TRL/ANE Research – RRIP & AFCAP
Design and Construction of Otta Seals in Mozambique

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Introduction

- Mozambique is a large country, SA to Tanzania
- More than 90% of the network is unsealed
- Good road construction materials are scare (e.g. haul distances of surfacing aggregate may exceed 400km)
- Vast areas are covered in coastal sands
- Previous research carried out by TRL and ANE showed an average rate of gravel loss on unpaved roads exceeding 50mm/year (maintenance demand is high)

Background

- ANE initiated the Rural Road Investment Programme (RRIP) supported technically by AFCAP: Phase 1 from 2008, Phase 2 from 2009, Phase 3 from mid-2011.
- More than 50km have been built and Otta seals constitute the bulk of the sections
- Designs also include concrete slabs and stone paving with concrete screed on steep ramps, emulsion treated bases, armoured bases, slurry seals, sand seals, penetration macadam, untreated sand bases, etc
- Designs were carried out by TRL in conjunction with provincial consultants. Construction is carried out mostly by local contractors
- ANE with assistance from SIDA provided funding for construction works and DFID is providing funding for technical support

Otta Seals in Mozambique

- The construction of Otta seals in Mozambique started well before RRIP/AFCAP Project.
- Designs were based on ANE manual the Normas de Execucao which is an extract of the Norwegian specs on Otta seals
- Single Otta seals have not performed well and normally double Otta seal or single Otta seal with a sand seal on top is preferred.
- Traffic is very low on some of the roads approx. 50vpd but some have over 100 vpd.
- Bitumen application rate is specified at 2L/m2.

Description of Otta Seals

- Otta Seal is a surfacing that was originally developed in Norway and is now being used in many other countries
- Otta seal surfacing consists of:
  - Graded aggregate for surfacing which may be processed natural gravels or crushed stone
  - Soft binders such as MC3000 or MC800 or 150/200 pen bitumen
- Otta seals can be used in the construction of low volume roads (up to 300vpd) to roads with medium traffic (300-1000vpd)
- Otta seals are not suitable for very low volumes of traffic (e.g. < 50vpd)

Standard Designs for Otta seals - Aggreate

AASHTO Sieve (mm)	Overall requirement	Preferred Open Grading AADT < 100	Preferred Medium Grading 100 < AADT <1,000
	% passing	% passing	% passing
25	100	100-	100
19	100	100	100
16	80 - 100	80 - 100	84 - 100
13.2	52 – 100	52 - 82	68 - 94
9.5	36 - 98	36 - 58	44 - 73
6.7	20 - 80	20 - 40	29 - 54
4.7	10 - 70	10 - 30	19 - 42
2.0	0 - 48	0 - 8	3 - 18
1.18	0 - 38	0 - 5	1 - 14
0.425	0 - 25	0 - 2	0 - 6
0.075	0 - 10	0 - 1	0 - 2

Standard Designs for Otta seals - Binders

Item No	Description of binder	Type of Material	Requirements
1.		Penetration Grade Bitumen	AASHTO M 20
1.1	AC 150/200	Grade 150-200	
2		Cut Back Bitumen	AASHTO M 18
2.1	MC- 3000	Medium Curing	
2.2	MC - 800	Medium Curing	

Application rates

Type of Otta seal	Hot bitumen spray rates for un-primed base course (ltr/m²)	
	Open grading	Medium grading
Single Otta seal with sand seal	1.6	1.7
Single Otta seal without sand seal	1.7	1.8
Double Otta seal 1st layer	1.6	1.7
Double Otta seal 2nd layer	1.5	1.6

Application Rate of Aggregate is 16L/m2

Construction of Otta Seals

- Aggregate is acquired by excavating natural gravel and sieving through 5mm sieves to remove excess fines and 20 (or 19)mm to remove over size stones
- Grading and strength tests should be carried out for approval purposes. Sieving may be repeated if aggregate remains with high content of fines ($P_{0.075}$ >10%)
- The base shall be prepared according specifications and primed. Heated binder shall be applied followed immediately by the application of aggregate
- Rolling is the most critical activity and shall be carried out using a pneumatic roller for a minimum of 3 days applying in total more than 36 passes of a 12 tonne roller or equivalent effort.
- Curing shall be carried using existing traffic directing it over the whole carriageway with cones

Inhacufera Machaze Road – Before situation

Single Otta seal surfacing – Inhacufera Machaze Project

Single Otta seal with sand seal on top - Inhacufera Machaze Project

Challenges

- Aggregate especially from clayey calcrete deposits and silty quartz gravels tends to be dusty and repeated sieving may be required to reduce the content of fines
- Weak aggregate tends to wear away leading to surfacing that is too rich in bitumen and at times slippery
- Pneumatic rollers are not readily available and this makes rolling of Otta seals very difficult without pnuematic rollers
- High bitumen application rates (2L/m2) have significantly increased the construction costs with global increase in the price of petroleum products
- On low volume roads i.e. ADT <100 and particularly ADT<50vpd curing is non-uniform and very slow (>18 months) leading to low durability of surfacing and stripping in some cases

Dusty calcrete aggregate – Cumbana Chacane Project

Recent research on Otta seal surfacing in Mozambique

- **Research showed that the main causes of slow curing of the Otta seal surfacing designed on the basis of standard specifications are that:**
  - **Aggregate is too coarse and requires a lot of effort for the binder to migrate upwards**
  - **Traffic volumes are too low to effect adequate curing**
  - **Prolonged rolling with pneumatic rollers is expensive and not favoured by contractors. Such compensatory rolling would take more than 3 weeks**
- **The only variable that can be changed easily is aggregate size.**
- **Finer aggregate sizes have been used, -13mm +5mm range i.e. aggregate sieved on 13 mm sieve and 5mm sieves instead of -19mm +5mm**
- **Application rates of binder were varied between 1.2-1.8L/m2**

Recent research on Otta seal surfacing in Mozambique - findings

Item	Conventional specs on low-volume roads	New Specs and Work Norms for LVR
Aggregate size	High yield during sieving	Lower yield as 14-19mm component is removed
Rolling	2 weeks of rolling inadequate	3-5 days rolling is sufficient
Bitumen content	High bitumen content leading to high costs	Lower bitumen content leading to lower costs and more mileage in output
Curing	Very slow curing and sometimes never cures fully	Rapid curing even at very low traffic
Quality of surfacing	Inadequate curing leads to poor quality surfacing at low traffic volumes, premature stripping noticed	High quality of surfacing produced with the appearance of asphalt. High durability anticipated on LVRs

Comments and recommendations

- **The research is ongoing and some sections are under long term monitoring in order to quantify performance parameters**
- **Preliminary results show that finer aggregate (-13mm +5mm) for Otta seals gives better quality surfacing which is anticipated to perform much better and give a longer service life while significantly reducing the construction and life-cycle costs.**
- **It is important for road sectors to ensure the availability of pneumatic rollers in road construction and especially for rolling Otta seals and other surfacings. It is also recommended to use pneumatic rollers for the compaction of coarse and fine materials and most marginal materials**

Comments and recommendations

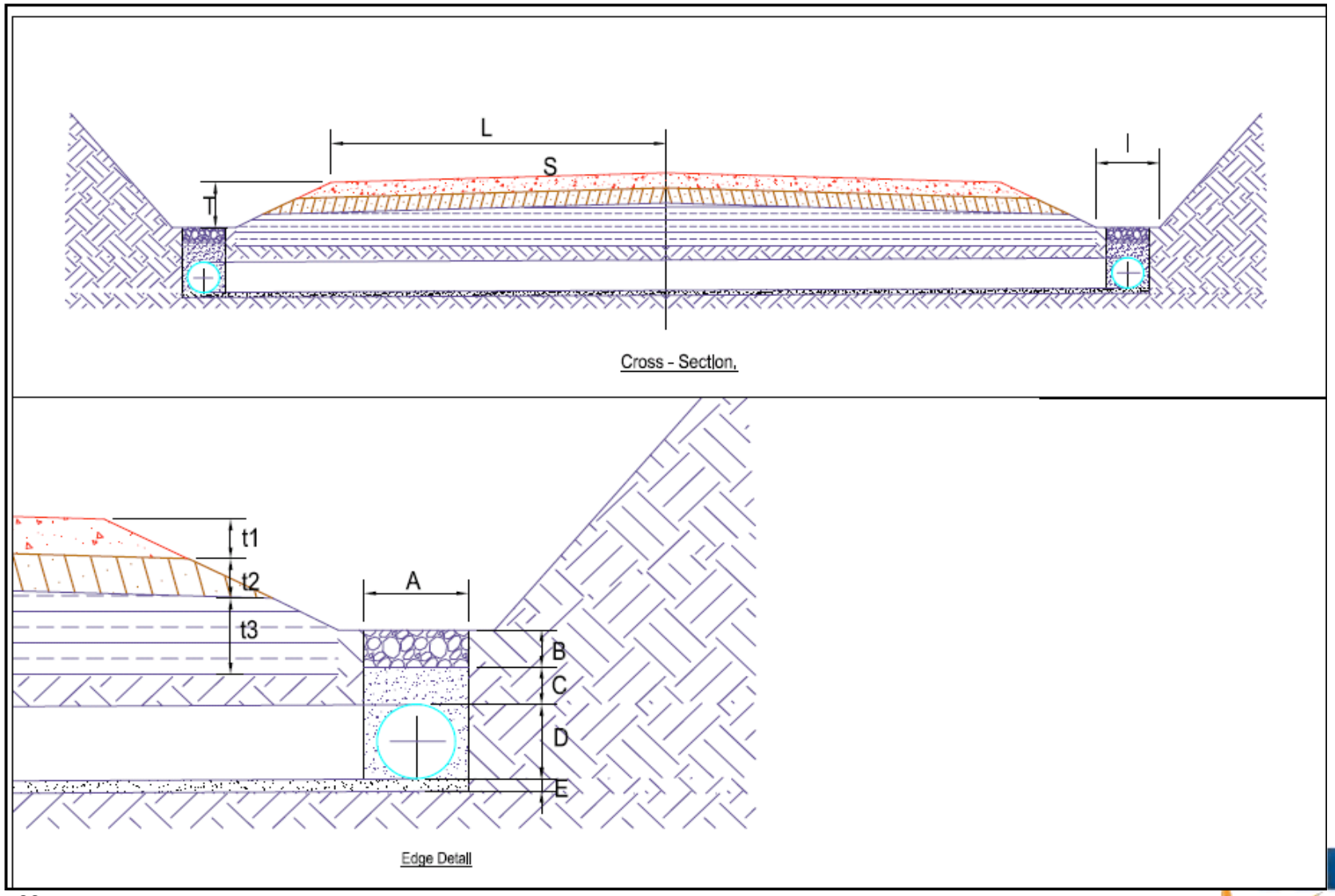
- **Lower bitumen application rates including 1.6, 1.5, 1.4, 1.3 and 1.2 L/m2 have been trialled and to date there is no difference between these sections and sections with the standard rates of 1.7 to 2.0 L/m2 of MC3000 binder.**
- **ANE has been able to build longer sections with the same budget as a result of the savings leading to mainstreaming of Otta seals before the conclusion of the research work.**
- **The change in specs has made it possible to build single Otta seals which had proven problematic in the past**
- **Good drainage is a prerequisite and subsurface drainage should be given priority in the design**
- **Maintenance should be given priority especially crack sealing. Otta seals are cheaper, have low maintenance demand and generally Life-Cycle Costs are lower.**

Single Otta seal with fine aggregate- Zero Mopeia Project

Section with 1.2L/m2 binder with fine aggregate – Zero Mopeia Project

Slow curing single Otta seal with coarse aggregate – Inhacufera Machaze Project

Illustration of subsurface drainage design



Thank you
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