Long Term Pavement Performance Monitoring of Trial Sections in Mozambique incorporating Capacity Building of Road Research Centre Personnel

Site Visit Report No. 2: 15th to 24th February 2017

Authors:

Robert Geddes

Adilson Vilinga

Project No. MOZ2093A

22nd March 2017

Cover Image: Scenes from the field visit

Quality assurance and review table			
Version	**Author(s)**	**Reviewer(s)**	**Date**
Draft	Robert Geddes Adilson Vilinga	Phil Paige-Green Nkululeko Leta	4 March 2017

ReCAP Project Management Unit

Cardno Emerging Market (UK) Ltd

Oxford House, Oxford Road

Thame

OX9 2AH

United Kingdom

ReCAP Completion Report Template

ReCAP Database Details: Economic Growth through Effective Road Asset Management			
Reference No:	MOZ2093A	**Location**	Mozambique
Source of Proposal	Tender	**Procurement Method**	Open Competitive Tendering
Theme		**Sub-Theme**	
Lead Implementation Organisation	Civil Design Solutions	**Partner Organisation**	Paige-Green Consultants Independent Software ASCO (Z) (Pvt) Limited
Total Approved Budget		**Total Used Budget**	
Start Date	1 October 2016	**End Date**	15 January 2018
Report Due Date	February 2017	**Date Received**	

Key Words

Visual Road Condition Surveys, Visual Assessment Index

Acronyms, Units and Currencies

$	United States Dollars
AFCAP	Africa Community Access Partnership
ANE	Administração Nacional de Estradas; National Road Administration
ASCAP	Asia Community Access Partnership
CDS	Civil Design Solutions
CSIR	Council for Scientific and Industrial Research
DFID	Department for Further International Development
EU	European Union
FWD	Falling Weight Deflectometer
GPS	Global Positioning System
LEM	Engineering Laboratory for Mozambique
LVR	Low Volume Road
PMU	Project Management Unit
RAI	Rural Access Index
ReCAP	Research for Community Access Partnership
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)
VCI	Visual Condition Index
VRCS	Visual Road Condition Survey

Contents

List of Figures

1 Introduction

1.1 Background to the Project

The Africa Community Access Partnership (AfCAP) is building on the programme of high quality research established under AfCAP phase 1 and taking this forward to a sustainable future. The aim is to ensure that the results of the research are adopted in practice and influence future policy in the roads sector.

As part of this initiative AfCAP is assisting the Mozambique National Roads Administration (ANE) to evaluate existing road experimental sections constructed previously in Mozambique under several programmes, including with AfCAP support. These trial sections were designed to demonstrate and verify different options in design, material utilisation and construction methods for rural roads (particularly low-volume rural roads- LVR).

Useful data have already been obtained from both old and newer trial sections and some have been monitored over time by ANE and with the support of AfCAP and TRL (UK). To achieve the objective of influencing future policy in the road sector, it is necessary to review the outcomes of all trial sections constructed in Mozambique and to start a process of establishing new trial sections. The as-built information and performance data from experimental sections needs to be consistent between the projects and over the monitoring periods, and the establishment of the trial sections must be geared towards providing reliable and appropriate data. The data needs to be consistent with regional protocols for establishing and monitoring trial sections.

1.2 Objectives

The objectives of the project are as follows:

1. To evaluate the nature and quality of information available from the existing trial sections.
2. To refine and implement existing regional guidelines and protocols to ensure that the establishment of road trials and collection of the information is standardised across Mozambique and the African region.
3. To establish new trial sections, and to collect data on the old and new trial sections in Mozambique on a consistent and continuous basis over a number of years.

The project is providing training and capacity building to the ANE Road Research Centre (RRC) for the development of an Electronic Data Management System (EDMS) to manage data generated from the trial sections and other research projects. Capacity building and training of the RRC personnel includes data input, processing and archiving of research data. The data management system will be closely aligned to a new protocol for monitoring research sections in roads, which is being developed under the project.

Civil Design Solutions has been engaged under AfCAP to provide technical assistance to the Mozambique Roads Research Centre (RRC) to achieve these objectives. The RRC is responsible for conducting the research and delivering the final outcomes.

2 Site Visit Activities

2.1 Purpose of the Report

This report describes the activities that were undertaken by the project team (ANE/LEM and CDS) at the site of the trial sections near Maxixe, Inhambane Province in the period 13th to 24th February 2017. The purpose of the visit included the following:

1. Present the draft Monitoring Protocol to ANE officials and receive feedback from participants.
2. Conduct demonstrations in gathering, processing and analysis of data on visual assessments, roughness measurements using the Merlin, and DCP measurements using the AFCAP DCP software.
3. Identify and mark the proposed monitoring and control sections.
4. Supervise and monitor the gathering of field data including visual surveys, roughness measurements, test pit profiling and sampling, DCP measurements, rut depth measurements and setting up the control section.

2.2 Location of LTPP, Experimental and Control Sections

The location of the research sections is as shown in Figure 2.1 below:

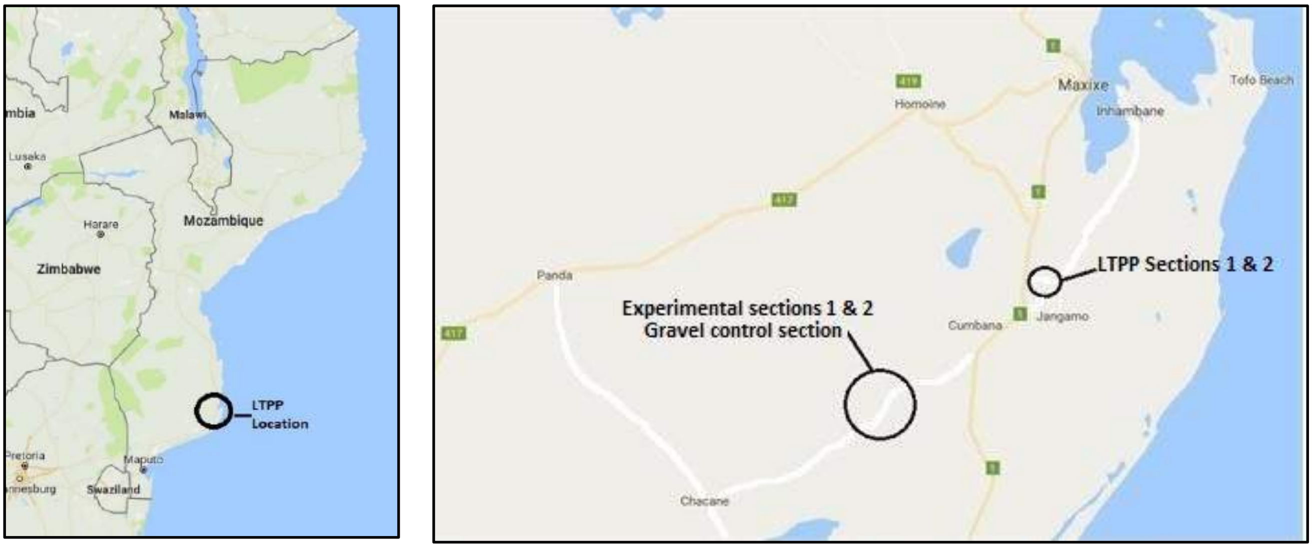


Figure 2.1: Location of LTPP and Experimental Sections

2.3 Team Composition

Mr Fernando Dabo, Road Research Centre, ANE
Mr Carlos Cumbane, LEM
Mr Moises Dzimba, Delegation Representative, Gaza Province
Mr Cedric Nambureta, Delegation Representative, Inhambane Province
Mr Paulo Guicuane, Materials Technician, Maxixe
Prof. Phil Paige-Green, Material Expert, Paige-Green Consultants

Mr Adilson Vilinga, Assistant Team Leader.

2.4 Monday, 13th February 2017

The CDS team arrived in Maxixe in the afternoon and met the other researchers to plan for the next day's activities. It was planned that the Materials Expert was to make a presentation on the Draft Protocol at the offices of the Provincial Delegation in the morning of Tuesday 14th February. It was learnt at the meeting that Ms Rubina was replaced by Mr Fernando, as Rubina has been promoted in ANE and is going to be too busy to participate in these research activities. Fernando was the former ANE Delegado for Inhambane Province for six years before being moved to Niassa Province and is now based at the ANE headquarters taking over responsibilities from Ms Rubina. Fernando oversaw the construction of the research sections on the Cumbane-Chacane Road.

2.5 Tuesday, 14th February, 2017

Prof Phil Paige-Green, the Materials Expert, delivered a Power Point presentation on the draft Monitoring Protocol to the research team, some engineers mainly from the Inhambane Delegation and a Consultant, twelve participants in all. The list of participants is shown in Annex I. A discussion was later held to clarify certain aspects of the Protocol. Some questions and responses were taken.

One important question was asked in relation to why the Protocol did not have a section on carrying out research on asphalt surfaced roads and the associated laboratory testing. The response was that AFCAP was mainly concerned with aspects on improving community access and this would entail conducting research on low volume roads which would normally exclude roads built with asphalt as these roads have higher levels of traffic and are expensive to build. (It is noted that test methods for asphalt were included in the ANE Research Centre strategy document prepared previously by CSIR).

The five participants listed above were identified to proceed in the research. The group includes two new researchers and three who participated in the first field visit for the LTPP project. Two roads, one connecting Agostinho-Neto with the Inhambane road and one between Cumbane-Chacane, were identified as the roads for the research with the former being a LTPP research-type road and the other being an experimental research-type road. A gravel control section was proposed on the Cumbane-Chacane road.

The equipment to be used in the site measurements was checked to be in working condition. In the afternoon, the team was on site to identify the LTPP sections on the Agostinho Neto road. Two sections were identified: one dealing with the effect of different subgrade conditions on performance and the other dealing with the effect of different edge restraint/support conditions on the pavement. Later in the afternoon, the team moved to the

Nyagibiga-Marengwe Road, a less trafficked paved road, to carry out demonstrations of the Merlin and DCP.

Presentation of the Draft Protocol at the Delegation Office

Demonstration of the Merlin

2.6 Wednesday, 15th February, 2017

Wednesday morning was spent on the Cumbane-Chacane Road identifying two experimental sections and the gravel control section. A demonstration on a visual assessment was planned, however, the weather deteriorated quite quickly due to the approaching cyclone and fieldwork had to be abandoned for the day.

The experimental sections identified were as follows:

1. Approximately 400m long with a sand seal and armoured sand base,
2. Approximately 400m on the penetration macadam and sand base section.

Both sections are in relatively good condition and are expected to have a longer remaining service life than other sections along the road. The Otta Seal sections were omitted as most of them are already in poor condition. The VCIs from the previous mission were used to assist in identifying the experimental sections.

A 3rd section was identified, which is a 300m long gravel control section on the Cumbane-Chacane road, located between the two paved experimental sections of the road. An attempt was made to carry out visual assessments but had to be curtailed due to the approaching storm. This type of road would normally be the alternative to the experimental surfacing sections constructed.

1st Experimental Section; Sand Seal on Armoured-Calcrete-Sand Base

2nd Experimental Section; Penetration Macadam on Sand Base

Gravel (Calcrete) Control Section

2.7 Thursday, 16th February 2017

Once the weather conditions had stabilised in the afternoon of Thursday, the team left for further field work. Two team members were unable to be present as they were dealing with the aftermath of the cyclone (damage to their houses). Most people did not report for work on this day in Maxixe. Demonstration of a detailed visual inspection was carried out on the Agostinho Neto Road, and data recorded for later analysis. More DCP tests were conducted.

Later in the evening the team met at a filling station, one of the few places with power, to carry out the demonstration of the AFCAP DCP software using the data collected. This was a successful capacity building session. Participants were encouraged to register and download the DCP software from the AFCAP website.

Demonstration of DCP and collection of data for analysis

Demonstration of detailed Visual Assessment and collection of data for further analysis

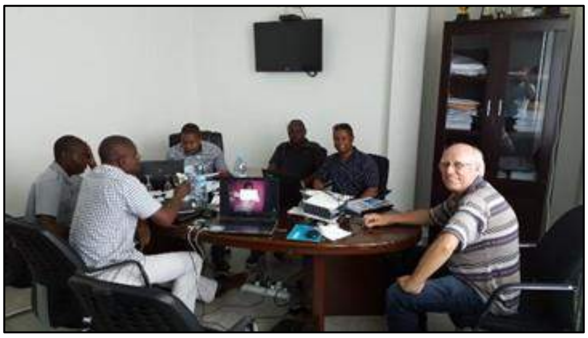
Demonstration of Visual Assessment

2.8 Friday, 17th February 2017

The team met with the Materials Expert on Friday morning before he left for the airport around 11:30am. A demonstration on calculating the VCI was conducted using the data collected previously. A training session was conducted on the analysis of the Merlin data to calculate the IRI. Participants were given most of the documents that they may require in the course of the following week's field work including visual survey forms, the draft Protocol and the PowerPoint presentation, VCI calculation spreadsheet, guidelines for test pit profiling, guidelines on visual surveys for paved and unpaved roads, guidelines on geotechnical tests required and guidelines on prediction of moisture content in untreated pavement layers.

The main issues discussed during the debriefing meeting after the training sessions were as follows:

1. The two members of the team that missed the Thursday afternoon and evening sessions were to be assisted with the analysis of the DCP data using the AFCAP DCP software and conducting visual surveys on flexible and unpaved roads in the coming week by the Assistant Team Leader.
2. Participants were made fully aware of what activities were to be carried out on each of the LTPP/Experimental/Control sections. Expected outputs from participants included: detailed measurements and marking out of the sections, trial pits and collection of soil samples for laboratory testing, IRI using the Merlin, DCPs and a detailed visual inspection and deriving the VCI for uniform sections within the chosen sections. Concrete benchmarks must be installed on the gravel control section and a survey of the 77 proposed data points with an automatic level is to be carried out to get the base data set on gravel loss. Deflection measurements will be conducted once the Benkelman Beam is in working condition and properly calibrated, and probably after the team receives some training on how to use it and how to analyse the data.
3. Participants were requested to make comments on the Protocol if any so that it can be concluded and translated into Portuguese.
4. The review of the current VCI calculation format was necessary to conform to the updated VCI visual survey form (Draft TMH 9 and TMH 22) for flexible pavements. There was also need to prepare a version for the VCI calculation for unpaved roads.
5. Participants were requested to submit their reports on establishing their monitoring sections **within two weeks** after leaving site. This was to be discussed in more detail at the end of the fieldwork.
6. The preliminary programme for the next week was discussed and indicated that participants were to carry out field work from Monday to Wednesday and spend Thursday on their draft reports. Team members chose to work independently on their particular sections, starting on Monday the following week.



Training Session, Maxixe

Analysing Merlin data, VCI calculation and debriefing meeting

2.9 Monday, 20th February 2017

Field work on this day started late as the team prepared the various forms and guidelines required for carrying out the tasks, the Merlin equipment was being repaired and arrangements were being made with one of the ANE contractors to assist with the opening and closing of the test pits. The effects of the cyclone were still being felt and making any arrangements was difficult. The Contractor was unreachable.

Once arrangements were in place the team proceeded to site. The locations of the research sections on the chosen roads are as shown in Figure 2.2 and 2.3 below.

Figure 2.2: LTPP Section 1 and 2 on Agostinho Neto Road

Figure 2.3: Experimental Sections and Gravel Control Section on Cumbane-Chacane Road

The following activities were carried out on the LTPP, Experimental and Control sections on this day:

1. LTPP section 1 (Carlos Cumbane)
    - Marking out the 500m section in accordance with the draft Protocol, subdividing the section into 25 No. x 20m sections. Five panels A to E were reserved for destructive testing (as shown in Figure 2.4).
    - GPS referencing of sections.
    - Conducting DCPs on five panels.

2. LTPP Section 2 (Dzimba)
    - Marking out the 500m section as described in the draft Protocol, subdividing the section into 25 No. x 20m sections. Five panels A to E were reserved for destructive testing (as shown in Figure 2.4).
    - GPS referencing of sections.
    - Conducting DCPs in five panels (A, 2,10, 15 & E).
    - 2 No. test pits in panel A and 2.

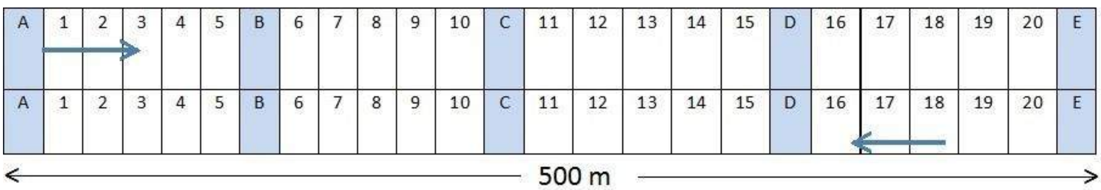


Figure 2.4: Layout of LTPP sections on Agostinho Neto

3. Experimental Section 1 and 2 (Dabo & Cedrik)

- Marking out the 250m sections as shown in the draft Protocol and subdividing into 13 panels (12No. x 20m and 1No. x 10m), Three panels A, B and C were reserved for destructive testing (as shown in Figure 2.5).
- Roughness was measured using the Merlin on section 1 and partly on section 2.

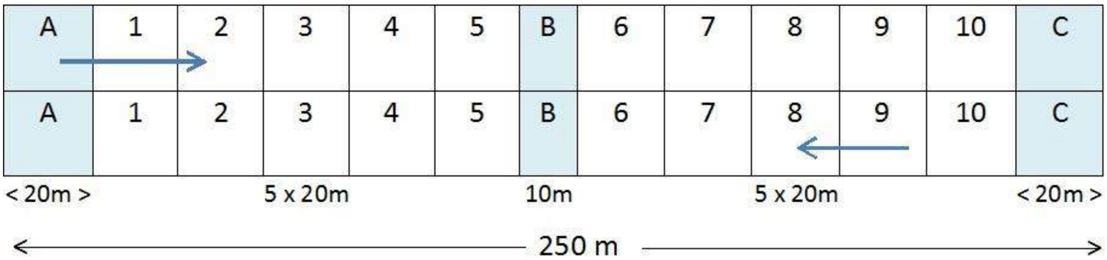


Figure 2.5: Layout of Experimental sections on Cumbane-Chacane

4. Control Section (Paulo)
   - This section was established on the unpaved section of the road between the two paved sections.
   - The 300m section was marked out, with the 50m gravel-loss section pegged within the 300m overall section (see Figure 2.6).

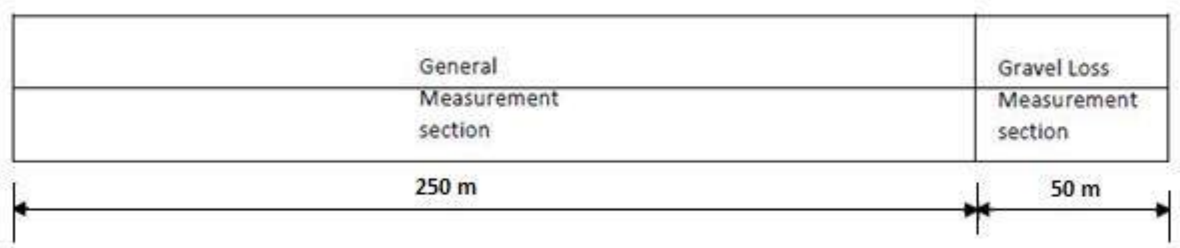


Figure 2.6: Layout of Gravel Control Section

After reviewing the days' work, it was discovered that the LTPP sections on this road were incorrectly marked while the CDS adviser was with the team on the Cumbane-Chacane road. Correct remarking of the sections was carried out the following day. It was also noted that sharing the available equipment would be difficult due to the distance between the sites. The team decided to mobilise a third vehicle for the use of the adviser to enable him to alternate between the sites and transfer the equipment more easily.

2.10 Tuesday, 21st February 2017

1. LTPP Sections 1 & 2
   - The marking of the LTPP sections was corrected and DCPs conducted in the correct panels near the proposed locations for the test pits.
   - One test pit was profiled and sampled on LTPP 2.

2. Experimental Sections 1 & 2
    - Roughness measurements using the Merlin on Section 1.

3. Control Section
    - Four permanent concrete gravel loss markers were installed under the gravel layer in the subgrade

The ANE Delegation team had to leave site at midday to attend to a meeting with the Governor who was visiting their offices that afternoon. It was also raining for most of the afternoon and no more field work was undertaken.

Roughness measurements on the LTPP 1

DCP on LTPP 2

Fixing permanent concrete benchmarks on the gravel control section

2.11 Wednesday, 22nd February 2017

1. LTPP sections
    - Section 1: Roughness measurements using the Merlin and the Visual assessment was carried out.
    - Section 2: The visual assessment, roughness using the Merlin and one test pit was profiled and sampled.
2. Experimental Sections
    - Section 1: Visual assessments.
    - Section 2: Visual assessments and DCPs.
3. Control Section
    - DCPs, 2No. Test pits profiled and sampled and survey of the current gravel levels. of the 77No. points on the gravel loss measurement section.

Again like the previous day, it rained for most of the afternoon and little could be done.

Test pit profiling on the Control Section

Excavation of Test pit on LTPP 2

Roughness Measurement on Experimental Section2

2.12 Thursday, 23rd February 2017

1. LTPP sections
    - Section 1: 2No. Test pit profiling and sampling and DCPs.
    - Section 2: Measurement of roughness using the Merlin and measurement of rutting using a straight edge and wedge of part of the section.
2. Experimental Sections
    - Section 1: 3No. Test pit profiling and sampling and DCPs
    - Section 2: 3No. Test pit profiling and sampling.
3. Control Section
    - Roughness measurements could not take place as the Merlin arrived late from the LTPP sections and it was raining.
    - Paulo was assisting in the test pit profiling and sampling on the experimental sections.

It was another rainy afternoon and work had to be suspended in the early afternoon. Roughness measurements and visual assessments were still to be undertaken on the control section. Rut measurements using the straight edge are outstanding on all sections.

2.13 Friday, 24th February 2017

The Assistant Team Leader was to leave for the airport around 11:30 in the morning. The team met in the morning at Farmar Hotel for a debriefing and plan for the remaining activities. The main points of the discussions during the debriefing meeting were as follows:

1. The team was to complete collection of the remaining field data (rut depths on all sections and roughness (using the Merlin) and visual assessment data on the control section).
2. All the field data collected would be sent to CDS once the team members had transferred the raw data to the appropriate forms.

3. The researchers were to mark each panel of the experimental/LTTP sections relative to a chainage from the start of the road. GPS coordinates of the start and end of the sections were determined when the sections were marked out.
4. Researchers were to collect all the design and as-built data for the sections chosen. Information for the Cumbane-Chacane road was available to some extent from the TRL documents. For Agostinho Neto, researchers were to obtain as-built information from the Delegation office in Maxixe. Total life cycle costs (including maintenance costs) to date of the sections must be collected as well.
5. For now, the VCI can be calculated using the current spreadsheet. This will be revised once the revised spreadsheet is released by the CDS advisers.
6. Traffic information must be collected from the Delegation office for the most recent traffic counts. Researchers undertook to carry out axle load surveys using a mobile weighbridge in the future. The ANE Delegations in Maxixe and Xai Xai have mobile weigh bridges.
7. Indicator/performance tests are required on the test pit samples collected to include the following:
    a. Moisture content determination
    b. Sieve analysis and sedimentation test (additional sieves: 1.18, 1.0, 0.9, 0.6, 0.425, 0.3, 0.25, 0.2, 0.15 and 0.075mm)
    c. Atterberg limits (both on material passing the 0.425mm and 0.075mm sieves; including shrinkage)
    d. OMC/Density
    e. CBR (base at 100 and 95% and subbase/subgrade at 95 and 90% of Mod).
8. Due to lack of internet at the hotel, team members were unable to register and download the AfCAP DCP software. An official and downloaded copy was given to all by the CDS adviser, who had already registered and downloaded the official version. But the members were encouraged to register and download from the AfCAP website.
9. The basic structure of the report each researcher will produce will contain the following main topics:
    a. Introduction/Background
    b. Methodology (to include the details of the experimental/LTPP sections with dimensioned sketches etc.)
    c. Results (all field data collected, lab results, DCP processed results, VCIs, soil profile logs etc.)
    d. Analysis (interpretation of the results, comments on findings etc.)
    e. Conclusions/recommendations for improvements
    f. Appendices of all raw and processed field data
    g. Picture log.
10. The team must collectively assist and mentor Paulo in producing the report for the control (gravel) section.

11. The team proposed that the reports will be submitted at the **end of March 2017** to allow for adequate time to have the soil samples tested and results collated.
12. All team members were to obtain a copy of the last team report. The final version of the report was first to be sent to CDS by Carlos before the team disbands on the same day.
13. It was agreed that the team must not hesitate to consult the CDS Advisers if they encounter any challenges; they are also to submit the drafts for review and comments to CDS before the final submission.

3 General Conclusions Recommendations

i. From observations made by the CDS team during the field work, it is apparent that the research team has a good grasp of the scope of what needs to be done to move the research forward.

ii. The research team has gained valuable knowledge and analysis tools from the training so far implemented. These include the workshop on the draft Protocol, calculation of the VCI, test pit profiling and sampling, the use of the AfCAP DCP software to carry out simple characterisation of the stiffness of different pavement layers and their thicknesses and the use and analysis of roughness data from the Merlin.

iii. Training in the use of the Bump Integrator (BI) to carry out roughness measurements and deflection measurements using a Light Weight Deflectometer (LWD) should be considered once the equipment is available. It is understood that ANE in Maputo has a BI which needs to be serviced.

iv. Other equipment that is required include a new DCP, straight edge and wedge, and GPS. A Lightweight Deflectometer (LWD) would also be most useful for this study and training.

v. The Protocol needs to be translated into Portuguese for full benefits to be achieved by the research team as this will improve its understanding and assimilation.

vi. It is important to maintain the same research team members in order to have continuity otherwise the research learning process will have to be restarted if a new member joins midway through the programme.

vii. The site baseline and monitoring data need to be made available to the CDS Database Expert in Maputo so that he can start to populate the database.

viii. The next visit of the CDS advisory team is expected in April/May 2017.

Annex I: List of Participants at the Presentation of the Draft Protocol in Maxixe

No.	Name	Organisation	Position	Contacts
1	Cedrik Namburete	ANE - INHAMBANE	Engineer	840488333 cedriknamburete@gmail.com
2	Rachide Racide	ANE - INHAMBANE	Engineer	849603694 rracide@hotmail.com
3	Alberto Jetimane	ANE - INHAMBANE	Senior Technican	ajetimane@yahoo.com.br
4	Amandio Luis	ANE – INHAMBANE	Technical, DEPLA	amandio.luis@yahoo.com.br
5	Condorce Dos Martires	INHAMBANE - CPG	Resident Engineer	condorce2001@yahoo.com.br
6	Moises A Dzimba	ANE – GAZA	Engineer	moises.dzimba@gmail.com
7	Fernando Dabo	ANE – DIMAN	Engineer-Maintenance Dept	82/843222390 fdabo@ane.gov.mz femidade@gmail.com
8	Jorge Rungo	ANE – INHAMBANE	Planning Engineer	jfrungo@gmail.com 847088436
9	Carlos Cumbane	LEM	Materials Engineer	carloscumbane@yahoo.com.br 843039282/823839252
10	Iracema Mascarenhas	ANE – INHAMBANE	Engineer	iracemamascarenhas@hotmail.com 848040830
11	Eugenio Cha-Verde	ANE – INHAMBANE	Technician	echaverde@yahoo.com 844349007/828703550
12	Paulo Guicuane	ANE – INHAMBANE	Lab Tech	846176164 paulo_guicuane@gmail.com
13	Adilson Vilinga	ASCO (Z) LTD.	Consultant	adilsonvilinga@gmail.com +258821265101/+260977756098
14	Phil Paige-Green	Paige Green Consulting	Consultant	paigegreenconsult@gmail.com +258877417709/+27824441121

Annex II: Power Point Presentation of the Draft Protocol

AfCAP
Africa Community Access Partnership

UKaid

Long Term Pavement Performance Monitoring of Trial Sections in Mozambique:
Monitoring Protocol

Cardno

MOZ2093A

AfCAP
Africa Community Access Partnership

Background

- Innovations in road construction are necessary in Mozambique
  - Low traffic
  - Poor materials
  - High costs
- Many experiments already constructed
- Should be designed to optimise outputs
- Require monitoring in a standard and consistent way to determine effectiveness

AfCAP
Africa Community Access Partnership

Background

- Various types of road
- Each with unique performance paths and properties
  - Flexible (i.e. with bituminous surfacings),
  - Rigid (concrete),
  - Block-paved
  - Unpaved (earth or gravel).
- Draft monitoring protocol for Mozambique has been developed for RRC
  - Included in this document

AfCAP
Africa Community Access Partnership

Purpose and Scope

Background to planning experimental sections
Experimental design

Monitoring them for maximum benefit

Types and uses of various monitoring techniques.

AfCAP
Africa Community Access Partnership

EXPERIMENTAL DESIGN

- Experiments for different purposes
- Design to satisfy these
  - Technical viability of an innovation
  - Economic viability of an alternative
  - Pavement deterioration modelling
- First two must have good control sections

AfCAP
Africa Community Access Partnership

Types of experiments

- **Replacement materials for traditional ones, e.g. an alternative material such as slag or industrial waste**
- **Innovative treatment of sub-standard materials in structural layers, e.g mechanical, traditional or non-traditional stabilisation.**
- **Innovative treatment of subgrades to reduce common problems, e.g. collapsible, expansive or saline materials**
- **Different pavement structures such as thinner layers or even omission of specific layers, e.g. for low volume roads**
- **Alternative surfacings such as Otta and sand seals, polymer slurry seals, hand-laid cold-mix asphalt, etc.**
- **Different construction methods, e.g. conventional versus in-place recycling.**

AfCAP
Africa Community Access Partnership

Monitoring requirements

- Experiments affecting the structural capacity
  - Structural effects (e.g. deflection),
- Experiments affecting the surface performance
  - Functional effects (riding quality or skid resistance)
- Other operational issues
  - Social, regional economic or environmental impacts
  - Specific design and monitoring requirements.

AfCAP
Africa Community Access Partnership

Design requirements

- Minimise external influences
- Must not contribute to variations
  - Traffic - this should not change between the sections
  - Subgrade - uniform as possible - check using a DCP
  - Climate – consistent – especially over longer experimental sections, micro-climatic changes
  - Drainage – the drainage alongside and crossing the experimental sections should be as uniform as possible.

AfCAP
Africa Community Access Partnership

Identification

- Clearly identified sections with permanent marking (sign boards or roadside cairns)
- Record the GPS coordinates of the start and end points and any important points within the section.
- Paint markings can be used for short term indications of testing points, etc., but do get lost with time. (Long nails)
- Local road inspectors/foreman and maintenance teams must be made fully aware of the reasons and location of experimental sections
  - Instruct them to keep the monitoring team fully informed of any actions affecting the experimental sections, including maintenance activities.
  - Signboards indicating the location and purpose of the test sections, provide useful information for local communities

AfCAP
Africa Community Access Partnership

Length

- Depends on the issue being investigated and the method of construction.
- Each section must only include one variable from the norm. I(more than one makes it difficult to attribute changes in performance to the specific variable).
- Rather have several shorter trials each with one variable
- Normally about 250 m long (250 m to 500 m may be required to provide sufficient sites to carry out the destructive testing)
- If roughness using automated roughness measuring devices is required, a central section of at least 300 m is required.

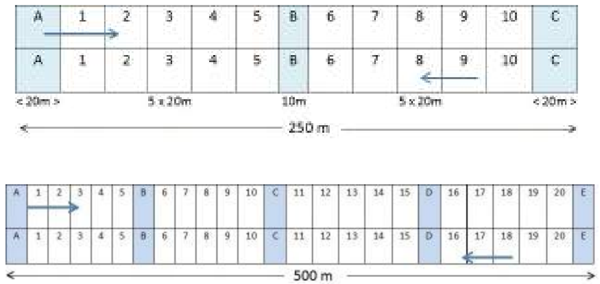
AfCAP
Africa Community Access Partnership

Length

- Trials will usually be built using conventional plant.
- The first and last 50 m of each section should be considered as transition zones (no monitoring or testing in these areas)
- Experimental investigations involving surfacings and surface treatments can be more easily controlled (transition zones of only a few metres required)
- The length of the sections should be 50 – 100 m, depending on the method of construction, with mechanised methods requiring longer sections.
- Other experimental types may require longer sections. For example, investigation of a climate resilience adaptation measure could require sections of many kilometres. Still require similar control section that excludes the adaptation technique for comparative purposes.

AfCAP
Africa Community Access Partnership

Length



Construction

- Highest quality, conforming fully with the local standards or those prepared for a specific project.
- Section cannot fails due to poor construction quality
- Only experienced contractors should be used for construction of experimental sections
  - New or different approach may require non-conventional construction techniques.
- Specified layer thicknesses and compaction densities must be achieved on both the experimental and control sections
- All materials must comply with the prescribed specifications for those materials.
- It is unacceptable, for example, that the trial of a new process fails because the thickness of the trial section was inadequate

Construction

- Conventional quality control measures must be implemented during construction.
- The number of samples and test sites should be increased by at least 50% to confirm uniformity of the experimental construction.
- Complete and accurate records of the construction process (including photographs and videos where appropriate), material sources and properties, application rates, quality control procedures and results, etc. must be collected and archived for ready access in later years.

Costing

- Most experimental sections require accurate costs for the total life cycle cost of the alternative compared with that of conventional practice.
- The total life cycle cost include :
  - construction costs
  - maintenance costs.
- We need all additional costs associated with the construction of the attribute being investigated. These costs include:
  - Any additional plant necessary on site specifically for the experimental construction
  - The cost of any additives, chemicals or treatments included in the experimental sections
  - The cost of any additional personnel required to implement the alternative construction
  - The cost of any additional time necessary to carry out the construction
  - Any additional costs related to the alternative, such as laboratory testing, special storage or transportation, etc.

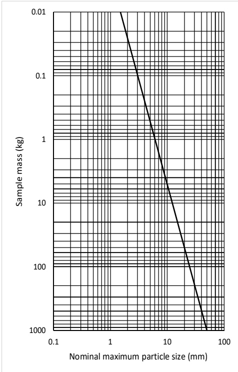
Costing

- Often, contractors tendering for innovative procedures and trials tend to inflate their prices
  - Unsure of timing, equipment requirements and other additional costs.
  - A typical example –experienced in asphalt – estimates for chip seals have been found to be significantly higher than for the asphalt
- One of the main components of total life-cycle costs is the ongoing maintenance cost. This needs to be carefully recorded and quantified
- The time and resources spent on maintenance of the experimental section must be separated from those of the reminder of the road and analysed separately

AfCAP
Africa Community Access Partnership

Sampling and testing

- All materials used must be sampled and tested before, during and immediately after construction.
- Samples from all layers and not only the “experimental layer”
- Standard sampling procedure should be used to ensure that sufficient material of the right type is obtained during the sampling.
- Always collect enough material



AfCAP
Africa Community Access Partnership

Sampling and testing

- Before construction, samples of borrow materials must collected – (test pits in the borrow pit)
- The test pit should be profiled and described - a description of each visibly distinct layer exposed in the side of the test pit using the parameters (MCCSSO).
- Each distinct layer in the soil profile (> 300 mm) must be sampled for the necessary testing - road indicator tests
- Samples must also be taken during construction after being dumped on the road, as well as after the layer has been worked.
- Some of the material should be retained as reference materials in case any additional testing is required later in the project

AfCAP
Africa Community Access Partnership

Sampling and testing

- Standard specifications apply to the material after construction. Borrow materials may change their properties, particularly their gradings, during construction. - Los Angeles Abrasion test (500 revolutions with steel charge)
- The test methods must be consistent and follow the local standards precisely. All testing of the highest quality
- After construction, dig a test pit to subgrade level to ensure that the construction thicknesses comply with the design and all materials used are within specification - profile and sample
- Additional information on the nature of the interlayer boundaries should also be recorded. For cemented layers, assess the in-situ condition of the stabilised layer – phenolphthalein

AfCAP
Africa Community Access Partnership

Sampling and testing

- Reinstate holes using material and layer thicknesses as closely as possible to those in the layers and then seal ensuring no water can penetrate the base – flush surface
- Take samples in positions that do not affect monitoring such as riding quality.
- Sampling holes must be large enough to provide sufficient material for the testing – a 1 x 1 m hole in a layer 150 mm thick will yield about 300 kg of material
- Any damage to the surfacing resulting from testing, e.g. DCP holes, moisture or density determination holes, etc., should be repaired - compacted cold-mix asphalt or some fine aggregate and bitumen emulsion

AfCAP
Africa Community Access Partnership

Monitoring

- Monitoring of unpaved and paved roads are entirely different.
- Specific programmes need to be established for the different types of roads.
- Unpaved roads continually change under traffic and climatic - can change from a good condition overnight following a severe weather condition or even after abnormal traffic
- Paved roads deteriorate at a slow but continuous rate under the effects of cumulative applications of heavy axles
- Flexible, rigid and block paved roads, all classed as paved roads, deteriorate totally differently
- Monitoring thus varies (Table)

AfCAP
Africa Community Access Partnership

Monitoring

AfCAP
Africa Community Access Partnership

VISUAL ASSESSMENT: UNPAVED ROADS

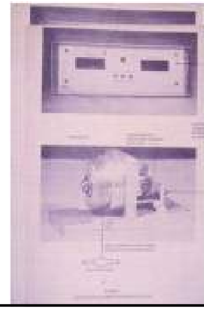
Monitoring

- Regular visual assessment of all experimental sections is essential.
- Compare the visual condition of the experiment with the control section to find any differences in performance.
- The visual assessments should be carried out by the same person or teams for consistency.
- The assessment should follow a fixed method

AfCAP
Africa Community Access Partnership

Monitoring

- Unpaved roads
  - Roughness
  - Visual
  - Gravel loss



AfCAP
Africa Community Access Partnership

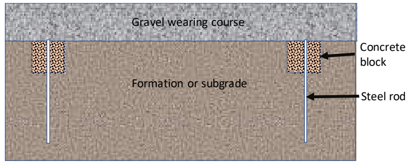
Monitoring

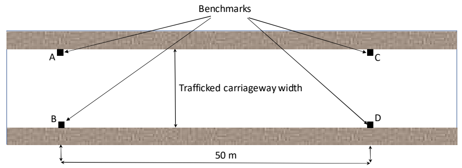
- Unpaved roads
  - Roughness
  - Visual
  - Gravel loss

AfCAP
Africa Community Access Partnership

Gravel loss

- Bench marks





AfCAP
Africa Community Access Partnership

Monitoring

- Paved roads
  - Bituminous
  - Concrete
  - Block
  - Other

AfCAP
Africa Community Access Partnership

Bituminous roads

- Riding quality
- Deflection
- Strength
- Moisture and density
- Visual
- Other

AfCAP
Africa Community Access Partnership

Concrete

- Mostly visual – cracking and faulting
- Skid resistance
- Riding quality

AfCAP
Africa Community Access Partnership

Other surfacings

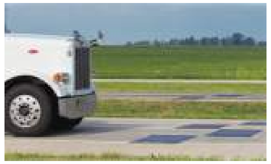
- Block paving, cobble-stones or hand-packed stone
- Visuals
- Riding quality
- DCP - structural condition of the support layers.

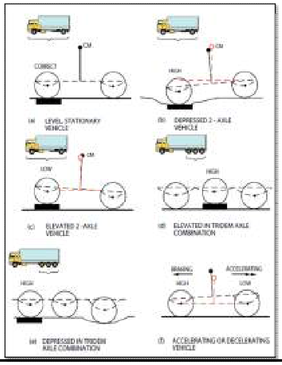
AfCAP
Africa Community Access Partnership

Monitoring equipment

- Traffic and axle loads

- Mostly portable weighing equipment
- Can use Weigh-in-motion but costly
- Manual counts





AfCAP
Africa Community Access Partnership

Monitoring equipment

- Traffic and axle loads

- Manual counts - where no automatic traffic count equipment
- Manual counts - used for short-term traffic counts – <1 week (24 hours a day for 7 days).
- Each passing vehicle is recorded on a survey form
  - vehicle type
  - time it was observed
  - In both directions for the full duration of the survey.
  - quality control is a major issue with manual traffic counts.

AfCAP
Africa Community Access Partnership

Monitoring equipment

- Traffic and axle loads

- Mechanical manual counters (clickers) used with clipboards
- Electronic manual counters in which the passage of each vehicle is recorded
- Video recorders that are used to record the traffic stream - with time and date stamps - permanent record

AfCAP
Africa Community Access Partnership

MONITORING EQUIPMENT

- Weather information

- Most interested in rainfall and precipitation
- May also require wind-speeds and direction, humidity, evaporation, etc.

AfCAP
Africa Community Access Partnership

Moisture and density

- Often need to characterise seasonal moisture movements
- Moisture difficult
  - Only gravimetric is accurate
  - Dual probe nuclear is probably next best
- Transverse profile
- Identify zone of equilibrium

AfCAP
Africa Community Access Partnership

Deflection

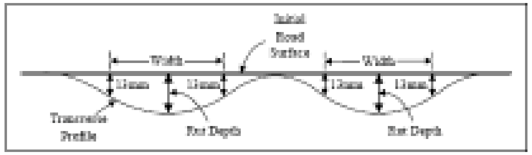
- Benkelmann beam
- FWD
- LWD

AfCAP
Africa Community Access Partnership

Surface deformation

- Transverse (rutting)
- Longitudinal (riding quality)

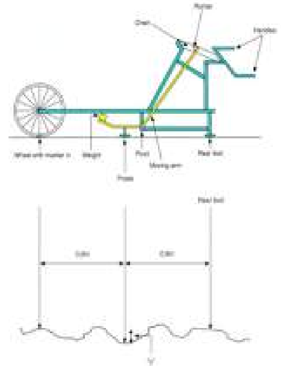
- Ruts
  - Straightedge (3m) and wedge
  - High speed profiler



AfCAP
Africa Community Access Partnership

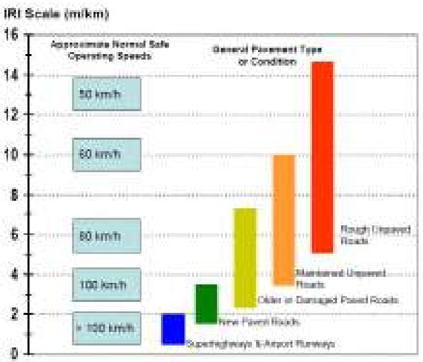
Surface deformation

- Riding quality
  - Response type measurement
  - Profilometer
  - MERLIN



AfCAP
Africa Community Access Partnership

Riding quality



AfCAP
Africa Community Access Partnership

Surface texture

- Specifically for surfacing trials
  - Towed "griptester"
  - Pendulum
  - Sand-patch

AfCAP
Africa Community Access Partnership

Laboratory testing

- All LTPP investigations will require *high qual*ity laboratory testing
- Depends on the materials and the intent of the investigation
- Could be subgrade soils and gravels, natural borrow materials, processed layer aggregates, surfacing chippings and bitumen, asphalt aggregates and binders, cemented materials and cementing agents, etc.
- Unique testing regime will be necessary
- Researcher carrying out the experiments defines which tests and how many should be done.

AfCAP
Africa Community Access Partnership

Reporting

- After any activity (construction, monitoring, maintenance), the data should be fully captured in the field on field forms.
- This data should be entered into a spread-sheet or data base as soon as possible
- The field forms must be digitally scanned and saved to a reliable storage medium.
- All input data should be checked for accuracy.

AfCAP
Africa Community Access Partnership

Reporting

- Reporting of the data will follow two formats
-

1. Initially, the data will be reviewed, checked and analysed in terms of its basic properties and statistics.
   - This is the descriptive phase of the analysis and reporting (based solely on the data provided)
   - No interpreted conclusions
   - This phase of analysis can be easily defended by a review of the information at hand.
2. The second level of analysis of the data is the interpretative analysis.
   - This extracts meaning from the data in terms of cause and effect
   - Often related to the experience and knowledge of the analyst.
   - The analyst will base conclusions on the data
   - These may differ from the conclusions of a second or other analysts
   - Can only be defended by the specific analysts based on their knowledge and interpretation of the information collected.

AfCAP
Africa Community Access Partnership

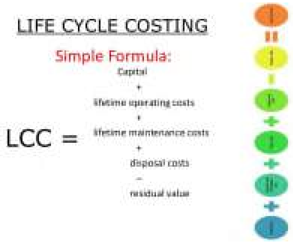
Visual condition index

- Allows comparison of visual assessment data
- Various ways – need to decide on one
  - Addition of weighted values
  - Point-deduct system
- Need to find the one that works best for "you"

AfCAP
Africa Community Access Partnership

Life cycle costing

- Usually main objective
- Which is more cost effective
- Needs to assess:
  - Construction costs
  - Maintenance costs
  - Operating costs
- Discounted over time
- Only real way to compare alternatives



AfCAP
Africa Community Access Partnership

13 APPENDICES

AfCAP
Africa Community Access Partnership

UKaid from the British people

Thank you for your attention

www.research4cap.org

Join the ReCAP Group on LinkedIn

Paigegreenconsult@gmail.com