PMB Facts

What are PMBs?

Increasing traffic volumes, vehicle loads and tyre pressures are causing accelerated degradation of our road pavements. Improved materials, such as polymer modified binders (PMBs), are being used as a means of better combating these effects.

PMBs are generally considered to provide prolonged life or enhanced pavement performance. In sprayed seal and interlayer (membrane) applications, polymers can greatly prolong pavement life by inhibiting reflective cracking. In dense-graded asphalt applications, PMBs are effective in reducing rutting and improving fatigue crack resistance. The higher shear resistance provided by PMBs can give beneficial effects in roundabouts, tight corners and other high stress areas. Polymers have also demonstrated the ability to prolong the life of open-graded surfacings by allowing thicker binder films, which are less prone to oxidation and tougher films that resist collection of foreign matter and dust, thus maintaining the desirable water drainage capacity of these mixes.

The role of a PMB varies in each different application. Also, the different PMBs work in different ways. It is therefore very important to choose the correct binder for each application, and it is equally important to design the mix or seal correctly

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History of PMBs in Australia

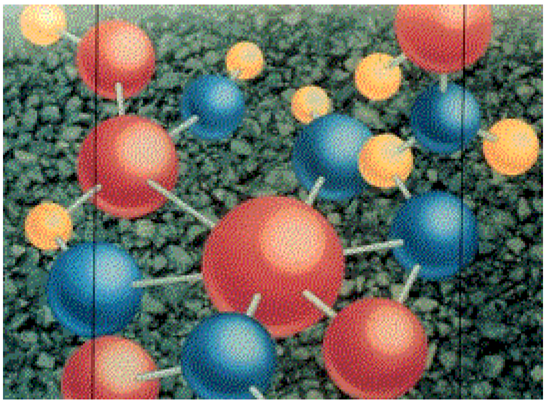
Polymer modified binders were introduced to the Australian market about ten years ago, although their development began long before that with the use in Europe of natural and synthetic rubbers. It was not until the 'second generation' of synthetic polymers, such as styrene butadiene styrene (SBS) and ethylene vinyl acetate (EVA), became available that polymer modified binders were more generally used in applications in Australia. The acceptance of these modified binders was helped by a requirement for more durable maintenance treatments and a need for improved binder properties to cope with increased traffic stresses on surfacings.
The Australian PMB market has traditionally been supplied with three different polymer systems. They are styrene butadiene styrene (SBS), ethylene vinyl acetate (EVA) and scrap rubber. Other polymer systems which have previously been available in Australia, or are used in small quantities for specialised applications, include polyethylene (PE), neoprene, and epoxy resin. Polymer systems, such as water-based emulsion latexes of styrene butadiene rubber (SBR) and natural rubber, are commonly used in bitumen emulsions for spray sealing applications and bituminous slurry surfacing. Over recent years, new polymer types, such as polybutadiene (PBD) and ethyimethacrylate (EMA), have been introduced to the Australian market to provide improved performance over the traditional varieties. All these polymer systems provide different characteristics to the finished PMB and therefore some have

advantages in specific applications over other polymer systems. Worldwide, there are many more polymer systems in common use.

What is a polymer?

'Polymer' is a derived word meaning "of many parts". Polymers can be thought of as long chemical strands that are made up of many smaller chemicals (monomers) that are joined together end-on-end. Polymers can therefore be made up of different numbers of the monomers and therefore they can have different 'chain lengths'. Only certain chain lengths may be suitable for a particular polymer type when used in bitumen. For example, the polymer 'polystyrene' is made up of many styrene molecules linked together one after the other. A copolymer has two different sorts of repeating molecular units. Block copolymers have these repeating molecular units in a regularly occurring block pattern.

The physical and chemical properties of a polymer will depend on the nature of the individual molecular units, the number of them in each polymer chain and their combination with other molecular types. Consequently, the different polymers behave in different ways and generally the different PMBs have to be tried out in bitumen applications before they can be considered suitable.



Two basic types of polymer are used in modifying bitumen for road applications:

- Elastomers
- Plastomers

An elastomer is a polymer that has a flexible 'rubber' backbone and large side-chains in its structure. Styrene butadiene styrene (SBS) is an example of this type.
A plastomer is a polymer that will deform in a plastic or viscous manner at melt temperatures and becomes hard and stiff at low temperatures, i.e. the structure is reversibly broken down with the application of heat. An example of such a material is ethylene vinyl acetate (EVA).

Styrene-butadiene-styrene (SBS)

SBS is a block copolymer incorporating polystyrene sections attached to a central polybutadiene section. The polystyrene parts of different polymer chains within the bitumen come together to form domains within the binder structure at low temperatures. This results in a polymeric network structure within the binder which can be reversed by heating until the styrene molecules become more soluble in the bitumen base.
As with all polymers, SBS is available in many different forms. The polymer molecules can be different lengths (different number of individual monomer molecules per polymer chain) and can have different arrangements of the molecules (microstructure). These differences can drastically affect the degree of modification provided by a polymer. SBS polymers can have different quantities of styrene relative to the butadiene content (usually expressed as % styrene, and typically around 30%). They can also have different arrangements of the polymer, being either a linear or radial configuration. It therefore follows that two different SBS PMBs may not behave the same or have the same storage stability due to differences in the structure of the SBS polymer used, i.e. one PMB containing 5% SBS may not have the same

properties as another PMB containing 5% SBS. This becomes a problem when PMBs are specified by content of polymer.

Initially, SBS-based PMBs were provided in the form of a 'concentrate', which could be subsequently diluted to the required polymer content by blending with bitumen. The practice of blending a concentrate with bitumen resulted in particular polymer concentrations being used for different applications. For example, it became common to use about 4% to 5% SBS polymer to produce a binder suitable for SAM seals. Commonly used SBS concentrations were 0.75%, 1.5%, 3%, 3.75%, 5%, 6% and 7.5%. These concentrations were used mainly because they correspond to simple dilution rates of 5%, 10%, 20%, 25%, 33.3%, 40% and 50% concentrate in bitumen, respectively. Eventually, specifications were drafted around this common practice.

SBS-based PMBs are usually highly elastic, however the extent is dependent upon the quantity of polymer in the PMB, the type of SBS used, the nature of the bitumen and the method or extent of blending used during manufacture. Usually, SBS-based PMBs require the addition of aromatic or other process oils (combining agents) to improve the 'solubility' of the polystyrene parts of the polymer. Too much aromaticity can reduce the effectiveness of the SBS by making the styrene part of the polymer molecules too soluble in the base binder.

The elastic properties of SBS-based PMBs are created by thermally reversible cross-linking of the SBS molecules through association of the polystyrene parts of the polymer, coupled with the elastic properties of the polybutadiene. It is generally believed that highly elastic properties are not achieved until the SBS content of the PMB is around 5% or greater.

SBS-based PMBs are reasonably easy to manufacture by blending powdered SBS polymer into a bitumen (or a bitumen mixed with an aromatic combining agent) using low to medium shear mixing.

The polymer content of SBS-based PMBs varies considerably in spray operations depending on the application. In spray sealing works around Australia, 1% to 3% SBS is typically employed to provide improved aggregate retention properties and 4% to 6% SBS is typically used in the first coat of two coat strain alleviating membrane (SAM) applications followed by a second coat containing about 1% SBS. Strain alleviating membrane interlayer (SAMI) applications are believed to require very high elasticity and to achieve this, SBS contents up to 7% or 8% have been used. Crack filling applications are usually undertaken with SBS concentrations of about 15% polymer.

Ethylene Vinyl Acetate (EVA)

Like SBS, there are many types of EVA polymers available. EVA polymers can contain different ratios of ethylene to vinyl acetate and can have different molecule weights, i.e. different polymer lengths. Typical vinyl acetate levels are 18% and 33%. These polymers are considered to be plastomeric and act by making the PMB stiffer than conventional bitumen. This feature is particularly useful in asphalt applications where they find most use, however stripping, possibly due to brittle failure of the PMB, has been a problem in some seal applications.

EVA polymers are easily blended into bitumen by simple low shear mixing. As with most PMB systems, there must be compatibility between the base bitumen and the EVA polymer to ensure optimum properties are achieved. Separation of the EVA polymer from the PMB can be a problem in storage.

Although EVA finds application in sealing work, particularly to provide high shear resistance to aggregate loss, the major applications are in open-graded asphalt and for the provision of deformation resistance in dense-graded asphalt.

Polybutadiene

Polybutadiene (PBD) is a polymer system which was introduced to the Australian market in 1989. PBD is an elastomeric polymer and, when properly incorporated into bitumen, provides a tough and strongly cohesive and adhesive binder. PBD has been extensively used in Europe in applications ranging from sprayed seals through to open-graded and dense-graded asphalt. The PBD-based PMBs are manufactured with special high-shear blending equipment and exhibit negligible polymer separation during storage and transport.