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DESCRIPTION

TECHNICAL FIELD

[0001] The disclosure pertains to asphalt processing and more particularly to cold-in-place asphalt recycling.

BACKGROUND

[0002] Cold-in-place recycling, commonly referred to as CIR, is a process where an existing bituminous pavement or a combination of bituminous pavement and untreated aggregate are milled or ground from a pavement surface to a depth of up to 15.24 cm (6 inches), combined with a virgin bituminous material, mixed, and repaved without removal of the materials from the existing grade. WO 02/103116 A2 discloses a cold-in-place recycling method wherein milled recycled pavement is mixed with an emulsion comprising asphalt solids, emulsifier and water.

SUMMARY

[0003] The invention is directed to improved processes for cold-in-place recycling of asphalt. The invention is as defined in the appended claims.

DETAILED DESCRIPTION

[0004] The invention pertains to improved CIR processes in which a lubricating additive is added to a foaming asphalt binder. This provides better coating, easier construction, improved compaction, and reduced processing temperatures. One indication of improved coating is the richer color of the paving material, as the more uniform the coating, the darker the color. The duller, browner color of conventional CIR foamed mix is observed when all of the particles are not coated. A firmer mat is also an indication that the binder is coated or more uniformly spread over all the particles rather than having small globules of asphalt interspersed among the fine aggregate particles.

CIR RECYCLING

[0005] CIR recycling is a process in which an existing bituminous pavement or a combination of bituminous pavement and untreated aggregate are milled or ground from a pavement surface to a depth of several inches, combined with a foamed asphalt material, mixed, and

repaved. In some embodiments, CIR recycling involves a train method in which a number of pieces of equipment are arranged, in order, to accomplish each of these tasks on site.

[0006] For example, in a train method, a milling machine may be positioned at the front of the line to mill existing pavement down a desired depth. A hammer mill crusher may be located behind the milling machine, or "downstream" with respect to the flow of materials, such that the hammer mill crusher (or another type of mill or crusher) receives the milled bituminous material from the milling machine. A pug mill may be located downstream of the hammer mill crusher to mix the milled and crushed material with a foamed asphalt binder in a continuous process. A tanker or other truck holding hot asphalt may be disposed between the hammer mill crusher and the pug mill.

[0007] Once the material has been mixed, it can be deposited on the road and transferred to a paver using a pickup machine. In some cases, the material can be dumped from the pug mill directly into the paver. The paver lays the mix and the mix is then rolled or compacted. In some cases, it has been determined that it is beneficial to drop the mix from the pug mill onto the grade and let the pickup machine transfer it to the paver as this can reduce or eliminate frequent stopping and starting of the paver.

[0008] In another process, a reclaimer is used to rip up or chew up the pavement. The removed material is tilled or reclaimed (sometimes virgin aggregate is added) and foamed asphalt is sprayed onto the reclaimed mix, which is then deposited behind the reclaimer. In some cases, a grader is used to shape the finished mix for thickness and slope. In some instances, the material as deposited is compacted without shaping. This process produces a recycled mix that is suitable for correcting poor grades, adding depth to the compacted layer (when using additional aggregate) and generally obtaining a water shedding surface on which additional layers of hot mix asphalt can be placed.

[0009] In another process, a stationary foaming mixing system can be used in combination with milled material that is collected on site and brought back to a central mixing location. This process can be used to produce a cold mix that can be either grader or paver laid to produce a hard, water shedding surface on which to add a chip seal or an overlay. In each of these processes, a lubricating surfactant can be used in the foaming process.

FOAMING PROCESS

[0010] A foamed asphalt binder can be produced using several different techniques. In one technique, a foamed asphalt binder is formed by injecting a small amount of water and compressed air into a very hot stream of asphalt binder which causes the asphalt binder to foam when the water/asphalt blend is sprayed onto the milled bituminous material. In this process, about 1 to 5 weight percent water is injected into virgin asphalt binder along with vigorous mixing of the components to create a foam. The resultant mix that is placed develops strength very quickly because of the relatively low level of water added to the asphalt binder to

make the foam and because of the relatively rapid loss of water through evaporation caused by the heat of the asphalt.

[0011] In some cases, quicker setting emulsions impart a chemical "break" to the emulsion which enables the emulsion to coat the milled material and then chemically bond the asphalt particles to the aggregate material and cause the water to break or separate from the asphalt. There can be a noticeably faster cure imparted to the emulsion system compared to conventional slow setting or medium setting emulsion mixed blends.

[0012] In some embodiments, lubricating surfactants can be added to the asphalt binder or to the water injected into the asphalt binder to enhance foaming and to lubricate and enhance spreading of the asphalt binder onto milled material particles. Consequently, recycled bituminous materials can be produced that provide rapid strength development while also providing about or up to 100 percent coating of particles and also provide the desired appearance and density. In some cases, the lubricating effect provided by the lubricating surfactants can prevent or substantially reduce the tendency of some foamed CIR mixtures to stick to the paver screed. Moreover, while foamed CIR may be performed using binders at approximately 182.2°C (360°F)

the use of lubricating, foam enhancing additives

can result in the reduction of the temperature needed for construction by as much as 33.3°C (60°F).

[0013] In some embodiments, a foamed asphalt binder can be produced by injecting water and compressed air, along with one or more lubricating surfactants, into a stream of hot asphalt. The hot asphalt stream may be a virgin asphalt such as PG 52-34 binder. In some cases, the lubricating surfactant is added to the asphalt prior to injecting the water and compressed air. In some instances, the lubricating surfactant is added to the water prior to injection of the water. In some embodiments,

the hot asphalt is flowing through a pipe or other structure, the water is injected into the hot asphalt stream via a first nozzle and the compressed air is injected into the hot asphalt stream via a second nozzle. In some cases, foaming may occur with injection of water in the absence of injection of compressed air.

ASPHALT BINDER

[0014] A variety of different asphalt binders are commercially available. As an example, several different asphalt binders are commercially available from a variety of sources. Non-limiting examples of asphalt binders are PG 52-34, PG 58-34, PG 64-28, PG 70-28, PG 76-28, PG 70-22 and PG 76-22. A particular asphalt binder is PG 52-34, which has an absolute viscosity (measured at 60°C (140°F)) of 54 Pa·s (540 Poise), a penetration (at 25°C (77°F)) of 236 dmm and a specific gravity (at 15.6 °C (60°F)) of 1.03.

LUBRICATING SURFACTANTS

[0015] A variety of lubricating surfactants can be used in producing foamed asphalt binders. Examples of suitable lubricating surfactants include naturally occurring compounds and more commonly synthesized chemical compounds from three categories of surfactants: detergents, wetting agents and emulsifiers. Surfactants can be specifically categorized as being anionic, cationic, amphoteric and nonionic.

[0016] Suitable anionic surfactants include but are not limited to fatty acids (saturated and unsaturated fatty acids), fatty acid pitch (stearic acid pitch), fatty acid derivatives (fatty acid esters and fatty acid sulfonates), and organo phosphates (alkyl phosphates).

[0017] Suitable cationic surfactants include, but are not limited to, alkyl amines, alkyl quaternary ammonium salts, heterocyclic quaternary ammonium salts, amido amines, and non-nitrogenous sulfur or phosphorous derivatives.

[0018] Suitable amphoteric surfactants, which include an anionic molecular portion and a cationic molecular portion, include but are not limited to amino acids, amino acid derivatives betain derivatives (alkylbetains and alkylaminobetains), imidazolines, and imidazoline derivatives.

[0019] Suitable nonionic surfactants include, but are not limited to, fatty acid ester bonds (SPANS and TWEENS), with surfactant ether bonds (alkylphenolpolyoxyethylenes and polyoxyethylenated alcohols), surfactants with amid bonds (alcanolamides, mono and diethanolamides and their derivatives), alkylated oxide copolymers and polyoxyethyleneated mercaptans.

[0020] Other surfactants and non-surfactant additives can be found in U.S. Patent Application Serial No. 11/871,782, filed October 12, 2007 entitled WARM MIX ASPHALT BINDER COMPOSITIONS CONTAINING LUBRICATING ADDITIVES, which application is hereby incorporated by reference herein in its entirety.

[0021] In some embodiments, the lubricating surfactant is an ethoxylated diamine. An illustrative but non-limiting example of a suitable ethoxylated diamine is DT-3, or tris(2-hydroxyethyl)-N-tallow-alkyl-1,3-diaminopropane. In some embodiments, about 0.5 weight percent DT-3 can be used in the asphalt binder.

COMPOSITIONS

[0022] In some embodiments, a foamed asphalt may be produced by injecting about 0.5 to 5 weight percent water and about 0.05 to about 3 weight percent of an ethoxylated diamine surfactant into a liquid asphalt stream. The liquid asphalt stream may be an asphalt binder

such as PG 52-34. In some embodiments, compressed air at a pressure of about 137.9 to 344.7 kPa (about 20 to about 50 psi) may also be injected into the liquid asphalt stream to enhance foaming. During the foaming process, the liquid asphalt stream is at a temperature in the range of about 148.9°C (300°F) to about 193.3°C (380°F). In some cases, the liquid asphalt stream is at a temperature in the range of about 160°C (320°F) to about 182.2°C (360°F).

[0023] The resulting foamed asphalt may be combined with milled bituminous material (either on site or at a central location) at a rate of about 0.5 to 4 percent foamed asphalt binder by weight of milled bituminous material. This material, once laid and compacted, can achieve a density, measured two days after compaction, of at least about 88 to about 95 percent of the theoretical maximum density of the mix being placed.

EXAMPLE ONE

[0024] A trial run was conducted using the "train method" of cold-in-place recycling. A PR1000T Caterpillar milling machine was used to mill the existing pavement approximately 8.89 cm (3.5 inches) deep. A portable 3033 Cedar Rapids hammer mill crusher with a double screen deck was used to size the milled material to 2.54 cm (1 inch) and smaller size. A portable Barber Green pugmill with a twin shaft approximately 3m (10 feet) long was used to mix the milled material with the foamed asphalt binder. The foaming process was conducted using a Soter spray bar to inject water into the asphalt stream just prior to introduction of the asphalt into the milled material. After mixing the milled material with the foamed asphalt, the mix was placed in a windrow behind the pugmill and a pickup machine was used to transfer the mix to a paver which then laid the mix. A screed on the paver provided initial compaction and final compaction of the mix was accomplished with pneumatic and steel wheeled rollers.

[0025] The asphalt binder used was a PG 52-34 at a nominal temperature of 182.2°C (360°F). The asphalt was delivered to the project in a tanker and transferred to smaller tank designed to straddle the windrow and so move down the paving project as the entire milling and mixing train operates on the project. One to two percent water is added at the milling head to cool the head and keep down dust and another 1-2% water is added during the crushing phase of the operation. This water is in addition to the water injected at the spray head to produce the foamed asphalt. The ambient temperature on this project was 21.11°C (70°F). A total of 1.65% virgin 52-34 binder by weight was added to the milled material. For this test 0.5% DT-3 ethoxylated diamine lubricating additive was added by weight to the PG 52-34 binder.

[0026] At the spray bar in the mixing chamber the mixture color was a darker richer looking color compared to comparable runs performed without the lubricating additive. The mix was more workable in the windrow and picked up easily for transfer to the paver. There was good flow through the paver, flights and under the screed. The coating was uniform and darker in color than the same mix produced without the lubricating additive. The mat behind the paver was firmer than the comparable untreated mix. The mix rolled well and mat appeared firmer

under the roller. There was an obvious color difference between the conventional foamed CIR mix and the CIR mix produced with the lubricating additive. Cores were taken from both the conventional and test sections 2 days after construction. These cores were tested for density. The average density of 5 cores in the conventional section was 2039.15 kg/m³ (127.3 lbs/ft³). The average density for 4 cores taken in the section produced with the lubricating additive was 2066.38 kg/m³ (129.0 lbs/ft³).

EXAMPLE TWO

[0027] Another trial run was conducted using the "train method" of cold-in-place recycling. A portion of the existing pavement was milled, crushed and mixed with a foamed asphalt binder.

[0028] The foaming process was conducted by injecting water into the asphalt stream just prior to introduction of the asphalt into the milled material. After mixing the milled material with the foamed asphalt, the mix was transferred to a paver which then laid the mix. A screed on the paver provided initial compaction and final compaction of the mix was accomplished with pneumatic and steel wheeled rollers.

[0029] The asphalt binder used was a PG 52-34 at a nominal temperature of 182.2°C (360°F). The asphalt was delivered to the project in a tanker and transferred to smaller tank designed to straddle the windrow and so move down the paving project as the entire milling and mixing train operates on the project. One to two percent water is added at the milling head to cool the head and keep down dust and another 1-2% water is added during the crushing phase of the operation. This water is in addition to the water injected at the spray head to produce the foamed asphalt.

[0030] By mid-morning, as the pavement and air temperatures increased, it was found that the asphalt mix developed a tendency to stick to the screed as a result of the fines and binder increasing in viscosity. An attempt was made to resolve the problem by reducing the binder content from 14.90 or 16.15 l/m (1.2 or 1.3 gallons per foot) to 9.94 l/m (0.8 gallons per foot). It was found that this reduced but did not eliminate the problem. Moreover, this resulted in a less-than-optimal binder content. It was found that by adding 0.3 weight percent of DT-3 to the binder, the binder content could be kept at 14.90 l/m (1.2 gallons per foot) while eliminating the mix sticking problem.

REFERENCES CITED IN THE DESCRIPTION

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liability in this regard.

Patent documents cited in the description

- WO02103116A2 [0002]
- US87178207 [0020]

P a t e n t k r a v

1. Fremgangsmåde til opskummet cold-in-place recycling omfattende:

at fremstille et opskummet asfaltbindingsmiddel ved at injicere en eller flere af vand og en komprimeret luftstrøm ind i en strøm af flydende asfalt med en temperatur på 148,9 °C (300 °F) til 193,3 °C (380 °F), der indeholder et smørende tensid;

at kombinere det opskummede asfaltsbindingsmiddel med bituminøst materiale i en kontinuerlig blandingsproces for at fremstille en recirkuleret bituminøs blanding;

at tilføre den recirkulerede bituminøse blanding til en vejbelægningsmaskine; og

at lægge den recirkulerede bituminøse blanding på en eksisterende skråning.

2. Fremgangsmåde ifølge krav 1, hvor vand og komprimeret luft injiceres separat ind i strømmen af flydende asfalt.

3. Fremgangsmåde ifølge krav 1, hvor vand, men ikke komprimeret luft injiceres ind i strømmen af flydende asfalt.

4. Fremgangsmåde ifølge krav 1, yderligere omfattende at komprimere laget af den recirkulerede bituminøse blanding for at danne en fortættet vejoverflade.

5. Fremgangsmåde ifølge krav 1, hvor fremstilling omfatter at injicere 0,5 til 5 vægtprocent vand og en separat komprimeret luftstrøm ved 137,9 til 344,7 kPa (20 til 50 psi) ind i en strøm af flydende asfalt, indeholdende 0,05 til 3 vægtprocent smørende tensid.

6. Fremgangsmåde ifølge krav 1, hvor kombinationen af det opskummede asfaltbindingsmiddel med formålet bituminøst materiale i en kontinuerlig blandingsproces for at fremstille en recirkuleret bituminøs blanding omfatter at kombinere det opskummede asfaltbindingsmiddel med formålet bituminøst materiale i et forhold på 0,5 til 4 vægtprocent asfaltbindingsmiddel af formålet bituminøst materiale.

7. Fremgangsmåde ifølge krav 1, hvor det smørende tensid omfatter et kationisk tensid, et anionisk tensid eller et ikke-ionisk tensid.
- 5 8. Fremgangsmåde ifølge krav 1, hvor den flydende asfalt har en temperatur på 160 °C (320 °F) til 182,2 °C (360 °F).
9. Fremgangsmåde ifølge krav 1, hvor det bituminøse materiale omfatter bituminøst materiale, der er frembragt ved anvendelse af en reclaimer.
- 10 10. Fremgangsmåde ifølge krav 1, hvor det bituminøse materiale omfatter formalet bituminøst materiale, der er frembragt på stedet.
11. Fremgangsmåde ifølge krav 1, hvor det smørende tensid omfatter et ethoxylet diamintensid.
- 15 12. Fremgangsmåde ifølge krav 11, hvor blanding af et ethoxylet diamintensid og vand med et flydende asfaltbindingsmiddel for at danne en opskummet sammensætning af tensid og asfalt omfatter at kombinere:
0,5 til 5 vægtprocent vand; og
20 0,05 to 3 vægtprocent ethoxylet diamintensid;
hvor resten er flydende asfaltbindingsmiddel.