The Africa Community Access Programme (AFCAP)

Overview of AFCAP……and a Vision for the Future

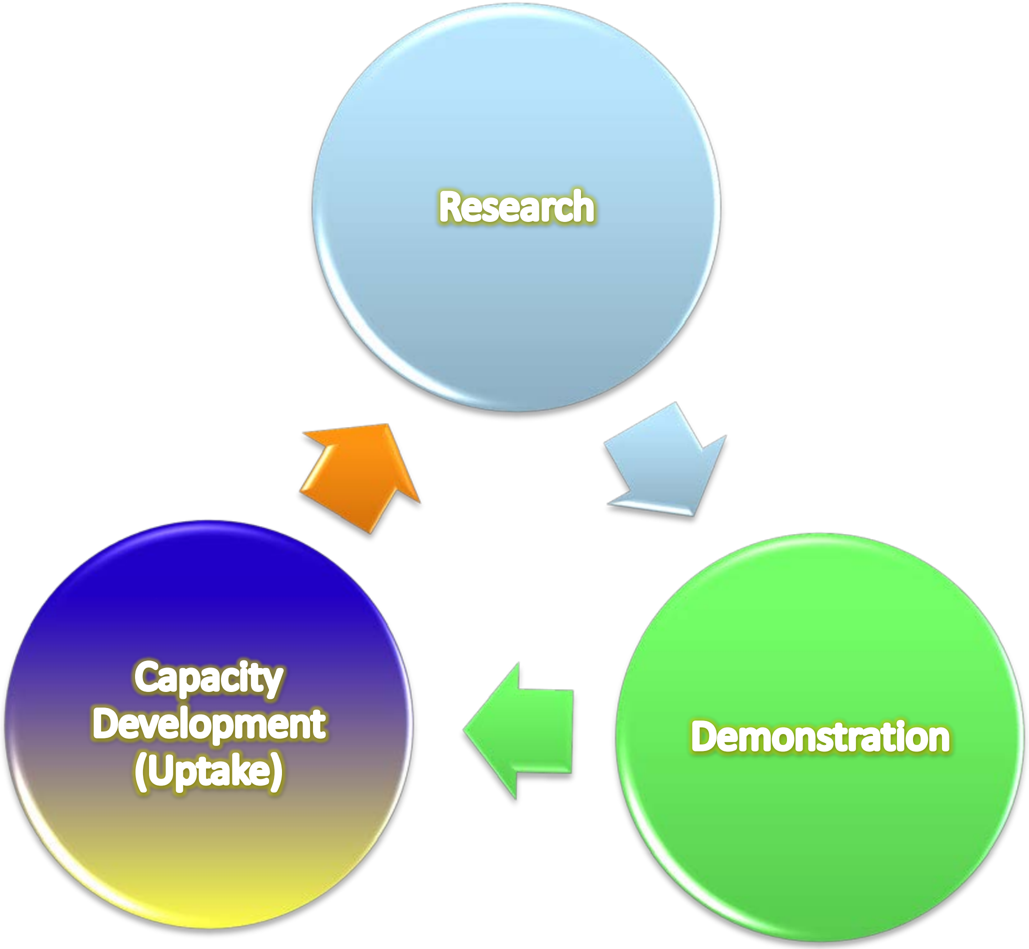
Nkululeko Leta
AFCAP Technical Manager

Kampala, Uganda

19th March 2014

What is AFCAP?

- Knowledge and research programme for the rural transport sector in Africa.
- June 2008 to 2014
- Core countries: Mozambique, Ethiopia, Malawi, Tanzania, Kenya, South Sudan, DRC.
- Also projects in SA, Zambia, Ghana, Nigeria and SADC.
- Crown Agents management contract.
- DFID budget £14.4 million (low cost high impact).
- AFCAP 2 approved by DFID, includes also ASCAP. Budget £24.2 million, 2014 - 2020



Project Conception & Implementation – Key Principles

- ❑ Host Institution in-country
- ✓ In-built local ownership and buy-in
- ✓ Funding of capital works
- ❑ AFCAP National Steering Committee
- ✓ Membership: (UNRA, URF, MoW, others)
- ✓ Identification and prioritisation of projects
- ✓ Approval of ToR
- ✓ Oversight of implementation of projects (site visits, approval of reports, SC meetings to review progress, etc)
- ❑ AFCAP Support
- ✓ Development of ToR for prioritised projects
- ✓ Procurement of required expertise based on approved ToR
- ✓ 100% funding for technical assistance, training, equipment
- ✓ Oversight during implementation of projects

PROJECT SELECTION: AFCAP 4-WAY TEST

Does the project have strong local ownership?

Does the project include mainly research or uptake of best practice?

Will the project contribute to building national or regional capacity?

Will the project contribute to sustainable improvements to rural transport?

Examples of AFCAP-supported projects in core countries

Engineering

- Research on innovative design methodologies, application of unconventional locally-available materials in pavements, and for surfacing
- Back-Analysis of old LVSRs
- Design, Construction and Monitoring of Demonstration Sites
- Study on Improved Maintenance Systems
- Establishment of Road Research Centres, procurement of lab equipment
- Preparation of Design Manuals for LVR

Transport Services

- Study on Causes of Rural Motorcycle Accidents on LVR (on-going)
- Study on Rural Transport Indicators
- Study on Rural Transport Services for Older People

Related Rural Roads Programmes

- EU-funded Rural Roads & Capacity Building Programmes
- DfID-funded Rural Roads Programme
- JICA TA Programmes
- World Bank support programmes

Research- Knowledge Generated

CROWN AGENTS

1. **Use of non-standard materials in upper pavement layers (LVSRs)**
   - Unstabilised sands
   - Calcrete
2. **Alternative surfacings**
   - Cold mix asphalt
   - Otta Seals (fine quartz gravels, calcrete, weathered basalt, cinder gravel).

Through:

- Back-analysis of existing pavements
- Construction and long-term monitoring of experimental and demonstration sections

UKaid from the British people

Use of Sand in Road Construction

Hoopstad-Bultfontein Experimental Section (1962):
Neat sand base
Potential Saving: >$50,000 per km (cement)
for countries like Mozambique

Research- Knowledge Generated

How transport services operate in rural areas:

- For the aged
- For people needing emergency medical care
- Small farmers
- Using motorcycle taxis.

Demonstration of Best Practice

Unstabilised laterite road bases

Thin cold mix asphalt

Environmentally Optimised Design







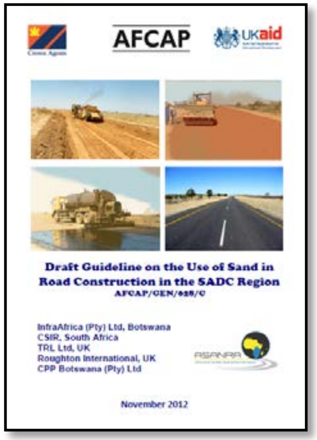


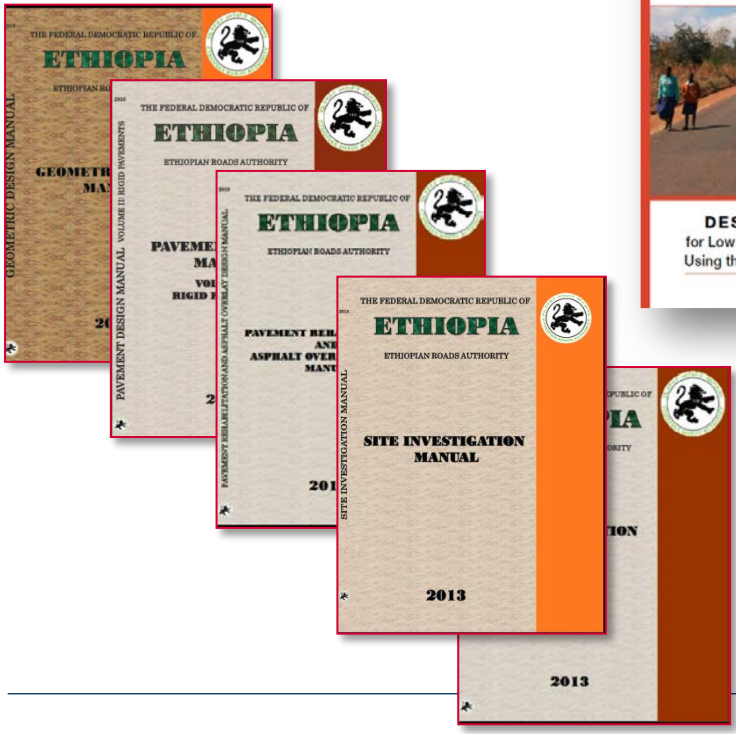


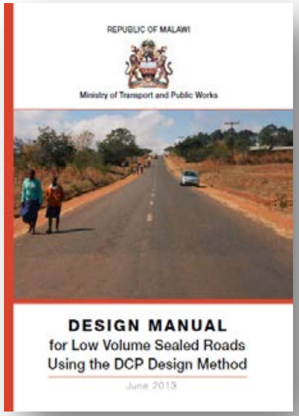
Knowledge sharing

Uptake of Knowledge

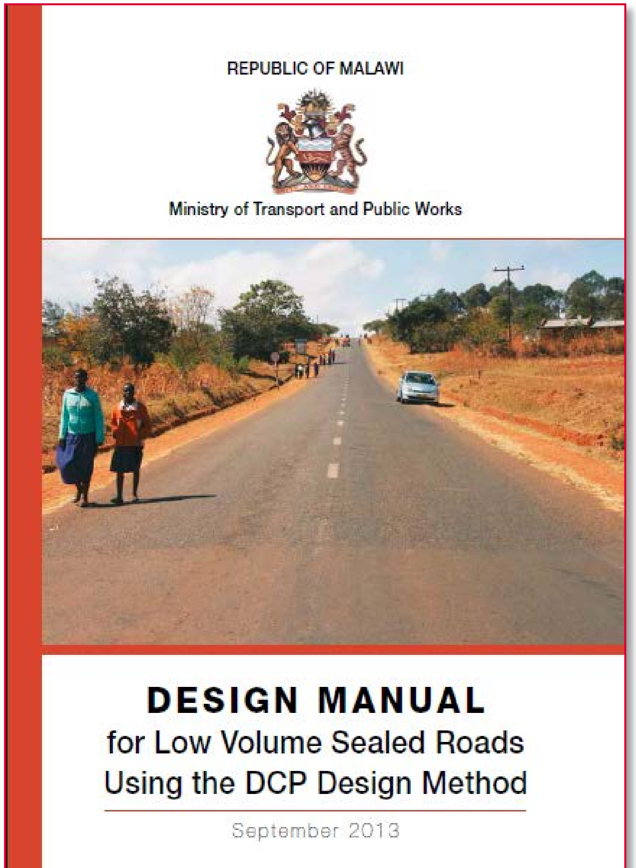
New knowledge must be brought into practice by updating design manuals, Standard Specifications etc.







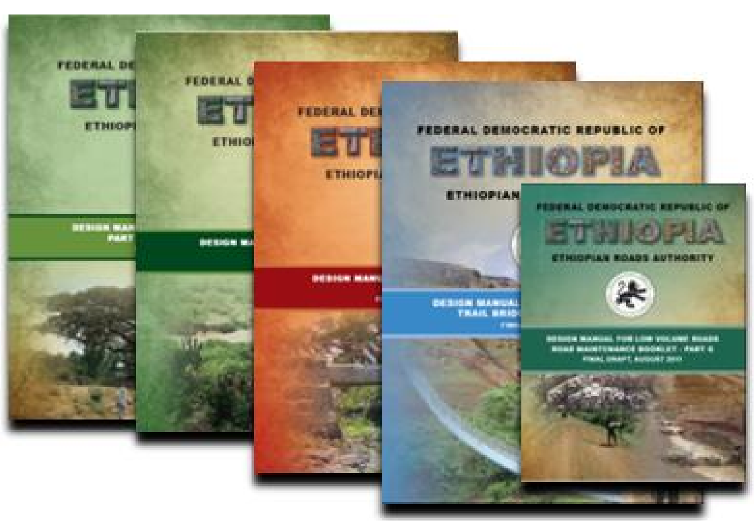
Malawi DCP Design Manual

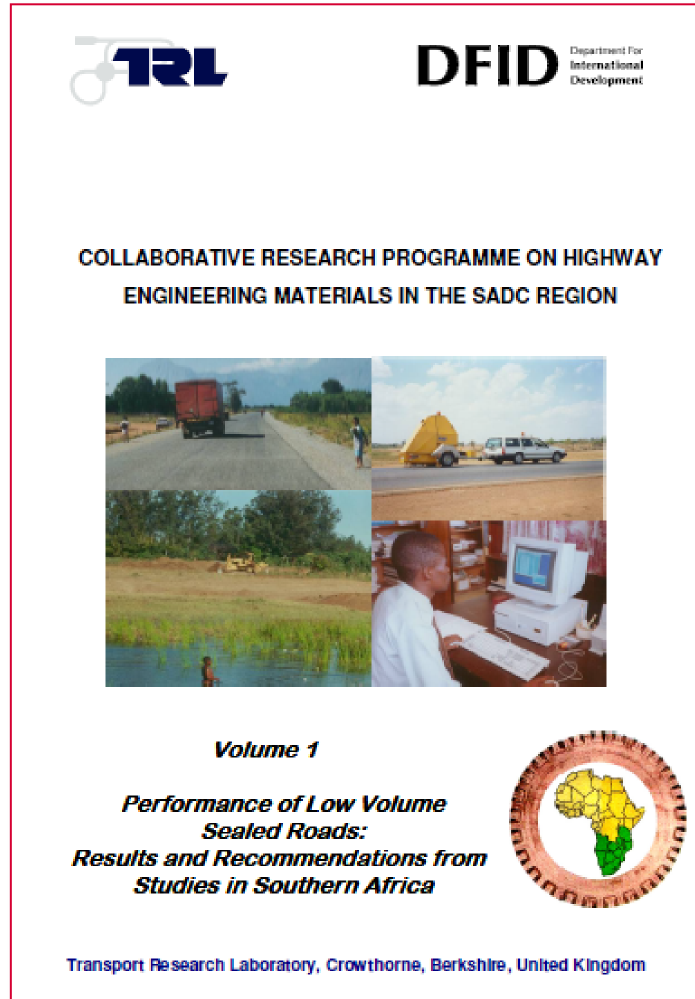


- Builds on pioneering work done in RSA (and Australia)
- Calibrated DCP catalogue for Malawi conditions
- Reduced reliance on conventional testing
- Supports an existing design approach
- Malawi plans to construct 100km LVSRs annually
- Also for design of LVSRs in Kenya and DRC. Tanzania and Mozambique keen to apply approach.

LVR Design Manuals -Ethiopia

- Published in 2011 for Universal Rural Roads Access Programme
- 70,000km gravel roads over 5 years
- Includes design catalogue for low volume sealed roads from 1990s research.




TRL

DFID Department For International Development

COLLABORATIVE RESEARCH PROGRAMME ON HIGHWAY ENGINEERING MATERIALS IN THE SADC REGION

Volume 1

Performance of Low Volume Sealed Roads: Results and Recommendations from Studies in Southern Africa

Transport Research Laboratory, Crowthorne, Berkshire, United Kingdom

UKaid from the British people

LVR Design Manuals -Ethiopia

Independent review findings:

- About 7,000 individuals in 2,000 organisations using manual.
- 3,600 professionals trained in LVR design using the Manual
- 28,000km upgraded to gravel all weather standard.
- 170km sealed roads designed through 15 villages.

Research Centres

AFCAP supporting development of research centres for rural transport in:

- **Ethiopia**
- **Mozambique**
- **Kenya**
- **South Sudan**
- **Tanzania**

Outcomes of AFCAP

- Contributed to the attainment of new knowledge
- Bridging the knowledge gap between countries
- Enabled the uptake of knowledge (new and existing) with benefits for local communities
- Demonstrated the value of research
- Created awareness of the need for more in-country research.

Vision

"Vibrant research community for the rural transport sector in Africa"

www.afcap.org

Key Future AFCAP Activities

Research & Uptake

- Continue with research activities, consolidation and search for new knowledge, systematic monitoring of trial sections
- Embed research knowledge into national standards, manuals and specifications

Strengthen Capacity Building

- Provide support to centres of research excellence
- Develop and implement structured programme of training and mentoring of African researchers

Knowledge Management

- Develop sustainable and easily accessible knowledge portals linked to rural road and transport services research
- Disseminate and mainstream best practice and evidence in rural LVR and transport services

UKaid from the British people

IMPACT OF CLIMATE CHANGE ON RURAL ACCESSIBILITY

Presented by:

Eng. Kakiiza Kagaba Robert

PHD (Cand.), REng., MSc., MBA, PGD, BSc.

Kampala Workshop 19/03/2014

Contents

- Introduction
- Current aspects of rural access roads
- Ongoing works: AFCAP / Phd Studies
- Approach to the study (AFCAP – Funded)
- A Case of Uganda
  - Potential impacts on Uganda's rural roads
  - Field study and risk model formulation
- Progress to date
- Conclusions

Introduction

AFCAP Funded research in collaboration with **Hearn Geoserve Ltd and the University of Birmingham**– studies in Uganda and Ethiopia *(Towards Sustainable Rural Access and Risk-Based Vulnerability Assessment for Rural Communities in the Changing Climate of SAA)*

Phd Research: Ensuring sustainability of rural access roads /LVR against impacts of climate change

Climate change is a significant and lasting change in the statistical distribution of weather patterns over a period of time . It may be a change in average weather conditions, or in the distribution of weather around the average conditions

Environment is the surroundings of a physical system that may interact with the system by exchanging mass, energy, or other properties

The two are different and not interchangeable

Current aspects of rural access roads

1. **Road designs**
    - Material quality vs Climate Change
    - Current formulas use max occurrence in return periods which occurrences are now more frequent
    - Do not include climate change in formulas and procedures used

2. **Vulnerability and adaptability of rural communities**
    - No Risk-Based Vulnerability Assessment tools
    - Limited knowledge on remote rural communities adaptation to changing levels of livelihood access
    - Limited knowledge of climate variability and climate change effects on rural access roads
    - No policy provisions
    - Responses to climate change impacts in Uganda are unplanned and treated as emergencies

3. **Development financing**
    - Based on vehicle volume making it not feasible for low volume roads

1. **Aim of AFCAP funded study :**

To assess rural community vulnerability to the potential impacts of climate change on rural access in SSA).

2. **The objectives of the research:**
   a) promoting sustainable rural access in SSA in the context of climate variability and climate change
   b) developing a risk-based methodology for assessing rural community risk to changing levels of road access, and
   c) strengthening local expertise and research capability in a) and b).

UKaid
from the British people

Additional work - Phd

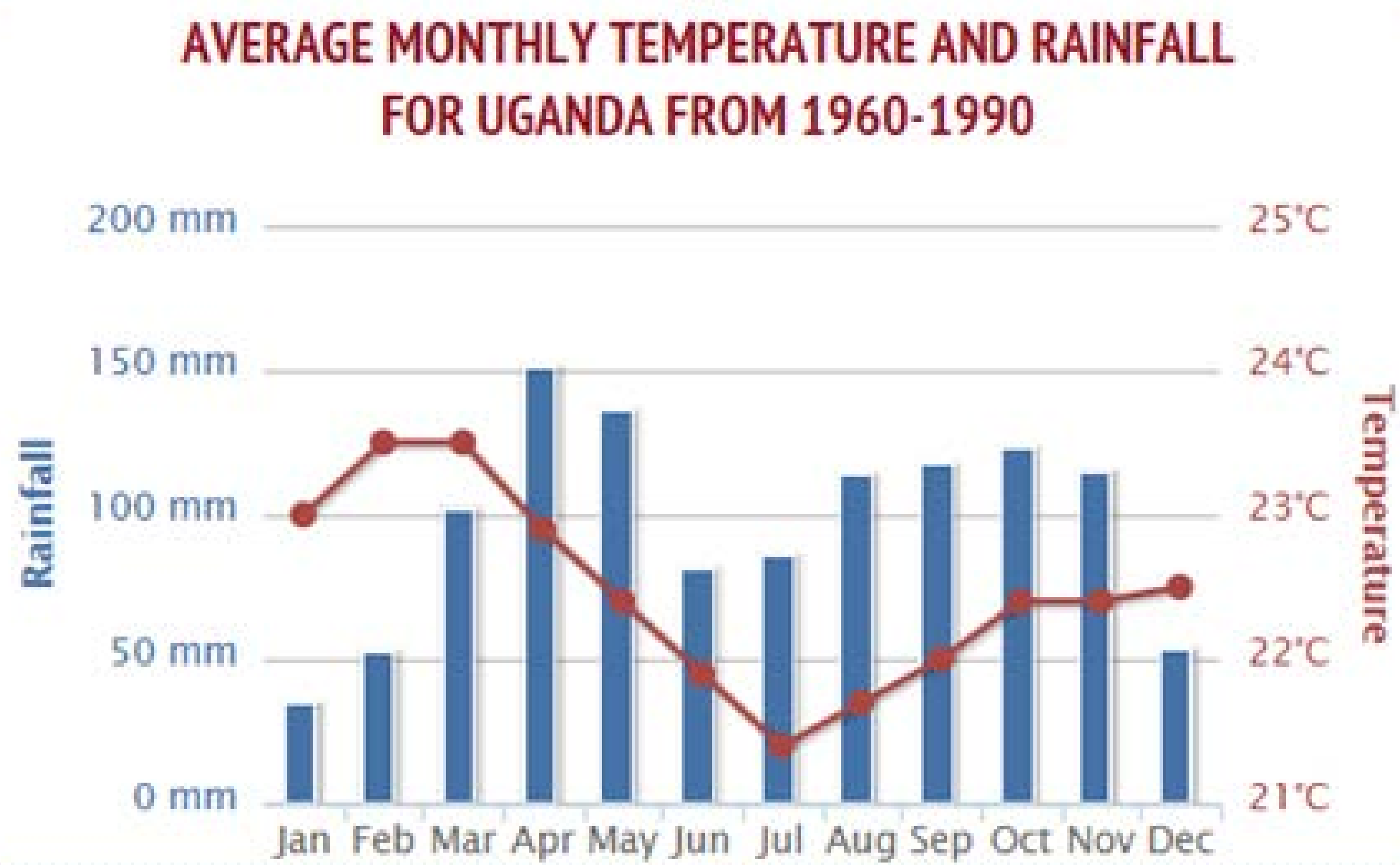
a) Model the impacts of climate variability and climate change in the design and management of rural access roads and

b) Provide appropriate solutions to development financing of rural access roads for sustainability (LVR)

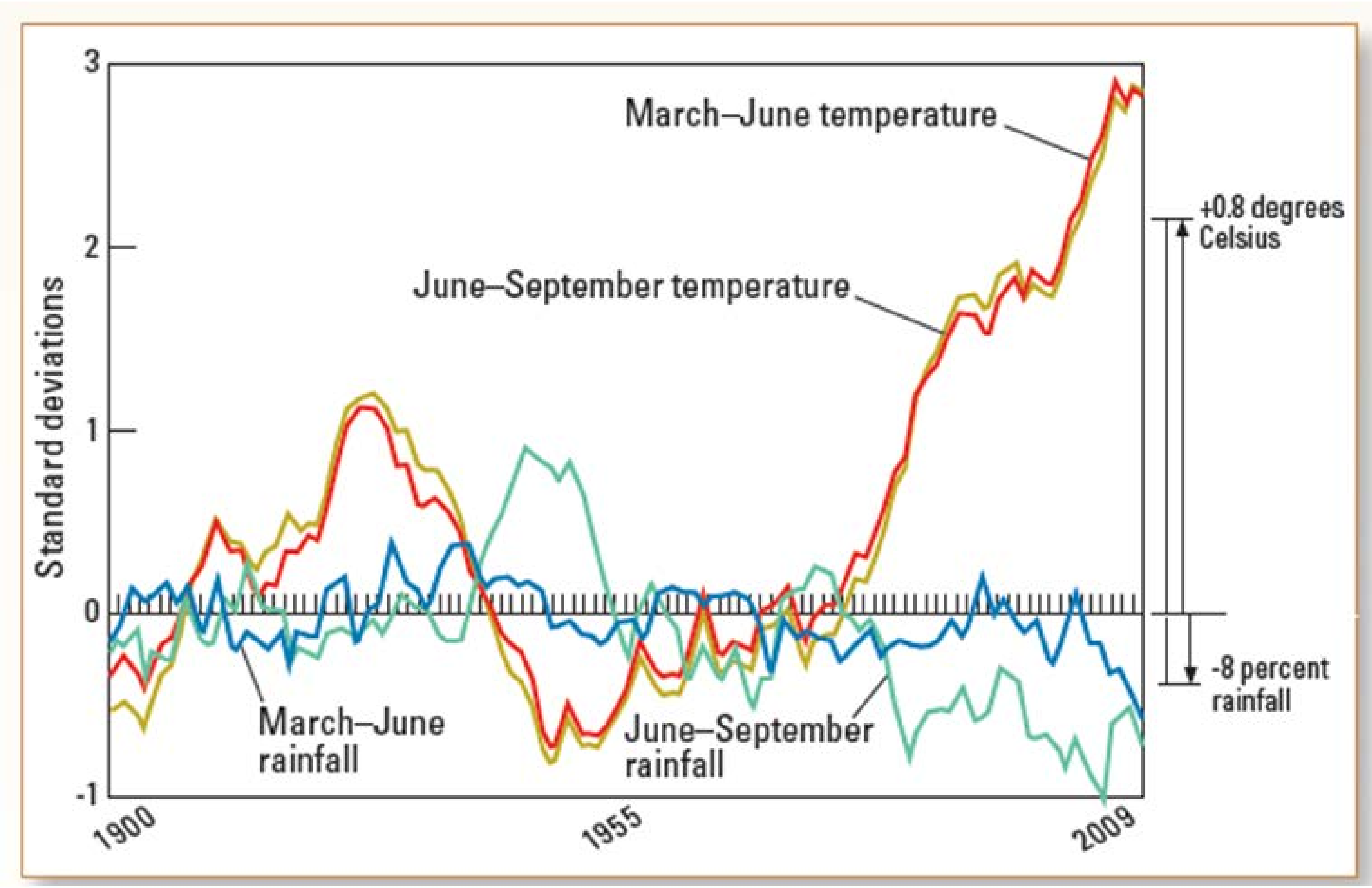
literature review of :

i. climate change in SSA
ii. potential effects of these on rural roads,
iii. studies of rural communities in Uganda and Ethiopia,
iv. development of risk based tool to bring together ii), iii) and iv)
v. Dissemination of results to stakeholders for policy guidence

A Case of Uganda (WB, 2014)



Climate trends in Uganda



Potential impacts on Uganda's rural roads

1. Floods
2. Landslides
3. Road wash offs
4. Bitumen bleeding
5. In adequate underpasses and drainage structures
6. Extreme silting for drainage structures
7. Impairment of accessibility to critical services
   Health, education, markets, community centers, etc
8. High wind speeds in some areas
9. Climate change related death

Bududa landslide

PICTORIAL IMPACTS

SUNDAY VISION

Floods cut off Nakaseke

PICTURES BY FREDERICK KIWANUKA

BY FREDERICK KIWANUKA

Floods triggered off by the current rains have cut off a Police post in Nakaseke and rendered several roads impassable, cutting off several villages from the rest of the district. Business has come to a standstill at Nakaseeta Police Post in Kasangombe after the premises were cut off by the floods.

The heavy rains, which intensified this week, have caused rivers like Lugogo and Lumansi to burst their banks, washing away several feeder roads.

The most affected sub-county is Kasangombe, which borders Luwero district. Here, two major access feeder roads to Nakaseke Hospital are completely ruined.

This has compelled motorists entering Nakaseke from Luwero to start using the longer Kahile-Nakaseke route.

The few motorcyclists who continue to use the flooded Luwero-Nakaseeta-Nakaseke and Wobulenzi-Nakaseke roads have hiked the fare to sh12,000 from the usual sh5,000.

Also submerged in the floods are crop fields owned by HNHE farm, a Chinese agricultural company based in Nakaseeta village.

Patients are stuck in villages without medical care, while several pupils have stopped attending school because parents are afraid that they might drown.

The district secretary for works, Benjamin Makanga, said on Wednesday that the authorities are looking for funds to

The floods that have hit Nakaseke have made several roads impassable


www.newvision.co.ug

1. Site chosen as test location to determine the wider applicability of the questionnaire (and risk model) and how they might be adapted. (kisomoro in Kabarole District western – Uganda)

1. **Multi-Criteria Analysis (MCA) to be adopted**
   a) **Cater for None monetized benefits (Social, Political, Cultural, environmental)**
   b) **Superior to CBA and Whole life cycle analysis**

2. **Pairwise questions to be asked (MCA)**

(How important is A relative to B - Preference index assigned 1 – 9)

Groups of people to be asked will include:

A select representative groups of 5 -10 members with the following characteristics:

a) All – Mixed

b) Female and male groups less than 18 years old

c) Female and male groups more than 18 but less than 60

d) Female and male groups more than 60

Progress to date

- Relevant literature for Uganda and Ethiopia reviewed
- Questionnaires formulated
- Field work has started in Ethiopia and will be starting soon in Uganda (25th /3/2014)
- Draft risk-based methodology for assessing rural community risk to changing levels of road access formulated
- Create awareness – (this workshop and others to come)

Conclusions

- There is a need to properly understand the implications of climate change on rural road accessibility and thereby the vulnerability of rural communities.

- Achieving sustainable rural access is key to strengthening the resilience of communities at risk from climate variability

THANK YOU

For further discussion, my contacts are:

Mobile phones: +256772418954/

E-mail: krkakiiza@yahoo.com / eng.kakiiza@gmail.com

Seminar on Outputs of African Community Access Programme
Kampala, Uganda
19th March 2014

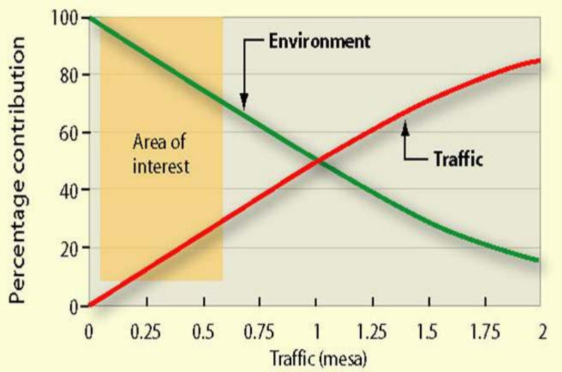
Introduction to the DCP Design Method for Low Volume Sealed Roads

Mike Pinard
AFCAP Consultant

Presentation Outline

- Background
- Traditional Design Approach
- DCP Design Principles
- DCP Design Method
- Summary and Conclusions

CONVENTIONAL SOAKED PAVEMENT DESIGN



- Use standard soaked CBR to classify soils
- Conservative
- Tried, trusted and understood
- Risk of failure minimal
- Responsive to EOD?
- Cost effective design?

BACKGROUND - CBR

- Developed in 1930's for subgrade soils
- What does it measure?
- Strength or stiffness ?
- Probably a "mini" plate load test more than shear strength test?
- Repeatability, reproducibility and precision are poor

AFCAP

BACKGROUND - CBR

- Standard deviation (σ) = 10^w where w = $(1.4771\text{-}0.9853^{CBR})$

CBR	σ	95% confidence	Range
10	4	± 8	2 – 18
30	7	± 14	16 – 44
60	12	± 24	36 – 84
80	16	± 32	58 – 122

Crown Agents

IS SOAKED STRENGTH NECESSARY ?

- Related to soaked material state and not in situ pavement situation
- In situ road conditions are seldom soaked
- Field investigations show that in situ moisture is seldom above OMC
- Equilibrium moisture content of base, subbase and subgrade is usually significantly below OMC
- Emery (1985) and others
  - Base - between 0.56 and 0.6 OMC
  - Subbase – between 0.7 and 0.82 OMC
  - Subgrade – depends on material – 0.7 to 1.05 OMC
- Material strength varies significantly with moisture content
  - Need to capitalise on this during design
  - *May require sealed shoulders in wet areas*
  - Need to consider seasonal moisture change zone

Approximate relationship between laboratory CBR and DN values at varying moisture contents

Material Classification/ CBR or DN	CBR and DN values at moisture content					
	Soaked		OMC		0.75 OMC	
	CBR	DN	CBR	DN	CBR	DN
NG80	80	3.7	95	3.2	150	2.2
NG65	65	4.5	90	3.8	145	2.5
NG45	45	5.7	70	4.2	110	3.0
NG30	30	8.0	60	4.7	95	3.2
NG25	25	9.1	55	5.0	85	3.5
NG15	15	14.0	50	5.4	80	3.6
NG10	10	19.0	35	7.0	60	4.6

IMPLICATIONS OF USING SOAKED STRENGTH (CBR)

- "Waste" of good materials
- Over-design – may involve additional layers
- Unnecessarily high safety factor in most layers
- Increased pavement costs

AFCAP

SOLUTION

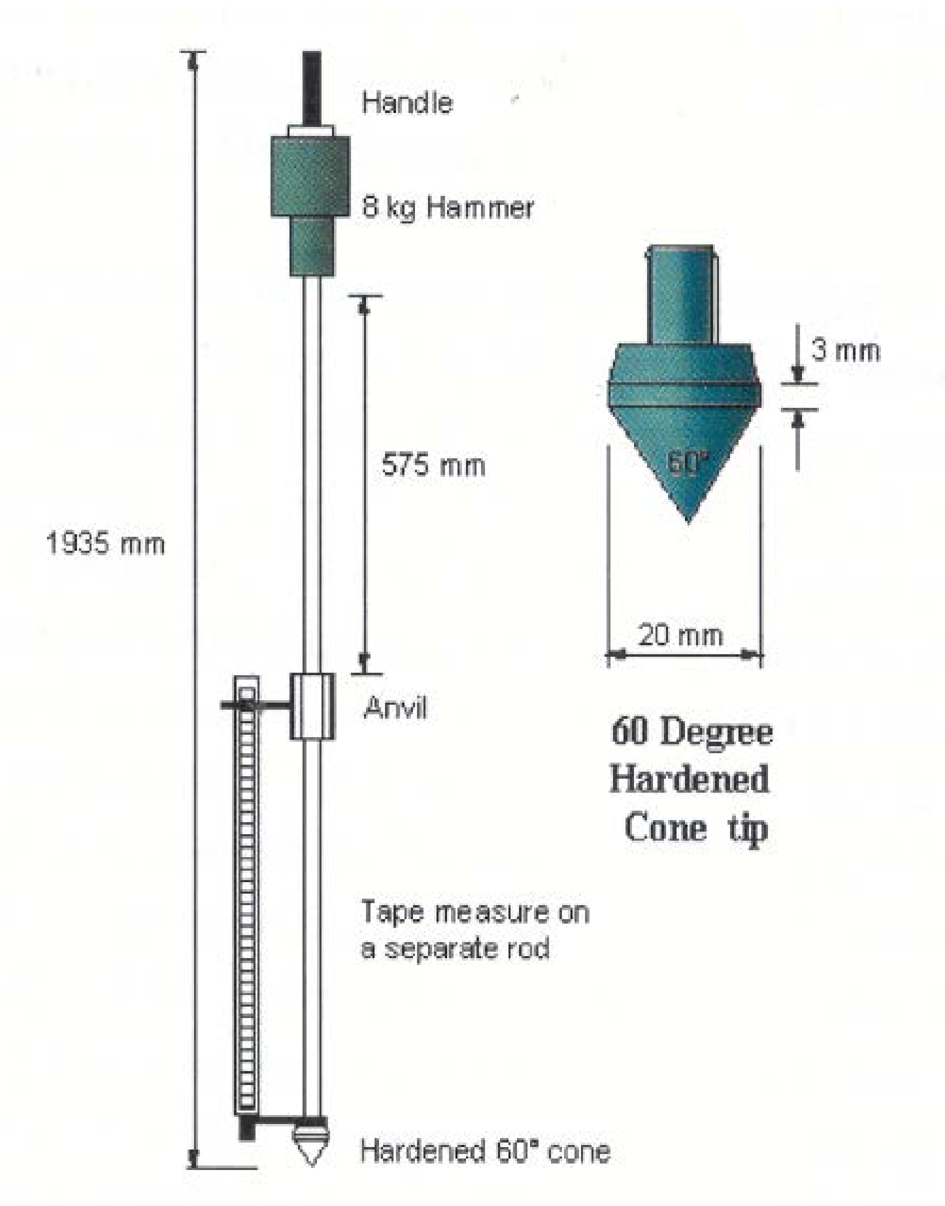
- Optimisation of in situ and local materials
- Optimisation of local moisture conditions
- How?
  - Check what is in the road
  - Make use of in situ (unsoaked) strength conditions
  - Import (if necessary) appropriate local materials
  - Ensure adequate and effective drainage
- Look at in situ strengths (supply) and traffic requirements (demand) then balance them.

Crown Agents

DCP Design Method

- An alternative to the traditional CBR-based approach
- Original development dates back to mid-1950s in Australia based on older Swiss design
- Used initially as non-destructive testing device to evaluate shear strength of material in a pavement
- Use for pavement design enhanced in mid-1960s and 1970s in South Africa where results verified from back-analysis of many pavement sections using Heavy Vehicle Simulator
- DCP design catalogue subsequently developed for various tarffic categories and moisture conditions.

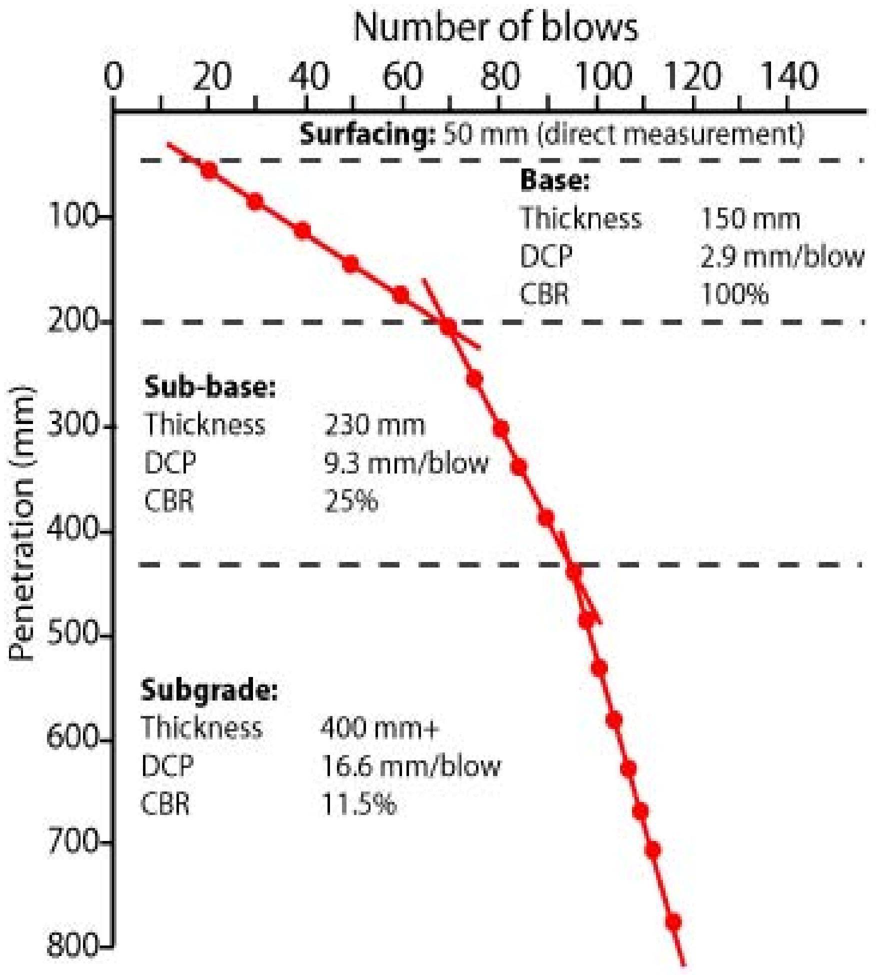
Dynamic Cone Penetrometer (DCP)



DCP test in process

DCP Test and Output

- Measures the weighted penetration per blow into a pavement through each of the different pavement layers
- Rate of penetration is a function of the in situ shear strength of the material at the in situ moisture content and density of the pavement layers at the time of testing.
- Profile in depth of the pavement gives an indication of the in situ properties of the materials in all the pavement layers up to the depth of penetration.

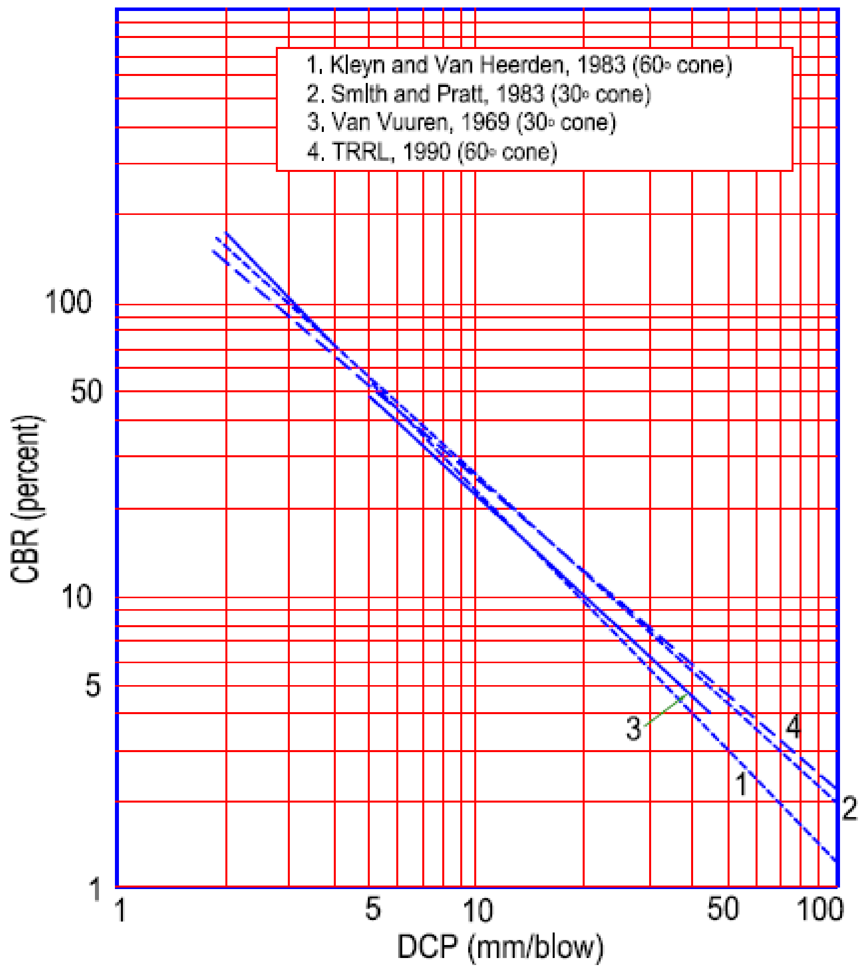


Development of DCP Design Method

- Extensive DCP testing was carried out in conjunction with Heavy Vehicle Simulator (HVS) testing of various roads.

  ➢ Allowed further correlations and developments, e.g. relationships between actual road performance and DCP results

Relationship between DN and CBR

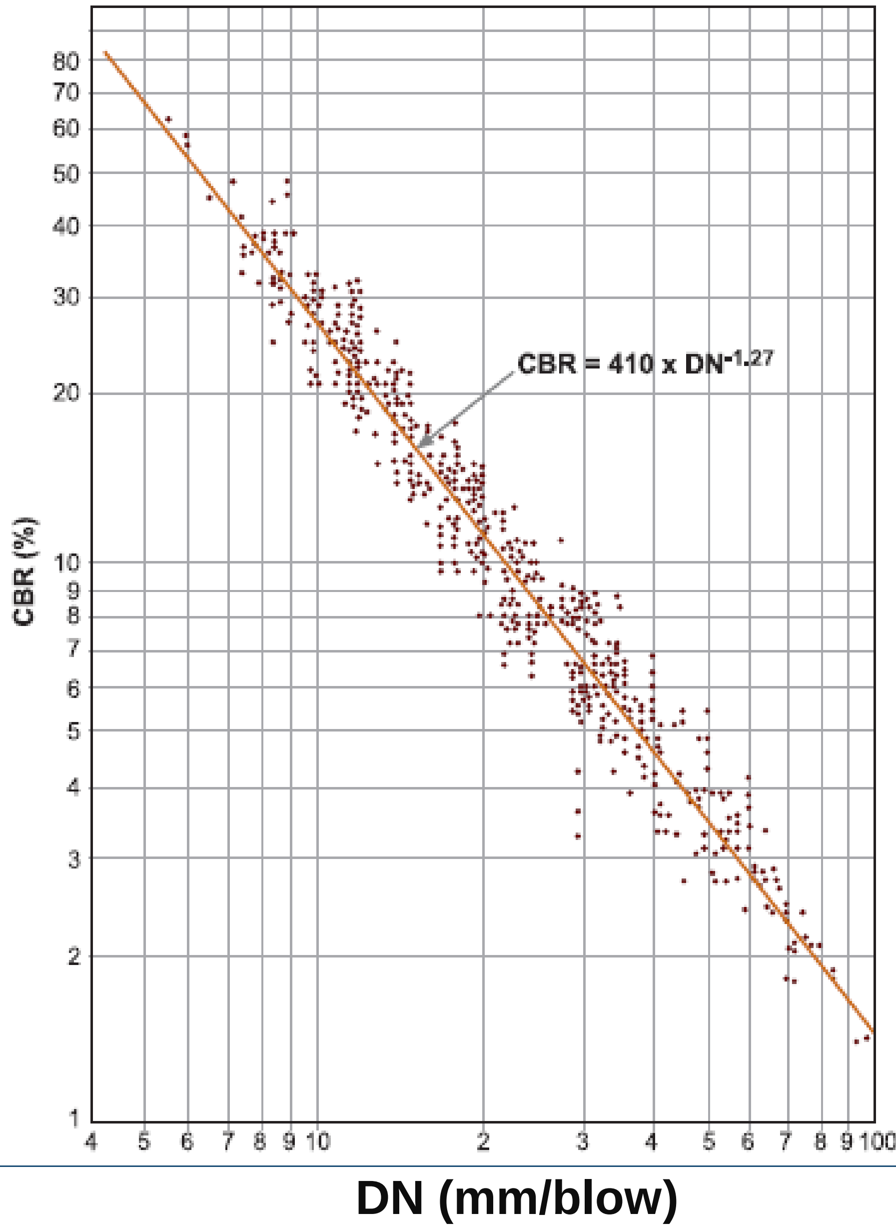


1. $\log_{10}(CBR) = 2{,}632 - 1{,}28\log_{10}(mm/blow)$
2. $\log_{10}(CBR) = 2{,}555 - 1{,}145\log_{10}(mm/blow)$
3. $\log_{10}(CBR) = 2.503 - 1.15\log_{10}(mm/blow)$
4. $\log_{10}(CBR) = 2{,}48 - 1{,}057\log_{10}(mm/blow)$

DN (mm/blow)

CBR-DCP relationship derived by various researchers

Relationship between DN and CBR



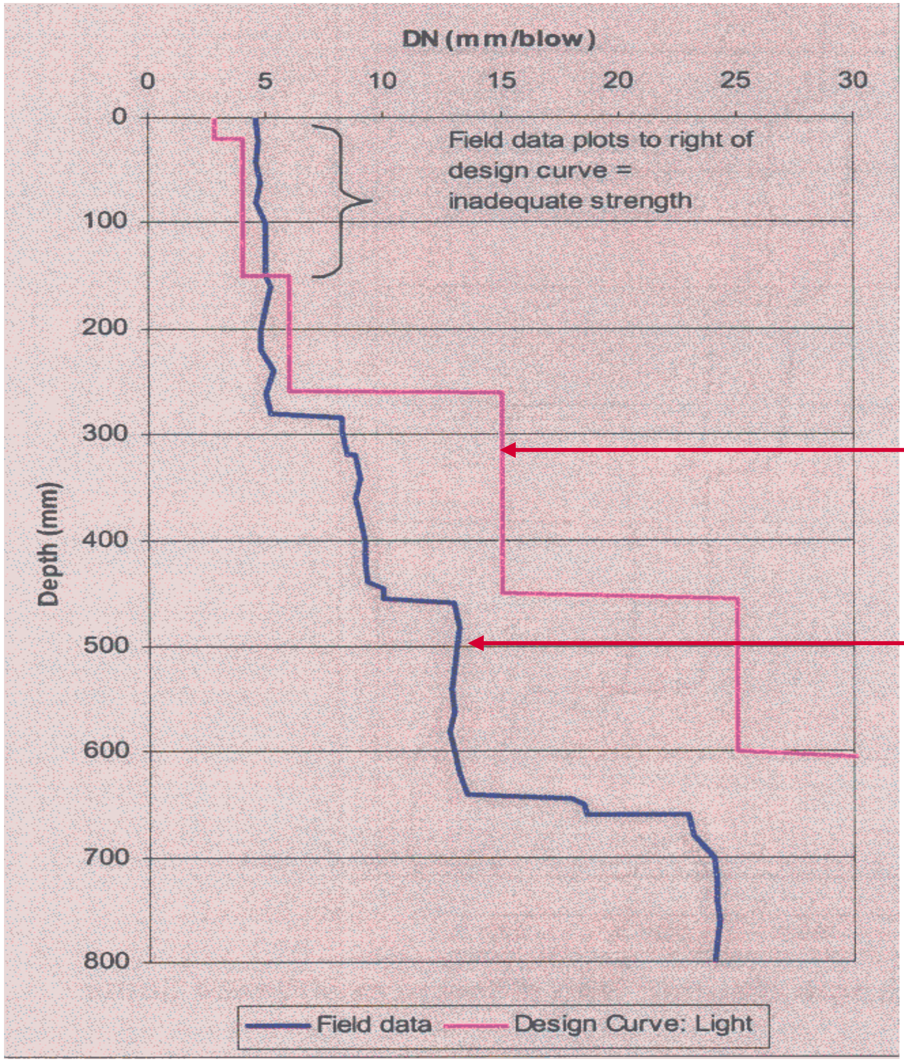
CBR-DCP relationship based on 2000+ measurements in South Africa (Kleyn)

DCP Design Approach

- Achieve balanced pavement design
- Make use of beneficial traffic moulding and consolidation of gravel road pavement over many wetting and drying cycles
  - Gravel road pavement should not be disturbed during upgrading

- Optimize utilization of in situ material strength as much as possible. Achieved by:
  - determining design strength profile required
  - Intergarating required strength profile with in situ sytrength profile

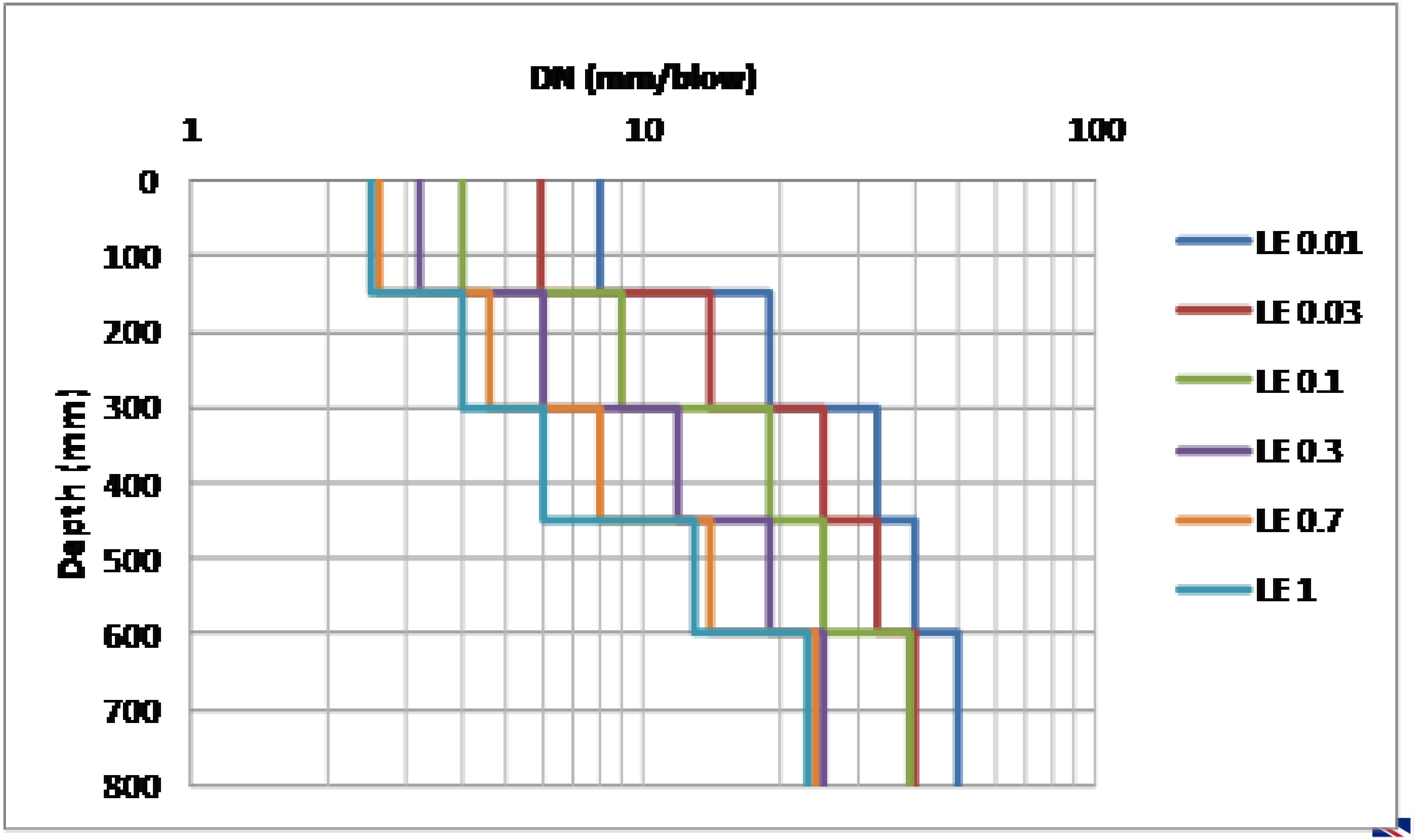
Integration of In Situ and Required Strength Profiles



Required strength profile

In situ strength profile

Required Strength Profiles by Traffic Class



DCP Design Catalogue

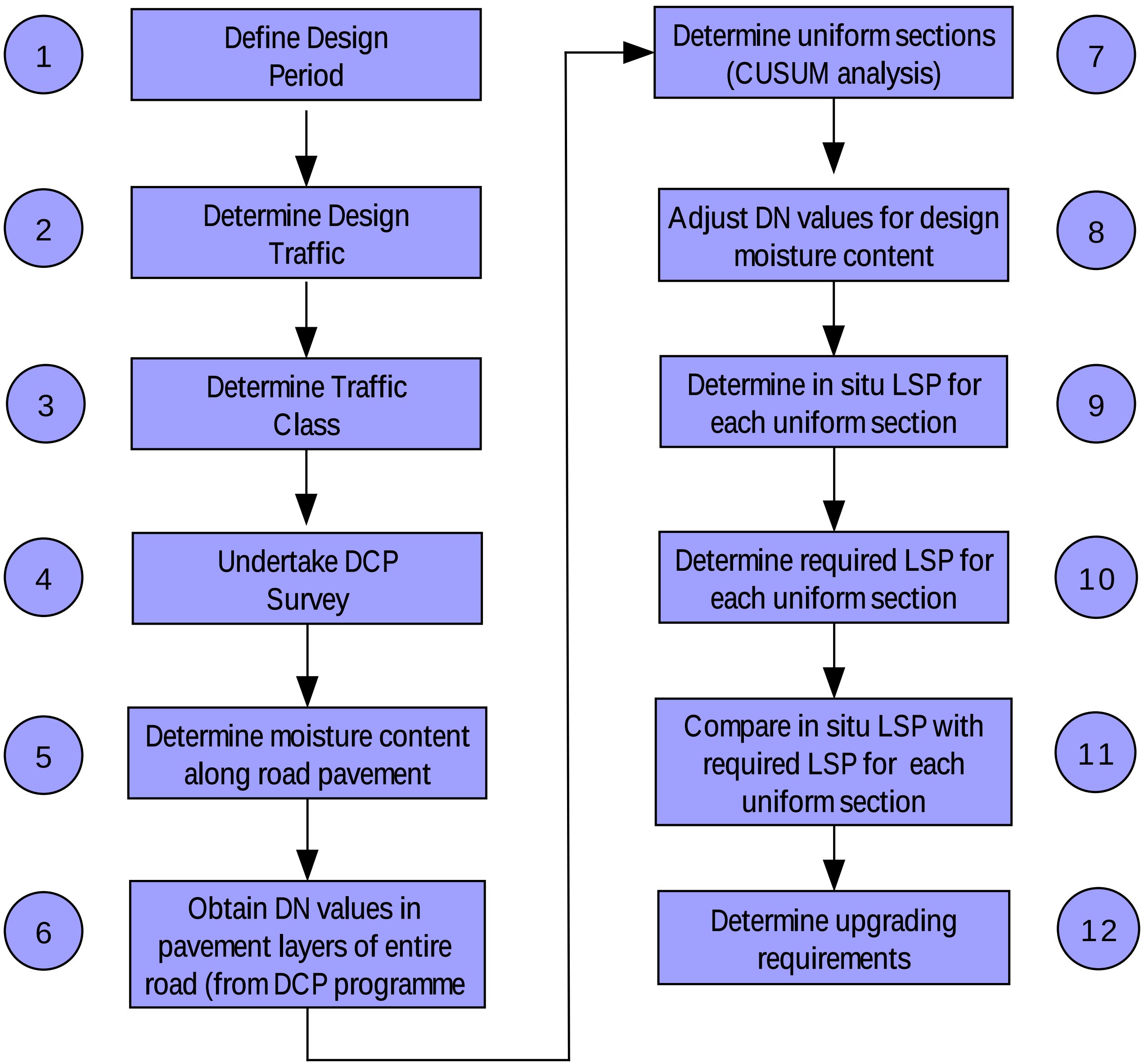
Traffic Class E80 x 10^6	LE 0.01 0.003 – 0.010	LE 0.03 0.010 – 0.030	LE 0.1 0.030 – 0.100	LE 0.3 0.100 – 0.300	LE 0.7 0.300–0.700	LE 1.0 0.700 – 1.0
0- 150mm Base **≥ 98% MAASHTO**	DN ≤ 8	DN ≤ 5.9	DN ≤ 4	DN ≤ 3.2	DN ≤ 2.6	DN ≤ 2.5
150-300 mm Subbase **≥ 95% MAASHTO**	DN ≤ 19	DN ≤ 14	DN ≤ 9	DN ≤ 6	DN ≤ 4.6	DN ≤ 4.0
300-450 mm subgrade **≥ 95%** MAASHTO	DN ≤ 33	DN ≤ 25	DN ≤ 19	DN ≤ 12	DN ≤ 8	DN ≤ 6
450-600 mm In situ material	DN ≤ 40	DN ≤ 33	DN ≤ 25	DN ≤ 19	DN ≤ 14	DN ≤ 13
600-800 mm In situ material	DN ≤ 50	DN ≤ 40	DN ≤ 39	DN ≤ 25	DN ≤ 24	DN ≤ 23
DSN 800	≥ 39	≥ 52	≥ 73	≥ 100	≥ 128	≥ 143

DCP Design – General Design Procedure

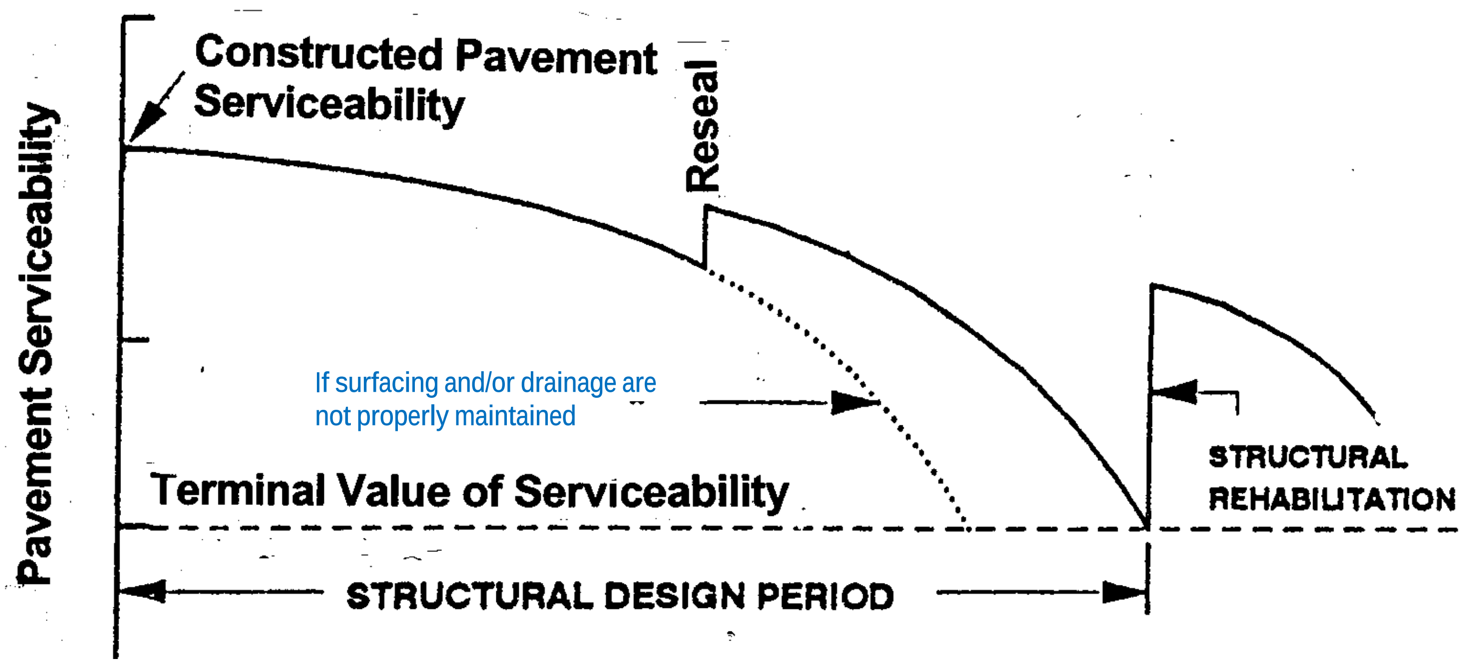
Design follows conventional procedure

- Determine design traffic
- Undertake DCP survey
  - DCP penetration to 800mm or refusal
  - Adjust DCP spacing in relation to variability
  - Assess moisture conditions
  - Identify uniform sections (use "cumulative sum" technique)
  - Analyse data in DCP programme
- Pavement Design
  - Fit pavement structure to in situ conditions on each uniform section
- Carry out design refinement

DCP Design Procedure

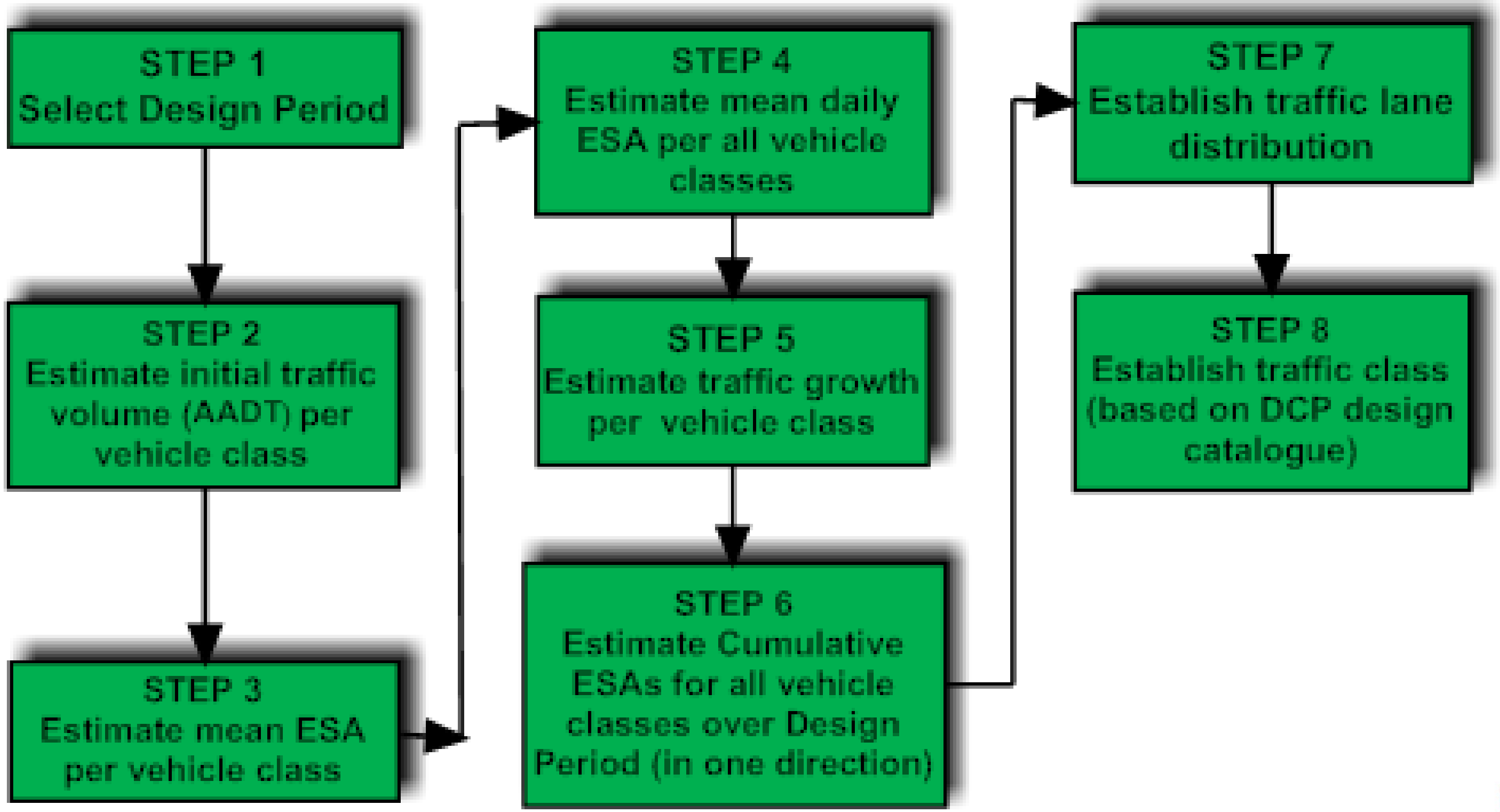


Step 1 - Design Period



Design data reliability	Importance/level of service	
	Low	High
Low	10 yrs	10 – 15 yrs
High	10 – 15 yrs	15 – 20 yrs

Steps 2 – Determine Design Traffic



Lane Width Adjustment Factors

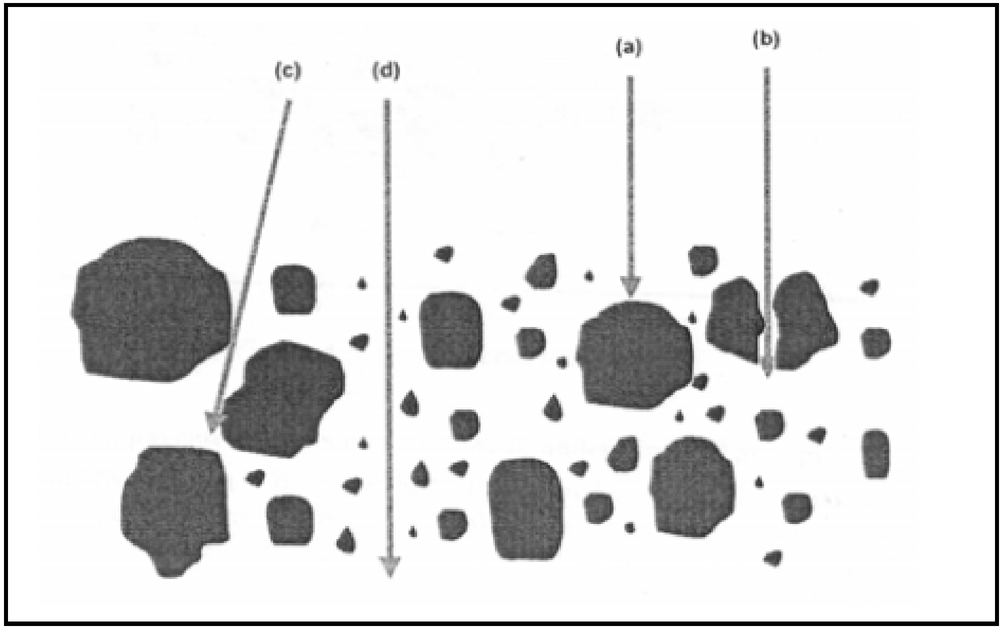
Cross Section	Paved width	Corrected design traffic loading (ESA)	Explanatory notes
Single carriageway	< 3.5 m	Double the sum of ESAs in both directions	The driving pattern on this cross-section is very channelized.
	Min. 3.5 m but less than 4.5.m	The sum of ESAs in both directions	Traffic in both directions uses the same lane
	Min. 4.5 m but less than 6 m	80% of the ESAs in both directions	To allow for overlap in the centre section of the road
	6 m or wider	Total ESAs in the heaviest loaded direction	Minimal traffic overlap in the centre section of the road.
More than one lane in each direction		90% of the total ESAs in the studied direction	The majority of vehicles use one lane in each direction.

Step 3 – Determine Traffic Class

Traffic Class	Cumulative Number of ESAs (CESA – one direction)
LE 0.01	0.003 – 0.01
LE 0.03	0.01 – 0.03
LE 0.10	0.03 – 0.10
LE 0.30	0.10 – 0.30
LE 0.70	0.30 – 0.70
LE 1.0	0.70 – 1.0

Step 4 – Undertake DCP Survey

Road condition	Frequency of testing/km*
Uniform (low risk)	5
Non-uniform (medium risk)	10
Low-lying/distressed (high risk)	20



Typical DCP effects with large stones in pavement layer:

(a) cone cannot penetrate at all and the test needs to be re-done;

(b) cone breaks stone but penetration is uncharacteristically hard and DSN_{800} is high;

(c) cone tries to push stone aside. Result is high because of side friction generated on cone shaft;

(d) Usually provides a normal result

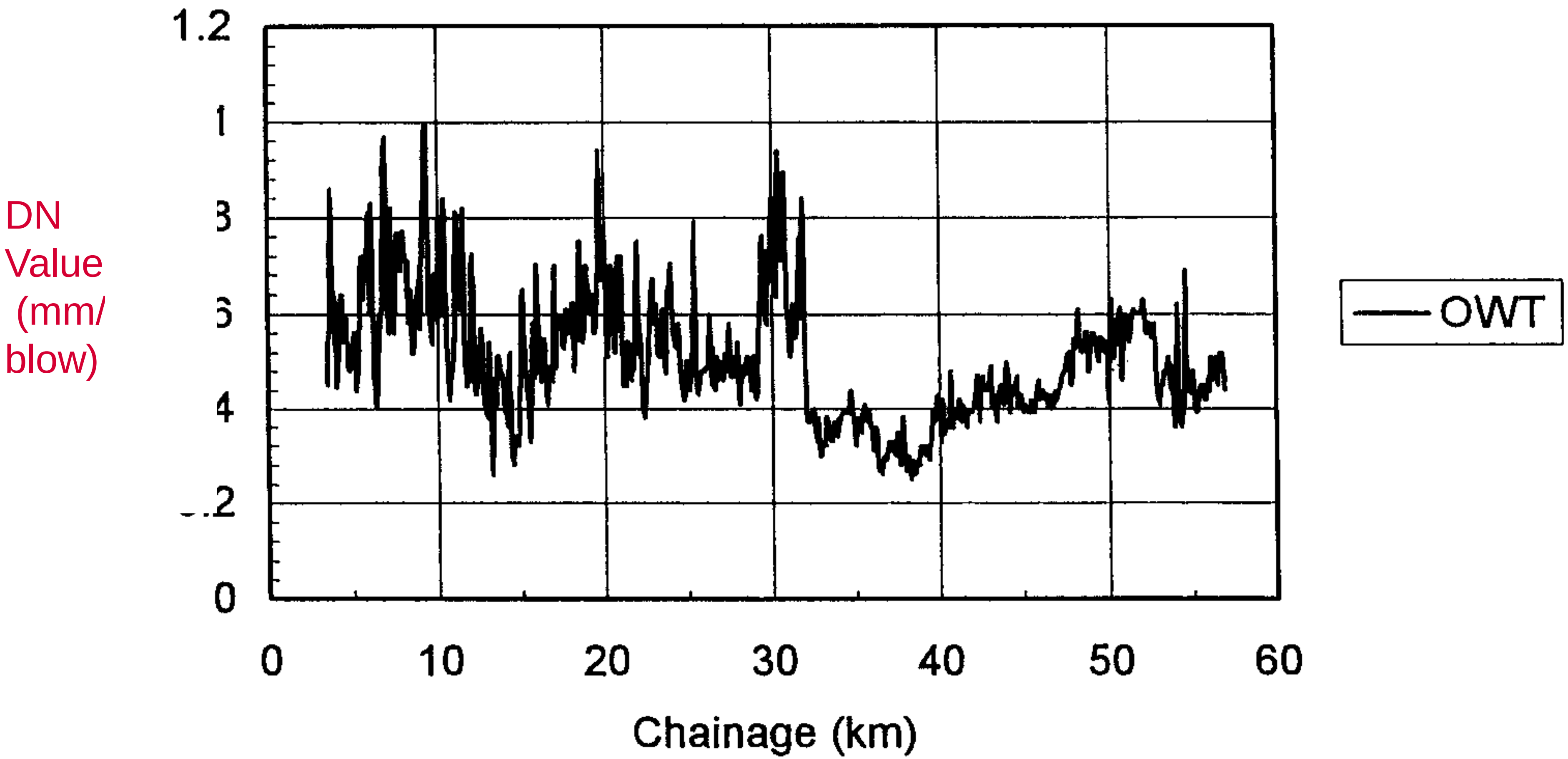
Step 5–Determine MC Along Road Pavement

- Inherent in situ strength of the material is strongly dependent on the prevailing moisture (and density) conditions

- it is essential that an estimate of the in situ moisture condition is made at the time of the DCP survey for comparison with the expected moisture regime in service

- To this end, at least 2 samples per kilometre should be obtained for moisture content determination from the outer wheel track road at depths of 0-150, 150-300 and 300-450 mm.

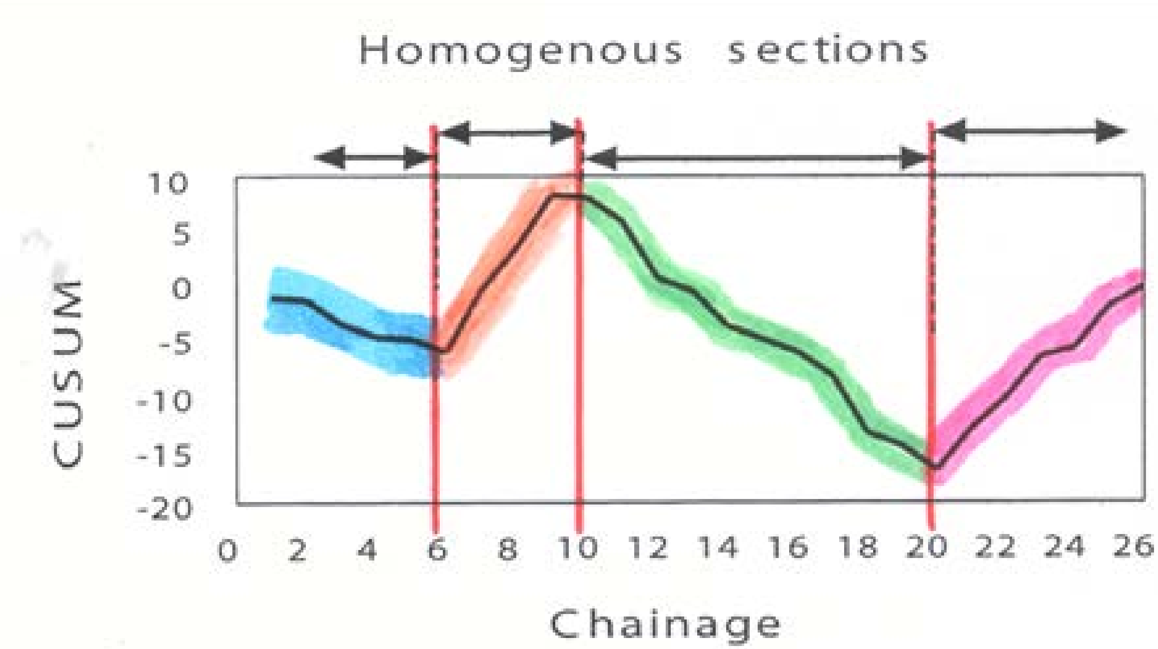
Step 6 – Obtain DN Values Along Road



DCP provides a good "picture" of in situ ground conditions

Step 7 – Determine Uniform Sections

	B	C	
Chainage (Km)	Measured DCP (DN Value -mm/blow)	Difference from average (A-B)	CUSUM (Accumulated values of C)
1	14	-1.2	-1.2
2	13	-0.2	-1.4
3	15	-2.2	-3.6
4	14	-1.2	-4.8
5	13	-0.2	-5.0
6	14	-1.2	-6.2
7	7	5.8	-0.2
8	9	3.8	3.4
9	8	4.8	8.2
10	13	-0.2	8.0
11	15	-2.2	5.8
12	18	-5.2	0.6
13	14	-1.2	-0.6
14	16	-3.2	-3.8
15	14	-1.2	-5.0
16	14	-1.2	-6.2
17	15	-2.2	-8.4
18	18	-5.2	-13.6
19	14	-1.2	-14.8
20	15	-2.2	-17.0
21	9	3.8	-13.2
22	10	2.8	-10.4
23	9	3.8	-6.6
24	12	0.8	-5.8
25	9	3.8	-2.0
26	11	1.8	-0.2
Average: A = 12.8			



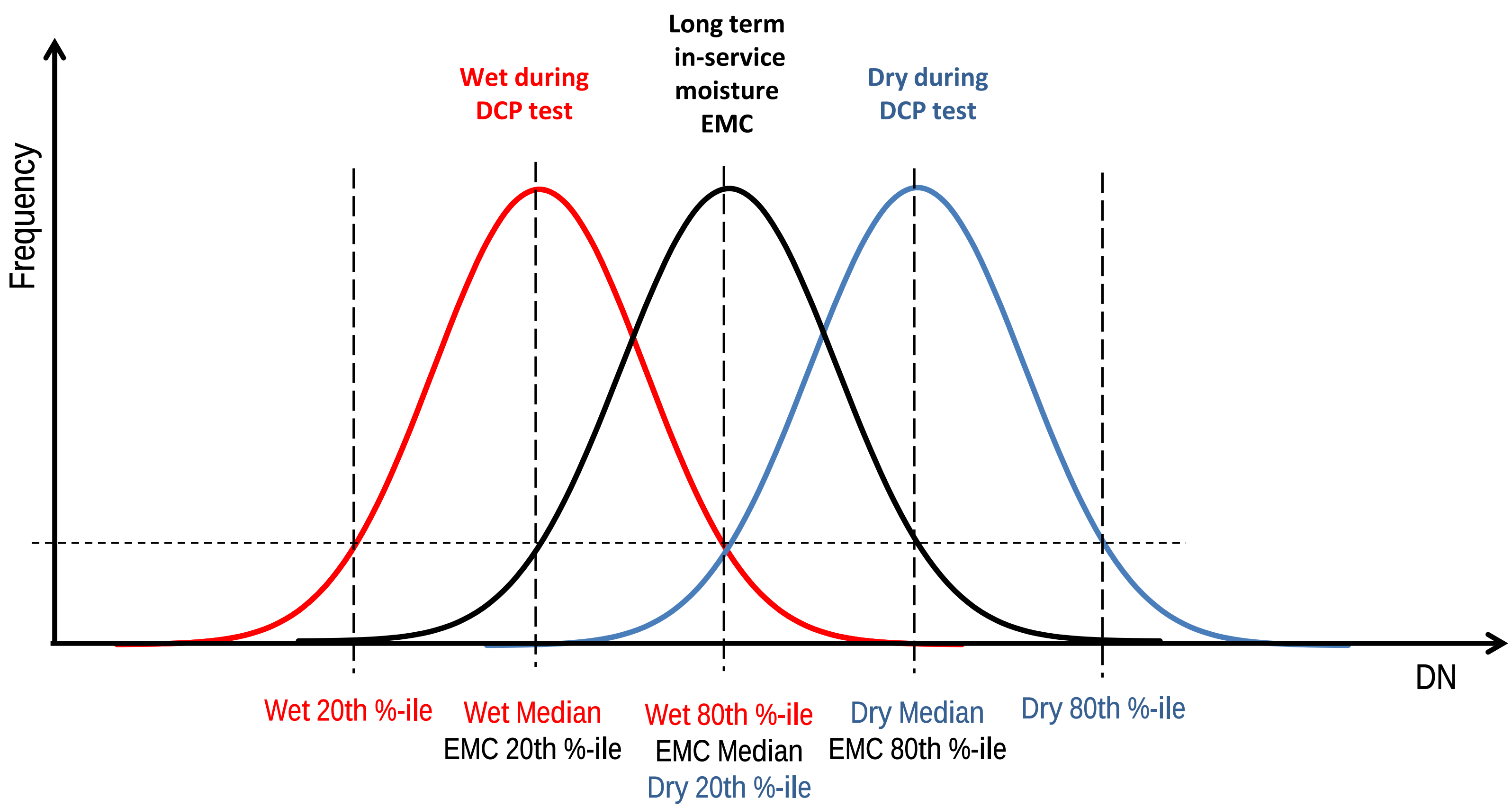
Step 8 – Adjust DN Values for Moisture Environment

Anticipated long-term in-service moisture content in pavement	Percentile of minimum strength profile (maximum penetration rate – DN mm/blow)	
	Design traffic < 0.5 MESA	Design traffic 0.5 – 1.0 MESA
Drier than at time of DCP survey	20	30
Same as at time of DCP survey	50	65
Wetter than at time of DCP survey	80	90

Step 8 – Adjust DN Values for Moisture Environment

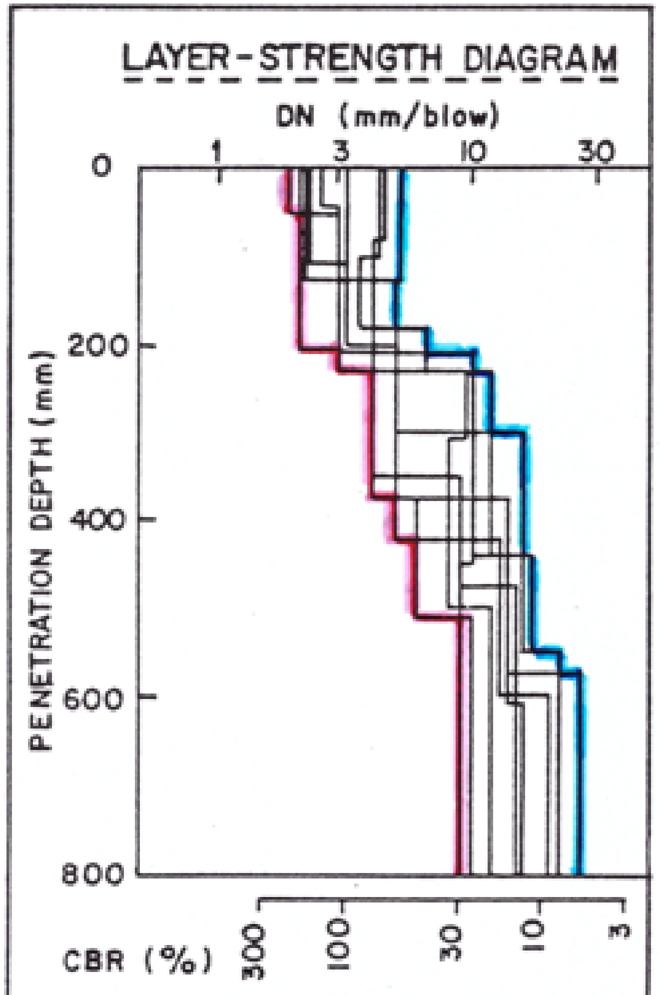
Chainage (km)	Point No	DN 0-150 (Base)	Percentile of minimum strength Profile (max. penetration rate – DN)		
			20th	50th (Mean)	80th
0.00	1	2.29	3.46**	5.24	8.19
0.25	2	4.44			
0.50	3	2.00			
0.75	4	8.67			
1.00	5	3.75			
1.25	6	8.07			
1.50	7	5.11			
1.75	8	5.37			
2.00	9	6.60			
2.25	10	10.12			
Anticipated long-term in-service moisture content in pavement*					
Drier than at time of DCP survey			3.46	N/A	N/A
Same as at time of DCP survey			N/A	5.24	N/A
Wetter than at time of DCP survey			N/A	N/A	8.19

Step 8 – Adjust DN Values for Moisture Environment

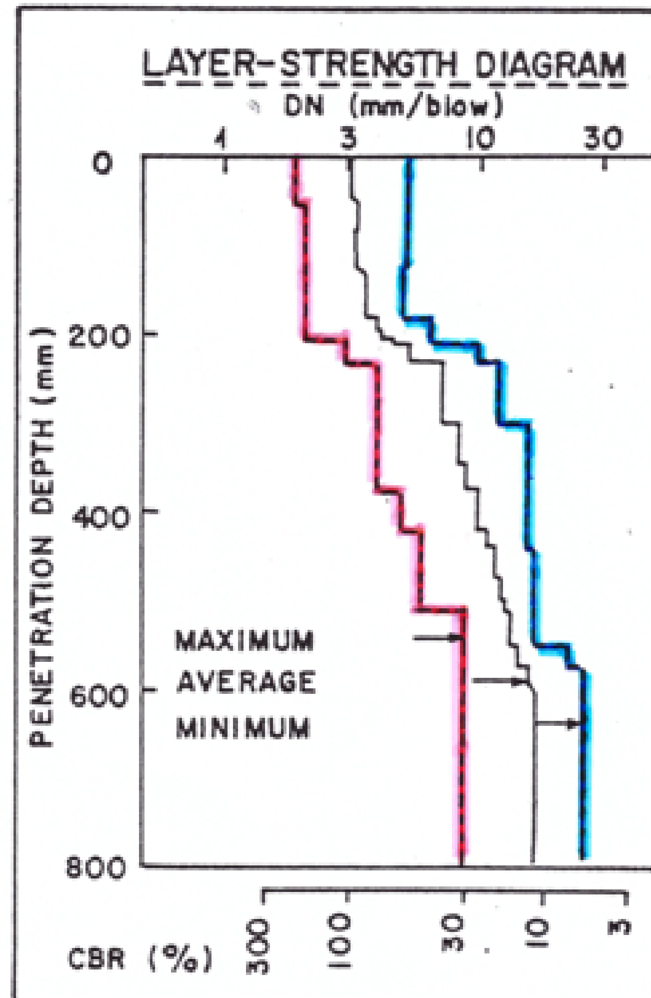


Step 9-Determine In Situ LSP For Each Uniform Section

CROWN AGENTS



Collective DCP strength profiles



Average and extreme DCP strength profiles

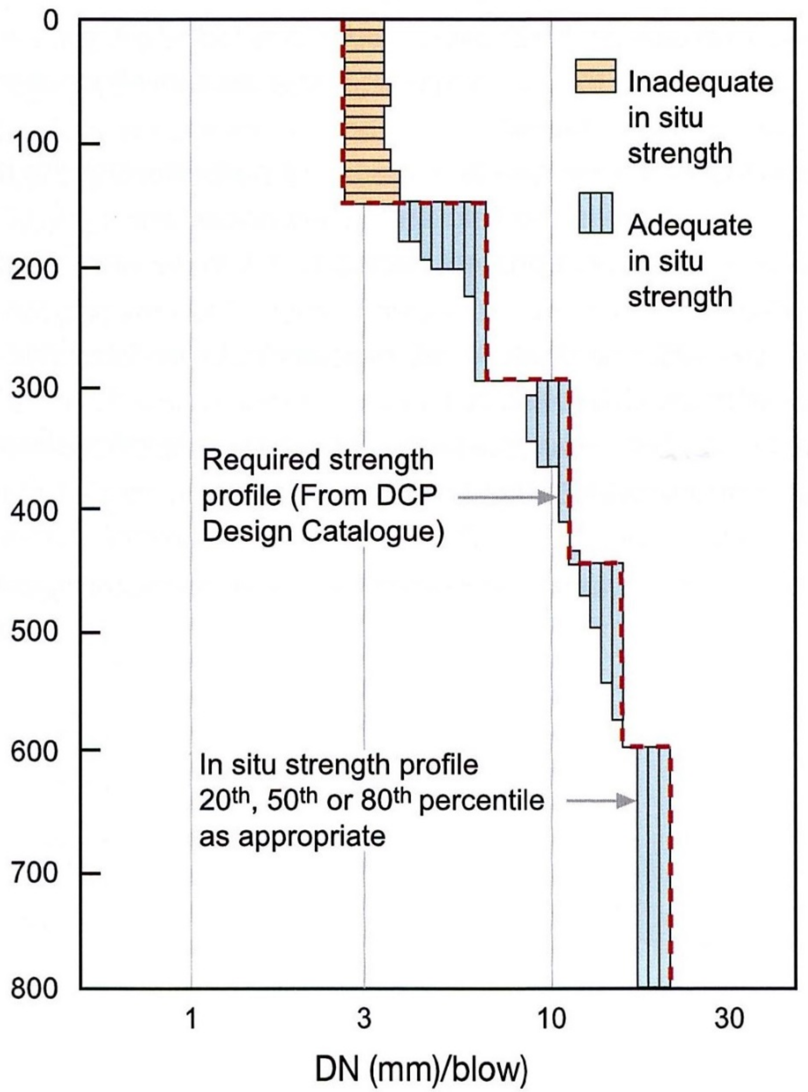
UKaid from the British people

Step 10-Required LSP for Uniform Section

Traffic Class E80 x 10^6	LE 0.01 0.003 – 0.010	LE 0.03 0.010 – 0.030	LE 0.1 0.030 – 0.100	LE 0.3 0.100 – 0.300	LE 0.7 0.300–0.700	LE 1.0 0.700 – 1.0
0- 150mm Base **≥ 98% MAASHTO**	DN ≤ 8	DN ≤ 5.9	DN ≤ 4	DN ≤ 3.2	DN ≤ 2.6	DN ≤ 2.5
150-300 mm Subbase **≥ 95% MAASHTO**	DN ≤ 19	DN ≤ 14	DN ≤ 9	DN ≤ 6	DN ≤ 4.6	DN ≤ 4.0
300-450 mm subgrade **≥ 95%** MAASHTO	DN ≤ 33	DN ≤ 25	DN ≤ 19	DN ≤ 12	DN ≤ 8	DN ≤ 6
450-600 mm In situ material	DN ≤ 40	DN ≤ 33	DN ≤ 25	DN ≤ 19	DN ≤ 14	DN ≤ 13
600-800 mm In situ material	DN ≤ 50	DN ≤ 40	DN ≤ 39	DN ≤ 25	DN ≤ 24	DN ≤ 23
DSN 800	≥ 39	≥ 52	≥ 73	≥ 100	≥ 128	≥ 143

UKaid from the British people

Step 11-Compare In Situ & Required LSP for Uniform Section



Step 12-Determine Upgrading Requirements

	Required DN Value for LV 0.3	DN Values - 80th Percentile						
		Section no.						
		1	2	3	4	5	6	7
0-150	≤ 3.2	8.07	4.81	4.90	4.03	4.45	6.57	3.95
150-300	≤ 6	10.47	7.75	10.07	5.37	5.99	9.71	4.94
300-450	≤ 12	9.69	8.78	10.27	7.79	7.09	9.68	7.37

Inadequate in situ layer

Adequate in situ layer(s)

Comparison of in situ and required layer strength profiles for uniform sections to assess upgrading requirements

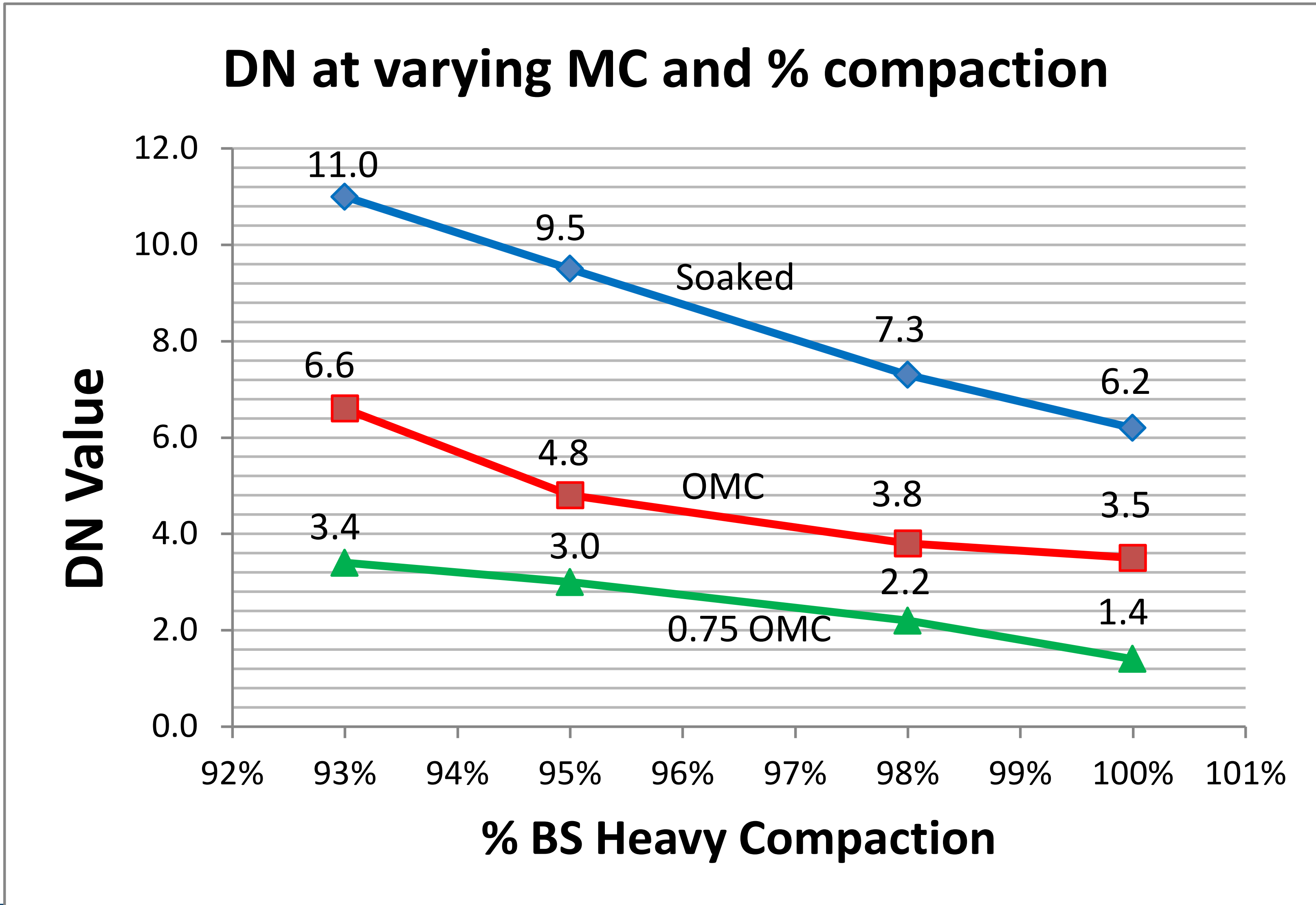
Determine Upgrading Requirements (Cont'd)

- Reworking the existing layer
  - if only the density is inadequate and the required DN value can be obtained at the specified construction density and anticipated in-service moisture content.
- Replacing the existing layer
  - if material quality (DN value at specified construction density and anticipated in-service moisture content) is inadequate, then appropriate quality material will need to be imported to serve as the new upper pavement layer(s).
- Augmenting the existing layer
  - if material quality (DN value) is adequate but the layer thickness is inadequate, then imported material of appropriate quality will need to be imported to make up required thickness prior to compaction.

Material Selection

- DN value serves as criterion for selecting materials to be used in upper/base layer of LVSR pavement
- Provided design DN value is achieved, then in service performance indirectly takes account of actual grading and plasticity at given moisture and density which do not need to be separately specified.
  - DN value provides is a composite measure of materials resistance to penetration (= shear strength) at given moisture and density and is effected by material grading and plasticity.

DN/Density/Moisture Relationship

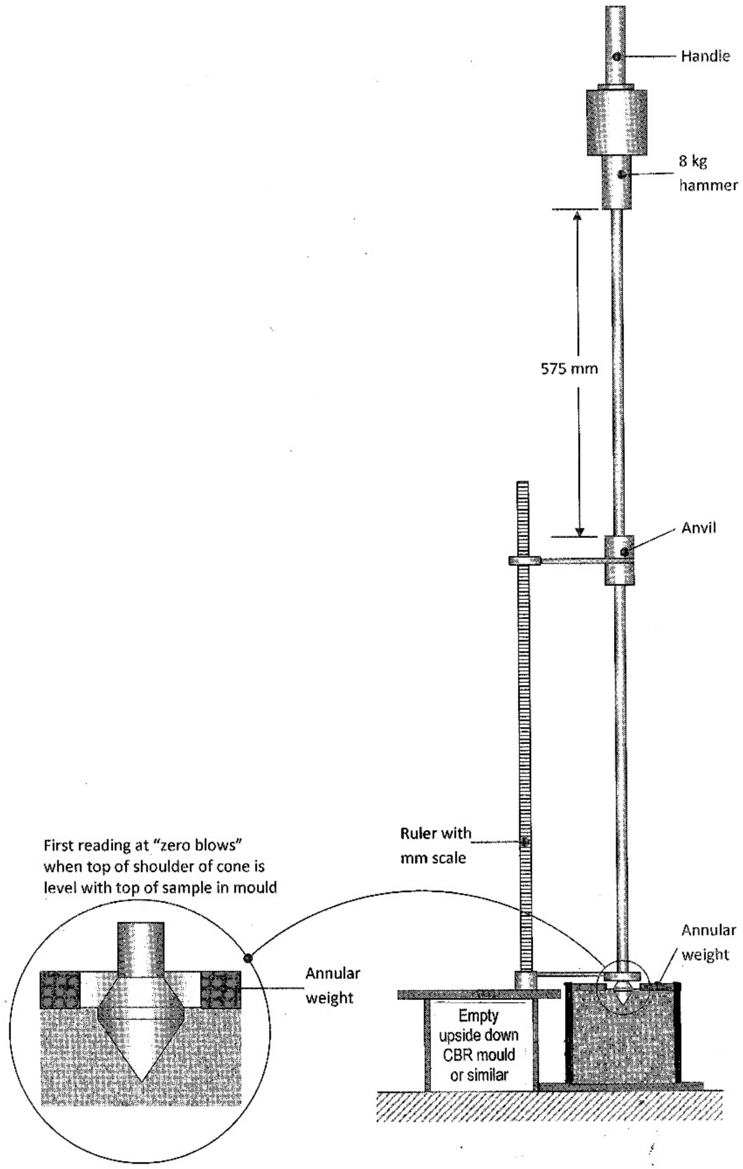


Determination of Laboratory DN Value

DN = h/r where:

h = depth of CBR mould

r= total number of blows to reach depth h



Summary of DCP Method-Strengths

- Relatively low cost, robust apparatus that is quick and simple to use allowing comprehensive characterization of the in situ road conditions.
- Provides improved precision limits compared to the CBR test
- Very little damage is done to the pavement being tested (effectively non-destructive) and very useful information is obtained.
- The pavement is tested in the condition at which it performs and the test can be carried out in an identical manner both in the field and in the laboratory.
- The simplicity of test allows repeated testing to minimize errors and also to account for temporal effects.
- The laboratory DN value is determined over a depth of 150 mm and not just the top 25 – 50 mm as with the CBR test.
- The method is as good or better than any other method in taking into account variations in moisture content and provides data quickly for analysis.

Summary of DCP Method - Limitations

- Use in very coarse granular or lightly stabilized materials.
- Very hard cemented layers in the pavement structure
- The possibility of not recording very weak or thin layers when taking depth measurements every 5 blows
- Poorly executed tests (hammer not falling the full distance, non-vertical DCP, excessive movement of the depth measuring rod, etc.).
- Changes to standard specifications and the associated bidding documents.
- As with all empirical methods, use outside the type of environment (materials, climate, traffic, etc.) in which it was developed.

Conclusions

- Design of light pavement structures using the DCP design method has been successfully carried out on a number of roads in the Southern African region.

- Procedure allows a simple and cost-effective design to be employed, often resulting only in the need to rip and re-compact the exiting upper layer of materials or else to import a single layer of appropriate material that can be placed directly on the reshaped in situ material.

- Using this technique, it will be possible to economically upgrade a significantly greater length of road (often using the in situ materials or at most requiring the importation of a single layer of material) than would be possible using conventional pavement design techniques, without increasing the risk of premature failures.

Thank You

Key Outcomes Of Research On Low Volume Sealed Roads In Ethiopia

19 March 2014

Alemayehu Ayele

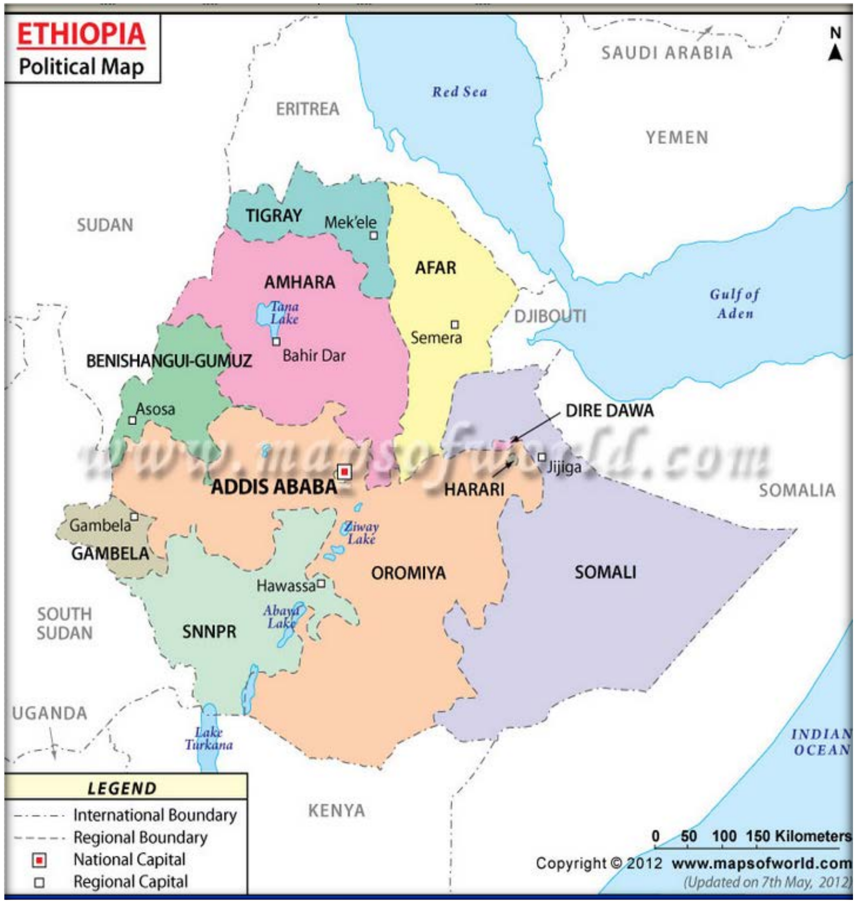
Ethiopian Roads Authority

1. Background
2. Road Research Center Establishment
3. Current Research Activities
4. Low Volume Roads Design Manuals
5. Conclusion

CROWN AGENTS

COUNTRY PROFILE

Name	:Ethiopia (FDRE)
Location	:East Africa
Area	:1.1 mil sq.km
Population	:> 85 mil
Gov't Structure	:Federal State
Economy	:GDP > USD 43 billion
	:Predominantly agricultural
Road Network	**:85,966 km**



Road Class	Length (Km)
Federal	25,756
Regional	32,582
Woreda	27,628
Total	**85,966**

Surface Type	Length (Km)
Sealed (AC & ST)	11,301
Unsealed	74,665
Total	**85,966**

- 70% Regional and Woreda = LVR/Rural Roads
- 86% Unsealed roads

- Low Volume Roads / Rural Roads in Ethiopia typically carry less than 300 vehicles per day
- 70% of the total road network size in the country
- Provide important links from homes, villages and farms to: Markets, health, education and other essential services.
- Wereda Centers and the Federal Road network.

- The provision of this access to the rural community is hugely challenging in terms of cost and quality.
- We need to be able to use locally available non standard construction materials by improving some of their properties.
- Need to adopt new technologies that have worked elsewhere through demonstrations
- The government understood the need to do research to support the big programs of providing access to the rural community.
- Embarked on institutionalizing road research and fulfill all required facilities to do research.
- In 2010 Research and Development Directorate was Established within the Ethiopian Roads Authority – with a task to establish Road Research Center (RRC)

UKaid from the British people

2. Road Research Center (RRC) Establishment

- Location for the research center selected
- Preparatory studies were carried out
- Study tours to major road research centers were conducted (CSIR, TRL, ARRB and KOTI)
- Awareness creation among the local stakeholders through different activities
- Linkages were formed to Academic Institutions (Universities)
- Research Management Committee (within ERA) and Research Steering Committee were formed
- Concept design for RRC was developed

Temporary Research Facility

- Laboratory (Equipment purchased by AFCAP)
- Offices
- Cafeteria
- Meeting rooms
- Library (KIC)
- Reference Books (purchased through AFCAP)

KSI 1- SUSTAINABLE FUNDING

KSI 2 – STAFF RETENTION

KSI 3 – BUILDING RESEARCH CREDIBILITY

- **at least 30 Peer-reviewed papers for publication in journals (by 2022) and conferences both local and international; Industry feedback seminars and conferences;**

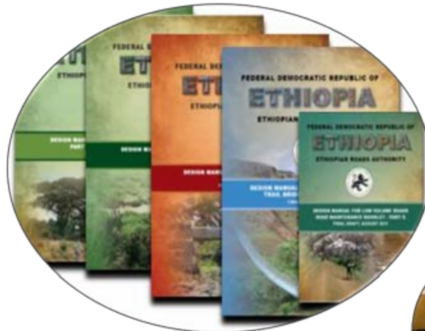
KSI 4 – HUMAN CAPACITY DEVELOPMENT

- **Short and Long term training; international workshops and seminars**
- **Placement of 3 staff /year for up to 6 months with international research organisations**

KSI5 – COORDINATION OF NATIONAL RESEARCH EFFORT

- **Minimum of 4 MOUs with international research organisations**
- **Be an associate member of FEHRL, relevant PIARC committees**
- **RRC staff will be actively involved with the IRF.**

3. Current Research Activities



Development of Pavement Design Standards for LVR in Ethiopia

UKaid
from the British people

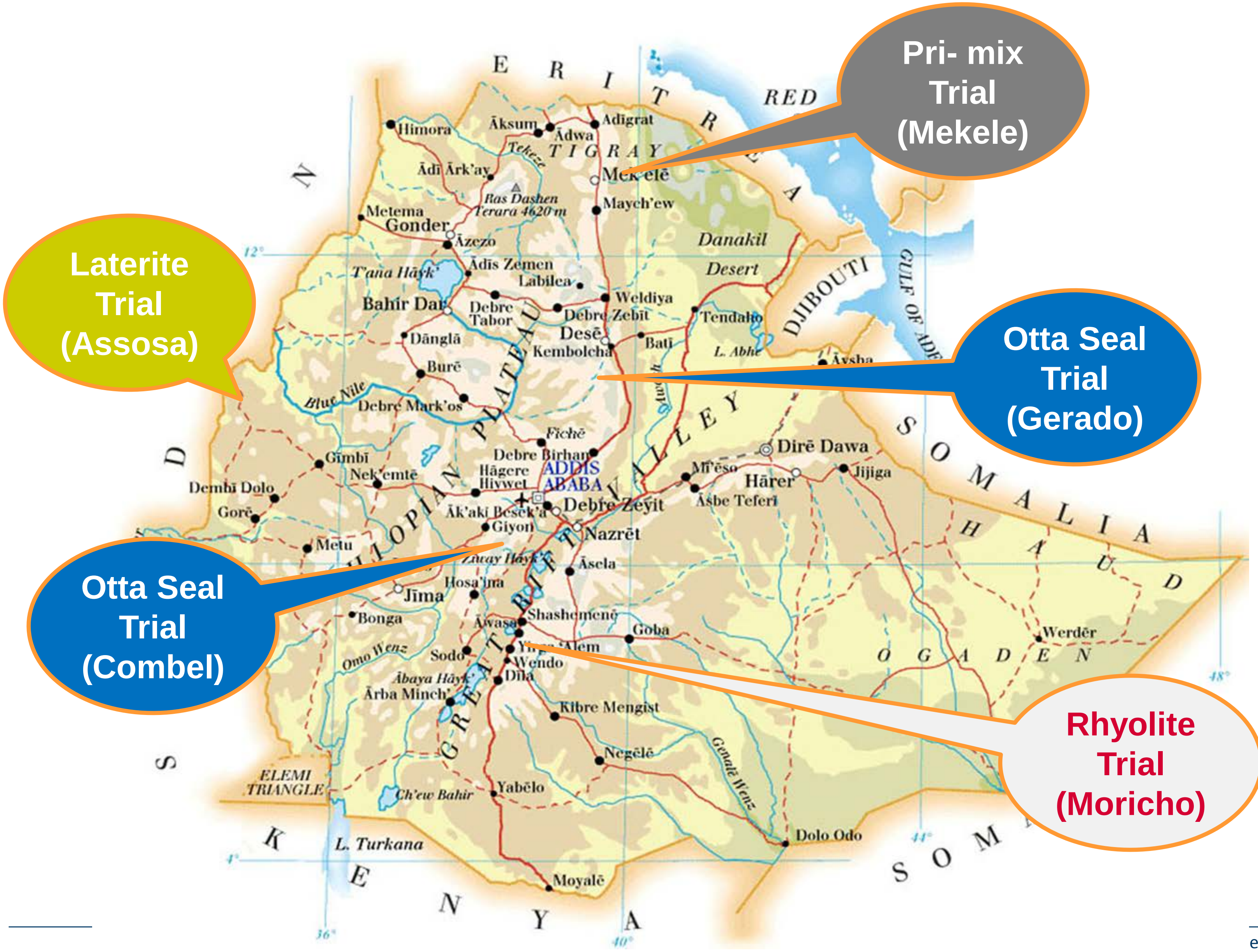
Research works

Development of Pavement Design Standards for LVR in Ethiopia

- Mainly focuses on use of locally available non standard road construction materials
- Pavement and surfacing design standards- particularly for LVRs - Four research sites:
- The projects are supported by AFCAP, Managed by Crown Agents
- Research works are carried out in collaboration with TRL

- Pavement and surfacing design standards- particularly for LVRs Four research sites
  a) Replacement of crushed stone base with laterite (Assosa)
  b) Two village sections with natural gravel road base and Otta Seal surfacing
  c) Improvements asphaltic concrete mix design (Hawusewa–Abala – Irebti Road in Tigray).
  d) Improving the performance of Rehyolite

- Other Research projects – in the areas of Project management,



Pri- mix Trial (Mekele)
Laterite Trial (Assosa)
Otta Seal Trial (Gerado)
Otta Seal Trial (Combel)
Rhyolite Trial (Moricho)
ERITREA
RED
TIGRAY
Aksum
Adwa
Adigrat
Himora
Adi Ark'ay
Mek'elē
Maych'ew
Ras Dashen Terara 4620 m
Metema
Gonder
Azezo
Adis Zemen
Labilea
T'ana Hāyk'
Bahir Dar
Debre Tabor
Weldiya
Debre Zebit
Desē
Kembolcha
Bati
Dānglā
Burē
Blue Nile
Debre Mark'os
Danakil Desert
DJIBOUTI
GULF OF ADEN
Tendaho
L. Abhe
Aysha
Fichē
Debre Birhan
ADDIS ABABA
Hāgere Hiywet
Debre Zeyit
Āk'aki Besek'a
Giyon
Nazrēt
Dirē Dawa
Mī'ēso
Hārer
Jijiga
Āsbe Teferi
Gīmbī
Nek'emtē
Dembī Dolo
Gorē
Metu
Jīma
Hosa'ina
Bonga
Zīway Hāyk'
Āsela
Shashemenē
Āwasa
Goba
Wendo
Dīla
Sodo
Omo Wenz
Ābaya Hāyk'
Ārba Minch'
Kibre Mengist
Negēlē
Genalē Wenz
Yabēlo
Ch'ew Bahir
ELEMI TRIANGLE
L. Turkana
Moyalē
Dolo Odo
Werdēr
OGADEN
HAUD
SOMALIA
SUDAN
KENYA
ETHIOPIAN PLATEAU
GREAT RIFT VALLEY

3.1. Replacement of crushed stone base with laterite (Assosa)

Objectives the project

- Demonstrate the use of laterite as a base material
- Investigate the effect of sealed and unsealed shoulders in cut and fill on pavement strength

Design Chart Requirement (S5, LV5)		**Consultant Design Values for the project**		**Applied on trial section**	
Layer	Thickness (mm), strength (soaked CBR %)	Material type	Thickness (mm), Strength (soaked CBR %)	Material type	Thickness (mm), Strength (soaked CBR %)
Base Layer	175, 80	Crushed stone	200, 80	Laterite at 100 % MDD	200, 70
Sub-base Layer	150, 30	Laterite	150, 45	Laterite at 95% MDD	150, 45

Construction of Trial section

Monitoring

Before and after rainy season to see the effect of moisture – in sealed and unsealed shoulder both in **cut** and **fill** sections

- Moisture content (9X4 locations across the road)
- Deflection Benkelman Beam
- DCP/CBR (9X4 locations across the road)
- Rut depth Measurement
- Classified traffic count
- Axle load
- Visual assessment (Defects)

- Three monitoring periods so far (Base line data was collected after the construction)

Key outcomes:

After construction the rate of deterioration is not significant and the pavement is intact.

It is expected that this research will show

- The effect of the sealing of shoulders on the performance of the base course (wheel path moisture and strength) both in fill and cut
- That Laterites can be used as base on low volume roads (up to 1 x 10^6 mesa)
- The effect of moisture variation on the performance of laterite base in unsealed shoulder both in cut and fill sections

3.2. Demonstration of Otta Seals

Objectives

Demonstration of approaches that have been used successfully elsewhere and could be applicable to roads in Ethiopia. (These include alternative pavement designs, appropriate use of local materials and various surfacing options).

Demonstration carried out in two locations

- Cobel Village (on Tulubolo – Kella Road)
- Gerado Village (On Combolcha – Mekaneselam Road)

Topography, cross section and Materials used

A) Combel

- Demonstration section length is 1900 m
- Road width varied between 5.00 and 7.00 meters.
- gradient between 3% and 5%.
- Materials used – *Weathered basalt, Cinder, Crushed stone and Crusher sand, Cutback Bitumen (MC-3000 and MC-800)*

B) Gerado

- Demonstration section length is 2900 m
- Road width varies between 7 and 10m
- Gradient between 2% to7%.
- Materials used - *Natural Hard Aggregate, Cutback Bitumen (MC-3000 and MC-800)*

Material Production

Cinder

Weathered Basalt

Construction

Base course correction

Application of Cinder

Application of crusher sand by labor

Compaction

Monitoring of Otta seal

Parameters

- Visual defect assessment
  - Raveling
  - Potholes
  - Bleeding
- Classified Traffic counts
- Axle load survey

Lessons Learned

- Materials with high percentage of fines and higher plasticity did not work
- Need to protect (cover) aggregates during wet season
- Need to apply second seals in most cases

Key Outputs

1. Weathered Basalt:- Performing very well
2. Cinder:- *1st quarry-failed*

   Why – high plasticity, too much fine

   2nd quarry – high strength - no fines -non plastic
3. Crushed stone and Crusher sand: Performing very well




2.3 Improvements asphaltic concrete mix design

1. Several sections on Hawusewa – Abala – Erebti for study
2. Sections in flat, and at grade, in high altitude and low altitude
3. Section 59+700 to 59+900 steep grade 9%, changed mix design
4. Still under research

2.4 Improving Performance of Rhyolite gravel

- Trial section constructed in Hawasa
- Different types of surfacing options were tried
    - Cold Mix
    - Stabilized natural rhyolite surfacing
    - Single Surface Treatment (Labor based)
    - Double surface Treatment
- Performance was evaluated for three years: Cold mix, DBST, SST

Key Outcome

- Rhyolite gravel can be used as a base course material for low Volume roads
- Single surface treatments are not long lasting and deteriorate fast under low traffic due to environmental factors

4. Development of Manuals

4.1. Design Manuals for Low Volume Roads

- Opportunities that would provide better and lower cost engineering solutions were missed:
  - Better use of locally available materials
  - Alternative options for road surfacing
  - Application of innovative construction techniques
  - Greater use of local labor

- Therefore, appropriate design standards for Low Volume Roads are required!

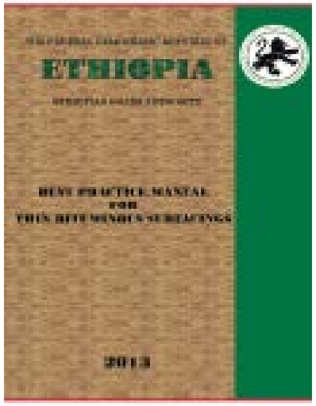
- The development of the manual captures local experiences and knowledge
- Involved all stakeholders in the industry through a series of four "information gathering" workshops
- Printed and distributed to all stakeholders (more than 1200 copies)
- Currently review of the use of manuals is carried out

Organisation	**Number**
ERA	42
Other Addis-based organisations	72
Regional Road Authorities	80
Zonal Road and Transport Offices	69
Woreda /District/ Road Offices	727
URRAP Consultants	271
TOTAL	**1,261**

4.2. Training on surface Dressing Practices

- To develop skill of professionals,
- To develop confidence of practitioners in using surface dressing in LVR construction

- Five one-week training courses for
  - Engineers
  - Technicians
  - Foremen
  - Trainers



- Class room training & practical training on field
- "Best Practice Manual thin bituminous surfacing" was prepared.
- The manual is distributed to the industry (contractors, consultants, road agencies etc)

5. Conclusion

1. LVR/Rural Road Network is still small and needs expansion
2. We need to understand behavior of our local materials for progress
3. Research on low volume roads design and construction shall be encouraged
4. Means of utilization of locally available construction materials shall be developed through research and demonstrations
5. Support from experts is highly needed through Technical Assistance programs in building capacity of local researchers
6. Currently ongoing research projects shall continue
7. Knowledge information sharing with others is very Important and enhances research and development Application – Monitoring – Feedback

THANK YOU !

Cold Mix Asphalt, DCP Design and Other Innovations from Kenya Roads 2000

AFCAP

CROWN AGENTS

UKaid from the British people

AFCAP KNOWLEDGE DISSEMINATION WORKSHOP IN KAMPALA, UGANDA
17th to 20th March, 2014

Presented by:

Esther E. O. Amimo

Assistant Engineer,

Materials Testing and Research Department, Ministry of Transport & infrastructure, Kenya

Presentation outline

1. Roads 2000 Background
2. DCP Design Method
3. Cold Mix Asphalt (CMA)Technique
4. CMA Construction
5. Quality control
6. Material properties
7. Discussion
8. Ongoing Activities

Roads 2000 Background

- Roads 2000 concept – developed in Kenya in early 1990's from challenges and experiences of the Rural Roads Access Programme (RARP)
- Main objectives
  - To provide sustainable all weather access to rural communities
  - To improve socio-economic development of the rural population
  - To create employment through labour intensive techniques in execution of roadworks
- Involves new construction, routine maintenance, spot improvements and rehabilitation of the road network

Roads 2000 Background

- Main Characteristics
  - Use of locally available “non-standard” materials and other resources
  - Use of labour intensive techniques or a combination of labour and equipment as practical
  - Continued Research and Innovations (Low cost seals, alternative stabilizers, DCP design Method etc)

- Phase II ongoing in Central province:
  - 400Km of gravel roads
  - 100Km of LVSR

DCP Design Method

- Introduced in Kenya in 2011 through AFCAP initiative
- Training Workshop in South Africa's Council for Scientific and Industrial Research (CSIR)
- 2 Engineers from MTRD and 3Engineers from KeRRA participated
- 5 trial sections proposed for design and construction in Central province
- *Design and Construction done for 3 trial sections i.e*
    - *Road D379 Kiambu (400m) – completed in June 2012,*
    - *Road E511 Muranga (900m) – in progress (500m complete)*
    - *Road D382 (600m)Nyandaura – in progress*
- Design guided by the Malawi DCP Design Catalogue

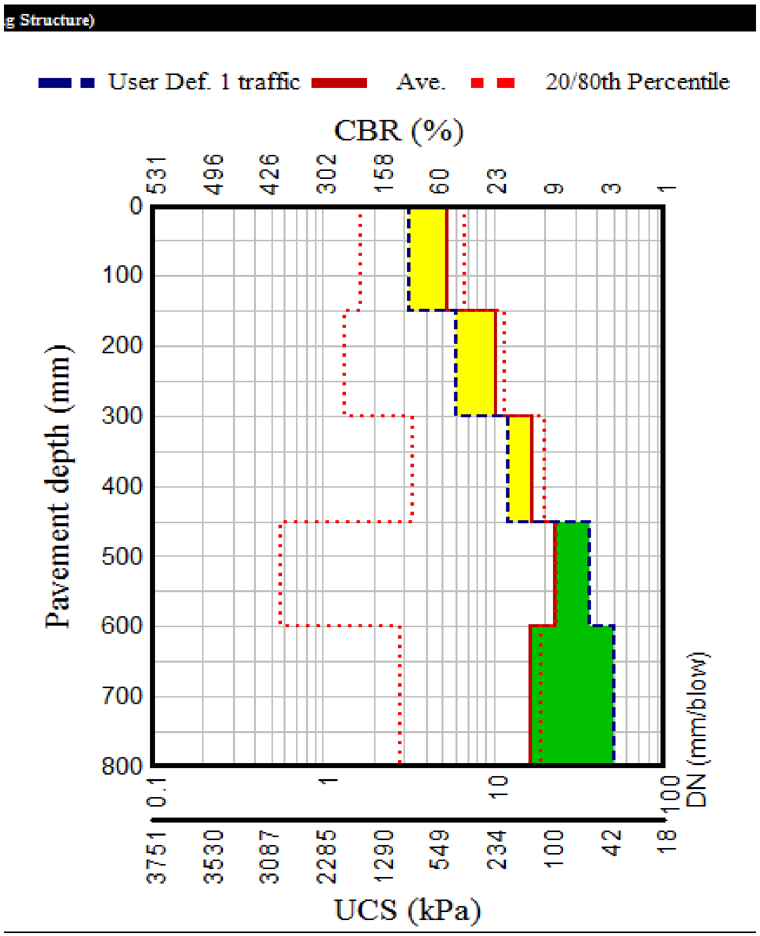
DCP Design Method

- Design Traffic Loading

Road	Traffic Loading ($E80x10^6$)	Traffic Classification* ($E80x10^6$)
D379	0.069	LV 0.1 (0.030 – 0.100)
E511	0.044	LV 0.1 (0.030 – 0.100)
D382	0.227	LV 0.3 (0.1 – 0.300)

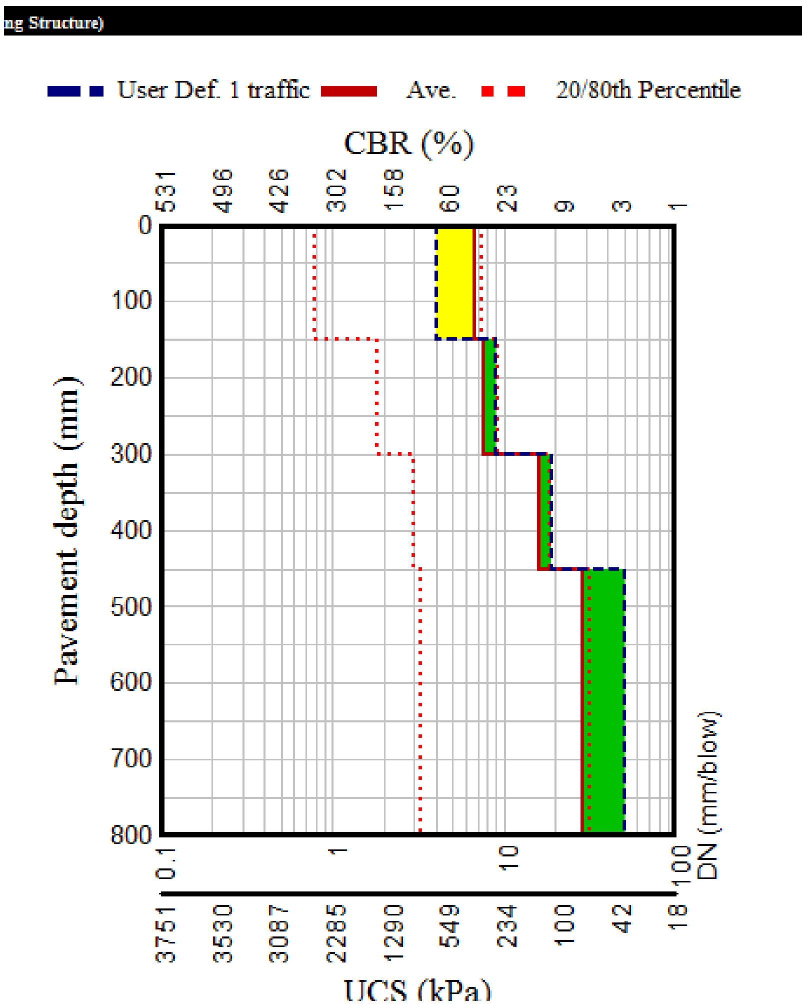
* Malawi traffic classification for LVSR

- DCP tests were carried out in November 2011 in the mid rainy season and in January during the dry season
- DCP data was analyzed using WINDCP software developed by CSIR

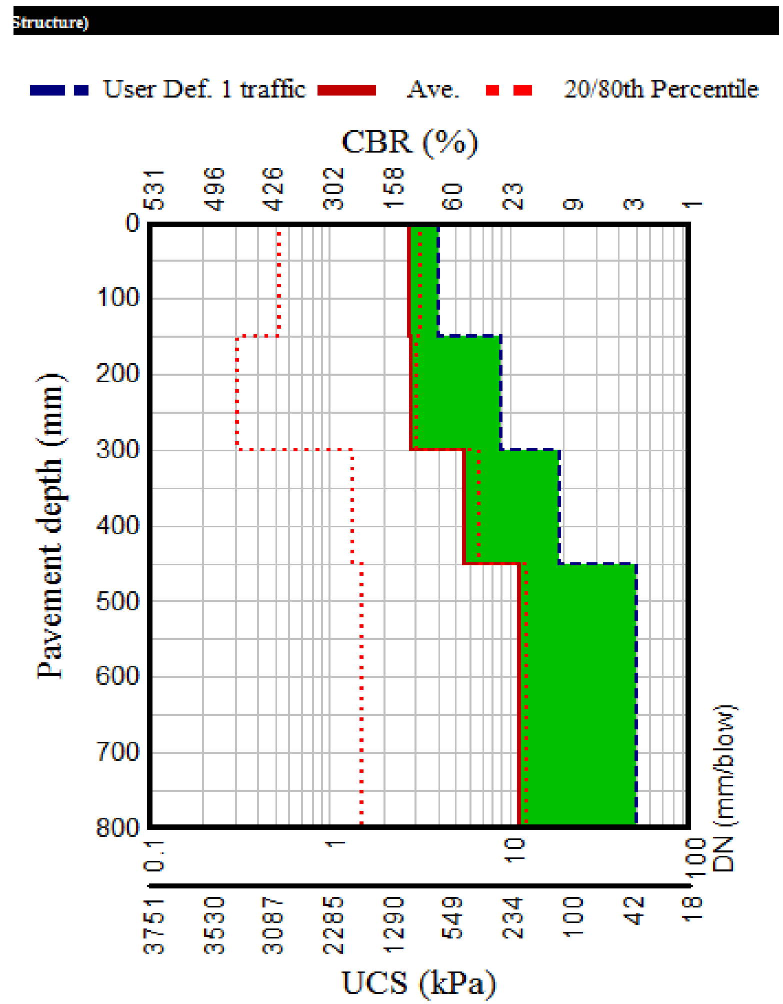


Layer Strength Diagram (Average) for D382 Nyandarua

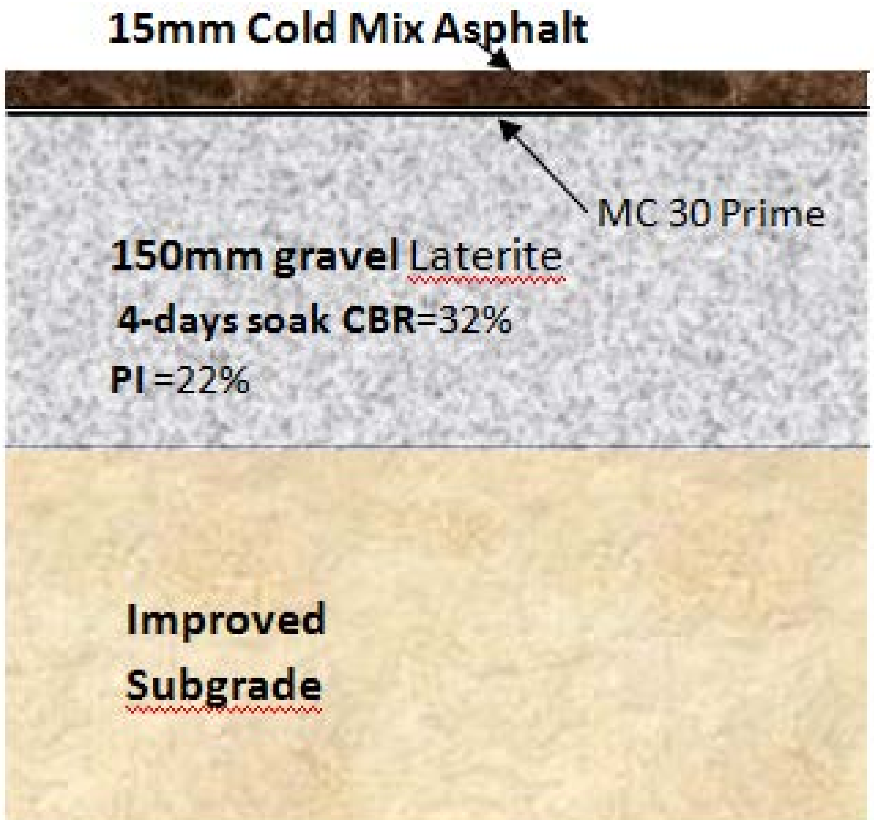
DCP Design Method



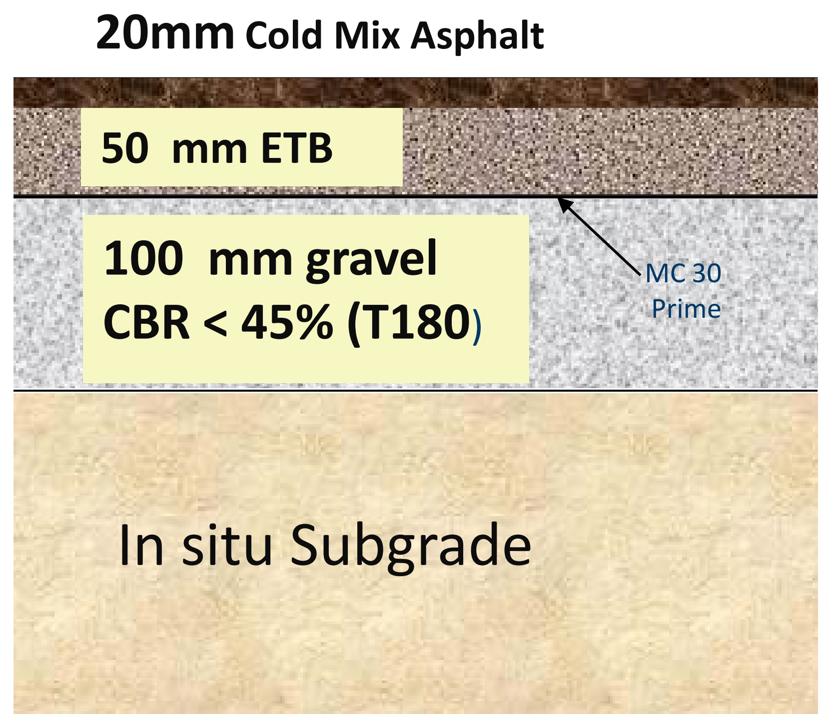
Layer Strength Diagram (Average) E511
Muranga



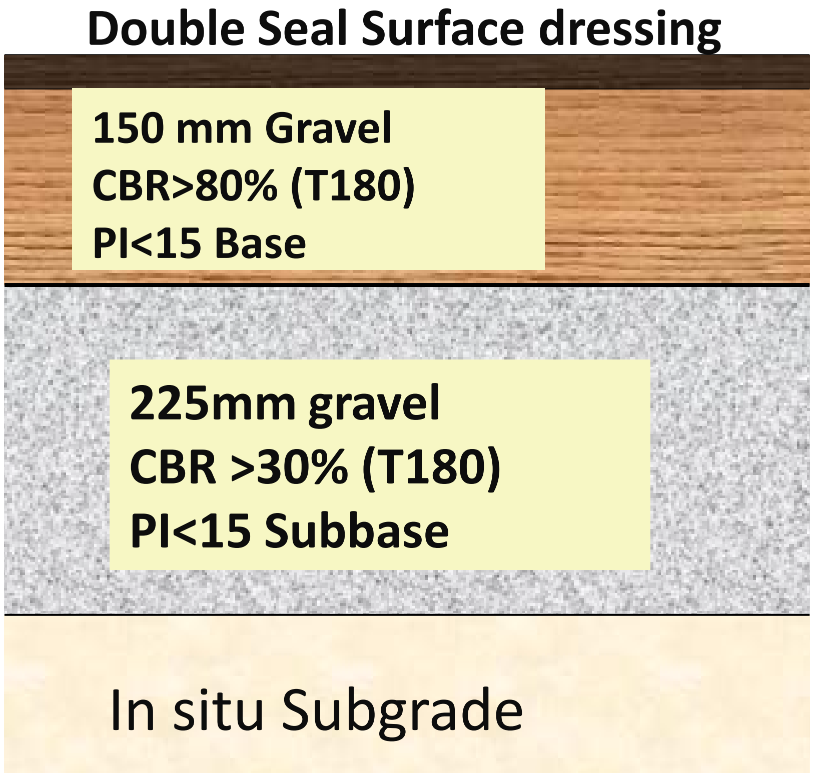
Layer strength Diagram (Average)
D379 Kiambu



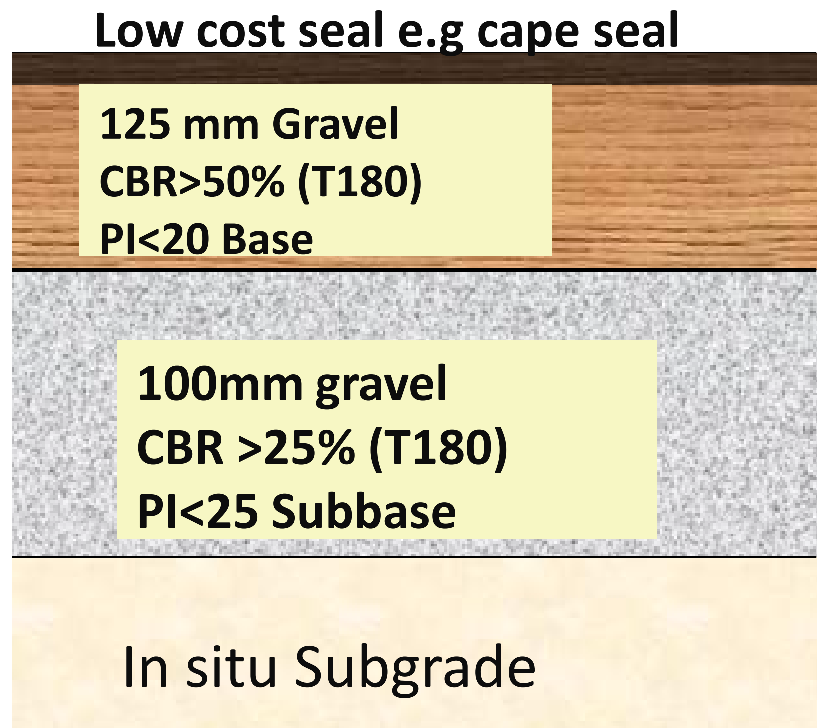
Constructed pavement structure for D379 trial section



Proposed pavement structure for D382 and E511 trial sections



Standard Pavement Structure based on Kenya RDM



Pavement Structure for Low volume roads (Chapter 12 of the RDM)

Cold Mix Asphalt Technique

CROWN AGENTS

Basic mix recipe applied and adapted through limited "hands-on" trial mixes before full scale application

Construction by labour

- Max. batch volume – 40 litres

Aggregates

- 6/10mm – 12litres
- 0/6mm – 28 litres

Binder

- CSS-65 cationic emulsion - 6litres
- Residual bitumen content 5 – 6 %

Water

- 1litre (if dry aggregates)

Tools and equipment

- Mixing tray
- Flat/square nosed spades
- 20x20mm steel guide rails
- Spreaders and screed
- Pedestrian roller
- Brooms
- Watering cans
- Batching boxes / measuring containers

UKaid from the British people

CMA Construction

Tack coat

- Thin layer of SS-60 applied by bucket or watering cans and brooms

CMA Construction

Mixing trays prefered over concrete mixers

- Can be made locally
- Easy to stack and transport
- Concrete mixers difficult to clean out

CMA Construction

Ready mix tipped in between guide rails

- Use of wheel barrows (double handling) not needed when tray placed adjacent to strip to be surfaced

CMA Construction

Mix spread and screeded level with top of guide rails

- Guide rails 20 x 20 mm gives approx 15 mm compacted CMA
- Thickness can be varied by using larger guide rails, e.g. 25 x 25 mm gives approx. 19 mm compacted CMA

CMA Construction

Compaction and traffic control

- Normally within ½ hour
- Pedestrian roller only required (e.g. Bomag 75)
- First pass in static mode
- Careful not to over-compact before emulsion has set
- Fresh CMA susceptible to damage by turning vehicles
- Traffic nomally allowed next day

Quality control

Control of CMA thickness

- Base corrections if required
- Placement of guide rails to prevent thin spots over high points in base

Batching

- Control of accurate mix proportions and mixing process

Spreading and screeding

- Use of correct tools (no rakes) and technique to prevent segregation of coarse aggrregates

Compaction

- Timing and correct compaction technique

Joints

- Open longitudinal and transverse construction joints sealed with emulsiuon and crusher dust

Material properties

CROWN AGENTS

Grading

- Continuous grading recommended for dense mix and impermeability
- High fines content may result in balling

Grading envelope			
Sieve size mm	Percentage passing		
	Min	Recomm.	Max
14	100	100	100
10	85	96	100
6.3	62	70	78
4	46	52	60
2	28	34	40
1	16	21	26
0.425	7	10	13
0.3	5	7.5	10
0.15	2	4	6
0.075	1	2	3

UKaid from the British people

Material properties

Strength and shape

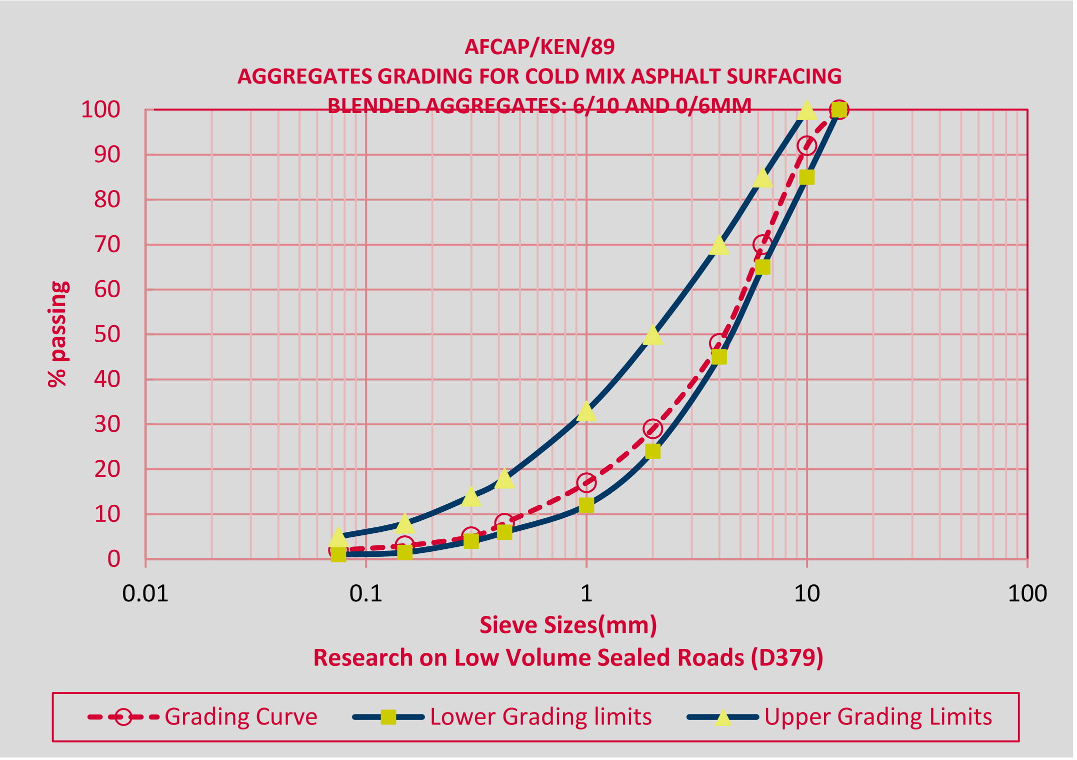
- Specifications basically adapted from Otta Seal (graded gravel/crushed aggregates)
- Lower quality stone than for Surface Dressing due to different performance characteristics.

Parameter	Spec.
Min. 10% FACT (dry)	90 kN
Wet/Dry strength ratio	0.60
FI (for 6/10 mm fraction (%)	Max 30
SSS	Max 12
PI on material passing 0.425 sieve	Non plastic

Outcome of CMA in Kenya

D379 Wamwangi – Karatu

- Grading towards lower side of envelope
- Appeared fairly open when fresh



Outcome of CMA in Kenya

D379 Wamwangi – Karatu

Position	IRI (m/km)
RHS - OWP	3.4
RHS - IWP	3.1
LHS - OWP	3.0
LHS – IWP	3.5
Average	**3.2**

Advantages of Cold Mix Asphalt

- Contractor and labour friendly
  - Removes hazards of working with hot bitumen
  - Technique easy to learn
  - Quality control simplified
- Eliminates need for heavy construction plant and equipment
- Permits “seal as you go” approach
- Contributes to creation of community employment
- Durable
- Good riding quality
- Ideally suited to maintenance operations

Discussions

- Design of lightly trafficked roads can benefit from the DCP design Method – simple quick and easy method
- DCP apparatus provides results that represent actual field conditions for pavement layers
- Sections with cold mix asphalt surfacing generally performed well
- Some development of hairline cracks (shrinkage in base)
- Initially CMA will appear to be fairly open and porous, but beds down and densifies quickly under traffic.
- No aggregate loss or bleeding observed

Ongoing Activities

- Continued monitoring of the trial sections for long term performance
- Further develop specifications, mix design procedures
- Develop mixing techniques for CMA surfacing to broaden the scope for using local materials
- Perform Marshall tests on samples for stability, density and void content
- Subsequent roads (in the Roads 2000 LVSR) constructed with 20mm CMA surfacing (ongoing) to counteract spots with uneven surface of base

Thank you /

Mozambique RRIP/AFCAP LVRs Research – Key Findings and Outcomes (TRL/ANE)

by Kenneth Mukura - TRL

MoW/AFCAP Low Volume Roads Workshop, 19 March 2013

CONTENT

1. Characteristics of Mozambique – the challenge
2. The Need
3. Details of Individual Research Projects

- Problem, solution through research, outputs, outcomes

4. Recommendations

Key characteristics of Mozambique

1 Mozambique is a very large country < 10% of low volume roads are sealed.

2 Costs: Cost of construction and maintenance is very high.

3 Materials: Good materials are very scarce, vast areas covered in fine coastal sands.

4 Rainfall: very low to high rainfall (with more frequent tropical storms and cyclones).

5 Temperatures: generally very high – up to 45˚C in some places.

6 Terrain: generally very flat – makes drainage design difficult.

Cabo Delgado – Xitaxi Moeda concrete slabs & LB CTB+surfacing





Maputo: Marracuene-Macaneta Rd

1. Phase 2: section 1

Passability: Rump

Soln: 150mm SG, 100mm ETB, slurry seal (0.78km long)

Section 2

Passability: floods (~ 0.5m) and is swampy

Solution: Min FL+ embankment needed+150mm gravelling (0.5km); 500mm embankment + gravelling for next 5.4km; 150mm SG+150mm base for km)

Design:

- 70% to 30% blend of sand and clay (matope) respectively
- ETB designed with 6% emulsion stabilisation of locally available unsuitable fine sand + 10mm slurry seal
-

Maputo: Marracuene-Macaneta Rd

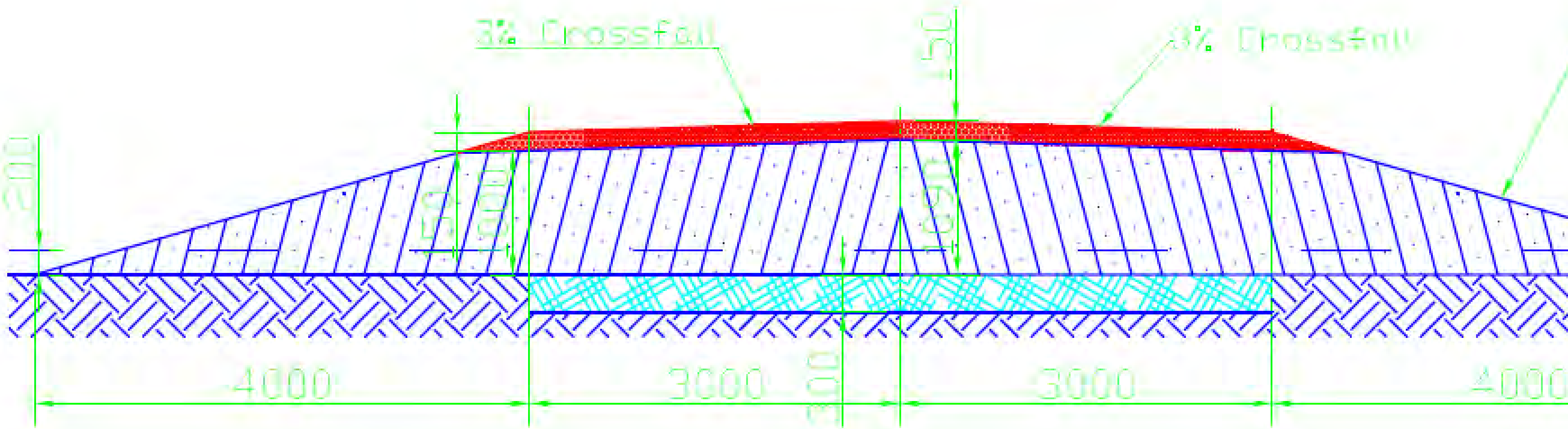
Sln: blended sand/clay (matope)- 70:30

All weather passability – 3yrs

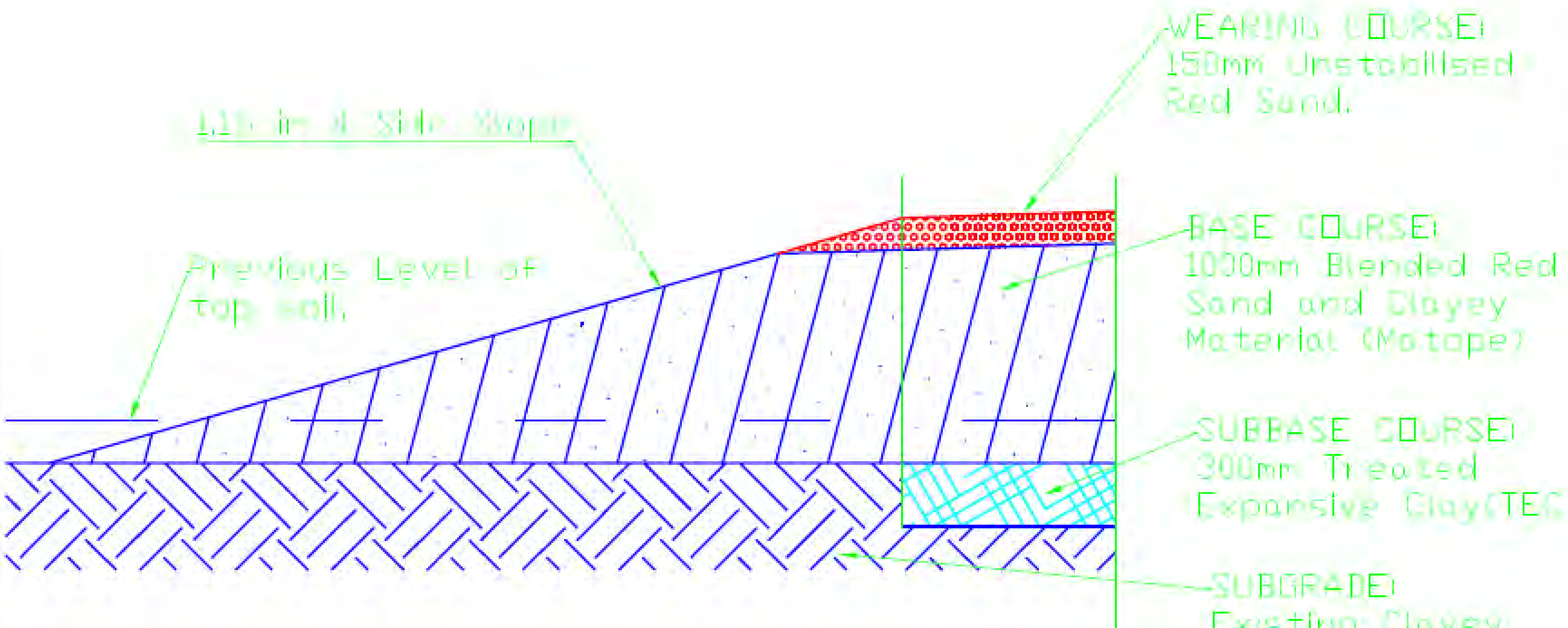
Black cotton soil & loose sand

Impassable during the rainy season, difficult to pass in dry season

Tidal flooding affecting passability during high tide



Trial Section 2: Treated Expansive Clay and Blended Clay Embankment Cross-sect



MOZAMB

Trial S
Expans
Blende
Sectior

Length

Drawing
Andrew

Februa

ETB Design

1. Traffic: > 250 vpd, 90% light vehicles (pick-ups), < 4% medium truck, zero heavy trucks.
2. Locally available materials: very fine coastal sands
3. Limited funding
4. Design:

Mainly passability criteria

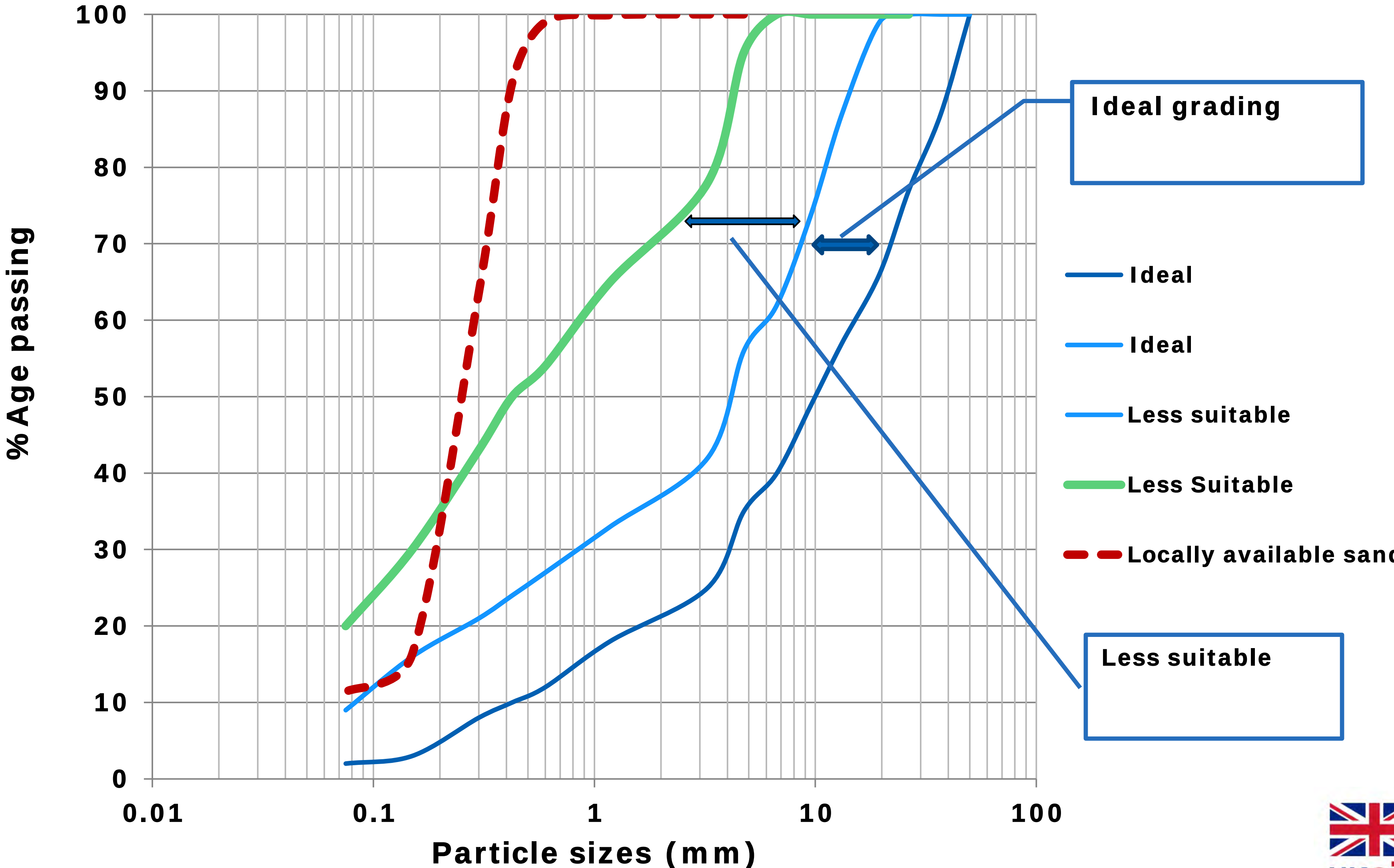
0+000 to 0+780: regularised existing road, 150mm subbase (old ETB and neat sand), ETB (50mm, 75mm, 100mm, 150mm).

1+000 to 10+000: embankment and wearing course – clay/sand mix, 30:70.

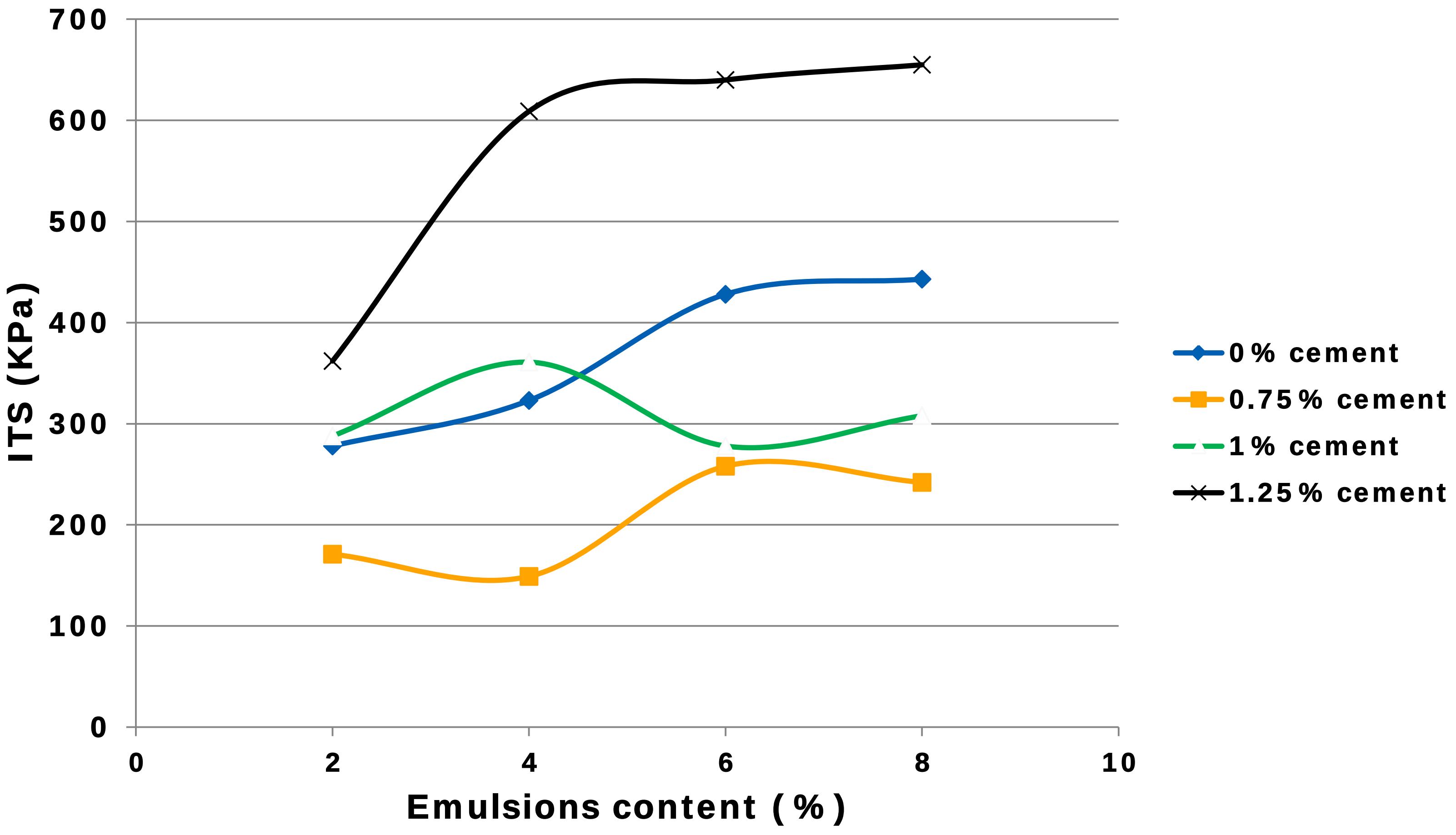
ETB Design Specs

	BSM1	BSM2	BSM3
Parameter	>6MESAs	<6MESAs	<1MESAs
ITS-dry (Kpa)	>225	175 -225	125 - 175
ITS-wet (Kpa)	>100	75 -100	50 - 75
UCS (Kpa)	1200-3500	700-1200	450-1200
P0.075		5-20	0-20
GM (Kpa)	2.0 -3.0	1.2 -2.7	0.15-1.2
PI	<6	6-12	>12

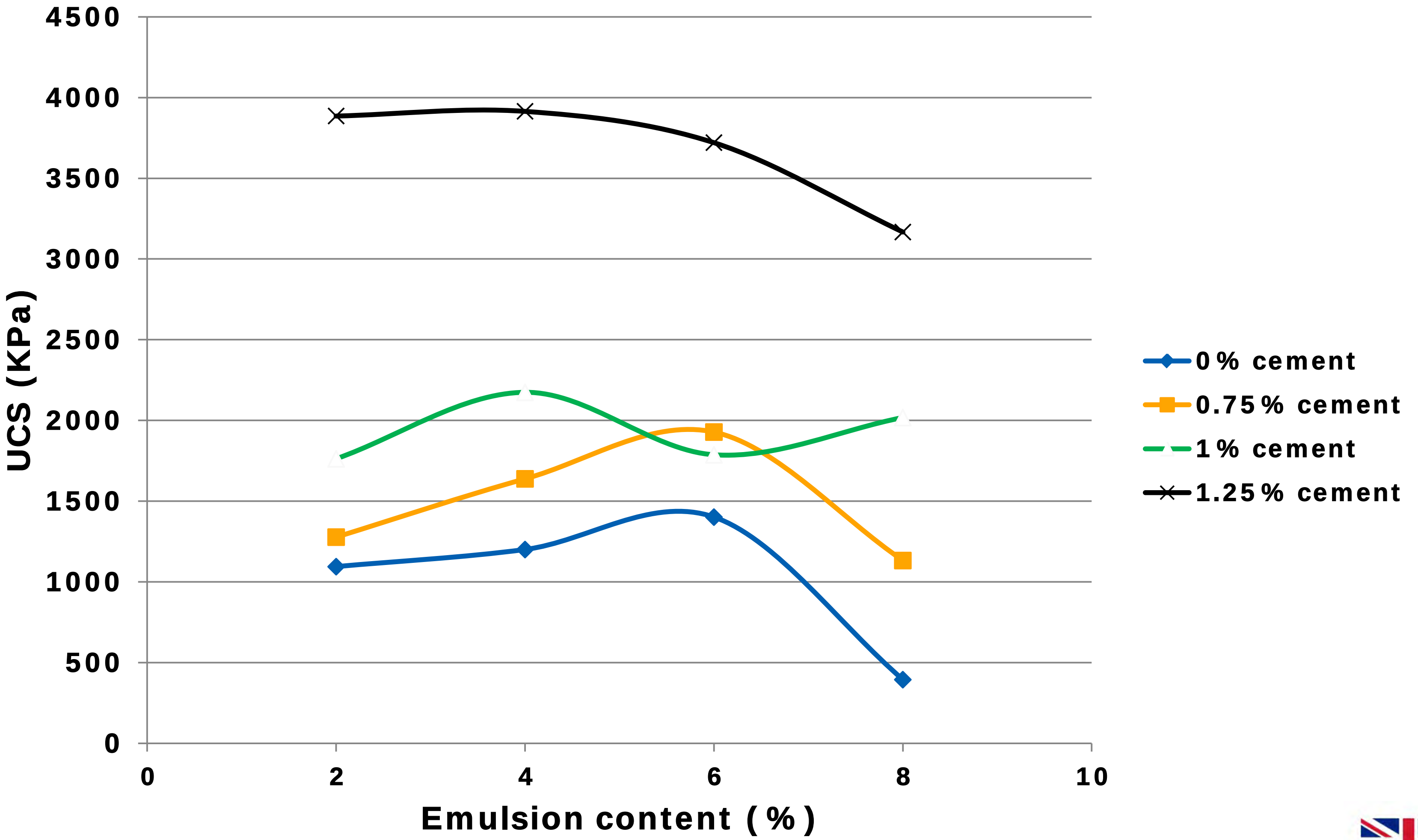
Materials – locally available sand



ETB Design – ITS (dry)



ETB Design: UCS dry



ETB Construction

1. Precautions

Control of optimum fluid content (OFC):

OFC = OMC (optimum moisture content of natural material)

Use light compaction equipment

Allow time for emulsion to break before full compaction

2. Technology

Labour based

Medium technology

Mechanised

Construction of ETB and slurry seal

Chinhacanine Nalazi Project

1. Project description

2km of embankment (1700mm)

300m of cement stabilised blend of clay and sand

1700m blended base 60/40 sand and clay+ armouring

Surfacing:

> **Penetration macadam (20-40mm aggregate first layer, 5-13mm second layer), single seal with sand seal, sand seal**

1. Observations

Armoured base was trafficked at start of rainy season on unprimed and primed sections – No deformation noticed on primed section but stone displacement noticed on unprimed sections – *positive performance indicator*.

No failures noticed on cement stabilised base.

Tropical storm caused washaways at culvert points and small bridge –*recommend construction of causeway or vented drift*

Water did cut the road at culvert points – *wing wall not open wide enough: need to change design std. and strengthen backfill of structures*

Chinhacanine Nalazi Project – Before and construction of blended/ armoured base






Inhambane: Cumbana Chacane Road

Section	Description	Remarks
Section 1 Unpaved (6km)	Blended wearing course 50:50 calcrete and sand	Performance based specifications developed by TRL were used
Section 2 and 3	Blended base 50:50 calcrete and sand with Otta seal	Resultant base with CBR=40%, Calcrete graded aggregate with nominal size of 13mm ACV=25.4. Binder rate 1.2, 1.5, 1.6, 1.8, 2.0, 2.4 L/m2
Section 4	Armoured base with sand seal	100 – 120mm neat sand base + layer of aggregate 20-40mm (50mm max)
Section 5	Neat sand base with penetration macadam surfacing	Red sand (CBR=26-36), penetration macadam 1st layer (20-40mm) second layer of 5-13mm or sand.

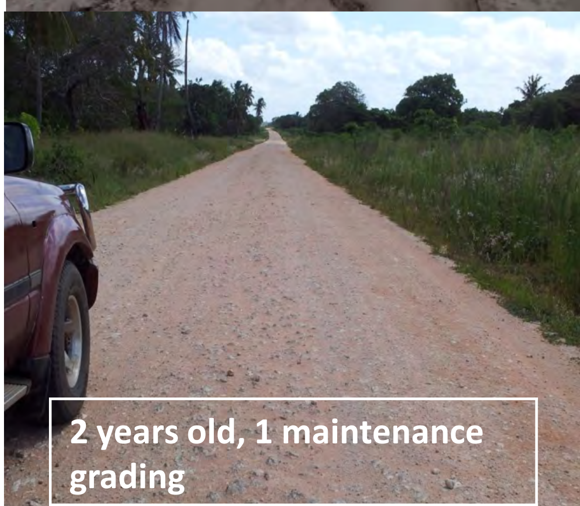
Cumbana Chacane Road – Blending

Before and after intervention


Before intervention


Blended wearing course and base


Otta seal surfacing


2 years old, 1 maintenance grading


Good construction


Poor construction

Challenges

1. The calcrete had too much powder (dust) and the dust was covering the binder before the aggregate landed.
2. The binder distributor was brand new but it was spraying badly – recommended for it to be converted into a water bowser.
3. ACV was good < 26 but there was a small percentage of weak aggregate
4. Due to low traffic volumes extended rolling of the Otta seal was required (compensatory rolling) to aid curing of the surfacing
5. The contractor did not correct the construction defects during the defects liability period

Cumbana Chacane – Ph3: Construction of armoured base

Cumbana Chacane – Ph3: Penetration macadam






Challenges

1. Armoured base

Distributing the aggregate evenly on the full width of carriageway

Getting adequate compaction

Ensuring that the aggregate protrude above the fine material

Construction was too slow – too long before second layer of sand was applied

2. Penetration macadam on neat sand base

Embedment of aggregate into sand base during heavy rolling

Inhacufera Machaze Project

CROWN AGENTS

1. Observations

Phase 2

Most sections are performing fairly.

Section where 1.4L/m^2 of binder was used shows signs of aggregate loss but 1.6L/m^2 or more are performing well structurally but stripping is taking place.

Section from 5+000 to 5+600 which went for a long time before opening to traffic due to uncompleted structures is also showing minor aggregate loss – *needs fog spray*

Phase 1

Section is approximately 5yrs old most sections are performing well structurally but aggregate loss noticed

A few small and shallow potholes were observed not exceeding 10m^2 in area caused by poor curing – *need patching*

UKaid from the British people

Inhacufera Machaze Road-Otta seal

Single Otta seal + sand seal
Single Otta seal + grit seal
Double Otta seal

In good condition after ~4.5years

Single Otta did not cure (19mm max aggregate

Single Otta cured, binder application was poor (13mm max aggregate

Beira Savane Project

1. **Phase 2 section: 4km in total**
2. **Section 1: 100mm ETB + 15mm slurry seal**
3. **Section 2: 100mm ETB +sand seal**
4. **Section 4: 100mm CTB + sand seal**
5. **Section 4: 100mm ETB + DSD**

MC30 prime applied at 0.6 – 0.8L/m2

SS60 binder applied at 4% emulsion content

ETB was trafficked for 7 months and did not fail

ETB Construction – Medium technology

ETB mixed using concrete mixer

ETB mixed using disc harrow

Zero Mopeia Project

1. Phase 2 section: 0+000 – 6+000

Construction completed 3yrs ago and traffic was 50vpd but has increased since

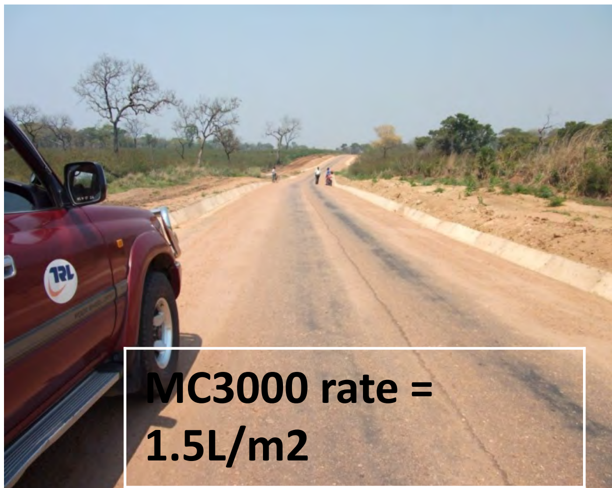
Aggregate is fine: -9mm and -13mm, P0.075~13%

MC30 prime applied at 0.6 – 0.8L/m2

MC3000 binder applied at 1.8, 1.7, 1.6, 1.5, 1.3, 1.2L/m2

All sections cured rapidly and turning black even with low traffic ~ 50vpd

Zambezia: Zero Mopeia Road -
Fine grained quartz Otta seal for comparison



Latest innovations – Otta seal using emulsions: Cumbana Chacane Rd.

Otta seal (nominal max aggregate = 13mm) using emulsion SS60

Praia da Bar– Blended base

Calcrete (PI = 36) + sand
Blend highly permeable (high PI due to powder calcrete not clay)

Muxungue Chibabava– Blended base

Blended base

No blending

Field investigations

Unusual observations

Rio Zambezi Nicoadala Site, N1 North South Highway with Heavy Trucks - 4.5 mesas.
Roadbase - Clayey soil: PI = 20, Soaked CBR = 5%, moist in-situ.

Yet No Failures Observed

Maniamba Lichinga Site, built in the 70s by the army, on high embankment.
Laterite base: very dry and hard upper part and wet and soft lower part
Red silt subgrade: very dry and hard upper part, wet and soft lower part
No failure. Sandwiched moisture?

Unusual observations

Oasse Mocimboa da Pria Site, upgrade to sealed road 13yrs before. Sand seal, ETB, imported sand subbase (wet), in-situ grey sand subgrade (dry)
DCP failed to penetrate grey in-situ sand subgrade – consolidation!!!

Oasse Mocimboa da Pria Site, upgrade to sealed road 13yrs old, 1.27 MESAs.
Sand seal, ETB, imported sand subbase, in-situ sand subgrade
Sand seal still in good condition???

Unusual observations

Nametil - Angoche Site, upgraded to sealed road 5yrs before.
Otta seal, laterite base, grey in-situ sand subgrade.
DCP failed to penetrate grey in-situ sand subgrade – consolidation!!!

Pambara - Rio Save Site, cement stabilised base > 40yrs old.
Hot sand asphalt, CTB, imported red sand subbase, red silt subgrade.
In-situ red silt stabilised with cement.
No cracks!!! No trace of cement???
100% Carbonation of cement???

General findings & recommendations

1. **Blended and armoured bases are viable solutions. Minimum requirements for the soaked CBR for low volume roads (CBR>40)**
2. **Otta seals cure very well for the finer aggregate even at very low traffic volumes**
3. **The blended wearing course performed very well (no maintenance grading for 2 years and very low rate of gravel loss) – the performance based specifications are key to good practice**
4. **No pavement failure – possible use reduced standards for materials and pavement structures**
5. **Most failure were in the surfacing – Bitumen was deteriorating twice as fast (RTFOT and Brookfield viscosity tests)**
6. **Need to improve quality of construction**
7. **Need for long term monitoring**
8. **Need to minimise construction and Life Cycle costs**

General Outcomes

1. **Applied Research - Research provided viable solutions for real problems**
2. **Research uptake – Uptake was immediate: implementation started before the research was completed.**
3. **Lower costs:**

Design option	Indicative costs
Blended Based + S/Otta seal (5/6 m width)	\$130 000/km
Blended base + S/Otta seal + sand capping (5/6 m width)	\$155 000/km
Armoured base + D/sand seal (amalgamated surfacing, 5/6 m width)	\$ 80 000/km
Emulsion treated base +slurry seal (5/6m width)	\$ 90 000/km
Penetration Macadam on untreated sand	\$ 100 000/km
Armouring	\$ 1.50/m²
ETB (100mm thickness)	\$ 4.00/m²

Thank you
Mazvita

Kenneth Mukura

kmukura@yahoo.com

+258825962184 or +263775748045

Transport Services in Rural sub Saharan Africa/

Nite Tanzarn
AFCAP Consultant/AFCAP Steering Group Member

Seminar to
update the Government of Uganda and transport sector stakeholders on the outputs of AFCAP
March 19, 2014
Kampala, Uganda

What is the presentation all about?

Broad focus:

What is the significance of the socioeconomic dimensions of transport [including transport services]?

Specific focus:

What is AFCAP's contribution to the broader question?

Significance of Socioeconomic Aspects of Transport- Illustrative cases of dichotomy

CROWN AGENTS

Typically disadvantaged	Typically advantaged
Women	Men
Elderly	Young
Persons with Disability	Able bodied
Children	Adults
Rural	Urban
Poor	Rich
Pedestrians	Motorists
Public vehicle users	Vehicle owners
Conflict-afflicted societies	Non-conflict afflicted societies
Fragile states	Stable states

UKaid from the British people

AFCAP's Transport Services [Research] Portfolio

- Transport services training
- Rural transport services indicators [Tanzania, Kenya, Cameroon]
- Transport knowledge management
- Linking rural communities with health services: Assessing the effectiveness of ambulance services in meeting the needs of rural communities in West Africa

AFCAP's Transport Services [Research] Portfolio contd.

- Motor-cycle taxi operations and road safety [Tanzania] – *very many lessons for Uganda*
- Rural logistics for smallholder farmers to meet new agricultural market demands [Kenya]
- Supply and pricing strategies of informal rural transport providers [RSA]
- Transport and social inclusion: aged, PWDs, etc.

AFCAP's Transport Services [Research] Portfolio contd.

CROWN AGENTS

- Linkages between transport, environment and climate change in Africa
- Value for money and economic analysis /Cost Benefit Analysis
- The role of transport and transport services in fragile and conflict-affected societies and states [South Sudan and DRC]
- Gender-Equitable Rural Transport Planning in Africa: Future Directions [Ghana, Lesotho, Uganda]

UKaid from the British people

CROWN AGENTS

Overview

- The project developed [and tested] indicators that can be used to assess how good rural transport services are at providing access for rural people.
- Complement the World Bank's Rural Access Indicator: % of the population living 2 km from an all weather road [**such roads may or may not have adequate transport services]**
- RTSIs combine proximity of transport infrastructure with the availability of affordable and reliable transport services.

UKaid from the British people

Overview

- The research project is designed to showcase successes, failings and challenges of existing work on gender-equitable rural transport planning in Africa in a global context.
- The main output of the project will be a Concept Paper that may include steps connected to the development of knowledge including the need for a repository of gender research.
- Document review suggests that Africa [Uganda???] is potentially leading the way in efforts to maintain a focus on gender in transport.

Project Overview

The objective of the research is to establish how transport infrastructure and services can help rebuild economies in post-conflict countries and lessen vulnerability to future conflict.

Some findings:

- Transportation infrastructure [e.g., roads] shrinks time-space and cost-space, thus enabling the government to move weapons and troops to contested or fragile areas to restore peace.
- A quantitative analysis of more than 133 countries,] showed that factors such as inaccessibility [as measured by road density] were better predictors of civil war than poverty measures. [Holtermann 2012]

Impact of AFCAP Work

- Through research and publication, building a body of knowledge on various [key] dimensions of/linkages to/significance of transport.
- Groundbreaking research on transport and mobile phones, transport and conflict/ fragile states etc.
- Raising consciousness of transport [services] amongst engineering and non engineering professionals in various African countries **THUS**
- Building a network of transport [services] experts

Impact of AFCAP Work

- Reflecting on alternative tools to CBA for prioritising investments in LVR
- Underscores the need to define minimum levels of transport services in terms of quantity, quality, time and cost as well as the rights, obligations and responsibilities of the clients

Impact of AFCAP Work

- Mainstreaming of gender in [AFCAP] evidence generation and validation,
- Supporting a revisiting of the earlier efforts to mainstream gender and reinvigorating them.




Impact of AFCAP Work

CROWN AGENTS

[In partnership with SLOCAT, SSATP, IFRTD] Engaging with various processes and spaces thus contributing to global and regional debates promoting [rural] transport from the margins to the centre of the development equation i.e. post MDGs [SDGs] discourse

HIGHLIGHTED

- The centrality of transport to the achievement of other sector goals
- The need for integrated [rural access] planning

UKaid from the British people

GOAL 06: Improve Agriculture Systems and Raise Rural Prosperity

Target 06c. Ensure universal access in rural areas to basic resources and infrastructure services (land, water, sanitation, modern energy, transport, mobile and broadband communication, agricultural inputs, and advisory services).

Potential and Illustrative SDG Indicator

Access to all-weather road (% access within [x] km distance to road)

GOAL 07: Empower Inclusive, Productive and Resilient Cities

Target 07b. Ensure universal access to a secure and affordable built environment and basic urban services including housing; water, sanitation and waste management; low-carbon energy and transport; and mobile and broadband communication.

Potential and Illustrative SDG Indicator

Proportion of urban households with access to reliable public transportation

Thank you /

Nite Tanzarn
AFCAP Steering Group Member

Director of Board
International Forum for Rural Transport and Development [IFRTD]

nite.tanzarn@ifrtd.org

www.ifrtd.org
www.mobilityandhealth.org
www.ruralwaterways.org