Training Services on the Use of the DCP Pavement Design Method for Low Volume Sealed Roads in Kenya

Training Report - Final

AUTHORS: M I Pinard and J Hongve, I T Transport Ltd

February 2014
CONTRACT REF NO. AFCAP/KEN/112/A

British Expertise
International Awards 2013:
Outstanding International Collaboration

This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

This material has been funded by UKaid from the Department for International Development, however the views expressed do not necessarily reflect the department's or the managing agent's official policies.

For further information visit https://www.afcap.org

Report summary

Training in the DCP Design Method for Low Volume Sealed Roads was carried out successfully in the period 22 January to 7 February, 2014 for a total of 65 participants from various roads agencies and other organisations in Kenya as well as 3 engineers from Tanzania who had been invited by AFCAP.

The training entailed three days of field training in the use of the DCP equipment for data collection and three classroom courses for Senior Management, Designers / Practitioners and Technicians in the design principles for Low Volume Sealed Roads (LVSRs) and the use of the DCP software for data analysis and design.

The DCP-DN design method differs in a number of respects form the more traditional CBR based pavement design methods and provides the scope for attaining more economical designs of LVSRs. This is achieved by ensuring that the design is carried out in an "environmentally optimized manner" whereby optimum is made of the local materials and the pavement design is matched to the road environment at a local level. When judiciously applied, the DCP-DN design method will produce LVSRs that are "fit for purpose" and facilitate access provision in the most economical manner. These design concepts were discussed at length during the training so as to engender a thorough understanding by the trainees.

The trainees that attended the courses have reached an intermediate competency level. More training is needed for them to reach advance level when they will be able to undertake with confidence a full scale design on their own. It is recommended that advanced training courses should be planned for the near future in order to build and sustain the momentum created by the training intermediate level courses.

Four trial projects designed by the DCP Method are currently being constructed in Central Province. It is recommended that more demonstration sections be constructed adjacent to sections designed by traditional methods for monitoring and confidence building before it is applied full scale and adopted in national standards.as an alternative method of design.

Table of Contents

List of Abbreviations

AFCAP	African Community Access Programme
CBR	California Bearing Ratio
CSIR	Council for Scientific and Industrial Research
CUSUM	Cumulative Sum
DCP	Dynamic Cone Penetrometer
DFID	Department for International Development
DN	DCP Number - Rate of DCP penetration in mm/blow
EOD	Environmentally Optimized design
EDD	Extended Design Domain
GPS	Global Positioning System
KeNHA	Kenya National Highways Authority
KeRRA	Kenya Rural Roads Authority
KIBHT	Kenya Institute of Building and Highways Technology
KURA	Kenya Urban Roads Authority
Km	Kilometre
LVR	Low Volume Road
LVSR	Low Volume Sealed Road
MDD	Maximum Dry Density
MESA	Million Equivalent Standard Axles
MTRD	Materials Testing and Research Division
OMC	Optimum Moisture Content
PMO-RALG	Prime Minister's Office-Rural administration and Local Government (Tanzania)
RMC	Relative Moisture Content
ToR	Terms of Reference
UK	United Kingdom

List of Tables

List of Figures

It should be noted that the BSI Symbol and UKAS Accreditation mark signify that Crown Agents operate a documented Quality Management System registered with the British Standards Institution to the international quality standard BS EN ISO 9001:2008. The provision of consultancy services in revenue enhancement and expenditure and debt management including: customs, taxation and trade, human institutional and organisational development, engineering, procurement management advice and reform, health logistics and procurement services. The management of party quality assurance and inspection services related to the supply of manufactured and processed products. International freight forwarding services utilising in house sub-contract warehousing. Verification of service as follows: Air Import – Clearance UK airport; Exports – Airport of departure; Sea Imports – Clearance UK port; Sea Exports – Port of loading.

FS3324

1. INTRODUCTION

1.1 Background

The Government of Kenya commits significant funding for the improvement of road infrastructure in the country, particularly in rural areas where a substantial proportion of the population live and work. It is therefore important that such funding is utilized efficiently and effectively by all roads agencies so as to maximize its contribution to national economic growth and development and poverty alleviation.

One of the major challenges faced by the various Roads Authorities in the country, such as the Kenya Rural Roads Authority (KeRRA), is the management of a large network of unpaved roads which has become increasingly difficult to sustain in that they:

- Impose a logistical, technical and financial burden on most road agencies due to constraints on physical, human, financial and natural resources.
- Require the continuous use of a non-renewable resource (gravel) which is being seriously depleted in many countries and, in the process, is causing serious environmental problems.

As a result of the above, the many rural communities cannot be provided with reliable access, especially during the rainy season when the roads become impassable to motorized traffic.

In keeping with the Ministry of Transport's goal of improving access to rural communities, there are plans through the Roads 2000 Programme to upgrade a substantial proportion of the rural road network that is of earth/gravel standard to an all-weather bitumen standard. However, the cost of doing so following traditional standards and specifications is prohibitive. Fortunately, research carried out in the region has resulted in the development of more appropriate, innovative design methods and materials specifications that significantly reduce the cost of road provision and upkeep.

One approach which provides the potential for cost-effectively upgrading unpaved roads to a paved standard in a manner not possible with the more traditional approaches is by the adoption of a regionally research-based pavement design method using the portable Dynamic Cone Penetrometer (DCP). This method lends itself ideally to evaluating in situ road conditions and, by integrating the design strength profile optimally with the in situ strength profile, to designing light road pavement structures, in a highly cost-effective manner. This approach allows maximum use to be made of the natural gravels in the unpaved road and, as a result, construction costs be reduced significantly thereby enabling the sealing of gravel roads to be economically justified in terms of life cycle costs often at traffic levels of less than 100 vehicles per day (vpd).

Fortunately, as part of KeRRA's Road Research Strategic Plan, provision has been made for the training of personnel at various levels in the use of the DCP Pavement Design Method. Such training is aimed at consolidating the capacity building efforts that were initiated under the initial stages of the project and will enable wider uptake and application of this innovative design methodology for cost-effective provision of LVSRs in Kenya.

1.2 Purpose and Scope of Training Programme

The main objective of the training programme, as stated in the Terms of reference (ToR) is:

"To provide training to personnel at various levels in the relevant government institutions and agencies, academia, and private sector on the use of the DCP Pavement Design Guide to enable wider application of this innovative design methodology for cost-effective provision of low volume sealed roads in Kenya".

This training was carried out across different staff categories and levels as follows:

- Senior Management
- Project Management
- Designers/Practitioners
- Technicians

The target organizations included:

- KeRRA
- KeNHA
- KURA
- MTRD
- KRB
- KIBIT
- Consultants working with above agencies.

1.3 General Approach

The general approach to undertaking the DCP training as inferred from the ToR is presented in Table 1 below which shows the grouping of the main tasks undertaken by the consultants in order to achieve the programme outcomes.

Table 1 – Scope of training programme

1	Preliminary Training Issues	2	Preparation for Training	3	Execution of Training	4	Review and Evaluation of Training
1.1	Hold meetings with stakeholders	2.1	Procure DCP Equipment	3.1	Undertake field training	4.1	Produce training report
1.2	Determine training categories & numbers	2.2	Develop training methodology	3.2	Undertake classroom training	4.2	Carry out assessment of training courses
1.3	Prepare training programme	2.3	Prepare training material/modules				
1.4	Select training site						
1.5	Produce Inception Report						

1.4 Training Categories and Numbers

The staff categories and number of staff to be trained to various competency levels as agreed with stakeholders is presented in Table 2 below.

Table 1: Training levels and staff categories

Training level	Staff category	No of staff	Competency level
1	Senior Managerial - Director General - General Managers Project Managerial - Regional Managers	10 10	- General knowledge of design principles and methods. Some practical exposure on site. - Reasonably conversant with design principles and methods. Limited practical excercise in field survey, data analysis and project design
2	Designers / Practitioners	30	- Fully conversant with design principles and methods. Full practical excercise in detailed field survey, data analysis and project design
3	Technicians	30	- General knowledge of design principles and methods. - Ability to carry out survey (under supervison); use DCP software including data entry; carry out materials sampling and laboratory testing and compile reports
Total		80	

The indicative breakdown of staff categories amongst the various road sector organizations was discussed and agreed with stakeholders at the introductory meeting held on 30th August, 2013, and is presented in Table 3 below:

Table 2: Training categories by organisation and by number

Organisation	Training categories by numbers		
	Senior/Project Managers	**Designers/Practitioners**	**Technicians**
KeRRA	5	6	8
KeNHA	3	6	4
KURA	3	6	4
MTRD	2	4	5
KRB	1	-	-
KIBHT	1	2	3
Consultants	5	6	6
Total	**20**	**20**	**30**

1.5 Training Schedule and Programme

Due to the delays in budget allocations to the various road sector organisations as a result of the devolution process after the 2013 elections, the training had to be postponed until these issues were resolved. It was therefore agreed to commence the training in mid January 2014 as shown in the revised Training Schedule below.

Table 3: Revised training schedule

Activity		January 2014																				February 2014								
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9
Preparations and field Training																														
Preparations	JH																													
Senior/Project Managers																														
Designers, practitioners & Technicians																														
Data compilation	JH																													
Classroom training																														
Senior/Project Managers	MP																													
1 group of 20	JH																													
Designers / practitioners	MP																													
2 groups of 20, 3 days each	JH																													
Technicians	MP																													
1 group of 20 over 2 days	JH																													

The detailed Classroom Training Programme is shown in Annex 1.

1.6 Objective of Report

Against the above background, the main objective of this Training Report is to provide feedback to stakeholders on the outcome of Phases 2, 3 and 4 of the training programme (ref. Table 1) including the prepartory activities undertaken prior to the start of the training, the execution of the training and a review and evaluation of the training including recommnedations on the way forward.

The activities carried out in Phase 1 of the training programme are comprehensively covered in the Inception Report.

2. PREPARATION FOR TRAINING

2.1 DCP procurement

Four sets of DCPs including spare bottom rods and 10 spare cones for each, and Extruders were procured from RT Agencies, South Africa and delivered to KeRRA before the end of 2013. However, there are reservations over the quality of this equipment supplied as reported in Annex 6.

2.2 Training Methodology

An application-oriented training approach was adopted with clearly defined topics, objectives and learning outcomes that are relevant to the substantive jobs held by the staff. This approach allowed 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 methodology and, also, to assess the suitability of the borrow pit materials for incorporation in the road pavement by undertaking or witnessing, as appropriate, laboratory DCP-DN measurements. Thus, the training methodology was devised in such a manner that the field, classroom and laboratory training were complementary to each other in a mutually reinforcing way.

2.3 Training materials and Modules

The AFCAP DCP Design Manual provided the necessary reference materials for each training session. This manual provides an in-depth explanation of the underlying development of the DCP design method, as well as a fully illustrated step-by-step guide to the design of LVR pavements based on this method.

The training modules were completed and approved by mid November 2013 and are presented in Annex 2.

2.4 Materials Testing

It had been agreed with the Regional Manager for Kirinyaga that representative samples of quarry waste from the quarry at Sagana were to be collected and tested in accordance with the procedures for the Laboratory DN testing. The results from these tests were then to be used for determination of the suitability of this material for a new pavement layer(s), if so required, for the training road based on the DCP Design for this road, which would be carried out by the trainees.

With the assistance of the Laboratory Technician from the AfD/GOK Roads 2000 project based in Nyeri, the tests were carried out in October/November 2013.

2.5 Selection and Mobilization of Trainees

An invitation letter was sent by KeRRA to all the respective roads agencies on 27 September 2013 requesting nomination of trainees. However, due to the aforementioned delays and the Christmas period when many officers were on leave, the full list of trainees was not complete until just before the start of the training in mid January. After meeting with the KeRRA Co-ordinator on 15 January, 2014, it was decided to postpone the Field Training by 2 days to start on 22 January instead of 20 January 2014 as originally planned to give more time to consolidate the list of trainees and for them to make the necessary arrangements to tarvel to the training site in Embu in pre-defined groups.

2.6 Preparation of samples for Laboratory DN Training

With the assistance of the laboratory staff in Kirinyaga, eight samples were prepared to be used during the classroom sessions to demonstrate the correct procedures and recording of data for the Laboratory DN tests.

- 4 samples at 95% compaction and OMC
- 4 samples at 95% compaction and 0.75% of OMC

The demonstration of two tests at different moisture contents during each course would then give the participants a good understanding of the test procedure.

2.7 Initial DCP Survey and Moisture Sampling

The training road of approximately 8.4 km in length, was too long to be covered by the trainees during the three field training days. DCP tests were thus done prior to the field training from km 0+000 to 3+800 at 200 m intervals. Each group of trainees would then do the remaining DCP tests, also at 200 m intervals, for sections of about 1.5 km each. In this way the trainees were be able to travel from their respective stations in the morning and return after the field training in the afternoon.

Samples were collected at four chainages from the top three 150 mm layers of the gravel pavement for determination of the relative moisture in the various layers. The results are shown in Table 5 and were used as an input to the DCP data analysis and subsequent pavement design.

Table 5 - Field moisture content at four points on the training road

Chainage	Layer	RMC (% of OMC)
0+100	0-150 mm	43%
	150-300 mm	60%
	300-450 mm	74%
0+720	0-150 mm	58%
	150-300 mm	77%
	300-450 mm	95%
4+400	0-150 mm	104%
	150-300 mm	112%
	300-450 mm	142%
5+000	0-150 mm	45%
	150-300 mm	141%
	300-450 mm	128%

3. EXECUTION OF TRAINING

3.1 Training Attendance

Table 6 shows the number of trainees invited to participate.

Table 4: Number of trainees invited by category

Field Training	Classroom Training		
	Senior Managers	Designers/ Practitioners	Technicians
64	19	33	31
	83		

The number includes the three engineers from PMORALG, Tanzania who were invited and sponsored by AFCAP.

The actual number of trainees who attended the training by organisation and category is presented in Table 7.

Table 5: Training attendance by organisation and category

Training attendance by organisation		**Field Training**			**Classroom training**								
					SM	**Designers/Practitioners**						**Techn.**	
		22.01	**23.01**	**24.01**	**28.01**	**29.01**	**30.01**	**31.01**	**03.02**	**04.02**	**05.02**	**06.02**	**07.02**
KeRRA	25	8	6	4	3	4	3	4	0	1	1	12	12
KURA	11				3	5	4	4				4	4
KenHA	7		6						2	2	3	3	3
KIHBT	4	1	1	1		1	1	1	1	1	1	1	1
MTRD	3	2		1								2	2
Consultants	15	7	1	4	1	4	4	4	5	5	5	4	4
PMORALG, Tanzania	3			3	3	3	3	3					
AFCAP	1				1	1	1	1					
Total / Present per day	**69**	**18**	**14**	**13**	**11**	**18**	**16**	**17**	**8**	**9**	**10**	**26**	**26**

The detailed training attendance is shown in Annex 3.

The deficit in the number of trainees was mainly due to lack of or reduced participation from KURA, KenHA and MTRD. The attendance from MTRD was limited to Technicians stationed in Muranga and Embu Regions due to coincidence with an internal training course at MTRD HQ on the use of Falling Weight Deflectometer. One civil engineering student attached to the laboratory in Embu also participated.

3.2 Field Training

The field training was carried out as planned for Designers/Practitioners and Technicians over three days 22-24 January 2014 on the training road E1641 in Kirinyaga County.
The objectives of the field training were:

- To familiarize the trainees with the condition of the road and drainage system so that they could relate the DCP data to design decisions during the classroom training.
- To familiarize the trainees with the assembly and correct use of the DCP equipment.

- Practice correct procedures for carrying out the DCP survey and quality assurance in the collection DCP data.
- Collect DCP data to be used in the subsequent design exercise during the classroom sessions. The analysis of the DCP field data will determine whether and to what extent material must be imported for additional pavement layer(s).

The field work is necessary for the designers to familiarize themselves with the road environment to be able to relate the DCP data to the actual conditions along the road. Localized areas that may require special interventions can then be identified, and if necessary, further DCP measurements can be made to identify the extent of such sections. This was discussed during the classroom sessions.

During the field work the designers should make note of:

- The time of the DCP survey in relation to the seasonal rainfall.
- The condition of the existing drainage system and the required improvements. A drainage system in bad condition will influence the DCP data in that the moisture in the existing pavement will most likely be higher than the anticipated moisture after the improvement of the road and drainage system.
- Traffic patterns along the road. This must be accompanied with traffic counts at key points along the route to determine the design traffic loading for the various sections.

Ideally a simple GPS longitudinal survey should be carried out prior to the DCP data collection. However, no survey data were available for the design and time did not allow for survey data to be collected.

Three day traffic counts at the start and end of the road had been carried out by the Design and Supervision Consultant for this road, which is part of the AfD/GOK Roads 2000 Programme in Central Province. Based on this preliminary count, the traffic loading was estimated to be below 100,000 ESA for a 15 year design period. This design traffic loading was subsequently used for the design exercise with the Designers/ Practitioners.

On the basis of the GPS survey, DCP data, the traffic pattern and loading and condition of the existing drainage system, the designer can then determine the required pavement improvements and design for the various sections.

Figure 1: Field training in DCP data collection on training road E1641

3.3 Classroom Training

The classroom training was carried out at the Training Venue at Izaak Walton Inn in Embu from 28 January to 7 February. 2014. The attendance during the various courses is shown in Table 7 above. Detailed training attendance is shown in Annex 3.

The objective of the classroom training was to impart knowledge of the various aspects involved in the DCP Design Method as per the competency levels defined in Table 2 above. During the training each group was exposed to the theoretical and practical aspects of DCP design including:

- Background and development of DCP design
- Justification for sealing of Low Volume Roads
- Alternative empirical methods of design for Low Volume Sealed Roads
- DCP design principles
- Environmentally Optimised Design (EOD) of LVSRs
- Use of the Win DCP design software
- Data entry (using the data collected previously during the field training exercise)
- Data analysis
- Pavement design
- Materials selection based on laboratory determination of DN values.
- Practical demonstration of Laboratory DN test

The Technicians Course placed more emphasis on the use of the WinDCP software and materials testing and less on the actual design. In the planning for the Technicians Course KeRRA wanted to allow all laboratory staff currently employed in the regions to attend. It was therefore expected to have a quite diverse group of technicians with widely different technical background attending. On this basis an extra day was allowed for this course since it was expected that extra time would have to be spent on technical issues to make sure everyone could benefit from the training.

As it turned out the Technicians that came for the course all had more or less the same minimum level of Technical training (Diploma level) and some were aspiring to do further studies and obtain a degree in civil engineering. The course could therefore comfortably be run in two days rather than three by going a bit beyond the planned time on each day.

3.4 Certificates of Competence

In recognition of the level of competence attained by the Designers and Technicians by virtue of their attendance and participation in the full training programme, a Certificate of Competence – Intermediate Level, has been discussed and agreed with KeRRA and will be awarded to all eligible participants.

4. REVIEW AND EVALUATION OF TRAINING PROGRAMME

4.1 Planning and Preparations

As indicated in Section 1.3 above, the original plan was to conduct the courses in October 2013. However, due to the delays caused by the devolution process and late allocation of budgets to the various road sector organisations, the only option was to hold the courses from mid-January due to the availability of the trainers. In the event, the total attendance of 65 Kenyan trainees out of the 81 persons invited is deemed to be quite satisfactory.

For the future training courses it would be necessary to fix the programme well in advance, by a minimum of about three months, and changes to the training schedule should be avoided as much as possible.

4.2 Objectives and Outcomes

The achievement of the training objectives and outcomes is assessed in Table 8 below.

Table 8: Assessment of achievement of training objectives and outcomes

Staff category	Competency level	Assessment and comments
Senior Managerial - Director General - General Managers Project Managerial - Regional Managers	- General knowledge of design principles and methods. Some practical exposure on site. - Reasonably conversant with design principles and methods. Limited practical excercise in field survey, data analysis and project design.	- Generally achieved - Most trainees travelled from their respective stations in the morning. Field visit and practical exposure on site not feasible due to late start - Laboratory DN test explained and demonstrated.
Designers / Practitioners	- Fully conversant with design principles and methods. Full practical excercise in detailed field survey, data analysis and project design	- Intermediate competency level achieved. Advanced training course needed before trainees can confidently apply method on their own. - Seven of those who attended the course full time did not attend the field training and were thus not exposed to the practical aspects of the DCP survey which was a bit of a draw-back. - WinDCP sofware, data input, analysis and pavement design method explained through interactivelyl worked example using data collected from the training road. - Laboratory DN test explained and demonstrated.
Technicians	- General knowledge of design principles and methods. - Ability to carry out survey (under supervison); use DCP software including data entry; carry out materials sampling and laboratory testing and compile reports.	- Intermediate competancy level achived.More training and practical exposure needed before trainees can confidently carry out DCP survey and operate the WinDCP software on their own. - Seven of those who attended the course full time did not attend the field training and were thus not exposed to the practical aspects of the

		DCP survey which was a bit of a drawback. - WinDCP sofware and data input explained through interactive entry of data collected from the training road - data analysis and pavement design method discussed detail using the the design carried out in the Designers/Practitioners course - Importance of following standard procedures for reliability of test results highlighted - Laboratory DN test explained and demonstrated - Use of DCP for quality control explained.

Table 9 summarises the trainees own evaluation of the courses. As can be seen their evaluation supports the assessment in Table 8 above with most trainees either strongly agreeing or agreeing that the objectives or the trainees expectations of the course had been achieved.

Table 6: Training evaluation summary

		Senior Management					Designers/Practitioners					Technicians				
	Item	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree
Overall objective and outcomes	The objectives of the workshop were achieved	3	8				17	7				8	15	3		
	The outputs of the workshop were achieved		10	1			14	10				5	16	5		
	The workshop has provided me with an adequate appreciation of the DCP design method	2	9				14	10				12	14			
Field trip and presentations	The field trip was beneficial to the classroom presentations	n/a (Field trip not held due to late start)					13	7				16	9	1		
	The workshop presentations were well made	2	6				17	4				13	11	2		
	The principles of the DCP design method were understood	3	5				10	11				7	16	3		
	The analysis of DCP data was understood	1	5	2			15	12				3	17	6		

		Senior Management					Designers/Practitioners					Technicians				
	Item	Excellent	Very Good	Good	Poor	Very poor	Excellent	Very Good	Good	Poor	Very poor	Excellent	Very Good	Good	Poor	Very poor
Workshop venue and organization	Workshop venue	3	4	4			1	8	15			7	14	5		
	Workshop organization	2	6	3			5	15	4			6	13	7		
	Workshop materials	1	4	5	1		2	17	5			5	14	7		
	Workshop content	1	7	3			7	13	4			7	13	6		
	Quality of food served	1	3	7			1	8	13	1		6	3	15	2	

4.3 Challenging Aspects of DCP Design

The DCP Method of Design is such a significant departure from the traditional CBR-based design method and introduces a number of new concepts that are relatively difficult to grasp without continued training and practical exposure.

Aspects that the trainees found most challenging were dealt with in depth to engender a thorough understanding of these difficult issues, including:

- The adoption of an Environmentally Optimised Design (EOD) approach in which the final design should be "fit for purpose" and should be responsive to all factors in the road environment.

- The application of an Extended Design Domain (EDD) principle which allows the existing alignment to be followed with minimal changes or improvement whilst not imposing undue risks on road users. The EDD will allow for varying travelling speed and potential traffic hazards can be mitigated e.g. by local widening, road marking, speed humps etc.

- The adjustment of the DCP DN values by the judicious choice of an appropriate percentile applied to the data set to account for the in situ moisture content at the time of the DCP survey in relation to the anticipated long-term in-service moisture content in the pavement.

- The undertaking of a Cumulative Sum or CUSUM analysis of the weighted average DN values to determine uniform sections.

- Optimised use of local materials, i.e. making the specifications fit the available materials rather than making the materials fit the specifications, by modification or stabilisation and avoiding the adoption of non-material specific specifications that are applied in a blanket fashion and, by so doing, do not reflect the real needs or the local environment.

- Test standards. The participants were quite shocked by the revelation of the unreliability of the CBR test that they routinely carry out on their projects. The DCP test also has a margin of error, but this has been found to be more accurate and reliable than the CBR test. No matter which tests one is using, the importance of following the test procedures to the letter was emphasised.

- The significant difference in test procedures of various international testing standards for carrying out, for example, compaction and CBR testing (e.g. TMH1/AASHTO versus BS standards) which produces results which are very different and not comparable.

4.4 Need for Further Training

Several of the trainees had been sensitised previously to the DCP Design Method through participation in the one-day workshop that was held in Nairobi in October, 2013. Some had also had some practical exposure through design exercises under Roads 2000 Central Province. Participants with this prior experience clearly benefitted the most from the training courses and expressed as much during the training.

It is the personal experience of the trainers, that in order to attain Advanced Competency, also for those who had some previous exposure, further training is needed. This would entail, in outline, undertaking all the activities required for the upgrading of a typical rural road of about 10 km in length, including DCP measurements, data analysis, pavement design, materials selection, etc., as well as, of course, other attendant design issues such as drainage, road safety, etc. Such courses should be planned in the not so distant future to retain the momentum and be designed as individual project designs under guidance and review by the trainers.

4.5 Attitudes to the Adoption of the DCP Design method

As with any new technology, and particularly a method that demands a paradigm shift in peoples' mind-set that brings them out of their comfort zone, the uptake and adoption is likely to be slow to start with. There will be a minority of those who actively oppose the new idea (inhibitors) and another minority who will be eager to adopt and promote the change (innovators). The vast majority will be somewhere in the middle and their tendency to change will be largely influenced by the persuasive ability of the inhibitors or innovators.

By a simple hands-up survey, most of the trainees seemed to be on the side of either following or wanting to adopt the change (innovators).

Only by continued training and application through demonstration projects will it be possible to build the required momentum to make the process of change in approach to pavement design for LVRs self-sustaining. Moreover, it is clear that the uptake of the DCP technology will only be facilitated after it is embedded in the national standards of the country.

4.6 Challenges to Implementation

Until the DCP Design Method is adopted as a national standard as an alternative to the traditional design method, full scale implementation will be constrained. However, a number (approx. 5) of small trial sections designed by the DCP Design Method are currently being constructed (the first one completed in June 2012). It is recommended that more demonstration projects should be constructed for evaluation and confidence building. Trial sections constructed adjacent to sections designed in the traditional way for evaluation and monitoring would be particularly useful in that regard.

4.7 Lessons Learned

A number of lessons were learnt by the trainers in organizing and undertaking the training courses. These may be summarized as follows:

- The trainees should download the DCP software should and should obtain the license key (provided by CSIR) well in advance of the course, so that they can familiarise themselves with its use, including reading of the User Manual.
- The trainees should have a copy of the DCP design manual as a reference document during the training programme.
- Trainees should participate in both the fieldwork and classroom training in order to derive maximum benefit from the course.
- The choice of demonstration project used to collect the DCP field data should provide a variety of conditions (terrain, drainage conditions, material type, etc.) so as to bring out a range of discussion points during the classroom training.
- The trainees should be chosen well in advance of the start date of the course, say a minimum of about 4 weeks, so that they can plan and prepare themselves accordingly.
- Every effort should be made by the in-country (host) organizers to ensure participation of as many senior managers as possible so as to engender at least an appreciation of the benefits of the introduction of any relatively new technology to their organizations, such as the DCP design method.

4.8 Next Steps

In order to facilitate uptake of the DCP design method amongst stakeholders - Senior Management in the road sector, politicians, and leaders at local and national level – the following should be considered as a basis for ultimately embedding the DCP design method in national standards as an alternative to the more traditional methods:

1. The training of trainers who will spearhead and sustain the continued development and application of the DCP technology in the country.
2. The involvement of training institutions such as KIBHT, technical institutions and universities whereby the DCP technology is included in their curricula.
3. The production of well-illustrated, reader-friendly, promotional leaflets that illustrate home-grown success examples in which the technical, economic and social benefits are quantified.
4. Visits to demonstration projects by key stakeholders, including political and technical decision-makers in the country.

Workshop Photographs

Senior Management Group

Designers/Practitioners (Group 1)

Designers/Practitioners (Group 2)

Technicians Group

Training session in progress

Demonstration of laboratory DN measurement

CROWN AGENTS

Crown Agents
St Nicholas House
St Nicholas Road
Sutton
Surrey
SM1 1EL
United Kingdom

T: +44 (0)20 8643 3311
F: +44 (0)20 8643 8232

e-mail enquiries@crownagents.co.uk
www.crownagents.com