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3,270,631 METHOD OF APPLYING SEAL COAT PAVING MIXTURES

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This invention relates to an improvement in road-surfacing treatment and, in particular, to an improvement in so-called "Seal Coat Treatment" of paved road surfaces.

The repair of worn out, eroded, or otherwise damaged portions of the surface of paved roads, particularly of those roads constructed with asphalt and asphalt-concrete, is an ever-present task facing the local and national authorities, and continuously calling for the expenditure of taxpayers' money. In endeavoring to postpone major repaving jobs, a number of interim small-scale repair techniques have been proposed and used in the past. These various techniques, however, more than often are not too satisfactory. Those patches prepared by applying asphalt cutbacks to cover and seal damaged and eroded areas of the road, by rolling or pressing them and covering the repaired surface by sand last but a short time. Similarly, application of patches of tar likewise covered with sand, are even more short-lived and, in addition, are quite troublesome in that they cause spattering by (and on) passing vehicles and thus result in the waste of tar. The same may be said of seal coat treatments with road oil, followed by application of sand or gravel. The oil sticks to the shoes of the pedestrians and to the tires, wheels and bodies of passing automobiles, splashes on curb and bridges and is unnecessarily wasted.

Another technique consists of heating a stone aggregate and a cutback asphalt of a medium-curing type, such as MC-5, mixing the two heated materials together and spreading the resulting mix as a patch over the portion of the pavement which needed repair, while maintaining the temperature of the mix being spread between 300 to 350° F. This last-mentioned paving technique is fraught, however, with certain objectionable features. While the maintenance of elevated temperatures in the range from about 300 to about 350° F. contributes to a rapid volatilization of the cutter stock, such as kerosene, or the like, from the cutback asphalt and permits thereby a faster cure of this later than it is possible with other paving-repair techniques, the relatively high content of the cutter stock—15% or more by volume of the whole cutback asphalt material—creates a hazard of fire and/or explosion at these high temperatures. Furthermore, these high temperatures contribute to emission of considerable volumes of offensive, nauseating fumes. These irritating fumes are particularly objectionable to the paving work-crew, and have been reported to have rendered men ill upon more or less prolonged exposure during the work day. Because of the high temperatures and, consequently, because of a rapid evaporation of the cutter stock, the asphalt binder hardens faster, and the asphalt-aggregate paving mix in accordingly harder to work. In the final result, the adhesion of the asphalt binder to the aggregate, particularly where siliceous aggregates are being used, falls short of the desired level.

The present invention provides an improved method of resurfacing damaged asphalt-concrete (AC) and Portland cement concrete (PCC) pavements, which offers a great flexibility of application, substantially minimizes and eliminates the various drawbacks which attend other known techniques of paving repair, and, surprisingly, permits forming repaired paved surfaces characterized by a strong bond between the asphalt and the aggregate.

According to the invention, the seal-coat mix is pre-

pared by intimately mixing in a suitable piece of equipment a densely-graded aggregate heated to a temperature of about $350 \pm 25^\circ$ F. with a cationic bituminous (asphalt) emulsion having a binder content of from about 70 to about 75% by weight and additionally containing from about 1.0 up to 10.0% by weight, and preferably from about 4 to about 6%, of a light petroleum hydrocarbon distillate, such as kerosene, which is added to the pre-formed asphalt emulsion prior to the mixing with the aggregate. Usually rapid-setting-type (RS) emulsions are utilized. The temperature of the so-preformed emulsion, when introduced into the corresponding mixing equipment (whether a stationary mixer at the asphalt plant or available as a suitable locomotive mixed-in-place equipment), may range from ambient temperature up to 190° F., preheating to temperatures from about 150 to about 180° F. being generally preferred in order to facilitate pumping and handling. Where the emulsion is so fluid as to make the problems of handling of less importance, temperatures of the order of 150 to 120° F. and lower may be used.

Upon contact with the hot stone aggregate in the mixer, the water component of the cooler cationic asphalt emulsion is flashed off and is allowed to escape via any suitably arranged means for the safe removal of steam. While the actual conditions in the mix cannot be precisely established, it is believed that the water escaping as vapor acts in the mix as a lubricant and facilitates the flow (penetration) of the asphalt among the particles of the aggregate.

At the same time, owing to a much smaller quantity of the petroleum hydrocarbon distillate cutter stock having been added to the emulsion to reduce viscosity and to provide fluidity and greater ease in handling, as compared with 15% or more by volume of a like hydrocarbon cutter stock diluent in cutback asphalts, the evolution of nauseating fumes so irritating to the paving crew and, in general, to those who happen to be present in the area, is greatly minimized.

Likewise, the risk of fire and explosion is practically eliminated.

The mix of asphalt emulsion and aggregate is spread over the area of the road to be repaired at temperatures of about 200° F. or lower, and is compacted, as by rolling. This compaction is carried out when the temperature of the laid (spread) mix is less than about 190° F., preferably from 170 to 130° F. It is surprising that at these temperatures, which would be considered too low by the previously described hot-mix paving practices, the so-laid seal coats remain pliable during the rolling operation, and the road can be open to traffic immediately thereafter.

Another surprising feature of the method of seal coat treatment according to the invention is that "priming" of the area to be repaired—a usual prerequisite in previous techniques of road repair—is no longer necessary, and the seal coat which has been applied without priming, e.g., with a dilution of a slow-setting (SS) asphalt paving emulsion, adheres nevertheless to the underlying base and forms firm construction joints with the existing pavement just as well as if applied over a primed section. Since cationic asphalt emulsions are used to prepare paving mixes which find their application in the method of seal coat treatment according to the present invention, the applicators no longer need to worry about a strongly electro-negative nature of certain siliceous aggregates, such as sand or the like. As a matter of fact, the resulting seal coats or repair patches display a strong bond between such siliceous aggregates and the asphalt and are much less affected by adverse weather conditions than the seal coats made from mixes of aggregates with cutback asphalts or anionic asphalt emulsions.

Also, because properly formulated mixes of aggregates and cationic asphalt emulsions, such as are contemplated by the seal coat technique of the present invention, do set up faster than corresponding mixes of anionic asphalt emulsions or asphalt cutbacks with aggregates, bleeding of asphalt on the laid surface is substantially eliminated, and more often than not an application of a tack coat (for instance, in the form of a dilute slow-setting emulsion of asphalt) becomes unnecessary, except perhaps for a quick "scratch coat" applied to fill the grooves or deeper cuts in the pavement, without covering the asperities. Neither is, as a rule, a sand cover required any longer to be applied on the surface of the repair patch to prevent pickup of asphalt, a common occurrence in using cutback asphalts for seal coat treatment.

Any suitable aggregate material may be employed for preparing the mixes with cationic asphalt emulsions in accordance with the invention; usually and preferably aggregates, whether siliceous or only partly siliceous, characterized by not more than about 6-5% passing through a 200-mesh sieve, less than 15-10% passing through a 100-mesh sieve, and from 100 to 85% passing through a No. 4 sieve, will be used. For best results, the void content of the mix should be so selected as to be less than 10, based on 50-blow Marshall Specimens, when laid.

The bituminous binder in the paving seal coat mix to be used according to the invention is preferably asphalt in the form of an oil-in-water type emulsion thereof and in amounts from about 70 to about 75% by weight. While any cation-active emulsifier may be used to emulsify the asphalt, the emulsion is preferably prepared with the aid of a cation-active emulsifier which does not decompose at mixing temperatures up to about 350° F., while the emulsion is being mixed with the heated aggregate. These action-active emulsifiers, whether thermally stable or decomposable at about 350° F., may be used in conventional proportions of from about 0.1 to about 2.0% by weight of the finished emulsion, and preferably in proportions from about 0.2 to about 1.0% by weight. Emulsifying agents which do so decompose, for instance, certain quaternary ammonium salts, such as an N-alkylbenzyl-N,N,N'-trimethyl ammonium chloride characterized by the presence of an average of 12 carbon atoms in the alkyl chain, are less desirable, and cationic asphalt emulsion prepared therewith, though effective when used for paving repair according to the method of the present invention may not provide as strong a bond between the particles of the aggregate and the asphalt.

The light petroleum hydrocarbon distillate added as a cutter stock or diluent to the preformed cationic asphalt emulsion in order to impart fluidity and to facilitate its mixing with the aggregate is preferably a distillate boiling in the range from about 300 to about 600° F. (ASTM D-86, such as kerosene. The quantity of this distillate cutter may vary depending on the viscosity of the asphalt; preferably, to be free from fire hazards and excessive fumes, it should not exceed 10% by weight of the preformed emulsion and may be as low as 1% by weight. The best range of amounts which provide the optimum workability and safety in operation and the least volume of fumes lies between about 4 to about 6% by weight.

Any suitable asphalt, emulsifiable in a conventional way to a quick-setting cationic emulsion and characterized by viscosities in the range from about 600 to about 6000 poises at 140° F. may be used to prepare the emulsion; for instance, an asphalt in this viscosity range having penetration values from about 190 to 210 (ASTM D-5) may be used for preparing emulsions suitable for making mixes with the aggregate for seal coat treatment in accordance with the invention. If desired, a harder asphalt but always within the same range of viscosities may be employed, by varying the content of the distillate

cutter somewhat in the range from about 1.0% to about 10.0% by weight to impart workability.

In formulating the desirable asphalt-aggregate mixtures (mixes) of this invention, the proportions of their two components—emulsion and aggregate—are so selected as to enable application of a surface coat of from about $\frac{3}{8}$ " to $\frac{1}{2}$ " of compacted thickness. Ordinarily very satisfactory seal coat treatments are achieved with mixes formulated from about 85 to about 95% by weight of densely-graded aggregate and from about 15 to about 5% by weight of a cationic asphalt emulsion of the type described hereinabove and treated with small (less than 10.0%) but sufficient amount of petroleum distillate cutter.

In applying these mixes to the areas to be paved (repaired), one may spread the mix, for instance, by blading with the aid of a self-propelled grader, and then following the spreading step by compacting the laid mix with a tandem roller. The application of a sand cover, as pointed out before, is purely optional.

Likewise, as mentioned already, no priming treatment of the damaged surface being repaired is necessary in the case of asphalt or asphalt-concrete (AC) road surfaces. However, the method of the invention is also applicable in applying seal coats to damaged, cracked Portland cement concrete (PCC) paved surfaces. In this case, the application of a priming coat with a suitable primer, such as a dilute slow-setting asphalt emulsion is recommended before applying the cationic asphalt emulsion-aggregate mix in accordance with the invention.

The following example illustrates the application of the method of the invention in actual practice:

A rapid-setting cationic emulsion in water of 185/215 penetration asphalt of Venezuelan origin was formed with the aid of a cation-active emulsifier, namely a hydrochloride of 1-(2-aminoethyl)-2-n-alkylene-2-imidazoline in which the alkylene group is a mixture of heptadecenyl and heptadecadienyl radicals. This 1,2-substituted fatty imidazoline diamine is sold on the market under the trade name "Nalcamine G-39M" and is readily converted to its hydrochloride salt in the emulsifying water by the addition of hydrochloric acid. The pH of the emulsifying water lies between 5.0 and 6.0. The composition of the emulsion was as follows:

Asphalt	74%.
Emulsifier	0.35-0.40%.
Water	Balance to 100% by weight.

After adding about 4% of kerosene boiling between 340 and 526° F. (ASTM D-86) to the emulsion, this latter was warmed up to a temperature of 175-180° F. and then mixed with aggregate in a Koehring Watrous Mixing Plant capable of producing 70 tons of paving mix per hour. The aggregate was of a 50/50 blend of pit-run screenings, and sand. The sieve analysis of this not too siliceous aggregate blend was as follows:

	Percent passing
$\frac{3}{8}$ "	100
No. 4	97.3
No. 8	88.7
No. 16	79.2
No. 30	55.1
No. 50	25.7
No. 100	11.0
No. 200	6.0

This aggregate was heated to an average temperature of 350±25° F. At the discharge from the hot mix plant, provided with means for the escape of steam, the temperature of the resulting mix was between 225-280° F. Approximately 170 pounds of the emulsion was used per each ton of the mix being prepared. It was transported to the job site in 1-ton batches while at a temperature of about 200° F., spread (bladed) over two test sections of a city street and then rolled to a thickness of

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about $\frac{1}{2}$ ", when the temperature of the mix was about 170–160° F. An extraction test indicated that the net asphalt content of the resulting seal coats on the two street sections was 7% and 7.46%, respectively. One part of each section was primed with a 50/50 aqueous dilution of a medium-setting anionic asphalt emulsion, the other part was left unprimed.

While being rolled with a 10-ton steel wheel tandem roller which was kept damp throughout the compacting operation, the laid mixes remained pliable although the temperature went down from 160° F. to about 130° F. No excessive volume of fumes evolved, and no adverse reaction on the workmen was observed.

After having been opened to traffic, which averaged as much as 2,000 motor vehicles (both passenged cars and heavy trucks) per 24 hours, this being a heavily traveled street in a residential district, the repaved surface was examined after three weeks. The several repaved sections appeared to be very good, slightly soft but physically unaffected in any way by the traffic, the unprimed sections having stood up as good as the primed ones.

About 7 months later, the repaved surface still stood up well under the traffic.

In another practical test application using the same mixing, spreading and compacting equipment and technique, the seal coat mix was prepared again in 1-ton batches. The cationic emulsion was prepared by emulsifying a like 190/205 penetration asphalt of Venezuelan origin in water with the same hydrochloride of "Nalcamine G-39M" as the cation-active emulsifier.

Again about 4% of kerosene boiling between 340 and 520° F. (ASTM D-86) was added to the emulsion. This brought the asphalt residue to a figure of 71%. Thus the composition of the emulsion, after the addition of kerosene, was the following:

Asphalt	71%.
Emulsifier	About 0.36%.
Kerosene	About 4%.
Water	Balance to 100% by weight.

The aggregate was a 50/50 mixture of pit-run screenings and sand. The sieve analysis of this aggregate blend was as follows:

	Percent passing
$\frac{3}{8}$ "	100
No. 4	95.7
No. 8	76.4
No. 16	58.0
No. 30	34.6
No. 50	17.9
No. 100	9.1
No. 200	5.2

The aggregate was heated to an average of 350° F. and then mixed in the mixing plant with the cationic asphalt emulsion warmed to 190° F. in approximate proportions of about 91% aggregate to about 9% emulsion. The resulting mix was transferred to an insulated truck and transported to the job site. The temperature of the mix on arrival to the job ranged from 240 to 210° F. It was applied to several test sections of the road—a by-pass highway—and rolled to a compacted thickness of $\frac{3}{8}$ " to $\frac{1}{2}$ ", while the temperature went down from 190 to 130° F. Because the road sections being repaved were those of an extremely worn asphalt pavement in poor condition, a "scratch coat," varying in thickness from a skin coat to $\frac{3}{4}$ " and averaging about 4.1 pounds per one square ft. of the road surface, of a dilute (50/50) medium-setting asphalt emulsion was applied first, before the application of the mix of aggregate and cationic asphalt emulsion in accordance with the invention. Throughout the rolling treatment the mix remained sufficiently flexible for satisfactory compaction. A total of 219 tons of the mix has been thus applied. Immediately

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following the compaction, the repaved areas of the road, which, as mentioned hereinabove, was a by-pass highway, was open to traffic without resorting to an application of a sand cover. The average traffic in this location was approximately 750 motor vehicles (mainly passenger cars) per 24 hours.

Again no excessive and irritating kerosene fumes have 219 tons of the mix has been thus applied. Immediately been produced, and consequently the work crew could not be adversely affected thereby. Subsequently observation of the laid road sections after 3 weeks disclosed a perfect appearance of the seal coat surface, undamaged by the traffic, with good, firm bond and excellent healing at the construction joints. Substantially the same conditions were observed after six months.

In still another test application a substantially identical cationic asphalt emulsion was warmed to about 150° F. and mixed at the plant with the aggregate heated to 325° F. The emulsions, before its mixing with the aggregate, received an addition of 4% of kerosene boiling between 340 and 526° F. (ASTM). The composition of the emulsion after this addition was substantially as in the preceding test repaving job. The aggregate was a blend of 90% coarse sand and 10% fine sand. Approximately 170 pounds of emulsion was required per each 1875 pounds of this siliceous aggregate. The temperature of the emulsion-sand mixture on leaving the mixing equipment was 225° F.

The mix was spread over a section of a street, without first applying a tack coat, and then compacted as described before, while the temperature decreased from about 190 to about 130° F. Again no excessive fumes were observed. The street was thrown open to traffic immediately after compaction. Three weeks later the surface appeared in good condition despite heavy traffic on this street in a residential district which averaged up to 2000 automobiles a day. More than six months later the surface was still good and ostensibly undamaged.

Thus the present invention consists in finding (1) that asphalt will adhere well to densely-graded aggregate heated to a temperature from about 325 to about 375° F. if applied in the form of emulsions in water, produced with the aid of cation-active emulsifying agents, preferably such as will remain thermally stable, that is, do not decompose, at temperatures of less than about 350° F., and (2) in finding that these cationic emulsions, when so used, need but a small quantity, less than about 10% and as little as 1.0%, and preferably from about 4 to about 6% by weight, of a petroleum hydrocarbon distillate, as a diluent for satisfactory workability and mixing with aggregate.

These findings make possible to produce and apply for paving repairs, according to the method of the invention, seal coat mixes of asphalt and aggregate, practically without evolution of fumes in volumes likely to irritate the applicators and the public, and virtually without any risk of explosion and fire, despite the high temperatures of the heated aggregate. These mixes, when applied for road repair work, remain sufficiently flexible while being compacted at temperatures from about 170 to about 130° F. and, once compacted, possess a firm, tenacious bond between the asphalt and the particles of the aggregate, and accordingly are capable to last under the average volume of road traffic.

The foregoing description and examples are offered solely to illustrate the invention and do not limit the scope thereof, so that any modifications coming within the scope of the invention are to be included in the definitions of the appended claims.

I claim:

1. The method of repairing worn and eroded road surfaces which comprises

(A) heating a densely-graded siliceous aggregate to a temperature from about 325 to about 375° F.;

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- (B) intimately mixing the heated aggregate with a cationic emulsion of from about 70 to about 75% by weight of an asphalt, characterized by a viscosity in the range from about 600 to about 6000 poises at 140° F. and emulsified in water with the aid of a cation-active emulsifier thermally stable up to about 350° F., sand emulsion, having dispersed therein from about 1.0 to about 10.0% by weight thereof, of a light petroleum hydrocarbon distillate boiling between about 300 and about 600° F. (ASTM D-86);
- (C) spreading the resulting mixture at a temperature of about 200° F. over the surface to be repaired; and
- (D) compacting the spread mixture at temperatures between about 190 and 130° F.

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2. The method of road surface repair as described in claim 1, wherein the petroleum hydrocarbon distillate dispersed in the cationic asphalt emulsion is present therein in an amount from about 4.0 to about 6.0% by weight.
3. The method of road surface repair as described in claim 1, wherein the petroleum hydrocarbon distillate dispersed in the cationic asphalt emulsion is kerosene.

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