LIME ASSOCIATION OF TEXAS

Stabilizes Susubgrade Soils • Enhances Poor Base Material • Increases Strength

• Dries Wet Soils • Provides Working Platform • Economical Benefits •

• Permanent • Flexible • Workability • Allows Use of Local Materials •

LIME:

A Quality Partner In The Texas Construction Industry

Combats Stripping In Hot Mix • Reduces Rutting • Active Mineral Filler

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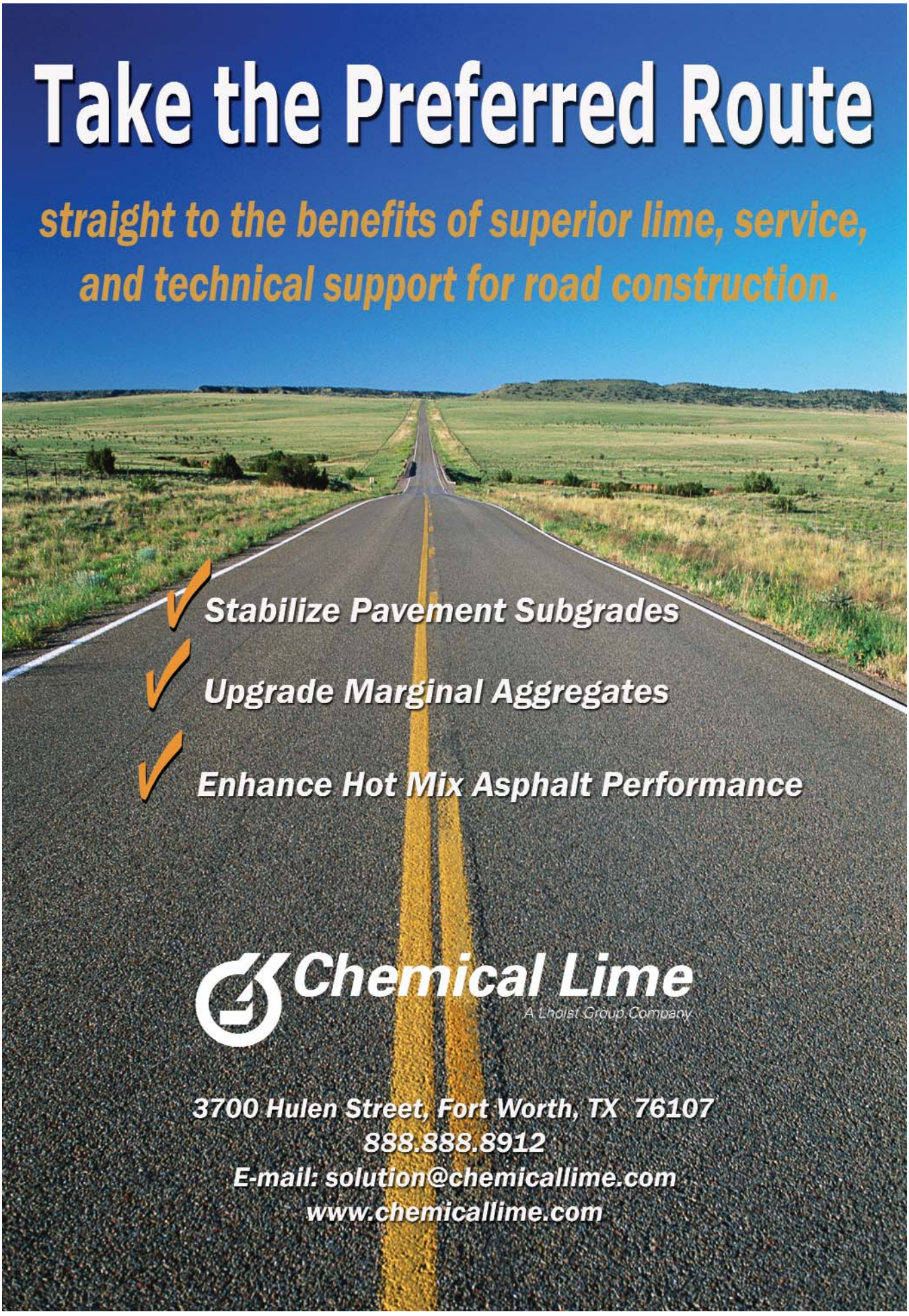
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Lime Association of Texas

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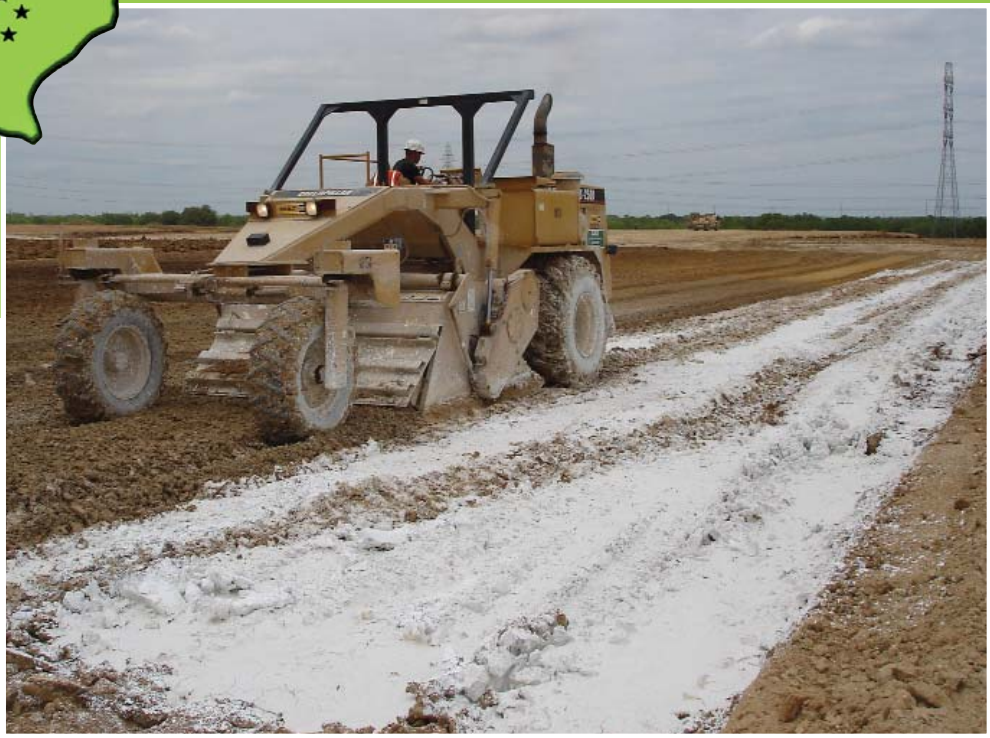


President's Message

Our job is to continue to fund research for improvements and provide learning tools to our partners in government and the construction industry, which offer more cost-effective construction methods with the use of lime.

Dear Colleagues in the Texas Construction Industry,

The Lime Association of Texas members, Texas Lime, Chemical Lime, and Austin White Lime are fortunate to be part of the Texas construction industry for lime needs ranging from masonry to soil stabilization and asphalt. Texas growth trends require continuous development of homes, offices, factories and highways to facilitate our families, our workers and the traffic of goods in this great state.

Texas pavements are being subjected to shorter life expectancy due to increasingly heavier loading with fewer maintenance dollars. Now more than ever, a uniform lime stabilized subgrade better utilizes money spent on pavement by assisting the pavement in reaching the intended design life. Additionally, where pavements have been constructed through areas of problem soils, especially expansive clays, lime has proven the best economic alternative. We highly recommend pre-construction soil testing at appropriate intervals in the project to achieve ultimate results.

Increasing the life of asphalt pavements has been another goal of the Lime Association of Texas. Laboratory and field studies performed by numerous states have proven that modifications made to hot mix asphalt with hydrated lime can reduce stripping, rutting, cracking and aging. Hydrated lime is also used for recycling asphalt pavement. We believe this saves dollars for use in future new construction projects.

While we are fortunate to be in a growth market, we are also living and working during a time of financial burdens felt by every level of government, from whom we are dependant for working relationships and funds. We can do our part in reducing government costs by producing quality products that will extend the life of buildings and roads, as well as, reduce maintenance cost throughout the years. Our job is to continue to fund research for improvements and provide learning tools to our partners in government and the construction industry, which offer more cost-effective construction methods with the use of lime.

We invite you to visit our website at www.limetexas.org for more information about us and helpful links to assist you with your lime applications.

Best regards,
Oscar Robinson, President
Lime Association of Texas

Message From

Mike Behrens - TxDOT Executive Director

The Texas Department of Transportation and its industry partners are constantly working together to make sure that mobility for Texans, both private citizens and commercial industries, is a reality.

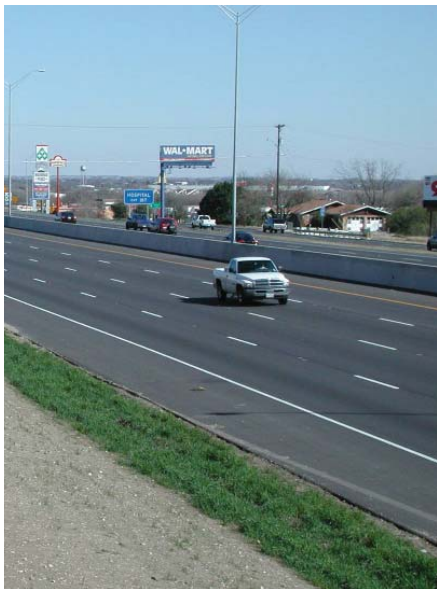
Mobility is certainly one of the key ingredients to ensure that the growing number of citizens living and moving to our great state will continue to enjoy the quality of life we have all come to expect. This is no easy task considering the population of Texas will exceed 30 million people by the year 2025.

The Texas Department of Transportation and its industry partners are constantly working together to make sure that mobility for Texans, both private citizens and commercial industries, is a reality. Meeting this challenge requires vision, innovation and determination. It also requires teamwork between the department and the various industry players. Well thought out pavement designs require good contractors and good material suppliers working together to make sure that we build high-quality, long-lasting pavements.

Texas is fortunate to have suitable reserves of raw materials available for use in maintaining and expanding our highway system. These materials, through the efforts of quality-minded industry members, can be processed into high-quality building materials. Together with TxDOT's prudent use of the right material for the right job and contractors' use of good construction practices, we can stretch our dollars further as we embark on building new highways and rehabilitating existing ones.

The lime industry is one of the numerous materials industries that the Texas Department of Transportation has counted on for supplying a consistent, high-quality product. For decades, lime has been used successfully to treat expansive clays in our pavement subgrades, enhance base materials and effectively mitigate stripping in our hot-mix asphalt pavements. TxDOT will continue to count on members of the Lime Association of Texas to help us successfully meet the mobility challenges of the future.

Multi-functional Performance of Hydrated Lime



Fatigue tests routinely demonstrate that asphalt mixtures containing hydrated lime can accommodate considerably more fatigue without failing than can mixtures made with common fillers

Hydrated lime has been studied in laboratories and the field for more than 40 years. During that time it has earned the reputation as the premier asphalt additive to mitigate moisture sensitivity. In addition, lime contributes benefits to asphalt pavements ranging from improved rutting and fatigue resistance to retarding the rate at which pavements oxidize and age. An excellent survey of hydrated lime's benefits titled, "The Benefits of Hydrated Lime in Hot Mix Asphalt" was written by Drs. Dallas Little and Jon Epps for the National Lime Association (NLA). The paper can be downloaded from the NLA's website at www.lime.org. Following is a summary of some of hydrated lime's benefits:

Moisture sensitivity Hydrated lime mitigates moisture sensitivity in two major ways. First, when applied to the surface of aggregates (particularly siliceous aggregates) it improves compatibility between the binder and aggregate (Kennedy and Ping, 1991). Lime also reacts with acid components of the asphalt binder to create insoluble calcium salts that are hydrophobic. The elimination of the acid components in the binder promotes the formation of strong nitrogen bonds between the asphalt and the aggregate (Petersen, 2005).

Fatigue resistance and fracture toughness As described above, hydrated lime reacts with acid components of the asphalt binder by adsorbing them onto the surface of the calcium. The newly formed compounds have a greater effective volume than the traditional fillers that comprise the asphalt mastic. The calcium based particles intercept micro-cracks and deflect them, preventing the formation of macro-cracks. Fatigue tests routinely demonstrate that asphalt mixtures containing hydrated lime can accommodate considerably more fatigue without failing than can mixtures made with common fillers (Little and Petersen, 2005).

Rutting resistance Hydrated lime is a very fine powder that often has more than 50 percent of its bulk smaller than 5 microns. Those small particles disperse throughout the asphalt mastic stiffening the mix through the "filler effect." That stiffening effect has been shown to be substantially greater at

high temperatures than equivalently sized traditional fillers but does not adversely affect the low temperature properties of the mix. At low temperatures, hydrated lime's activity is reduced and it behaves as a traditional filler (Lesueur et al, 1998).

Oxidation and aging The reactions between hydrated lime and the acid components of asphalt binders reduce the viscosity producing components of the asphalt. As a consequence, the asphalt binders retain greater ductility for a longer period of time than they would otherwise. That greater ductility represents a reduced rate of oxidation in the pavement along with a reduction of the brittleness that contributes to cracking (Petersen et al, 1987).

Life-cycle improvement The synergistic benefits that the addition of hydrated lime contributes to asphalt pavements combine to extend the life of the pavements. A study completed for the Nevada Department of Transportation compared the field performance of equivalent pavements with and without lime modification using laboratory tests and analysis of the state's pavement management records. The study concluded that lime's contributions extended the customary eight year life of the pavements by an average of three years. The savings attributed to the additional pavement life, along with savings resulting from reduced maintenance totaled 38 percent compared to a 12 percent higher first cost for the asphalt mix (Sebaaly et al, 2001). Another study modeled life cycle costs of lime treated pavements versus non treated pavements based upon actual data provided by the Federal Highway Administration, ten states, and ten contractors. The analysis identified life cycle cost savings ranging from "$2 to $4 per square yard; or, $14,000 to $30,000 per lane mile [3 percent to 40 percent of project life cycle costs]" (Hicks and Scholz, 2001). The cost savings were based solely on an analysis of moisture sensitivity and did not consider the numerous other benefits of hydrated lime which would further increase the life cycle benefits.

In the final analysis there is no doubt that hydrated lime is not only the best moisture sensitivity additive available, but also an additive that contributes many other benefits to asphalt pavements. Those benefits work together synergistically to extend pavement life and improve performance. Even the best liquid antistripping additives only affect the adhesion between bitumen and aggregate. Studies that compare hydrated lime and liquid antistripping additives over multiple freeze/thaw cycles conclude that ultimately lime lasts longer and performs better (Kennedy and Ping, 1991). Considering the many other benefits that hydrated lime contributes to asphalt mixtures, it is undoubtedly the best choice for high-performance pavements.

References

The Lime Association of Texas will provide copies of the following papers on request.

1. Hicks, R.G. and Scholz, "Life Cycle Costs for Lime in Hot Mix Asphalt," National Lime Association, 2001.

2. Lesueur, D., Little, D. N., Epps, J. A., "Effect of Hydrated Lime on the Rheology, Fracture and Aging of Bitumen and Asphalt Mixtures," paper presented at Lhoist HMA Symposium, Dusseldorf, Germany, June 1998.

3. Little, D.N. and Epps, J. A., "The Benefits of Hydrated Lime in Hot Mix Asphalt," National Lime Association, 2001.

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5. Kennedy, T. W. and Ping, W. V., "Evaluation of Effectiveness of Antistripping Additives in Protecting Asphalt Mixtures from Moisture Damage," Journal of the Association of Asphalt Paving Technologists, from the Proceedings of Technical Sessions, 1991.

6. Petersen, J. C., "Mechanism of the Hydrated Lime - Asphalt Reaction: Its Effect on Pavement Moisture Resistance, Asphalt Age-Hardening and Physical Properties," presentation at North Carolina State University, February 2005.

7. Petersen, J. C., Plancher, H., Harnsberger, P. M., "Lime Treatment of Asphalt to Reduce Age Hardening and Improve Flow Properties," AAPT, Volume 56, 1987.

8. Sebaaly, P. E., McCann, M., Hitti, E., Epps, J. A., "Performance of Lime in Hot Mix Asphalt Pavements," Nevada Department of Transportation, 2001.

TxDOT's Use of Lime in Hot Mix

The author, Dale Rand, is flexible pavements branch director for TxDOT.

The Texas Department of Transportation has relied on the use of lime for many years to improve the performance of our pavements. The performance of many local paving materials can be improved with the addition of lime. Most engineers and designers are well aware of the benefits that lime provides in terms of soil and base stabilization; however, fewer are aware of the positive benefits that lime can provide when used in hot mix. TxDOT uses lime in hot mix for three primary reasons. The first is to provide resistance to moisture damage, the second is to act as mineral filler, and the third primary reason is to provide stiffness to the binder when needed.

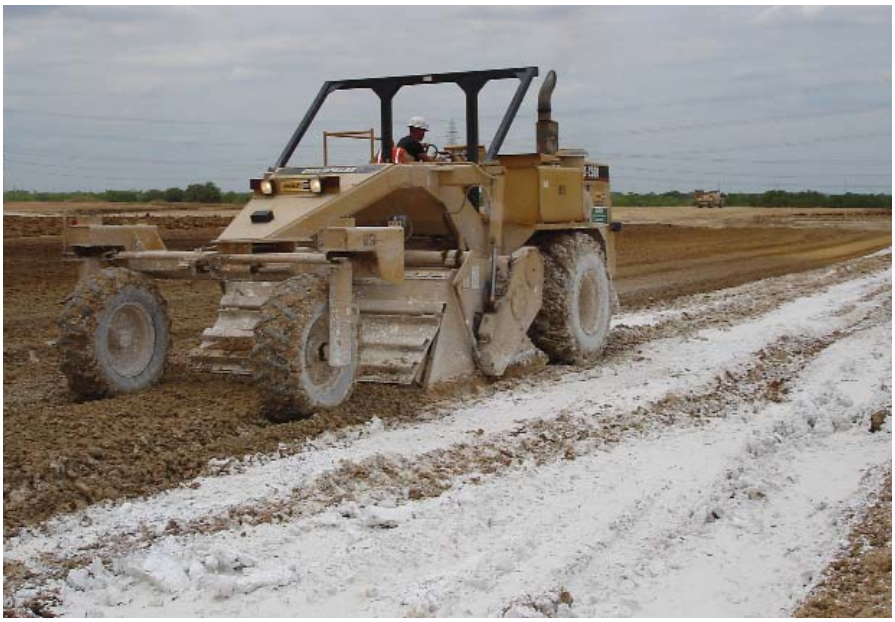
The use of lime has shown the ability to dramatically improve the Hamburg Wheel Track test results. In recent years, TxDOT has implemented the Hamburg Wheel Track test in most of our standard specifications. As a result, we have seen both rutting and moisture damage diminish on pavements in Texas. Lime can be credited for part of this success along with the fact designers are doing a better job of evaluating hot mix designs with the Hamburg test to see what works best. The real key is to match aggregates, asphalts, additives (when necessary) that are chemically and physically compatible. Lime is not a panacea to all rutting and moisture damage problems in hot mix but TxDOT's Hamburg database of approximately 3,000 tests clearly shows that lime very often dramatically improves the mixture performance.

In the past 5 years, TxDOT has dramatically increased the use of specialty mixes such as Permeable Friction Course and Stone Matrix Asphalt. Lime is often an important component in these type of mixes. PFC mixes have a high asphalt film thickness. The high asphalt film thickness tends to cause freshly placed PFC mixtures to act somewhat tender. Lime is added to PFC not only to provide resistance to moisture damage but also to provide more stability to the binder. The stiffening effect provided by the lime helps overcome this tenderness issue and also enables the freshly placed mix to be opened to traffic quicker. Lime is often used in SMA mixes for similar reasons to why it is used in PFC mixtures; however, lime also functions as a mineral filler in SMA mixtures.

The versatile properties of lime provide a variety of benefits in the paving industry. The benefits of lime in flexible pavement systems range from modification or stabilization of the subgrade and base to providing resistance to moisture damage, functioning as a mineral filler and providing stability to hot mix asphalt mixtures with high film binder film thicknesses such as PFC and SMA.

Testing and evaluation of paving materials is the key to knowing if and how lime or any other additive can provide improved performance. The wide range of local paving materials in Texas presents many challenges to the highway construction industry. Engineers and designers continue to rely on lime to meet these challenges by improving the performance local paving materials.

Tough Trucks - Tough Lime-Treated Subgrade



"The workability in construction and effectiveness of using lime in soil of this type has been very helpful to the contractor and the success of the project thus far."

Profile of Fred Tucker - Chemical Lime Company

A Lifelong Career in the Highway Construction Industry

Fred admits Texas is his love and being back here with the road and highway contractors is a real pleasure. He says the old friends he already had and the new ones he meets is what "keeps an old salesman going."

It is almost impossible to travel around in Texas, Nevada or Colorado and talk to a highway contractor or supplier who doesn't know Fred Tucker. Whether by accident or on purpose, Fred has dedicated a career to working in the highway construction industry. For over 45 years, Fred has been making his rounds in a number of sectors in our industry, with the last 18 at Lime Association of Texas member Chemical Lime Company.

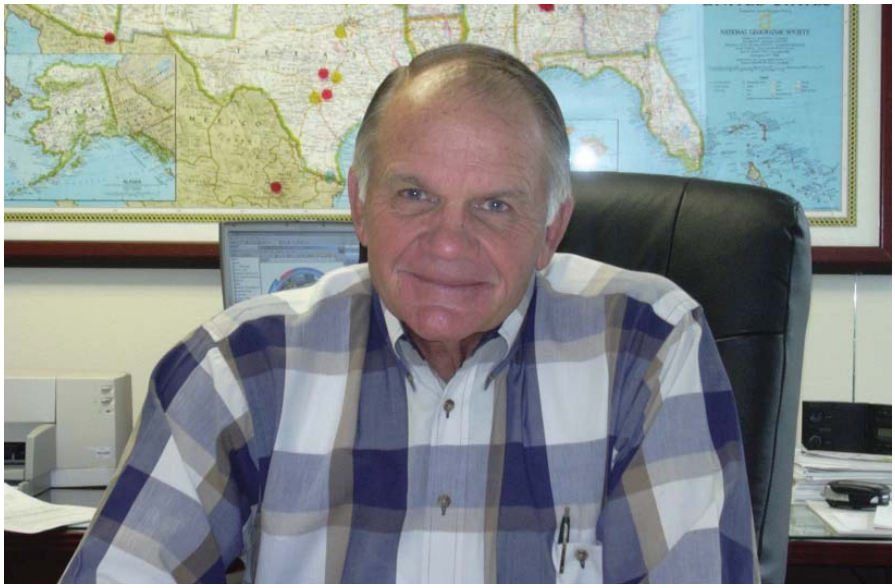
Fred was born in Fort Worth 68 years ago. He was raised in Waco and then moved to the then relatively small town of Arlington in 1952. He graduated from Arlington High and went to four colleges (Arlington State, TCU, Texas Tech and Adams State). Fred said colleges and he didn't agree with each other, but he still received an associate's of science degree from Arlington State in 1958. It was while attending Arlington State and TCU that Fred got his first taste of highway work, and whether he knew it or not, he was hooked. During that time he worked afternoons and summers for T.L. James Construction building the DFW toll road now known as IH-30. He remembers it as "working your way from up from the bottom." He started as a laborer and moved to operating equipment, the first piece being a form grader. Then, when nobody was around, he ran a scraper. During his final summer he operated a spreader and finishing machine on the concrete paving crew. Fred says the experience he gained from that job has been very valuable to him.

In 1960 Fred went to work for Austin Paving Company in the estimating department. When an asphalt manager became ill, they had Fred fill in for him. The manager was unable to return so it became a full-time position. Fred was overseeing three hot-mix plants in Dallas County and about 75 people. Eventually he became general superintendent over the asphalt and concrete divisions. He worked for Austin Paving Company for 25 years.

In 1973 while at Austin Paving, Fred had his first experience with his eventu-

al employer, Chemical Lime Company. Charlie Cook, with Chemical Lime Company, made a sales call to Fred. Chemical Lime had just started a plant in Clifton and needed some business. At the time, very little lime was being used in the Metroplex. It started to really catch on, however, and Austin Paving was one of the first companies to use Halliburton's Jet Valves to slurry Hydrate. As more cities and towns in the DFW area specified lime in their subgrades, Fred's employers became one of Chemical Lime's biggest customers in that part of the state.

Fred left Austin Paving in 1985 and after a brief stint at Uvalde Paving he received "the best phone call of his life." It was Charlie Cook asking Fred if he would like to go to Nevada and work for Chemical Lime Company. Fred had never been in sales and thought it would be a great challenge. He spent his first five years in Las Vegas, which was a real experience, and worked throughout Nevada, New Mexico, Colorado, Idaho, northern California and western Wyoming. His main customers were construction companies and gold mines. Lime was used as a pH control for the cyanide used to extract the gold from the crushed ore. Fred saw the development of lime in subgrades blossom some with one of the brightest being the development of Denver International Airport. To date, DIA is still one of the largest lime jobs in history and Chemical Lime played a big role in it, at one time shipping lime from three different plants. Fred recalls Zachry Construction as being one of the contractors and that it was a real pleasure to do business with a Texas company.



Fred enjoyed his time in the West and was able to see some beautiful country. From the deserts to the beauty of western Wyoming and the mountains and lakes of Idaho, Fred enjoyed the natural surroundings. He made many good lifelong friends while there and enjoyed stories from the old timers about growing up in the West and the hardships many routinely experienced in such wild country. He says watching people pan for gold in the mountain streams is a sight to see.

Fred returned to Texas in 1993 and was over slurry operations in Dallas and Houston as well as dry sales for all of Texas. In addition, he oversaw an operation purchased in Baton Rouge, La., and serviced the steel mills in Blytheville, Ark. He became involved in the Rio Grande Valley when CLC bought APG lime. The Valley, Fred says, was "an experience all of its own."

Fred admits Texas is his love and being back here with the road and highway contractors is a real pleasure. He says the old friends he already had and the new ones he meets is what "keeps an old salesman going." Fred says that his involvement with the Texas Asphalt Pavement Association, the Board of Directors of the Lime Association of Texas, AGC of Texas and working with the many TxDOT, city and county officials has been very rewarding. He appreciates the technical support he has always received from Chemical Lime Research folks and likens it to being able to call 911 for help. His last nearly two decades with Chemical Lime have been very enjoyable and an experience that one could only dream about. He only wishes he were younger and could do it all over again.

The next time you see Fred, congratulate him for his career of service to our highway construction industry. He certainly has earned it.

Tips On Storing Lime For Laboratory Testing

Importance of Proper Storage

When using lime in the laboratory for design, it is critical that the lime is as fresh as possible. The term "Lime" is used to describe two different products, "quicklime" (CaO) and the hydrated form "Hydrate" (Ca(OH)2). Quicklime is normally in a pebble or granular form while hydrate is a fine white powder. Each of these will react with products in the atmosphere and degenerate with age. With proper handling, the degeneration can be held to a minimum. It is important to keep all lime dry and in airtight containers. If lime is exposed to moisture or CO2, the following reactions can occur.

CaO + H2O -> Ca(OH)2
Ca(OH)2 + CO2 -> CaCO3

Storage

1. It is best to purchase no more than a four to six month supply of lime at a time.
2. Upon receipt, the total supply should be transferred from bags into airtight containers, five-gallon buckets are recommended. The date received should be marked on each container.
3. It is helpful to "tap" the full buckets on the ground to achieve some degree of lime settling. This compaction will help limit atmospheric exposure of the lime below the surface.
4. A smaller "lab" container is needed to hold the lime used in day-to-day testing.
5. The lab container must also be airtight and should hold a one to two week supply (one gallon). The use of a lab container avoids exposing the lime supply to the atmosphere and limits the number of times a storage bucket must be opened. The storage bucket only needs to be opened a couple of times a month rather than daily.
6. These care measures are important for both quicklime and hydrate. The presence of moisture catalyzes carbonation, so it is especially important for hydrate, which inherently contains moisture.

Use/Sampling

1. Each time lime is transferred from a storage container to a lab container the top .5 to one inch of lime should be discarded.
2. Before each testing job, the top .5 to one inch of lime should be discarded from the lab container.
3. Prior to transferring lime from a storage container to the lab container, all lime remaining in the lab container should be discarded.
4. No container should be left open when not being used. If a bucket is to be unused for 10 minutes, close it tight!

Quick Method for Testing Lime Carbonation/Aging

This is a quick test that can be performed before each testing job. As little as one percent CaCO3 can be easily detected using this fast and easy test.

TEST:

1. Add approximately 0.5g of lime to a small beaker.
2. Add approximately 15 mL of 10 percent HCl acid and swirl.
3. While swirling, listen for a fizz.

When 10 percent HC1 acid is added to lime in a beaker, a fizz will be heard and seen as CO2 is effervesced. With only a slight fizz, the lime can be over one percent carbonated and a new sample should be used from storage.

Due to the simplicity of this test, there are limitations. The laboratory technician needs to remember that a "fresh" lime can contain a measurable amount of CaCO3. While it is possible, and most desirable, to have no detectable effervescence, even potent limes can have a detectable fizz. Since a fresh lime can contain over 0.5 percent CaCO3, this test should be done with a known "fresh" lime so all lab personnel can become familiar with a typically acceptable result.

For the laboratories interested in exploring this further, several test samples can be mixed using different amounts of lime and powdered CaCO3. A distinct difference can be seen in samples

Continued on page 14

containing one, two, or three percent CaCO3.

While this test checks carbonation of both quicklime and hydrate, the appearance of quicklime must also be considered. While quicklime may pass this carbonate test, there may be a degree of hydration that has occurred. CaO + H2O -> Ca(OH)2. The physical appearance of quicklime will change with hydration. If a portion of the quicklime changes from its granular appearance to a fine white powder, hydration has occurred, and should be discarded.

If care is taken to follow these storage methods, and stock is rotated often, the lime quality should remain at acceptable levels.

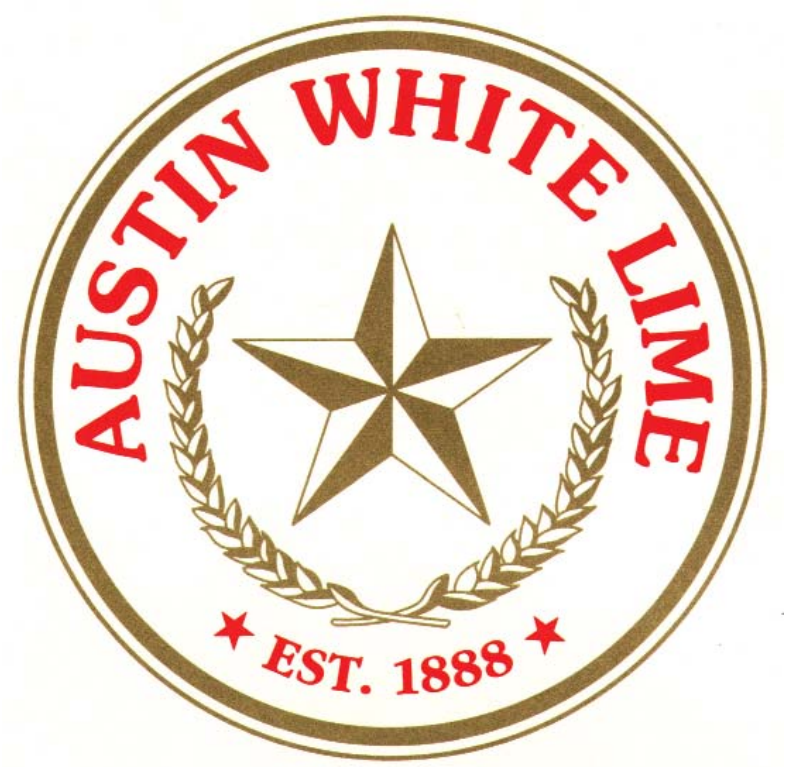
In the mid-90s the National Lime Association, through its Texas members, commissioned the writing of an excellent book by Dr. Dallas Little, P.E. of Texas A&M University titled, "Stabilization of Pavement Subgrades and Base Courses With Lime."

The Lime Association of Texas now possesses the copyright to this book and has made it available to all interested parties. This comprehensive handbook, which is 219 pages and is presented in a handsome blue hardback, was created to assist engineers and pavement construction professionals in the technically advanced uses of lime for stabilization and modification of pavement subgrades and base courses.

"Stabilization of Pavement Subgrades and Base Courses With Lime" is designed to provide a comprehensive reference on:

- Mechanisms of reaction between lime and soil
- Mixture design
- Engineering properties derived as a result of lime stabilization of soils and aggregates
- Pavement thickness design considerations
- Construction and quality control considerations
- Life cycle cost analysis

"Stabilization of Pavement Subgrades and Base Courses With Lime" begins by introducing you to lime, including definitions of pertinent terms, a description of the types and forms of lime available for roadbed stabilization, a discussion of practical and important physical and chemical properties of quicklimes and hydrated limes as well as a brief introduction to the production of lime.



Chemical, Building, and Stabilization Lime

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