Development of Pavement Design Standards for Low-Volume Roads in Ethiopia

AFCAP/ETH/005/A

Assosa – Kurmuk Laterite Base Trials: Baseline Monitoring Report

Report No. CPR 1577

A. Otto
P.A.K. Greening

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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.

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The behaviour of Laterites varies significantly from other natural materials of high plasticity. The plasticity of laterite contributes significantly to strength upon drying back by acting as "cement" to the nodules.
The site on Assosa-Kurmuk road was constructed to demonstrate this principle as well as to investigate the influence of sealed or unsealed shoulders on wheel path moisture and strength both in cut and fill.
The results from long term monitoring should provide information that can update current practice in the use of neat natural bases as well as on the use of sealed and unsealed shoulders.

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1 Introduction

1.1 Background

The demonstration/research section on the Assosa-Kurmuk road in Ethiopia is a project in which the Ethiopia Road Authority are collaborating with TRL under the DFID-funded African Community Access Programme (AFCAP), which has the main goal of providing safe and sustainable access for poor communities in Africa. Revised manuals have been produced under the Ethiopia component of AFCAP which reflect current knowledge and practice and provide practitioners in Ethiopia with a wider choice in the design and construction of rural roads based on results of successful research.

Included in AFCAP are projects primarily aimed at demonstrating the benefits from the application of research-based evidence on pavement design standards together with country-specific research aimed at solving problems in the transport sector in Ethiopia. A fuller description of the project is contained in the Construction report.

The project described in this report is part demonstration and part research in that it builds on previous research in other countries whilst providing additional information on in-situ moisture sensitivity for some of the lateritic material found in Ethiopia.

1.2 Initial survey

Construction of the demonstration/research project was completed in April 2012 and this report is a record of the baseline data collection exercise, which together with the collection of further time series data will enable performance of the section to be monitored. Analysis of the performance data will enable the Ethiopia Road Authority to confirm or refine the 'Low Volume Roads' design manual.

Analysis of some of the results of the data collected in this survey has been carried and relationships produced as examples only of the type of analysis that might yield information when more data are available. There is little significance of relationships derived from one set of measurements.

2 Technical Summary of Baseline Data on Assosa – Kurmuk Site

2.1 Sections

The demonstration and research sections are as shown in Table 2.1. The embankments are up to 10m high whereas the cuts are up to 6m high.

Table 2.1 ERA Research Directorate sections on Assosa-Kurmuk Road

Chainages	Length (m)	Shoulders	Location
Section 1: 49+140 - 49+225	85	Unsealed	Cut
Section 2: 49+225 - 49+275	50	Unsealed	Fill
Section 3: 49+275 - 49+460	185	Sealed	Fill
Section 4: 49+460 - 49+545	85	Sealed	Cut
Section 5: 49+545 - 49+650	105	Unsealed	Cut
Section 6: 49+650 - 49+760	110	Sealed	Fill
Section 7: 49+760 - 49+970	210	Unsealed	Fill
Total	830		

2.2 Measurement points

The points where regular measurements will be made are shown in Table 2.2. There are four cross-sections where strength and moisture profiles will be measured seasonally. Two cross-sections in cut and two cross-sections in fill. Each monitoring period, at these four cross-sections, measurements will be made 1.2m longitudinal away from the previous measurement points.

Table 2.2 Measurement points for the sections

Section 1: 49+140-49+225	**Position Remark**	**Tests**
49+150	Fixed (Non-Dest)	R, DF
49+170	Fixed (Non-Dest)	R, DF
49+190	Fixed (Non-Dest)	R, DF
49+200	Fixed (Non-Dest)	R, DF
49+210	Fixed (Non-Dest)	R, DF
49+220	Fixed (Non-Dest)	R, DF
Section 2: 49+225-49+275		
49+230	Fixed (Non-Dest)	R, DF
49+250	Fixed (Non-Dest)	R, DF
49+270	Fixed (Non-Dest)	R, DF
Section 3: 49+275-49+460	**Position Remark**	**Tests**
49+280	Fixed (Non-Dest)	R, DF
49+300	Fixed (Non-Dest)	R, DF
49+320	Fixed (Non-Dest)	R, DF
49+340	Fixed (Non-Dest)	R,DF,DCP,MC
49+360	Variable (Dest)	R, DF
49+380	Fixed (Non-Dest)	R, DF
49+400	Fixed (Non-Dest)	R, DF
49+420	Fixed (Non-Dest)	R, DF
49+440	Fixed (Non-Dest)	R, DF
Section 4: 49+460-49+545		
49+460	Fixed (Non-Dest)	R, DF
49+480	Fixed (Non-Dest)	R, DF
49+500	Fixed (Non-Dest)	R, DF
49+510	Variable (Dest)	R, DF
49+520	Fixed (Non-Dest)	R,DF,DCP,MC
49+540	Fixed (Non-Dest)	R, DF
Section 5: 49+545-49+650		
49+560	Fixed (Non-Dest)	R,DF,DCP,MC, BS
49+570	Fixed (Non-Dest)	R, DF
49+580	Fixed (Non-Dest)	R, DF
49+600	Variable (Dest)	R, DF
49+620	Fixed (Non-Dest)	R, DF
49+640	Fixed (Non-Dest)	R, DF
Section 6: 49+650-49+760		
49+660	Fixed (Non-Dest)	R, DF
49+700	Fixed (Non-Dest)	R, DF
49+740	Fixed (Non-Dest)	R, DF
Section 7: 49+760-49+970		
49+780	Fixed (Non-Dest)	R,DF,DCP,MC
49+820	Fixed (Non-Dest)	R, DF
49+840	Fixed (Non-Dest)	R, DF
49+860	Variable (Dest)	R, DF

Notes

R: Rutting (maximum value by 1.8m or 2m straight edge), placed on tip of mark 0.5m from lane edge

DF: Deflection measured by Benkelman Beam on outer wheel tracks estimated to be at 1m from the edge

DCP: DCP, these are done at the same MC points

MC: Moisture contents are measured for the base on both sides of the centreline at; 0, 2.5, 3.0, 4.0, and 4.5m

BS: Bulk samples are taken for sieve analysis gradation

2.3 Rutting and deflections

Rutting is a measure of how well the pavement layers are able to withstand deformation stresses induced by traffic under the existing environmental conditions of moisture and temperature. One of the symptoms of pavement deterioration is a change in the depth of a rut in the vehicle wheel paths, especially in the outer wheel path under which the pavement might be subjected to moisture ingress.

Indications of early rutting may be due to the initial densification/consolidation of the pavement layers, construction irregularities or from construction traffic. It is therefore important to capture the baseline rut depths as soon as possible after construction to allow for these initial factors and then to determine any increase in rutting caused by normal traffic in subsequent monitoring surveys.

The Rut depths together with deflection measurements are shown in table 2.3. The average rut depths range between 4mm and 6mm which are low and as expected are well below the critical level of 20mm. Traffic on this road is currently low and in these circumstances, traffic tends to meander across the road and wheel paths are less well defined. Thus in this early stage of trafficking and most traffic seemed to drive within the centre of the road.

Deflections are used to compute the stiffness of pavements and are proxy for the stiffness value of the pavement with low deflections corresponding to high stiffness. The values shown in Table 2.3 are low and therefore represent high stiffness. The deflections where measured using a Benkelman beam with a truck with rear axle load of 9200kg and tyre pressures of 650kPa. The values shown in Table 2.3 have been normalised to 8160Kg load (the standard value). Proof that the rut depths are not resulting from pavement strength/weakness at this stage is shown in Figure 2.1 and Figure 2.2, which show no correlation between the rut depth and the deflections. The same figures show the kind of analysis that will be done after each monitoring to identify any relationship or trends that may be occurring. As shown in the same figures, at this early stage after construction no relationship between these variables can be expected.

Deflections will be measured both in the rainy season and dry season at the same points to check for any significant changes in stiffness between the seasons.

Table 2.3 Rut depth and deflection values

Section 1: 49+140-49+225	Shoulder	LHS "Rut Depth" (mm)	LHS Deflection (mm^{-2})	RHS Deflection (mm^{-2})	RHS "Rut Depth" (mm)
49+150	Unsealed, Cut	3	37	40	9
49+170		6	36	27	6
49+190		5	33	42	5
49+200		5	33	18	14
49+210		9	35	28	4
49+220		6	20	26	7
Average		**6**	**33**	**30**	**8**
Section 2: 49+225-49+275	**Shoulder**	**LHS "Rut Depth" (mm)**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**	**RHS "Rut Depth" (mm)**
49+230	Unsealed, Fill	5	18	30	6
49+250		7	47	34	6
49+270		11	20	28	5
Average		**8**	**28**	**31**	**6**
Section 3: 49+275-49+460	**Shoulder**	**LHS "Rut Depth" (mm)**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**	**RHS "Rut Depth" (mm)**
49+280	Sealed, Fill	7	13	22	5
49+300		5	22	35	6
49+320		3	29	13	5
49+340		2	15	44	4
49+360		2	33	40	5
49+380		10	27	23	4
49+400		2	30	20	5
49+420		2	39	16	5
49+440		4	22	27	5
Average		**4**	**26**	**27**	**5**
Section 4: 49+460-49+545	**Shoulder**	**LHS "Rut Depth" (mm)**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**	**RHS "Rut Depth" (mm)**
49+460	Sealed, Cut	7	29	27	6
49+480		9	26	29	4
49+500		3	27	29	8
49+510		6	18	30	3
49+520		8	35	25	4
49+540		5	44	42	6
Average		**6**	**30**	**30**	**5**
Section 5: 49+545-49+650	**Shoulder**	**LHS "Rut Depth" (mm)**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**	**RHS "Rut Depth" (mm)**
49+560	Unsealed, Cut	9	46	23	7
49+570		2	34	13	5
49+580		2	34	13	5
49+600		2	35	19	3
49+620		3	30	31	4
49+640		6	40	18	9
Average		**4**	**36**	**20**	**6**
Section 6: 49+650-49+760	**Shoulder**	**LHS "Rut Depth" (mm)**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**	**RHS "Rut Depth" (mm)**
49+660	Sealed, Fill	5	44	37	9
49+700		3	43	49	8
49+740		3	28	49	6
Average		**4**	**39**	**45**	**8**
Section 7: 49+760-49+970	**Shoulder**	**LHS "Rut Depth" (mm)**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**	**RHS "Rut Depth" (mm)**
49+780	Unsealed, Fill	2	35	41	2
49+820		4	25	22	6
49+840		4	39	24	6
49+860		7	35	29	6
Average		**4**	**33**	**29**	**5**

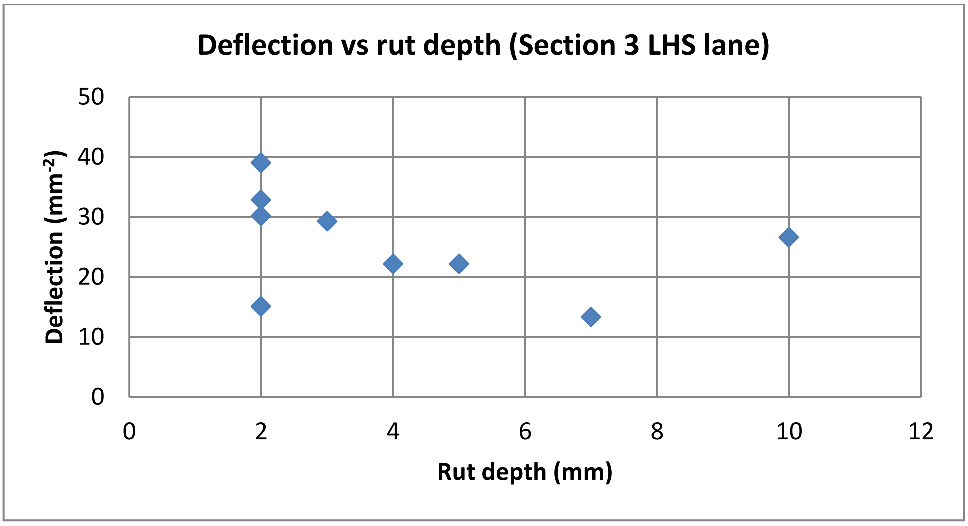

Figure 2-1 Correlation of rut depth with deflection on LHS lane

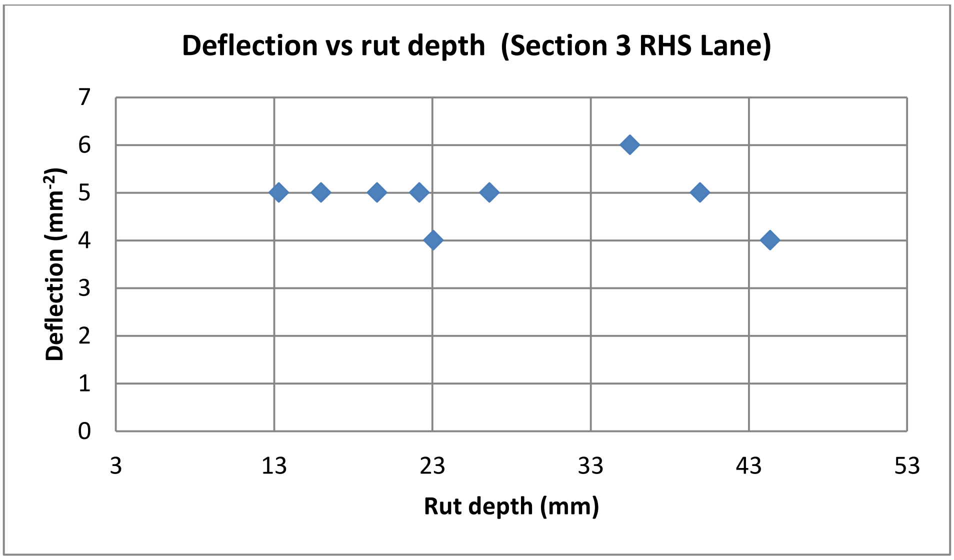

Figure 2-2 Correlation of rut depth with deflection on RHS lane

2.4 Rainfall

The rainfall received in the five months since the sections were constructed is presented in the table below. The station closest to the section is the Homosha station which is located at Km 39, whereas the section is located at km 49. This is within 10km of the test section and can be regarded as the representative station for the site. The amount of rainfall received is rather low compared to Assosa and Kurmuk. The change in moisture levels in the pavement will be measured.

Table 2.4 Rainfall data at areas near the site

Month 2012/ Station	May	Jun	July	Aug	Sep	Sum (mm)
Assosa	143.4	183.6	193.3	272.2	116.3	908.8
Homosha	90.5	76.6	172.3	170.3	18.5	528.2
Kurmuk	78.5	270.1	295.1	221.1	N/A	864.8

2.5 Particle Size Distribution

Compared to the ERA gradation specifications for base material, the laterite used falls out of specification before and after compaction as can be seen in Figure 2.3. This should not be a source of worry but should act to make the research aspect more interesting to check how far specifications can be relaxed for laterites.

The laterite however falls within gradation specifications for sub-bases as seen in Figure 2.4, both before and after compaction.

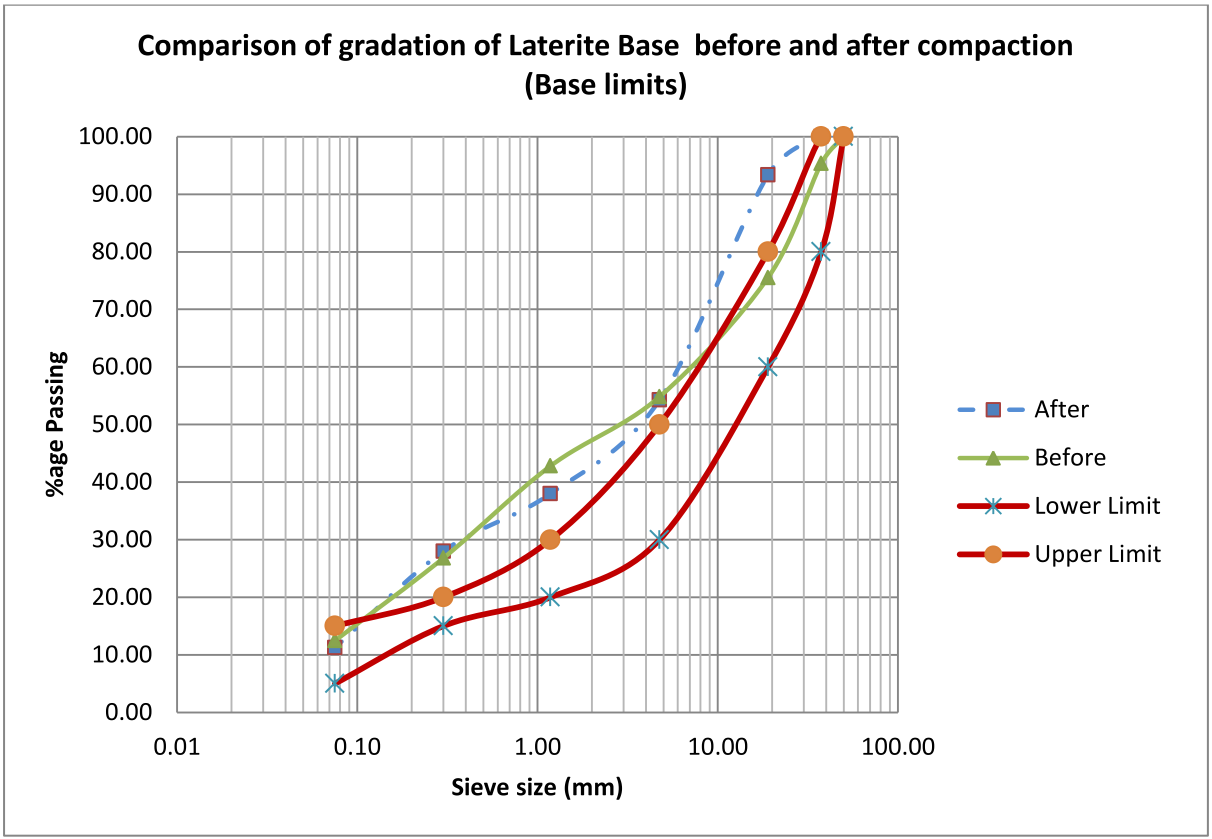

Figure 2-3 Gradation of laterite base as compared to the designed base specifications

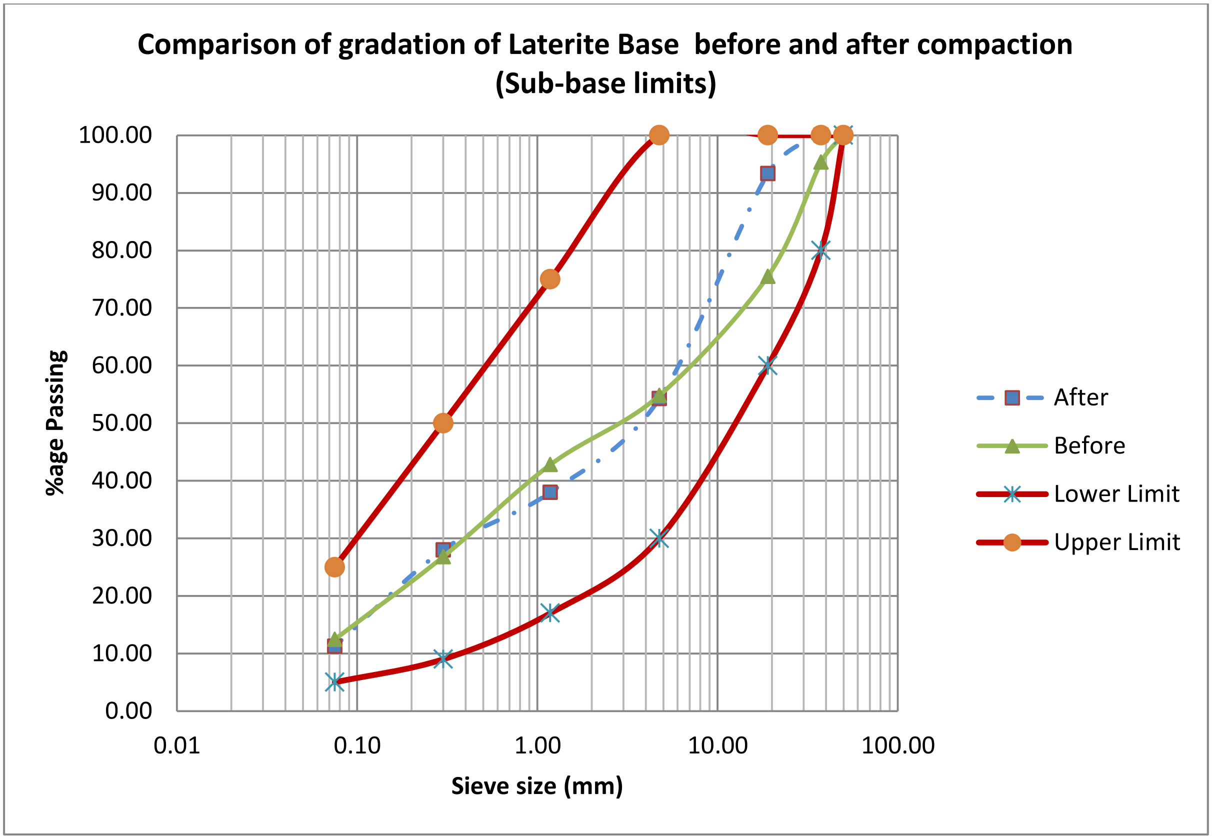

Figure 2-4 Gradation of laterite base as compared to the designed sub-base specifications

2.6 Axle Load Counts

The axle load summary is shown in Table 2.5 below. Another axle load survey is required because of the small size of the sample that was surveyed during the baseline monitoring.

The pavement was, however, subjected to abnormally high loading of about 120ESAs per day for about 2 months when crushed stone base material was being transported to Kurmuk and moreover, this was during the rainy season.

2.7 Moisture

From the charts shown in Figure 2.5 and Figure 2.6 it can be seen i) that the moisture levels in all the four profiles are similar albeit with minor variations, ii) that the variations in moisture levels between sealed and unsealed shoulders is higher in fills than in cuts. It is advisable not to make any conclusions at this stage until at least 4 monitoring surveys including the dry season surveys.

Table 2.5 Axle loading on Assosa – Kurmuk road

Vehicle Category	Configuration	Number Surveyed	Estimated Vehicles per day	Average ESA per vehicle	Estimated ESA/day
Small Truck	1.2	15	8	0.0009	0.0072
Medium Bus	1.2	3	8	0.057	0.456
Medium Truck	1.2	3	12	0.027	0.324
Heavy Truck	1.2	1	4	1.78	7.12
Heavy Truck	1.2.2	1	4	0.47	1.88
Total		23	36		**10**

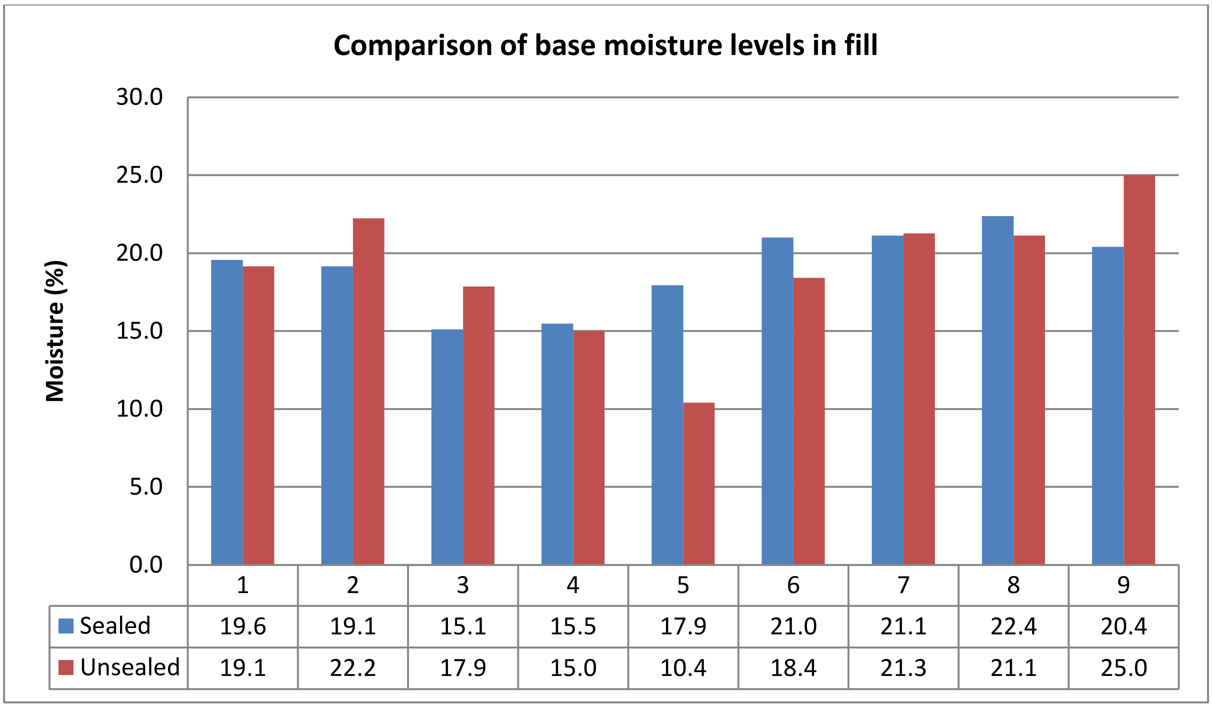

Figure 2-5 Moisture comparison in Fill

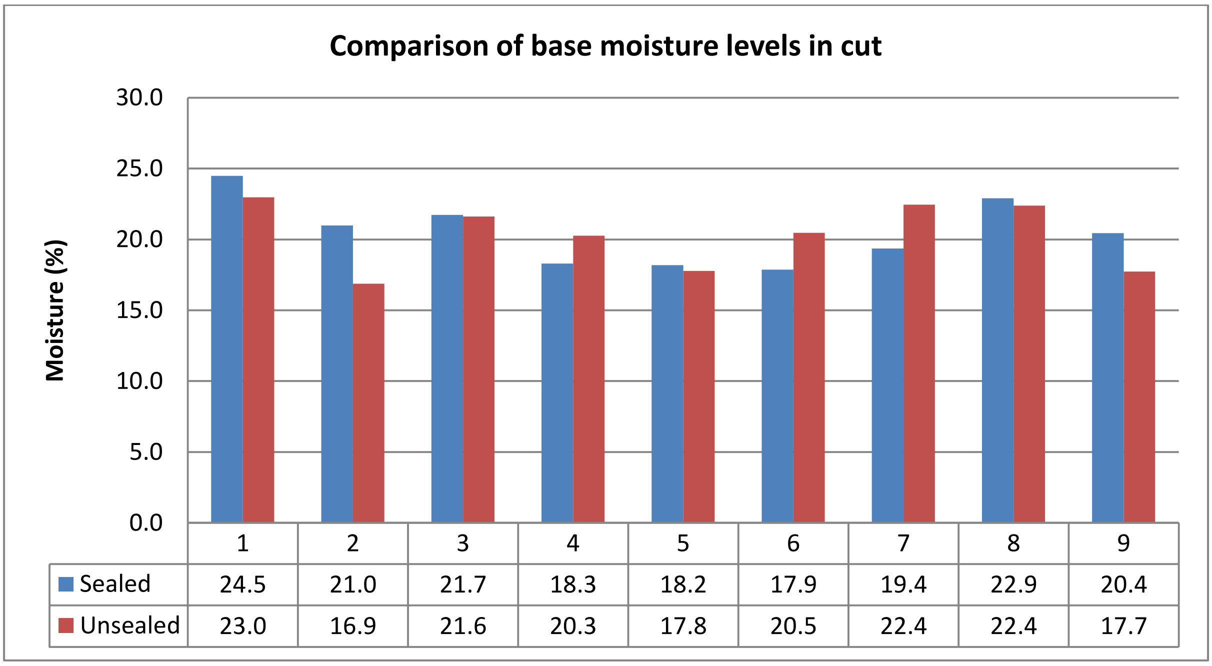

Figure 2-6 Moisture comparison in Cut

2.8 In-situ Strength (DCP Method)

Table 2.6 shows the moisture content and corresponding DCP CBR values of the base layer at points measured along the four cross-section profiles chosen for the study. It can be noted that the strengths (CBRs) are higher in the fill than in the cut; and that for sealed shoulders in fill, the difference in strength between the centre value and the values up to 3m away from the centre (2m away from the shoulder edge) is lower than the difference in values in fill with unsealed shoulders.

In cut, there is not much difference in strength between corresponding values in unsealed and sealed shoulders.

No conclusion should be drawn until at least 4 monitoring surveys have been undertaken, at which time trends may be starting to emerge as the pavement begins to settle down to an equilibrium state. The results shown here are included as an example of the analysis that can be undertaken at a later stage.

Table 2.6 Cross section profiles of DCP CBR and Moisture in the base

Sections in Fill									
Offsets	-4.5	-4.0	-3.0	-2.5	0.0	+2.5	+3.0	+4.0	+4.5
Moisture: 49+340 (Sealed Shoulder Fill)	19.6	19.1	15.1	15.5	17.9	21.0	21.1	22.4	20.4
DCP CBR: 49+340 (Sealed Shoulder Fill)	17.0	22.0	71.0	76.0	81.0	33.0	23.0	23.0	19.0
Moisture: 49+780 (UnSealed Shoulder Fill)	19.1	22.2	17.9	15.0	10.4	18.4	21.3	21.1	25.0
DCP CBR: 49+780 (UnSealed Shoulder Fill)	28.0	31.0	24.0	44.0	87.0	22.0	23.0	21.0	20.0
Sections in Cut									
Offsets	-4.5	-4.0	-3.0	-2.5	0.0	+2.5	+3.0	+4.0	+4.5
Moisture: 49+520 (Sealed Shoulder Cut)	24.5	21.0	21.7	18.3	18.2	17.9	19.4	22.9	20.4
DCP CBR: 49+520 (Sealed Shoulder Cut)	21.0	21.0	45.0	49.0	55.0	49.0	25.0	21.0	19.0
Moisture: 49+560 (UnSealed Shoulder Cut)	23.0	16.9	21.6	20.3	17.8	20.5	22.4	22.4	17.7
DCP CBR: 49+560 (UnSealed Shoulder Cut)	26.0	32.0	32.0	31.0	58.0	39.0	25.0	25.0	30.0

Figure 2-7, Figure 2-8, Figure 2-9, and Figure 2-10 show the graphical relationships between in-situ CBR and the moisture content for the four study profiles. It can be seen that the relationships bear resemblance to that derived in the laboratory (refer to design and construction report).

The graphs representing the profiles in fill show steeper gradients than the profiles in cut. This means there is higher moisture variation across the road profile in fill than in cut. More conclusions will be drawn after subsequent surveys.

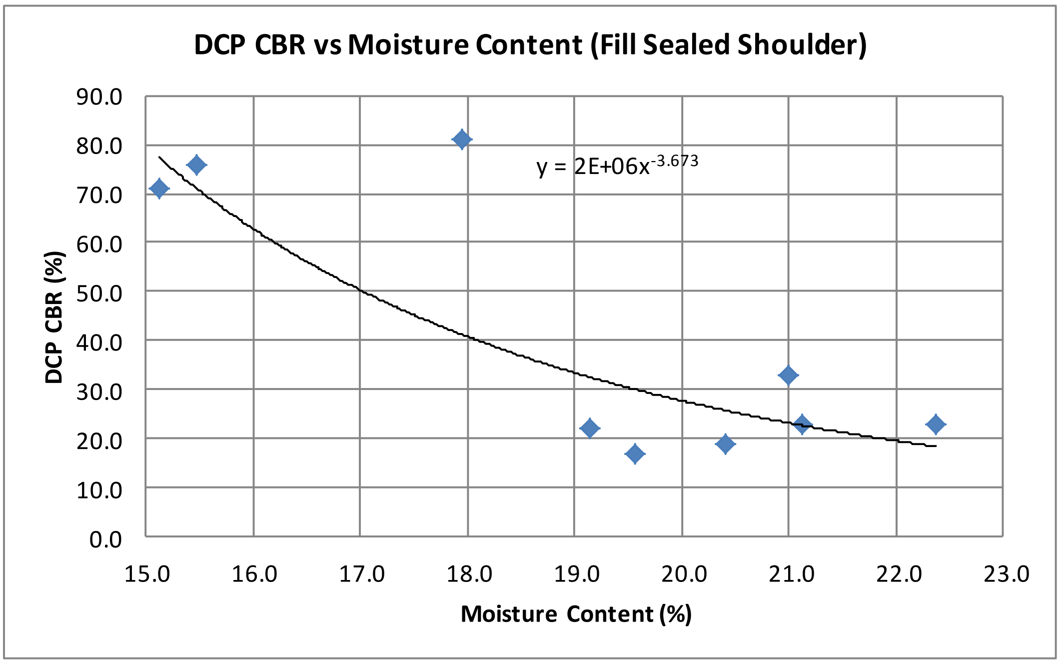

Figure 2-7 DCP CBR – Moisture relationship in Fill with sealed shoulders

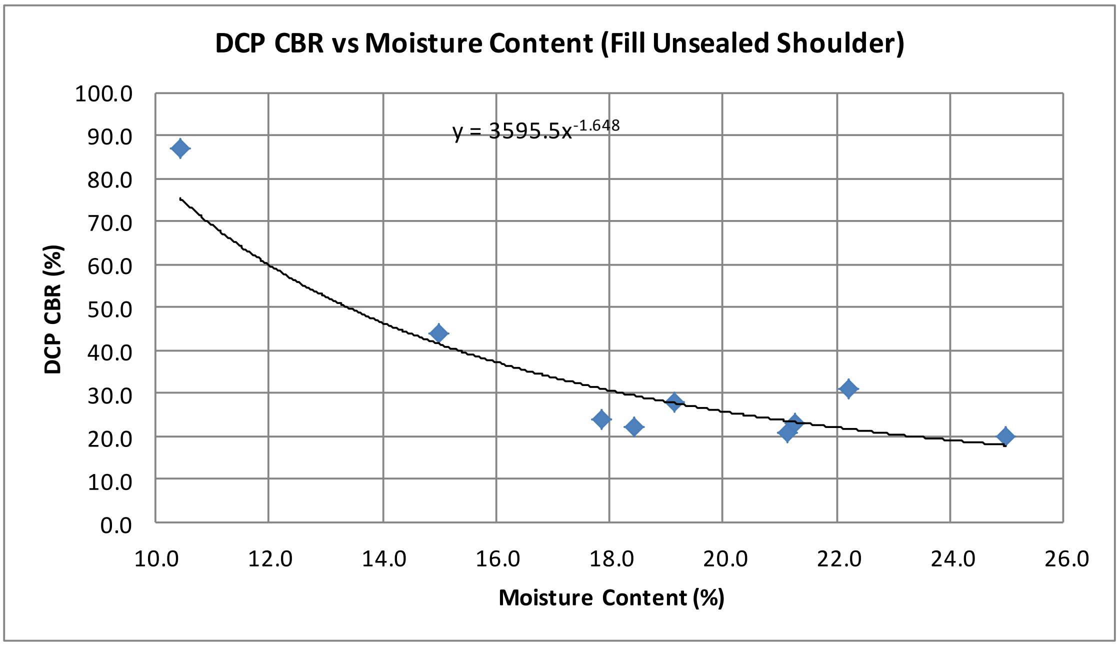

Figure 2-8 DCP CBR – Moisture relationship in Fill with unsealed shoulders

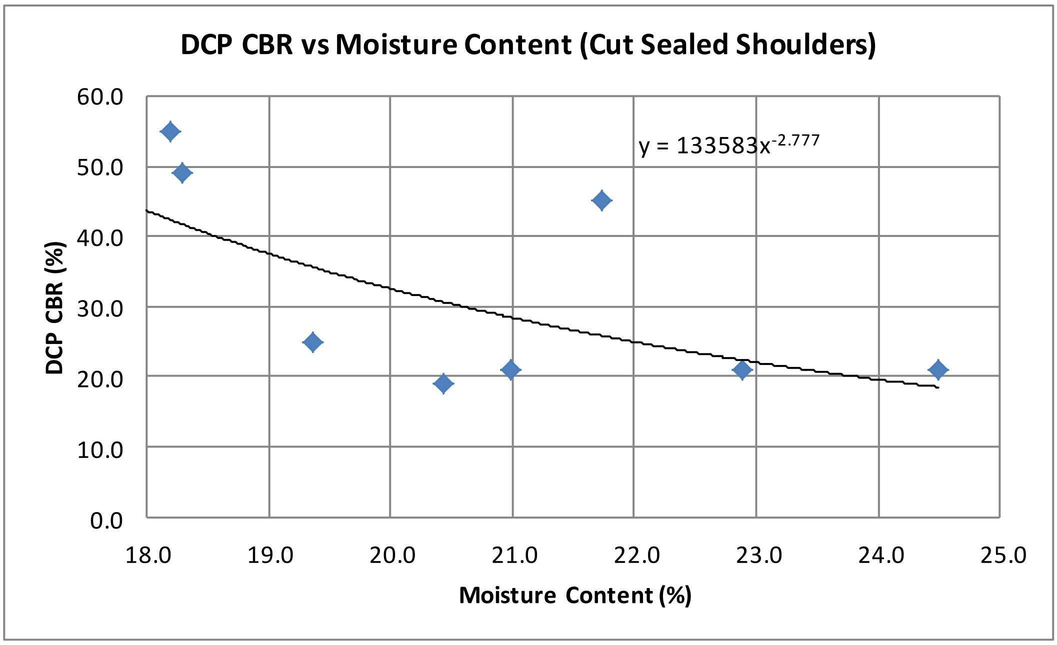

Figure 2-9 DCP CBR – Moisture relationship in Cut with sealed shoulders

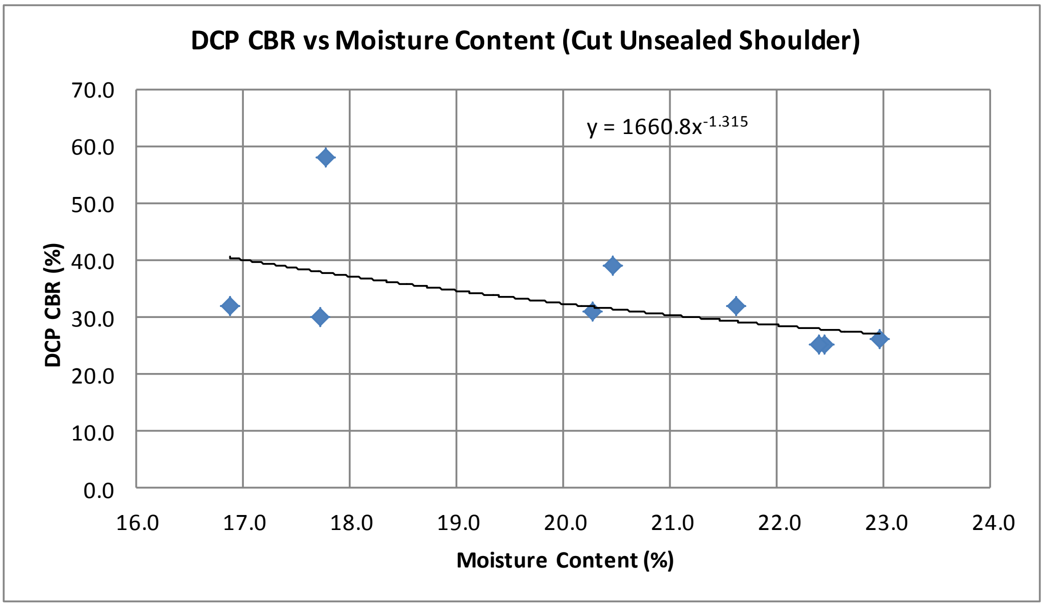

Figure 2-10 DCP CBR – Moisture relationship in Cut with unsealed shoulders

2.9 Other points to note

1. The spillage of petroleum products on the surfacing seems to be rampant and may adversely affect the seal. Unfortunately enforcement for this kind of practice cannot be easily managed.
2. Bleeding on the inner side of the curve on one wheel path for about 10m has been observed. This has occurred due to the tendency of drivers in both directions to use the

inner lane on curves. The consultant has instructed the contractor to correct bleeding along the whole road.

3. The next monitoring is scheduled for February or March 2013 and will focus on the measurement of Moisture profiles, DCPs, Rutting and Deflection.
4. Once the defects liability period ends for the main contract, monitoring has to be done on the standard road construction with a crushed stone base. Sections that are in cut and fill similar to the laterite sections have to be chosen and studied in a similar way.

Figure 2-11 Short length of bleeding on the inner lane of a curve

Figure 2-12 Spillage of petroleum products on the surfacing

Figure 2-13 More spillage of petroleum products

Figure 2-14 A section of the road with sealed shoulders

APPENDICES

Appendix 1

Rut Depth Forms

Project:	Ethiopia AFCAP Demos			Sheet:	Survey No.:	1
Province:	Benshangul Gumuz			Surveyor:	Asmera	
Road Name:	Assosa-Kurmuk			Date:	23/10/2012	
Section:			Direction of counting on each		Assosa-Kurmuk	
Chainage:	49+150					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			3			9
Chainage:	49+170					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			6			6
Chainage:	49+190					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			5			5
Chainage:	49+200					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			5			14
Chainage:	49+210					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			9			4

Chainage:	49+220					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			6			7

Chainage:	49+230					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			5			6

Chainage:	49+250					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			7			6

Chainage:	49+270					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			11			5

Chainage:	49+280					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			7			5

Chainage:	49+300					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			5			6

Chainage:	49+320					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			3			5
Chainage:	49+340					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			4
Chainage:	49+360					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			5
Chainage:	49+380					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			10			4
Chainage:	49+400					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			5
Chainage:	49+420					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			5
Chainage:	49+440					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			4			5

Chainage:	49+460					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			7			6

Chainage:	49+480					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			9			4

Chainage:	49+500					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			3			8

Chainage:	49+510					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			6			3

Chainage:	49+520					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			8			4

Chainage:	49+540					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			5			6

Chainage:	49+560					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			9			7

Chainage:	49+580					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			5

Chainage:	49+600					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			3

Chainage:	49+620					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			3			4

Chainage:	49+640					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			6			9

Chainage:	49+660					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			5			9

Chainage:	49+700					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			3			8

Chainage:	49+740					
Lane:	LEFT			RIGHT		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			3			6

Chainage:	49+780					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			2			2

Chainage:	49+820					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			4			6

Chainage:	49+840					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			4			6

Chainage:	49+860					
Lane:	**LEFT**			**RIGHT**		
Location	Outer Wheelpath	Inner Wheelpath		Outer Wheelpath	Inner Wheelpath	
Reading (mm):			7			6

Appendix 2:

Measured Deflections (Not Standardised)

Section 1: 49+140-49+225	Shoulder	LHS Deflection (mm^{-2})	RHS Deflection (mm^{-2})
49+150	Unsealed, Cut	37	40
49+170		36	27
49+190		33	42
49+200		33	18
49+210		35	28
49+220		20	26
Average		**33**	**30**
Section 2: 49+225-49+275	**Shoulder**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**
49+230	Unsealed, Fill	18	30
49+250		47	34
49+270		20	28
Average		**28**	**31**
Section 3: 49+275-49+460	**Shoulder**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**
49+280	Sealed, Fill	13	22
49+300		22	35
49+320		29	13
49+340		15	44
49+360		33	40
49+380		27	23
49+400		30	20
49+420		39	16
49+440		22	27
Average		**26**	**27**
Section 4: 49+460-49+545	**Shoulder**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**
49+460	Sealed, Cut	29	27
49+480		26	29
49+500		27	29
49+510		18	30
49+520		35	25
49+540		44	42
Average		**30**	**30**
Section 5: 49+545-49+650	**Shoulder**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**
49+560	Unsealed, Cut	46	23
49+570		34	13
49+580		34	13
49+600		35	19
49+620		30	31
49+640		40	18
Average		**36**	**20**
Section 6: 49+650-49+760	**Shoulder**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**
49+660	Sealed, Fill	44	37
49+700		43	49
49+740		28	49
Average		**39**	**45**
Section 7: 49+760-49+970	**Shoulder**	**LHS Deflection (mm^{-2})**	**RHS Deflection (mm^{-2})**
49+780	Unsealed, Fill	35	41
49+820		25	22
49+840		39	24
49+860		35	29
Average		**33**	**29**

Rainfall Data (2012)

Rainfall for Assosa Meteorology Station (2012)					
M/D	May	Jun	July	Aug	Sep
1	0	11	11.8	1	0
2	0	14.3	3	11.2	1
3	0	R	R	1	10
4	0	4.3	4.8	2.5	TR
5	0	21.5	0	22.5	5.1
6	0	8.2	22.2	4.8	9.6
7	5	0	11.1	7.8	1.6
8	6.5	0	0.2	5.1	0
9	0	18.6	4.7	10	10
10	14.5	0	5.3	27.1	4.5
11	1.7	2.2	6.8	1.5	2.2
12	1.9	0.9	0	15.5	0
13	1.2	0	19.5	9.1	23
14	13.5	0	24.8	1.5	16
15	0	9.1	0.7	19	3.1
16	1.8	14.6	TR	1.5	0
17	2.2	1.5	8	TR	15.1
18	TR	2	3.6	32.5	0
19	4.9	0.4	0	16.4	0
20	7.4	12.9	0	1.9	0
21	4.4	0.8	TR	4.6	0
22	8.8	21.5	13	11.3	0.5
23	27.5	TR	12.8	0	2.8
24	0	8.6	1.8	18.1	3.4
25	26.6	21.8	30	4.1	1.9
26	0	0	1.3	14.8	0
27	TR	0	4.8	0	1.5
28	9.3	0	1.2	0	0
29	6.2	9.4	1.5	TR	5
30	TR	0	0	13.1	TR
31	0	-	0.4	14.3	-
Sum (mm)	143.4	183.6	193.3	272.2	116.3
Grand (mm)	908.8				

Rainfall for Homosha Meteorology Station (2012)					
M/D	May	Jun	July	Aug	Sep
1	7.8	5.7	6.7	8.7	0.0
2	0.0	0.0	14.7	4.3	0.0
3	1.5	0.2	1.0	7.1	0.7
4	18.5	0.0	0.0	0.0	0.0
5	0.0	10.8	18.7	14.5	0.0
6	0.0	5.4	7.2	13.7	0.0
7	7.9	0.0	0.0	11.5	5.9
8	0.0	0.0	0.0	7.6	0.0
9	0.0	0.0	13.7	0.0	6.0
10	15.4	0.0	0.0	10.5	0.0
11	0.0	8.2	0.0	0.0	0.0
12	0.0	9.5	17.1	0.0	0.0
13	0.0	0.0	0.0	16.5	0.0
14	10.5	0.0	0.0	0.0	0.0
15	0.1	9.7	0.1	6.0	0.1
16	0.0	0.0	20.2	0.0	0.0
17	7.6	0.0	18.4	0.0	0.0
18	3.2	10.5	0.0	3.5	5.8
19	0.0	0.0	3.4	8.6	0.0
20	0.0	0.0	0.0	0.0	0.0
21	5.0	7.6	0.0	0.0	0.0
22	2.5	0.0	0.0	5.7	0.0
23	3.0	0.0	0.0	0.0	0.0
24	0.0	0.0	6.8	0.0	0.0
25	0.0	0.0	0.0	10.6	0.0
26	4.0	9.0	17.4	0.0	0.0
27	0.0	0.0	5.7	0.0	0.0
28	0.5	0.0	13.0	0.5	0.0
29	0.0	0.0	0.0	13.0	0.0
30	0.0	0.0	0.0	13.5	0.0
31	3.0	-	8.2	14.5	-
Sum (mm)	90.5	76.6	172.3	170.3	18.5
Grand (mm)	528.2				

Rainfall for Kurmuk Meteorology Station (2012)

M/D	May	Jun	July	Aug	Sep
1	6.2	11	0	1	-
2	0	14.3	25.1	11.2	-
3	1	TR	10	1	-
4	0	4.3	0	2.5	-
5	0	21.5	0	22.5	-
6	0	8.2	6.9	4.8	-
7	0	0	0	7.8	-
8	18.6	0	0	5.1	-
9	0	18.6	15.1	10	-
10	0	0	0	17.1	-
11	0	2.2	48.6	1.5	-
12	11.3	0.9	0	15.5	-
13	0	0	0	9.1	-
14	0	0	0	1.5	-
15	0	9.1	18.5	19	-
16	0	14.6	0	1.5	-
17	0	1.5	0	TR	-
18	4.1	2	0	32.5	-
19	0	0.4	0	16.4	-
20	0	12.9	17.1	1.9	-
21	0	0.8	30.6	4.6	-
22	0	21.5	0	11.3	-
23	0	TR	28.1	0	-
24	30.8	8.6	0	18.1	-
25	0	21.8	0	4.1	-
26	0	0	66.9	0	-
27	TR	60.8	0	0	-
28	0.3	0	3.1	1.1	-
29	6.2	0	0	0	-
30	TR	35.1	25.1		
31	0			0	-
Sum (mm)	78.5	270.1	295.1	221.1	0.0
Grand (mm)	864.8				

Appendix 3

Base Moistures (Lab Data)

Chainage: 49+340 (Sealed Shoulder Fill)	-4.5	-4.0	-3.0	-2.5	0.0	+2.5	+3.0	+4.0	+4.5
Container Number	J	A1	1	41	21	C1	10	6	B1
Wt of Wet Soil Sample + Container (S_1)	67	138	115	115	58	147	104	110	75
Wt of Dry Soil Sample + Container (S_2)	58	120	102	102	51	126	89	93	65
Wt of Container (S_3)	12	26	16	18	12	26	18	17	16
Wt of Moisture (W_m) =(S_1-S_2)	9	18	13	13	7	21	15	17	10
Wt of dry Soil (W_d) = (S_2-S_3)	46	94	86	84	39	100	71	76	49
Moisture Content (m) = (W_m/W_d)*100	19.6	19.1	15.1	15.5	17.9	21.0	21.1	22.4	20.4

Chainage: 49+520 (Sealed Shoulder Cut)	-4.5	-4.0	-3.0	-2.5	0.0	+2.5	+3.0	+4.0	+4.5
Container Number	3	F1	K	G3	6	L	G1	2	B1
Wt of Wet Soil Sample + Container (S_1)	76	124	73	114	108	82	135	119	136
Wt of Dry Soil Sample + Container (S_2)	64	107	63	99	94	72	117	100	117
Wt of Container (S_3)	15	26	17	17	17	16	24	17	24
Wt of Moisture (W_m) =(S_1-S_2)	12	17	10	15	14	10	18	19	19
Wt of dry Soil (W_d) = (S_2-S_3)	49	81	46	82	77	56	93	83	93
Moisture Content (m) = (W_m/W_d)*100	24.5	21.0	21.7	18.3	18.2	17.9	19.4	22.9	20.4

Chainage: 49+560 (UnSealed Shoulder Cut)	-4.5	-4.0	-3.0	-2.5	0.0	+2.5	+3.0	+4.0	+4.5
Container Number	6.1	103	AX	O	15	102	C	15	A2
Wt of Wet Soil Sample + Container (S_1)	108	114	107	105	69	124	76	100	111
Wt of Dry Soil Sample + Container (S_2)	91	100	91	90	61	106	65	85	97
Wt of Container (S_3)	17	17	17	16	16	18	16	18	18
Wt of Moisture (W_m) =(S_1-S_2)	17	14	16	15	8	18	11	15	14
Wt of dry Soil (W_d) = (S_2-S_3)	74	83	74	74	45	88	49	67	79
Moisture Content (m) = (W_m/W_d)*100	23.0	16.9	21.6	20.3	17.8	20.5	22.4	22.4	17.7

Chainage: 49+780 (UnSealed Shoulder Fill)	-4.5	-4.0	-3.0	-2.5	0.0	+2.5	+3.0	+4.0	+4.5
Container Number	R	H1	A	P	B+	10	H	11	Q
Wt of Wet Soil Sample + Container (S_1)	71	67	78	63	65	57	69	103	63
Wt of Dry Soil Sample + Container (S_2)	62	57	68	57	60	50	59	88	53
Wt of Container (S_3)	15	12	12	17	12	12	12	17	13
Wt of Moisture (W_m) =(S_1-S_2)	9	10	10	6	5	7	10	15	10
Wt of dry Soil (W_d) = (S_2-S_3)	47	45	56	40	48	38	47	71	40
Moisture Content (m) = (W_m/W_d)*100	19.1	22.2	17.9	15.0	10.4	18.4	21.3	21.1	25.0

Appendix 3

DCP Measurements

UK DCP Test Data Sheet																		
Project name	Assosa Survey 1 49+340																	
Test number	1		2		3		4		5		6		7		8		9	
Chainage (km)	49.34		49.34		49.34		49.34		49.34		49.34		49.34		49.34		49.34	
Location	Carriageway		Carriageway		Carriageway		Carriageway		Carriageway		Shoulder		Shoulder		Shoulder		Shoulder	
Lane number	1		1		1		2		2									
Offset (m)	0		2.5		3		-3		-2.5		-4.5		-4		4		4.5	
Direction	Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk	
Zero error (mm)	85		94		100		89		93		109		98		97		100	
Test date (dd/mm/yyyy)	24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012	
Remarks																		
Layers removed	1		1		1		1		1		1		1		1		1	
Surface type	Other		Other		Other		Other		Other		Other		Other		Other		Other	
Surface moisture																		
Surface thickness (mm)	20		20		20		20		20		20		20		20		20	
Surface condition	Unknown		Unknown		Unknown		Unknown		Unknown		Unknown		Unknown		Unknown		Unknown	
Surface strength coefficient	0.1		0.1		0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Base type																		
Base thickness (mm)																		
Base condition																		
Base strength coefficient																		
	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)
	0	105	0	114	0	121	0	109	0	113	0	129	0	118	0	117	0	120
	1	111	1	128	1	134	1	115	1	120	1	143	1	132	1	131	1	140
	1	119	1	135	1	143	2	122	2	127	1	156	1	142	1	140	1	155
	2	126	1	143	1	152	2	131	2	132	1	168	1	149	1	151	1	170
	2	133	1	150	1	161	2	136	2	139	1	183	1	158	1	162	1	183
	2	139	1	158	1	170	2	141	2	146	1	196	1	167	1	170	1	195
	2	146	1	165	1	179	3	154	2	154	1	211	1	178	1	179	1	210
	2	153	1	172	1	189	3	165	2	160	1	228	1	189	1	192	1	225
	2	160	1	180	1	200	3	174	2	166	1	242	1	200	1	205	1	242
	3	170	1	189	1	211	3	184	2	173	1	255	1	211	1	222	1	259
	3	179	1	197	1	222	3	192	3	184	1	270	1	223	1	230	1	275
	3	188	1	206	1	233	3	202	3	195	1	289	1	236	1	241	1	290
	3	197	1	217	1	246	3	212	3	204	1	305	1	250	1	253	1	302
	3	207	1	226	1	260	3	224	3	204	1	322	1	265	1	265	1	313
	3	219	1	237	1	274	3	239	3	212	1	340	1	281	1	277	1	324
	3	229	1	248	1	288	2	248	3	225	1	356	1	295	1	288	1	334
	3	239	1	259	1	302	2	257	3	237	1	374	1	306	1	300	1	345
	3	251	1	270	1	315	2	270	3	251	1	390	1	316	1	319	1	355
	3	264	1	281	1	326	2	280	3	268	1	406	1	325	1	322	1	366
	3	280	1	291	1	338	2	290	3	285	1	424	1	335	1	329	1	378
	3	295	1	303	1	349	2	300	3	299	1	442	1	344	1	336	1	394
	3	309	1	315	1	361	2	307	3	311	1	463	1	352	1	345	1	417
	3	319	1	325	1	372	2	315	3	319	1	486	1	361	1	355	1	452
	3	329	1	334	1	384	2	322	3	327	1	510	1	370	1	369	1	486
	3	337	1	344	1	394	2	327	3	335	1	533	1	379	1	382	1	520
	3	346	1	353	1	405	2	333	3	341	1	556	1	389	1	400	1	558
	3	356	1	361	1	417	2	339	3	348	1	583	1	399	1	422	1	602
	3	364	1	370	1	431	2	345	3	356	1	610	1	409	1	445		
	3	373	1	381	1	449	3	352	3	362			1	421	1	481		
	3	383	1	390	1	475	3	361	3	370			1	432	1	515		
	3	393	1	400	1	516	3	370	3	377			1	444	1	555		
	3	403	1	412	1	579	3	376	3	384			1	457	1	597		
	3	413	1	425	1	626	3	384	3	390			1	473	1	632		
	3	423	1	440	1	654	3	393	3	397			1	490	1	647		
	3	435	1	460			3	402	3	404			1	510	1	660		
	3	445	1	495			3	410	3	410			1	532				
	3	456	1	535					3	419			1	556				
	3	468	1	582					3	426			1	583				
	3	481	1	625					3	434			1	610				
	3	494	1	650					3	441								
	3	508							3	449								
	3	522							3	457								
	3	535							3	467								
									3	476								
									3	487								
									3	499								
									3	513								
									3	529								
									3	545								
									3	561								
									3	578								

UK DCP Test Data Sheet																		
Project name	Assosa Survey 1 49+520																	
Test number	1		2		3		4		5		6		7		8		9	
Chainage (km)	49.52		49.52		49.52		49.52		49.52		49.52		49.52		49.52		49.52	
Location	Carriageway		Carriageway		Carriageway		Carriageway		Carriageway		Carriageway		Shoulder		Shoulder		Shoulder	
Lane number	1		1		1		2		2		2							
Offset (m)	0		2.5		3		-3.5		-3		-2.5		-4.5		4		4.5	
Direction	Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk	
Zero error (mm)	95		97		100		107		110		96		110		110		109	
Test date (dd/mm/yyyy)	24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012	
Remarks																		
Layers removed	1		1		1		1		1		1		1		1		1	
Surface type	Other		Other		Other		Other		Other		Other		Other		Other		Other	
Surface moisture																		
Surface thickness (mm)	20		20		20		20		20		20		20		20		20	
Surface condition	Unknown		Unknown		Unknown		Unknown		Unknown		Unknown		Unknown		Unknown		Unknown	
Surface strength coefficient	0.1		0.1		0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Base type																		
Base thickness (mm)																		
Base condition																		
Base strength coefficient																		
	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)
	0	115	0	117	0	121	0	127	0	131	0	116	0	130	0	130	0	129
	3	139	2	131	2	143	2	148	1	140	2	130	1	146	1	150	1	148
	3	155	2	140	2	162	2	171	1	146	2	136	1	159	1	162	1	160
	3	170	2	151	2	182	2	192	1	152	3	147	1	172	1	175	1	171
	3	186	2	161	2	204	2	215	1	157	3	159	1	185	1	187	1	186
	3	200	2	170	2	229	1	226	2	169	3	172	1	197	1	201	1	198
	3	214	2	179	2	250	1	239	2	180	3	185	1	210	1	211	1	212
	3	227	2	190	2	275	1	252	2	192	3	200	1	224	1	222	1	226
	3	240	2	201	2	293	1	268	2	206	3	216	1	235	1	235	1	241
	3	257	2	214	2	309	1	281	2	219	3	235	1	248	1	249	1	254
	3	272	2	224	2	321	1	295	2	229	3	257	1	260	1	260	1	268
	3	289	2	234	2	333	1	307	2	244	2	271	1	271	1	273	1	283
	3	305	2	249	2	346	1	321	2	258	2	281	1	278	1	286	1	296
	3	316	2	263	2	358	1	335	2	271	2	291	1	285	1	299	1	310
	3	326	2	275	2	371	1	348	2	283	2	299	1	292	1	309	1	322
	3	334	2	288	2	384	1	363	2	294	3	309	1	299	1	318	1	333
	3	349	2	296	2	396	1	376	2	305	3	320	1	305	1	326	1	344
	3	363	2	308	2	410	1	388	2	316	3	329	2	316	1	333	1	355
	3	378	2	315	2	425	1	399	2	326	3	340	2	332	1	341	1	365
	3	391	2	324	2	442	1	409	2	338	3	352	2	347	1	348	1	375
	3	405	2	333	2	457	1	418	2	348	3	364	2	365	1	356	1	385
	3	417	2	341	2	475	1	428	2	361	3	376	2	385	1	365	1	395
	3	428	2	349	2	490	1	439	2	375	3	390	2	403	1	374	1	405
	3	439	2	358	2	507	1	449	2	391	3	402	2	420	1	384	1	416
	3	448	2	366	2	524	1	460	2	402	3	415	2	438	1	395	1	427
	3	458	2	377	2	543	1	471	2	416	3	426	2	457	1	406	1	437
	3	467	2	388	2	564	1	480	2	428	3	434	2	479	1	417	1	446
	3	477	2	397	2	587	1	490	2	439	3	439	1	493	1	429	1	454
	3	488	2	407	2	614	1	500	2	450	4	446	1	507	1	442	1	463
	3	497	2	416			1	509	2	461	4	452	1	521	1	454	1	470
	3	507	2	426			1	517	2	473	4	459	1	538	1	464	1	480
	3	516	2	437			1	526	2	486	4	467	1	560	1	475	1	490
	3	528	2	446			1	536	2	500	4	476	1	580	1	486	1	500
	3	540	2	455			1	547	2	516	4	485	1	621	1	498	1	511
	3	555	2	466			1	555	2	535	4	495			1	511	1	525
	3	572	2	475			1	572	2	555	5	509			1	524	1	539
	3	589	2	485			1	586	2	584	5	522			1	535	1	554
	3	611	2	495			1	603	2	619	5	534			1	548	1	570
			2	504			1	622			4	549			1	562	1	588
			2	517							4	564			1	575	1	607
			2	530							4	580			1	589	1	627
			2	541							4	600						

UK DCP Test Data Sheet

Project name	Assosa Survey 1 49+560								
Test number	1	2	3	4	5	6	7	8	9
Chainage (km)	49.56	49.56	49.56	49.56	49.56	49.56	49.56	49.56	49.56
Location	Carriageway	Carriageway	Carriageway	Carriageway	Carriageway	Shoulder	Shoulder	Shoulder	Shoulder
Lane number	1	1	1	2	2				
Offset (m)	0	2.5	3	-3	-2.5	-4.5	-4	4	4.5
Direction	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk	Towards Kurmuk
Zero error (mm)	94	99	105	111	108	119	110	103	120
Test date (dd/mm/yyyy)	24/10/2012	24/10/2012	24/10/2012	24/10/2012	24/10/2012	24/10/2012	24/10/2012	24/10/2012	24/10/2012
Remarks									
Layers removed	1	1	1	1	1	0	0	0	0
Surface type	Other	Other	Other	Other	Other	Unpaved	Unpaved	Unpaved	Unpaved
Surface moisture						Wet	Wet	Wet	Wet
Surface thickness (mm)	20	20	20	20	20				
Surface condition	Unknown	Unknown	Unknown	Unknown	Unknown				
Surface strength coefficient	0.1	0.1	0.1	0.1	0.1				
Base type									
Base thickness (mm)									
Base condition									
Base strength coefficient									

Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)
0	114	0	119	0	125	0	131	0	128	0	119	0	110	0	103	0	120
2	129	1	130	2	151	1	145	1	139	1	131	1	121	1	120	1	132
2	138	1	137	2	173	1	155	1	148	1	142	1	133	1	132	1	142
2	147	1	144	2	194	1	161	1	154	1	154	1	141	1	143	1	150
2	155	1	151	2	214	1	170	1	163	1	164	1	148	1	152	1	158
2	165	1	157	1	225	1	177	1	171	1	175	1	155	1	160	1	166
2	174	2	171	1	234	1	186	1	179	1	182	2	168	1	168	1	175
2	183	2	182	1	245	1	194	2	194	1	189	2	179	1	176	1	184
2	194	2	196	1	256	1	202	2	213	1	195	2	190	1	183	1	192
2	204	2	212	1	267	2	219	2	233	1	200	2	200	1	189	1	200
2	213	2	230	1	278	2	236	2	252	1	205	2	210	2	202	1	206
2	222	2	248	1	288	2	255	2	274	2	212	2	219	2	213	1	216
3	238	2	268	2	305	2	277	2	295	2	219	3	233	2	224	1	222
3	257	2	287	2	321	2	301	2	314	3	231	3	246	2	234	1	231
3	278	2	304	2	338	2	320	2	335	3	242	3	262	2	245	1	238
3	297	2	312	2	359	1	340	2	354	3	254	3	277	2	256	1	245
3	314	2	329	2	380	1	350	2	381	3	269	3	294	2	268	1	251
3	329	2	346	2	401	1	360	2	406	3	286	3	310	2	279	1	258
3	348	2	360	2	419	1	370	1	421	3	304	3	334	2	289	1	265
3	366	2	374	2	435	1	382	1	433	3	327	2	351	2	297	1	270
3	384	2	389	2	450	1	394	1	443	3	343	2	368	2	307	1	278
3	400	2	407	2	462	1	407	1	451	2	362	2	388	2	317	1	283
3	416	2	423	2	474	1	420	1	459	2	382	2	408	2	327	2	296
3	430	2	439	2	484	1	429	1	464	2	403	1	419	2	338	2	309
3	447	2	451	2	496	1	441	1	471	2	423	1	429	2	349	2	323
3	458	2	464	2	507	1	451	1	478	2	446	1	438	2	361	2	338
3	466	2	472	2	519	1	460	2	489	1	462	1	446	2	375	2	354
4	479	2	481	2	529	1	468	2	499	1	476	1	456	2	387	2	371
4	490	2	490	2	541	1	475	2	509	1	494	1	466	2	400	2	391
4	506	2	500	2	555	1	486	2	518	1	509	1	477	2	413	1	408
4	519	2	512	2	569	1	492	2	528	1	524	1	490	2	429	1	418
4	536	2	523	2	584	1	500	2	537	1	539	1	502	2	443	1	428
4	552	2	534	2	599	2	511	2	548	1	551	1	512	2	459	1	437
4	568	2	547	2	615	2	524	2	559	1	565	1	525	2	472	1	448
4	590	2	561	2	634	2	536	2	568	1	579	1	538	2	485	1	456
4	613	2	576			2	547	2	578	1	595	1	553	2	495	1	465
4	637	2	594			2	560	2	586	1	611	1	568	2	505	1	472
		2	615			2	574	2	595	1	620	1	584	2	513	1	480
		2	634			2	588	2	604			1	600	2	519	1	487
						2	604	2	611			1	610	2	525	1	496
						2	621					1	623	2	542	1	502
														2	561	1	512
														2	573	1	522
														2	588	1	529
														2	608	1	536
														2	638	1	547
																1	557
																1	569
																1	582
																1	595
																1	611
																1	627

UK DCP Test Data Sheet																		
Project name	Assosa Survey 1 49+780																	
Test number	1		2		3		4		5		6		7		8		9	
Chainage (km)	49.78		49.78		49.78		49.78		49.78		49.78		49.78		49.78		49.78	
Location	Carriageway		Carriageway		Carriageway		Carriageway		Carriageway		Shoulder		Shoulder		Shoulder		Shoulder	
Lane number	1		1		1		2		2									
Offset (m)	0		2.5		3		-3		-2.5		-4.5		-4		4		4.5	
Direction	Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk		Towards Kurmuk	
Zero error (mm)	99		105		105		111		104		120		130		127		110	
Test date (dd/mm/yyyy)	24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012		24/10/2012	
Remarks																		
Layers removed	1		1		1		1		1		0		0		0		0	
Surface type	Other		Other		Other		Other		Other		Unpaved		Unpaved		Unpaved		Unpaved	
Surface moisture											Wet		Wet		Wet		Wet	
Surface thickness (mm)	20		20		20		20		20									
Surface condition	Unknown		Unknown		Unknown		Unknown		Unknown									
Surface strength coefficient	0.1		0.1		0.1		0.1		0.1									
Base type																		
Base thickness (mm)																		
Base condition																		
Base strength coefficient																		
	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)	Blows	Depth (mm)
	0	119	0	125	0	125	0	131	0	124	0	120	0	130	0	127	0	110
	2	131	1	135	1	137	1	146	1	132	1	132	1	137	1	145	1	132
	2	136	1	145	1	147	1	156	1	138	1	142	1	149	1	155	1	144
	2	144	1	156	1	155	1	166	1	141	1	149	1	160	1	167	1	157
	2	150	1	166	1	164	1	175	2	154	1	158	1	170	1	180	1	168
	3	156	1	177	1	172	1	186	2	165	2	165	1	178	1	193	1	180
	3	165	1	188	2	193	1	195	2	175	2	178	1	187	1	205	1	192
	3	176	1	200	2	217	1	209	2	190	2	190	1	193	1	216	1	205
	3	185	1	214	2	241	1	221	2	205	2	203	1	201	1	230	1	216
	3	197	1	224	1	253	1	235	2	220	2	216	1	209	1	242	1	228
	3	209	1	235	1	264	1	250	2	235	2	229	1	216	1	254	1	242
	3	221	1	250	1	276	1	266	2	254	2	240	1	223	1	265	1	255
	3	235	1	264	1	290	1	281	2	275	2	255	2	239	1	275	1	267
	3	254	1	276	1	304	1	300	2	295	2	269	2	256	1	287	1	278
	2	269	1	290	1	318	1	316	2	314	2	280	2	272	1	296	1	289
	2	284	1	304	1	331	1	333	2	332	2	295	2	291	1	307	1	299
	2	299	1	316	1	346	1	349	2	350	2	313	1	300	1	316	1	309
	2	313	1	326	1	361	1	361	2	365	1	323	1	309	1	325	1	318
	2	325	1	337	1	377	1	372	2	380	1	333	1	321	1	335	1	327
	2	336	1	350	1	399	1	385	2	396	1	341	1	329	1	345	1	338
	2	344	1	364	1	419	1	399	2	414	1	350	1	338	1	357	1	351
	2	352	1	377	1	441	1	411	2	434	1	360	1	345	1	371	1	365
	2	359	1	395	1	464	1	429	2	456	1	369	1	351	1	386	1	381
	2	365	1	412	1	484	1	447	2	479	1	377	1	359	1	405	1	399
	2	371	1	431	1	504	1	465	2	500	1	384	1	366	1	421	1	419
	3	379	1	451	1	516	1	483	2	524	1	391	2	381	1	442	1	439
	3	386	1	471	1	529	1	498	2	553	1	399	2	393	1	462	1	463
	3	394	1	490	1	540	1	515	2	588	2	414	2	407	1	482	1	482
	3	404	1	509	1	553	1	533	1	605	2	431	2	422	1	499	1	499
	3	410	1	525	1	566	1	551	1	625	2	452	2	436	1	512	1	516
	3	418	1	537	1	578	1	576			2	474	2	451	1	524	1	534
	3	429	1	548	1	591	1	600			2	502	2	467	1	535	1	557
	3	437	1	560	1	606	1	621			1	517	2	484	1	546	1	584
	3	445	1	575	1	621					1	530	2	503	1	560	1	618
	3	455	1	590							1	550	2	526	1	571	1	653
	3	465	1	609							1	570	1	542	1	586		
	4	478	1	629							1	600	1	565	1	605		
	4	488									1	642	1	573	1	626		
	4	501											1	631				
	4	511																
	4	524																
	4	539																
	4	555																
	4	570																
	4	586																
	4	600																