Sprayed Seal Design

Definition

Sprayed Seal – A thin layer of binder sprayed onto a pavement surface with a layer of aggregate incorporated and which is impervious to water.

Aggregate – A material composed of discrete mineral particles of specified size or size distribution, produced from sand, gravel, rock of metallurgical slag, using one or more of the following processes – selective extraction, screening, blasting, and crushing.

Binder (asphalt or slurry surfacing) – A bituminous material used for the purpose of holding aggregate particles together as a coherent mass.

Binder (sealing) – A bituminous material used for waterproofing the surface and holding an aggregate layer to the base.

Double/Double Seal – A seal consisting of two successive applications of binder each followed by an application of aggregate.

Polymer Modified Binder (PMB) – a binder consisting of polymeric materials dispersed in bitumen with enhanced binder performance for particular applications.

Single/Double Seal - A seal consisting of a single application of binder followed by a double application of aggregate.

Single/Single Seal – A seal consisting of a single application of binder followed by a single application of aggregate.

The Case for Sprayed Sealing

Sprayed sealing is an effective procedure for extending the service life and preserving the value of road assets thus ensuring asset performance.

The application of bitumen acts as a waterproofing agent as well as a binder to hold the aggregate. The aggregate in turn provides the wearing surface for traffic. Sprayed sealing generally improves surface characteristics, particularly waterproofing and skid resistance. However, it does not add strength to the pavement.

The selection of a sprayed seal over other forms of surface treatments such as asphalt, is dependent on factors including the operating environment and financial considerations.

Factors influencing the selection of treatment type and materials.

Some of the most important factors affecting seal performance and therefore selection of the most appropriate treatment type are:

- Pavement structure and condition – When resal work is considered, the structural integrity and strength of the pavement needs to be ensured by patching or granular overlay.
- Traffic – affects seals in several ways all of which may lead to loss of service integrity or reduced safety. Friction between vehicle tires and aggregate may cause aggregate to wear and polish. In addition, the vertical force exerted by the vehicle through the tires may push the aggregate into the substrate, leading to the embedment of the stone in the underlying layer. Embedment may also result from high contact pressures, i.e. high tyre inflation.
- Environment – In hot, dry weather, the range of suitable treatments is large. In contrast, colder environments have limited options and the use of emulsions may be preferable. The risk of brittleness is higher in colder regions resulting in increased risk of cracking and ravelling. This may also negatively affect the seal life of highly flexible pavements. Regions with high ultra-violet radiation usually experience accelerated binder aging or oxidation.

Materials for Sprayed Seal Construction

Aside from correct design, the correct choice of material is crucial to alleviate the elevated risk factors associated with adverse conditions. A sprayed seal is composed of two materials:

1. **Aggregate** which must have adequate strength, must be angular, and must meet high polishing standards. Typical aggregate sizes ranges from 5 to 20 mm, the most commonly used being 7, 10, and 14 mm. Double/Double seals use larger aggregate sizes. More information on aggregate classes and associated specification limits can be found in Australian Standard AS 2758.2-2009.

2. **Binder**, the most common of which is Class 170 bitumen. Class 320 has also
been used successfully particularly in hot regions or where heavy traffic is probable. The class designation refers to viscosity (Pa.s) of the binder at 60°C. Where a softer binder is required, a Class 170 binder may be mixed with a softer grade at the refinery. Harder bitumen (C320 and above) tends to grade at the refinery. Harder binder may be mixed with a softer binder if required, a Class 170 binder.

Elasticity and reduce temperature successfully used to increase for spray sealing. Modified binders limited deflection by design. Higher particularly detrimental on low heavy traffic, C320 binders perform particularly well. For roads built to carry heavy traffic, C320 binders perform well. In hot regions or where heavy traffic is probable, it is usual practice to prime all new pavements prepared for sprayed seal or asphalt surfacing.

Most Commonly used Sprayed Seal Treatments
Sprayed bituminous treatments can be classified into three groups:

A. Initial Treatments which consists of:

1. Prime - involves priming or the application of a suitable primer to a prepared pavement as an initial treatment prior to applying a more permanent bituminous surfacing. The prime must be able to:
   - Mitigate surface dust
   - Penetrate and seal the surface pores in the pavement material
   - Bind the pavement near its surface
   - Waterproof the pavement binding materials

   It is usual practice to prime all new pavements prepared for sprayed seal or asphalt surfacing.

2. Initial Seal - is the application of a suitable initial seal and fine cover aggregate to a prepared pavement. It is used as a temporary treatment before applying the next bituminous surfacing. The success of initial seals rely on:

   - Selection of an appropriate initial sealing treatment
   - Appropriate binder application and aggregate spread rates
   - Preparation and condition of base materials
   - Application procedures (workmanship)

B. Secondary Treatment – application of a sprayed bituminous treatment on an initial treatment.

C. Retreatment – an application of a sprayed bituminous treatment on an existing bituminous surfacing.

Design of Sprayed Seals

Design Philosophy
Sprayed seals consist of a single sized aggregate spread over a bitumen film sprayed beforehand on the road surface. The design objective is to achieve a durable uniform surface by the aggregate submerging into the bitumen up to 55-65% of its height under traffic two years after construction. For a given aggregate, the volume of the voids is controlled by the average least dimension (ALD) in the size and flakiness index – representing the shape of the stone. As a result, once the size and shape of the aggregate are known, it is easy to estimate the volume of binder necessary to fill the voids between the aggregates.

Design Principles
The principles on which sprayed seal design is based are (Austroads 2006a):

- Sound, single sized aggregate is used
- Aggregate is spread in a single layer, one stone thick
- The aggregate is spread with some interlock and forming a shoulder-to-shoulder mosaic
- The aggregate least dimension is near vertical – achieved through rolling during construction and the action of vehicle tyres early in the seal’s life
- The layer has typically 40 to 60% voids
- The binder should be 50 to 60% up the height of the aggregate

Design of binder application rate
The binder application rate depends on the size of the aggregate (ALD) and the expected traffic. Section 3.4.3 of ROADguide, IPWEA NSW Roads & Transport Directorate 2012, provides more information on binder application rate.

Design of binder spread rate
Aggregate spread rate is calculated as a function of the aggregate size (ALD) and the traffic volume on the road. Further information on the range of aggregate spread rates for single/single seals can be found in Austroads (2006a).

Common Issues:
Spray sealing is considered to be a relatively simple and economical technology that offers substantial benefits to road planners and asset managers. Needless to say, experience and expertise in the design and construction of sprayed seals is still imperative to avoid premature failure or reduced service life.

Seal performance issues may be categorized according to the time of their appearance, with early failures often having to do with design and construction issues. If a seal performs satisfactorily immediately after construction, it is likely to perform well throughout its service life. The most common causes of defective seals are due to the following issues (VicRoads & GeoPave 2004):

- Poor/inadequate surface preparation, wet surface, sand/soft material on the surface, too much or too little primer
- Poor/inexperienced design practice; too much or too little bitumen sprayed, inappropriate aggregate spread rate,
- Poor construction practice; blocked spray bar, inappropriate finish (i.e. without paper), run out of bitumen
- Poor materials, unsuitable stone, wet or dusty aggregate
- Inclement weather

More information on the common and critical issues associated with spray sealing can be found in ROADguide, IPWEA NSW Roads & Transport Directorate 2012.

Use of Polymer Modified Binders (PMB)
Polymer modification has some advantages only when the PMB is applied with due care. Some issues in the use of PMBs are:

- PMBs have a typical shelf life of 1-3 days. Polymers and bitumen do not mix naturally but are forced into a mixture. PMBs are not stable constitutes tend to separate if appropriate conditions are not maintained.
- PMBs have better retentive capacities than bitumen without added polymer
- Inappropriate handling or longer storage can cause more damage than just losing the advantages of polymer modification
- Selecting the polymer needs careful consideration

REFERENCES and FURTHER READING:
The information contained in this Information sheet has been summarized from a number of resources. More detailed information may be sourced from the references below:


Austroads 2016 Selection and Design of Initial Treatments for Sprayed Seal Surfacing, AP-T310-16, Austroads, Sydney, NSW

Austroads 2006a Update of the Austroads Sprayed Seal Design Method, AP-T68-06, Austroads, Sydney NSW

Austroads 2006b Specification framework for polymer modified binders and multigrade bitumens, AP-T41-06, Austroads, Sydney, NSW

Austroads 2006c Guide to the selection and use of polymer binders and multigrade bitumens, AP-T42-06, Austroads, Sydney, NSW

IPWEA (NSW) Roads & Transport Directorate, 2012 ROADguide Road Design and Performance, Sydney NSW