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DRY PROCESS RUBBER IS A *MIX* MODIFIER

When rubber is used as a binder modifier, there are common misconceptions: rubber is primarily a binder modifier, and the addition of rubber is the same as binder in a mix design. In fact, there are different forms of rubber that behave differently in asphalt binders *and* mixes. The two rubber groups include vulcanized (scrap tire rubber) and un-vulcanized rubber ("polymer" additives). Rubber polymers are added to binders as modifiers, but scrap tire rubber can be added to the binder as a modifier, and it can also be added to the mix as a *mix modifier* when added as an Engineered Crumb Rubber (ECR).

POLYMERS AND SCRAP TIRE RUBBER AS BINDER MODIFIERS

Rubber polymers can include both natural and synthetic rubber compounds. When heated to sufficient temperatures for an appropriate time in an asphalt binder, these un-vulcanized rubber materials will melt, and their droplets will be dispersed throughout the binder where they react with sulfur compounds in the binder to cross-link. They are typically added in very small quantities (1-3% of binder weight), and because they melt and disperse, they are generally considered to be a part of the binder liquid. Cross linked binders help produce a more crack and rut-resistant pavement.

The vulcanized (tire) rubber used in asphalt binder and mix modification typically comes from ground scrap tires (GTR). These rubber compounds have already reacted with sulfur in the vulcanization process, and the GTR cannot melt at asphalt plant temperatures. Virtually all of the GTR added to asphalt mixes or binders remains as a granular solid in the mix after addition. These rubber additions are not binder, nor do they function as a binder. So, when we add rubber-modified binders where rubber can represent up to 20% of the weight of a modified binder, a failure to keep neat binder additions close to the design optimum can result in premature pavement failure because the mix is too dry.

In binder modification, the addition of roughly 3% by weight of neat binder SBS will provide a two-grade performance grade bump and improved cracking resistance. The addition of about 10% GTR by weight of neat binder to the binder can provide similar benefits. Percentages of both modifier types will vary somewhat based on binder characteristics.

DRY PROCESS MIX MODIFICATION

In mix modification, the addition of properly designed and applied ASTM-compliant ECR during mix production can meet or exceed the performance enhancements delivered through binder modification with GTR/polymers. These pavement performance enhancements are driven by two changes to the mix: stiffening of the mix and rubber crumb crack deflection/pinning (See Fig. 1).

Lab comparisons of unmodified, polymer-modified and rubber-modified binders shows that the presence of rubber can greatly enhance binder cracking resistance (See Figure 2).

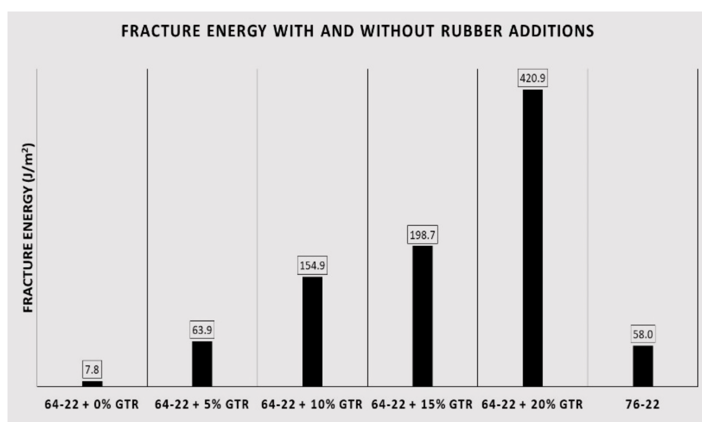

Figure 2: Increasing Binder Fracture Energy with the Addition of Rubber

The addition of crumb rubber to mixes can also increase rutting resistance (See Figure 2).

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Independent lab and field investigation of dry process rubber pavements supports the use of ECR as a mix modifier. On the NCAT Test Track (a fatigue cracking region), Section N-9 in the 21-23 Testing period A dense-grade surface mix exhibited 0% cracking and 4 mm of rut after 7.2 million ESALs.

Figure 2: Increased Rut Resistance with ECR

Researchers for the Illinois Toll Road (a 250 mile collection of Interstate Highways around the City of Chicago that is subject to heavy traffic and thermal cracking) have placed hundreds of thousands of tons of polymer and GTR-modified binder mix designs as well as Dry Process ECR mix design pavements in service within their system. The ECR-modified SMA mix designs placed in the system exhibit mix production DCT results that ranged from 650 to 1,300 J/M^2, similar to polymers and terminal blend rubber and indicating significant resistance to thermal cracking. Eight years of field deployment for ECR mixes shows polymer-modified, terminal blend rubber-modified and ECR mixes all performing comparably.

The Georgia DOT started using GTR additions as a binder, then as a mix modifier, laying the first US Interstate pavements with dry process mix modification in 2006. GDOT initially required contractors to show that pre-testing of rubber and binder proportions would pass MSCR but discovered that although rubber benefitted mix performance in the field, the MSCR results of the GTR-modified binders consistently failed (See Technical Bulletin #6). GDOT has deployed more than a million tons of ECR- Dry Process modified asphalt mixes and reports no issues with either rutting or premature cracking.

Multiple additional state DOTs have asked the same basic question: can dry process ECR mix designs perform similarly to other modified asphalt binder mix designs? TXDOT, ODOT, MODOT, VDOT, SCDOT and multiple other parties have all placed side-by-side comparisons between ECR and other modified asphalt pavements, and all report similar, comparable performance (See Figure 3).

Dry Process Mix Modification and BMD

The FHWA reports that more than 50% of all states are now at various stages of BMD adoption as the industry moves beyond SuperPave. That exodus was driven by less than optimum pavement performance caused by excessive cracking, which was in turn driven by sub-optimum binder content. Even though the binder quality was carefully regulated under SuperPave, the mixes required a better design process, hence BMD.

As a *Mix Modifier,* Dry Process ECR is an effective BMD tool. It uses a better understanding of the mix production process to enhance mix quality and simplify mix production at a significant cost discount.

Figure 3: Dry Process ECR Pavements Compared to Polymer, Terminal Blend Rubber and PPA Pavements