# The Science

**Roadbond EN 1** has significant advantages over lime in the following ways:

Roadbond EN 1 is applied close to neutral pH and doesn't generate an adverse reaction in tree roots.

Roadbond EN 1 has no particulate matter so it can penetrate somewhat larger clay balls and therefore require less machine mixing time.

Roadbond is applied in a diluted solution of between 100:1 or 300:1 and then brought to optimum moisture for compaction. It does not require remixing and work can continue 24 hours after installation. It does not require moisture curing.

Because Roadbond has no calcium, it does not allow the CAS hydrate known as Ettringite to form.

Roadbond EN 1 can be used with either cement or fly ash in the lower PI clays and utilize the available aluminum in those materials to gain greater strength. When cement is used to stabilize road base, it is common to experience shrinkage cracking when the percentage gets above 3%. Many cities successfully use a combination of 3% cement and Roadbond EN 1 to stabilize mined road base in some of the older neighborhoods. Roadbond does not cause shrinkage cracking.

Roadbond does not require higher amounts of solution in the very high PI clays. In fact, the fatter the clay, the better Roadbond performs.

Roadbond EN 1 does not destroy the impermeable nature of clay. In fact, it makes it more impermeable by an order of magnitude, approximately 1.0E7cm/sec. Tests on Roadbond treated material mixed with an asphalt emulsion measured 1.08E8 cm/sec. Actually, the value was higher than that. The test was suspended after 4 days and much of the water had still not permeated the mix.

When considering machine time and labor, Roadbond EN 1 can be applied for approximately one half the cost of lime.

## How does it work?

Roadbond EN 1 is a proprietary mix containing sulfuric acid, limonene oils, soaps, and other materials and uses a mechanism to achieve strength and stabilization which is substantially different from lime.

Water in clay is either adsorbed or absorbed. The absorbed water can be thought of as pore water, water held between the particles due to surface tension or mechanical action. The adsorbed water is

held by electrical charge, both inside and outside the particle. Water is weakly ionized. If sulfonated oil, which has a hydrophilic head and a hydrophobic tail, is mixed in, the water will be displaced and strong bonds will form between the high valence metal ions (aluminum and magnesium) and the sulfate ion. The bonds are permanent. In addition, new compounds will be formed: such as aluminum sulfate, aluminum hydroxide, calcium sulfate (gypsum) and magnesium sulfate. Aluminum sulfate is a very powerful flocculant used in water treatment to clarify water with a high amount of colloidal material. Remember, we define expansive clay as having a high percentage of colloidal material, material passing the minus 200 sieve. That flocculant nature of Roadbond EN 1 treated clay is what increases the impermeability of Roadbond stabilized subgrades. The soaps act as a wetting agent, and the oils aid in compaction.

Roadbond EN 1 provides the dry working platform by increasing the ability of the clay to shed water quickly rather than making the clay frangible and allowing it to drain through. Shaping the subgrade to allow drainage is important for both lime and Roadbond EN 1.

## What about the Plasticity Index? Why doesn't it change?

Atterburg Limit testing begins by breaking down the clay matrix in order to determine the liquid limit (the max amount of water that the material can hold and still behave like a plastic material) and the plastic limit (the amount of moisture that a sample string of clay can be rolled on a glass plate into a 3 mm string without breaking up and becoming brittle). The difference between LL and PL is referred to as Plasticity Index (PI) and has been incorrectly associated with the ability of the soil to expand. It is ideal for measuring the efficiency of lime because lime also breaks down the clay matrix. Atterberg Limit testing does not work for Roadbond EN 1 treated material and the reason lies in the AL test itself. The first step in the AL test is to screen the clay through the #40 screen. Remember, aluminum sulfate is a flocculant; it binds together fine colloidal material into large particles. In water treatment they get heavy and settle to the bottom of the tank. In AL testing they get screened out of the test material.

In fact, montmorrilinite clay is naturally agglomerative. One of the most significant errors in AL testing is to allow high PI smectite clay to dry on the floor overnight. It is specifically warned against by the University of Washington's published procedures for students running AL tests, but is almost universally done by testing laboratories.

In short, Roadbond EN 1 has significant advantages over lime. In a scientific study conducted at the Texas Transportation Institute at A&M and sponsored by TXDOT,
**Roadbond EN 1** outperformed both lime and its competitors.