Tack Coats for Asphalt Pavement

An Online Continuing Education Course for Engineers

Course Number: T-2024

Credit: 2 Hours / 2 PDH / 2 CPD

Tack Coats for Asphalt Pavement

Mark R. Knarr, P.E.

INTRODUCTION

Warm- and hot-mix asphalt can be used to construct entirely new asphalt pavement starting at the base course. Or these mixes can be used as overlays to repair older pavement, whether it be existing asphalt concrete or Portland cement concrete.

Regardless of whether the surface is an asphalt lift laid hours ago or Portland cement concrete that is 12 years old, any new lift of asphalt concrete must adequately bond to the pavement underneath to prevent the layers from sliding independently of each other; and so that traffic loads at the surface are transmitted down through the whole pavement structure.

Such bonding is the essential purpose of tack coat. By definition, tack coat is a sprayed application of an asphalt binder…

1. between layers of fresh asphalt, or
2. upon an existing asphalt or Portland cement concrete pavement surface prior to an overlay.

The purpose of tack coat is to bond old and new pavement layers together, creating a monolithic structure which performs as a unit as opposed to unbound, independent, layers. If the layer above is not properly bonded to the layer below, then horizontal shear forces at the layers' interface will increase the tendency for cracking, de-bonding, and fatigue failure to occur in the upper portion of the pavement structure. Delamination may occur between the layers, resulting in slippage or sliding failure of the new pavement on top of the existing pavement.

Materials used today for tack coats are asphalt emulsions and performance grade (PG) asphalt binders, with emulsions being much more common.

Cost

The Asphalt Institute analyzed bid tabs from projects in 2013 to gage the proportion of project cost for tack coat. From their study, tack coat was 0.1% to 0.2% of the total project costs for new construction or reconstruction of pavement. For mill & overlay projects, tack coat was 1.0% to 2.0%. If a bond failure occurred and remedial action was needed, the cost to replace just the top lift was found to be 30 to 100% of the original project costs. The lower end of this range was for new or reconstructed pavements consisting of multiple lifts of asphalt; the higher end was for mill & overlay of pavements with just a single lift.

So, proportionately speaking, the cost of tack coat is insignificant in a paving project, but the cost of fixing a bond failure is major. When one adds onto that cost the additional disruption to the public, tack coat is clearly low-cost insurance for achieving good bonding between all layers of the pavement structure and preventing premature failure.

TACK COAT MATERIALS - EMULSIONS

"*The most widely used tack coat material in the world is emulsified asphalt*." - NCHRP REPORT 712, 2012.

As a tack coat material, emulsions are popular for several reasons. They lend themselves to application uniformity, and contractors are familiar with their usage. Asphalt emulsions are relatively safe to work with in the field because they are non-flammable and emit minimal fumes.

Emulsions are compatible with additives such as polymers, latex, fillers, anti-strips, stabilizers, and other modifiers, yielding a vast variety of tack coats with diverse physical properties suitable for almost any application.

Disadvantages of emulsions include the time it takes for the emulsion to break and set; and the potential for tracking, i.e. the transference of tack coat material to adjacent pavement typically via construction vehicles or equipment (Figure 8). Despite these drawbacks, emulsions can render excellent performance when they render the right quantity of asphalt residual; and when they can break and set.

Composition

An emulsion is a mixture of two or more liquids that are normally immiscible. In the case of tack coats, the two phases are water and asphalt (Figure 1). All asphalt emulsions have three fundamental ingredients:

- asphalt cement (binder); 55 – 70% by weight
- water, 44 – 29%
- emulsifying agent, <1%

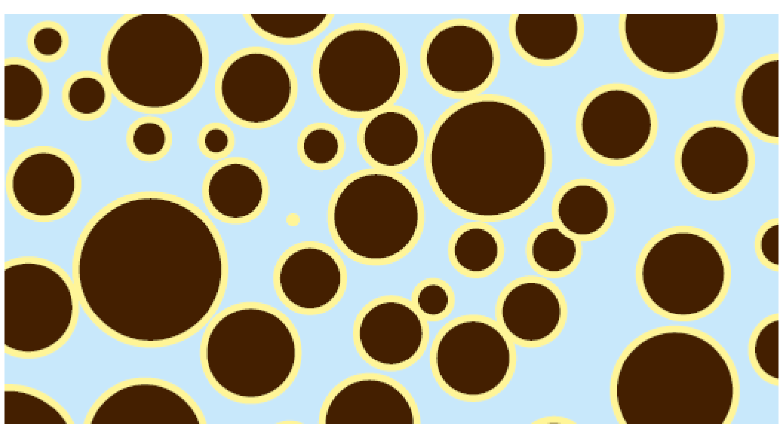


Figure 1. Microscopic view of emulsion with asphalt droplets coated in emulsifier, suspended in water.

The emulsifying agent (also referred to as emulsifier or surfactant) greatly influences the properties of an asphalt emulsion. In addition to keeping the asphalt particles in suspension and controlling breaking time, the emulsifier also determines whether the emulsion is cationic or anionic. Chemical compatibility of the emulsifying agent with the asphalt cement is essential for producing a stable emulsion.

Asphalt emulsions are produced by separately metering the hot liquid asphalt and the solution of water and emulsifier into a colloid mill, which then shears the asphalt globules into microscopic particles. The size of the particles affects the physical properties of the emulsion.

Sometimes additives, such as polymers, acids, and latex, are mixed into the emulsion to further alter its physical properties.

Break and Set

There are two key phenomena associated with asphalt emulsions: break and set.

Upon application to the pavement, the emulsion is brown in color (see Figure 8a). Brown indicates that the micron-sized asphalt particles are still suspended in the water. Eventually, the asphalt particles will separate from the water as indicated by a change in color from brown to black. This point is called *break*, and the emulsion is said to have broken. Later, all the water will evaporate, leaving behind only the asphalt binder. This point is called *set*.

Paving over a tack coat should not commence until the emulsion breaks!

Generally, emulsions break in 10 to 20 minutes and set in 30 minutes to 2 hours. The variability in break time is due to a variety of actors, as listed in Table 1.

	Slower	Faster
Emulsion grade	*SS*	*RS*
Application rate	*High*	*Low*
Dilution ratio	*High*	*Low*
Wind speed	*Low*	*High*
Temperature, tack coat	*Low*	*High*
Temperature, ambient air	*Low*	*High*
Temperature, pavement surface	*Low*	*High*

Table 1. Factors affecting break and set of asphalt emulsions.

Classification

Asphalt emulsions have alphanumeric designators to indicate their various properties. Examples include SS-1, SS-1h, SS-1hP, CSS-1, CSS-1h, CRS-2P, RS-1, RS-2, CRS-1 and CRS-2, HFMS-1, and HFMS-1s.

Emulsions are categorized by their ionic charge as cationic, anionic, or nonionic. Charge is important when selecting an emulsion for compatibility with certain aggregates. Cationic emulsions have a positive (+) electrical charge, and anionic emulsions have a negative (-) charge in a zeta potential test. Cationic emulsions are most common and are identified by the letter "C" as the initial character of the designator. If the grade has no prefix "C", then it is anionic. For use as tack coat, the selection of anionic or cationic emulsion is generally inconsequential due to the relatively very small amount of emulsion applied to the existing pavement surface. Nonionic emulsions are not generally used for pavement construction.

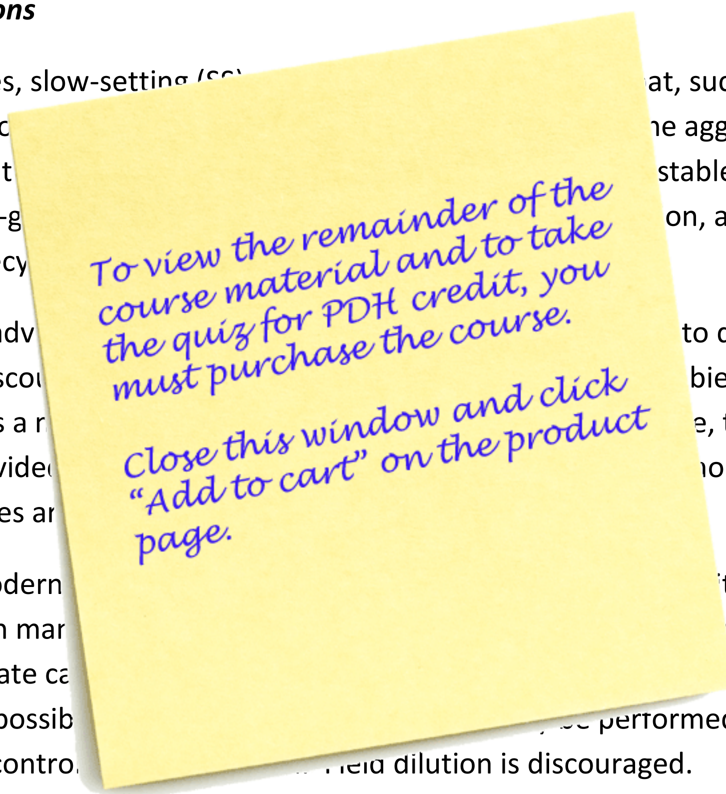
Following the charge designator are two alpha characters to identify the set rate: slow set (SS), rapid set (RS), medium set (MS), and quick set (QS). Following the set designation is either the digit 1 or 2 to indicate the relative viscosity of the emulsion; 1 is low and 2 is high.

Suffixes "h" or "s" denotes a harder or softer asphalt base, respectively. Harder bases are used in 'trackless' emulsions to reduce the amount of tracking that might occur on the tires of the haul trucks and other vehicles.

Suffixes “P” and “L” indicate the presence of polymer and latex modifiers, respectively, which are sometimes added to the emulsion to increase strength, elasticity, adhesion, and durability to the pavement. Polymer-modified asphalt emulsions (PMAE) are increasingly being used for specialty applications, including spray-paver applications. PMAE can be less brittle at low temperatures to resist cracking; and stiffer at high temperatures to resist rutting and bleeding. Polymers permit the application of micro surfacing in wheel-path ruts and other locations where multiple stone depths are required. The use of a PMAE may be justified at locations where there is a substantial stopping and/or turning traffic on to the new asphalt surface.

Slow Set (SS) Emulsions

Of all emulsion grades, slow-setting (SS) ... at, such as SS-1, SS-1h,
CSS-1, and CSS-1h. Slo ... ne aggregates to allow
for maximum mixing t ... stable emulsions and
can be used in dense-g ... on, asphalt surface
courses, and some recy



Historically, the key adv ... to dilution. Diluted
emulsions are less visco ... bient temperatures,
which in turn renders a r ... e, the additional
volume of water provide ... normal speed when
lower application rates ar

However, today’s modern ... thout dilution.
Furthermore, dilution mar ... added by dilution
so that the residual rate ca ... hout such control,
residual rates are impossib ... performed by the supplier
where more quality contro ... ield dilution is discouraged.

It’s important to check your state’s transportation department for their guidance on diluting emulsions. Texas, for example, has prohibited dilution since 2004. Other states allow dilution but impose strict conditions, such as requiring the resident engineer to approve it; setting limits on how much it can be diluted; or specifying who or where the dilution occurs.

As noted in Table 1, diluted emulsions need more time to break and set than undiluted emulsions because of the increased amount of water that must evaporate from the surface. Diluted SS emulsions may take several hours to break or even several days to completely set. In addition, an overlay tacked with slow-setting emulsion may be vulnerable to slippage during its early life. Such an overlay exposed to heavy traffic immediately after construction could experience excessive slippage in a short period of time.