Implementation of Technical Auditing and Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Training Report

J. Hongve & E. Mukandila

AFCAP Project Reference Number MAL2007C

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AFRICA COMMUNITY ACCESS PARTNERSHIP (AfCAP)

Safe and sustainable transport for rural communities

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

See www.afcap.org
## Acronyms, Units and Currencies

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AASTHO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>AfCAP</td>
<td>Africa Community Access Partnership</td>
</tr>
<tr>
<td>ASWAP-SP</td>
<td>Agriculture Sector Wide Approach Support Project</td>
</tr>
<tr>
<td>DCP</td>
<td>Dynamic Cone Penetrometer</td>
</tr>
<tr>
<td>DN</td>
<td>DCP Number (mm/blow)</td>
</tr>
<tr>
<td>EOD</td>
<td>Environmentally Optimised Design</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre</td>
</tr>
<tr>
<td>LVSR</td>
<td>Low Volume Sealed Road(s)</td>
</tr>
<tr>
<td>m</td>
<td>Metre</td>
</tr>
<tr>
<td>mm</td>
<td>Millimetre</td>
</tr>
<tr>
<td>MDD</td>
<td>Maximum Dry Density</td>
</tr>
<tr>
<td>Mod</td>
<td>Modified</td>
</tr>
<tr>
<td>OMC</td>
<td>Optimum Moisture Content</td>
</tr>
<tr>
<td>RA</td>
<td>Roads Authority</td>
</tr>
<tr>
<td>ToT</td>
<td>Training of Trainers</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom (of Great Britain and Northern Ireland)</td>
</tr>
<tr>
<td>UKAid</td>
<td>United Kingdom Aid (Department for International Development, UK)</td>
</tr>
</tbody>
</table>
## Contents

Acronyms, Units and Currencies ................................................................................. 4

1 Executive summary .................................................................................................. 6

2 Introduction ............................................................................................................. 8
   2.1 Background ..................................................................................................... 8
   2.2 Objectives of the Assignment ....................................................................... 9
   2.3 Purpose and Scope of the Report .................................................................. 9

3 Training Programme ............................................................................................... 10
   3.1 Preparations .................................................................................................. 10
   3.2 Training Modules and Programme ............................................................... 10
   3.3 In-country preparations .............................................................................. 11
       3.3.1 Practical training .................................................................................. 12
       3.3.2 Classroom training ............................................................................. 13

4 Conclusion ............................................................................................................... 15

5 Next Steps ............................................................................................................... 16
   5.1 Training of Trainers ..................................................................................... 16
   5.2 Demonstration projects ............................................................................... 16
   5.3 Recommendations ....................................................................................... 16

Annex 1: Mission Itinerary and Programme ............................................................. 17
Annex 2: Training Methodology and Modules ......................................................... 18
Annex 3: List of participants .................................................................................... 21
Annex 4: Summary of Course Evaluation .................................................................. 23
Annex 5: Summary Report from Laboratory Module ............................................. 25
Annex 6: Presentations ............................................................................................. 26
Annex 7: AfCAP LVR-DCP v1.03 Snaglist ............................................................... 48
Annex 8: Evaluation forms ....................................................................................... 51
1 Executive summary

The AfCAP project MAL2007 was formulated to support the uptake and embedment of the DCP-DN Design Method in Malawi. The project is carried out in phases as follows:

- Phase 1
  - Training of the local consultant Royal Associates and staff from RA in the DCP-DN Design Method. Following this training course, Royal Associates prepared designs for 40 km of LVSRs in 5 districts, all of which are currently under construction.
  - Design Review for all five legs of the ASWAP-SP project
  - Technical Audit at start of construction of the two northerly projects, D11 Kalenge bridge - Misuku at Chitipa and the T357 Parachute Battalion - Lifuwu at Salima

- Phase 2
  - Mid-term Technical Audit of the three southerly projects, D387 Nsangwe – Dolo in Chikwawa District, S135 Mwanza - Kunenekude in Mwanza District and S134 Kasinje - Kandeu in Ntcheu District
  - Training of a new batch of local consultants and RA staff in the DCP-DN Design Method
  - Final Technical Audit of all five projects at the end of the construction period

Phase 1 was completed in September 2015 and the Mid-term Technical Audit of the three southerly projects carried out in June 2016. The following reports document the activities and outcomes of the previous activities under MAL2007:

- Training Report - February 2014
- Design Review and Training Report - October 2014
- Technical Audit Report - October 2015

Upon a request from the Roads Authority who wishes to broaden the base among local consultants for undertaking LVSR design using the DCP-DN method a new training course was conducted in the period 11-22 July 2016. The course had 29 participants divided in two groups, each of which went through a one-week practical and theoretical course. The participants also included one staff member from Roads Development Agency in Zambia, where the method is to be introduced later in the year.

The training objectives of bringing all participants to an intermediate or higher level in the use of the AfCAP LVR DCP software and imparting LVR design philosophy and EOD design principles for cost-effective provision of LVSR have been achieved. This is reflected in the course evaluation by the trainees, a summary of which is shown below:

<table>
<thead>
<tr>
<th>Course evaluation summary</th>
<th>Average score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
</tr>
<tr>
<td>DCP-DN design and use of AfCAP LVR DCP software</td>
<td>1.75</td>
</tr>
<tr>
<td>Organisation</td>
<td>2.52</td>
</tr>
<tr>
<td>Venue</td>
<td>2.27</td>
</tr>
</tbody>
</table>

Key to score: 1 – best, 5 – worst
Some further coaching will be required to enable the trainees to undertake a full pavement design using the DCP-DN method. Development of in-country training capacity is recommended to build on the momentum from the initial training and construction of the five projects under ASWAP-SP.

The Training-of-Trainees (ToT) should include the full project cycle from planning and design to construction and long term monitoring of demonstration projects. Possible candidates for future Trainers have been identified from the participants. It is recommended that a ToT project be considered for commencement during Financial Year 2016/17 and subsequent construction of demonstration sections in FY 2017/18.
2 Introduction

2.1 Background

The second phase of the Africa Community Access Partnership (AfCAP) is a programme of research and knowledge dissemination funded by the UK government through the Department for International Development (DFID). The aim of the new AfCAP initiative, under the overall Research in Community Access Partnership (ReCAP) umbrella, is to build on the programme of high quality research established under AfCAP phase 1 and take this forward to a sustainable future in which the results of the research are adopted in practice and influence future policy.

AfCAP is promoting safe and sustainable rural access in Africa through research and knowledge sharing between participating countries and the wider community in order to make a vital contribution to the sustainable socio-economic development of the more remote regions, and in particular their disadvantaged groups, in terms of access to markets, schools, health facilities and employment opportunities.

Previous AFCAP activities in Malawi included the preparation of a new pavement design manual for low volume sealed roads which is based on the DCP-DN design method. The manual was developed through a highly collaborative approach in-country and an international review process. It has now been published as an official Malawi Government document and is available in hard and soft copy. It was used for the design of 40 km of low volume sealed roads under the World Bank financed Agriculture Sector-Wide Approach Support Project (ASWAP-SP) programme. A contract was signed by the Roads Authority with a locally based consulting firm, Royal Associates, to undertake the design and construction supervision of these roads. The contracted consulting firm had no previous experience with the use of the DCP-DN design method.

The AfCAP project MAL2007 was formulated to support the uptake and embedment of the DCP-DN Design Method in Malawi. The project is carried out in phases as follows:

- **Phase 1**
  - Training of the local consultant Royal Associates and staff from RA in the DCP-DN Design Method. Following this training course, Royal Associates prepared designs for 40 km of LVSRS in 5 districts, all of which are currently under construction.
  - Design Review for all five ASWAP-SP LVSR projects, each approx. 8 km long
  - Technical Audit at start of construction of the two northerly projects, D11 Kalenge bridge - Misuku at Chitipa and the T357 Parachute Battalion - Lifuwu at Salima

- **Phase 2**
  - Mid-term Technical Audit of the three southerly projects, D387 Nsangwe – Dolo in Chikwawa District, S135 Mwanza - Kunenekude in Mwanza District and S134 Kasinje - Kandeu in Ntcheu District
Training of a new batch of local consultants and RA staff in the DCP-DN Design Method

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- Technical Audit Report - October 2015

This report covers the training of a new batch of local consultants as well as staff from Roads Authority upon a request from the Roads Authority who wishes to broaden the base among local consultants for undertaking LVSR design using the DCP-DN method. To this end a new course was conducted in the period 11-22 July 2016. The course had 29 participants divided in two groups, each of which went through a one-week practical and theoretical course. The participants also included one staff member from Roads Development Agency in Zambia, where the method is to be introduced later in the year.

2.2 Objectives of the Assignment

The objective of the assignment was to provide training to local consulting firms and Roads Authority staff in the use of the DCP-DN Pavement Design Method to enable wider application of this innovative design methodology for cost-effective provision of LVSR in Malawi.

2.3 Purpose and Scope of the Report

The purpose of this report is:

- to provide detailed feedback from the training courses held at the Golden Peacock Hotel in Lilongwe during the period 11-22 July 2016,
- to provide feedback on the use of the recently upgraded AfCAP LVR-DCP software, and
- to provide concrete proposals for the way forward for demonstration of the DCP-DN Pavement Design Method on a wider scale and establishment of in-country training capacity.

The Mission Itinerary and Programme is attached in Annex 1.

The report covers the following:

- **Section 3** – Implementation of Training Activities: This section provides a summary of the training activities and experiences in the use of the AfCAP LVR-DCP software.

- **Section 4** – Conclusion: This section provides an assessment of the training outcome by the Trainers as well as a summary of the Course Evaluation by the Trainees.

- **Section 5** – Next Steps: This section presents proposals for the next steps for demonstrating the application of the DCP-DN Pavement Design method on a wider scale and establishment of in-country training capacity for uptake of the DCP-DN design method as a viable alternative to the traditional CBR based design method.
3 Training Programme

3.1 Preparations

3.2 Training Modules and Programme

With 29 participants the Training Programme was divided in two equal parts, each of one-week duration, with 12 and 17 participants in Group 1 and 2 respectively. This was based on previous experience from similar training courses to ensure that each participant could be given satisfactory attention during the classroom training.

The Training Methodology, Modules and Programme are shown in Annex 2. The list of participants is shown in Annex 3.

Figure 1: Group 1 participants
3.3 In-country preparations

The training road had been identified and agreed with Roads Authority during the Technical Audit mission in June 2016.

Due to the limited time available for the Trainers in Malawi, preparations for the training had to be done by Roads Authority and Central Materials Laboratory prior to the start of the training programme. To this end a schedule of preparatory activities was prepared and sent to Roads Authority to ensure that the preparations of samples and testing were carried out.

The preparations included:

- Centre line samples for determination of Field Moisture Content (FMC) of the three upper 150 mm layers and the FMC/OMC ratio
- Classification tests for borrow pit materials
- Preparation of samples for demonstration of the Laboratory DN test

The preparatory activities were only partially done when the training started and were only fully completed by the start of the second week. This meant that the samples for the Laboratory DN test had not had enough time for curing and that no centre line Relative Moisture Contents were available for the design exercise for the 1st Group.
3.3.1 Practical training

DCP Field tests
The field exercises were carried out on S126 Linthipe 1 – Lobi which is situated some 50 km south-east of Lilongwe. The first 4.4 km of the road from the junction with M1 is under upgrading by a local contractor. The DCP tests therefore started at km 4+400. In all 26 DCP tests divided between the two groups of trainees, were carried out at 100 m intervals up to km 6+900.

Figure 3: Training road S126 Linthipe 1 - Lobi

The field training included the following:

- Checking condition of the equipment before use (hammer dropping height, condition of roads and cones
- Set-up for DCP test (team of three with one person holding DCP in vertical position, one person lifting the hammer and one person recording the readings)
- Seating of the cone before start of DCP test and recording of zero blows reading
- Procedure for counting out loud the no of blows and reading out loud the DCP readings to avoid recording of erroneous results
Laboratory DN test
Base material from the ongoing upgrading contract on the first part of the road had been collected and six moulds had been prepared, all at BS Heavy compaction, for the Laboratory DN test:

- 2 Soaked
- 2 at OMC
- 2 at 0.75 OMC

Each group witnessed and took part in penetration of three moulds and later used the AfCAP LVR DCP Laboratory Module to enter and analyse the data.

A Summary report for the two moulds at OMC is shown in Annex 5. This indicates that the material used for base construction may not be of sufficient quality for the assumed Traffic Load Class TLC 0.3 on this road.

3.3.2 Classroom training

Presentations
The presentations given covered the following main topics:

- Introduction and background to the DCP-DN design method (J. Hongve)
- LVSR Environmentally Optimised Design (EOD) principles (J. Hongve)
The DCP-DN Design Method (J. Hongve & E. Mukandila)
Importance of compaction and compaction control using the DCP (J. Hongve)
Materials prospecting and testing procedures incl. Laboratory DN testing (E. Mukandila)

The presentations are shown in Annex 6.

**Introduction to the AfCAP LVR-DCP software**

The DCP test results from the field exercises were used to introduce the trainees to the features of the AfCAP LVR-DCP software, including:

- Opening a new project file
- Showing the use of the various menu options
- DCP system settings
- Choosing Traffic Load Class (TLC) design curve
- Setting report options
- Entering DCP test data (from field exercises)
- Performing Single Point and Multiple Point analysis
- Explaining the use of percentiles for moisture adjustments of DN values
- Explaining the Layer Strength Diagram (LSD) and Normalised/Redefined LSD
- Explaining the Pavement Balance concept and the effect on the Power Exponent for well-balanced pavements for estimation of Design Traffic Loading

**Pavement design exercises using the AfCAP LVR-DCP software**

The trainees were introduced to the AfCAP LVR DCP software as an on-screen guide exercise, explaining each feature and use of the menus and toolbar. Manual entering of DCP data was exercised before they were taught how to copy from the Excel template into the programme and eventually how to import the full project data set, which had been prepared in advance, for the design exercise. They were also explained how to do a Cumulative Sum (Cusum) analysis of the data sets in order to understand what the programme is doing in the background.

Having gone through in detail the software features and concepts of the DCP-DN design using the DCP data from the field exercise, the trainees were given full data sets from various projects in Kenya, Tanzania and DRC on which to go through the whole design process, analyse the data, determine uniform sections and determine the pavement design for the various sections.

The trainees worked both individually and in groups to produce designs. The latest revision of the software is now so user friendly that most of the trainees quickly got up to speed in the operation of the programme and learned how to define uniform sections, apply different percentiles for moisture adjustment of the DCP data and do sensitivity analysis of the designs by applying different Traffic Load Classes.

It was, however, emphasised several times during the course that the software is only an additional tool in the designer’s toolbox and not a replacement for sound engineering judgement and that getting intimately familiar with the road by walking the alignment and getting to know the materials is a prerequisite for producing reliable designs.

The result of the design exercise for the Training road is shown in Figure 5 below.
Figure 5: Design for Training road S126 Linthipe 1 - Lobi

<table>
<thead>
<tr>
<th>Pavement Layer (mm)</th>
<th>Required DN value for TLC 0.3</th>
<th>Section no.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4.4 to 5.5 km</td>
<td>5.5 to 5.7 km</td>
</tr>
<tr>
<td>0-150</td>
<td>&lt;= 3.2 (3.5)</td>
<td>4.9 (80P)</td>
</tr>
<tr>
<td>150-300</td>
<td>&lt;= 6 (6.9)</td>
<td>5.8 (80P)</td>
</tr>
<tr>
<td>300-450</td>
<td>&lt;= 12 (14)</td>
<td>7.0 (80P)</td>
</tr>
<tr>
<td>450-600</td>
<td>&lt;= 19</td>
<td>8.3 (80P)</td>
</tr>
<tr>
<td>600-800</td>
<td>&lt;= 25</td>
<td>10.0 (80P)</td>
</tr>
</tbody>
</table>

Experiences with the use of the upgraded AfCAP LVR-DCP software

The software in its current form is user friendly and a very versatile and powerful tool in the hands of a good designer. Analysis of different design options, sensitivity analysis for different Traffic Load Classes, application of different percentiles for moisture adjustment etc. can be done within minutes.

Some issues in the software still need to be sorted out, but these are minor issues and do not cause problems in producing designs. A Snaglist of things still to be fixed is provided in Annex 7.

4 Conclusion

The engineering background and experience of the trainees contributed to interesting discussions during the classroom sessions. This offered opportunities to repeat difficult issues and further clarify key concepts in the design method and use of the software. It is the impression of the Trainers that the objectives of the assignment have been achieved and that the Trainees have got a solid foundation for application of the DPC-DN Pavement Design Method, although some further coaching and guidance will be required.

With 29 participants (of which one only attended sporadically and should not be regarded as having gone through the training) there will naturally be some spread in the level of proficiency attained by the trainees. Particularly those who had limited computer operating skills tended to fall behind and therefore took longer to acquaint themselves with all the features in the software. With individual attention and repetition of the exercises it is still felt that all participants had by the end of the week attained a reasonable skills level in the operation of the software as well as an appreciation of the DCP-DN design method and an understanding of the LVR design philosophy and principles.
This assessment is largely confirmed by the course evaluation by the Trainees shown in Table 2. Two participants in Group 1 were not present during the demonstration of the Laboratory DN test and the following classroom exercise on the Laboratory Module. This has contributed to the lower score on this issue compared to Group 2. Full details of the course evaluation are shown in Annex 4.

Roads Authority were quite late in inviting trainees, especially for the first group and lunch and refreshments had not been arranged for the days of the field exercise. This is reflected particularly in the score for Organisation by Group 1. The organisation at the venue Golden Peacock hotel was also not quite as expected during the first week, but improved after complaints about the services.

Table 1: Course evaluation summary

<table>
<thead>
<tr>
<th>Course evaluation summary</th>
<th>Average score</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>1.75</td>
<td>1.51</td>
<td></td>
</tr>
<tr>
<td>Organisation</td>
<td>2.52</td>
<td>1.95</td>
<td></td>
</tr>
<tr>
<td>Venue</td>
<td>2.27</td>
<td>1.71</td>
<td></td>
</tr>
</tbody>
</table>

Score: 1 (best), 5 (worst)

5 Next Steps

5.1 Training of Trainers

It is important that this initial training is followed up with establishment of in-country training capacity to ensure uptake of the DCP-DN design method on a broad basis.

Potential candidates for a future Training-of-Trainers course were identified. These are highlighted in the List of Participants in Annex 3.

5.2 Demonstration projects

For promotion and uptake of the new approach to LVSR pavement design, it is imperative to construct demonstration projects. This will greatly contribute to the acceptance of the new technology in the engineering community and among political and local leaders. The ASWAP-SP projects currently under construction will serve that purpose, but for future trainers to become fully proficient in the design of LVSR, a Training-of-Trainers course should include the design, construction and monitoring of demonstration sections.

5.3 Recommendations

To build on the momentum from the initial training in the application of the DCP-DN pavement design method, the following is recommended:

- Identify candidates for Training of Trainers (ToT) course during 2017.
- Identify suitable demonstration project(s) and secure funding for construction during financial year 2017/18.
- For the promotional effect, the demonstration section(s) should be within easy reach of Lilongwe.
- Pavement Design and Construction Supervision of the demonstration projects, incorporating the use of the Guideline for using the DCP for quality control, should be an integral part of the Training of Trainers course. The ToT course should therefore span the entire project cycle for the demonstration projects, while at the same time training of more engineers can be done, initially with assistance of the international Trainers.
Annex 1: Mission Itinerary and Programme

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>10.07</td>
<td>Arrival in Lilongwe</td>
</tr>
<tr>
<td>Mon</td>
<td>08.02</td>
<td>Field Training Group 1</td>
</tr>
<tr>
<td>Tue</td>
<td>09.02</td>
<td>Classroom Training Group 1</td>
</tr>
<tr>
<td>Wed</td>
<td>10.02</td>
<td>Classroom Training Group 1</td>
</tr>
<tr>
<td>Thu</td>
<td>11.02</td>
<td>Classroom Training Group 1</td>
</tr>
<tr>
<td>Fri</td>
<td>12.02</td>
<td>Laboratory Demo, Wrap-up and Course Evaluation Group 1</td>
</tr>
<tr>
<td>Sat</td>
<td>13.02</td>
<td>Rest day</td>
</tr>
<tr>
<td>Sun</td>
<td>14.02</td>
<td>Rest day</td>
</tr>
<tr>
<td>Mon</td>
<td>15.02</td>
<td>Field Training Group 2</td>
</tr>
<tr>
<td>Tue</td>
<td>16.02</td>
<td>Classroom Training Group 2</td>
</tr>
<tr>
<td>Wed</td>
<td>17.02</td>
<td>Classroom Training Group 2</td>
</tr>
<tr>
<td>Thu</td>
<td>18.02</td>
<td>Laboratory Demo and Classroom Training Group 2</td>
</tr>
<tr>
<td>Fri</td>
<td>19.02</td>
<td>Wrap-up and Course Evaluation Group 2</td>
</tr>
<tr>
<td>Sat</td>
<td>20.02</td>
<td>Departure from Lilongwe</td>
</tr>
</tbody>
</table>
Annex 2: Training Methodology and Modules

Methodology
An application-oriented training approach will be adopted with clearly defined topics, objectives and learning outcomes that are relevant to the substantive jobs held by the staff. This approach will allow the trainees to actually undertake DCP data collection in the field and to subsequently use this data in the classroom to design a LVR pavement based on the DCP-DN method. The field training will take place on S126 branching off from M1 at Linthipe 1 about 40 km south-east of Lilongwe.

The first 4 km of this road is currently under upgrading by a local contractor and RA has planned to continue the upgrading of this road during the next year or so. The DCP field data collection and DCP-DN pavement design exercise will be done on the following 4-5 km up to a village centre.

To re-inforce the pavement design principles and use of the AFCAP LVR-DCP Design Software, several DCP data sets from Malawi, Kenya and Tanzania will also be used for group and individual work and the trainees will be asked to present and defend their design decisions based on the available data.

The training will also focus on the materials investigation and assessment of the suitability of borrow pit materials for incorporation in the road pavement by undertaking or witnessing, as appropriate, laboratory DCP-DN measurements.

To prepare for the classroom and laboratory exercises, the Central Materials Laboratory has been requested to undertake the following:

For Lab DN test:
- Sample material from the base layer material that is currently being dumped on the first section of the road branching off M1 at Linthipe 1.
- Carry out MDD/OMC in CBR moulds at MOD AASHTO compaction and standard classification tests (Atterberg, Grading, PI). No CBR test required.
- Prepare six moulds at OMC compacted at MOD AASHTO compaction (5 layers, 55 blows per layer with 4.5 kg hammer) as follows:
  o 2 moulds to be dried back to 75% of OMC, then sealed in plastic bag or with wax
  o 2 moulds to be retained at OMC and sealed as above
  o 2 moulds to be soaked for 4 days, then sealed as above

Cure samples in moulds as per procedure in Malawi DCP Design Manual

Centre line samples for determination of Field Moisture Content in relation to OMC:
- At two locations (one at a high point and one at a low point) take samples from the three uppermost 150 mm layers (make sure not to mix the layers!!!). Samples have to be big enough for carrying out the following tests:
  o Carry out MDD/OMC in CBR moulds at MOD AASHTO compaction. Determine actual Field Moisture Content and FMC/OMC ratio for each layer at both points.

Each group will participate in the Laboratory DN test on three moulds per group (one soaked, one at OMC and one at 75% of OMC, all at Mod AASHTO compaction).

Thus, the training methodology will be divided in such a manner that the field, classroom and laboratory training are complementary to each other in a mutually reinforcing way.

With up to 30 participants, it has been found necessary, based on prior experience with similar courses, to divide the trainees in two groups with a one week course for each group to enable two-way interaction between the trainees and the trainers and to give adequate attention to each trainee as required.

An outline of the Training Programme is shown in Table 1. The time for the training sessions / modules may vary somewhat from the proposed programme.

Training Programme and Modules

- Module 1: Field Work
  o Road inspection
  o DCP testing and data collection
- Module 2: Overview of Low Volume Roads philosophy and the DCP design principles
  o Introduction/Background
  o Design Philosophy and Principles
  o Materials
  o Drainage
  o Surfacings
  o Pavement Design
  o Geometric design
  o Road safety
  o Sustainability
- Module 3: Materials sampling and testing
- Module 4: AfCAP LVR DCP software (on screen guided exercise)
Exploring the programme features and User Manual
- Entering DCP data
- Lab DN test and data entry
- Module 5: Applying the AfCAP LVR DCP software for pavement design
  - Step by step procedure using the DCP data to produce a pavement design (on screen guided exercise)
  - Individual and group work on additional DCP data sets with presentation and defence of design decisions by the trainees.

**Table 2: Training Programme Outline**

<table>
<thead>
<tr>
<th>Week 1 – Group 1 (up to 15 participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
</tr>
<tr>
<td><strong>1. session</strong></td>
</tr>
<tr>
<td><strong>Registration</strong></td>
</tr>
<tr>
<td><strong>Break 10.00-10.30</strong></td>
</tr>
<tr>
<td><strong>2. session</strong></td>
</tr>
<tr>
<td><strong>Module 1: Field work</strong></td>
</tr>
<tr>
<td>• Road and borrow pit inspection</td>
</tr>
<tr>
<td>• DCP testing</td>
</tr>
<tr>
<td><strong>Lunch 12.00-13.00</strong></td>
</tr>
<tr>
<td><strong>3. session</strong></td>
</tr>
<tr>
<td><strong>Module 1 cont.</strong></td>
</tr>
<tr>
<td>• Background</td>
</tr>
<tr>
<td>• LVR design</td>
</tr>
<tr>
<td><strong>Break 14.30 – 15.00</strong></td>
</tr>
<tr>
<td><strong>4. session</strong></td>
</tr>
<tr>
<td><strong>Module 1 cont.</strong></td>
</tr>
</tbody>
</table>
## Annex 3: List of participants

### Registration for DCP Design Course, Lilongwe 11-22 July 2016

#### First group 11-15 July

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Organisation</th>
<th>E-mail address</th>
<th>Cell no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewis Phiri</td>
<td>Engineer</td>
<td>EMC Jatula Associates CE</td>
<td><a href="mailto:lewis.phiri@yahoo.com">lewis.phiri@yahoo.com</a></td>
<td>0882817924</td>
</tr>
<tr>
<td>Derick Manda</td>
<td>Maintenance Eng.</td>
<td>Roads Authority</td>
<td><a href="mailto:dmanda@ra.org.mw">dmanda@ra.org.mw</a></td>
<td>0888687111</td>
</tr>
<tr>
<td>Omen Metani</td>
<td>Highway Eng.</td>
<td>L. Gravam Consulting</td>
<td><a href="mailto:omen.m.metani@gmail.com">omen.m.metani@gmail.com</a></td>
<td>0888422151</td>
</tr>
<tr>
<td>Ashley Kanyoza</td>
<td>Engineer</td>
<td>Polytechnic (Blantyre)</td>
<td><a href="mailto:akanyoza@poly.ac.mw">akanyoza@poly.ac.mw</a> <a href="mailto:ashley.kanyoza@ruoconsultants.com">ashley.kanyoza@ruoconsultants.com</a></td>
<td>0888312307</td>
</tr>
<tr>
<td>D. Kara</td>
<td>Engineer</td>
<td>Bua Consulting Engineers</td>
<td><a href="mailto:kara.daud@yahoo.com">kara.daud@yahoo.com</a></td>
<td>0991851849</td>
</tr>
<tr>
<td>Flora Hauya</td>
<td>Engineer</td>
<td>Roads Authority</td>
<td><a href="mailto:fhauya@ra.org.mw">fhauya@ra.org.mw</a></td>
<td>0888439181</td>
</tr>
<tr>
<td>Sydney Phiri</td>
<td>Maintenance Eng.</td>
<td>Roads Authority</td>
<td><a href="mailto:sphiri@ra.org.mw">sphiri@ra.org.mw</a></td>
<td>0888711413</td>
</tr>
<tr>
<td>Emmanuel Maluwa</td>
<td>Maintenance Eng.</td>
<td>Roads Authority</td>
<td><a href="mailto:emaluwa@ra.org.mw">emaluwa@ra.org.mw</a></td>
<td>0888209050</td>
</tr>
<tr>
<td>Brian Nyirongo</td>
<td>Maintenance Eng.</td>
<td>Roads Authority</td>
<td><a href="mailto:brianlorringsnyirongo@gmail.com">brianlorringsnyirongo@gmail.com</a></td>
<td>0999469205</td>
</tr>
<tr>
<td>Chris Chirwa</td>
<td>Highway Engineer</td>
<td>Bua Consulting Engineers</td>
<td><a href="mailto:clchirwa.bua@gmail.com">clchirwa.bua@gmail.com</a></td>
<td>0999957753</td>
</tr>
<tr>
<td>Walinase Munthali</td>
<td>Structural Eng.</td>
<td>GK Works Consultants</td>
<td><a href="mailto:walimunthali14@gmail.com">walimunthali14@gmail.com</a></td>
<td>0881079490</td>
</tr>
<tr>
<td>Okendeni Kondowe</td>
<td>Engineer</td>
<td>Mphizi Consulting Engineers</td>
<td><a href="mailto:okendeni001@yahoo.com">okendeni001@yahoo.com</a></td>
<td>0888843903</td>
</tr>
</tbody>
</table>

Okendeni Kondowe only sporadically present and should not be regarded as having taken the course

Potential future Trainers highlighted
Registration for DCP Design Course, Lilongwe 11-22 July 2016

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Organisation</th>
<th>E-mail address</th>
<th>Cell no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Elias Sisya</td>
<td>Chief Engineer (N)</td>
<td>Roads Authority</td>
<td><a href="mailto:esisya@ra.org.mw">esisya@ra.org.mw</a></td>
<td>0888861640</td>
</tr>
<tr>
<td>14. Charles Mtawali</td>
<td>Senior Engineer</td>
<td>Roads Authority</td>
<td><a href="mailto:cmtawali@ra.org.mw">cmtawali@ra.org.mw</a></td>
<td>0888209334</td>
</tr>
<tr>
<td>15. Martin Chavula</td>
<td>Highway Engineer</td>
<td>BMM/Infratech Joint Venture</td>
<td><a href="mailto:martinchavula@gmail.com">martinchavula@gmail.com</a></td>
<td>0999591708</td>
</tr>
<tr>
<td>16. Paul Kulemeka</td>
<td>Partner</td>
<td>PJK&amp;P Consulting Engineers</td>
<td><a href="mailto:paulkulemeka@yahoo.com">paulkulemeka@yahoo.com</a></td>
<td>099983656</td>
</tr>
<tr>
<td>17. Washington Chimuzu</td>
<td>Associate Director (BD)</td>
<td>Infrastructure Consultants Ltd</td>
<td><a href="mailto:washingtonchimuzu@infracon.mw">washingtonchimuzu@infracon.mw</a></td>
<td>0999920644</td>
</tr>
<tr>
<td>18. Joseph Chibwe</td>
<td>Pavement Engineer</td>
<td>RDA - Zambia</td>
<td><a href="mailto:jchibwe@roads.gov.zm">jchibwe@roads.gov.zm</a></td>
<td>260 977 348140</td>
</tr>
<tr>
<td>19. Tamandani Kachiwala</td>
<td>Highway Engineer</td>
<td>MSCAT Consulting Engineers</td>
<td><a href="mailto:tamakachiwala@yahoo.com">tamakachiwala@yahoo.com</a></td>
<td>0993335455</td>
</tr>
<tr>
<td>20. Wammie D. Mkumbira</td>
<td>Measurement Engineer</td>
<td>David Consulting Engineers</td>
<td><a href="mailto:wdmkumbira@yahoo.com">wdmkumbira@yahoo.com</a></td>
<td>0999777802</td>
</tr>
<tr>
<td>21. Florence Ndenguma</td>
<td>Ag. Chief Engineer (S)</td>
<td>Roads Authority</td>
<td><a href="mailto:fndenguma@ra.org.mw">fndenguma@ra.org.mw</a></td>
<td>22. 0888858185</td>
</tr>
<tr>
<td>22. Walker P Kaulembe</td>
<td>Highway Engineer</td>
<td>Hadero&amp; Partners</td>
<td><a href="mailto:kaulembew@yahoo.com">kaulembew@yahoo.com</a></td>
<td>0994338804</td>
</tr>
<tr>
<td>23. Steven Luwemba</td>
<td>Civil Engineer</td>
<td>TM Associates</td>
<td><a href="mailto:sdaluwemba@gmail.com">sdaluwemba@gmail.com</a></td>
<td>0881461469</td>
</tr>
<tr>
<td>24. Samuel Kadangwe</td>
<td>Ag. Director of Construction</td>
<td>Roads Authority</td>
<td><a href="mailto:skadangwe@ra.org.mw">skadangwe@ra.org.mw</a></td>
<td>088843905</td>
</tr>
<tr>
<td>25. Nelson Kachali</td>
<td>Project Engineer</td>
<td>Pamodzi Consulting Limited</td>
<td><a href="mailto:Nelson_kachali@yahoo.com">Nelson_kachali@yahoo.com</a></td>
<td>0992362425</td>
</tr>
<tr>
<td>26. Joel Longwe</td>
<td>Construction Engineer</td>
<td>Roads Authority</td>
<td><a href="mailto:jlongwe@ra.org.mw">jlongwe@ra.org.mw</a></td>
<td>0999230913</td>
</tr>
<tr>
<td>27. Francis Dimu</td>
<td>Dir. of Planning and Design</td>
<td>Roads Authority</td>
<td><a href="mailto:fdimu@ra.org.mw">fdimu@ra.org.mw</a></td>
<td>088843906</td>
</tr>
<tr>
<td>28. Willard Kaunde</td>
<td>Chief Engineer</td>
<td>Roads Authority</td>
<td><a href="mailto:wkaunde@ra.org.mw">wkaunde@ra.org.mw</a></td>
<td>088844343</td>
</tr>
<tr>
<td>29. Newton Busani</td>
<td>Maintenance Engineer</td>
<td>Roads Authority</td>
<td><a href="mailto:nbusani@ra.org.mw">nbusani@ra.org.mw</a></td>
<td>0888208855</td>
</tr>
</tbody>
</table>

Potential future Trainers highlighted. In addition, the RA Director of Planning and Design identified Mr. Sharmey Banda, who has participated in training earlier, as a potential Trainer.
## Annex 4: Summary of Course Evaluation

<table>
<thead>
<tr>
<th>Course Evaluation - Group 1 (12 Participants)</th>
<th>Number of forms filled in</th>
<th>Scores</th>
<th>Average score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Training</td>
<td>11</td>
<td>1 2 3 4 5 Blank W.A.</td>
<td></td>
</tr>
<tr>
<td>The objectives of the course were generally achieved</td>
<td>6 4 1 0 1,55</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>The classroom presentations were well presented and understood</td>
<td>3 7 1 0 1,82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the characteristics of Low Volume Roads</td>
<td>4 6 1 0 1,73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the design principles for Low Volume Roads</td>
<td>4 4 3 0 1,91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method</td>
<td>4 4 3 0 1,91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have got a good understanding of the Laboratory DN testing procedure and how to interpret the results</td>
<td>4 6 1 0 1,73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There was enough time for practical exercises using the software and discussions / clarifications</td>
<td>7 3 1 0 1,55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The practical instructions were well delivered and understood</td>
<td>7 4 0 0 1,36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Organisation</td>
<td></td>
<td></td>
<td>2,52</td>
</tr>
<tr>
<td>I was informed about the course in time for me to organize my personal arrangements for travel to and participation in the training</td>
<td>2 3 2 4 0 3,27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrangements for accommodation during the course was satisfactory</td>
<td>3 1 4 1 2 2,44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was given satisfactory support from my employer/organization for participation in the course</td>
<td>3 6 1 1 0 2,18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The course was well organized</td>
<td>2 5 4 0 0 2,18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Venue</td>
<td></td>
<td></td>
<td>2,27</td>
</tr>
<tr>
<td>The classroom facilities were satisfactory</td>
<td>3 7 1 0 1,82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The practical training site was well organized</td>
<td>6 4 1 0 2,55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The meals and refreshments were satisfactory</td>
<td>7 3 1 0 2,45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key to Scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average

Two participants were not present on Friday 18 July for the course evaluation and submitted their score sheets by e-mail. One of these had reversed the scores (5 best, 1 worst), but this has been taken into account in the summary.
## Course Evaluation - Group 2 (17 Participants)

<table>
<thead>
<tr>
<th>Number of forms filled in</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>Blank</th>
<th>W.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.35</td>
</tr>
<tr>
<td>The objectives of the course were generally achieved</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>1,35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The classroom presentations were well presented and understood</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>1,35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the characteristics of Low Volume Roads</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>1,35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the design principles for Low Volume Roads</td>
<td>9</td>
<td>8</td>
<td>0</td>
<td>1,47</td>
<td></td>
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<td></td>
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<tr>
<td>I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method</td>
<td>8</td>
<td>9</td>
<td>0</td>
<td>1,53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the design process for Low Volume Roads using the AfCAAP LVR-DCP software</td>
<td>9</td>
<td>8</td>
<td>0</td>
<td>1,47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have got a good understanding of the Laboratory DN testing procedure and how to interpret the results</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>1,88</td>
<td></td>
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</tr>
<tr>
<td>There was enough time for practical exercises using the software and discussions / clarifications</td>
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<td>6</td>
<td>4</td>
<td>0</td>
<td>1,82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The practical instructions were well delivered and understood</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>1,38</td>
<td></td>
<td></td>
<td></td>
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<td>2. Organisation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.12</td>
</tr>
<tr>
<td>I was informed about the course in time for me to organize my personal arrangements for travel to and participation in the training</td>
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<td>6</td>
<td>4</td>
<td>0</td>
<td>3,12</td>
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<tr>
<td>Arrangements for accommodation during the course was satisfactory</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>1,54</td>
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<tr>
<td>I was given satisfactory support from my employer/organization for participation in the course</td>
<td>11</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1,44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The course was well organized</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1,69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Venue</td>
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<td></td>
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<td>1,71</td>
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<tr>
<td>The classroom facilities were satisfactory</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>1,59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The practical training site was well organized</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>1,71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The meals and refreshments were satisfactory</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>1,82</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key to Scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average

One participant had reversed the score (6 best, 1 worst), but this has been taken into account in the summary.
Annex 5: Summary Report from Laboratory Module

**DCP Detailed Report - Multiple Mould Analysis**

- **Job Ref. no:** [Job Reference Number]
- **Project No.:** [Project Number]
- **Date:** 15 July, 2016
- **Analysis Date:** 21 July, 2016

**Moulds included in analysis:**

<table>
<thead>
<tr>
<th>Borrow Pit</th>
<th>Test Pit</th>
<th>Layer Depth in Test Pit (mm)</th>
<th>Sample</th>
<th>Mould</th>
<th>Survey Date</th>
<th>OMC (%)</th>
<th>Moisture Content</th>
<th>Compactive Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bp1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>15 July, 2016</td>
<td>16.8</td>
<td>OMC</td>
<td>Heavy</td>
</tr>
<tr>
<td>Bp1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>15 July, 2016</td>
<td>16.8</td>
<td>OMC</td>
<td>Heavy</td>
</tr>
</tbody>
</table>

**Average Design Structure Number (DNS) (mm) (Blows):** 24

**Design DN (mm/Modul):** 25

**Average equivalent strength for Existing Moulds:**

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>W. Ave. DN. * (mm/Modul)</th>
<th>Best Fit DN. (mm/Modul)</th>
<th>Blows</th>
<th>Ave. E-Moduli (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-105</td>
<td>7.68</td>
<td>7.73</td>
<td>22</td>
<td>130</td>
</tr>
</tbody>
</table>

*Weighted average penetration rate:

**DCP Laboratory Curve Profile**

**Normalized Curve**

**Average equivalent strength for (Redefined-EasyDCP Moulds):**

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>W. Ave. DN. * (mm/Modul)</th>
<th>Blows</th>
<th>Ave. E-Moduli (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 60</td>
<td>6.67</td>
<td>9</td>
<td>149</td>
</tr>
<tr>
<td>60 - 105</td>
<td>8.68</td>
<td>12</td>
<td>122</td>
</tr>
</tbody>
</table>

*Weighted average penetration rate:

Project file: C:\Wec\jobs\Document\WinDCP\Projects\Lahore\Pavement Lab Demo.dcp

Page 25
Annex 6: Presentations

Module 2
Overview of Low Volume Roads philosophy and the DCP design principles.

Overview of Presentation
- Introduction/Background
- Design Philosophy
- Analysis
- Exchange
- Surcharge
- Pavement Design
- Geometric design
- Road safety
- Sustainability

Traditional Approaches to LVR Provision
- Higher emphasis on the importance of different environments
- sprawling infrastructure leading to a lack of focus on the importance of different environments
- Technology, research and knowledge about LVRs have advanced significantly in the recent 10-20 years
- New LVR systems have been developed to accommodate new developments in LVR technology

The Stark Facts
- Major rural roads in developing countries carry relatively light traffic
- They are the means for the majority of the population of rural communities to travel to access major cities, access work and access services
- They are potential conduits for economic growth and development of the region and are a key component of poverty reduction
- They are the reason for the high poverty levels in areas where these roads are located
- They are potential conduits for economic growth and development of the region and are a key component of poverty reduction
- They are potential conduits for economic growth and development of the region and are a key component of poverty reduction
- They are potential conduits for economic growth and development of the region and are a key component of poverty reduction

Rural Accessibility Index (2007)

July 16
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

July 16

Poverty and Accessibility (Vietnam, 2003)

Our Challenge
- Poverty is linked to lack of local access — a constitutional/human right?
- Need to close accessibility gap by doing more with less
- Traditional approaches have generally not worked
- Need for new approaches that are research-based
- New approaches may challenge conventional paradigms, but...
- We cannot make progress without making change!

Characteristics of Low Volume Roads
- Traffic: up to about 300 vpd and less than about 1.0k tesa.
- Constructed mostly from non-standard, often “non-standard”, moisture-sensitive materials.
- Adoption of “environmentally optimized design” (EOD).
- Pavement deterioration driven primarily by environmental factors.
- Agreements may not necessarily always be truly “engineered”.
- A need to cater for a significant amount of non-motorized traffic.
- Variable travel speeds: allowing 60 kmh, most often 40-60 kmh would be acceptable.

Sustained Mode of Deterioration

Design Philosophy
- Full understanding by the design engineer of the local environment (natural and social).
- Ability to work within the demands of the local environment and to turn these to a design advantage.
- Recognition and management of risk.
- Innovative and flexible thinking through application of appropriate engineering solutions other than following traditional thinking related to road design.
- A client who is open and responsive to innovation.
- Assured routine and periodic maintenance.
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

July 16

Road Environment Factors

Implementation within an ECD Context

Framework for sustainable provision of GVs

Environmentally Optimised Design Approach

Use of Local Materials

The use of local materials is an important aspect of sustainable design. The use of local materials reduces the environmental impact by reducing the energy required for transportation and processing. Additionally, local materials are often more cost-effective than imported materials.

Unfortunately, the use of local materials is often limited by the availability of suitable materials and the associated challenges in terms of quality and consistency.

In order to achieve sustainable design, it is important to consider the availability and potential for local materials and to develop strategies to overcome any limitations.

Drainage Design

Ensure adequate drainage - fundamental!

Menu of Surfacing Options for Consideration

- Paved pavement
- Unpaved pavement
- Mixed pavement
- Other options
Examples of Non-Bituminous Surfacing

Geometric Design

- Alignment engineered to follow an alignment function.
- Existing alignment will be the base alignment.
- Acceptable alignment generally at 3% or 4% or potentially problematic sections where road safety may be an issue so that horizontally engineered measures are provided.
- Alignment will need to consider the speeds at which they will need to consider the alignments.
- Alignment will need to consider the speeds at which they will need to consider the alignments.
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Geometric Design

- Design speed will be the base alignment.
- Existing alignment generally at 3% or 4% or potentially problematic sections where road safety may be an issue so that horizontally engineered measures are provided.

Geometric Design

- "Low-speed and high-speed" (1969) found accidents to be the usual cause of road failure. Furthermore, there was almost no evidence to indicate that higher standards of pavement width or surface type would reduce the already small number, although they found that highway engineers appeared to believe the opposite. From an economic standpoint, accidents and errors found to be of a lower order of magnitude than construction and operating costs."

(Bryan, M.Donald, Pearse & Robinson, 1968)
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Geometric Design

\[ \text{Conctacts/\text{km/hr}} = \frac{\text{ADT} \times \text{Speed}}{36} \]

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Contact (km/hr)</th>
<th>Speed (km/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>6.0</td>
<td>12.0</td>
</tr>
<tr>
<td>60</td>
<td>10.0</td>
<td>18.0</td>
</tr>
<tr>
<td>80</td>
<td>16.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

- LVR with ADT<3000psd function as single lane exists most of the time

Geometric Design

Low volume road in Norway, ADT in with ADT 200.

Page 30
**Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method**

Training Report

*July 16*

---

### Determination of Uniform Sections

- The sample arithmetic average is not always representative if the effective penetration rate varies through the layer and ideally, a weighted average penetration should be determined.
- When the top 50 mm of a 150 mm base layer for instance has a penetration rate of 1.1 mm/100 blow and the lower 100 mm has a value of 4.0 mm/100 blow:
  - the simple arithmetic average would be \(\frac{2.5}{2}\) mm/100 blow
  - the weighted average would be \(3.03\) mm/100 blow

\[
\text{Weighted Average} = \frac{(1.1 \times 50) + (4.0 \times 100)}{50 + 100} = 3.03 \text{ mm/100 blow}
\]

---

### Integration of In Situ and Required Strength Profiles

---

### Average Penetration Rates “DN” (DCP Generation Number)

- The simple arithmetic average is not always representative if the effective penetration rate varies through the layer and ideally, a weighted average penetration should be determined.
- When the top 50 mm of a 150 mm base layer for instance has a penetration rate of 1.1 mm/100 blow and the lower 100 mm has a value of 4.0 mm/100 blow:
  - the simple arithmetic average would be \(\frac{2.5}{2}\) mm/100 blow
  - the weighted average would be \(3.03\) mm/100 blow

\[
\text{Weighted Average} = \frac{(1.1 \times 50) + (4.0 \times 100)}{50 + 100} = 3.03 \text{ mm/100 blow}
\]

---

### DCP Structural Number

- A full DCP penetration profile should be obtained to a depth of 400 mm. Last reading shall be “zero error” plus 800 mm.
- The DCP structural number (DSN) is the number of blows required to meet a depth of 600 mm.
- Typically, when a depth of 600 mm is not obtained, the penetration profile can be extrapolated either based on the last few readings or using a specified or expected penetration rate

\[
\text{DSN} = \frac{\text{Number of Blows}}{600 \text{ mm}}
\]

---

### Adjusting for Moisture

- Measure samples should be taken from the top three layers, at least 2 samples per cm or uniform section.
- The designer must ask:
  - Will the pavement fail:
    - Directly at the time of the DCP Survey \(27\) percentile of CI
    - Same as at the time of the DCP Survey \(50\) percentile of CI
    - Later than at the time of the DCP Survey \(80\) percentile of CI

---

Page 32
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Training Report

July 16

Adjusting for moisture

The DCP-DN Design Catalogue

Determine upgrading requirements

Strength Measurement - Lab DR value

4 days water-saturated, 28 days DR
Sample to BSC, soaked for 4-7 days, 3-4 days

Page 33
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

July 16

Materials investigation and choice of suitable road materials

Materials for Low Volume Roads
- LVR Pavement Materials usually consist of local gravels derived from weathering of in situ rock or materials that have been transported by some natural force (e.g., water, wind, gravity).
- Expensive aggregate from the crushing of hard rock are not often used. Only limited to bituminous surfacings or concrete structures.

Types of Materials for Low Volume Roads
- Weathered and Residual Materials: Chemical alteration of the minerals in the rocks to form different minerals such as clay, except quartz, which is relatively resistant, and changes the hard rock to a residual material that would be eroded by natural forces.
- Transformed Materials: Physical or chemical transformation by wind, water, ice, or gravity.
- Pedogenic Materials: Minerals present in or on rocks that have been transported and deposited elsewhere (e.g., pedogenic materials transported by water or wind).
- Other Materials: Materials that do not fit into the above categories.

Weathering classification system

<table>
<thead>
<tr>
<th>Weathering</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Fresh</td>
</tr>
<tr>
<td>Early</td>
<td>Partially</td>
</tr>
<tr>
<td>Complete</td>
<td>Fully</td>
</tr>
</tbody>
</table>

Typical properties of residual materials derived from various rock types

Borrow Pit Management
- The identification and development of good sources of pavement construction material for LVR is essential to the cost-effective use of construction and maintenance funds.
- Up to 75% of the construction cost of LVR relate to pavement materials production and supply.
- Aggressive replacement costs often 50% of the maintenance costs of an unpaved road.
- Therefore, need proper investigation and borrow pit management for cost efficiency.
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Training Report

July 16

BORROW PIT INVESTIGATION

- Using test pits
  - Number of test pits: to cover the entire borrow pit area
- Material testing requirements

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat, organic material</td>
<td>Weekly</td>
</tr>
<tr>
<td>Rock, gravel, boulder</td>
<td>Monthly</td>
</tr>
<tr>
<td>Clay, silt</td>
<td>Daily</td>
</tr>
<tr>
<td>Sand, fine material</td>
<td>Weekly</td>
</tr>
</tbody>
</table>

- Investigate borrow pit area
  - Existing borrow pit
  - New borrow pit

BORROW PIT TEST AREA

- Environmental and social considerations
  - Potential to cause significant negative impacts on the social environment
  - Air emissions
  - Noise
  - Watercourse pollution
  - Safety
  - Access to borrow pit

BORROW PIT MANAGEMENT

- Borrow pit preparation and material extraction
  - Estimation of expansion, surfacing, and general engineering requirements
  - Borrow pit material extraction

Borrow pit material extraction, labour based methods
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Training Report

July 16

**Dealing with Oversize**
- Manual removal
- Appropriate excavation method
- Screwing
- Chiselling

**Centre Line Test Pitting**
- **Materials testing requirements**
  - Number of test pits: every 500m to 1000m
  - Number of DCP tests: every 50m to 100m
  - Sieve analysis testing: at least 1 required layer per test pit
  - Atterberg limit testing: at least 1 required layer per test pit
  - MDD, OMC, PFC testing: least 1 required layer per test pit

**Example of test pits**
- Centre line test pitting at a depth of about 1m
- Test pits can also be dug manually

**Test Pit**
- **Test pit size**
  - Centre line area: 1.25m x 0.75m; depth: 900 mm
  - Borrow pit: ± 3m or refusal, but not less than 2m
**Overview of Presentation**
- Importance of compaction
- Factors affecting compaction
- Vertices of compaction quality control
- Compaction factors
- Compaction control procedure using the DCP
- Evaluation procedure
- Strengths and limitations of using the DCP

**Importance of compaction**
- Compaction is arguably the most important aspect of road construction
- Materials typically account for a large proportion of construction costs (up to 70%)
- Compaction accounts for a small proportion of construction costs
- Substantial influence on durability, performance, and whole-life costs

**Factors affecting compaction**
- Effectiveness of compaction procedure depends on interrelated factors such as:
  - Soil type
  - Compaction moisture content
  - Compactive effort
  - Number of roller passes
  - Loose layer thickness
  - Other factors (constant pressure, speed of rolling, soil temperature)

**Compaction phases**
- During compaction the soil goes through three phases:
  - Plastic phase
  - Elastic-plastic phase
  - Elastic phase

**Benefits of proper compaction**
- Improved strength bearing capacity and stiffness
- Increased density with decreased susceptibility to deformation and rutting
- Decreased permeability and susceptibility to moisture ingress and resultant loss of strength
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Methods of compaction quality control

Traditional:
- Density gage (85% subgrade, 95% subbase, 94% base)
- Do not reflect the most important engineering properties of the soil such as stiffness
- Problems with density as measure of compaction:
  - Large range between volume of material tested to that compacted (typically 1-1.5 times)
  - Poor correlation between laboratory and field compaction and poor reproducibility of results
  - No sufficient account is taken in the test method for inherent variability of natural reclaimed materials

Preferred methods:
- RCDP (Rapid Compaction Control Device)
  - Similar in function to DCP
  - Spring loaded mechanism
  - Different cone than DCP
- DCP
  - Good correlation with stiffness
  - Can be used as supplement to dry density methods or as a standalone method for compaction control
  - Criteria must be established for assessing when satisfactory compaction has been achieved through carefully executed compaction trials

Compaction trials

- Control hardness:
  - As short as possible practical
  - At regular intervals or whenever material changes
  - Recommended minimum frequency every 2,000 m3 of material. At 0.5 m width this equates to one control section every 3 km
- Control of compaction moisture:
  - At or close to OMC (+1% - 2% from OMC)
  - Control of adding and mixing of compaction water
  - Manual control of compaction moisture most effective after addition in laboratory to bring down the mean of the material at OMC

Compaction to refusal:
- Warning:
  - Certain materials may break down due to excessive rolling of the coarse fractions
  - Compaction must then stop at least 10% below the desired density and stiffness of the layer
- Compaction to refusal makes optimal use of available materials
Compaction trials
- Control of compaction moisture
  - Hand�speek method
    > Moisture content measured in laboratory
    > Assessed against project specification
  - Tamping method
    > Uses tamping rod to force material into the compacted area
    > Assessed against project specification

Compaction trials
- Establish optimal compaction procedure for the material
  - Compaction amplitude at the various passes
  - No. of passes required to attain elastic state
  - Compaction to be done only in one direction (forward/returning roller)

Compaction trials
- The first pass with maximum amplitude to break down oversize material and compact to the bottom of the layer
- Intermediate passes with medium amplitude to densify the middle and top of the layer
- Finishing passes at low or no amplitude to achieve an even surface with a slightly indented and no surface cracks

Compaction control procedure
- For each lift (200 – 300 mm), do 10 DCP tests to the full depth of the layer in a staggered pattern
- Pattern not the same for each lift, but following general guidance
- Offset from CI to be varied
- No tests closer than 1/2 of the lift or edge of layer (e.g., 0.2 m)
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Evaluation procedure

Check for outliers in the sample

\[ T_{c} = \frac{\bar{x} - \mu}{s} \]

n = No. of tests in sample

\( T_{c} \) = Critical value of \( T_{c} \)

<table>
<thead>
<tr>
<th>Test no.</th>
<th>n</th>
<th>( x )</th>
<th>( \bar{x} )</th>
<th>S</th>
<th>Tc</th>
<th>Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
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<td>4.0</td>
<td>0.5</td>
<td>1.0</td>
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<tr>
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<td>7.2</td>
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<td>1.0</td>
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<td>4.7</td>
<td>7.2</td>
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<td>6.9</td>
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<td>1.644935397</td>
</tr>
</tbody>
</table>

Evaluation procedure

Step 2: Recalculate \( \text{STDEV} \), MILE for the sample without the outlier

<table>
<thead>
<tr>
<th>Test no.</th>
<th>n</th>
<th>( x )</th>
<th>( \bar{x} )</th>
<th>S</th>
<th>Tc</th>
<th>Critical value</th>
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</thead>
<tbody>
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</tr>
<tr>
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<td>8.061397</td>
<td>7.1</td>
<td>1.0</td>
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<td>4.0</td>
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<td>1.0</td>
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<td>8.061397</td>
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<td>8.061397</td>
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<td>4.0</td>
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<td>8.061397</td>
<td>7.1</td>
<td>1.0</td>
<td>1.961259699</td>
</tr>
</tbody>
</table>

Evaluation procedure

Step 3: Plot the \( \text{STDEV} \) and MILE for the sample without the outlier in the Judgement Chart for the Target DN that has been established

Acceptance

- Mean \( \leq \text{Mean}_{DN} \)
- \( \text{STDEV} \leq \text{STDEV}_{DN} \)

Conditional Acceptance

- Mean \( \leq \text{Mean}_{DN} \)
- \( \text{STDEV} \leq \text{STDEV}_{DN} \) & \( \text{STDEV} \leq \text{STDEV}_{conditional} \)

Strengths and limitations of using the DCP

Strengths:

- Equipment inexpensive, commonly available and portable
- No maintenance of equipment required
- Tests are easy and quick to carry out, hence more tests can be done for greater statistical validity than with traditional density tests
- Technicians can easily be trained to carry out the tests confidently
- The DCP test is more repeatable than the CBR test
- The same test can be used for load investigations and design, laboratory tests and on-site quality control without the need to convert the DN values to equivalent CBR values or dry densities
Strengths and limitations of using the DCP

Limitations:
- Research has identified effect on DN value due to vertical confinement pressure. However, this is deemed to be negligible for layers less than 200 mm thick.
- DCP test can be affected by stones or coarse gravel in the pavement layers.

Reliable results depend on:
- DCP equipment in good order.
- Correct use.

Thank you
Annex 7: AfCAP LVR-DCP v1.03 Snaglist

1. Tab-order for data to be entered in the left panel for new points should be:
   Chainage -> Road width -> Dist. From CL -> Road side -> Survey date
2. Common data should be retained (inherited) for new points when set for the first point, e.g. Road width 5 m to be retained and user to change as/when width changes
3. If dist from CL has been set to zero, Road side should automatically be set to CL or vice versa.
4. Chainage to be formatted with 3 decimals, Dist. From CL and Road Width to be formatted with 1 decimal

5. Point at xx m from CL at LHS does not display correctly in the analysis window, shows as CL:2
6. Position in analysis window to be displayed as say 2.0 m LHS
7. Calculation of averages for uniform section

I asked the question during our last meeting in Pretoria of how the programme calculates averages for uniform sections and there seemed to be some disagreement on this. Below is an illustration of how I think the programme does it at the moment and how I think it should be done:

Currently:
Average Section 1 = (5+7+9)/3=7
Average Section 2 = (3+6)/2=4.5

Correctly:
Average Section 1 = (5+7+9)/3=7
Average Section 2 = (9+3+6)/3=6

The point at the section delimiter must be included in average for both sections, otherwise there will be discontinuity and in this case too low average for section 2 in the current method. The DN just after point 3 is more likely to be close to 9 than close to 3, hence if point 3 is included the average for section 2 it will be more representative.

8. The chainages in the “Determine Sections from Properties” and “DCP Sections” screens to be displayed with 3 decimals, the section delimiters may display as say 5.10 in those windows and 5.095 in the DCP Sections Report. The adjustment of section delimiters is very sensitive and one needs to zoom in to do it accurately at the moment. Would be easier if 3 decimals are displayed.

9. The Normalised curve to be removed from Report from Lab Module. Does not make sense to have it there.
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Training Report
Annex 8: Evaluation forms

Group 1:

Course Evaluation - Group 1 (12 Participants)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall performance</td>
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</tr>
<tr>
<td>Understanding of the course material</td>
<td>4.00</td>
</tr>
<tr>
<td>Technical knowledge</td>
<td>4.00</td>
</tr>
<tr>
<td>Motivation</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Course Evaluation - Group 2 (11 Participants)

<table>
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<th>Objective</th>
<th>Average Score</th>
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</thead>
<tbody>
<tr>
<td>Overall performance</td>
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<tr>
<td>Understanding of the course material</td>
<td>4.00</td>
</tr>
<tr>
<td>Technical knowledge</td>
<td>4.00</td>
</tr>
<tr>
<td>Motivation</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Key to Scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average
Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

Training Report

Course Evaluation - Group 1 (12 Participants)

<table>
<thead>
<tr>
<th>1. Training</th>
<th>Number of forms filed in</th>
<th>Average score</th>
<th>#DV/3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The objectives of the course were generally achieved</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>The classroom presentations were well presented and understandable</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the characteristics of low volume roads</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>The new knowledge gained during the design process for low volume roads</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the strengths and limitations of the DCP-DN Design Method</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the key inputs in the DCP-DN design process</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the Laboratory DN testing procedures and how to interpret the results</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was enough time for practical exercises using the software and discussions</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Practical exercises were well designed and understandable</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Key to scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average

Course Evaluation - Group 1 (12 Participants)

<table>
<thead>
<tr>
<th>1. Training</th>
<th>Number of forms filed in</th>
<th>Average score</th>
<th>#DV/3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The objectives of the course were generally achieved</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>The classroom presentations were well presented and understandable</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the characteristics of low volume roads</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>The new knowledge gained during the design process for low volume roads</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the strengths and limitations of the DCP-DN Design Method</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the key inputs in the DCP-DN design process</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was a good understanding of the Laboratory DN testing procedures and how to interpret the results</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>There was enough time for practical exercises using the software and discussions</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Practical exercises were well designed and understandable</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Key to scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average
### Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

### Training Evaluation - Group 1 (12 Participants)

<table>
<thead>
<tr>
<th>Objective</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>The objectives of the course were generally achieved</td>
<td>✅</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The classroom presentations were well presented and understandable</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The participants gained a good understanding of the characteristics of low Volume roads</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The participants gained a good understanding of the design principles for low Volume roads</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The participants gained a good understanding of the strengths and limitations of the DCP-DN Design Method</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The participants gained a good understanding of the design process for Low Volume Roads using the ARCLAP-VL-DN software</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The participants had enough time for practical exercises using the software and discussions / justifications</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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</tbody>
</table>

### Organisation Evaluation - Group 1 (12 Participants)

<table>
<thead>
<tr>
<th>Objective</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>The participants were well organised</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The practical training was well organised</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The participants had sufficient support from their employer / organisation for participation in the course</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The course was well organised</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

### Venue Evaluation - Group 1 (12 Participants)

<table>
<thead>
<tr>
<th>Objective</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>The classroom facilities were satisfactory</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The practical training site was well organised</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>The meals and refreshments were satisfactory</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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</tbody>
</table>

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*Key to Scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average*
Submitted by e-mail, scores reversed

<table>
<thead>
<tr>
<th>Course Evaluation - Group 1 (12 Participants)</th>
<th>Number of forms filled in</th>
<th>Scores</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Blank</th>
<th>W. A.</th>
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</thead>
<tbody>
<tr>
<td>1. Training</td>
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<td>Average score</td>
<td>1,56</td>
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<tr>
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<td>2</td>
<td>2,00</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>The classroom presentations were well presented and understood</td>
<td>2</td>
<td>2,00</td>
<td></td>
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<tr>
<td>I have now got a good understanding of the characteristics of Low Volume Roads</td>
<td>1</td>
<td>1,00</td>
<td></td>
<td></td>
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<tr>
<td>I have now got a good understanding of the design principles for Low Volume Roads</td>
<td>1</td>
<td>1,00</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method</td>
<td>1</td>
<td>1,00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I have now got a good understanding of the design process for Low Volume Roads using the AFRAPAT LVR/DCP software</td>
<td>1</td>
<td>1,00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have got a good understanding of the Laboratory DN testing procedure and how to interpret the results</td>
<td>3</td>
<td>3,00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>There was enough time for practical exercises using the software and discussions / clarifications</td>
<td>1</td>
<td>1,00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>The practical instructions were well delivered and understood</td>
<td>2</td>
<td>2,00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Organisation</td>
<td></td>
<td>Average score</td>
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<td>I was informed about the course in time for me to organise my personal arrangements for travel to and participation in the training</td>
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<td>3,00</td>
<td></td>
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<tr>
<td>Arrangements for accommodation during the course was satisfactory</td>
<td>3</td>
<td>3,00</td>
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<tr>
<td>I was given satisfactory support from my employer/organisation for participation in the course</td>
<td>5</td>
<td>5,00</td>
<td></td>
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<tr>
<td>The course was well organised</td>
<td>2</td>
<td>2,00</td>
<td></td>
<td></td>
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<tr>
<td>3. Venue</td>
<td></td>
<td>Average score</td>
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<td></td>
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<td>The classroom facilities were satisfactory</td>
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<td>2,00</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The practical training site was well organized</td>
<td>3</td>
<td>3,00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The meals and refreshments were satisfactory</td>
<td>3</td>
<td>3,00</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Key to Scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average</td>
<td></td>
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</tbody>
</table>

Submitted by e-mail
### Training of New Batch of Local Practitioners in the DCP-DN Pavement Design Method

#### Group 2:

<table>
<thead>
<tr>
<th>Course Evaluation - Group 2 (17 Participants)</th>
<th>Scores</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Blank</th>
<th>W.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Training</strong></td>
<td>Average score</td>
<td>4D/1/F</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The objectives of the course were generally achieved</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>The classroom presentations were well prepared and understood</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>The practical instructions were well explained and understood</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>The course was well-organized</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td>✔️</td>
<td>✔️</td>
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<td><strong>Organisation</strong></td>
<td>Average score</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>The organisation was satisfactory</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>The practical training site was well organised</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>The refreshments were satisfactory</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

#### Key to Scores:
- 1: Strongly agree
- 2: Agree
- 3: Partially agree
- 4: Disagree
- 5: Strongly disagree
- WA: Weighted average
## Course Evaluation - Group 2 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 3 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 4 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 5 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 6 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 7 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 8 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 9 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average

---

### Course Evaluation - Group 10 (?? Participants)

![Table](image)

### Key to Scores:
- 1 = Strongly agree
- 2 = Agree
- 3 = Partially agree
- 4 = Disagree
- 5 = Strongly disagree
- WA = Weighted average
### Course Evaluation - Group 2 (?? Participants)

<table>
<thead>
<tr>
<th>Number of forms filled in</th>
<th>Scores</th>
<th>Average score</th>
<th>#DIV/0!</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 1. Training
- The objectives of the course were generally achieved: ✔
- The classroom presentations were well prepared and understood: ✔
- I have now got a good understanding of the design principles for low volume roads: ✔
- I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method: ✔
- I have now got a good understanding of the design process for Low Volume Roads using the HCAAP/LV-DP software: ✔
- I have got a good understanding of the Laboratory DN testing procedure and how to interpret the results: ✔
- There was enough time for practical exercises using the software and discussion/clarifications: ✔
- The practical instructions were well delivered and understood: ✔

#### 2. Organisation
- I was informed about the course in time for me to organise my personal arrangements for travel to and participation in the training: ✔
- Arrangements for accommodation during the course were satisfactory: ✔
- I was given satisfactory support from my employer/organisation for participation in the course: ✔
- The course was well organised: ✔

#### 3. Venue
- The classroom facilities were satisfactory: ✔
- The practical training site was well organised: ✔
- The meals and refreshments were satisfactory: ✔

### Course Evaluation - Group 1 (?? Participants)

<table>
<thead>
<tr>
<th>Number of forms filled in</th>
<th>Scores</th>
<th>Average score</th>
<th>#DIV/0!</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 1. Training
- The objectives of the course were generally achieved: ✔
- The classroom presentations were well prepared and understood: ✔
- I have now got a good understanding of the characteristics of low volume roads: ✔
- I have now got a good understanding of the design principles for low volume roads: ✔
- I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method: ✔
- I have now got a good understanding of the design process for low volume roads using the HCAAP/LV-DP software: ✔
- I have got a good understanding of the laboratory DN testing procedure and how to interpret the results: ✔
- There was enough time for practical exercises using the software and discussion/clarifications: ✔
- The practical instructions were well delivered and understood: ✔

#### 2. Organisation
- I was informed about the course in time for me to organise my personal arrangements for travel to and participation in the training: ✔
- Arrangements for accommodation during the course were satisfactory: ✔
- I was given satisfactory support from my employer/organisation for participation in the course: ✔
- The course was well organised: ✔

#### 3. Venue
- The classroom facilities were satisfactory: ✔
- The practical training site was well organised: ✔
- The meals and refreshments were satisfactory: ✔

### Key to Scores:
- 1: Strongly agree
- 2: Agree
- 3: Partially agree
- 4: Disagree
- 5: Strongly disagree

### WA: Weighted average
### Course Evaluation - Group 2 (?? Participants)

<table>
<thead>
<tr>
<th>Number of forms filled</th>
<th>Scores</th>
<th>Average score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

#### Training
- The objectives of the course were generally achieved: ✔
- The classroom presentations were well prepared and understood: ✔
- I have now got a good understanding of the characteristics of Low Volume Roads: ✔
- I have now got a good understanding of the design principles for Low Volume Roads: ✔
- I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method: ✔
- I have now got a good understanding of the design process for Low Volume Roads using the AASHTO LRFD software: ✔
- I have a good understanding of the Laboratory DN testing procedure and how to interpret the results: ✔
- There was enough time for practical exercises using the software and discussions/clarifications: ✔
- The practical exercises were well delivered and understood: ✔

#### Organisation
- It was informed about the course in time for me to organize my personal arrangements for travel to and participation in the training: ✔
- Arrangements for accommodation during the course were satisfactory: ✔
- It was given satisfactory support from my employer/organization for participation in the course: ✔
- The course was well organized: ✔

#### Venue
- The classroom facilities were satisfactory: ✔
- The practical training sites were well organized: ✔
- The meals and refreshments were satisfactory: ✔

---

### Course Evaluation - Group 2 (?? Participants)

<table>
<thead>
<tr>
<th>Number of forms filled</th>
<th>Scores</th>
<th>Average score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

#### Training
- The objectives of the course were generally achieved: ✔
- The classroom presentations were well prepared and understood: ✔
- I have now got a good understanding of the characteristics of Low Volume Roads: ✔
- I have now got a good understanding of the design principles for Low Volume Roads: ✔
- I have now got a good understanding of the strengths and limitations of the DCP-DN Design Method: ✔
- I have now got a good understanding of the design process for Low Volume Roads using the AASHTO LRFD software: ✔
- I have a good understanding of the Laboratory DN testing procedure and how to interpret the results: ✔
- There was enough time for practical exercises using the software and discussions/clarifications: ✔
- The practical exercises were well delivered and understood: ✔

#### Organisation
- It was informed about the course in time for me to organize my personal arrangements for travel to and participation in the training: ✔
- Arrangements for accommodation during the course were satisfactory: ✔
- It was given satisfactory support from my employer/organization for participation in the course: ✔
- The course was well organized: ✔

#### Venue
- The classroom facilities were satisfactory: ✔
- The practical training sites were well organized: ✔
- The meals and refreshments were satisfactory: ✔

---

### Key to Scores: 1=Strongly agree, 2=Agree, 3=Partially agree, 4=Disagree, 5=Strongly disagree, WA=Weighted average
## Course Evaluation - Group 2 (?? Participants)

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<tr>
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