AFCAP/KEN/089 - TRAINING REPORT ON DCP DESIGN METHOD D415 Muruka – Kandara, Muranga Region 03-07.12.2012

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18 December 2012

This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

This material has been funded by UKaid from the Department for International Development, however the views expressed do not necessarily reflect the department's or the managing agent's official policies.

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The Africa Community Access Programme (AFCAP) is a regional programme funded by the UK government through the Department for International Development (DFID) which is supporting research, knowledge dissemination and training for improved access for rural communities in Africa.

One of the objectives of AFCAP is to operationalize the SADC Guideline for Low Volume Sealed Roads (LVSR).

A significant portfolio of research activities has now been established in the AFCAP participating countries. AFCAP provides technical assistance for these activities and promotes the uptake of the research findings through revised, country specific LVSR design manuals and specifications.

On this background a proposal was formulated to research on the application of the DCP Design Method in Kenya with the overall objective to support rural development through establishment of appropriate LVSR pavement design standards which in turn can facilitate the expansion of the paved rural road network.

This research project is part of the AFCAP research portfolio and is funded by Kenya Rural Roads Authority (KeRRA), and Crown Agents, UK. For budgetary and logistical reasons, the project initially aims to design and construct three short test sections located in Central Province. The sections are located in areas with different soils, topography and climatic conditions.

The project has a training component in the application of the DCP Design Method.

This report covers the first training exercise for selected trainees from KeRRA, Materials Testing and Research Department as well as private sector consultants.

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Background

The Malawi DCP Design Manual, the first of its kind, was completed in October 2012 following a study and back analysis of a number of Low Volume Sealed Roads in Malawi which concluded that the DCP Design Method and Catalogue is appropriate for the design of LVSRs. The method enables designers to more effectively utilize local materials for LVSR pavements thereby reducing the costs of upgrading gravel and earth roads to sealed road standard.

Under AFCAP/KEN/089/G the Malawi DCP Design Manual was presented to KeRRA, Materials Testing and Research Department and private sector consultants involved in AfD Roads 2000 Central project.

The presentation resulted in a general consensus that a draft Kenya DCP Manual should be produced and that it should be followed up with a more thorough dissemination and training exercise early 2013.

It is evident that extensive training and guidance will be needed for the successful application of the DCP Design Method since it's a new concept breaking quite radically from the conventional CBR base design methods.

A proposal for starting the training on the extension of D415 Muruka – Kandara in Muranga Region already in December 2012 under AFCAP/KEN/089 for selected trainees from KeRRA, Materials Testing and Research Department and private sector consultants was therefore presented to KeRRA with the intention that the data collected from this training exercise could also be used for the upcoming training in 2013.

The extension of D415 from Muruka to Kandara is about 7.5 km long and goes through rolling terrain. It was rehabilitated to gravel standard in Roads 2000 Phase 1 and completed around June 2008. The current condition is fair and the drainage is reasonably good, but very little of the laterite wearing course remains.

The Training Programme

Objectives

The objectives for this training exercise were:

- To give the trainees hands-on experience in carrying out the DCP testing in the field
- Show correct handling of the equipment
- Determination of acceptable tests and which tests to abort and/or reject
- Demonstrate the main features of the DCP software and give the trainees hands-on experience in data entry and analysis.

The first part of training programme covered in this report is shown in table 1 below:

Date	Activity
Day 1 - 03.12.2012	Gathering at Muruka 09.00 AM Brief Visual Assessment DCP tests, Soil sampling
Day 2 - 04.12.2012	DCP tests, Soil sampling
Day 3 - 05.12.2012	DCP tests, Soil sampling
Day 4 - 06.12.2012	Entering data (AFCAP consultant and Max & Partners only)
Day 5 - 07.12.2012	Preliminary design using the DCP software

Table 1: Training programme for the week 03-07 December

The DCP testing is repetitive, hence the trainees needed only one day in the field to get hands-on experience with the DCP test and an orientation about the possible pitfalls when carrying out the tests. On Day 4 the DCP data was entered in the WinDCP software by the AFCAP consultant and Max & Partners to prepare for the common session for all trainees on Day 5 on the use of the programme and doing the preliminary design.

The last day gathered 19 trainees, some of whom had not participated in the field work.

Some delays were encountered since none of the trainees had downloaded and installed the WinDCP Software. It came to light that obtaining the license code free of charge was only for AFCAP participants. This was resolved with CSIR during the morning hours such that many trainees managed to install the software and participate in the training exercises in the use of the programme.

Issue covered were in short:

- Creating a new project, storage location of project files
- Main features of the opening screen
- DCP data entry
- Defining pavement layers
- Pre-defined and User defined DCP Design Curves
- Single point analysis
- Average analysis

The trainees were given DCP DN values to enter for one point and shown how to do a single point analysis. Copies of the data file for all points were then handed out so that they could also define an average analysis for selected points.

The preliminary findings were discussed in light of the pattern that emerged from the average analysis. However, the moisture test results were not available at the time so only an indication of the likely pavement design could be made.

Due to the delays with installation of the software there was no time to do a Cusum Analysis to determine uniform sections. However, the DCP data indicates that the whole road is fairly uniform with the variability in DN values caused by differences in moisture content and local variations in the materials and field densities.

This was deemed to be the most effective way of conducting the training and limit the time the trainees have to stay out of their respective stations.

Table 2 shows the outline of the training programme up to final design and the joint workshop with AFCAP/KEN/089/G in February 2013.

Outline of initial training programme on DCP Design on D415 MacKenzie-Kandara														
Activities	**Responsible/Participants**	12-16 Nov	19-23 Nov	26-30 Nov	03-07 Dec	10-14 Dec	17-21 Dec	24-28 Dec	1-4 Jan	7-11 Jan	14-18 Jan	21-24 Jan	27-31 Jan	3-7 Feb	10-14 Feb
Field work, prelim design	All, AFCAP, DCS Consultant						X-mas break								
Field moisture content	Thika lab														
Borrowpit samples, Lab DN value	DCS Consultant, Thika lab														
Final design	All														
AFCAP/KEN/089G Workshop	All														

Table 2: Outline of Training Programme under AFCAP 1 (ending March 2013)

Trainees

Table 3 shows the proposed staff to be included in the initial training progamme. Due to the coincidence with the AfD Mission, the actual dates of attendance differ somewhat from the proposed dates. A full list of participants is provided in Annex 1.

Firm/Department	**No of persons**	**Attendance**				
Max & Partners (Roads 2000)	2	03.12	04.12	05.12	06.12	07.12
CAS Consultants (Roads 2000)	2	03.12				07.12
Regional Manager Muranga	1		04.12			07.12
Regional Manager Kiambu	1		04.12			07.12
Regional Manager Nyandarua	1	03.12				07.12
Regional Manager Nyeri	1			05.12		07.12
Regional Manager Kirinyaga	1	03.12				07.12
Regional Manager Laikipia	1			05.12		07.12
Egis International/Norken (Roads 2000)	1			05.12		07.12
KeRRA HQ	1		04.12			07.12
Materials & Testing Department	1	03.12				07.12
Total	**13**	**7**	**5**	**5**	**5**	**13**

Table 3: Proposed trainees and attendance dates

Data collection

Traffic data

Traffic counts and Axle Load Survey was done in October on the completed part of D415. It was intended to use these data for the DCP design exercise. However, the report was not yet out and assumptions on the Design Traffic Loading therefore had to be made. The 15 year Design Traffic loading was set to 0.1 -0.3 MESA for the training exercise based on previous data from the completed section of D415.

DCP tests

For a full DPC design it was estimated that at approx. 75 DCP tests would have to be done, on average one test every 100 m. However, during the DCP testing it became evident that the section was fairly uniform throughout, hence the number of tests was reduced to 41. A

further 13 tests had to be aborted due to stones in the ground or hard layers making it impossible to penetrate to the full depth of 800mm. The DCP tests were completed during the three field days. Copies of the Data Collection sheets are provided in Annex 2. Annex 3 shows the chainage and position of each DCP test. It was found that this format is useful during the data analysis since it is easy to identify all tests done at similar positions (related to offset from centre line) for average analysis.

Picture 1: Regional Managers doing DCP test

Moisture tests

The tests were carried out towards the end of the short rains. It was therefore assumed that the pavement would be at or close to its highest relative moisture content.

The three days prior to the field tests and during the morning of the first field day it was raining quite heavily and persistently. In the afternoon on the first field day the weather cleared up and became quite warm and sunny. It remained warm and sunny for day two and three. The field moisture results should be seen in this light.

The DCP penetration rate (DN value) is highly dependent on the moisture content in the pavement. Sampling of the alignment soils was therefore done at the same time as the DCP tests to determine the relative field moisture content, RMC, compared to OMC at the time of the DCP tests. Samples were taken at 0-150mm, 150-300mm and 300-450mm depth at eight locations with at least one test for every kilometer. The samples were taken and analyzed by the Materials Laboratory in Thika who were present during all three field days. The moisture test results are shown in Table 4 below.

Additional pavement layer(s)

The final design may incorporate one additional pavement layer. The source for the pavement layer should be identified and the material tested in the laboratory using the DCP to determine the DN value at various compaction efforts and moisture contents as described in the Malawi DCP Manual Section B6, Annex 5A: Determination of Laboratory DN value. Representative samples from the borrow pit should be taken and for each sample 9 DCP tests should be carried out. ***For testing at 0.75 OMC, it is important that the samples are compacted at OMC, then dried back to 0.75 OMC, sealed and left for four days for the moisture to equilibrate.***

Trial pit	Km	Position	Depth mm	MDD kg/m3	FMC %	OMC %	RMC % of OMC	Description
3	0+210	LHS 3 m	0 - 150	1735	28,2 %	17,1 %	165 %	Red soil
			150 - 300		16,1 %		94 %	mixed with
			300 - 450		27,8 %		163 %	gravel
10	0+910	LHS 3 m	0 - 150	1650	24,1 %	21,1 %	114 %	Red soil
			150 - 300		19,3 %		91 %	mixed with
			300 - 450		26,7 %		127 %	gravel
11	1+110	CL	0 - 150	1540	28,0 %	19,7 %	142 %	Red soil
			150 - 300		21,4 %		109 %	mixed with
			300 - 450		25,8 %		131 %	gravel
21	2+600	LHS 3 m	0 - 150	1685	14,2 %	21,5 %	66 %	Red soil
			150 - 300		26,3 %		122 %	mixed with
			300 - 450		20,0 %		93 %	gravel
26	3+500	CL	0 - 150	1560	17,2 %	19,7 %	87 %	Red soil
			150 - 300		25,0 %		127 %	mixed with
			300 - 450		27,6 %		140 %	gravel
31	4+500	RHS 2,5 m	0 - 150	1485	20,2 %	22,6 %	89 %	Red soil
			150 - 300		30,6 %		135 %	mixed with
			300 - 450		22,4 %		99 %	gravel
36	5+500	CL	0 - 150	1678	17,6 %	22,5 %	78 %	Red soil
			150 - 300		18,5 %		82 %	mixed with
			300 - 450		15,1 %		67 %	gravel
40	6+300	LHS 3 m	0 - 150	1538	15,6 %	20,6 %	76 %	Red soil
			150 - 300		27,2 %		132 %	mixed with
			300 - 450		16,6 %		81 %	gravel

Table 4: Relative Moisture Content RMC at the time of DCP tests

Data analysis

Table 5 shows a summary of the DN values per layer sorted on test number and dates.

No effect of drying out during the hot and dry days (half day 1, entire day 2 and 3) can be detected from these data.

Table 6 shows the same data sorted on offset position (offset from centre). The data now clearly shows a distinct difference in strength between points 2.0 m from centre and points 2.5 m from centre. From this we can assume that the old road before rehabilitation in 2007/08 probably had an effective width of about 4.0 m which had been consolidated under traffic.

The pattern of the layer strength diagrams clearly shows the effect of the rain during 3 days prior to the tests. However, some of the moisture data are not consistent with the DN values one would expect for RMC below OMC. The reason for this is not quite clear. Testing of the samples taken for moisture tests with the DCP at various compaction efforts and moisture contents is expected to shed some more light on this and help to determine the measures to be taken for the upgrading of the pavement.

				Weighted average DN per layer				
Test no	Chainage	Offset	Date	0-150 mm	151-300 mm	301-450 mm	451-600 mm	601-800 mm
1	0,010	CL	03.12.12	4,37	2,04	2,97	5,1	7,02
4	0,310	CL	03.12.12	7,07	4,37	3,07	6,06	9,96
7	0,410	CL	03.12.12	4,16	3,76	2,62	4,28	7,66
11	1,110	CL	03.12.12	4,28	3,1	5,1	6,73	9,88
13	1,410	CL	03.12.12	7,35	5,84	6,81	3,45	4,69
15	1,810	CL	03.12.12	14,34	5,5	2,71	3,53	6,73
18	2,300	CL	04.12.12	6,73	6,18	3,09	3,41	6,04
20	2,500	CL	04.12.12	3,89	4,59	4,42	3,16	2,55
23	2,800	2,0 RHS	04.12.12	6,97	8,43	7,1	11,52	13,61
24	3,000	CL	04.12.12	7,61	2,26	2,66	5,22	9,63
25	3,300	2,5 LHS	04.12.12	13,69	12,52	7,67	12,21	19,21
26	3,500	CL	04.12.12	11,36	6,06	1,98	5,96	8,68
28	3,900	2,0 LHS	04.12.12	6,61	4,7	2,82	4,94	9,28
29	4,100	2,0 RHS	04.12.12	7,32	5,29	6,15	3,51	5,36
30	4,300	2,0 LHS	04.12.12	12,73	13,25	4,56	7,00	11,32
31	4,500	2,5 RHS	04.12.12	6,1	6,53	5,47	7,43	10,72
32	4,700	2,5 LHS	04.12.12	11,03	12,29	6,83	11,28	18,81
34	5,100	2,5 LHS	05.12.12	10,77	30,3	16,55	9,39	10,6
35	5,300	2,0 RHS	05.12.12	4,06	2,9	3,08	6,11	9,89
36	5,500	CL	05.12.12	3,39	4,28	2,34	5,15	7,99
37	5,700	2,0 LHS	05.12.12	4,05	3,19	3,33	6,65	9,17
39	6,100	CL	05.12.12	4,07	3,01	4,24	7,13	7,58
41	6,410	2,0 RHS	05.12.12	6,09	3,74	3,36	5,00	6,94
		Average DN per layer		7,31	6,70	4,74	6,27	9,27

Table 5: Summary of DN values per layer (sorted on ascending test number and dates)

				Weighted average DN per layer				
Test no	Chainage	Offset	Date	0-150 mm	151-300 mm	301-450 mm	451-600 mm	601-800 mm
1	0,010	CL	03.12.12	4,37	2,04	2,97	5,10	7,02
4	0,310	CL	03.12.12	7,07	4,37	3,07	6,06	9,96
7	0,410	CL	03.12.12	4,16	3,76	2,62	4,28	7,66
11	1,110	CL	03.12.12	4,28	3,10	5,10	6,73	9,88
13	1,410	CL	03.12.12	7,35	5,84	6,81	3,45	4,69
15	1,810	CL	03.12.12	14,34	5,50	2,71	3,53	6,73
18	2,300	CL	04.12.12	6,73	6,18	3,09	3,41	6,04
20	2,500	CL	04.12.12	3,89	4,59	4,42	3,16	2,55
24	3,000	CL	04.12.12	7,61	2,26	2,66	5,22	9,63
26	3,500	CL	04.12.12	11,36	6,06	1,98	5,96	8,68
36	5,500	CL	05.12.12	3,39	4,28	2,34	5,15	7,99
39	6,100	CL	05.12.12	4,07	3,01	4,24	7,13	7,58
31	4,500	2,5 RHS	04.12.12	6,10	6,53	5,47	7,43	10,72
25	3,300	2,5 LHS	04.12.12	13,69	12,52	7,67	12,21	19,21
32	4,700	2,5 LHS	04.12.12	11,03	12,29	6,83	11,28	18,81
34	5,100	2,5 LHS	05.12.12	10,77	30,30	16,55	9,39	10,60
23	2,800	2,0 RHS	04.12.12	6,97	8,43	7,10	11,52	13,61
29	4,100	2,0 RHS	04.12.12	7,32	5,29	6,15	3,51	5,36
35	5,300	2,0 RHS	05.12.12	4,06	2,90	3,08	6,11	9,89
41	6,410	2,0 RHS	05.12.12	6,09	3,74	3,36	5,00	6,94
28	3,900	2,0 LHS	04.12.12	6,61	4,70	2,82	4,94	9,28
30	4,300	2,0 LHS	04.12.12	12,73	13,25	4,56	7,00	11,32
37	5,700	2,0 LHS	05.12.12	4,05	3,19	3,33	6,65	9,17
		Average DN per layer		7,31	6,70	4,74	6,27	9,27

Table 6: Summary of DN values per layer (sorted on offset from centre)

In the following are shown average analysis for points at different offsets from centre. The user defined design curve for traffic class LV 0.3 for 0.1 to 0.3 MESA was used:

- 0-150 mm DN≤3.2
- 151-300 mm DN≤6
- 301-450 mm DN≤12
- 451-600 mm DN≤36
- 601-800 mm DN≤50

These clearly show the relatively low strength of the upper 150 mm, mostly due to moisture. The layers from 150mm to 450 mm depth within 2.0 m from centre are considerably stronger whereas at 2.5m and 3.0 m from centre these layers are much weaker probably due to a combination of moisture and less compaction under traffic.

Preliminary design and construction approach

Based on these observations preliminary recommendations for the upgrading of this road would be as follows:

From 2.0 m from centre each side:

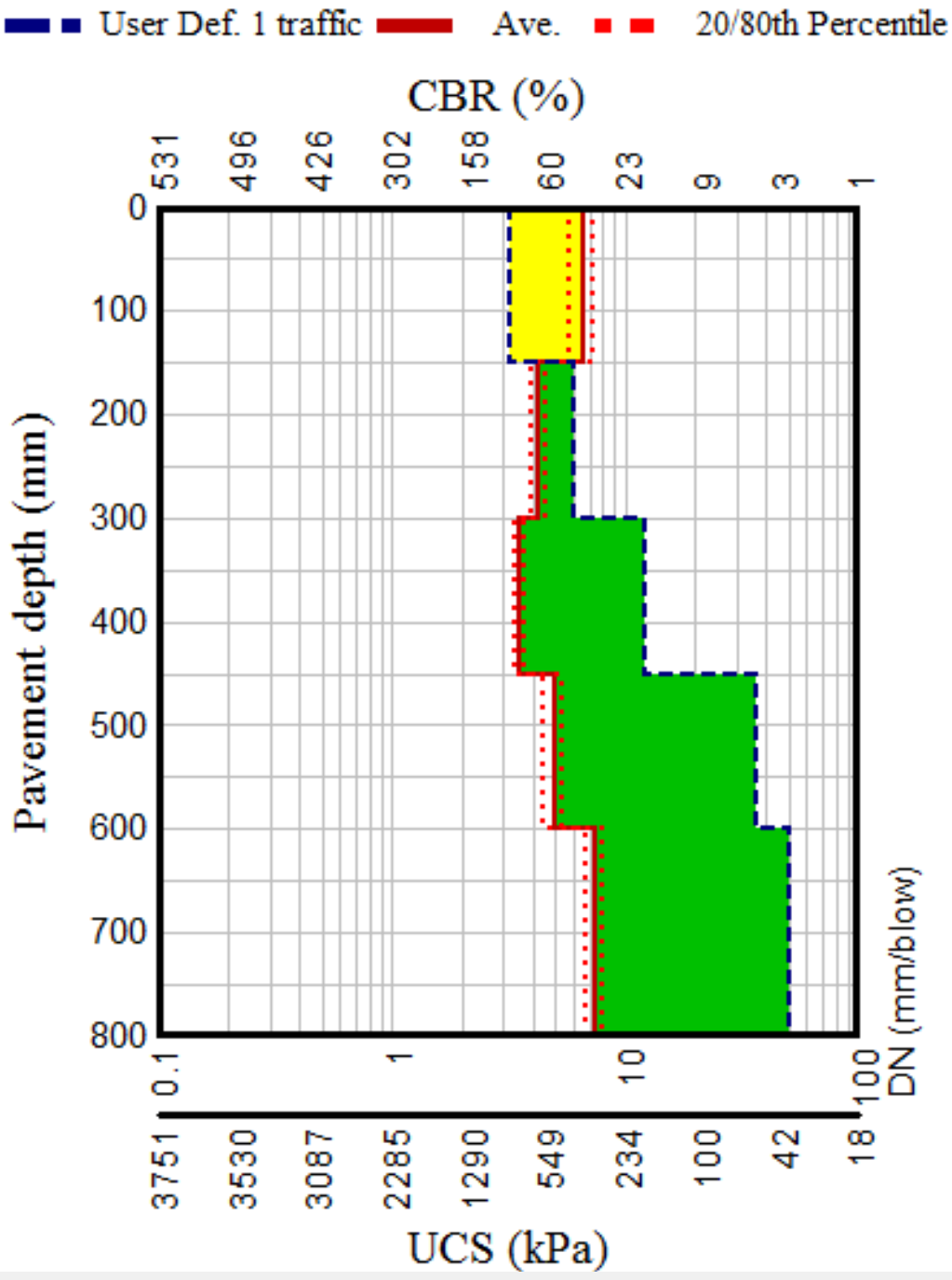
- Cut to drain invert level at least 750mm below finished crown, windrow the material for the upper layers in the benches
- Bench in 150 mm layers up to 150 mm from the final level using in situ subgrade in the lower layers and the material from the existing pavement in the upper layers. Compact each layer to refusal.

For the middle 4.0 m:

- Scarify the top 150 mm and use the material for the top of the benches on each side
- Shape and proof roll to refusal the subgrade formation

New base layer:

- Import laterite gravel of known quality for a 150 mm thick base for the whole width of the road, shape to 3.5% camber and compact to refusal.

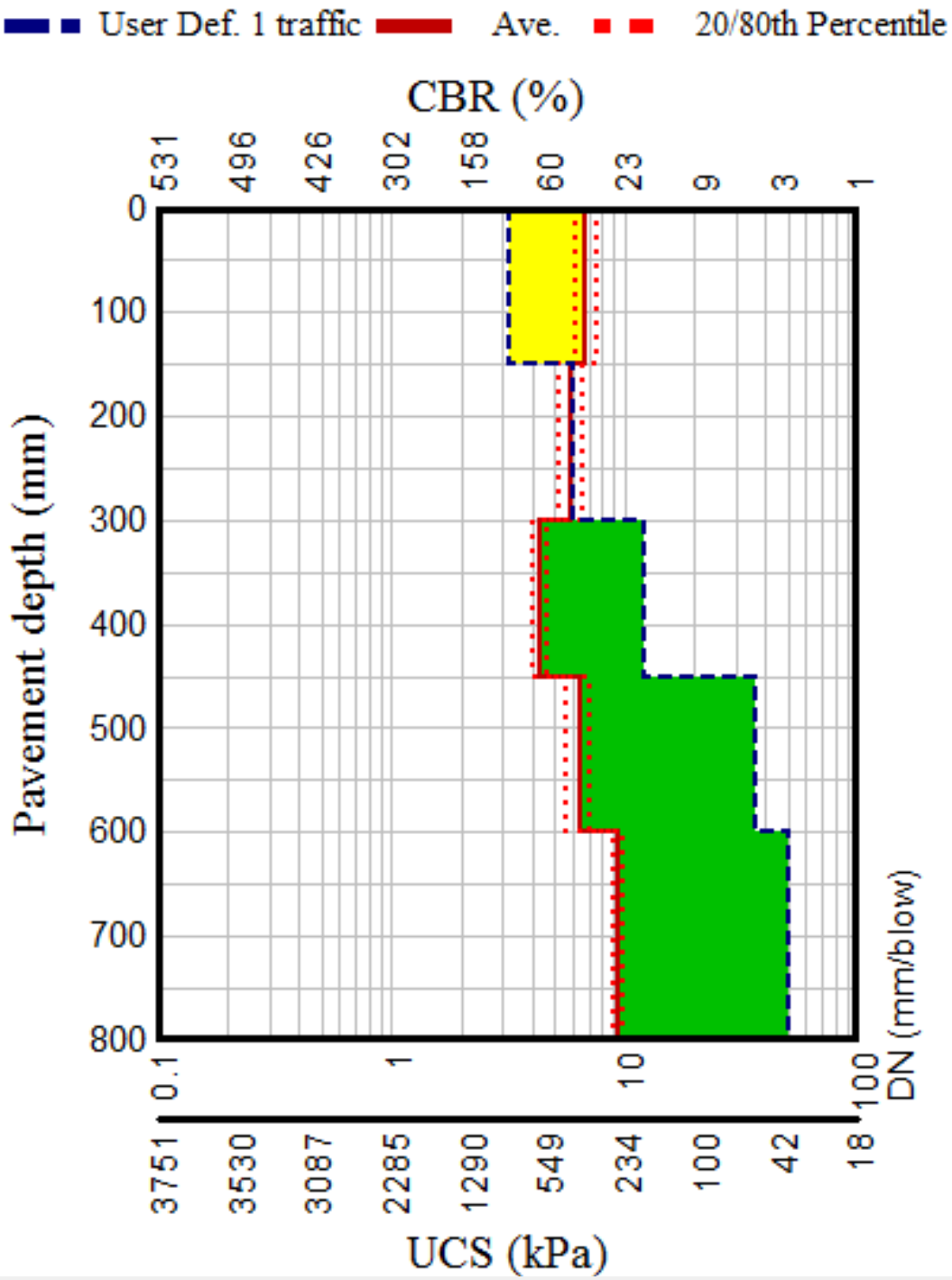


Structure number (DSN800)	192
Struct. Cap. (MISA)	2.9
RUT Limit	20mm
Balance curve is where	B=6, A=3070

Depth (mm)	W. Ave. Pen (mm/blow)	Blows	SD (mm/blow)	80P (mm/blow)	CBR(%)	UCS(kPa)
0 - 150	6.55	30	0.9	7.3	38	366
151 - 300	4.25	45	0.4	4.6	65	593
301 - 450	3.50	51	0.2	3.6	83	736
451 - 600	4.93	34	0.6	5.4	54	502
601 - 800	7.37	32	0.7	8.0	32	321

MISA = Million Standard Axles. Category VI : Poorly Balanced Deep Structure (PBD)

Figure 1 : Average analysis centre line points

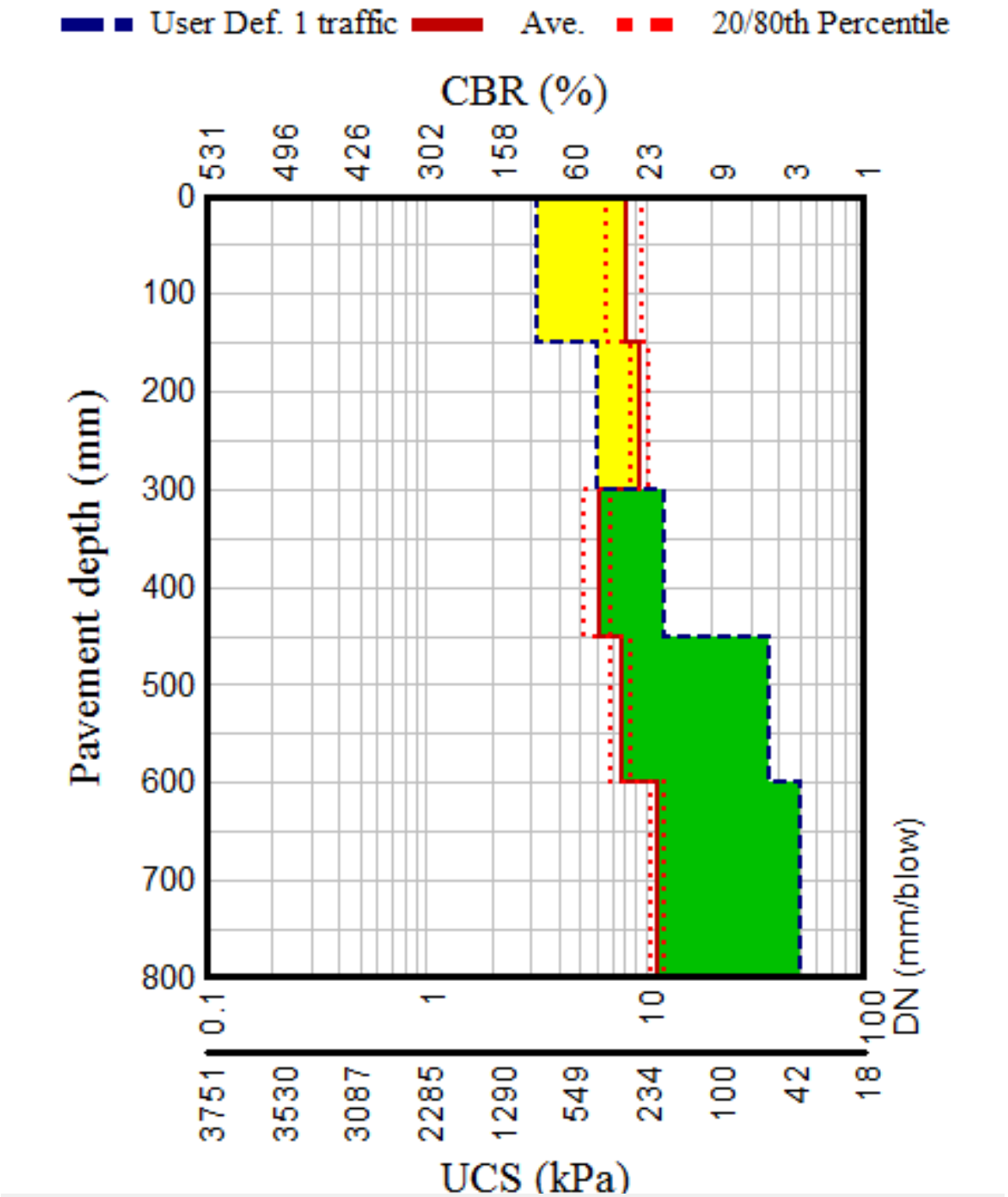


Structure number (DSN800)	152
Struct. Cap. (MISA)	1.3
RUT Limit	20mm
Balance curve is where	B=6, A=2800

Depth (mm)	W. Ave. Pen (mm/blow)	Blows	SD (mm/blow)	80P (mm/blow)	CBR(%)	UCS(kPa)
0 - 150	6.83	26	0.9	7.6	36	349
151 - 300	5.93	35	0.9	6.7	43	409
301 - 450	4.34	40	0.3	4.6	63	579
451 - 600	6.39	27	0.9	7.2	39	376
601 - 800	9.37	23	0.6	9.9	24	245

MISA = Million Standard Axles. Category V : Averagely Balanced Deep Structure (ABD)

Figure 2: Average analysis of points 2.0 m from centre

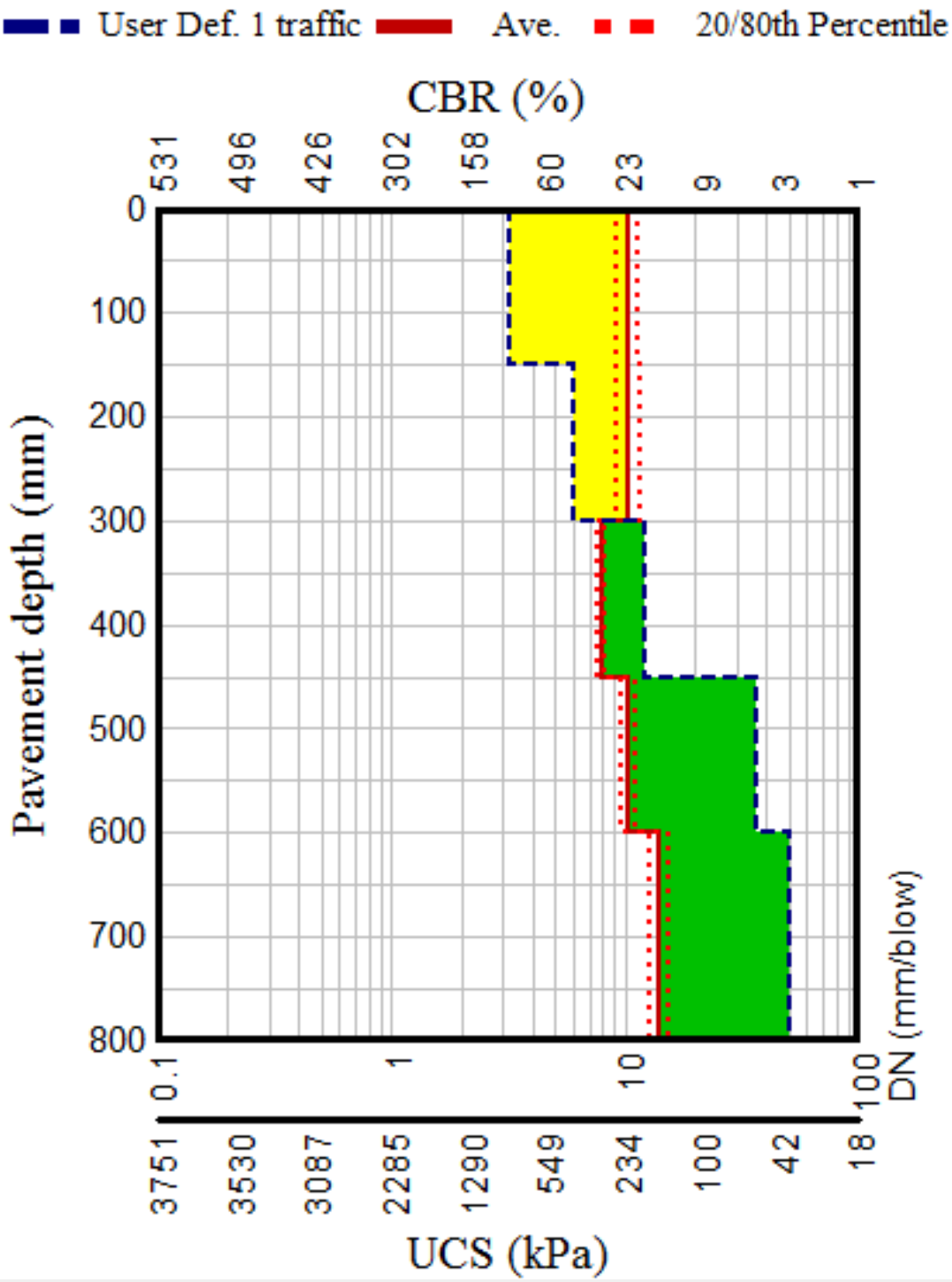


Structure number (DSN800)	127
Struct. Cap. (MISA)	0.7
RUT Limit	20mm
Balance curve is where	B=6, A=2268

Depth (mm)	W. Ave. Pen (mm/blow)	Blows	SD (mm/blow)	80P (mm/blow)	CBR(%)	UCS(kPa)
0 - 150	8.13	23	1.8	9.7	29	287
151 - 300	9.38	27	1.0	10.2	24	245
301 - 450	6.08	33	1.0	6.9	41	397
451 - 600	7.73	23	0.9	8.5	31	304
601 - 800	11.36	20	1.0	12.2	19	198

MISA = Million Standard Axles. Category V : Averagely Balanced Deep Structure (ABD)

Figure 3: Average analysis of points 2.5 m from centre



Structure number (DSN800)	107
Struct. Cap. (MISA)	0.4
RUT Limit	20mm
Balance curve is where	B=7, A=1832

Depth (mm)	W. Ave. Pen (mm/blow)	Blows	SD (mm/blow)	80P (mm/blow)	CBR(%)	UCS(kPa)
0 - 150	10.19	21	1.2	11.2	22	223
151 - 300	10.39	24	1.4	11.5	21	218
301 - 450	7.94	26	0.4	8.2	30	295
451 - 600	10.25	18	0.9	11.0	21	222
601 - 800	14.04	18	1.5	15.3	14	156

MISA = Million Standard Axles. Category V : Averagely Balanced Deep Structure (ABD)

Figure 4: Average analysis of points 3.0 m from centre

Annex 1: List of participants

Item	Name	Designation	Organisation
		5TH DECEMBER 2012	
1.	Julius M. Wambugu	Technologist	MOR material Dept
2.	Caroline Naliaka	Training Technician	MSC
3.	Musuku P. Gaitano	Training Technician	MSC
4.	Eng. P. Githere	RM Laikipia	KeRRA
5.	Eng. J. N. Kabiru	RM Nyeri	KeRRA
6.	Eng. W. K. Mburu	RM Kirinyaga	KeRRA
7.	Stephen J. Ochieno	Road Engineer	Max and Partners
8.	Chomba A. Gateri	Training Technician	MSC
9.	Etale Tunya	TL/Road Engineer	Max and Partners
10.	Richard M.Migwi	CRO Kandara	KeRRA
		4TH DECEMBER 2012	
1.	Etale Tunya	TL/Road Engineer	Max and Partners
2.	Julius M.Wambugu	Technologist	MOR Material Dept
3.	Joseph Rugenyi	Superintendent Roads	Kerra Kiambu
		3RD DECEMBER 2012	
1.	Julius M. Wambugu	Technologist	MOR material Dept
2.	……..	CRO Nyandarua	KeRRA
3.	Chomba A. Gateri	Training Technician	MSC
4.	Eng. Methu	TL/Road Engineer	CAS Consultants
5.	Kent Kopar	Road Engineer	CAS Consultants
6.	James Nguyo	Road Engineer	Max and Partner

GROUP: KENYA RURAL ROADS AUTHORITY

DATE: 7th March 2013

DESCRIPTION: CONFERENCE ATTENDANCE

NAME	~~RANK~~ TITLE	ROOM NO.	SIGNATURE
1. ~~NAME~~ NAME	Title	Organization	
2.			
3. Willy K. Mburu	DM-Kisumu	KeRRA	
4. Henry Orwa	T.A. DOSE	HSC	
5. Paul Methu	AE NYEST	CAS (on	
6. Eng. J. Muriuki	RM-Kitui	KeRRA	
7. RICHARD MUGWI	CRO Nairobi	KERRA	
8. CHOMBA AK LAZAI	Transit Tech.	MSC	
9. CAROLINE N. MANJA	"	MSC	
10. MUGWIRO P. GRETHARD	"	MSC	
11. RICHARD K. WAMBUGU	Ag Sen. Eng NM	KeRRA	
12. Eng. Joseph MANGUA	RM	KeRRA	
13. Eng. P. Githere	RM	KeRRA	
14. Engg J.N. KABIRU	RM	KeRRA	
15. Julius Wambugu	Technologist	MOR, Materials	
16. JAMES NGUYO	DSC Rd Engineer	MAX	
17. LAWI K. MANGU	Ag Sen Eng	KeRRA	
18. Jairus M Muriuki	Jr Eng	Nyeri I LM	
19. JOAN SIEBEN OCHIENG	RDAS ENG	MAX	
20. ETALE TUNTA	ROADS SUP	MAX	
21. KENT KOMER	Road ENG	CAS (ON	
22.			
23.			
24.			
25.			
26.			

Annex 2: Data collection sheets

Road:	D415 Murulegama - Kandalama							Date:	03-12-2012	
Chainage	0+000	0+110	0+210	0+310	0+410	0+510	0+610	0+710	0+810	0+910
Offset	6m	3m RHS	6m	3m LHS	6m	3m RHS	3m LHS	6m	RHS	3m LHS
No of blows	Test no									
0	65	81	50	86	82	36	53	75	95	96
5	110	169	111	161	137	136	164	111	136	152
10	135	205	138	228	165	202	256	134	157	170
15	157	234	163	279	191	272	419	152	300	182
20	176	253	189	325	211	330	472	167		195
25	195	270	173	358	231	349	515	181		208
30	219	289	186	376	251	373	551	194		218
35	236	307	202	392	273	393	591	206		226
40	247	324	219	406	296	413	634	219		236
45	256	345	235	419	324	434	687	230		247
50	265	365	250	432	349	459	745	245		257
55	272	383	268	443	365	492	812	259		271
60	280	404	282	463	378	564	903	274		282
65	290	423	296	482	390	686		292		297
70	300	444	309	472	402	839		315		314
75	309	465	319	483	416	976		335		333
80	315	488	330	490	431			356		350
85	327	514	339	509	447			373		372
90	337	537	346	521	462			398		388
95	349	563	264	525	476			414		403
100	363	587	363	550	491			427		418
105	372	616	370	567	507			438		432
110	384	648	375	585	526			449		448
115	393	682	386	601	547			460		466
120	401	714	391	618	571			470		485
125	410	749	398	636	598			481		505
130	419	783	402	653	631			493		527
135	430	817	405	673	665			504		555
140	446	854	412	693	705			515		556
145	461	895	416	715	758			527		627
150	477	—	—	739	810			539		676
155	493			763	859			553		722
160	510			800	908			568		791
165	531			839	—			586		831
170	552			854				667		912
175	576			—				621		
180	599							659		
185	626							690		
190	652							724		
195	681							760		
200	713							800		
205	746							840		
210	781							854		
215	812							—		
220	849									

Road:	B415 Muruka - Kandara							Date:	03-12-2012	
Chainage	0+710	0+930	0+950	1+190	1+490	1+510	1+730	1+950	1+970	1+990
Offset	3M LHS	C/L	C/L	C/L	3M LHS	C/L	3M RHS	3M RHS	3M LHS	C/L
	Test no									
No of blows		X	X	X			X	X		
0	93.	79	90	85	107.	58.	93	160	85.	82.
5	140.	122	149	129	169.	127.	153	144	127.	127.
10	173.	157	193	162	231.	148.	201	184	165.	171.
15	233.	179	223	186	266.	165.	227	211	195.	202.
20	276.	200	246	209	290.	181.	236	227	226.	223.
25	328.	216	272	226	340.	194.	244	240	255.	240.
30	396.	238	290	247	317.	208.	249	253	283.	257.
35	485.	261	301	265	330.	219.	255	265	315.	275.
40	567.	282	313	276	341.	230.		275	352.	300.
45	635.	299	322	286	352.	242.		285	385.	332.
50	725.	310	325	293	365.	253.		294	416.	376.
55	865.	317	336	303	382.	271.		301	441.	415.
60	1075.	324	346	310	400.	283.		311	460.	462.
65	—	329	353	317	419.	297.		319	515.	488.
70		—	361	322	438.	311.		329	555.	502.
75			368	331	460.	325.		337	590.	522.
80			374	336	483.	341.		345	633.	537.
85			—	341	509.	357.		354	677.	551.
90				—	540.	376.		361	711.	566.
95					577.	397.		371	759.	582.
100					631.	420.		378	802.	596.
105					690.	445.		387	843.	614.
110					736.	471.		395	892.	632.
115					856.	498.		403	—	650.
120					981.	525.		412		672.
125					—	552.		420		692.
130						584.		429		709.
135						619.		440		728.
140						652.		446		746.
145						689.		456		766.
150						734.		—		787.
155						787.				809.
160						838.				835.
165						886.				865.
170						—				909.
175										—
180										
185										
190										
195										
200										
205										
210										
215										
220										

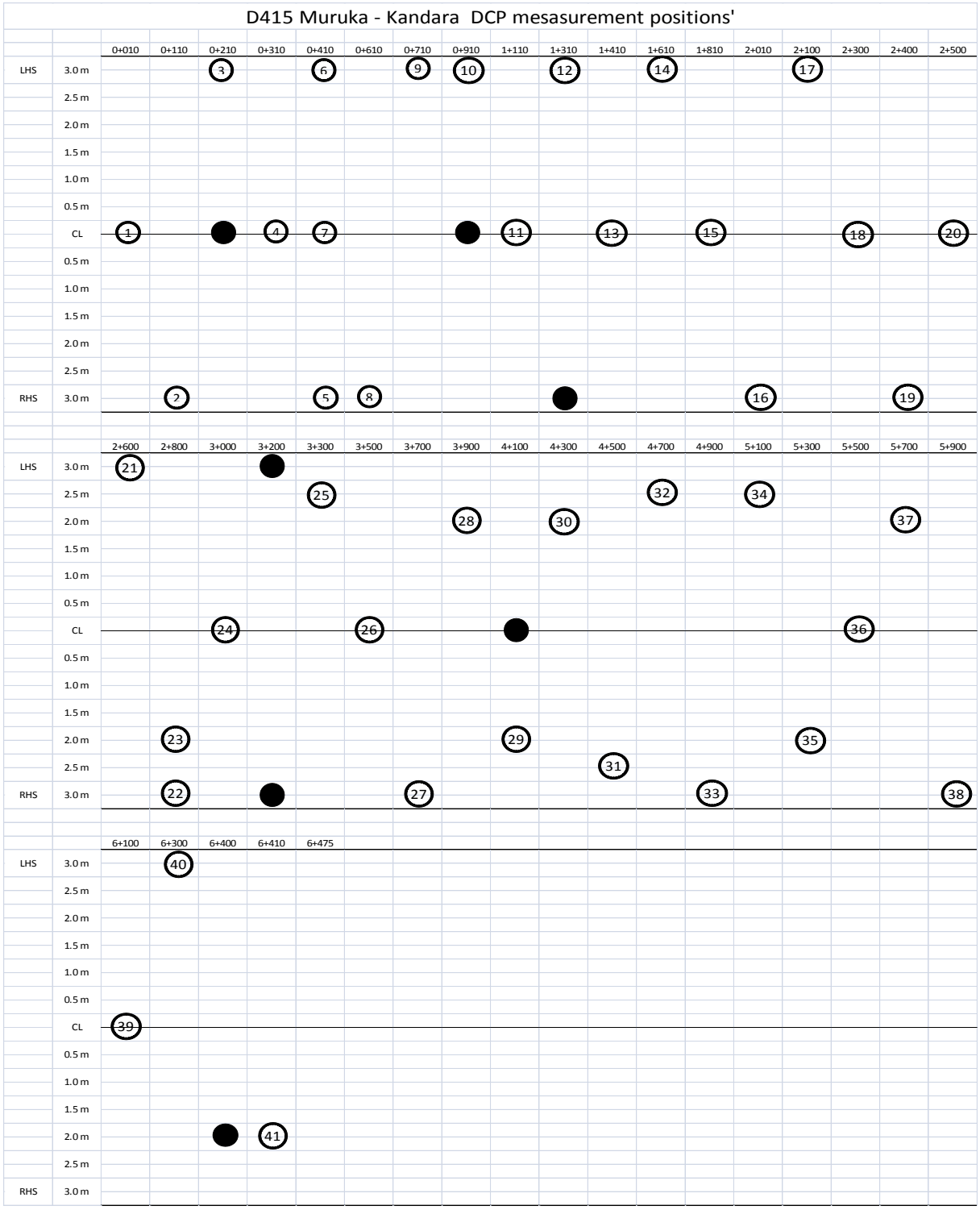
Road:	D415 Mpanke – Kandera							Date:	03-12-2018	
Chainage	14+610	14+510	14+410							
Offset	5m Left	℄	5m Right							
	Test no									
No of blows										
0	52	100	93							
5	129	177	141							
10	156	245	185							
15	177	285	224							
20	195	310	259							
25	213	336	284							
30	232	363	313							
35	253	385	349							
40	272	399	357							
45	293	411	427							
50	312	421	460							
55	332	439	500							
60	352	439	549							
65	375	493	606							
70	400	558	685							
75	439	568	728							
80	459	479	764							
85	473	491	796							
90	530	506	832							
95	561	524	875							
100	587	545	925							
105	610	564	—							
110	632	582								
115	657	592								
120	682	612								
125	705	626								
130	732	644								
135	766	662								
140	800	681								
145	829	702								
150	852	725								
155	—	749								
160		775								
165		807								
170		845								
175		889								
180		935								
185		—								
190										
195										
200										
205										
210										
215										
220										

Road:	D 415 Muruka - Kamara							Date:	04-12-2012	
Chainage	2+100	2+340	2+490	2+500	2+600	2+800	2+820	3+000	3+200	3+200
Offset	Lhs 3M	Centre	3M Rhs	C/L	3M LHS	3M RHS	2 RHS	C	3M LHS	3M RHS
	Test no 2nd									
No of blows									X	X
0	76	82	78	75	76	78	72	78	85	90
5	105	131	97	98	102	130	97	110	112	113
10	134	154	120	119	130	182	125	165	134	122
15	177	184	142	137	157	256	162	145	154	131
20	224	224	168	156	191	498	204	216	172	139
25	261	236	195	173	240	602	248	235	190	149
30	294	261	221	190	288	684	281	264	204	165
35	324	290	254	209	341	755	364	263	215	180
40	362	335	290	229	384	825	370	288	225	197
45	385	357	317	246	410	900	410	296	232	215
50	414	381	342	265	437	12	437	291	245	234
55	437	403	367	281	463		466	304	257	263
60	457	421	391	301	491		502	310	269	302
65	476	437	420	322	525		549	317	280	327
70	496	453	449	349	565		602	326	290	345
75	516	467	480	383	603		667	336	301	362
80	536	479	513	417	642		734	345	309	378
85	560	491	553	440	696		802	353	317	390
90	587	504	600	457	720		871	359	325	402
95	615	516	656	479	773		942	365	330	413
100	647	530	722	490	831			376	335	425
105	683	544	798	506	918			388	340	435
110	730	561	879	520				400	345	443
115	779	580		535				410		452
120	832	597		549				422		464
125	895	615		560				433		472
130	L	631		575				446		480
135		647		590				458		488
140		664		602				470		496
145		682		617				484		505
150		700		632				500		512
155		721		652				515		520
160		743		672				540		530
165		770		692				561		537
170		799		710				584		545
175		835		729				604		553
180		873		741				635		562
185		926		753				645		570
190				763				700		579
195				773				721		588
200				782				750		599
205				791				812		610
210				804				904		621
215				814						634
220				824						647

Road:	D45 Muruka – Kam							Date:	04.12.12	
Chainage	3+720	3+500	3+260	3+040	4+100	4+160	4+300	4+300	4+500	A+700
Offset	2m LHS	℄	2m RHS	2m LHS	℄	2m RHS	℄	LHS 2m	RHS 2m	2m LHS
	Test no									
No of blows					X		X			
0	77.	82.	82.	85.	82.	82.	80	86.	100.	83.
5	105.	120.	119.	107.	98	129.	111	123	121.	111.
10	155.	187.	160.	141.	116	170.	143	174	145.	154
15	252.	253.	240.	177.	128	197.	170	264.	182.	225.
20	324.	297.	326.	214.	151	221.	195	340	214	300.
25	359.	322.	362.	246.	167	248.	217	377.	246	352.
30	390.	334.	392.	278.	188	278.	237	407.	281.	400.
35	424.	345.	423.	301.	216	303.	272	430.	319.	431.
40	462.	354.	459.	323.	172	325.	296	455.	354.	467.
45	500.	362.	500.	339.	150	348.	282	473.	381.	485.
50	548.	373.	543.	357.	131	377.	292	490.	403.	523.
55	605.	380.	605.	376.	299	408.	305	512.	433.	567.
60	672.	388.	672.	395.	316	441.	317	534	465.	620.
65	734.	396.	734.	411.	335	476.	330	560.	489.	686.
70	854.	402.	864.	422.	357	525.	339	590.	513.	769.
75	930.	408.	944.	436.	371	570.	352	622.	538.	870.
80		417.		447.	384	550.	360	662.	566.	987.
85		427.		459.	399	565.	371	708.	599.	
90		435.		473.	408	581.	383.	754.	632.	
95		443.		485.	423	597.	394.	812.	673.	
100		452.		500.	429	615.	402.	875.	720.	
105		462.		512.	443	639.	412.	953.	770.	
110		471.		529.	460	650.	422.		821.	
115		481.		546.	469	669.	430.		880.	
120		492.		562.	485	687.	441.		940.	
125		503.		582.	503	716.	452.			
130		514.		605.	519	743.	460.			
135		528.		627.	535	774.	471.			
140		545.		655.	550	797.	481.			
145		570.		690.	565	821.				
150		598.		729.	576	847.				
155		629.		774.	595	875.				
160		663.		824.	600	904.				
165		701.		875.						
170		743.		931.						
175		794.								
180		826.								
185		873.								
190		932.								
195										
200										
205										
210										
215										
220										

Road:	D415 - Mugunda - Kandara							Date:	26/12/12	
Chainage	4+900	5+100	5+300	5+500	5+700	5+900	6+100	6+300	6+400	6+600
Offset	3 RHS	2.5 L	2.0 R	℄	2.0 Lft	3.0 RHS	℄	3 RHS	2.0 RHS	2.0 RHS
	Test no									
No of blows									X	
0	80.	99.	83.	79.	75.	96.	96.	88.	90.	88.
5	99.	125.	103.	94.	94.	114.	114.	109.	107.	108.
10	128.	144	121.	110.	110.	124.	134.	130.	121	132.
15	182.	177.	138.	126.	137.	138.	156.	169.	139	167.
20	248.	263.	156.	142.	152.	154.	176.	232.	160	204.
25	306.	427.	175.	155.	172.	176.	197.	319.	185	234.
30	342.	485.	194.	169.	194.	186.	218.	385.	205	259.
35	370.	537.	220.	183.	213.	206.	238.	442.	220	275.
40	397.	592.	244.	200.	225.	224.	258.	495.	232.	289.
45	423.	634.	268.	224.	254.	246.	279.	537.	245	301.
50	457.	676.	285.	248.	276.	266.	297.	580.	255	316.
55	480.	722.	299.	275.	289.	290.	310.	625.	269	332.
60	514.	770.	310.	304.	304.	308.	324.	686.	280	353.
65	554.	822.	321.	328.	316.	321.	336.	758.	294	372.
70	599.	881.	329.	344.	332.	332.	348.	835.	306	397.
75	647.	955.	340.	355.	345.	346.	360.	920.	319	420.
80	697.		348.	365.	358.	357.	372.		323	436.
85	754.		359.	375.	370.	372.	385.		346	452.
90	814.		370.	383.	381.	385.	398.		358	466.
95	876.		378.	391.	394.	400.	410.		370	479.
100	940.		388.	400.	405.	415.	425.		380	492.
105			400.	409.	419.	434.	439.		390	509.
110			410.	420.	431.	454.	456.		400	523.
115			423.	428.	445.	477.	475.		409	539.
120			434.	438.	468.	501.	500.		417	559.
125			446.	449.	480.	526.	524.		426.	580.
130			460.	460.	502.	556.	557.		435	603.
135			477.	471.	524.	589.	595.		443	627.
140			493.	483.	552.	622.	631.		452.	655.
145			512.	497.	582.	663.	668.		460	685.
150			535.	511.	615.	706.	700.		469	719.
155			557.	528.	652.	752.	734.		479	751.
160			586.	549.	690.	807.	775.		488	785.
165			615.	572.	735.	880.	811.		496.	819.
170			646.	595.	778.	941.	851.		504.	854.
175			684.	622.	823.		889.		513	893.
180			724.	649.	875.				523	
185			776.	680.						
190			829.	715.						
195			880.	755.						
200			935.	794.						
205				835.						
210				879.						
215										
220										

Annex 3: DCP test positions



Aborted tests