LIME
The Versatile Chemical

Fact Sheet

Hydrated Lime – A Solution for High Performance Hot Mix Asphalt

Asphalt pavements are a crucial part of our nation's strategy for building a high performance transportation network for the future. Asphalt construction is fast and relatively simple; it is economical, and the materials to make it are widely available. Asphalt pavements and wearing course layers can be recycled as they reach the end of their useful life. Hydrated lime is a modifier that improves performance in multiple ways to create high performance asphalt pavements. For more details, see [Sebaaly, Little, & Epps].

Hydrated Lime – A Multi-Functional Asphalt Modifier

Hydrated lime in asphalt pavements can reduce stripping, rutting, cracking, and aging. Hydrated lime substantially improves each of these properties when used alone, and also works well in conjunction with polymer additives, helping to create pavement systems that will perform to the highest expectations for many years. Typically, the amount of hydrated lime added is 1 to 2 percent by weight of the mix, or 10 to 20 percent by weight of the liquid asphalt binder. Many states - with different climates and road conditions - report that modifying hot mix asphalt with hydrated lime will add years to pavement life. Field studies confirm that lime-treated pavements last longer--for example, a Nevada study concludes that lime increases pavement life by 38%. Life cycle cost analysis demonstrates that lime is also cost-effective [Hicks & Scholz].

Mechanistic-empirical modeling further demonstrates lime's benefits in asphalt. Dynamic modulus (E*) testing of seventeen different asphalt mixtures based on six different project sites across the United States shows that the addition of hydrated lime increases the dynamic modulus of the HMA mix between 17 and 50 percent [Bari & Witczak].

Several highway agencies have proven the effectiveness of lime with cold-in-place recycled (CIR) mixtures. Lime treatment of the CIR mixtures 1) increases their initial stability which allows the early opening of the facility to traffic and 2) improves their resistance to moisture damage which significantly extends the useful life of the pavement.

Hydrated Lime is a Superior Anti-Stripping Agent

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Hydrated lime is the most effective anti-stripping agent available, and is widely specified by states with serious stripping problems. Stripping occurs when the bond between the asphalt cement and the aggregate breaks down due to the presence of moisture, and the binder separates from the aggregate. Certain types of aggregates are particularly susceptible to stripping. In addition to that chemical phenomenon, environmental characteristics such as heat, heavy rains, freeze/thaw cycles, and traffic play a major role in stripping.

When lime is added to hot mix, it reacts with aggregates, strengthening the bond between the bitumen and the stone. At the same time that it treats the aggregate, lime also reacts with the asphalt itself. Lime reacts with highly polar molecules to inhibit formation of water-soluble soaps that promote stripping. When those molecules react with lime, they form insoluble salts that no longer attract water [Petersen, et al]. Rigorous testing designed to simulate long-term performance (e.g., multiple freeze-thaw cycles) can be used to demonstrate lime's superior antistripping properties.

In addition, the dispersion of the tiny hydrated lime particles throughout the mix makes it stiffer and tougher, reducing the likelihood the bond between the asphalt cement and the aggregate will be broken mechanically, even if water is not present.

Hydrated Lime Improves Stiffness and Reduces Rutting

Rutting is permanent deformation of the asphalt, caused when elasticity is exceeded.

The ability of hydrated lime to make an asphalt mix stiffer, tougher, and resistant to rutting, is a reflection of its superior performance as an active mineral filler. Rutting is permanent deformation of the asphalt, caused when the elasticity of the material is exceeded. Hydrated lime significantly improves the performance of asphalt pavement in this respect. Unlike most mineral fillers, lime is chemically active rather than inert. It reacts with the bitumen, removing undesirable components at the same time that its tiny particles disperse throughout the mix, making the pavement more resistant to rutting and fatigue cracking.

The stiffening that results from the addition of hydrated lime can increase the PG rating of an asphalt binder. Depending upon the amount used (generally 10 to 20% by weight of liquid asphalt binder) the PG rating may increase by one full grade. In other words, a PG 64-22 can be increased to a PG 70-22. The addition of the lime will not, however, cause the mix to become more brittle at lower temperatures. At low temperatures the hydrated lime becomes less chemically active and behaves like any other inert filler.

Hydrated Lime Retards Oxidation and Aging

Oxidation & Aging occur over time to generate a brittle pavement—in particular, polar molecules react with the environment, breaking apart and contributing to pavement failure.

Another benefit that results from the addition of hydrated lime to many asphalt cements is a reduction in the rate at which the asphalt oxidizes and ages. This is a result of the chemical reactions that occur between the calcium hydroxide and the highly polar molecules in the bitumen. If left undisturbed in the mix, many of those polar molecules will react with the environment, breaking apart and contributing to a brittle pavement over time. Hydrated lime combines with the polar molecules at the time that it is added to the asphalt and thus, they do not react with the environment. Consequently, the asphalt cement remains flexible and protected from brittle cracking for years longer than it would without the contribution of lime [Petersen, et al].

Hydrated Lime Reduces Cracking

Cracking can result from causes other than aging, such as fatigue at low temperatures.

Hydrated lime reduces asphalt cracking that can result from causes other than aging, such as fatigue at low temperatures. Although, in general, stiffer asphalt mixes crack more readily, the addition of lime improves fatigue characteristics and reduces cracking. Cracking often occurs due to the formation of microcracks. These microcracks are intercepted and deflected by tiny particles of hydrated lime. Lime reduces cracking more than inactive fillers because of the reaction between the lime and the polar molecules in the asphalt cement, which increases the effective volume of the lime particles by surrounding

them with large organic chains [Lesueur & Little]. Consequently, the lime particles are better able to intercept and deflect microcracks, preventing them from growing together into large cracks that can cause pavement failure.

Hydrated Lime: Synergistic Benefits

The broad array of benefits that result from the addition of hydrated lime to hot mix asphalt work together to produce a superior, high performance product. Though the benefits have been described individually, all of them work synergistically, contributing in multiple ways to the improvement of the final product. Synergistic benefits also accrue when lime is used in conjunction with polymer modifiers. Research has shown that in some situations lime and polymers used together can produce improvements greater than each of them used alone [Mohammad, et al].

Adding Hydrated Lime to Hot Mix Asphalt

Hydrated lime can be added to hot mix asphalts in a variety of ways [National Lime Association]. As a general rule, the application rate is one percent by weight of the mix, though in cases where severe stripping is anticipated the application amount may increase. The most commonly used methods of addition are described below:

- Dry Method: This method was pioneered by the State of Georgia in the mid-1980s when the state decided to require the addition of lime to all of its hot mix asphalt. One percent hydrated lime by weight of the mix is used, and is added to the drum at the same time as the mineral filler. (Since using lime, Georgia has significantly reduced its severe stripping problems as well as the majority of its rutting problems.) Georgia has required modifications to the drum mixer to minimize the loss of lime when it is added. The hydrated lime comes in contact with the aggregate itself, directly improving the bond between the bitumen and the stone, while the balance enters the bitumen. The lime in the bitumen can react with the polar molecules that contribute to both stripping and oxidation, while simultaneously stiffening and toughening the mix. The dry method is the simplest to implement of the commonly used application methods.

  There are also other drum methods, such as ASTEC's double barrel mixer, for example. In this system, fine materials can be added efficiently because they enter the mix in a turbulence- free zone. This application method was used for several sections of the NCAT test track that included lime.

- Dry Lime on Damp Aggregate Method: This method is the one most commonly used throughout the country. It involves metering the lime onto a cold feed belt carrying aggregate that has been wetted to approximately 2-3% over its saturated-surface-dry (SSD) condition. The lime-treated aggregate is then run through a pug mill to insure thorough mixing before it is fed into the plant. Lime is applied to damp aggregate in order to insure more complete coverage of the stone than is achieved using the dry method. Lime that does not adhere to the stone is dispersed throughout the mix where it will contribute to the other improvements that have been described. The "dry on damp" method of adding hydrated lime to hot mix is also relatively simple, but driving off the water required by the process uses additional fuel and may slow down plant production to some degree. At least one state that uses this method requires the aggregate to be marinated in stockpile before use to provide additional time for the lime to react with the surface of the stone and further improve anti-stripping performance.

- Slurry Method: This method utilizes a slurry mixture of lime and water that is applied at a metered rate to the aggregate, insuring superior coverage of the stone surfaces. After the slurry is applied, the aggregate can either be fed directly into the plant or marinated in stockpile for some period of time, allowing the lime to react with the aggregate. Because the lime is bound to the stone, it is also the method that results in the least dispersion of the lime throughout the rest of the mix.

Hydrated Lime in Hot Mix Asphalt – A Growing Track Record

Hydrated lime has been renowned for many years as the premier asphalt modifier to correct stripping (moisture sensitivity) problems. As its use has grown, many other benefits have been identified, both in laboratory and field projects across the country. The need to produce high performance asphalt pavements increases the importance of lime as a multi-functional asphalt modifier. Even as the number of states specifying hydrated lime increases, research into its benefits and field procedures continues to support future applications. Highway professionals and the public demand high performance asphalt pavements and hydrated lime provides an important tool to help meet those demands.

For more information,
visit the National Lime Association's website at www.lime.org,
or contact us at asphalt@lime.org.

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