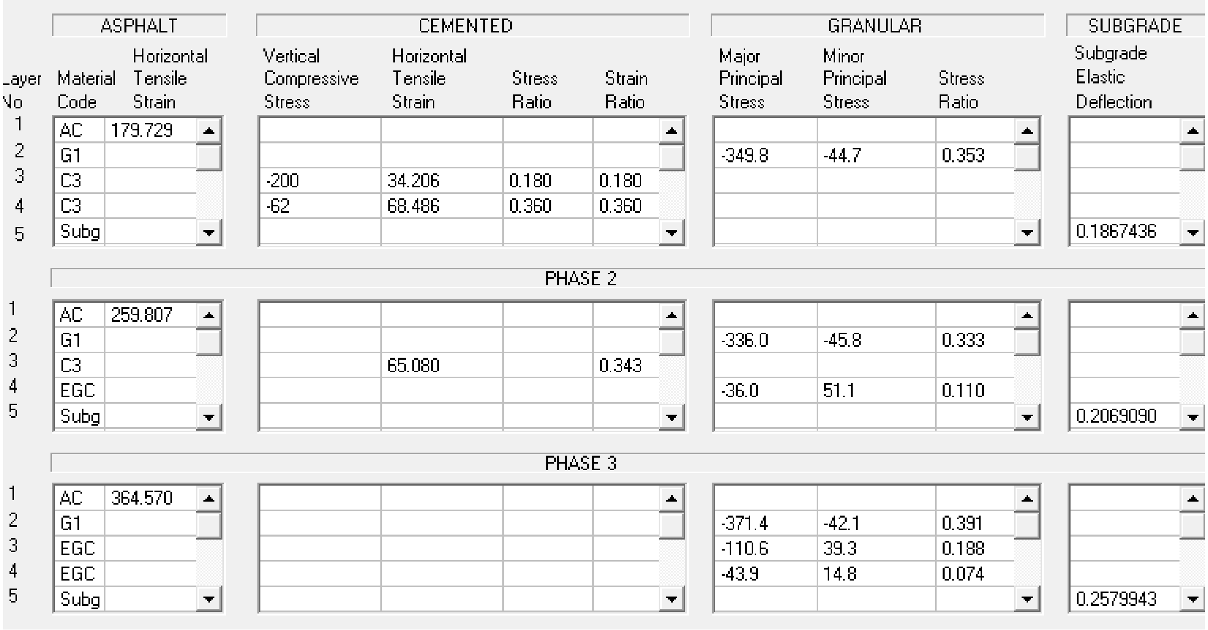
PHASE 3

1	AC	196.984								
2	G1						-314.1	-48.7	0.297	
3	EGC						-105.0	37.3	0.179	
4	EGC						-43.3	14.5	0.073	
5	Subg									0.2571867

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	3.30E+07	2.72E+07	3.47E+06	9.50324	2.87E+06	1.05E+06	1.35E+06	24.5251	42719.4	7.62E+06
G1	2.47E+07	1.89E+07	2.52E+07	1	1.89E+07	1.71E+07	2.35E+07	1.04872	1.63E+07	2.39E+07
C3	8.25E+06	2.49E+06	6.03E+06	1.36967	1.82E+06	0	2.43E+07	1	2.43E+07	3.19E+07
C3	5.76E+06	0	2.49E+07	1	2.49E+07	2.31E+07	2.50E+07	1	2.31E+07	3.07E+07
Subgrade	2.61E+07	2.04E+07	2.21E+07	1.1812	1.73E+07	1.54E+07	1.55E+07	1.6906	9.13E+06	1.67E+07

- 750 kPa

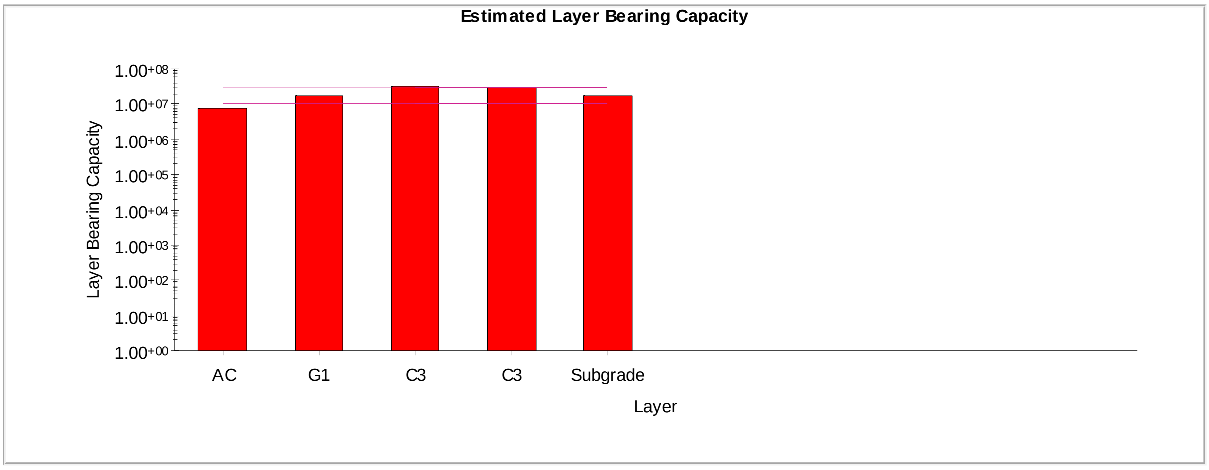


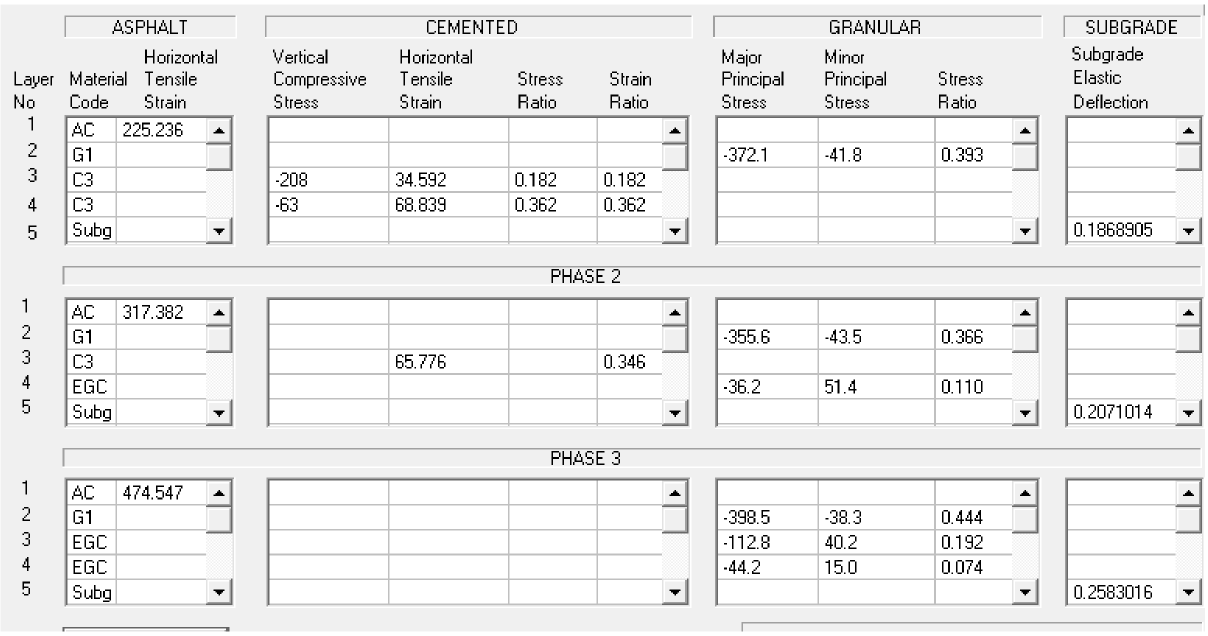


	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	179.729								
2	G1						-349.8	-44.7	0.353	
3	C3		-200	34.206	0.180	0.180				
4	C3		-62	68.486	0.360	0.360				
5	Subg									0.1867436
PHASE 2										
1	AC	259.807								
2	G1						-336.0	-45.8	0.333	
3	C3			65.080		0.343				
4	EGC						-36.0	51.1	0.110	
5	Subg									0.2069090
PHASE 3										
1	AC	364.570								
2	G1						-371.4	-42.1	0.391	
3	EGC						-110.6	39.3	0.188	
4	EGC						-43.9	14.8	0.074	
5	Subg									0.2579943

Layer	**Phase Life**	**Residual After Phase 1**	**Phase Life**	**Equivalence Factor**	**Residual before Phase**	**Residual after Phase 2**	**Phase 3 Life**	**Equivalence Factor**	**Residual before Phase**	**Layer Life**
AC	2.17E+06	0.00E+00	3.19E+05	1	0.00E+00	0.00E+00	5.49E+04	1	0	7.49E+06
G1	2.04E+07	1.47E+07	2.15E+07	1	1.47E+07	1.29E+07	1.85E+07	1.10031	1.17E+07	1.92E+07
C3	8.17E+06	2.46E+06	5.91E+06	1.38112	1.78E+06	0	2.42E+07	1	2.42E+07	3.17E+07
C3	5.71E+06	0	2.49E+07	1	2.49E+07	2.31E+07	2.50E+07	1	2.31E+07	3.06E+07
Subgrade	2.61E+07	2.03E+07	2.20E+07	1.18193	1.72E+07	1.54E+07	1.54E+07	1.69353	9.11E+06	1.66E+07

- <u>900 kPa</u>





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	225.236								
2	G1						-372.1	-41.8	0.393	
3	C3		-208	34.592	0.182	0.182				
4	C3		-63	68.839	0.362	0.362				
5	Subg									0.1868905

PHASE 2

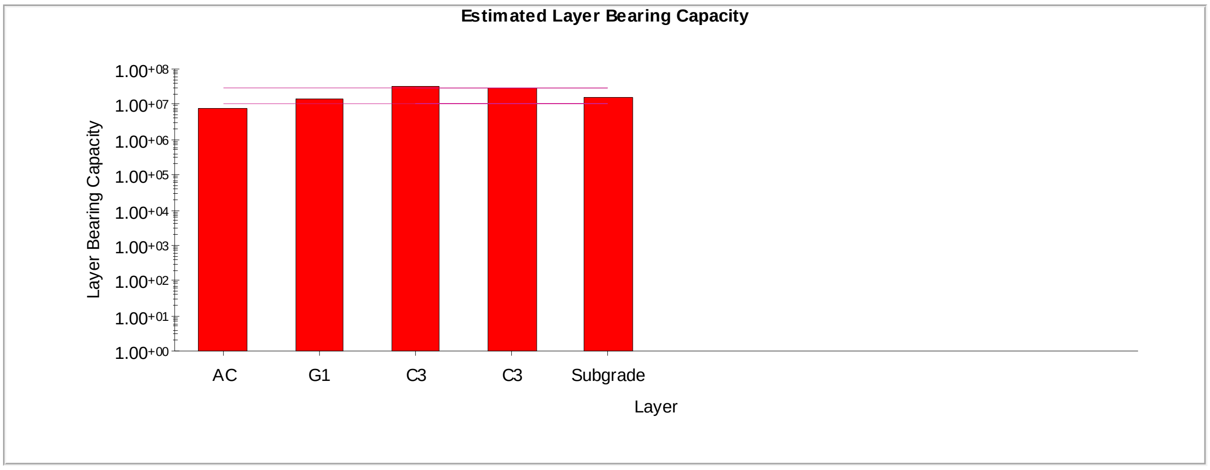
1	AC	317.382								
2	G1						-355.6	-43.5	0.366	
3	C3			65.776		0.346				
4	EGC						-36.2	51.4	0.110	
5	Subg									0.2071014

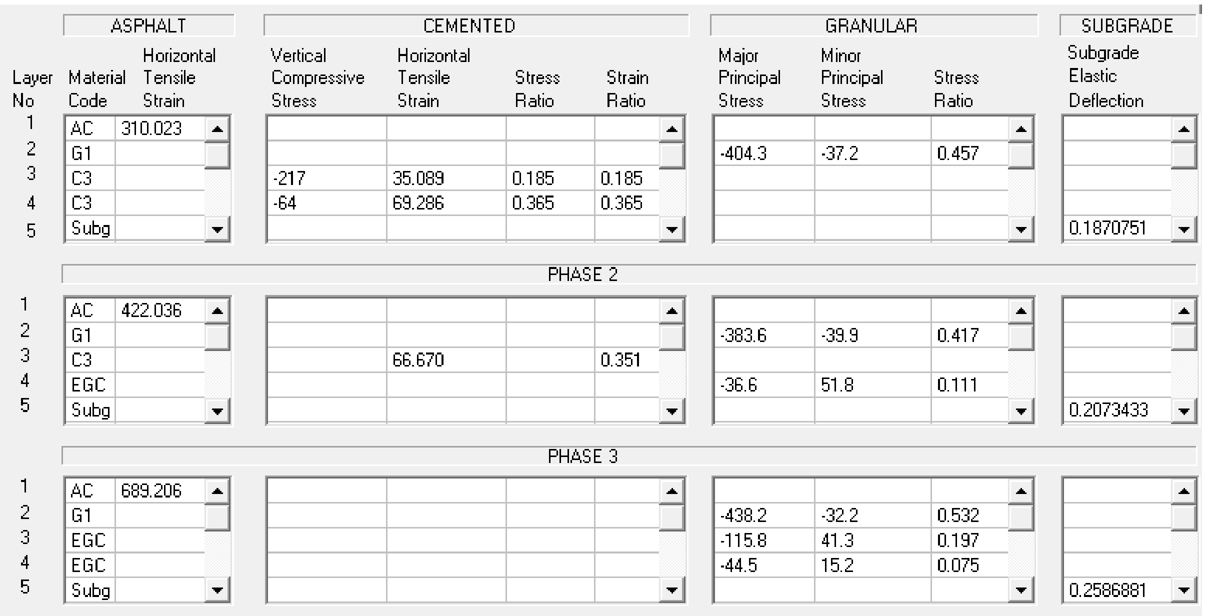
PHASE 3

1	AC	474.547								
2	G1						-398.5	-38.3	0.444	
3	EGC						-112.8	40.2	0.192	
4	EGC						-44.2	15.0	0.074	
5	Subg									0.2583016

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	6.71E+05	0.00E+00	1.13E+05	1	0.00E+00	0.00E+00	1.40E+04	1	0	7.45E+06
G1	1.84E+07	1.27E+07	1.98E+07	1	1.27E+07	1.10E+07	1.62E+07	1.13624	9.66E+06	1.71E+07
C3	8.14E+06	2.45E+06	5.87E+06	1.38561	1.77E+06	0	2.41E+07	1	2.41E+07	3.16E+07
C3	5.69E+06	0	2.49E+07	1	2.49E+07	2.31E+07	2.50E+07	1	2.31E+07	3.06E+07
Subgrade	2.60E+07	2.03E+07	2.20E+07	1.1822	1.72E+07	1.54E+07	1.54E+07	1.69465	9.11E+06	1.66E+07

- 1200 kPa





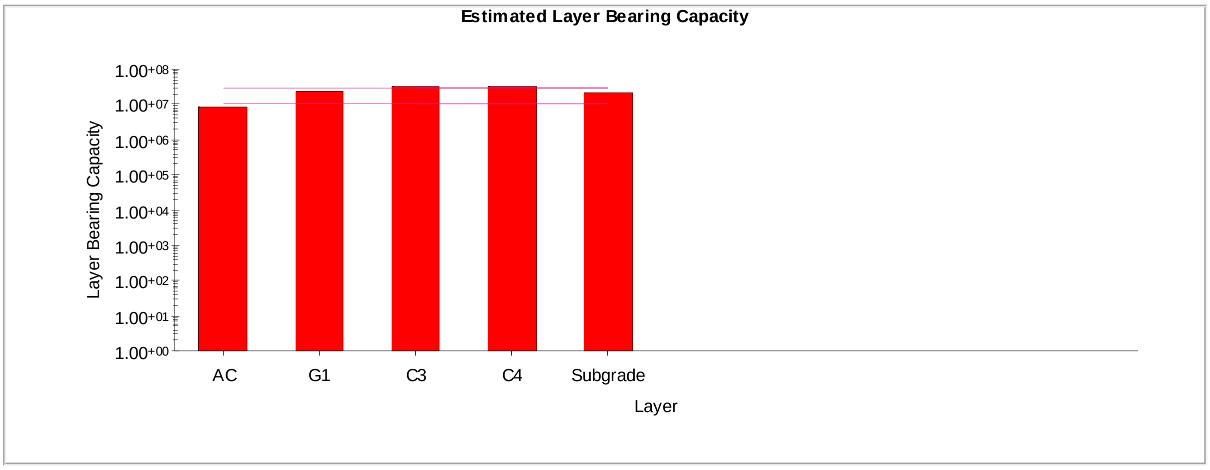
	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	310.023								
2	G1						-404.3	-37.2	0.457	
3	C3		-217	35.089	0.185	0.185				
4	C3		-64	69.286	0.365	0.365				
5	Subg									0.1870751
	PHASE 2									
1	AC	422.036								
2	G1						-383.6	-39.9	0.417	
3	C3			66.670		0.351				
4	EGC						-36.6	51.8	0.111	
5	Subg									0.2073433
	PHASE 3									
1	AC	689.206								
2	G1						-438.2	-32.2	0.532	
3	EGC						-115.8	41.3	0.197	
4	EGC						-44.5	15.2	0.075	
5	Subg									0.2586881

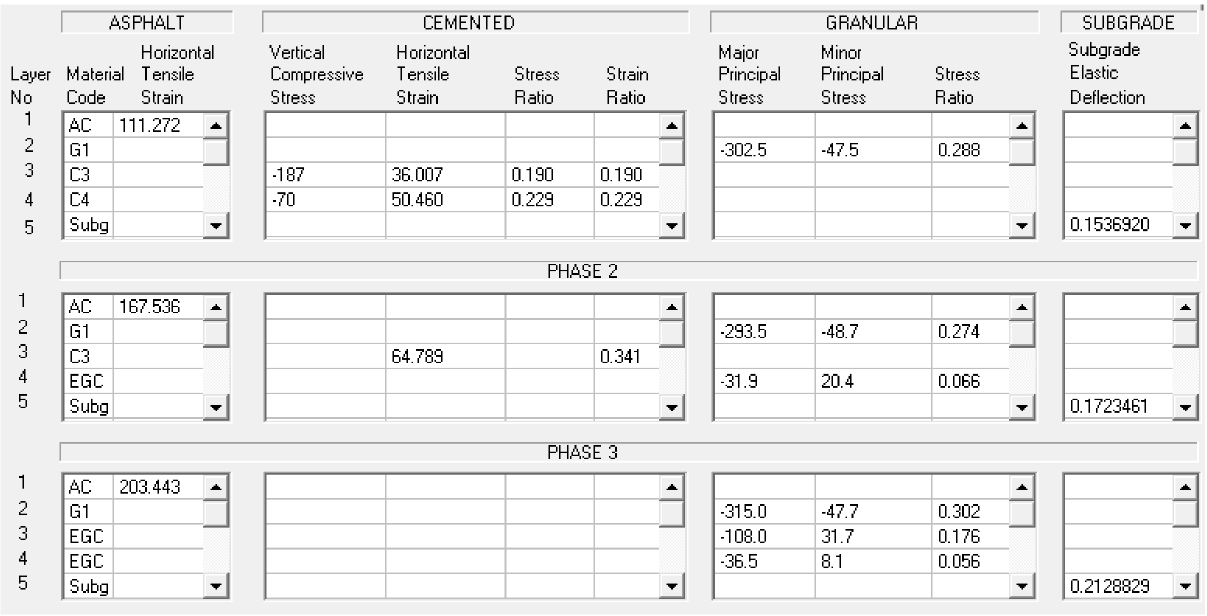
Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	1.28E+05	0.00E+00	2.57E+04	1	0.00E+00	0.00E+00	2.01E+03	1	0	7.41E+06
G1	1.57E+07	1.00E+07	1.74E+07	1	1.00E+07	8.27E+06	1.30E+07	1.20918	6.84E+06	1.42E+07
C3	8.09E+06	2.43E+06	5.82E+06	1.39137	1.75E+06	0	2.40E+07	1	2.40E+07	3.14E+07
C3	5.66E+06	0	2.49E+07	1	2.49E+07	2.31E+07	2.50E+07	1	2.31E+07	3.05E+07
Subgrade	2.60E+07	2.03E+07	2.20E+07	1.18255	1.72E+07	1.54E+07	1.53E+07	1.69605	9.10E+06	1.65E+07

Pavement Structure D

- 40mm Asphalt (AC)
- 150mm G1 (import)
- 300mm C3 upper subbase
- 150mm C4 lower subbase
- The layers beneath the existing subbase will remain untouched

- <u>520 kPa</u>

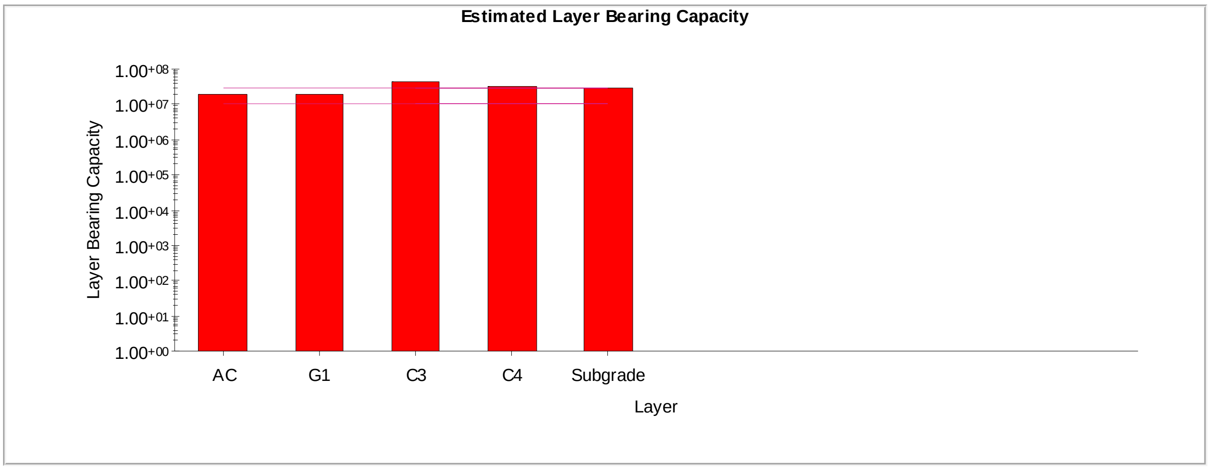


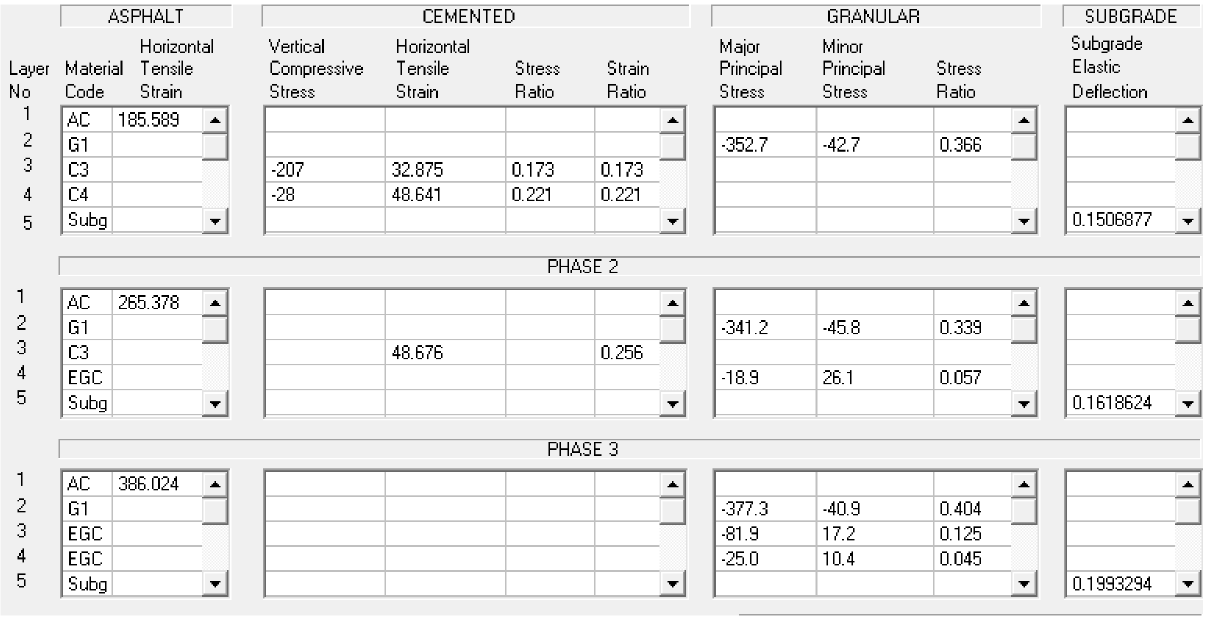


	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	111.272								
2	G1						-302.5	-47.5	0.288	
3	C3		-187	36.007	0.190	0.190				
4	C4		-70	50.460	0.229	0.229				
5	Subg									0.1536920
	PHASE 2									
1	AC	167.536								
2	G1						-293.5	-48.7	0.274	
3	C3			64.789		0.341				
4	EGC						-31.9	20.4	0.066	
5	Subg									0.1723461
	PHASE 3									
1	AC	203.443								
2	G1						-315.0	-47.7	0.302	
3	EGC						-108.0	31.7	0.176	
4	EGC						-36.5	8.1	0.056	
5	Subg									0.2128829

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	2.61E+07	1.81E+07	3.12E+06	8.38028	2.16E+06	2.16E+06	1.14E+06	22.9814	94143.2	8.11E+06
G1	2.40E+07	1.60E+07	2.49E+07	1	1.60E+07	1.60E+07	2.32E+07	1.03458	1.55E+07	2.35E+07
C3	8.02E+06	0.00E+00	5.93E+06	1	0.00E+00	0	2.43E+07	1	2.43E+07	3.24E+07
C4	1.98E+07	1.18E+07	2.50E+07	1	2.50E+07	2.50E+07	2.50E+07	1	2.50E+07	3.30E+07
Subgrade	3.58E+07	2.78E+07	2.97E+07	1.20529	2.30E+07	2.30E+07	2.10E+07	1.7007	1.35E+07	2.16E+07

- <u>750 kPa</u>





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	185.589								
2	G1						-352.7	-42.7	0.366	
3	C3		-207	32.875	0.173	0.173				
4	C4		-28	48.641	0.221	0.221				
5	Subg									0.1506877

PHASE 2

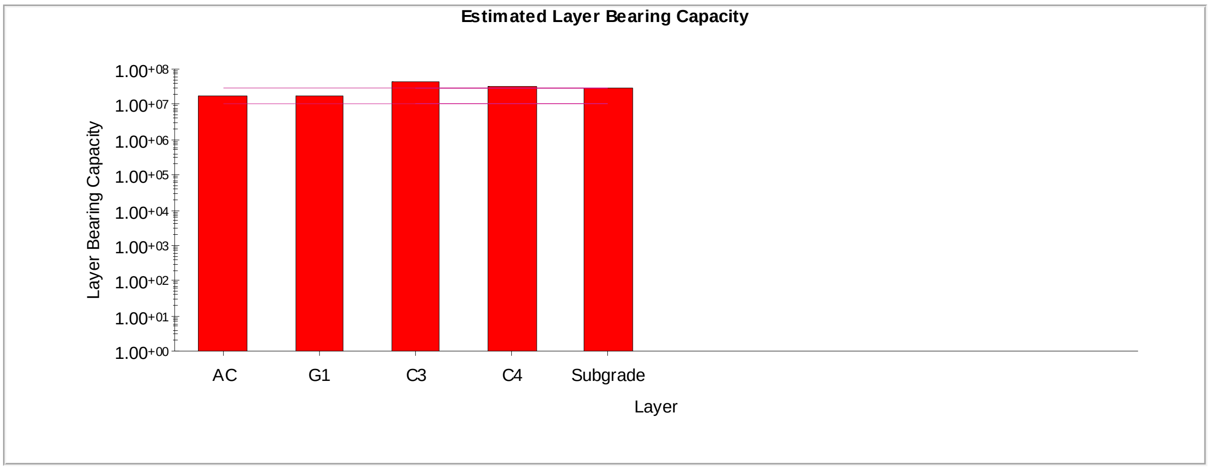
1	AC	265.378								
2	G1						-341.2	-45.8	0.339	
3	C3			48.676		0.256				
4	EGC						-18.9	26.1	0.057	
5	Subg									0.1618624

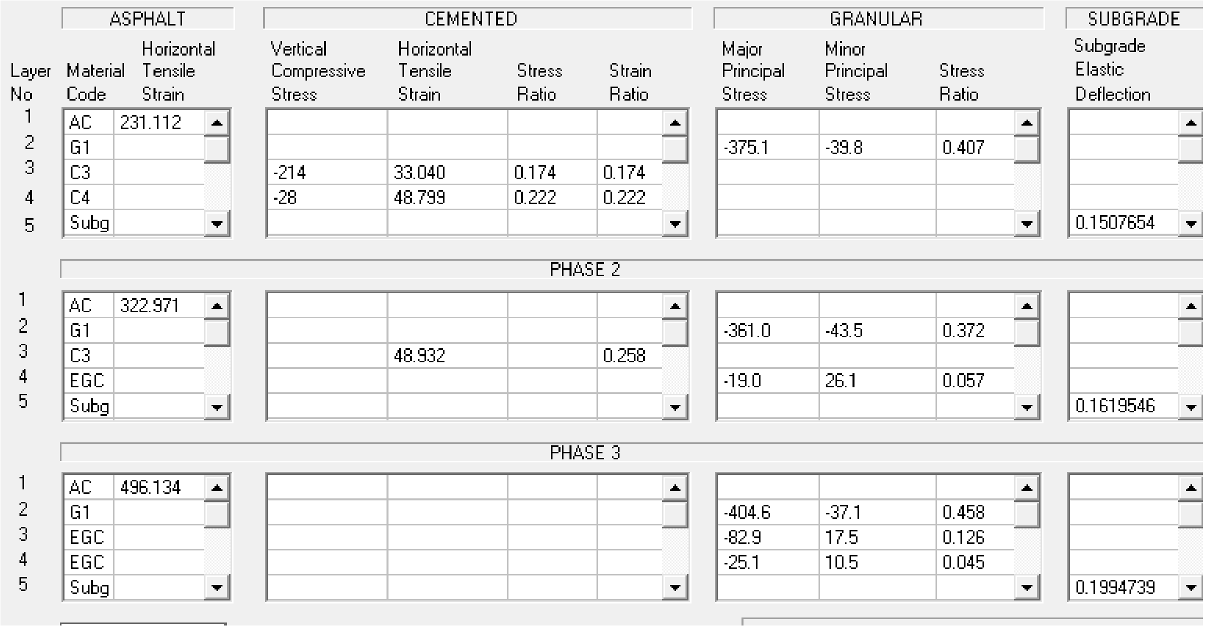
PHASE 3

1	AC	386.024								
2	G1						-377.3	-40.9	0.404	
3	EGC						-81.9	17.2	0.125	
4	EGC						-25.0	10.4	0.045	
5	Subg									0.1993294

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	1.83E+06	0.00E+00	2.86E+05	1	0.00E+00	0.00E+00	4.08E+04	1	0	1.97E+07
G1	1.97E+07	1.22E+07	2.11E+07	1	1.22E+07	0.00E+00	1.79E+07	1	0.00E+00	1.97E+07
C3	2.22E+07	1.46E+07	1.88E+07	1.1797	1.24E+07	205511	2.48E+07	1	2.48E+07	4.45E+07
C4	7.53E+06	0.00E+00	2.50E+07	1	2.50E+07	1.28E+07	2.50E+07	1	1.28E+07	3.26E+07
Subgrade	3.70E+07	2.94E+07	3.29E+07	1.12368	2.62E+07	1.40E+07	2.34E+07	1.57774	8.87E+06	2.86E+07

- <u>900 kPa</u>

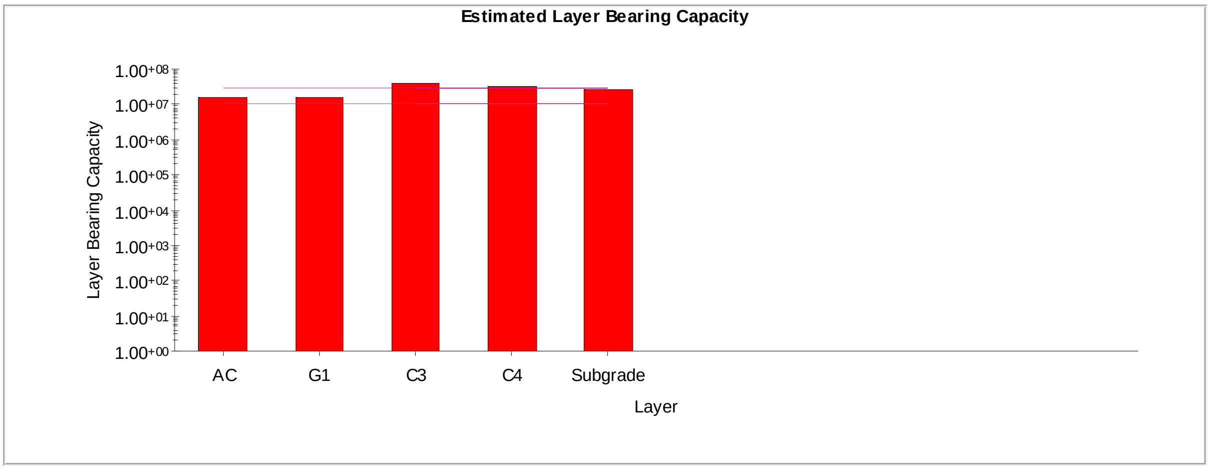


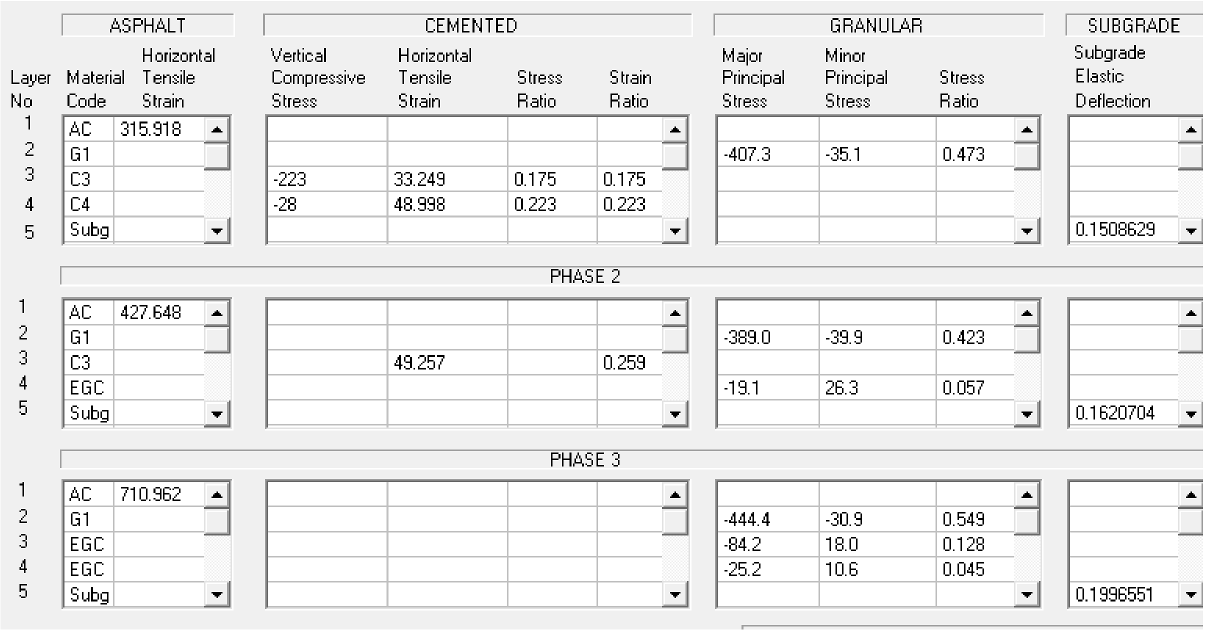


	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	231.112								
2	G1						-375.1	-39.8	0.407	
3	C3		-214	33.040	0.174	0.174				
4	C4		-28	48.799	0.222	0.222				
5	Subg									0.1507654
	PHASE 2									
1	AC	322.971								
2	G1						-361.0	-43.5	0.372	
3	C3			48.932		0.258				
4	EGC						-19.0	26.1	0.057	
5	Subg									0.1619546
	PHASE 3									
1	AC	496.134								
2	G1						-404.6	-37.1	0.458	
3	EGC						-82.9	17.5	0.126	
4	EGC						-25.1	10.5	0.045	
5	Subg									0.1994739

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	5.87E+05	0.00E+00	1.03E+05	1	0.00E+00	0.00E+00	1.11E+04	1	0	1.78E+07
G1	1.78E+07	1.03E+07	1.94E+07	1	1.03E+07	0.00E+00	1.56E+07	1	0.00E+00	1.78E+07
C3	2.21E+07	1.46E+07	1.87E+07	1.18083	1.24E+07	2.10E+06	2.48E+07	1	2.48E+07	4.26E+07
C4	7.52E+06	0.00E+00	2.50E+07	1	2.50E+07	1.48E+07	2.50E+07	1	1.48E+07	3.26E+07
Subgrade	3.69E+07	2.94E+07	3.29E+07	1.12378	2.62E+07	1.59E+07	2.34E+07	1.57827	1.01E+07	2.79E+07

- <u>1200kPa</u>





	ASPHALT		CEMENTED				GRANULAR			SUBGRADE
Layer No	Material Code	Horizontal Tensile Strain	Vertical Compressive Stress	Horizontal Tensile Strain	Stress Ratio	Strain Ratio	Major Principal Stress	Minor Principal Stress	Stress Ratio	Subgrade Elastic Deflection
1	AC	315.918								
2	G1						-407.3	-35.1	0.473	
3	C3		-223	33.249	0.175	0.175				
4	C4		-28	48.998	0.223	0.223				
5	Subg									0.1508629

PHASE 2

1	AC	427.648								
2	G1						-389.0	-39.9	0.423	
3	C3			49.257		0.259				
4	EGC						-19.1	26.3	0.057	
5	Subg									0.1620704

PHASE 3

1	AC	710.962								
2	G1						-444.4	-30.9	0.549	
3	EGC						-84.2	18.0	0.128	
4	EGC						-25.2	10.6	0.045	
5	Subg									0.1996551

Layer	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life
AC	1.16E+05	0.00E+00	2.40E+04	1	0.00E+00	0.00E+00	1.71E+03	1	0	1.51E+07
G1	1.51E+07	7.55E+06	1.71E+07	1	7.55E+06	0.00E+00	1.24E+07	1	0.00E+00	1.51E+07
C3	2.21E+07	1.46E+07	1.87E+07	1.18225	1.23E+07	4.78E+06	2.48E+07	1	2.48E+07	3.98E+07
C4	7.50E+06	0.00E+00	2.50E+07	1	2.50E+07	1.75E+07	2.50E+07	1	1.75E+07	3.25E+07
Subgrade	3.69E+07	2.94E+07	3.28E+07	1.1239	2.61E+07	1.86E+07	2.34E+07	1.57895	1.18E+07	2.68E+07

9.5 Appendix E: Pavement Design Calculations for Bitumen Treated Base (BTB)

Under Heavy Traffic Loads (From Pomona Road to Elgin Street)

700MPa BTB ,0km/h - 700kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	2,28E+06	0,00E+00	3,04E+06	1,00E+00	0,00E+00	0,00E+00	1,24E+07	1,00E+00	0	1,75E+07	17,51
BC	100	7,59E+09	7,58E+09	1,18E+10	1,00E+00	7,58E+09	7,57E+09	2,67E+05	2,84E+04	2,67E+05	1,78E+07	17,78
C3	300	2,21E+07	1,46E+07	1,51E+07	1,46E+00	9,99E+06	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,25E+07	42,53
C4	150	7,52E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,51E+07	2,51E+07	1,00E+00	1,51E+07	3,26E+07	32,57
Subgrade		3,57E+07	2,82E+07	3,07E+07	1,16E+00	2,42E+07	1,42E+07	1,87E+07	1,90E+00	7,48E+06	2,50E+07	24,99
											Pavement life	**17,78**

700MPa BTB ,0km/h - 1400kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	2,54E+04	0,00E+00	2,87E+04	1,00E+00	0,00E+00	0,00E+00	5,00E+04	1,00E+00	0,00E+00	1,73E+07	17,35
BC	100	2,86E+09	2,86E+09	4,15E+09	1,00E+00	2,86E+09	2,85E+09	1,64E+05	1,75E+04	1,63E+05	1,75E+07	17,51
C3	300	2,20E+07	1,45E+07	1,50E+07	1,47E+00	9,86E+06	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,24E+07	42,36
C4	150	7,48E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,52E+07	2,51E+07	1,00E+00	1,52E+07	3,25E+07	32,54
Subgrade		3,56E+07	2,81E+07	3,06E+07	1,16E+00	2,42E+07	1,43E+07	1,87E+07	1,91E+00	7,51E+06	2,49E+07	24,86
											Pavement life	**17,51**

1200MPa BTB, 10km/h - 700kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	6,44E+07	5,66E+07	8,53E+07	1,00E+00	5,66E+07	4,53E+07	2,70E+08	1,00E+00	4,53E+07	6,44E+07	
BC	100	4,91E+09	4,90E+09	5,17E+09	1,00E+00	4,90E+09	4,89E+09	3,73E+06	1,31E+03	3,72E+06	2,28E+07	22,81
C3	300	2,25E+07	1,47E+07	1,73E+07	1,30E+00	1,13E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,41E+07	44,10
C4	150	7,78E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,37E+07	2,50E+07	1,00E+00	1,37E+07	3,28E+07	32,82
Subgrade		3,96E+07	3,18E+07	3,49E+07	1,13E+00	2,81E+07	1,67E+07	2,32E+07	1,70E+00	9,83E+06	2,89E+07	28,92
											Pavement life	**22,81**

1200MPa BTB ,10km/h - 1400kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	5,25E+05	0,00E+00	5,87E+05	1,00E+00	0,00E+00	0,00E+00	9,05E+05	1,00E+00	0,00E+00	1,89E+07	18,95
BC	100	2,14E+09	2,13E+09	2,24E+09	1,00E+00	2,13E+09	2,12E+09	2,29E+06	9,35E+02	2,27E+06	2,12E+07	21,21
C3	300	2,23E+07	1,46E+07	1,71E+07	1,30E+00	1,12E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,40E+07	43,95
C4	150	7,74E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,39E+07	2,50E+07	1,00E+00	1,38E+07	3,28E+07	32,79
Subgrade		3,95E+07	3,17E+07	3,48E+07	1,13E+00	2,80E+07	1,68E+07	2,32E+07	1,70E+00	9,85E+06	2,88E+07	28,80
											Pavement life	**21,21**

1800MPa BTB ,30km/h - 700kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	9,07E+08	8,99E+08	1,29E+09	1,00E+00	8,99E+08	8,87E+08	4,57E+09	1,00E+00	8,87E+08	9,07E+08	
BC	100	3,80E+09	3,80E+09	3,52E+09	1,08E+00	3,51E+09	3,50E+09	8,28E+06	4,60E+02	7,62E+06	2,73E+07	27,30
C3	300	2,28E+07	1,48E+07	1,80E+07	1,26E+00	1,17E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,47E+07	44,70
C4	150	7,98E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,34E+07	2,50E+07	1,00E+00	1,34E+07	3,30E+07	33,03
Subgrade		4,29E+07	3,49E+07	3,80E+07	1,13E+00	3,09E+07	1,92E+07	2,49E+07	1,72E+00	1,12E+07	3,08E+07	30,85
											Pavement life	**27,30**

1800MPa BTB ,30km/h - 1400kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	5,35E+06	0,00E+00	6,08E+06	1,00E+00	0,00E+00	0,00E+00	9,41E+06	1,00E+00	0,00E+00	1,95E+07	19,54
BC	100	1,83E+09	1,82E+09	1,71E+09	1,07E+00	1,71E+09	1,70E+09	5,32E+06	3,44E+02	4,93E+06	2,45E+07	24,48
C3	300	2,27E+07	1,47E+07	1,79E+07	1,27E+00	1,16E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,46E+07	44,57
C4	150	7,95E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,35E+07	2,50E+07	1,00E+00	1,35E+07	3,30E+07	33,00
Subgrade		4,28E+07	3,49E+07	3,79E+07	1,13E+00	3,09E+07	1,93E+07	2,48E+07	1,72E+00	1,12E+07	3,07E+07	30,73
											Pavement life	**24,48**

2200MPa BTB ,50km/h - 700kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	3,54E+09	3,54E+09	4,93E+09	1,00E+00	3,54E+09	3,52E+09	2,01E+10	1,00E+00	3,52E+09	3,54E+09	
BC	100	3,38E+09	3,37E+09	2,98E+09	1,13E+00	2,98E+09	2,97E+09	1,20E+07	2,82E+02	1,05E+07	3,05E+07	30,49
C3	300	2,29E+07	1,49E+07	1,84E+07	1,25E+00	1,19E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,50E+07	45,01
C4	150	8,08E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,32E+07	2,50E+07	1,00E+00	1,32E+07	3,31E+07	33,13
Subgrade		4,47E+07	3,66E+07	3,96E+07	1,13E+00	3,24E+07	2,05E+07	2,59E+07	1,73E+00	1,19E+07	3,19E+07	31,87
											Pavement life	**30,49**

2200MPa BTB ,50km/h - 1400kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	1,71E+07	9,07E+06	1,91E+07	1,00E+00	9,07E+06	0,00E+00	3,04E+07	1,00E+00	0,00E+00	1,99E+07	19,86
BC	100	1,70E+09	1,69E+09	1,53E+09	1,11E+00	1,52E+09	1,51E+09	7,89E+06	2,16E+02	7,00E+06	2,69E+07	26,85
C3	300	2,28E+07	1,48E+07	1,82E+07	1,25E+00	1,18E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,49E+07	44,89
C4	150	8,05E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,33E+07	2,50E+07	1,00E+00	1,32E+07	3,31E+07	33,10
Subgrade		4,46E+07	3,65E+07	3,95E+07	1,13E+00	3,24E+07	2,06E+07	2,58E+07	1,73E+00	1,19E+07	3,18E+07	31,75
											Pavement life	**26,85**

2600MPa BTB, 80km/h - 700kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	1,07E+10	1,07E+10	1,49E+10	1,00E+00	1,07E+10	1,07E+10	7,26E+10	1,00E+00	1,07E+10	1,07E+10	
BC	100	3,05E+09	3,04E+09	2,60E+09	1,17E+00	2,59E+09	2,58E+09	1,59E+07	1,92E+02	1,35E+07	3,37E+07	33,70
C3	300	2,31E+07	1,49E+07	1,87E+07	1,24E+00	1,21E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,53E+07	45,28
C4	150	8,16E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,30E+07	2,50E+07	1,00E+00	1,30E+07	3,32E+07	33,22
Subgrade		4,62E+07	3,80E+07	4,10E+07	1,13E+00	3,37E+07	2,16E+07	2,67E+07	1,73E+00	1,25E+07	3,28E+07	32,76
											Pavement life	**32,76**

2600MPa BTB, 80km/h - 1400kPa Inflation Pressure

Layer	Thickness (mm)	Phase Life	Residual After Phase 1	Phase Life	Equivalence Factor	Residual before Phase	Residual after Phase 2	Phase 3 Life	Equivalence Factor	Residual before Phase	Layer Life	Layer Life (Million E80s)
AC	40	4,41E+07	3,60E+07	4,94E+07	1,00E+00	3,60E+07	2,40E+07	8,15E+07	1,00E+00	2,40E+07	4,41E+07	44,10
BC	100	1,59E+09	1,58E+09	1,38E+09	1,15E+00	1,38E+09	1,36E+09	1,06E+07	1,49E+02	9,14E+06	2,93E+07	29,27
C3	300	2,30E+07	1,49E+07	1,86E+07	1,24E+00	1,20E+07	0,00E+00	2,50E+07	1,00E+00	2,50E+07	4,52E+07	45,16
C4	150	8,14E+06	0,00E+00	2,51E+07	1,00E+00	2,51E+07	1,31E+07	2,50E+07	1,00E+00	1,31E+07	3,32E+07	33,19
Subgrade		4,61E+07	3,79E+07	4,09E+07	1,13E+00	3,36E+07	2,17E+07	2,66E+07	1,73E+00	1,25E+07	3,26E+07	32,65
											Pavement life	**29,27**

9.6 Appendix F: Test Pits - Summary of Results

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

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www.roadlab.co.za

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR :** CONSTANTIA STREET **- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.		I3503	I3504		
CONTAINER USED FOR SAMPLING		Black Sampling Bags	Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE		±70kg's	±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL		Slightly Moist	Slightly Moist		
HOLE No. / Km. / CHAINAGE		TP01	TP01		
LAYER TESTED / SAMPLED FROM		110-360mm	360-610mm		
DATE SAMPLED		2018/05/11	2018/05/11		
DATE RECEIVED		2018/05/11	2018/05/11		
CLIENTS MARKING		None	None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)		Grey Olive Silty Sandy Gravel	Yellow Orange Brown Silty Sandy Gravel		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANA - LYSIS (mm) **(TMH A1a)**	75.0	100	100		
	63.0	100	100		
	53.0	100	100		
	37.5	92	94		
	26.5	90	78		
	19.0	76	69		
	13.2	62	65		
	4.75	38	51		
	2.00	27	35		
	0.425	17	18		
	0.075	8	9		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%				
	P.I.	SP	NP		
	LS%	0.7			
GM		2.48	2.38		
CLASSIFI - CATION	H.R.B.*	A-1-a(0)	A-1-a(0)		
	COLTO*	G5	G7		
	T.R.H. 14*	G5	G7		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%	6.1	7.2		
	MDD(KG/M³)	2392	2191		
C.B.R.	COMP MC	5.8	7.0		
	% SWELL	0.10	0.15		
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%	209	70		
	98%	137	48		
	97%	111	39		
	95%	73	27		
	93%	48	18		
	90%	25	10		
MOD ITS : DRY (kPa) **(A16T)**		N/A	N/A		
PROCTOR ITS : DRY (kPa)		N/A	N/A		
STABILISED WITH	IN LAB				
	ON SITE	Neat	Neat		
TEST TYPE		IND - CBR	IND - CBR		
SAMPLED BY		Roadlab	Roadlab		
DELIVERED BY		Roadlab	Roadlab		
SAMPLED ACCORDING TO		Clients Requirements	Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED		Sunny	Sunny		
REMARKS & NOTES		None	None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : Two Layers
TRACK NO: 280845

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m³)	OMC(%)	COMPACTION(%)
110 - 360 mm	0-150mm	2474	2377	4.1	2392	6.1	99.4
360 - 610 mm	0-150mm	2104	1934	8.8	2191	7.2	88.3
					AVERAGE COMPACTION:		92.8

MOISTURE CONTENT

SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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JOB NO: 15274 **DATE REPORTED :** 2018/06/07

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.		13807			
CONTAINER USED FOR SAMPLING		Black Sampling Bags			
SIZE / WEIGHT OF SAMPLE		±70kg's			
MOISTURE CONDITION OF SAMPLE ON ARRIVAL		Slightly Moist			
HOLE No. / Km. / CHAINAGE		TP1			
LAYER TESTED / SAMPLED FROM		660-800mm			
DATE SAMPLED		2018/05/11			
DATE RECEIVED		2018/05/11			
CLIENTS MARKING		None			
DESCRIPTION OF SAMPLE (COLOUR & TYPE)		Dark Red Orange Clayey Silty Sandy Gravel			
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANA - LYSIS (mm) **(TMH A1a)**	75.0	100			
	63.0	100			
	53.0	89			
	37.5	79			
	26.5	63			
	19.0	57			
	13.2	51			
	4.75	37			
	2.00	27			
	0.425	14			
	0.075	7			
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%				
	P.I.	SP			
	LS%	1.0			
GM		2.52			
CLASSIFI - CATION	H.R.B.*	A-1-a(0)			
	COLTO*	G6			
	T.R.H. 14*	G6			
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO	OMC%	8.3	8.3	3.5	
(TMH A7)	MDD(KG/M3)	2286			
C.B.R.	COMP MC	8.1			
	% SWELL	0.09			
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%	88			
	98%	66			
	97%	57			
	95%	42			
	93%	31			
	90%	20			
MOD ITS : DRY (kPa) (A16T)		N/A			
PROCTOR ITS : DRY (kPa)		N/A			
STABILISED WITH	IN LAB				
	ON SITE	Neat			
TEST TYPE		IND - CBR			
SAMPLED BY		Roadlab			
DELIVERED BY		Roadlab			
SAMPLED ACCORDING TO		Clients Requirements			
ENVIRONMENTAL CONDITION WHEN SAMPLED		Sunny			
REMARKS & NOTES		None			

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : All Layers
TRACK NO: 290848
SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 16248
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
660-800mm	0-150mm	2279	2125	7.3	2286	8.3	93.0
					AVERAGE COMPACTION:		93.0

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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Accreditation No.: T0296

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JOB NO: 15274 **DATE REPORTED :** 2018/06/07

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.		I3828			
CONTAINER USED FOR SAMPLING		Black Sampling Bags			
SIZE / WEIGHT OF SAMPLE		±70kg's			
MOISTURE CONDITION OF SAMPLE ON ARRIVAL		Slightly Moist			
HOLE No. / Km. / CHAINAGE		TP2			
LAYER TESTED / SAMPLED FROM		40-190mm			
DATE SAMPLED		2018/05/11			
DATE RECEIVED		2018/05/11			
CLIENTS MARKING		None			
DESCRIPTION OF SAMPLE (COLOUR & TYPE)		Light Brown Sandy Gravel			
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANA - LYSIS (mm) **(TMH A1a)**	75.0	100			
	63.0	100			
	53.0	89			
	37.5	79			
	26.5	69			
	19.0	62			
	13.2	56			
	4.75	35			
	2.00	27			
	0.425	16			
	0.075	6			
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%				
	P.I.	SP			
	LS%	1.0			
GM		2.51			
CLASSIFI - CATION	H.R.B.*	A-1-a(0)			
	COLTO*	G6			
	T.R.H. 14*	G6			
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%	8.1			
	MDD(KG/M3)	2221			
C.B.R.	COMP MC	7.9			
	% SWELL	0.13			
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%	59			
	98%	52			
	97%	49			
	95%	43			
	93%	38			
	90%	31			
MOD ITS : DRY (kPa) (A16T)		N/A			
PROCTOR ITS : DRY (kPa)		N/A			
STABILISED WITH	IN LAB				
	ON SITE	Neat			
TEST TYPE		IND - CBR			
SAMPLED BY		Roadlab			
DELIVERED BY		Roadlab			
SAMPLED ACCORDING TO		Clients Requirements			
ENVIRONMENTAL CONDITION WHEN SAMPLED		Sunny			
REMARKS & NOTES		None			

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : All Layers
TRACK NO: 290852

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 16248
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
TP02	0-150mm	2295	2179	5.4	2221	8.1	98.1
					AVERAGE COMPACTION:		93.6

MOISTURE CONTENT

SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		40-190mm	6.6	182	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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www.roadlab.co.za

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3518		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP2		
LAYER TESTED / SAMPLED FROM			190-320mm		
DATE SAMPLED			2018/05/11		
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Dark Brown Clayey Sandy Gravel		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
	75.0		100		
SIEVE	63.0		100		
	53.0		100		
	37.5		100		
ANA -	26.5		93		
	19.0		87		
	13.2		74		
LYSIS	4.75		46		
(mm)	2.00		35		
(TMH A1a)	0.425		28		
	0.075		24		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG	LL%		34.0		
LIMITS	P.I.		15.0		
(TMH A2&A3)	LS%		7.4		
GM			2.13		
CLASSIFI - CATION	H.R.B.*		A-2-6(0)		
	COLTO*		G8		
	T.R.H. 14*		G8		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO	OMC%		13.7		
(TMH A7)	MDD(KG/M^3)		2011		
	COMP MC		13.6		
C.B.R.	% SWELL		0.94		
	100%		18		
U.C.S.	98%		15		
(TMH A13T)	97%		14		
C.B.R.	95%		13		
(TMH A8)	93%		11		
	90%		9		
MOD ITS : DRY (kPa) **(A16T)**			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : All Layers
TRACK NO: 280838

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
190-320mm	0-150mm	2031	1768	14.9	2011	13.7	87.9
					AVERAGE COMPACTION:		87.9

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		190-320mm	2.1	336	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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RL-S-150-01

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

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TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3829		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP2		
LAYER TESTED / SAMPLED FROM			320-520mm		
DATE SAMPLED			2018/05/11		
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Dark Red Orange, Clayey Sandy Gravel (diamictite)		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
	75.0		100		
SIEVE	63.0		88		
	53.0		82		
	37.5		80		
ANA -	26.5		75		
	19.0		67		
	13.2		48		
LYSIS	4.75		33		
(mm)	2.00		26		
(TMH A1a)	0.425		18		
	0.075		7		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG	LL%		20.0		
LIMITS	P.I.		3.0		
(TMH A2&A3)	LS%		1.7		
GM			2.49		
CLASSIFI - CATION	H.R.B.*		A-1-a(0)		
	COLTO*		G8		
	T.R.H. 14*		G8		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO	OMC%		11.2		
(TMH A7)	MDD(KG/M3)		2103		
	COMP MC		11.0		
C.B.R.	% SWELL		0.84		
	100%		40		
U.C.S.	98%		29		
(TMH A13T)	97%		25		
C.B.R.	95%		18		
(TMH A8)	93%		13		
	90%		8		
MOD ITS : DRY (kPa) (A16T)			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED	IN LAB				
WITH	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : All Layers
TRACK NO: 290852

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 16248
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
TP03	0-300mm	2087	1876	11.3	2103	11.2	89.2
					AVERAGE COMPACTION:		93.6

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		600-940mm	8.1	266.0	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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Accreditation No.: T0296

RL-S-150-01

JOB NO: 15274 **DATE REPORTED :** 2018/06/05

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TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3518		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP3		
LAYER TESTED / SAMPLED FROM			100-220mm		
DATE SAMPLED			2018/105/11		
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Dark Brown Clayey Sandy Gravel		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
	75.0		100		
SIEVE	63.0		100		
	53.0		100		
	37.5		100		
ANA -	26.5		93		
	19.0		87		
	13.2		74		
LYSIS	4.75		46		
(mm)	2.00		35		
(TMH A1a)	0.425		28		
	0.075		24		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG	LL%		34.0		
LIMITS	P.I.		15.0		
(TMH A2&A3)	LS%		7.4		
GM			2.13		
CLASSIFI - CATION	H.R.B.*		A-2-6(0)		
	COLTO*		G8		
	T.R.H. 14*		G8		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO	OMC%		13.7		
(TMH A7)	MDD(KG/M^3)		2011		
C.B.R.	COMP MC		13.6		
	% SWELL		0.94		
	100%		18		
U.C.S.	98%		15		
(TMH A13T)	97%		14		
C.B.R.	95%		13		
(TMH A8)	93%		11		
	90%		9		
MOD ITS : DRY (kPa) **(A16T)**			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : All Layers
TRACK NO: 290838

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
100-220mm	0-150mm	2031	1768	14.9	2011	13.7	87.9
					AVERAGE COMPACTION:		87.9

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		100-2200mm	16.5	246.0	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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Accreditation No.: T0296

RL-S-150-01

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

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www.roadlab.co.za

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3829A		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP3		
LAYER TESTED / SAMPLED FROM			220-520mm		
DATE SAMPLED			2018/05/11		
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Dark Red Orange, Clayey Sandy Gravel (diamictite)		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANA - LYSIS (mm) **(TMH A1a)**	75.0		100		
	63.0		88		
	53.0		82		
	37.5		80		
	26.5		75		
	19.0		67		
	13.2		48		
	4.75		33		
	2.00		26		
	0.425		18		
	0.075		7		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%		20.0		
	P.I.		3.0		
	LS%		1.7		
GM			2.49		
CLASSIFI - CATION	H.R.B.*		A-1-a(0)		
	COLTO*		G8		
	T.R.H. 14*		G8		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%		11.2		
	MDD(KG/M3)		2103		
C.B.R.	COMP MC		11.0		
	% SWELL		0.84		
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%		40		
	98%		29		
	97%		25		
	95%		18		
	93%		13		
	90%		8		
MOD ITS : DRY (kPa) (A16T)			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY :	Jabulani & Rabelani	**SAMPLING METHOD :**	AS PER CLIENT
ROAD / AREA TESTED :	Constantia Street	**TEST METHOD :**	TMH A10b-Troxler 16248
LAYER TESTED :	All Layers	**DATE TESTED :**	2018-05-11
TRACK NO:	290852	**WEATHER CONDITIONS:**	Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
TP03	0-300mm	2087	1876	11.3	2103	11.2	89.2
					AVERAGE COMPACTION:		93.6

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		220-520mm	8.1	266.0	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

Accreditation No.: T0296

RL-S-150-01

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www.roadlab.co.za

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR :** CONSTANTIA STREET **- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3504A		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP04		
LAYER TESTED / SAMPLED FROM			150-250mm (base layer)		
DATE SAMPLED			2018/05/11		
DATE RECEIVED					
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Dark Brown Silty Sandy Gravel		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANALYSIS (mm) **(TMH A1a)**	75.0		100		
	63.0		100		
	53.0		100		
	37.5		94		
	26.5		78		
	19.0		69		
	13.2		65		
	4.75		51		
	2.00		35		
	0.425		18		
	0.075		9		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%				
	P.I.		NP		
	LS%				
GM			2.38		
CLASSIFICATION	H.R.B.*		A-1-a(0)		
	COLTO*		G7		
	T.R.H. 14*		G7		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%		7.2		
	MDD(KG/M³)		2191		
C.B.R.	COMP MC		7.0		
	% SWELL		0.15		
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%		70		
	98%		48		
	97%		39		
	95%		27		
	93%		18		
	90%		10		
MOD ITS : DRY (kPa) **(A16T)**			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED :
TRACK NO: 280845

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m³)	OMC(%)	COMPACTION(%)
150- 250mm					2191	7.2	
					AVERAGE COMPACTION:		

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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Accreditation No.: T0296

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JOB NO: 15274 **DATE REPORTED :** 2018/06/05

TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3518B		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP4		
LAYER TESTED / SAMPLED FROM			250-2500m		
DATE SAMPLED					
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Yellow Orange Brown Silty Sandy Gravel		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANA - LYSIS (mm) **(TMH A1a)**	75.0		100		
	63.0		100		
	53.0		100		
	37.5		100		
	26.5		93		
	19.0		87		
	13.2		74		
	4.75		46		
	2.00		35		
	0.425		28		
	0.075		24		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%		34.0		
	P.I.		15.0		
	LS%		7.4		
GM			2.13		
CLASSIFI - CATION	H.R.B.*		A-2-6(0)		
	COLTO*		G8		
	T.R.H. 14*		G8		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%		13.7		
	MDD(KG/M³)		2011		
C.B.R.	COMP MC		13.6		
	% SWELL		0.94		
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%		18		
	98%		15		
	97%		14		
	95%		13		
	93%		11		
	90%		9		
MOD ITS : DRY (kPa) **(A16T)**			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED : All Layers
TRACK NO: 290838

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST POSITION	DEPTH TESTED	FIELD DENSITY(kg/m3)		FIELD MOISTURE(%)	AASHTO TMH A7		*RELATIVE COMPACTION(%)
		WET DENSITY	DRY DENSITY		MDD(kg/m³)	OMC(%)	
250-500mm	0-150mm	2031	1768	14.9	2011	13.7	87.9
					AVERAGE COMPACTION:		87.9

MOISTURE CONTENT

SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		100-250mm	16.5	246.0	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

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Testing Laboratory

Accreditation No.: T0296

RL-S-150-01

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

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TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3538		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP4 - Sulected+Subgrade		
LAYER TESTED / SAMPLED FROM			500-650mm		
DATE SAMPLED			2018/05/12		
DATE RECEIVED					
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Dark Red Speckled Black, Silty Clayey Gravel (diamictite)		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANA - LYSIS (mm) **(TMH A1a)**	75.0	100	100		
	63.0		100		
	53.0		100		
	37.5		100		
	26.5		100		
	19.0		100		
	13.2		100		
	4.75		97		
	2.00		89		
	0.425		81		
	0.075		73		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%		50.0		
	P.I.		25.0		
	LS%		12.4		
GM			0.57		
CLASSIFI - CATION	H.R.B.*		A-7-6(15)		
	COLTO*		<G9		
	T.R.H. 14*		<G10		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%		23.5		
	MDD(KG/M³)		1621		
C.B.R.	COMP MC		23.2		
	% SWELL		2.13		
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%		15		
	98%		14		
	97%		10		
	95%		3		
	93%		5		
	90%		1		
MOD ITS : DRY (kPa) **(A16T)**			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY :
ROAD / AREA TESTED :
LAYER TESTED :
TRACK NO:

SAMPLING METHOD :
TEST METHOD :
DATE TESTED :
WEATHER CONDITIONS:

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m³)	OMC(%)	COMPACTION(%)
					AVERAGE COMPACTION:		

MOISTURE CONTENT

SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

Accreditation No.: T0296

RL-S-150-01

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

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TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3530		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP15		
LAYER TESTED / SAMPLED FROM			160-310mm (subbase)		
DATE SAMPLED			2018/05/11		
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Slightly Moist, Dark Olive, Medium Dense, Intact, Clayey Sandy Gravel with Cobbles (Sandstone)		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
	75.0		100		
SIEVE	63.0		85		
	53.0		67		
	37.5		61		
ANA -	26.5		59		
	19.0		58		
	13.2		55		
LYSIS	4.75		43		
(mm)	2.00		36		
(TMH A1a)	0.425		30		
	0.075		19		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG	LL%		35.0		
LIMITS	P.I.		15.0		
(TMH A2&A3)	LS%		7.5		
GM			2.15		
CLASSIFI -	H.R.B.*		A-2-6(0)		
CATION	COLTO*		<G9		
	T.R.H. 14*		G10		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO	OMC%		10.0		
(TMH A7)	MDD(KG/M3)		2062		
	COMP MC		9.7		
C.B.R.	% SWELL		0.73		
	100%		20		
U.C.S.	98%		11		
(TMH A13T)	97%		9		
C.B.R.	95%		5		
(TMH A8)	93%		3		
	90%		1		
MOD ITS : DRY (kPa) (A16T)			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED :
TRACK NO:

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED :
WEATHER CONDITIONS:

TEST	DEPTH	FIELD DENSITY(kg/m3)		FIELD	AASHTO TMH A7		*RELATIVE
POSITION	TESTED	WET DENSITY	DRY DENSITY	MOISTURE(%)	MDD(kg/m^3)	OMC(%)	COMPACTION(%)
					2062	10.0	
					AVERAGE COMPACTION:		

MOISTURE CONTENT					
SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	
		160-310mm	15.9	103.0	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

Accreditation No.: T0296

RL-S-150-01

JOB NO: 15274 **DATE REPORTED :** 2018/06/07

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TEST REPORT : **GEOTECHNICAL INVESTIGATION FOR : CONSTANTIA STREET- CBR TEST RESULTS**

Please find the attached test results for the sample/s as submitted to and tested by Roadlab (Pty)Ltd in Primrose.
The unambiguous description of the sample/s as received are as follows :

SAMPLE INFORMATION & PROPERTIES					
SAMPLE No.			I3535		
CONTAINER USED FOR SAMPLING			Black Sampling Bags		
SIZE / WEIGHT OF SAMPLE			±70kg's		
MOISTURE CONDITION OF SAMPLE ON ARRIVAL			Slightly Moist		
HOLE No. / Km. / CHAINAGE			TP16		
LAYER TESTED / SAMPLED FROM			310-760mm		
DATE SAMPLED			2018/05/11		
DATE RECEIVED			2018/05/11		
CLIENTS MARKING			None		
DESCRIPTION OF SAMPLE (COLOUR & TYPE)			Light Orange Brown Clayey Sandy Gravel		
GRADING ANALYSIS - % PASSING SIEVES (TMH1 1986 : METHOD A1 (a)					
SIEVE ANALYSIS (mm) **(TMH A1a)**	75.0		100		
	63.0		100		
	53.0		100		
	37.5		90		
	26.5		75		
	19.0		66		
	13.2		64		
	4.75		63		
	2.00		60		
	0.425		52		
	0.075		39		
ATTERBERG LIMITS ANALYSIS (TMH1 1986 : METHOD A2 & A3 ; TMH1 1986, TMHA4 1974)					
ATTERBERG LIMITS **(TMH A2&A3)**	LL%		35.0		
	P.I.		17.0		
	LS%		8.7		
GM			1.49		
CLASSIFICATION	H.R.B.*		A-2-6(0)		
	COLTO*		<G9		
	T.R.H. 14*		<G10		
CALIFORNIA BEARING RATIO (TMH1 1986 : METHOD A7, A8) / UNCONFINED COMPRESSIVE STRENGTH (TMH1 1986 : METHOD A7, A14) (ITS A16T)					
MOD AASHTO **(TMH A7)**	OMC%		12.8		
	MDD(KG/M3)		1728		
C.B.R.	COMP MC		12.6		
	% SWELL		0.91		
U.C.S. **(TMH A13T)** C.B.R. **(TMH A8)**	100%		6		
	98%		4		
	97%		3		
	95%		2		
	93%		1		
	90%		1		
MOD ITS : DRY (kPa) (A16T)			N/A		
PROCTOR ITS : DRY (kPa)			N/A		
STABILISED WITH	IN LAB				
	ON SITE		Neat		
TEST TYPE			IND - CBR		
SAMPLED BY			Roadlab		
DELIVERED BY			Roadlab		
SAMPLED ACCORDING TO			Clients Requirements		
ENVIRONMENTAL CONDITION WHEN SAMPLED			Sunny		
REMARKS & NOTES			None		

TESTED BY : Jabulani & Rabelani
ROAD / AREA TESTED : Constantia Street
LAYER TESTED :
TRACK NO:

SAMPLING METHOD : AS PER CLIENT
TEST METHOD : TMH A10b-Troxler 66993
DATE TESTED : 2018-05-11
WEATHER CONDITIONS: Hot

TEST POSITION	DEPTH TESTED	FIELD DENSITY(kg/m3)		FIELD MOISTURE(%)	AASHTO TMH A7		*RELATIVE COMPACTION(%)
		WET DENSITY	DRY DENSITY		MDD(kg/m³)	OMC(%)	
					AVERAGE COMPACTION:		

MOISTURE CONTENT

SAMPLE NO	HOLE	LAYER	% MOISTURE	TIN NO	

 # MOD SAMPLE TAKEN AT THIS POINT/ PREVIOUS LAYER TESTED FOR MOD

sanas
Testing Laboratory

Accreditation No.: T0296

RL-S-150-01

9.7 Appendix G: Test Pits Profile

9.7.1 Roadway Trial Logs (Test Pit 01 to Test Pit 05)

Ndlovu Engineering Techniks Pty Ltd
23 Mesolite Crescent ,Ennerdale Ext 5
Ennerdale, 1830
Johannesburg

PROJECT: **Constantion Street - Upgrade**

DATE: 2018/06/12
Drill: TP01
Prepared by: M Wata

GEOTECHNICAL BOREHOLE LOG

TP01

Elevation: 1654
Location: Constantia Street, Pomona AH, Kempton Park

Depth (m)	Technical log & Sampling	Soil Description & Classification	Classification	Gravel	Sand	Fines < 76 µm	Clay < 2 µm	% Organics	Plasticity index IP
	1. D	Asphalt Surfacing (AC)	-						
	2. D	BTB (19mm stone)	-						
	3. D	Grey Olive Silty Sandy Gravel (Crushed Stone Gravel)	-	38.0	35.0	10.0	8.0	0.0	0.0
	4. D	Yellow Orange Brown Silty Sandy Gravel	-						
	5. D	Crusher run gravel , imported	-						
	6. D	Dark Red Orange, Clayey Sandy Gravel (diamictite)	-						
1									

Other columns (no values entered): Ground water table; Stratigraphy; Depth (m); Standard Penetration Test (Blows per 15cm; N (blows/30cm) 0 10 20 30 40 50); Atterberg lim.: Liquit limit WL, Plastic limit WP; Physical Characteristics: Water content w%, Bulk density g, Dry density gd, Spec. density G, Void ratio e, Saturat. degree Sr%; Vane Test: Cu, (remoulded) Cu,r; Strength (kPa) qu; Shear Test: phi' deg, c' kPa; Triaxial Compression Test: Test type, phi deg, c kPa, phi' deg, c' kPa; 1D Consolidation Test: Cc, Cs, Cv cm²/s, M MPa, Pc kPa; Depth (m)

1.20 m : End of borehole.

Scaled to fit

ABBREVIATIONS

D: Disturbed core barel sample
C: Dry core barrel sample
U: Undisturbed stationary double tube sample
N: Split spoon sample

g: Bulk density (kN/m³)
gd: Dry density (kN/m³)
G: Specific density (kN/m³)
Cu - Cu,r: Undrained strength form VST (kPa)
qu: Unconfined compression strength (kPa)

CU: Consolidated sample, undrained loading conditions
UU: Unconsolidated sample, undrained loading conditions
CUPP: Consolidated sample, undrained loading conditions with pore pressure measurements
CD: Consolidated sample, drained loading conditions
phi, c: Friction angle, cohesion (total values)

phi', c': Friction angle, cohesion (effective values)
Cc, Cs: Compression index (loading, unloading)
Cv: Consolidation coefficient
M: Compression modulus
Pc: Effective preconsolidation stress

Ndlovu Engineering Techniks Pty Ltd
23 Mesolite Crescent ,Ennerdale Ext 5
Ennerdale, 1830
Johannesburg

PROJECT: Constantion Street - Upgrade

DATE: 2018/06/12
Drill: TP02
Prepared by: M Wata

GEOTECHNICAL BOREHOLE LOG

TP02

Elevation: 1654
Location: Constantia Street, Pomona AH, Kempton Park

Depth (m)	Technical log & Sampling	Ground water table	Stratigraphy	Soil Description & Classification	Classification
	1. D			40mm Asphalt Surfacing over a 13.2 mm Cape Seal	-
				Light Brown Sandy Gravel Base Layer	
	2. D				-
				130mm Dark Brown Clayey Sandy Gravel	
	3. D				-
				Dark Red Orange, Clayey Sandy Gravel (diamictite)	
	4. D				
					-
	5. D				
1					

Depth (m)	Standard Penetration Test: Blows per 15cm	Standard Penetration Test: N (blows/30cm) 0 10 20 30 40 50
1		

Grain size analysis: Gravel | Sand | Fines < 76 µm | Clay < 2 µm | % Organics

Atterberg lim.: Liquit limit WL | Plastic limit WP | Plasticity index IP

Physical Characteristics: Water content w% | Bulk density g | Dry density gd | Spec. density G | Void ratio e | Saturat. degree Sr%

Vane Test: Cu | (remoulded) Cu,r | Strength (kPa) qu

Shear Test: phi' deg | c' kPa

Triaxial Compression Test: Test type | phi deg | c kPa | phi' deg | c' kPa

1D Consolidation Test: Cc | Cs | Cv cm²/s | M MPa | Pc kPa

Depth (m): 1

1.20 m : End of borehole.

Scaled to fit

ABBREVIATIONS

D: Disturbed core barel sample
C: Dry core barrel sample
U: Undisturbed stationary double tube sample
N: Split spoon sample

g: Bulk density (kN/m³)
gd: Dry density (kN/m³)
G: Specific density (kN/m³)
Cu - Cu,r: Undrained strength form VST (kPa)
qu: Unconfined compression strength (kPa)

CU: Consolidated sample, undrained loading conditions
UU: Unconsolidated sample, undrained loading conditions
CUPP: Consolidated sample, undrained loading conditions with pore pressure measurements
CD: Consolidated sample, drained loading conditions
phi, c: Friction angle, cohesion (total values)

phi', c': Friction angle, cohesion (effective values)
Cc, Cs: Compression index (loading, unloading)
Cv: Consolidation coefficient
M: Compression modulus
Pc: Effective preconsolidation stress

Ndlovu Engineering Techniks Pty Ltd
23 Mesolite Crescent ,Ennerdale Ext 5
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Johannesburg

PROJECT: Constantion Street - Upgrade

DATE: 2018/06/12
Drill: TP03
Prepared by: M Wata

GEOTECHNICAL BOREHOLE LOG

TP03

Elevation: 1654
Location: Constantia Street, Pomona AH, Kempton Park

Depth	Technical log & Sampling		Soil Description & Classification		Depth	Standard Penetration Test		Grain size analysis					Atterberg lim.			Physical Characteristics						Vane Test			Shear Test		Triaxial Compression Test					1D Consolidation Test					Depth
(m)		Ground water table	Stratigraphy		Classification	(m)	Blows per 15cm	N (blows/30cm) 0 10 20 30 40 50	Gravel	Sand	Fines < 76 µm	Clay < 2 µm	% Organics	Liquit limit WL	Plastic limit WP	Plasticity index IP	Water content w%	Bulk density g	Dry density gd	Spec. density G	Void ratio e	Saturat. degree Sr%	Cu	(remoulded) Cu,r	Strength (kPa) qu	phi' deg	c' kPa	Test type	phi deg	c kPa	phi' deg	c' kPa	Cc	Cs	Cv cm²/s	M MPa	Pc kPa	(m)
			🟩	40mm AC surfacing age and cracked	-																																	
			🟦	60mm Surfacing or Bitumen treated Base	-																																	
			🟪	120mm Dark Brown Clayey Sandy Gravel	-																																	
			🟧	Dark Red Orange Clayey Sandy Gravel (diamictite nodules)	-																																	
1						1																														1

1.20 m : End of borehole.

Scaled to fit

ABBREVIATIONS

D: Disturbed core barel sample
C: Dry core barrel sample
U: Undisturbed stationary double tube sample
N: Split spoon sample

g: Bulk density (kN/m³)
gd: Dry density (kN/m³)
G: Specific density (kN/m³)
Cu - Cu,r: Undrained strength form VST (kPa)
qu: Unconfined compression strength (kPa)

CU: Consolidated sample, undrained loading conditions
UU: Unconsolidated sample, undrained loading conditions
CUPP: Consolidated sample, undrained loading conditions with pore pressure measurements
CD: Consolidated sample, drained loading conditions
phi, c: Friction angle, cohesion (total values)

phi', c': Friction angle, cohesion (effective values)
Cc, Cs: Compression index (loading, unloading)
Cv: Consolidation coefficient
M: Compression modulus
Pc: Effective preconsolidation stress

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23 Mesolite Crescent ,Ennerdale Ext 5
Ennerdale, 1830
Johannesburg

PROJECT: Constantion Street - Upgrade

DATE: 2018/06/12
Drill: TP04
Prepared by: M Wata

GEOTECHNICAL BOREHOLE LOG

TP04

Elevation: 1654
Location: Constantia Street, Pomona AH, Kempton Park

Depth (m)	Technical log & Sampling	Ground water table	Stratigraphy	Soil Description & Classification	Classification	Depth (m)
			🟩	50mm Asphalt Overlay	-	
			🟦	50mm AC (old surfacing)	-	
			🟫	150mm Dark Brown Clayey Sandy Gravel	-	
			🟧	Yellow Orange Brown Silty Sandy Gravel	-	
			🟥	Dark Red Speckled Black, Silty Clayey Gravel (diamictite)	-	
1						1

Standard Penetration Test		Grain size analysis					Atterberg lim.			Physical Characteristics						Vane Test			Shear Test		Triaxial Compression Test					1D Consolidation Test					Depth
Blows per 15cm	N (blows/30cm) 0 10 20 30 40 50	Gravel	Sand	Fines < 76 µm	Clay < 2 µm	% Organics	Liquit limit WL	Plastic limit WP	Plasticity index IP	Water content w%	Bulk density g	Dry density gd	Spec. density G	Void ratio e	Saturat. degree Sr%	Cu	(remoulded) Cu,r	Strength (kPa) qu	phi' deg	c' kPa	Test type	phi deg	c kPa	phi' deg	c' kPa	Cc	Cs	Cv cm²/s	M MPa	Pc kPa	(m)
																															1

1.20 m : End of borehole.

Scaled to fit

ABBREVIATIONS

D: Disturbed core barel sample
C: Dry core barrel sample
U: Undisturbed stationary double tube sample
N: Split spoon sample

g: Bulk density (kN/m³)
gd: Dry density (kN/m³)
G: Specific density (kN/m³)
Cu - Cu,r: Undrained strength form VST (kPa)
qu: Unconfined compression strength (kPa)

CU: Consolidated sample, undrained loading conditions
UU: Unconsolidated sample, undrained loading conditions
CUPP: Consolidated sample, undrained loading conditions with pore pressure measurements
CD: Consolidated sample, drained loading conditions
phi, c: Friction angle, cohesion (total values)

phi', c': Friction angle, cohesion (effective values)
Cc, Cs: Compression index (loading, unloading)
Cv: Consolidation coefficient
M: Compression modulus
Pc: Effective preconsolidation stress

Ndlovu Engineering Techniks Pty Ltd
23 Mesolite Crescent ,Ennerdale Ext 5
Ennerdale, 1830
Johannesburg

PROJECT: Constantion Street - Upgrade

DATE: 2018/06/12
Drill: TP05
Prepared by: M Wata

GEOTECHNICAL BOREHOLE LOG

TP05

Elevation: 1654
Location: Constantia Street, Pomona AH, Kempton Park

Depth (m)	Technical log & Sampling	Ground water table	Stratigraphy	Soil Description & Classification	Classification
				60mm Asphalt surfacing	-
				100mm Slurry Bound Macadam	-
				Slightly Moist, Dark Brown, Medium Dense, Intact, Clayey Sandy Gravel with few Cobbles (Sandstone) - Imported	-
				Light Orange Brown Clayey Sandy Gravel	-
				Dark Red Speckled Black, Silty Clayey Gravel (diamictite)	-
1					

Depth (m)	Standard Penetration Test: Blows per 15cm	Standard Penetration Test: N (blows/30cm) 0 10 20 30 40 50	Grain size analysis: Gravel	Sand	Fines < 76 µm	Clay < 2 µm	% Organics	Atterberg lim.: Liquit limit WL	Plastic limit WP	Plasticity index IP	Physical Characteristics: Water content w%	Bulk density g	Dry density gd	Spec. density G	Void ratio e	Saturat. degree Sr%	Vane Test: Cu	(remoulded) Cu,r	Strength (kPa) qu
1																			

Shear Test: phi' deg	c' kPa	Triaxial Compression Test: Test type	phi deg	c kPa	phi' deg	c' kPa	1D Consolidation Test: Cc	Cs	Cv cm²/s	M MPa	Pc kPa	Depth (m)
												1

1.00 m : End of borehole.

Scaled to fit

ABBREVIATIONS

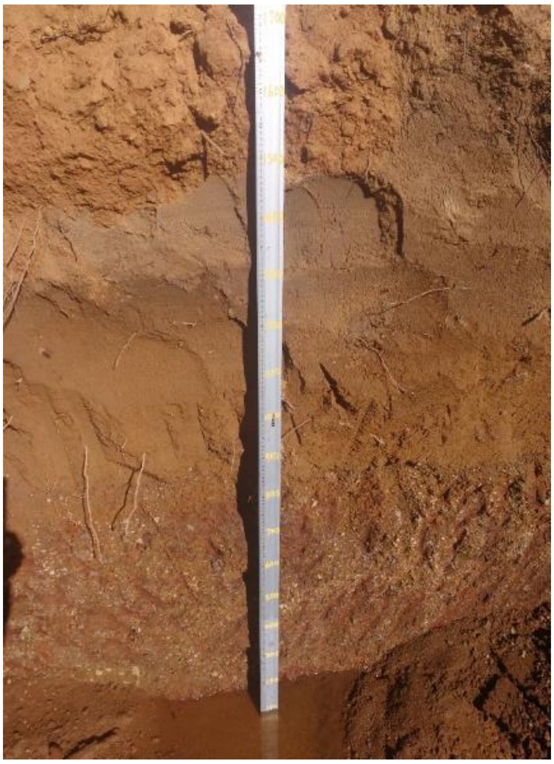
D: Disturbed core barel sample
C: Dry core barrel sample
U: Undisturbed stationary double tube sample
N: Split spoon sample

g: Bulk density (kN/m³)
gd: Dry density (kN/m³)
G: Specific density (kN/m³)
Cu - Cu,r: Undrained strength form VST (kPa)
qu: Unconfined compression strength (kPa)

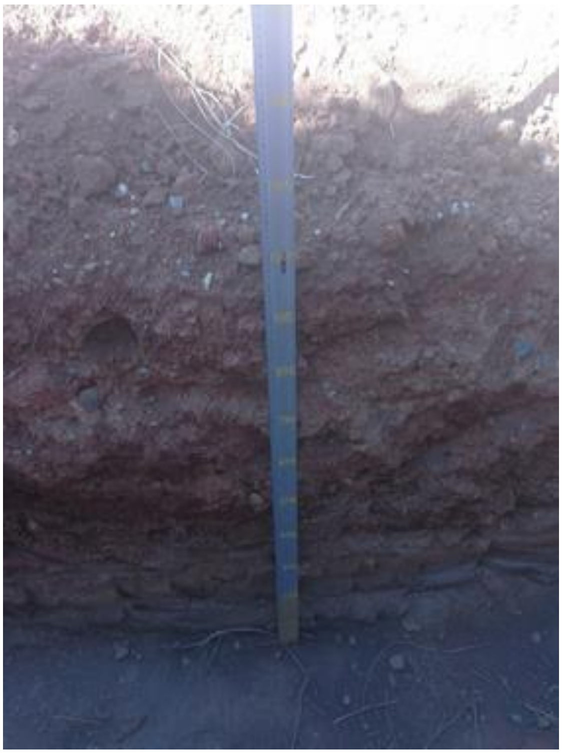
CU: Consolidated sample, undrained loading conditions
UU: Unconsolidated sample, undrained loading conditions
CUPP: Consolidated sample, undrained loading conditions with pore pressure measurements
CD: Consolidated sample, drained loading conditions
phi, c: Friction angle, cohesion (total values)

phi', c': Friction angle, cohesion (effective values)
Cc, Cs: Compression index (loading, unloading)
Cv: Consolidation coefficient
M: Compression modulus
Pc: Effective preconsolidation stress

9.7.2 Test Pit Profile Photos for TP6 to TP 16 (Road Reserve)


TP06: 26° 5'54.58"S 28°15'43.41"E


TP07: 26° 5'58.49"S 28°15'47.33"E

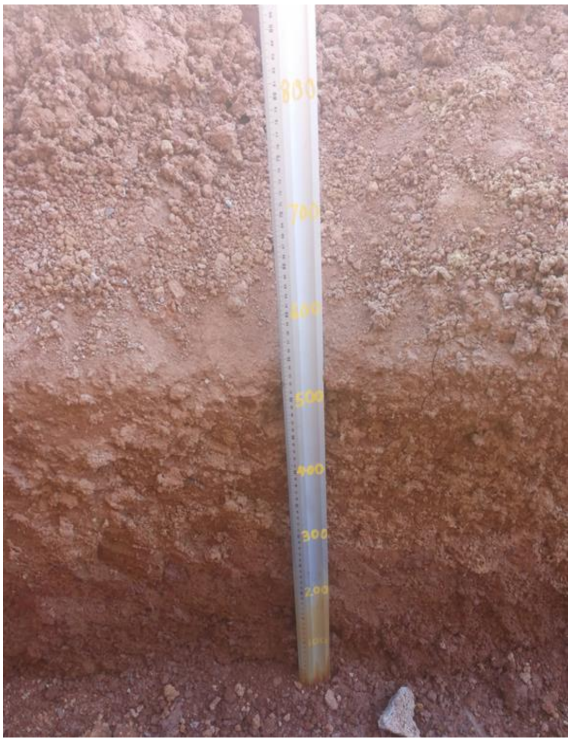


TP08: 26° 6'9.27"S 28°15'54.75"E

TP09: 26° 6'8.50"S 28°15'55.26"E

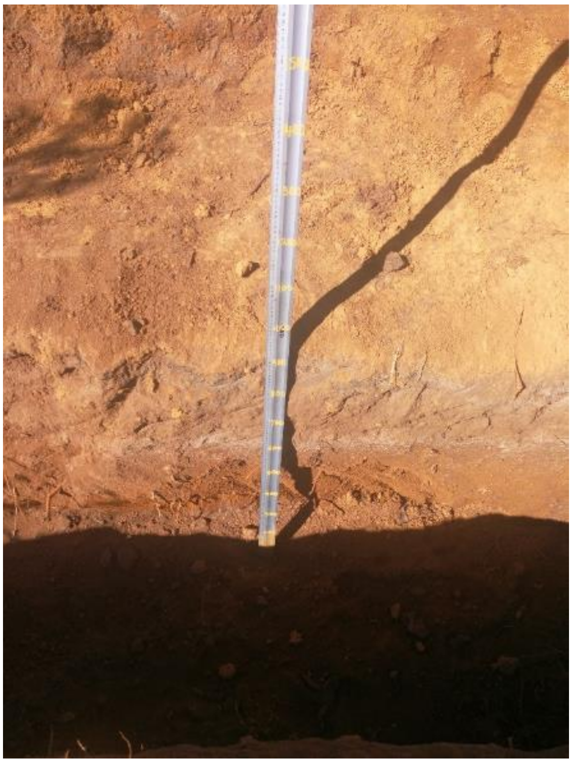
TP10: 26° 6'11.19"S 28°15'56.48"E

TP11: 26° 6'13.41"S 28°15'58.97"E

TP12: 26° 6'18.35"S 28°16'2.84"E



TP13: 26° 6'30.49"S 28°16'11.60"E



TP14: 26° 6'37.64"S 28°16'17.25"E

TP15: 26° 6'46.26"S 28°16'24.29"E

TP16: 26° 6'45.63"S 28°16'25.22"E (outside road reserve – in a private property)