SARF COURSE

PRACTICAL ROAD PAVEMENT ENGINEERING

8. DESIGN OF SURFACE TREATMENTS

DESIGN OF SURFACE TREATMENTS

1. TYPES OF SURFACE TREATMENT

1.1 Prime

A prime is a light spray of bitumen applied to an unsurfaced basecourse, and it prepares the gravel or crushed stone for the application of the surface treatment, and provides adhesion between the two.

A prime is recommended for all roads, which are to have a bitumen surface, unless good quality control and maintenance capabilities exist. It protects the pavement materials against rain during construction, and, depending on the type of prime, assists in reducing carbonation of bound materials. For roads with thin bituminous surfacings (single seal and sand seal), intermittent nozzle blockages, can cause areas of underspray, and the prime will compensate for this and make a significant improvement in the performance of the surfacing.

The adhesion of the surfacing to the base on weak and fine grained base materials can also be a problem. Many of the finer grained materials have layers of loose material beneath the surfacing along which the surfacing can slide and move. A non-viscous deep-penetrating prime (cutback bitumen, tar, quick drying tar) can be used on finer basecourse materials to strengthen the upper portion of the base.

The materials used for a prime include cutback bitumen or bitumen emulsion. Because of its carcinogenic effect tar is no longer used in SA road construction. It is usually applied to give a residual binder of 0,4-0,6 l/m^2 (which is 0,65-1,0 l/ m^2 for MC-30 or 60% emulsion). The prime should be completely absorbed within 24hours. For a tightly bound surface, the application rate should be at the lower end of the range.

1.2 Enrichment Spray

This is a simple and economical method of extending the normal reseal cycle. Stable grade (SS) emulsion is diluted with water and applied to a dry and porous surface that has started to lose aggregate owing to age or to shortage of previous binder. The treatment is sometime also called “mist spray”, or “fog spray” or “dilute emulsion application”. However, enrichment aptly describes its function of giving new life to an old surface.

The dilute emulsion flows into the old surface, to leave the major proportion of the bitumen in the voids where it is required, and the minimum film on the traffic bearing stone nodules. No cover material is necessary. To protect vehicles from splash, it is preferable, but not essential, to keep traffic off the freshly sprayed surface. A fogspray is also used as a cover coat after construction of a single or double seal to ensure that the chips are all retained. When a fog spray is applied, chips need not be precoated.

Stable spray grade emulsion (SS60) diluted 1:1 volume with water (this is done in the distributor and is sprayed at 0,4 to 1,4 l/ m^2. This will leave 0,12 to 0,42 l/ m^2 residual bitumen on breaking.

DESIGN OF SURFACE TREATMENTS

1.3 Light Surface Treatment

The light surface treatments are:

Dust Palliative Bituminous dust palliatives are the lowest cost of bitumen surfacings. They typically consist of a cutback bitumen applied to the surface of a base course with a sand cover, which acts as both a prime and a surfacing. They can be effective as a short term surfacing. However, the maintenance costs rise steeply with time, and they require timely retreatment or resealing to be cost-effective. On temporary works such as deviations, or as a form of stage construction, these materials may, however, have significant benefits.

Single seal A single spray of bitumen (penetration grade, cutback or emulsion), with a single layer of stone. This is the most common surfacing but can give problems due to nozzle blockages and other defects during construction (remember to prime!), and is only acceptable if good maintenance and construction is expected.

Sand seal A single spray of bitumen (penetration grade, cutback or emulsion), with a single layer of sand. The main difference from a dust palliative is that the application rate of sand is controlled most closely here. Fair performance if thick (i.e. several layers), and fair to poor performance if thin (i.e. one layer). It is more of a temporary surfacing and must be resurfaced (often with a second sand seal within a year.

1.4 Heavy Surface Treatment

The heavy surface treatments are:

Double seal A lower spray of bitumen (<u>tack coat</u>: penetration grade, cutback, or [less commonly] emulsion), with a lower layer of large stone. On top is the second spray of bitumen (<u>penetration coat</u>: penetration grade, cutback, or [less commonly] emulsion), with an upper layer of small stone. Note that in some cases the upper layer can be an engineered application of sand instead of stone. Good performance in rural areas and fair performance in urban areas. Needs at least 50 v.p.d. to keep binder alive.

Slurry Slurries are a mixture of graded stone/sand, emulsion, cement (acting as a catalyst) and water. Fair performance if thick and coarse (20mm), and poor performance if thin (6mm), when used as an initial surfacing. As an initial surfacing it should be applied in two layers each of 6 to 10mm since a single 6mm layer will ravel quickly due to inadequate depth on high spots in bases. As a resurfacing, it can be used to fill moderate ruts. Rapid setting slurries are used on roads which have to be opened to traffic quickly.

Cape Seal A lower spray of bitumen (<u>tack coat</u>: usually emulsion, with a lower layer of large stone, and a second spray of bitumen (<u>penetration coat</u>: usually penetration grate). On top is a thin slurry. Good performance under most conditions. The smooth strong appearance gives an image of a high quality surfacing.

DESIGN OF SURFACE TREATMENTS

Asphalt A plant blended mixture of bitumen, aggregate (usually graded), and filler. The mixture drives its strength from interlock and packing of the aggregate, and its cohesion/stability from the properties of the bitumen. The grading of the aggregate can be varied to produce different grades and properties of the mix. (common gradings are continuous, gap, open). Excellent performance under all conditions. Requires asphalt plant nearby, and the typically good quality control in such plants means good quality on the road. High cost, good lifecycle cost, generally costs, good lifecycle cost, generally maintenance free, poor if very weak pavement structure. Excellent for urban roads. The smooth strong appearance gives an image of a high quality surfacing. General agreement that minimum thickness required is 25mm.

2. CHOICE OF BITUMINOUS SURFACING

2.1 New seals

The selection of the appropriate bitumen surfacing for a new seal is done to take into account the actual conditions on the road.

The surfacing type must be reviewed for each set of conditions. One should not assume that any previous good experience with a particular surfacing type is applicable for different environmental conditions. This is particularly true for the lighter surfacings such as single seals, sand seals and thin slurries.

In choosing the appropriate surfacing, there are three main aspects to consider: ENVIRONMENT, MAINTENANCE CAPABILITY, and GRADIENT, and a surfacing should not be chosen if it is unsuitable for one or more aspects. The choice of surfacings is discussed in Tables 3.1 - 3.5 in SABITA (1992) Manual 10: Appropriate Standards for Bituminous Surfacings.

2.2 Reseals

The selection of surfacing for a reseal depends on the current condition and distress type and severity, the requirements of the condition after reseal, and the cost of the different possible actions. The performance of a surfacing as a reseal can be quite different from its performance as an initial seal, and the selection of reseal type is more complex than the selection of the initial surfacing. It is shown in Manual 10: Table 3.7.

3. AGGREGATE FOR SURFACE TREATMENTS

In a seal, the aggregate transmits the load from the type to the base, and it also resists abrasion. In sand seals and slurries, the aggregate is more of a stabiliser and filler. The aggregate source can be crushed/screened from rock g(which is usually an angular stone), or screened gravel from the river bed (which is usually a rounded stone) or slag. In addition to specified requirements for the aggregate, the properties of skid resistance and of stone-bitumen adhesion must be considered.

DESIGN OF SURFACE TREATMENTS

3.1 Requirements

The requirements for an aggregate to be used in a surface treatment are given in TRH 14 (1985) Guidelines for road construction materials, in the various provincial Roads Material Manuals, and specified in standard specifications (COTO DS (2020)).

The selection of surfacing aggregate shall be done by considering all of grading, crushing strength, polished stone value, fines and sand equivalent, and bitumen/stone adhesion.

Shape	The best is if particles are like a cube. A measure of the quantity of flat particles (undesirable) is the flakiness index test.
Grading (size)	Sieve analysis. The ideal for a seal is that all the aggregate particles are very close to one size. It is regarded as acceptable if two thirds pass one sieve size, but not the next sieve size with an opening of ⅔ of the original. The size of the aggregate for the seal design purpose is taken as the average least dimension (ALD).
Resist wear	Traffic associated wear. Use the Polished stone value test or Los Angeles Abrasion test.
Strength	The crushing strength. Either the 10% Fine Aggregate Crushing Test or the Aggregate Crushing Value test.
Fines	There is a limit to the amount of dust that is permitted.

3.2 Skid Resistance

The aggregate is important in determining the skid resistance of the surfacing, both in terms of microtexture (the texture of the stone itself), and macrotexture (the rough texture of the whole road resulting from the aggregate sticking up above the bitumen). At low speed (such as urban roads), microtexture is most important, and at high speed (such as rural roads), macrotexture is most important particularly when the road is wet. Note that aggregate is susceptible to polishing, especially in the acceleration and stop zones. Polish stone value pendulum test. SCRIM

3.3 Adhesion

The adhesion of bitumen to the aggregate is affected by dust and by water. Not all types of rock adhere equally well to bitumen or tar. Bitumen, in particular, does not adhere well to “acid” rocks. Although there is experience of the different adhesive properties of “acid” and “basic” rocks, it is safer to be guided by the surface texture of the crushed stone. However, when tar or cationic bitumen emulsions are used, such problems do not usually occur.

To improve adhesion, precoat the stone with diluted bitumen. An amine type agent can be used to give the bitumen a small positive electrical charge which promotes adhesion of the binder onto damp aggregate by displacing the film of water thereon, and prevents loss adhesion under subsequent rain. Pullout test, Riedel and Weber test.

4. BITUMEN

There are a wide variety of bituminous binders available for use on roads: conventional bitumen, either as penetration grade, cutback or emulsion, and modified bitumen, either hot applied or emulsion.

The choice of bitumen type is governed by the fact that its viscosity can be made to vary considerable by several means.

> To spray or mix bitumen, its viscosity must be low (it must be liquid). This can be achieved by heating the bitumen to a high temperature (required for penetration grade bitumens; cutbacks and emulsions may be heated slightly), mixing it with a solvent (cutback bitumen), or by grinding it finely and putting it into an emulsion with water (emulsion).
>
> To perform well in service, the bitumen must be sufficiently stiff (high viscosity) to hold the stone. This means that it must be cool (for penetration grade bitumen), or the solvent must have evaporated (for cutbacks), or the emulsion must have broken (for emulsions).

Conventional bitumen

Conventional bitumen, either as penetration grade, cutback or emulsion, is the most common binder used on low volume roads. Specifications for conventional binder have been developed in South Africa over many years in order to ensure good surfacing performance. These specifications are well described in COTO, as SANS 4001 specifications. Recently Performance Graded specifications have been introduced to be used in parallel with SANS 4001 for critical properties of bituminous binder. These specifications are polymer blind.

Modified bitumen

The use of modified binders in South Africa is commonly used to improve properties and road performance of these products. The major polymer and elastomer modifiers used in bitumens in South Africa are the following:

Styrene-butadene rubber latex (SBR)	Crumb rubber
Styrene-budadene-Styrene (SBS)	Natural rubber latex
Ethylene vinyl acetate (EVA)	Styrene tester

Crumb rubber and SBS are at this stage the most commonly used modifiers and are accepted by road authorities as being more cost effective than the conventional binders for many applications. During a study on the field performance of bitumen-rubber reseals, evidence was found of extended life in excess of 70% over that afforded by conventional seals on rapidly deteriorating pavements.

Table 1 Summary of Bitumen Types

BITUMEN TYPE	ADVANTAGES	DISADVANTAGES	EXAMPLE
Penetration grade	Most cost effective, can open to traffic quickly	Must be heated to 180º C for spraying. No tolerance for damp	80/100 150/200 B10
Cutback	Stays soft for several days which helps in winter	Cost of solvent. Time to reach hardness	MC30 MC3000
Emulsion	Can use at ambient temperature, less sensitive than pen. grade. Can tolerated damp	Cost of buying and transporting	SS60 CAT65
Modified	Better properties at extremes of road temperature	Cost	Latex emulsion Bitumen-rubber

5. DESIGN

In the design of seals there are factors that are common to all types of seal and it is therefore logical to consider these before the design is commenced and to treat them in a uniform and consistent manner. TRH 3 has recently been significantly revised and and is available as SABITA Manual 40/TRH3 (2020).

5.1 Traffic

The volume of traffic that a road carries and is likely to carry during the surface life of the seal is a major factor affecting the quantity of binder to be applied and the size of the stone selected. From observations of the performance of seals, it is clear that the usual equivalency factors used in structural pavement design for converting light axle roads (cars) to heavy axle loads 9(trucks) do not apply to seal design. Light traffic such as cars is of no consequence in structural pavement design but plays an important part in the design and performance of seals.

Generally it is assumed that one truck is equivalent to 40 cars (this is equivalent to light vehicles or elv). In the design methods discussed, present traffic per lane of a road in one direction is considered and no allowance is usually made for normal growth.

5.2 Climatic Conditions

For seals, the embedment of the layer of stone in contact with the road surface is of particular importance in the subsequent performance of the seal. Some embedment is necessary to ensure that the seal is bonded well with the existing road surface. However, excessive embedment can result in premature bleeding of the seal. It is therefore essential to assess the hardness and permeability of the road that is to be sealed. The ball penetration test for surfacing seals has been developed to assess the hardness of the road surface.

Although no quantitative method of assessing the permeability of the road surface is yet available, an experienced observer can obtain valuable information by merely pouring water, to which some detergent solution has been added, onto the road surface and observing the rate of ingress into the surface.

5.3 Other Factors that Influence the Rate of Binder Application

There are a number of other factors that influence the rate of application of binder that must be taken into account:

a) Absorption of binder by stone: Stone that meets the requirements of TRH 14 usually has a low binder absorption. Where absorptive stone is used (water absorption greater than 2 per cent) this factor must be taken into account by increasing the cold rate of application of binder by up to 10 per cent.

b) Absorption of binder by underlying layer: the rate of application of binder makes allowance for some absorption of binder by the underlying layer and usually no additional allowance will be necessary. This problem is most likely to occur in a calcrete base.

c) Steep upgrades: where the gradient of the road to be sealed is greater than 5 percent, decrease the cold rate of application of binder in the upgrade land by up to 10percent.

d) Construction traffic: a particularly severe condition is encountered when a newly laid surfacing seal is trafficked by heavily loaded trucks engaged in the construction of other parts of the road. If this traffic has not been taken into account in the design of the seal, decrease the cold rate of application of binder by up to 15 per cent.

5.4 Design Methods for Different Seals

The actual design methods including single seal, double seal and Cape seal are available in SABITA Manual 40 / TRH 3 Sections E4 to E11. The methods all aim to determine the quantity of binder which will fill most of the voids in the layer of stone that makes up the seal layer.

The quantity of voids to be filled can be found by a process of elimination. A certain portion of voids must be left unfilled in order to give adequate skid resistance (i.e. adequate texture depth). The will also be some loss in voids during the life of the seal as a result of embedment of the aggregate at the bottom of the seal layer, and wear of aggregate at the top of the seal layer. The rest of the voids can be filled with binder.

The key to any method is the true size of the aggregate being used. When the aggregate is spread, rolled and compacted by traffic, they assume a position with their least dimensions vertical, hence it is the average least dimension (ALD) of the aggregate that one is interested in. The relationship between nominal size and ALD depends on the shape of the aggregate, and so ALD is best found by laboratory test and not estimated from nominal size.

The various methods were based on either graphs or tables for the determination of binder content (see example below), significant adjustment must be made for traffic, texture depth of the existing surface, and ball penetration. Fine adjustment must be made for the factors listed in the previous sub-section.

The result is generally a calculated binder quantity as net, residual, and cold. Allowance must be made for the expansion of bitumen on heating, as well as the dilutant effect of cutbacks or emulsion. Thus the spray rate of binder for different types of bituminous binder should be determined by multiplying the cold binder application rate by one of the factors in Table E10 in SABITA Manual 40/TRH 3. The stone spread rate is found from the ALD of the stone and its flakiness index (F1).

6. APPLICATION RATES

While the Manual 40 document gives reasonable application rates on an “average” basis for the various seals, and includes a number of adjustments that should be made to the calculated design rate). In the past some of these were either incorrect or misunderstood. Significant changes have been made to the document in the year 2020 to address these issues. On a pragmatic basis – other similar designs should be reviewed on an ongoing basis, looking particularly at bleeding, richness, ravelling and leanness. Consult other people carrying out the same type of seals in the area, to test you design application rate.

Critical factors are: steep gradients, up and down (breaking)
High ambient and road temperatures
Concentrations of heavy traffic
Turning movements (intersections)

Careful consideration and supervision of seal construction is essential to ensure even uniform application. Special care should be paid to the binder distributor to ensure an even distribution across the whole spraybar.

SURFACING SEALS

MAIN FUNCTIONS

- **Provide a waterproof cover to the underlying pavement.**

- **Provide a safe, all weather, dust free riding surface for traffic with adequate skid resistance.**

- **Protect the underlying layer from the abrasive and disruptive forces of traffic and the environment.**

Failure to fulfil any one of the above would indicate the end of the surfacing's effective service life

Since most seals are relatively thin, they have no load distribution properties. However the seal itself should be able to handle the horizontal and vertical traffic-induced stresses.

SURFACING SEALS

FACTORS INFLUENCING PERFORMANCE

- **PAVEMENT STRUCTURE AND CONDITION**
  (base type, flexural properties)

- **EXISTING SUBSTRATE**
  (softness, cracking …)

- **TRAFFIC**
  (volume, loading, tyre pressure, speed …)

- **ROAD GEOMETRY**
  (grade, curves, intersections, width …)

- **DESIGN**
  (appropriatness, correctness …)

- **MATERIALS**
  (aggregates, binders …)

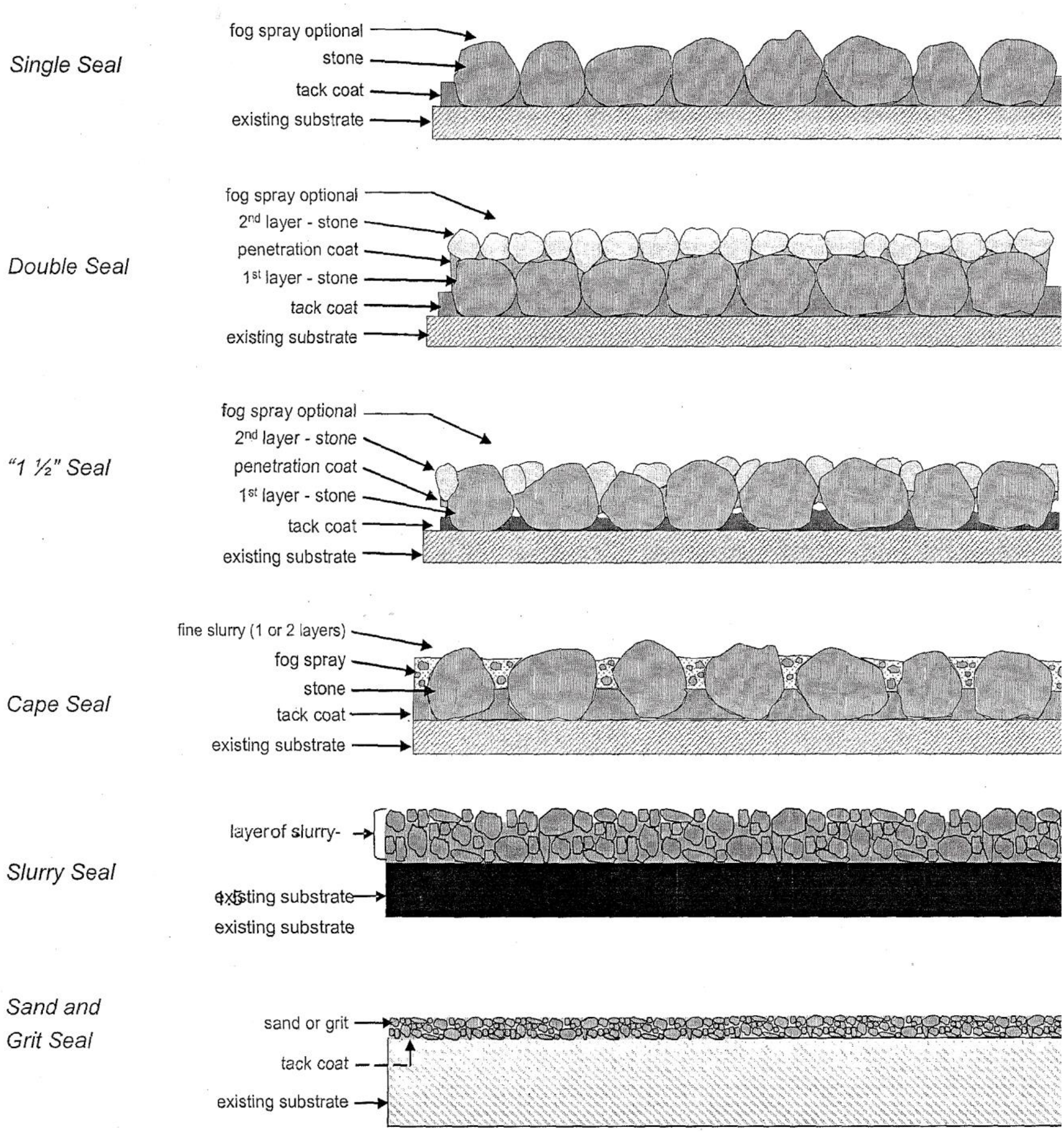
- **PREPARATION, PRE-TREATMENT & REPAIRS BEFORE CONSTRUCTION.**

- **CONSTRUCTION & SUPERVISION (conformance …)**

- **MAINTENANCE**
  (capacity, timeous …)

- **PHYSICAL & SOCIAL ENVIRONMENT**
  (climate, drainage, mech. Damage, spillage …)

SCHEMATIC ILLUSTRATION OF SEAL TYPES



SCHEMATIC ILLUSTRATION OF SEAL TYPES

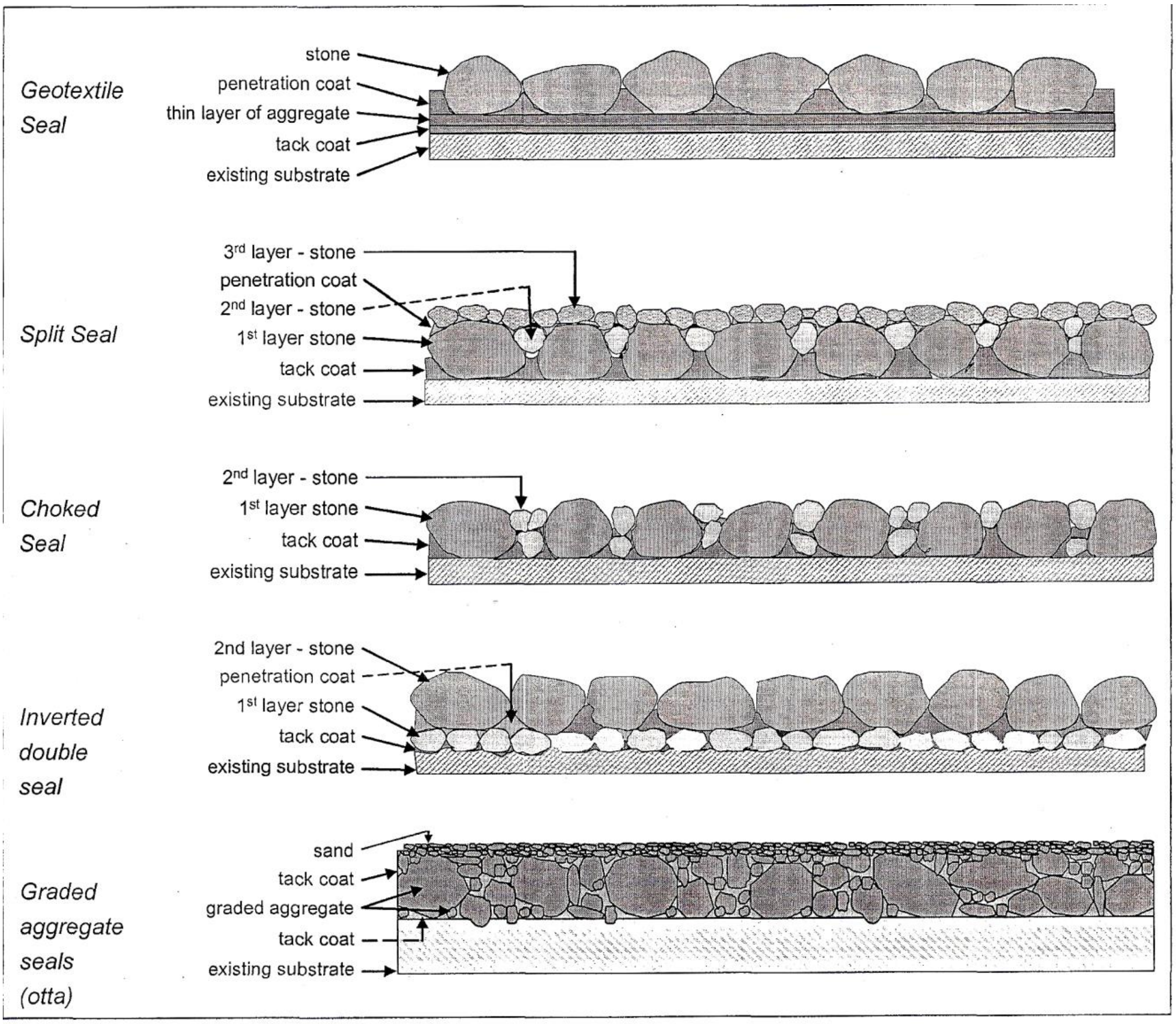


Figure 1-2 Schematic illustrations of various seals

SARF COURSE

PRACTICAL ROAD PAVEMENT ENGINEERING

9. ASPHALT DESIGN

ASPHALT DESIGN

1. INTRODUCTION

In its simplest form asphalt as used in South Africa is a combination of aggregate (including fines) and bitumen in sufficient quantity to “glue” the particles together. Hot mix is asphalt (HMA) which has been plant mixed where both the aggregate and binder has been heated to ensure thorough mixing.

As things stand the TRH8 (1987) guidelines have been overtaken by SABITA Manual 35 / TRH 8 (2019) "Design and use of Asphalt in Road Pavements" A summary of the contents is given in Annexure A.

This document represents the latest thinking on detailed HMA design in SA and particularly the spatial composition/volumetric's approach is strongly recommended. If you have a complex problem involving at least medium volume traffic, find a specialist(s) in the field of HMA and take advice! Manual 35 divides mix design into three Levels based on anticipated E80s traffic. These are: Level IA & IB (less than 3 million), level II (3 to 30 million) and Level III (greater than 30 million).

2. CURRENT SITUATION

There are a number of standard mixes available in the major centres of South Africa. In addition there are certain special mixes such as Bitumen-Rubber Asphalt, SMA, Thin Layer and Porous Asphalt for special applications. For a start attempt to stick with these mixes. It is only where a plant is set up remote from major centres and known aggregate sources, or where a new type of mix with specific extraordinary properties is required that new mix design is necessary. Under these circumstances you are strongly recommended to talk to specialists. However, having said that, a basic understanding of mix design will improve you appreciation of HMA usage. To this end the broad guidelines are worth studying.

3. COMPONENTS

3.1 Aggregate

Aggregates provided the structural skeleton of the mix and can be subdivided into Filler or “Fines” (material passing the 0,075mm sieve) and Aggregate (material coarser that 0,075mm). The following properties are important in the selection and performance of the aggregate:

Grading:	Particle Distribution – Continuous, Gap, Open, etc
Shape:	Cubical or Flaky
Surface Properties:	Roughness and Binder Absorption
Hardness:	General and Polishing

Fillers can consist of rock flour, flue-dust (baghouse fines), lime, cement, slag, fly-ash, etc. The filler should contain no clay or other deleterious material. The filler acts as an extender to the binder and does two things:

- It acts as a void-filler contributing to a dense mix.
- It stiffens the mix and improves resistance to plastic deformation.

Fillers can affect the workability of the mix and lime inhibits stripping (hydraulic removal of binder film from aggregate).

3.2 Binder

Binders in general used for HMA usually lie in the range of 60 to 100 Penetration Grade bitumen. While the refineries produce bitumens to a SABS mark which covers properties such as viscosity, softening point, ductility, solubility and thin-film oven tests for ageing; because of the various and varying sources of crude available, the basic chemical ingredients (asphaltenes, maltenes, aromatics, etc) can show significant changes in their proportions. This variability can affect the properties of the binder. In SA we are moving towards a Performance Grade (PG) specification of Binder.

Binder properties can be varied by means of the addition of “modifiers”.

Bitumen-rubber – rubber crumb part digested by the hot binder to form a gel: modifies viscosity so more flexible at low temperatures and stiffer at high temperatures, increases elasticity and toughness, carbon black results in resistance to ageing and the HMA costs up to 30% more than conventional.

SBS (Styrene-butadiene-styrene) is a networking polymer, which forms a stable bond with the bitumen, and : improves softening point, toughness and tenacity, elasticity, low temperature flexibility and resistance to rutting. High temperature viscosity is only moderately increased and the HMA (depending on percentage modifier added) could cost up to 25% more than conventional.

EVA (ethylene Vinyl-acetate) forms three dimensional structures with the bitumen and : improves softening point (less than SBS), significantly increases resistance to rutting – little used in HMA in Southern Africa.

Fibres – uses particularly to reduce run-off of binder from the aggregate particularly in porous asphalt, some use with SMA asphalt mixes.

4. MIX PROPERTIES

The following are mix properties that should be considered when designing a new mix.

4.1 Durability

Resistance to the effects of traffic, sunlight, water and extreme surface temperatures.

ASPHALT DESIGN

You are looking for the following:

Thicker binder film

Dense aggregate packing

Sound aggregate

Resistance to stripping

4.2 Resistance to Cracking

Cracking mainly comes from interaction of heavy traffic and the pavement structure resulting in repeated deflections. Other cracking can be caused by temperature effects and soil movements. To design for crack resistance, one needs a good estimate of the pavement support. Smaller deflections (cemented pavement layers) can have a stiffer HMA, flexible high deflection pavements need a less stiff more3 ductile mix.

4.3 Resistance of Plastic Deformation

Mainly consolidation (rutting) or shoving of HMA under heavy traffic at elevated temperatures. You are looking for:

Increased stiffness (ITS, dynamic creep)

Increased tensile strength

Dense aggregate packing or high stone content

Harder or modified binder

Lower sensitivity to high temperature

4.4 Flexibility

Ability to deform as pavement profile changes under loading.
Looking for:

Higher binder contents

More open aggregate gradings.

4.5 Skid Resistance

Looking for:

Surface texture

Polish resistant aggregates

No bleeding

4.6 Permeability

The resistance to penetration of water.

Looking for:

High binder content

Dense mix

Compactibility

4.7 Workability

The ability to construct the HMA layers to the required finish and compaction.

Looking for:

Higher binder content

Lower viscosity binder

Rounder/less sharp fillers/fines (sand?)

Less angular/flaky aggregate

Higher mix temperature (not too high?)

4.8 General

From the above it will be seen that a number of the above properties produce conflicting requirements and most mixes designs are a compromise. The advent of the modifiers such as B-R and SBS now permits us more room to move.

5. MIX SELECTION

5.1 Identify Performance Requirements

Consider road Category (TRH4), environmental conditions, traffic and underlying pavement structure. Decide on which mix properties you need to place particular emphasis (see Annexure B).

5.2 Check Performance Requirements of Known HMAs

ASPHALT DESIGN

Start with the most basic HMA mixes available/known and assess whether they will do the job. For example will a continuous medium asphalt, with a straight pen bitumen, perform? What does local experience and history say? If not, look at other possible mixes. The following table is not an exhaustive listing and is given as a guide to set you thinking.

HMA DESCRIPTOR	**BINDER**	**DEPTH** (mm)	**USE**
Continuous Medium	Pen Bit	30 to 50	General
Continuous Fine	Pen Bit	20 to 35	Thin surfacings, sidewalks
Continuous Medium	Modified	30 to 50	Enhanced stiffness and fatigue
Continuous Large	Pen Bit	50 to 100	Resistance to deformation
Stone Mastic	Pen Bit	25 to 50	Increased stiffness, deformation resistance
Gap & Semi Gap	Pen Bit	30 to 50	General (Rolled in Chips)
Porous	Modified Binder	30 to 50	Reduce splash and noise
Thin Layers	Various	< 30	Friction courses & cheap overlays (urban residential)

5.3 Practicalities

Consider what aggregate is available. Are there local manufacturing capabilities? What are the climatic constraints? What construction equipment will be required?

6. MIX DESIGN

A single step by step procedure is given in Annexure C, which reflects a reasonable approach to mix design. Arguably the best approach to the overall mix design philosophy, once the basic property milestones have been achieved, is to look carefully at the spatial composition of the mix i.e. the 3-D arrangement of the mix constituents. Voids in the mix (VIM) and voids on the road are at present the simplest way in which to ensure reasonable performance on the road. VIM's are laboratory based data that gives an indication of compactibility and permeability and voids on the road indicate success of compaction and voids available in the paved HMA.

High VIMs: Difficult to compact, likely to be permeable and subject to ageing.

Low VIMs: Easy to compact, likely to have poor stability and also to bleed under traffic.

While VIMs can assist you in controlling the mix up to the end of construction there still remains the question, what will happen to the mix under repeated traffic loading? Gyratory compaction to a "refusal density" could give a very useful indication of the likely final voids on the road. From this data one could assess the risk of consolidation under traffic.

Where one is dealing with critical situations such as very heavy traffic and high volumes with steep grades or intersections, wheel tracking tests such as the MMLS (University of Stellenbosch) or Wheel Track Testing (Transportek) should be considered. These can simulate field conditions and at least evaluate on a relative basis different mixes, mix variations, and binder modifiers.

ASPHALT DESIGN

ANNEXURE A

SUMMARY OF DESIGN OF ASPHALT FOR ROAD PAVEMENTS 2019

- Mix Type selection (Section 2)
- Binder Selection (Section 3)
- Aggregate Selection (Section 4)
- Mix Selection (Section 5)

  5.2 Properties
  1. Workability
  2. Durability
  3. Stiffness
  4. Resistance to Rutting
  5. Resistance to Fatigue Cracking
  6. Permeability
  7. Thermal Cracking

  5.3 Composition of Asphalt

  5.4 Volumetric Properties

  5.5 Mix design Levels

  5.6 Design of Special Mixes
  1. Cold Mixes
  2. Porous Asphalt (SABITA Manual 17)
  3. Mixes for Light Residential Asphalt (SABITA Manual 27)
  4. Warm Mix Asphalt (SABITA Manual 32)
  5. EME Asphalt (SABITA Manual 33 - High Modulus Asphalt)
  6. Mixes with Reclaimed Asphalt (RA)
  7. Stone Mastic Asphalt (Appendix B)

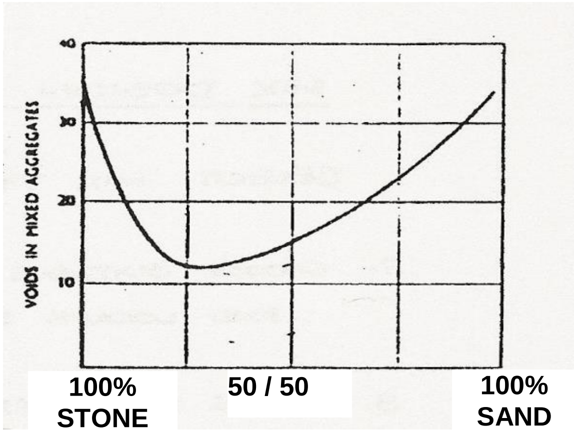
- Link with Asphalt Pavement Design (Section 6)
- Quality Management Procedures (Section 7)

ASPHALT DESIGN

ANNEXURE B

EFFECT OF STONE CONTENT

For most mixes low voids - but must leave space for binder



MIX COMPONENTS AND THEIR EFFECT ON MIX PRPERTIES

PROPERTY	BINDER		AGGREGATE		Filler	TESTING		
	Content	**Pen.**	**Grad.**	**Shape**	**Cont.**	**Voids in Aggr**	**Mix Density**	**Other Tests**
Durability	High	Mod.	Dense	-	Opt.	Low	High	Air Perm.
RT (resistance to) Cracking	High	Mod.	Gap	-	Opt.	Opt.	Opt.	ITS
RT Deformation	Low	Low	Dense	Ang.	High	Low	High	Creep
RT Shrinkage	High	High	Cont.	Round	High	Mod. High	High	VMA(H) VMH(L)
RT Skidding	Low	Low	Open*	Ang #	Opt.	Mod. High	Opt.	SCRIM
Flexibility	High	High	Gap	Round	Low	High	-	-
Stiffness	Opt	Low	Dense	Ang.	High	Low	High	Resilient Modulus
Workability	High	High	Cont.	Round	Opt.	High	High	-
Permeability	High	Mod.	Dense	Round	Opt.	Low	High	Air Perm.

* Gap + Rolled In Chips   # Resistant to Polishing

ASPHALT DESIGN

ANNEXURE C

<u>MIX DESIGN : SIMPLE APPROACH CONTINOUS, GAP & SEMI-GAP</u>

1. Select mix type

2. Choose suitable grade of bitumen (modifier if required) and locate satisfactory aggregates and filler.

3. Make up aggregate (total) grading using the recommended envelopes or the Bailey method.

4. Make up trial mixes using a range of binder contents and carry out appropriate tests.

   Marshall stability, flow & density; Rice's density; grading and binder content; voids in mineral aggregate; voids in mix; binder film thickness; indirect tensile strength (ITS) and creep.

   Vary modifier contents and do dynamic creep and gtratory.

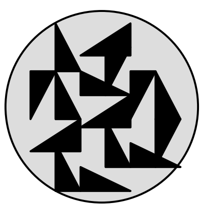
5. Compare test results with target requirements.

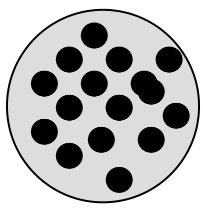
6. Adjust mix where necessary to obtain the required properties.

   The following mix components can be altered to change the mix characteristics:

Binder	:	Content and Penetration
Grading	:	Continuous, Gap, Open - Density
Aggregate	:	Stone content and shape
Filler	:	Content and active component

VOIDS IN CONTINUOUS GRADING





VOIDS IN GAP GRADING

<u>GOOD</u>	<u>POOR</u>	<u>GOOD</u>	<u>POOR</u>
Density + Durability Stiffness Resistance to Deformation	Fatigue Permeability Skid Resistance	Fatigue Resist Impermeable	Resist to Deformation Stiffness