



AfCAP
Africa Community Access Partnership



Training-of-Trainers Programme for participants from Ghana, Sierra Leone and Liberia in the use of the DCP-DN Pavement Design Method

Construction Report 2



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Cover Photo: Construction of base layer (Author’s photo)

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RESEACH FOR COMMUNITY ACCESS PARTNERSHIP (ReCAP) *Safe and sustainable transport for rural communities*

ReCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable transport for rural communities in Africa and Asia. ReCAP comprises the Africa Community Access Partnership (AfCAP) and the Asia Community Access Partnership (AsCAP). These partnerships support knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources. The ReCAP programme is managed by Cardno Emerging Markets (UK) Ltd.

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Acronyms, Units and Currencies

AfCAP	Africa Community Access Partnership
DCP	Dynamic Cone Penetrometer
DFR	Department of Feeder Roads
DN	DCP Number (mm/blow)
GHA	Ghana Highways Authority
GoG	Government of Ghana
Km	Kilometre
LVSR	Low Volume Sealed Road(s)
LVR	Low Volume Road(s)
M	Metre
ToT	Training of Trainers
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)
VO	Variation Order

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1 Executive summary

The contractor mobilised to site in September 2017 and commenced work on the Trial- and Control Sections being part of the upgrading of the 13 km long Akyem Kukurantumi – Asafo road in Eastern Region. The works are carried out under a Variation Order (VO) to an ongoing contract for similar road works in the region.

Due to the delay in the commencement of the works from the originally planned start in February 2017, a revision of the Construction Programme was required. To date no revised programme has been submitted, but in a Site Meeting on 11 October 2017 the contractor informed that completion of the Trial Section would be prioritised over the works on the other sections of the road.

The AccCAP Consultants visited Ghana in the period 4 – 24 March in connection with the third ToT course.

On the team's arrival in Koforidua on 5 March, 2018 the widening and reshaping of the formation on the Trial Section was complete, but levels had not yet been set out for accurate control of camber and layer thickness.

On inspection of the borrow pit it was observed that the borrow pit was badly organised and not enough material had been stockpiled.

In a Site Meeting on 7 March, 2018, the contractor assured the meeting that the borrow pit would be properly managed and that instruction would be given to immediately start winning and stockpiling more materials. He also indicated that the Trial Section would be completed within a few weeks. On this basis, it is assumed that the Trial Section will be substantially complete before end of April 2018 with only final clearing activities remaining.

The Site Activities were severely hampered by constant delays due to, among other things, lack of fuel for the construction plant. Frequent rain showers also complicated the works with flooding of the borrow pit and soaking of the base material.

Much of the time on site was devoted to the establishment of procedures for correcting and checking the camber and layer thickness as well as processing of the base material to ensure uniform and correct moisture content before final shaping and compaction.

The procedure for carrying out a compaction trial was demonstrated, but due to the high moisture content of the base material a realistic Target DN to be used for subsequent compaction quality control could not be established.

Material tests were carried out both at the GHA laboratory in Accra and at the DFR laboratory in Koforidua. On close inspection it was evident that the DFR test results were not reliable due to, among other factors, equipment that was not calibrated. The test results from the GHA laboratory were thus taken to be representative for the material from the borrow pit.

Moisture sensors were successfully installed in the pavement for monitoring of the long-term equilibrium moisture regime in the subgrade, subbase and base at three positions across the road. This is expected to yield valuable information for a review of the pavement design practice in Ghana.

A reliable person has also been identified for the recording of rainfall data in the area.

In "Section 6 Summary and Recommendations" a comprehensive list of issues to be addressed by the contractor and DFR is provided.

2 Introduction

2.1 Background

The background, context, project phases and overall objectives of the project – Training of Trainers from Ghana, Sierra Leone and Liberia in the DCP-DN Pavement Design Method - are presented in the Inception Report.

During the Inception Mission to Ghana in October 2016, a number of potential sites were visited and the Akyem Kukurantumi – Asafo road in Eastern Region was eventually selected for the Trial Section. Following the Inception Mission, it was decided to accelerate the procurement of the works for the construction of the Trial Section through a Variation Order (VO) to an ongoing contract on a similar project in the area. Phases 1 and 2 were then combined and the overall Work Programme was amended accordingly. Construction of the Trial Section was then planned to commence in February 2017. However, the contractor only mobilised to site and commenced work during September 2017.

The AfCAP Consultants visited Ghana in connection with the second course under the ToT programme. Observations and recommendations from that visit is documented in Construction Report 1, October 2017. This report covers observations and recommendations from the visit in the period 4 – 24 March, 2018 in connection with the third and last course of the ToT programme.

2.2 Objective

The objective of the DCP-DN pavement design and construction of the Trial Section is to compare the performance of the Trial Section with that of the Control Section, which has been designed using the existing DFR feeder roads design standards, and thus to provide inputs for the adoption of more appropriate LVSR design standards in Ghana.

2.3 Mission Itinerary and Activities

The AfCAP Consultants visited Ghana in the period 4 – 24 March to inspect the construction of the Trial Section and conduct the last of the three ToT Courses. The itinerary and activities of the team during the visit were as follows:

Table 1: Itinerary and activities

Dates	Activities	By whom
4 March	Team arrival in Accra	All
5-9 March	Inspection of site, borrow pit, analysis of test results and meeting with contractor and DFR.	J. Hongve, E. Mukandila, P. Paige-Green
12-23 March	Third ToT Course with focus on practical construction issues, materials testing and reinforcement of LVSR design principles	J. Hongve, E. Mukandila
24 March	Departure	J. Hongve, E. Mukandila

2.4 Purpose and Scope of the Report

The purpose and scope of this report is thus to provide detailed information on the construction of the Trial Section collected during the visit, particularly as regards the achievement of the quality of the works, construction materials and the attainment of the specified drainage requirements. These factors will influence the performance of the Trial Section which will be compared with the performance of conventional pavement design applied on the Control Section.

3 Construction progress

3.1 General

3.1.1 Works Contract

The works is carried out under a VO to an ongoing contract for similar road works in the region. The format and contents of the VO follows the standard DFR contract format with the inclusion of estimated quantities for the works. However, upon request by the Consultants it appeared that the contractor’s Site Staff had not been provided with any drawings or setting out records required for the construction.

3.1.2 Site Meetings and Progress Reports

In the Site Meeting on 11 October 2017 it was agreed that Site Meetings would be held on a monthly basis and that Progress Reports would be compiled using the standard DFR format.

No records of Site Meetings or Progress Reports have been received since then.

A second Site Meeting was held during the visit on 7 March 2018 at the DFR Head Office, Koforidua. For ease of reference the minutes from both Site Meetings are attached in Annex 1.

The Minutes provide an accurate record of the discussions, issues raised and decisions reached during the meetings.

3.1.3 Construction programme

Contrary to the promise by the contractor during the Site Meeting on 11 October, 2017 to submit a revised Construction Programme, and despite several subsequent requests by DFR, the contractor has still not submitted a revised programme as of March, 2018.

In the Site Meeting on 7 March, 2018 the contractor did however indicate that the construction of the Trial Section would be completed within a few weeks. A tentative programme for completion of the Trial Section is as follows:

Week starting	12/03/2018	19/03/2018	26/03/2018	02/04/2018	09/04/2018	16/04/2018	23/04/2018
Remaining activities							
Correcting subbase							
Constructing Base							
Base drying out							
Surfacing							

Figure 1: Tentative programme for completion of Trial Section

3.1.4 Contractor’s mobilisation

The contractor mobilised on site in September 2017. A camp has been established next to the access to the village at the start of the Trial Section.

Construction plant and equipment

The contractor's fleet of construction plant and equipment is adequate for the works under the contract and includes the following items:

- 5 tipper trucks
- 2 10-ton vibrating rollers
- 2 graders
- 1 Dozer

The construction plant appeared to be in a reasonably good condition.

The contractor also had two low-bed trucks on site for transport of heavy equipment, one of which has broken down and is parked on the road side within the Trial Section. This must be removed to enable the completion of the works.



Figure 2: Site camp



Figure 3: One of the two 10-ton vibrating rollers



Figure 4: One of the two graders



Figure 5: One of five tipper trucks

Site staff

The current Site Staff include:

- Site Agent
- Foreman
- Surveyor
- Supervisor/Gang Leader for concrete works
- Plant operators and drivers

3.2 Materials

3.2.1 General

During the design and initial materials testing in February 2017 it was observed that the test results from the DFR laboratory in Koforidua were not reliable, due, at least in part, to the laboratory equipment not being calibrated. It was therefore decided to send borrow pit samples to the GHA laboratory in Accra for testing.

Despite this problem having been reported to DFR, the quality of the testing at the DFR laboratory has apparently not improved. Among other things, the weighing scales are still inaccurate and the oven does not have a thermometer for control of the oven temperature.

New samples from the borrow pit were thus sent for testing to the GHA laboratory in February 2018. Classification and compaction tests were also carried out during the visit at the DFR laboratory. The results from the DFR laboratory differ by quite a wide margin from the results from the GHA laboratory, particularly for the OMC of the material which is crucial for the Laboratory DN tests and compaction in the field.

In the following, qualitative assessments are therefore made of the laboratory and compaction tests carried out by the DFR laboratory based on observations in the laboratory and on site.

3.2.2 Borrow pit

On the AfCAP Consultants' arrival in Koforidua on 5 March, the borrow pit was badly organised and had only a small stockpile of material which were to be used on another section of the road.



Figure 6: Stockpiling in process



Figure 7: Flooding of the borrow pit

After several days delay due to, among other things, lack of fuel on site, stockpiling of fresh material only commenced the following week on 13 March. The working of the borrow pit was then deemed to be carried out in a satisfactory manner.

The borrow pit was not properly drained and frequent rains made the stockpiled material soaked. Material dumped on the road therefore required drying out to OMC before final shaping and compaction.

3.2.3 Materials testing

Based on the experiences from the previous testing carried out at the DFR laboratory in Koforidua, DFR proposed during the Site Meeting on 11 October, 2017 that parallel testing should be carried out at the DFR Laboratory and the GHA Laboratory in Accra, at least initially. Routine testing can then possibly be carried out in Koforidua provided it has been shown that their results are reliable.

As mentioned above, the test results from the DFR Laboratory are still not reliable. DFR must therefore take immediate measures to ensure that reliable testing be carried out for the remainder of the construction period.

3.2.4 Testing schedule

The materials testing schedule shown in Table 2 was submitted with Construction Report 1. Routine.

Table 2: Materials testing schedule

Testing schedule	No of bulk samples	Tests (on each bulk sample)
Initial tests of stockpiled material	2 representative bulk samples from different locations in each stockpile	<ul style="list-style-type: none"> - Classification tests - MDD/OMC - Lab DN test <ul style="list-style-type: none"> - 3 soaked at light, intermediate and heavy compaction - 3 at OMC at light intermediate and heavy compaction
Routine (during construction)	1 bulk sample from every 10 th tipper load dumped on the road	<ul style="list-style-type: none"> - Classification tests - MDD/OMC - Lab DN test <ul style="list-style-type: none"> - 3 at OMC at heavy compaction
	1 bulk sample from the compacted layer(s) for every 200 m	<ul style="list-style-type: none"> - Classification tests - MDD/OMC - Lab DN test <ul style="list-style-type: none"> - 3 at OMC at heavy compaction

3.2.5 Test results

Lab DN test

The results from the Laboratory DN test at the GHA Laboratory in Accra in February 2018 are summarised in Table 3 and Figure 8 below.

Table 3: Summary of Lab DN test at GHA Laboratory, Accra

Borrow pit #	Sample #	Mould #	Survey date	Compactive Effort	OMC (%)	Moisture regime	W.Avg. DN (mm/blow)	Best fit DN (mm/blow)	Average DN	Average RC
2+500	1	1-55	20/02/2018	Heavy	6.3	OMC	3.31	2.95	2.5	1.00
2+500	1	2-55	20/02/2018	Heavy	6.3	OMC	2.79	2.28		
2+500	1	3-55	20/02/2018	Heavy	6.3	OMC	2.51	2.37		
2+500	1	1-25	20/02/2018	Intermediate	6.3	OMC	6.26	5.59	5.1	0.94
2+500	1	2-25	20/02/2018	Intermediate	6.3	OMC	5.18	4.57		
2+500	1	3-25	20/02/2018	Intermediate	6.3	OMC	5.56	5.1		
2+500	1	1-10	20/02/2018	Light	6.3	OMC	11.12	10.06	8.9	0.86
2+500	1	2-10	20/02/2018	Light	6.3	OMC	8.85	8.66		
2+500	1	3-10	20/02/2018	Light	6.3	OMC	8.26	7.9		
2+500	1	1-55s	20/02/2018	Heavy	6.3	SOAKED	7.31	6.75	6.6	1.00
2+500	1	2-55s	20/02/2018	Heavy	6.3	SOAKED	9.22	7.64		
2+500	1	3-55s	20/02/2018	Heavy	6.3	SOAKED	6.23	5.43		
2+500	1	1-25s	20/02/2018	Intermediate	6.3	SOAKED	13.79	13.18	15.1	0.92
2+500	1	2-25s	20/02/2018	Intermediate	6.3	SOAKED	15.1	13.16		
2+500	1	3-25s	20/02/2018	Intermediate	6.3	SOAKED	20.3	19.03		
2+500	1	1-10s	20/02/2018	Light	6.3	SOAKED	78	78	48.4	0.85
2+500	1	2-10s	20/02/2018	Light	6.3	SOAKED	32.01	30.17		
2+500	1	3-10s	20/02/2018	Light	6.3	SOAKED	47.42	36.91		

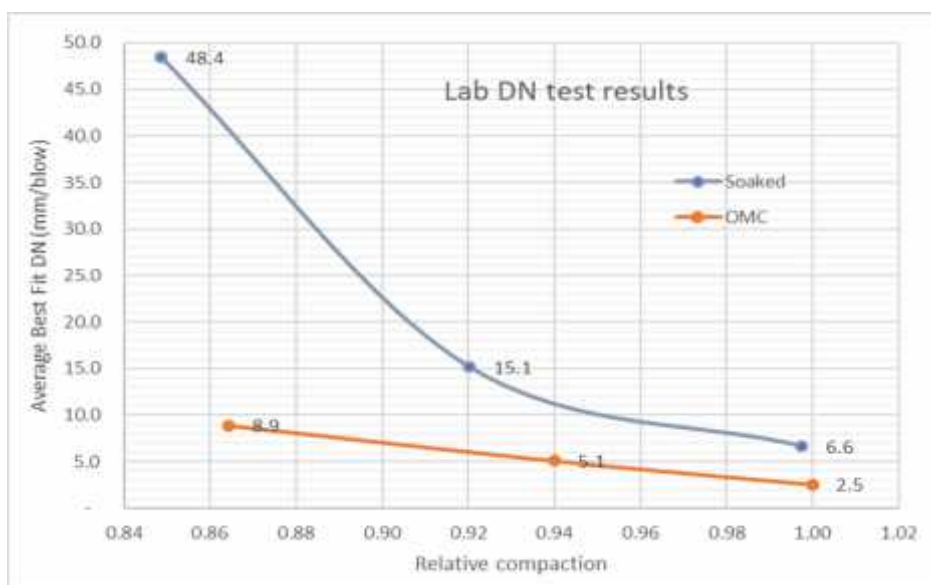


Figure 8: Lab DN test results

The Lab DN test results are close to the results obtained from testing carried out on material from the same borrow pit in April 2017 and are deemed to give a good representation of the strength of the material. The borrow pit material is thus deemed to satisfy the requirement for TLC 0.3 with DN ≤ 3.2 mm/blow.

Compaction and classification test

Compaction tests were carried out both at the GHA Laboratory and the DFR Laboratory in Koforidua. The results differ with quite a wide margin, particularly for the OMC.

Classification tests were also carried out at the DFR laboratory in Koforidua, but it turned out on close examination that their results are not reliable due to a variety of factors, most importantly weighing scales that were not calibrated.

The results from the GHA laboratory are therefore regarded as more reliable, in particular for the OMC. By observation, the OMC determined by the DFR laboratory is deemed to be too high. This assumption is corroborated by the Laboratory DN at the DFR laboratory carried out at a moisture content of 8.0% (supposedly OMC), at which the relative compaction heavy compaction only reached +/- 92%.

Table 4: Summary of Laboratory DN test at DFR laboratory

Compaction effort	Relative compaction	DFR Laboratory	
		Best fit DN	RMC
Refusal (75 blows)	92.4	4.8	127%
Heavy (55 blows)	89.0	6.0	128%
Intermediate (25 blows)	89.0	6.3	121%

*RMC is relative to the OMC of 6.3% as determined at the GHA laboratory

The test results and the assumed representative values are summarised in Table 5 below. Table 6 shows the results of the sieving analysis. Further details of the materials test results are shown in Annex 2.

Table 5: Summary of Compaction and Classification tests

Test	GHA Laboratory	DFR Koforidua Laboratory		Assumed representative values
		Sample A	Sample B	
MDD (kg/m ³)	2190	2170	2250	2190
OMC %	6.3	11.1	8.2	6.3
GM		≈ 1.66	≈ 1.66	1.66
PM		462	244	353
LL		24.6	25.0	24.8
PL		16.8	16.8	16.8
PI		7.8	8.2	8.0

*GM calculated using the nearest BS sieve sizes

Table 6: Sieve analysis of borrow pit material

DEPARTMENT OF FEEDEROADS REGIONAL MATERIAL LABAORATORY (KOFORIDUA) SIEVE ANALYSIS					DEPARTMENT OF FEEDEROADS REGIONAL MATERIAL LABAORATORY (KOFORIDUA) SIEVE ANALYSIS				
NAME: ASIEDU MINTAH		SAMPLE NO: BDBP-A			NAME: ASIEDU MINTAH		SAMPLE NO: BDBP-B		
PROJECT: KUKURANTUMI - ASAFO		DATE : 13/03/2018			PROJECT: KUKURANTUMI - ASAFO		DATE : 13/03/2018		
LOCATION: KUKURANTUMI - ASAFO km 2+500					LOCATION: KUKURANTUMI - ASAFO km 2+500				
BS Sieve	Wt. Retained	% Retained	% Passing	Riffed Wt.	BS Sieve	Wt. Retained	% Retained	% Passing	Riffed Wt.
38.10mm(1½in)			100.0	100	38.10mm(1½in)			100.0	100
25.40mm(1in)		0.0	100.0	100	25.40mm(1in)	21	0.7	99.3	99
19.05mm(¾in)	7	0.2	99.8	100	19.05mm(¾in)	16	0.5	98.8	99
12.70mm(½in)	69	2.3	97.5	98	12.70mm(½in)	47	1.6	97.2	97
9.52mm(3/8in)	107	3.6	93.9	94	9.52mm(3/8in)	106	3.5	93.7	94
6.35mm(¼in)	228	7.6	86.3	86	6.35mm(¼in)	185	6.2	87.5	88
4.76mm(3/16in)	131	4.4	81.9	82	4.76mm(3/16in)	93	3.1	84.4	85
2.40mm(7mesh)	300	10.0	71.9	72	2.40mm(7mesh)	231	7.7	76.7	77
1.20mm(14mesh)	508	16.9	55.0	55	1.20mm(14mesh)	548	18.3	58.4	58
600um(25mesh)	387	12.9	42.1	42	600um(25mesh)	461	15.4	43.1	43
400um(36mesh)	172	5.7	36.4	36	400um(36mesh)	221	7.4	35.7	36
300um(52mesh)	108	3.6	32.8	33	300um(52mesh)	122	4.1	31.6	32
150um(100mesh)	152	5.1	27.7	28	150um(100mesh)	203	6.8	24.9	25
75um(200mesh)	46	1.5	26.2	26	75um(200mesh)	63	2.1	22.8	23
PAN	785	26.2			PAN	683	22.8		
TOTAL	3000				TOTAL	3000			

3.3 Formation

Reshaping and compaction of the existing formation on the Trial Section was complete.

However, the following observations were made:

- Levels were not yet set out; hence accurate levels and camber could not be attained.
- The width of the formation on the Trial Section is approximately 10 m, sufficient to accommodate the finished road width.
- As no drawings had been provided to the contractor, there was some confusion regarding the width of the finished sealed roadway. It was therefore agreed that the finished sealed width should be as per the proposed width in the Trial Section Design Report:
 - 6 m carriageway (2 x 3 m lanes), plus
 - 2 x 1 m sealed shoulders
- The amount of oversize in the existing improved subgrade/subbase on the Trial Section appeared to be acceptable.
- Windrows of loose material deposited outside the drain, must be removed to prevent silting up and blockage of the side drains.

It was apparent that the Site Staff were just following what they considered to be normal construction practices on Feeder Roads projects with little regard for quality control, especially as regards compaction, the shape of the road and achievement of correct camber. DFR therefore needs to take immediate measure to ensure that proper quality control is e

Much of the time on site was therefore devoted to the correction of the camber using standard construction practice with level pegs and string lines to guide the grader operator as illustrate in Figure 9 below.

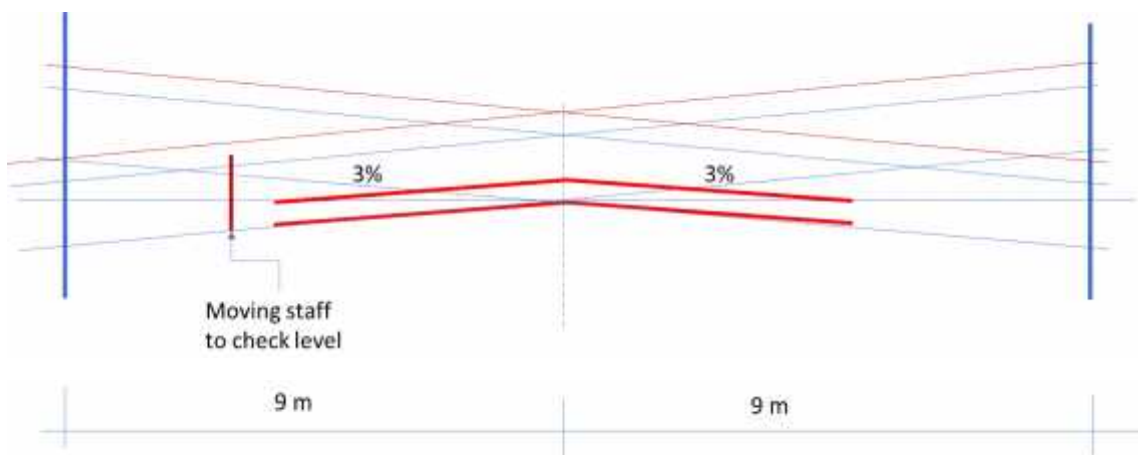


Figure 9: Common construction practice for checking camber and layer thickness

After some attempts, the grader operator understood the procedure. His skill level in achieving a proper camber subsequently increased significantly.



Figure 10: Establishing level pegs



Figure 11: Checking the camber



Figure 12: Correcting the camber to +/- 3%



Figure 13: Windrows on backslope to be removed

3.4 Access culverts

Construction of five concrete box culverts at property accesses are complete. However, the invert level of one access culvert at approx. km 8+700 RHS is too low and prevents draining out standing water in the side drain. It must be demolished and replaced, either by a new culvert or a concrete dish drain, which will be cheaper to construct and easier to maintain.



Figure 14: Access culvert at km 8+700 LHS must be replaced with new culvert or dish drain at correct invert level

3.5 Construction of new base layer

3.5.1 General

As mentioned in the previous sections, due to the constant delays on site for various reasons, construction of the new base layer could only start on Friday 23rd March, the last day of the Consultants visit.

3.5.2 Design adaptations

During the correction of the camber the previous week, it was observed that the gravel wearing course on the last 200 m of the Trial Section (km9+200 – 9+400) had mostly been washed away since the DCP survey was carried out in October 2016. It was therefore decided that both subbase and base would be constructed on this section as a transition to the pavement on the control section.

On the first approximately 100m of the Trial Section, the new pavement must be constructed to tie in with the top of the concrete U-drains on the left-hand side over that section. The existing subbase already has +/- 3% camber from the centre line to the top of the U-drain. A full 150 mm base layer would therefore make the tie-in over the width of the 1.0 m wide shoulder too steep and awkward for pedestrians and bicyclists using the shoulder. It is therefore proposed to reduce the pavement thickness over this section and only augment the existing subbase with 75 mm of new base material as illustrated in Figure 15.

Accurate records of the chainages and the constructed pavement layers as per the proposed design adaptations must be kept for reference during the performance monitoring.

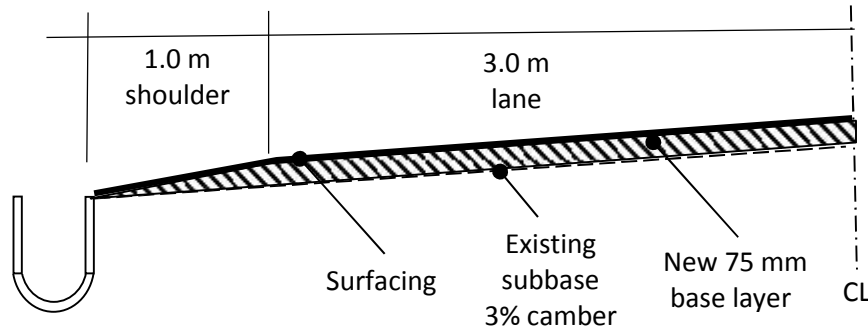


Figure 15: Reduced base layer on concrete U-drain section km 8+400 - 8+500

With the above design adaptations, the length of the actual Trial Section will be reduced, but it will still accommodate a Long-Term Pavement Performance (LTPP) monitoring section of at least 500 m, schematically illustrated in Figure 16.

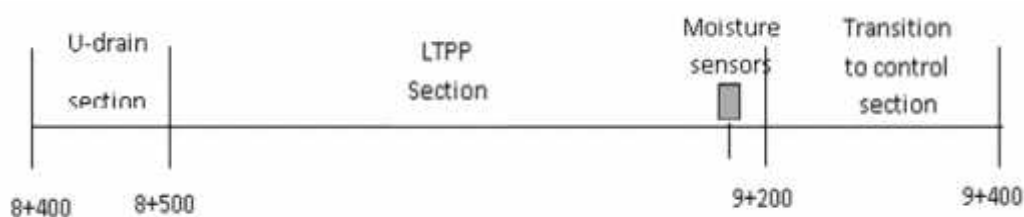


Figure 16: Schematic layout of Trial Section

3.5.3 Material processing

Due to the high moisture content in the base material, the Site Staff was guided on how to process the material to reduce the moisture content to OMC by windrowing and mixing using the grader before final shaping and compaction. It is vital that this process is judiciously applied for the remainder of the base construction.

The camber and layer thickness were controlled using the procedure illustrated in Figure 9 above.



3.6 Quality Assurance / Control

3.6.1 General

Attainment of high quality of the works is essential to the performance of the Trial- and Control Sections.

As per Conditions of Contract the Contractor must submit a Quality Plan for the works for approval by the Client. The Quality Plan was said to have been submitted, but no proof of it was shown to the Consultants.

3.6.2 Project Management and Site supervision

In the meeting 11 October, 2017 it was agreed that DFR would implement proper project management procedures with Monthly Progress Meetings and Technical Site Meetings in between as and when required. To date no such meetings have been held or any records submitted apart from the meetings held during the visits of the AfCAP Consultants.

The DFR Operations Manager, J. Kittoe, is responsible for the day-to-day project management and site supervision. Quality Control tests are being carried out by the DFR Laboratory in Koforidua.

As noted above, the test results from the DFR Laboratory are deemed not to be reliable. Density tests have been carried out over the entire length of the road on the subgrade and subbase/existing gravel wearing course. Average densities reported are:

- Subgrade 93-94%
- Subbase 96-98%

The densities are therefore seemingly adequate. However, the testing procedures and condition of the DFR laboratory equipment mentioned above cast some doubt on the accuracy of these test results. The density test results are shown in Annex 3.

The key items, which are to be carefully controlled and approved, include:

- The quality of the materials;
- The quality of construction, particularly of layer thickness and compaction;
- Attainment of 3.0 % camber to ensure rapid drainage of water from the road surface;
- The provision of adequate drainage including attainment of minimum 750 mm height difference between the side drain invert and the crown of the camber and adequate grades in the side drains, and mitre drains at regular intervals to ensure free flow of water and drainage away from the road;
- Clearing and desilting of the cross culvert at km 9+400 plus river training upstream and downstream to ensure proper drainage of the low-lying area around the culvert;
- The construction of the 14/10 Double Surface Dressing. It is essential that a good quality surfacing is attained to prevent moisture ingress into the pavement through the seal.

3.6.3 Compaction Trial

The procedures for carrying out a compaction trial were demonstrated on Wednesday 21 March. However, due to the soaked condition of the material, a reliable Target DN value to be used for compaction control on the base layer could not be determined.

Notwithstanding the above, six roller passes of the 10-ton vibrating roller is deemed to be the optimum number of passes for compaction to refusal.

The results of the compaction trial and density test are shown in Table 7. Again, the relative compaction determination by Sand Replacement seems not to be reliable and is probably much too low.

Table 7: Compaction Trial results

Compaction Trial	2 passes	4 passes	6 passes
Best fit DN (average of 3)	9.6	8.5	7.9
Relative compaction	-	-	89%
Moisture content	-	-	8.96%

4 Monitoring of pavement moisture

4.1 General

Monitoring of the pavement moisture regime over time will give valuable information for a review of the pavement design under the wet tropical climate in Ghana.

Previous research carried out in South Africa indicate that even in wet climates with rainfall exceeding 1000 mm/year, the long-term pavement moisture equilibrates at or below OMC. The data collected under this project will thus be useful for corroboration or adjustment of the previous research data for the Ghanaian conditions.

4.2 Installation of moisture sensors

The moisture sensor equipment was installed at km 9+175. The sensors were installed in the subgrade and subbase during the correction of the subbase, whereas the sensors in the base were installed on the last day of the visit after compaction of the new base.

The software for downloading and analysing the moisture data was installed on the laptop of the Operations Manager, J. Kittoe, and tests showed that all sensors are functional.

The moisture content in the pavement layers is reported as m^3 (water)/ m^3 (material). The properties of the material in the pavement layers therefore need to be accurately determined before the relative moisture content can be established. To this end bulk samples were taken from the pavement layers, but the results have not been submitted as of the writing of this report.



Figure 21: Installation of sensors in the subgrade and subbase



Figure 22: Compaction of trench after installation



Figure 23: Installation of sensors in the base



Figure 24: Data loggers connected to all sensors

The sensors were installed and coded as shown in

Figure 25 to enable sorting of the moisture data downloads.

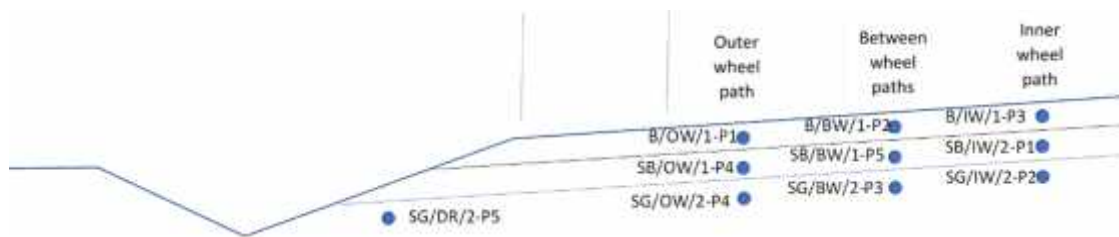


Figure 25: Sensor positions and coding

As shown in Figure 24, the data loggers are mounted in a solid steel cabinet, which is securely mounted on a concrete foundation and locked with two padlocks and, in the opinion of DFR, are satisfactory secured against theft and tampering.

4.3 Collection of rainfall data

An agreement with the spokesperson for the local chief, who resides just next to where the data loggers are installed, was reached for collection of rainfall data. DFR must follow-up to ensure that data are collected on a daily basis and recorded accurately on the provided forms shown in Annex 4.

A proper rain gauge to be installed at the property of the spokesperson has not yet been procured and DFR should seek to procure a rain gauge in Accra as soon as possible. If it is found that proper rain gauges are not available in Ghana, it is recommended that one be brought from South Africa on the planned final visit in May 2018.

5 Next visit

Subject to the construction of the Trial Section being completed as indicated in Figure 1 above, the next and final visit to complete the combined Phases 1 & 2, is planned for the week starting 7 May, 2018.

The objective of the visit will be to carry out a Technical Audit on the construction of the Trial Section and make plans for Phase 3, which includes the training of DFR staff in the establishment monitoring programme of the LTPP section.

6 Summary and recommendations

For the successful construction of the Trial- and Control Sections, the following recommendations are made:

- Weather permitting, the construction of the Trial Section is expected to be completed before end of April 2018;
- The contractor must judiciously apply correct construction procedures as discussed and demonstrated during the visit, including:
 - Correcting the camber of the subbase to 3% to ensure even layer thickness of 150 mm of the base and adequate carriageway runoff;
 - Controlling the compaction moisture content in the base material to ensure adequate compaction. Based on the tests at the GHA laboratory, the OMC of the borrow pit material is set to 6.3%;

- Compacting the base to refusal. Based on the compaction trial carried out during the visit, six passes with the 10-ton vibrating roller is deemed to be adequate, but this needs to be confirmed by a new compaction trial carried out at the correct compaction moisture content;
- Ensure proper drainage by:
 - removal of windrows outside the drains,
 - provision of sheet drainage on the embankment (no side drains needed),
 - replacement of the access culvert at km 8+700 RHS,
 - provide mitre drains as required,
 - ensure proper flow in the side drains to prevent ponding;
- Clearing the marshy area around km 9+400 downstream from the existing box culvert to prevent flooding;
- DFR must implement proper quality control procedures, including:
 - Immediately taking measures to ensure that materials testing and quality control is done in a reliable manner;
 - Carrying out compaction quality control using the DCP following the procedure in the guideline. For the establishment of a realistic Target DN, a new compaction trial will have to be carried out;
 - Compilation of accurate construction and quality control records for reference during the performance monitoring and comparison between the Trial- and Control Sections;
- Other issues:
 - On section 9+200 to 9+400 both subbase and base shall be constructed as a transition to the Control Section;
 - On the section 8+400 to approximately 8+500 along the LHS concrete U-drain, a thinner base of 75 mm is recommended to facilitate a tie-in with the top of the U-drain;
 - DFR must procure a proper rain gauge to be installed next to the Trial Section and make a formal agreement with the person identified during the visit to record rainfall data on a daily basis on the provided "Rainfall data collection form";

Annex 1: Minutes of Site Meetings

TRAINING OF TRAINERS ON DCP-DN DESIGN METHOD FOR LOW VOLUME SEALED ROADS (AfCAP PROJECT_GHA2097A).

MINUTES OF FIRST RESEARCH PROJECT SITE MEETING ON KUKURANTUMI – ASAFO FEEDER ROAD (13.000KM)

ATTENDANCE:

	<u>NAME</u>	<u>ORGANISATION</u>	<u>POSITION</u>
1.	Dr. K. O. Ampadu	DFR Head Office	Deputy Director Planning
2.	Dr. Patrick Amoah Bekoe	DFR Head Office	Principal Engineer
3.	Jerry Mendis Kittoe	DFR Koforidua	Operations Manager
4.	Asiedu Mintah	DFR Koforidua	Material Technician
5.	Dr. Estime Mukandila	AfCAP	AfCAP Trainer
6.	Jon Hongve	AfCAP (Chairman)	AfCAP Trainer
7.	Dr. Phil Paige-Green	AfCAP	AfCAP Trainer
8.	Nana Opore	M/s Jilcon Co Ltd.	Managing Director
9.	Samuel Opore	M/s Jilcon Co Ltd	Site Foreman
10.	Jackson Amponsem	M/s Jilcon Co Ltd	Surveyor

1. Opening

The meeting took place in KTC conference hall on the 11th of October 2017 at 1:30 pm. The chairman welcomed members to the meeting after which there was a self-introduction of members.

The chairman then went on to explain the purpose of the meeting, which was to get a report on the status of the works including the Contractor's mobilization, the Construction Programme for the Trial and Control Sections, and to discuss various issues related to the research aspects of the project.

2. Work Programme

The chairman explained that the construction of the Trial and Control Sections was meant to be carried out concurrently with the Training Courses. Under the current Training Programme, only one course remains to be held in November/December 2017. AfCAP therefore requested an updated Construction Programme so that the practical training activities to be carried out on site can be planned accordingly.

The MD of Gilcon Co. Ltd, gave the progress of works as follows:

- Clearing and widening - 100%
- Formation and ditching - 40%
- Compaction is in progress
- Construction 5 No. Junction culverts in progress
- Extension and opening of the gravel pit is delayed due to the incessant rains

He also informed the meeting that the programme of works has been submitted and the works are being executed in accordance with the programme of work. The chairman asked the contractor to submit a revised programme of work as per the Conditions of Contract which he promise to submit in due course.

Dr. Bekoe remarked that the contractor has not deviated so much from their original programme of works which covers the entire 13km of Asafo - Kukurantumi F/R, but admitted that DFR had failed to explain to the contractor that the focus of this project is on the 2km section of the road between chainage 8+400 and 10+400 that is included in the V.O. No. 4. He further suggested to the contractor to submit his programme of works on that section of the road since he now understands the whole programme.

Dr. Bekoe informed the contractor that the experimental section does not need any new cross culvert; the existing box culvert needs to be desilted and cleared of vegetation on both inlet and outlet channels. Downstream river training should be carried out to ensure that the low lying section is well drained.

The meeting agreed that the Contractor should submit a revised programme of works in which the works on the Trial and Control Sections are given priority.

3. Quality Assurance / Quality Control

Dr. Mukandila informed the meeting that apart from the normal quality control and assurance mechanisms put in place, the DCP equipment will be used for the compaction quality control in accordance with the Guideline, which should be part of the VO for the works.

4. Borrow pit

The chairman asked if the use of an alternative borrow pit towards the Asafo end of the road had been explored and could be used if required.

Dr. Ampadu replied that for consistency and quality, it will be proper to use material from the same source if the quantity of material is enough to complete the works.

The chairman emphasized that the winning and stockpiling gravel material in the borrow pit needs proper technical supervision in order not to mix up good and bad materials. The contractor agreed and said that they will seek DFR support and supervision for the extension of the borrow pit and excavation and stockpiling of the material.

Dr. Bekoe however suggested that all testing including classification and Laboratory DN tests should be in parallel in DFR Koforidua laboratory and GHA Central laboratory in Accra.

The AfCAP Team will submit a schedule of tests to be carried out.

He also informed the meeting that the programme of works has been submitted and the works are being executed in accordance with the programme of work. The chairman asked the contractor to submit a revised programme of work as per the Conditions of Contract which he promise to submit in due course.

Dr. Bekoe remarked that the contractor has not deviated so much from their original programme of works which covers the entire 13km of Asafo - Kukurantumi F/R, but admitted that DFR had failed to explain to the contractor that the focus of this project is on the 2km section of the road between chainage 8+400 and 10+400 that is included in the V.O. No. 4. He further suggested to the contractor to submit his programme of works on that section of the road since he now understands the whole programme.

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Dr. Bekoe however suggested that all testing including classification and Laboratory DN tests should be in parallel in DFR Koforidua laboratory and GHA Central laboratory in Accra.

The AfCAP Team will submit a schedule of tests to be carried out.

5. Construction of Trial Section

The works are being delayed due to the abnormal rainfall pattern experienced in the region this year. For effective supervision and quality control it may thus be advisable to defer the works on the Trial Section until November/December 2017, in order for the trainees and the AfCAP team to be present during the construction and carry out training on the use of the DCP for compaction quality control.

It was clarified to the contractor the Trial Section is between km 8+400 and 9+400 and the Control Section, having the "normal" DFR design, between km 9+400 and 10+400.

6. Schedule of site meetings and progress reports

Dr. Bekoe suggested that site meetings should be conducted monthly, but the technical meetings can be conducted weekly or as required, particularly when the AfCAP team is back on 27th November as agreed.

Progress reports should be in accordance with DFR's normal reporting format.

7. Contractor's establishment on site

The chairman wanted to know from the contractor about his equipment's on site particularly the capacity of his compaction equipment.

The Contractor informed the meeting that his roller(s) on site are 15-tonnes weight.

8. Surfacing aggregates

The AfCAP Team expressed some doubt about the quality of the surfacing aggregates that is stockpiled in the village next to the site, particularly as regards aggregate size and shape.

Dr. Bekoe assured the meeting that all materials will be subjected to necessary testing and be approved before use.

The Supervising Engineer from DFR (J. M Kittoe) informed the meeting that the DFR Materials Engineer had taken samples of the chippings for testing, but that he is yet to submit his report.

9. Pavement moisture data collection

Moisture monitoring sensors have been procured and are to be installed in the pavement to collect data on pavement moisture content during the monitoring of the of the Trial Section.

The sensors will be installed during the next visit of the AfCAP team.

It was agreed that DFR must have a tamper-proof steel box produced for installation of the data logger, which is to be mounted on a pole on the backslope of the side drain.

A reliable person must be appointed to be responsible downloading the data on a regular (weekly or bi-weekly) basis.

Dr. Bekoe informed the meeting that he is in talks with a DFR engineer who is currently doing his masters in Kwame Nkrumah University to take up that responsibility as part of his research work, to which the meeting agreed.

Arrangements must also be put in place for collection of rainfall data. For this, DFR must procure rain gauge(s) and make an agreement with a local school/teacher or resident for collecting and recording the rainfall data.

10. Next visit by AfCAP Team

The next visit by the AfCAP team is scheduled to take place from 27th November to 15th December.

11. AOB

The M.D of Gilcon Co. Ltd, raised concern about the V.O issued and the rates used. He said the contract was awarded in November 2012 and the same rates were still used for the currents works, for which he thinks the rates must be reviewed.

Dr. Ampadu advised the contractor to apply for a review of the rates through the regional office of DFR.

The chairman advised the contractor to quote for a realistic rate noting that the Trial Section specifications are different from those of DFR, particularly as regards compaction requirements.

12. Closing

The meeting ended at 3:30 p.m and members proceeded to site for inspection of the on-going works.

Recorded by
JERRY MENDS KITTOE

Approved by
DR. K.O. AMPADU

**Training-of-Trainers from Ghana, Sierra Leone and Liberia on the DCP-DN
Pavement Design Method for Low Volume Sealed Road (GHA2100A)
Construction of Trial- and Control Section on Kukurantumi – Asafo road.**

Minutes of Site Meeting at DFR Head Office, Koforidua 7th March 2018 at 11.00

Present:

J. M. Kittoe	Operations Manager IV, DFR
F. K. Addison	Operations Manager II, DFR
N. O. Kwafo	Managing Director, Jilcon
E. Astigbui	Site Engineer, Jilcon
J. Amponsem	Surveyor, Jilcon
A. Mintah	Materials Technician, DFR
C. Ampah	Materials Technician, DFR
E. Mukandila	Consultant, AFCAP
P. Paige-Green	Consultant, AFCAP
J. Hongve	Consultant, AFCAP (Chairman)

1. The chairman welcomed members to the meeting after which there was a self-introduction of members.

The chairman then went on to explain the purpose of the meeting, which was to get a report on the status of the works including the Contractor's mobilization, the Construction Programme for the Trial and Control Sections, and to discuss various issues related to the research aspects of the project.

2. The meeting was informed that the last of the Training-of-Trainers courses would take place during the following two weeks starting 12th March. The course would focus on the practical aspects of construction of the Trial Section with particular emphasis on quality control:

1st week:

- Correction of subbase to ensure proper compaction and correct cross-section/camber

2nd week:

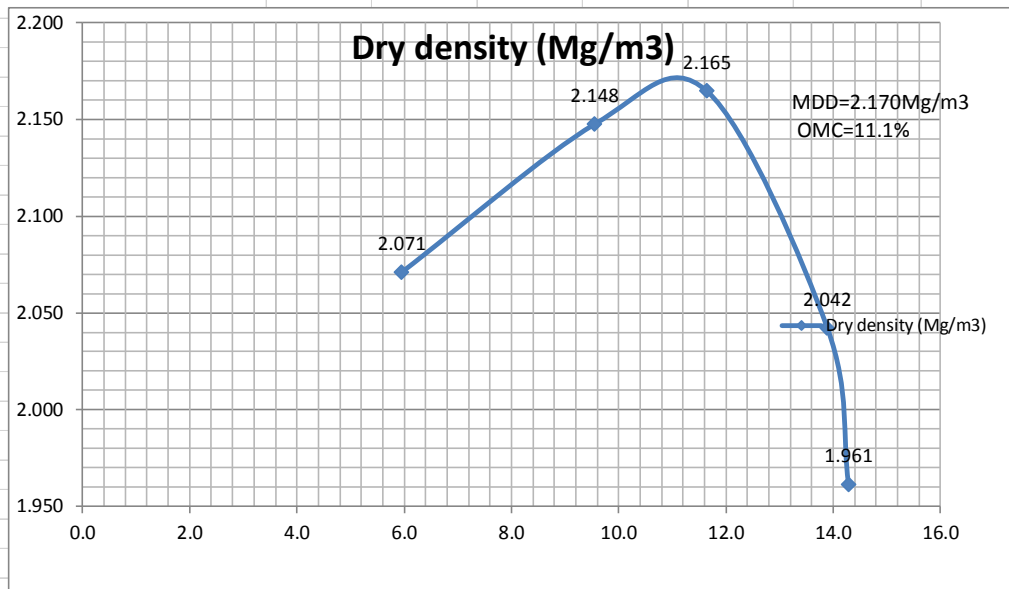
- Compaction trial on the base layer
- Demonstration of Compaction Quality Control using the DCP
- Installation of moisture sensors in the pavement.

3. The following activities were therefore on the critical path to achieve the objectives of the training:
 - Correction and approval of the existing gravel wearing course/subbase in terms of cross-section/camber and compaction
 - Winning, stockpiling, testing and approval of sufficient base material from the borrow pit at km 2+500
4. On a visit to the borrow pit on 5 March, it was noted that the previously stockpiled material was nearly depleted and that the borrow pit was not very well organised. The contractor was therefore requested that further works in the borrow pit be planned and organised in such a way as to ensure that gravel and overburden are not mixed.

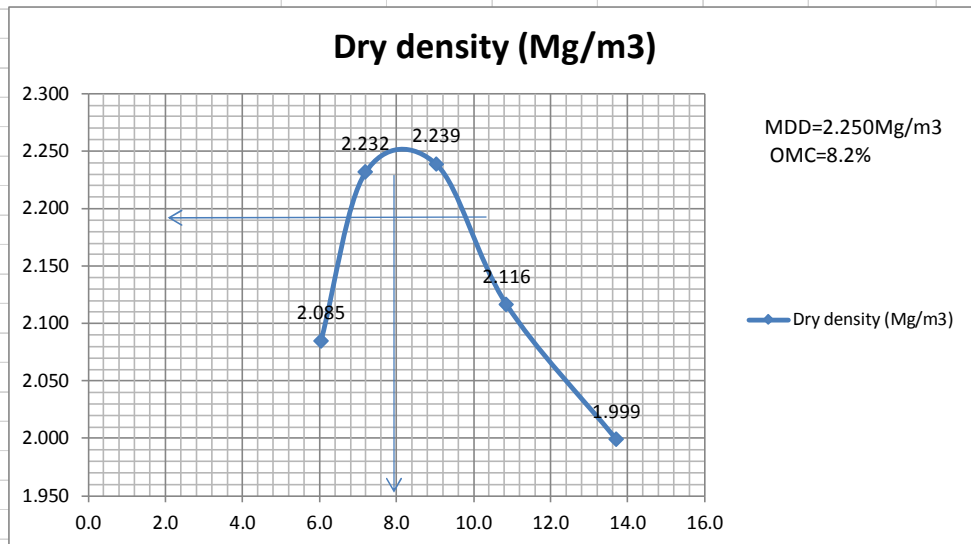
5. Samples from the previously stockpiled material had been sent to Ghana Highways laboratory for testing in February. Test results were received on 5 March, but had not yet been analysed.
6. The contractor reported that the remaining stockpile in the borrow pit was meant for another part of the Kukuratumi – Asafo road project and that he had issued instructions for winning and stockpiling of more gravel to be used for the Trial section. He also assured the meeting that the borrow pit would be managed in a proper manner.
7. The DFR Materials Technician was requested to ensure that the required equipment (scales, speedy moisture and Sand Replacement test equipment etc.) would be available for the compaction trial.
8. The contractor was requested to mobilise a Plate Compacter for the installation of the moisture sensors.
9. It was agreed that the contractor and his staff will be given an orientation on the DCP-DN design method and use of the DCP for quality control.
10. The contractor requested that DFR accommodate the extra work items resulting from the research aspects of the project in the works contract.
11. It was suggested that, to the extent that such work items had not yet been included in the contract, provision could be made for Dayworks items.
12. The contractor was requested to submit a short term revised programme of works to cover the completion of the Trial Section.
13. DFR was requested to submit a Seal Design for the Double Surface Dressing on the Trial Section.
14. DFR informed the meeting that samples from the aggregate stockpiles would be collected for testing on the day of the meeting.
15. It was pointed out to the contractor that windrows along the Trial Section should be removed to ensure proper drainage.
16. The contractor requested that the communication with the Client be improved.
17. The Meeting was closed at 13.00

Annex 2: Material test results

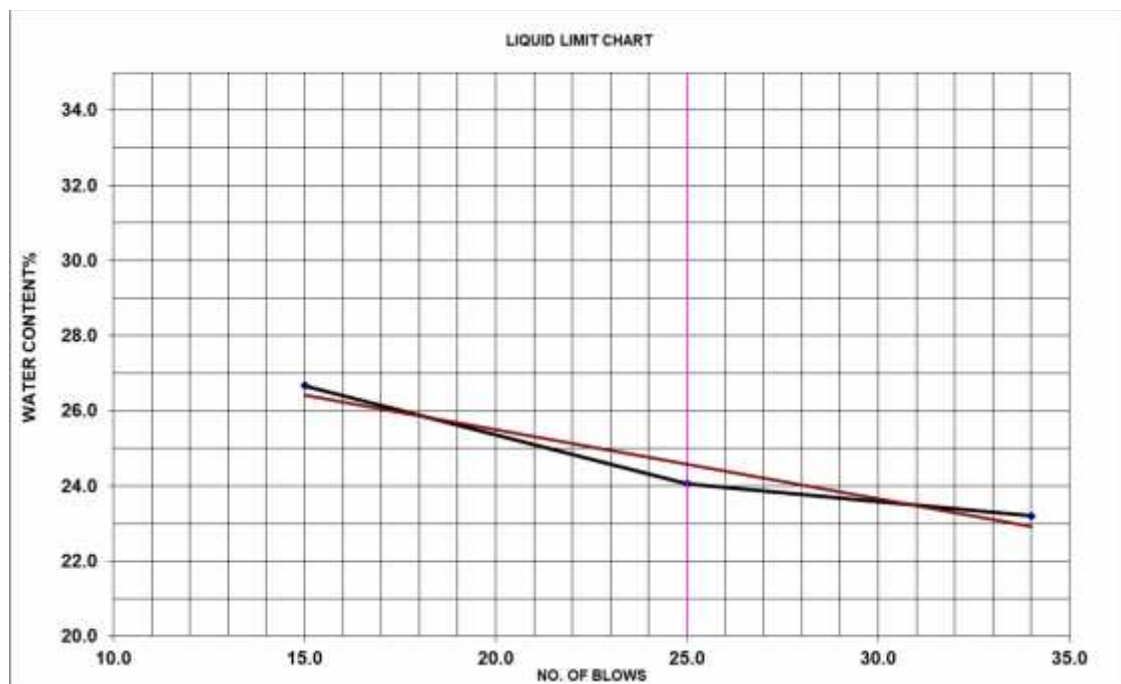
DEPARTMENT OF FEEDER ROADS							
BORROW PIT. AT ASAFO - KUKRANTUMI A.		MATERIALS DIVISION					
M/S JILCON LIMITED		COMPACTION TEST					
Name: Asiedu Mintah A.	Lab. Ref. No.				Date: 13 th MARCH.2018		
	Station: KOFORIDUA				Vol. of Mould=2.305m ³		
Wt of cylinder & wet soil(gm)	9237	9602	9750	9540	9346	Column1	Column2
Wt of cylinder (gm)	4179	4179	4179	4179	4179		
Wt of wet sample(gm)	5058	5423	5571	5361	5167		
Wet density (Mg/m ³)	2.194	2.353	2.417	2.326	2.242		
Container No.....	5	14	8	1	12		
Wt. of cont. & wet soil (gm)	256	274	242	243	277		
Wt. of cont. & dry soil (gm)	246	257	225	223	252		
Wt. of water(gm)	10.0	17.0	17.0	20.0	25.0		
Wt. of cont.(gm)	78	79	79	79	77		
Wt. of dry sample(gm)	168	178	146	144	175		
Water content %	6.0	9.6	11.6	13.9	14.3		
Dry density (Mg/m ³)	2.071	2.148	2.165	2.042	1.961		



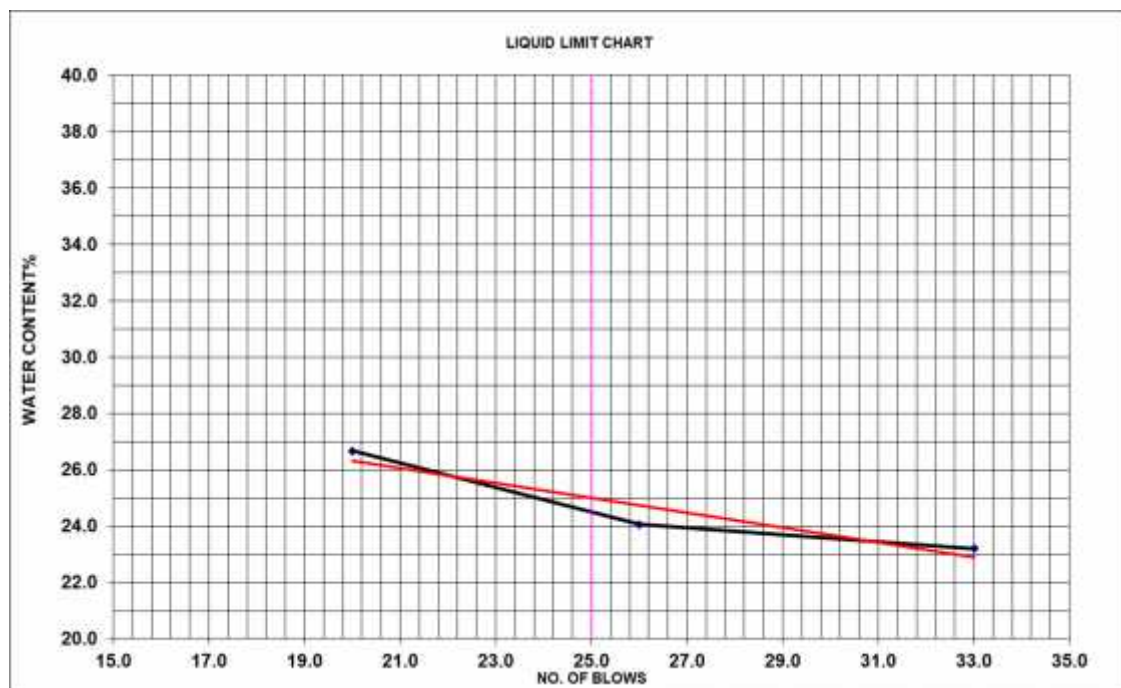
DEPARTMENT OF FEEDER ROADS						
BORROW PIT. B . AT ASAFO -KUKURANTUMI						
MATERIALS DIVISION						
COMPACTION TEST						
Name: Asiedu Mintah A.	Lab. Ref. No.			Date:12 th MARCH.2018		
	Station: KOFORIDUA			Vol. of Mould=2.305m ³		2.305
CONTRACTOR: M/S JILCON LIMITED.						
Wt of cylinder & wet soil(gm)	9275	9693	9805	9587	9418	Column1 - Column2
Wt of cylinder (gm)	4179	4179	4179	4179	4179	
Wt of wet sample(gm)	5096	5514	5626	5408	5239	
Wet density (Mg/m ³)	2.211	2.392	2.441	2.346	2.273	
Container No.....	11	6	9	10	31	
Wt. of cont. & wet soil (gm)	236	242	258	272	358	
Wt. of cont. & dry soil (gm)	227	231	243	253	324	
Wt. of water(gm)	9.0	11.0	15.0	19.0	34.0	
Wt. of cont.(gm)	78	78	77	78	76	
Wt. of dry sample(gm)	149	153	166	175	248	
Water content %	6.0	7.2	9.0	10.9	13.7	
Dry density (Mg/m ³)	2.085	2.232	2.239	2.116	1.999	



DEPARTMENT OF FEEDER ROADS				HOLE ID	Stockpile
REGIONAL MATERIALS LABORATORY				SAMPLE	DATE:13/03/2018
KOFORIDUA-GHANA				PROJECT	Kurkurantumi - Asafo
ATTERBERG LIMITS				LOCATION	Kurkurantumi - Asafo
				PROJECT No.	BORROW PIT A
LIQUID LIMIT DETERMINATION					
TRIAL NO	1	2	3		
NO. OF BLOWS	34.0	25.0	15.0		
CONTAINER NO.	P42	P17	P16		
Wt OF WET SAMLPE + CONTAINER	31.7	32.4	32.1		
Wt OF DRY SAMLPE + CONTAINER	27.5	27.9	27.3		
Wt OF WATER	4.2	4.5	4.8		
Wt OF CONTAINER	9.4	9.2	9.3		
Wt OF DRY SOIL	18.1	18.7	18.0		
MOISTURE CONTENT	23.2	24.1	26.7		LL 24.6
PLASTIC LIMIT DETERMINATION					
TRIAL NO	1	2			
CONTAINER NO.	P34	P20			
Wt OF WET SAMLPE + CONTAINER	24.3	22.7			
Wt OF DRY SAMLPE + CONTAINER	22.1	20.8			
Wt OF WATER	2.2	1.9			
Wt OF CONTAINER	9.2	9.3			
Wt OF DRY SOIL	12.9	11.5			
MOISTURE CONTENT	17.1	16.5	PL =	16.8	PI 7.8



DEPARTMENT OF FEEDER ROADS				HOLE ID	Stockpile
REGIONAL MATERIALS LABORATORY				SAMPLE	DATE:13/03/2018
KOFORIDUA-GHANA				PROJECT	Kurkurantumi - Asafo
ATTERBERG LIMITS				LOCATION	Kurkurantumi - Asafo
				PROJECT No.	BORROW PIT B
LIQUID LIMIT DETERMINATION					
TRIAL NO	1	2	3		
NO. OF BLOWS	20.0	26.0	33.0		
CONTAINER NO.	P33	P11	P5		
Wt OF WET SAMLPE + CONTAINER	32.1	32.4	31.7		
Wt OF DRY SAMLPE + CONTAINER	27.3	27.9	27.5		
Wt OF WATER	4.8	4.5	4.2		
Wt OF CONTAINER	9.3	9.2	9.4		
Wt OF DRY SOIL	18.0	18.7	18.1		
MOISTURE CONTENT	26.7	24.1	23.2		LL = 25.0
PLASTIC LIMIT DETERMINATION					
TRIAL NO	1	2			
CONTAINER NO.	P21	P13			
Wt OF WET SAMLPE + CONTAINER	24.3	22.7			
Wt OF DRY SAMLPE + CONTAINER	22.1	20.8			
Wt OF WATER	2.2	1.9			
Wt OF CONTAINER	9.2	9.3			
Wt OF DRY SOIL	12.9	11.5			
MOISTURE CONTENT	17.1	16.5		PL = 16.8	PI = 8.2



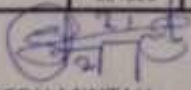
Annex 3: Compaction test results on existing subgrade and subbase


MINISTRY OF ROADS AND HIGHWAYS
DEPARTMENT OF FEEDER ROADS,
MATERIALS DIVISION
SUMMARY OF FIELD DENSITY TEST RESULTS

ROAD NAME: RESEALING AND SURFACING OF KURURANTUMI - ASAFO AND OTHERS FEEDER ROAD
 CONTRACT NO : DFR/ER/SA/RT/SURF/LOT.2/2012
 CONTRACTOR : M/S JILCON LIMITED.

LOT NO:2 DATE: 26/02/2017

Date of test	Location or Chainage	Layer	Max. Dry Density by Modified	Optimum Moisture Content	Field Density (Mg/m ³)	% Compaction Achieved	Remarks
15/2/2018	7+835	SUB-BASE	2.216	6.7	2.154	97.2	AV.
"	7+935	"	2.216	"	2.138	96.5	THICKNESS
"	8+035	"	2.216	"	2.169	97.9	OF
"	8+135	"	2.216	"	2.163	97.6	100MM
"	8+235	"	2.216	"	2.161	97.5	
23/02/2017	8+335	"	2.216	"	2.136	96.4	
"	8+400	"	2.216	6.7	2.152	97.1	AV.
							THICKNESS
"	10+810	SUB-BASE	2.216	"	2.165	97.7	OF
"	10+910	"	2.216	6.7	2.145	96.8	100MM
	11+010	"	2.216	"	2.163	97.6	
23/02/2017	11+110	"	2.216	"	2.174	98.1	
"	11+175	"	2.216	"	2.163	97.6	
"	12+850	SUB-BASE	2.216	6.7	2.163	97.6	AV.
"	12+950	"	2.216	"	2.147	96.9	THICKNESS
23/02/2017	12+965	"	2.216	"	2.161	97.5	OF
							100MM
"	13+100	SUB-BASE	2.216	"	2.161	97.5	
"	13+200	"	2.216	"	2.161	97.5	
	13+350	"	2.216	"	2.123	95.8	


ASIEDU MINTAH
 ASST. CHIEF TECH. ENG. (MATERIALS.)


OPERATIONS MANAGER II

MINISTRY OF ROADS AND HIGHWAYS
DEPARTMENT OF FEEDER ROADS.
MATERIALS DIVISION
SUMMARY OF FIELD DENSITY TEST RESULTS

ROAD NAME: RESEALING AND SURFACING OF KUKURANTUMI - ASAFO AND OTHERS FEEDER ROAD
 CONTRACT NO : DFR/ER/SB/RT/SURF/LOT.2/2012
 CONTRACTOR : M/S JILCON LIMITED.

LOT NO:2

DATE: 26/02/2017

Date of test	or Chainage	Layer	Max. Dry Density Modifie Field	Density (MG/m ³)	Optimum Moistur %	Compaction Achieve	Remarks
5/2/2018	7+400	FILLING TO	1.974	1.848	15.6	93.6	
"	7+550	CULVERT	1.974	1.861	"	94.3	
"	7+700	APPROACHES	1.974	1.846	"	93.5	
"	7+850	AND LOWLYING	1.974	1.828	"	92.6	
"	8+000	AND LOWLYING	1.974	1.846	"	93.5	
5/2/2018	8+150	AREAS	1.974	1.863	15.6	94.4	
"	8+300		1.974	1.860	"	94.2	
"	8+400		1.974	1.832	"	92.8	
5/2/2018	10+950	FILLING TO	1.974	1.846	15.6	93.5	
"	11+100	CULVERT	1.974	1.863	"	94.4	
"	11+175	APPROACHES	1.974	1.854	"	93.9	
"		AND LOWLYING			"		
5/2/2018	12+900	AND LOWLYING			15.6	94.8	
"	12+975	AREAS	1.974	1.865	"	94.5	
5/2/2018	13+150		1.974	1.861	15.6	94.3	
"	13+300		1.974	1.867	"	94.6	
"	13+400		1.974	1.877	"	95.1	

ASIEDU MINTAH
 ASST.CHIEF TECH.ENG.(MATERIALS.)

OPERATIONS MANAGER IV

Annex 4: Rainfall data collection form

Rainfall data collection form					
Project:		Kukuratumi - Asafo Feeder Road		Month:	Year:
Day of month	Readings in mm				
	Time: 06.00	Time:	Time:	Time: 18.00	Total
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
Instructions:				Monthly total:	
Record the rainfall every day at 06.00 and 18.00.					
In case of mid-day showers, record the rainfall after the shower and the time of the reading.					
After each reading, empty the container and mount it back on the stand.					