GEOTECHNICAL INVESTIGATION For United Nations Development Programme (UNDP) Medical Stores Limited's Regional Warehouse Hubs MPIKA



FINAL REPORT

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Geotechnical Report

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1. Introduction

Rankin Engineering Consultants was contracted by the United Nations Development Programme (UNDP) 18th August 2016 to carry out geo-technical investigations at the proposed sites for Mongu, Choma, Mansa, Mpika and Chipata Medical Stores Limited's Regional Warehouse Hubs. This report presents the findings based on the tests carried out in the field and laboratory testing.

Field testing included test pit, DPSH and SPT's.

Laboratory testing of samples included Sieve Analysis, Atterberg Limits, Moisture Content, MDD and CBR.

Field investigation was carried out over the period of 7th to 15th September 2016.

The map of the investigation area is included in Appendix A.

2. Technical Standards

The following technical standards were applied to this project: BS EN 1997-2:2007 Geotechnical Design – Ground Investigation and testing BS 1377-9:1990 Methods of test for Soils for Civil Engineering Purposes – In-situ tests SANS 3001-GR1: 2013 Wet preparation and particle size analysis BS 1377-2: 1990 Tests 1.2, 1.3 and 1.4 Liquid Limit, Plastic Limit & Plasticity Index, Linear Shrinkage SANS 3001-GR30: 2013 Determination of the maximum dry density and optimum moisture content SANS 3001-GR40: 2013 Determination of the California bearing ratio BS 1377-2: 1990 Moisture Content



3. General Description of Project Area

The investigated area is rural, dominated by grass vegetation, with some small vegetable farms developed.

The whole area is covered by moist reddish brown soft sandy clay in the upper layers and moist light reddish brown soft to firm gravelly sandy clay at depth.

4. Geology

The geology of the Mpika is of Precambrian in age. The geological succession shown in three main lithological units: quartzites and sandstones of the Kibaran System mainly occurring in the northwest but also dominating the Mpika-Isoka Ridge Land Region; granite in a central zone north-east to south-west but also surrounding the Luangwa Valley in the extreme east; and the shales, siltstones, mudstones and sandstones of the Kundelungu System, which is found both along the Luapula Valley where it is known as the Luapula Beds and in the south-east of the Chambesi-Bangweulu Plain Land Region where it is called the Luitikila Beds. Zambia was subjected to at least two periods of granitic intrusion (Reeve, 1963); the granite found in the project area, however, seems to belong to the older intrusion. Apart from some very small and scattered basic outcrops, igneous rocks can also be found surrounding the Kibaran System in the north-west of the project area, as an intermittent volcanic or hypabyssal suite. The geological map of the project area (Figure 1) is based on a revision of the 1:1 000 000 Geological Map of Zambia published by the Geological Survey of Zambia (formerly Northern Rhodesia) in 1960. North of Mpika, there is a basaltic mesa and further basaltic outcrops found to the south-west of this mesa, which give rise to smectoid (or more active) clays. The folded rocks of the Kibaran System attain their maximal width north of Mpika where 'the quartzite formations are repeated six or seven times from north-west to south-east by major folds' (Marten, 1968a). The folding decreases in width north-east and south-west from this area.¹

¹ Land Resources of the Northern and Luapula Provinces, Zambia reconnaissance assessment. Volume 4 The biophysical environment.



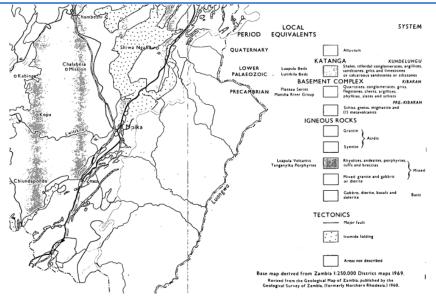


Figure 1: Map of Mpika Terrane

5. Methodology

The field work comprised a combination of soil profiling using undisturbed methods to extract samples of the soil to 5.0 metres depth where conditions allowed, combined with In-situ testing using Standard Penetration Test (SPT) 'down the hole' at every 1m level. Laboratory testing was done to classify the soil types encountered and to determine their engineering characteristics. Test pitting was also carried out on one point.

6. Results of field work

6.1 SPT

A total of 4 SPT tests were carried out at the test locations as shown on the map in Appendix A. The SPT test was performed using a split cone, with a 150mm seating blow. This test is used to directly determine the allowable bearing capacity under in-situ conditions. The number of blows required to advance the cone through the final 300mm of a 450mm test range is reported as the 'N' value. The SPT test records are included in Appendix B. A summary and interpretation is given in Table 1.

The allowable bearing capacity is a function of the foundation size and depth. Without knowing these in advance, an approximation of bearing capacity for various widths at the top of the excavation has been used.



It should be borne in mind that conditions at the time of testing may not be the worst condition that can be experienced over the life of the foundation, particularly with respect to saturated conditions in soils which are highly susceptible to softening under moisture. Reference should therefore also be made to soil classification results.

6.1.1 Analysis of SPT results

The SPT values recorded were processed using relationships developed by Bowles based on Meyerhof relationships. Calculated values for the site are given in the table below.

Mpika						
Point ID	Depth	N Value	Proposed founding depth (m)	Possible foundation width (m)	Average SPT in zone of influence	Allowable bearing capacity (kPa)
	1	6		0.8	11	135
	2	15		1	11	135
SPT1	3	10	2.0	1.5	11	130
	4	9		2	11	130
	5	14				
	1	5		0.8	10	125
	2	7		1	10	125
SPT2	3	17	2.0	1.5	9	110
	4	7		2	9	110
	5	10				
	1	12		0.8	8	95
	2	9		1	8	95
SPT3	3	9	2.0	1.5	10	115
	4	6		2	10	115
	5	12				
	1	3		0.8	9	100
	2	11		1	9	100
SPT4	3	31	2.0	1.5	13	160
	4	6		2	13	160
	5	15				

Table 1: Bearing Capacity based on SPT N Values

The results indicate that on Mpika site, an allowable bearing capacity of 100kPa at a minimum founding depth of 2.0 metres below the ground surface may be appropriate.



At the site, the materials in the proposed founding layer are moist reddish brown yellowish gravelly sand-clay mixture. The soil matrix itself appears firm.

As the field testing was done during the dry season, it is anticipated that lower results would have been achieved during the rainy season. Reference is therefore made to the laboratory results.

6.2 Trial Pits

A total of 1 Trial Pits tests were carried out at the test locations as shown on the map in Appendix A.

Conditions on site allowed excavation as deep as 3.0m due to presence of moist reddish brown yellowish gravelly sand-clay mixture.

The soil profiles (Appendix C) in trial pit revealed that the whole area is covered by moist reddish brown sandy clay in the upper layers.

Deletin		GPS Cool	dinates	Photo
Point ID		E	N	Tested Comple
¢	수) 25 - 11	328727	86923	Tested Sample
	Sample	5		Mpika - TP1
		Moist reddish b	rown	
	i i	yellowish gravell	y sand-	Contraction of the second second
1		clay mixture (Re	sidual)	A CONTRACT OF A CONTRACT OF
0.00				A she been a she that at a
	Depth:			A THE REAL AND A REAL AND A DECIMAL AND A
		0.8-3.0m		
	-			A REPRESENTATION OF A REPORT OF A REPORT



7. Results of laboratory testing

Laboratory testing was used to classify materials and to corroborate the results of the SPT testing. The tests included Sieve Analysis, Atterberg Limits, Moisture Content, MDD and CBR.

A total of 4 undisturbed samples from the SPT borings were obtained for testing.

Soils were cohesive with low plasticity and moisture contents ranging from 13.4% to 19.7%. The materials exhibit low shrinkage. The CBR of the material was 81%.

The actual lab test results are presented in Appendices D to H.



Table 2: Laboratory test summary

Mpika

			Depth			Linear			Sie	ve analy	sis								Pro	ctor		CBR	
Lab #	ID #	Visual Description	Depui	USCS classification	Moisture Content (%)	Lilleal			% passin	g sieve s	ize (mm)			Ы	Shrinkage	Grading	Plasticity	Grading	MDD	ОМС		CDK	
			(m)			Shrinkage	0,075	0,425	2,0	5,0	28,0	50,0	63,0		Product	Co-efficient	Modulus	Modulus	(Kg/m³)	(%)	93%	95%	98%
3269	TP1	Moist reddish brown sandy clay (Residual)	0.8-3.0	CL															2041	15.3	88	81	-
3270	SPT1	Moist reddish brown soft sandy clay (Residual)	0-1.3	CL	19.7	9.29	76.3	92.6	97.8	99.6	100	100	100	20.6	860	7	1572	0.3					
3271	SPT2	Moist light reddish brown soft gravelly sandy clay (Residual)	3.4-5.0	CL	14.5	5.21	50.3	62.6	74.2	<mark>9</mark> 3	100	100	100	18.4	326	35	926	1.1					
3272	SPT3	Moist reddish brown yellowish soft gravelly sand-clay mixture (Residual)	1.0-3.1	SC	18.2	5.21	48.7	63.7	75.8	93.1	100	100	100	17.3	332	34	843	1.1					
3273	SPT4	Moist reddish brown yellowish firm gravelly clayey sand with fragments of sandstone and quartzitic stone (Residual)	1.4-3.7	SC	13.4	6.0	32.5	42.1	53.7	72.1	92.8	100	100	16.6	253	37	540	1.7					

CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays

SC Clayey sands, poorly graded sand-clay mixtures



8. Conclusions

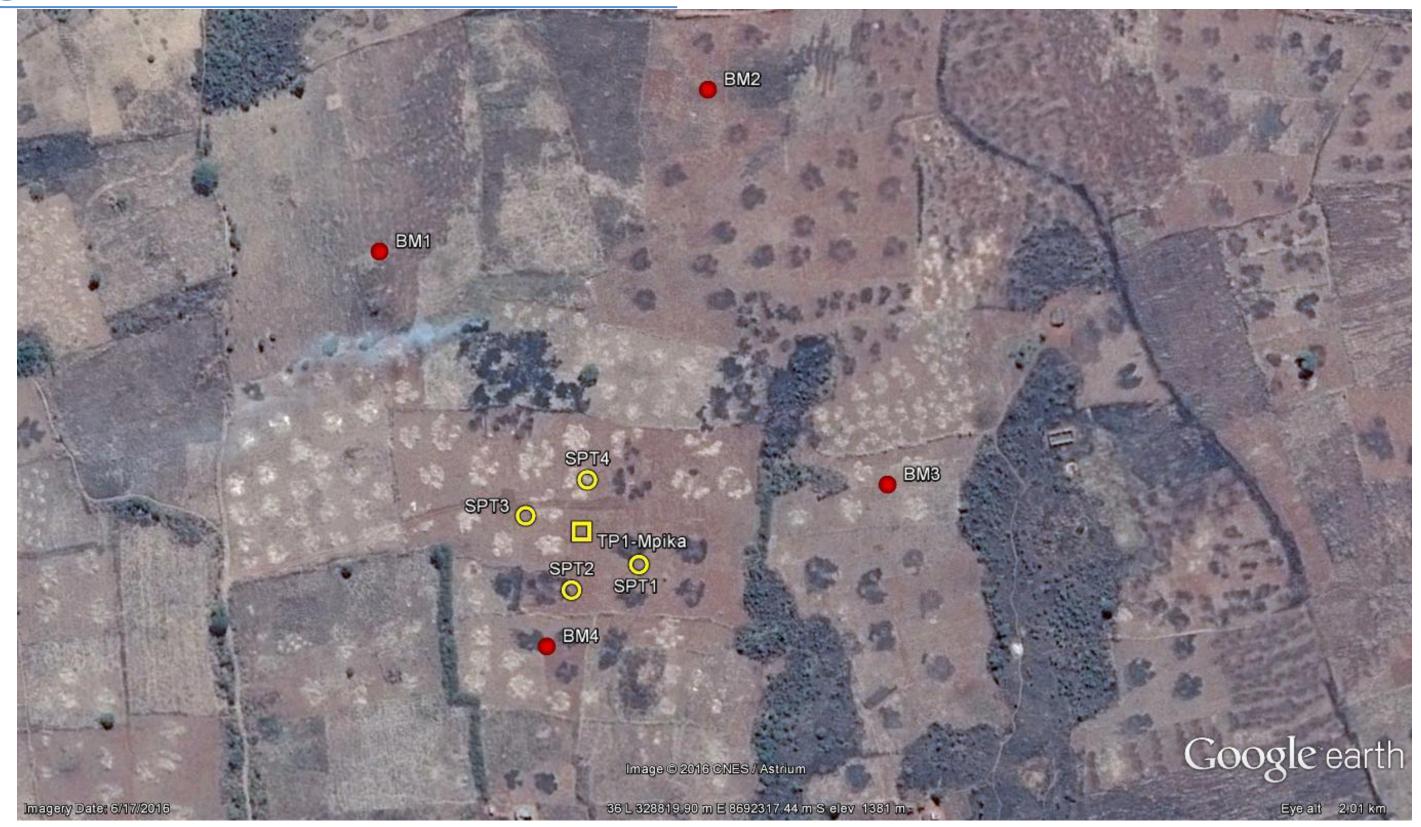
From the investigation carried out, the following conclusions can be drawn:

- An allowable bearing capacity of 100kPa would be the maximum recommended.
- The soil at this site is mostly moist reddish brown soft sandy clay in the upper layers and moist light reddish brown soft to firm gravelly sandy clay at depth with occurrence of sand-stone and quartz fragments in depth of 3.0-3.5m.
- SPT'N' Values reveal that soil stratum is soft to firm from ground level up to investigated depth.
- Groundwater was not encountered within the boreholes up to 5.0m depth during investigation.
- A minimum foundation depth of 2.0m is proposed.
- In-situ materials can be used as fill and as road pavement layers. Compacted to 95% MDD, a CBR of at least 80 is expected.
- All foundations for a single structure should be placed in the same strata and therefore should be at the same level.



Appendix A – Map





Final Geo-technical Report for UNDP, Medical Stores Limited's Regional Warehouse Hubs MPIKA



Appendix B – SPT test records



RECORD FO	K SUBSU	RFACE EX	PLORATION							RANKIN
YPE OF BO	RING:	SPT 1			DATE OF B	ORING:	13/09/20	16		Engineering Consultants
			eotechnica		BORING N	o: BH-1				RANKIN HOUSE, CHOZI ROAD, NORTHMEAD
ROJECT NA	ME:	-	or Medical							
			's Regiona	l Hubs						
		(Mpika)								P.O. BOX 50566, LUSAKA
OPERATOR'	S NAME:	СН								TEL/FAX +260 - 211 - 290085
OCATION:	328740	869228	1		Elevation:	1375m				
DES	SCRIPTION	1	PROFILE	DEPTH	BLOWS	SAMPLE	N	wc	Y	REMARKS
				m						
					3					
					3					
Moist red	dish brov	vn soft			3					
sandy cl	lay (Resi	dual)		1.0	6	+	6			
				1.0	6	↓ [▲]				1
					7					
					8					
				2.0	15	*	15			
					6					
Moistre	eddish br	own			6					
yellowis					4					
	clay mixt									
	esidual)			3.0	10	•	10			
	,				3					
					4					
					5					
				4.0	9 4	*	9			
Moist light	traddich	brown			5					
firm grav					9					
-	esidual)	y ciuy								
10	caraaan			5.0	14	¥	14			No Ground Water Level Found
				5.1	2	<u> </u>				
				5.2	5					
				5.3	2					
				5.4	3					
Moist light	t reddish	brown		5.5	7					
firm grav	ellysand	ly clay	DPSH	5.6	7					
	esidual)			5.7	9					
				5.8	8					
				5.9	11					
				6.0	12					
				6.1	19 RUUK SAMA			•	•	
			1		BULK SAMI			•	В	
SROUND LE	VEL		¥		DISTURBE	D SAMPLE		•	D	
VATER LEV	EL		<u> </u>		UNDISTUR	BED SAMP	LE		U	
.P.T			•		WATER SA	MPLE		•	W	
SKETCH MA	P OF BOR	ing hol	E							



			PLORATION	1						RANKIN
YPE OF BO	RING:	SPT 2			DATE OF B	ORING:	13/09/20	16		Engineering Consultants
			Geotechnica		BORING N	o: BH-2				RANKIN HOUSE, CHOZI ROAD, NORTHMEAD
ROJECT NA	ME:	-	for Medical I's Regiona)							P.O. BOX 50566, LUSAKA
OPERATOR'	S NAME:	СН								TEL/FAX +260 - 211 - 290085
OCATION:	328704	869229	2		Elevation:	1375m				
DES	SCRIPTION	ı	PROFILE	DEPTH	BLOWS	SAMPLE	N	wc	Y	REMARKS
					3					
					2					
					3					
				1.0	5	+	5			
sandy cl	lay (Resi	dual)			2					
					3					
					4					
							-			
				2.0	7	.	7			
					7					
					10					
	_									
	ECT NAME: UND Surve Limit (Mpi 28704 869) DESCRIPTION st reddish brown so andy clay (Residual) loist reddish brown llowish firm gravelly sand-clay mixture (Residual) st light reddish brow ft gravelly sandy clay (Residual) st light reddish brow ft gravelly sandy clay (Residual)			3.0	17	+	17			
(R	OF BORING: SPT IECT NAME: UNDI Surve Limit (Mpi RATOR'S NAME: CH ATION: 328704 8692 DESCRIPTION DESCRIPTION And Clay (Residual) And Clay (Residual) And Clay mixture (Residual) Residual) St light reddish brown (Residual) Sandy Clay (Residual) St light reddish brown (Residual) Sandy Clay (Residual) UND LEVEL UND LEVEL				3	<u> </u>				
					4					
					5					
Moist light	t reddish	brown		4.0	9	★	9			
					2					
					4					
	-				6					
				5.0	10	+	10			No Convertility and Found
				5.0 5.1	2	•	10			No Ground Water Level Found
				5.2	4					
				5.3	5					
				5.4	5					
-			DPSH	5.5	6					
			DPSH	5.6	7					
(R	esidual)			5.7	9					
	DIECT NAME: Surv IMPORTORY NAME: CH ATION: 328704 869 DESCRIPTION DIESCRIPTION Moist reddish brown so sandy clay (Residual Moist reddish brown ellowish firm gravell sand-clay mixture (Residual) ist light reddish brown oft gravelly sandy cla (Residual) DUND LEVEL TER LEVEL			5.8	9					
				5.9	10					
				6.0	11					
					BULK SAMI	PLE		•	В	
GROUND LE	VEL		¥		DISTURBE	D SAMPLE		•	D	
NATER LEV	EL		<u></u>		UNDISTUR	BED SAMP	LE		U	
S.P.T			_		WATER SA	MPLE		•	W	
KETCH MA	P OF BOR	ING HOL	E							
SKETCHIMA	POFBOR		E							



		RFACE E	XPLORATIO	DN							RANKIN
TYPE OF BO	KING:		SPT 3			DATE OF B		13/09/20	16		Engineering Consultants
				eotechnica or Medical		BORING N	o: BH-3				RANKIN HOUSE, CHOZI ROAD, NORTHMEAD
PROJECT NA	ME:			s Regiona							
			(Mpika)								P.O. BOX 50566, LUSAKA
OPERATOR'S	S NAME:		СН								TEL/FAX +260 - 211 - 290085
OCATION:	328709	86923	37			Elevation:	1374m				
										-	
	DESCRIP	TION		PROFILE	DEPTH	BLOWS	SAMPLE	N	wc	Y	REMARKS
					m						
						8					
Moist red	ldish bro	wn firm	n sandy			6 6					
(clay (Res	idual)				v					
					1.0	12	+	12			
						4					
						4					
						5					
Moist redd	ish brow	n yellov	wish soft		2.0	9	*	9			
	ly sand-c	-				3					
	(Resid	ual)				4					
						5					
					3.0	9	¥	9			
					5.0	1	_	9		_	
						3					
						3					
Moist ligh	nt reddisł	h brown	n soft to		4.0	6	•	6			
firm grave	lly sandy	clay (R	esidual)			3 5					
						7					
					5.0	12	•	12			No Ground Water Level Found
					5.1	1					
					5.2	2					
					5.3 5.4	4					
Moist ligh	nt reddish	h brown	n soft to		5.5	6				_	
firm grave				DPSH	5.6	5					
					5.7	6					
					5.8	7					
					5.9 6.0	8					
					0.0	BULK SAM	PLE	I	•	в	
GROUND LE	VEL					DISTURBE			•	D	
WATER LEVE				<u> </u>		UNDISTUR		LE		U	
				_		WATER SA				w	
S.P.T					1	Line of			-		



			PLORATION	1						RANKIN
YPE OF BO	RING:				DATE OF B	ORING:	14/09/20	16		Engineering Consultants
					BORING N	o: BH-4				RANKIN HOUSE, CHOZI ROAD, NORTHMEAD
ROJECT NA	ME:	Limited	's Regiona							P.O. BOX 50566, LUSAKA
OPERATOR'S	S NAME:									TEL/FAX +260 - 211 - 290085
OCATION:	328746	869233	2		Elevation:	1375m				
DES	SCRIPTION	I	PROFILE	DEPTH	BLOWS	SAMPLE	N	wc	Y	REMARKS
					2					
					1					
					2					
		-								
Sont Sandy	ciay (Re	sidual)		1.0	3	+	3			
					4					
					5					
					6					
Moist re	ddish br	own		2.0	11	*	11			
yellowisł	h firm gra	avelly			16 21					
clayey	sand wi	th			10					
fragments	s of sand	stone			10					
	UNDP-Geoted Survey for Mer Limited's Regination ATOR'S NAME: CH TION: 328746 8692332 DESCRIPTION PRO st reddish brown very sandy clay (Residual) PRO oist reddish brown lowish firm gravelly clayey sand with greents of sandstone nd quartzitic stone (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO st light reddish brown ng ravelly sandy clay (Residual) PRO St light reddish brown ng ravelly sandy clay (Residual) PRO St light reddish brown ng ravelly sandy clay (Residual) PRO St light reddish brown ng ravelly sandy clay (Residual) PRO JND LEVEL A		3.0	31	+	31				
(Re	OF BORING: SPT 4 UNDP-Geote Survey for M Limited's Rei (Mpika) RATOR'S NAME: CH ATION: 328746 8692332 DESCRIPTION PR ist reddish brown very t sandy clay (Residual) PR Adiost reddish brown ellowish firm gravelly clayey sand with gments of sandstone and quartzitic stone (Residual) PR ist light reddish brown m gravelly sandy clay (Residual) Image: Calence Calenc		5.0	2	<u> </u>	- 21				
	lowish firm gravelly clayey sand with ments of sandstone nd quartzitic stone				3					
					3					
					-					
				4.0	6	+	6			
Moist light	t reddish	brown			4	<u> </u>				
firm grave	ellysand	ly clay			7					
(Re	esidual)				8					
				5.0	15	•	15			No Ground Water Level Found
				5.1	1					
				5.2	3					
				5.3	4					
Moist light	t reddish	brown		5.4	4					
-			DPSH	5.5	6					
_				5.6	6					
				5.7 5.8	7					
				5.8	8					
				6.0	9					
				0.0	BULK SAM		•	•	в	
	VEL				DISTURBEI				D	
			¥		UNDISTUR		16	•	U	
S.P.T	EL		*		WATER SA		LC	•	w	
			_ _		WATER 3A	WIFLE		•	vv	

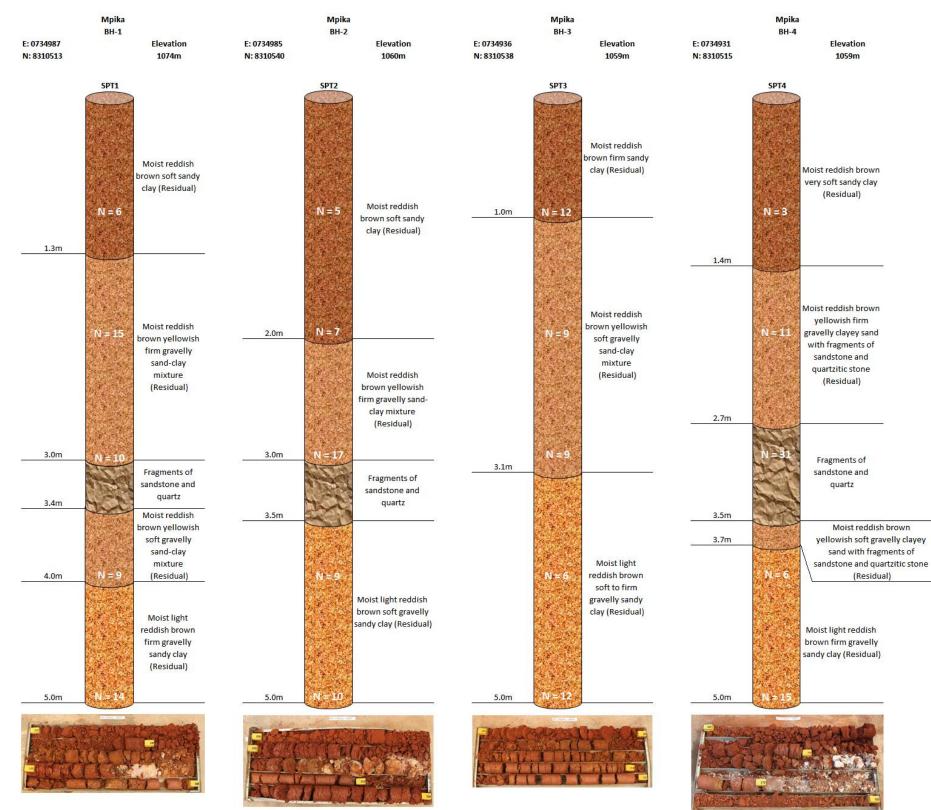


Appendix C – SPT and Test Pits Logging

C-1



Figure 2: SPT Logging

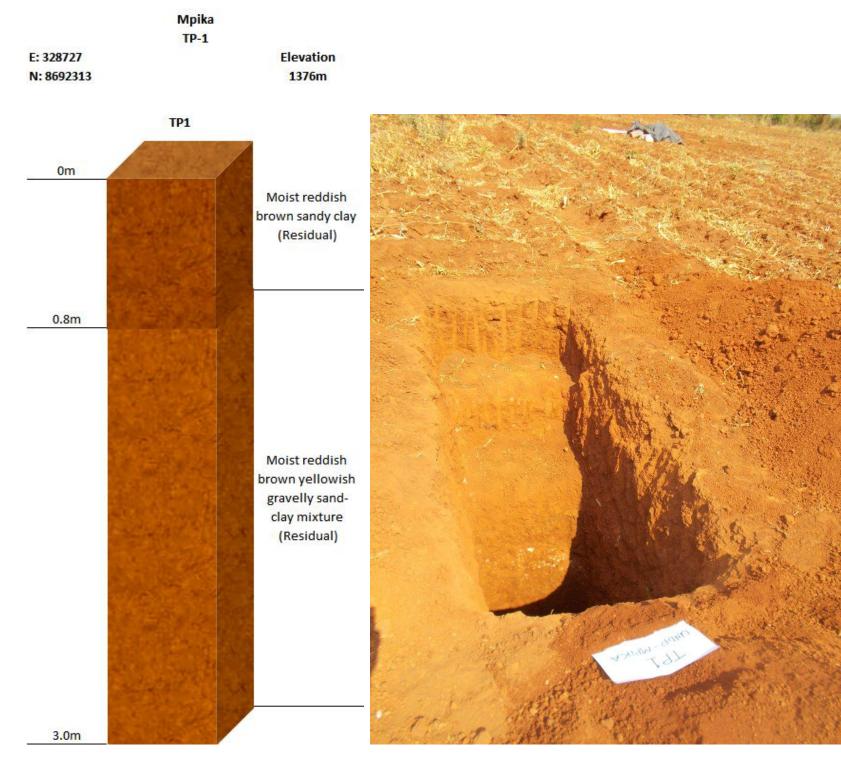


Final Geo-technical Report for UNDP, Medical Stores Limited's Regional Warehouse Hubs MPIKA





Figure 3: Test Pits Logging



Final Geo-technical Report for UNDP, Medical Stores Limited's Regional Warehouse Hubs MPIKA

C-3



Appendix D - Sieve Analysis Results



CLIENT: Ur	NALYSIS nited Nations De	velopment Programme (L	FORM: SANS 3001-GR	1: 2013		TT-	Ranki Engineering Consu	
							Rankin House	
ROJECT: M	edical Store Lin	ited's Regional Hubs-Mpi	ka			4 4	Chozi Road	
	DI		DATE	40/00/0040		ch ch	Lusaka, Zambia	
UPERVISOR:	DL		DATE:	19/09/2016			Tel/Fax: 260-1-291	195
OPERATOR		BZ		SAMPLE SOURCE:		SPT 1 (0 -	1.30m)	
DATE OF SOA	KING:	19/09/2016			Moist re	ddish brown soft	sandy clay (Residu	al)
DATE OF TEST	TING:	19/09/2016		Soil Description	Lab No. 3270			
nitial Dry Mass	s (m ₁) 2413.4	g						
Sieve Op	pening (mm)		tained (g)	% Retained (<u>m)*100</u> (m ₁)	% Passing (p)	Cumulative % passing		
		Actual	Corrected		100.0	100		
	75.0	0						
1	63.0	0	0	0.0	100.0	100		
	50.0	0	0	0.0	100.0	100		
	37.5	0	0	0.0	100.0	100		
	28.0	0	0	0.0	100.0	100		
	20.0	0	0	0.0	100.0	100		
Passing 20 mm		2413.4	2413.4					
otal (checked)	with m ₁)	2413.4		-				
iffled (m₃)		631.7						
iffled and wash	ned (m ₄)	156.2						
Correction facto	me	130.2						
somection facto	m ₃		3.82				-	
	14.0	0	0	0.0	100.0	100		
	5.0	2.7	10	0.4	99.6	100		
	2.0	11.5	44	1.8	97.8	98		
	0.425	32.7	125	5.2	92.6	93		
				3.6	89.0	89		
C	0.250	22.8	87					
C	0.150	35	134	5.5	83.4	83		
C	0.075	44.8	171	7.1	76.3	76		
<0.0)75 (+ 475.5	482.2	1842	76.3				
	OTAL		2413.4					
т			2413.4					
т	0.7.2		(C)/400			0.3		
		<2mm-%<0.425mm-%<0.07	'5mm)/100			0.5		
Grading Modulu	us: GM = (300 -%							
Grading Modulu Grading Coeffic	us: GM = (300 -% 	<2mm-%<0.425mm-%<0.07				7.4		
Grading Modulu	us: GM = (300 -% 							
Grading Modulu Grading Coeffic	us: GM = (300 -% 					7.4		
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% 					7.4		
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,					7.4		
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,					7.4		
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,					7.4	110.00	
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,					7.4	100.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,					7.4		
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00	
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,					7.4	90.00 80.00	
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	90.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	90.00 80.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	90.00 80.00 70.00 60.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	90.00 80.00 70.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	90.00 80.00 70.00 60.00	
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00 90.00 80.00 70.00 60.00 50.00 40.00	
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00 90.00 80.00 70.00 60.00 50.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00 90.00 80.00 70.00 60.00 90.00 90.00 90.00 90.00 90.00 90.00	
Grading Modulu Grading Coeffic JSCS classific:	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00 90.00 80.00 70.00 60.00 90.00 90.00 90.00 90.00 90.00 90.00	
Grading Modulu Grading Coeffic	us: GM = (300 -% tient: GC= (%<28,	0-%<0.425) x (%<5.0mm)/1				7.4	100.00 90.00 20.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00	
Srading Modulu Srading Coeffic JSCS classific SIEVE SIZE BY	us: GM = (300 -% tient: GC= (%<28 ation Y LOG SCALE	0-%<0.425) x (%<5.0mm)/1		2	6 ^{10.00}	7.4	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00	
Grading Modulu Grading Coeffic USCS classific SIEVE SIZE BY	us: GM = (300 -% ient: GC= (%<28. ation Y LOG SCALE	0-%<0.425) × (%<5.0mm)/1		2 Fine	6 10.00	7.4 CL	100.00 90.00 20.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00	



				FORM: SANS 3001-GR1	1: 2013		TI	Rankin
LIENT: Un	nited Nat	ions Deve	elopment Programme (UNDP)				Engineering Consultants Rankin House
ROJECT: Me	edical St	tore Limit	ted's Regional Hubs-Mp	ika				Chozi Road
	_						I I	Lusaka, Zambia
UPERVISOR:		DL		DATE:	19/09/2016			Tel/Fax: 260-1-291195
or Entricont.								1001 04. 200 1 201100
PERATOR			BZ		SAMPLE SOURCE:		SPT 2 (3.4	- 5.0m)
			40/00/0046					
ATE OF SOAF	KING:		19/09/2016		Soil Description	Moist light redd	ish brown soft g	ravelly sandy clay (Resid
ATE OF TEST			19/09/2016		Son Description	Lab Na 2274		
ATE OF TEST	ING:					Lab No. 3271		
tial Dry Mass	(m1)	1539.4	g					
	1.11			etained (g)	% Retained (m)*100	% Passing (p)	Cumulative %	
Sieve Op	pening (m	ım)			(m1)		passing	
			Actual	Corrected		100.0	100	
7	75.0		0			100.0	100	
6	63.0		0	0	0.0	100.0	100	
E	50.0		0	0	0.0	100.0	100	
	37.5		0	0	0.0	100.0	100	
	28.0		0	0	0.0	100.0	100	
					0.0	100.0	100	
2	20.0		0	0	0.0	100.0	100	
ssing 20 mm	n (m ₂)		1539.4	1539.4				
al (checked w	with m ₁)		1539.4					
ed (m ₃)			431.6					
ed and washe		ma	217.1					
rrection facto	or -	m ₂ m ₃	1	3.57				
	14.0		0	0	0.0	100.0	100	
					7.0	93.0	93	
	5.0		30.1	107	18.9	74.2	74	
	2.0		81.4	290				
0	.425		49.8	178	11.5	62.6	63	
0	.250		16.1	57	3.7	58.9	59	
					4.2	54.7	55	
0	150		10.0	65	4.2			
).150		18.2	65			-	
).150).075		18.2 19	65 68	4.4	50.3	50	
0		214.5					-	
0. <0.07).075	214.5	19	68	4.4		-	
0 <0.07 TC	0.075 75 (+ : OTAL		19 217	68 774 1539.4	4.4		-	
0 <0.07 TC	0.075 75 (+ : OTAL		19	68 774 1539.4	4.4		50	
0 <0.07 TC ading Modulu:	0.075 75 (+ : OTAL IS: GM =	(300 -%<	19 217	68 774 1539.4 75mm)/100	4.4		50	
0 <0.07 TC ading Modulu: ading Coeffici	0.075 75 (+ : 0TAL IS: GM = ient: GC=	(300 -%<	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulu:	0.075 75 (+ : 0TAL IS: GM = ient: GC=	(300 -%<	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50	
0 <0.07 TC ading Modulu: ading Coeffici SCS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulu: ading Coeffici	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulu: ading Coeffici GCS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	90.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	90.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	90.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	90.00 90.00 80.00 70.00 60.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	90.00 90.00 70.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	90.00 90.00 80.00 70.00 60.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00
0 <0.07 TC ading Modulur ading Coeffici CS classifica	0.075 75 (+ OTAL Is: GM = ient: GC= ation	(300 -%<ź	19 217 2mm-%<0.425mm-%<0.0	68 774 1539.4 75mm)/100	4.4		50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00
0 <0.07 ading Modulu ading Coefficiency CS classification EVE SIZE BY	0.075 75 (+ 0TAL is: GM = ient: GC= ation // LOG SC	(300 -%< = (%<28.0- CALE	19 217 2mm-%<0.425mm-%<0.0 -%<0.425) x (%<5.0mm)/	68 774 1539.4 75mm)/100 100			50 1.1 34.8 CL	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00
0 <0.07 ading Modulu ading Coefficiency SIZE BY Use SIZE BY	0.075 75 (+) 0TAL is: GM = ient: GC= ation // LOG SC // LOG	(300 -%< = (%<28.0- CALE	19 217 2mm-%<0.425mm-%<0.0 %<0.425) x (%<5.0mm)/	68 774 1539.4 75mm)/100	4.4	50.3	50 1.1 34.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00



	IS		FORM: SANS 3001-GR1	: 2013		TT -	Ranki	
LIENT: United I	lations Dev	elopment Programme (UI	NDP)			11-	Engineering Consu Rankin House	ultants
ROJECT: Medical	Store Limit	ted's Regional Hubs-Mpik	a			7	Chozi Road	
						I. 7	Lusaka, Zambia	
JPERVISOR:	DL		DATE:	19/09/2016	1.1-1	1	Tel/Fax: 260-1-291	195
PERATOR		BZ		SAMPLE SOURCE:		SPT 3 (1.0	- 3.1m)	
		19/09/2016			Moist reddish	brown vellowis	sh soft gravelly san	d clav
ATE OF SOAKING:		13/03/2010		Soil Description	Moist reduisit	mixture (Re		u-ciay
ATE OF TESTING:		19/09/2016			Lab No. 3272			
tial Dry Mass (m ₁)	1288.4	g						
Sieve Opening	(mm)	Mass Ret	ained (g)	% Retained (m)*100	% Passing (p)	Cumulative % passing		
Sieve Opening	(((((((((((((((((((((((((((((((((((((((Actual	Corrected	(m ₁)		pacong		
75.0		0			100.0	100		
63.0		0	0	0.0	100.0	100		
				0.0	100.0	100		
50.0		0	0	0.0	100.0	100		
37.5		0	0					
28.0		0	0	0.0	100.0	100		
20.0		0	0	0.0	100.0	100		
assing 20 mm (m ₂)		1288.4	1288.4					
	\ \		.200.4					
tal (checked with m	1)	1288.4						
fled (m3)		316						
fled and washed (ma)	164.2						
orrection factor	m ₂ m ₃		4.08					
	1113			0.0	100.0	100		
14.0		0	0					
5.0		21.8	89	6.9	93.1	93		
2.0		54.6	223	17.3	75.8	76		
0.425		38.3	156	12.1	63.7	64		
0.250		12	49	3.8	59.9	60		
				4.9	55.0	55		
0.150		15.6	64					
0.075		19.7	80	6.2	48.7	49		
	+ 151.8	154	628	48.7				
<0.075 (101.0							
	131.0		1288 /					
<0.075 (TOTAL	. 131.0		1288.4					
TOTAL								
TOTAL		2mm-%<0.425mm-%<0.07				1.1		
TOTAL		2mm-%<0.425mm-%<0.07						
TOTAL rading Modulus: GN	= (300 -%<	2mm-%<0.425mm-%<0.07 %<0.425) x (%<5.0mm)/10	5mm)/100			1.1 33.8		
TOTAL rading Modulus: GN	= (300 -%<		5mm)/100					
TOTAL rading Modulus: GM rading Coefficient: G	= (300 -%<		5mm)/100			33.8		
TOTAL rading Modulus: GN	= (300 -%<		5mm)/100					
TOTAL rading Modulus: GM rading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8		
TOTAL rading Modulus: GM	= (300 -%< C= (%<28.0		5mm)/100			33.8		
TOTAL rading Modulus: GM rading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8	110.00	
TOTAL rading Modulus: GM rading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8		
TOTAL rading Modulus: GM rading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8	110.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8		
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	90.00 80.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	90.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	90.00 80.00	
TOTAL ading Modulus: GM ading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00	
TOTAL ading Modulus: GM ading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8	90.00 80.00 70.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	90.00 90.00 80.00 70.00 60.00 50.00	
TOTAL ading Modulus: GM ading Coefficient: G	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00	
TOTAL ading Modulus: GM ading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00	
TOTAL ading Modulus: GM ading Coefficient: G SCS classification	= (300 -%< C= (%<28.0		5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00 90.00 90.00 90.00 90.00 90.00 90.00	
TOTAL ading Modulus: GM ading Coefficient: G CCS classification EVE SIZE BY LOG	= (300 -%< C= (%<28.0	%<0.425) x (%<5.0mm)/1(5mm)/100			33.8	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00	
TOTAL ading Modulus: GM ading Coefficient: G SCS classification EVE SIZE BY LOG	C= (%<28.0	%<0.425) x (%<5.0mm)/10	5mm)/100	2		33.8 SC	100.00 90.00 80.00 70.00 60.00 50.00 40.00 20.00 20.00 10.00	
TOTAL ading Modulus: GM ading Coefficient: G SCS classification EVE SIZE BY LOG	C= (%<28.0	-%<0.425) x (%<5.0mm)/1(5mm)/100	2 Fine	6 10.00 Gravel	33.8 SC	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00	

D-4



	d Nations Deve	elopment Programme (I	FORM: SANS 3001-GR	1: 2013			Rankin Engineering Consultants
ROJECT: Medic	al Store Limit	ed's Regional Hubs-Mpi	ika				Rankin House Chozi Road
					L	I I	Lusaka, Zambia
JPERVISOR:	DL		DATE:	19/09/2016	L. F		Tel/Fax: 260-1-291195
PERATOR		BZ		SAMPLE SOURCE:		SPT 4 (1.4	- 3.7m)
ATE OF SOAKING	G:	19/09/2016					n firm gravelly clayey sar Id quartzitic stone (Resid
ATE OF TESTING):	19/09/2016		Soil Description	Lab No. 3273		
tial Dry Mass (m ₁			etained (g)	% Retained (m)*100	% Passing (p)	Cumulative %	
Sieve Openir	ng (mm)		Corrected	(m ₁)		passing	
75.0	1	Actual 0	Conected		100.0	100	
63.0		0	0	0.0	100.0	100	
50.0		0	0	0.0	100.0	100	
				0.0	100.0	100	
37.5		0	0	7.2	92.8	93	
28.0		229.4 155.7	229 156	4.9	87.9	88	
ssing 20 mm (m ₂		2785.1	2785.1				
al (checked with		3170.2					
ed (m3)		716.5					
ed and washed (r	m.)	454.1					
ed and washed (r rection factor	<u>m</u> 2	404.1					
	m ₃		3.89	2.9	85.0	85	
14.0		23.4	91	12.9			
5.0		105.2	409		72.1	72	
2.0		150.1	583	18.4	53.7	54	
0.425	5	94.8	368	11.6	42.1	42	
0.250)	25	97	3.1	39.0	39	
0.150)	23.2	90	2.8	36.1	36	
	5	29.4	114	3.6	32.5	33	
0.075							
		265.4	1032	32.5			
	(+ 262.4	265.4	1032 3170.2	32.5			
<0.075 TOTA	(+ 262.4 L	265.4 ?mm-%<0.425mm-%<0.0	3170.2	32.5		1.7	
<0.075 TOTA ading Modulus: G	(+ 262.4 L GM = (300 -%<2	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5			
<0.075 TOTA ading Modulus: G ading Coefficient:	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-		3170.2 75mm)/100	32.5		1.7	
<0.075 TOTA ading Modulus: G	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5			
<0.075 TOTA ading Modulus: G ading Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	
<0.075 TOTA ading Modulus: G ading Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	
<0.075 TOTAI ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00
<0.075 TOTAI ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	90.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	90.00 80.00 70.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00 70.00 60.00 50.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00 70.00 60.00
<0.075 TOTA ading Modulus: G ading Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00 70.00 60.00 50.00
<0.075 TOTA ading Modulus: G ading Coefficient:	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00 70.00 60.00 50.00 30.00
<0.075 TOTA ading Modulus: G ading Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00 70.00 60.00 50.00 40.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100			36.6	100.00 90.00 80.00 70.00 60.00 50.00 30.00
<0.075 TOTA ding Modulus: G ding Coefficient: CS classification VE SIZE BY LO	(+ 262.4 L GM = (300 -%<2 GC= (%<28.0-	2mm-%<0.425mm-%<0.0 %<0.425) x (%<5.0mm)/	3170.2 75mm)/100			36.6	100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00
<0.075 TOTA ading Modulus: G ading Coefficient: CS classification	(+ 262.4 L SM = (300 -%<2 GC= (%<28.0-) OG SCALE	?mm-%<0.425mm-%<0.0	3170.2 75mm)/100	32.5		36.6	100.00 90.00 80.00 70.00 50.00 40.00 30.00 20.00 10.00



Appendix E - Atterberg Limit Results



	Rankin														
	Engineering Cons	ultant	s						CC	DNE	E P	ENE	TROM	IETER	
THD	Rankin House														
and the second second	Chozi Road												astic Lin		
	Lusaka, Zambia Tel/Fax: 260-1-29	1195							Line	ar Shi	inkage	e and Si	nrinkage Pro	oduct	
	Medical Store Lim			al Hubs-M	lpika					DESC	RPTN	I: SPT	l (0 - 1.30m) Mo	bist reddish brow	n soft sandy clay (R
ENT :	United Nations De	evelop	ment Pro	ogramme	(UND	P)			-	LAB	lo:		3270	DATE :	19/09/201
	FECHNICIAN :	тк				,					KED :		DL	APPROVE	D: SR
ST METHOD				тс	STS	4	0 1 2 /	and 1	1 -	A DC	1277	· Dort (D ← 1000		
					513	1.	2, 1.3 i	anu i.4	+, 1	ы. DS	13/1	. Part 2	2: 1990		
			LIQUID	LIMIT									PLASTIC L	іміт	
TEST	T NO.			1		2			3			4	1	2	Average
al gauge readi	-	mm	0.0	0.0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 0.0	-		
al gauge readir		mm	15.0		18.3		18.0	21.0		21.0	24.2	24.2			
rage penetrati		mm		5.0 K37		18. RNK			21.0 RNK4			4.2 NK2	IV	J14	
tainer Numbe		g		5.5		27.			29.5			1.1	12.8	12.8	
s of dry soil &		g		2.3		27.			24.7			5.6	11.7	11.8	
ss of container		g	1.	4.3		14.	1		14.1		1	4.3	7.2	7.5	
ss of dry soil		g	8	.0		9.4	1		10.6		1	1.3	4.5	4.3	
ss of moisture		g	3	.2		4.()		4.8		ļ	5.5	1.1	1.0	
isture content		%	4	0.0		42.	6		45.3			8.7	24.4	23.3	23.9
C 30	1								y:	= 1.0	601	(- 27.2	203		
0														Sample pre	paration :
N E ²⁵														a) As recei	
											_			b) Airdried	
P														c)Washed	
E ²⁰						-	+-	-						d) Oven dri	
N					_									e) Not knov	vn
E 15														Dreparties	and ing on 425
Τ '														µm sieve :	bassing on 425
R														93	
A 10															UT
T					<u> </u>		<u> </u>								
I										+					
0 5						+								PLASTIC L	
N															<mark>23.9</mark> %
														PLASTICIT	
0 Li 38.0	40.0		42.0		· · ·	44.0		46	0		48	0	50.0		20.6
00.0	10.0			моізті			TENT		.0		10	.0	00.0	PI =	20.0 %
								,							
r			D C · · · = ·			<u></u>									
	L Specimen referer		K SHRI	NKAGE	and	SHR	INKAG	E PRO	JUCI	г 1		2	3	4	5
-	Initial Length			L ₀				mr	n	14		-		- T	2
				LD				mr		12					
	Oven dried length									1 14					
	Oven dried length Linear Shrin		LS = 10		/L ₀))			%		9.2	29				

E-2



Ranki Engineering C		5		CO	NE PI	ENE	TROM	IETER	
Rankin House Chozi Road Lusaka, Zambi Tel/Fax: 260-1	a				Liquid a	nd Pl	astic Lin nrinkage Pro	nits	
ROJECT : Medical Store	_imited's	Regional Hubs-N	Ipika	I	DESCRPTN		(3.4 - 5.0m) Mo Residual)	bist light reddish brow	n soft gravelly sa
LIENT : United Nations	Developi	ment Programme	(UNDP)	l	LAB No :		3271	DATE :	20/09/2016
ESPONSIBLE TECHNICIAN :	тк			(CHECKED :		DL	APPROVED :	SR
ST METHOD		TE	STS 1.2, 1.3	and 1.4, ref	f. BS 1377	: Part 2	2: 1990		
		LIQUID LIMIT					PLASTIC L	іміт	
TEST NO.		1	2	3		4	1	2	Average
ial gauge reading	mm	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0	0.0 0.0 0	0.0 0.0			
al gauge reading	mm	15.0 15.0) 18.3 18.2	21.0	21.0 24.2	24.3			
erage penetration	mm	15.0	18.3	21.0	24	4.3			
ntainer Number		x	DOC9	127	A	B6	DX	2B1	
ss of wet soil & container	g	26.3	28.5	30.7	3:	3.3	13.3	13.8	
ss of dry soil & container	g	22.8	24.3	25.7	2	7.2	12.1	12.5	
ss of container	g	14.0	14.3	14.4	14	4.1	7.4	7.2	
ss of dry soil	g	8.8	10.0	11.3	1:	3.1	4.7	5.3	
ss of moisture	g	3.5	4.2	5.0	e	.1	1.2	1.3	
isture content	%	39.8	42.0	44.2	40	5.6	25.5	24.5	25.0
C 30 N 25 P 20 N E 25 N E 15 R A 10 I O 5 0 39.0 40.0	41.0	42.0 MOIST	43.0 JRE CONTENT		45.0	46.0	47.0	Sample prepara a) As received b) Airdried : c) Washed on 4 d) Oven dried : e) Not known Proportion pass µm sieve : 63 LIQUID LIMIT LL = 43.4 PLASTIC LIMIT PL 25.0 PLASTICITY IN PI = 18.4	° C 425 µm ° C ing on 425
Specimen refe Initial Length Oven dried len Linear S	rence gth	R SHRINKAGE L ₀ L _D LS = 100* (1-(L _t	and SHRINKAG	E PRODUCT mm mm %	1 140 132.7 5.21	2	3	4	5
Shrinkage Pro	luct, SP =	= LS* % <425um			326.41				

E-3



Rankin	1							
Engineering Co Rankin House	onsultant	S			IE PENE			
Chozi Road Lusaka, Zambia Tel/Fax: 260-1-					quid and Pl hrinkage and S			
ROJECT : Medical Store I	imited's.	Regional Hubs-M	/lpika	DES		3 (1.0 - 3.1m) Me -clay mixture (Re	oist reddish brown yello esidual)	wish soft gravel
LIENT : United Nations	Develop	oment Programme	e (UNDP)	LAB	3 No :	3272	DATE :	20/09/2016
ESPONSIBLE TECHNICIAN :	тк			СНЕ	ECKED :	DL	APPROVED :	SR
ST METHOD		TE	STS 1.2, 1.3	and 1.4, ref. B	S 1377 : Part 2	2: 1990		
						PLASTIC L	іміт	
TEST NO.		1	2	3	4	1	2	Average
tial gauge reading	mm	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	_		
al gauge reading	mm	15.6 15.2	2 18.1 18.2	21.0 21.1	1 24.0 24.0			
erage penetration	mm	15.4	18.2	21.1	24.0			
ntainer Number		JK1	RNK4	SN2	RNK2	J14	IV	
ss of wet soil & container	g	26.2	28.7	30.4	32.1	12.3	12.5	
ss of dry soil & container	g	23.0	24.7	25.6	26.7	11.43	11.5	
iss of container	g	14.3	14.1	13.9	14.3	7.5	7.2	
iss of dry soil	g	8.7	10.6	11.7	12.4	3.9	4.3	
ass of moisture	g	3.2	4.0	4.8	5.4	0.9	1.0	
visture content	%	36.8	37.7	41.0	43.5	22.1	23.3	22.7
O N E 25 P E 20 N E 15 R A 10							Sample preparat a) As received b) Airdried : c) Washed on 4: d) Oven dried : e) Not known Proportion passii µm sieve : 64 LIQUID LIMIT LL = 40.0 PLASTIC LIMIT DI = 22.7	° C 25 µm ° C ng on 425 %
I 5 N 5 0 36.0 37.0	38.0	39.0 MOIST	40.0 JRE CONTENT	41.0 42.0 (%)) 43.0	44.0	PL = 22.7 PLASTICITY IN PI = 17.3	Mex %
N 0 36.0 37.0	LINEA	MOIST		(%)			PLASTICITY INI PI = 17.3	%
N 0	LINEA	MOISTU R SHRINKAGE	JRE CONTENT	(%) E PRODUCT	1 2 140	44.0		
N 0 36.0 37.0 Specimen refe Initial Length Oven dried leng	LINEA rence	MOIST	JRE CONTENT	(%) E PRODUCT mm 7 mm 1	1 2 140 32.7		PLASTICITY INI PI = 17.3	%
N 0 36.0 37.0 Specimen refe Initial Length Oven dried length Linear St	LINEA rence yth rinkage,	MOIST(R SHRINKAGE	and SHRINKAG	(%) E PRODUCT mm 1: % E	1 2 140		PLASTICITY INI PI = 17.3	%



	Rankin Engineering Cons Rankin House	ultant	s						cc	DNI	ΕP	ΈN	E.	TRON	IETER	R		_
	Chozi Road Lusaka, Zambia Tel/Fax: 260-1-29	01195							Line					astic Lin rinkage Pro				
ROJECT :	Medical Store Lim	nited's	Region	al Hub	s-Mpika		-			DES	CRPTI	N : C		sand with frag	pist reddish bro ments of sands			
IENT :	United Nations De	evelop	oment Pr	ogram	me (UNI	DP)				LAB	No :			3273	DATE :	:	20/09/201	16
SPONSIBLE	TECHNICIAN :	тк								СНЕ	CKED	:		DL	APPROVE	ED :	SR	
	2			1	TESTS	1.	2, 1.3 a	and 1.4	1, re	ef. BS	5 1377	′:Pa	rt 2	: 1990				
																		-
			LIQUID	LIМІТ	г									PLASTIC L	іміт			
TE	ST NO.			1		2	-		3			4		1	2		Average	,
tial gauge rea	ding	mm	0.0	0.0	0.0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
nal gauge read	ling	mm	15.0		15.2 18.3		18.1	21.6		21.5	24.3	2	4.3					
erage penetra	ation	mm	1	5.1		18.	2		21.6			24.3						
ontainer Numb	er		R	K4		RNK	(12		MG1		R	NK37		TAO	LB			
ass of wet soil	& container	g	2	8.3		30.	.1		32.4		:	34.1		13	12.7	,		
ass of dry soil	& container	g	2	4.9		26	0	:	27.6		:	28.6		12.1	11.8	}		
ass of contain	er	g	1	4.3		14	.1		14.3			14.3		7.2	7.1			
ass of dry soil		g	1	0.6		11.	.9		13.3			14.3		4.9	4.7			
iss of moistur	e	g	3	3.4		4.	1		4.8			5.5		0.9	0.9			
oisture conten	t	%	3	2.1		34.	.5		36.1		:	38.5		18.4	19.1		18.8	
C 30 O N E 25 P 20 N E 15 T R A 10 T I O 5 N 0 31.0	32.0	33.0		34.0 MOIS		35.0 CON	ITENT	* 36.0 (%)		37.0		38.0		• • 39.0	Sample pr a) As rece b) Airdriec c) Washe e) Not kno Proportion µm sieve : 42 LIQUID LI LL = PLASTIC PL = PLASTIC PI =	passir MIT 35.4 1: 2: 2: 2: 2: 2: 2: 2: 2: 2: 2: 2: 2: 2:	° C 25 µm ° C ng on 425 %	, , , ,
			R SHR	NKAC	GE and	SHR	INKAG	E PROI	DUCI									
	Specimen referen Initial Length	ice		L ₀				mr	n		1 40	2	-	3	4		5	+
	Oven dried length			LD				mr			1.6							1
	Linear Shrin	kage,	LS = 10	0* (1-((L _D /L _O))			%		6.	00							
	Shrinkage Produc										2.60	_	_					-

Final Geo-technical Report for UNDP, Medical Stores Limited's Regional Warehouse Hubs MPIKA



Appendix F – Moisture Content Results

F-1



MOISTURE CONTENT			FORM M1						
						- 1			
CLIENT: United Nation	ons Development Pr	ogramme (l	UNDP)			43	RANKIN Ho		TANTS
PROJECT: Medical Sto	ore Limited's Region	al Hubs-Moi	ika			7—	CHOZI ROAL		
	ine Elimited & Region	ar nabo-mp					LUSAKA, ZA	MBIA	
TECHNICIAN:	тк		DATE 16/09/	2016			Tel/Fax: 260-	1-291195	
SAMPLE SOURCE:	SPT1 (0 - 1.3m) I	Moist reddis	sh brown soft	sandy clay (R	esidual)				
	Lab # 3270								
TEST ref: BS 1377: Part 2	: 1990								
Container Number		K9	AB6	Н					
Mass of wet soil & conta	iner (g) (m ₂)	42.1	49.0	50.3					
Mass of dry soil & conta	iner <mark>(g)</mark> (m₃)	37.5	43.3	44.4					
Mass of container (g) (m	1)	14.0	14.1	14.1					
Mass of dry soil (g) (m ₃ ·	- m ₁)	23.4	29.2	30.4					
Mass of moisture (g) (m ₂	2 - m3)	4.6	5.8	5.9					
Moisture content (%)		19.8%	19.8%	19.5%					
AVERAGE			19.7%						
CHECKED BY:	DL								
DATE:	DATE 16/09/2016								



MOISTURE	CONTENT			FORM M1				DЛ	ΝК	IN
CLIENT:	United Nation	s Development Pro	ogramme (l	INDP)			-			
JEILITT.		o bororopinoner n	granno (,				RANKIN HO	USE	
PROJECT:	Medical Store	Limited's Regiona	al Hubs-Mpi	ika				CHOZI ROA	D	
								LUSAKA, ZA		
TECHNICIAN	N:	ТК		DATE 17/09/	2016			Tel/Fax: 260-	1-291195	
SAMPLE SC	OURCE:	SPT2 (3.4 - 5.0m)) Moist light	t reddish brov	wn soft gravel	ly sandy clay	(Residual)			
		Lab # 3271								
TEST ref: BS 1	1377: Part 2 : 1	990								
Container Nu	umber		RK15	K13	BBB					
Mass of wet	soil & containe	er (g) (m ₂)	61.8	48.6	52.9					
Mass of dry	soil & containe	er (g) (m₃)	55.5	44.1	48.4					
Mass of con	tainer <mark>(</mark> g) (m ₁)		14.2	13.9	14.0					
Mass of dry	soil (g) (m ₃ - m	11)	41.2	30.2	34.4					
Mass of moi	isture (g) (m ₂ -	m3)	6.4	4.5	4.5					
Moisture cor	ntent (%)		15.4%	14.8%	13.2%					
AVERAGE				14.5%						
										1
CHECKED E	BY:	DL								
DATE:		DATE 17/09/2016								



MOISTUR	E CONTENT			FORM M1				-		
0. JENT										
CLIENT:	United Nation	ns Development Pro	ogramme (UNDP)			4	RANKIN Ho		ANIS
PROJECT:	Medical Store	e Limited's Regiona	al Hubs-Mp	ika				Chozi Roa	D	
		<u> </u>						Lusaka, Za	MBIA	
TECHNICIA	AN:	тк		DATE 16/09/2	2016			Tel/Fax: 260-	1-291195	
SAMPLE S	SOURCE:	SPT3 (1.0 - 3.1m)) Moist redo	lish brown ye	llowish soft g	ravelly sand-clay	mixture	(Residual)		
		Lab # 3272								
EST ref: BS	1377: Part 2 :	1990								
Container N	Number		F06	RNK32	RK2					
Mass of we	et soil & contain	er (g) (m ₂)	69.1	60.1	46.4					
Mass of dr	y soil & contain	er (g) (m ₃)	60.7	53.0	41.4					
Mass of co	ntainer (g) (m ₁)		13.8	14.4	14.3					
Mass of dr	y soil (g) (m ₃ - r	n1)	46.9	38.6	27.1					
Mass of m	oisture (g) (m ₂ -	m3)	8.4	7.1	5.0					
Moisture c	ontent (%)		18.0%	18.3%	18.3%					
AVERAGE				18.2%						
										_
CHECKED	BY:	DL								
DATE:		DATE 16/09/2016								

F-4



MOISTURE	CONTENT			FORM M1						1 KI
0.1515							L-			
CLIENT:	United Nation	ns Development Pro	ogramme (UNDP)		54	14	RANKIN Ho		ANIS
PROJECT:	Medical Stor	e Limited's Regiona	al Hubs-Mo	ika				CHOZI ROAL	D	
								LUSAKA, ZA	MBIA	
TECHNICIA	N:	ТК		DATE 16/09/	2016			Tel/Fax: 260-	1-291195	
SAMPLE S	OURCE:	SPT4 (1.4 - 3.7m) quartzitic stone (l		lish brown ye	ellowish firm g	ravelly clayey	sand with	n fragments o	f sandstone a	Ind
		Lab # 3273								
TEST ref: BS	1377: Part 2 :	1990								
Container N	lumber		F4	A2	100					
Mass of we	t soil & contain	ner (g) (m ₂)	87.5	76.1	77.5					
Mass of dry	/ soil & contain	er (g) (m ₃)	78.8	69. 1	69.7					
Mass of cor	ntainer (g) (m ₁)		14.1	13.9	14.2					
Mass of dry	/ soil (g) (m ₃ - r	m1)	64.6	55.2	55.5					
Mass of mo	oisture (g) (m ₂ -	- m ₃)	8.8	6.9	7.8					
Moisture co	ontent (%)		13.6%	12.6%	14.1%					
AVERAGE				13.4%						
CHECKED	BY:	DL								
DATE:		DATE 16/09/2016								



Appendix G – MDD Test Results

G-1



Ref. BS13//:Part4:1990 lient UNDP Project: Medical Store Limited's Regional Hubs-Mpika te Sampled: 13/9/2016 Sample By: Sample Description: Moist reddish brown sandy clay (Residual) Sample St.: Offset from ¢ (m): Lane: Work Area: 0.8-3.0m Source: TP1 Ould no. 30 Mass 4866 g Volume 2305 (m³) ATER ADDED 0 2 4 6 8 ould no. 30 Mass 4866 g Volume 2305 (m³) ATER ADDED 0 2 4 6 8 eight of mould + sample g 9798.0 10054.0 10174.0 10079.0 9898.0 eight of sample g 4932.0 5188.0 5308.0 5213.0 5032.0 y Density kg/m³ 1921 1985 1998 1923 1828 otor of mould:	3269
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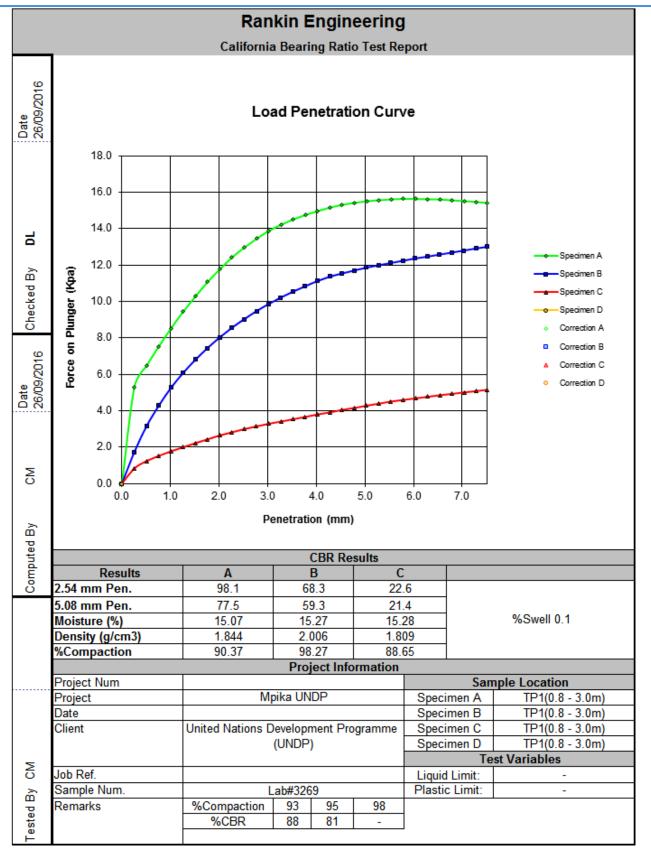
G-2



Appendix H – CBR Test Results

H-1





H-2