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PROPERTIES AND USES FOR HIGH FLOAT EMULSIONS

By

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Materials and Tests Division

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What is a high float emulsion?

A high float emulsion is an emulsion the residue of which has some special characteristics that the original asphalt-cement from which it was produced does not have. The primary difference is a gel structure which imparts resistance to flow or creep by the emulsion residue.
This report covers the properties and uses for high float emulsions.

In Figure 1, the can of asphalt on the left is a 140 penetration asphalt. This asphalt was used to make a high float rapid-setting emulsion--HFRS. The can on the right is the distillation residue from this HFRS. These two cans were placed in their present position on the plate in the laboratory six hours before this picture was taken. You can see that there is a considerable difference in resistance to creep or flow at ambient temperature.

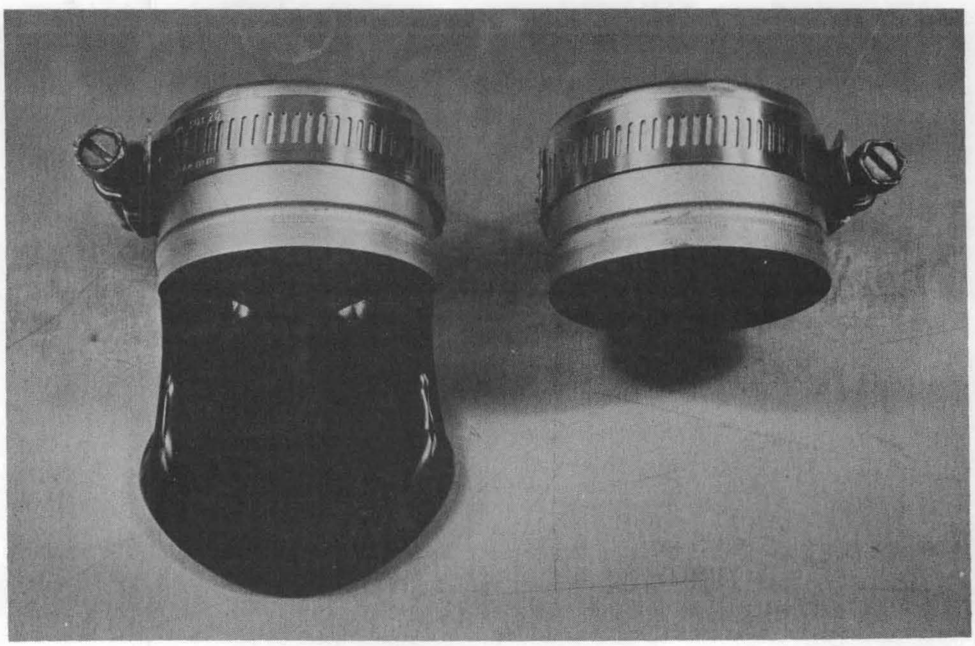

Figure 1

Why is an emulsion of this type referred to as a "high float" emulsion? The reason for this name or designation comes from the laboratory test used to measure this gel property, and it is called the float test. This test was originally devised so that a measurement of consistency could be obtained on asphalts that were too soft to determine their penetration at 77 F. In this test, the hot asphalt is poured into a float collar, which is a small truncated cone made of brass with male threads on the small or upper end (see Figure 2). After the asphalt has cooled to room temperature, the collar is chilled in a 40 F water bath and the

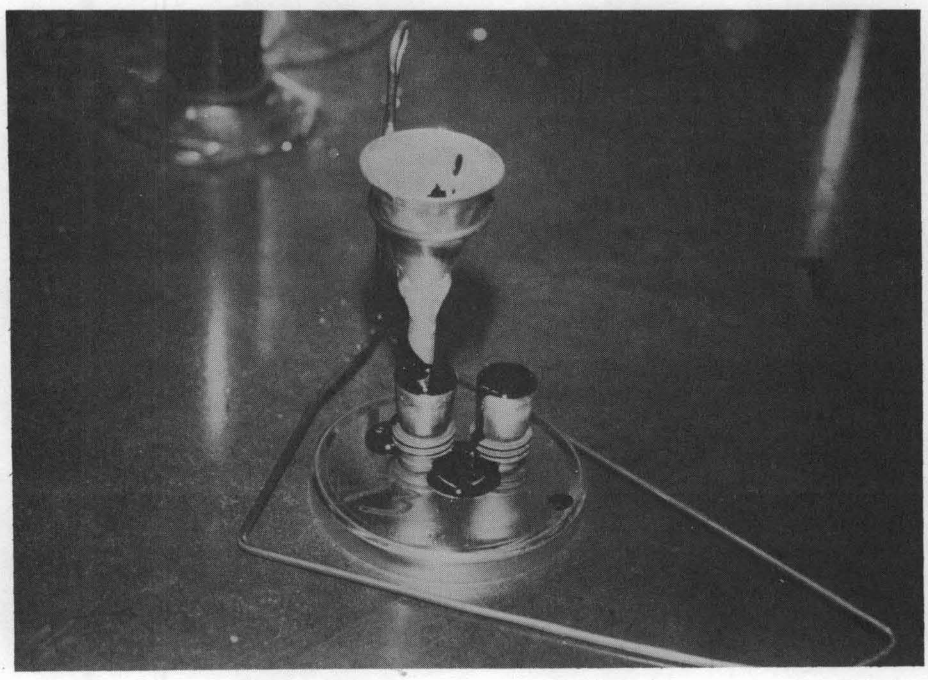

Figure 2

asphalt is trimmed. The asphalt-filled collar is then returned to the 40 F bath for a period of 15 to 30 minutes, after which it is threaded into an aluminum float; the complete assembly is shown in Figure 3. This assembly is then placed in a hot water bath (see Figure 4). For testing of residue from emulsions we are discussing, the temperature is maintained at 140 F. When the apparatus is floating in the bath,

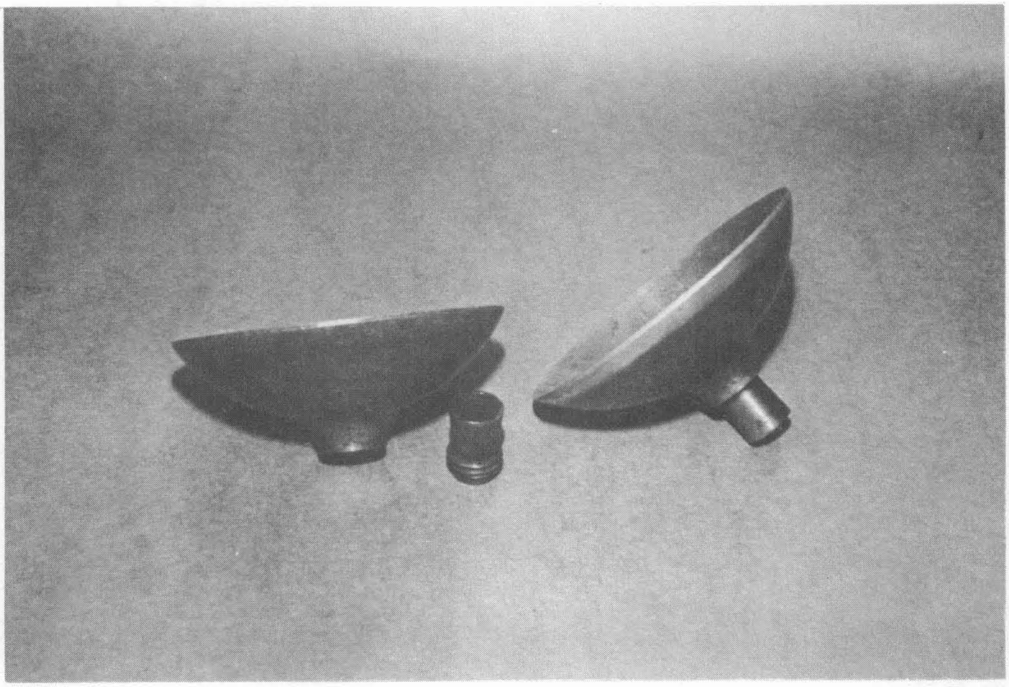

Figure 3

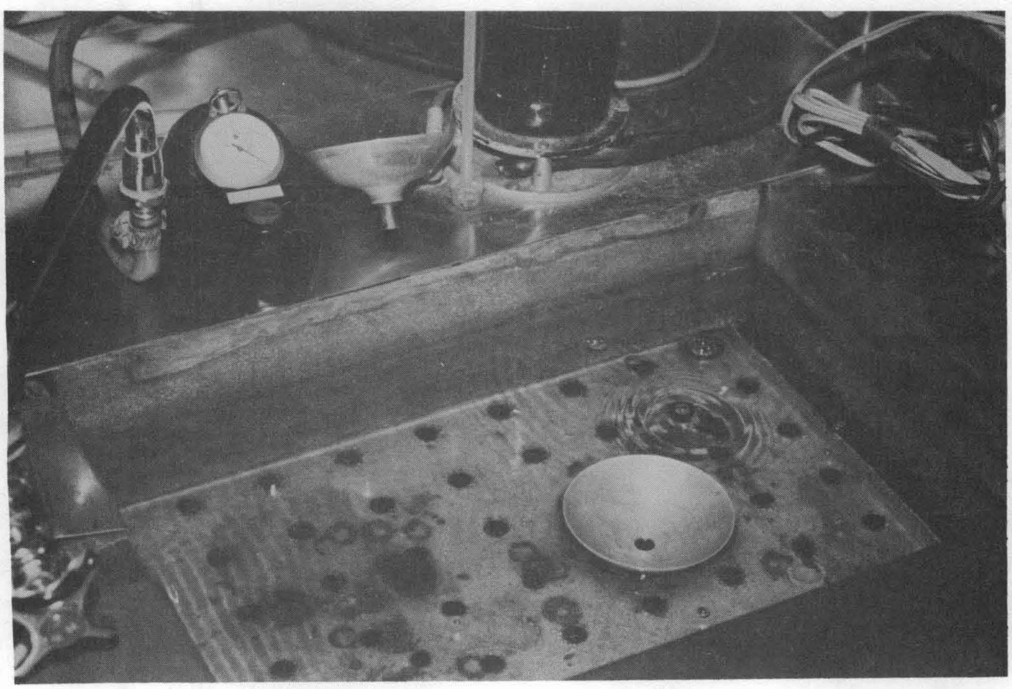

Figure 4

there is about one-inch head of water on the plug of asphalt in the collar. For asphalt cement from which emulsions are normally produced, the time required for the hot water to soften and penetrate the asphalt plug would be on the order of 200 to 300 seconds.

The residue of a high float emulsion will withstand penetration of the hot water for a much longer period of time--in some cases, almost indefinitely--they have a high float value, thus the name "high float" emulsions. Typically, a high float emulsion has a minimum float time requirement of 1200 seconds on the distillation residue.

What gives a high float emulsion its unique property? The properties of the high float emulsion residues are imparted by the emulsifying agents used. The agents normally used are produced by reacting crude tall oil with sodium hydroxide. The tall oil contains a rosin acid component which saponifies with the sodium hydroxide, forming a tall oil soap. As the emulsion breaks or cures, the tall oil soap crystallizes or forms a lattice structure that produces the gel or resistance to flow of the asphalt. This is more of a physical phenomenon than a reaction with the asphalt. In the emulsion distillation, the asphalt residue is taken to a temperature of 500 F. The question has been raised as to whether or not this gel structure will form in actual use of the emulsion where the temperature may never exceed 160 F. Emulsion residues can be obtained by evaporation at relatively low temperatures, and it has been demonstrated that these residues do have a gel structure or resistance to flow. High float emulsions are anionic emulsions. It may be possible to produce a high float emulsion that is non-ionic or even cationic, but all the high float emulsions in actual use are anionic.

What benefit is the gel structure imparted to high float residues? The most important is reduced temperature susceptibility. The residue has a considerably higher viscosity or film strength at the upper road temperatures, and the researchers have shown it is also less brittle than the original asphalt at low temperatures.

Research has also shown that there is a slight improvement in resistance to age hardening of high float residues compared to the original asphalt.

We really need to look at the various types of high float emulsions and their uses. Some specific advantages can be pointed out for various applications.

High float emulsions came into use in the late 1950's. The first use of them was in the midwest. The first high float emulsions were medium-setting types containing some solvent. Their primary use was in making stockpile mixes. The first use of a high float emulsion in Texas was in the latter part of 1974. This was the original version of AES-300, and it was used in lieu of AC-3 and primer in making HM-CL. (This was a drum mix operation.)

During 1978, emulsion suppliers began to promote the use of high float rapid-setting emulsion for seal coat work, and a number of you have worked with this material. At the present time, we have special specifications covering two high float materials--AES-300 and HFRS.

There are specifications covering many versions of high float emulsions used by various agencies. ASTM has requirements for four high float emulsions, none of which correlate with our AES-300 or HFRS. Canada has made extensive use of high float emulsions and has specifications covering several different types.

Our AES-300 specification is based on Indiana's AE-300 material.

Let's look at four uses of high float emulsions:

1. Dense-graded stockpile mixes
2. Open-graded mixes
3. Dense-graded seal coats
4. One-size aggregate seal coats

The AES-300 was designed for making mixes. A copy of the special provision covering AES-300 is attached. This material contains some solvent in the kerosene or diesel range. The specification requires that the residue from the emulsion distillation be a minimum of 300 penetration--quite soft. This emulsion has been used quite successfully in lieu of AC-3 and primer in making hot mix-cold laid material. A typical set of conditions for producing mix in a batch plant has been as follows:

Aggregate temperature - 200 F

AES-300 temperature - 100 to 120 F

Discharge temperature of mix - 150 to 155 F

The AES-300 lends itself well to drum mixes. As previously indicated, the first use of AES -300 was in making a stockpile mix with a drum plant.

The advantages of AES-300 for a stockpile mix are:

1. Good initial coating of aggregate.
2. Good retention of workability. The gel structure helps produce thicker, more uniform films of asphalt on the aggregate and also helps retain the solvent present.
3. More resistance to stripping in the stockpile and after placement than AC.
4. Gel structure imparts resistance to rutting and shoving.

Stripping of the asphalt coating in the stockpile, either immediately after production because of water vapor being released or stripping as a result of weather has often been a problem with our standard Item 350 material. One of the producers began using AES-300 primarily for this reason. We prepared some laboratory mixes with this producer's aggregate and AES-300 and with water, primer and AC-3, and then compared their resistance to stripping using the boiling stripping test. Figure 5 shows an AES-300 mix and an AC-3 mix after the stripping test. The test was performed on the mixes within 24 hours after preparation--no significant curing. As you can see, the AES-300 mix evidenced less stripping. Figure 6 shows the results of the same test performed on the mixes after 24 hours of curing at 140 F to remove moisture and volatiles. There is not as much difference in performance, but the AES-300 mix still did better.

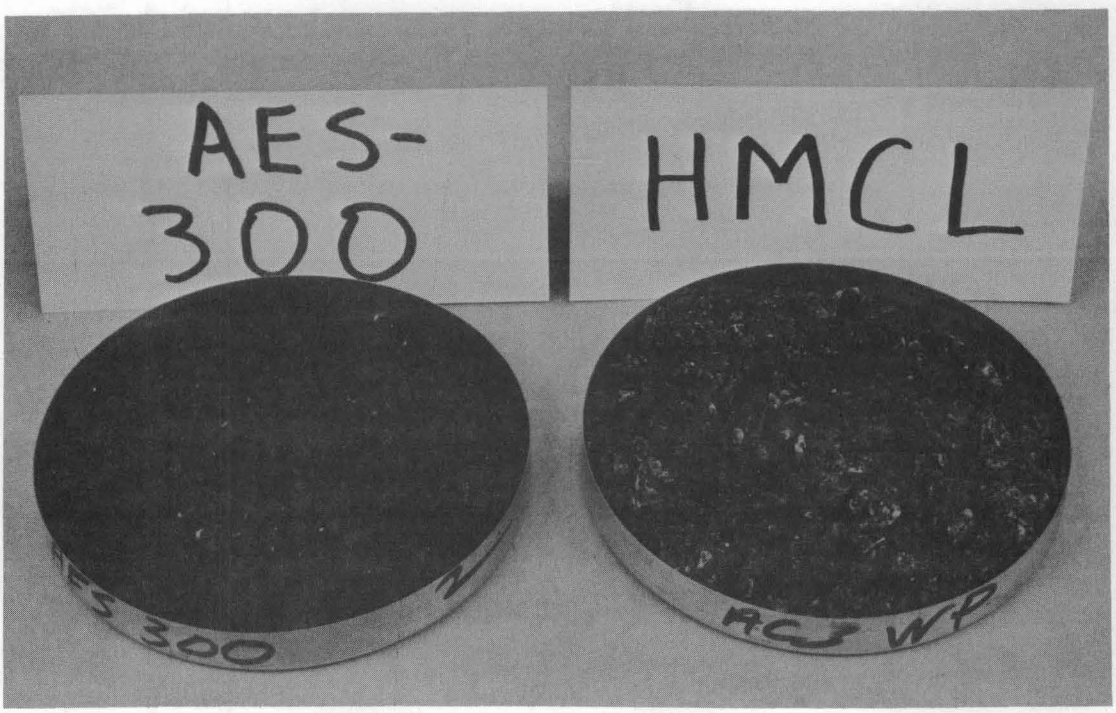

Figure 5

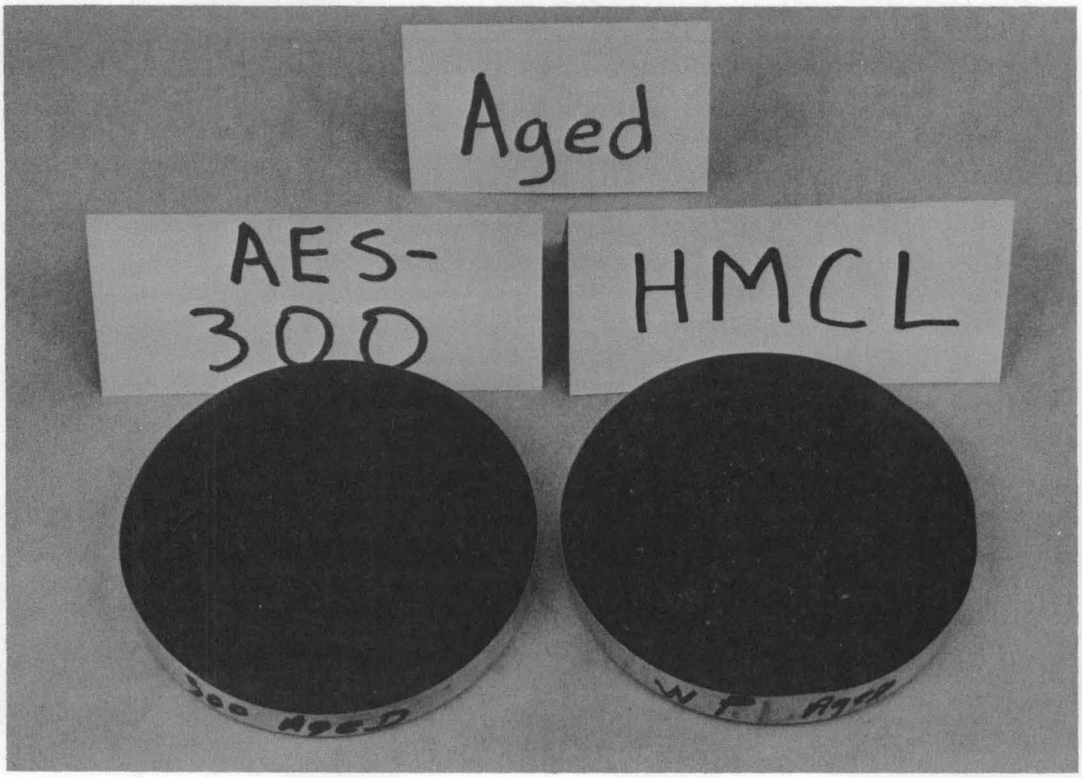

Figure 6

For open-graded mixes, a mixing grade high float emulsion with less solvent--one that will have a distillation residue with a harder penetration would be desirable. For open-graded mixes, high float emulsions offer the following advantages:

1. Gel structure gives thick film of asphalt on aggregate--prevents draindown.
2. Fair resistance to stripping.
3. Film strength helps retard closing up of voids.

For quite some time, the Canadians have been placing dense-graded seal coats on low traffic roads using pit run or crusher-run gravels and high float emulsions. These aggregates typically are 100 percent passing the 1/2 inch sieve, about 50 percent passing the No. 4, with as much as

15 percent and 4 percent respectively passing the Nos. 40 and 200 sieves. The primary reason for using these pit or crusher run aggregates was the scarcity and high cost of nominal one-size aggregate. However, the Canadians also state that the dense-graded material is more stable than a one-size aggregate when initially placed and is less susceptible to dislodgement by traffic. Considerably less traffic control during construction is required.

In order to obtain a good stick with dense-graded aggregates, it was found that a medium setting emulsion containing some solvent was needed in order to get sufficient wetting out of the aggregate. Conventional emulsions of this type didn't work well, because the seal coat would eventually bleed. The Canadians found that a high float emulsion applied at the proper rate would not bleed.

The advantages of the high float emulsion for dense-graded seal coats are:

1. Good wetting out of the aggregate.
2. Greater film strength which gives better aggregate retention.
3. Resistance to bleeding. (Higher viscosity @ higher temp.)
4. Allows use of softer residues. This is important for cold climates.

The use of HFRS emulsions for conventional seal coats is relatively new, but several Districts have tried this material and can better comment on its performance than I. A copy of the latest special provision for HFRS is attached.

First let's look at the difference in specification requirements between an HVRS and an HFRS emulsion.

1. The HFRS has a minimum float requirement of 1200 seconds at 140 F, the HVRS has no float requirement.

2. The HFRS has a minimum demulsibility of 50 percent compared with 60 percent for an HVRS.

3. The penetration range of distillation residue is 100 to 140 for the HFRS, compared with 120 to 160 for HVRS.

The demulsibility is related to the stability of the emulsion, and should be an indication of how fast it will break or cure. For an HVRS, the demulsibility normally will be around 90 percent, and for an HFRS it will be around 55 to 60. As we will see in a few moments, this doesn't necessarily mean the HFRS is slower curing. The lower penetration range of 100 to 140 is based on emulsifying the same asphalt as is used in an HVRS. The gelling effect of the high float agent results in a penetration value of 20 to 30 points lower.

In theory, the HFRS material offers the following advantages:

1. Greater film strength at elevated road temperatures.
2. More resistance to shelling out at low temperature.

If better bond strength in hot weather is what you need, then the 100 to 140 penetration range HFRS should offer some benefit. On the other hand, if the bond strength at elevated temperatures with standard HVRS or CRS-2 is adequate, but you need more resistance to shelling out in cold weather, an HFRS with a penetration range of 120 to 160 or perhaps 140 to 180 would be better. Some of you have specified HVRS or CRS-2 with one to two percent diesel or kerosene emulsified along with the asphalt for use in cool weather. This same technique can be used with HFRS to make the residue even less brittle at low temperature.

We did some work in the laboratory to compare the cure rate and resistance to wash-out of HVRS, HFRS and CRS-2. The cure rate was compared for both a limestone and a gravel. This was done at a temperature of 72 F and a relative humidity of 72 percent. The ranking of the various combinations with regard to degree of cure or set after 1 1/2 hours at 72 F and 72 percent relative humidity is shown below:

1. CRS-2 + limestone
2. CRS-2 + gravel
3. HFRS + limestone
4. HVRS + limestone
5. HFRS + gravel
6. HVRS + gravel

This indicates that the HFRS emulsion falls between a CRS-2 and an HVRS as far as speed of cure or development of film strength. At the 1 1/2 hour point, we took the eumulsion-aggregate test specimens and subjected them to washing with water to determine their relative resistance to water at that point. The procedure used was as follows:

1. Pans placed in sink and surface sprayed with water at medium pressure from hand attachment for one minute.
2. One minute was allowed to elapse with water standing on the surface.
3. Pan was then held with surface vertical and it was sprayed with water for two minutes. Spray head was held approximately six to eight inches from the surface and rotated over the surface of the asphalt and aggregate.

The weight percent aggregate lost for each emulsion-aggregate combination was as follows:

CRS-2		HFRS		HVRS	
Limestone	Gravel	Limestone	Gravel	Limestone	Gravel
None	None	11	12	31	34

Figures 7 and 8 show the limestone and gravel test pans respectively.

As you can see, the HFRS is not as resistant to wash-out in the early stages of cure as CRS-2, but it does perform better than HVRS. Based on our laboratory evaluation, an HFRS would fall between HVRS and CRS-2 with respect to both cure rate and resistance to loss of rock because of rain soon after placement.

We in D-9 solicit the input of you who are using the high float emulsions. Your experience will help determine the best ways to use these materials and changes that may need to be made in the specification requirements.

Certainly, we are available to assist you any way we can in making the best use of these materials.

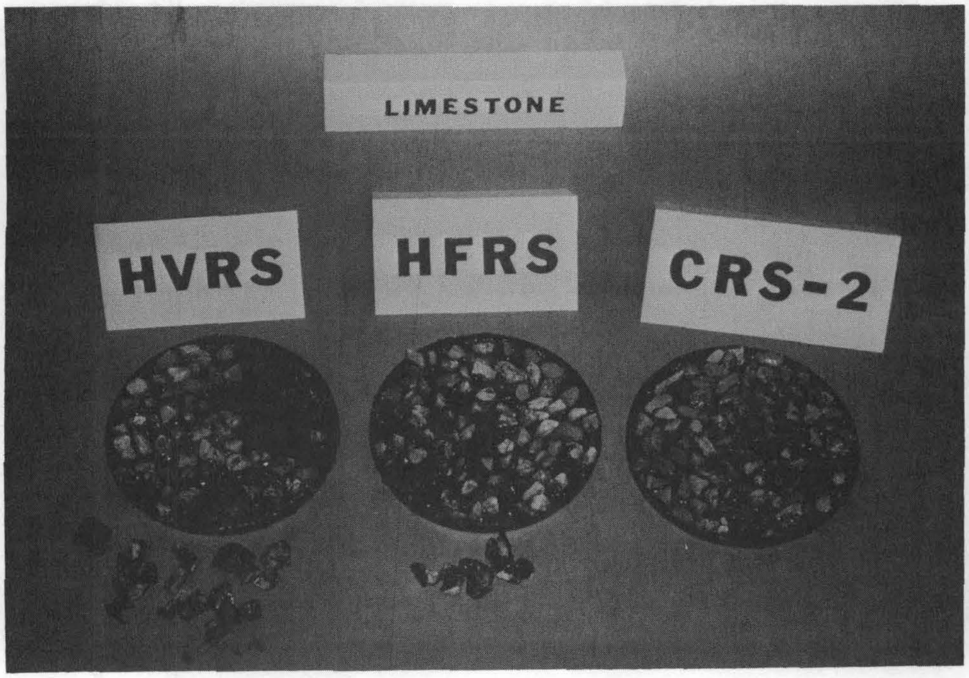

Figure 7

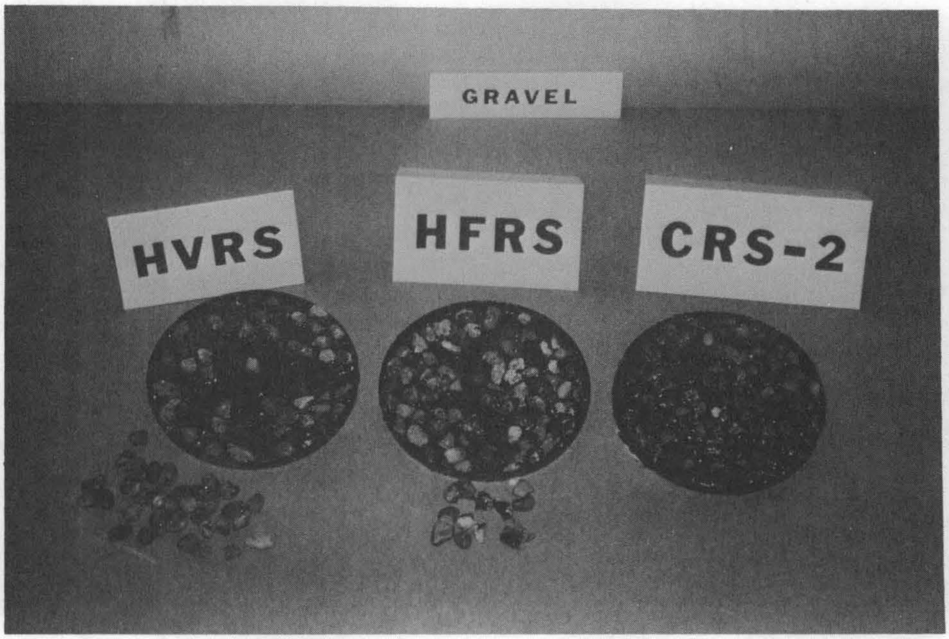

Figure 8

TEXAS HIGHWAY DEPARTMENT

SPECIAL PROVISION

TO

ITEM 300

ASPHALTS, OILS AND EMULSIONS

For this project Item 300, "Asphalts, Oils and Emulsions", of the Standard Specifications, is hereby amended with respect to clauses cited below and no other clauses or requirements of this Item are waived or changed hereby.

Article 300.2. Materials, Subarticle (7) Emulsions. The table of Anionic Emulsions is supplemented by the following.

Type	High Float	
Grade	AES-300	
	Min.	Max.
Furol Viscosity 77 F, secs.	75	400
Residue by distillation, wt. %	65	
Oil Portion of Distillate, % by Vol. of Emulsion		7
Coating Test *	Passing	
Settlement, 5 days, %		5
Tests on Distillation Residue:		
Penetration, 77 F, 100 g. 5 sec.	300	
Solubility in Trichloroethylene, %	97.5	
Float Test ** at 140 F, sec.	1200	

* ASTM Method D 244 except that the mixture of stone and asphalt emulsion shall be capable of being mixed vigorously for 5 minutes, at the end of which period the stone shall be thoroughly and uniformly coated. The mixture shall then be completely immersed in tap water and the water poured off. The stone shall then be not less than 90 percent coated.

** ASTM Method D 139 except that the residue from distillation shall be poured immediately into the float collar at 500 F.

SPECIAL PROVISION

TO

ITEM 300

ASPHALTS, OILS AND EMULSIONS

For this project Item 300, "Asphalts, Oils and Emulsions", of the Standard Specifications, is hereby amended with respect to clauses cited below and no other clauses or requirements of this Item are waived or changed hereby.

Article 300.2. Materials, Subarticle (7) Emulsions. The table of Anionic Emulsions is supplemented by the following:

Anionic Emulsions

Type	Rapid Setting	
Grade	EA-HVRS-HF	
	Minimum	Maximum
Furol Viscosity at 122 F, Sec.	200	400
Residue by Distillation, %	63	
Oil Portion of Distillate, %	-	2.0
Sieve Test, %	-	0.1
Demulsibility 35 cc of N/50 $CaCl_2$, %	50	-
Settlement, 5 Days, %	-	5.0
Tests on Residue:		
Penetration at 77 F, 100 g, 5 Sec.	100	140
Solubility in Trichloroethylene, %	97.5	-
Ductility at 77 F, 5 cm/min, cms	100	
*Float	1200	-

*ASTM Method D-139 except that the residue from distillation shall be poured immediately into the float collar.

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