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

by Kenneth Mukura - TRL

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Introduction

1. **Low cost sealing of rural roads is crucial for the sustainability of the rural road network of Ghana - Research is key to development of best practice.**
2. **Ghana has natural locally available road building materials which do not meet conventional specifications (i.e. marginal materials) – How can we make them work?**
3. **Surfacing of roads adds value, protects road investment and minimises maintenance demand – How can we minimise costs and prolong the service life of low volume roads? Doing more for less!!!!**

Introduction

1. **The appropriateness of design methodologies and specifications is absolutely essential for provision and maintenance of roads – Are the designs and specifications being used in Ghana appropriate for the local materials, climate, road environment, etc.?**
2. **Quality of construction is getting poorer at Regional level and costs are increasing – is there enough capacity for quality control and testing? What can be done about the ever dwindling experience and skills base?**
3. **Maintenance resources are inadequate, yes - but how about wastage? Is there performance data or any ongoing studies/investigations on in-service performance of low volume sealed roads?**

Background- Issues to consider

1. **Road Authorities losing more than they are building – the vicious cycle!!**

Tanzania $1bn WB loan with 10 yr. grace period – but 10yrs later there was nothing to show, all roads deteriorated badly.

Cycle of death: poor construction –little maintenance - ooh!!! rehabilitation.

2. **Roads in South Africa, Brazil and Zimbabwe, performing well, why?**

'Home grown' specifications.

Continual local research.

How much research is being carried out in Ghana? What proportion of your specifications were developed locally and likewise imported?

Research under AFCAP/RRIP - Moz

1. **ANE initiated the Rural Road Investment Programme (RRIP) supported technically by AFCAP: 2008-2011 followed Phase 4.**
2. **Innovative designs, construction of and monitoring trial sections and Back Analysis of existing roads.**
3. **Designs included concrete slabs and stone paving with concrete screed on steep ramps, emulsion treated bases, blended bases, armoured bases, slurry seals, sand seals, penetration macadam, untreated sand bases, amalgamated surfacings, etc. using non-standard materials. > 50km of trial sections built.**
4. **Designs were carried out by TRL and provincial consultants.**
5. **Funding: Road Fund, SIDA and DFID through AFCAP funded the projects.**

Key characteristics of Mozambique

1. Mozambique is a big country but < 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) - climate change!!!
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

Black cotton soil & loose sand

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

Tidal flooding affecting passability during high tide

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

All weather passability – 3yrs

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

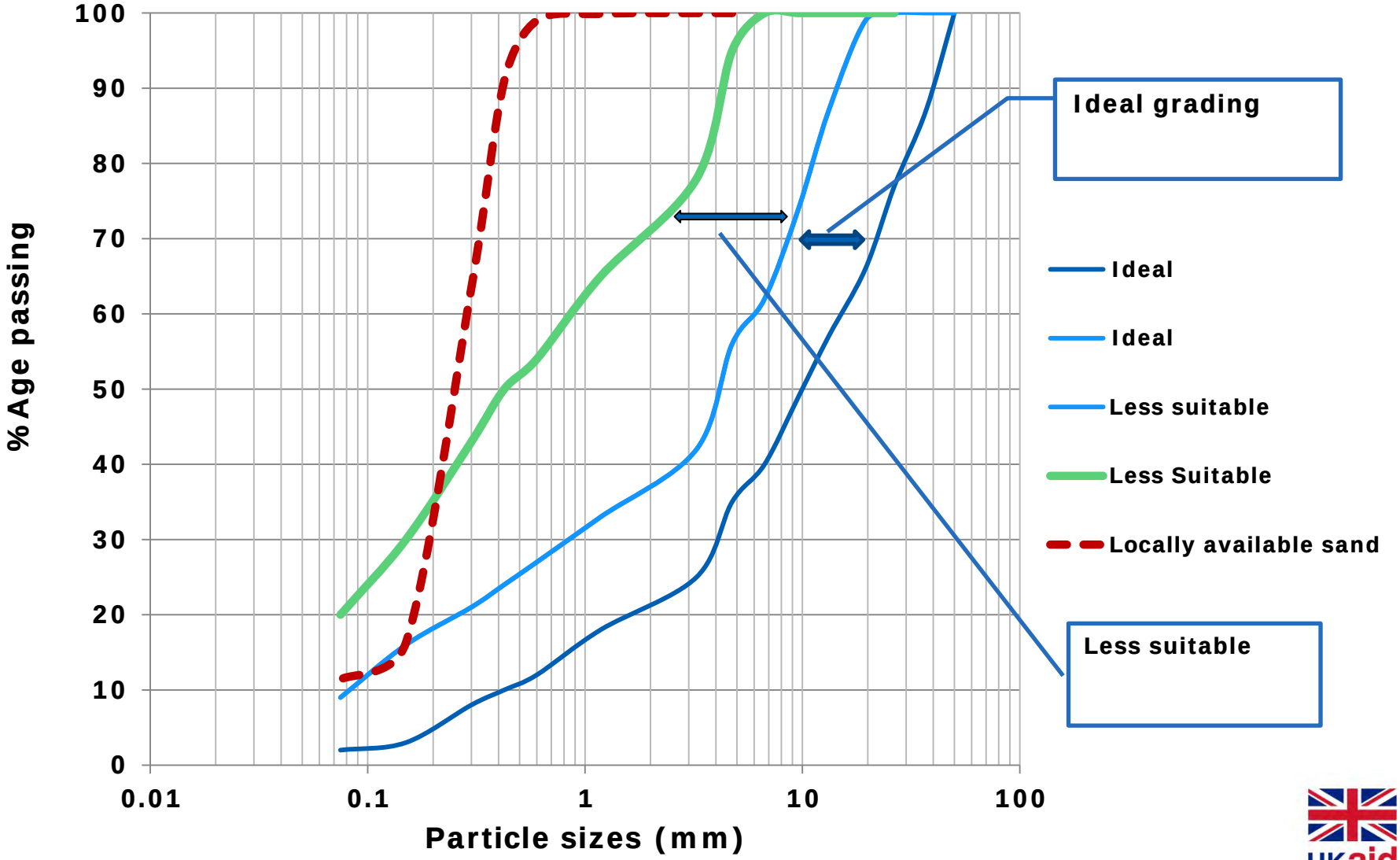
0+000 to 0+780: regularised existing road, 150mm subbase (old ETB and neat sand), ETB (50mm, 75mm, 100mm, 150mm).

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

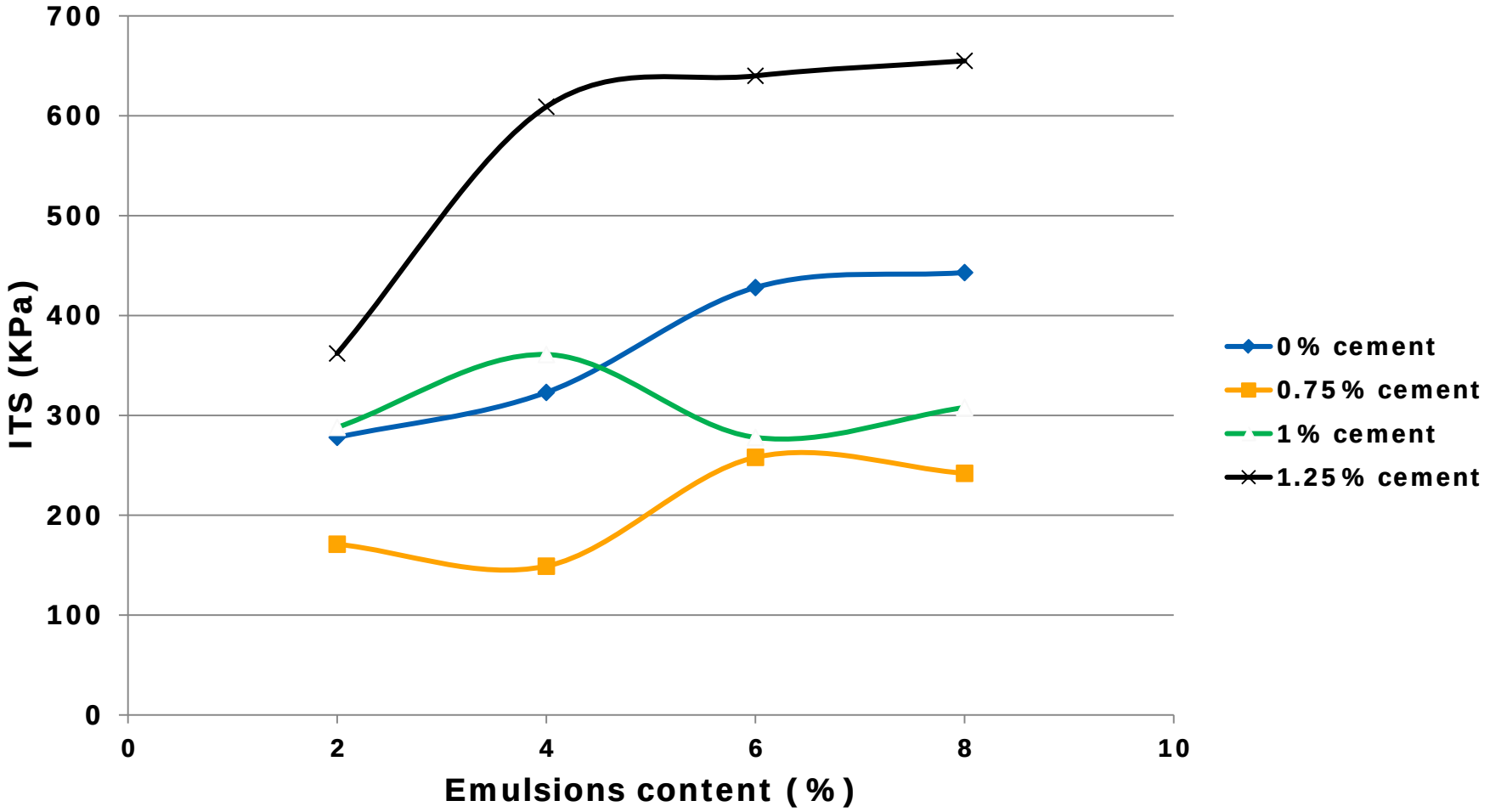
Emulsion Treated Base (ETB) Design Specifications

	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

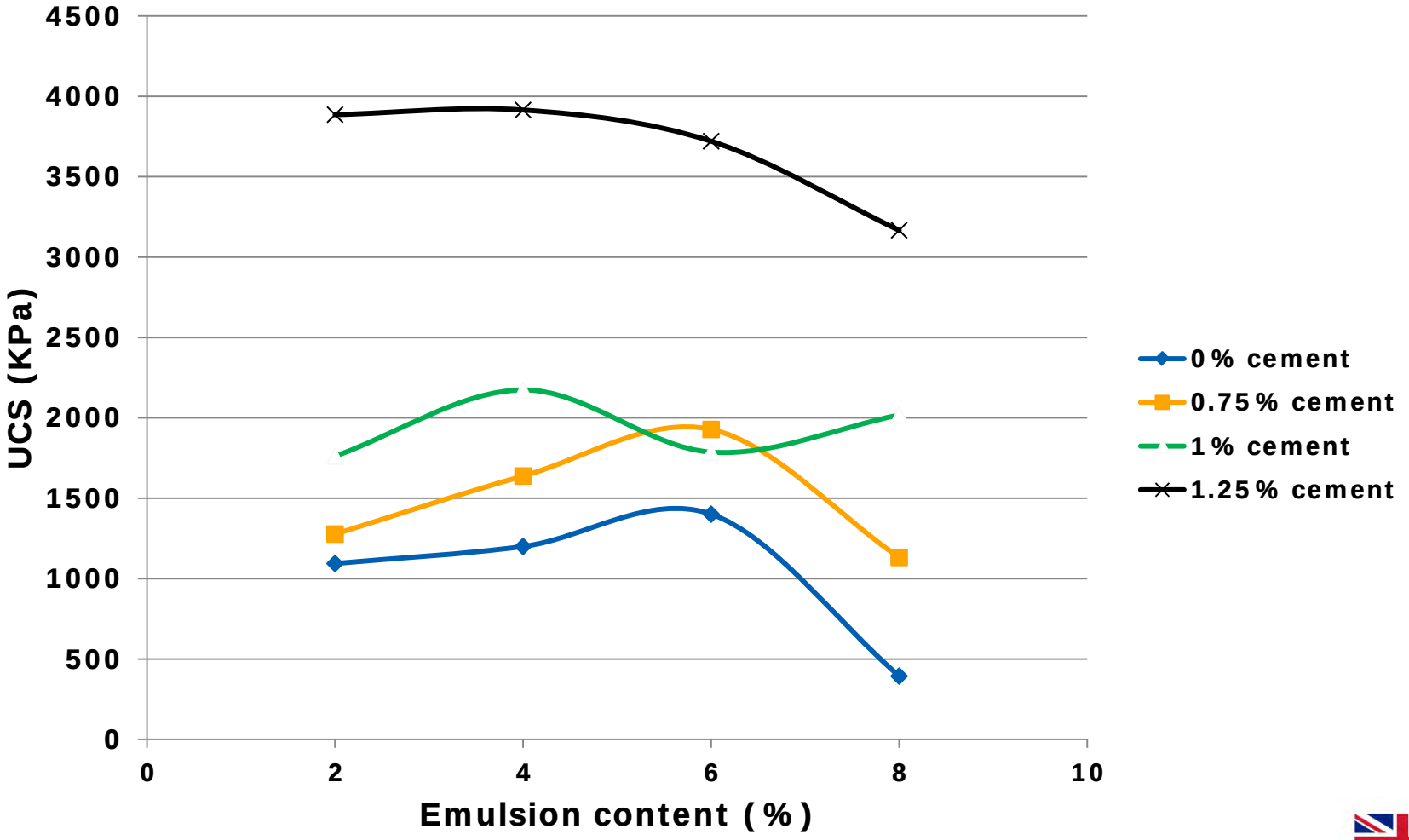
Materials – locally available sand



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

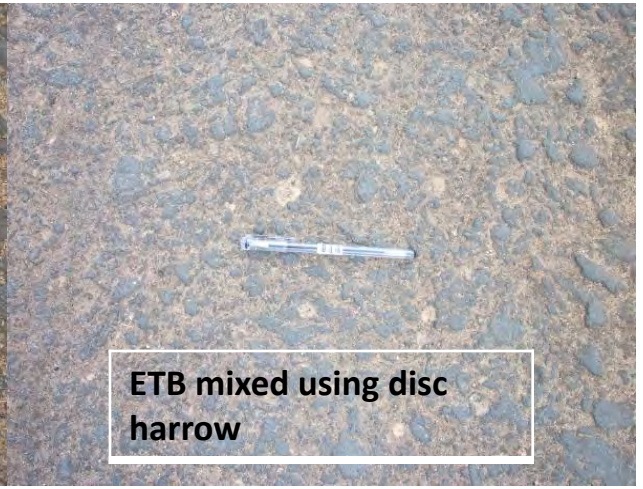
Medium technology

Mechanised

Construction of ETB and slurry seal

ETB Construction – Medium technology (4% - 6% emulsion content)

ETB mixed using concrete mixer

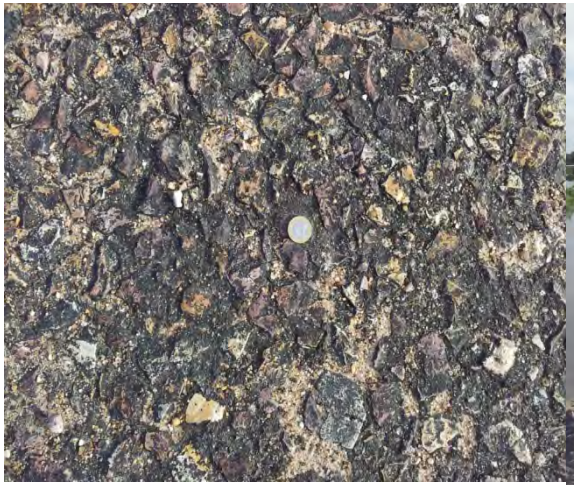


ETB mixed using disc harrow

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








Cumbana Chacane Road – Blending

Before and after intervention

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 on untreated sand base






Inhacufera Machaze Road-Otta seal

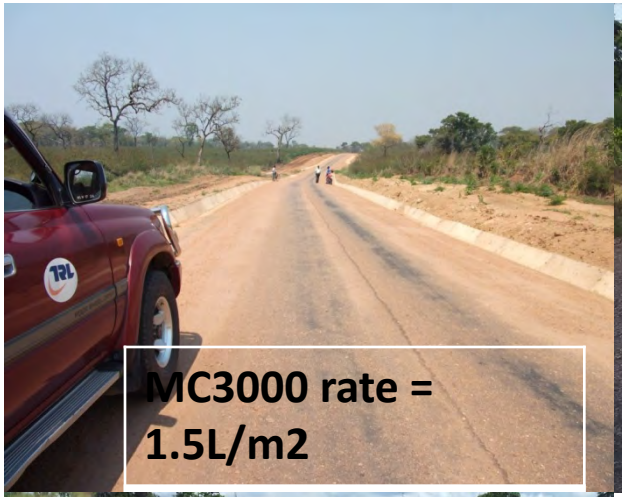
Single Otta seal + sand seal
Single Otta seal + grit seal
Double Otta seal

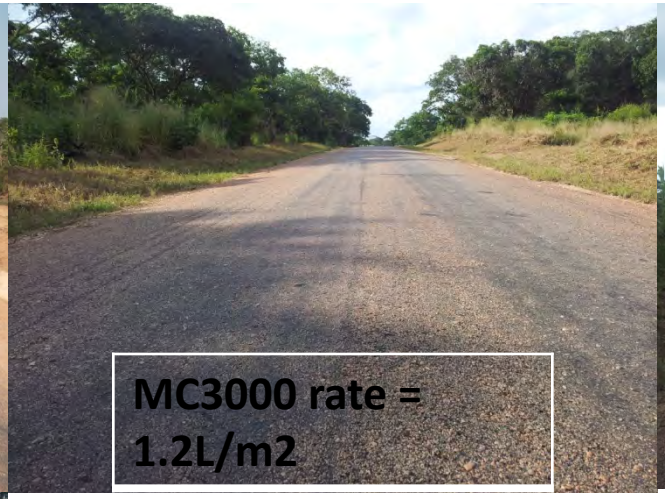
In good condition after ~4.5years

Single Otta did not cure (19mm max aggregate

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

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





Trialled locally available fine grained aggregate for Otta seal nominal max of 13mm.

Applied 1.4L/m2 – 1.8L/m2 => uniform performance for 4 years. Future ????

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

Clayey silty soil.

Blended base clayey silty soil with non-plastic material

Back analysis of performance of old sealed roads

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 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: Previous costs $200,000 - $250,000/km**

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/m^2
ETB (100mm thickness)	$ 4.00/m^2

Thank you

Kenneth Mukura

kmukura@yahoo.com

+258825962184 or +263775748045