How to Add Hydrated Lime to Asphalt
An Overview of Current Methods

National Lime Association

LIME

The Versatile Chemical

September 2003

Table of Contents

List of Figures

Introduction

There are several proven and effective methods for adding hydrated lime to asphalt. Multiple methods exist because States have developed different approaches to meet their specific requirements. Highway contractors are successfully using all of these techniques.

This report provides an introduction to the following methods:

- Hydrated lime injected into drum mixer
- Hydrated lime added to aggregate in pug mill
- Dry hydrated lime added to moist aggregate with marination
- Slurry lime added to aggregate with or without marination

The descriptions are based on site visits to four states made in 2002.[1]

Although hydrated lime creates multiple benefits in asphalt, it is currently primarily used as an antistripping agent.[2] Numerous states have successfully used hydrated lime in asphalt for many years, including

State	Year Use Began
Georgia	1981
Arizona	1982
South Carolina	1983
Texas	1983
Oregon	1984
Nevada	1987
Utah	1989
California	1990
Colorado	1990
Mississippi	1991

[1] The states visited were:

STATE	METHOD
Georgia	Hydrated lime into drum
South Carolina	Hydrated lime to aggregate in pug mill
Nevada	Dry hydrated lime to moist aggregate with marination
Utah	Lime slurry with or without marination

[2] Hydrated lime in asphalt also reduces rutting, slows oxidation and age-hardening effects, and improves low-temperature cracking resistance—see Little & Epps, 2001.

Over time, these states have developed different methods of adding hydrated lime to asphalt:

State	Method of Adding Hydrated Lime to Asphalt				
	In Drum	Dry Hydrated Lime to Dry Aggregate	Dry Hydrated Lime to Wet Aggregate	Lime Slurry to Aggregate	Is Lime-Treated Aggregate Marinated?
Arizona			√*		No
California				√*	Required
Colorado			√*	√	Optional
Georgia	√	√**			No
Mississippi			√		No
Nevada			√		Required
Oregon			√*		Optional
South Carolina			√*		No
Texas	√		√*	√	No
Utah				√*	Optional

* Hydrated lime and wet aggregate mixed in pug mill
** Hydrated lime added this way for both batch and drum plants

Other states also use hydrated lime in asphalt, including Florida (injecting hydrated lime into the drum or adding lime slurry to aggregate), Montana (injecting hydrated lime into the drum), Wyoming (adding dry hydrated lime to wet aggregate), New Mexico (adding dry hydrated lime to wet aggregate), and South Dakota (adding dry hydrated lime to wet aggregate).

States have developed specifications and procedures that are tailored to local materials and the capabilities of construction firms and equipment. Nevertheless, all of these methods have proven successful in producing asphalt mixes with enhanced performance. This record indicates that regardless of the method used, hydrated lime effectively reacts with both the aggregate and the binder in asphalt mixes.

The list of resources at the end of this report provides additional information on the use of hydrated lime in asphalt and contact information for technical experts within lime companies.

Hydrated Lime Injected Into Drum

This section provides an overview of injecting hydrated lime into an asphalt drum mixer. In the early 1980s, the method of introducing hydrated lime into hot mix asphalt (HMA) in Georgia was to inject the hydrated lime in the drum mixer just "downstream" of the point at which the asphalt binder was injected. Introducing hydrated lime close to the asphalt was intended to reduce the amount of hydrated lime that would be carried out with exhaust gases into the baghouse. Some critics felt hydrated lime was being enveloped in asphalt binder instead of coating aggregate surfaces. At the same time, the performance of new asphalt pavements was questioned and drum mixers generally came under fire. The proposition was that light ends were being stripped out of asphalt cement in the drum mix process.

The HMA plant industry responded to criticism about light end stripping by developing counter flow drums to keep the hot exhaust gases away from the binder and hot aggregate mixing zone. One such system has an additional length of drum behind the burner zone. Mixing takes place in this extended part of the drum. Another such system is the double drum system, which wraps the external mixing zone around the aggregate drier/heater drum. The configuration is a drum within a drum--the outer shell is static and the inner drum rotates while drying and heating aggregates. Asphalt binder and hydrated lime are injected into the area between the two drums to mix with the hot aggregates in a zone where there are no hot exhaust gases to harm the liquid asphalt binder. Because there is no positive pressure in the mixing part of the double drum, hydrated lime entrainment into exhaust gases and baghouse fines are minimized.

The photos illustrating this process are from a plant in Georgia equipped with a new double drum system. There are two silos, one for hydrated lime and the other for mineral filler or fly ash (Figure 1). The hydrated lime silo has a capacity of 60 tons and is replenished pneumatically by road tankers. The hydrated lime feed is typical for this type of plant: the weigh pot dispenses 450 pounds of hydrated lime through a rotary vane feeder that feeds hydrated lime into a screw conveyor and is then injected into the outer shell of the double drum (Figure 2). The entry point for the hydrated lime is about one meter before the point at which the asphalt binder is injected on the other side of the drum. The amount of hydrated lime used is typically 0.9 percent of total mix.

The hydrated lime silo has an aeration system equipped with a dehumidifier to prevent bridging of hydrated lime above the feed point. The air inlet is located about three feet above the cone of the silo and blows ambient air into the silo whenever the hydrated lime-metering system is in use. The silo is also equipped with a small filter baghouse on top to prevent loss of hydrated lime on refilling or aerating.

Figure 1: Double drum mixer & two silos, one for hydrated lime and the other for mineral filler or fly ash.

Figure 2: Weigh pot (1) dispenses hydrated lime through rotary vane feeder that feeds hydrated lime into a screw conveyor (2) and is then injected into outer shell of double drum (3).

Hydrated Lime Added to Aggregate in Pug Mill

This section provides an overview of adding hydrated lime to aggregate in a pug mill. The photos illustrating this application (Figure 3) are from a plant in South Carolina. The hydrated lime storage silo has a capacity of about 35 tons, which is enough for one day's production of HMA. The silo is replenished by pneumatic delivery from road tankers. Hydrated lime is dispensed from the silo through a weigh pot (Figure 4) and transferred to the pugmill by a conventional screw conveyor.

Figure 3: Hydrated lime added to aggregate & mixed in a pug mill.

The South Carolina DOT specification for hydrated lime systems calls for a water delivery system to be mounted over the aggregate belt conveyor so that aggregates have a water content of at least 3 percent (total) before being mixed with hydrated lime.[3] Specifically, the specification requires "all virgin aggregates being fed to the plant shall pass under the spray bar. The spray bar shall have a minimum of 3 nozzles equally spaced across the width of the conveyor belt."[4] (The gray pipe in Figure 5 shows the location of the spray bar at this plant.) All hydrated lime systems must be approved by the state engineer.

[3] In practice, aggregates may already contain enough water so that additional water is not needed.
[4] South Carolina also allows a slurry system instead of the damp aggregate system.

Figure 4: Hydrated lime is dispensed from the silo through a weigh pot

Figure 5: Water delivery system mounted over aggregate belt conveyor (see arrow)

Hydrated lime is mixed with dampened aggregate in a twin-shafted pugmill. From the pugmill, the hydrated lime-aggregate material is transferred to the drum mixer. At this plant, hydrated lime is included in all mixes at a concentration of one percent by mass of virgin aggregate. All baghouse fines are returned to the mix to ensure that no hydrated lime is lost.

Dry Hydrated Lime Added to Moist Aggregate with Marination

This section provides an overview of treating moist aggregate with dry hydrated lime followed by marinating the treated aggregate. The procedure is illustrated by a plant in Nevada. Hydrated lime is transferred pneumatically from supply tankers into an 80-ton vertical silo (Figure 6). The

Figure 6: 80-ton vertical silo for hydrated lime.

hydrated lime from the silo is fed through a rotary vane feeder at the base of the silo onto a weigh belt. From there the hydrated lime is moved by a screw conveyor and discharged into a twin-shafted pugmill for mixing with the aggregate fraction (coarse or fine) of the intended mix.[5] The required hydrated lime application rate in the Nevada DOT specification is not less than 1 percent and not more than 2.5 percent of the mass of the dry aggregate. At the point of hydrated lime entry into the pugmill, water is added as needed at a rate according to the stockpile moisture content of the limestone aggregate. Nevada DOT recommends the moisture content be 3 percent (above SSD[6]) for coarse aggregates and 6 percent (above SSD) for fine aggregates for the pugmill mixing step. However, the actual amount of moisture has to be approved. The intent

[5] Some plants apply lime to aggregate using on-belt mixers and wind guards.
[6] SSD = saturated-surface-dry.

is to ensure there is sufficient moisture available to thoroughly wet the aggregate and activate the hydrated lime. The pugmill is required to be configured to alter the mixing pattern and rate of flow to ensure the aggregate is thoroughly coated with hydrated lime.

The hydrated lime-coated aggregate discharges from the pugmill onto a transfer conveyor for stockpiling (Figure 7). Nevada DOT requires stockpiles to marinate for at least 48 hours. Nevada DOT requires the marinated aggregate to be used within 45 days.

Figure 7: Hydrated lime-coated aggregate stockpiled to marinate.

Lime Slurry Added to Aggregate Without Marination

This section provides an overview of treating aggregate with lime slurry. The method is illustrated with photos from two plants in Utah.

The first plant is equipped with an 80-ton vertical hydrated lime storage silo, which is refilled pneumatically via an underground pipe because of restricted access (Figure 8). Hydrated lime is

Figure 8: 80-ton hydrated lime storage silo, which is filled pneumatically via underground pipe because of restricted access.

metered volumetrically through a calibrated rotary vane feeder into a screw conveyor and water is introduced via a number of nozzles, which are located above the screw conveyor (Figure 9). The hydrated lime-treated material is discharged from the pugmill onto a conveyor belt for transit to the drying, heating, and mixing process.

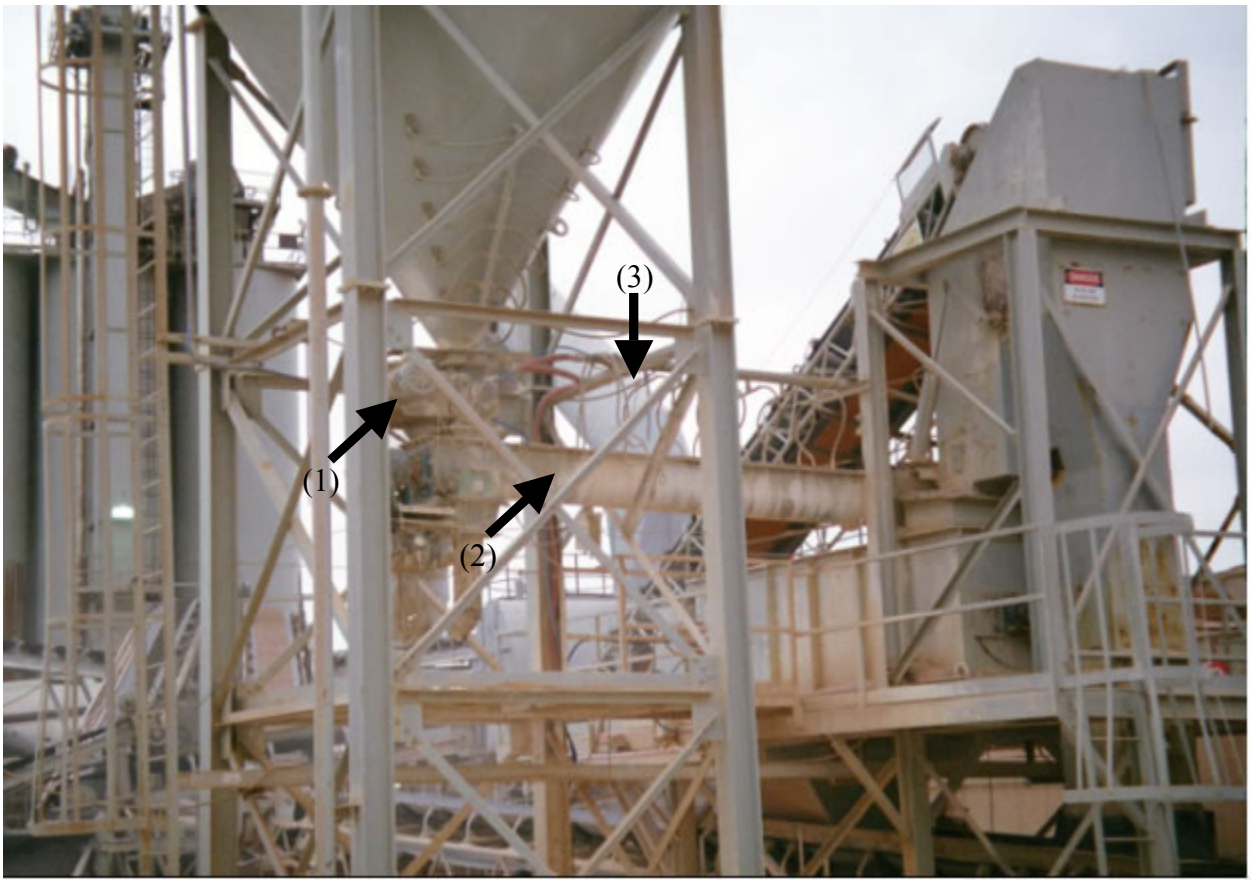

Figure 9: Hydrated lime metered volumetrically through calibrated rotary vane feeder (1) into screw conveyor (2). Water introduced via nozzles located above the screw conveyor (3).

At the second plant, the hydrated lime storage silo has a capacity of 50 tons and has a weigh pot at the base, feeding hydrated lime to a rotary vane feeder and raised by screw conveyor to a vertical cylindrical tank. A hydrated lime slurry is formed in this tank. Aeration is used to keep the hydrated lime in suspension.[7] From the lime solution tank, the slurry is fed by gravity to a twin-shafted pugmill where mixing with the aggregate occurs (Figure 10). The treated aggregate then goes to the dryer drum (Figure 11).

[7] Agitation of the solution was formerly accomplished by means of a propeller. However this was discontinued because of bearing problems in the propeller and general agglomeration of lime.

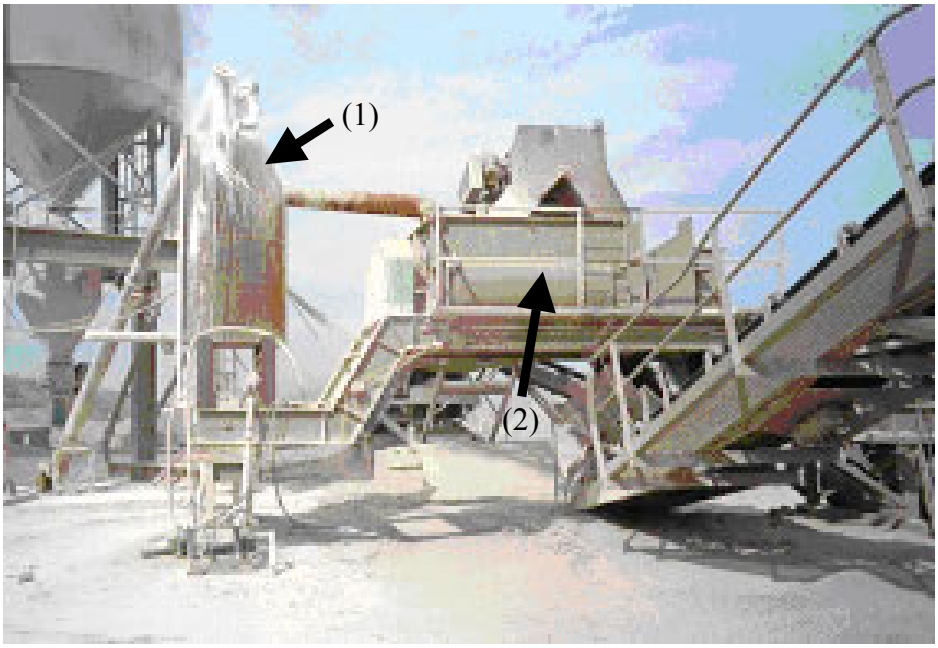

Figure 10: Lime slurry is formed in solution tank (1). Mixing of lime slurry and aggregate occurs in the pugmill (2).

Figure 11: Lime-treated aggregate headed to dryer drum.

Hydrated Lime Storage and Feeding[8]

It is considered good practice in the HMA industry to use a silo large enough to hold two truckloads of hydrated lime. This allows delivery of a whole truckload without waiting for the silo to completely empty and consequently being shutdown while waiting for lime delivery.

There are two different types of feed systems to move measured amounts of hydrated lime from the silo into the process: "volumetric" and "mass flow." The mass flow system is the more consistently accurate of the two. The volumetric system is subject to variations in feed rate due to changing bulk density of hydrated lime, depending upon how long it has been in the silo, how much aeration is being used, and how much material is in the silo. Using a vessel, like a weigh pot, not mounted on load cells is good practice for a volumetric system. It eliminates the head of material in the silo as a factor influencing bulk density.

When adding hydrated lime to the cold feed in a continuous process, as in Utah, it is best to add the hydrated lime downstream of the conveyor's belt scale. This is done to eliminate influence on liquid asphalt content through the plant's control system.

[8] General guidance on lime handling is available from the publication "Lime Handling, Application & Storage," (Bulletin 213) available from http://www.lime.org/publications.html .

List of Resources

National Lime Association Asphalt Publications (http://www.lime.org/publications.html):

Hydrated Lime – A Solution for High Performance Hot Mix Asphalt: fact sheet that summarizes hydrated lime's multifunctional benefits in asphalt (2001, 4 pp.).

Hydrated Lime - More Than Just a Filler: short technical paper summarizing research that demonstrates hydrated lime's multifunctional benefits in asphalt (2001, 15 pp.).

The Benefits of Hydrated Lime in Hot Mix Asphalt, Literature Review (Volume 1) by Dallas N. Little & Jon A. Epps: comprehensive literature review of hydrated lime's multi-functional benefits in asphalt: reduce stripping and water sensitivity; increase mix stiffness and reduce rutting; diminish oxidation and age-hardening effects; and improve low-temperature cracking resistance (2001, 49 pp.).

Life Cycle Costs for Lime in Hot Mix Asphalt, by R. Gary Hicks and Todd V. Scholz:

- *Life Cycle Cost Analysis (LCCA) Software for Pavement Design*: Windows-based application to perform economic analyses of pavement alternatives. Designed for new construction or rehabilitation projects (available as download or on CD).
- *Volume 1, Summary Report*: summary of life cycle costs for pavements with and without hydrated lime, based on interviews with numerous state and highway construction engineers (2003, 33 pp.).
- *Volume 2, Appendices*: supporting data for Volume 1 (2003, 160 pp.).
- *Volume 3, LCCA Software User's Guide* (2003, 54 pp.).

Lime Handling, Application & Storage: solutions to process problems, discusses the pros and cons, limitations and attributes of various types of equipment used in highway construction and other applications (1995, 109 pp.).

Hydrated Lime Suppliers: http://www.lime.org/usstate.html

Other References:

Nevada DOT Field Study (http://www.wrsc.unr.edu/WRSCMoisture_files/report.pdf): hydrated lime increases pavement life by an average of 38%.