

REJUVENATORS:

Bring Life Back to Aging

Asphalt Binder

With the opportunity to increase RAP usage and lower mixture costs, the time has come to better understand rejuvenators



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When asphalt binder is exposed to oxygen and the sun's ultraviolet rays, it begins to age and oxidize. The changes that occur to asphalt binders are primarily due to the chemical composition of the asphalt. Asphalt pavement changes occur in two stages: short-term and long-term. Short-term aging is mainly due to volatilization, oxidation, and/or absorption of oily components. Long-term aging happens in the field and is mainly due to changes in composition through reaction between asphalt constituents and atmospheric oxygen.

These aging processes leave binders stiffer, less ductile, and with lower temperature susceptibility than conventional paving grade asphalts.^{1,2}

The aging process reduces the ratio of oily maltenes in the binder, leaving a greater ratio of stiffer asphaltenes, which cause the asphalt binder to become less ductile. These viscosity and elasticity changes result in a hardened, brittle asphalt binder.

Rejuvenators and Their Uses

Rejuvenators were introduced in the 1960s as a pavement preservation treatment to restore both the physical and chemical properties of the aged binders in the field. The goal of any rejuvenator, or recycling agent, is to return the hardened asphalt binder close to its original viscoelastic state.

There are multiple uses for rejuvenators today. Once the rejuvenator penetrates the surface of the reclaimed pavement, the viscosity, flexibility and brittleness of the binder can be improved. Additionally, they

can act as surface sealants, which minimizes the effects of oxidation, moisture damage, and raveling, thereby extending a pavement's life.

Recently, research has focused on combining specific amounts of rejuvenators with reclaimed asphalt pavement (RAP) and/or recycled asphalt shingles (RAS) to create a high recycled binder.

Each year, it is estimated that contractors receive about 80 million tons of asphalt materials.³ In addition, approximately 11 million tons of waste asphalt shingles are generated, of which 10 million tons are from installation scraps and tear-offs from re-roofing and one million tons are from asphalt shingle manufacturing.⁴ These materials can be processed for use as RAP and RAS in asphalt mixtures to reduce cost of materials and conserve natural resources and valuable landfill space; however, rejuvenators are one way to improve some performance properties of the asphalt binders found in RAP and RAS.

Most state agencies limit the recycled binder content in their asphalt mixtures depending on the pavement layer. These agencies fear that because the asphalt binder is stiffer, less ductile when RAP and/or RAS are used in the mixture, it will be more susceptible to cracking in the field. Although research has begun on the use of rejuvenators with asphalt mixtures containing higher recycled contents in the field, there are still many questions that need to be answered regarding their use. Laboratory studies have shown that rejuvenators can be used to improve the performance of RAP and/or RAS mixtures;⁵ however, one must take care

Like skin, when asphalt binder is exposed to oxygen and the sun's ultraviolet rays, it begins to age and oxidize. While the aging of asphalt is similar to that of skin, the changes that occur to asphalt binders are primarily due to the chemical composition of the asphalt.

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to ensure that the proper amount of rejuvenator is used to restore the original properties of the asphalt binder. Field tests of these mixtures need to be completed to ensure field performance. In addition, NAPA hosted an industry tour of Japan in 2014 and learned that Japan is successfully paving roads with higher RAP mixtures through the use of rejuvenators.

Types of Rejuvenators

Some researchers^{6,7} have tried to separate recycling agents into two categories—softening and rejuvenating agents. Softening agents, including flux oil, lube stock, lubricating oil, and slurry oil, can lower the viscosity of the aged binder. Rejuvenating agents, which contain a high proportion of maltene constituents such as lube extracts and extender oils, can

Texas and Alabama are two states that currently have field projects evaluating the use of multiple rejuvenators. The field data, as well as laboratory data, will be used to determine what effects rejuvenators actually have on high recycled content mixtures.

help restore the balance between maltenes and asphaltenes that were changed during the aging process. As a result, the use of rejuvenating agents can improve the relaxation, ductile, cohesive and adhesive properties of the recycled binder.

Recently, some proprietary recycling agents made from bio-based oils have been marketed and sold as rejuvenating agents for use with asphalt mixtures containing high RAP and RAS contents. The specific chemical composition of these oils is not readily published

at this moment. It is expected that there will be more bio-based products like this available in the market in the near future. Table 1 provides a partial list of currently available rejuvenators arranged by category.

Recycling agents are specified according to AASHTO R14 (or ASTM D 4552), Classifying Hot Mix Recycling Agents. Based on these specifications, a recycling agent must have a low enough viscosity to mix with the reclaimed material, but must also have a sufficiently

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Table 1. Types of Rejuvenators⁸

CATEGORY	EXAMPLES	DESCRIPTION
Paraffinic Oils	Wast Engine Oil (WEO) Waste Engine Oil Bottoms (WEOB) Valero VP 165® Storbit®	Refined used lubricating oils
Aromatic Extracts	Hydrolene® Reclamite® Cyclogen L® ValAro 130A®	Refined crude oil products with polar aromatic oil components
Nathenic Oils	SonneWarmix RJ™ Ergon HyPrene®	Engineered hydrocarbons for asphalt modification
Triglycerides & Fatty Acids	Waste Vegetable Oil Waste Vegetable Grease Brown Grease Delta S*	Derived from vegetable oils *Has other key chemical elements in addition to triglycerides and fatty acids.
Tall Oils	Sylvaroad™ RP1000 Hydrogreen®	Paper Industry byproducts Same chemical family as liquid antistrip agents and emulsifiers

high flash point to be safe and must not evaporate quickly during the production and construction, or from the pavement in its early life. Lower viscosity (softer) agents can be used with recycled mixtures containing higher amounts of reclaimed materials. The ratio of the binder viscosity at 60°C is used as an indicator of the agent's durability.

Researching the Future of Rejuvenators

Texas and Alabama are two states that currently have field projects evaluating the use of multiple rejuvenators. The field data, as well as laboratory data, will be used to determine what effects rejuvenators actually have on high recycled content mixtures. NCHRP Project 09-58 is evaluating the effectiveness of rejuvenators in HMA and WMA mixtures with high RAS, RAP, or combined RAS/RAP binder ratios in

laboratory and field experiments.⁹ When these projects are completed, states and contractors will be able to understand which rejuvenators work and how they should be incorporated into asphalt mixtures for optimal mixture performance. **AP**

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