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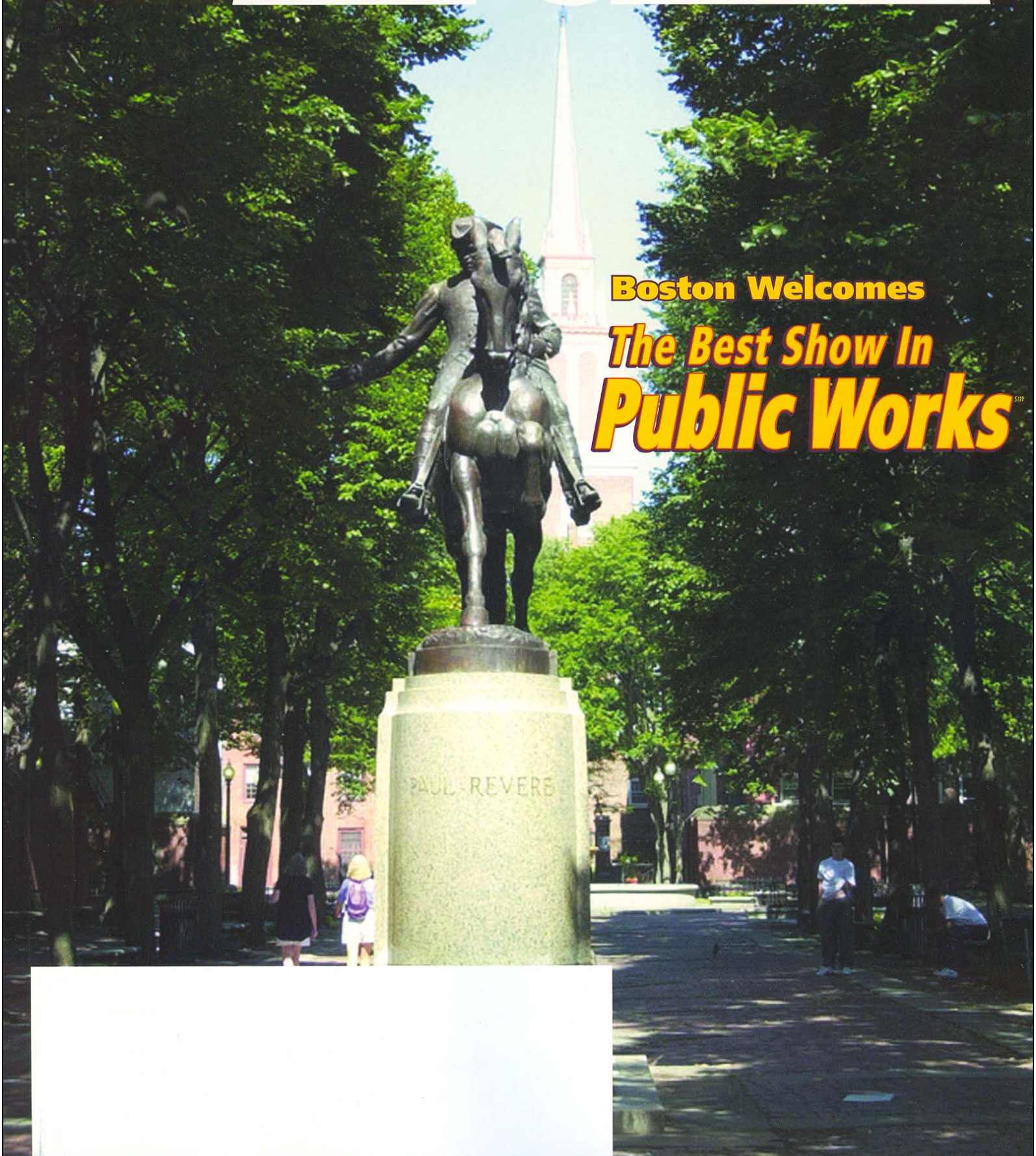

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Comparisons of rubberized asphalt binders

Asphalt-Rubber and Terminal Blend

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Introduction

This article discusses the two processes used to incorporate recycled tire rubber in hot mix asphalt and seal coats. These two processes are distinct and produce two completely different binders, namely: Asphalt-Rubber and Terminal Blend (Figures 1 and 2). Each of these binders has its own properties and unique applications.

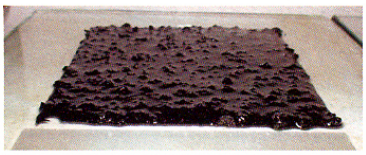

Figure 1. Asphalt-Rubber Binder

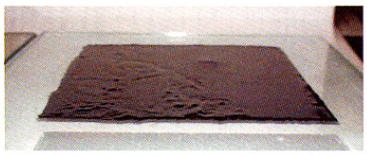

Figure 2. Terminal Blend Binder

Asphalt-Rubber

Asphalt-Rubber (Figure 1) has been successfully utilized for over 35 years and is historically known as the "wet process" and is a public domain process defined by ASTM as: "A blend of asphalt binder, reclaimed tire rubber, and certain additives in which the rubber component is at least 15 percent by weight of the total blend and has reacted in the hot asphalt binder sufficiently to cause swelling of the rubber particles."

The application of crumb rubber modifier (CRM) in asphalt mixtures is intended to improve the properties of binder by reducing the binder's inherent temperature susceptibility. During the interaction with asphalt binder, the CRM particles in asphalt-rubber absorb a portion of the oils in asphalt binder and the particles swell, therefore increasing the viscosity and stiffness of the CRM binder. This does not occur in Terminal Blend binders.

The addition of rubber into the asphalt binder increases the elasticity and resilience of the binder. It improves the durability and resistance to fatigue and reflective cracking in hot mixes and chip seal applications. Also, it enhances the chip retention in chip seals.

Terminal Blend (Modified Binder or PG 70-22TR and PG 76-22TR)

The Terminal Blend binder is a patented, proprietary rubberized asphalt binder that utilizes a fine mesh of crumb rubber blended in the refinery or stationary asphalt terminal with asphalt binder and the component materials are heated over an extended period of time. This results in dissolving of the rubber particles (Figure 2). The amount of rubber used in this process may vary anywhere between 5 to 20 percent. It is important to note that an independent test verification of actual rubber percentage has not been developed to date. This binder is manufactured similar to polymer modified asphalt. Recently the specifications used for Terminal Blend have utilized the PG grading system similar to the ones used for polymer modified asphalt.

General Comparisons

Asphalt-Rubber and Terminal Blend are distinctly different binders. Both have shown improvements over conventional binders but based on the case studies and laboratory tests cited elsewhere [1], Asphalt-Rubber exceeds Terminal Blends

in terms of its performance. Asphalt-Rubber has more performance history since this process started over 35 years ago.

There are uses for each binder. When it comes to hot mixes, one of the best uses for Terminal Blend is in DGAC whereas Asphalt-Rubber is best utilized in RAC-G and RAC-O. This is because the gap gradation and open gradation allow space for the Asphalt-Rubber particles. Asphalt-Rubber should not be used in dense graded mixes since the rubber particles can create a compaction problem because the space requirements for the particles are not there. Moreover, the lower viscosity of Terminal Blends results in lower optimum binder contents in hot mixes, that translate into less performance life.

Surface chip seals and interlayers have been performing successfully using Asphalt-Rubber. Terminal Blend's history in this area has not been long enough to provide a comprehensive understanding of its performance. However, the lower viscosity of Terminal Blend binders results in lower application rates than if the higher viscosity of Asphalt-Rubber binder is used. The lower application rates mean less binder per unit area indicating less performance life than if Asphalt-Rubber is used. The ability to inject more binder in the mix translates to better fatigue and reflective cracking performance.

It should be mentioned that both binders (Asphalt-Rubber and Terminal Blend) will still perform better than if only a conventional asphalt binder is used. It is important to consider key factors affecting performance such as binder properties and binder contents or application rates. Combining these factors together produces a positive compounding effect on the performance.

Historical Perspective

Several pioneering states, including Arizona, California, Texas and Florida, and some countries have been using recycled tire rubber in Asphalt-Rubber chip seal applications since the early 1970s, and in hot mix applications since the mid 1980s. Early trials included the use of both the Asphalt-Rubber wet process and the dry process of incorporating recycled rubber; however, most of the work completed in the 1990s and in this decade has employed the Asphalt-Rubber wet process. As a result of all of these many trials, test sections and research activities, specifications and practices have improved and construction procedures have been refined to provide consistently good performance. The superior performance of Asphalt-Rubber led to the development of reduced thickness design for Asphalt-Rubber gap graded mixes by up to 50 percent as compared with conventional dense graded mixes. Also, reflective cracking equivalencies for Asphalt-Rubber interlayers were developed by Caltrans [2, 3]. In addition, the Caltrans Maintenance Technical Advisory Guide (MTAG) considers Asphalt-Rubber chip seals as the only single application chip seal recommended for control of load-associated cracks and climate-associated cracks [4].

Material Properties and Key Specification Parameters

The performance of rubber-modified binders depends on the elastomeric properties which are influenced by the manufacturing process. It is important to achieve the required level of digestion of the rubber in the binder through adequate dispersion to create a rubber-network or matrix within the asphalt binder. The physical aspect of mixing creates a physiochemical interaction between the asphalt and the rubber.

It is difficult to compare the material properties of Asphalt-Rubber and Terminal Blend binders since the Terminal Blend process has been a moving target in terms of the amount of rubber added to the binder. Performance specifications have been used that can be met with either a polymer-modified asphalt or a combination of CRM and polymer to modified asphalt binder.

Terminal Blend technology has been evolving. The effect of heating the binder over time has not yet been clearly understood. The questions that remain to be answered include: (1) Do the binder properties degrade as a result of the extended heating over time? (2) Does the melting of the rubber particles enhance the properties and performance of the binder? (3) How well can the amount of rubber be determined in the binder? and (4) How important is the solubility requirement in the specifications?

Conclusions

It can be concluded that Asphalt-Rubber and Terminal Blend are distinctly different binders. The two binders are not equal or equivalent materials. The following are the highlights of some of these differences:

- Performance tests showed Asphalt-Rubber to have better performance than Terminal Blend.
- Asphalt-Rubber chip seal is the only single application chip seal recommended for control of load-associated cracks and climate-associated cracks per the Caltrans Maintenance and Advisory Guide (MTAG). The two binders have completely distinct specification requirements. Asphalt-Rubber has a long-established and consistent specification utilizing the same ingredient components. Terminal Blend specifications continue to evolve and change with little laboratory or field data to determine the effect of such changes.
- The Terminal Blend specifications can be met with a polymer-modified binder.
- The viscosity of Terminal Blend averages over 36 times lower than the viscosity of Asphalt-Rubber resulting in much lower application rates and binder contents which translate into less fatigue and reflective cracking resistance. Higher viscosity in Asphalt-Rubber relates to greater film thickness which provides extended service life performance.

- The rubber in the Asphalt-Rubber binder does not degrade through the curing process, opposed to Terminal-Blends, where rubber is completely dissolved.
- Fully digested rubber in a binder (Terminal Blend) does not provide for substantial resistance to load and climatic cracking when compared with an Asphalt-Rubber chip seal.
- Asphalt-Rubber binder should not be used in dense graded mixes where Terminal Blend is best utilized.
- Asphalt-Rubber has shown a long performance history in chip seals, interlayers and gap graded mixes. Terminal Blend is new, and a currently experimental product with a limited performance history concerning chip seals, interlayers, and gap grade mixes.
- Both binders provide improvements over strategies that use conventional asphalt cement.

For a full version of this article, please refer to the Rubber Pavements Association's (RPA) website at www.rubberpavements.org. A full version is also available on the Western Pavement Maintenance Association's (WPMA) website at www.westernpma.org.

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Shakir Shatnawi has a Ph.D. in civil engineering with a specialty in pavements and a master's degree in civil engineering with a specialty in construction management. He served as the Caltrans State Pavement Engineer and Chief Division of Pavement Management, responsible for the state's 50,000 lane miles of highways. His many awards include the Director's Superior Accomplishment Award for outstanding accomplishments in pavement preservation. He is currently the President/CEO of Shatec Engineering Consultants and can be reached at (916) 393-7257 or sshatnawi@sbcglobal.net.