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

Training Workshops Report (Final)

Civil Design Solutions

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Cover photo: Training Workshop at ANE offices in Maputo, August 2018.

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Abstract

The Africa Community Access Partnership (AfCAP) is supporting the Road Research Centre of the Mozambique National Roads Administration (ANE) to evaluate existing road experimental sections constructed previously in Mozambique. These trial sections were designed to demonstrate and verify different options in design, material utilisation and construction methods for low volume rural roads. AfCAP support includes training of RRC members in the establishment of road monitoring sections and data collection methods. A "Guideline for Monitoring of Experimental and Long-Term Pavement Performance Sections in Mozambique" has been developed and translated into Portuguese. A computerised database has been established and RRC members have been trained in the entry of data from the monitoring sites. Six-monthly data collection is ongoing on five monitoring sites in Inhambane and Zambezia Province and a gravel control section in Inhambane.

A series of three workshops was held in Maputo as part of the capacity building objectives of the project. The third workshop was the last input by Civil Design Solution on the project. Training was provided in how to identify, prioritise and carry out research projects on roads. A list of possible future research projects for the RRC was developed and prioritised. RRC members were also provided with assistance in the preparation of technical papers which were submitted to the SARF/IRF/PIARC Regional Conference for Africa to be held in Durban in October 2018.

The RRC members identified a need for training in pavement design to enable them to work more closely with the road design department in ANE including in the approval of road designs. The RRC members feel that they are doing useful work and seek greater recognition of the value of research from ANE senior management. The 2014 strategic plan for the RRC envisaged the employment of a full-time manager for the RRC but this has not been possible due to the financial crisis in Mozambique that started in 2016. No new recruitment is allowed in the civil service until advised otherwise. The lack of full-time management in the RRC is constraining its development as all of its members have other responsibilities.

Key words

Performance Monitoring, Low Volume Roads, Capacity Building

Acronyms, Initialisms, 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
CPR	Centro de Pesquisa Rodoviária
CSIR	Council for Scientific and Industrial Research
DFID	Department for Further International Development
DIMAN	Directorate of Maintenance
DIPRO	Directorate of Projects
EU	European Union
FWD	Falling Weight Deflectometer
GPS	Global Positioning System
IRIM	Inter-Regional Implementation Meeting
IRF	International Road Federation
LEM	National Engineering Laboratory for Mozambique
LTPP	Long-Term Pavement Performance
LVR	Low Volume Road
LVSR	Low Volume Sealed Road
PIARC	World Road Association
PMU	Project Management Unit
RAI	Rural Access Index
ReCAP	Research for Community Access Partnership
RRC	Road Research Centre
SANS	South Africa National Standards
SARF	South Africa Road Federation
TMH	Technical Methods for Highways
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)

1 Introduction

1.1 Background to the Project

The Africa Community Access Partnership (AfCAP) is assisting the Mozambique National Roads Administration (ANE) and the National Engineering Laboratory for Mozambique (LEM) to monitor and 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 low-volume roads. The project includes a review of the outcomes of trial sections previously constructed in Mozambique and the start of a process to establish new trial sections. Data obtained from monitoring the performance of these trial sections over time will be used to influence policy for LVRs in Mozambique, including national standards and specifications.

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 members of the ANE/LEM Road Research Centre (RRC). This includes training in field data collection and 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, including implementation of the regional protocols.

The monitoring data are consistent with regional protocols for establishing and monitoring trial sections, which are being developed with AfCAP support under separate regional research projects including the "Back-Analysis of Experimental Roads in Southern Africa" (RAF2069A) and "Capacity Building and Mentorship for the Establishment and Implementation of Monitoring & Evaluation Programmes on Experimental and Long-Term Pavement Performance (LTPP) Sections in Six AfCAP Countries and Myanmar" (GEN2132A).

1.3 Progress

The project commenced in September 2016. The following progress has been achieved by the project:

- Four monitoring sections have been established in Inhambane Province and one in Zambezia Province. In Inhambane there is also a gravel road control section.
- Data are being collected on a routine basis from the monitoring sections by the Road Research Centre (RRC/CPR[1]) in accordance with a Monitoring Guideline for Mozambique developed under the project.

[1] Centro de Pesquisa Rodoviária is the Portuguese name for the RRC.

- The field data are being entered into a new Electronic Data Management System (known as "Rhino"), which was developed as part of the project. Training was carried out for RRC staff on the use of the database by the CDS Data Management Expert in June 2018. The data are available for use in research projects on LVRs in Mozambique and the region. The database is compatible with the database that has been developed under the ReCAP Regional Back Analysis Project.
- Two technical papers prepared by RRC staff have been accepted for presentation at the SARF/IRF/PIARC Regional Conference for Africa to be held in Durban from 9th to 11th October 2018.

1.4 Purpose of this Report

The purpose of this report is to summarise the proceedings of three workshops held at the ANE offices in Maputo as part of the capacity building objectives of the project.

1. The first workshop was held on the 30th and 31st August 2017. The purpose was to assist RRC staff to identify research projects that they could develop from data collected on the Inhambane research sections and would be suitable for dissemination at the SARF conference.
2. The second workshop was held on the 24th and 25th January 2018. The purpose was to assist RRC staff to prepare abstracts for technical papers to be submitted to the SARF conference.
3. The third workshop was held on the 29th and 30th August 2018. The purpose was to guide RRC staff on the process of identifying and prioritising research projects and the methodology for carrying out research.

2 Workshop for Identification of Research Projects

2.1 Objectives

The workshop was held on the 30th and 31st August 2017. The purpose of the meeting was to review progress to date on the LTPP project and to assist the staff involved in the field monitoring to clearly define their research objectives and plan their research activities.

The following were present at the meeting:

- Irene Simões (Director of ANE DIMAN – attended part of meeting);
- Rubina Normahomed (ANE DIMAN – attended part of the meeting);
- Fernando Dabo (ANE DIMAN and RRC Coordinator);
- Carlos Cumbane (LEM and RRC member);
- Cedrik Namburete (ANE Inhambane and RRC member);
- Manuel Cossa (ANE DIMAN);
- Raquel Langa (ANE DIPRO and RRC member – attended part of the meeting);
- Rob Geddes (CDS Team Leader);
- Phil Paige-Green (CDS Materials Expert); and
- Adilson Vilinga (CDS Deputy Team Leader).

The workshop was opened by the Director of DIMAN. The CDS Team Leader made a presentation summarising progress on the project to date and the objectives of the workshop.

2.2 Review of Progress

2.2.1 Review of the existing trial sections by the provinces

ANE has carried out a review of all trial sections built under the previous AfCAP project. Information was provided by ANE staff in the provinces who carried out a visual inspection of each road. The reports tended to focus on the problems (failures) occurring on the roads, though some sections of road were found to be performing well.

The lessons learned from the review were summarised as follows:

- Drainage is a critical factor in road design- many of the failures are drainage related;
- Research projects should not have too many variables;
- Very thin seals are generally not successful as they require a re-seal after a short period of time; and
- Some of the research projects are not a good advert for the low volume sealed road approach due the high number of failures.

It was recommended that the RRC should consolidate the reports from the provinces into one table of information to be kept on record and updated periodically. The following data should be recorded:

- Province;
- Name of road;
- Length of road;
- Length of experimental sections and coordinates;
- Objective of experiment;
- Road width and shoulders;
- Drainage structures;
- Pavement structure and surfacing for each different research section;
- Year of construction;
- Overall condition of the road (photographs); and

- Typical defects (photographs).

2.2.2 Study Visit to CSIR in July 2017

A study visit was organised for the RRC to the Council for Scientific and Industrial Research (CSIR) in Pretoria in July 2017. Ten representatives from ANE and LEM participated. The key observations and lessons learned included:

- The management of research projects can include out-sourcing to universities, consultants etc.;
- Researchers don't need to do all testing required for a research project but need to know what to look for and should supervise the testing; and
- The Light Weight Deflectometer is a useful tool for monitoring pavement stiffness.

The group was inspired by the sophistication of the research work being carried out by CSIR, in particular the facilities and equipment.

2.3 Conducting a Research Project

Phil Paige-Green made a presentation on how to identify, plan and implement a research project on low volume roads. The presentation covered the following topics:

1. Every research project should have a clear aim, the result should be an indisputable conclusion based on measurable facts, and the research should be repeatable by anyone else.
2. The design of an experiment should seek to:
    - Minimise external influences;
    - Ensure that traffic, climate, drainage, subgrade etc. are consistent between sections that are being compared;
    - Include control sections (to compare with the experimental results);
    - Include randomisation of data so that the findings can't be attributed to another cause – avoid bias; and
    - Include replication – more than one test should be carried out to ensure "universal" applicability
3. Key aspects of the layout, construction and future maintenance of experimental sections include:
    - Clearly mark experimental sections with sign boards and GPS coordinates;
    - Construct sections to the highest quality using experienced contractors;
    - Keep complete and accurate records of the construction process; and
    - Inform maintenance personnel of the location of experimental sections and ensure that the researcher is notified prior to any maintenance intervention.
4. Monitoring and data collection include the following:
    - Gravel road measurements: roughness, visual condition and gravel loss;
    - Bituminous road measurements: Riding quality, deflection, strength, moisture and density, visual condition and skid resistance;
    - Concrete roads: Visual condition (cracking and faulting), skid resistance and riding quality; and
    - Block paving, cobble-stones and hand-packed stone: Visual condition, riding quality and condition of the support layers.

    Visual assessments should be carried out by the same teams using the same methods to ensure consistent and comparable results.

5. In order to facilitate the analysis of data:
    - Field data should be fully captured in the field on field forms;
    - The data should be entered into a spread-sheet or data base as soon as possible;
    - Field forms should be digitally scanned and saved to a reliable storage medium; and
    - All input data should be checked for accuracy.

    The analysis of data is usually based on statistical methods. The type of analysis depends on what aspects are being investigated.

6. Reporting of research projects is made on two levels:
    - First level: Initial descriptive/factual analysis based on the data with no interpreted conclusions; and
    - Second level: interpretative analysis to extract meaning from the data in terms of cause and effect and deriving conclusions.

2.4 Materials Testing and Interpretation

Phil Paige-Green made a presentation on Materials Testing and Interpretation. The presentation described best practice for:

- Materials sampling including excavation and reinstatement of test pits;
- Sample preparation;
- Standard laboratory tests required for typical LVR research projects:
    - Soil strength;
    - Compaction characteristics;
    - Atterberg limits;
    - Grading;
    - Aggregate strength; and
    - Durability.
- Classification of soils;
- Field testing:
    - Deflection;
    - Surface deformation; and
    - Dynamic Cone Penetrometer.

2.5 Research Sections on Cumbane-Chacane Road in Inhambane

Cedrik Namburete and Fernando Dabo presented an update of progress with the data collection and analysis on the research section on the Cumbane-Chacane Road in Inhambane. Issues arising from the discussion were as follows:

- The objective of the research is to compare the whole life cost of the paved road sections (penetration macadam and armoured base + sand seal) with the gravel road option;
- The Monitoring Guideline should include a typical layout of a gravel control section[2];
- Wet densities measured with the nuclear gauge are generally accurate but need to be adjusted using moisture content measured in the laboratory;
- The RED model can be used to estimate vehicle operating costs;

[2] This was subsequently provided to the RRC.

- Construction costs for the sections are available but the construction of short experimental sections is more expensive (per km) than constructing an entire road;
- There has been no need for on-carriageway maintenance of the penetration macadam section since construction;
- Roughness measurements using the MERLIN should be carried out every three months on the gravel control section to obtain an approximate average roughness;
- 6-monthly measurements on each section should include: DCP and insitu moisture, rut depth, roughness, visual condition;
- The comparison between in situ moisture content and OMC is important as strength of naturally occurring materials normally depends on the moisture content;
- "Bar linear shrinkage" (retração linear) is being measured rather than "shrinkage limit" (limite de retração) indicated on the testing forms;
- The laboratory test data should record which laboratory undertook the testing;
- The traffic count form should record if a vehicle is loaded;
- Deflection measurements should be taken once the equipment is available;
- Rainfall data should be obtained from the nearest weather station; and
- The researchers should set up a simple Excel model for comparing the whole life costs.

It was agreed that the following specific actions were required:

- Redo the CBR tests for the base at test pits B1 and C1 since the shape of the CBR penetration curve is incorrect (There should be an approximately straight-line relationship between the CBR results at 3 different densities)[3];
- Calculate the Visual Condition Index (VCI) from the visual inspection data; and
- Take photographs of the surfacing with a pen/scale on the surface to indicate the scale.

2.6 LTPP Research Section on Agostinho Neto Road in Inhambane

Carlos Cumbane presented an update of progress with the data collection and analysis on the research section on the Agostinho Neto Road in Inhambane. Issues arising from the discussion were as follows:

- The purpose of the research project is to compare pavement performance on wet versus dry subgrades: part of the LTPP section is on an embankment across a wet area;
- Regarding the test pit profiles:
  - It is necessary to record the colour of the material in each layer;
  - The "soil type" should be "gravel" or "sand" but not "medium-dense" as shown in the presentation;
  - It is necessary to redo the CBR tests for TP 1 (0 -300mm depth) as only 2 results were available[4];
  - The moisture contents should be carried out by oven drying to compare with the nuclear gauge and Speedy results (the sample size for the laboratory test is at least 500g for sands and 1kg for gravels); and
  - The insitu moisture contents should be indicated, only optimum moisture contents are shown.

[3] Test pit logs for the experimental sections on the Cumbane-Chacane Road are included in the following paper submitted to the SARF/PIARC Regional Conference: Namburete, C. E., Dabo, F, and Zacarias, C. (2018), Surfacing Options for Low Volume Roads in Mozambique. The paper includes a sketch of the layout of the monitoring section, which is in accordance with the Mozambique LTPP monitoring guideline "Guiao para Monitoramento ee Secoes Experimentais (2017)".

[4] Test pit logs for the LTPP research sections on the Agostinho Neto Road are included in the following paper submitted to the SARF/PIARC Regional Conference: Cumbane, C. and Dzimba, M. (2018), Performance of Mechanically Stabilised Sand Road Bases in Mozambique.

- Samples for moisture content to depth of 800mm should be obtained with a hand auger and laboratory tested.

2.7 LTPP section on Agostinho Neto Road in Inhambane

Moises Dzimba submitted an update of progress with the data collection and analysis on the research section on the Agostinho Neto Road in Inhambane. Eng Dzimba was not present at the meeting as he was on a study visit to Denmark. His slides were presented by Eng Namburete. Issues arising from the discussion were as follows:

- The purpose of the research is to investigate the effect of in situ moisture content on pavement performance, including a comparison between a section length with kerbs and a section without kerbs along both edges of the carriageway;
- Failures are occurring on the left lane towards the start of the LTPP section, which could be due to heavier traffic in this direction or lower construction quality of the left lane;
- More DCP tests should be carried out in the left and right lanes where the failures are occurring - the DCP tests provide an indication of moisture content given that the material in the pavement (type and density) is uniform;
- The VCI results for the beginning and end panels of the section appear to have been mixed up;
- For the test pit profiles:
  - Record the colour of the material in each case; and
  - The “soil type” should be “gravel”, “fine sand” etc.
- Deflection measurements would help to compare the stiffness of sections that have failures (Panel A) and sections that are performing well (Panel E); and
- It would be useful to prepare a diagram/graph showing how the area of patches varies along the section with time.

2.8 Way Forward

The following next steps were identified and agreed:

- The next field visit to Inhambane would be carried out in September or October 2017 to enable the researchers to collect dry season data;
- Better planning is required for the field work including availability of testing equipment and transport;
- Initial analysis and findings from each test section will be discussed at a meeting in Maputo towards the end of 2017; and
- Abstracts for technical papers will be submitted to the SARF/IRF/PIARC Regional Conference for Africa to be held in Durban in October 2018.

The SARF conference was identified as an appropriate forum for submission of papers, with its theme of “Roads to Social and Economic Growth”. The Terms of Reference for the LTPP project envisage the preparation of “at least one technical paper” based on research carried out under the project.

3 Workshop for Conference Paper Preparation

3.1 Objectives

The need for a workshop on the preparation of conference papers was agreed at the workshop in August 2017. The objective of the workshop was to identify trends emerging from the field monitoring work carried out in Inhambane Province, prioritise initial findings from the monitoring, and prepare abstracts for submission to the conference.

3.2 Workshop Methodology

The workshop was held at the ANE offices in Maputo on 17th and 18th January 2018. It was attended by RRC staff that are participating in the LTPP project, namely:

- Fernando Dabo;
- Carlos Cumbane;
- Cedrik Namburete;
- Moises Dzimba; and
- Calisto Zacarias.

The meeting was presided over by the Acting Director of DIMAN, Rubina Normahomed. ReCAP PMU was represented by Nkululeko Leta (Deputy Team Leader) and Henry Nkwanga (Regional Technical Manager). CDS was represented by Rob Geddes (Team Leader) and Phil Paige-Green (Materials Expert).

The following activities were carried out:

- The RRC members gave an update on the data monitoring process in Inhambane and Zambezia Provinces. The next round of data collection was scheduled for March 2018. It was agreed that CDS would not need to participate in the March monitoring visit as the RRC team is sufficiently experienced in all of the data collection and measurement activities.
- A discussion was held on the measurement of rut depth. It was agreed that the maximum rut should be measured on each side of the road rather than in the inner and outer wheel path as specified in the Monitoring Guideline. The Guideline needs to be updated (by the RRC).
- Phil Paige-Green made a presentation on the preparation of technical papers for conferences including why conference papers are important, and how to go about preparing them (see Annex 3).
- The RRC members divided into two groups and discussed options for technical papers. Each group prepared a draft abstract which they presented to the rest of the meeting. The two abstracts were discussed word by word resulting in final version of each (see Annex 1). A lead author was appointed for each paper. The titles of the two papers are:
    - Surfacing Options for Low Volume Roads in Mozambique (Cedrik Namburete, Fernando Dabo and Calisto Zacarias); and
    - Performance of Mechanically Stabilised Sand Road Bases in Mozambique (Carlos Cumbane and Moises Dzimba).

3.3 Follow-up Activities

The paper abstracts were subsequently submitted by the lead authors on the conference web site and were accepted for submission of full papers. The authors prepared the draft papers which were reviewed by CDS and submitted to the conference organisers by the deadline of 2nd May 2018. Comments were

received from the organisers on each paper, corrections were made by the authors and the papers re-submitted. ReCAP is providing support to the authors to enable them to attend the conference and present their papers.

CDS also assisted the RRC by reviewing a draft paper prepared by Daniel Patel dos Santos of ANE for the SARF conference. The title of the paper is entitled “Performance Evaluation of a Road Surface Layer Consisting of Hot Sand Asphalt”. It was accepted for presentation at the conference.

4 Workshop for Identifying and Prioritising Research Projects

4.1 Objectives

The workshop was held at the ANE DIMAN offices on 29th and 30th August 2018. The purpose of the workshop was to guide RRC staff (at their request) on the process of identifying research projects which could be part of an updated medium and long-term strategic research plan for the RRC. The meeting was attended by RRC staff that are participating in the LTPP project and CDS representatives, namely:

- Fernando Dabo;
- Carlos Cumbane;
- Cedrik Namburete;
- Moises Dzimba;
- Rob Geddes;
- Phil Paige-Green; and
- Alexander van Oostenrijk (Database Expert) - morning of the 29th August only.
- Mr Pateguana (ANE IT Technician) – part of the morning of 29th August only.

The meeting was opened by the Director of DIMAN, Irene Simões. Rob Geddes summarised the purpose of the meeting and introduced the agenda of items intended to be discussed (see Annex 2).

4.2 Review of Progress

A brief discussion was held on the following aspects of the LTPP project:

1. Progress with the collection of monitoring data on the research sites

Wet season data were collected from the Zero-Mopeia monitoring site in April 2018.

2. Input of the data to the Rhino database

RRC staff have been entering data following training provided by the CDS Database Expert in June. Several problems have been encountered which need to be rectified as follows:

- More than one person should be prevented from entering data on a particular road simultaneously - a road is "owned" by the user who created it, but he/she may give editing privileges to other users;
- A "button" is required for export of data -data export should be possible at database level and road level;
- Export of data should be to Excel format and it should be possible to export part or all of the data in the database;
- Some of the Portuguese terms are not accurate and it would be better to use English terms - it was suggested that English terms are primary and Portuguese terms appear in a smaller font;
- Saving of data is problematic- it is not clear to the operator that newly entered data have been saved;
- Include a recycle bin showing a history of data - every time data is saved a new history record is created and users should be able to review history and revert to an older dataset;
- Add a note for PI data that "0" means non-plastic and "1" means slightly plastic: the field only accepts numeric characters;
- Mouse movement can cause numbers to change without the operator noticing - this is due to the spinner arrow attached to each edit box (removing the spinner arrows will alleviate this problem);
- In the structure of the database "Sections" should be moved under "Roads" – "Sections" and "Measurements" will no longer be accessible as separate sections but only through "Roads";

- VCI is measured per panel;
- The average height of gravel surfacing needs to be entered at each time of monitoring; and
- A field should be added for the Drainage Factor measure both sides of the road in every panel.

3. Ongoing Management of the Rhino database

It was established that ANE has adequate computer hardware (servers) to host the Rhino database but does not have in-house expertise in the appropriate database management. Since database management is not core business of ANE it should be out-sourced. In-house management would lead to security risks for the data including possible loss of the data. It was recommended that Independent Software (the company of Alexander van Oostenrijk) should be engaged by ANE on a long-term basis to host the database and to provide technical support. The Director of DIMAN requested a written proposal from Independent Software to provide this service[5].

4.3 Presentations for the SARF Conference

The two authors nominated to present the papers at the SARF Conference used the workshop as an opportunity to practice their presentations. Comments and guidance were provided by the CDS team and by their colleagues. Specific comments included:

- The presenters should "tell the story" of what they did on the research project and what they learnt;
- Unnecessary data should be removed from the slides;
- Text should be kept to a minimum;
- Whole tables should generally not be copied and pasted from the paper (the conference participants will have access to the paper);
- More photographs of the roads should be included; and
- In each case the traffic using the road should be described.

4.4 Research Identification

Phil Paige-Green made a presentation on the following aspects of research:

1. The identification of research projects;
2. The prioritisation of research projects based on their perceived benefits and the resources required to carry out the project;
3. Carrying out a research project including:
   - Defining the objectives;
   - Setting up the research team;
   - Planning the project;
   - Obtaining approval and funding;
   - Desk study including literature review;
   - Field work;
   - Laboratory testing;
   - Analysis of results;
   - Reporting;
   - Demonstration of the results through field testing;
   - Full implementation of proven techniques; and

[5] A proposal was submitted to DIMAN on 10th September 2018.

- Monitoring, evaluation and feedback.

4.5 Use of the Nominal Group Technique to Identify Potential Projects

After describing the fundamental concepts of the process, an exercise was carried out using the "Nominal Group Technique" to identify potential projects for the RRC. (It is noted that only five people and the facilitator took part in the exercise, all with similar engineering interests, which probably limited the range of possible projects that would be identified).

The participants were given 15 minutes to note down their identified projects, without any discussion. These were then presented by the participants in a round robin format and were as follows:

1. Specifications for climate resilience;
2. Calcrete for asphalt surfacing;
3. Cost-effectiveness of blending for gravel wearing course;
4. Use of coal-waste to reduce PI;
5. Labour based cold mix asphalt;
6. Practical guidelines for construction;
7. Fibre reinforcement of sands;
8. Use of local materials in concrete;
9. Polymer stabilisation;
10. Specifications for sand bases;
11. Use of river sands in construction;
12. Aggregate specification for blended bases;
13. Guidelines for armoured base;
14. Traffic estimation for rural roads;
15. Regional design standards;
16. Design for emulsion stabilisation;
17. Drainage factors;
18. Geometric standards for safety;
19. Rural road drainage;
20. Hot sand asphalt;
21. Handling bureaucracy;
22. Funding;
23. Equipment and testing;
24. Unpaved roads;
25. Alternative materials; and
26. Asset management.

The ideas were then clarified where necessary and discussion on each carried out so that there was a general understanding of each topic. The projects were then grouped into various "headings" (groups) based on similar objectives as follows (noting that there could be some overlap in groups for some projects):

1. Specifications:

- Specifications for climate change;
- Use of river sand for blending or road base;
- Specification for sand road base;
- Aggregate specification for blended base; and
- Guidelines for armoured base.

2(a) Materials (surfacing):

- Calcrete for asphalt surfacing; and

- Hot sand asphalt.

2(b) Materials (layer works):

- Use of river sands; and
- Alternative materials.

2(c) Materials (other)

- Use of local materials in concrete;
- Calcrete for surface on asphalt; and
- Concrete of local materials.

3. Soil improvement

- Cost effectiveness of blending;
- Use of coal waste to improve materials;
- Fibre reinforcement of sands;
- Design of emulsion stabilisation; and
- Polymer stabilisation.

4. Construction

- Labour based cold-mix; and
- Practical guideline for construction.

5. Design

- Labour-based cold mix;
- Traffic estimation for rural road;
- Regional design standards;
- Drainage factors for rural road;
- Geometric design for safety;
- Rural road drainage; and
- Unpaved roads.

6. Management

- Bureaucracy;
- Funding;
- Equipment and testing; and
- Asset management.

Once the groups had been agreed upon and the projects allocated to the different groups, voting for priority of projects was carried out where each participant prioritised their top 3 projects. These were allocated to each group as follows:

1. Specifications √ √
2. Materials √ √ √ √
3. Soil Improvement √ √ √ √ √
4. Construction √
5. Design √ √ √
6. Management √

On the basis of the voting, the projects related to Soil Improvement were identified as the highest priority, followed by Materials and then Design.

The methodology for a Soil Improvement research project was then discussed as follows:

1. Set the objective - i.e. to improve any sub-standard materials;
2. Carry out Review (literature, existing information, Internet, References in documents located, etc.);

3. Identify types of soil improvement, gaps in the existing knowledge, which the research should concentrate on and outline proposed project;
4. The actual project definition will be a function of manpower available, funding, timing, equipment, etc.);
5. Finalise detailed project design, revise as necessary and source funding – identify individual human resources;
6. Field work (inspections of existing locations, sampling of materials, etc.);
7. Laboratory testing of samples;
8. Analysis and recommendations;
9. Demonstration/experimental sections;
10. Monitoring; and
11. Interim and Final Reporting.

4.6 The Way Forward

The workshop was the final input of CDS under the LTPP project. It was concluded with a general discussion on the way forward for the RRC. The following issues were discussed, and recommendations made:

- The RRC members identified a need for training in pavement engineering including the DCP-DN design method and training in the use of the Mozambique Low Volume Roads Design Manual. This would enable the RRC to participate in the approval of road designs and to work closer with the road design department in ANE. It was recommended that the RRC members consider attending courses run by SARF in South Africa.

- The RRC members feel that they are doing useful work and seek greater recognition of the value of research from ANE senior management. It was agreed that the individual members of the RRC can actively address this issue through their research work. (The research activities - including the two SARF papers - were due to be presented to the Research Technical Committee the following week).

- The pilot Proficiency Testing Scheme (PTS) for materials laboratories, which is being supported by ReCAP, was reported to be going well.

- Six-monthly data collection will continue on the five monitoring sites and the gravel control section in Inhambane.

- Some of the Portuguese terms used in the Monitoring Guideline (and the database) are not accurate and should rather be replaced with English terms. The RRC is the owner of the Guideline and was encouraged to make these corrections.

- The 2014 strategic plan for the RRC envisaged the employment of a full-time manager for the RRC. The “Short-Term Technical Assistance Programme” for the establishment of the RRC carried out by CSIR in 2015 recommended that full time Technical Assistance should be provided to RRC for one year. Neither of these basic requirements for the development of the RRC has been possible due to the financial crisis in Mozambique that started in 2016. No new recruitment is allowed in the civil service. The lack of full-time management in the RRC is constraining its development as all of the members of the RRC have other responsibilities.

Annex 1 Abstracts for SARF Conference

SURFACING OPTIONS FOR LOW VOLUME ROADS IN MOZAMBIQUE

Authors:

Namburete, Cedrik Edson - Administração Nacional de Estradas, Inhambane-Moçambique

Dabo, Fernando - Administração Nacional de Estradas, Maputo-Moçambique

Calisto, Zacarias - Administração Nacional de Estradas, Zambézia-Moçambique

Abstract

Mozambique has a classified road network of about 30 000 km, of which only 20% is paved. Most of the unpaved roads are rural with low volumes of traffic and cannot justify the conventional pavement design and material usage standards. The scarcity of conventional road construction materials in some areas of the country is also a major challenge.

Two low volume roads in Inhambane and Zambezia provinces have been constructed using locally available materials not complying with traditional standards as base course. Four different surfacing options were used on these roads: gravel, penetration macadam, Otta seal and sand seal (armoured base). The roads were built between 2009 and 2013.

Monitoring sections have been established on these roads and are being regularly assessed in terms of the Mozambique standard Monitoring Protocols. After up to 7 years the sections are generally performing well. Localized defects are attributed to poor construction quality and inadequate supervision on site.

The performance of the three surfacing solutions was analysed and compared with the performance of the gravel section.

The paper summarizes the findings of the investigations and concludes that all the surfacing options are technically viable. However, each situation needs to be assessed in terms of its economic viability, particularly on roads carrying low traffic (less than 100 vpd) or where the necessary construction materials must be hauled over long distances.

PERFORMANCE OF MECHANICALLY STABILISED SAND ROAD BASES IN MOZAMBIQUE.

Authors

Cumbane, Carlos Rodrigues - Laboratório de Engenharia de Moçambique- Maputo Moçambique

Dzimba, Moises - Administração Nacional de Estradas, Maputo-Moçambique

Abstract

In Mozambique only 20% of the classified road network is paved. Locally available materials for the base are often out of specification and the solution normally adopted for pavement layers is conventional chemical stabilization. The Agostinho-Neto to Mutamba Road in Inhambane Province was constructed under a programme of Targeted Interventions for Low Volume Roads. The objective of the programme was to find technical and economically viable options for local conditions. The road was constructed in 2015 and is 5.5 km long and 6.0m wide. The first 4.3 km section of the road comprises a base of blended sand and calcrete (50:50). The remaining 1.2 km has a base of neat red local sand armoured with crushed calcrete. The subbase is neat red sand throughout, and the road is surfaced with an Otta seal and slurry. Monitoring sections were established on each type of base to evaluate the road performance. Routine monitoring of

these sections is being carried out according to a standard protocol developed for Mozambique. In general, the section with the armoured base is performing better than the blended base section, which shows cracks and deformation and has required extensive pothole repairs. The potholes are attributed to the higher moisture content in the base. This is related to the pavement/formation structure and whether there is a kerb. The research project has shown that the locally available sandy materials can be mechanically stabilized to provide an adequate base course without the high cost of conventional stabilization.

Annex 2 Agenda for Workshop on 29th and 30th August 2018

1. Introductions and purpose of the meeting (R Geddes).
2. Progress with the collection of monitoring data on the research sites (ANE).
3. Progress with the input of the data to the Rhino database (ANE/A van Oostenrijk).
4. Linking of the Rhino database to the ReCAP Regional Back-Analysis Database.
5. Update on papers submitted to the SARF/PIARC conference in Durban in October and arrangements for attendance at the conference (practicing of presentations).
6. The process of identification of research projects (P Paige-Green).
7. The process of carrying out a research project (P Paige-Green).
8. Practical exercises in groups – identification of new research projects for Mozambique.

Annex 3 Workshop PowerPoint Presentations

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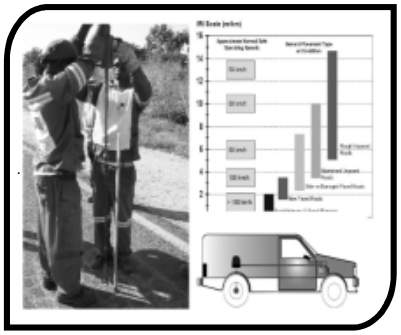

Long Term Pavement Performance Monitoring of Trial Sections in Mozambique: *Research*

Cardno

MOZ2093A

RRC stakeholders meeting, August 2017, Maputo, Mozambique

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How to identify, plan and implement a research project on low volume roads

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Outline of presentation

1. Background
2. The "Scientific method"
3. Low volume road investigations
4. Experimental design
5. Layout and construction
6. Monitoring and data collection
7. Analysis of data
8. Report
9. Interpretation of test results

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Background

- It is important that a research project has an aim
- This is then targeted using the "scientific method"
- The result should be an indisputable conclusion based on measurable facts !
- It should be able to be repeated by anyone else

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The "Scientific Method"

- What is this ?
- Gather observable, empirical and measurable evidence
- Collected through observation and experimentation
- Formulation and testing of hypotheses.
- Must be objective with no bias
- This is more than 1000 years old

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The "Scientific Method"

- Requires intelligence, imagination and creativity
- Ongoing cyclical process

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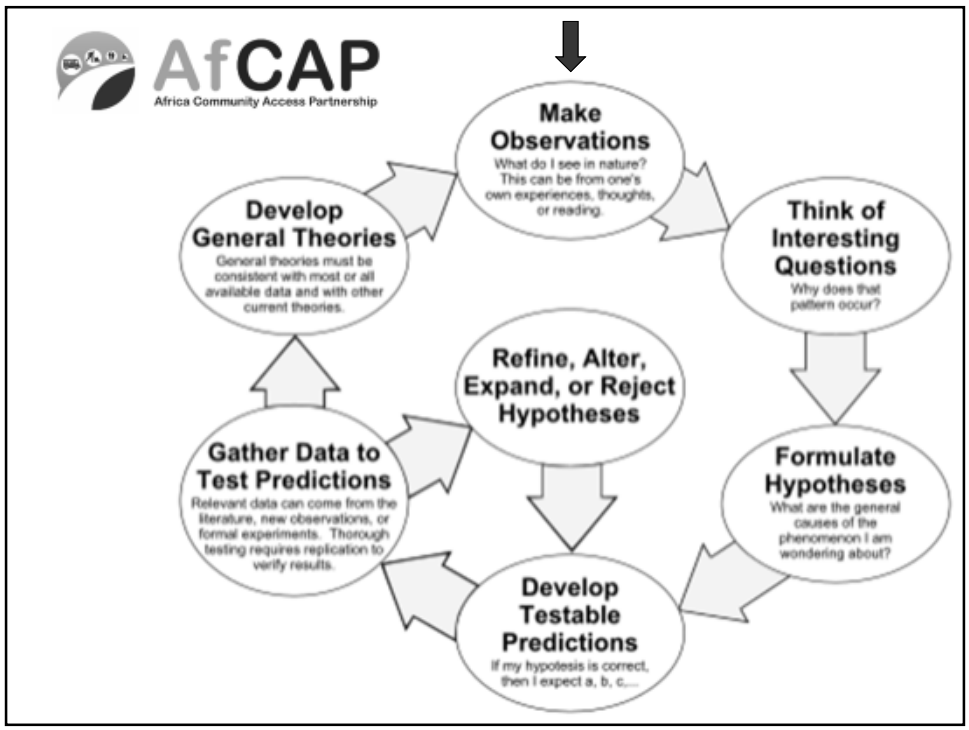

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Hypothesis

- Subgrade moisture is related to rutting !
- Identify 2 sections, one dry subgrade and one wet subgrade *(preferably a few at different locations)*
- Monitor rut depth and traffic regularly (time is a co-linear variable with traffic)
- Wet section should rut more than dry if hypothesis is correct

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Low volume road investigations

- The first roads ever constructed were low volume roads
- As traffic increased, the sophistication increased
- Problems to overcome heavier loads were the main centres-of-interest
- Little work on LVRs – top down !!

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Typical types of LVR experiments

- Replacement materials for traditional ones, e.g. the use of soil or slag as structural layers
- 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. wet, collapsible, expansive or saline materials
- Different pavement structures such as thinner layers or even omission of some layers
- Alternative surfacings such as Otta and sand seals, polymer slurry seals, hand-laid cold-mix asphalt, etc.

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Typical types of LVR experiments

- How does the subgrade affect the pavement performance ?
- How deep down does water have an effect ?
- Can good drainage result in the use of lower standard materials ?
- Can we use sand as a base-course material ?
- *Basically a scientific philosophy*

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Experimental design

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

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Experimental 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.

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Experimental design types

- Most important part of the investigation
- Get this wrong and results may be meaningless
- Good idea to get a statisticians input early
- Various types of experimental design:
  - Really look at cause and effect
  - Does a change in something affect the outcome ?
  - Factorial, Latin squares, randomised, matched pairs, etc.

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Experimental design types

- Three principles:
  - Control – something to compare the experimental results with
  - Randomisation – no bias – can't attribute findings to another cause – e.g compare sand with a gravel base but with different subgrades
  - Replication – more than one test to ensure "universal" applicability

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Experimental design types

- Factorial design
  - Different factors with different levels
  - e.g. climate, material, traffic
  - NB: Each new factor doubles the number of sections for monitoring considerably
  - 2 climate and 2 material levels = 4 sections min
  - 2 climate, 2 materials and 2 traffic levels = 8 sections
  - 2 climate, 3 materials and 3 traffic levels = 18 sections

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- Investigate influence of subgrade moisture and subgrade PI on road performance
- X could be one road with MC < OMC as control
- All X's would be a full factorial (with replicates) = 16 sections

	Traffic	PI < 6	PI 6-12	PI > 12
Subgrade MC > OMC	> 300 vpd	X X	X	X
	< 300 vpd	X	X X	X
Subgrade MC < OMC	> 300 vpd	X	X	X X
	< 300 vpd	X	X X	X

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Layout and construction

- Sections must be carefully laid out and marked
- 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.

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Identification

- Identify clearly 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 can be used)

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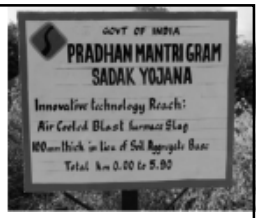
Identification



- 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

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Section length

- Each section must only include one variable from the norm (more than one makes it difficult to attribute changes in performance to the specific variable).
- Rather have several shorter trials each with one variable
- If roughness is measured using automated roughness devices, a central section of at least 300 m is required.

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Length

- Experiments are usually 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)

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Length

- The length of the sections should be a minimum of 50 – 100 m
- Depends on the method of construction
  - mechanised methods requiring longer sections because of mixing at ends
- Preferably > 250 m

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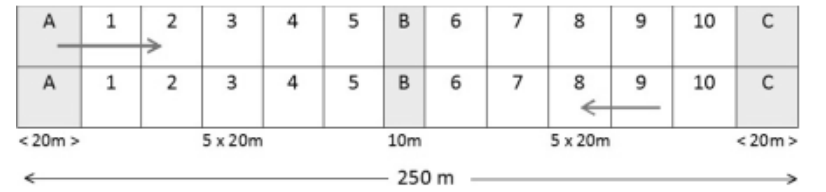
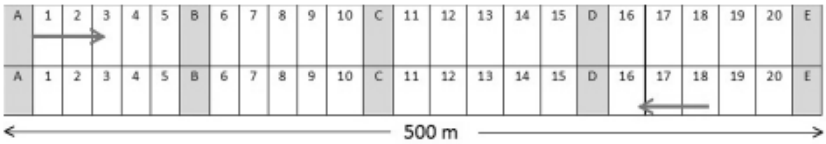
Length and layout





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Construction

- Highest quality, conforming fully with the local standards or those prepared for a specific project.
- Section *must not fail* 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

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Construction

- Specified layer thicknesses and compaction densities must be achieved on both the experimental and control sections
- All materials in control sections must comply with the prescribed specifications for those materials – *also experimental materials*
- It is unacceptable, for example, that the trial of a new process fails because the thickness of the trial section was inadequate

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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 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.

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Monitoring

- Not covered in detail in this presentation
- Note that monitoring of unpaved and paved roads are entirely different
- Specific programmes need to be established for the different types of roads and experiment – to achieve objective
- Unpaved roads continually change under traffic and climate - can change from a good condition overnight following a severe weather condition or even after abnormal traffic

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Monitoring

- 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 techniques and frequency thus vary

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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 must follow a fixed method

VISUAL ASSESSMENT: UNPAVED ROADS

Road Authority:		Route Class:							
Region/Suburb:		Traffic:		VL	L	M	H	VH	
Road No/Street Name:		Gradient:		Flat		Med		Steep	
		Terrain:		Flat		Rolling		Mount	
Segment (From – To):									
Segment Dimensions:	Length (m):				Width (m):				
Road Type:	Gravel		Earth			Track			
Moisture:	Wet		Moist			Dry			

MATERIAL INFORMATION/GRAVEL PROPERTIES

Material Type	Ferricrete	Calcrete	Quartzite	Chert	Dolomite
	Sandstone	Granite	Shale	Dolorite	Varies
Material Quality	V Good	Good	Moderate	Poor	V Poor
Problem	Oversize	Clay/Silt	Loose Gravel		Loose Sand
Maximum Size		< 13 mm	13-25mm	25-50 mm	>50 mm
Grading			Coarse	Medium	Fine
Estimated 'PI'			Low	Medium	High
Layer Thickness	>125 mm	100 - 125mm	50 – 100 mm	25 – 50 mm	0 mm
Exposured Subgrade			None	Isolated	Frequent	Continious
Subgrade Quality				Good	Moderate	Poor
Problem				Wet	Clay/Mud	Sand

SURFACE DISTRESS/ENGINEERING ASSESSMENT

	DEGREE					EXTENT				
	Slight		Warning		Severe	Isolated				Extensive
	0	1	2	3	4	5	1	2	3	4	5
Potholes											
Corrugations											
Rutting											
Loose Material											
Stoniness (Fixed)											
Stoniness (Loose)											
Erosion (Transverse)											
Erosion (Longitudinal)											

FUNCTIONAL ASSESSMENT

Roughness		V Good	Good	Moderate	Poor	V Poor
Problem	Deform / Potholes	Stoniness	Outcrop	Corrugat.	Rutting	Erosion
Trafficability		V Good	Good	Moderate	Poor	V Poor
Problem	Loose Mat.	Clay	Rocky	Vegetation	Steep	Drainage
Safety		V Good	Good	Moderate	Poor	V Poor
Problem		Dust	Skid Resist.	Slipperiness	Drainage	
Drainage (On the Road)		V Good	Good	Moderate	Poor	V Poor
Problem		Windrows	Rutting	Road Shape	Road Level	
Drainage (Side of Road)		V Good	Good	Moderate	Poor	V Poor
Problem		Culvert Invert	Side Drains	Mitre Drains	Road Level	

SUMMARY

Overall Pavement Condition	V Good	Good	Moderate	Poor	V Poor

Notes:

Assessor: Date:

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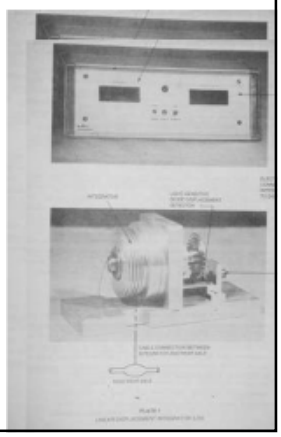
Monitoring

- Unpaved roads
  - Roughness
  - Visual
  - Gravel loss



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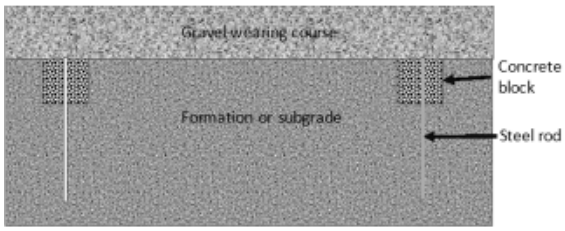
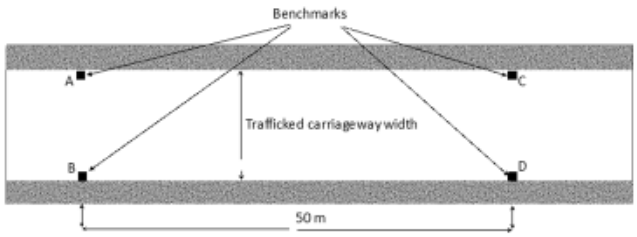
Gravel loss

- Bench marks





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Monitoring

- Paved roads
  - Bituminous
  - Concrete
  - Block
  - Other
- All different

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Monitoring

- Bituminous Roads
  - Riding quality
  - Deflection
  - Strength
  - Moisture and density
  - Visual
  - Skid resistance
  - Other

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Monitoring

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

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Monitoring

- Other surfacings
- Block paving, cobble-stones or hand-packed stone
  - Visuals
  - Riding quality
  - DCP - condition of the support

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Analysis

- 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.

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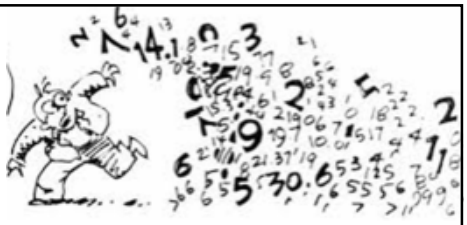
Analysis



- Analysis is usually based on statistical methods
- Look at means, different percentiles, standard deviation, CoV, standard errors, etc
- Each analysis depends on what was being investigated
- Some times may be a simple yes or no !
- Can we use an innovative material ? Yes – there is no measurable difference between the control and experimental section

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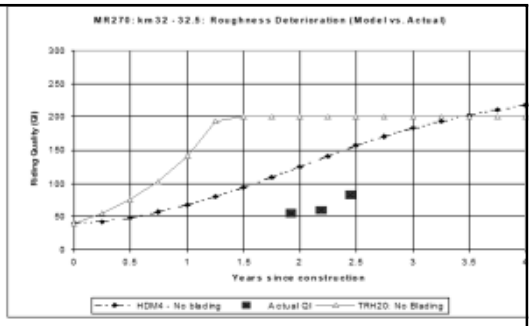
Analysis



- Other times we may need to see if there is a statistically significant difference
  - Analysis of variance – discrete variables
  - Regression – continuous variables
  - Software usually required – depends on amount of data
- Plots of behaviour or performance.

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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.

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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.
   - Descriptive 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 actual data collected

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Reporting

2. The second level of analysis of the data is the interpretative analysis.
   - Extracting meaning from the data in terms of cause and effect
   - Related to the experience and knowledge of the analyst
   - Conclusions based 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

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Reporting

- Descriptive Report will include:
  - Background to the project (what is being investigated)
  - Summary of previous observations and studies
  - What was done, by whom and how - methods
  - Summary of field results and measurements (actual data and results in Appendix)
  - Photos and other observations made
  - Summary of laboratory test results (data in Appendix)
  - Details of where full information is stored

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Reporting

Interpretive Report (may be a part of the Descriptive report) which describes analysis and interpretation of the data

- Background as to how the data was analysed
- Statistical techniques used, software used, etc.
- Interpretation of the data in terms of the objectives of the experiment/monitoring
  - Usually with graphs, tables, plots and figures
- Conclusions based on the data – does it prove the original hypothesis ?
- References- NB. Plagiarism !!

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Research in general

- Not a one-off exercise
- Must keep up to date with current situations
- Must read all you can about the subject
- Should publish results in journals and at conferences
  - Peer review
  - Contact with like researchers

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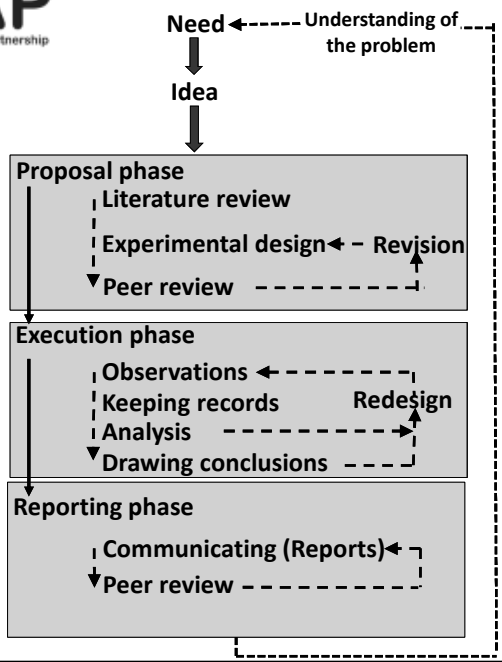
Summary



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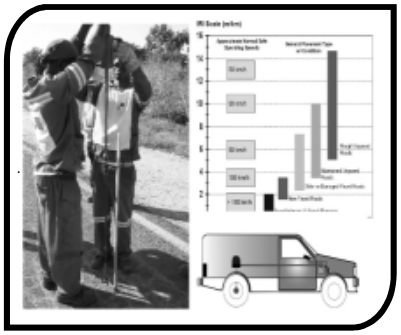

Long Term Pavement Performance Monitoring of Trial Sections in Mozambique: *Publication*

Cardno

MOZ2093A

LTPP Training Workshop, January 2018, Maputo

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How to prepare a paper for publication

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Outline of presentation

1. Why do we publish?
2. Preparing the abstract
3. Preparing the paper
4. Publication process

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Why do we publish?

- Duty of every researcher to communicate findings
- Duty to sponsors, society, peers and yourself
- Research work not communicated might as well not be done
- Number of publications is normally a measure of success of a researcher

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Objectives of publishing

- Disseminate new knowledge
- Get feedback from peers
- Identify workers in similar areas
- Improve your standing and credibility

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Where do we publish?

- Various options
  - Reports – not always available widely
  - Conferences – limited, but usually interested audiences
  - Journals – wider audience of specialists
  - Books
  - Others – newspapers, magazines, etc. – not usually recognised – no peer review

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Process

- Different for Conference and journal
- Conference:
  - Submit abstract
  - Reviewed – accepted or rejected
  - If accepted – submit paper – reviewed
  - Accepted or rejected (minor corrections?)
  - May be poster or oral presentation
  - *Sometimes need to register before paper is accepted*

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Publication process

- Journal
  - Submit full paper
  - Reviewed by 2 or 3 specialists
  - Usually stricter than conferences – higher quality
  - Accepted, rejected or request changes
  - If accepted – published (time lag!)

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Preparing the abstract

- The conference organisers "first cut" is based on the abstract
- Must be strong enough to gain their attention

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Preparing the abstract

- Abstract must:
  - Be short and to the point (200 – 500 words)
  - Bad abstract usually won't even get past the organisers
  - Abstract must win the reviewers attention and convince them that it must be in the conference

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Abstract content

- Background to the project
- Where carried out
- What was done
- How it was done
- General conclusions

- *Enough for reviewers to decide whether it is worth considering as a paper – punchy !!*

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Preparing the paper

- Lengths of papers vary from one conference or journal to another
- Conferences usually 6 to 10 printed pages
- Journals – 4 or 5 up to 30 or 40 – even longer – 63 pages

THE USE OF NATURALLY OCCURRING MATERIALS FOR PAVEMENTS IN WESTERN AUSTRALIA

ABSTRACT

1 INTRODUCTION

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Readers preferences

- Readers prefer shorter, more concise papers
  - 2.5 million scientific papers published each year
- Normally read the abstract first – see if the paper has anything useful in it for them !
- Then read the conclusions
- Then read the introduction
- Then maybe read the full paper !!
  - Mostly copy and save it and never look at it again

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Preparing the paper

- Paper content
  - Title and authors/affiliations
  - Abstract
  - Introduction
  - Literature review ?
  - Methods
  - Results
  - Discussion
  - Conclusions (and recommendations)
  - Acknowledgments
  - References
  - Appendices - ??

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Preparing the paper

- Title
  - Short and punchy
  - First indication of whether anyone will read it
  - e.g "Treatment of expansive clay with lime"
  - Not "An assemblage of evidence on the injudicious use of of structural instrumentation"
- Authors/affiliations
  - Main author/s – contributors
  - Where you are from , who you are, contact details
    - Depends on Conference. Journal

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Preparing the paper

- Introduction
  - < 1 page
  - Identify problem
  - What was done
  - How it was done
  - Why it was done
- Literature review
  - If necessary - usually ?
  - What has been done
  - Avoid repetition

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Preparing the paper

- Methods
  - How the work was done
  - Sampling
  - Field and laboratory testing –
  - Methods followed (TMH, SANS, ASTM, etc.)
- Results
  - Presentation of results
  - Usually summary of results
    - Tables, figures or plots
  - Full results in Appendix (if applicable) or referenced

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Preparing the paper

- Discussion
  - Most important part of paper
  - Factual discussion of results
    - What do they mean
    - What do they show
    - Not arguable
  - Interpretive discussion of results
    - Authors views and interpretation
    - May be debatable

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Preparing the paper

- Conclusions
  - Short section – concise and to-the-point
  - Reasons for research and methods
  - What is concluded by the author
  - May also include recommendations
    - Additional work
    - Additional trial sections.
    - etc.

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Preparing the paper

- Acknowledgements
  - Thanks to
    - Sponsors of research
    - Other contributors
    - Published with permission of ??

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Preparing the paper

- References
  - Important that anything not original is referenced
  - Avoid plagiarism
  - Standard format – varies, but includes"
    - Author(s), date, title, where published, page numbers
- Appendices
  - May or may not be included
  - Depends on its size and the publisher
  - Good to present results so that other researchers can re-look at the data (perhaps in a different way)

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Paper writing process

- Prepare the figures and tables – decide if there is a paper
- Write the Methods section
- Write up the Results section
- Write the Discussion
  - Finalize the Results and Discussion before writing the introduction
- Write a clear Conclusion
- Write a compelling Introduction
- Finalise the Abstract
- Compose a concise and descriptive Title

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Summary

- Now you know how to prepare a paper
- Need to do it
- Abstracts for PIARC conference due 15th Feb 2018
- Need to be approved by AfCAP first

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Conference focus areas

- **FA2 – Optimal Standards**
- This focus area will cover optimising standards for pavement structure, road geometry, construction, infrastructure capacity. Given the scarce resources of the African continent, road infrastructure should be provided at the lowest possible whole life costs, taking into account all relevant externalities.
- http://www.sarf-irf2018.co.za/call-for-papers/#focus

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Conference focus area

- The conference will inter alia examine:
- the viability of traditional approaches in the setting of design and construction standards for the African region
- smart mobility – reducing congestion and fostering faster, greener, and cheaper transportation options
- innovations in pavement materials composition e.g. end-of-life materials, secondary (waste) materials and alternative binders
- design of low volume / low cost road pavements
- the use of naturally occurring materials in Africa, e.g. pedogenic deposits, to provide more cost-effective road pavement structures

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Title

- Short and punchy
- First indication of whether anyone will read it
- Say what the paper is about

- Authors/affiliations
  - Main author/s – contributors
  - Contact details

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Abstract

- Short and to the point (200 – 500 words)
- Must win the reviewers attention and convince them that it must be in the conference
  - Background to the project
  - Where carried out
  - What was done
  - How it was done
  - General conclusions

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

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LTPP Workshop, August 2018, Maputo

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Workshop aim

- Objectives are :
  1. Process of identification of research projects
  2. How to carry out a research project
  3. Review of RRC strategic plan projects (CSIR 2014)

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Identification of Research Projects

- Not always straight forward
- Usually requires team input
- Must keep in mind:
  - Takes time, money and commitment
  - Must be relevant
  - Must have a useful outcome and either:
    - Be implementable (typical problem solver)
    - Have a scientific need (fundamental research – MSc, PhD)
    - Should have a positive benefit/cost outcome

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Identification of Research projects

- Process:
- Select appropriate "team"
  - Identify problems that need to be solved
    - "Brain storming"
    - Prioritise these - nominal group technique
    - Various techniques
    - Select most beneficial
  - Prepare ranked list of potential projects
  - Put some "meat on the bones"

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Identification of Research projects

- Which ones do we do first?
  - Short term – high benefit
  - Short term low benefit – high visibility
  - Long term high benefit
  - Long term low benefit
- Look at available resources
  - Adequate funding
  - Appropriate staff
  - Adequate facilities

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Nominal Group technique

- Introduction and explanation: explain the purpose and procedure
- Silent generation of ideas: Each participant gets a sheet of paper - write down all ideas that come to mind when considering the question - no consultation or discussion (± 10 min)
- Sharing ideas: Share the ideas generated - record each idea on a flip chart - round robin until all ideas have been presented. No debate - any new ideas that may arise – written record of all ideas generated (15–30 mins)
- Group discussion: Verbal explanation or further details about any of the ideas produced that may not be clear - process must be as neutral as possible, avoiding judgment and criticism. May be some new items for discussion - combine items into categories - no ideas should be eliminated (30–45 mins)
- Voting and ranking: Each member votes for order of priority. Immediate results in response to the question available - concludes with a specific outcome.

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Nominal Group technique

- Will go through the process shortly

QUESTIONS ??

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Carrying out a Research Project

- Full process needs to be followed
  1. Identify project
  2. Define objective
  3. Set up research team to cover all issues – mix experience and age
  4. Plan the project
  5. Get approval and funding
  6. Start project – "scientific method" where possible

- Research must be original (no plagiarism), credible, defendable and based only on findings (do not alter results)

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What is the "Scientific Method" ?

- Set hypothesis
- Gather observable, empirical and measurable evidence - observation and experimentation
- Test hypotheses.
- Must be objective with no bias
- If correct – good – if not try again !
- New hypothesis or additional data

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Carrying out a Research Project

- Set objectives
  - What do we want out of the project?
  - Define objectives clearly – solution required !
  - Identify what is needed to reach these objectives
  - Review original project plan and update
  - Prepare full project management plan (Gantt Chart)
    - Resources
    - Tasks
    - Timing (critical path, deadlines, etc)
    - Finances and cash flow
    - Milestones, reports, etc.

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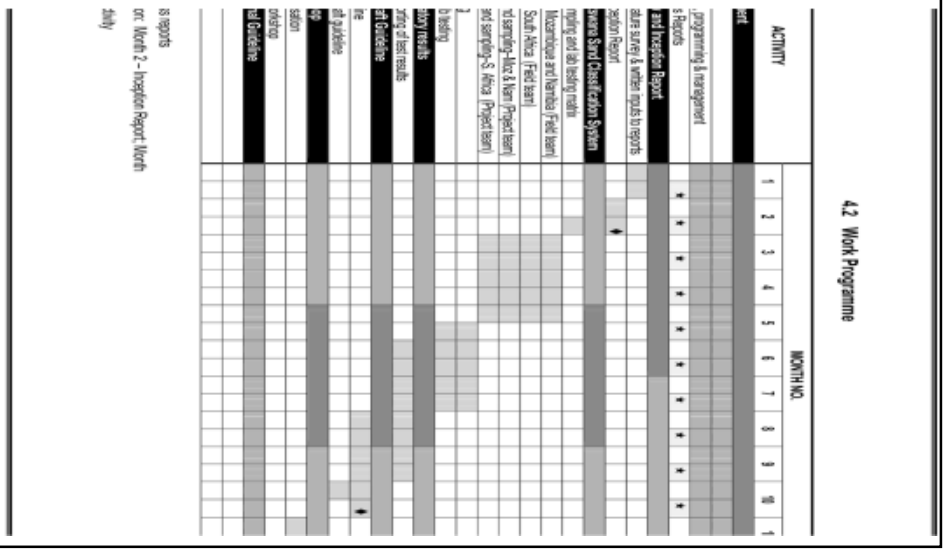
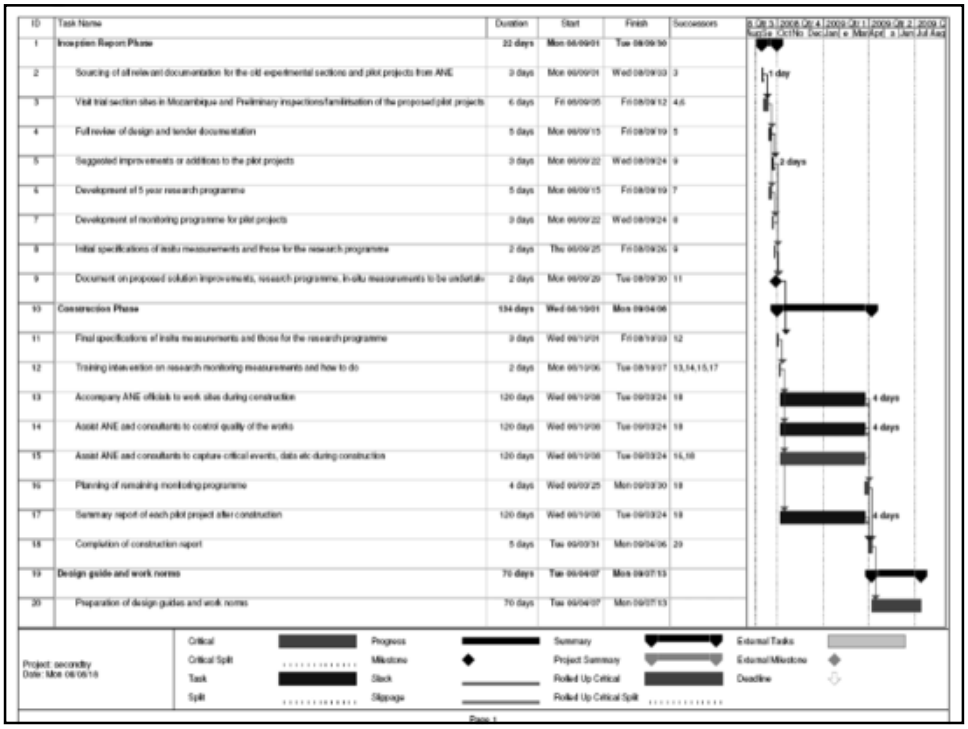
- Project /activity plan





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Carrying out a Research Project

- Literature review
  - Obtain all literature possible
    - From client
    - Internet (library searches) – appropriate key-words
    - From References in literature obtained (NB)
  - Read carefully and see what is relevant – make lots of summaries and notes
  - Prepare a literature review document
    - Summarise relevant information
    - Be systematic – care with layout and section headings, etc.
    - Highlight important issues
    - Identify missing information
    - Tabulate relevant results

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Carrying out a Research Project

- Revisit original project plan
  - Review where necessary
    - Some assumptions may not have been correct - Work already done !!)
    - Expected information may not be available
    - Different resources may be necessary
    - Time estimates may have been inaccurate
    - Budget may need to be altered
  - Develop revised plan if necessary
  - New project management plan
  - Plan investigation detail

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Carrying out a Research Project

- Carry out field work as necessary
- Differs from project to project
  - Could be sampling, interviews/consultations, surveys, study of satellite imagery, etc.
- Must use recognised techniques and methods where available
  - Local or international standards
  - Good experimental design to optimise data collection
  - Make sure that sufficient "sample" is obtained 1st time
  - Check data obtained carefully (validation), enter into "data-base" and carefully store all records

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Carrying out a Research Project

- Carry out laboratory work as necessary
- Also differs from project to project
  - Usually materials, but could be paint, guard rails, cats-eyes, or anything
  - Closely supervise personally
- Test using recognised techniques and methods
  - Local or international standards – multiple testing
  - May need to modify – note this carefully
  - Development of new methods – document method and include in final reports
  - Check results carefully (do they make sense), enter into "data-base" and carefully store all records
  - Factual information

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Carrying out a Research Project

- **Analysis of results**
  - Enter results into "data base" as they are obtained
  - Easier to see if things are going wrong
  - Analysis can be simple or complex – typically the more data, the more complex the analysis
  - Initially simple statistics (mean, σ, CoV, max, min, distributions, ranking, etc).
  - Identify and handle outliers – statistically – don't just throw away without reason

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Carrying out a Research Project

- **Advanced analysis of results**
  - Requires experience – speak to a statistician – not always easy!!
  - Correlations and regressions – simple or multiple – linear or non-linear, etc
  - Confidence limits and significance
  - Analysis of variance, discriminant analysis, cluster analysis, etc

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Carrying out a Research Project

- **Reporting**
  - Prepare interim/progress reports at all appropriate stages
  - Document exactly what was done, how it was done and the findings and results
  - Don't draw too many interpretive conclusions at this stage
  - Just to keep you thinking and for record purposes
  - Makes final report much easier and quicker – C&P
  - Keep potential solutions as simple and practical as possible

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Poor specification (sand base for sealed LVR <0.1M E80)

Essential requirements

- Colour: yellowish-brown or reddish- brown (not white or grey)
- AASHTO classification: A-2-4(0)
- Unified classification: SM
- GM: 0.75–1.10
- P075: 10–25%
- TMH 1 PI on P425 fraction: NP-SP
- TMH 1 PI on P075 fraction: SP-6
- TMH 1 IF075: 20–120
- Minimum soaked 2.54 mm CBR at 100% MAASHO: 50%
- Minimum unsoaked 2.54 mm CBR at OMC at 100% MAASHO: 60%
- Maximum MAASHO CBR swell: 0.1%
- Minimum CBD-extractable Fe: 0.3% or, less reliably, minimum Fe_2O_3 content by XRF analysis: 1.2% Fe_2O_3.

Probably desirable:

- Sand equivalent: 13 – 40
- Particle angularity:
  - Minimum uncompacted voids (ASTM C1252) on the plus 075 µm fraction: 45%, or
  - Mostly angular particles visible under stereo microscope
- Dominant clay mineral: kaolinite.

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Carrying out a Research Project

- **Reporting**
  - Towards the end of the project:
    - Incorporate relevant parts of interim reports into "draft" final document
    - "Interpret" results and start drawing conclusions
    - Circulate "Draft" to peers for comment and review
    - Finalise and submit to "Client"
    - Publish if possible in conference or journal

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Carrying out a Research Project

- **Checking**
  - Once the "solution" to the problem has been identified
  - Carry out pilot implementation (demonstration sections)
    - Check that everything concluded does actually work, is practical and can be implemented cost/effectively
    - Identify any special needs (equipment, training, etc.)
    - Monitor to check if the predicted performance is actually happening
    - Can use accelerated testing or some other technique – e.g. short design life !

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Carrying out a Research Project

- **Full Implementation**
  - Once confidence has been gained
  - Good research must be implemented
  - Incorporated into local, national, or international practice
  - Initially included in “Manuals” or “Guidelines”
  - Test in general practice

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Carrying out a Research Project

- **Monitoring**
  - New research that is implemented must be monitored to ensure that it is actually applicable
  - Different scenarios of climate, traffic, etc.
  - Monitor according to locally accepted protocols

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Carrying out a Research Project

- **Feedback (*is the food of champions*)**
  - Research that works well with new cost-effective solutions must be fed back to users
  - If accepted, this will usually find its way into specifications
  - New research that is implemented must be monitored to ensure that it is actually applicable
  - Different scenarios of climate, traffic, etc.
  - Monitor according to locally accepted protocols

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Carrying out a Research Project

- **Feedback**
  - Good research will always be subject to peer review
  - Publish in recognised journals and important conferences
  - Increases implementation and credibility of researcher (more money for research?)

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

MOZ2093A

Cardno

Workshop, August 2018, Maputo

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Workshop aim

- Objectives are :
  1. Process of identification of research projects
  2. How to carry out a research project
  3. Review of RRC strategic plan projects (CSIR 2014)

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RRC Strategic Plan

- AfCAp project by CSIR (August 2015)
- Establishment of a Road Research Centre in Mozambique: Short-Term Technical Assistance Programme (Final Report)
- Included various potential research projects for the RRC

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Identification of Research projects

- Road Research Technical Committee identified twelve priority research projects.
  - Six high priority “quick win” and/or “Immediate Need” projects - “breakthrough projects” - address the most pressing needs - high impact - demonstrate the value of the RRC to stakeholders early in its existence;
  - Four high priority “quick win” or medium to longer-term projects with a similar high impact - not perceived to be “Immediate Need” projects - yield benefits similar to those of the former group of projects
  - Two Cross-cutting high priority activities - develop and implement in association or in parallel with projects in other two categories

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High priority projects that address immediate research needs

- Mapping of natural materials for road construction and development of a database
- Use of local material
- Protocols for improving the proficiency of material testing laboratories
- Protocols and database for systematic collection and recording of data generated during implementation of road projects
- Characterisation of road assets
- Guidelines for the design of small bridges
- Analysis of the effects of traffic overloading on pavement performance
- Implementation of a national / regional strategy for vehicle overloading control
- Manual for design of surface seals
- Standard specification for roads

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Identification of Research projects

Cross-cutting yet high priority activities that can be developed and implemented in association or in parallel with the above projects:

- Further exploitation of results from previous research projects and practical implementation of results
- Manuals for roads

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Identification of Research projects

- Six of these projects address research and development needs directly or indirectly associated with low-volume access roads:
  - Mapping of natural materials in road construction and development of a database;
  - The use of local materials in roads;
  - Protocols for improving the proficiency of material testing laboratories;
  - Protocols and database for systematic collection and recording of data generated during the implementation of road projects;
  - Guidelines for the design of small bridges
  - Manual for the design of surface seals.

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Identification of Research projects

- ANE also desired a continuation of two additional projects initiated in AFCAP1:
  - Finalise the development of a Mozambican Design Manual for Low-Volume Roads initiated by TRL under AFCAP1 - not completed as AFCAP1 ended
  - Finalising the study on the Use of Road Works to Enhance Community Water Supplies in Mozambique – including:
    - Preparation of detailed technical designs and specifications for pilot Road Pond structures
    - Preparation of draft tender documents
    - Undertaking a participatory sociological survey at each site to establish community Road Pond committees.
  - Phase 2 was completed in April 2013.

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Identification of Research projects

- A full concept note (4 -5 pp) was provided for each project as follows:
  - Mapping of Natural Materials for Road Construction and Development of a Database
  - Background
  - Problem Statement
  - Project Objectives
  - Expected Benefits
  - Methodology
  - Deliverables
  - Implementation
  - Project team/personnel
  - Project Inputs and Budget

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Identification of Research projects

- Methodology (1)
  - Review work carried out by TRL and obtain a thorough understanding of the remote sensing and botanical indicator principles applied. Check, using the literature, if there are any other techniques that could complement these, e.g. soil mapping, digital terrain modelling, etc.
  - Obtain any additional and/or newer remote sensing data for Inhambane Province. Apply as many of the principles identified as possible to a small selected area in the Province (preferably a problematic area) and develop a desk study base map based purely on accessible information that addresses all materials in the area. A good knowledge of the requirements of the different materials for road construction purposes will be necessary.
  - The researcher/s will then need to visit the area assessed and carry out a detailed investigation of the local soils and geology, to confirm which of the techniques or principles employed works best for which materials. This will entail significant probing, pitting and sampling. Ideally, a three dimensional map of the upper 1.5 to 3.0 m of the entire area should be developed.

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Identification of Research projects

- Methodology (2)
  - Field investigations will involve use of the calcrete probe, test pitting and soil profiling (Brink and Bruin method) and sampling at selected sites showing potentially useful materials of any kind (calcrete, sands, gravels).
  - Laboratory testing will include normal grading, Atterberg limits, CBR testing and aggregate strength (ACV, AIV, 10%FACT, etc). X-ray diffraction (XRD) studies of some of the materials may also be useful. This would be carried out by LEM.
  - Based on the results obtained from the "pilot area", the optimum assessment techniques should be identified. These must then be applied to a desk-study of a second selected area. Only those sites that show positive potential should then be evaluated and the success rate of the process determined. Areas that weren't successful should be investigated to determine "what went wrong"?

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Identification of Research projects

- Methodology (3)
  - Once the process has been adequately fine-tuned, the entire province should be "mapped" and sampled according to the method developed.
  - The results of the material location and sampling must then be placed in a data base linked to a GIS such that anyone requiring material information in the province can quickly access the available data.
  - Prepare a manual on the use of the system and the data base including a method for users to supply all additional data to the data base manager for addition to the existing information.
  - Once this has been successfully completed, the process should be applied to the other provinces in Mozambique. This would be different projects in different phases

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Identification of Research projects

- Let us have a look at some projects of our own now!!

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Thank you for your attention

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