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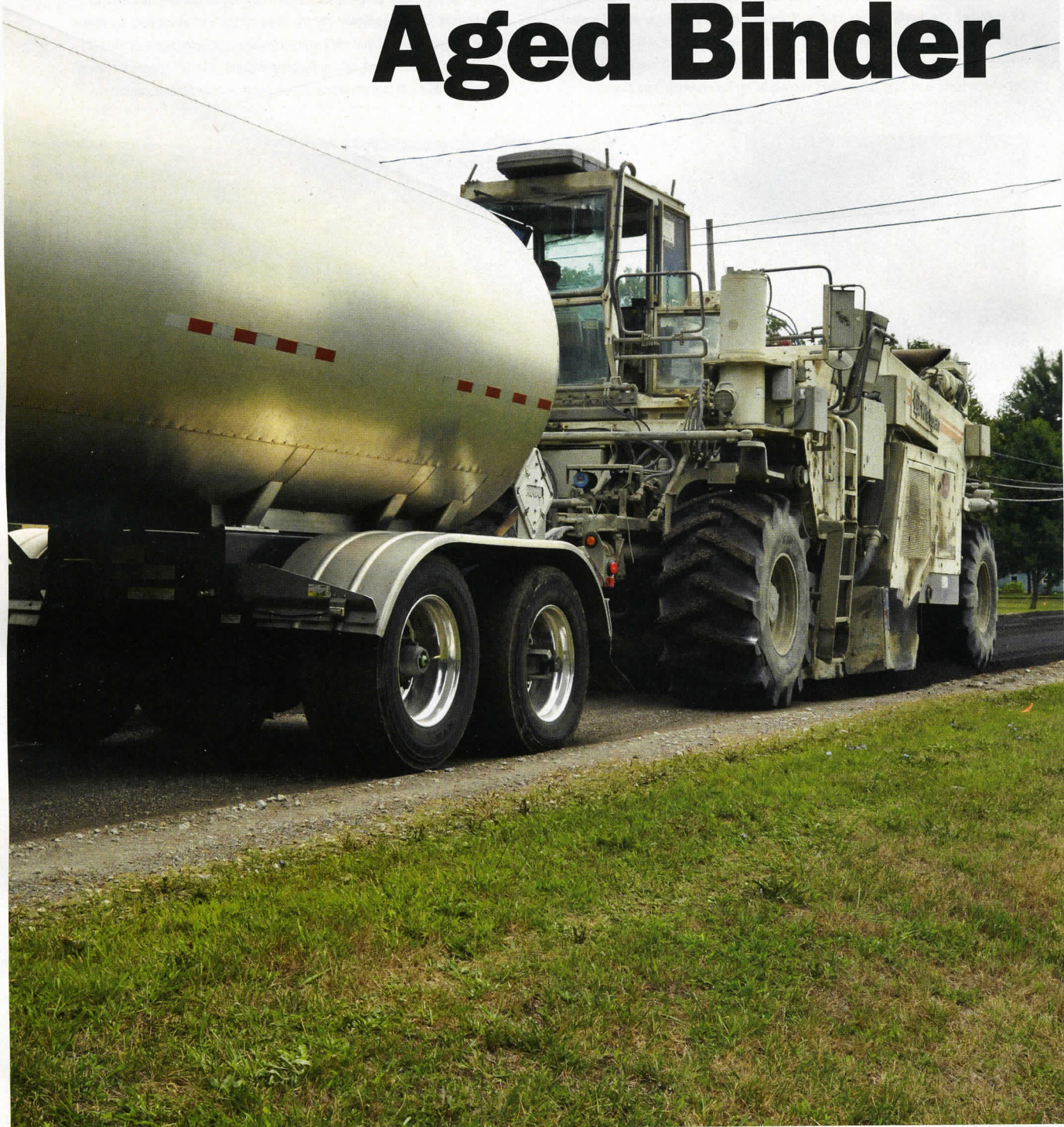
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# Asphalt Emulsions Provide **Cohesion, Improve Aged Binder**



**On the Monroe County, MI, full depth reclamation, engineered asphalt emulsion is injected into reclaimed materials as they are mixed.**

*Photo Credit: Asphalt Materials Inc.*

## Full-depth reclamation with asphalt emulsions creates an ideal treatment for thin bituminous pavements needing upgrading or rehab

*By Tom Kuennen, Contributing Editor*

**F**or failed pavements, full-depth reclamation (FDR) reclaims and treats an entire road structure – including underlying materials – to produce a stabilized base course ready for overlay.

With FDR, an asphalt pavement is pulverized, mixed with a stabilizing agent, shaped or graded, compacted and topped by an optional thin surface or wearing course. This results in a cost-effective, new pavement structure

mostly built with recycled materials.

Pavements with failed Portland cement concrete driving surfaces also may be full-depth reclaimed, after the concrete slabs are removed and themselves crushed into recycled concrete aggregate (RCA).

Environmentally sustainable FDR saves money when dealing with pavements that have exhausted their design lives, or are at the limit of life extension via pavement preservation techniques. At this stage FDR is a powerful option because:

- Most pavement distresses can be cured with FDR and ride quality is improved.
- Hauling costs and the exhaust and dust environmental problems of continuous truck hauls are minimized, as most of the recycled mix consists of existing material
- Significant structural improvements can be made, especially in base layers, and
- Demolition material disposal problems are avoided entirely and tipping fees avoided, while landfill capacity is conserved.

“Full-depth reclamation is a cost-effective technique for correcting deficiencies, reclaiming distressed pavements and providing structurally sound bases for existing roads,” says the Asphalt Emulsion Manufacturers Association (AEMA). “Structure is rebuilt down into the pavement during the process.”

### Emulsions for FDR

While stabilizing agents are specified according to specific field conditions, asphalt emulsions are emerging as the value-added material

for stabilization of recycled materials in FDR, when right for the application.

FDR with asphalt emulsions constitutes an ideal treatment for thin bituminous pavements needing upgrading or rehabilitation. The candidate may have high severity distresses such as ruts, cracks, potholes and base problems. Depending upon the severity of the base distress, base corrections may need to be made or base rock added, AEMA says.

Following laboratory testing of materials from the road, an emulsion mix design is executed. Based on that design, a reclaimer/stabilizer pulverizes the existing pavement and its base uniformly four to 10 inches deep, and mixes the asphalt emulsion in. The stabilized material is compacted with a padfoot compactor to work out the moisture. The road is then bladed to level the surface and compacted in preparation for a new surface.

The base should be strong enough to support the equipment. The road should have good drainage, or provision made for correcting the drainage. Full depth reclamation is also a good choice for strengthening shoulders.

“In my former role as a contractor, about 25% of the FDR work we did involved injection of asphalt emulsions to stabilize a base,” says Mike Buckingham, principal

**FDR with asphalt emulsions eliminates danger of corrosive cement, fly ash or lime fugitive dust escaping work zone.**

*Photo Credit: Wirtgen America Inc.*



with Buckingham Consulting in South Carolina. "These emulsions are an alternative to chemical additives like lime, cement and fly ash. Asphalt emulsions constitute one of the choices that a buyer agency has for a stabilizing agent."

Despite being a value-added manufactured product, asphalt emulsions don't represent a more expensive quantity than the commodity-priced bulk lime or cement, he said. "Emulsions are not necessarily more expensive," Buckingham says. "It depends on the makeup of what you are trying to stabilize, and what will build strength better to the level you are trying to achieve. If you are doing dirt or sand products, you might be more apt to use a dry stabilizer with water, rather than emulsion."

"Otherwise we might use emulsion by itself, or in combination with the other products," Buckingham added. "Emulsion-treated FDR may be cheaper than dry chemical reclamation when considering the entire structure — reclaimed base plus overlay — as emulsion-treated bases have a higher structural value."

### Asphalt emulsions do more

Unlike other chemical stabilizing agents, asphalt emulsions do more than just stabilize; they improve cohesive strength of the recycled pavement material while refreshing the residual asphalt present in reclaimed materials. Thus emulsions used in FDR can add structural value to a pavement.

"Asphalt emulsion helps to increase cohesion and load bearing capacity of the mix," according to 2015's *Design and Construction Guidelines for Full Depth Reclamation of Asphalt Pavement*, issued by the New York

**In advance of FDR, cores reveal the nature of the base beneath the pavement, which will determine the appropriate stabilizing agent.**

Photo Credit: Texas DOT



State DOT (NYSDOT) in August 2015. "It also helps in rejuvenating and softening the aged binder in the existing asphalt material."

A construction advantage of using emulsion, is that emulsions are low in viscosity and very suitable for application through an on-board liquid additive system in the recycling equipment. The onboard metering system provides much greater control over the amount of asphalt emulsion placed than would be possible with distribution of dry, corrosive chemical agents like cement or fly ash.

"After the blending of the subbase material and emulsified asphalt, the emulsion 'breaks' and water separates out from the asphalt cement," NYS DOT says. "This water is forced out of the subbase during compaction or will evaporate out during curing period. The resulting residual asphalt cement has high viscosity and, therefore, helps in improving the cohesion of the subbase material."

Likewise, the National Cooperative Highway Research Program (NCHRP) Synthesis 421: *Recycling and Reclamation of Asphalt Pavements Using In-Place Methods* (2011), says asphalt emulsions improve the strength and moisture resistance of the base material, soften the aged asphalt binder in the RAP, and reduce shrinkage cracking seen with cement and lime stabilizers.

"When the emulsion breaks," NCHRP 421 says, "the asphalt droplets join, and the water separates from the asphalt. Compaction helps force the water out of the stabilized base, but sufficient time for the moisture content to drop below about 1.0% is still needed for all of the moisture to evaporate before the placement of the next lift."

### Emulsion stabilization

An asphalt emulsion for FDR — or any other application — is a homogeneous mixture of two insoluble substances, oil and water. In it particles of liquid asphalt (the dispersed phase) are surrounded by molecules of water (the continuous phase).

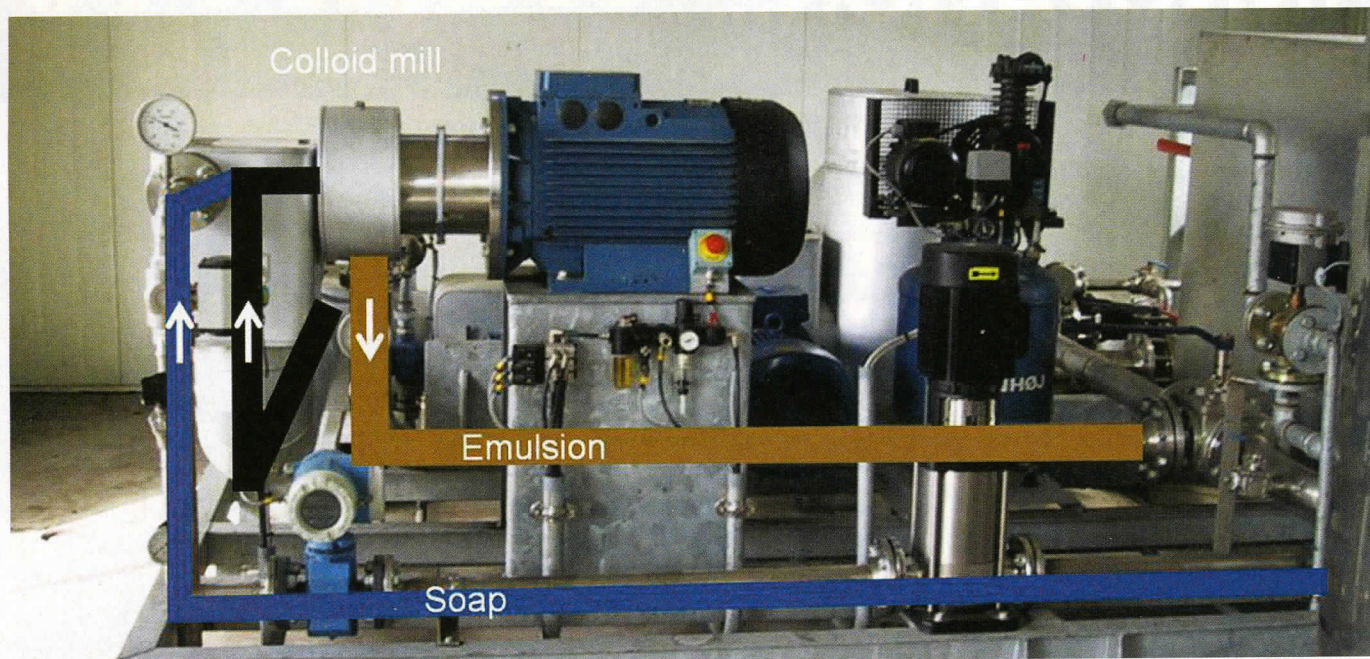
Asphalt emulsions are produced by dispersing tiny globules of asphalt cement into water treated with a small quantity of emulsifying agent. The dispersion takes place in a powerful blender, called a colloid mill, where spinning blades break or shear the liquid asphalt into suspended microscopic particles. The water, or soap solution, is immediately introduced to form the emulsion.

The emulsifier — an engineered surfactant (detergent) or surface-active agent — maintains the microscopic asphalt droplets in a stable suspension, keeping them from



**Detail of Monroe County 151 base recycled with engineered asphalt emulsion and RAP as 'add rock.'**

Photo Credit: Asphalt Materials Inc.



recombining. The amount and type of surfactant used, along with other variables, controls properties of the emulsion critical to performance in the field application.

Historically, bituminous FDR stabilization has been done with either asphalt emulsions or “cutback” asphalts.

Cutback asphalt is “neat” liquid asphalt to which a petroleum distillate — like kerosene or diesel — has been added to reduce its viscosity. Cutbacks served well for decades, but their use has been greatly curtailed in recent years due to their release of volatile organic compounds (VOCs) to the atmosphere, which has been restricted by environmental regulations.

Instead, the market has moved to asphalt emulsions. The emulsions are generally mixing grades of anionic (negatively charged) slow-setting; cationic (positively charged) slow-setting; or high-float emulsions containing petroleum distillate, and possessing extended workability.

An “alphabet soup” of letters designates the types of asphalt emulsions that are available, but this needs not be confusing, as the letters correspond to the attributes of the emulsion. Cationic emulsions begin with a “C.” If there is no C, the emulsion is usually anionic.

Emulsified asphalts come in rapid-, medium-, and slow-setting grades for different applications. Rapid-, medium-, and slow-setting grades are developed through the use of different emulsifying agents and the addition of some solvents. Still, their asphalt droplets

particles will be either anionic or cationic. Rapid-setting emulsions are used mostly for chip sealing, while the medium- and slow-setting grades are used for recycling, fog seals, or bond coats placed in advance of asphalt lifts.

After the charge designation, the next set of letters describes how quickly an emulsion will set or coalesce to a continuous asphalt mass. The standard terms are RS (Rapid Set), MS (Medium Set), SS (Slow Set), and QS (Quick Set).

An HF that precedes the setting time designation indicates a high float emulsion. Polymer modified HF emulsions are made with a special family of emulsifying agents that leaves a gel structure behind in the asphalt residue, and carry the designator P.

RS emulsions break rapidly and have little or no ability to mix with an aggregate. MS emulsions are designed to mix with aggregates, and are often called mixing grade emulsions, the Asphalt Institute says. MS emulsions are used in FDR, cold recycling, cold and warm dense-graded aggregate mixes, patch mixes and other mixes.

Asphalt binders used in recycling processes can be typical paving-grade asphalts or emulsions, such as CSS-1, CSS-1h, and CSS-1hP, CMS-2S, HFMS-2, HFMS-2S, HF-150, HF-300P, and proprietary solventless emulsions.

### **Recycler/reclaimers today**

Road reclaiming full-depth is eased by a new generation of soil stabilizing machines/asphalt pavement recyclers that is revolutionizing base

**Asphalt emulsions are produced by dispersing tiny globules of asphalt cement into water treated with a small quantity of emulsifying agent.**

*Photo Credit: AkzoNobel*

stabilization in the United States.

These new machines incorporate an increase in size and horsepower, which has improved productivity and permitted greater depths of treatment. They also incorporate high-tech systems for controlling liquid additives and water. They can be used for soil stabilization and pavement recycling, and are a far from the old equipment, which could seldom cut as deep as 6 in. Today’s recyclers/reclaimers will cut and mix emulsion or other materials as deep as 20 in. in one pass.

There is no special trick to constructing durable, stable road bases, experts say. The key is to design the base, predicated on existing materials and soils, anticipated traffic counts and loads, and final pavement, and then stick to it.

There are three separate layers beneath a pavement: the base course (just beneath the pavement); the subbase, which is structural section material between the basement soil and the base course; and the basement soil itself.

A roadway’s base and subbase are structural elements of a pavement. Along with the top riding course or level, they spread wheel loads out over an area of the subgrade or soil bed. A pavement’s base is the support layer right

beneath the trafficked course, and always is of greater strength than the underlying soil layer. The wheel load pressure is always a lot less than the pressure at the surface, and is distributed as an inverted bell curve.

The area of load transfer, and the constant distribution of pressure across the subbase and subgrade, depends on the type and shape of granular materials or aggregate, including size, grading, angularity and compression resistance, and whether it is bound or unbound. A high compaction density improves aggregate interlock and load transfer. Bituminous stabilizing agents such as asphalt emulsions improve load bearing capacity.

### Specifications for FDR

In its recent technical report, *Developing Standards and Specifications for Full Depth Pavement Reclamation*, the Pennsylvania DOT (PennDOT) observes other states' successes with asphalt emulsions for FDR.

Illinois local road agencies have successfully used asphalt emulsions in their FDR mixture design procedures, PennDOT notes. "The quality of construction is achieved through controlling the asphalt emulsion properties, moisture content before emulsion, maximum material size, emulsion content, compaction density, and reclaiming depth," PennDOT says.

PennDOT FDR specs state that FDR of an existing flexible pavement or unpaved road surface includes pulverization of existing pavement layers, and incorporation of additional materials using reclamation techniques and compaction as specified, in-place.

For PennDOT, the FDR maximum particle size must not exceed 2 in. in its greatest dimension, with 95% passing the 50 mm (2-inch) sieve. According to the mix design, bituminous material is added to the reclaimed material, including CMS-2, SS-1h, CSS-1h, or polymer modified grades of these

"The addition of bituminous stabilizing materials to the pulverized layer can increase the stiffness of the layer, and improve resistance to water related damage," PennDOT says. "Since bituminous-stabilized FDR is more flexible than other forms of FDR, this product could, depending upon the design details, provide improved fatigue resistance to loading as compared with others.

"Most emulsified asphalt used in stabilization consists of approximately 60% to 65% residual bitumen," PennDOT adds. "When the water dissipates the emulsion is said to have broken, at which point the residual asphalt particles revert to a continuous film which coats the reclaimed material particles."

### Emulsion FDR in Michigan

A recent use of asphalt emulsion in FDR was in Monroe County Road 151 in Michigan. Following demolition and off-site recycling of a failed concrete pavement, a critical element of the project was the in-place recycling of existing base to a depth of 8-in., with a 6-in. depth of minus 2-in. reclaimed asphalt pavement (RAP) added, placed by an asphalt paver.

The RAP and base were mixed in place by a Wirtgen WR 2500 recycler, which injected an engineered recycling asphalt emulsion into the mixing chamber of the recycler.

The emulsion was engineered to provide mixing time, permitting the contractor time to grade, shape and begin compaction. Depending on the weather, he would have 60 to 90 minutes before it becomes difficult to move. Then, when mixing is done, the emulsion was designed to release the water from the pavement.

This particular emulsion was designed by Asphalt Materials, Inc., expressly for recycling work, and was much different from conventional emulsions used for chip seals or other surface treatments. The firm created the emulsion for use with the materials in the road base, obtained by coring.

Coring went right through the existing concrete down to the aggregate base, as the designers needed to determine how thick that base was, its composition, and whether it was a good enough quality material to incorporate into the recycling process. The emulsion was designed to work with the composition and gradation of those existing materials, plus the RAP, quickly resulting in the enhanced cohesion and stability needed to get traffic back on the road.

Following creation of the stabilized base, the contractor created a crown in the stabilized base course by motor grader, and the graded base was compacted to refusal by a padfoot roller, using a front-mounted dozer blade to smooth the surface when moving in reverse. That dimpled surface was smoothed by use of a tandem asphalt roller to create a usable driving surface for local residents and businesses. Finally, a 3.5-in. virgin asphalt overlay was placed in two lifts as the surface course. **AC**



**FDR with asphalt emulsion is ideal for rural applications.**

Photo Credit: Ergon Asphalt & Emulsions Inc.