



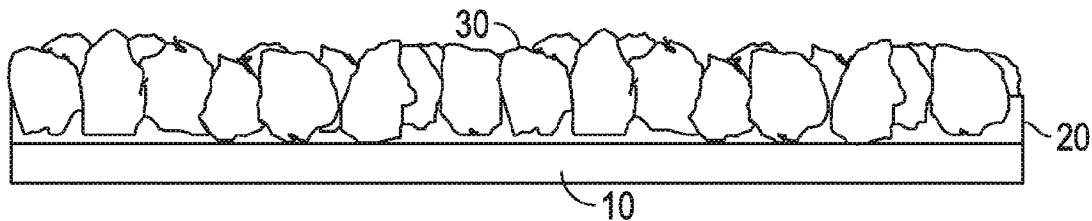
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Clopotel et al.(10) **Pub. No.: US 2016/0201271 A1**(43) **Pub. Date: Jul. 14, 2016**(54) **SURFACE TREATED PAVEMENT AND
METHODS FOR TREATING PAVEMENT
SURFACES TO IMPROVE CHIP RETENTION****Publication Classification**(71) Applicant: **HONEYWELL INTERNATIONAL
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8, 2015.(51) **Int. Cl.****E01C 7/35** (2006.01)**E01C 23/06** (2006.01)**E01C 19/16** (2006.01)(52) **U.S. Cl.**CPC **E01C 7/358** (2013.01); **E01C 19/16**
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ABSTRACT

Surface treated pavement and methods for treating pavement surfaces are provided herein. A method is also provided for treating pavement to improve chip retention. The method includes contacting a surface of the pavement with a bitumen emulsion containing an adhesion modifier to form a layer of bitumen emulsion. Aggregate is applied on the layer of bitumen emulsion. The adhesion modifier includes at least one polymer having a carboxylic acid and/or anhydride functional group, such as oxidized high density polyethylene.



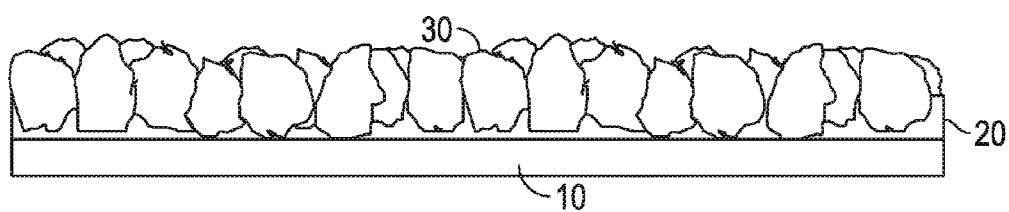


FIG. 1

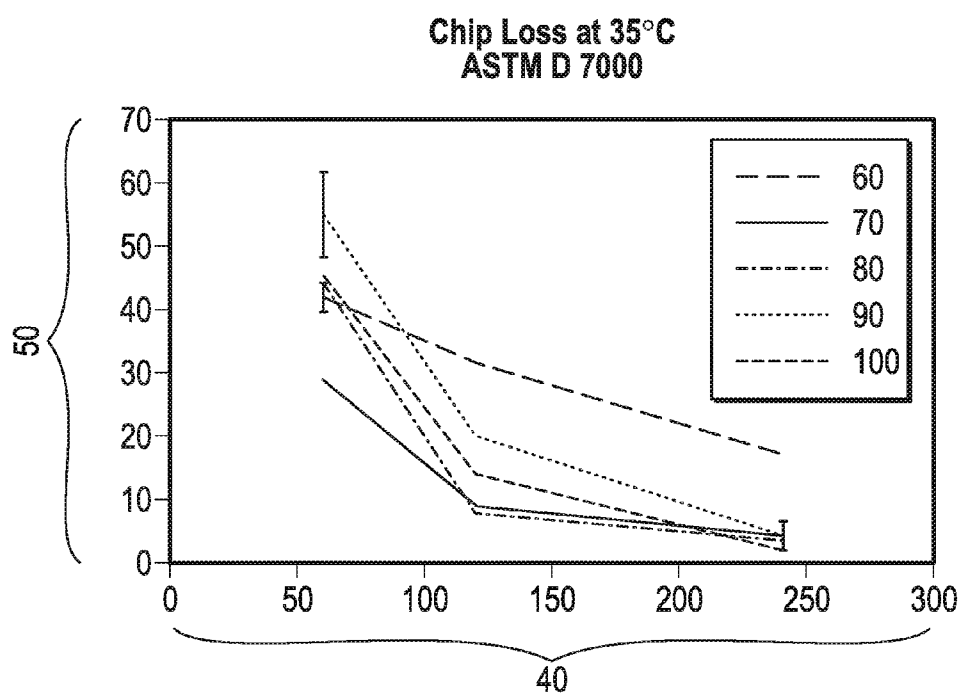


FIG. 2

SURFACE TREATED PAVEMENT AND METHODS FOR TREATING PAVEMENT SURFACES TO IMPROVE CHIP RETENTION

PRIORITY CLAIM

[0001] This application claims the benefit of U.S. Provisional Application No. 62/101,191, filed Jan. 8, 2015.

TECHNICAL FIELD

[0002] The technical field generally relates to surface treated pavement and methods for treating pavement surfaces to improve chip retention, and more particularly relates to a method of improving chip retention using a polymer modified bitumen.

BACKGROUND

[0003] Chip seal techniques are the most prevalent preventive maintenance treatment for flexible pavements and are desirable for prolonging the pavement lifecycle. In such techniques, a rapid setting aqueous bituminous emulsion is distributed onto the pavement to be surface treated, and then an aggregate is applied thereto. Upon contact, the aggregate causes the rapid setting emulsion to set rather quickly and form an emulsion residue. One of the advantages of chip seal techniques is that they allow highways, roads and other pavements being repaired to be reopened to traffic in a rather short order. Chip seal techniques are also attractive due to low cost compared to other pavement preservation techniques and cause minimal environmental impact in terms of gas emission and energy consumption.

[0004] The aggregate employed in chip seal techniques, which is commonly also referred to as stone, generally has a size on the order of about one-quarter inch to about one-half inch, and may be calcareous, siliceous or granitic in nature. It will readily be appreciated that in such chip seal techniques, it is desirable that the emulsion residue have strong adhesion to the aggregate to prevent it from being dislodged, which could cause damage to windshields and the like.

[0005] Early raveling and premature loss of aggregate chips are a primary failure experienced following chip seal treatment, which can cause vehicle damage. Dislocated aggregate chips may result from inadequate adhesion between the emulsion residue and the aggregate chips. Aside from vehicle damage, premature chip loss can lead to other failures in the seal and an overall loss in the skid resistance (the friction between vehicle tires and asphalt pavement) due to a reduction in surface tension.

[0006] Accordingly, it is desirable to provide surface treated pavement with improved chip retention to minimize premature chip loss. In addition, it is desirable to improve the bonding between an emulsion residue and aggregate to prevent car damage, particularly windshield damage, from loose aggregate. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background.

BRIEF SUMMARY

[0007] Surface treated pavement and methods for treating pavement surfaces are provided herein. In an embodiment, a method is provided for treating pavement to improve chip retention. The method comprises contacting a surface of the pavement with a bitumen emulsion comprising an adhesion

modifier to form a layer of bitumen emulsion. Aggregate is applied on the layer of bitumen emulsion. The adhesion modifier comprises at least one polymer having carboxylic acid and/or anhydride functional groups.

[0008] In another embodiment, a chip seal method is provided for treating pavement to improve chip retention. The method comprises contacting the pavement with a bitumen emulsion to form a layer of bitumen emulsion and applying aggregate to the layer of bitumen emulsion, wherein the bitumen emulsion is prepared by combining an adhesion modifier and molten bitumen to form an adhesion modified bitumen and emulsifying the adhesion modified bitumen, and wherein the adhesion modifier comprises at least one polymer having carboxylic acid and/or anhydride functional groups.

[0009] In another embodiment, a surface treated pavement is also provided. The surface treated pavement comprises an aggregate layer bonded to an emulsion residue comprising oxidized high density polyethylene.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The various embodiments will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and wherein:

[0011] FIG. 1 shows a treated pavement surface; and

[0012] FIG. 2 shows a graphical illustration of chip loss retention of various pavement samples as measured by ASTM D7000.

DETAILED DESCRIPTION

[0013] The following detailed description is merely exemplary in nature and is not intended to limit the surface treated pavement and methods for treating pavement as described herein, or the application and uses of the surface treated pavement and methods for treating pavement as described herein. Furthermore, there is no intention to be bound by any theory presented in the preceding background or the following detailed description.

[0014] Surface treated pavement and methods for treating pavement are provided herein. The surface treated pavement and methods for treating pavement provide improved chip retention and minimize premature chip loss by employing an improved bitumen emulsion, as described in further detail below. In an exemplary embodiment, a method for treating pavement to improve chip retention includes contacting, by employing conventional chip seal equipment, a surface of the pavement with a bitumen emulsion that includes an adhesion modifier and aggregate. The adhesion modifier includes a functionalized polymer, such as polymers having carboxylic and anhydride functional groups. The bitumen emulsion cures/hardens to form an emulsion residue on the surface of the pavement.

[0015] Without being bound by any particular theory, it is believed that functional groups in the polymer improve the bonding between the emulsion residue and aggregates which may break from the emulsion residue, thereby resulting in reduced chip loss. The functional groups interact with the polar surface of the aggregates, thereby changing the surface energy of the aggregates and improving compatibility with the bitumen.

[0016] In an exemplary embodiment, the improved bonding between the emulsion residue and aggregate chips is measured by the Sweep Test (ASTM D7000). Chip loss is measured at about 35° C. (95° F.) and about 240 minute cure.

The chip loss using the improved bitumen emulsion as described herein is typically less than about 5%, and more typically less than about 4%.

[0017] In an exemplary embodiment, the method for treating pavement includes forming a substantially uniform layer of the bitumen emulsion on the surface of the pavement and then applying the aggregate on the layer. Without being bound by any particular theory, it is believed that the adhesion modified bitumen emulsion breaks in the setting process and bonds the aggregates to the bitumen. A treated pavement surface that includes aggregate bonded to the emulsion residue is formed. FIG. 1 shows a chip seal structure; a bitumen emulsion (20) is spray applied to a pavement surface (10) and then covered with a layer of aggregates (30) and rolled to seat the aggregates (30). In a further embodiment, a second bitumen emulsion layer may be applied to the aggregate layer (30) followed by a second layer of aggregates. In a still further embodiment, a third bitumen emulsion layer may be applied to the second layer of aggregates followed by a third layer of aggregates.

[0018] As referred to herein, “aggregate” or “chip” is a collective term for mineral materials, such as, for example, sand, gravel, or crushed stone. The aggregate may comprise natural aggregate, manufactured aggregate, or a combination thereof. Natural aggregate is typically extracted rock from an open excavation (e.g. a quarry) that is reduced to usable sizes by mechanical crushing. Manufactured aggregate is typically a byproduct of other manufacturing processes such as slag from metallurgical processing (e.g. steel, tin, and copper production). Manufactured aggregate also includes specialty materials that are produced to have a particular physical characteristic not found in natural rock, such as, for example, low density.

[0019] Improved bonding results from using the adhesion modifier in the bitumen emulsion as contemplated herein. As referred to herein, “adhesion modifier” collectively includes all compounds present in the bitumen emulsion that exhibit adhesion modification properties. The adhesion modifier contains at least one polymer. The polymer includes functional groups, such as carboxylic acid and anhydride groups.

[0020] In an exemplary embodiment, the adhesion modifier comprises oxidized polyethylene, such as oxidized low density polyethylene (LDPE), oxidized linear low density polyethylene (LLDPE), oxidized medium density polyethylene (MDPE), particularly oxidized high density polyethylene (HDPE) having a density of about 0.96 g/cm³ or above, particularly about 0.98 g/cm³ or above. Oxidation introduces various functional groups, particularly carboxylic acid functional groups, which interact with the polar surface of the aggregates. Suitable examples of oxidized high density polyethylene include, but are not limited to, Honeywell Titan® 7686 and 7456. Other polymers having functional groups include, but are not limited to, maleic anhydride modified polypropylene (MAPP), maleic anhydride modified polyethylene (MAPE), ethylene acrylic acid (EAA), ethylene methacrylic acid (EMAA) and/or mixtures thereof.

[0021] The molecular weight of the polymer generally is in the range of from about 800 to about 50,000 and particularly from about 1,000 to about 10,000. The molecular weight of the functionalized polymer as contemplated herein is determined by conventional gel permeation chromatography (GPC). For the purpose of GPC, the functionalized polymer to be measured is dissolved in 1,2,4-trichlorobenzene at 140° C. at a concentration of 2.0 mg/ml. The solution (200 μ L) is

injected into the GPC containing two PLgel 5 μ m Mixed-D (300 \times 7.5 mm) columns held at 140° C. with a flow rate of 1.0 mL/minute. The instrument is equipped with two detectors (refractive index and viscosity detector). The molecular weight (weight average molecular weight, Mw) is determined using a calibration curve generated from a set of linear polyethylene narrow Mw standards. The functionalized polymer generally has an acid number (a measurement of the degree of oxidation or the amount of carboxylic acid or anhydride comonomer via copolymerization or grafting) from about 5 to about 50 mg KOH/gm and particularly from about 15 to about 40. The acid number is determined by titrating a solution of the functionalized polymer with a 0.1N alcoholic potassium hydroxide solution to a visual “pink” endpoint using phenolphthalein as an indicator.

[0022] In embodiments, the functionalized polymer is present in the bitumen emulsion in a concentration in the range of from about 0.5 wt. % to about 1.5 wt. %, such as about 0.75 wt. %, the wt. % being based on the total weight of the bitumen.

[0023] It is to be appreciated that the adhesion modifier may further include one or more additional compounds that exhibit adhesion modification properties, such as styrene-alkadiene copolymer, which improves elasticity. In an exemplary embodiment, the styrene-alkadiene copolymer is styrene butadiene styrene (SBS). The molar proportion of styrene:butadiene is typically in the range from about 20:80 to about 45:55, and the molecular weight of the SBS typically is in the range of from about 50,000 to about 150,000. In embodiments, the concentration of the styrene-alkadiene copolymer is in the range of from about 0.5 wt. % to about 4.0 wt. %, such as about 2.25 wt. %, based on the total weight of the bitumen.

[0024] In embodiments, the bitumen emulsion is prepared by combining the oxidized polyethylene and molten bitumen, either prior to or after combining the styrene-alkadiene copolymer and the molten bitumen, to form adhesion modified bitumen. Fuels, such as diesel, may also be added to the molten bitumen. Separately, an emulsifier agent is prepared by combining emulsifier to warm water containing an acid in accordance with conventional techniques to form a cationic emulsion. In an exemplary embodiment, the emulsifiers include, but are not limited to, wood product derivatives, such as tail oils, rosins and lignin, fats, vegetable oils, proteins, polymers and minerals. In an exemplary embodiment the acids include, but are not limited to, hydrochloric acid, phosphoric acid, acetic acid or sulfuric acid. In embodiments, the emulsifier content in the emulsifier agent is in the range of from about 0.5 wt. % to about 0.75 wt. %, based on the total weight of the final bitumen emulsion. The emulsion may also contain other conventional materials, such as fuels, oil, stabilizers, coating improvers, break control agents and the like to modify the properties of the emulsion, the breaking or setting process or the final emulsion residue. The compositions as contemplated herein include anionic emulsions.

[0025] In an exemplary embodiment, a colloidal mill may be used to prepare the bitumen emulsions, which include the adhesion modified bitumen and emulsifier agent. In embodiments, the bitumen emulsions are prepared under the following conditions. The adhesion modified bitumen is supplied to the colloidal mill at a temperature in the range of from about 135° C. (275° F.) to about 163° C. (325° F.). The emulsifier agent is supplied to the colloidal mill at a temperature in the range of from about 38° C. (100° F.) to about 46° C. (115° F.)

and a milling back-pressure in the range of from about 18 psi to about 20 psi. The adhesion modified bitumen is supplied in an amount in the range of from about 65% to about 70% (by weight, based on the total weight of the resulting bitumen emulsion) and the emulsifier agent is supplied in an amount in the range of from about 30% to about 35% (by weight, based on the total weight of the resulting bitumen emulsion).

[0026] In another embodiment, it is envisioned that an emulsion of the adhesion modifier can be prepared and used to prepare the emulsifier agent prior to contacting with the bitumen in the colloidal mill. In yet another embodiment, emulsions of bitumen and the adhesion modifier, separately prepared, can be mixed together.

[0027] The following example includes representative methods of chip seal retention. These examples are not to be construed as limiting as other equivalent embodiments will be apparent in view of the method contemplated herein and appended claims.

EXAMPLE 1

[0028] Five emulsion bitumen samples were subjected to Sweep Testing as measured by ASTM D7000, the standard test method for measuring % chip loss of bituminous emulsion surface treatment samples. This test method measures the curing performance characteristics of bituminous emulsion and aggregates by simulating the brooming of a surface treatment. The base bitumen was a PG 58-28. Bitumen alone was compared to oxidized HDPE (Honeywell Titan® 7686) modified bitumen and SBS-modified bitumen. The oxidized HDPE and SBS were added to samples of molten bitumen under continuing agitation. The oxidized HDPE was added in amounts of 0.50, 0.75 and 1.0% by weight of total bitumen and SBS was added in an amount of 2.25% by weight of total bitumen. Mixing continued at 145° C. until all of the oxidized HDPE was dissolved and homogenized in each sample. The SBS was incorporated at higher mixing temperatures and times. The modified bitumen samples were emulsified using a laboratory-scale Charlotte G-5 Colloid Mill. Indulin AA-89, available from MeadWestvaco Corporation, was used as the emulsifier agent. The amount of surfactant and milling conditions were adjusted slightly for those emulsions containing the adhesion modifier to produce emulsions with similar de-emulsifiability. Lime aggregates were washed, dried and screened over a 6.3 mm sieve to ensure uniformity in the aggregate size prior to sweep testing. The aggregates contained less than about 5% flat and elongated pieces and were 100% fractured. Chip loss was measured at 35° C. (95° F.) at time intervals of 60, 120 and 240 minutes.

[0029] The results are shown in FIG. 2. In FIG. 2, the x axis (40) is Cure Time (min) and the y axis (50) is Chip Loss (%). FIG. 2 shows chip loss % using no adhesion modifier (60); 2.25% SBS (70), 0.50% oxidized HDPE (80), 0.75% oxidized HDPE (90); and 1.0% oxidized HDPE (100). The chip loss was determined at 60 minutes, 120 minutes and 240 minutes. As can be seen in TABLE 1 below, at 240 minutes the chip loss was 5% or less using the oxidized HDPE as compared to 18% chip loss using no adhesion modifier and 5% using the SBS at a higher concentration. The Sweep Test showed that the performance of the oxidized HDPE modified emulsion was equivalent or better than the SBS emulsion despite the fact that it contained less than half of total polymer loading.

TABLE 1

Chip Loss	Control	2.25% SBS	0.50% oxidized HDPE	0.75% oxidized HDPE	1.0% oxidized HDPE
60 min	42%	29.0%	44%	55%	46%
120 min	32%	9%	8%	20%	14%
240 min	18%	5%	4%	5%	3%

[0030] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A method for treating pavement to improve chip retention, wherein the method comprises:
 - a) contacting a surface of the pavement with a bitumen emulsion comprising an adhesion modifier to form a layer of bitumen emulsion, wherein the adhesion modifier comprises at least one polymer having a functional group, wherein the functional group is selected from the group consisting of carboxylic acid, anhydride or mixtures thereof and
 - b) applying aggregate on the layer of bitumen emulsion.
2. The method of claim 1, wherein the polymer having a functional group is present in an amount in a range of from about 0.5% to about 1.5% by weight of total bitumen.
3. The method of claim 1, wherein the polymer having a functional group is selected from the group consisting of oxidized low density polyethylene, oxidized linear low density polyethylene, oxidized medium density polyethylene, oxidized high density polyethylene, maleic anhydride modified polypropylene, maleic anhydride modified polyethylene, ethylene acrylic acid, ethylene methacrylic acid, and mixtures thereof.
4. The method of claim 3, wherein the polymer having a functional group is present in an amount of about 0.75% by weight of total bitumen.
5. The method of claim 1, wherein the adhesion modifier further comprises a styrene-alkadiene copolymer.
6. The method of claim 5, wherein the styrene-alkadiene copolymer is styrene-butadiene-styrene copolymer.
7. The method of claim 1, wherein the styrene-alkadiene copolymer is present in an amount in a range of from about 0.5% to about 4% by weight of total bitumen.
8. The method of claim 1, wherein chip loss at 35° C. and about 240 minute cure is less than about 5% as measured by ASTM D7000.
9. The method of claim 8, wherein the chip loss at 35° C. and about 240 minute cure is less than about 4% as measured by ASTM D7000.
10. A chip seal method for treating pavement to improve chip retention, wherein the method comprises:

contacting the pavement with a bitumen emulsion to form a layer of bitumen emulsion and

applying aggregate to the layer of bitumen emulsion,

wherein the bitumen emulsion is prepared by combining an adhesion modifier and molten bitumen to form adhesion modified bitumen and emulsifying the adhesion modified bitumen, and wherein the adhesion modifier comprises at least one polymer having a functional group, wherein the functional group is selected from the group consisting of carboxylic acid, anhydride, and/or mixtures thereof.

11. The method of claim **10**, wherein the polymer having a functional group is present in an amount in a range of from about 0.5% to about 1.5% by weight of total bitumen.

12. The method of claim **10**, wherein the at least one polymer having a functional group is oxidized high density polyethylene in an amount of about 0.75% by weight of total bitumen.

13. The method of claim **10**, wherein the modifier further comprises a styrene-alkadiene copolymer.

14. The method of claim **13**, wherein the styrene-alkadiene copolymer is styrene-butadiene-styrene copolymer.

15. The method of claim **13**, wherein the styrene-alkadiene copolymer is in an amount in a range of from about 0.5% to about 4% by weight of total bitumen.

16. The method of claim **9**, wherein chip loss at 35° C. and about 240 minute cure is less than about 5% as measured by ASTM D7000.

17. The method of claim **16**, wherein the chip loss 35° C. and about 240 minute cure is less than about 4% as measured by ASTM D7000.

18. A surface treated pavement comprising aggregate bonded to an emulsion residue comprising oxidized high density polyethylene.

19. The surface treated pavement of claim **18**, wherein the emulsion residue further comprises styrene-butadiene-styrene copolymer.

20. The surface treated pavement of claim **18**, wherein chip loss at 35° C. and about 240 minute cure is less than about 5% as measured by ASTM D7000.

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