Liquid Asphalts and Their Uses

H. C. Offutt, Asphalt Engineer
The Ohio Oil Company
Robinson, Illinois

Highway asphalts vary in consistency from the water-thin liquids used in dust palliatives to solid asphalts pulverized into powder form and used for blending purposes. The various types include:

Hard Asphalts
Asphalt Cements
Slow-Curing Liquid Asphalts (SC Road Oils)
Rapid-Curing Liquid Asphalts (RC Cutbacks)
Medium-Curing Liquid Asphalts (MC Cutbacks)
Asphalt Emulsions

Since hard asphalt is a solid material, it will not be discussed in this paper as the subject assigned covers only the liquid types.

ASPHALT CEMENTS

Asphalt cement is a black, sticky, semi-solid substance composed of hydrogen and carbon combinations some of which are in the form of asphaltenes, others in the form of resins, and still others in the form of oils.

The asphalt cements found in rock asphalts, in nature, or recovered from petroleum, in the main are composed of asphaltenes, resins, and oils. The three constituents are mutually dissolved in each other. The asphaltenes give asphalt its hardness; the resins give it its cohesion; and these two in combination give asphalt its cementing, preserving, and waterproofing properties. The oils give asphalt mobility and plasticity, making it workable for all uses. The proportions of each ingredient in the asphalt indicate its character as a bonding and preserving material. Hard asphalt, such as Gilsonite, is composed mostly of asphaltenes, with some resins. Paving asphalt cement is composed of asphaltenes and resins, with some oils. The harder the grade of asphalt cement, the less oils it contains; conversely, the softer the grade of asphalt cement, the more oils it contains. Asphalt cement is measured in penetration units. The harder grades, 30-70 penetration, are for crack filling and

similar uses. The 70-100 penetration grades are used in high-type paving mixtures to serve heavy traffic. The 100-150 penetration grades are used in high-type paving mixtures to serve lighter traffic. The soft grades, 150-300 penetration, are used in low-cost plant mixtures and surface-treatment work. Records show asphalt to have existed for over 4,000 years as the bonding medium in mastic made and used by the Sumerians and neighboring states. Pavements have served extremely heavy traffic in metropolitan cities for thirty or more years without replacement. Asphalt cement is one of the best preservatives known to man. It is a most effective and durable waterproofing material and is considered the best shield against corrosion and decay.

LIQUID ASPHALTS

Liquid asphalts are composed of asphalt cement carried in various solvents; therefore their character and behavior in highway work are largely dependent upon the character and amount of solvent present. In practically all highway work the aggregate particles forming the framework of the pavement structure must be coated with films of asphalt cement, either by mixing processes or penetrative treatments. During the coating process, the asphalt must be a liquid in order that it may spread over the surface of the particle. A Furol viscosity of about 100 seconds is believed to be the desirable fluidity for good coating.

In hot-mix work, asphalt cement is heated sufficiently to produce the viscosity for good coating. It is then mixed with heated aggregate to keep the asphalt a liquid until the paving mixture is laid and compacted. In low-cost work, a liquid asphalt is used which will coat sun-warmed aggregates in the mixing process or treatment.

The solvent is placed in liquid asphalt to make it a fluid product. It is a substitute for heat. In certain work the solvent is more useful than heat because its liquifying effect extends over a longer period of time. The fluidity of a liquid asphalt is a function of the amount of solvent contained in the product. An asphalt cement may be fluxed to almost water consistency with a large amount of solvent. Any desired consistency may be obtained by using the proper amount of solvent.

The character of the solvent affects the behavior of liquid asphalts. The more volatile the solvent, the more rapid will be the curing period following the use of the liquid asphalt and the harder it will be for the liquid asphalt to coat fine aggregate. The less volatile the solvent, the more is required to bring an asphalt of a given consistency to a desired degree of viscosity; also, the harder the base asphalt, the more solvent is required to produce a given degree of viscosity.

Cutback asphalts are liquid asphalts made by dissolving asphalt cement in volatile solvents of the nature of unfinished naphtha or kerosene. After the liquid asphalt has been mixed or applied to an aggregate, the solvent should separate from the asphalt mixture either by evaporation or capillary action, leaving the asphalt cement in place as the bonding and waterproofing medium. The rapidity with which cutback asphalts may be expected to revert back to asphalt cement after use depends upon the amount and kind of solvent present and the conditions attending their use. For certain types of work cutback asphalts are of great value, especially in primers, tack coats, surface treatments, and seals and as binders for some open-graded aggregates where there is no serious hindrance to the escape of the volatile solvents. Their function as a binder for paving mixtures is limited. The amount of cutback that may be used in the mixture is restricted, so that proper waterproofing of the aggregate framework is not accomplished and the pavements are subject to rapid weathering, soon lose their flexibility, and do not have a long life of service.

From a standpoint of utility, liquid asphalts are of primary value because at warm-weather temperatures they will easily coat the aggregate in road-mix operations or will penetrate surfaces upon which they are applied and will bond covering aggregate in surface-treatment and sealing work. Being diluted with solvent, they cannot be expected to perform and give the service of asphalt cements. Since the heavier grades of liquid asphalt contain the higher percentages of asphalt cement, engineers should use the heaviest grade of liquid asphalt possible that will do the desired work.

Slow-Curing Liquid Asphalts

SC oils are recovered from petroleum by distillation which is operated to give the desired grade or they may be manufactured by combining asphalt cement with additional oils to produce the different grades of material. They are marketed in the following grades:

SC-0	SC-3
SC-1	SC-4
SC-2	SC-5

SC-0 Liquid Asphalt. SC-0 is used for:

a. Dust-palliative work on dirt roads or aggregate roads containing dirty aggregates.

SC-1 Liquid Asphalt. SC-1 is used for:

a. Dust-laying purposes on dirt roads or aggregate roads containing dirty aggregate when the soils are more open in texture.

SC-2 Liquid Asphalt. SC-2 is used for:

a. Dust-laying purposes on dirt roads or aggregate roads when soils are sandy in texture and aggregate roads are quite open in texture.

b. Earth-oiling work with most soils where systematic annual reconditioning and retreatments are being maintained.

c. Blotter or mulch treatments with aggregate that contains an excess of fines.

d. Road-mix work in cool weather with dense-graded aggregate containing a high percentage of 200-mesh material.

e. Surface-treatment work with sand-gravel covering aggregate.

SC-3 Liquid Asphalt. SC-3 is used for:

a. Road-mix work in warm weather with dense-graded aggregate containing a high percentage of 200-mesh material or with 1-inch maximum aggregate graded down to a medium percentage passing the 200-mesh sieve.

SC-4 Liquid Asphalt. SC-4 is used for:

a. Cold-patch mixture with dense-graded aggregate.

b. Cold-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material.

c. Medium hot-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material.

SC-5 Liquid Asphalt. SC-5 is used for:

a. Cold-patch mixture with dense-graded aggregate in hot climates.

b. Cold-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material.

c. Medium hot-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material.

Note: SC-4 and SC-5 have the same uses. The grade selected depends upon the nature and efficiency of the mixing and laying equipment and the temperature of the weather. Where possible, the heavier grade of binder should be used.

Road Oils

Road oils, as the first slow-curing liquid asphalts were called, were being used on roads as early as 1898 for dust laying and treatment of earth and aggregate roads. Satisfactory results are indicated because they have continued in use to the present time. During the boom in low-cost road construction, beginning about 1924, engineers acquainted with road-oil treatment took a step forward when they began the construction of oil-mat wearing courses. During the initial stage of construction, the general conception held that the oil-mat mix was a cheap surfacing, and only a temporary expedient. It was hard to believe that the low cementing strength of road oils could bond an aggregate together and waterproof the aggregate sufficiently to develop a stable, durable pavement structure.

It was among the oil-mat engineers that the idea of combining aggregates to develop their ultimate stability became prevalent. The cohesion of the asphalt binder was considered as only a factor of safety. When aggregate gradations having a strong framework were developed, it was found that strong asphalt-cement binder was not necessary in the construction of stable wearing courses.

Under this impetus, the oil-mat mix made progress. It has developed and grown and is being used in many areas throughout the United States, particularly where rainfall is light and the weathering conditions are not severe. Road oils had been used in the penetrative treatments because they were plentiful and cheap and had the ability to penetrate deeply into tight bonded surfaces. In the change-over from penetration to road-mix work, they were retained for the above reasons and their quick coating of dust-coated particles. SC oils are an ideal binder for dense-graded aggregates. The mixture is now known as the oiled-aggregate mix. It retains the dense-graded aggregate specified in high-type work, but substitutes a liquid asphalt for asphalt cement.

The development of the oiled-aggregate mix has given the paving industry a valuable type of wearing course for secondary roads. It gives good service where the climate is dry but does not fare so well in wet regions and bad freezing weather. The use of heavier grades of SC oil and plant-mix methods are recommended for use in areas having unfavorable weather.

Rapid-Curing Liquid Asphalt

RC cutback asphalts are manufactured by combining 80-120 penetration asphalt cement with a naphtha solvent. The naphtha is varied

in amount to produce the different grades of RC material. They are marketed in the following grades:

Grade of RC	*Approximate Amount of Naphtha Solvent*
RC-0	40%
RC-1	32%
RC-2	25%
RC-3	20%
RC-4	15%
RC-5	10%

RC cutback asphalt was developed about 1924 because of the need for a liquid asphaltic product that could be used in primes, tack coats, and binder for penetrative treatments, and coating of sun-warmed aggregates in road-mix operations. It was found to be very satisfactory for some of the needs and has proved to be a valuable addition to the group of asphalt road materials. As a binder in paving mixtures it is best adapted for use with clean mineral aggregates containing little or no 200-mesh particles. The first road mixes used a medium-sized macadam aggregate (1½ inch-¼ inch). The compacted mix was then choked and sealed with surface treatment. The design was patterned after the penetration macadam pavement which was being extensively constructed in many parts of the country. Modern practice has gone to finer sizes (1-inch to No. 10) in road-mix work. This wearing-course construction is also sealed with surface treatment. RC liquid asphalt is used in other kinds of bituminous work. The recommended practice includes the following:

RC-0 Liquid Asphalt. RC-0 is used for:

a. Penetrative treatments, with or without covering aggregate. Light applications are made to old bituminous surfaces to stop ravel and disintegration. The new asphalt softens the old binder, fluxes with it, and increases the bitumen content of the old paving. The old surface must be open so that the additional asphalt will not flush to the surface of the road and cause skidding in wet weather.

RC-1 Liquid Asphalt. RC-1 is used for:

a. Tack-coat work in cool weather or on tight-bonded bituminous bases. The application is a part of the preparation of the old surface to receive the new wearing course. The tack-coat asphalt penetrates into the old bituminous binder, softens

its surface, and after evaporation of the solvent becomes a cementing medium to bond the old surface and new wearing course firmly together.

b. Surface-treatment work with coarse sand or ¼-inch covering aggregate.

c. Road-mix work in cool weather with sand aggregate.

RC-2 Liquid Asphalt. RC-2 is used for:

a. Tack-coat work in warm weather or more open bituminous bases.

b. Surface-treatment work with coarse sand and ¼-inch and ½-inch covering aggregate.

c. Road-mix work in warm weather with coarse sand or fine macadam aggregate.

d. Base stabilization work with sand aggregate.

e. Cold-lay plant-mix work with sand aggregate.

f. Cold-patch mixture with open graded aggregate (½-inch to No. 10).

Note: This type of patch mixture is open and porous and is short-lived. Fortunately for the paving industry, it is losing its popularity and is going out of use.

RC-3 Liquid Asphalt. RC-3 is used for:

a. Surface-treatment work with ½-inch and ⅝-inch covering aggregate.

b. Drag-leveling course work with open-graded aggregate usually passing 1-inch and retained on No. 10 sieve.

c. Road-mix work with macadam aggregate.

d. Cold-lay plant-mix work with coarse sand or open graded aggregate (1-inch to No. 10).

e. Seal-coat work with sand or fine covering aggregate.

RC-4 Liquid Asphalt. RC-4 is used for:

a. Surface treatment work with ⅝-inch and ¾-inch covering aggregate.

b. Cold-lay plant-mix work with macadam aggregate.

c. Seal-coat work with coarse sand or fine covering aggregate.

d. Crack filler for narrow cracks and joints in brick and cement concrete pavements. Coarse sand cover is usually required in

hot weather to prevent the asphalt from tracking when run over by traffic.

RC-5 Liquid Asphalt. RC-5 is used for:

a. Penetration macadam work. Asphalt cement 85/100 penetration is most generally used in this work.
b. Cold-lay plant-mix work with macadam aggregate.
c. Medium hot-lay plant-mix work with aggregate used in Class F mixtures.
d. Crack filler for narrow cracks and joints in brick or cement concrete pavements. Covering aggregate is used, depending upon the temperature of the pavement at time of pouring.

Summary

RC paving mixtures are laid and compacted shortly after preparation. This type of solvent evaporates quickly and the mixture becomes hard to manipulate and handle within a few hours after mixing begins. The compacted paving course is open and after curing is given an application of surface treatment to choke the voids and seal the surface from rainwater.

The relatively low surface area of macadam and open-graded aggregates will retain only so much asphalt binder. The use of more asphalt results in unstable paving. The restricted amount of asphalt that necessarily must be used does not adequately fill the voids in the compacted aggregate nor properly waterproof the aggregate structure. The openness allows the entrance of water and other weathering agents to accelerate the attack on the films of asphalt binder and permits the water to seep through to the base and subgrade, causing them to soften and lose load-supporting strength.

The stability of the open-aggregate structure depends primarily on the keying and interlocking action of the coarse-aggregate particles, held together by the strong cementing strength of the asphalt binder. This interlocking is easily disrupted by the movement of a weak base or subgrade when subjected to heavy loads. With the interlock broken, raveling and disintegration begin and the wearing course is destroyed. Many miles of this type of wearing surface are lost during spring thaw periods when the subgrade saturated with water has low bearing values. Dense-graded paving mixtures may also fail where the movement is very bad, but the mileage lost is not so great, for they are more elastic and can withstand greater base and subgrade movement.

The life of open-graded aggregate paving is usually short unless it is placed on a strong base and a well-drained subgrade and is properly maintained by surface treatment and sealed against the entrance of water.

RC paving mixtures follow a fundamental law of high-type paving in that they coat the aggregate particles with asphalt cement. Unfortunately, the asphalt content of the paving approximates only 60 percent of that used for the same aggregate in high-type work. On the other hand, the RC mixtures disregard entirely the law requiring a dense paving mass which confines weathering to the surface of the pavement.

Medium-Curing Liquid Asphalt

MC cutback asphalts are manufactured by combining 120-300 penetration asphalt cement with a kerosene solvent. The kerosene is varied in amount to produce the different grades of MC material. These asphalts are marketed in the following grades:

Grade of MC	*Approximate Amount of Kerosene Solvent*
MC-0	40%
MC-1	32%
MC-2	25%
MC-3	20%
MC-4	15%
MC-5	10%

MC liquid asphalt was devised about 1930 because of the need for a liquid-asphalt priming material and a faster-setting, stronger-cementing liquid asphalt that would coat dense-graded aggregates. The light grades of RC cutback were not found to be satisfactory for priming tight-bonded bases. The naphtha solvent as it penetrates the base does not pull its asphalt along with it but leaves the asphalt cement lying on the surface where it cannot function as a prime. The light grades of SC oil penetrate tightly-bonded bases but the penetration is slow and the curing time too long for good construction operations.

The new cutback was found to give excellent satisfaction in priming work and good results with dense-graded mixtures. MC cutback is used in many other varieties of work. The recommended practice includes the following:

MC-0 Liquid Asphalt. MC-0 is used for:

a. Dust-palliative work on dirt roads or aggregate roads containing dirty aggregate.

b. Priming work on tight-bonded bases. It is considered one of the best materials now in use for priming.

MC-1 Liquid Asphalt. MC-1 is used for:

a. Dust-palliative work on dirt roads or aggregate roads containing dirty aggregate. This grade is used on more open soils and aggregates.

b. Priming work on slightly open bases and loosely-bonded fine aggregate bases.

MC-2 Liquid Asphalt. MC-2 is used for:

a. Base-stabilization work with moderately plastic soils.

b. Priming work on loosely-bonded fine aggregate bases and coarse aggregate bases.

c. Tack-coat work on brick and cement concrete pavements.

d. Surface-treatment work with coarse sand, and ¼-inch aggregate cover, also with graded gravel or gravel mulch covering aggregate.

e. Drag-leveling course work with dense-graded aggregate.

f. Road-mix work with dense-graded aggregate containing a high percentage of 200-mesh material or with dense-graded aggregate 1-inch maximum size graded down to a medium percentage of 200-mesh material.

g. Cold-patch mixtures with dense-graded aggregates.

MC-3 Liquid Asphalt. MC-3 is used for:

a. Surface-treatment work with ¼-inch, ½-inch, and ⅝-inch covering aggregate or graded gravel aggregate cover.

b. Drag-leveling course work with open-graded or dense-graded aggregate.

c. Road-mix work with coarse-sand, open-graded aggregate 1-inch maximum size and a high percentage of 10-mesh material, and with dense-graded aggregate 1-inch maximum size and a medium percentage of 200-mesh material.

d. Cold-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material.

e. Cold-patch mixture with either open-graded or dense-graded aggregate. The dense-graded mixture is recommended as the more durable material.

MC-4 Liquid Asphalt. MC-4 is used for:

a. Surface treatment work with ½-inch, ⅝-inch, and ¾-inch covering aggregate.
b. Drag-leveling course work with open-graded aggregate.
c. Seal-coat work on new construction with fine aggregate cover.
d. Cold-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material or 1-inch maximum-size aggregate graded down to a medium percentage of 200-mesh material.
e. Cold-patch mixture with open-graded aggregate or dense-graded aggregate with a medium percentage passing the 200-mesh sieve.

MC-5 Liquid Asphalt. MC-5 is used for:

a. Surface-treatment with ⅝-inch and ¾-inch covering aggregate.
b. Seal-coat work on new construction with fine aggregate cover.
c. Cold-lay plant-mix work with open-graded aggregate containing 1-inch maximum-size aggregate having a high percentage of 10-mesh material.
d. Cold-lay plant-mix work with dense-graded aggregate containing 1-inch maximum-size aggregate having a medium percentage of 200-mesh material.
e. Hot-lay plant-mix work with aggregate used in Class F mixture.

Summary

MC mixes cure and harden faster after preparation than SC mixes. For this reason they were thought to be an improvement over the SC type. Accordingly there was a swing to the MC mixtures in many parts of the country. The substitution of MC cutback for SC oil required no radical change in construction procedure. The principles of design and construction were little different from those applying to the oiled-aggregate mixture. However, the percentage of liquid asphalts is increased to provide for the lesser amount of base asphalt in the MC cutback.

MC mixtures require manipulation until a considerable portion of the volatile solvent has evaporated. The aeration operation is beneficial in several ways. (1) More asphalt may be used without loss of stability so that a more durable pavement may be constructed. (2) The additional asphalt provides thicker asphalt coatings on the aggregate particles, which lessen the rate of hardening of the asphalt so that the pavement does not become hard and brittle nearly as soon as the leaner one. (3) The removal of the solvent before spreading and compaction prevents the richer mixture from shoving and pushing.

MC cutback does provide greater cohesion than the SC oil. This property may be utilized where it becomes necessary to employ smooth, rounded sand-gravel aggregate in the paving mixture. The greater cohesion of the MC cutback often provides sufficient additional stability to make the aggregate usable.

Experience has shown that MC pavements harden and become brittle earlier than SC pavements. The studies made on early hardening indicate in many instances that the pavements were low in asphalt content. In some cases it was found that the solvent may affect the hardening of the base asphalt. The asphalt recovered from the cutback showed a greater tendency to harden and crack than did the base asphalt from which it was made. The studies also indicated that the more volatile the solvent, the faster the rate of hardening.

In road-mix work, where availability of funds is paramount, most engineers believe the MC cutback—dense-graded aggregate mixture to be the low-cost paving type that gives the best return for the expenditure. The mix uses the aggregate grading found in high-type work and a soft asphalt cement binder, but its asphalt content is lowered because of the liquid character of the binder at time of use.

ASPHALT EMULSION

Asphalt emulsions are made by combining asphalt cement and water with the aid of emulsifying agents to make a liquid product. The asphalt is not dissolved in the water. The emulsion is a special material having special problems and, while a liquid product, it is not called a liquid asphalt as are SC, RC, and MC products, where the asphalt cement is dissolved in the solvent.

Two kinds of asphalt emulsion are found in highway work. The kind generally used contains molecules of asphalt coated with an emulsion film and carried in sufficient water to make the desired viscosity for good coating. The other kind of asphalt emulsion is a mixture containing minute particles of water coated with the emulsion film and carried

in the asphalt. It is called the *inverted* type of asphalt emulsion. The life of the emulsion film in both kinds is controlled to break under certain conditions after distributor application or preparation and laying of paving mixture, allowing the asphalt to return to its original form in coatings on the aggregate particles.

Several types and grades of asphalt emulsion are now in use. Various groups and organizations throughout the country use the products and terminology originating in their locality. This situation causes confusion and retards the progress and development of the product. Standardization of the types and grades is needed. The Asphalt Institute, the Highway Research Board, the American Society for Testing Materials, and other organizations have adopted the following terminology and recommend the standardization of asphalt emulsion types and grades as follows:

Rapid-Setting Asphalt Emulsion (RS)

RS-1, a medium-consistency emulsion for penetration and surface treatment.

Medium-Setting Asphalt Emulsion (MS)

MS-1, a low-consistency emulsion for road mixes with coarse aggregate.

MS-2, a medium-consistency emulsion for plant-mix with coarse aggregate.

MS-3, a high-consistency heavy pre-mix grade of emulsion for plant-mix or patching with coarse aggregate.

Slow-Setting Asphalt Emulsion (SS)

SS-1, a slow-setting emulsion for fine aggregate mixes.

SS-2, a slow-setting emulsion for stabilization of soils.

The various uses of the types and grades follow:

RS-1 Rapid-Setting Asphalt Emulsion. RS-1 emulsion contains about 60 percent of 100-200 penetration asphalt cement. It has a Furol viscosity at 77°F of 20 to 100. It is used for:

a. Priming work on loosely-bonded coarse aggregate bases.

b. Tack-coat work on old bituminous bases, brick, and cement concrete bases.

c. Surface-treatment work with coarse sand, ¼-inch, ½-inch, ⅝-inch, and ¾-inch macadam aggregate, or graded aggregate cover.

d. Penetration macadam work under certain conditions.

e. Seal-coat work on open-type wearing courses.
f. Crack filler with coarse sand cover.

MS-1 Medium-Setting Asphalt Emulsion. MS-1 emulsion contains about 60 percent of 100-200 penetration asphalt cement and has a Furol viscosity at 77°F of 20 to 100. It is used for:

a. Drag-leveling course work with open-graded aggregate.
b. Road-mix work with sand or macadam aggregate.

MS-2 Medium-Setting Asphalt Emulsion. MS-2 emulsion contains about 60 percent of 100-200 penetration asphalt cement and has a Furol viscosity at 77°F over 100. It is used for:

a. Drag-leveling course work with open-graded aggregate.
b. Cold-lay plant-mix work with 1-inch maximum-size aggregate graded down to a high percentage passing the #10 sieve.

MS-3 Medium-Setting Asphalt Emulsion. MS-3 emulsion contains about 70 percent of 100-200 penetration asphalt cement and is more viscous than MS-2. It is used for:

a. Cold-patch mixture with open-graded aggregate.
b. Cold-lay plant-mix with macadam aggregate.

SS-1 Slow-Setting Asphalt Emulsion. SS-1 emulsion contains about 60 percent of 100-200 penetration asphalt cement and has a Furol viscosity at 77°F of 20 to 100. It is used for:

a. Dust-palliative work on dirt roads or aggregate roads containing dirty aggregate, when diluted by adding three parts water for one part emulsion.
b. Blotter or mulch-treatment work with aggregates containing an excess of fines, when diluted by adding three parts water for one part emulsion.
c. Priming work on loosely-bonded fine aggregate bases, when diluted by adding three parts water for one part emulsion.
d. Surface-treatment work with gravel mulch when diluted by adding three parts water for one part emulsion.
e. Drag-leveling course work with dense-graded aggregate.
f. Cold-lay plant-mix work with dense-graded aggregate containing a high percentage of 200-mesh material or a 1-inch maximum-size aggregate graded down to a medium percentage of 200-mesh material.

SS-2 Slow-Setting Asphalt Emulsion. SS-2 emulsion contains about 60 percent of 40-90 penetration asphalt cement and has a Furol viscosity at 77°F of 20 to 100. It is used for:

a. Base stabilization for soils.

b. Crack filler consisting of a mixture of SS-2 emulsion and sand so proportioned that the mastic will flow.

The Indiana State Highway current specifications for asphalt emulsion do not follow the above terminology or the types and grades advocated above. However, there is quite a similarity in their uses, as shown in the following tabulation.

Highway Research Board Designation	Penetration of Asphalt Residue	Indiana State Highway Designation	Penetration of Asphalt Residue
RS-1	100-200	AE-150Q	150-200
MS-1	100-200	AE-200, AE-150	150-250
MS-2	100-200	AE-150, AE-90	90-200
MS-3	100-200	AE-90, AE-60	60-130
SS-1	100-200	AES-1, AES-2, AES-3	Soft Cement
SS-2	40-90	AES-3	Soft Cement

The Indiana State Highway specifications call AE 150-Q a quick-setting emulsion and all the other types slow-setting emulsions. A study of the uses made of the various products indicates that AE-60, AE-90, AE-150, and AE-200 are medium-setting products and the AES emulsions are slow-setting products. The asphalt emulsions made in accordance with the Indiana specifications have the following uses:

AES-1 is a slow-setting asphalt emulsion containing about 60 percent of soft asphalt cement, and having a viscosity at 77°F under 65. It is used for priming aggregate roads when slightly diluted by adding one part water to two parts emulsion. Undiluted, it is used for priming macadam aggregate and water-bound macadam bases. Some contractors call the diluted emulsion AES-0.

AES-2 is a slow-setting asphalt emulsion containing about 60 percent of soft asphalt cement and having a viscosity at 77°F of 20 to 75. It is used for:

a. Priming work for macadam aggregate and water-bound macadam bases.

b. Road-mix work with dirty fine aggregate.

AES-3 is a slow-setting asphalt emulsion containing about 60 percent of soft asphalt cement and having a viscosity at 77°F of 20 to 90. It is used for:

a. Sealing of penetration macadam surfaces.

b. Binder in surface treatment work.
Binder in bituminous compacted aggregate surfaces with graded aggregate No. 63.

AE-200 is a medium-setting asphalt emulsion containing about 60 percent of 150-250 penetration asphalt cement and having a viscosity at 77°F greater than 30. It is used for:

a. Tack-coat work on old bituminous bases before laying the new bituminous surface.
Tack-coat work on binder course before laying bituminous-coated aggregate surface.

b. Sealing of bituminous-compacted aggregate surfaces.
Sealing of bituminous-coated aggregate surfaces.
Sealing of surface treatment.

c. Binder in bridge-approach mixture.
Binder in surface treatment.
Binder in bituminous-compacted aggregate surface with graded aggregate No. 63.
Binder in bituminous-coated aggregate surfaces, Class F plant-mix, with Type B graded aggregate.

AE-150 is a medium-setting asphalt emulsion containing about 60 percent of 150-200 penetration asphalt cement and having a viscosity at 77°F of 200 to 90. It is used for:

a. Tack coat on old bituminous bases before laying the new bituminous surface.
Tack coat on binder course before laying bituminous-coated aggregate surface and bituminous concrete surface "AH."

b. Sealing of penetration macadam surface.
Sealing of bituminous-compacted aggregate surfaces.
Sealing of bituminous-coated aggregate surfaces.
Sealing of bituminous-retread surfaces.
Sealing of surface treatment.

c. Binder in penetration macadam surface.
Binder in bituminous-retread surface when work is done by road-mix operations.
Binder in surface treatment.

AE-150-Q is a rapid-setting asphalt emulsion containing 60 percent of 150-200 penetration asphalt cement and having a viscosity at 77°F of 20 to 90. It is used for:

a. Tack coat on old bituminous bases, before laying the new bituminous surface.

b. Binder in penetration macadam surface.
Binder in sealing of new construction.

AE-90 is a medium-setting asphalt emulsion containing about 70 percent of 90-130 penetration asphalt cement. It is used for:

a. Tack coat on binder before laying bituminous concrete surface "AH."

b. Binder in sealing of new construction work.
Binder in penetration macadam surface.
Binder in bituminous-retread surface when machine mixing is specified.
Binder in bituminous-coated aggregate surface, Class F, plant-mix Type A open-graded aggregate.

AE-60 is a medium-setting asphalt emulsion containing about 70 percent of 60-90 penetration asphalt cement. It is used for:

a. Tack coat on old bituminous bases before laying new wearing course.
Tack coat on binder course before laying bituminous concrete surface "AH."

b. Sealing surface treatment.
Sealing bituminous-coated aggregate surface.
Sealing bituminous-compacted aggregate surface.

c. Binder in penetration macadam surface.
Binder in bituminous-retread surface when machine mixing is specified.
Binder in bituminous-coated aggregate surface, Class F, plant-mix Type A open-graded aggregate.