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METHOD OF CONSTRUCTING ROADS

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This invention relates to a method for the construction of earth works including roads, and building sites upon which corrosible structures may be erected.

It is known that soil containing various amounts of water-soluble salts is destructive to all kinds of building materials, including iron and asphalt. Such soil is usually referred to as "alkali" soil. Two types of "alkali" soil, commonly referred to as "white alkali" and "black alkali" are distinguished. The destructive matter in "white alkali" soil is mostly sodium sulfate; in "black alkali" soil it is mostly sodium carbonate. In some cases, small amounts of sodium hydroxide are also present. The amounts of these water-soluble electrolytes present in the soil vary.

Asphalt roads, and metallic structures such as tanks, constructed in areas of such soil show severe corrosion and erosion within a few months after construction. This is especially noticeable in times of rainfall, when the water-soluble electrolytes have a tendency to creep to the surface by capillary action. It has been observed that the "alkali" works itself through all kinds of ordinary sub-surface constructions and then destroys tank bottoms or asphalt pavings.

Asphalt pavings made by either cold or hot-mix methods become uneven and develop little hills and bulges and eventually crack up into loose pieces of asphalt, the electrolytes coming through the asphalt as a white powder giving the appearance of a mold growing on the asphalt. The action of the "alkali" on the asphalt is not well understood, but it is possibly, in the case of "black alkali" soils, a kind of saponification of the asphalt, which can be assumed to contain ester linkages and free asphaltic acids.

It is an object of my invention to protect asphaltic paving and metallic structures from the attack by the "alkali" soil. Summarizing my invention, I place a suitable water impermeable membrane or layer of a material unaffected by "alkali" under the asphalt to seal off the "alkali" from the asphalt. I employ as a material for such purpose a hydrocarbon which is substantially free of saponifiable material and is of such thermoplastic or viscous characteristic that it will form a continuous membrane and not be affected by the "alkali." It should be sufficiently fluid at elevated temperatures to be easily applied by conventional equipment such as is used for the application of hot asphalt or road oil. It should have sufficient adhesion to the soil and be of sufficiently high viscosity at ordinary temperatures to remain in place over an extended period of time. It should be available at low cost and in large amounts.

My preferred materials are the solvent extracts from the refining of lubricating oil, containing a high percentage of resinous bodies and a minor percentage, below about 25%, of saturated hydrocarbons. These are the most desirable for the purposes of my invention. Solvent extracts—being predominantly hydrocarbon material and unsaponifiable, having a very steep temperature-viscosity curve in that they are thinly liquid at elevated temperatures and highly viscous at lower temperatures, having good adhesion to soil, and being available in large quantities and at low cost—answer the requirements stipulated above.

I have found that there is present in crude oils of the naphthenic, substantially wax-free type a component or fraction of such viscosity characteristics as to be properly termed resinous. These components of such crude oils are the unsaturated components thereof which have such a large temperature coefficient of viscosity as to be highly viscous or semi-solid at ordinary temperatures, being thermoplastic solids of resinous or resinophoric character and thereby liquid at elevated temperatures. The

resinous fraction which I have found particularly desirable is a material of honey-like to solid consistency at ordinary atmospheric temperature, and liquid at elevated temperature having the properties of thermoplastic resins, being substantially non-volatile and substantially stable under atmospheric conditions in that it will not change to a hard, brittle product on prolonged exposure to air and sunlight. Unlike the saturated oils, these petroleum resins form a strong adhesive bond with the solid particles.

Thus, for example, I may isolate these resinous components, having properties such as described herein, by solvent refining of waxy, naphthenic or mixed base oil fractions, either residual or distillates, and by de-waxing procedures, if necessary I may also obtain those desirable resinous materials by removing them from clays which have been employed in the clay treatment of residual or distilled oil fractions, and which clays carry the resins which they have adsorbed from oils which have been refined by such clays. Such methods for recovery of the adsorbed fractions from clays are well known in the prior art.

Thus, I have found that the components of the petroleum oil suited for my invention are the unsaturated, resinous components of the selective solvent extract fraction, preferably of a distillate produced from a naphthenic base crude, naturally substantially free of solid wax fractions. Many different selective solvents for extraction of such oil have been suggested for the manufacture of lubricating oils, as is evidenced by the art of selective solvent extraction of petroleum oils. Current commercial practice in the lubricating oil industry generally is to use sulfur dioxide sulfurdioxide-benzol mixture, furfural, or phenol. As is well known, these solvents selectively dissolve the unsaturated, naphthenic fraction and other reactive components of the oil (sometimes referred to as aromatic components) to produce an extract, and leave the saturated aliphatic and the saturated naphthenic fractions as the undissolved raffinate. However, the selectivity of the solvents is not sharp, and there may be a substantial quantity of the saturated hydrocarbon fractions dissolved in the extract. This may be minimized, as is well known in the art, by several expedients, such as temperature control, solvent to oil ratio, and rejection procedures such as supplementary solvent washes (as with light hydrocarbons), the addition of water, etc.

The preferred type of resins having the unique properties and giving the unique results described are found in those solvent extracts (most usefully produced from distillate fractions) which are substantially free of asphaltic materials and wax, which are reddish in color in bulk and transparent in thin layers, and which contain a preponderant proportion of unsaturated components and but a minor proportion of saturated components and usefully less than 25% saturated components, preferably less than 15% of saturated components, and, in fact, the lower the percentage of saturated components the better.

As an example, and not as a limitation of my invention, extracts having, in addition to the desirable concentration of unsaturated components, the following characteristics are desirable for the purposes of this invention:

TABLE I

	Extract 1	Extract 2	Extract 3	Extract 4
Physical characteristics:				
Specific gravity	1.02	1.02	1.03	1.00
Viscosity @ 70° F. (cps.)	13,000	32,000	100,000	900
Viscosity @ 210° F. (cps.)	30	65	225	11
Chemical analysis:				
Asphaltenes	0.0	0.0	0.0	0.0
N-bases	18.7	23.1	27.1	12.4
Unsaturated hydrocarbons, Group I	15.5	21.0	18.9	13.9
Unsaturated hydrocarbons, Group II	55.0	47.2	47.1	63.0
Saturated hydrocarbons	10.8	8.7	6.9	10.7

Wherever referred to in this specification, the term

"saturated components" and its percent content in the fraction, and the terms "unsaturated hydrocarbons, group I," and "unsaturated hydrocarbons, group II," and the percentage content, and the term "nitrogen bases" and its percentage content, and the term "asphaltenes" and its percentage content, shall mean those determined and defined in "Compounding rubber with petroleum products," by Rostler and Sternberg, published in Industrial and Engineering Chemistry, vol. 41, pp. 598–609, March 1949. The percentage content is therein given as a weight percent and is so employed in this specification and claims.

The viscosity and the specific gravity shall be determined by conventional procedure, as will be understood by those skilled in the art.

The adhesion of the resinous extracts and the cohesion of the soil sub-base are improved by the addition of small amounts of soluble, high molecular weight polymeric material. The most practical additions appear to be between about 0.1% and about 5% of a material classified in the plastic arts under the generic name "elastomers," that is an elastic, high polymeric material, such as natural rubber, GR–S, butyl rubber, or polychloroprene, polybutylene polymer resins.

All of these high polymeric substances when dispersed in the extract resin have the property of increasing the viscosity temperature susceptibility of the extract, i. e., the rate at which the viscosity increases with decrease of temperature, thus enhancing the membrane forming properties of the resin at low temperatures without impairing the suitably low viscosity of the petroleum extract resin at higher temperatures.

It does not appear to be absolutely necessary to obtain complete solution as long as the resulting mix can be applied through ordinary spraying and spreading equipment. The high polymeric material can be added in various ways. For example, one may dissolve the high polymeric material, in powder or granular form, in the extract under stirring at elevated temperatures. The other is to add the high polymeric material in form of latex to the hot extract, again under stirring, until the water of the latex evaporates and the polymer material is dissolved or dispersed.

The dispersion solutions of high polymeric material in the extract are an improvement over the straight extract.

Without intending to limit the generality of the disclosure, Table II illustrates compositions and viscosity of the various preparations. The dispersions were obtained by dispersing the high polymeric material at 150 to 200° C. under stirring for three hours.

TABLE II

Sample	Composition	Viscosity at 75° F. (Cps.)	Viscosity at 210° F. (Cps.)
1	Extract 1 (Control)	8,500	22
2	Extract 1+½% Natural Rubber	11,100	26
3	Extract 1+1% Natural Rubber	13,100	31
4	Extract 1+2% Natural Rubber added as Latex.	30,000	127
5	Extract 1+3% Natural Rubber	21,000	65
6	Extract 1+1% Butadiene-styrene copolymer.	17,600	39
7	Extract 1+1% Butadiene-styrene copolymer added as Latex.	21,100	39
8	Extract 1+1% Polychloroprene	21,200	25
9	Extract 1+1% Polychloroprene added as Latex.	19,000	45
10	Extract 2, No additive	54,000	37
11	Extract 2+1% Natural Rubber	67,000	68
12	Extract 2+3% Natural Rubber	96,000	123
13	Extract 2+1% Natural Rubber added as Latex.	200,000	115
14	Extract 2+0.1% Natural Rubber added as Latex.	187,000	40

In building roads and pavements, the above petroleum resinous material is melted and applied by spraying or other means as is conventionally employed when consolidating road bases with hot asphaltic road oil.

Since the resinous material is soluble in hot asphalt or asphaltic road oil, I then cover the earth surface to which the hot resinous membrane has been applied, with a parting barrier which will separate the resin from the asphalt which I apply on top of the resin membrane. Such a parting barrier is conveniently a layer of dirt, or coarser aggregate, if such aggregate is in a sufficiently thick course or sufficiently densely packed to prevent the intrusion of the hot asphalt into the membrane formed by the petroleum resin layer. I then follow this application by applying the surface asphaltic coat either as road or as sheet asphalt or as macadam.

I have found it desirable, however, particularly in dry or dusty places to precede the applications of the petroleum resin by a preliminary treatment with the resin in the form of a fairly dilute solution of such emulsions and then use a dust binder as in application Serial No. 170,487, filed June 26, 1950, now Patent No. 2,646,361. In making such emulsions for use as the preliminary treatment, I may employ any one of the above resin extracts 1 to 4 inclusive, Table I, with or without the addition of the polymers, as described above, and emulsify them with water.

I have found that for the purposes of my invention, the dust laying emulsion should preferably have the following characteristics. It should be light yellow in color and be free-flowing, containing dispersed semi-liquid, resinous petroleum bodies, preferably within the range of 57 to 63 parts by weight and water as the continuous phase not less than about 25 parts by weight and preferably in the range of 37 to 43 parts by weight, and also an emulsifier. The resinous petroleum bodies should have a sufficiently high initial boiling point to give a flash point in excess of 400° F. and have a specific gravity of from 1 to 1.04 when measured at 60° F. as compared to water at 60° F. (60°/60°). The emulsion is stable in the sense that it will not break when stored for long periods in clean, closed containers at ordinary atmospheric temperature above freezing.

Many different emulsifiers may be used for such resins to produce such emulsions. For example, I may use: cetyl pyridinium chloride; "Duponol G," sold by E. I. du Pont de Nemours and Co. Inc., and believed to be fatty alcohol sulfates; "Duponol WA Paste," sold by E. I. du Pont de Nemours and Co., Inc., and believed to be principally sulfates of lauryl alcohol; "Oronite Wetting Agent," sold by Oronite Chemical Co., and believed to be petroleum sulfonates; sodium oleate; "Golden Bear Sulfonates"; sodium petroleum sulfonates, sold by Golden Bear Oil Co., and constituting the water soluble sodium salts of the sulfonic acids extracted by alcohol in the refining of white oil with sulfuric acid; and bentonite.

This list is not intended to be exhaustive, and is but suggestive of the emulsifying agents which may be employed. Many agents useful for emulsifying petroleum oils are effective in various concentrations. Those listed above will be found to be useful in concentrations of 5% or less, based on the resin phase.

In addition to the emulsifying agent, stabilizers may be used to stabilize the emulsion against electrolytes which may be present in the water used for making or diluting the emulsion. The use of hard water or water treated with chlorine will require the addition of such stabilizers to the emulsion. Stabilizers will also guard against premature breaking of the emulsion by the soil before it has reached the interstices thereof. Such stabilizers include casein, glue, and various gums and synthetic protective colloids and thickeners. Again, it is desirable to use highly active ingredients so that the amount employed may, for practical reasons, be kept to a minimum. These synthetic, highly active stabilizers include, for example, "Cellosize," manufactured by Carbide & Carbon Chemicals Corp., and believed to be hydroxy-ethylcellulose; "Methocel," sold by Dow Chemical Co., and believed to be methylcellulose, the grade preferred for my use being 25 centipoises, or one of lower viscosity; "Driscose," sold by Drilling Specialties Co., or "Hercules CMC," sold by Hercules Powder Co., both believed to be sodium carboxy-methylcellulose; "Vinsol NVX," sold by Hercules Powder Co., and believed to be the sodium salt of "Vinsol Resin," which is also sold by Hercules Powder Co., and which is believed to be a dark-colored resin having a specific gravity of about 1.218, a melting point of 234–239° F., largely insoluble in petroleum solvents, and derived from pine wood and containing phenol, aldehyde, and ether groups.

I may similarly emulsify the above resinous components using an equal weight of water and as emulsifier 1% of cetylpyridiniumchloride or ½% of "Duponol WA Paste" or 5% of bentonite. I may also emulsify the resin in the ratio of 60 parts of resin to 40 parts of water, using ½% of sodium oleate.

Such emulsions may be diluted with, for example,

four parts of water to one part of the emulsion and spread and disked into the soil.

The following examples are given for purpose of illustrating my invention and not as a limitation thereof.

Example 1

The following experiments were carried out to test the suitability of solvent extracts for use as an impermeable membrane to seal off "alkali" from the surface of the ground. The soil used in the experiments and later in the commercial application, extracted with distilled water, showed that it contained three per cent (3%) water-soluble salts which were alkaline when tested with litmus.

(1) A crystallizing dish 14.7 cm. in diameter (having an area of 170 sq. cm. requiring 77 cc. of fluid to equal 1 gallon per square yard) was filled to a height of 1.5 inches with an "alkali" soil taken from an area in the vicinity of Taft, California, in the southwestern section of the San Joaquin Valley. The material was compacted evenly by applying pressure with a smaller crystallizing dish. On top of the so-compacted layer was placed a 1-inch layer of a material used as overburden in road construction and consisting of a mixture of coarse sand and fine gravel, which was mixed with a 10% by weight of dust laying emulsion described above, containing about 85% water, and the layer was again compacted by use of the smaller crystallizing dish.

(2) A crystallizing dish of the same dimensions as above was charged in an identical manner as above except that sufficient solvent extract from the refining of lubricating oil was poured on the first layer ("alkali" soil) to form a continuous membrane. The amount used was 51 cc., which equals ⅔ of a gallon per square yard. The characteristics of the lubricating oil extract used were as follows:

Specific gravity	1.02
Viscosity at 70° F.—cps.	8500
Viscosity at 210° F.—cps.	22

The composition of this extract by chemical analysis was as follows:

Asphaltenes	0.0
N-bases	16.9
Unsaturated hydrocarbons, group I	18.0
Unsaturated hydrocarbons, group II	53.0
Saturated hydrocarbons	12.1

To apply the extract, it was heated until thinly fluid and was poured on top of the "alkali" layer through a narrow funnel before the overburden mix was put on.

The above test with the solvent extract layer was repeated several times using different extracts, the characteristics of which are given in Table I.

The above described experiments showed the following:

(1) While the "alkali" came through the overburden within a few hours in the crystallizing dish which did not contain the extract layer, no "alkali" was visible on the top of the crystallizing dishes containing the layers of extracts after several months, thus proving that the solvent extracts seal off the "alkali."

(2) The higher viscous extracts form a better seal in that they penetrate less into the soil and form a better cohesive membrane.

Example 2

The application of the above laboratory experiments to a practical test of the invention in road construction was undertaken. The area was that from which was taken the "alkali" soil used in the above-outlined experiments. The construction materials, as well as the amounts used, were basically the same as used in the laboratory experiments. The application was carried out as follows:

A road, which had been previously surfaced with black oil and had become eroded by the "alkali," was dug up to a depth of about three inches. The soil thus dug up and some additional material (gravel and sand) which was brought in was mixed with the dust laying emulsion used in the experiment of Example 1 and bladed to one side. Solvent extracts (Table I) heated to about 250° F. were then spread on the sub-surface at a rate of about ⅔ of a gallon per square yard. Upon cooling, the extract formed a continuous membrane over the area. The mixed soil, which had been moved to one side, was then bladed back over the treated sub-surface and compacted by wheel-packing.

Example 3

A second experiment was carried out. Road was built on "black alkali" soil. The construction used in this case was similar to that described in Example 2 except that the road surface was covered with hot asphalt. After the application of the dust binder and the hot resin sealing membrane, the road was coated by applying hot molten asphalt in the conventional manner by spraying on top of the road bed.

The roads built according to the practice of the foregoing examples have been subjected to various atmospheric conditions and wear over a period of less than a year. No "alkali" is to be seen coming through the surface either of the road built without "black top," i. e., asphalt, on "white alkali" soil or on the second road constructed, which was black-topped, and which was built on "black alkali" soil, while asphaltic roads without the use of the resin sealing coat built at later dates in that area show signs of progressive disintegration as is usual and as has been described above.

The property of the petroleum resins described above to form an impervious water resistant membrane is also useful where, as has been described above, no asphaltic top coat is used. Thus, for the purpose of earth consolidation where a water resistant earth structure is desired the earth may be mixed with the hot resin, as described above. This will find useful application in the construction of earth dams and other earth structures, as, for example, in the consolidation of earthen roads, when it may be used in place of asphaltic oils. The property which makes the resin resistant to alkali and impervious to water is thus useful in this and many other connections which will be clear to those skilled in this art as a result of the disclosures made herein.

While I have described a particular embodiment of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

I claim:

1. In a method of forming a substantially alkali impervious membrane for earth structures, the step which comprises coating said structure with a material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the structure coated.

2. In a method of forming a substantially alkali impervious membrane for earth structures, the step which comprises coating said structure with material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than 25% of said petroleum fraction and from about 1/10 to about 3% of an elastomer dispersed therein, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the structure coated.

3. In a method of forming a substantially alkali impervious membrane for earth structures, the step which comprises coating said structure with a hot molten material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, said petroleum resin having a viscosity at 25° C. in excess of about 750 centipoises and a specific gravity of not less than 1, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the structure coated.

4. A method of forming roads which comprises treating the sub-surface of said road with a hot molten material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, said material being applied with a viscosity and in an amount

sufficient to form a substantially continuous membrane over the area of the sub-surface treated.

5. A method of forming roads which comprises treating the sub-surface of said roads with a hot molten material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, said petroleum resin having a viscosity at 25° C. in excess of about 750 centipoises and a specific gravity of not less than 1, laying a parting layer of aggregate on the treated sub-surface, and surfacing said road with asphalt over said parting layer, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the sub-surface treated.

6. An earth structure, said earth structure having a surface, a substantially continuous sealing membrane on said earth surface extending over at least a portion of said surface, said membrane consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction.

7. An earth structure, said earth structure having a surface, a substantially continuous sealing membrane on said earth surface extending over at least a portion of said surface, said membrane consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said petroleum fraction and from about 0.1% to about 5% of an elastomer dispersed therein.

8. An earth structure, said earth structure having a surface, a substantially continuous sealing membrane on said earth surface extending over at least a portion of said surface, said membrane consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, said petroleum resin having a viscosity at 25° C. in excess of about 750 centipoises and a specific gravity of not less than 1.

9. A method of forming roads which comprises treating the sub-surface of said roads with a material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, covering the road so treated with said resinous fraction with a parting barrier of aggregate, and surfacing said road with asphalt over said parting layer, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the sub-surface treated.

10. A method of forming roads which comprises treating the sub-surface of said road with a material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction and from about 0.1% to 5% of an elastomer dispersed therein, covering the road so treated with said resinous fraction with a parting barrier of aggregate, and surfacing said road with asphalt, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the sub-surface treated.

11. A method of forming roads whilch comprises treating the sub-surface of said road with a material consisting essentially of a resinous petroleum fraction substantially free of saponifiable material and containing saturated hydrocarbons in an amount not more than about 25% of said resinous petroleum fraction, said petroleum resin having a viscosity at 25° C. in excess of about 750 centipoises and a specific gravity of not less than 1, covering the road so treated with said resinous fraction with a parting barrier of aggregate, and surfacing said road with asphalt, said material being applied with a viscosity and in an amount sufficient to form a substantially continuous membrane over the area of the sub-surface treated.

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