

Another asphalt application joins the ranks



Through foaming it's possible to mix hot asphalt with cold, damp aggregate

By Dave Collings

In most instances, asphalt is applied in three forms: as a hot product, typically higher than 300°F (149° C); as a warm “cutback” product, mixed with a suitable, volatile solvent; and as a cold product emulsified with chemicals in a water suspension. However, a fourth form is now being used on road construction projects — foamed asphalt.

What is foamed asphalt?

Similar to what happens in the kitchen when water is accidentally dropped into a pot of hot cooking oil, hot asphalt explodes into millions of bubbles when it comes into contact with small amounts of cold water. This phenomenon causes the asphalt to expand many times beyond its original volume and the resulting froth is known as foamed asphalt.

Because it is regarded as a nuisance by many refineries, anti-foaming agents are sometimes added to the bitumen manufacturing process. However, in 1957 Ladis Csanyi, a professor at Iowa State University,

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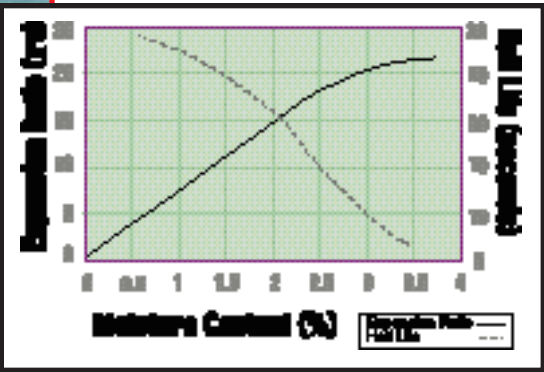


Figure 1: Effect of water on expansion ratio and half life.

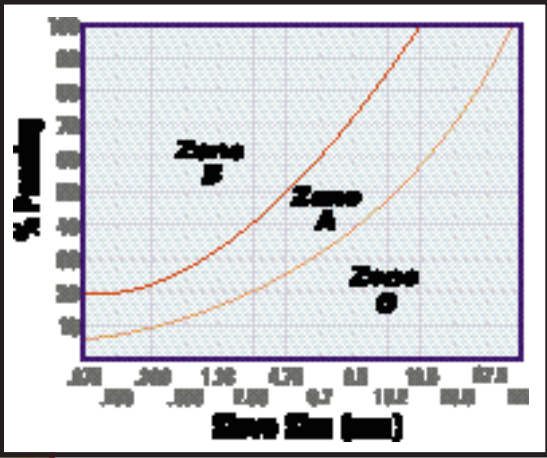


Figure 2: Guide for selection of aggregate.

proved that the foamed material could be useful. He showed it was possible to mix hot asphalt with cold damp aggregate by first foaming the asphalt.

Characteristics of foamed asphalt

When a carefully metered amount of cold water is introduced into hot asphalt a foam is formed, increasing its volume and surface energy. This enables stiff road-grade asphalt to be mixed together with cold, moist aggregate without having to resort to the added cost of cutting back the binder with a solvent or emulsifying it. In the foaming process, the viscosity of the asphalt is greatly reduced, enabling it to be properly dispersed through the aggregate.

Two parameters have been developed which assist in characterizing foamed asphalt:

- **Expansion ratio.** This is the ratio of the maximum

volume of the asphalt in its foamed state to the volume of asphalt once the foam has completely subsided.

- **Half life.** The half life is the time in seconds it takes for the foam to settle to half of the maximum volume attained.

Both expansion ratio and half life are influenced by the grade and type of asphalt, as well as by the amount of water injected into the hot asphalt during the foaming process. Logically, the greater the expansion ratio, the less viscous the asphalt will be and the result should be a better dispersion of the asphalt in the mixed product. Likewise, a longer half life implies there is more time for the asphalt to be mixed with the material while it is still in its foam form.

However, Figure 1 (this page) shows these character-

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Material with foamed asphalt can either be treated in place using a recycling machine or fed through a stationary mixing plant. Each method has its particular merits, but for rehab work, in place treatment by recycling is generally more cost effective.

istics have an inverse relationship. The expansion ratio increases as the amount of water added to the asphalt increases, while the increase in water causes the half life to reduce. In practice, it is necessary to understand this relationship and determine the amount of water, measured as a percentage by mass of the asphalt, that will produce a foam with a maximum expansion ratio and the longest possible half life.

The expansion ratio and half life of asphalt may be enhanced by the introduction of chemical additives to either or both the asphalt and the water used to produce the foam. Additives are essential when anti-foaming agents are introduced into the asphalt during the manufacturing process.

Material treated with foamed asphalt

A distinct difference between mixes produced using foamed asphalt and HMA, or mixes using emulsified asphalt, is the way in which the asphalt is dispersed through the aggregate. In the latter cases, the asphalt

tends to coat all the particles, while in foamed asphalt mixes the large particles are not fully coated. The foamed asphalt disperses itself among the finer particles, forming a mortar which bonds the mix together.

This partial coating accounts for the small change in the color of aggregates treated with foamed asphalt. Similar materials mixed with hot asphalt, or cold mixed with asphalt emulsion, tend to be much darker, or even black. If a light colored aggregate is used, the foam treated product will remain lightly colored.

Using foamed asphalt in road construction

Foamed asphalt has been used successfully worldwide for the treatment of a variety of materials, including cohesionless dune sands, natural gravels, reclaimed asphalt millings and crushed aggregates.

The grading of the aggregate is an important consideration. As a guide to the suitability of aggregates for treating with foamed asphalt, grading curves for three zones of relative suitability are shown in Figure 2,

(page 17.) Material from Zone A is suitable without modification. Except for low traffic roads, materials with gradings falling within Zone B tend to be too fine and require blending with a coarser aggregate for effective treatment with foamed asphalt. Fine material needs to be added to material falling into Zone C.

In some countries it is standard practice to add one percent road lime — measured by mass of the material being treated — to reduce the plasticity of natural gravels and to enhance the adhesion between the material and the asphalt. To provide additional protection against the possibility of the asphalt “stripping” from the aggregate, an anti-stripping agent is often added to the asphalt before it is foamed.

Mix design procedures

The mix design procedure requires the use of a small laboratory plant to produce foamed asphalt. It is important that this equipment closely simulate the foamed asphalt that will be produced during full-scale production.

The lab foamed asphalt plant consists essentially of a kettle to heat the asphalt and two calibrated pumping systems, one for the hot asphalt and the other for the water used to produce the foam. Predetermined amounts of hot asphalt and cold water are injected into a specially designed expansion chamber where the asphalt is foamed before being discharged through a nozzle. The expansion ratio and half life of the foamed asphalt can be varied by altering the proportion of water added to asphalt, or by the addition of chemical additives.

Once the required water/asphalt ratio has been determined, a predetermined volume of foamed asphalt is discharged directly into a sample of aggregate while it is being agitated in a lab mixer. Normally five samples are produced in this way, with varying asphalt contents. Prior to adding

the foamed asphalt, moisture is added to bring the material to its optimum moisture content. If necessary, road lime is also added at this stage.

The optimum binder content is based on volumetric and Marshall stability design curves — same as HMA — except that the briquettes are not soaked at an elevated temperature before stability testing. Instead, the susceptibility of the mix to moisture at various binder contents is checked by conducting additional Marshall stability testing on vacuum soaked specimens. Indirect tensile strength tests on unsoaked and soaked specimens may also be used as an additional means of evaluating the mix at different binder contents.

Road construction with foamed asphalt

There are two common methods of treating material with foamed asphalt. Material can either be treated in place using a recycling machine or fed through a stationary mixing plant. Each method has its particular merits, but for rehab work, in place treatment by recycling is generally more cost effective. The double handling of material, coupled with the cost of hauling, limits the application of stationary plants to new construction or specialized operations.

The economics of foamed asphalt

The foamed asphalt process is a very cost effective way of mixing asphalt with aggregates. There are no aggregate heating costs, which



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are significant in the cost of producing asphalt. Also, there are no manufacturing costs, which make asphalt emulsion relatively expensive. The foamed asphalt process uses only straight penetration grade asphalt and water.

In most countries, the purchase price of a ton (metric ton) of penetration grade asphalt is similar to that of asphalt emulsion. However, only the residual asphalt component of an emulsion is of interest in the final mix produced, not the water component, which is typically 40 percent. To compare costs it is necessary to adjust the cost of emulsion to reflect only the cost of the asphalt component. ■

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Property	Material Type			
	Calculated Best Best	Marshall Recycle Recycle	Crushed Aggregate	Mixture of 20% recycle and 70% HMA
Blissman Content (%)	4.5	2.5	2.5	2.0
Marshall Dry Stability (kN)	5	10	15	20
Resilient Modulus (MPa)	1500	2000	2000	2000
Dynamic Creep (MPa)	10	15	20	15
Indirect Tensile Strength (MPa)	100	150	250	200

Figure 3: Typical properties of foamed asphalt treated materials.

Foam, from page 39