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(54) Title: ASPHALT MIXTURE

(57) Abstract: An asphalt mixture comprising a thermochromic compound is disclosed. The asphalt mixture can be used to prepare roads that change colour in response to a change in temperature. The colour change can alert road users of potential hazards.

ASPHALT MIXTURE

Field of the Invention

The invention relates to an asphalt mixture that is suitably used to prepare asphalt pavements.

Background of the Invention

Many road traffic accidents occur when roads are icy, at road temperatures of 5°C or less. To improve road safety it is desirable to inform road users that the temperature of the road has fallen below this threshold, so that they can take additional precautions when travelling on the icy road surface.

It has been proposed that temperature-sensitive indicators should be incorporated into road surfaces to warn road users of icy conditions. For example, GB 2 189 989 describes a reflective marker that can be applied to a road surface. The reflective marker comprises a liquid-crystal material that reflects white light above 0°C and blue light at or below 0°C. In another example, GB 2 332 466 describes a road reflector comprising a thermochromic plastic material which changes colour at about 0°C.

It has also been proposed that temperature-sensitive marking materials should be applied to roads. US 2006/0047019 describes a road-marking material comprising a thermochromic pigment, wherein the pigment changes the colour of the road-marking material below 5°C.

The temperature-sensitive indicators and temperature-sensitive marking materials have not been widely adopted. The present inventors have sought to provide an alternative means of indicating a change in temperature of a road surface. In addition to warning road users that a road may be icy, it may be useful to

warn road users and/or those responsible for maintaining a road that a road surface is above a threshold temperature above which road softening and resulting degradation, particularly rutting, is likely to occur.

Summary of the Invention

Accordingly, the present invention provides an asphalt mixture comprising a binder and aggregate, and further comprising a thermochromic compound.

Road surfaces (known as pavements) are routinely constructed from asphalt mixture, which is a composite of binder and aggregate. For most pavements, the binder is bitumen, a viscous liquid or a solid consisting essentially of hydrocarbons and their derivatives. However, in recent years synthetic binders have also been used. Synthetic binders, such as Shell's Mexphalte C ® possess similar rheological and mechanical properties to the bituminous binders typically used in road applications. The synthetic binders are typically clear, so they are readily pigmented and are used to obtain coloured asphalt mixture. In this description, the term "binder" covers both bituminous materials and synthetic materials having similar rheological and mechanical properties.

The present inventors have developed an asphalt mixture that changes in colour in response to a change in temperature. The asphalt mixture can be used to form pavements, and the colour change can indicate to road users that they should adjust their behaviour in response to the temperature of the road. In contrast to the known methods of indicating a change in temperature of a road surface, the present invention does not require additional features such as indicators or road marking to be applied to a road surface; instead the road itself

changes colour in response to a temperature change and the road user is warned of the temperature change by the colour of the road. The present invention avoids the problems of indicators becoming detached from the road surface or road markings wearing away.

The asphalt mixture of the invention may also be used in applications other than roads, e.g. in roofing or waterproofing applications. For example, a visual indication that a roofing or waterproofing surface is experiencing a very high temperature could be used to indicate that maintenance of the surface is required to prevent or repair deterioriation of the surface.

Detailed Description of the Invention

The binder in the asphalt mixture may be a bituminous binder or may be a synthetic binder having similar rheological and mechanical properties to a bituminous binder. The penetration at 25°C of the binder (as measured according to EN 1426) is preferably between 10 and 350, more preferably between 10 and 250. The softening point of the binder (as measured according to EN 1427) is preferably between 30 and 70°C, more preferably between 35 and 55°C.

The binder may be in the form of an aqueous emulsion. The aqueous emulsion comprises the binder, water and one or more additives to assist in the formation and stabilisation of the emulsion. Suitable additives are known to the skilled person and may include cationic emulsifiers such as monoamines, diamines, quaternary ammonium compounds, alkoxylated amines or amidoamines; anionic emulsifiers such as fatty acids or sulphonates; non-ionic emulsifiers such as nonylphenolethyoxylates or ethoxylated fatty acids; or clays such as natural or processed clays and bentonites.

The thermochromic compound may be incorporated into the asphalt mixture by first incorporating the thermochromic compound into the aqueous emulsion.

In one embodiment of the invention, the binder in the asphalt mixture is a clear synthetic binder. The advantage of using a clear synthetic binder is that the colour change of the resulting road is likely to be more visible than if a coloured binder (e.g. a bituminous binder) is used. Clear synthetic binders are described for example in US 4,629,754. Clear binders may comprise components of vegetable origin, e.g. vegetable oils and natural rosins. Clear binders comprising components of vegetable origin are described in EP 1 466 878.

In another embodiment of the invention, the binder in the asphalt mixture is a bituminous binder. Bituminous binders are commonly used because they are inexpensive and typically have suitable mechanical properties.

The thermochromic compound is a compound that changes colour in response to a change in temperature. Thermochromic compounds are generally available for the temperature range between about -5°C and 200°C and the colour change usually occurs in a 1 to 5°C interval.

The thermochromic pigment may be an inorganic compound or an organic compound such as a leucodye, a liquid crystal or a polymer. Inorganic thermochromic compounds are known to the skilled person and examples include materials chosen from metal oxides, metal halides or metal sulphates wherein the metal is zinc, lead, cadmium or vanadium. Organic thermochromic compounds are known to the skilled person. Examples of leucodyes include melamin formaldehyde, spirolactones, fluorans, spiropyrans and fulgides. They are typically used in combination with weak acids such as bisphenol A,

parabens, 1,2,3-triazole derivates and 4-hydroxycoumarin. The weak acid acts as a proton donor, changing the dye molecule between its leuco form and its protonated coloured form. Organic thermochromic compounds may be microencapsulated, i.e. the dye is coated in a thin film.

The thermochromic compound may be used in combination with a conventional pigment, producing a colour change between the colour of the conventional pigment and the colour of the conventional pigment combined with that of the thermochromic compound.

The asphalt mixture may comprise more than one thermochromic compound. The thermochromic compounds can be chosen such that they change colour at different temperatures and the resulting road will therefore change colour at two different temperatures.

In a preferred embodiment of the invention, the thermochromic compound changes colour at a temperature between -5°C and 5°C, preferably around 0°C. The resulting asphalt mixture and road will then change colour at around 0°C and the colour change can indicate to road users that the road is likely to be icy and slippery.

In another preferred embodiment of the invention, the thermochromic compound changes colour at a temperature between 40°C and 70°C, preferably around 60°C. The colour change of the resulting asphalt mixture and road can indicate to road users that the road is liable to degradation, particularly rutting, if used. In such circumstances it might be possible to divert traffic onto an alternative carriageway, e.g. the hard shoulder, to reduce the load on the road. Alternatively, heavy traffic could be prevented from using the road. Additionally, the colour change can warn those responsible for maintaining a road (or a roofing or waterproofing surface) that the

asphalt has experienced a high temperature and may have deteriorated so that maintenance is required.

The weight ratio of thermochromic compound to binder in the asphalt mixture is preferably less than 1:1, more preferably less than 1:2. Sufficient thermochromic compound is required such that the colour change of the pavement prepared using the binder composition is visible to the road user. However, the thermochromic compound is likely to be the most expensive component in the asphalt mixture, so it is desirable to minimise the amount of thermochromic compound.

The amount of thermochromic compound in the asphalt mixture of the present invention is preferably greater than 0.1wt%, more preferably greater than 0.5wt% and most preferably greater than 1wt% based upon the weight of the asphalt mixture. The amount of thermochromic compound is preferably less than 10wt%, more preferably less than 7wt% and most preferably less than 5wt%, based upon the weight of the asphalt mixture. The amount of thermochromic compound is a balance between achieving a visible colour change and minimising the use of expensive thermochromic compound.

The binder in the asphalt mixture may comprise a polymer. Preferred polymers are thermoplastic elastomers or plastomers, for example styrenic block copolymers, styrene-butadiene rubbers (synthetic and natural), olefinic copolymers, polyurethane and polyether-polyester copolymers. The binder may comprise a mixture of more than one polymer. The amount of polymer in the binder is preferably from 0.5 to 15wt%, based upon the weight of the binder, preferably from 1 to 7wt%.

The binder in the asphalt mixture may comprise further additives, e.g. softening agents such as wax or penetration index boosters such as waxes, polyphosphoric acid and ethylene polymers.

Asphalts mixtures are essentially made of binder with aggregate, in particular filler, sand and stones. There are many different types of asphalts available and their characteristics can vary quite significantly. The design of asphalts for paving application is largely a matter of selecting and proportioning materials to obtain the desired properties in the finished construction. The design of the asphalt mixture is typically based on the grading of aggregates and asphalt mixtures are usually classified into dense graded, gap graded and open graded. The asphalt mixture of the invention may fall into any of these categories.

The amount of binder in the asphalt mixture of the present invention will vary depending on the application for which the asphalt is to be used. However, the asphalt mixture used in the present invention preferably comprises in the range of from 1 to 20wt% of the binder, more preferably in the range of from 2 to 10wt%, and most preferably in the range from 3 to 7wt%, based on total weight of asphalt.

The present invention further provides an asphalt pavement comprising an asphalt mixture according to the invention.

The binder used to prepare the asphalt mixture of the invention may be prepared by blending a thermochromic compound with a binder, preferably at an elevated temperature such that the binder can flow. If the binder composition is an aqueous emulsion, the binder composition may be prepared by mixing a thermochromic

compound with the aqueous emulsion comprising binder, water and emulsifying additives at ambient temperature. The thermochromic compound is preferably used in the form of a powder, pellets or an aqueous emulsion.

Polymers such as thermoplastic elastomers or plastomers may be incorporated into the binder using known techniques.

The asphalt mixture of the invention may be prepared by combining a binder composition comprising a thermochromic compound (which may be an aqueous emulsion)with aggregate. Alternatively, the asphalt mixture composition may be prepared by combining a binder with aggregate and a thermochromic compound. In one embodiment of the invention, the asphalt mixture composition is prepared in a hot mix process wherein aggregate is heated to a temperature of at least 120°C, preferably at least 140°C and a binder and a thermochromic compound are added to the aggregate. In another embodiment of the invention, the asphalt mixture composition is prepared in a cold mix process, wherein aggregate, a thermochromic compound and an aqueous emulsion of a binder are mixed at a temperature of less than 80°C, preferably at ambient temperature. The thermochromic compound is preferably used in the form of a powder, a pellet or an aqueous emulsion.

The asphalt mixture can be used to form asphalt pavement in conventional pavement-laying processes.

Examples

The invention will now be described by reference to examples which are not intended to be limiting of the invention.

Hot Mix Asphalt Process (Sample 1)

Aggregate (40 parts 2mm/6mm, 52 parts 0/2mm and 2 parts filler) was heated to 160°C. A clear synthetic binder (6 parts Mexphalte® C from Shell) was added and the mixture was homogenised. 1 part of powdered thermochromic pigment (melamin formaldehyde resin microencapsulated with isopropylidenediphenol) was added to the aggregate/binder mix.

Cold Mix Asphalt Process (Samples 2-4)

For Sample 2, aggregate (94 parts 2mm/6mm), an aqueous emulsion of a clear synthetic binder (6 parts Spramul CS emulsion from Shell) and a powdered thermochromic pigment (1 part, melamin formaldehyde resin microencapsulated with isopropylidenediphenol) were mixed at ambient temperature. The same method was used for Samples 3 and 4 except that an aqueous slurry of thermochromic pigment (melamin formaldehyde resin microencapsulated with isopropylidenediphenol) was used. 1 part of the aqueous slurry was used in Sample 3 and 3 parts were used in Sample 4.

Temperature Change Tests

The asphalt mix samples were put into an autoclave and heated and cooled to test their ability to change colour. The samples were exposed to simulated aging processes by placing in UV light in water or air. The results are shown in the table below:

	Aging	Appearance at ambient temperature	Appearance below 0°C
Sample 1	No aging	No colour	Pink colour
Sample 1	24 hours in UV light in air	No colour	Pink colour
Sample 1	24 hours in UV light in water	Slightly pink	Pink colour
Sample 1	72 hours in UV light in air	Slightly pink	Slightly pink
Sample 1	72 hours in UV light in water	No colour	Pink colour
Sample 2	No aging	No colour	Pink colour
Sample 2	24 hours in UV light in air	No colour	Pink colour
Sample 2	24 hours in UV light in water	No colour	Pink colour
Sample 2	72 hours in UV light in air	Slightly pink	Slightly pink
Sample 2	72 hours in UV light in water	No colour	No colour
Sample 3	No aging	No colour	Slightly pink
Sample 3	24 hours in UV light in air	No colour	No colour
Sample 3	24 hours in UV light in water	No colour	No colour
Sample 4	No aging	No colour	Pink colour
Sample 4	24 hours in UV light in air	No colour	Pink colour
Sample 4	24 hours in UV light in water	No colour	Pink colour
Sample 4	72 hours in UV light in air	No colour	Pink colour
Sample 4	72 hours in UV light in water	No colour	Pink colour

For all four samples there was a discernible colour change at around 0°C when the sample was fresh. For sample 4, the colour change was marked even after aging for 72 hours in water or air. The colour change was completely reversible.

C L A I M S

1. Asphalt mixture comprising a binder and aggregate, and further comprising a thermochromic compound.

2. An asphalt mixture according to claim 1, wherein the binder is a clear synthetic binder.

3. An asphalt mixture according to claim 1 or claim 2, wherein the binder is a bituminous binder.

4. An asphalt mixture according to any preceding claim, wherein the thermochromic compound is an inorganic compound.

5. An asphalt mixture according to any preceding claim, wherein the thermochromic compound is a leucodye, a liquid crystal or a polymer.

6. An asphalt mixture according to any preceding claim, comprising more than one thermochromic compound.

7. An asphalt mixture according to any preceding claim, wherein the thermochromic compound changes colour at a temperature between -5°C and 5°C.

8. An asphalt mixture according to any preceding claim, wherein the thermochromic compound changes colour at a temperature between 40°C and 70°C.

9. An asphalt mixture according to any preceding claim, wherein the binder is in the form of an aqueous emulsion comprising water and and one or more additives to assist in the formation and stabilisation of the emulsion.

10. An asphalt pavement comprising an asphalt mixture according to any preceding claim.