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Contech Geotechnical Laboratory

Construction Quality Control, Foundations, Soil Testing & Materials Surveys

29th August 2016

National Pharmaceutical Company (NatPharm)
14 Lobengula Road
Southerton
Harare

RE: PROPOSED NEW WAREHOUSE CONSTRUCTION FOR NATPHARM IN MASVINGO
GEOTECHNICAL INVESTIGATIONS FOR STRUCTURAL ENGINEERING DESIGNS

Thank you for commissioning us to carry out geotechnical investigations for Structural Engineering designs at the above site, where a new warehouse building construction development project is due to commence.

Please find attached:

i) Field and Laboratory Results
ii) Geotechnical investigations report

We trust the information given is sufficiently comprehensive for your requirements and would be pleased to assist further should the need arise.

Yours faithfully

P. Madamombe **(Pr.Eng.Tech. – Materials Testing / Geotechnology)**
For: Contech Geotechnical Laboratory

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1.0 INTRODUCTION / SCOPE OF WORK

Contech Geotechnical Laboratory was tasked to conduct geotechnical site investigations at the proposed site for a new warehouse for the National Pharmaceutical Company (NatPharm), in Masvingo. The field investigations included the excavation of five (5) trial holes to depths of over 2 m. The terms of reference of the geotechnical investigation were to conduct field and laboratory work and to provide recommendations on:

i) In situ soils classification
ii) In situ soils bearing capacity
iii) Foundation founding conditions for the building structures.

This report presents the results of the geotechnical investigations undertaken by Contech Geotechnical Laboratory for this proposed project.

2.0 SITE DESCRIPTION

- The site is located in Masvingo town centre.
- It is proposed to construct a warehouse building structure at the site.
- There is an existing warehouse building structure within the proposed site.
- The proposed site has short grass cover.
- The grass cover to the northern side of the proposed site is burnt.
- Several anthills were observed within the proposed site.
- The land is fairly level.
- The location of the trial holes is as shown in **Appendix D.**

3.0 FIELD AND LABORATORY WORK

- Five (5) trial holes were excavated by hand during the course of the investigation.
- Soil profiling was done for the trial holes as recorded in **Appendix "A"**
- Representative disturbed samples were obtained from the trial holes and the samples were subjected to careful visual examination as well as subsequent laboratory testing to determine insitu soils classification.
- Field Direct Cone Penetrometer (DCP) testing was carried out to determine the in situ bearing capacity of the soils for the warehouse construction. (**Refer to Appendix "B"**).
- The site investigations and laboratory testing were conducted using methods described in ZWS185: Part 1 (1998), ZWS185: Part 2 (2001), BS1377, BS5930 (1981) and Byrne and Berry (2008).

No ground water conditions were encountered in all the excavated trial holes.

4.0 ANALYSIS OF TEST RESULTS

4.1 In situ Soils Classification

The results of the in situ soils classification tests are shown in Table 1. The in situ soil is generally a course decomposed granite / quartz gravel with clay down to over 2 m below ground level. The soil type is generally of medium plasticity, with the plasticity index averaging 18.9. The in situ soils classification affects the depth of the foundation and also the loads to be carried by the foundation.

Table 1: Summary of Insitu Soil Classification Tests

Hole No	Depth (mm)	Liquid Limit LL %	Plasticity Index PI %	Coarseness Index +2,36 mm %	Fineness Index -75 µm%	Plasticity Product PP	Soil Classification
TH 1	0-500	31	13	16	51	663	GC
	500 - 1300	26	11	48	10	110	GC
	1300 -2000	31	17	24	18	306	GC
TH 2	200 - 400	39	21	13	47	987	GC
	400 - 1200	31	16	28	31	496	GC
	1200 - 2000	41	22	22	56	1232	GC
TH 3	0 - 400	24	15	09	45	675	GC
	400 - 700	29	18	27	26	468	GC
	700 - 2000	41	22	11	52	1144	GC
TH 4	0 - 500	42	23	16	51	1173	GC
	500 - 1500	25	13	55	16	208	GC
	1500 - 1900	31	21	21	54	1134	GC
	1900 - 2000	49	30	04	68	2040	CL
TH 5	300 - 800	42	20	29	25	500	GC
	800 - 2000	36	21	15	47	987	GC

4.2 In situ Soils Bearing Capacity

The in situ soils bearing capacity values are shown in Table 2.

Table 2: Summary of in situ soils bearing capacity results

Location	Depth below ground level (m)	Equivalent bearing capacity (kPa)
Trial Hole 1 (TH 1)	0 – 0.4	800
	0.4– 1.0	280
	1.0 – 2.1	630
	2.1 – 3.0+	Refusal
Trial Hole 2 (TH 2)	0 – 0.2	795
	0.2 – 1.0	315
	1.0 – 2.1	848
	2.1 – 3.0+	Refusal
Trial Hole 3 (TH 3)	0 – 1.0	795
	1.0 – 2.1	795
	2.1 – 3.0+	630
Trial Hole 4 (TH 4)	0 – 1.0	315
	1.0 – 1.4	800
	1.4 – 2.0	500
	2.0 – 2.7	88
	2.7 – 3.0+	200
Trial Hole 5 (TH 5)	0 – 1.0	400
	1.0 – 2.1	630
	2.1 – 3.0+	848

The in situ soil consistency for trial pits TH1, TH2, TH3 and TH5 is generally very hard and strong from the surface and down to over 3.0 m below ground level. The insitu soil consistence for trial pit TH4 is hard and strong from the surface down to 2,0m below ground level. Thereafter, there is a very weak layer between 2.0 m and 2.7 m below ground level, and the bearing capacity values are generally low, at 88 kPa. Beyond 2.7 m below ground level, the in situ soil consistency gradually increases to become hard and strong.

4.3 Shear Box Test Results

The results of the shear strength tests carried out on the soil are shown in Table 3.

Table 3: Shear Box Test Results

	@2,0m	@2,0m
Apparent cohesion (c) (kN/m²)	0	0
Angle of shearing resistance (Ø)°	23	18
Moisture content @ test %	9,1	15,4
Specific gravity	2.58	2.71
Soil description	Light grey decomposed granite	Brown/fawn decomposed granitic clay

4.4 CBR & Moisture / Density Test Results

The results of the moisture / density relationship and the California Bearing Ratio (CBR) of the soil are as shown in Table 4 below:

Table 4: CBR & Moisture / Density Test Results

Sample No. / Description	Maximum dry density (kg/m3)	Optimum moisture content (%)	CBR @ Optimum moisture content (%)
TH 1 – decomposed granite with clay@2.0m	1990	8.0	40
TH 2 – decomposed granite with clay @2.0m	1980	7.0	30
TH 3 – decomposed granite@2.0m	2200	8.0	55
TH 4 – quartz clayey gravel@2.0m	2050	8.0	30
TH 5 – decomposed granite@2.0m	2260	8.0	45

5.0 CONCLUSION

The insitu soil is decomposed granite / quartz gravel with a substantial proportion of clay. The DCP test results indicate a hard soil layer down to over 3.0 m below ground level. However for trial hole TH4, there is a weak soil layer between 2.0m and 2.7 m below ground level. Thereafter, the in situ soil layer becomes hard and strong.
These considerations have been taken into account in making the recommendations for foundation design and construction for the proposed warehouse building structure. The foundation construction has to be conducted after detailed structural designs are produced. This will prevent shear failure of the soil, differential settlement and cracking. The foundation must be reinforced.

6.0 RECOMMENDATIONS

All anthills must be excavated to waste, and ant kill applied before any construction works commences.

6.1 Foundation Founding Conditions for Building Structures

The minimum foundation founding depth and the in situ bearing capacity of soil should be per structural engineer recommendations. The bearing capacity values of the soil are generally high and normal reinforced foundations are required if the structure is to support high loads.

The footing should be reinforced to withstand any cracking which might result from differential ground settlements caused by the clayey soil. Structural design of the foundations must be conducted before construction.

The Foundation Type, Systems and Dimensions will be as per Structural Engineer Designs.

6.2 Ground Treatment

The following ground treatment must be done and inspected during the construction of the foundations.

- The under floor topsoil must be excavated to waste, to a minimum depth of 400 mm below concrete floor casting levels.
- Backfill with selected granular fill material compacted in layers not exceeding 200 mm, to 96% Lower Compactive Effort (LCE) or to the satisfaction of the Engineer.

6.3 Hard standing area and backfilling construction materials

The insitu soil at the proposed site is a course gravelly clay soil of medium plasticity. Such fine soils do not present any challenges to work with during compaction.
The cut insitu soil is predominantly a decomposed granite/quartz gravel material of medium plasticity, with a CBR above 30, a maximum dry density above 2000kg/m^3, and an optimum moisture content of 8.0%.
We propose and recommend that the cut material at site be used for the construction of fill to base layers for the hard standing areas. Compaction at site has to be controlled.
However, we advise that the cut material around TH4 be avoided to be used as fill material, since the clay content is on the higher side.

REFERENCES

BS1377-2., 1990. Methods of Tests for Civil Engineering Purposes. Part 2: Classification tests. British Standards Institution, London, United Kingdom.

BS1377-7., 1990. British Standard Methods for Soils for Engineering Purposes. Part 7: Shear Strength Tests (total stress). British Standards Institution, London, United Kingdom.

BS5930, 1981. Code of Practice Site Investigations. British Standards Institution, London, United Kingdom.

Byrne, G. and Berry, A.D. (Eds.), 2008. A Guide to Practical Geotechnical Engineering in Southern Africa, Fourth Edition. Franki Africa. Published by VIVO Design Associates.

ZWS185 Part 1, 1998. Methods of Testing Soils for Civil Engineering Purposes. Part 1. Preparation, Classification and Density of Soil. Standards Association of Zimbabwe (SAZ), Harare, Zimbabwe.

ZWS185 Part 2, 2001. Methods of Testing Soils for Civil Engineering Purposes. Part 2. Strength Tests. Standards Association of Zimbabwe (SAZ), Harare, Zimbabwe.

APPENDIX 'A': Soil Profile

Hole No	Moisture	Colour	Consistency	Soil Type
TH 1				
0 – 500	Moist	Grey	Hard	Sandy top soil
500 -1300	Moist	Brown	Hard	Laterite gravel
1300 - 2000+	Moist	Light grey	Hard	Slightly decomposed granite
TH 2				
0 – 200	Moist	Grey / brown	Hard	Sandy top soil
200 – 400	Moist	Grey / brown	Hard	Quartz gravel
400 - 1200	Moist	Light grey	Hard	Quartz gravel mixed with decomposed granite
1200 - 2000+	Moist	Light grey	Hard	Slightly decomposed granite
TH 3				
0 – 400	Moist	Grey	Hard	Sandy top soil
400 - 700	Moist	Brown	Hard	Quartz gravel
700 - 2000+	Moist	Light grey	Hard	Slightly decomposed granite
TH 4				
0 – 500	Moist	Grey	Hard	Clayey sand top soil
500 – 1500	Moist	Brown /fawn	Hard	Rounded quartz cobbles mixed with decomposed granite
1500 – 1900	Moist	Fawn	Hard	Decomposed granite
1900 – 2000+	Moist	Fawn	Hard	Advanced decomposed granite mixed with clay
TH 5				
0 – 300	Moist	Grey	Hard	Clayey sand top soil
300 - 800	Moist	Brown	Hard	Quartz gravel
800 - 2000+	Moist	Light grey with yellow pickles	Hard	Slightly decomposed granite with yellow stripes

APPENDIX B: PROPOSED NATPHARM WAREHOUSE - DCP TEST

TH 1

No of Blows	Depth Below Ground Level (mm)	Penetration Per Blow (mm)	Equivalent Bearing Pressure (KPa)
	At Surface		
0	0	-	-
2	35	18	125
5	70	7	400
5	90	4	795
5	115	5	630
5	130	3	800
5	140	2	848
5	160	4	795
5	170	2	848
5	185	3	800
5	200	3	800
5	215	3	800
5	230	3	800
5	245	3	800
5	260	3	800
5	270	2	848
5	290	4	795
5	320	6	500
5	350	6	500
5	370	4	795
5	410	8	315
5	455	9	280
5	510	11	225
5	570	12	200
5	610	8	315
5	630	4	795
5	660	6	500
5	700	8	315
5	750	10	250
5	800	10	250
5	850	10	250
5	900	10	250
	At 1.0m		
0	0	-	-
2	25	13	180
5	60	7	400
5	80	4	795
5	100	4	795
5	115	3	800
5	135	4	795
5	160	5	630
5	180	4	795
5	210	6	500
5	275	13	180
5	285	2	848
5	305	4	795
5	325	4	795
5	345	4	795
5	375	6	500
5	385	2	848
5	410	5	630
5	415	1	1000
5	435	4	795
5	450	3	800
5	460	2	848
5	480	4	795
5	490	2	848
5	510	4	795
5	540	6	500

5	570	6	500
5	600	6	500
5	630	6	500
5	670	8	315
5	710	8	315
5	760	10	250
5	800	8	315
5	840	8	315
5	895	11	225
	At 2.0m		
0			
2	0	-	-
5	20	4	795
5	40	4	795
5	75	7	400
5	85	2	848
5	120	7	400
5	140	4	795
5	145	1	1000
	Refusal		

TH 2

No of Blows	Depth Below Ground Level (mm)	Penetration Per Blow (mm)	Equivalent Bearing Pressure (KPa)
	At Surface		
0	0	-	-
2	20	10	250
5	35	3	800
5	55	4	795
5	70	3	800
5	90	4	795
5	115	5	630
5	130	3	800
5	160	6	500
5	180	4	795
5	210	6	500
5	240	6	500
5	280	8	315
5	320	8	315
5	360	8	315
5	400	8	315
5	430	6	500
5	475	9	280
5	510	7	400
5	540	6	500
5	570	6	500
5	610	8	315
5	650	8	315
5	690	8	315
5	740	10	250
5	780	8	315
5	830	10	250
5	850	4	795
5	900	10	250
	At 1.0m		
0	10	-	-
2	20	5	630
5	35	3	800
5	50	3	800
5	60	2	848
5	70	2	848

5	75	1	1000
5	80	1	1000
5	85	1	1000
5	95	2	848
5	100	1	1000
5	105	1	1000
5	105	-	1000+
5	110	1	1000
5	115	1	1000
	At 2.0m		
0	10	-	-
2	20	2	848
5	30	2	848
5	50	4	795
5	70	4	795
5	85	3	800
5	100	3	800
5	105	1	1000
5	**Refusal**		

TH 3

No of Blows	Depth Below Ground Level (mm)	Penetration Per Blow (mm)	Equivalent Bearing Pressure (KPa)
	At Surface		
0	0	-	-
2	15	8	315
5	30	3	800
5	45	3	800
5	60	3	800
5	75	3	800
5	100	5	630
5	110	2	848
5	125	3	800
5	170	9	280
5	205	7	400
5	230	5	630
5	260	6	500
5	285	5	630
5	305	4	795
5	330	5	630
5	350	4	795
5	365	3	800
5	375	2	848
5	400	5	630
5	410	2	848
5	415	1	1000
5	420	1	1000
5	430	2	848
5	440	2	848
5	445	1	1000
5	460	3	800
5	475	3	800
5	500	5	630
5	530	6	500
5	590	12	200
5	610	4	795
5	630	4	795
5	660	6	500
5	680	4	795
5	705	5	630
5	735	6	500
5	780	9	280
5	815	7	400
5	825	2	848
5	850	5	630
5	870	4	795

5	890	4	795
	At 1.0m		
0	10	-	-
2	35	13	180
5	70	7	400
5	90	4	795
5	100	2	848
5	110	2	848
5	120	2	848
5	125	1	1000
5	130	1	1000
	At 2.0m		
0	0	-	-
2	30	15	155
5	45	3	800
5	55	2	848
5	70	3	800
5	85	3	800
5	110	5	630
5	140	6	500
5	165	5	630
5	200	7	400
5	240	8	315
5	275	7	400
5	300	5	630
5	330	6	500
5	360	6	500
5	390	6	500
5	435	9	280
5	470	7	400
5	500	6	500
5	540	8	315
5	580	8	315
5	605	5	630
5	635	6	500
5	670	7	400
5	700	6	500
5	730	6	500
5	760	6	500
5	790	6	500
5	810	4	795
5	840	6	500
5	870	6	500
5	900	6	500

TH 4

No of Blows	Depth Below Ground Level (mm)	Penetration Per Blow (mm)	Equivalent Bearing Pressure (KPa)
	At Surface		
0	20	-	-
2	40	10	250
5	95	11	225
5	140	9	280
5	175	7	400
5	210	7	400
5	255	9	280
5	280	5	630
5	315	7	400
5	350	7	400
5	385	7	400
5	415	6	500
5	450	7	400
5	485	7	400
5	520	7	400
5	570	10	250
5	610	8	315
5	650	8	315
5	690	8	315
5	730	8	315
5	770	8	315
5	800	6	500
5	830	6	500
5	870	8	315
5	900	6	500
	At 1.0m		
0	0	-	-
2	30	15	155
5	55	5	630
5	70	3	800
5	90	4	795
5	110	4	795
5	115	1	1000
5	115	-	1000+
5	120	1	1000
5	120	-	1000+
5	120	-	1000+
5	130	2	848
5	145	3	800
5	155	2	848
5	165	2	848
5	175	2	848
5	185	2	848
5	205	4	795
5	230	5	630
5	250	4	795
5	255	1	1000
5	260	1	1000
5	270	2	848
5	275	1	1000
5	285	2	848
5	295	2	848
5	310	3	800
5	330	4	795
5	345	3	800
5	360	3	800
5	385	5	630
5	420	7	400
5	460	8	315
5	490	6	500

5	510	4	795
5	540	6	500
5	570	6	500
5	600	6	500
5	640	8	315
5	670	6	500
5	720	10	250
5	745	5	630
5	770	5	630
5	800	6	500
5	840	8	315
5	875	7	400
5	900	5	630
	At 2.0m		
0	0	-	-
2	75	38	51
5	145	14	165
5	245	20	110
5	370	25	88
5	515	29	72
5	650	27	80
5	720	14	165
5	795	15	155
5	855	12	200
5	900	9	280

TH 5

No of Blows	**Depth Below Ground Level (mm)**	**Penetration Per Blow (mm)**	**Equivalent Bearing Pressure (KPa)**
	<u>At Surface</u>		
0	0	-	-
2	10	5	630
5	25	3	800
5	60	7	400
5	85	4	795
5	110	5	630
5	135	5	630
5	170	7	400
5	220	10	250
5	245	5	630
5	270	5	630
5	300	6	500
5	340	8	315
5	370	6	500
5	415	9	280
5	465	10	250
5	510	9	280
5	550	8	315
5	595	9	280
5	630	7	400
5	670	8	315
5	710	8	315
5	755	9	280
5	800	9	280
5	840	8	315
5	885	9	280
5			
	At 1.0m		
0	0	-	-

2	20	10	250
5	50	6	500
5	70	4	795
5	100	6	500
5	125	5	630
5	155	6	500
5	180	5	630
5	200	4	795
5	215	3	800
5	235	4	795
5	250	3	800
5	275	5	630
5	285	2	848
5	300	3	800
5	320	4	795
5	355	7	400
5	370	3	800
5	385	3	800
5	400	3	800
5	415	3	800
5	420	1	1000
5	450	6	500
5	480	6	500
5	510	6	500
5	540	6	500
5	570	6	500
5	600	6	500
5	625	5	630
5	655	6	500
5	690	7	400
5	710	4	795
5	745	7	400
5	780	7	4000
5	805	5	630
5	840	7	400
5	875	7	400
5	900	5	630
	At 2.0m		
0	10	-	-
2	25	8	315
5	50	5	630
5	70	4	795
5	80	2	848
5	90	2	848
5	100	2	848
5	115	3	800
5	130	3	800
5	145	3	800
5	150	1	1000
5	160	2	848
5	165	1	1000
5	175	2	848
5	180	1	1000
5	190	2	848
5	200	2	848
5	210	2	848
5	215	1	1000
5	220	1	1000
5	230	2	848
5	235	1	1000
5	245	2	848
5	250	1	1000
5	260	2	848
5	265	1	1000

APPENDIX C – INDICATOR TEST RESULTS

SUMMARY OF INDICATOR TEST RESULTS

JOB: PROPOSED WAREHOUSE BUILDING CONSTRUCTION, MASVINGO **CLIENT: NATPHARM**

Sample No	Depth (mm)	% PASSING											Reject Index (IR)	Liquid Limit (WL)	Plasticity Index (Ip)	Schedule of Grouping
		37.5	26.5	19.0	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075				
	0-500		100	-	-	93.0	84.0	76.0	67.2	57.2	52.2	50.6	-	31	13	Gr 1360b
TH 1	500-1300		100	96.8	83.8	67.4	51.9	36.7	24.2	16.7	12.1	9.9	-	26	11	Gr 1305e
	1300-2000		100	-	92.8	85.8	75.6	56.4	44.4	29.6	21.6	17.6	-	31	17	Gr 1815c
	200-400			100	-	98.4	87.4	73.8	60.8	53.8	49.0	47.4	-	39	21	Gr 2345b
TH 2	400-1200			100	94.2	85.2	72.4	60.0	49.2	40.2	33.2	30.8	-	31	16	Gr 1835c
	1200-2000			100	91.7	86.4	78.4	70.7	64.7	61.4	58.4	56.4	-	41	22	Gr 2360c
	0-400		-	100	98.0	95.2	90.8	85.2	74.4	59.2	47.6	44.6	-	24	15	Gr 1345a
TH 3	400-700		100	95.5	88.5	77.0	73.0	63.5	43.7	32.5	28.8	26.0	-	29	18	Gr 1825c
	700-2000		100	100	96.7	94.3	89.3	80.2	72.8	62.8	54.6	52.4	-	41	22	Gr 2360b
	0-500				100	93.0	84.0	76.0	67.2	57.2	52.2	50.6	-	42	23	Gr 2360b
	500-1500		100	84.8	75.4	60.0	45.0	33.2	27.0	21.3	17.5	15.7	-	25	13	Gr 1315f
TH 4	1500-1900				94.6	88.6	79.4	72.7	65.8	62.3	57.4	54.2	-	31	21	Gr 2360c
	1900-2000					100	96.0	89.0	81.0	74.0	69.6	67.6	-	49	30	Gr 2860a
	300 - 800		100	94.5	87.0	75.2	70.8	61.2	43.4	31.6	27.6	24.8	-	42	20	Gr 1825c
TH 5	800 - 2000				100	97.0	85.0	70.0	60.4	53.4	48.4	47.4	-	36	21	Gr 2345b
									Tested by...Contech lab							
									Date.....26/08/2016							

Appendix D: POSITION OF TRIAL HOLES