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ARTICLES PRODUCED BY CASTING OF SULFUR ASPHALT

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4 Claims

ABSTRACT OF THE DISCLOSURE

Sulfur-asphalt pavements and construction articles are produced by casting sulfur-asphalt-aggregate mixes in forms without the application of densification pressure. The mixes employed to produce the cast articles have weight ratios of sulfur to asphalt of at least 1:1.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to cast sulfur-asphalt articles and to a method of preparing same. More particularly it relates to sulfur-asphalt pavements and construction materials having very desirable properties formed by the casting of sulfur-asphalt-aggregate mixes.

Description of the prior art

The use of sulfur in asphaltic compositions is well known in the art. In low concentrations, e.g., sulfur to asphalt weight ratios of 1:1 or less, sulfur in paving compositions behaves essentially as a filler. At higher concentrations, sulfur adds strength to the mix thereby contributing to the mechanical stability of the resulting pavement and increasing its resistance to plastic displacement. Such paving compositions are described, for example, in Canadian Pat. 755,999.

While sulfur-asphalt-aggregate mixes having high sulfur to asphalt ratios have been employed to a limited extent in road-building applications, these mixes are subject to certain disadvantages which detract from their utility. For example, at high temperatures, e.g., above the melting point of sulfur, these mixes are very difficult to compact employing conventional rolling techniques. Even if successfully compacted, the properties of the resulting pavements are often less than satisfactory which is now believed due to the sulfur bonding being destroyed by the compaction pressure. While the compaction properties of sulfur-asphalt mixes can be improved by reducing the concentration of sulfur or by applying the mix at lower temperatures, such practices substantially reduce or eliminate the advantages of the use of sulfur in the mix.

DESCRIPTION OF THE INVENTION

It has now been found that sulfur-asphalt pavements and building materials of substantially improved strength can be prepared by casting sulfur-asphalt-aggregate mixes having high ratios of sulfur to asphalt instead of employing conventional densification or compaction techniques. The cast sulfur-asphalt articles of the invention have been found to possess many desirable properties. A particularly advantageous feature of the invention is that cast sulfur-asphalt pavements prepared from heretofore non-usable aggregates, such as poorly graded sand, were found to have properties comparable or superior to pavements prepared

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from conventional mixes employing well-graded, low VMA aggregates.

Because sand and other relatively cheap aggregates can be satisfactorily employed in the cast articles of the invention, the present method is ideally suited for such applications as the preparation of base courses and working platforms for heavy equipment, which would be uneconomical to construct from sulfur-asphalt mixes if well-graded low VMA aggregates were required. Working platforms or similar load-bearing surfaces are generally employed where major construction must be accomplished on a relatively weak subgrade. Commonly an unbound sub-base or cement-treated soil is employed for this purpose. However, such materials suffer from certain technical disadvantages. For example, unbound layers are not very efficient in carrying loads and tend to act as water traps both during construction and during the service life of the pavement. Production of cement-treated soils requires special equipment and the resulting material must cure for a period of time before being opened to traffic. The cast sulfur-asphalt pavements of the invention do not suffer from these disadvantages, or at least to an appreciably lesser extent, and therefore offer an attractive alternative to presently employed methods of constructing base courses and working platforms.

A further advantage of the castable mixes of the invention is that they are useful to pave roads having irregularities, e.g., shallow ruts, which otherwise could not be filled because the irregularities would appear on the surface again when the road is rolled. The present articles are also advantageous in that they do not bleed and can be used to cover areas where bleeding has destroyed the rough surface required for anti-skid properties.

Mixes suitable for forming the cast sulfur-asphalt articles of the invention essentially comprise sulfur, asphalt and aggregate, the weight ratio of sulfur to asphalt being at least 1:1 and preferably from about 2:1 to 5:1 or higher. Cast articles having sulfur to asphalt ratios of from 1.0:1 to 2.5:1 are particularly suitable as flexible pavements, while articles having ratios above 5:1 make suitable rigid pavements, building blocks and the like. Cast articles having an intermediate ratio of 2.5:1 to 5:1 form very strong but still flexible pavements.

The sulfur employed in these mixes is elemental sulfur, that is, sulfur in the free state—not as a compound. Any of the physical forms of sulfur are satisfactory for use because the sulfur is generally mixed with the asphalt in a molten state, although it is not necessary to do so.

Asphalt materials which may be suitably employed in these mixes include any asphalt generally used in road building, particularly pyrogenous asphalts derived from petroleum residues, e.g., residual oils, blown petroleum asphalt, soft and hard residual asphalt and the like. Other pyrogenous residues such as tar and pitch may also be used as well as mixtures of such materials with asphalt. Natural asphalt such as gilsonite may also be employed. Penetration grade asphalts, that is, those having a penetration (ASTM Method D5) of 40–300, are particularly preferred. Asphalt is employed in the mix in an amount sufficient to bind the aggregate, e.g., generally at least 3% by weight of the total composition. Mixes containing from about 4 to about 7% by weight asphalt are especially suitable.

The aggregate used in the mix is generally defined as particulate inorganic matter and includes sand, stone,

gravel, slag and the like, which may be either acidic or basic as in the case of granite and limestone, respectively. As previously mentioned, sand which is readily available at most construction sites has been found to form highly satisfactory pavements when mixed with sulfur and asphalt and applied in accordance with the present casting method.

The casting of the mixes to form the improved pavements of the invention is generally accomplished by bringing the mix to a temperature at which it becomes sufficiently fluid to level itself into forms, e.g., a temperature of from about 260° to about 350° F. While temperatures of above 350° F. can be employed, at these higher temperatures hydrogen sulfide may be released; therefore, it is preferred to operate at temperatures below 350° F. After the mix is introduced into the form or mold it may be stirred or vibrated or subjected to some other form of agitation to consolidate the mix and minimize the voids content. It is generally desirable that the voids content of the final sulfur-asphalt article be less than 15%, and preferably less than 10%, by volume. When the present casting process is employed to prepare surface courses, some smoothing may be required to give a satisfactory finish to the surface of the road.

The invention will be further described by means of the following examples. These examples are given for illustrative purposes only; therefore, the invention in its broader aspects should not be limited thereto.

EXAMPLE I

In order to demonstrate the improved properties of the cast sulfur-asphalt pavements of the invention, four pavement sections having the compositions shown in Table I were evaluated by means of a High Frequency Dynamic Tester. This method of evaluating pavements is described in the article "Surface Wave Techniques for Measuring the Elastic Properties and Thickness of Roads: Theoretical Development," R. Jones, British Journal of Applied Physics, 1962, vol. 13, pages 21-29. Each test section was approximately 100 feet in length by 12 feet in width. The thickness of each section is shown in the table.

Pavement Sections 1, 2 and 3 were compacted employing normal rolling techniques, while Section 4 was constructed by the casting method hereinbefore described and was not subjected to any compaction pressure.

TABLE I											
Composition							Dynamic tester results				
Pavement section	Asphalt 150/200, percent w.	Sulfur, percent w.	Sulfur asphalt ratio	Crashed gravel	Sand	Design thickness, cm.	Density, g./cc.	Thickness, cm.	Shear wave velocity, m./sec.	Dynamic modulus, kg./cm. ²	Test temp. ° C
1-----	5.0	0	0	X	-----	15	2.400	15	1,220	9.50×10 ⁴	25
2-----	4.85	4.65	1.0	X	-----	10	2.476	10	1,030	7.00×10 ⁴	29
3-----	4.45	7.5	1.7	-----	X	20	2.130	19	850	4.10×10 ⁴	27
4-----	6.0	12.2	2.0	-----	X	7.5	2.024	6.2	1,400	1.10×10 ⁵	29

From the foregoing shear wave velocity and dynamic modulus data, it is evident that Pavement Section 4 prepared in accordance with the invention is superior to Section 1 constructed normally from asphalt and good quality crushed gravel aggregate. Section 4 is also superior to Sections 2 and 3, the latter of which was prepared from a similar sulfur-asphalt-aggregate mix, but which had been compacted, i.e., subjected to densification pressure, instead of having been cast. Section 2 demonstrates the action of sulfur as a filler.

EXAMPLE II

To further demonstrate the excellent properties of the pavements of the invention, comparisons were made between the tensile properties of cast sulfur-asphalt pavements and conventional pavements. The compositions of the pavements tested and the results of these determinations are presented in Table II. The test runs at temperatures of 0° F. and 30° F. were conducted on an Instron Testing Machine employing a cross-head speed of 0.05

cm./min. The results for the 70° F. run were obtained from the constant load tensile creep test data.

TABLE II

Composition No.	Temp., ° F.	Tensile strength, kg./cm. ²	Strain at break× 10 ⁻⁴	Stiffness modulus, kg./cm. ²
5.....	0	29	27	10.7×10 ³
6.....	0	25	26	9.6×10 ³
7.....	0	26	22	11.8×10 ³
10.....	30	24	43	5.6×10 ³
6.....	30	15	34	4.4×10 ³
7.....	30	18	29	6.2×10 ³
5.....	70	0.8	105	0.08×10 ³
7.....	70	3.1	21	1.5×10 ³

NOTE.—Composition 5=4.5% w. 150/200 Penetration grade asphalt, 95.5% w. crushed gravel having a VMA of 16.0% v.; Composition 6=3.5% w. 150/200 Penetration grade asphalt, 96.5% w. crushed gravel having a VMA of 16.0% v.; Composition 7=4.0% w. 150/200 Penetration grade asphalt, 16% sulfur (sulfur/asphalt ratio of 4:1) and 80% of sand having a VMA of 27.0% v.

The above data indicate that at low temperatures the tensile properties of the cast sulfur-asphalt-sand mix (Composition 7) are quite similar to the conventional asphalt mixes prepared from a good quality crushed gravel. At higher temperatures the tensile strength and stiffness modulus of the cast sulfur-asphalt composition of the invention are appreciably higher than those of conventional asphalts with a considerably lower strain at break.

In addition to the cast sulfur-asphalt pavements hereinbefore described, the present casting method is applicable to the preparation of numerous other sulfur-asphalt articles which have utility in construction and related fields. For example, mixes having sulfur to asphalt ratios in accordance with the invention were cast into building blocks dimensionally similar to concrete building blocks. These cast sulfur-asphalt blocks, formed without the application of densification pressure, have properties equivalent to those of concrete blocks. Other suitable uses for the present cast articles is in the construction of dams, the lining of water courses and like applications.

We claim as our invention:

1. A non-compacted, cast sulfur-asphalt-sand pavement formed by pouring, cooling and solidifying on a road base or weak subgrade without the application of densification pressure, a uniform mix of molten elemental sulfur, asphalt and sand, the weight ratio of sulfur to

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3-----	4.45	7.5	1.7	-----	X	20	2.130	19	850	4.10×10 ⁴	27
4-----	6.0	12.2	2.0	-----	X	7.5	2.024	6.2	1,400	1.10×10 ⁵	29

asphalt being from 2:1 to 5:1 and the amount of asphalt being from about 4 to about 7% by weight.

2. The pavement of claim 1 wherein the temperature of the uniform mix prior to cooling is from 260° F. to 350° F.

3. The pavement of claim 2 wherein the voids contents of the final pavement is less than 15%.

4. The pavement of claim 3 wherein the ratio of sulfur to asphalt is about 2 and the density of the pavement is about 2.0 g./cc.

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