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SURFACE STABILISER AND USES THEREOF

TECHNICAL FIELD

The invention described herein relates to a system for stabilizing soil materials. In particular, the invention is directed to a system for stabilizing or bonding soil for road or pavement constructions, thereby providing improved vehicular access, although the scope of the invention is not necessarily limited to the above. Other materials the invention can be used to stabilise or bond include minerals, rocks, aggregates and biogenic substances. The invention can also be utilized for pothole repairs or suppression of dust particles, or crack sealing or sealing of pavements, prime, sand, single or two coat or asphalt.

BACKGROUND ART

One of the earliest forms of road or pavement construction was the use of cobblestones. Cobblestones are small, rounded stones that are set in sand or bound together using mortar. Cobblestones had advantages over non-cobbled paths and roads, such as being usable in wet weather and not developing ruts. However, the nature of cobblestones is that the resultant surface is uneven, and there is a high level of wear and tear on any vehicle using the surface.

To overcome the problems associated with cobblestones, setts were used. In contrast to cobblestones which are rounded and therefore provided an uneven surface, setts are quarried stones with a relatively even shape and surface and were laid in regular patterns. The resultant surface was therefore smoother than a cobblestone surface, had the same advantages of cobblestones, being usable in wet weather and not developing ruts, but with a lower level of wear and tear than that associated with cobblestones.

Since the early 20th century, asphalt has been commonly used as a surfacing material. The presence of bitumen binders in the asphalt provides the asphalt with the ability to remain intact despite significant environmental effects. Asphalt can be laid directly on subsoil, but generally it is laid on a gravel base. The thickness of the gravel base is dependent on the nature of the subsoil. Where the subsoil is very soft, or prone to substantial expansion and/or contraction, such as heavy clay, a thick gravel base is required to adequately support the asphalt. Stabilization of the subsoil with cement may also be required.

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Many regions throughout the developing world have limited access due to the lack of made roads. Conventional roads require a number of layers built up as part of a time consuming process. This process includes preparing the sub-base, covering with a road base, laying an asphalt base course and finally applying an asphalt surface course. Not only is this process time consuming, but it is also costly and can be difficult, particularly in areas where the natural ground surface is unstable or the road is to be built in an area of difficult terrain.

In some cases, the road is only intended to be temporary, but during its lifetime is intended to cope with heavy vehicle traffic. Therefore, even for a temporary road, all-weather access is required. Conventional roads require maintenance over periods of heavy rains and high temperatures. Conversely, long periods of dry weather or cold temperatures can also result in damage to traditional road surfaces, leading to maintenance costs.

There thus exists a need to construct cost-effective roads for rural and remote communities.

It is an aim of the invention to provide a system for soil stabilization which overcomes or ameliorates one or more of the disadvantages or problems described above, or which at least provides the consumer with a useful choice.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a stabilizing composition comprising at least one monomeric material and at least one polymeric material as a homogenous aqueous emulsion.

According to a second aspect of the invention, there is provided a method of stabilizing a quantity of soil, the method comprising the step of combining a stabilizing composition comprising at least one monomeric material and at least one polymeric material as a homogenous aqueous emulsion with a quantity of soil.

Referring to the first aspect, the monomeric material can be an acrylate-based monomer, such as acrylate or styrene acrylate. Alternatively, the monomeric material can be a butadiene-based monomer, such as styrene butadiene.

The polymeric material of the composition can be a homopolymer such as a polyacrylate, or the polymeric material can be a copolymer such as styrene butadiene rubber,

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carboxylated styrene butadiene rubber, natural rubber latex or synthetic latex in an aqueous solution. In a preferred embodiment, the polymeric material is cross-linked polystyrene divinyl benzene.

5 The homogenous aqueous emulsion of monomeric and polymeric materials can comprise additives such as a polyether-ethoxylated nonylphenol to stabilize the emulsion.

Stabilizing compositions according to the invention can comprise any suitable ratio of monomeric material to polymeric material as an aqueous emulsion. Preferably, the ratio of monomeric material to polymeric material is within the range 0.1:1 to 6:1 (w/w). Even more preferably, the ratio of monomeric material to polymeric material in a stabilizing composition
10 of the invention is within the range 0.8:1 to 1.3:1 (w/w). The ratio of monomeric material to polymeric material in a stabilizing composition of the invention can thus be 0.8:1, 0.9:1, 1:1, 1.1:1, 1.2:1 or 1.3:1.

The stabilizing composition can further comprise a coalescing agent. Coalescing agents are known in the art of preparing polymer films and are routinely used in that art, as
15 they evaporate readily, allowing the resultant polymeric film to 'cure'. Any coalescing agent known in the art can be used in the compositions of the invention. Preferably, the coalescing agent is a glycol ether, such as trimethyl pentanediol monoisobutyrate.

Optionally, the stabilizing composition can comprise a defoamer. Any suitable defoamer known in the art can be used, for example a defoamer based on hydrocarbons and
20 non-ionic surfactants such as Foamaster® NXZ or similar. The presence of a defoamer in the compositions of the invention allows the compositions to be mixed and transported without incorporation of air which would inhibit use of the compositions.

As a further option, stabilizing compositions of the invention can comprise a bactericide. The presence of a bactericide ensures that the compositions remain free from microbial growth
25 for an appropriate period of time. The presence of a bactericide thus extends the shelf-life of the stabilizing compositions. The bactericide can be any bactericide known in the art, such as a blend of methyl and benzisothiazolinone (Acticide™ MBS) or similar.

To assist in even application of the stabilizing compositions, a dispersant may also be added. An example of a suitable dispersant is a finely dispersed aqueous dispersion of a
30 carboxylated styrene-butadiene copolymer (Lipaton SB 4520) or similar.

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Preferably, stabilizing compositions of the invention comprise 40-60 % w/w water, 5-30 % polymeric material, 5-30 % monomeric material, 0.1-0.5 % defoamer, 0-10 % coalescing agent and 0.1-2 % bactericide. Particularly preferred stabilizing compositions comprise 44-50 % water, 20-25 % polymeric material, 20-25 % monomeric material, 0.1-0.5 % defoamer, 1-3 % coalescing agent and 0.5-2 % bactericide as a homogeneous aqueous emulsion.

Compositions of the invention can additionally comprise an anionic bitumen emulsion. Preferably, compositions comprising an anionic bitumen emulsion also comprise one or more plasticizing agents to assist in combining the anionic bitumen emulsion with the aqueous emulsion of monomeric and polymeric materials. Any suitable plasticizing agents known in the art can be used, including but not limited to, a dibenzoate plasticizer such as K-FlexTM Dibenzoate Plasticizer.

Stabilizing compositions of the invention can therefore comprise 40-60 % water, 5-30 % polymeric material, 5-30 % monomeric material, 0.1 %-0.5% defoamer, 0-10 % coalescing agent, 40-60 % bitumen, 1-10 % plasticizing agent and 0.1-2 % bactericide. Particularly preferred stabilizing compositions comprise 40-50 % water, 10-15 % polymeric material, 10-15 % monomeric material, 0.1-0.5 % defoamer, 1-3 % coalescing agent, 45-55 % bitumen, 1-10 % plasticizing agent and 0.5-2 % bactericide.

The stabilizing compositions of the invention are prepared at a temperature between about 0 °C and about 70 °C. Preferably, the stabilizing compositions of the invention are prepared at a temperature between about 5 °C and about 60 °C. The stabilizing compositions of the invention can therefore be prepared at a temperature of about 5 °C, 10 °C, 15 °C, 20 °C, 25 °C, 30 °C, 35 °C, 40 °C, 45 °C, 50 °C, 55 °C or 60 °C.

Turning to the second aspect of the invention, the soil which can be stabilized can be any soil type, ranging from gravel (which can be further classified as coarse, medium or fine gravel), through sand (coarse or fine) to silt and clay. Each of these soil types has specific characteristics which has previously made stabilization difficult.

For example, clay is notoriously difficult to stabilize, as it has a high Plastic Index (PI). In order to stabilize clay, it has previously been necessary to reduce the PI by the addition of a granular material, such as sand. Lime and cement can also be added to clay to

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reduce the PI. However, large amounts of such additives are required to lower the PI of clay sufficiently to enable stabilization. This is not only time consuming, but also adds to the cost of stabilizing clay. Consequently, it has previously been costly and time-consuming to build a road, even a temporary road, on a clay soil-type.

5 A stabilizing composition comprising at least one monomeric material and at least one polymeric material as a homogenous aqueous emulsion can be added to a quantity of soil, which can either be a sample of soil for the purposes of testing (such as a laboratory analysis) and/or optimizing the stabilizing composition, or the quantity of soil can be a ground surface which is required to be stabilized, for example, for the purpose of building a road or
10 pavement.

Preferably, the composition is added to the soil at a temperature between about 0 °C and about 70 °C. Preferably, the composition is added to the soil at a temperature between about 5 °C and about 60 °C. The composition can therefore be added to the soil at a temperature of about 5 °C, 10 °C, 15 °C, 20 °C, 25 °C, 30 °C, 35 °C, 40 °C, 45 °C, 50 °C,
15 55 °C or 60 °C.

Following addition of the stabilizing composition to the soil, the soil and composition can be mixed. Any suitable method of mixing can be used. Where the soil is a ground surface to be stabilized to a predetermined depth, the mixing can be undertaken using a stabilizing machine such as those routinely used in building roads. Alternatively, the mixing
20 can be undertaken using a grader. As a further alternative, the stabilizing composition can be incorporated with the soil using a pug mill.

The method can comprise repeated applications of the stabilizing composition to the soil to achieve the desired level of stabilization. Dependent on the soil to be stabilized, the method can comprise between 1 and about 50 applications of a stabilizing composition.

25 In order that the invention may be more readily understood and put into practice, one or more preferred embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is schematic of a clay particle.

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Figure 2 is a schematic of several clay particles illustrating the relationship between the particles and associated water.

Figure 3 is a schematic of a clay particle stabilized by a composition according to an embodiment of the invention.

5 Figure 4 is schematic of the clay particle shown in Figure 3, further stabilized by a composition according to an embodiment of the invention.

Figure 5 is a schematic of several clay particles stabilized by a composition according to an embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

10 Referring firstly to Figure 1, there is shown a particle of clay 10, indicating the highly negatively charged surface of the particle 10. The highly negatively charged surface of the particle 10 is a natural attractant for cations such as sodium, potassium and calcium which are present in ground water. As a result, the clay particle 10 has an adsorbed water layer 12.

Several clay particles 10 are shown in Figure 2. Each clay particle 10 has an adsorbed
15 water layer 12. Additionally, there is water 14 between neighbouring clay particles 10 which is held in place by surface tension. Finally, there is also capillary water 16 in the pores between clay particles 10. This figure is illustrative of the position and amount of water which exists in and around clay particles. The volume of water which can be associated with clay particles 10, means that when clay is exposed to water, it has substantial capacity to
20 uptake and hold water, both in and around the clay particles. The significant expansion that takes place when clay is exposed to water is one of the main reasons that clay is a particularly difficult soil to work with.

A schematic of a clay particle 10 stabilized by a composition according to the present invention is shown in Figure 3. The clay particle 10 is naturally highly negatively charged,
25 however, the water layer which is usually present around the clay particle 10 (as seen in Figure 1) has been replaced by a layer 18 of a stabilizing composition according to the present invention. The layer 18 of stabilizing composition effectively forms a polymer film around the clay particle 10. The presence of the polymer film 18 effectively neutralizes the clay

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particle 10, so that water is no longer attracted to the clay particle 10, thereby minimizing the effect of any water on the clay particle 10.

The effect of further stabilization of the clay particle 10 of Figure 3 is shown in Figure 4. The clay particle 10 initially stabilized with a polymer film 18 resulting from exposure of the clay particle 10 to a stabilizing composition of the present invention, has undergone a subsequent treatment with a stabilizing composition of the invention, resulting in a second polymer film 20 surrounding the first polymer film 18. The process of exposing a stabilized clay particle 10 to a stabilizing composition of the invention can be repeated until the desired level of stabilization is achieved. The number of treatments is dependent on a number of factors, including the cation exchange capacity (CEC) of the clay particles being treated (higher for highly negatively charged clay), the amount of water present around the clay particles and the level of stabilization required.

The effect of subsequent stabilizing treatments on a group of clay particles 10 is shown in Figure 5. In this schematic, the clay particles 10 have been subjected to multiple treatments with a stabilizing composition of the present invention. A first treatment has replaced the water on the surface of each clay particle 10 with a first polymer film 18. Further treatments of the clay particles 10 have resulted in the sequential addition of a second polymer film 20, bonding film 22 at the points of contact between the clay particles 10 (replacing the water between neighbouring particles) and pore polymer 24 (replacing the capillary water in the pores between clay particles 10).

Thus the first polymer film 18 assists with effectively neutralizing the clay particles 10 to provide a first level of stabilization. The second polymer film 20, bonding film 22 and pore polymer 24 all contribute to bonding the clay particles 10 together, thereby providing a second level of stabilization.

Having broadly described the invention, non-limiting examples of stabilizing compositions of the invention, their preparation, and methods of use, will now be given.

Example 1

Styrene acrylic monomer, s400 resin (a cross-linked polystyrene divinylbenzene) and water are reacted together and stabilized with a polyether-ethoxylated nonyl phenol to form a polymer system as a homogenous aqueous emulsion. The following components are then

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added sequentially in this order: defoamer comprising hydrocarbons and non-ionic surfactants, an aqueous dispersion of a carboxylated styrene-butadiene copolymer as a dispersant, trimethyl pentanediol monoisobutyrate as a coalescing solvent and a bactericide comprising a blend of methyl and benzisothiazolinone. Following addition of each component to the homogenous aqueous emulsion, the mixture is thoroughly mixed to ensure even distribution of each component.

The final composition comprises 0.1-0.5% defoamer, 0-10% coalescing solvent, 0.1-2% bactericide, 5-30% styrene monomer, 5-30% s400 resin and 40-60% water as a homogenous aqueous emulsion.

Example 2

Styrene acrylic monomer, s400 resin (a cross-linked polystyrene divinylbenzene) and water are reacted together and stabilized with a polyether-ethoxylated nonyl phenol to form a polymer system as a homogenous aqueous emulsion. The following components are then added sequentially in this order: defoamer comprising hydrocarbons and non-ionic surfactants, an aqueous dispersion of a carboxylated styrene-butadiene copolymer as a dispersant, trimethyl pentanediol monoisobutyrate as a coalescing solvent, a bactericide comprising a blend of methyl and benzisothiazolinone, anionic bitumen emulsion and a dibenzoate plasticizer. Following addition of each component to the homogenous aqueous emulsion, the mixture is thoroughly mixed to ensure even distribution of each component.

The final composition comprises 0.1-0.5% defoamer, 0-10% coalescing solvent, 0.1-2% bactericide, 5-30% styrene monomer, 5-30% s400 resin, 40-60% bitumen, 1-10% plasticizer and 40-60% water as a homogenous aqueous emulsion.

The invention thus provides stabilizing compositions which encapsulate soil particles with a polymer film. The stabilizing compositions thus stabilize the soil particles in a manner which reduces or inhibits their attraction to water. Stabilized soil particles are no longer subject to the severe expansion that can occur when exposed to water or the shrinkage that can occur when the water is removed.

The stabilizing compositions of the invention provide a further stabilizing effect on soil particles following multiple applications of the compositions. The additional applications result in the formation of inter-particle polymer films and polymer films in air voids between

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the particles. Therefore, unlike roads and pavements made from traditional materials using traditional methods, roads and pavements made from soil stabilized with compositions of the invention are not affected by water and consequently are longer lasting and do not require substantial maintenance.

5 Additionally, due to the exclusion of water from in and around the soil particles, roads and pavements prepared using the stabilizing compositions of the present invention are not affected by variations in temperature. Roads and pavements can thus be built in regions which are subject to large seasonal temperature variations and large seasonal rainfall variations.

10 It can therefore be seen that the invention provides compositions which can be used in pavement or road construction to create a traversable surface that is water resistant and resilient, irrespective of the soil-type upon which the pavement or road is to be constructed.

 The foregoing embodiments are illustrative only of the principles of the invention, and various modifications and changes will readily occur to those skilled in the art. The invention
15 is capable of being practiced and carried out in various ways and in other embodiments. It is also to be understood that the terminology employed herein is for the purpose of description and should not be regarded as limiting.

 The term "comprise" and variants of the term such as "comprises" or "comprising" are used herein to denote the inclusion of a stated integer or stated integers but not to exclude any
20 other integer or any other integers, unless in the context or usage an exclusive interpretation of the term is required.

 Any reference to publications cited in this specification is not an admission that the disclosures constitute common general knowledge in Australia.

CLAIMS:

1. A stabilizing composition comprising at least one monomeric material selected from the group consisting of an acrylate-based monomer and a butadiene-based monomer, and at least one polymeric material selected from the group consisting of polyacrylate, styrene
5 butadiene rubber, carboxylated styrene butadiene rubber, natural rubber latex, synthetic latex and cross-linked polystyrene divinyl benzene, as a homogenous aqueous emulsion.
2. The stabilizing composition of claim 1, wherein the at least one monomeric material is an acrylate-based monomer.
3. The stabilizing composition of claim 1, wherein the at least one monomeric material
10 is a butadiene-based monomer.
4. The stabilizing composition of any one of claims 1 to 3, wherein the at least one monomeric material and the at least one polymeric material are present in a ratio of about 0.1:1 to 6:1 (w/w).
5. The stabilizing composition of claim 4, wherein the at least one monomeric material
15 and the at least one polymeric material are present in a ratio of about 0.8:1 to 1.3:1 (w/w).
6. The stabilizing composition of any one of claims 1 to 5, further comprising an additive to stabilize the homogenous aqueous emulsion.
7. The stabilizing composition of claim 6, wherein the additive is polyether-ethoxylated nonylphenol.
- 20 8. The stabilizing composition of claim 6 or claim 7, further comprising a coalescing agent.
9. The stabilizing composition of claim 8, wherein the coalescing agent is a glycol ether.
10. The stabilizing composition of claim 8, wherein the coalescing agent is trimethyl pentanediol monoisobutyrate.
- 25 11. The stabilizing composition of any one of claims 1 to 10, further comprising a defoamer.
12. The stabilizing composition of claim 11, wherein the defoamer comprises hydrocarbons and non-ionic surfactants.

13. The stabilizing composition of any one of claims 1 to 12, further comprising a bactericide.
14. The stabilizing composition of claim 13, wherein the bactericide comprises methyl and benzisothiazolinone.
- 5 15. The stabilizing composition of any one of claims 1 to 14, further comprising a dispersant.
16. The stabilizing composition of claim 15, wherein the dispersant is a finely dispersed aqueous dispersion of a carboxylated styrene-butadiene copolymer.
17. The stabilizing composition of claim 16, comprising 40-60 % w/w water, 5-30 %
10 polymeric material, 5-30 % monomeric material, 0.1-0.5 % defoamer, 0-10 % coalescing agent and 0.1-2 % bactericide as a homogenous aqueous emulsion.
18. The stabilizing composition of claim 16, comprising 44-50 % water, 20-25 % polymeric material, 20-25 % monomeric material, 0.1-0.5 % defoamer, 1-3 % coalescing agent and 0.5-2 % bactericide as a homogenous aqueous emulsion.
- 15 19. A stabilizing composition comprising at least one monomeric material selected from the group consisting of an acrylate-based monomer and a butadiene-based monomer, at least one polymeric material selected from the group consisting of polyacrylate, styrene butadiene rubber, carboxylated styrene butadiene rubber, natural rubber latex, synthetic latex and cross-linked polystyrene divinyl benzene, and an anionic bitumen emulsion as a homogenous
20 aqueous emulsion.
20. The stabilizing composition of claim 19, wherein the at least one monomeric material is an acrylate-based monomer.
21. The stabilizing composition of claim 19, wherein the at least one monomeric material is a butadiene-based monomer.
- 25 22. The stabilizing composition of any one of claims 19 to 21, wherein the at least one monomeric material and the at least one polymeric material are present in a ratio of about 0.1:1 to 6:1 (w/w).
23. The stabilizing composition of claim 22, wherein the at least one monomeric material and the at least one polymeric material are present in a ratio of about 0.8:1 to 1.3:1 (w/w).

24. The stabilizing composition of any one of claims 19 to 23, further comprising at least one plasticizing agent.
25. The stabilizing composition of claim 24, wherein the at least one plasticizing agent is a dibenzoate plasticizer.
- 5 26. The stabilizing composition of any one of claims 19 to 25, further comprising an additive to stabilize the homogenous aqueous emulsion.
27. The stabilizing composition of claim 26, wherein the additive is polyether-ethoxylated nonylphenol.
28. The stabilizing composition of claim 26 or claim 27, further comprising a coalescing
10 agent.
29. The stabilizing composition of claim 28, wherein the coalescing agent is a glycol ether.
30. The stabilizing composition of claim 29, wherein the coalescing agent is trimethyl pentanediol monoisobutyrate.
- 15 31. The stabilizing composition of any one of claims 19 to 30, further comprising a defoamer.
32. The stabilizing composition of claim 31, wherein the defoamer comprises hydrocarbons and non-ionic surfactants.
33. The stabilizing composition of any one of claims 19 to 32, further comprising a
20 bactericide.
34. The stabilizing composition of claim 33, wherein the bactericide comprises methyl and benzisothiazolinone.
35. The stabilizing composition of any one of claims 19 to 34, further comprising a dispersant.
- 25 36. The stabilizing composition of claim 35, wherein the dispersant is a finely dispersed aqueous dispersion of a carboxylated styrene-butadiene copolymer.
37. The stabilizing composition of any one of claims 19 to 36, comprising 40-60 % water, 5-30 % polymeric material, 5-30 % monomeric material, 0.1 %-0.5% defoamer, 0-10 %

coalescing agent, 40-60 % anionic bitumen, 1-10 % plasticizing agent and 0.1-2 % bacticide as a homogenous aqueous emulsion.

38. The stabilizing composition of any one of claims 19 to 36, comprising 40-50 % water, 10-15 % polymeric material, 10-15 % monomeric material, 0.1-0.5 % defoamer, 1-3 %
- 5 coalescing agent, 45-55 % anionic bitumen, 1-10 % plasticizing agent and 0.5-2 % bacticide as a homogenous aqueous emulsion.