Ethiopian Road Authority

Africa Community Access Programme (AFCAP)

FINAL REPORT

Review of surface dressing practice in Ethiopia

by Kym Neaylon and Gerrie van Zyl

001351- December 2009

SUMMARY

The objective of this consultancy was to analyse and understand the causes of surface dressing failures in Ethiopia, and provide recommendations for improved practice

To achieve this the authors undertook: a review of existing design methods and standard specifications; visited a sample of sites where surface dressings were being constructed and where surface dressing failures have occurred; conducted interviews with government, university and industry representatives; and presented the preliminary study findings to a workshop attended by government and industry representatives.

Tender prices in Ethiopia proved to be a sensitive issue, however all other countries in the world that use surface dressings find them to be a cheaper alternative to asphaltic concrete.

If surface dressings can be purchased for a lower cost than AC and constructed such that they last the usual lifetime, then the extent of the road network covered each year could be *increased*, for the same budget outlay.

There were several issues identified during the initial site visit, and the authors have prioritised them in order of most important problem first:

1. Standard of workmanship
2. The master specification is not enforced or understood, and is often weakened by inappropriate project specifications
3. Inappropriate treatment selection
4. Understanding of seal design.

There are also further background issues, but these are beyond the scope of this review:

1. Apparent lack of a maintenance strategy
2. Standard of base course construction.

A proposed strategy for restoring the skills base is

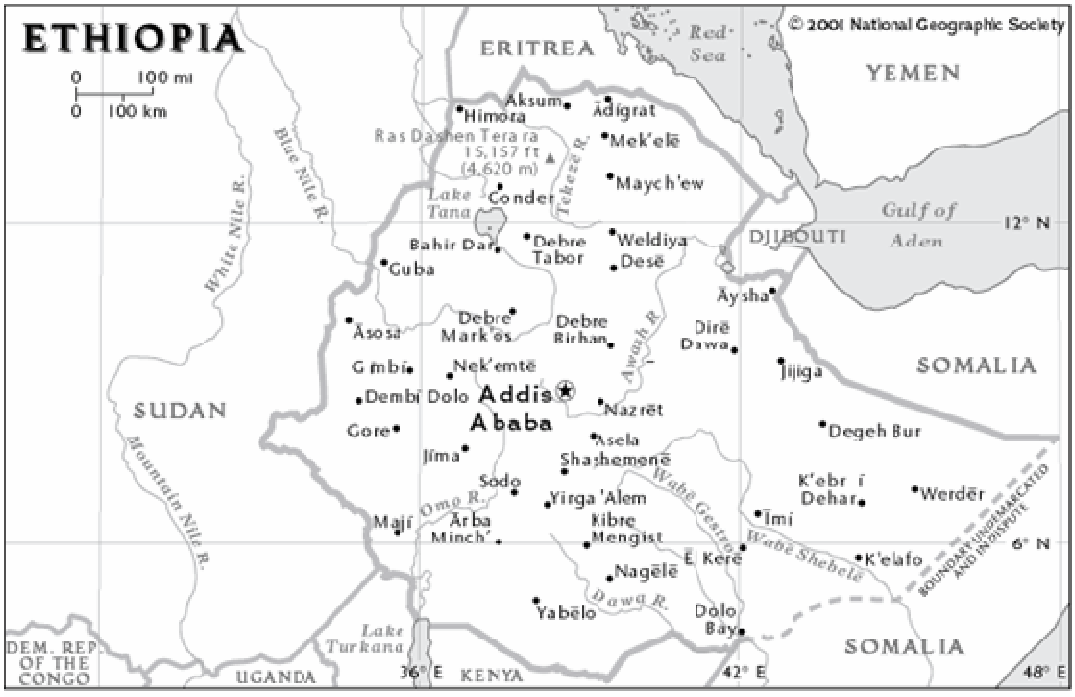
1. Workmanship
    a. Hands-on training of contractors, preferably on-site
    b. Implement ‘trial sections’ in certain contracts to reduce the contractual risk in acquiring and applying new skills and methodologies
    c. Quality assurance training for consultants.
2. Specifications
    a. Review applicability of existing specifications
    b. Review applicability of some overseas specification clauses
    c. Training of contractors, consultants and ERA in understanding the reasons for the specified practices and the implications and risks in not enforcing them.
3. Treatment selection
    a. Production of a ‘low volume roads manual’ for Ethiopia, giving guidance on selection of treatment type and binder selection
    b. Production of a ‘best practice guide’ for Ethiopia.

An outline term of reference for recommended follow-up activities is included as Appendix B.

CONTENTS

1 BACKGROUND

1.1 Ethiopia



A brief introduction to Ethiopia, from the National Geographic Atlas of the World, Eighth Edition, 2004, is as follows

> Ethiopia is a landlocked country in the northeast African region known as the Horn of Africa. The country has a high central plateau, with some mountains reaching more than 4,000 meters (13,000 feet). The Great Rift Valley splits the plateau diagonally. The western highlands get summer rainfall; the lowlands and eastern highlands are hot and dry. Most people reside in the western highlands as does the capital, Addis Ababa—the highest capital city in Africa at 2,400 meters (8,000 feet).

By 2004 the Ethiopian road network totalled 36,469 km, of which 6,980 km were paved and 29,489 km unpaved (CIA, 2009).

There are five levels of road hierarchy in Ethiopia, being:

1. **Federal** - Ethiopian Road Authority.

2. **Regional** - Twelve historical regions, each with their own government, president and cabinet.

3. **Woreda** - There are about 700 districts, known as Woredas, throughout the regions.

4. **Kebele** - This is the lowest government administration level, and there are about 18,000 Kebeles in Ethiopia.

5. **Community** - the hierarchy below Kebele.

1.2 AFCAP

The Africa Community Access Program (AFCAP) is a research programme funded by the UK Government's Department for International Development (DFID), which is promoting safe and sustainable rural access in Africa. AFCAP supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

AFCAP has been asked by the Ethiopian Road Authority (ERA) to support this research consultancy as outlined in sections 1.4 and 1.5.

1.3 AFCAP background to review

Thin bituminous surface dressings are an appropriate and cost-effective technology for sealing both low and medium volume roads in Ethiopia. Seals of this type constructed in Ethiopia more than thirty years ago are still performing well, but in recent years there have been widespread failures. The causes of these failures are not well understood, but it is thought they could be due to a combination of factors such as flaws in the standard design procedures or their interpretation, inadequate specifications, poor quality bitumen and aggregates, poor workmanship, etc.

As a result of the widespread failure of surface dressings there is a risk that asphalt concrete surfacing will be increasingly specified, even for low traffic roads. This will contribute to unnecessarily high construction costs, as well as high maintenance costs in the longer term. The failure of surface dressings is potentially a constraint to the expansion of the paved road network and delivery of the Road Sector Development Programme in Ethiopia, which are critical for social and economic development in rural areas.

The Ethiopian Road Fund has engaged the University of Addis Ababa Civil Engineering Department to undertake a review of surface failures on the Alemgena-Lemen-Butajira road. The construction of this road was completed in 2005. Initial findings of the university team show variations in the current condition of the road. Some sections of the road are severely damaged, others have experienced only moderate damage, and some sections are still in relatively good condition. The major types of failure include loss of aggregate, cracking of the seal, edge break and potholes. In some isolated cases there is local deformation, indicating a failure of the road pavement. The university now plans to undertake a detailed review of the design and construction process, including materials tests undertaken at the time, and to undertake further field and laboratory investigations where necessary. This will assist the university to identify the causes of failure of the surfacing and to devise appropriate remedial measures.

Meanwhile ERA has embarked on a project to prepare a series of manuals for the planning, design, construction and maintenance of low volume roads in Ethiopia, as well as accompanying standard bidding documents. The purpose of these documents is to promote the rational, appropriate and affordable implementation of projects providing low volume roads that makes appropriate use of local resources and is cost-effective and sustainable. The project includes training and dissemination of the manuals and bidding documents to stakeholders in the federal and regional governments, the private sector and within academic institutions. The manuals and the bidding documents will be written by expert authors recruited both locally and internationally. The project is being supported by AFCAP.

ERA is also constructing demonstration sites under a parallel project known as "Design Standards & Specifications for Low Volume Roads". The demonstration sites are being established in the principal regions of the country, and will include the construction of thin bituminous seals using labour-based as well as equipment-based methods. This project is also being supported by AFCAP.

1.4 Objectives

The objective of this consultancy is to analyse and understand the causes of surface dressing failures in Ethiopia, and provide recommendations for improved practice. An important part of this objective is to engage and inform key decision makers in the road sector in Ethiopia concerning the role of surface dressings in a sustainable road investment and maintenance programme for the country.

1.5 Scope

1. Undertake a review of existing design methods and standard specifications for typical thin bituminous seals used in Ethiopia. This includes a review of Terms of Reference of designers and supervision consultants.

2. Visit a sample of sites where surface dressings are being constructed and where surface dressing failures have occurred.

3. Conduct interviews with government representatives, university and industry actors.

4. Provide recommendations for additional testing of materials or field investigations that may be needed to understand the causes of surface dressing failures. Undertake an analysis of the test results.

5. Prepare a draft report on the causes of surface dressing failures, and recommendations for improved practice. The draft report should include outline Terms of Reference for follow up activities, which may include the revision of design manuals and standard specifications, revision of training materials and university curricula, training programmes for consultants and contractors etc. (The recommendations of this study will inform the content of the new design manuals and standard bidding document for low volume roads).

6. Present the study findings to a workshop attended by government and industry representatives, and assist the workshop to define an appropriate role for surface dressings in the Ethiopian road investment and maintenance programme.

7. Update the draft report to reflect the workshop discussions and other comments received from stakeholders on the draft report and submit the final report.

2 DEFINITIONS

The nomenclature used in surface treatments (Ethiopia) - also known as surface dressings (UK), sprayed seals (Australia), surfacing seals (RSA), chip seals (NZ) or seal coats (USA) – changes from country to country, and can easily cause misunderstanding and confusion. For example, in Australia *tack coat* means a thin spray of diluted emulsion, typically used to bond a new layer of asphaltic concrete to old asphaltic concrete.

To minimise confusion, the following definitions are provided.

Table 1: Surface dressing definitions

Schematic	Layer	Ethiopia	South Africa	Australia
	Diluted emulsion	Fog spray	Fog spray	Fog spray
	Smaller chippings	Seal coat	Penetration coat	Top coat
	Binder			
	Chippings	Tack coat	Tack coat	Bottom coat
	Binder			
	Prime (no aggregate)	Prime	Prime	Prime
	Basecourse	Basecourse	Base	Basecourse

The Ethiopian definitions above have been used throughout this report.

The American term *asphalt* has also been replaced with the British term *bitumen*, and asphalt herein means hot mix asphaltic concrete, abbreviated to AC.

3 INTERVIEWS

Interviews and discussion were held by Mr Kym Neaylon and Mr Gerrie van Zyl as part of the scope of work and at the commencement of the commission. These interviews were held with the following people, chosen by ERA as they represent various government agencies, consultants, contractors, laboratories, and universities.

Ato Zerfu, Deputy Director General, of **Ethiopian Roads Authority (ERA)**

Dr Colin Gourley, DFID advisor to ERA, UK **Department for International Development**.

Ato Muse Belewe, Senior Engineer, **ERA**

Dr Gilmar Berhein, of **University of Addis Ababa**

Ato Huesein, General Manager; and Ato Iffa, Engineer; of **Oromyia Regional Road Authority**

Ato Efrem G/egziabher, Deputy Manager, of **Core Consulting Engineers**

Ato Ahmed, project manager**, HEC (Consultant)**

Ato Wogayehu, project engineer, **Sunshine construction (Contractor)**

Ato Gizachio, site engineer, of **ERA**

Ato Wondwossen Dejene, General manager; Ato Jemal Saed, engineering geologist; and two other engineers; of **Transport Construction Design** Share Company

Ato Samson Bekure, General Manager; Ato Hayredin Mohammed, Head Design Department; and the laboratory manager; of **SABA Engineering** Private Limited Company

Ato Fekadu Haile; General Manager, **Addis Ababa City Road Authority** (AACRA)

Ato Tesfaye Ayele, procurement specialist Ethiopia, and Ato Heile, (both formerly of distinguished engineering careers in ERA), the **World Bank**

Mr Kenneth Mukura and Mr Andrew Otto, **TRL** Awasa

Ato Bekele Negussie, planning and program divisional manager, **ERA**

Presentation, questions and answers, with a group of 25 **ERA** practising engineers

4 SUMMARY OF INTERVIEWS

Although the interviewer had a list of topics that he intended to cover, the approach taken was to ask each respondent what were the issues that they saw as the most important, so that important unexpected issues were not missed. After this the conversations were fleshed out until all remaining issues had been covered.

4.1 Double bituminous surface treatment design

All commentators endorsed the continued use of TRL Overseas Road Note 3, 'A guide to surface dressing in tropical and subtropical countries', 2nd edition 2000, (TRL 2000) and no designers indicated any serious concern with this method.

However one example was found where the same job was designed and redesigned by three different people and gave three substantially different results. The explanation offered was that the different designers used different assumptions within the same design method.

One consultant advised they could only ever use assumed Average Least Dimensions (ALDs - an important aggregate characterisation, crucial in design) because actual ALDs could not be obtained until after crushing. The authors regard this as an unacceptable high-risk practice, and field spraying should never commence until the design has been checked using the actual ALDs.

Another consultant asserted that they always used actual ALDs for designs, with ALDs obtained from the gradation and flakiness nomograph from Overseas Road Note 3. It was also possible to obtain ALDs from direct measurement of a sample of individual chippings.

Some engineers and contractors undertake 100 m pilot design trials on site, to validate the bitumen application rate, chipping spread rate, and base course embedment for their particular materials and conditions. This is considered to be a sensible and pragmatic approach, given the circumstances.

4.2 Specification and contract documents

Comment was made that the actual bitumen application rate on many jobs was well above that allowed for in the specification and contract documents.

In the authors' view, the nominal contract rate cannot be applied independent of variations of design traffic counts from site to site. The lower the traffic, the higher the bitumen application rate, and the nominal application rates are not qualified for any particular design traffic. Therefore, it is possible that the contracted rates could differ from the actual sprayed rates. As mentioned under paragraph 4.1, the design can only be finalised once the aggregate is delivered to site.

4.3 Tender rates

One commentator suggested that Ethiopian contractors do not understand how to price a surface dressing, so they price it the same as an AC which they understand better. The authors can not judge whether this belief is true or not.

4.4 Materials

4.4.1 Bitumen

A refinery existed in Ethiopia producing 180/200 Pen grade bitumen, but since the border war with Eritrea in the late 1990s, the refinery now lies out of reach on the Eritrean side of the disputed boundary.

Bitumen is now imported cold in drums, primarily from Iran and Saudi Arabia, through the port in Djibouti. Common types of bitumen imported are MC3000, 180/200 Pen, 120/150 Pen and sometimes 80/100 Pen. There are no bulk storage facilities for bitumen in Ethiopia.

The National Oil Company (NOC) imports all of Ethiopia's bitumen.

There was general concern that more quality control is needed for bitumen imports, as the current quality is variable. One consultant said they had no confidence at all in the bitumen quality.

The Ethiopian current affairs website EthioBlog from 12 Nov 2008 reports that 'NOC appears to have scored a third victory in a running dispute over 44 million birr of asphalt (bitumen) it supplied to the Addis Ababa City Roads Authority. Though there were reports that the product was not up to standard, the company is now claiming it has passed laboratory inspections' (EthioBlog 2008).

4.4.2 Emulsion

There are no emulsion plants in Ethiopia, and all emulsions (for example fog sprays) must be imported. Normal emulsions consist of 40% water, which becomes a waste product after the emulsion is sprayed and breaks. Thus with imported emulsions Ethiopia pays to import 40% of water, which is then discarded.

4.4.3 Chippings

There appeared to be significant confusion related to the gradings of chippings to be used.

The old 1968 ERA specification allowed continuously graded aggregate. Although a successful surfacing can be made this way, it can not be designed by a chip seal design, but is more like an Otta Seal (Ministry of Works Transport and Communications 1999).

Most surface dressing designs in the world require a single grading of chipping size. Although the new 2000 ERA specification requires chippings very close to single sized, most engineers do not seem aware of this.

One consultant also expressed concern that more quality control is needed for chippings.

Another Engineer commented that the old 'affinity test' of aggregates to bitumen is no longer carried out.

4.4.4 Precoating and adhesion agents

One consultant advised that adhesion agents are not used on aggregates or in bitumens. Observations from the authors' subsequent site visits also supported this view.

It can be noted, however, that the Bill of Quantities for Butajira - Hossana (km 120.000 - km 215.000) provide for "Precoating aggregate with 'Colcote S' or similar". The authors consider that the reintroduction of precoating with adhesion agents would greatly reduce the risk of stripping.

4.5 Construction

In most cases the standard of construction was highlighted as being the main area where improvements could be made.

Time and time again the issue of poor workmanship was raised as a hindrance to surface dressing in Ethiopia.

Overall the message was received of an almost complete loss of surface dressing construction skills, combined with no quality control.

Asphaltic concrete is unanimously seen as being much easier to construct.

One contractor commented that there is a need for more appropriate equipment to maintain uniformity of bitumen and chip application. This would lessen the reliance on individual skills. The authors agree with this sentiment, and it was subsequently noted that another contractor had done just this, and was producing highly successful outcomes.

4.5.1 Pavement

A school of thought was expressed that the pavement must be soft to allow correct embedment of chippings into the base. If this does not happen then ravelling occurs. In the opinion of the authors, this view is severely erroneous. However, pursuing issues of base course construction was beyond the scope of this brief.

An experienced engineer believes the current specified compaction limits may not be enough. In the past base courses were compacted to refusal. There are also further pavement issues with natural drainage and high ground water levels.

4.5.2 Spraying bitumen

It was understood that some bitumen distributors do not have variable bitumen pumps to adjust pump RPM to spray the design application rate, and some do not have accurate forward speed indicators other than the speedometer to ensure the design application rate.

One consultant advised that the lack of start paper at the beginning of spray runs caused subsequent bleeding at the start.

Cutter is never added on site to penetration grade bitumens, despite it being allowed in the specification, and it being routine practice in Australia to enable sufficient aggregate wetting and adhesion during localised pavement temperature variations. This practice can help prevent later stripping.

4.5.3 Chip spreading

In most cases the chipping application is controlled visually, and thus is highly dependent on the skill of the operators. More use could be made of mechanically controlled chip spreaders to provide a measured and uniform outcome.

4.5.4 Rolling

The number of roller passes is often decided upon after a trial run. One consultant rolls the trial until the aggregate starts to break, and then uses this for the rest of the job. This is considered a somewhat unusual approach.

Another engineer uses no more than two passes of a 10 t steel roller, followed by four to five passes of a 14 t pneumatic roller, on both the tack coat and the seal coat. However sometimes there are no pneumatic rollers available on site and rolling practices can vary from site to site.

The authors note that the specified rolling differs from the above.

4.5.5 Fog spray

There was strong support for the use of a fog spray to hold the surface dressing under traffic, and an example was given where a surface dressing continued to strip until a fog spray was applied. Further sections have not stripped because a fog spray was then applied as a matter of routine.

The authors agree that fog sprays are successful in reducing the incidence of stripping, however they are also of the opinion that when design and workmanship issues are resolved, fog sprays should no longer be required as a matter of course.

Further benefits claimed from fog sprays are that they limit aging of the binder below, and give additional protection from moisture ingress. These claims are true, but increased bitumen design rates in the seal coat or tack coat layers could supply the same benefits.

4.5.6 Opening to traffic

There is an almost universal belief that the tack coat of a new surface dressing must be left untrafficked for a minimum of 24 hours, to enable ‘curing’, and then that the subsequent seal coat be closed to traffic for a further two days. This practice would be unacceptable in Australia, New Zealand and South Africa where trafficking is allowed immediately.

4.6 Site supervision

Repeated comments were made that the surface dressing process is very sensitive to error, both from people and machines. It requires very skilled manpower, and can not be given to just anyone. The authors entirely agree with this comment, but do not see it as a reason to cease using surface dressings. Solutions can be found, and have been found elsewhere, to address these issues.

4.7 Road maintenance

One contractor advised that routine maintenance was very scarce, and therefore when maintenance did occur a whole crew needed to be mobilised, which is expensive.

It is understood from another source that the National Road Fund office finances maintenance work, with distributions in the order of ERA 75%, Regions 20%, Municipal roads 5%.

80% of all Ethiopian vehicles are located in the city of Addis Ababa.

4.8 Training and skills

In the past, new engineering graduates with ERA used to undergo one to two years of induction training, spending about a month with each division/section. Now graduates spend only about three months of induction, and then choose to move to the private sector where salaries are higher.

Also, it appears that people keep on doing what they have been doing, despite failures. People do not seem to be learning from their mistakes. However one consultant commented that there is a need to go back and revisit work after 3, 6 and 12 months to see how it is performing. This is an excellent way of learning how small changes made on the job may affect future performance.

One comment was made that in some cases knowledge is power, and a skilled person may not pass on their knowledge to others in their team, as they can then remain the only person skilled enough to gain a higher paying job elsewhere.

Another comment was made that regions were reluctant to specify surface dressings, as the bigger contractors might not bid, leaving the smaller, less skilled contractors to bid. The concern then is that their skills may not be good enough to produce a product that is acceptable to both the region and the community.

It was also commented that people are now different, and the ‘quality culture’ that was in the workforce 30 years ago does not seem to be present any more.

5 DESIGN AND SUPERVISION CONSULTANT TERMS OF REFERENCE

The Standard RFP for the Procurement of Consultancy Services issued by the PPA (Version 1, January 2006), part 2: section 6 'Terms of Reference', was provided for review.

In this document the stated objective of a consulting service is

> To conscientiously fulfil to the highest professional standards the role of the Engineer/Engineer's Representative, as defined under the Works Contract and to supervise construction of the works (on behalf of the client) throughout the entire construction period, including the defects liability (maintenance) period.

The scope of services included is substantial, and on first reading appears as a wish list of everything that would be 'nice to have'. Complete enforcement of this expansive scope would require significant resources of the Employer.

The Terms of Reference requires about four or five staff on site at any given time, with specialists called in as needed. By necessity it covers a wide range, from mobilisation, materials sourcing, approving set out, checking construction of flexible pavements and concrete bridges, preparing design changes as necessary, issuing engineers instructions and variation orders, keeping of detailed records, claims management and financial reporting.

The 19 page terms of reference does not individually cover surface dressing, but one related general clause states:

> 3 vi) With due diligence and efficiency supervise fully the construction of the works which are to be executed in accordance with sound technical administration, financial and economic practices. The consultant shall perform all duties associated with such tasks to ensure that only the best construction practice is followed and that the final product in all respects is equal to that specified, at the most economic cost and is executed in full compliance with the specifications.

The Terms of Reference has a strong focus on managing road alignment, pavement construction, soil and materials investigations, and bridge structures. Accordingly, it instructs that the consultant's personnel list shall include:

- Resident engineer, experienced in road construction and design
- Deputy resident engineer, also with some experience in road construction and design
- Pavement/material engineer, experienced in road construction
- Structural engineer
- Geotechnical engineer
- Highway engineer
- Quantity surveyor
- Senior surveyor

- Claims expert
- Environmentalist
- Two soil lab technicians
- Two surveyors
- Material inspector
- Structural inspector
- Inspector of works
- Draftsperson
- Office secretary

It was found the terms of reference are silent on any surface dressing experience or skills that may be needed by the consultant.

The TOR appears to focus on the high cost/high risk issues, but surface dressing is a low cost/high risk activity.

Successful surface dressing is highly dependent on the available skills of people, and is not likely to be successfully learnt from reading a specification. It may be necessary to specify that an experienced surface dressing engineer be present prior to and during surfacing operations, until the local skills base has been restored.

It is recommended that a clause similar to the following be included in the terms of reference:

> *For works involving bituminous surfacings treatments, at least one person with more than 3 years supervisory experience in the bituminous industry shall be required on site to supervise the planning and the operation of the surfacings works. CV's shall be provided for such staff, clearly setting out levels of experience / qualifications in the bituminous industry including:*
>
> - *experience/capability on projects of similar complexity and value to the category being applied for*
> - *evidence of training relevant to the area, including training plans.*

6 REVIEW OF EXISTING DESIGN METHODS AND STANDARD SPECIFICATIONS

6.1 Design methods

The ERA Design Method (Ethiopian Roads Authority 2001) is based directly on TRL Overseas Road Note 3, 'A guide to surface dressing in tropical and subtropical countries', 2nd edition 2000.

The authors of this report do have their own preferences towards specific design aspects and, therefore, do not agree with all recommendations of Overseas Road Note 3. The following serves as examples:

- During discussions with practitioners, it was often mentioned that the large aggregate of a double surface treatment must penetrate. This statement originates from the ERA Design Manual (page 9-15) and ORN 3 (paragraph 5.9)

  'In the case of a hard existing surface, where very little embedment of the first layer of chippings is possible, such as newly constructed cement stabilized road base or a dense crushed rock base, a 'pad coat' of 6mm chippings should be applied first followed by 10 mm or 14 mm chippings in the second layer. The first layer of small chippings will adhere well to the hard surface and will provide a 'key' for the larger stone of the second dressing'.

  It is the opinion of the authors of this report that embedment of the aggregate is not required for good performance.

- Polishing Stone Values as recommended in Table 9-3 of the ERA Design Manual are considered "Very High" and might result in unnecessary high cost due to long haul distances.

However, it is accepted that TRL Overseas Road Note 3 is widely used and that it provides acceptable binder application rates for conditions in Ethiopia. The continued use of this Design Guide as the basis for the ERA Design Manual is, therefore, supported.

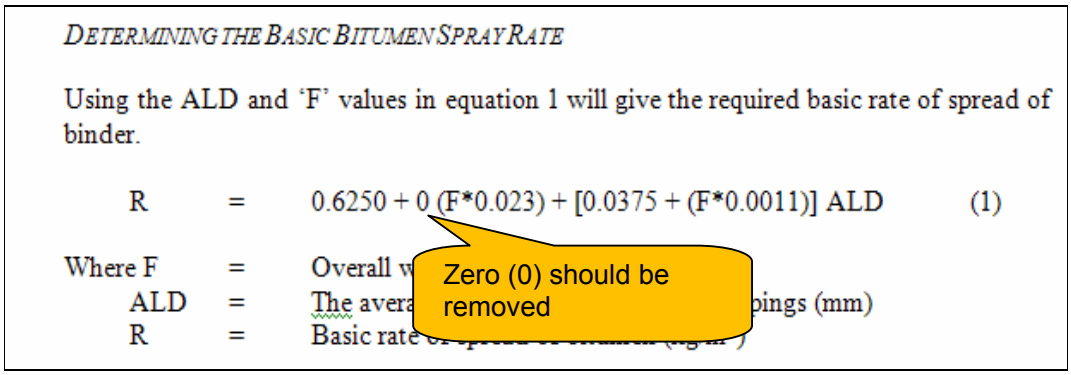
Training of surface dressing design will certainly improve consistency of recommendations and performance.

Some concerns exist regarding terminology and compatibility with the Standard Specifications e.g.:

- Table 9-2 , Table 9-3 and Table 9-13 refer to different nominal sizes and gradings than the Standard Specifications

- Rubber modified bitumen referred to under Polymer Modified bitumens is different to the product specified in the Standard Specifications

The formula in the ERA Design Manual, as shown below, has an error when compared to Road Note 3.



DETERMINING THE BASIC BITUMEN SPRAY RATE

Using the ALD and 'F' values in equation 1 will give the required basic rate of spread of binder.

R = 0.6250 + 0 (F*0.023) + [0.0375 + (F*0.0011)] ALD (1)

Where F = Overall w
ALD = The avera ...pings (mm)
R = Basic rate ...

Zero (0) should be removed

From observations and discussions with practitioners, the opinion is held that more guidelines are required in the ERA Design Manual to:

- select appropriate surfacing types for specific conditions, both for initial construction and periodic maintenance
- identify the need for periodic maintenance – resurfacing and/or rejuvenation
- guide designers in identifying sections on a road requiring different designs e.g.:
    - steep grades
    - intersections

6.2 Standard specifications

The ERA Standard Specifications have, to a large extent, been taken from other specification documentation such as the South African Standard Specifications for Road and Bridge Works, referred to as the COLTO document published by the Committee of Local Transport Officials in South Africa (COLTO 2008).

Some errors still exist in the COLTO document and several changes to the COLTO specifications have been introduced in South Africa. However, the ERA Specifications have not been updated to reflect these changes.

Differences exist between the ERA Design Manual and the ERA Standard Specifications e.g. description of standard aggregate sizes and gradings.

A review of the existing ERA Standard Specifications, applicable to surface dressings was done to identify errors and potential shortcomings.

Tables are provided to highlight specific items of concern. Comments are categorised as minor errors, significant issues and just comments (aspects to reconsider).

Division 6100 Bituminous Prime Coat				
Item	**Aspect**	**Minor errors/issues**	**Significant issues**	**Comment**
6105e	Weather limitations	Dry out to 50% of OMC		Although also in COLTO, not always practical. Moisture increase to 60% - 80% of OMC in pavement
6108	Application of prime coat	Aggregate spread rate in m^3/m^2 Consistency required	More detail required regarding lane overlap and 150 mm wider (Is this full application?)	This is also not clear in COLTO
6110	Depot spray test	Spelling errors 8th par. (lime) instead of (time) and words missing (width)		Is this method practical in Ethiopia ?
6111			More detail required – relating to 6108	Make sketch
Division 6200 Tack Coat				
6200	Tack coat			Check terminology, this refers to a tack coat before asphalt concrete overlay
6202(b)	Materials	Water quality type A is referenced where?		
6205e	Weather limitations			If emulsion is used could be less than 20 deg (10 deg C)
6207	Preparation of surface	Refers to Clause 52.11 – This should be Clause 5211		
6208	Application of tack coat	Now in kg/m^2 - other applications in l/m^2 ?	Wider application 100 mm – fully applied or 1/2 coverage ? More detail required	This is also not clear in COLTO
6210	Tolerances		Area measurement incorporating overlap - 1/2, or 1/3 spray ? – More detail required	
Division 6300A Surface Treatments: Materials and General Requirements				
63A02a	Bituminous binders	3rd par. – The cost of (of) missing		
(ii)	Non-homogeneous		Check COLTO and TG1 for revisions	

(iv)	Homogeneous cold applied		Table 6300 A/6 Modified Vialit not specified in South Africa anymore	SBR not used anymore unless specified purposes – Check TG1
(v)	Homogeneous hot applied		Table 6300 A/7 - outdated	
(c)	Chippings		Chippings Table 6300A/8	Different to Design Manual
(i)	Grading		Sands Table 6300 A/9 Texture improvement irrelevant	This is also not an error in COLTO
(ii)	Hardness		Hardness 10% FACT and ratio 75% PSV values different to Guideline doc – to be adjusted for LVR	To be adjusted, 75% ratio irrelevant
(d)	Aggregates for slurry seal	Table 6300A/11 Bitumen content – note to state only for tender purposes	Already specified hardness in terms of LA value – in table now also ACV – why?	Reconsider which test applicable
(d)	Aggregates for slurry seal	Table 6300A/12 Add note that binder content only for tender purposes		Check consistency – binder contents in two tables as % or litres.
(e)	Filler			Only one filler ? colour changes to normal quite fast
(f)(i)	Precoating	12 l/m^3 only applicable to specific size of aggregate. Add note – only for tender		Could also provide table for other sizes of aggregate
(iii)	Steel-tired flat rollers		Steel-tired flat rollers conflict about mass – also conflict when used (only first coat ?) see Section 63A11	
63A04 General Limitations and Requirements				
(b)	Weather limitations	Table 6300A/13	Min Temperatures incorrect	E.g. 150/200 requires higher temp than 80/100 – 20 cannot be right

63A05 Cutting Back of Bitumen				
63A05			Reference to cut back from 150/200 Pen bitumen	Suggest also add column for 80/100. Is this still acceptable in terms of safety?
63A06 Heating of Bituminous Binders				
(a)	Table 6300A/15	Spray of 60/70 pen bitumen		Is this not too hard for Ethiopian conditions?
Page 6000-39	Conventional binders	Table 6300A/16 refer to spray temp limits for 80/100 where clause 63A05 refers to `50/200		
63A06 (b) 5	Non-homogeneous binder		Stored binder (BR) heated to >160 must be removed	Check current practice regarding in-blending
63A11 Construction of Surface Treatment				
(c)	Joints between binder sprays		Longitudinal Joints – 100mm overlap specified - for all cases ?	More detail required to prevent confusion
(d)	Application of chippings		… not later than 10min after spray of binder ? Not applicable to non-homogenous hot binder	Add rider
63A12 Rates of Application				
63A12			Provide conversion factors	
63A13 Areas inaccessible to Mechanical Equipment				
63A13 (b)	Bituminous mixture			Why is only this mix referred to ?
(c)	Surface treatment	Terminology – check penetration spray versus seal coat	Engineer may require slurry on areas subjected to traffic?	Would actually be better to apply slurry where no or little traffic is expected
(d)	Slurry		Actually refers to Cape seal but states a specific slurry application	Confusing
63A15 Defects				
63A15	Defects		Check whether this clause is in line with General Conditions	

(a)	(ii) Single seal with slurry		Refer to ball penetration test. Is this test referenced anywhere?	Different to Road Note 3 penetration testing
(a)	(ii) Single seal with slurry	Spelling error (rood) instead of road) x2		
(a)	(iii)(2)		Refers to Clause 5211 to treat coarse areas – This clause does not address this issue. Also states … which shall then be covered with a single seal in accordance with Division 6300 C. (Note this Division refers to double surface treatments) – should be B	
(b)	(i) Slight loss of aggregate		Specifies a fog spray but then refers to cationic emulsion at 0,55 l/m^2 (diluted ?)	Too low application
(ii)	Loss of aggregate in limited areas due to low temperature		Fogspray application 30% anionic or cationic spray-grade at 0.4 l/m^2 – Too low	
(v)	Loss of aggregate in large areas due to binder deficiency	Spelling (bed applied) instead of (be)	This action will not work – requires at least non-diluted emulsion plus a fogspray on top	
63A16 Maintenance				
63A16				Refers to “Maintenance Certificate” – should this not be “Completion Certificate”
63A19 Testing				
63A19		Table 6399A/17 Not clear – Cross Section - not specified, All Rough areas should be next to smoothness (also small letter “s”)	Confirm if LA Abrasion is required or other hardness test	

DIVISION 6300B Single Surface Treatments				
Item	**Aspect**	**Minor errors/ issues**	**Significant issues**	**Comment**
63B02	Materials		ALD specifications very high - Could be relaxed	
63B03 (a)	Construction	Table 6300B/2 Conventional binder – should be Net cold binder ?		
(a)	Application	Table 6300B/3 Chippings in m^3/m^2		
(g)	Bitumen Rubber	Chippings not more than 2 min after BR - Correct , but check elsewhere for consistency.	Table 6300B/3 General consensus minimum = 1.8 l/m^2.	BR according to specifications referred to, not suitable for 9.5 mm aggregate
63B04	Opening to traffic		This refers to very hot climates. Normal to open when surface temperature increases above 25 deg to prevent aggregate loss	This aspect to be discussed and more guidelines provided
63B.02	Variations	Anionic spray grade ?		Should this not be anionic stable grade?
DIVISION 6300C Double Surface Treatments				
Item	**Aspect**	**Minor errors/issues**	**Significant issues**	**Comment**
63C03	Construction		Table 6300C/2Check rates e.g. BR at 1.6 l/m^2	As discussed before – not practical, too low application rate
(iii)	Broom drag and final rolling	… the layer shall be rerolled (does not specify with what type of roller) - add pneumatic		
63C04	Opening to traffic		Needs more clarity – this specification related to very hot climates and cutback binders	
Item 63C.02	Variations	Check (j) and (k) are exactly the same – One should be “cold applied”		Why not this more comprehensive list with the single seals ??

DIVISION 6300D Triple Surface Treatments				
Item	**Aspect**	**Minor errors/issues**	**Significant issues**	**Comment**
63D02	Materials		ALD not more than 50% of preceding layer - rule cannot be applicable if a triple seal of 19/9.5/6.7 is specified	Conflicting rule
63D04	Opening to traffic	m^3/m^2 aggregate - consistency		Same issues apply than with double surface treatments
63 D.02	Measurement and payment	(i) and (j) similar		
DIVISION 6300E Single Surface Treatment with Slurry (Cape Seals)				
Item	**Aspect**	**Minor errors/issues**	**Significant issues**	**Comment**
63E02	Materials Minimum ALD			Might consider lower specifications for LVR
63E03	TABLE 6300E/2	l/m2 – not super script		
63E04©	Slurry composition	Allows fine, medium and coarse slurry gradings		Not practical to use coarse slurry in Cape Seal
(e)	Application of slurry		Specifies two layers of slurry with 19 mm. OK but nothing said about the grade. Also specifies a 27 ton PTR and permeability less than 1l/h – method not specified	Medium and coarse grade not practical to apply in two layers
63E05		Measurement and payment		
Item 63E.02	Variation	(i) and (j) exactly the same		
Item 63E.04	Variation - Slurry		Formula - Why 0.72 times ?	
DIVISION 6300F: Sand Seals				
Item	**Aspect**	**Minor errors/issues**	**Significant issues**	**Comment**
63F01	Scope	Only on new pavements - Why?		
63F03 (a)	Equipment			Still same as for seals – could just refer
(b)	Preparation		The layer shall be rolled and swept until a fine texture is obtained. Note: Dependent on the type of base and material this might not	Uncertainty regarding purpose of this type of sand seal

			be possible. Surface will be damaged	
(c)	Application of sand seal	1.0 l/m2 net bitumen cold Aggregate spread = 0.007 m3/m2 Precoating specified at 7 l/m3		(no super scripts)
DIVISION 6800: Treatment of Certain Defects in Existing Bituminous Surfacing				
Item	**Aspect**	**Minor errors/issues**	**Significant issues**	**Comment**
6802	Materials			
(iii)	Fog spray		Only spray-grade emulsion specified	Stable grade more appropriate for rejuvenation
(iv)	Tack coat for texturing		Note: OK as discussed under Texturing p 124 – Check if the same as COLTO also in this case referred to double washed aggregate of medium grade for slurry	Some confusion.
(viii)	Binder in asphalt for patching	Specifies a tack coat 60% stable emulsion		Check consistency
(viii)	Bitumen rubber	Note: No degree symbol shown		
6804(a)	Fogspray	Spray grade specified		Add note: not for rejuvenation
(c)	Slurry seal	Should be slurry texture treatment - not a slurry seal		
6806	Measurement and payment			
68.02	Texturing		ERROR: Application of slurry seal with double washed aggregate Second paragraph irrelevant here	This is not a slurry seal

7 FIELD INSPECTIONS

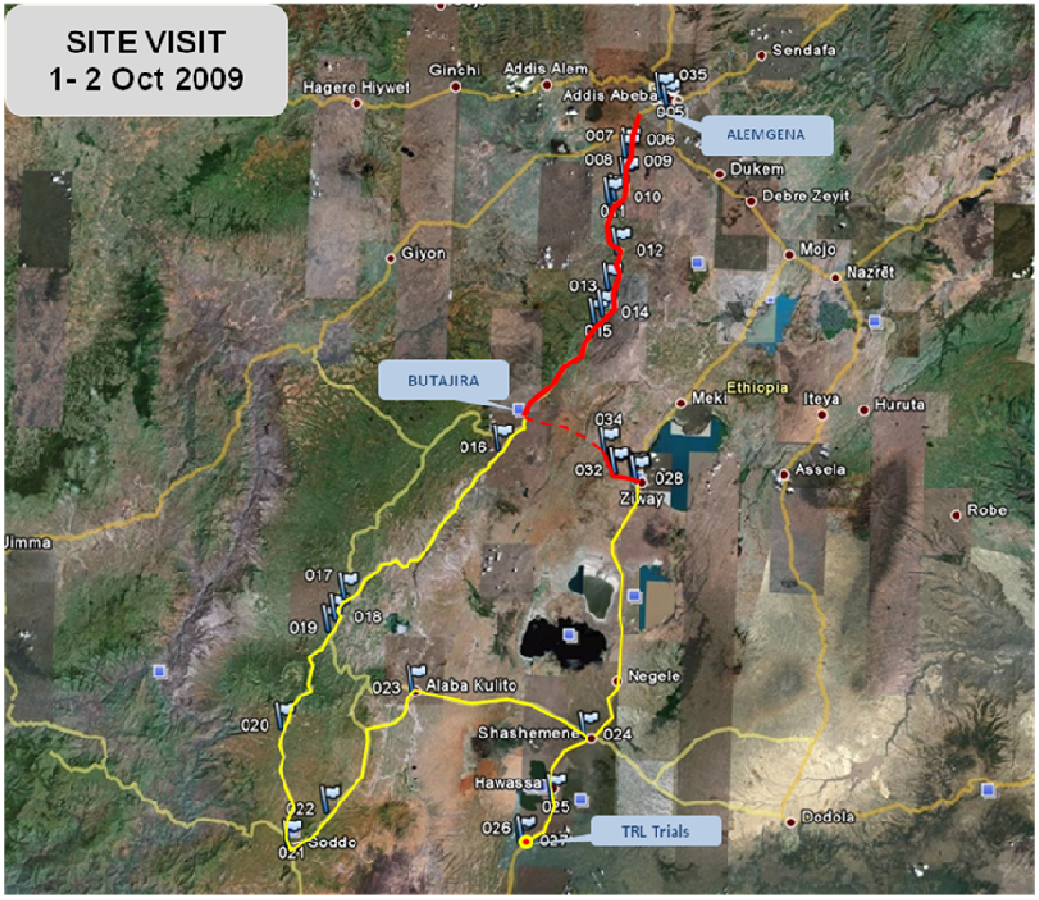
7.1 Purpose and scope of this section

The purpose of this section is to record and to discuss observations made during a two-day field inspection and to identify aspects which could improve the performance of surface dressings in Ethiopia.

7.2 General

Field inspections were conducted on 1 and 2 October 2009 and included:

- inspection of the following road sections
  - Alemgena to Sodo with emphasis on the section from Alemgena to Butajira
  - TRL trial section (Moiocho – Leku Road)
  - Ziway - Butajira
- inspection of quarries and crushers utilised for these projects
- discussions with site staff.



7.3 Alemgena to Butajira

7.3.1 General information

The construction of this road was completed in 2005. Initial findings of the university team show variations in the current condition of the road. Some sections of the road are severely damaged, others have experienced only moderate damage, and some sections are still in relatively good condition. The major types of failure include loss of aggregate, cracking of the seal, edge break and potholes. In some isolated cases there is local deformation, indicating a failure of the road pavement.

7.3.2 Design and "as-built" information (related to the surface dressing)

Documentation provided, confirmed that all aspects of construction were certified to be within specification.

7.3.3 Performance

The major portion of the surface dressing, now 4-5 years old, performs poorly. Typical surfacing defects observed are:

- tramlining/ streaking i.e. aggregate loss in parallel lines (refer Photograph 1)
- aggregate loss of the 9.5 mm layer (Photograph 2)
- low binder content/ brittleness on first 50 km (Photograph 3)
- poor longitudinal joint construction (Photograph 4)
- higher binder content on sections resulting in fattiness
- aggregate loss due to poor transverse distribution (Photograph 5)
- fattiness/ bleeding on transverse joints (Photograph 6).

Structural defects observed are:

- failures and potholes (Photograph 7, Photograph 8)
- fatigue cracking (crocodile cracking) (Photograph 9, Photograph 10).

Maintenance work done to prevent further aggregate loss has not been effective as shown in Photograph 11 and Photograph 12.

Performance of the bituminous surfacing improves towards Butajira due to improved workmanship and an observed increase in binder content (Photograph 14 and Photograph 15).

Photograph 1 Aggregate stripping due to poor binder transverse distribution

Photograph 2 General loss of 9.5 mm aggregate

Photograph 3 Very low binder content (no adhesion)

Photograph 4 Longitudinal joint failure

Photograph 5 Streaking regardless of much higher binder application

Photograph 6 Fattiness on transverse joint

Photograph 7 Structural failures

Photograph 8 Pothole - also observe penetration of prime

Photograph 9 Crocodile/fatigue cracking in wheel tracks

Photograph 10 Fatigue cracking and pumping of fines

Photograph 11 Repair of aggregate loss (not effective)

Photograph 12 Repair done using binder distributor (MC 3000 + 9.5 mm)

Photograph 13 Aggregate loss treated with MC3000 + sand

Photograph 14 Good performing double surface dressing close to Butajira

Photograph 15 Close-up of good performing section

7.4 TRL Trial section (Moiocho – Leku Road)

7.4.1 General information

The purpose of the project is described as 'Improving the performance of limestone wearing courses and low cost surfacings in Ethiopia'.

The 'low cost' surface dressings specified for this project consist of either:

- 13.2 mm + 6.7 mm double seal using MC 3000 binder or
- 13.2 mm single seal using MC 3000 binder.

The field visit took place on the first day of construction and the team was still training newcomers and struggling with the equipment. The TRL team reported significant improvement during the subsequent days.

The errors, observed during the initial stages of the project, are typical of many surface dressing projects and provide good material for discussion and training purposes.

7.4.2 Comments on design

The use of MC3000 for the tack coat (first binder application) initially raised some concerns. However, the construction process, quality of equipment and high dust content makes this binder more appropriate than 80/100 penetration grade bitumen for the conditions at hand. It was also mentioned, in the case of the double seal, that the first layer will be trafficked for at least a week before the second layer is applied, therefore allowing a large component of the volatiles in the MC3000 to evaporate before application of the second layer.

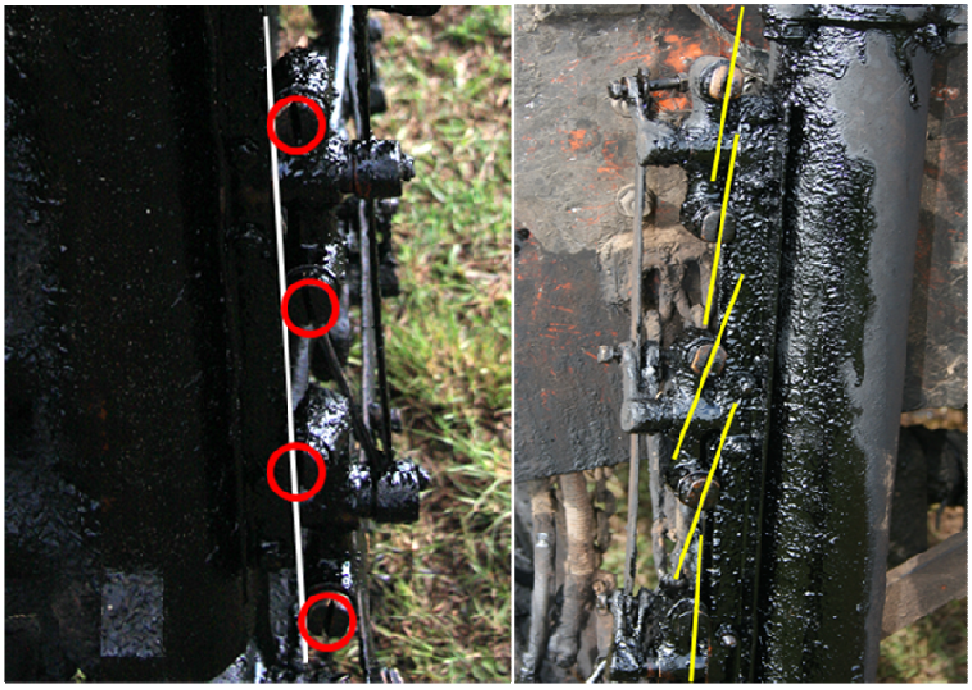
7.4.3 Observations during construction

Quality of equipment

Key equipment used is in poor condition and not well maintained. Some examples to support this statement are:

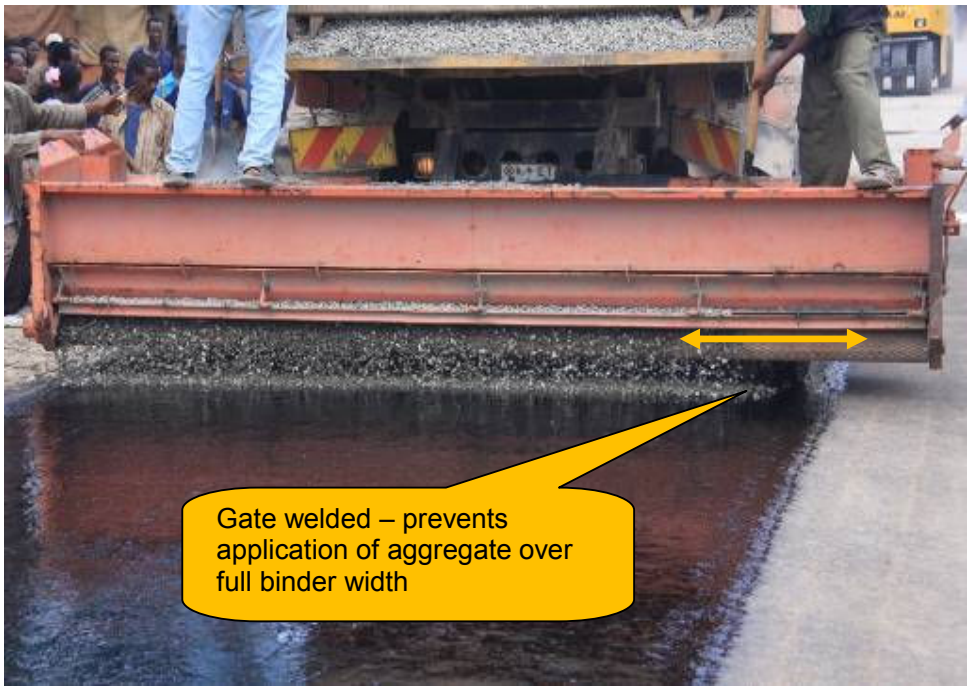
- Distributor
    - fifth wheel not operational (Photograph 16)
    - nozzles not aligned and not to correct angle (Photograph 17)
    - binder pipes (under pressure) patched (Photograph 18)
    - diesel leaking.
- Chip spreader
    - gate welded, not allowing aggregate application over full sprayed width (Photograph 19)

Photograph 16 Fifth wheel not operational



Photograph 17 Nozzles not aligned and at incorrect angles

Photograph 18 Leaking/ patched pipe (pressurized)



Photograph 19 Chip spreader not spreading aggregate over full width

Workmanship

Workmanship of the team is not yet up to acceptable standard, mainly due to poor quality equipment, experience and lack of training. It is accepted that the team has not worked together and that the workmanship will improve. The following aspects could be improved upon:

- Binder application
  - no joint paper on transverse joint, resulting in overspray and dripping on surface (Photograph 20)
  - poor transverse distribution due to incorrect flair angles (Photograph 21)
  - no string-line to guide distributor driver (Photograph 22)
- Rolling
  - rolling not effective due to over application of aggregate (Photograph 24)
- Aggregate application
  - not chipping on line, allowing the chip spreader running on bitumen (Photograph 23)
  - much too high aggregate application (Photograph 24)

Photograph 20 No joint paper used

Photograph 21 Incorrect flair angles

Photograph 22 Distributor not driving a straight line

Photograph 23 Damage due to poor line and chip spreader wheels on bitumen

Photograph 24 Over-application of aggregate

Materials

Graded and dusty aggregate used, result in poor adhesion with the binder.

Photograph 25 Initial over-application and high dust content

Photograph 26 Over-size aggregate and poor adhesion due to dust

7.4.4 Summary on the TRL trials

Poor construction of the surfacing is mainly due to:

- inexperience
- lack of quality control
- poor equipment

The aggregate is dusty and appears to be graded from fine to very coarse (not single sized). The dust prevents good adhesion between the binder and aggregate and could result in aggregate loss and a rigid seal (due to high aggregate surface area and low binder film thickness).

Quality control, according to Section 6000 of the Ethiopian Roads Authority Standard Technical Specifications, would eliminate the majority of problems observed. It is believed that, better equipment and training of site staff would dramatically reduce the risk of poor performing surface dressings.

7.5 Ziway - Butajira

7.5.1 General information

Construction of the road between Ziway and Butajira is well underway. The pavement structure consists of a stabilised sub-base and a crushed stone base. The specified bituminous surfacing is a 19.0 and 9.5 mm double seal.

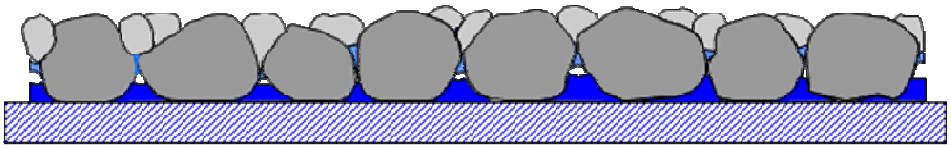


Figure 1 Double surface dressing

7.5.2 Observations

General appearance

Although fattiness occurs on the steep grades, the general appearance of the surface dressing could be described as “Good”.

Photograph 27 General view of surface dressing

Personal preferences vary regarding the volume of binder in the surface dressing. The opinion is held that a slightly higher application of binder would reduce/ prevent aggregate loss as observed on some curves (refer Photograph 28).

Photograph 28 Close-up view of surface dressing

Workmanship

The workmanship on the surface dressing could be described as “Very Good”, resulting in a surface dressing that could perform well for 10 – 15 years.

Both the Contractor and Supervising Engineer confirmed the construction of trial sections to confirm binder and stone spread application rates and to familiarise the team with the sequence of events. Photograph 29 shows the road surface after:

- application, rolling and brooming of the 19 mm aggregate
- application, rolling and brooming of the 9.5mm aggregate
- application of the final fog spray.

Aspects that might still be improved upon are:

- attention to joint construction
- type and sequence of rolling
    - The variable shape of the 19 mm aggregate results initially in more than one layer of 9.5 mm aggregate, attached only slightly as a result of the fog spray.
    - The excess 9.5 mm aggregate is lost soon after construction. Although the net result is still acceptable, it is believed that the type and sequence of roller application could improve the performance.

Photograph 29 Different stages of construction

Photograph 30 Coarse appearance on 19/9 surface dressing

Design

Regardless of different grades and vehicle speed on the road, only one design has been specified.

Based on observations, the opinion is held that the binder application rate could be increased for the current process of construction on flat and downhill sections and decreased on the uphill sections.

Equipment

Photographs taken on site and shown in this section provide sufficient proof that the equipment is new and well maintained.

Photograph 31 Binder distributor

Note: During inspection of the distributor it was noted that the spray bar was clean and that the nozzles were removed and stored in paraffin.

Photograph 32 Self-propelled chip spreader

Photograph 33 Pneumatic tyred rollers

Photograph 34 Mechanical broom

Aggregate crusher and screening plant

The plant, as shown in Photograph 35, is new and in good working order.

Photograph 35 New crushing and screening plant

7.5.3 Summary of the Ziway- Butajira project

The surface dressing constructed on this project is an example of what could be achieved on all projects in Ethiopia.

Both the Supervising Engineer and the Contractor should be congratulated on their commitment and attention to detail.

Construction of trial sections, adjustment of design and construction as well as quality control exercised, contributed to the good performance to date.

Further improvements to the design and construction techniques could be achieved by training.

7.6 DISCUSSION AND POSSIBLE IMPROVEMENTS

7.6.1 General

From observations, the opinion is held that the performance of surface dressings in Ethiopia could be improved through:

- improvement in design, appropriate for local conditions
- workmanship and training
- quality control
- appropriate maintenance treatment.

The quality of work on the Ziway – Butajira project is an example of what can easily be achieved

7.6.2 Design aspects

General

Design methods for surface dressings are mainly developed for single sized aggregate, packed shoulder to shoulder after compaction. Therefore, application rates determined using these design methods will not be appropriate when graded aggregate is used.

Binder application rates

From discussions, it appears as if the application rates, as provided in the standard specifications or project specifications (at time of tender), are used and then adjusted according to the ERA Design Manual.

It should be mentioned that the best practice is to design a surface dressing for each uniform section on a road after the aggregate has been delivered to site.

Aggregate spread rate

Spread rates in tender specifications are only provided to ensure a level playing field for all tenderers.

Current practice on many seal projects is to hand-spread the aggregate (1 m^2) to the matrix required after rolling. Hereafter, the mass per square metre is measured, agreed with the contractor, and from thereon controlled.

Photograph 36 Verify spread rate by "hand-packing" 1 m^2

7.6.3 Workmanship during construction

General

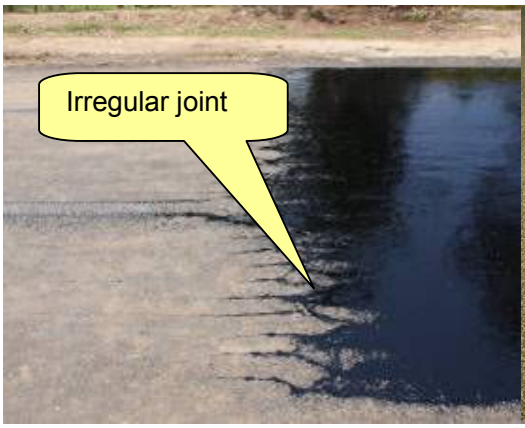
A checklist is provided as Appendix A to this report which could be of value to the seal foreman and site supervisors.

Binder application

Joint paper and drip trays

The use of joint paper allows a neat joint without double applications. It also serves as a drip tray when the distributor is stationary before spray.

Note: The use of reinforced joint paper is specified in the ERA Standard Specifications



Photograph 38 Observed

Photograph 37 Recommended

Tram lining observed

"Tram lining" as observed (refer Photograph 5) typically occurs as a result of:

- Incorrect bar height (Either too high or too low) – refer Fig. 2
- Too low pressure in the spray bar due to pump deficiencies or Too high binder viscosity normally as a result of too low temperature – refer Fig 3.

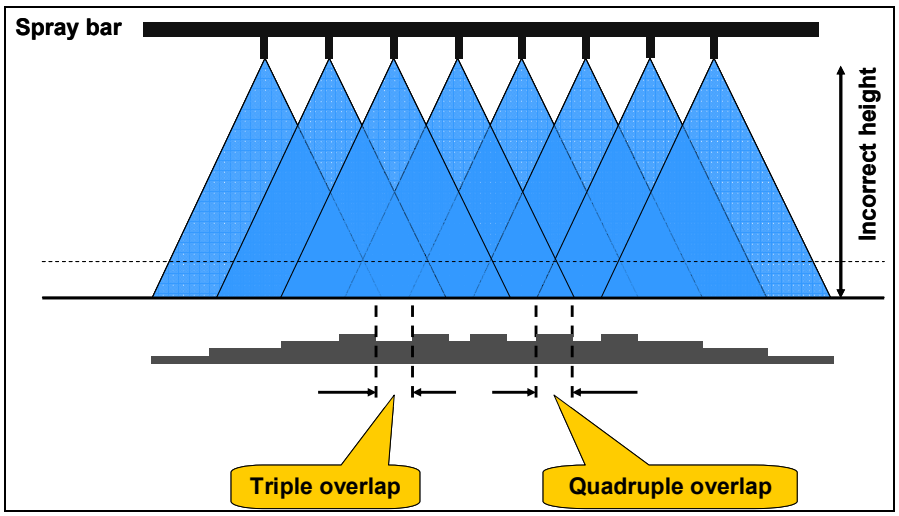


Figure 2 Effect of incorrect bar height

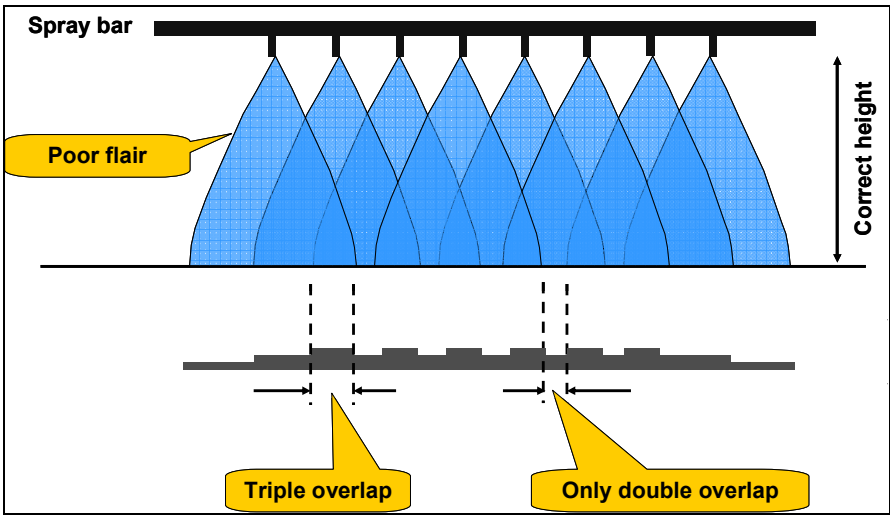


Figure 3 Tramlining caused by a poor flair

Aggregate application and rolling

The appropriate roller type/s, sequence and number of passes required are dependent on the type, size and spread of aggregate and what must be achieved as the end result.

The over-application of aggregate, as observed on site, results in a situation where the roller cannot orientate the stone to its ALD (intention displayed in Figure 5). Also as a result of the friction between the aggregate particles, less downward pressure is applied on the aggregate in contact with the bitumen binder (refer Figure 4).

The main purpose of the pneumatic rolling is to facilitate increased of surface area in contact with the binder (refer Figure 5). In our case on site (refer Photograph 24), this does not happen due to the over-application and multilayer-effect of the aggregate.

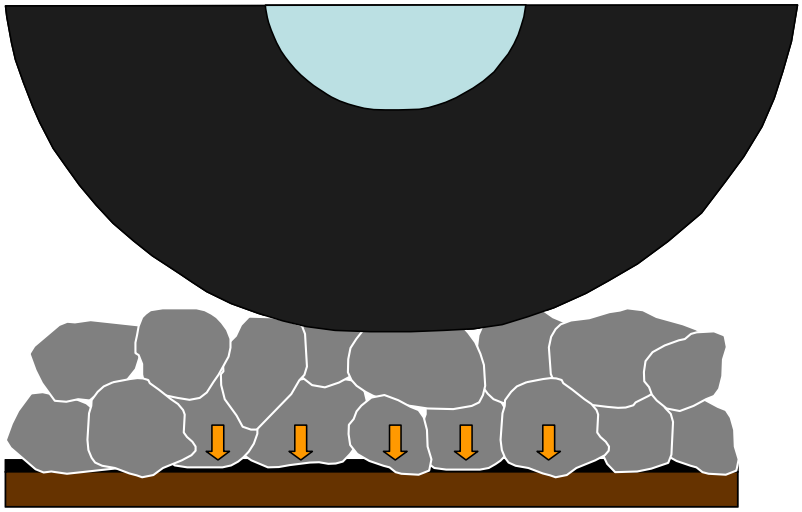


Figure 4 Effect of aggregate over-application

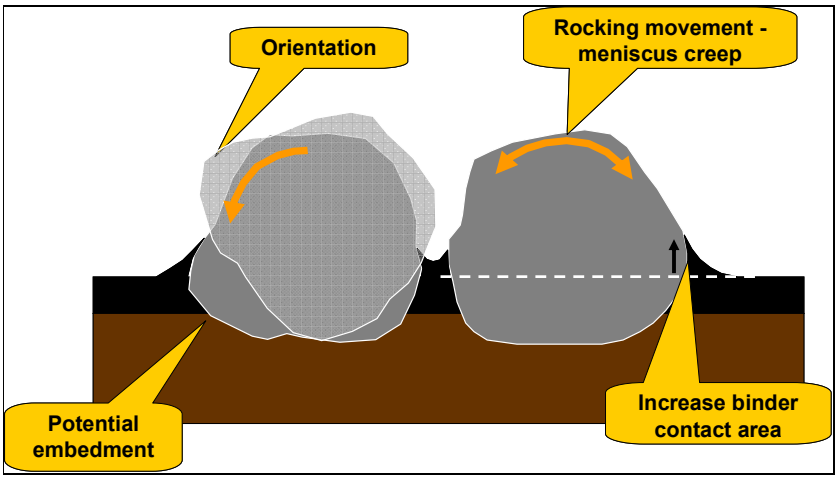


Figure 5 Effects of rolling a single layer

7.6.4 Appropriate maintenance treatments

Aggregate loss or the sensitivity to aggregate loss as observed on some roads in Ethiopia, could be reduced/ eliminated by application of appropriate measures. Examples of inappropriate measures applied are:

- application of MC3000 and coarse aggregate (refer Photograph 11 and Photograph 12,) resulting in aggregate loss
- application of MC 3000 and fine sand (refer Photograph 13), resulting in a bleeding surface

An appropriate measure would have been to apply an aggregate, smaller than a 9.5 mm, such as 6.7 mm or 4.75 mm, with low fines (material smaller than 0.075 mm).

8 OUTCOMES FROM NATIONAL WORKSHOP

8.1 General

A 'Surface Treatment' workshop, forming part of the 'Workshop on Design Manual, Specifications and Standard Bidding Documents for Low Volume Roads', was held on 26 November 2009 in Adama.

The workshop was attended by approximately seventy consultants, contractors, engineers from the Ethiopian Road Authority, and regional representatives.

The main purpose of the workshop was to obtain opinions and comments from local specialists and practitioners regarding the causes of poor surface treatment performance and recommendations to improve current practice.

The aspects requiring urgent attention, as identified by workshop attendees, are as follows:

- selection of appropriate surface treatments for different conditions
- selection of the most suitable bituminous binder
- quality improvement
    - workmanship
    - supervision
    - design
- documentation
    - design manual
    - specifications
    - best practice guidelines
- maintenance planning
- accurate cost information
- guidance for upgrading of gravel roads.

8.2 Selection of appropriate surface treatments

The majority of comments and requests related to the selection of an appropriate surfacing for any specific condition in Ethiopia. Apart from the bituminous surfacings options that include DBST and asphaltic concrete, this also incorporates non-bituminous surfacing types such as block paving and concrete.

Guidelines are required to assist practitioners with the selection of appropriate surfacing types and should take account of the following:

- life-cycle strategy (expected performance, maintenance)
- initial and life-cycle costs
- performance risks
- quality of construction/ supervision
- marginal materials/ availability of materials
- heavy vehicle volumes, tyre pressures, overloading and turning actions
- pavement structural capacity and flexibility
- base quality (hardness, density, moisture sensitivity, etc.)
- grades, topography and curvature (geometry)
- maintenance capability
- environment & climate (Temperature, rainfall, etc.)
- labour intensive work requirements
- expected traffic changes due to the development of the road network
- balance between what is affordable and an acceptable level of service.

These guidelines should be drawn up with full understanding of Government development strategies and the medium to long term road/ transportation master plan.

More than one surfacing type could be appropriate for any given situation. In order to further evaluate the cost-effectiveness of alternatives, the following should be considered:

- development of a “Cost Database” to more accurately estimate the cost of different alternatives
- collecting pavement performance data for Ethiopian conditions. Formal experimental sections and/or calibration sections, as used for HDM4 were mentioned.
- evaluating existing “tools/ procedures” to compare alternatives.

8.3 Selection of most suitable binder

Concern was expressed regarding:

- quality and variability of bituminous binders
- importation of bitumen emulsion (long distance hauling of water)
- potential introduction of modified binders in Ethiopia.

The need was identified for guidelines to select appropriate binders for any given situation in Ethiopia. Aspects, identified during the workshop, to be taken into consideration are:

- climate
    - constructability
    - durability
- surface dressing type
- purpose e.g. retard crack reflection
- costs
- environment (stresses)
- labour intensive requirement.

8.4 Quality improvement

8.4.1 Training

There is general agreement that training is required to improve the quality of work and, hence the performance of surface dressings. Training should include both practical and theoretical training.

Specific course needs as identified are:

- workmanship
- supervision and quality assurance
- selection of appropriate surface treatments
- design and specifications.

8.4.2 Trial and experimental sections

The need to improve the performance of bituminous surfacing and the road pavement was re-emphasised. However, it is also accepted that quality improvement might take some time and that consideration should be given to identify "lower risk" surfacing, where poor quality of equipment, delays, poorer aggregate and low skill levels could be accommodated.

Therefore, the need exists to introduce:

- trial sections on all contracts, the main purpose being to familiarize the surfacing team with the specifications, sequence of events and make best with the available equipment and skill levels
- experimental sections to construct different surfacing types and then to formally monitor the performance thereof.

The monitoring of the experimental sections could be done by universities or a Technology Transfer (T^2) institution, reporting to a 'Research Committee'.

8.5 Documentation

Based on the review of relevant documents, as part of this study, the presentation and discussion of shortcomings and errors, the following recommendations from the workshop were recorded:

8.5.1 ERA Design Manual

The following improvements to the ERA Design Manual are supported namely:

- correction of errors
- practical adjustments for Ethiopia
- incorporation of design of additional surface dressing types
- incorporation of guidelines for selection of:
    - appropriate surfacing type (including limitations)
    - appropriate binder type.

8.5.2 ERA specifications for surface dressings

Similar to the Design Manual, the need for improvement to the ERA specifications for surface dressings was also confirmed during the workshop, and includes:

- correction of errors
- updating to reflect current best practice e.g. incorporating improvements in "base" documents, such as COLTO

- reconsidering and revising specifications to ensure they are achievable in the Ethiopian situation
- ensuring compatibility between the ERA Design Manual and Specifications.

8.6 Maintenance planning

The performance of a road and the bituminous surfacing is dependent on routine and periodic maintenance.

As discussed during the workshop, a surface dressing could be a much cheaper option than an asphalt concrete surfacing. However, it is a higher risk surfacing and is more sensitive to maintenance than the thicker and more expensive asphalt overlay.

Experience and observations in Ethiopia also indicate a huge maintenance backlog.

The need was expressed for the development of practical guidelines to assist decision makers with the identification of suitable maintenance actions, timing and prioritisation.

This activity should be incorporated/ be part of the envisaged Pavement Management System.

9 TENDER PRICES

During the initial interviews, and then at the subsequent workshop, the topic of DBST tender prices proved to be a very sensitive issue. A statement was made that 'the market price *is* the market price'.

In countries such as Australia, South Africa and New Zealand, the majority of the sealed road network is surfaced with a surface dressing rather than asphaltic concrete, because surface dressings cost from a half down to a tenth the cost of surfacing with AC. These countries cannot afford to surface their whole networks with AC.

The materials component of surface dressing should be much less than for AC, as less bitumen and less aggregate is required. Also the complexity of mechanical equipment required for surface dressing is less than that required for AC.

9.1 Materials in one m² of double surface dressing

Assume a 19/9.5 mm double bituminous surface dressing using the nominal rates of the series 6000 specification (clause 63C03 Construction) of 1.0/1.0 L/m² of bitumen, and aggregate with bulk density of 1350 kg/m³ spread at 77/167 m²/m³

Bitumen used = 1.0 + 1.0 = 2.0L

Aggregate used = 1350 kg/m³ / (77 + 167) m²/m³ = 5.5 kg

9.2 Materials in one m² of 50mm AC

Assume AC14, containing 5% bitumen, 4% air voids, 91% continuously graded aggregate

Volume = 1 x 1 x 0.050 = 0.050 m³

Bitumen used = 5% of 0.050 m³ = 0.0025 m³ = 2.5 L

Aggregate used = 91% of 0.050 m³ x 1350 kg/m³ = 61.4 kg

9.3 Surface dressing savings

Fundamentally the same materials are used for DBST as for asphaltic concrete, so that the unit rate costs of the materials should be the same.

Using the estimates from 9.1 and 9.2, a nominal DBST uses 80% of the bitumen and only 10% of the aggregate resources as a nominal asphaltic concrete alternative, therefore there are undeniable savings in material costs.

The capital equipment investment needed for a surface dressing (bitumen distributor, chip spreaders, pneumatic rollers, mechanical sweeper) is also less than that needed for asphaltic concrete (mobile asphalt plant, delivery trucks, asphalt paver, steel drum rollers, and pneumatic rollers).

Some recent examples of the additional cost of contract variations to change from surface dressings to asphalt are shown in Table 2.

It should also be noted that pavements designed for a surface dressing may not be rigid enough to support the AC subsequently applied, and this AC may prematurely fail.

Table 2: Recent additional costs of changing to asphalt

Job	Ethiopian Birr (ETB)
Sodoloy – Gobgob	95,335,071.53
Gobgob - Gashene	59,549,188.91
Sasheshemene – Km35	22,800,562.85
Km35 – Dodola J.	24,707,044.84
Shashehemene wod - Gem	15,852,465.44
Total	**218,244,333.57**

9.4 Extended network coverage

If surface dressings can be purchased for a lower cost than AC, and constructed such that they last the expected lifetime, this would mean that the extent of the network covered each year could be *increased*, for the same budget outlay.

10 RESTORING THE SKILLS BASE

There were several issues identified during the initial site visit, and the authors have prioritised them in order of most important problem first:

1. Standard of workmanship
2. The master specification is not enforced or understood, and is often weakened by inappropriate project specifications
3. Inappropriate treatment selection.
4. Understanding of seal design

There are also further background issues, but these are beyond the scope of this particular review:

5. Apparent lack of a maintenance strategy
6. Standard of base course construction.

A proposed strategy for restoring the skills base is

1. Workmanship
    a. Hands-on training of contractors, preferably on-site
    b. Implement 'trial sections' in certain contracts to reduce the contractual risk in acquiring and applying new skills and methodologies
    c. Quality assurance training for consultants
2. Specifications
    a. Review applicability of existing specifications
    b. Review applicability of some overseas specification clauses
    c. Training of contractors, consultants and ERA in understanding the reason for the specified practices and the implications and risks in not enforcing them
3. Treatment selection
    a. Production of a 'low volume roads manual' for Ethiopia, giving guidance on selection of treatment type and binder selection
    b. Production of a 'best practice guide' for Ethiopia.

11 RECOMMENDATIONS

Following the review of surface dressing practice in Ethiopia and the workshop in Adama, the recommended strategy towards improvement of surface dressings in Ethiopia is summarised in a provisional three-year plan as shown in Table 3 .

Table 3 Three-year improvement plan

Year 1	Year 2	Year 3
Practical training by international specialist on QA and workmanship	Practical training by international and national specialist on QA and workmanship	Practical training by national specialist on: QA and workmanship
Training course by international specialist on treatment selection, design and specifications	Training course by international and national specialists on treatment selection, design and specifications	Training course by national specialist on treatment selection, design and specifications
Update, design and specifications		
Incorporate experimental sections in selected contracts & monitor performance, involving local universities and specify trial sections in contracts		
Develop “best practice” guidelines on interpretation of standards, surface dressing selection, construction and maintenance		
	Establish a formal technology transfer framework	
		Audit surface dressing performance improvement

Year one

- Focus on resolving workmanship, quality assurance, treatment selection and design deficiencies through practical training by external specialists
- Identify and incorporate appropriate experimental sections in contracts. Experimental design, quality assurance, documentation and monitoring to be executed by academic or research institution

- Start with development of “best practice” guidelines on Interpretation of standards, surface dressing selection, construction and maintenance

Year two

- Undertake appropriate additional experimental sections within selected contracts and continue with performance monitoring
- Complete “best practice manuals”
- Present courses on design and specifications by a team of international and national specialists
- Practical training on QA and workmanship by a team of international and national specialists
- Identify the most appropriate place for surface dressing expertise to reside and establish a formal technology transfer framework

Year three

- Develop, implement and nurture local expertise and knowledge so that Ethiopian expertise remains self-sufficient and sustainable. Nurture the ability to continue learning from any mistakes made.
- Presentation of courses on design/ specifications and practical training on QA and workmanship by national specialists
- Audit the improvement of surface dressing performance and knowledge gain.

Based on the above recommendations an outline for a Terms of Reference is provided in Appendix B to this document.

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APPENDIX A TERMS OF REFERENCE FOR REVIEW OF SURFACE DRESSING PRACTICE IN ETHIOPIA

AFCAP/ETH/021

The Africa Community Access Programme[1] (AFCAP) is a research programme funded by the UK Government's Department for International Development (DFID), which is promoting safe and sustainable rural access in Africa. AFCAP supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

AFCAP has been asked by the Ethiopia Road Authority (ERA) to support a research consultancy outlined in these Terms of Reference. The project will assist the Government of Ethiopia in the "Review of Surface Dressing Practice in Ethiopia".

A.1 Background to Project

Thin bituminous surface dressings are an appropriate and cost effective technology for sealing both low and medium volume roads in Ethiopia. Seals of this type constructed in Ethiopia more than thirty years ago are still performing well, but in recent years there have been widespread failures. The causes of these failures are not well understood, but it is thought they could be due to a combination of factors such as flaws in the standard design procedures or their interpretation, inadequate specifications, poor quality bitumen and aggregates, poor workmanship, etc.

As a result of the widespread failure of surface dressings there is a risk that asphalt concrete surfacing will be increasingly specified, even for low traffic roads. This will contribute to unnecessarily high construction costs, as well as high maintenance costs in the longer term. The failure of surface dressings is potentially a constraint to the expansion of the paved road network and delivery of the Road Sector Development Programme in Ethiopia, which are critical for social and economic development in rural areas.

The Ethiopian Road Fund has engaged the University of Addis Ababa Civil Engineering Department to undertake a review of surface failures on the Alemgena-Lemen-Butajira road. The construction of this road was completed in 2005. Initial findings of the university team show variations in the current condition of the road. Some sections of the road are severely damaged, others have experienced only moderate damage, and some sections are still in relatively good condition. The major types of failure include loss of aggregate, cracking of the seal, edge break and potholes. In some isolated cases there is local deformation, indicating a failure of the road pavement. The university now plans to undertake a detailed review of the design and construction process, including materials tests undertaken at the time, and to undertake further field and laboratory investigations where necessary. This will assist the university to identify the causes of failure of the surfacing and to devise appropriate remedial measures.

[1] AFCAP is a DFID funded programme of research, knowledge dissemination and training designed to address the challenges of providing safe and sustainable access to poor communities in Africa. The management of AFCAP has been contracted by DFID to Crown Agents.

Meanwhile ERA has embarked on a project to prepare a series of manuals for the planning, design, construction and maintenance of low volume roads in Ethiopia, as well as accompanying standard bidding documents. The purpose of these documents is to promote the rational, appropriate and affordable implementation of projects providing low volume roads that makes appropriate use of local resources and is cost-effective and sustainable. The project includes training and dissemination of the manuals and bidding documents to stakeholders in the federal and regional governments, the private sector and within academic institutions. The manuals and the bidding documents will be written by expert authors recruited both locally and internationally. The project is being supported by AFCAP.

ERA is also constructing demonstration sites under a parallel project known as "Design Standards & Specifications for Low Volume Roads". The demonstration sites are being established in the principal regions of the country, and will include the construction of thin bituminous seals using labour-based as well as equipment-based methods. This project is also being supported by AFCAP.

A.2 Objectives

The objective of this assignment is to analyse and understand the causes of surface dressing failures in Ethiopia, and provide recommendations for improved practice. An important part of this objective is to engage and inform key decision makers in the road sector in Ethiopia concerning the role of surface dressings in a sustainable road investment and maintenance programme for the country. A secondary objective is to impart specialist hands-on knowledge in the use of surface dressings to staff and students at the University of Addis Ababa Civil Engineering Department, through assistance with their analysis of failures on the Alemgena-Lemen-Butajira road.

A.3 Scope of the Services

The consultants will provide the following services:

- Undertake a review of existing design methods and standard specifications for typical thin bituminous seals used in Ethiopia. This includes a review of Terms of Reference of designers and supervision consultants.
- Visit a sample of sites where surface dressings are being constructed and where surface dressing failures have occurred.
- Conduct interviews with government representatives, university and industry actors.
- Undertake a review of the work done by the University of Addis Ababa concerning surface failures on the Alemgena-Lemen-Butajira road. Provide comments on their draft findings.
- Provide recommendations for additional testing of materials or field investigations that may be needed to understand the causes of surface dressing failures. Undertake an analysis of the test results.
- Prepare a draft report on the causes of surface dressing failures, and recommendations for improved practice. The draft report should include outline Terms of Reference for follow up activities, which may include the revision of design manuals and standard specifications, revision of training materials and university curricula, training programmes for consultants and contractors etc. (The recommendations of this study will inform the content of the new design manuals and standard bidding document for low volume roads).

- Present the study findings to a workshop attended by government and industry representatives. Assist the workshop to define an appropriate role for surface dressings in the Ethiopia road investment and maintenance programme.
- Update the draft report to reflect the workshop discussions and other comments received from stakeholders on the draft report. Submit the final report.

A.4 Assignment Period, Indicative Milestones and Deliverables

The total duration of the assignment is 2 months. The study inputs will include an initial two week visit to Ethiopia for data collection, including site visits and interviews with stakeholders, as well as recommendations for further materials testing. The draft final report will be prepared at home base and submitted within one week the end of the initial visit. A second visit to Ethiopia of one week will include analysis of any additional testing undertaken since the initial visit, plus the workshop to discuss the findings of the draft report. The final report will be prepared at home base.

All reports should be in English and may be submitted in electronic format.

A.5 Transfer of Knowledge/Training

The project has an important training and capacity building component. The consultants will work closely with ERA staff, and with staff and students of the University of Addis Ababa. The study workshop will provide an opportunity for the consultants to impart their knowledge to a wider group of industry and sector representatives.

A.6 Minimum Experience requirements

Two international consultants are required to undertake this assignment. Both consultants should have a degree in Civil Engineering (or equivalent) and a minimum of 20 years experience in the road sector. They must have proven hands-on expertise in the design and construction of surface dressings for low and medium trafficked roads.

It is anticipated that each consultant will provide a total of one month of input to the project.

A.7 Facilities, services and resources to be provided the consultant

The consultant is responsible for providing for their transport and accommodation in Addis Ababa, and their accommodation in regional centres and in the field. The consultant is also responsible for providing office equipment including computers, printers, copiers, etc., as well as office consumables and communications. If flights are needed to regional centres these will be provided for by the consultants on a reimbursable basis.

A.8 Facilities, services and resources to be provided by ERA

ERA will provide all necessary letters of introduction to other Ministries and authorities to facilitate the entry of expatriate consultants. ERA will also provide road transport for field visits. ERA, the Regional Road Authorities and the University will provide transport to the field for their own staff, as well as accommodation and subsistence for their staff while in the field.

ERA will arrange any testing of materials recommended by the consultants, with support from AFCAP if necessary.

ERA will organise the stakeholder workshop, with assistance from AFCAP if necessary.

A.9 Management and administration

The consultants will liaise with the Deputy Director General of ERA or his representative for all day-to-day aspects of the implementation of the project.

For all contractual and administrative matters the consultants will report to the AFCAP Procurement Manager.

APPENDIX B FRAMEWORK FOR A FUTURE TERMS OF REFERENCE

B.1 Revival of surface dressing practice in Ethiopia

The Africa Community Access Programme (AFCAP) is a research programme funded by the UK Government's Department for International Development (DFID), which is promoting safe and sustainable rural access in Africa. AFCAP supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

B.2 Background to project

Thin bituminous surface dressings are an appropriate and cost effective technology for sealing both low and medium volume roads in Ethiopia. In 2009 AFCAP commissioned a review of surface dressing practice in Ethiopia. An important part of that project was to identify follow up activities, which are detailed below.

ERA has embarked on a project to prepare a series of manuals for the planning, design, construction and maintenance of low volume roads in Ethiopia, together with accompanying standard bidding documents. ERA is also constructing demonstration sites under a parallel project known as "Design Standards & Specifications for Low Volume Roads". The demonstration sites are being established in the principal regions of the country, and will include the construction of thin bituminous seals using labour-based as well as equipment-based methods. This project is also being supported by AFCAP.

These projects should be considered in conjunction with this TOR.

B.3 Objectives

The objective of this assignment is to restore the skills base of the practice for bituminous surface dressing of rural roads, to the stage where a viable skills base is self-sufficient.

B.4 Scope of the services

B.4.1 Year one

1. Identify existing surface dressing training course materials, from countries such as Republic of South Africa, Australia and New Zealand, and review them for suitability as a one day course, for each of the following topics:

    a. Treatment selection

    b. Surface dressing design using TRL Overseas Road Note 3

    c. Quality assurance and surface dressing contract supervision

    d. Surface dressing construction practices – classroom

    e. Surface dressing construction practices – on site.

2. Where required courses are not in existence (possibly 'design using TRL ORN3'), or they exist but are unsuitable (possibly 'treatment selection'), provide client with a cost estimate for their production.

3. Advise ERA of any licence fees that may be applicable for the use of existing courses.

4. In cooperation with ERA, identify an appropriate local training partner to engage as understudy in the short term but with a view to taking over the training in the long term (e.g. ERA training group, industry training providers, or the Ethiopian Road Research Centre (ERRC)).

5. With the assistance of the local training partner, adapt identified existing training courses for suitability to Ethiopian culture and conditions.

6. With the assistance of the local training partner, locate suitable venue, and run one each of the above training courses, one day per topic.

B.4.2 Year two

1. Train the local training partner to assist in the running of the 5 training courses developed the previous year, and run the courses again.

2. In cooperation with ERA, identify appropriate trial topics to test common international practices in Ethiopian conditions (e.g. rolling patterns, rolling equipment, aggregate precoating, aggregate spread rates, binders, etc.).

3. Establish trial methodologies in conjunction with the local training partner and a university.

4. Supervise the establishment of the first trial, and its subsequent monitoring by the local training partner and/or university.

5. Recommend any appropriate specification changes to the ERA, that have been identified during the work to date.

B.4.3 Year three

1. Supervise and mentor the local training provider in the content of a 'best practice manual'.

2. Be present and mentor the local training provider, in the running of the training courses by themselves.

3. Audit improvements in surface dressing performance

    a. Interviews

    b. Construction practices in action

    c. Assessment of recent jobs