CEMENT ASPHALT BALLAST GROUT COMPOSITION FOR TRACK

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Int. Cl. .................................... C04B 7/02
Field of Search ...................... 106/89, 96, 87

References Cited
UNITED STATES PATENTS
1,889,437 11/1932 DeLange........................................ 106/96
2,560,871 7/1951 Johnson et al.............................. 106/96
3,155,526 11/1964 Klein...................................... 106/89

Primary Examiner—J. Poer
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

ABSTRACT
A cement asphalt ballast grout composition comprising cement, an asphalt emulsion, calcium sulfoaluminate hydrate-forming mineral, an electrolyte, a thickener and a foaming agent is excellent in the workability of mortar and in the property of hardened mortar, and is suitable as a cement asphalt ballast grout composition for directly joining-type track.

6 Claims, 7 Drawing Figures
FIG_1

FIG_2

Flow down time through the J-funnel (sec)

<table>
<thead>
<tr>
<th>Mixing time (min)</th>
<th>Flow down time</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Comparative test
Example 1
**FIG. 3a**

Mortar temp.: 5°C

Example 1

Comparative test

**FIG. 3b**

Mortar temp.: 20°C

Example 1

Comparative test
FIG_3c

Mortar temp.: 35°C

Comparative test

Example 1

Sinking Percentage (%) vs. Expanding Percentage (%) vs. Time (hr)
Figure 4

Unevenness of the amount of asphalt from the theoretical amount in the hardened mortar (%)

Distance from the upper surface of the hardened mortar (mm)
FIG. 5

Example 1

Lower surface of the hardened mortar

Comparative test

Upper surface of the hardened mortar

Shrinkage (%) vs. Age (day)
Cement Asphalt Ballast Grout Composition for Track

The present invention relates to a cement asphalt ballast grout for track.

In the conventional track, correction of irregularity of track and renewal of ballast are often necessary, and a great deal of labor is required in the maintenance of the track. In order to obviate such drawbacks, various maintenance-free track structures have been developed. Among these track structures, the slab track, which is produced by injecting cement asphalt mortar (hereinafter referred to as mortar) under the concrete slab, is a most preferable track. Because, in the slab track the irregularity of track hardly occurs, and the sinking of track can be restored by injecting mortar, and therefore the maintenance of the slab track is very easy.

A method for constructing the slab track will be explained with reference to FIG. 1. A roadbed concrete is firstly placed, a concrete slab is arranged on the roadbed concrete, adjusted by a jack so as to form a planned alignment and then supported at four points by supporting rods, a space formed between the roadbed concrete and the concrete slab is enclosed with a frame, a mortar is injected into the space 3 through holes and after the mortar reached a predetermined strength, rails are laid.

The mortar to be injected in the above described method is required to satisfy the following conditions.

1. The physical properties of the mortar satisfies the dynamic theory for track.
2. The mortar has workability.
That is, mortars having the following physical properties are advantageously used in the construction of the slab track.
1. The mortar has a compressive strength of 10 ~ 20 Kg/cm².
2. The mortar has an elasticity of 0.5 ~ 5.0 × 10⁴ Kg/cm².
3. The mortar, at the injection, has such a consistency that the flow down time through the J-funnel is 17 ~ 26 seconds.
4. After injection, the mortar does not separate.
5. The hardened mortar does not cause dry shrinkage.
6. The fineness modulus of sand in the mortar is not limited.

In the conventional cement asphalt grout, a mixture of an anionic, cationic or nonionic asphalt emulsion with cement has been used. However, when this cement asphalt grout is used in the above described method, the resulting mortar has insufficient compressive strength and elasticity, but is still insufficient in the other various physical properties.

The present invention provides a cement asphalt ballast grout composition for directly joining-type track, which comprises 100 parts by weight of cement, 20 ~ 400 parts by weight of an asphalt emulsion, 5 ~ 20 parts by weight of a calcium sulfoaluminate hydrate-forming mineral, 0.1 ~ 5.0 parts by weight of an electrolyte, 0.01 ~ 5.0 parts by weight of a thickener and 0.01 ~ 0.03 part by weight of a foaming agent.

The cement to be used in the present invention includes Portland series cement, mixed cement and the like.

As the calcium sulfoaluminate hydrate-forming mineral to be used in the present invention, mention may be made of, for example, type K, type M and type S minerals described in American Concrete Institute Journal, 1970, No. 8, pages 584 ~ 589. Among these minerals, ones having a fineness of a Blaine value of 4,000 ~ 10,000 cm²/g are preferably used.

The calcium sulfoaluminate hydrate-forming mineral is used in an amount of 5 ~ 20 percent by weight based on the weight of cement. Among the above described calcium sulfoaluminate-forming minerals, ones having such a property that a cement mortar prepared from 5 ~ 20 percent by weight of the mineral and the remainder of cement has a free expansion coefficient of about 0.05 ~ 0.5 percent are preferably used.

Furthermore, when a mixture of 85 ~ 95 percent by weight of a powdery calcium sulfoaluminate series mineral and 15 ~ 5 percent by weight of a powdery mineral consisting mainly of 3CaO·3Al₂O₃·CaF₂ is used in an amount of 5 ~ 20 percent by weight based on the weight of cement, a cement asphalt hardened mortar having a higher strength can be obtained.

The calcium sulfoaluminate hydrate-forming mineral forms calcium sulfoaluminate hydrate, that is, ettringite, in the resulting mortar and the mortar expands for about 7 days. Therefore, the sinking of the mortar, just after the placing, can be prevented by the actions of the foaming agent and the ettringite, and further the shrinkage of the hardened mortar due to drying does not occur and cracks does not appear in the hardened mortar.

The mortar of the present invention shows the thixotropy phenomenon by the actions of the powdery calcium sulfoaluminate hydrate-forming mineral and the thickener. That is, the mortar has a good fluidity during the mixing and injection operations, and in the static state after the mortar is injected, the viscosity of the mortar increases quickly, and the separation of sand can be prevented.

The thickener to be used in the present invention includes polyvinyl alcohol, carboxymethylcellulose, starch, gelatin, etc., and mixtures thereof. The thickener is used in an amount of 0.01 ~ 5.0 percent by weight based on the weight of cement.

The electrolyte to be used in the present invention includes sodium chloride, lithium chloride, potassium chloride, calcium chloride, magnesium chloride, barium chloride, etc., and mixtures thereof. The electrolyte is used in an amount of 0.1 ~ 5.0 percent by weight based on the weight of cement. The electrolyte prevents the decomposition of asphalt emulsion, and can prolong the time of gelation of mortar.

The foaming agent to be used in the present invention includes aluminum, aluminum nitride, zinc, tin, calcium silicon alloy, etc., and mixtures thereof. The foaming agent is used in an amount of 0.01 ~ 0.03 percent by weight based on the weight of cement.

The asphalt emulsion is used in an amount of 20 ~ 400 percent, preferably 100 ~ 300 percent by weight, based on the weight of cement. When the addition amount is less than 20 percent by weight, the elasticity of the hardened mortar is too high, and the characteristic property of the cement asphalt is lost. While, the addition amount exceeds 400 percent by weight, a very long time is required in the hardening of mortar.

It is desirable that the asphalt emulsion to be used in the present invention is stable against alkaline sub-
stances. For example, asphalt emulsions containing cationic surfactants, such as aliphatic amine salt, quaternary ammonium salt, alkylpyridinium salt and the like, ones containing anionic surfactants, such as aliphatic acid salt, sulfonic acid ester of higher alcohol, sulfate of aliphatic amine or aliphatic amide, phosphoric acid ester of aliphatic alcohol, and the like, and ones containing nonionic surfactants, such as polyoxyethylene alkyl ether, polyoxyethylene alkylphenol ether, sorbitan aliphatic acid ester and the like, can be used in the present invention.

As described above, the mortar produced from the grout composition of the present invention is small in the variation of consistency, has a low sinking percentage even when the temperature is varied, and further does not cause separation of raw materials during the hardening, and the hardened mortar does not cause dry shrinkage. Accordingly, the grout composition of the present invention is an excellent cement asphalt ballast grout composition for directly joining-type track.

For a better understanding of the invention, reference is taken to the accompanying drawings, wherein:

FIG. 1 is a perspective view of a slab track;
FIG. 2 is a graph showing the consistency of mortar;
FIG. 3 is a graph showing the sinking percentage of mortar;
FIG. 4 is a graph showing the separation of raw materials in the hardened mortar; and
FIG. 5 is a graph showing the shrinkage of the hardened mortar due to drying.

In each of FIGS. 2 - 5, the mortar of the present invention and that of comparative test produced in the following Example 1 are compared in order to explain the merit of the present invention.

The following examples are given for the purpose of illustration of this invention and are not intended as limitations thereof.

**EXAMPLE 1**

A mixture of 160 parts by weight of a cationic asphalt emulsion, 15 parts by weight of a powdery mineral (Blaine value: 6,000 cm²/g) consisting mainly of 3CaO·3Al₂O₃·CaSO₄, 0.45 part by weight of lithium chloride, 0.1 part by weight of a blend of polyvinyl alcohol and carboxymethylcellulose in a ratio of 50:50 (by weight), 0.013 part by weight of powdered aluminum, 85 parts by weight of Portland cement, 200 parts by weight of sand and 40 parts by weight of water was mixed in a vertical type mixer.

The above described powdery mineral consisting mainly of 3CaO·3Al₂O₃·CaSO₄ was produced by burning at 1,350°C a powdery mixture of 19 parts by weight of CaO (purity: 96 percent), 35 parts by weight of Bauxite (purity: 86 percent) and 46 parts by weight of anhydrous gypsum.

For a comparison, a mixture of 100 parts by weight of Portland cement, 200 parts by weight of a cationic asphalt emulsion, 200 parts by weight of sand, 1.5 parts by weight of powdery aluminum and 25 parts by weight of water was mixed in the same manner as described above.

The above obtained mortar of the present invention and that of the comparative test were tested with respect to the flow time (consistency), sinking percentage, separation of raw materials, dry shrinkage, compressive strength (age: 28th day) and elasticity (age: 28th day).

The flow time test was effected by changing the mixing time as shown in the following Table 1. The sinking percentage was measured by using a mortar which was prepared by mixing the raw material mixture for 20 minutes. The tests for the separation of raw materials, the dry shrinkage, the compressive strength and the elasticity were effected by using a hardened mortar, which was prepared from the same mortar as used in the test for sinking percentage.

The test method are as follows.

1. Flow time (consistency):

   The flow down time (unit: second) of a sample mortar through a J-funnel having a capacity of 700 ml and provided with a leg of 1 cm diameter is measured.

2. Sinking percentage:

   The sinking percentage is measured by a cylinder method at a mortar temperature of 5°C, 20°C or 35°C.

3. Separation of raw materials:

   Samples are taken from the hardened mortar having a thickness of 50 mm at 10 mm intervals from the upper surface of the mortar. Each of the samples is extracted by means of a Soxhlet’s extractor, and the distribution of asphalt in the hardened mortar is measured.

4. Dry shrinkage:

   The dry shrinkage is measured by a comparator method.

5. Compressive strength:

   The compressive strength is measured by means of a one axis compression tester.

6. Elasticity:

   The elasticity is measured by means of an automatic elasticity measuring apparatus.

The obtained results are shown in the following Table 1 and in FIGS. 2 - 5.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
</tr>
<tr>
<td>Example 1</td>
</tr>
<tr>
<td>Mixing time (min.)</td>
</tr>
<tr>
<td>Flow down time through the J-funnel (sec.)</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>Influence of temperature upon sinking percentage</td>
</tr>
<tr>
<td>6 hours</td>
</tr>
</tbody>
</table>
The results obtained in the above described tests will be explained more minutely with reference to FIGS. 2 and 5.

FIG. 2 shows a relation between the mixing time of a mortar and the flow down time (unit: second) of the mortar through the J-funnel.

It is clear from FIG. 2 that the mortar of the present invention has a constant flow down time through the J-funnel within the range of 18 - 20 seconds.

FIG. 3 shows sinking percentages of a mortar kept at temperatures of 5°, 20° and 35°C. It can be seen from FIG. 3 that the mortar of the present invention does not substantially sink even when the temperature is varied.

FIG. 4 shows a relation between the distance from the upper surface of a hardened mortar and the amount of asphalt contained in the hardened mortar at the distance. In FIG. 4, the ordinate represents the unevenness of the amount of asphalt from the theoretical amount in the hardened mortar, and the mark (−) means that the amount of asphalt is larger than the theoretical amount and the mark (+) means that the amount of asphalt is smaller than the theoretical amount.

It is clear from FIG. 4 that asphalt is distributed uniformly in the hardened mortar of the present invention.

FIG. 5 shows a relation between the age (day) of a hardened mortar and the shrinkage of the hardened mortar due to drying. It is clear from FIG. 5 that the hardened mortar of the present invention does not shrink at all.

**EXAMPLE 2**

A mortar was prepared and tested under the same condition as described in Example 1, except that a powdery mixture of 13.5 parts by weight of a calcium sulfoaluminate series mineral and 1.5 parts by weight a mineral consisting mainly of 3CaO·3Al2O3·CaF2 was used as a calcium sulfoaluminate hydrate-forming mineral, and 0.45 part by weight of sodium chloride was used instead of lithium chloride.

The obtained results were the same as the results obtained in Example 1, except that the hardened mortar at the age of 28 days had a compressive strength of 15 Kg/cm² and an elasticity of 1.8x10⁸ Kg/cm².

The above described mineral consisting mainly of 3CaO·3Al2O3·CaF2 was produced in the following manner. A powdery mixture of 44.3 parts by weight of alumina (purity: 99.5 percent), 11.9 parts by weight of calcium fluoride (purity: 95 percent), and 43.8 parts by weight of calcium carbonate (purity: 99 percent) was melted at a temperature of 1,400°C and cooled, and the resulting melt was pulverized to a Blaine value of 6,000 cm²/g. It was confirmed from the X-ray diffraction meter that this product was 3CaO·3Al2O3·CaF2 mineral.

The above described calcium sulfoaluminate series mineral had a chemical composition as shown in the following Table 2.

### Table 2

<table>
<thead>
<tr>
<th>Ignition loss</th>
<th>Insoluble component</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>Total CaO (Free CaO)</th>
<th>MgO</th>
<th>SO₃</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>0.7</td>
<td>1.3</td>
<td>7.9</td>
<td>1.0</td>
<td>51.6 (15.7)</td>
<td>0.6</td>
<td>35.9</td>
<td>99.9</td>
</tr>
</tbody>
</table>

What is claimed is:

1. A cement asphalt ballast grout composition for directly joining-type track, which comprises 100 parts by weight of cement, 20 - 400 parts by weight of an asphalt emulsion, 5 - 20 parts by weight of a calcium sulfoaluminate hydrate-forming mineral, 0.1 - 5.0 parts by weight of an electrolyte, 0.01 - 5.0 parts by weight of a thickener and 0.01 - 0.03 part by weight of a foaming agent.

2. The grout composition as claimed in claim 1, wherein said calcium sulfoaluminate hydrate-forming mineral is a mixture of 85 - 95 percent by weight of a powdery calcium sulfoaluminate series mineral and 15 - 5 percent by weight of a powdery mineral consisting mainly of 3CaO·3Al2O3·CaF2.

3. The grout composition as claimed in claim 1, wherein said calcium sulfoaluminate hydrate-forming mineral has such a property that a cement mortar prepared from the mineral and cement has a free expansion coefficient of 0.5 - 0.5.

4. The grout composition as claimed in claim 1, wherein said electrolyte is at least one compound selected from the group consisting of sodium chloride, potassium chloride, lithium chloride, calcium chloride, magnesium chloride and barium chloride.

5. The grout composition as claimed in claim 1, wherein said thickener is at least one compound selected from the group consisting of polyvinyl alcohol, carboxymethyl cellulose, starch and gelatine.

6. The grout composition as claimed in claim 1, wherein said foaming agent is at least one compound selected from the group consisting of aluminum, aluminum nitride, zinc, tin and calcium silicon alloy.
UNIVERS STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,867,161
DATED : February 18, 1975
INVENTOR(S) : Okihiko TORII et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE HEADING:

Under Assignees: Correct second Assignee's name to read

-- Denki Kagaku Kogyo Kabushiki Kaisha --

Signed and sealed this 27th day of May 1975.

(SEAL)
Attest:

RUTF. C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks