PATENT SPECIFICATION

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(54) ASPHALT CONSTRUCTIONAL COMPOSITION

(71) We, MITSUBISHI JUKOGYO KABUSHIKI KAISHA, a Japanese Body Corporate, of 5—1, Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to an asphalt constructional composition comprising asphalt and aggregate and more specifically to effective utilization of the by-product gypsum obtained from the exhaust gas desulfurization process in which sulfur oxides are removed from sulfur oxide-bearing gases using a lime slurry solution as an absorbent.

In the construction of asphalt-surfaced roads, asphalt paving mixtures are used to make the foundation and wearing courses. A typical composition of such mixtures for forming the wearing surface is shown in Table 1.

TABLE 1

Aggregates	Sieve opening (max. dia.) (mm)	20	13	5	2.5	0.6	0.3	0.15	0.074
	Sieve passage (wt %)	100*	95 –100	55 –75	35 –50	18 –29	13 –23	6 –16	4–8
Asphalt percentage (wt % on basis of total aggregate weight) 5.0 – 7.0									

* Of the 100 wt % of the aggregates, from 4 to 8 wt % is accounted for by stone dust.

Depending upon the grading desired, varying proportions of crushed stone, sand, screenings, and stone dust are mixed to a desired aggregate composition. Of those materials, stone dust constitutes the fine fraction, also referred to as filler. The stone dust in general use consists of ground limestone or igneous rock, the standard grading range being as given in Table 2.

TABLE 2

Sieve opening (max. dia.) (mm)	0.6	0.15	0.074
Sieve passage (wt %)	100	90–100	70–100

According to one aspect of the present invention there is provided an asphalt constructional composition comprising asphalt and aggregate incorporating coarse and fine fractions, the fine fraction comprising ground calcium sulfate hemihydrate or ground anhydrous calcium sulfate and at least one additive selected from slaked lime, cement and ground quick lime.

According to another aspect of the invention there is provided a method of making an asphalt constructional composition including the step of mixing asphalt with aggregate comprising coarse and fine fractions, the fine fractions comprising ground calcium sulfate hemihydrate or ground anhydrous calcium sulfate and at least one additive selected from slaked lime, cement and ground quick lime.

Today, gypsum is coming out in large quantity as a by-product of the wet exhaust gas desulfurization, and future oversupply of gypsum is forecast. With these in view, we have made extensive investigations about effective usage of the by-product and, as part of the effort, we have explored the possibility of its use as an asphalt filler. This quest for the new application orginated from our idea that the by-product gypsum from the wet process of exhaust gas desulfurization, in the powder form with a particle size not greater than about 0.074 mm, might be a useful substitute for stone dust. Thus, in place of the stone dust, we added the calcium sulfate hemihydrate obtained by dehydrating the by-product gypsum at 160°C to the aggregates, mixed them with asphalt, and then subjected the mixture to a Marshall stability test. The test piece was immersed in thermostatically controlled hot water bath at 60°C for 30 minutes (in conformity with the Marshall stability test procedure). However, as indicated by Reference Example 3 to be described later, the test piece swelled and softened, and it could not be taken out of the thermostatic water tank without being deformed. Of course, the subsequent measurement of its stability was impossible.

The deformed test piece taken out of the thermostatic tank became solid upon cooling to a room temperature, when it developed a number of cracks with some white granules not larger than 0.5 mm in diameter formed therein. Microscopic examination revealed that they were needles of crystal gypsum. The needles had resulted from hydration of the calcium sulfate hemihydrate. Importantly it was an indication that the calcium sulfate hemihydrate surface had not been coated with asphalt.

From this clue, we took note of the deophilic properties of alkaline compounds and repeated experiments on mixing alkaline materials, such as slaked lime, in calcium sulfate hemihydrate. Finally we obtained a favorable result as represented by Example 2 to be described later, and it led to the present invention. In further experiments, cement or quick lime powder was mixed, in place of slaked lime, with calcium sulfate hemihydrate or anhydrous calcium sulfate, and the mixtures gave satisfactory results in Marshall stability tests. The anhydrous calcium sulfate is prepared by heating and dehydrating the gypsum secondarily produced, for example, by the wet process of exhaust gas desulfurization.

If the by-product gypsum from the process is directly used, the gypsum will be dehydrated during mixing, and evaporation of water from its surface will make the gypsum poorly coated with asphalt, thus giving a paving mixture with a low Marshall stability. It is therefore important that calcium sulfate hemihydrate or anhydrous calcium sulfate is used in powdered form because of the fine particle size requirement.

The amount of slaked lime, cement, or ground quick lime to be added to calcium sulfate hemihydrate or anhydrous calcium sulfate preferably ranges from 3 to 10 wt% on the basis of the calcium sulfate weight, as indicated in the following Examples. Although an amount of more than 10 wt% is not objectionable for the properties of the resulting mixture, it is not advisable for cost reason.

Examples 1, 2 & Reference Examples 1—4.

Asphalt concrete test pieces of ordinary dense grades were made using the aggregates of the grading distribution as shown in Table 3, and they were evaluated by Marshall stability tests. Throughout these examples the amount of asphalt used was 6 wt% on the basis of the total weight of the aggregates and each test piece was compacted on both sides, 75 times per side.

TABLE 3

Sieve opening (max. dia.) (mm)	13	5	2.5	0.6	0.3	0.15	0.074
Sieve passage (wt %)	100	65.4	43.9	25.3	14.7	9.0	7.2

Test pieces of the following examples with the respective aggregate compositions were immersed in a thermostatically controlled water bath at 60°C for 30 minutes or for one full day, and then Marshall stability values and flow factors were determined. The results are summarized in Table 4.

Reference Examples 1:— As the aggregates, a mixture of No. 6 crushed stone (10—5 mm in diameter), No. 7 crushed stone (5—2.5 mm), screenings, sea sand, and stone dust was employed. (This was the composition of the ordinary dense grade asphalt concrete shown in Table 1).

Reference Example 2:— The stone dust in Reference Example 1 was replaced by a powdery mixture of 50% by weight stone dust and 50% by weight of calcium sulfate hemihydrate.

Reference Example 3:— The stone dust in Reference Example 1 was replaced by calcium sulfate hemihydrate.

Reference Example 4:— The stone dust in Reference Example 1 was replaced by anhydrous calcium sulfate.

Example 1:— The stone dust in Reference Example 1 was replaced by a powdery mixture of 90% by weight anhydrous calcium sulfate and 10% by weight slaked lime.

Example 2:— The stone dust in Reference Example 1 was replaced by a powdery mixture of 90% by weight of calcium sulfate hemihydrate and 10% by weight slaked lime.

TABLE 4

Example	Immersion time	Stability (kg)	Residual Stability (%)	Flow factor ($\frac{1}{100}$ cm)
Reference Example 1	30 min. One day	854 647	75.8	33 44
,, 2	30 min. One day	559 215	38.5	39 44
,, 3	30 min. One day	* *		
,, 4	30 min. One day	405 *		43 —
Example 1 of Invention	30 min. One day	805 601	74.7	40 40
,, 2	30 min. One day	713 638	89.5	40 42

* Unmeasurable.

The stability of more than 500 kg and the flow factor of 20—30 after the immersion time of 30 minutes are generally regarded standard. Examples 1 and 2 of the invention both satisfied these conditions.

Example 3.

Marshall stability tests were conducted with test pieces using the aggregates of the grading distribution shown in Table 1 and employing powdery mixtures of gypsum and slaked lime. The powdery compositions used and the test results are given in Table 5. It was observed that the less the proportion of slaked lime relative to calcium sulfate hemihydrate, the greater the possibility of their being hampered from being uniformly mixed and the lower the stability.

TABLE 5

	Calcium Sulfate Hemihydrate	Slaked lime	Marshall stability (after 30 min. immersion)
(1)	95%	5%	710 kg
(2)	97	3	673
(3)	99	1	426

Examples 4—11 & Reference Example 5.

Test pieces of dense grade asphalt concrete were formed using aggregates in different compositions consisting of No. 6 crushed stone (10—5 mm in diameter), No. 7 crushed stone (5—2.5 mm), and screenings (2.5 mm or less) of hard sandstone, and river sand, with the addition of calcium sulfate hemihydrate, slaked lime, portland cement, and ground quick lime, in proportions as shown in Table 6. Their qualities were evaluated by

TABLE 6

	No. 6 crushed 10 – 5 mm	No. 7 crushed 5 – 2.5 mm	Screenings 2.5 mm>	River sand	Stone dust	Calcium sulfate hemihydrate	Slaked lime	Portland cement	Ground quick lime	Asphalt
Reference Example 5	31	29	22	12	6	0	0	0	0	6
Example 4	31	29	22	12	0	5.5	0.5	0	0	5.8
,, 5	31	29	22	12	0	5.5	0	0.5	0	5.8
,, 6	31	29	22	12	0	5.7	0	0.3	0	5.8
,, 7	31	29	22	12	0	5.9	0	0.1	0	5.8
,, 8	31	29	22	12	0	5.5	0	0	0.5	5.8
,, 9	31	29	22	12	0	5.7	0	0	0.3	5.8
,, 10	31	29	22	12	0	5.5	0.3	0.2	0	5.8
,, 11	31	29	22	12	0	4.8	1.2	0	0	5.8

Marshall stability tests. In each test piece the amount of asphalt (in percent by weight) was on the basis of the total aggregate weight and the piece was compacted on both sides, 75 times per side. Table 7 gives a summary of the test results.

TABLE 7

(after 30 min. immersion)

	Stability
Reference Example 5	1220 kg
Example 4	1300
,, 5	1140
,, 6	1070
,, 7	880
,, 8	1240
,, 9	1160
,, 10	1320
,, 11	1330

Example 12.

No. 6 crushed stone (10—5 mm in diameter), No. 7 crushed stone (5—2.5 mm), screenings (2.5 mm or less), sea sand, calcium sulfate hemihydrate, slaked lime, and asphalt were mixed in an asphalt plant, in proportions as close to the control targets given in Table 8 as possible. The asphalt paving mixture thus obtained was subjected to hot-aggregate composite grading, Marshall stability, and asphalt extraction tests. The results were favorable, as shown in Tables 9, 10 and 11, respectively.

TABLE 8

Control targets for composition

No. 6 crushed stone	No. 7 crushed stone	Screenings	Sea sand	Calcium sulfate hemihydrate	Slaked lime	Asphalt
33	27	17	17	5.5	0.5	6.0

Note: The aggregates are all in percent by weight. Asphalt is in percent by weight on the basis of the total aggregate weight.

TABLE 9

Hot-aggregate composite grading (after plant mixing) – Percent sieve passage in % by weight

Sieve opening (max. dia.) (mm)	13	5	2.5	0.6	0.3	0.15	0.074
Grading distribution	100	69	44.2	25.5	13.1	8.0	6.3

TABLE 10

Marshall stability test results

Density	Stability	Flow factor	Residual stability
2.342	823 kg	37	89.8%

TABLE 11

Asphalt extraction test results

1	2	3	Mean
6.06%	6.10%	6.04%	6.07%

WHAT WE CLAIM IS:—

1. An asphalt constructional composition comprising asphalt and aggregate incorporating coarse and fine fractions, the fine fraction comprising ground calcium sulfate hemihydrate or ground anhydrous calcium sulfate and at least one additive selected from slaked lime, cement and ground quick lime.

2. An asphalt composition according to claim 1, wherein said calcium sulfate hemihydrate or said anhydrous calcium sulfate is prepared from the by-product gypsum from an exhaust gas desulfurization process.

3. An asphalt composition according to claim 1 or 2 containing from 90 to 97 Wt% of ground calcium sulfate hemihydrate or ground anhydrous calcium sulfate and from 10 to 3 Wt% of the said at least one additive.

4. An asphalt composition as claimed in claim 1 substantially as herein described.

5. An asphalt composition substantially as described in any of the foregoing Examples 1 to 12.

6. A method of making an asphalt constructional composition including the step of mixing asphalt with aggregate comprising coarse and fine fractions, the fine fraction comprising ground calcium sulfate hemihydrate or ground anhydrous calcium sulfate and at least one additive selected from slaked lime, cement and ground quick lime.

7. A method of making an asphalt constructional composition according to claim 6 substantially as herein described.

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