



## Development of Design Standards for Low-Volume Roads in Ethiopia AFCAP/ETH/005/A

Otta Seal Demonstration project: Combel Village, Tulubolo-Kela Road  
Construction and Workshop Report  
Report No. CPR1614

C Overby (Consultant)  
A Otto

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

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

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# 1 Background

The Ethiopian Road Authority (ERA) has included demonstration projects on the use of Otta seal surfacing under the Africa Community Access Programme (AFCAP). This type of seal is an alternative to the more commonly used chip seal and other more conventional surface treatments. The main project objectives in Ethiopia were to demonstrate Otta seal technology and to research the use of locally available materials.

Two sections of the road network were identified for inclusion in the demonstration project. One section 1900 metres in length was located at Combel village along the Tulubulo – Kela road and the other section 3000 metres long was located in the village of Gerado on the Combolcha – Mekaneselem road. This report deals with the construction of the section at Combel.

## 1.1 Project objectives

The demonstration project had three objectives:

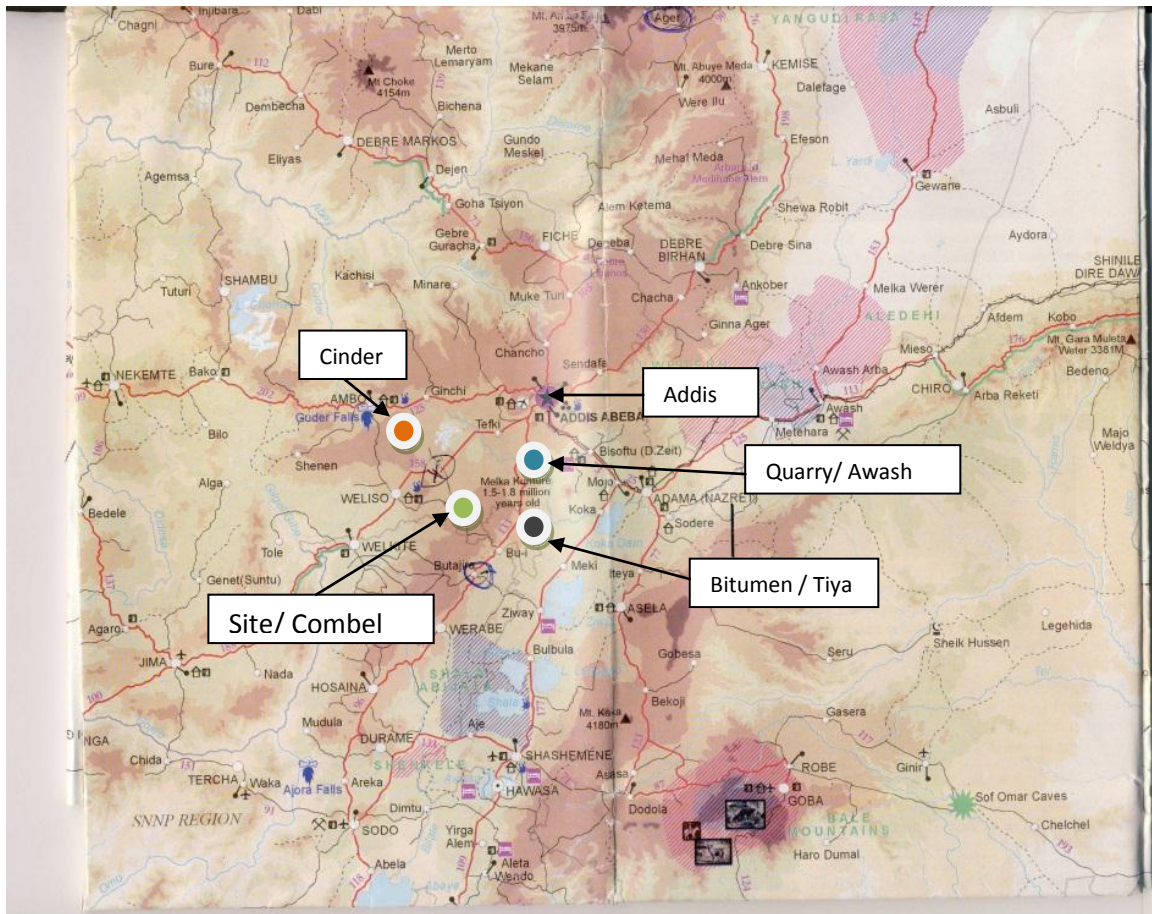
1. Demonstrate an Otta seal using aggregate that is within the prescribed grading and strength requirements
2. Demonstrate the use of locally available natural gravel (decomposed weathered basalt and volcanic cinder aggregate) that might perform satisfactorily although outside the specified aggregate requirements.
3. Demonstrate that waste fines from crushing (crusher dust) could be used as a sand seal.

# 2 Site Location

The Tulubola – Kela road through the Combel village is situated south of Addis Ababa, 37 km from Tulubolo – along the Tulubolo – Kela road. One of the reasons for this location was that it was relatively close to the capital Addis Ababa and that the sources of aggregate used were relatively close to the project site. Bitumen was hauled from the Tiya heating plant, 69 km along Alemegena – Butajira road. Figure 1 shows the location of the demonstration project.

The village location was selected in order to demonstrate the potential benefits of using the technique to improve rural roads including roads through rural residential areas. The benefits of sealing these roads include improved all-weather access to facilities within the village as well as the significant environmental benefits from reduced dust pollution compared with the existing gravel road.

Figure 1 Location of the project area



## 2.1 Topography and cross section

The demonstration section itself is 1900 m in length. Transition zones of 75 metres at the start of the section and 34 metres at the end were also constructed. The first 200 metres are located on relatively flat terrain. The following 900 metres includes an uphill gradient of between 3% and 5% in the direction towards the village with a relatively flat section through Combel village itself up to the end of the trial.

The road width varied between 5.00 and 7.00 metres. The maximum sealed road width was 6.30 metres. The side drainage has been adequately improved throughout the entire section.

## 3 Pavement Design

The pavement was designed on the basis of the ERA's "Design Standards for Low Volume: Part B 2011".

### 3.1 Existing road and materials

A simple classified traffic count was carried out. The design traffic estimated over a period of 15 years is shown in Table 3.1 in which a summary of laboratory and field results are also given.

A key note from the table is the fact that the design chart requires a G65 base layer on top of a G30 sub-base layer each of 125mm thickness. It was not possible to find natural gravel within the project

site that met the materials strength and plasticity requirements in the design charts. The choice of materials was moving a crusher near the site so that the harder 'fresh' basalt could be used as a base course,, hauling crushed stone base from an established source more than 130km away, or using the available weathered basalt.

Field tests using the Dynamic Cone Penetrometer (DCP) on the existing wearing course showed that the lowest in-situ CBR was 120% and the average thickness of gravel was 170mm. The soaked CBR of the weathered basalt proposed for use as base course was only 45% but its strength at optimum moisture content (OMC) and specified density was 65%.

### 3.1 Pavement design for Otta seal

Based on the measurements taken on the existing road, it was considered appropriate to construct a 200mm layer of weathered basalt base course on top of the existing wearing course, which would act as a sub-base and met the strength requirements for sub-base materials in the design chart.

Table 3.1 Pavement Design Parameters

Pavement Design Parameters

<b>Commercial Vehicles (ADT)</b>	<b>Two-way ADT</b>	<b>Estimated ESA/vehicle</b>	<b>ESA/day</b>
Large Bus	24	1.0	24.0
Medium Trucks	8	2.5	20.0
Heavy Trucks	4	5.0	20.0
Sum			64.0
ESAs/Day in one direction			32.0
Design MESA (15 yrs, 5% growth)			0.04
Design Class			LV 2
<b>Laboratory Results</b>			<b>Others</b>
Subgrade CBR (4-day soaked, Mod AASHTO)	15	S5	PI = 22
Existing Gravel Wearing Course CBR (%)	44	G45	PI = 23
Proposed Base Material CBR (%)	45*; 65**	G45	PI = 20
Proposed Base Material	MDD = 2.26g/cm <sup>3</sup>	OMC = 8%	
*soaked at OMC **at OMC			
<b>Field Tests</b>			
<b>Existing Layer</b>	<b>CBR (%)</b>	<b>Thickness (mm)</b>	<b>Class</b>
Gravel Wearing Course CBR	120	170	<b>G80</b>
<b>Design Chart Requirement (S5, LV2)</b>	<b>Thickness (mm)</b>	<b>Strength Class</b>	<b>Others</b>
Base Layer	125	G65	PI<15, PM<400, Grading "B"
Sub-base Layer	125	G30	

There is clearly a risk involved in using weathered basalt materials due to their susceptibility to damage from moisture ingress but the costs of extracting and hauling conventional materials that fully met the specifications for base course were prohibitive. The perceived risks were reduced by the decision to use a double seal and to seal the carriageway right up to the side drains. It is expected that this will reduce the possibility of the ingress of moisture and of any subsequent deleterious effects to the performance of the basalt base and sub-base. On areas of flat geometry

where there is a possibility of ponding of storm water, it is proposed that the side drains should be lined.

### 3.2 Construction of the pavement layers

In the latest ERA Design Manual, the recommended standard for roads in villages is that the carriageway should be 9.3m wide. The existing carriageway was 5.5m wide but at this location, there were various constraining influences which limited widening of the carriageway and ERA recommended a maximum design paved width of 6.3m which was used throughout the trial section. During construction, the existing road was widened to a nominal width of 7metres by a benching technique with material from the borrow pit used for construction of the base. The edge of the road was then trimmed on both left and right hand sides to form the side drains. The existing carriageway was then scarified to 150mm depth and re-compacted.

The weathered basalt base material was imported from borrow pit, which was located 7km from the site, spread 250mm thick on the finished sub-base to 2.5% camber and compacted to a thickness of approximately 200mm. The material before compaction had a significant quantity of oversize material which broke down upon compaction.

The rainy season began in July 2012, before construction of the base was completed, and work was suspended. The rains continued for a period of more than 3months. The major detrimental effect of the rains was soaking of the base course and washing out the fines from the base material. When construction resumed, it was clear that considerable damage to the base had occurred. The base was scarified, patched and extra material added where required. Fine material was added under vibration compaction. The remedial works took place in January 2013. Further re-compaction was also required on some sections following the remedial work on the base. As a consequence of the rains and the re-working of the base, some smoothness and tightness of the base was lost. This necessitated some sections of the carriageway being re-cut and the final road width varied between 5m and 7m. The final base compaction densities before sealing are shown in the Table 3.2.

**Table 3.2 Base compaction Base Compaction**

Chainage	Test Location	Relative compaction (% of MDD)
39.125	CL	99
38.950	LHS	100
38.775	RHS	95
38.6	CL	100
38.425	LHS	95
38.25	RHS	100
38.075	CL	99
37.9	LHS	96
37.725	RHS	97
37.55	CL	99
37.375	LHS	98

### 3.3 Primed base layer

The gravel road base layer of weathered basalt road base was primed with MC 30 at an application rate of +/- 1.0 l/m<sup>2</sup> about a week before the sealing operation started.

The primed base was in a general satisfactory condition but segregation in the base material in localised areas left the base rather open in general from chainage 0 to 600 metres. The binder application rates for the surfacing were slightly increased in these areas to allow for this. From chainage 600 – 1000 metres, the base was very dense and hard. At the end of the section chainage 1000 – 1900 metres the base had become somewhat loose and areas with lamination and had to be improved prior to sealing. Figure 2 shows two photographs of the primed base.

**Figure 2 Coarse base and dense base layers after priming**



### **3.4 Layout of the demonstration project**

The demonstration project comprises of four sections of various length using the following different types of aggregate and bitumen viscosity.

All sections will eventually have a double seal, which will be applied 3 months after completion of the first seal. This is to ensure that all the volatile oils (solvent) have evaporated prior to the second seal being applied. If the volatile oils trapped are between the two seals, then the result will be heavy bleeding and instability of the seal. The layout of the demonstration project through Combel village is shown in Appendix A.

### **3.5 Properties of the aggregate**

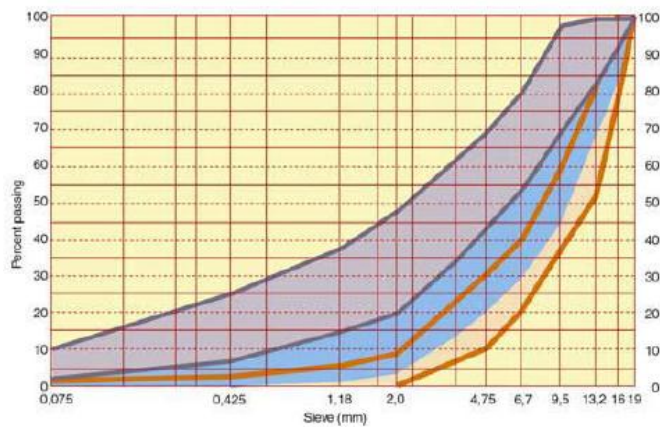
The demonstration project used four types of aggregate:

- Plant crushed from Awash quarry “hard” fresh rock basalt.
- Crusher dust < 5.0 mm from Awash quarry.
- Decomposed basalt labour screened from project road.
- Volcanic cinder gravel screened by labour to produce the required grading.

## **4 Surfacing aggregate**

The recommended grading limits and other commonly-used key aggregate properties for an Otta seal are shown in Figure 3.

Figure 3 recommended aggregate properties for an Otta seal



AADT	Best suited grading
Less than 100	"Open"
100 - 1000	"Medium"
More than 1000	"Dense"

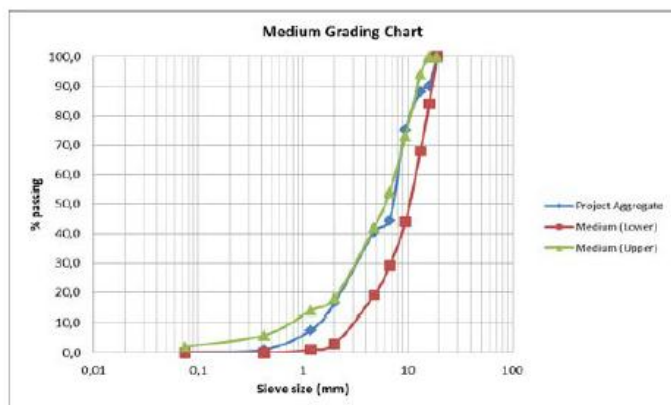
Aggregate strength requirements	Vehicles per day at the time of construction		BS Test Designation
	< 100	> 100	
Min Dry 10% FACT	90 k N	110 k N	BS 812
Min Wet/Dry strength ratio	0.90	0.75	

Water absorbency max. 4%. PI max. 10.  
Flakiness Index for crushed aggregate 30

### 4.1 Crushed rock aggregate

The aggregate produced from crushed rock was obtained from the quarry at Awash. The parent rock was "hard" fresh rock basalt. Three size fractions (¾", 3/8" and < 5.0 mm) were produced at the quarry, hauled to site and mixed at site in the proportions of 2 + 2 + 1, respectively, to produce the required grading. The resulting grading and other key properties are shown in figure 4.

Figure 4 Grading curve from Awash quarry after mixing including other key properties



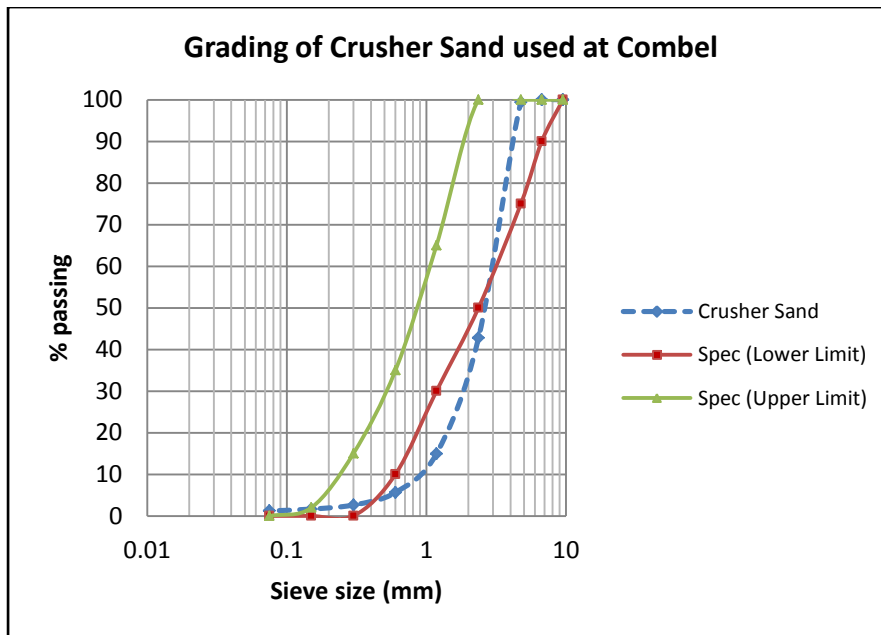
PI = 9  
Flakiness Index = 15  
10% FACT (dry) = 300. dry/wet ratio = 0,87  
Water absorption = 1,0%

The grading of the above material follows the "medium" grading in the Otta seal Design Guide, although the material is somewhat gap-graded because the fraction between 6,7mm and 4mm is missing. The other key properties are well within the requirements such (e.g. PI of 9, Flakiness of 15, 10% FACT dry as high as 300kN and a wet/dry value of 0.87. Water absorption is low at 1,0%.

### 4.2 Crusher dust

The crusher dust is the fine fraction (< 5mm) produced at the crusher. It is also often referred to as crusher -waste. The grading curve for the crusher dust is shown in Figure .

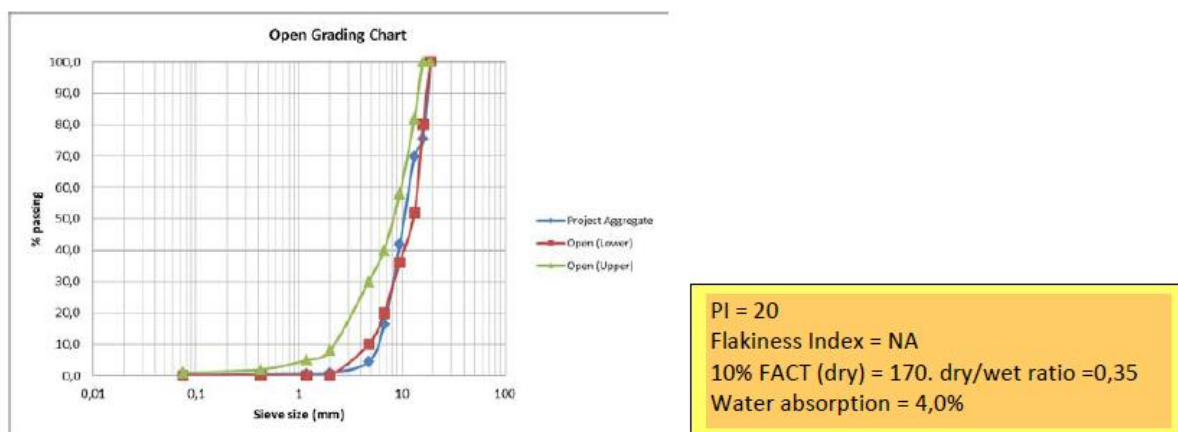
Figure 5 Grading curve of crusher dust from Awash quarry.



### 4.3 Weathered basalt

The source of the weathered basalt used for the base as surfacing aggregate was located approximately 5 km south of the demonstration project along the same road as the trial section. The aggregate was screened using labour-based techniques in order to remove oversize (> 19 mm) and fines. During the screening process some of the screens broke and as a result about 10 – 15% oversize were included. The grading and other key properties as shown in figure 6.

Figure 6 Grading curve for natural gravel of weathered basalt (screened) including other key properties



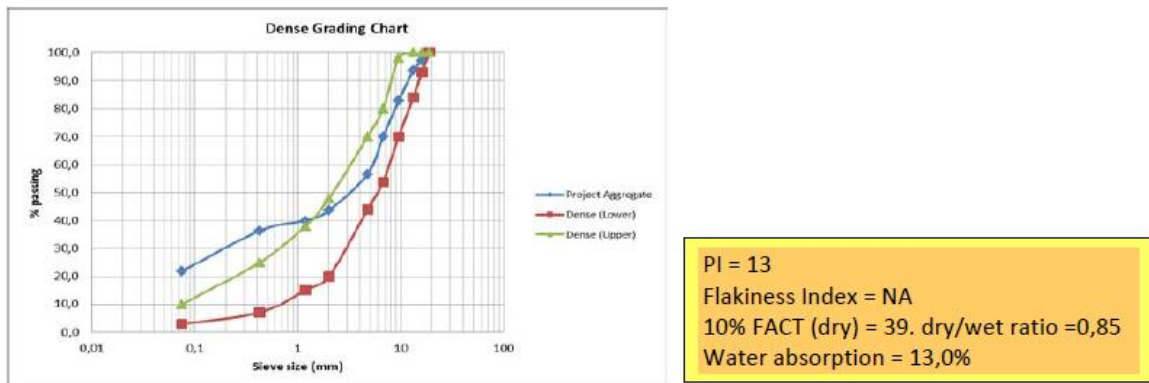
The grading follows the “open” grading, slightly gap-graded between the fractions 16 – 13 mm. The PI is as high as 20 and is in fact the double of what is recommended. The water absorption is 4% and is on borderline of what is recommended. The 10% FACT dry value is 170 kN and is within the strength requirement of 90 kN, however the wet/dry ratio of 0.35 is only ½ of the 0.75 requirement.

## 4.4 Volcanic Cinder aggregate

Volcanic Cinder aggregate is abundant in the project area and in other places within the country. The aggregate can easily be extracted and screened by labour to remove oversize and fines from the bulk sample.

The source was about 46 km west of the demonstration project. Figure 7 shows the grading and other key properties for the cinder aggregate.

Figure 7 Grading curve for volcanic cinder gravel (screened) including other key properties



The grading follows the “dense” grading down to about the 2 mm sieve, then follows a much finer grading (about 10 %) than the recommended Otta seal grading requirements. The fraction passing the 0.075 mm sieve is 22%, which is more than double than the recommended value. The other key properties such as a PI of 13 is higher than the recommended value (10). The 10% FACT dry is as low as 39 (requirement 90) but the wet/dry ratio is 0.85. The most challenging parameter is the high water absorption value of 13%.

## 5 CONSTRUCTION OF THE OTTA SEAL / SAND SEAL

### 5.1 Introduction

The sealing work was carried out by an ERA Emergency Works Unit, using the following equipment:

- Bitumen distributor (6000 l capacity).
- Self-propelled chip-spreader.
- 2 tipper trucks (capacity 9 m<sup>3</sup>)
- Pneumatic roller (12 tons)
- Steel roller (8 tons)
- Front-end loader.
- Wheel barrows, brooms and shovels incl. an adequate number of labours.

The primed base was protected by a diversion and watchmen patrolled the primed area in order to keep livestock, the hooves of which picked up the bitumen-based prime leaving ‘dimples’ of unpromed base material. The aggregate to be used were stockpiled on site adjacent to the road. The sealing operation took place between the 30<sup>th</sup> of January and 8<sup>th</sup> of February 2013.

## 5.2 Type of binder and spraying

Two types of binders were used. The base binder bitumen was MC 3000 and a quantity was cut back to MC 800 viscosity by adding 15% by volume of MC 30 used for priming. Cutting-back was carried out on site. The bitumen hot spray rates ranged from 1.1 -3.9 l/m<sup>2</sup>.

The binder application rates were initially increased from the original design values by 0.1 – 0.2 l/m<sup>2</sup> due to the coarseness of the base and the amount of fines in the aggregate which appeared to be significantly different from the results obtained in the laboratory.

The bitumen distributor did not have a dip stick to measure the volume in the distributor tank which is normally used as a check on volume delivered and hence the spray rate. Consequently the spray rate was controlled using a low speed gauge on the dashboard. This made it very difficult for the driver to maintain an accurate speed whilst at the same time ensuring that the vehicle followed the required spray line. Hence, the actual spray rates produced were rather erratic and adjustments had to be made on a regular basis as the rate of spray was checked after each run using trays placed on the road prior to spraying the binder. The laboratory personnel weighed the trays and calculated the actual binder spray rate applied by the distributor.

Prior to the daily sealing operations, the nozzels of the bitumen distributor where checked on site as shown in Figure 8.

Figure 8 Checking the spray bar nozzels prior to spraying of binder



The actual binder spray rates for each “spray pull” for each sub-section of the trial is given for the sand seal, cinder gravel, weathered bassalt, in Table 5.1, Table 5.2, Table 5.3 and Table 5.4 respectively and for both the right hand side (RHS) and left hand side (LHS) of the road.

Table 5.1 Binder spray rates for the sand seal section 0 – 100 m, including transition zone.

RHS Chainage (m)	Type of seal	Binder used	Bitumen distributor Speed	Actual spray rate (kg/m <sup>2</sup> )	Comments
Minus 0 - 74	Sand seal (crusher dust)	MC 3000	0.8	0.90	Transition zone. Crusher dust applied by labours
0 – 40			1.15	1.69	Crusher dust applied by labour
40 – 100			0,9	1.47	
LHS Chainage (m)					

Minus 0 - 74	Sand seal (crusher dust)	MC 3000	0.8	1.11	Transition zone
0 – 50			NA	1.08	Crusher dust applied by labour
50 – 100			0.8	1.07	Crusher dust applied by labour

Table 5.2 Actual binder spray rates for the section 100m to 300m using screened volcanic cinder aggregate

RHS Chainage (m)	Type of seal	Binder used	Bitumen distributor Speed	Actual spray rate (kg/m <sup>2</sup> )	Comments
100 – 190	Otta seal, cinder aggregate	MC 800	1.8	2.77	Bitumen flowing on the primed base
190 – 300			1.9	3.90	
LHS Chainage (m)					
100 – 210	Otta seal, cinder aggregate	MC 800	1,7	2.2	
210 – 300			1.7	2.04	

Table 5.3 Actual spray rates for the section 300m to 600m using screened weathered basalt

RHS Chainage (m)	Type of seal	Binder used	Bitumen distributor Speed	Actual spray rate (kg/m <sup>2</sup> )	Comments
300 – 400	Otta seal, screened weathered basalt	MC 800	18	2.20 *	* Not measured in tray
400 – 500			18	2.20*	* Not measured in tray
500 – 600		MC 3000	17	1.94	Aggregate applied by labour
LHS Chainage (m)					
300 – 400	Otta seal, screened weathered basalt	MC 800	18	1.90	Longitudinal joint no overlap in short places
400 – 500			18	1.96	
500 – 600		MC 3000	18	2.20	Aggregate applied by labour

Table 5.4 Actual binder spray rates for the section 600m to 1900m and 34m transition zone using crushed basalt

RHS Chainage (m)	Type of seal	Binder used	Bitumen distributor Speed	Actual spray rate (kg/m <sup>2</sup> )	Comments	
600 -710	Otta seal, crushed hard basalt	MC3000	15	2.18		
710 – 810			14	1.89		
810 - 860			14	1.88		
860 -960			14	1.80		
960 - 1060			14	2.00		
1060 - 1160				1.90 *	* Not measured in tray	
1160 - 1270				1.90		
1270 - 1400				16	2.56 ?	
1400 - 1530				14	1.60 *	* Not measured in tray Aggregate applied by labour
1530 – 1580					2.06	

1580 – 1630				1.85	Aggregate applied by labour
1630 – 1680			16	2.06	
1680 – 1730			16	2.20	
1730 – 1780			16	2.06	
1780 - 1900			16	2.20	
1900 - 1934				2.20 *	* Not measured in tray Aggregate applied by labour

LHS Chainage (m)	Type of seal	Binder used	Bitumen distributor Speed	Actual spray rate (kg/m <sup>2</sup> )	Comments
600 - 700	Otta seal, crushed hard basalt	MC 3000	1,8	2.56	
700 - 800			17	2.42	
800 - 860			16	2.26	
860 – 960			15	2.70	
960 – 1060			15	2.28	
1060 - 1160			14	1.56	
1160 - 1260			16	1.78	
1260 - 1360			15	1.70 *	* Not measured in tray
1360 – 1460			14	1.54	
1460 – 1560			15	1.70	
1560 – 1660			16	1.89	
1660 – 1760			16	1.90 *	* Not measured in tray
1760 – 1860			16	1.90	
1860 - 1900			16	1.90 *	* Not measured in tray
1900 – 1934					1.90 *

Paper was laid between each start and stop position of the distributor in order to achieve straight transverse joints as shown in Figure 9.

Figure 9 Paper laid to achieve straight transverse joints



### 5.3 Aggregate application

The aggregate was pre-stockpiled in the site camp and before loading the aggregate into the tipper trucks, the front-end loader “aired” the aggregate in order to remove as much dust as possible. This entailed tipping the aggregate from a height above stockpile to allow the wind to blow away excess dust as shown in figure 10.

Figure 10 The front-end loader “airing” the aggregate in order to remove dust



The aggregate application was carried out by a self-propelled chip spreader which applied the aggregate evenly. However, due to two breakdowns some section of the medium hard natural decomposed basalt aggregate and the hard basalt aggregate had to be applied by the use of labour. This worked effectively but the spray length of the sections had to be reduced to about 50 metres in length to enable the aggregate to be applied when the binder was still hot. Also, for the sand seal section the crusher dust had to be spread by labour as the minimum opening for the chip spreader was too big for crusher dust.

The application rate of all the four types of aggregate was on the high side (about 25 l/m<sup>2</sup> or even more) because of the relatively high rate of binder applied due to the difficulty of controlling the distributor spray rates. In fact, most of the entire length of the demonstration section was re-chipped with aggregate due to the high binder spray rates in order to avoid excessive bleeding during the rolling operation. Figure 11 shows the self-propelled chip-spreader in operation and the spreading of aggregate by the use of labours.

Figure 11 Self-propelled chipspreader in operation and the sprading of aggregate by the use of labour.



#### Rolling during construction and after

- The rolling during the construction and after was carried out using a 12 tonne pneumatic roller, a 5 tonne steel roller and the two tipper trucks fully loaded with aggregate (capacity 9 m<sup>3</sup>). The rolling was carefully supervised so the entire width of the surfacing and all sections in the trial received adequate rolling. After completion of the sealing operations the entire length of the trial (1000 – 1800) received three days of full rolling using the same equipment,

except for the cinder aggregate which received only two passes of the steel to avoid the weak aggregate was crushed down.

Figure 12 shows rolling with a loaded tipper truck and the pneumatic roller immediately after the chip-spreader

Figure 12 Rolling in progress by the use of both a pneumatic roller and the loaded tipper truck.



#### 5.4 Weather condition during construction

The weather conditions during the sealing operations were mainly sunny and partly cloudy with temperatures ranging between 17 – 23 C°. However, strong wind prevailed all times and on Saturday 2<sup>nd</sup> February rain started in the late of the afternoon and the sealing operation had to be suspended.

## 6 CONSTRUCTION CONSTRAINTS

### 6.1 General

This section highlights some of the problems that occurred during the construction of the Otta seals.

#### 6.1.1 Bitumen distributor.

The most significant part was the hauling of bitumen and the inaccuracy of the spray rates from the bitumen distributor. The haulage of bitumen from Tiya 69 km from Alemgena – Butajira road took more the 5 hours each way for the bitumen distributor and as a result the sealing operation could not take place every day causing significant delays. This also caused problems when sealing operations took place as the bitumen had to be heated to spray temperatures from early in the morning and as this took time very seldom the sealing operations took place before 1300 in the afternoon.

The inaccuracy of the bitumen spray rates also caused far too much bitumen for a number sections as seen in the tables 1 - 4. This was partly due to the fact the bitumen operator had difficulties in maintaining the set speed accurately and at the same time looking at the bitumen spray line. The situation improved when placing a person inside the bitumen distributor assisting the operator keep constant speed.

#### 6.1.2 Aggregate.

The crushed basalt and natural weathered basalt contained too much oversize aggregate and may cause potholes at an early stage as the bitumen may not hold the oversize aggregate. The breakdown of the chip-spreader at two locations and the fact that the aggregate opening was too

open for the crusher dust caused minor problems as the aggregate was applied by the use of labour and, the bitumen “pull” had to be reduced to 50 metres instead of 100 metres.

### **6.1.3 Sealing operations.**

Construction of the the seal was generally well executed, given that this surfacing technique is new to Ethiopia. Following a slow start in which the constuction team were trained in the various activities, which understandably required close supervision, the whole operation proceeded without any major problems.

## **7 CONSIDERATIONS FOR APPLICATION OF THE SECOND SEAL**

The second seal is planned to be placed after a minimum period of 12 weeks allowing the volatile oil (solvent) to evaporate. During this period, dislodged aggregate (first 4 – 5 weeks) can be broomed back in order to ensure a fully matured Otta seal and sand seal. Thereafter all the loose aggrgate can be broomed off.

Prior to construct the second seal all aggregates need to be stockpiled at site and covered with tarpaulins in order to keep the aggregate dry in the case of rain.

Obviously, all defects in the first seal must be repaired prior to the construction of the second seal. All bituminous repair work should be completed at least 3-4 week before sealing operations take place.

The experience with the bitumen distributor giving very high spray rates for the first seal requires serious consideration for the second seal and the second seal spray rates need to be adjusted based on a visula assessment after the seal has been in service for 12 weeks.

The side drains/ditch on the flat area in the village from 0+900 metres to 1+500 metres need to be lined to protect the weathered basalt since water is likely to pond in these areas. Scour checks need to be constructed in the drains on the steep sections to minimise erosion..

## **8 WORKSHOP AND FIELD VISIT**

### **8.1 Introduction**

The construction of the trial presented an opportunity to promote the Otta seal concept and a one-day workshop was held to discuss the trial with local stakeholders (ERA engineers, Consultants and Contractors) on the 4<sup>th</sup> February 2013 at Dreamliner Hotel in Addis Ababa. The workshop was attended by 34 participants.

### **8.2 Purpose and Scope**

The pupose and scope of the workshop and the field visit to the project site the following day were to promote the Otta seal concept and in general terms providing a better understanding of following aspects regarding application of an Otta seal:

- 1 - An Overview of gravel roads vs Sealed roads
- 2 - Various types of Surface Treatments
- 3 - What is the Otta Seal including the economic aspects

#### 4 - How to Design and Construct an Otta Seal

- The Condition of the road to be sealed.
- Materials on site.
- Plant / Equipment / tools.
- The Design of the Otta Seal
- Construction.
- Quality Assurance.
- “After Care”
- Reporting.

Slides from the power point presentation are shown in Appendix B.

### 8.3 Field visit

On the field visit, the workshop participants travelled to the demonstration site in the village of Combel. At the borrow pit nearby to the village, the participants were able to observe the full production process for the decomposed basalt aggregate. This included excavation, primary screening, secondary screening, transportation and stockpiling and demonstrated the process of using Otta Seal aggregate obtained by screening the material that had also been used for constructing the base course.

At the village, they were able to observe the construction of the Otta Seal using MC3000 binder and the decomposed basalt aggregate. The process of cutting back MC3000 with MC30 to obtain MC800 that was used to construct the Cinder Gravel Otta Seal was also demonstrated.

## 9 Provisional cost estimates for Combel

The aggregates used for the project were:

- 1) Crushed Stone Aggregate from Awash Crusher plant, located 130km from the site
- 2) Crusher Sand (Crusher Dust) from the same plant in 1)
- 3) Cinder gravels obtained from 60km from the site
- 4) Decomposed Basalt obtained from 7km from the site

### 9.1 Distortion of costs

An attempt has been made to assess the relative costs but it is very difficult to estimate costs on small scale research projects and there are no benefits from “economies of scale”. The mobilisation costs are a much higher component of the total costs than in larger projects. For instance if a Dozer is transported by a low-bed truck to stockpile material for 300m of road, the unit cost would be much higher than when the same machine is used to stockpile material for say 10km of road.

Furthermore, materials may be resourced and hauled from further afield because they need to be included in the research rather than because they are the most economic source of available material.

Because of factors such as these, the equipment mobilisation and materials stockpiling cost was excluded from the rate build up and instead a mark-up of 15% was added to the material cost as an alternative.

For aggregates 1) and 2) which were purchased from a crusher plant, the purchase cost, haulage cost (fuel) and a mark-up of 15% for truck wear and tear, crew, handling and storage were used to build the rates.

The Emergency Works Unit which carried out the construction is part of ERA and some of the cost components which would normally be assigned to a contract by a contractor do not apply in this case or are not easily quantifiable. The mark-up of 15% was used as an estimate of the actual costs.

For natural aggregates 3) and 4), the cost of simple tools, labour for screening and haulage costs were used to build the rates. A mark-up of 15% for truck wear and tear, crew, handling and storage were used to build the rates. The cost of heavy plant to produce the natural materials have been excluded and assumed to be part of the cost of producing the base material. This is because the screened natural aggregates used for Otta Seals and the materials for the base course were sourced from the same borrow pit using the same equipment.

## **9.2 Estimated costs**

The cost estimates are presented in the Table 9.1 below:

**Table 9.1 Table of costs for construction of Otta seal at Combel**

Material	Aggregate Unit Cost		Design application rate of Bitumen	Prime + Bitumen Cost (Design)		Aggregate Cost (Design)		Otta Seal or Surfacing Cost	
	Birr/m <sup>3</sup>	US\$/m <sup>3</sup>		Litres/m <sup>2</sup>	Birr/m <sup>2</sup>	US\$/m <sup>2</sup>	Birr/m <sup>2</sup>	US\$/m <sup>2</sup>	Birr/m <sup>2</sup>
Crushed Stone Aggregate	597	31.4	1.8	89	4.7	11	0.6	100	5.3
Crusher Sand (Crusher Dust)	651 411*	34.3 21.6*	1.1	67	3.5	8	0.4	75	3.9
Cinder Gravels	376	19.8	2.3	105	5.5	7	0.4	112	5.9
Decomposed Basalt	238	12.5	2.0	95	5.0	5	0.3	100	5.3

\* factored at 0.63 as a ratio of application rate of Sand to Otta seal aggregate for comparison

### 9.3 Discussion of cost estimates

The costs of crushed aggregates obtained from blasted rock are usually significantly higher than the cost of natural aggregates (extracted and screened). The two advantages of the aggregate component of this type of seal is that (a) a larger fraction of the crusher output can be used than for a chip seal when using a crushed rock source and (b) the ability to use screened locally available (weaker) aggregate.

The relative bitumen/asphalt costs are the opposite of the aggregate costs in that these costs are higher for natural aggregates than crushed rock. This is because the natural aggregates demand higher quantities of binder than the crushed aggregates. The extra demand occurs as a result of the dense grading and relatively high absorption of natural aggregates compared to the medium grading and low absorption of the crushed aggregates. However, the cost of the increased application rate of binder compared, for example with a chip spray, is offset by the additional life-cycle benefits from increased durability.

However costs are distorted on small-scale research projects as is evident from Table 9.1.

As a result of these factors, the costs of both crushed aggregates and natural aggregates all tend to a central value of between US\$5.3 and US\$5.9 (excluding contractor's mark-up for overheads and profits) per square metre of the surfacing.

The crusher sand seal is cheapest and ideal for very low volume roads although not very durable as a single seal, especially on a relatively weak base.

### 9.4 Final remarks on costs

The aggregate from the crusher plant appears to be unusually expensive, especially since crusher sand is the most expensive material from the plant. This could be a result of the plant spreading its running costs uniformly over all aggregate sizes. It is known, for example, that 1.0m<sup>3</sup> of blasted rock produces about 0.75m<sup>3</sup> of aggregate that can be used for an Otta Seal but 1m<sup>3</sup> of blasted rock produces only about 0.3m<sup>3</sup> useful aggregate for Double Bituminous Surface Treatment which uses single sized aggregates. Therefore for a large-scale project, it is cheaper per volume of output to produce aggregate from a crushing plant for Otta Seals than for conventional bituminous surfacing.

The cinder gravel was hauled unscreened from the borrow pit, which is an unusual practice. The screening was then carried out on site. This meant that an additional cost was incurred in hauling "waste" material. The gravel was hauled from a source 60km away compared to the decomposed basalt for which the haul distance was 7km. If both the cinder gravel and basalt had been located at a similar distance, the cost of the cinder would be cheaper because of the ease of extraction and screening.

Blasting and crushing rock is expensive and at a certain haul distance it will also become uneconomic to transport crushed stone aggregate or even mobilise a crusher plant near the construction site. The exploitation of natural aggregates for rural road construction is usually much more economical, especially if the same material can be used for both base course and can be screened for use surfacing aggregate in an Otta seal and is clearly cheaper than crushed aggregate as well as creating employment in both material extraction and screening.

The initial construction costs of Otta Seals may be higher than that of some other bituminous surface treatments but the life cycle costs of Otta Seals can be up to 40% lower due to their increased durability. Also, the technique has significant potential for using labour-based technology with

relatively low mobilisation costs and is, therefore, ideally suited for spot improvement/targeted interventions such through villages or problem sections on the rural road network.

## **10 Prevailing problems with mainstreaming Otta seal technology.**

A major problem in the construction of Otta seals is that they are not yet mainstreamed in most of the LIC countries in which it has been demonstrated and almost every project continues to be, in effect, a research/demonstration project using different materials in a different environment. This leads to a situation where quantities are varied on site with external expert advice, which is not a sustainable option in terms of local use.

Another related problem is that significant variations are carried out on site and the items in the Bill of Quantities produced on the basis of the Guideline often to need to be changed during construction so that both the quantities of materials and the associated costs may no longer apply. Whilst this is not particularly important for small-scale research/demonstration projects, such changes could have more serious implications in full-scale projects. It is important for a consultant to be confident in a design based on the Guideline and a contractor to be confident about the prices in the BoQ.

The situation is further exacerbated by the Guideline document being outdated, not reflecting current knowledge, experience gained in various developing countries nor the wide range of materials that are currently candidate materials for use in Otta seals. It needs to give far more comprehensive guidance to be of use to local practitioners. Whilst it is recognised that a certain amount of engineering judgement may be necessary in many projects and that the document is a Guideline rather than a manual, it should contain sufficient guidance to enable experienced engineers to construct the seal relatively unaided. In its current form, it clearly falls short in providing the required guidance.

Therefore, if the technique is to be more widely used, there is an urgent need for the Guideline to be updated.

## **Appendix A**

### **Layout of test sections**

### Layout of the Demonstration/Research sections

<b>6.3</b>												
37+325		37+900 COMBEL VILLAGE, width 6,30m										39+330
175m		200m		300m			500m		830m			
-65	0	100	200	300	600	800	1100	1200	1400	1600	1900	1930
Double Crusher Sand Seal	Double Otta Seal Cinder aggr.	Double Otta Seal Natural aggregate		Crusher Sand Cover Seal		Double Otta Seal Crushed Aggregate					Transition	
Transition				Single Otta Seal Crushed Aggregate								

# **Appendix B**

## **Workshop Presentations**



**KUONK KNOH HELBIM AIPIS ABINESA**  
2010, JANUARY 2013

**A Practical and Economic Alternative to Traditional Bituminous Surface Treatments in particular for Low - volume roads**

by **Charles Overby,**  
Consultant

International Public Health Association

**Format of the Work Shop Presentation:**

- 1 - An Overview of the gravel roads vs Sealed roads
- 2 - Various types of Surface Treatments
- 3 - What is the Otta Seal including the economy
- 4 - How to Design and Construct an Otta Seal

The Condition of the road to be sealed:

- a) The Condition of the road to be sealed.
- b) The Design of the road to be sealed.
- c) The Design of the Otta Seal
- d) Construction.
- e) Quality Assurance.
- f) "High Cost"
- g) Reporting.

International Public Health Association

**The Provision for Low - volume Sealed Roads (LVSRs) an Overview.**

**"It is not wealth that creates roads, but roads that create wealth"**

...John F. Kennedy

International Public Health Association

**Why Invest in Low - volume Sealed Roads ?**

- Facilitate/increase trade;
- Improve access to jobs, education, health care and other services;
- Enhance incomes and economic well being;
- Increase personal mobility and facilitate economic growth;
- Reduce poverty and contribute toward social development.


International Public Health Association

**Common Factors Affecting the Adoption of Appropriate Standards for Low - volume Sealed Roads ?**

- Political/public perception;
- Political acceptance of risk;
- Design;
- Construction/maintenance technology;
- Use of regional standards;
- Unsuitable evaluation tools.

International Public Health Association

**Gravel Extraction for Gravel roads**



The successful provision of a reasonably good surface is an essential approach.

**There is no need to invest in costly bituminous technology.**

International Public Health Association

**Gravel roads will need Frequent Re-gravelling**

If not, this could be the situation after only 3-4 years in service?

Source: [www.roadandtransport.gov.au](http://www.roadandtransport.gov.au)

**Gravel roads vs Sealed roads (1):**

1) Gravel Roads have 20% Proportionate maintenance (daily re-gravelling)

2) Sealed Roads have 80% Proportionate maintenance (once in 20 years)

3) Gravel Roads have 20% Proportionate maintenance (once in 20 years)

Source: [www.roadandtransport.gov.au](http://www.roadandtransport.gov.au)

**Gravel roads will need Frequent Re-gravelling**

Source: [www.roadandtransport.gov.au](http://www.roadandtransport.gov.au)

**Role and Function of Bituminous Surfacing (1)**

Source: [www.roadandtransport.gov.au](http://www.roadandtransport.gov.au)

**Format of the Work Shop Presentation:**

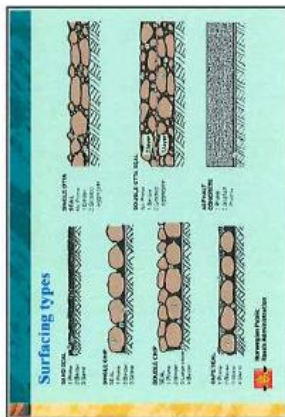
- 1 - An Overview of the gravel roads vs Sealed roads
- 2 - Various types of Surface Treatments
- 3 - What is the Otta Seal Including the economy
- 4 - How to Design and Construct an Otta Seal

- a) The Condition of the road to be sealed.
- b) The Design of the Otta Seal
- c) Plant / Equipment / Tools
- d) The Design of the Otta Seal
- e) Quality Assurance
- f) "After Care"
- g) Reporting

Source: [www.roadandtransport.gov.au](http://www.roadandtransport.gov.au)

**Adoption of Innovative and Appropriate Technologies such as the Otta Seal Concept**

Source: [www.roadandtransport.gov.au](http://www.roadandtransport.gov.au)



### Economy

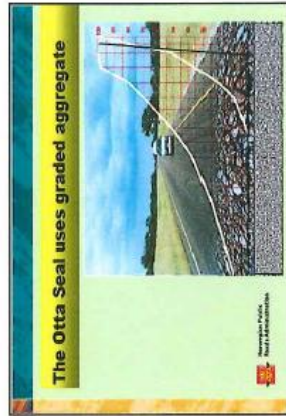
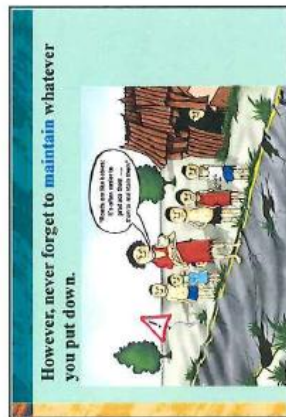
For all type of seals a life-cycle costing should always be carried out. The assessment of only construction cost does not give the true picture.

**Source:** Public Road Maintenance

### Typical range of Service Lives of Bituminous Surface Treatments

Type of Seal	Typical range of service life (years)
Single Seal	2 - 4
Slurry Seal	2 - 6
Single Chip Seal	4 - 6
Double Seal	6 - 9
Double Chip Seal	7 - 10
Single Otta Seal + Sand Seal	8 - 10
Chip Seal (Thin + Loose slurry)	8 - 10
Chip Seal (Thick + Loose slurry)	10 - 14
Double Otta Seal	12 - 16

**Source:** Public Road Maintenance



### Otta Seals

#### What is it ?

- An Otta Seal is formed by placing graded aggregate on a relatively thick firm of comparatively soft binders which, on rolling and trafficking, can work its way upwards through the aggregate interstices.
- In this manner, the graded aggregate relies on both mechanical interlocking and bitumen binding for its strength - a bit like a bituminous premix.

**Source:** Public Road Maintenance

### Mechanism of Performance of Surfacing Types

Single layer OTS (0.8 mm)  
Double layer OTS (1.5 mm)  
Triple layer OTS (2.5 mm)

Hydrophobic aggregate is composed of bitumen-granular admixture, a mixture of hydrophobic aggregate which is quite different to that of Category B aggregate.

Source: Highway Note 8, March 2006 version

### Performance Characteristics (1)

The texture of an Otta Seal is playing a vital role in its performance.

The dense textures as formed by many particles thick layer of aggregates where the interstices are filled with comparatively soft bitumen has been found to be very durable.

Source: Highway Note 8, March 2006 version

### Performance Characteristics (2)

- Often preferred on roads with low bearing capacity due to its flexible behaviour.
- It seems that the close-texture grading as formed by the Otta Seal concept is less susceptible to binder aging than a chip seal.

Source: Highway Note 8, March 2006 version

### General Grading and Strength Requirements

AADT	Best suited grading
Less than 100	"Open"
100 - 1000	"Medium"
More than 1000	"Dense"

Traffic Volume (AADT)	Minimum thickness (mm)		
	LS	CS	ES
100	10	15	20
1000	15	20	25
10000	20	25	30
100000	25	30	35

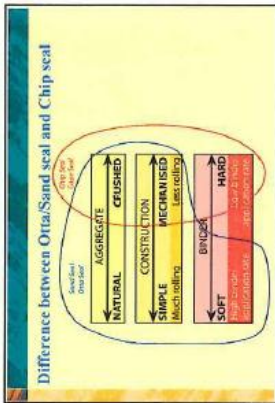
Source: Highway Note 8, March 2006 version

### Aggregate used in Otta Seals

Source: Highway Note 8, March 2006 version

### Thickness of an single Otta seal.

Source: Highway Note 8, March 2006 version



- ### Format of the Work Shop Presentation:
- 1 - An Overview of the gravel roads vs Sealed roads
  - 2 - Various types of Surface Treatments
  - 3 - What is the Otta Seal including the economy
  - 4 - How to Design and Construct an Otta Seal
    - a) The Condition of the road to be sealed.
    - b) Materials on site.
    - c) The Design of the Otta Seal
    - d) Construction.
    - e) After Care.
    - f) Reporting.

### Otta Seals

#### Why?

#### Economy

- ▶ Construction cost
- ▶ Maintenance life time costs

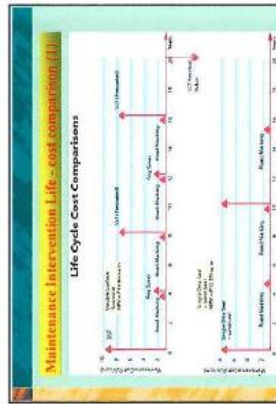
### Construction costs

- Reduced cost in aggregate production
- Hauling cost is reduced because of utilization of local materials
- In most cases prime is omitted
- In many cases surfining operations costs are reduced

In general, this gives a cost saving in the order of 35 - 40% have been reported.

### Maintenance Intervention Life - cost comparison (1)

Life expectancy, construction activities and maintenance	Otta Seals		Double Chip Seal
	11	15	7
Life expectancy	11	15	7
Maintenance activities	Resurface 10 years, Resurfacing 2 years	None	Resurface after 1 year, Resurfacing 2 years, After road intervention (4 times)
Initial relative cost of construction	1.0	1.2	1.2



### Maintenance Intervention Life-cycle cost comparison (2)

Cost Comparison of Otta Seal (1000 m<sup>2</sup> Road) to Seal

Material	Cost
Otta Seal	071,540
Seal	102,600

For Botswana the cost savings in comparison with:  
 - Single Otta Seal with Sand cover Seal  
 - Double Chip seal  
**COST RATIO 0.50**

Over a period of 15 years, it has conservatively being estimated a 50% cost saving for Otta Seal. The roughy is estimated to be similar to the cost of a new trunk road standard 50 km long.

Ministry of Works  
 Botswana Department

### Format of the Work Shop Presentation:

- 1 - An Overview of the gravel roads vs Sealed roads
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- 4 - How to Design and Construct an Otta Seal
  - a) The Condition of the road to be sealed.
  - b) Materials on site.
  - c) Plant / Equipment / tools.
  - d) The Design of the Otta Seal
  - e) Construction.
  - f) Quality Assurance.
  - g) "After Care"
  - h) Reporting.

Ministry of Works  
 Botswana Department

### 4 - How to Construct an Otta Seal

The Sequence of the road to be sealed:

- a) The Condition of the road to be sealed.
- b) Materials on site.
- c) Plant / Equipment / tools.
- d) The Design of the Otta Seal
- e) Construction.
- f) Quality Assurance.
- g) "After Care"
- h) Reporting.

Ministry of Works  
 Botswana Department

### Pavement Strength

Like all other bituminous surface treatments, an Otta Seal will not contribute significantly to the structural strength of the pavement.

The pavement layers and drainage must therefore be adequately designed and constructed to withstand the expected traffic loading through its design life.

Ministry of Works  
 Botswana Department

### Road section to be primed and/or surfaced

- 1 - The road length must have reference numbers at least 50 meters intervals, preferably at 20 m intervals.
- 2 - The road width and center line must established.
- 3 - The surface must be broomed and free of all dust or any other foreign matter before commencing the surfacing/printing.
- 4 - Deep depressions must be filled by aggregate and slurry.
- 5 - Any shallow depressions should be filled by single sized aggregate prior to spraying binder.

Ministry of Works  
 Botswana Department

### 4 - How to Construct an Otta Seal


- a) The Condition of the road to be sealed.
- b) Materials on site.
- c) Plant / Equipment / tools.
- d) The Design of the Otta Seal / Sand seal.
- e) Construction.
- f) Quality Assurance.
- g) "After Care"
- h) Reporting.

Ministry of Works  
 Botswana Department

**Materials on site**

The following must be checked as early as possible prior to surfacing operations:

- 1- Bitumen type and quantity, certificate from supplier required.
- 2- Paraffin and engine oil quantity.
- 3- Aggregate type and quality.
- 4- Aggregate grading, water absorption and strength properties.
- 5- Prepare appropriate blending site for cutting back. **RollerComp is made to RPPA Publication no. 95 page 23.**


 Department of Public Works and Government Services Canada

Publication no 93 from NRPRA

A Guide to the Use of Otta Seals




 Department of Public Works and Government Services Canada


- a) The Condition of the road to be sealed.
- b) Materials on site.
- c) **Paraffin & Engine Oil Quantity**
- d) The Design of the Otta Seal.
- e) Construction.
- f) Quality Assurance.
- g) "After Care"
- h) Reporting.


 Department of Public Works and Government Services Canada

**Plant / Equipment / tools requirements (1)**

The following plant/equipment must be on site, and in good working conditions prior to surfacing operations:


- 1- Bitumen distributor. Tank capacity? What is the minimum volume in the tank for heating. Check accuracy in spray rates, cleanliness of spray nozzles. **RollerComp** in the spray tankers, i.e. emulsion being previously sprayed. Level of heater burners, i.e. capacity in tank when no further heating can take place.
- 2- Pneumatic rollers? (weight minimum 12,0 tonnes). Check wheels and tyre pressure.
- 3- Aggregate spreader. Check if aggregate is applied evenly over the entire width.


 Department of Public Works and Government Services Canada

**Plant / Equipment / tools requirements (2)**

The following plant/equipment must be on site, and in good working conditions prior to surfacing operations:


- 4- Water bowser, check water application evenness.
- 5- Number of supply trucks?
- 6- Mechanical broom.
- 7- Backing truck or tractor with trailer used for back-chipping.
- 8- Paper for use at start spraying position.
- 9- 200 l drums being cut into half to cater for spillage during spray bar control prior to spraying.


 Department of Public Works and Government Services Canada

**Plant / Equipment / tools requirements (3)**

The following plant/equipment must be on site, and in good working conditions prior to surfacing operations:

- 10- Minimum three 3 – wheel barrows.
- 11- Hand brooms and shovels, minimum 5k – 6 of each.
- 12- Traffic cones, minimum 50.


 Department of Public Works and Government Services Canada

### 1. How to Construct an Otta Seal

- The Condition of the road to be sealed.
- Materials on site.
- Plant / Equipment / tools.
- Preparation of the base
- Construction.
- Quality Assurance.
- "After Care"
- Reporting.

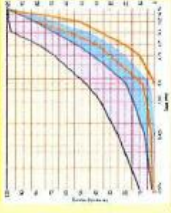


### Design of the Otta Seal (1)

- AADT - AADT-H during construction
- Rolling capacity during construction
- Aggregate grading, open - medium or dense
- Water absorption, low - medium or high
- Primed or un-primed base
- Weather conditions




### General Grading and Strength Requirements



AADT	Best suited grading
Less than 100	"Open"
100 - 1000	"Medium"
More than 1000	"Dense"

Aggregate	Moisture	Stabilisation	Region
Open	10%	10%	10%
Medium	10%	10%	10%
Dense	10%	10%	10%

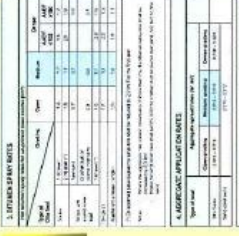



### Design of the Otta Seal (2)





### Design of the Otta Seal (3)





### Design of the Otta Seal (4)

- Cutting back with paraffin to obtain adequate viscosity during construction.
- Decide on hot spray application rate.
- Estimate proportion of binder (160/200 penetration grade and % by volume engine oil / paraffin).



### Common Bitumen Hot Spray Rates

Traffic level at time of construction (AADT)	Hot spray rates (l/m <sup>2</sup> )
< 100	1,8 – 2,2
100 – 500	1,8 – 2,0
> 500	1,6 – 1,8

Highway Public  
 Highway Engineering

- ### 4 - How to Determine an O/S
- The Condition of the road to be sealed.
  - Materials on site.
  - Plant / Equipment / tools.
  - The Design of the O/S Seal / Sand seal.
- Quality Assurance.
  - "After Care"
  - Reporting.
- Highway Public  
 Highway Engineering

### Binders and cutting back

**Type of binder of pavement importance.**

**Correct viscosity range:**  
 Normally MC 300 or MC 300 bitumen em. Bitumen grade 10220  
**80/100 pen. bitumen grade shall NEVER be used.**

Delivered bulk is 1022000 - grade being requested. used for site.

As cutting back can only be carried out on site providing correct safety measures are applied.

Highway Public  
 Highway Engineering

### Cutting back calculations

Highway Public  
 Highway Engineering

Truck capacity 9000l  
 Volume for road from 125 degrees (from table) to 155 degrees (from table) 2000l

Parameter	Value
Bitumen distributor capacity (l)	6750
Temperature of bitumen	155
Temperature of cut	140
Temperature of bitumen	140
Temperature of bitumen	135
Temperature of bitumen	130
Temperature of bitumen	125
Temperature of bitumen	120
Temperature of bitumen	115
Temperature of bitumen	110
Temperature of bitumen	105
Temperature of bitumen	100
Temperature of bitumen	95
Temperature of bitumen	90
Temperature of bitumen	85
Temperature of bitumen	80
Temperature of bitumen	75
Temperature of bitumen	70
Temperature of bitumen	65
Temperature of bitumen	60
Temperature of bitumen	55
Temperature of bitumen	50
Temperature of bitumen	45
Temperature of bitumen	40
Temperature of bitumen	35
Temperature of bitumen	30
Temperature of bitumen	25
Temperature of bitumen	20
Temperature of bitumen	15
Temperature of bitumen	10
Temperature of bitumen	5
Temperature of bitumen	0

4250 x 100 = 425000  
 425000 x 2 = 850000  
 850000 x 10 = 8500000

Highway Public  
 Highway Engineering

### Binders, cutting back on site to required viscosity

The appropriate type of binder and viscosity may be obtained by cutting back with engine oil and power paraffin on site.

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 Highway Engineering

### Construction (1)

Preparatory work prior to sealing operations

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 Highway Engineering

**Preparation of the road base prior to scaling (1)**


**Lamination**



Work on the road base surface is done in layers. The top layer is the surface course, followed by the base course and the sub-base course. The bottom layer is the sub-grade. The road base is prepared in layers to ensure a strong and durable surface.

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**Construction (2)**



Light watering of the broomed base before spraying, the binder will enhance the bond between the surfacing and the base layer.

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**Prime**




Apply a uniform layer of prime coat to the road base surface. The prime coat is applied to the road base surface to ensure a strong and durable surface.

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**Check road surface.**




Check for small depressions and fix them before scaling.



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**Q/A of adequate binder application prior to surfacing**



**Checking of spray nozzles.**

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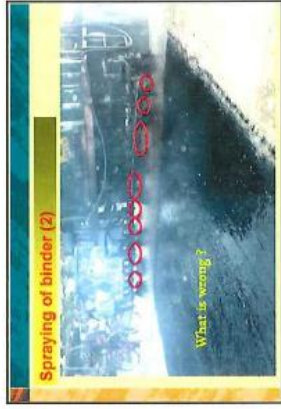
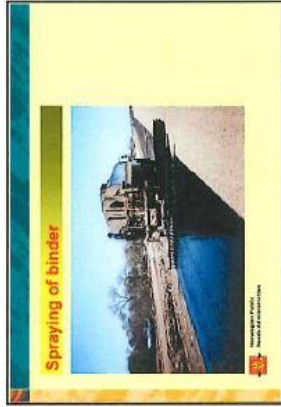
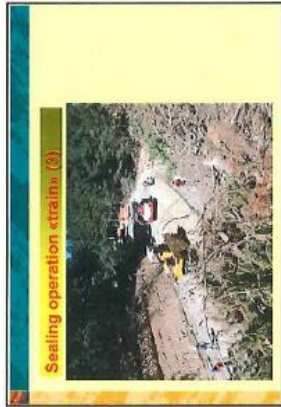
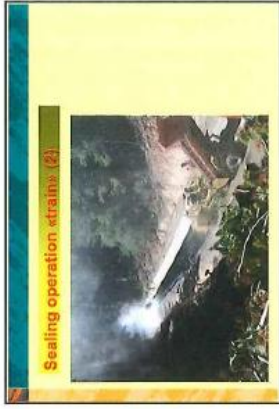
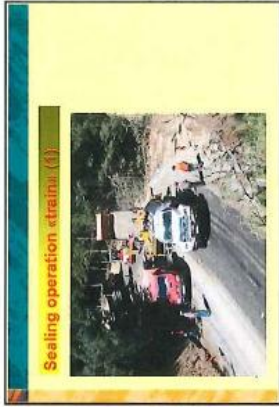
**Quality Assurance of the blumen distributor spray bar**

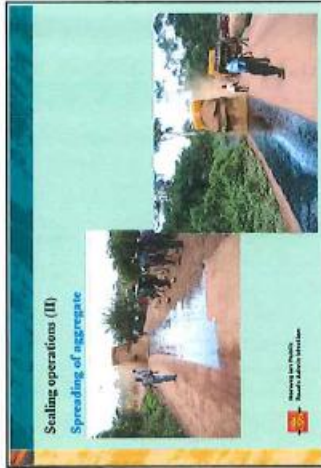
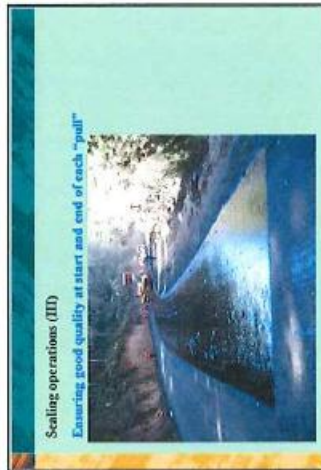
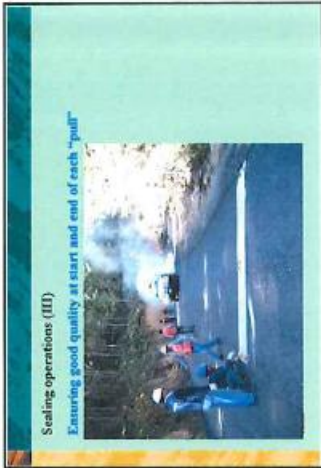
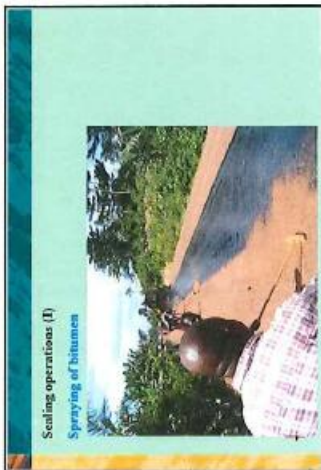


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**Q/A during before and during construction**

- Seve analysis from roadside.
- Check road surface, any small depressions to be filled with course aggregate.
- Ensure that spraying gun has been established, and correctly.
- Check spray nozzle prior to spraying for the use of 7.5 cut drains. Spread the aggregates along with "full" to allow spray to take. Make sure the aggregates are well mixed and that the aggregate application, and perform Seve analysis from same material.
- Ensure that road signs are placed prior to any work, (mass speed 40km/h limit, 70km/h limit, etc.)




**Fines and dust are allowed in an Otta Seal**




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Scaling operations (IV- a)  
**ROLLING**



Scaling operations (IV- b)  
**.... and ROLLING, we can never compromise the rolling**



**Rolling of Aggregate (3)**




**Rolling**




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**Rolling of Aggregate (4)**




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Scaling operations (V)  
**Back chipping in fatty spots**




**Sealing operations (VI)**  
*When things goes "shit" and the head is boiling*



*The road was too narrow!!*




*Is this really the best way?*




*The slurry discharge is sealing more like a slurry seal!!*

**The sealing operations are completed (VII)**  
*.... We can go home*



**The sealing operations are completed**  
**Early stage of an Otta seal, looks more like a gravel road**



**After care**  
**After 8-12 weeks excess of aggregate is swept off the road and collected for reusing in another Otta Seal**



*Excess is coming to the surface*

**Over size aggregate can ruin the final product as potholes will develop quickly.**




*Over size aggregate can ruin the final product as potholes will develop quickly.*

**Difference in texture due to different volume of rolling**



### Longitudinal Joints (1)

Inundation compacts, resulting in entrapment of binder and aggregate.

November 2016  
North Carolina  
Road & Transportation

### Longitudinal Joints (2)

November 2016  
North Carolina  
Road & Transportation

### The Situation Immediately after Construction

November 2016  
North Carolina  
Road & Transportation

### The Situation After 1 - 2 weeks

November 2016  
North Carolina  
Road & Transportation

### 4 - Review Construction of Orta Seal

- The Condition of the road to be sealed.
- Plant / Equipment / tools.
- The Design of the Orta Seal / Sand seal.
- Construction.
- Quality Assurance.
- Reporting.

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North Carolina  
Road & Transportation

### The Channeling of traffic is an important part of the maturation of the Orta seal.

To force the traffic onto the shoulders or outer part of the seal is essential during the first two - three weeks after sealing operations.

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North Carolina  
Road & Transportation

**3 - 4 weeks after Construction, some Excessive Aggregate has been Dislodged by Traffic.**

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**Some bleeding "fatty up" form a part of the maturation process.**

"Fatty up" areas is immediately covered by Otta seal aggregate or river sand / crusher dust

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**Sweeping back Dislodged Aggregate is a part of the "After Care Work".**

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**8 - 10 weeks after Construction**

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**The Otta Seal Matrix**

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**Before and after, sealing a road in KwaZulu Natal, South Africa, targeting the people in the rural areas.**

Benefiting people in the rural areas, and thereby reduce poverty and improve quality of life by improved accessibility.


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← **Final Construction Close-Out**

- a) The Condition of the road to be sealed.
- b) Plant / Equipment / tools.
- c) The Design of the Otta Seal / Sand seal.
- d) Construction.
- e) Quality Assurance.
- f) "After Care"

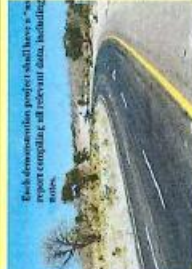
**Quality Assurance**

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Roads Services Division




**Reporting**


Each demonstration project shall have a built-in construction reporting component, all relevant data, including contractor activity



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Roads Services Division




**The End, thank you for your attention**



"Come on lads, this Otta scurrying is really something to walk on, dense and smooth. This is what I call "Elephant Walk"

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Roads Services Division



4. Review Construction and Otta Seal

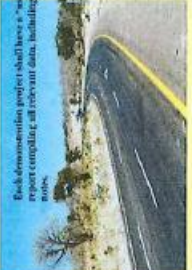
- a) The Condition of the road to be sealed.
- b) Plant/ Equipment/ Tools.
- c) The Design of the Otta Seal / Sand seal.
- d) Construction.
- e) Quality Assurance.
- f) "After Care"

**Aftercare**

Ministry of Public Works and Infrastructure  
Roads and Motor Vehicle Division

**Reporting**

Each demonstration project shall have a "no build" construction report compiling all relevant data, including a camera and diary notes.



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Roads and Motor Vehicle Division

**The End, thank you for your attention**



"Come on leads, this Otta Sealing is really something to walk on, dense and smooth. This is what I call "Elephant Walk"

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Roads and Motor Vehicle Division