BITUMEN EMULSION USES IN ROAD WORKS IN SOUTHERN AFRICA

EMERY, Stephen J[1], and O'CONNELL, J[2]

1 Group Technical Director, Colas Southern Africa, Po Box 882, Isando, Johannesburg, Southern AFRICA, 1600. Phone +27 11 392 5610 Fax +27 11 974 9760

2 Binder Chemist, Colas Southern Africa

ABSTRACT

The paper deals with the use of bitumen emulsions in road works in Southern Africa, and shows how they have evolved to meet the particular climatic and operational needs of Southern Africa. These include base bitumens with low acid values and difficult compositional balance, operations and manufacture at altitudes from sea level to 1800m, and in warm to very hot climates.

The range of bitumen emulsions in Southern Africa is at least as wide as most other countries. Both cationic and anionic emulsions are produced at up to 70% concentration. Specialist emulsions include inverted emulsions and polymer modified emulsions.

The more unusual aspects are the extensive use of SBR (styrene-butadiene-rubber) modified emulsions as a lower cost alternative to SBS emulsions, the use of rubber latex in emulsion used in fogsprays, and an invert emulsion based rejuvenator for roads in hot, arid climates. Design innovations include the use of emulsion as the final spray in an otherwise conventional double seal (surface treatment) using hot bitumen; the use of fogsprays and/or slurry as a pre-treatment prior to resurfacing roads with flushing/bleeding and/or with variable surface texture, and the development of labour enhanced construction technologies for developing regions using emulsions.

L'UTILISATION DES ÉMULSIONS DE BITUME DANS LES TRAVAUX D'ENTRETIEN DES ROUTES DANS L'AFRIQUE AUSTRALE

RÉSUMÉ

Cet article traite de l'utilisation des émulsions de bitume dans les travaux d'entretien des routes dans l'Afrique australe et monte leur évolution pour correspondre aux besoins climatiques et opérationnel de l'Afrique australe. Y compris sont des bitumes de base avec des valeurs d'acide peu élevés et un équilibre des composants difficile d'accomplir, le traitement et la fabrication des bitumes à des altitudes qui s'étendent du niveau de la mer jusqu'à 1800 mètres, et dans les climats chauds et très chauds.

L'assortiment des émulsions de bitume dans l'Afrique australe est au moins pareil à l'assortiment de la plupart des pays du monde. Des émulsions cationiques et anioniques sont fabriquées à des concentrations jusqu'à 70%. Parmi les émulsions specialisées se comptent des émulsions inversées et des émulsions modifiées avec des polymères.

Quelques aspects exceptionnel sont l'utilisation fréquente des émulsions modifiées avec SBC (styrène-butadiene-caoutchouc) comme succédané des émulsions SBS, l'utilisation d'une émulsion de latex pour fabriquer des sprays, et un rajeunisseur pour les routes dans les climats chauds et arides. Parmi les nouveaux projets se comptent l'utilisation d'une émulsion comme spray final dans un double enduit qui est autrement conventionnel avec le bitume chaud (traitement de surface); l'utilisation des sprays et/ou des bitumes peu épais comme traitement avant de refaire la surface d'une route dégageante/sécrétante et/ou qui a une structure de surface variable, et le développement des technologies de construction qui nécessitent l'emploi d'ouvriers pour développer des régions avec des émulsions.

1. INTRODUCTION

1.1 The Road Network

The road network in southern Africa is primarily unsurfaced, with surfaced roads usually confined to main roads and highways. The surfaced roads are shown in the table below

COUNTRY	SURFACED ROAD NETWORK (km)
South Africa	59 900
Angola	18 200
Zimbabwe	17 400
Zambia	7 100
Mozambique	5 500
Malawi	5 100
Botswana	1 700
Lesotho	800
Swaziland	800

1.2 Southern African Climate and Topography

Climatic variations within Southern Africa are large. The coastal areas are at sea level and the climate ranges from cool humid conditions to subtropical conditions. Most of the inland areas are on a plateau where the altitude generally ranges from 1000 to 1800m and the climate is hot and dry. In summer, temperatures of over 40 °C occur and in winter, temperatures of 0°C are common. As a result of these variations, the base bitumen is varied from 60/70 penetration to 150/200 penetration, with 80/100 being the most common. Manufacturing methods vary from region to region, with soap temperatures at higher altitude plants being lowered 5-10°C to counter the lower boiling point. Mill back-pressure or heat exchangers are rarely used, for simplicity of manufacturing.

1.3 Emulsion Products

Both anionic and cationic emulsions are produced. The demand for anionic emulsions is still strong due to historical preferences. Anionic emulsion types are:

Grade	Bitumen content	Uses
Slow set	60%	Slurry sealing, fog spray (upon dilution), base stabilisation
Medium set	60%	Pre-mixed asphalt maintenance mixes (high float emulsions)
Rapid set	60%	Fog spray upon dilution
Crack sealants	various	SBR modified crack sealant with mineral filler

Inverted emulsions are also used, for basecourse priming and as a rejuvenating agent.

Cationic emulsion types are:

Grade	Bitumen content	Uses
Slow set	60%	Slurry sealing
Medium set	60%	Pre-mixed asphalt maintenance mixes
Rapid set	60%, 65%, 70%	Chip sealing, fog sprays (upon dilution)
SBR modified rapid set	65%, 70%	Chip sealing, microsurfacing

The reasons for the wide range of emulsion products available are:

- the mineral composition of the aggregate partially dictates whether an anionic or cationic emulsion is used,
- the wide range of climate conditions, and
- there exists within Southern Africa a proliferation of road authorities, each with its own preferences and prejudices with regards to certain products.

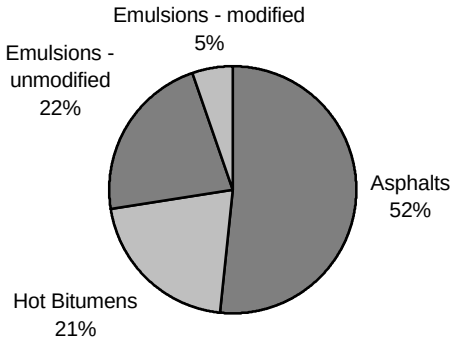
1.4 Emulsion Usage

The breakdown of emulsion usage is:

TYPE	MARKET SHARE
Anionic	31%
Cationic	65%
Inverted	4%

The bitumen volumes absorbed by emulsion manufacture as compared to bitumen volumes absorbed by other products such as asphalt and hot binders are as follows:

Bitumen Usage in Southern Africa



1.5 Specifications For Emulsion Products

The specifications for most unmodified emulsion products have been drawn up by the South African Bureau of Standards (SABS). These are based around ASTM test methods. In many cases, contracts and tenders call for such emulsion products to conform to the SABS specifications. Modified emulsions conform to either manufacturers' specifications or to specifications drawn up by the manufacturers' association: SABITA.

2. SPECIALISED EMULSIONS USED IN SOUTHERN AFRICA

2.1 CSS 60

CSS 60 is a cationic slow set (stable grade) emulsion with a 60% binder content. It has been developed to replace the use of SS60 in areas where quartzitic crusher dust resulted in poor bitumen-aggregate adhesion. CSS 60 gives a breaking time of between 2-4 hours. The several formulations available are based partly on South African developed emulsifiers owing to the scarcity of such emulsifiers on from other sources. The typical properties of CSS 60 are:

Property	Typical Values	Test Method
Binder Content	60 - 63 %	ASTM D244
Saybolt Furol Viscosity	20 -50 s	ASTM D244
Residue	0.05 - 0.25 g / 100 ml	IP 91
Coagulation	nil	SABS 309

2.2 SBR-modified CRS

Styrene Butadiene Rubber (SBR) is used to modify CRS, by adding between 2% and 5% SBR latex to it (SABITA, 1991). It was developed as a replacement for hot modified binders in cool humid climatic areas where intermittent rain can cause construction problems with the use of hot binders. The local cost of SBR as a 60% latex emulsion is about half the cost of SBS powder, which gives the SBR modifiers a relative cost advantage. However local experience is that the performance of SBR modified bitumens is slightly less than that of SBS modified bitumens. The typical properties of a 5% SBR-modified CRS are:

Property	Typical Values	Test Method
Binder Content	70 - 72 %	ASTM D244
Saybolt Furol Viscosity	min 80 s	ASTM D244
Residue	0.05 - 0.30 g / 100 ml	IP 91
Recovered binder R&B	min 55^{o}C	ASTM D36
Elastic recovery @ 10^{o}C	min 52%	Ductilometer
% adhesion at @ 5^{o}C	min 90%	Vialit

2.3 MSP3

This is an inverted emulsion which is used as a rejuvenator for the very hot and arid areas of Southern Africa, where the bituminous surfaces are especially vulnerable to uv degradation and

oxidation. The binder in MSP3 consists of bitumen with considerable diluents and aromatic fluxes. It is significantly improved and different in performance to a conventional fogspray or dilute emulsion. As might be expected, it acts by penetrating the 3-8 millimetres of the road surface and enriching the bitumen content, as well as replacing some oxidised aromatic components. Its use is restricted by the need to close the road for up to 48 hours after application to allow it to dry, although traffic on light traffic roads and airports can usually be accommodated. The typical properties of MSP3 are:

Property	Typical Values	Test Method
Binder Content	80 % min	ASTM D244
Saybolt Furol Viscosity	25 -40 s	ASTM D244
Bitumen Content	~ 43 %	

3. THE USE OF EMULSIONS IN UNUSUAL CONSTRUCTION METHODS

3.1 Fogspray as a final spray in new seal construction

The fogspray is a diluted emulsion with a 30 % binder content and is used in new seal (chip and spray) surfacing construction (TRH 3, 1986). It is used as the final spray of a double seal, on top of the upper stone layer; no further stone is placed on top. The emulsion has a low viscosity, allowing it to run down and penetrate the stones of the seal. A fogspray is applied at 0,7-0,8 litre/m^2 and the net binder is included in the total designed binder requirements. Its use is limited to hot, dry areas, although over the full spectrum of traffic levels.

The reported advantages of this construction technique are twofold, viz. :

- There is improved adhesion of the second layer aggregate to the seal, with less stone whip-off. It is therefore useful for high speed roads where the seal binder is an unmodified bitumen.
- Cosmetically, the resultant initial surface has a uniform black appearance which may be an advantage when using certain lighter coloured stones.

3.2 Dilute emulsion or fogspray as a maintenance application

The dilute emulsion or fogspray is a diluted emulsion with a binder content varying from 20-40%. It is used as a life extender to maintain existing oxidised seals, or to hold stones where the binder is inadequate and sufficient texture is still available. It has been used as a life extender on asphalt occasionally. Its performance is rather less than MSP3, but the road can be quickly opened to traffic. The dilute emulsion must have a low viscosity, to allow it to run down around the stones in the seal. It is applied gross at between 0,5-1,0 litre/m^2 and the net binder ranges from 0,12-0,42 litre/m^2. The base emulsion is usually a slow set anionic 60%, and the road is closed for 2-4 hours until the dilute emulsion dries. However the use of rapid set cationic 60% emulsion is becoming common where there is a need to open the road to traffic within 30 minutes.

3.3 Stone and sand double seal with SBR modified CRS

This surfacing is an option for reseals on cracked roads, because of its ability to retard crack reflection compared to unmodified emulsions. The emulsion is the SBR modified CRS referred

to in the previous section. The binder is designed at 10% higher net application rates than for unmodified bitumen or emulsions which the SBR modifier permits. The SBR modifier also ensures better stone retention in the 24-48 hours after spraying. The sand used is actually a crushed single size 4 mm grit. The main advantage of the stone/sand combination over a single stone seal is that the sand prevents post-application pick-up of the binder by early traffic. The other advantages of this seal are minimal windscreen damage, since the only whip-off is the sand which is too small to damage windscreens. This type of seal is useful in lightly trafficked areas where the construction and early traffic rolling is inadequate to fully form the seal matrix. The application rates are (Colas, 1996):

BINDER HOT APPLICATION RATE (l/m^2)			
13mm & sand		9,5mm & sand	
Bottom	Top	Bottom	Top
1,3	1,1	1,2	1,0

STONE APPLICATION RATE (m^3/m^2)			
13mm	Sand (top)	9,5mm	Sand (top)
0,010	0,005	0,0075	???

3.4 The use of slurry/microsurfacing for texture treatment

A common problem in designing reseals over existing seals is the variable surfacing texture of the existing road. Often the seal in the wheeltracks is flushed or bleeding, while the seal between the wheeltracks is open-textured. The binder application rate is accordingly compromised. A thin slurry/microsurfacing (2-3mm) is used as a texture treatment or initial overlay to reduce the texture variability (Van Zyl, 1990). Then after 2-24 months, a conventional reseal is applied over the top; the design binder application rate is then easy to determine. The extra cost of the texture treatment is offset by the increased life of the reseal.

3.5 Broom slurry

A broom slurry is a very fine slurry. It is applied over an existing asphalt surface some 1-2mm thick and then all excess slurry is vigorously broomed off, leaving only the voids and interstices of the asphalt filled with fine slurry.. The slurry uses an anionic stable grade 60% emulsion combined with a very fine grading of crusher dust. Broom slurry is used to:

- close excess voids in a permeable asphalt surfacing
- repair or retard ravelling, usually of asphalt

The broom slurry is applied by shovel or slurry machine and broomed off shortly thereafter using mechanical brooms or labour intensive practices. The application rate can vary from 200-400 litre/m^3, depending on the existing surface and the crusher dust grading. The surface can be re-opened to traffic within 15 to 30 minutes of application.

4. CONCLUSION

The use of emulsions in southern Africa has evolved despite competition with hot binders and asphalts. Emulsions have found application in generic products such as seals and slurries, and in

innovative surfacings such as stone/sand seals. The warm to hot climates of the region have lead to the development of rejuvenators and fogsprays as maintenance treatments. The ratio of bitumen used in manufacturing emulsions compared to bitumen used in all road techniques is 27%, which is higher than the worldwide average of 17% (SFERB, 1995).

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