TECHNICAL RECOMMENDATIONS
FOR HIGHWAYS

Draft TRH 1 PRIME COATS AND BITUMINOUS CURING MEMBRANES

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PREFACE

TECHNICAL RECOMMENDATIONS FOR HIGHWAYS (TRH) are written for the practising engineer and describe current, recommended practice in selected aspects of highway engineering. They are based on South African experience and the results of research and have the full support and approval of the Committee of State Road Authorities (CSRA).

To confirm their validity in practice, TRHs are circulated in draft form for a period of trial before being submitted to the CSRA for approval. This document, Draft TRH1, will therefore be in use for a limited period during which you are welcome to send suggestions for improvement to the Chief Director, National Institute for Transport and Road Research, P O Box 395, Pretoria, 0001. Eventually, a revised document, approved by the CSRA, will be issued as a full TRH in both languages.

NOTE

This document is published by the National Institute for Transport and Road Research for and with the approval of the Highway Materials Committee of the Committee of State Road Authorities.

SYNOPSIS

The functions of and requirements for prime coats and bituminous curing membranes for granular pavement layers are described. Recommendations are made on the type, grade and rate of application of binders to be used as prime coats for crushed stone bases and natural gravel bases, as well as on the type, grade and rate of application of binders to be used as curing membranes for cemented pavement layers. Suitable construction techniques are detailed.

SINOPSIS

Die funksies van en vereistes vir drenklae en bitumineuse nabehandelingsmembrane vir korrelplaveisellae op paaie word beskryf. Aanbevelings word gemaak oor die tipe, graad en aanwendingskoers van bindmiddels wat as drenklae vir kroonlae van gebreekte klip en natuurlike gruis gebruik word asook oor die tipe, graad en aanwendingskoers van bindmiddels wat as nabehandelingsmembrane vir gesementeerde plaveisellae gebruik word. Geskikte konstruksietegnieke word in detail aangegee.

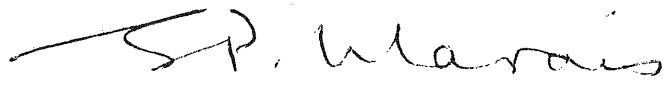
KEYWORDS

Curing membranes, prime coats, road surfacings

FOREWORD

In 1970 TRH1 "Guide on prime coats, tack coats and temporary surfacings for the protection of bases", was published. Since that time developments in binder technology have introduced new binders and further experience in road technology has caused the original TRH1 to become outdated.

This document therefore is an updated version of TRH1 (1970) and incorporates current practice in South Africa at this time. The section dealing with tack coats used for asphalt surfacings has been taken out of this document and now appears in Draft TRH8, "The design and use of hot-mix asphalt in pavements". A section dealing with bituminous curing membranes for use with cemented pavement layers has been added to this document and the section dealing with temporary surfacings has been deleted.



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DEFINITIONS

Bituminous binder	A material derived from petroleum, coal tar or gasification tar.
Bituminous curing membrane	A coat of suitable bituminous binder applied to a newly constructed pavement layer to which a cementitious stabilizing agent has been added, to promote the reaction of the stabilizing agent in order to improve the strength properties of the layer and prevent carbonation and salt migration from taking place.
Cemented pavement layer	A pavement layer to which a cementitious stabilizing agent, which imparts a cementing action, has been added (e.g. ordinary Portland cement (OPC), Portland blastfurnace cement (PBFC), a mixture of OPC and milled granulated blastfurnace slag, a mixture of lime and milled granulated blastfurnace slag, a mixture of lime and fly ash (FA), or lime).
Prime coat	A coat of suitable bituminous binder applied to a non-bituminous granular pavement layer as a preliminary treatment before the application of a bituminous base or surfacing, to promote adhesion between this layer and the bituminous base or surfacing, and to assist in sealing the voids and in binding the aggregate near the surface of the layer.

1 INTRODUCTION

Road engineers have sometimes asked whether prime coats serve a useful purpose in road construction and whether they justify the extra cost and time involved in their application. This is because roads constructed without a prime coat have given a satisfactory performance. On the other hand, failures have occurred owing to the omission of the prime coat. The application of a prime coat reduces the risk of failure resulting from imperfections that may occur in the base, which can be very costly to rectify. The use of bituminous curing membranes for cemented pavement layers is recognized as being a cost-effective means of ensuring the proper curing of such layers and also of preventing the carbonation of the layers and salt migration in the layers.

This document discusses some of the principles involved and makes general recommendations that can be applied to specific cases in practice.

2 PRIME COATS

2.1 FUNCTIONS OF A PRIME COAT

(a) It assists in promoting and maintaining adhesion between a granular base and a subsequently applied bituminous surfacing (which may be a seal coat or an asphalt surfacing) by precoating the surface of the base and penetrating the voids near the surface*.

(b) It helps to seal the surface pores in the base, thus reducing the migration of moisture and to a great extent preventing the absorption of the first spray of surfacing binder.

(c) It helps to strengthen the base near its surface by binding the finer particles of aggregate.

(d) It provides the base with a temporary protection against the detrimental effects of weather and light traffic until the surfacing can be constructed.

2.2 REQUIREMENTS FOR A PRIME

A prime must be capable of wetting and penetrating the dust film covering a granular base, and coating the aggregate particles with a strongly adhering film of bituminous binder. It must also be capable of penetrating the surface of the base to a limited extent. (The depth of penetration is dependent on the density of the base; the denser the base, the lower the penetration.) These requirements are met if low viscosity cutback bitumens, invert bitumen emulsions or tars which are solutions of bitumen or coal tar pitch in light and heavy oils are used as primes. Bituminous materials of a higher viscosity, such as the type used in surfacing construction, are not suitable for coating a surface when dust is present. They also penetrate most types of base to a limited extent only. Ordinary bitumen emulsions are not suitable either, as they will not normally penetrate dense-graded bases, since the minute bitumen droplets coalesce rapidly to form a film of bitumen on the surface.

After a prime is sprayed, it cures because of the loss of water and/or light oils by evaporation and, particularly in the case of tars, there is selective absorption of the heavier oils by the base. The prime must be so constituted that once it has been sprayed, any light oils present are able to evaporate rapidly, thus enabling the prime to dry within a reasonable time. The drying of a prime depends on a number of factors such as type of prime, rate of application, base porosity, weather conditions, and so on, and may take from a few days to several weeks. A prime is

* Where a bitumen or tar hot-mix base is laid over a granular subbase, the subbase should be primed.

considered to be "dry" when it will permit the passing of light traffic without undue pick-up of primed material by the tyres.

If puddles of wet prime are still evident after the prime has been left to dry for as long as possible, such puddles should then be covered with a blinding layer of small stone (6,7 mm nominal single size), but not sand or crusher dust*. Bleeding may occur if a surfacing is placed over a wet prime. When access to a road has to be provided during construction, as is normally the case with city streets, the freshly primed surface should be covered with a blinding layer of small stone (6,7 mm nominal single size) as soon as it is necessary to open the road to traffic.

The use of quick-drying prime should be limited to special circumstances, such as when the road is to be surfaced as soon as possible, when cold wet conditions occur or when the base is very dense.

2.3 TYPES OF PRIME

(a) Cutback bitumens

MC-30, MC-70 } manufactured from penetration grade bitumen (specified in SABS 308[1])

(b) Tar primes prepared from coke-oven crudes
Quick-drying (specified in Amendment No 1 to SABS 748[2]) and
RTH 3/12P (specified in SABS 748[2])

(c) Tar prime prepared from Lurgi gasification crude
RTL 3/12P (specified in SABS 749[3])

(d) Invert bitumen emulsion prime (no SABS specification; refer to supplier)

(e) Gasworks primes (normally conform to SABS 749[3]; refer to supplier).

2.4 SELECTION OF TYPE AND GRADE OF PRIME AND RATE OF APPLICATION

2.4.1 General considerations

The main factors that govern the selection of the type and grade of prime and its rate of application are the type of base on which it is to be used and the absorptive characteristics of the base. Weather conditions must also be taken into account, since some types of prime are slow drying in winter.

In the case of seals a prime coat should normally be applied to natural gravel bases (untreated with a cementitious binder) and also in every case where the construction of the surfacing has to be delayed after the

* Other methods have also been found to be successful, such as brooming or watering the primed surface followed by pneumatic-tyred rolling to wash off excess prime.

TABLE 1 : *Types of prime and application temperatures**

		Cutback bitumen		Tar prime prepared from coke-oven crude		Tar prime prepared from Lurgi gasification crude	Invert bitumen emulsion prime
		MC-30	MC-70	Quick-drying	RTH3/12P	RTL3/12P	
Kinematic viscosity at 60 °C ($\times 10^{-6}$ m^2/s)		30 to 60	70 to 140	—	—	—	
Minimum temperatures for pumping**		10 °C	25 °C	14 °C	29 °C	29 °C	†
Maximum storage temperatures	15 hrs	70 °C	90 °C	60 °C	60 °C	60 °C	
	24 hrs	50 °C	70 °C	40 °C	40 °C	40 °C	
Spraying temperature range**		45 °C to 60 °C	60 °C to 80 °C	35 °C to 50 °C	54 °C to 68 °C	54 °C to 68 °C	

* Where possible application temperatures have been given as a guide. The range applicable to a particular product should be obtained from the manufacturer.

** Based on a viscosity of 750 x 10^{-6} m^2/s for pumping and on a viscosity range of 40-100 x 10^{-6} m^2/s for spraying.

† Technical information on this prime to be obtained from the supplier.

completion of the base. On good quality crushed-stone bases which can be swept to a clean, strong, stony surface free of dust priming is preferred, but it may not always be essential to prime the base in order to promote adhesion of the surfacing binder. However, in an area with a predominantly wet climate, it is a safeguard to prime this type of base to maintain adhesion.

It is essential to prime a base which is to receive an asphalt surfacing, except in the case of cemented bases where a curing membrane has been applied. In some cases, however, it may also be necessary to apply a tack coat[4] on the primed surface immediately before the laying of an asphalt surfacing because the adhesion of the asphalt to the base is not obtained as readily as with a seal.

Ideally the viscosity and rate of application should be chosen so that the surface will absorb all the applied prime and leave only a thin layer on the surface which dries quickly.

The types of prime available in South Africa and their application temperatures are given in Table 1. Experimental work on the rate of drying of different types of prime has shown that this is not determined solely by the viscosity. For example, under certain conditions tar prime prepared from coke-oven crude dries more slowly than the higher viscosity tar prime prepared from Lurgi gasification crude. Therefore, when considering what type of prime to use in a given case, one must take into account not only its viscosity but also its constitution.

2.4.2 **Normal priming on bases**

2.4.2.1 *Crushed-stone bases*

A typical crushed-stone base has a tightly bonded surface. A prime coat may be omitted for this type of base under certain conditions (see 2.4.1) especially where double seals are constructed.

If the prime coat is to be omitted the construction of the surfacing seal should proceed without delay; the first spray of surfacing binder should be increased by approximately 0,15 ℓ/m^2 more than is used for a primed base, to allow for the absorption of binder by the base.

If, however, a prime coat is used, a prime of relatively low viscosity sprayed at a low rate of application should be applied to avoid an excess of unabsorbed prime on the surface.

All types of prime have been found to be suitable at spray rates of between 0,65 and 0,75 ℓ/m^2.

The slow rate of drying of tar primes in winter or in very humid conditions may be a problem, which can be overcome by using the quick-drying tar prime.

2.4.2.2 *Graded natural gravel bases*

A layer of dust that can only be partly removed by brooming is usually present on the surface of these bases. They usually have higher absorptive properties and a lower dry density than the crushed-stone bases described above. The same types of prime are used as for crushed-stone bases. Suitable spray rates vary between 0,65 and 1,00 ℓ/m^2 depending on the porosity of the base and the viscosity of the prime.

2.5 A GUIDE TO THE PRIMING PROCESS

2.5.1 When to prime

Priming should generally be carried out as soon as possible after completion of the base. However, if the base is very moist, priming must be delayed until the top 10 to 25 mm have dried out somewhat (to about 50 per cent of optimum moisture content).

2.5.2 Preparation of the base

The surface of the base should be well broomed with a mechanical broom until all loose soil binder and foreign materials have been removed and the stone or hard particles of gravel are exposed. Moistening the surface by light sprinkling immediately before priming, particularly in the case of gravel bases, reduces the surface tension and helps the prime to cover the surface uniformly and adhere to the base. Care should be taken, however, not to apply an excess of water, since voids that are filled with water cannot be filled with prime.

For some types of base and under certain weather conditions it has been found that satisfactory priming can be carried out without first wetting the base. It is therefore advisable to test a small section to determine which method is more effective.

2.5.3 Weather conditions

Priming should not be carried out when the road surface temperature is lower than 10 °C, or when the spraying performance of the distributor might be affected by wind, or when rain is threatening. Should rain fall soon after priming, the drying of the prime will be delayed, but its performance will most probably not be affected unless it is washed off by the rain.

2.5.4 Type of prime and rate of application

The type of prime may be selected according to the purpose for which it is required, as recommended in 2.4. The initial rate of application should preferably be near the lower end of the recommended range. If neces-

sary, the rate of application can be increased as the job proceeds. In this way the optimum performance of the prime consistent with a reasonable drying time will be obtained (see 2.2).

2.5.5 Spraying the prime

The prime should be sprayed with a binder distributor calibrated to give an accurate rate of application and tested for satisfactory transverse distribution according to TMH2[5]. A guide to pumping, storage and spraying temperatures for the different types of prime available is given in Table 1. To prevent the undue evaporation of volatiles which will result in the hardening of the material, the prime should not be heated to more than 10 °C above the highest temperature of the range given. Where the prime has to be heated from the cold state it should be heated slowly even when it is in a viscous condition, to avoid overheating that part of the prime that is close to the source of heat. The prime should be circulated, through a pump or by means of some stirring mechanism, while it is being heated. It may be advisable to turn off the heaters for short periods.

2.5.6 Drying of the prime

Traffic barriers should be erected to keep traffic off the road as the primed surface must be left undisturbed until the prime has dried or at least until it is no longer picked up on the tyres of vehicles. Where an alternative route cannot be provided and it is necessary to allow traffic to use the road before the prime has dried, the primed surface should be covered with a blinding layer of small stone (6,7 mm nominal single size). A quick-drying prime is preferable to a blinding layer; however, under certain conditions, even quick-drying prime may require a blinding layer. Before proceeding with the construction, care must be taken to remove any loose stones from the surface by brooming.

3 BITUMINOUS CURING MEMBRANES

3.1 FUNCTIONS OF A CURING MEMBRANE

(a) It prevents the loss of moisture in cementitious stabilized materials, which allows the hydration process to proceed.

(b) It prevents any detrimental carbonation or salt migration from taking place in the layer.

(c) It provides a waterproof membrane which protects the base from damage which may be caused by surface water.

Thermal stresses induced in the surface of the layer as a result of the black membrane may lead to the development of cracks.

3.2 USE OF BITUMINOUS CURING MEMBRANES WITH CEMENTED PAVEMENT LAYERS

Bituminous curing membranes are used only on cemented pavement layers. It should be noted that the excessive penetration of any bituminous material into the cemented pavement layer before it has been properly cured, may be detrimental.

3.3 BINDERS USED AND RATES OF APPLICATION

The most effective bituminous curing membranes have been found to be bitumen emulsion (anionic (SABS 309[6]) and cationic (SABS 548[7])) (spray grade). Suitable spray rates vary between 0,65 and 1,00 ℓ/m^2 depending on the coarseness of the base surface.

Alternatively, a bitumen based prime may be used. In this case the surfacing or hot-mix base should be applied as soon as the prime has dried sufficiently. A tar prime should not be applied to a cemented pavement layer until it is at least ten days old, during which period it should have been carefully cured by some other means.

3.4 CONSTRUCTION OF BITUMINOUS CURING MEMBRANES

The bituminous curing membrane must be applied as soon as possible after the completion of the compaction process of the pavement layer. It should not be applied to a dry powdery surface but should be applied while the surface is damp. Moisten the surface by light sprinkling immediately before applying the curing membrane. The recommended spraying temperatures are given in Table 2.

If a sudden increase in temperature occurs, vapour pressure may build up under the bituminous curing membrane, causing blisters to form, especially if the membrane was applied when the base was too wet. In

general traffic should not be allowed on a curing membrane, because the membrane will be picked up by the tyres of the vehicles. The passage of traffic will also be detrimental to the cementing process of the cemented pavement layer. However, where trafficking is unavoidable (e.g. at an intersection), a blinding layer of natural sand or crusher sand should be applied over the affected area. The placing of a blinding layer should be postponed as long as possible.

TABLE 2 : *Recommended spraying temperatures for bitumen emulsions*

Bituminous content	Spraying temperature °C
60 per cent (anionic and cationic)	45-60
65 per cent (cationic)	55-65
70 per cent (cationic)	60-70

4 SPECIAL CASES

4.1 OPENING THE PRIMED BASE TO TRAFFIC BEFORE CONSTRUCTING THE SURFACING

When it is necessary to delay the construction of the surfacing for several weeks or longer, and particularly when it is necessary to open the primed base to traffic, a type of prime must be used that is sufficiently durable to resist weathering and has good binding properties that will help prevent disintegration of the base by the traffic.

There are certain advantages to opening a primed base to controlled traffic, such as -

- unsound areas of the base are shown up;
- proper drying of the prime is ensured.

During the trafficking the primed base should be inspected regularly to avoid damage. Speed control notices should be posted to limit the destructive effect of traffic and any damaged areas should be repaired before the surfacing is constructed.

In the case of crushed-stone bases the type of prime used is not critical and all the types of prime mentioned in 2.3 are suitable for normal application on this type of base. However, the rate of application could be increased to as much as 0,85 ℓ/m^2, depending on the length of time the base is likely to be open to traffic.

On natural gravel bases the disintegrating effect of traffic is influenced by the type of prime used, its viscosity and its rate of application. The following types of prime are suitable for natural gravel bases:

MC-30 (maximum 1 week traffic),
MC-70 (maximum 2 to 3 weeks traffic),
cutback bitumen, RTH 3/12P or RTL 3/12P tar prime, and invert bitumen emulsion prime.

For these, too, the rate of application may be increased depending on the length of time the base is likely to be open to traffic and the porosity of the base.

4.2 BASE MATERIALS CONTAINING SOLUBLE SALTS

The adhesion of bituminous materials to pavement layers may be adversely affected by the presence of soluble salts with an electrical conductivity greater than 0,15 S/m, as measured by the conductivity test (Method A21T of TMH1[8]) in this particular layer at the time of application. It has been found that the dissolved salt is transported by moisture moving through the pavement and is deposited where the migration ceases, i.e. near the surface of the road. In some cases this problem ar-

ises soon after a prime coat has dried, manifesting itself in the form of patches of eruptions or blisters on the primed surface which leave the surface loose and powdery. This is due to the loss of adhesion caused by the deposition of salts in localized areas immediately beneath the primed surface. A higher viscosity prime deals with this problem better than one of lower viscosity. A higher rate of application of the prime is also often beneficial. A bitumen emulsion curing membrane also gives more satisfactory results than a prime coat. If a sudden increase in temperature occurs, vapour pressure may build up under the bituminous layer causing blisters to form.

The surfacing should be constructed as soon as possible after the prime or curing membrane has dried. The surfacing should be of low permeability and, in general, double seals and Cape seals have given better performance than asphalt. With high salt contents the prime may disintegrate before it can be surfaced. In such cases it may be advisable to omit the prime and to apply the surfacing as soon as possible.

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