Interim guidelines for primes and stone precoating fluids

Manual 26
November 2006

Published by Sabita
Postnet Suite 56
Private bag X21
Howard Place 7450

ISBN 1-874968-29-2

Manuals published by Sabita

Manual 1	Construction of bitumen rubber seals
Manual 2	Bituminous products for road construction
Manual 3*	Test methods for bitumen rubber
Manual 4*	Specifications for rubber in binders
Manual 5	Manufacture and construction of hot mix asphalt
Manual 6*	Interim specifications for bitumen rubber
Manual 7	SuperSurf: Economic warrants for surfacing unpaved roads
Manual 8	Safe and responsible handling of bituminous products
Manual 9	Bituminous surfacings for temporary deviations
Manual 10	Appropriate standards for bituminous surfacings
Manual 11	Labour enhanced construction for bituminous surfacings
Manual 12	Methods and procedures - Labour enhanced construction for bituminous surfacings
Manual 13	LAMBS - The design and use of large aggregate mixes for bases
Manual 14	GEMS - The design and use of granular emulsion mixes
Manual 15*	Technical guidelines for seals using homogenous modified binders
Manual 16	REACT - Economic analysis of short-term rehabilitation actions
Manual 17	The design and use of porous asphalt mixes
Manual 18	Appropriate standards for the use of sand asphalt
Manual 19	Technical guidelines for bitumen-rubber asphalt
Manual 20	Sealing of active cracks in road pavements
Manual 21	ETB: The design and use of emulsion treated bases
Manual 22	Hot Mix Paving in Adverse Weather
Manual 23	Bitumen Hauliers' Code: Guidelines for loading bitumen at refineries
Manual 24	User guide for the design of hot mix asphalt
Manual 25	Quality management in the handling and transport of bituminous binders
Manual 26	Interim guidelines for primes and stone precoating fluids

* These manuals have been withdrawn and their contents have been incorporated in a manual entitled: *The use of modified binders in road construction* published as Technical Guideline 1 by the Asphalt Academy

Training Guides

TRIP	Bituminous pavement repairs:Technical Recommendations in Practice
HMA	Hot mix Asphalt Training Series
HSE	Health, Safety and Environmental Guidelines for bitumen and coal tar products
CEP	Councillor Empowerment Programme

Sabita Video Series

Testing of bituminous products

Bitumen

AV-1 Penetration test / Softening point (ring and ball)
AV-2 Spot test / Rolling thin film oven test
AV-3 Brookfield viscosity / Ductility

Bitumen Emulsion

AV-4 Saybold furol viscosity / Water content of emulsions
AV-5 Sedimentation value of emulsions / Residue on sieving
AV-6 Coagulation value with chippings / Coagulation value with Portland cement
AV-7 Binder content of slurry / Particle charge test

Hot Mix Asphalt

AV-8 Optimum binder content for asphalt
AV-9 Marshall test
AV-10 Binder content / Moisture content
AV-11 Static creep test / Immersion index
AV-12 Rice's density and binder absorption/Bulk relative density and voids

Bitumen Rubber

AV-13 Ball penetration and resilience test / Dynamic viscosity
AV-14 Compression recovery / Flow test
AV-15 Bulk density of crumb rubber / Grading and loose fibre test of crumb rubber

Blacktop Roads

AV-21 Blacktop roads for reconstruction and development
AV-22 Blacktop surfacing and repair (with Instructor Training Manual)
AV-23 Pavement surfacing and repair for blacktop roads

Hot Mix Asphalt

AV-25 Manufacture
AV-26 Paving
AV-27 Compaction

Health, Safety and Environmental Conservation

AV-28 BitSafe - The safe handling of bitumen (DVD)

DISCLAIMER

Considerable effort has been made to ensure the accuracy and reliability of the information contained in this publication. However, neither Sabita nor SAT nor a any of their members can accept any liability whatsoever for any loss, damage or injury resulting from the use of this information. The contents of this publication do not necessarily represent the views of all members of Sabita and SAT.

CONTENTS

Preface 7
Introduction 9

Section A: Priming of bases 10

1. Definition of a prime 10
2. Functions of a prime 10
3. Requirements of a prime 12
4. When do you need a prime? 12

Types of prime 13

1. Standard products 13
2. Proprietary products 13

Selection criteria 14

Construction considerations 15

1. Application rates 15
2. Preparation of the base 16
3. Spraying of the prime 16
4. Drying of the prime 16
5. Priming bases that contain soluble salts 17

Section B: Stone precoating fluids 18

1. Definition of a stone precoating fluid 18
2. Functions of a stone precoating fluid 18
3. Requirements of a stone precoating fluid 18
4. Factors dictating the need to precoat 19

Construction considerations 23

1. Procedures for precoating 23
2. Application rates 23
3. Alternative construction techniques to the use of precoating fluids 23

References 25

PREFACE

This interim guideline has its foundation in Sabita's publicly stated undertaking to implement global standards of worker safety, health and environmental conservation into southern Africa's road construction and bituminous products industry.

International best practice in recent years had established that the use of coal tar products in road construction introduces inherent carcinogenic hazards, while at the same time posing a serious contamination threat to the environment – including groundwater and its aquatic life.

Encouraging the discontinuation of coal tar usage in the bituminous products industry has become a cornerstone of Sabita's Health, Safety and Environmental Conservation (HSE) policy, and is part of a broader undertaking, driven by the organisation's Centre for Occupational Safety, Health and Environmental Conservation (COSHEC). Integral to this initiative are several current activity areas including the Bitumen Safety course (BitSafe), the Load Accreditation Programme (LAP), an Incident Reporting framework, Sabita Safety File and the safe disposal of bitumen waste.

By mid-2006 Sabita's awareness programme aimed at discouraging the use of coal tar products had yielded significant returns, and the South African National Roads Agency Limited (SANRAL), the Western Cape Provincial Administration, the Gauteng Department of Public Transport, Roads and Works, and the Roads Agency Limpopo have now banned the use of these products. Regrettably, very few of the 248 local government authorities have followed suit, despite ample proof that alternative, bitumen-based products, are readily available albeit at a marginal increase in cost.

It is hoped that the position paper outlining the carcinogenic dangers and environmental hazards inherent in the use of coal tar products, prepared by Sabita's former executive director Piet Myburgh and forwarded to COTO and IMIESA for broader exposure, will complement this guideline and entrench the global move towards safer, environmentally friendly alternatives to coal tar products.

This document focuses only on priming granular bases and precoating surfacing stone. It is intended to serve as an interim guideline to capture best practice until such time as documents such as the outdated TRH 1: *Prime coats and bituminous curing membranes*, which was published in 1986, are updated. Precoating of road stone is primarily done to improve the adhesion between the stone and binder. In the absence of a national specification, it is proposed that a product specification for bitumen-based precoating fluid be provided to replace its coal tar equivalent. Users of bitumen based primes and precoating fluids need to be aware that these products contain petroleum cutters and every effort must be taken to ensure that all workers are aware of the hazards and risks associated with these products. To this end all suppliers are required by law to provide Material Safety Data Sheets which inter alia state the hazards and dangers associated with their products.

Trevor Distin
Chief Executive Officer
Sabita

Acknowledgments

Sabita gratefully acknowledges the contributions made by the following people in the compilation of this document:

Dennis Rossmann	SANRAL
Kobus Louw	Colas South Africa
Johan Muller	Tosas
Trevor Distin	Sabita

Introduction

Although the use of coal tar for priming granular bases and precoating surfacing aggregates has been common practice in South Africa, global best practice now dictates the discontinuation of these binders for reasons of protecting worker health and environmental conservation.

The purpose of this guideline is to assist road authorities with the selection of proven alternative products and processes that have been used successfully. These recommendations are based on a series of workshops hosted by the Society of Asphalt Technology (SAT), during which the use of alternative products and processes was presented and discussed.

While coal tar has been used in a variety of road construction applications over many decades, this document focuses only on priming granular bases and precoating surfacing stone.

SECTION A: PRIMING OF BASES

1. Definition of a prime

A coat of suitable bituminous binder applied to a non-bituminous granular pavement layer as a preliminary treatment prior to the application of a bituminous base or surfacing.

Note:

A tack coat on the other hand is applied to a primed surface or bituminous surface to promote adhesion between the existing and a new asphalt pavement layer. Especially during the compaction of the latter, bitumen emulsions are almost invariably used for this purpose and are normally applied to a primed surface immediately before placing a hot mix asphalt layer.

2. Functions of a prime

The main function of a prime is to penetrate the layer to which it is applied while leaving a small residual amount of binder on the surface to:

- Assist in promoting adhesion between the base and the newly applied bituminous surfacing or layer;
- Inhibit the ingress of water from rain into the base while not hampering the migration of water in the vapour phase out of the base;
- Limit the absorption of binder from the next spray application into the base;
- Bind the finer particles on the upper zone of the base to accommodate light construction traffic for a short period until the new surfacing can be placed.

Note:

Primes are not suitable to be applied to cementitious stabilised materials as curing membranes to prevent the loss of moisture and carbonation from taking place in the layer. To this end normal bitumen emulsions have been found to perform the best.

Figure 1: Non-penetrating effect of an 'oil-in-water' bitumen emulsion

Figure 2: Penetrating effect of an inverted bitumen emulsion prime

3. Requirements of a prime

Low viscosity cutback bitumens or inverted bitumen emulsions generally meet the requirements of a prime. Ordinary oil-in-water type bitumen emulsions such as Stablemix and spray grades are not suitable as primes as they do not penetrate dense bases. The bitumen droplets coalesce on the surface to form a skin after the water has been absorbed or evaporated.

After a prime has been sprayed it penetrates the base layer and starts to cure through the loss of volatiles by evaporation and absorption. The prime should be formulated in such a way that once it is sprayed, it dries within a reasonable period to allow for the construction of the next layer to take place without pick-up by the tyres of construction plant. The viscosity of the prime should not be reduced to improve penetration through heating. In other words all primes should be able to penetrate at ambient temperature.

4. When do you not need to prime?

Priming of a base is not required when:

- Spraying MC 3000 cutback bitumen on G1 bases exhibiting a dense matrix of smooth stone surfaces;
- Surfacing a surface enriched with emulsion or foam treated base;
- Spraying a semi-priming binder for the construction of a graded seal such as an Otta seal.

If the prime is omitted the construction of the seal should proceed without delay, and the first spray application should be increased by $\pm$ 0.15 ℓ/m² to allow for some absorption of the binder into the base.

Types of prime

1. Standard products:

- MC 30 and MC 70 cutback bitumen grades complying with SANS 308;
- Inverted bitumen emulsion complying with SANS 1260.

Problems have been reported with MC 30 not penetrating dense crushed stone bases and natural gravel bases with a high clay content. The prime can take up to one week or longer to dry under these conditions. In order to improve the penetration of these primes into dense bases, the viscosity of MC 30 can be lowered by adding 10 -15% additional illuminating paraffin, and the prime application rate can also be lowered. The addition of cutter should take place in a controlled environment at the binder manufacturers blending plant, both for safety reasons and to ensure that a homogenous mix is achieved. In the case of an inverted emulsion, the cutter and/or water content can be increased. In the latter case the maximum water content limit of 20% of the total volume should not be exceeded.

2. Proprietary products:

If primes are to be used that do not comply with SANS specifications, the supplier should provide specifications against which his product can be tested for compliance. These specifications should meet the following SANS requirements for the distillation test:

- Minimum residue from distillation of 50% of the total volume; and
- Penetration at 25^0 C of the residue should be between 90 and 180 dmm.

Selection criteria

The main factors that influence the selection of the type of prime to be used are the type and the absorptive properties of the base and the prevailing weather conditions.

Table 1: Selection matrix

Type of base	MC 30	MC 70	Inv. emul.
Graded natural gravel e.g. weathered G2+	1	2	1
Crushed stone e.g. unweathered G1/G2	2*	-	1
Lime or cement stabilised	1	2	1
Bituminous stabilised	-	-	2
Calcrete	1	2	1
Containing soluble salts	-	2	-
Absorptive properties of base material			
High moisture content	-	-	-
Low moisture content	1	2	1
High degree of densification	-	-	2
Low degree of densification	1	2	1
High porosity	2	1	2
Low porosity	-	-	2
Plasticity index >7	-	-	-
Plastic Index <7	1	1	1
Open graded	2	1	2
Climatic conditions			
High Humidity	1	2	-
Wet	-	-	2
Road temperature >25^{0}C	1	1	2
Road temperature <25^{0}C	2	-	1

Key: 1 = primary recommendation; 2 = secondary recommendation; - = not suitable
** Lower viscosity by cutting back with illuminating paraffin.*

1. Application rates

Ideally, the selected application rate should be such that the surface will absorb the applied prime and deposit a thin, quick drying film on the surface. The application rates will vary according to the type of base and its absorptive properties, and these rates should also be adjusted to take into consideration the net residual binder of each product. (See Table 2)

As a rule of thumb the application rates selected should render a net residual binder of 0.35 kg/m^2 which equates to a spray rate of 0.7 ℓ/m^2 for MC 30, 0.6 ℓ/m^2 for MC 70 and 0.95 ℓ/m^2 for inverted bitumen emulsions. The following adjustments to the net residual binder are recommended:

- If the base is coarse or open increase the application rate by 15%;
- If the base is fine and dense decrease the application rate by 15%.

However, to ensure that the correct application rate is selected, it is recommended that a 'paint' test be done on the prepared base. This is best achieved by marking out areas of one square metre and applying the candidate prime with a brush at different application rates to determine the ideal application rate.

Table 2: Typical properties of primes for determining application rates

Product	Density @ 20^{0}C (kg/ℓ)	Spray temperature (^{0}C)	Density @ spray temperature (kg/ℓ)	Net residual binder content (%m/m)
MC 30	0.93	55	0.91	55
MC 70	0.95	70	0.92	64
Inv. Emul.	0.92	60	0.90	41

2. Preparation of the base

Priming should be carried out only after the base has dried out sufficiently to obviate the entrapment of excess moisture, which may lead to an undesirable build up of moisture under the newly placed surfacing and possibly lead to premature distress. The base should be broomed clean of all loose material until the larger gravel and stone aggregates are exposed. The surface of the base should be moistened by a light sprinkling of water prior to priming to reduce the surface tension and to avoid the formation of 'fish eyes' in the primed surface. Care should be taken not to apply excess water and thus saturate the layer as voids filled with water cannot be filled with prime.

3. Spraying of the prime

Spraying of prime should not be done if the expected minimum air temperature for the ensuing seven days is below 10^0C, or when rain is imminent. Spraying should only be done when the surface temperature of the base is 10^0C and rising. The actual spray rate should not deviate by more than 0.06 ℓ/m^2 of the target rate.

Care should be taken when heating the prime prior to application as the spray temperature could be above the flash point of the cutter. In the case of both MC grades and inverted emulsions, illuminating paraffin is used as the cutter, and has a flash point of $\pm$ 40^0C. The heating of prime should only be carried out as soon as is practicable before spraying so as to prevent loss of the volatile fractions. The reason for heating the prime is to ensure that it flares properly when discharged through the nozzles on the spray bar of the distributor. Cutback and inverted emulsion primes are pumpable at ambient temperature and thus do not need to be heated during loading, transport, offloading and storage.

4. Drying of the prime

For a given prime the drying time will depend on the porosity of the base and the prrevailing weather conditions. The prime should be allowed to dry before opening to traffic or proceeding with construction of the next layer. Any pooling of prime on the surface should be blinded with crusher dust and removed.

5. Priming bases that contain soluble salts

The adhesion of bituminous materials to pavement layers containing soluble salts can be a problem. Experience has shown that the base should be primed immediately after completion and be surfaced within 24 hours with hot bitumen or modified bitumen. The base should not be dampened before priming as this can cause the dissolved salts to migrate to the surface and re-crystallise during curing of the prime.

SECTION B: STONE PRECOATING FLUIDS

The process of precoating surfacing aggregates has become common practice and is considered a cost effective measure to minimise the risk of poor adhesion and the possibility of early chip loss and stripping in seals. Precoating should not be replaced by adding cutter to the binder, nor should it be seen as a substitute for proper workmanship or accepting dirty aggregates.

1. Definition of a precoating fluid:

A low viscosity bituminous based binder containing petroleum cutters and a chemical adhesion agent which is used to precoat surfacing aggregates to improve the adhesion of the aggregate to the bituminous binder.

2. Functions of a precoating fluid:

The precoating fluid assists in reducing the surface tension between the cold surfacing aggregate and the freshly sprayed hot viscous binder during construction of the seal, thereby aiding the initial bond between the aggregate and the binder as the latter cools down.

3. Requirements of a precoating fluid:

The precoating fluid should have a low enough viscosity to coat damp or dusty surfacing aggregates, and be able to dry in a reasonable period to deposit a non-tacky residual film on the surface of the aggregate. The fluid should not cause a deposit of binder to be left on the site that would be harmful to the environment.

Note:

The use of bitumen emulsion or diesel has been found in most cases to be unsuitable for use as precoating fluids.

The addition of at least 0,5% of a chemical adhesion agent to the total mass of the precoating fluid is essential to:

- enhance the adhesion of aggregate to the binder in the presence of moisture; and
- improve the adhesion of aggregates that have a poor affinity for bitumen for e.g. quartzitic or siliceous aggregates.

In the absence of a national standard specification the following recommendation is made based on the successful use of proprietary bitumen-based precoating fluids.

Table 3: Specification for a bituminous-based precoating fluid

Property	Requirement	Test method
Density @ 25^{0}C, kg/ℓ	0.85 – 0.95	
Saybolt Furol viscosity @ 50^{0}C, SFs	10 - 30	ASTM D 244
Distillation to 360^{0}C, v/v% To 190^{0}C 225^{0}C 260^{0}C 316^{0}C	 0 – 15 10 – 55 45 – 75 70 – 95	ASTM D 402
Residue from distillation to 360^{0}C, v/v%	45 – 60	ASTM D 402
Dynamic viscosity @ 25^{0}C of residue distilled to 360^{0}C (cps)	300 - 500	ASTM D4402
Stripping number	Report[1]	Riedel & Weber

1. This test should be conducted to assess the effect of precoated aggregate versus unprecoated aggregate on the adhesion to the project binder.

4. Factors dictating the need to precoat

The main factors influencing the need to precoat surfacing aggregates depend on the type of aggregate, binder and seal to be used. The selection of certain types of seals and the concomitant use of bitumen emulsions and clean washed aggregates can dispense with the need to precoat aggregates. Table 4 provides a guideline on when to precoat.

Figure 3: Influence of an adhesion agent on precoated aggregate after the stripping test

Figure 4: Precoated aggregate without adhesion agent after the stripping test

Table 4: Criteria for precoating surfacing aggregates

Key: 1 = *essential*; 2 = *optional*; - = *not required*

Seal type	Recommendation
Single seal	1*
Multiple seal	2**
Cape seal	2**
Graded seal	-***
Binder type	
Penetration	1
Cutback	2
Emulsion	-
Hot polymer	1
Bitumen rubber	1
Type of aggregates	
Hydrophilic	1
Dust content >2%	1
Porous	1
Quartzitic	1
Granite	1

* *Not required if emulsion used as a tack spray.*
** *Not required if diluted emulsion used as a cover spray.*
*** *Not required if the binder is cutback or an adhesion agent is added to the binder.*

To a lesser extent the following considerations may also influence the need to precoat the surfacing stone:

1. Black surface

The need to precoat is sometimes deemed desirable in order to create a dark surface in order to contrast the line markings especially when light coloured aggregates are used.

2. Low road and ambient temperatures

When lower than normal working temperatures are expected to be encountered the need to precoat is recommended in order to reduce the risk of stripping in the early life of the seal as the precoating fluid will promote adhesion between the binder and aggregate. The use of a precoating fluid is preferred to cutting back the binder when cooler weather is expected as the latter can lead to bleeding of the seal with the onset of warmer weather and under heavy traffic.

3. Traffic

If the design traffic volume and/or vehicle speed is high then the risk of stripping can be reduced by precoating as the precoating fluid will promote adhesion between the binder and aggregate. The same applies to high stress areas where the radii of curvature are tight and the incidence of turning actions of vehicles is high.

1. Procedures for precoating

Aggregates can either be precoated on site using a front end loader prior to surfacing, or they can be coated in a drum plant which is usually situated at a quarry. The stone to be precoated should be slightly damp but not wet. Once the precoating fluid is added at ambient temperature, it should be thoroughly mixed to ensure a uniform coating. The stockpile may have to be protected from rain to prevent wash-off. The precoated aggregates should be allowed to dry for at least four days before use. The precoated aggregates have an unlimited stockpile life as long as they are protected from dust and rain.

2. Application rates

The quantity of precoating fluid should be sufficient to coat each aggregate particle uniformly. Experience to date indicates that while the application rate for bituminous based precoating fluids is generally slightly higher than that used for coal tar based products, the quantity will depend mainly on both the cleanliness and porosity of the aggregates. Dusty aggregates will require a heavier application than clean dry aggregates of the same type and size. Similarly the rate for porous aggregates will be higher than for dense smooth aggregates.

Table 5: Typical application rates for bitumen based precoating fluids

Stone size (mm)	6.7	9.5	13.2	19
Litre/m^3	13 - 18	12 - 17	11 - 16	10 - 15

The recommended method for determining the application rate is to precoat small samples of the job aggregates with varying quantities of precoating fluid, and then make a visual assessment as to the quantity which renders the ideal coating.

3. Alternative construction techniques to the use of precoating fluids

The need to precoat the surfacing aggregate can be dispensed with by splitting the application of the binder spray in the construction of the seal. The tack and penetration sprays can be reduced to allow for the use of a diluted bitumen emulsion as a cover spray over the completed stone seal. This is applicable to

both multiple and Cape seals where the lower layer of aggregate will be locked in by the second application of smaller aggregates or slurry respectively.

In the case of graded seals or hot polymer modified binders, an adhesion agent can be preblended into the binder prior to spraying to improve adhesion.

References

1. Draft TRH 1 - 1986: *Prime coats and bituminous curing membranes*
2. SANS 308 - 1973: *Standard Specification for cutback bitumen*
3. SANS 1260 – 1979: *Standard Specification for invert bitumen emulsion*
4. COLTO – 1998: *Standard specifications for road and bridge works for state road authorities*
5. www.colas.co.za - *Typical binder contents, spray application temperatures and Product Data Sheets*
6. Tosas - *Product Specifications for Bitukote Data Sheet #B4*
7. AAPA Pavement work tips No 23 - Sept 2000: *Sprayed Sealing – Aggregate Precoating*

Sabita members

Ordinary Members

AJ Broom Road Products (Pty) Ltd
Akasia Road Surfacing (Pty) Ltd
Bitumen Construction Services (Pvt) Ltd
Bitumen Supplies & Services (Pty) Ltd
Black Top Holdings (Pty) Ltd
BP SA (Pty) Ltd
Brisk Asphalt Surfacing (Pty) Ltd
Chevron South Africa (Pty) Ltd
Colas SA (Pty) Ltd
Engen Petroleum Ltd
Javseal (Pty) Ltd
Milling Techniks (Pty) Ltd
More Asphalt
Much Asphalt (Pty) Ltd
Murray & Roberts Construction Ltd
National Asphalt (Pty) Ltd
Nikamandla Construction (Pty) Ltd
Nyanga Roads (Pty) Ltd
Phambili Road Surfacing (Pty) Ltd
Polokwane Surfacing (Pty) Ltd
Rand Roads (a division of Grinaker-LTA Ltd)
Roadsmart (Pty) Ltd
Sasol Oil (Pty) Ltd
Shell SA Marketing (Pty) Ltd
Spray Pave (Pty) Ltd
Tarfix (Pty) Ltd
Tosas (Pty) Ltd
Total SA (Pty) Ltd
Van Wyk Tarmac cc
Zebra Bituminous Surfacing cc

Associate Members

Africon Engineering International (Pty) Ltd
Arcus Gibb (Pty) Ltd
Asch Professional Services (Pty) Ltd
BCP Engineers (Pty) Ltd
BKS (Pty) Ltd
Cape Peninsula University of Technology
Dick King Lab Supplies (Pty) Ltd
Entech Consultants (Pty) Ltd
GMH/CPP Consulting Engineers (Pty) Ltd
Goba (Pty) Ltd
Holcim SA (Pty) Ltd
Iliso Consulting (Pty) Ltd
Jeffares and Green (Pty) Ltd
Kaymac (Pty) Ltd t/a Kaytech
Lafarge South Africa Ltd
Lidwala Consulting Engineers (Pty) Ltd
Ninham Shand (Pty) Ltd
PD Naidoo and Associates (Pty) Ltd
Rankin Engineering Consultants
Sasol Technology Fuels Research
Sasol Wax (a division of SCI)
Siyenza Engineers cc
Specialised Road Technologies (Pty) Ltd
Stewart Scott International (Pty) Ltd
Tshepega Engineering (Pty) Ltd
Unitrans Fuel and Chemical (Pty) Ltd
Vaal University of Technology
Vela VKE Consulting Engineers (Pty) Ltd
WSP SA Civil and Structural Engineers (Pty) Ltd

Affiliate Members

Beosumbar and Associates cc
DMV Harrismith (Pty) Ltd
Salphalt (Pty) Ltd
The Synthetic Latex Co (Pty) Ltd
TPA Consulting cc

NOTES

NOTES

NOTES

NOTES

NOTES