

**VARIATIONS IN OTTA SEAL APPLICATION FOR DIFFERENT SCENARIOS (MANICA AND ZAMBEZIA PROVINCES IN MOZAMBIQUE)**

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**Abstract**

This paper describes the Otta seal project in Manica and Zambeze Provinces in Mozambique, which contributes to the Rural Road Investment Programme. The RRIP aims to improve Mozambique's unpaved road network by increasing the possibility of all weather access and reducing long-term maintenance costs. The Otta Seal is a low-cost type of road surface with an asphalt surface treatment constructed by placing a graded aggregate on top of a thick application of relatively soft bituminous binding agent. Otta seals can be used as an impermeable surfacing for moisture susceptible gravel roads with low bearing capacity. It shields the base material from moisture infiltration and is flexible enough to withstand the relatively large deflections associated with low bearing capacity roads without exhibiting significant distress.

## 1. INTRODUCTION

This document aims to present in summary the two phases of the Otta Seal project in Manica Province (Inhacufera Machaze road) and Zambeze Province (Zero Mopeia road) in Mozambique.

The Otta Seal is a low-cost type of road surface with a 16-30mm thick mixture of bitumen and crushed rock or natural gravel. An Otta seal is an asphalt surface treatment constructed by placing a graded aggregate on top of a thick application of relatively soft bituminous binding agent. Local aggregates that would not meet the requirements for high quality paving aggregate are often used in Otta seals.

Mozambique is a vast country stretching from the border with South Africa in the south to the border with Tanzania in the north, a two and half hour aeroplane flight. The logistical problems related to road management are unique where, for instance, the distance between provincial centres averages over 500km. In between the provincial centres there are a few business centres, but most of the country is a vast rural area where the majority of people dwell, some in the most appalling state of poverty. Driving through the countryside is excruciatingly painful for a visitor though this is the way of life for the majority of Mozambique's populace. While Mozambique, in general, has improved in terms of the state of the economy and condition of infrastructure, more focus has been given to the trunk road network, and rightfully so. The Rural Road Investment Programme (RRIP) comes at a time when the country needs an "uplift" of its rural population in line with the Millennium Development Goals, with increasing demand from a more aware rural folk.

The aim of this project is to contribute to ANE's Rural Road Investment Programme aimed at improving Mozambique's unpaved road network by increasing passability and all-weather access and reducing long-term maintenance costs. The project is based on targeted interventions, in other words, the concept of spot improvements.

The RRIP is an ambitious but practical programme, focusing on the development of the rural road network and the provision of all-weather access to the rural communities. Considering the vastness of Mozambique and its scattered settlements, what may be considered an adequate network may very well be unattainable, but the urgency of the need to act in a practical manner cannot be over emphasised. The RRIP is a project-oriented programme where road sections will be improved to enhance passability whilst, at the same time, applied research will help to develop more appropriate interventions and better quality.

While the actual projects are funded by ANE with some donor support, an opportunity arose in which an African regional programme, the African Community Access Programme (AFCAP), was initiated with funding from DFID and some local contributions. Mozambique was selected among five other countries to be the first beneficiaries of the programme. Funding was made available through AFCAP to engage a research consultant to manage and provide technical support to RRIP by introducing new or innovative approaches for the required interventions, to enhance quality assurance and to prepare guidelines on specifications and work norms which will support the future expansion of the RRIP. Crown Agents are the appointed managers of AFCAP and TRL is the research consultant for the first part of this Mozambique of AFCAP project.

The Mozambique AFCAP commenced effectively in October 2008 after a “no objections” letter was issued by ANE to the AFCAP management. Administrative issues regarding the project set up and structure of the research team led to some delays in commencement of the project, but these issues have been resolved and the project is now running smoothly.

The project has been set up in the same manner as previous and very successful research work carried out by TRL and ANE in which a collaborative approach was used. This collaborative approach involves the formation of a local team mainly comprising ANE Head Office staff and the ANE Delegations in the provinces. In this project the provincial consultants and contractors are part of the provincial team and local involvement has been maximised. The external team is made up of experts from TRL and other consultants whose inputs in certain particular fields may be deemed crucial for the successful implementation of particular technologies of which they have unique experience.

## **2. PROJECT OBJECTIVES**

The main objective of the AFCAP Project is to contribute to ANE’s Rural Road Investment Programme aimed at improving Mozambique’s unpaved road network by increasing passability and all-weather access and reducing long-term maintenance costs. The project is based on targeted interventions, in other words, the concept of spot improvements.

The aim is to apply a range of road design and construction technologies suitable for varying conditions in Mozambique, focusing mainly on the use of locally available materials and low cost solutions and ensuring their cost effectiveness and technical sustainability. Evaluation and improvement of these solutions will be assessed through trialling on pilot projects.

Thus AFCAP is intended to support ANE in the effective, efficient and sustainable delivery of its rural road programme. The improved rural road network will provide a vital component in enabling and enhancing the participation of poor marginalised communities in the national economy, thus reducing poverty.

## **3. PROJECT INPUTS AND OUTPUTS**

It was planned that the RRIP and AFCAP would be carried out in 2 phases. The first phase would run for six months and focus on piloting spot improvement interventions. The second phase is expected to run for three years and will focus on implementation.

The outputs of the first phase include:

1. Initial programme definition
2. Implementation of the pilot projects
3. Initial measurements and analysis
4. Drafting of guidelines on specifications and work norms to be used for the second phase.



## 5. OTTA SEAL SURFACING

### 5.1 Inhacufera Machaze – Manica Province

Phase 1: 0+000 to 5+000

Phase 2: 5+000 to 11+000

#### Background

The project has been executed in two phases. The Phase 1 section was designed by Cotop (the Provincial Consultant) and the designs were reviewed and modified by TRL. Construction was carried out by a contractor called TARCON. The section had previously been built as a gravel road with very coarse quartzitic gravel. The oversize material was very large and some stones were about 200 to 300mm. The road was very rough and almost impassable to small vehicles. The design involved reprocessing of the existing base and surfacing using Otta seal with MC3000 and natural graded quartzite sieved on 20mm and 5mm sieves. The excavation and sieving of the aggregate were carried out using labour based methods using a local labour force.

During Phase 2 the design included scarification and regularisation of the existing road surface, a 150mm natural gravel base layer consisting of quartzitic gravel from gravel pits located within the vicinity of the project site. The construction of the base and surfacing was carried out using machine based methods. The acquisition and processing of Otta seal aggregate was carried out using labour based methods. The design was carried out by TRL in conjunction with the provincial consultant, Cotop, and the works were executed by TARCON.

Some experimental sections have been incorporated which include:

1. Phase 1:
  - a. single Otta seal,
  - b. double Otta seal,
  - c. single Otta seal with sand seal on a steep slope,
  - d. 1 ½ Otta seal
  - e. single Otta seal on primed base
  - f. single Otta seal on unprimed base
2. Phase 2:
  - a. single Otta seal at 2.0L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> < 10%
  - b. single Otta seal at 2.0L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> ~ 13%
  - c. single Otta seal at 1.8L/m<sup>2</sup> binder application rate with washed aggregate
  - d. single Otta seal at 1.9L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> < 10%
  - e. single Otta seal at 1.8L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> < 10%
  - f. single Otta seal at 1.7L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> < 10%
  - g. single Otta seal at 1.6L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> < 10%
  - h. single Otta seal at 1.4L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> < 10%
  - i. sand seal at 1.0L/m<sup>2</sup> binder application rate.

#### Observations

##### Phase 1 section:

The bulk of the section is in good condition. However, there are short sections on the single Otta seal where stripping has occurred. The sections with 1 ½ and double Otta seal and single Otta seal with sand seal on top are intact,

Figure 1: 1.



**Figure 1: Single Otta seal with sand seal, Double Otta seal and 1 ½ Otta seal**

### **Phase 2 sections**

No defects have been noticed after 4 months of trafficking. The first 1.2 km was not trafficked for about 2 weeks. This section remained closed because there were a number of water crossing structures which had not been completed. The rest of the sections have been opened to traffic and to date the performance is very good on all sections.

Particular attention was given to the section where the binder application rate was reduced to 1.4L/m<sup>2</sup>. Apparently, there has not been any difference in performance or outlook compared to sections where higher application rates of the binder were used. A crude test was carried out on this section and it involved hard braking a Toyota Land Cruiser at speed. No rolling or stripping of the stone was observed. This section covers a steep slope, a gentle curve and a straight and flat stretch of road.

It is anticipated that further monitoring may show that with high levels of quality assurance it is possible to lower application rates of bitumen without adversely affecting the overall performance of the Otta seal surfacing.



**Figure 2: End of section with 1.6L/m<sup>2</sup> binder and beginning of section with 1.4L/m<sup>2</sup>**

The road is looking very good and this can be attributed to the high level of quality assurance



applied during construction.

Figure 2 2 shows the end of the section where the binder application rate of 1.6L/m<sup>2</sup> was applied and the beginning of the section where the rate of 1.4L/m<sup>2</sup> was applied.

An additional experimental section of sand seal was incorporated. Sand seal has been used before in Mozambique. However, the quality of sand obtained in this area was poor. It was very fine, like fine beach sand. The sand was available locally in streams that are close to site.



**Figure 3: End of Otta seal and beginning of sand seal**

Figure 3 shows the end of the Otta seal and the beginning of sand seal. Both sections are still under the curing process. The sand seal section will look black once all loose sand is removed from the surface.

## **5.2 Project: Zero Mopeia, Zambezia Province**

Phase 2: 0+000 to 6+000

### **Background**

At the initial stages of the project under Phase 1 of the RRIP, the road was reshaped and gravelled. Some low lying sections which flooded during the rainy season were raised through construction of embankments. The whole 40km was covered under this phase.

Under Phase 2, the project involves the construction of base using locally available quartzitic gravel and Otta seal surfacing using sieved natural quartz aggregate which is also available locally.

The aggregate for the Otta seal surfacing was prepared using labour based methods, i.e. the excavation and the sieving. The construction of the base and the surfacing was carried out using machine based methods.

The design was carried out by TRL in conjunction with the provincial consultant, Consultec. The road was built by CETA. The design was based on the Normas de Execusao which is the referral Manual used by ANE. The manual stipulates application rates of  $1.0\text{L}/\text{m}^2$  for the prime,  $2.0\text{L}/\text{m}^2$  for the binder and  $16\text{L}/\text{m}^2$  for the application of aggregate. This is basically a SATCC specification that was translated into Portuguese.

Some experimental sections have been incorporated which include

- a. single Otta seal at  $1.8\text{L}/\text{m}^2$  binder application rate,  $P_{0.075} \sim 13\%$
- b. single Otta seal at  $1.7\text{L}/\text{m}^2$  binder application rate,  $P_{0.075} \sim 13\%$

- c. single Otta seal at 1.6L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> ~ 13%
- d. single Otta seal at 1.5L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> ~ 13%
- e. single Otta seal at 1.4L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> ~ 13%
- f. single Otta seal at 1.3L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> ~ 13%
- g. single Otta seal at 1.2L/m<sup>2</sup> binder application rate, P<sub>0.075</sub> ~ 13%

The nominal maximum size of the aggregate was between 9 and 13mm compared to 19mm given in the specifications. The percentage of fines P<sub>0.075</sub> was greater than the maximum figure allowed in the specifications of 10%. Generally the aggregate was fine and did not meet standard specifications. The application rate for the prime was 0.6L/m<sup>2</sup>

Most importantly, there exists a myth that single Otta seals don't work in Mozambique and therefore most sections built previously are either double Otta seals or single Otta seals with a sand seal capping. This is a costly design for low volume roads. The original design prepared by TRL involved a single Otta seal, but this had been changed to double Otta seal based on the myth. However, TRL changed the designs back to single Otta seal during construction.

## Observations

### Phase 2 sections

The section was traversed four times during inspections and no obvious defects were noticed. The bitumen has migrated to the surface and the carriageway is beginning to look black especially on the wheel tracks. The same has occurred on all sections including the last kilometre where the application rate of the binder was 1.2L/m<sup>2</sup>. There is currently no noticeable difference in appearance or performance between sections with high and low binder application rates. See Figure 4, Figure 5, and Figure 6.

Some sections along the cross-sections of the carriageway have not been trafficked at all and this is owing to the low volume of traffic. Traffic has concentrated more on the centre of the road and on the inside of curves.

The road is looking very good and the surfacing is intact. However, the centreline is a little crooked and the jointing was not very neat though the sealing is intact. There are some longitudinal lines on the surfacing on some sections which are an indication of uneven spray of binder across the width of the carriageway. It is not anticipated that this will have any significant effect on the performance of the surfacing. This project is likely to be influential in the review of specifications for Otta seal for low volume roads in Mozambique.

A binder application rate of 1.5L/m<sup>2</sup> was used for most of the phase 2 sections and further reduction of application rates to 1.2L/m<sup>2</sup> led to significant savings.

Particular attention was given to the section where the binder application rate was reduced to 1.2L/m<sup>2</sup> during inspection. It is actually difficult to distinguish this section from the rest. However, further monitoring will reveal performance aspects which will be instrumental in the development of Otta seal specifications for Mozambique.



**Figure Error! No text of specified style in document.1: Otta seal surfacing in curing process**



**Figure 2: Otta seal section with 1.2L/m<sup>2</sup> binder**



**Figure 3: Otta seal surfacing with 1.2L/m<sup>2</sup> binder**

It is apparent that finer aggregate leads to more rapid curing of the Otta seal than coarse aggregate at low traffic volumes.

## **6. CONCLUSION**

A few conclusions can be drawn from the observations described above.

1. It is apparent that finer aggregate leads to more rapid curing of the Otta seal than coarse aggregate at low traffic volumes.
2. There are opportunities to use Otta seal more extensively in Mozambique and more work need to be done to find other sources and materials.

3. The research component will help Mozambique develop specifications which suit materials found in the country
4. Otta seal can reduce construction costs significantly if proper specifications and work norms are developed for the Mozambique situation.

**KEY WORDS**

Otta Seal, Natural Gravel, Low Volume Roads