Mozambique RRIP/AFCAP Back Analysis Research Project (TRL/ANE)

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This presentation comprises…

1. Characteristics of Mozambique – the challenge
2. The study
3. Methodology
4. Overall performance of test sections
5. Performance of surfacings and binder quality tests
6. Observations – anomallies
7. Conclusions
8. 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.

Analysing the performance of some existing sealed roads known to have been constructed using materials which don not meet current specifications.

Selection of road sections: 8 roads, 22 test sections

a) Traffic (ADT= 55 – 1000vpd).

b) Materials (cement stabilised and unstabilised laterites, emulsion treated sands, gravel, basalts, decomposed granite, rhyolite).

c) Condition (good, fair, poor, very poor).

d) Type of surfacing (surface dressing, sand seals, Otta seals, hot sand asphalt).

Field investigations

Overall performance of the sections

Overall performance - measured from an overall index of deterioration - a combination of the Rut Depth, Cracking, Potholing and Patching:

DI = RdI + CrI + PPI

Where DI = deterioration index

RdI = average rut depth in mm

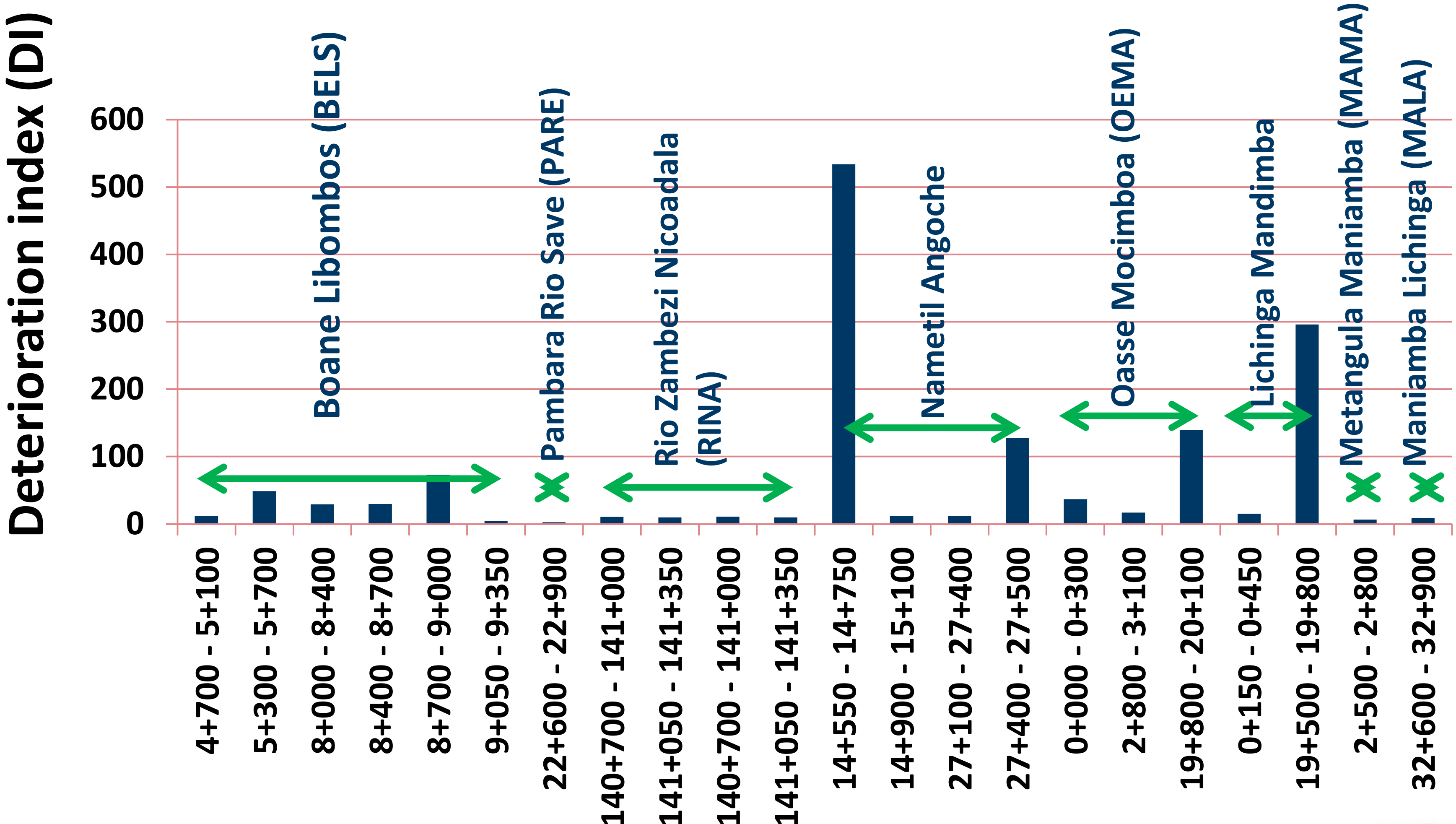
CrI = cracking intensity x extent

PPI = Pothole/patching area (m) x extent

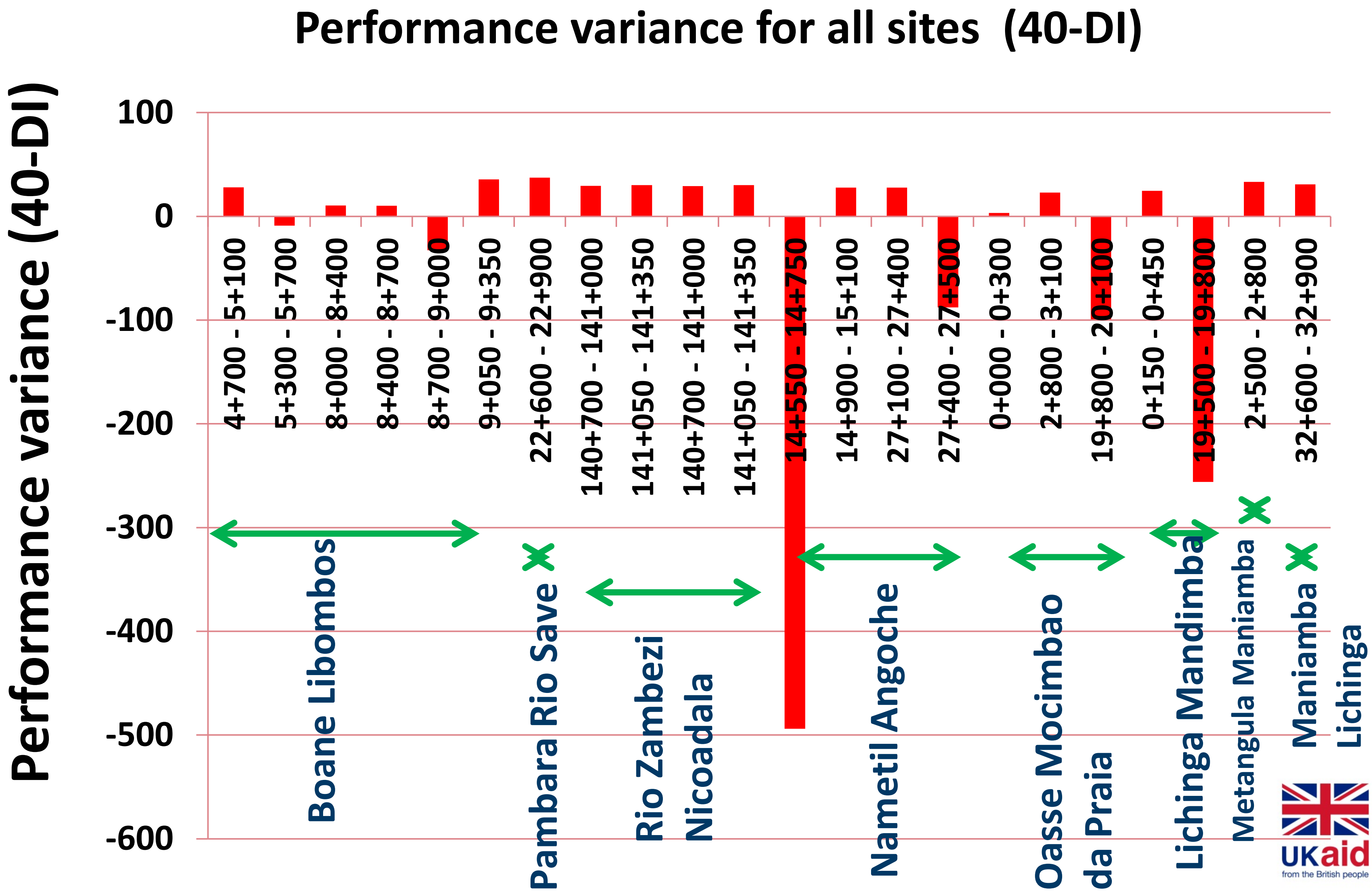
Overall Performance of the Sections

- DI ≤ **40** is indicative of a surfacing in good condition.
- DI > 40 not satisfactory.
- 6 sections out of 22 were considered unsatisfactory but 2 were only marginally so.
- Low values of rut depth indicate very little if any structural failures.
- Cracking, potholes (and their patching) were the main reasons for deterioration.

Deterioration Index



Performance variances



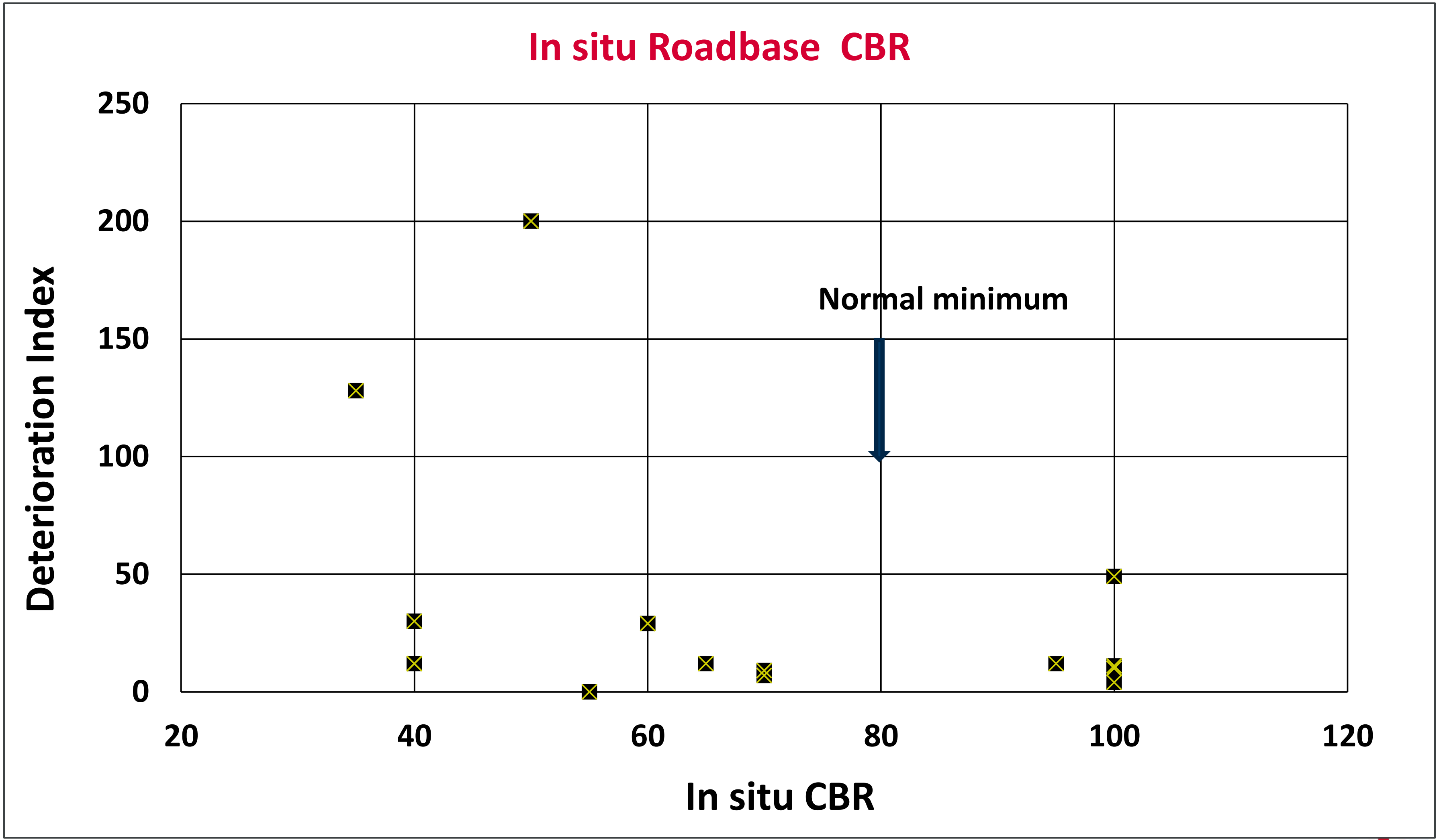
Traffic data

ROAD NAME	Age of Road	Age of Surface	Daily Traffic			Cumulative mesas on surfacing	Cumulative mesas on pavement
			Light	Heavy	Total		
Boane-Libombos	13	13	315	171	486	1.7	1.7
Pambarra-Rio Save	30	4	450	222	672	1.0	~ 3
Oasse-Mocimboa da Praia	13	13	709	284	993	2.7	2.7
Metangula-Maniamba	5	5	108	58	166	0.3	0.3
Maniamba-Lichinga	41	4	108	58	166	0.2	~ 0.7
Lichinga-Mandimba	8	8	191	100	191	0.6	0.6
Nametil-Angoche	5	5	125	105	229	0.3	0.3
Rio Zambezi-Nicoadala	30	4	445	419	864	1.3	~ 4.5

Analysis – key issues

1. Performance of a road depends on a large number of parameters including:
    a) **Properties of surfacing, roadbase, sub-base, subgrade**
    b) **Traffic factors**
    c) **Drainage**
    d) **Environmental factors**
    e) **Quality of construction**
2. For roadbase: Grading, PI, Soaked CBR, in situ CBR, field moisture content (FMC), OMC.
3. There are also important interactions e.g. PI might only be important if the amount of fines is high hence the Plasticity Modulus (PM) rather than PI alone might be critical.
4. Surfacing: Quality and ageing of bitumen

Road base - in situ CBR

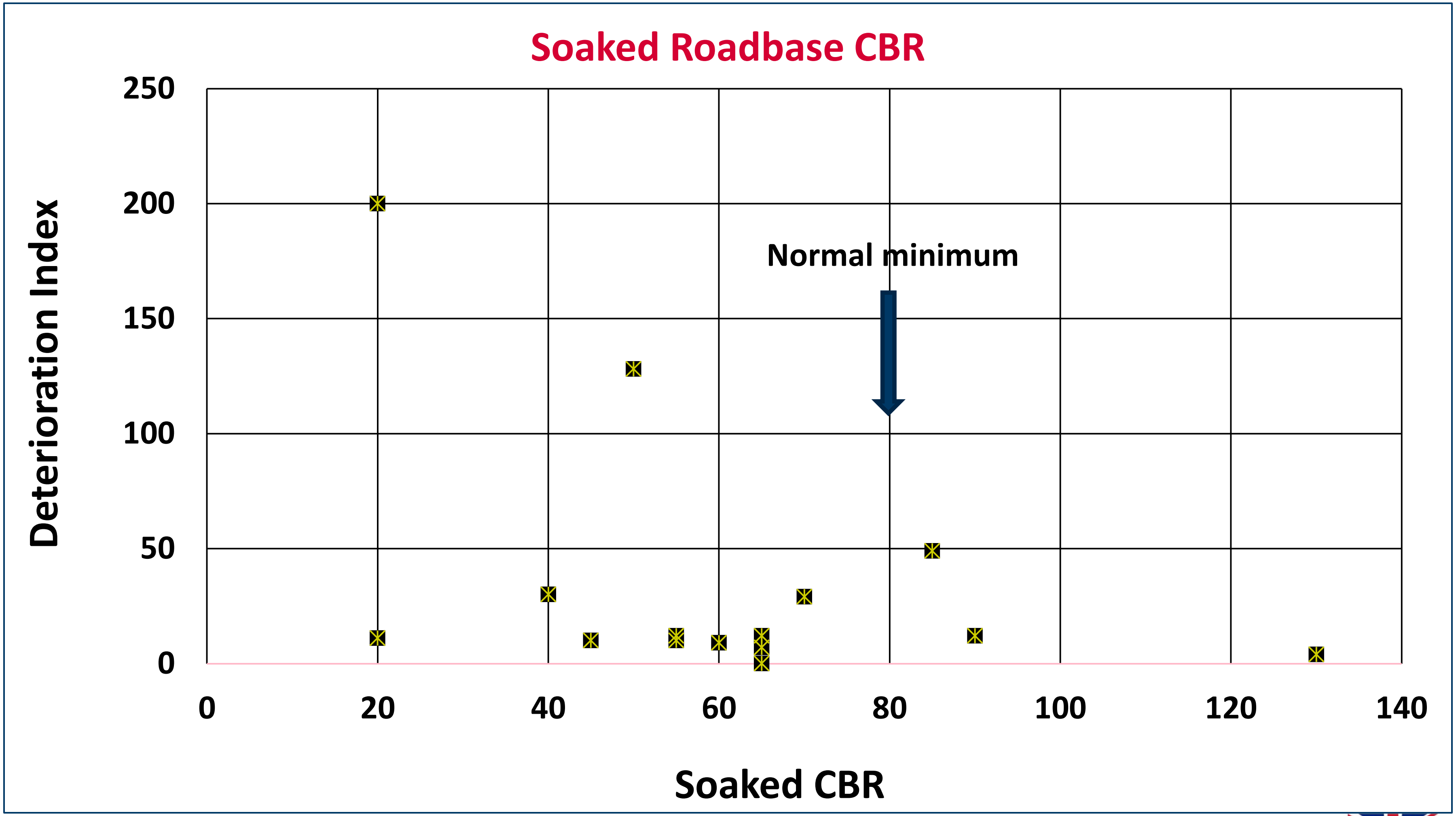


Road base - in-situ strengths

1. 40% of the road bases had in-situ CBR > 90%.
2. 20% of the road bases had in-situ CBR < 55%.
3. 10% of road bases had in-situ CBR < 40%.

No structural failures were noted.

Road base – soaked CBR

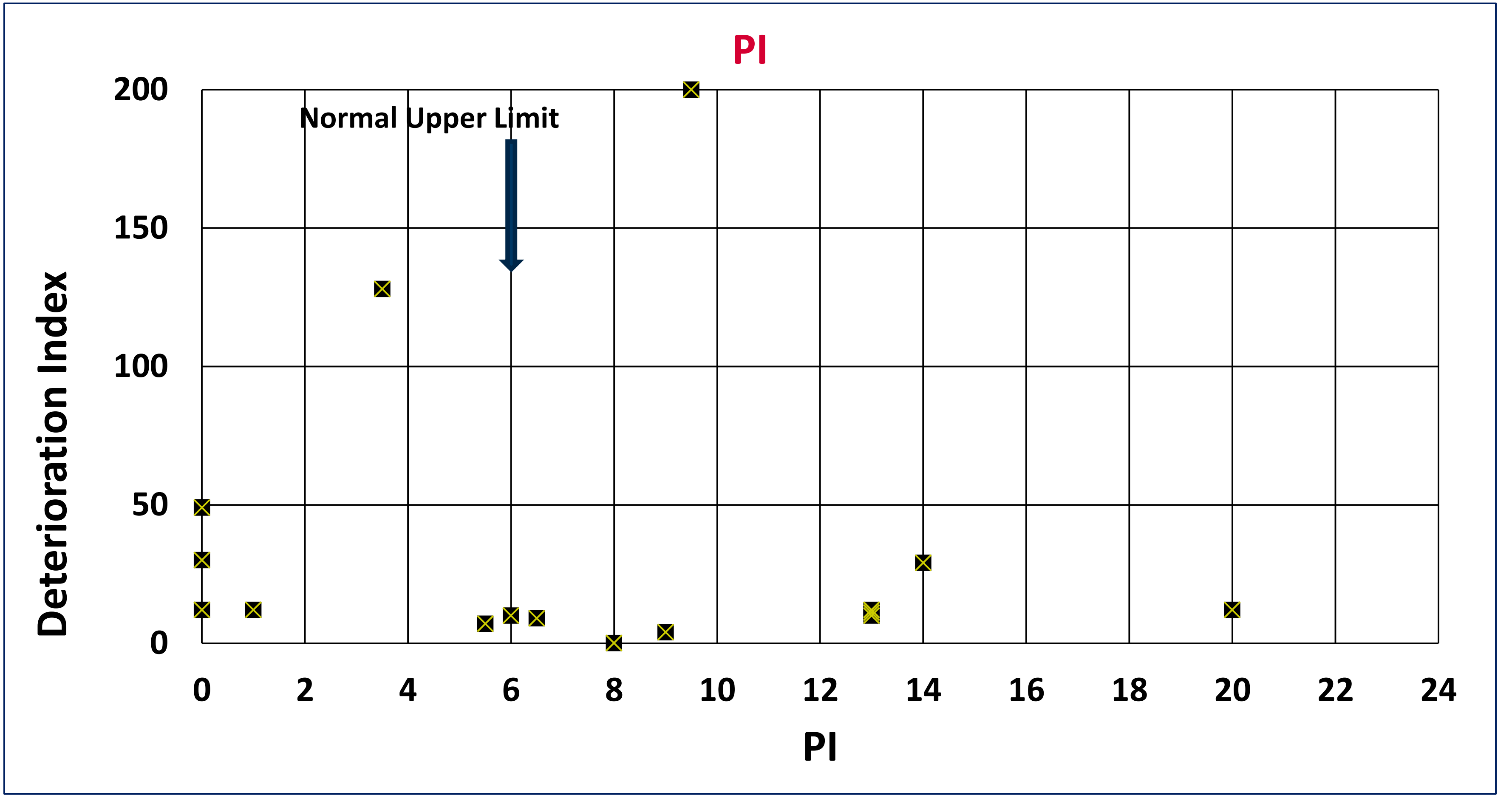


Road base - soaked CBR

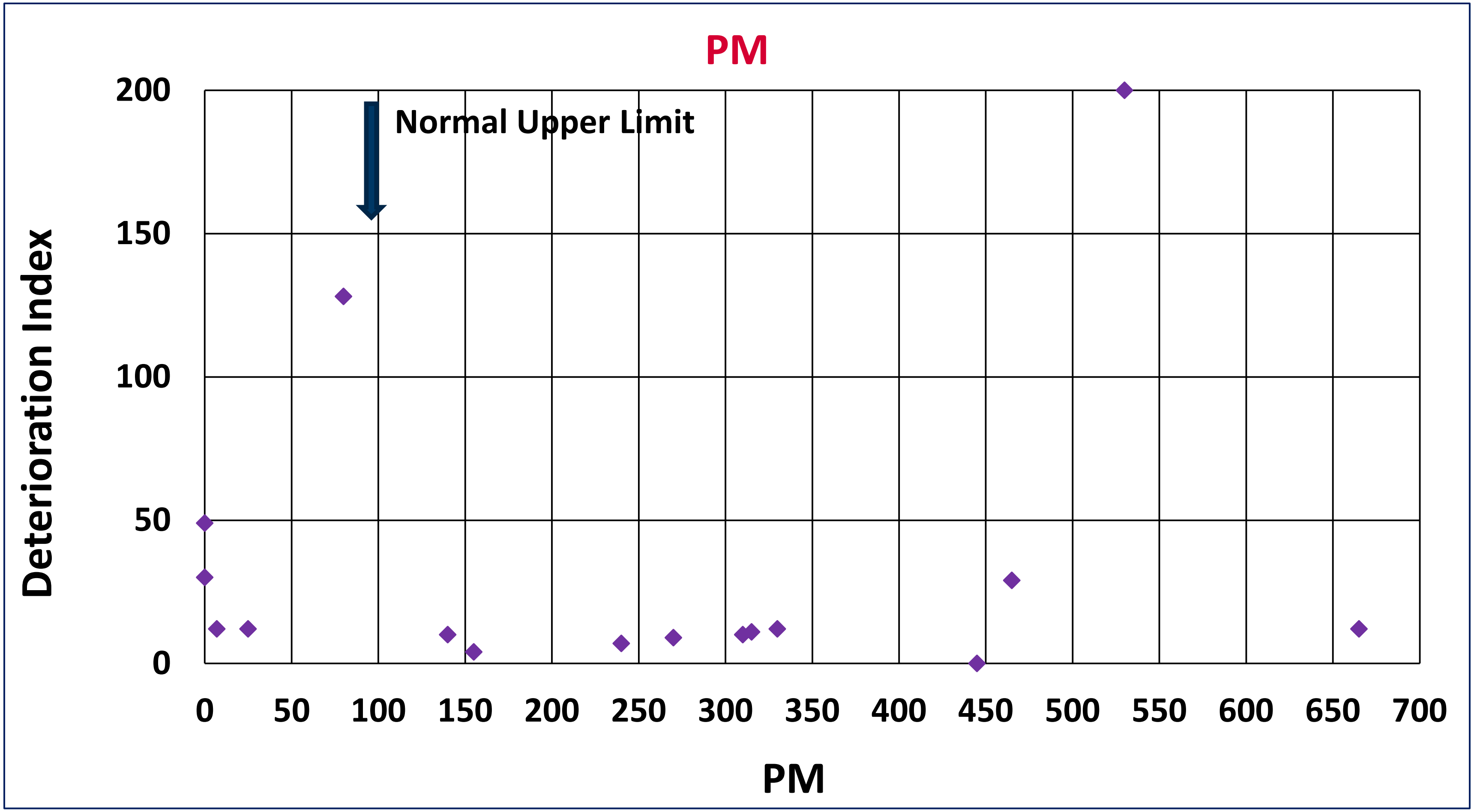
1. 20% of the road bases had soaked CBR > 80% CBR, the basic conventional specification.
2. 40% of the road bases had soaked CBR < 50% CBR, a value frequently used for LVRs
3. 3 road bases had soaked CBRs < 30%

No structural failures were noted

Road base – Plasticity Index (PI)

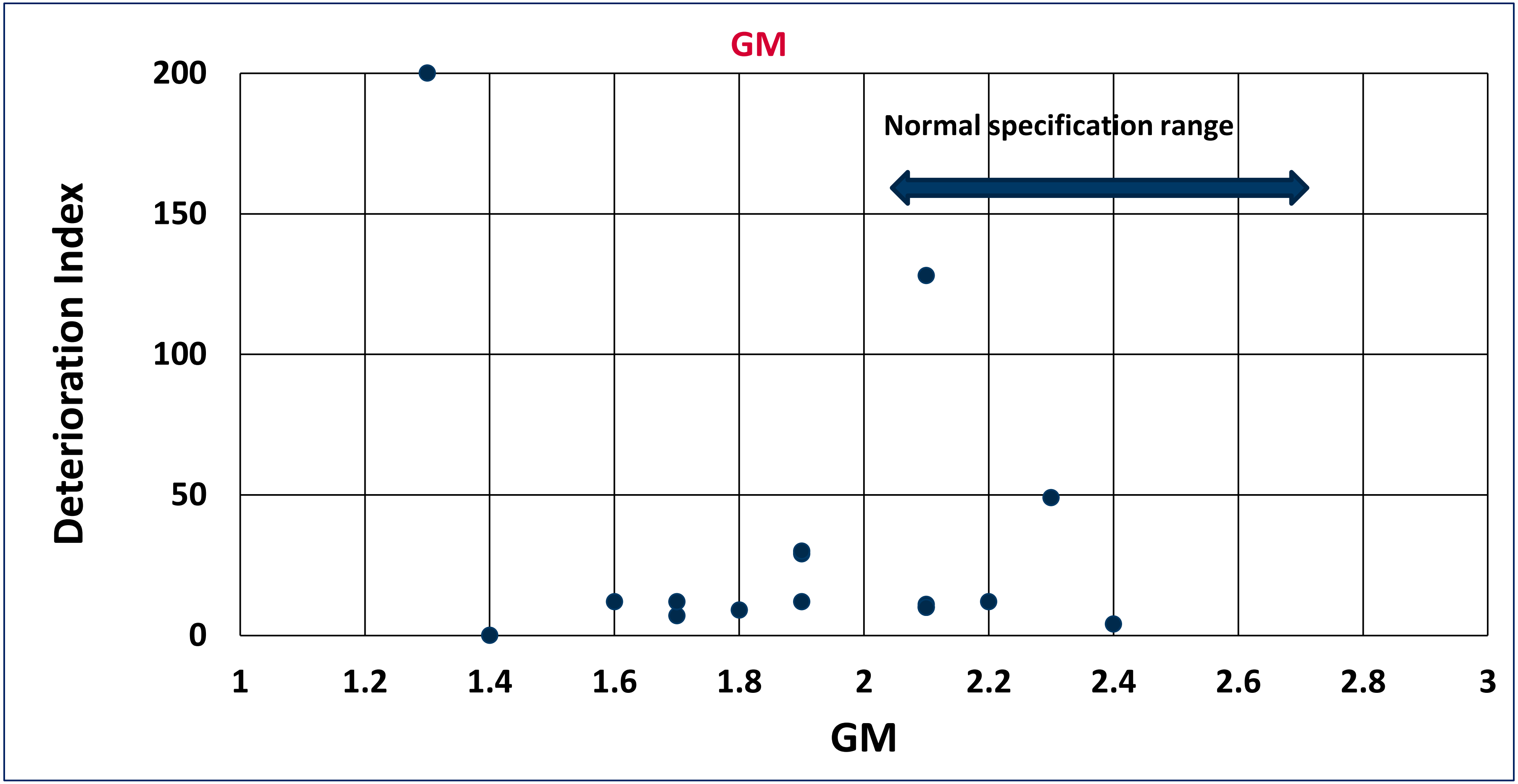


Road base – Plasticity Modulus (PM)



Road base – Grading Modulus (GM)

CROWN AGENTS



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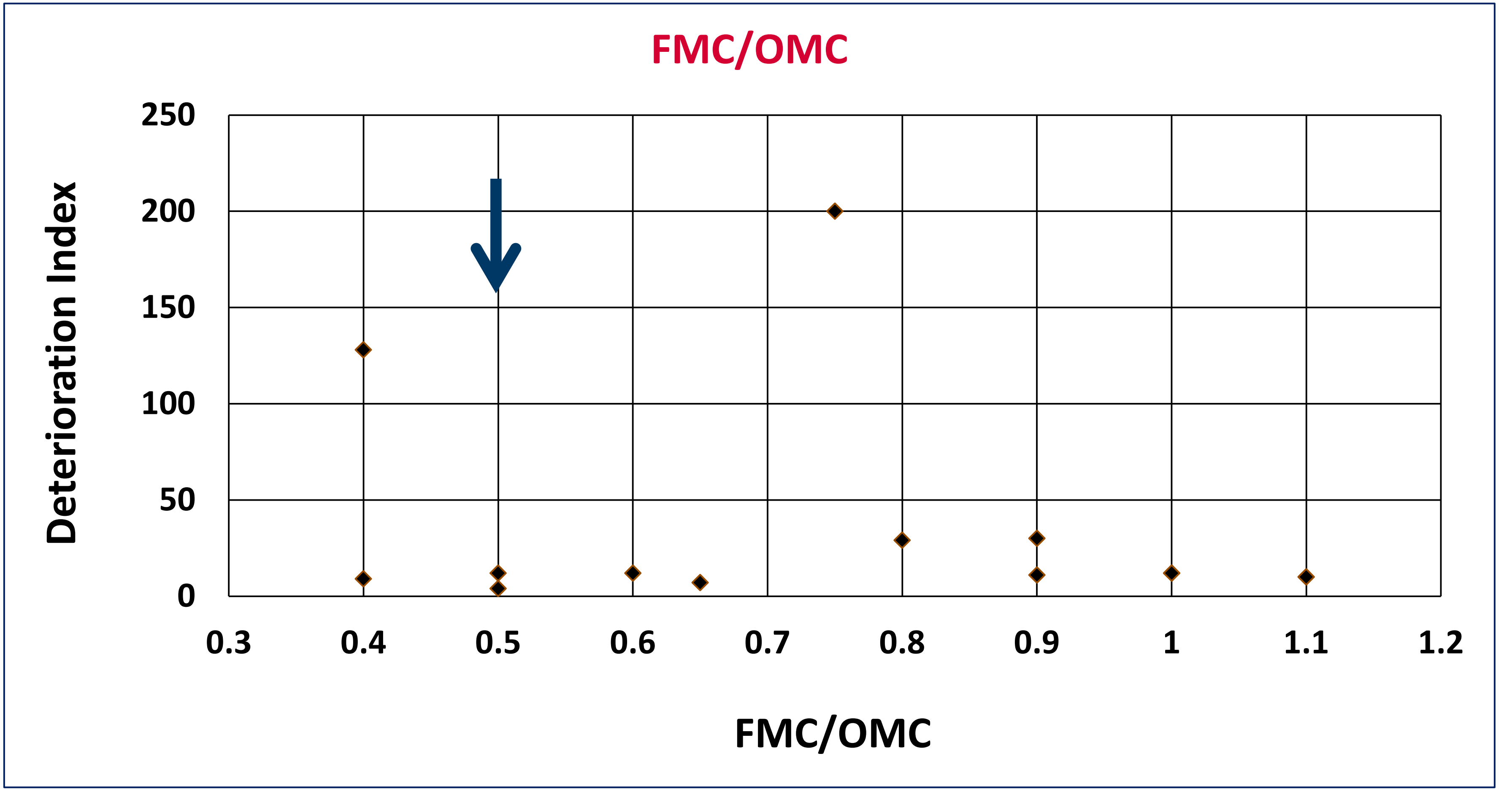
Road base - Field MC/Optimum MC



The surfacings

1. The ageing of bitumen is identified by the changing viscosity which can be measured in various ways.

   a) **Penetration**

   b) **Softening Point**

   c) **Viscosity**

2. Summary of results

Penetration on fresh bitumen from Mozambique was 58dmm instead of the expected 80/100.

Penetration on extracted samples mostly <5dmm and only a few > 10dmm, maximum 35dmm

Oxidation and loss of volatile is the main causes of deterioration

Ageing of bitumen – Field vs Lab.

Site	Parameter	Test results			
		Actual aging in-service	Simulated aging in laboratory (RTFOT)	Deterioration factor	Age of surfacing
Pambara Rio Save	Ductility	373	>1000	> 2.7	4
	Viscosity (Pas) @120˚C	2.4	1.2	2.0	
Nametil Angoche	Ductility	481	>1000	> 2.1	5
	Viscosity (Pas) @120˚C	2.1	1.2	1.7	
Nametil Angoche	Ductility	475	>1000	> 2.1	5
	Viscosity (Pas) @120˚C	2.4	1.2	2.0	

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Unusual observations

Rio Zambezi Nicoadala Site, N1 North South Highway with Heavy Trucks - 4.5mesas.
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

CROWN AGENTS

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???

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Conclusions (pavements and materials)

1. Results demonstrate that good performance ***can*** be obtained from materials that do not fully meet current specifications. Materials in-service are generally drier giving higher strength and performance. Crown height had no effect on performance within the range studied.

3. Consolidation on existing roads leads to increased capacity to carry higher traffic loading. Need to take advantage of consolidation in the design for upgrading existing roads to sealed road standards (follow existing alignment as much as possible)

Conclusions - (surfacings)

1. The performance of surfacings is dependent on the content, quality and durability of the binder.
2. A large number of samples of binder extracted from surfacings had penetrations below 5dmm and only a few above 10dmm – Binders had become brittle after a relatively short in-service life.
3. Binders were deteriorating more than twice as fast as the anticipated rate obtained from simulation (Rolling thin film over tests, RTFOT). Rapid binder deterioration attributed to hot climate in Mozambique.

Recommendations - 1

1. Review specifications for materials for LVRs to accommodated materials excluded under current specifications. Redefine upper and lower limit specs.
2. Review the impact of traffic on the performance of LVRs (>4 mesas but no failure).
3. Review design methodologies for low volume roads to allow for consolidation on existing roads and secondary consolidation after construction. The latter is more critical.
4. Incorporate effect of environmental factors in the design of surfacings (binder deterioration factors) for selection of best binders and surfacing types (Inc. QA in construction).

Thank you
Obrigado
Mazvita

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