

## **DESCRIPTION**

### **TITLE OF INVENTION: PAVEMENT MATERIAL FOR PAVEMENT OF GUIDED RUBBER-TYRE TRAM LANE, AND PAVING METHOD THEREOF**

#### **TECHNICAL FIELD**

**[0001]** The present invention belongs to the field of subgrade and pavement design for guided rubber-tyre tram, and more particularly, relates to a pavement material for a corridor of a guided rubber-tyre tram system, and a paving method thereof.

#### **BACKGROUND**

**[0002]** The guided rubber-tyre tram system is a new and high-end system of intelligent rail transit. It relies on rubber-tyred bearing and does not require the laying of dedicated physical tracks. Furthermore, based on a virtual track following technology, it can achieve functions such as automatic tracking and autonomous guidance within a corridor (a dedicated lane for system operation). Vehicles are not only a new type of transportation means with “zero pollution” and “zero emissions”, but also have advantages such as short construction period, low infrastructure investment, high adaptability to cities, and strong comprehensive transportation capacity, which are expected to provide core technical support for the construction of smart transportation in small and medium cities. The Zhuzhou guided rubber-tyre tram System Project was promoted at the Second United Nations Global Conference on Sustainable Transport.

**[0003]** A system vehicle has 6 axles, with a length twice that of an 18-meter articulated bus. Its axle configuration is single-axle and single-wheel, with the tire size and load capacity being larger than those of an ordinary bus, its tire pressure is as high as 1.2 MPa, it features complete channelization, multi-axis load, and heavy load, and its pavement loading mode is significantly different from that of existing bus vehicles. Therefore, the corridor pavement structure suitable for the guided rubber-tyre tram system has particularities, requiring targeted research and design. When ordinary asphalt materials are adopted, the corridor pavement suffers from severe rutting in the early stage of opening to traffic, accompanied by problems such as shifting and congestion, which are particularly serious in platform areas.

**[0004]** The Zhuzhou guided rubber-tyre tram system experience line segment was first put into use in China in 2018, with a vehicle frequency of 14 trips per day, mostly empty. After more than one year of operation, due to the special driving mode and high tire pressure of the

system vehicles, obvious rutting occurred on the test road, with a rut width of about 400 mm and a maximum depth of 25 mm. For the Sports Center Station that was milled and repaved, the rutting depth reached 11 mm again within two months. The initial operation plan of the Yibin guided rubber-tyre tram system was 166 trips per day. System vehicles serve as the primary public transportation means for local residents, while the pavements under the action of the system vehicles are poor in service performance, and the rut depths in platform areas generally exceed 20 mm. Due to the use of mixed road rights on some sections, the number of turning buses has increased significantly, which has aggravated rutting and caused displacement. For example, the rut depth at the intersection of Yibin Park Station even reaches 80 mm. Rutting not only affects the road appearance, but also easily causes secondary distresses such as potholes and water damage, accelerating the destruction of a road surface structure. Moreover, pavement deformation will affect the tracking accuracy of vehicles, especially the docking accuracy when the system vehicles enter the station. On rainy days, water accumulation in ruts may easily cause hydroplaning and skidding of vehicles, reducing driving safety; and in addition, unevenness of the road surface caused by ruts can make passengers feel bumpy, thus reducing the service level and riding comfort of the vehicles. To further promote the application of the guided rubber-tyre tram system, the problem of rutting on corridor pavements urgently needs to be solved.

**[0005]** Patent CN113136761A proposes a paving solution for a corridor pavement of the guided rubber-tyre tram system using a grouted semi-flexible pavement, which can effectively address the problem of rutting on corridor pavements. The pavement structure has been disclosed, but there is no corresponding material ratio scheme for the traffic characteristics of heavy load, channelization, and multi-axis load on the pavement, which may cause problems such as cracking and insufficient durability after operation. Patent CN114716180B discloses a high-performance colored semi-flexible pavement material suitable for urban heavy-duty roads, and discloses a method for obtaining grout composition and grout color, without limiting the material characteristics for heavy-duty roads. Patent CN103866667B discloses a heavy-duty semi-flexible pavement structure, which defines the combination of the upper, middle, and lower layers of a pavement and solves the rutting problem, but does not involve relevant material parameters.

**[0006]** Numerous studies have shown that vehicle pavements with autonomous driving characteristics, such as the corridor pavement of the guided rubber-tyre tram system, have special traffic features of heavy load, complete channelization, and multi-axis load. The semi-flexible material design system of an ordinary pavement cannot be used. Instead, multiple

factors such as rut resistance, crack resistance, and fatigue resistance should be comprehensively considered to achieve a long service life of the corridor pavement of the guided rubber-tyre tram system, thereby significantly reducing road construction costs and maintenance investment.

### SUMMARY

**[0007]** In view of the deficiencies in the prior art, the present invention provides a pavement material for a corridor of a guided rubber-tyre tram system, and a paving method thereof to solve the problems of severe rutting and cracking of the existing corridor pavement.

**[0008]** To achieve the above objective, the present invention provides the following technical solutions:

**[0009]** A pavement material for a corridor of a guided rubber-tyre tram system includes a grouting material and a large-void asphalt mixture matrix;

the grouting material is prepared from the following components in parts by weight: 100 parts of powder and 28-35 parts of water, where the powder in the grouting material is prepared from the following components in parts by weight:

- 50-90 parts of cement,
- 0-10 parts of elastomer latex,
- 5-22 parts of an active filler,
- 0-3 parts of a superplasticizer,
- 0-6 parts of a reinforcing agent,
- 0-3 parts of a stabilizer, and
- 0-5 parts of conductive particles;

the large-void asphalt mixture matrix is prepared from the following components in parts by weight:

- 100 parts of aggregates,
- 3.2-5.5 parts of asphalt,
- 0-0.6 parts of a surface-active binder, and
- 0.2-0.4 parts of fibers;

a void ratio of the large-void asphalt mixture matrix is 10-28%; and

a synthetic gradation of the aggregates in the large-void asphalt mixture matrix is as follows:

- 100% passing rate of the aggregate through 16 mm sieve holes,
- 70-100% passing rate of the aggregate through 13.2 mm sieve holes,
- 10-50% passing rate of the aggregate through 9.5 mm sieve holes,

5-25% passing rate of the aggregate through 4.75 mm sieve holes,  
4-20% passing rate of the aggregate through 2.36 mm sieve holes,  
3-18% passing rate of the aggregate through 1.18 mm sieve holes,  
3-16% passing rate of the aggregate through 0.6 mm sieve holes,  
3-14% passing rate of the aggregate through 0.3 mm sieve holes,  
2-12% passing rate of the aggregate through 0.15 mm sieve holes,  
1-10% passing rate of the aggregate through 0.075 mm sieve holes, where  
a total percentage of the aggregates with different particle sizes is 100%.

**[0010]** In the large-void asphalt mixture matrix, the asphalt serves as a main cementing material, and the surface-active binder mainly improves the wettability of the asphalt and enhances the adhesion to a cement interface; and after mixing, the fibers are distributed in asphalt mortar, which enhances the toughness of the material and also realizes a certain oil absorption capacity, thereby increasing the thickness of an asphalt film and enhancing the flexibility.

**[0011]** Preferably, the grouting material has a final strength of 35-45 MPa, a 2-hour strength of 10-30 MPa, and a fluidity of 10-14 s.

**[0012]** Preferably, a weight ratio of the grouting material to the large-void asphalt mixture matrix is (10-30):(70-90).

**[0013]** Preferably, the elastomer latex in the grouting material is used for improving the flexibility of the rigid grouting material, and is selected from a mixture of any one or more of epoxy emulsion, polyester latex, terpolymer elastomer latex, and acrylic polymer, where the terpolymer elastomer latex is selected from a mixture of any one or more of chlorotrifluoroethylene-vinylidene fluoride copolymer elastomer latex, vinylidene fluoride-perfluoropropylene copolymer elastomer, and vinylidene fluoride-tetravinylidene fluoride-perfluoropropylene.

**[0014]** Preferably, the active filler in the grouting material is used for increasing the reactivity of the grouting material, and is selected from a mixture of any one or more of blast furnace slag, pozzolanic powder, fly ash, lime powder, and active mineral powder.

**[0015]** Preferably, the superplasticizer in the grouting material is used for enhancing the fluidity of the grouting material under a certain water-cement ratio, and is selected from a mixture of any one or more of sulfonate-type, polycarboxylate-type, aliphatic-type, and polyoxyethylene-type superplasticizers.

**[0016]** Preferably, the reinforcing agent in the grouting material is used for improving the strength and wettability of the grouting material, and is selected from a mixture of any one or

more of active mineral powder, nano-diatomite, nano-silica, metal-organic framework materials, carbon nanotubes, graphene, and nano-silicon.

**[0017]** Preferably, the stabilizer in the grouting material is used for enhancing the system stability of the grouting material during its service time, and is selected from a mixture of any one or more of fibers, an expansion agent, a shrinkage reducing admixture, and a heat-absorbing stabilizer.

**[0018]** Preferably, the conductive particles in the grouting material are used for conducting the electric current inside vehicle bodies, with particle sizes of less than 1.18 mm.

**[0019]** Preferably, in the large-void asphalt mixture matrix, the asphalt serving as a binder for the asphalt matrix mixture is selected from a mixture of any one or more of base asphalt, styrene-butadiene-styrene (SBS)-modified asphalt, high-viscosity modified asphalt, rubber asphalt, epoxy asphalt, and polyurethane asphalt; the surface-active binder is an amphiphilic block copolymer; and the fibers are selected from a mixture of any one or more of lignin fibers, polymer fibers, steel fibers, and basalt fibers.

**[0020]** Preferably, the aggregates in the large-void asphalt mixture matrix serve as the skeleton component of the asphalt matrix mixture and further include conductive particles; the conductive particles are mixed into the aggregates as block materials, and a total volume of the conductive particles in the grouting material and the aggregates accounts for 10-27% of that of the pavement material; and the particle size distribution of the conductive particles in the aggregates is  $(4.75-9.5\text{cm}):(9.5-13.5\text{cm})=2:5$ . It can effectively eliminate the induced voltage generated by electric vehicles during charging and ensure safe operation and maintenance.

**[0021]** Preferably, in the pavement material, the conductive particles in the grouting material are metal conductive particles, which are used for conducting the electric current inside vehicle bodies.

**[0022]** The particle size ratio of the conductive particles in the large-void asphalt mixture matrix according to the present invention not only matches the aggregate gradation, but also has its own gradation that enables effective interlocking and connection, which is conducive to electrical conduction.

**[0023]** The present invention also provides a paving method of the pavement material for the corridor of the guided rubber-tyre tram system, including the following steps:

(1) laying a large-void asphalt mixture matrix: putting all material components of the large-void asphalt mixture matrix into an asphalt mixing plant pugmill according to parts by mass, and mixing at 160-180°C for 40-55 s to obtain an asphalt mixture; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1-1.25, and rolling for

compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C to obtain the laid large-void asphalt mixture matrix, where

a surface-active binder is added in two ways: one is to uniformly mix the surface-active binder into molten asphalt, and the other is to spray the surface-active binder at a mass of 0.05-0.2kg/(cm\*m<sup>2</sup>) onto the laid asphalt mixture matrix at 40-90°C;

(2) preparing a grouting material: putting powder and water into a mixer according to parts by mass, and mixing for 90 s at a stirring speed of not less than 200 r/min to obtain the grouting material;

(3) grouting: pumping the grouting material obtained in step (2) onto a surface of the asphalt mixture matrix laid in step (1), allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 0.6-5 mm.

**[0024]** The paving method of the pavement material according to the present invention employs a vibration compaction process, mainly because vibration compaction can reshape an aggregate skeleton and make the skeleton more compact.

**[0025]** The present invention also provides the use of the pavement material for the corridor of the guided rubber-tyre tram system in pavements for automatic tracking or autonomous driving vehicles.

**[0026]** Compared with the prior art, the present invention has the following beneficial effects:

**[0027]** (1) The corridor pavement used in the guided rubber-tyre tram system is made of the cement-asphalt composite material, which has both the flexibility of asphalt and the rigidity of cement, with beneficial material strength and proportion, matched rigidity of rigid and flexible materials, and good adhesion; and the pavement exhibits outstanding rutting resistance and durability under the conditions of heavy load, complete channelization and multi-axis load of system vehicles.

**[0028]** (2) By controlling gradation and employing a reasonable rolling process, the pavement material for the corridor of the guided rubber-tyre tram system can achieve a larger connected void ratio and better grouting fullness, thus possessing excellent load-bearing capacity.

**[0029]** (3) The paving method for the corridor pavement used in the guided rubber-tyre tram system is simple and easy to implement.

## **DETAILED DESCRIPTION OF THE EMBODIMENTS**

**[0030]** Based on the embodiments of the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts shall fall within the protection scope of the present invention.

**[0031] Embodiment 1**

**[0032]** A pavement material for a corridor of a guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and 28 parts of water; a void ratio of the large-void asphalt mixture matrix is 10%; the grouting material has a final strength of 35 MPa, a 2-hour strength of 10 MPa, and a fluidity of 10 s;

the powder in the grouting material includes 57 parts of cement, 10 parts of epoxy emulsion elastomer latex, 22 parts of fly ash, 3 parts of a sulfonate-type superplasticizer, 5 parts of an active mineral powder and nano-diatomite mixture reinforcing agent (in a ratio of 1:4), and 3 parts of an expansion stabilizer;

the asphalt mixture matrix includes 100 parts of aggregates, 4.2 parts of SBS-modified asphalt, 0.3 parts of a surface-active binder and 0.2 parts of lignin fibers, and the surface-active binder is an amphiphilic block copolymer;

the large-void asphalt mixture matrix includes block-shaped conductive metal aggregates, the volume of which accounts for 10% of the total volume of the road surface, and the particle size distribution of the metal aggregates is (4.75-9.5cm):(9.5-13.5cm)=2:5; and

the synthetic gradation of the aggregates in the asphalt mixture matrix is shown in Table 1.

**Table 1 Synthetic gradation of aggregates in asphalt mixture matrix (Embodiment 1)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 94   | 49  | 18   | 11   | 8    | 7   | 7   | 6    | 6     |

**[0033]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 160°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling

when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 0.6-5 mm.

#### **[0034] Comparative Embodiment 1**

**[0035]** The ordinary cast-in-place pavement material is used, with a final strength of 60 MPa and no strength after 2 h. All other conditions remain the same as those in Embodiment 1.

#### **[0036] Comparative Embodiment 2**

**[0037]** The void ratio of the large-void asphalt mixture matrix is 25%, and the gradation is not within the upper and lower limits specified in the present invention, as shown in Table 2. The SBS-modified asphalt accounts for 3.2%. All other conditions remain the same as those in Embodiment 1.

**Table 2 Synthetic gradation of aggregates in asphalt mixture matrix (Comparative Embodiment 2)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 79   | 8   | 5    | 5    | 4    | 4   | 4   | 4    | 3     |

#### **[0038] Comparative Embodiment 3**

**[0039]** The vibration procedure is not used during rolling compaction, and the number of vibratory compaction passes is replaced by static compaction. All other conditions remain the same as those in Embodiment 1.

#### **[0040] Embodiment 2**

**[0041]** A pavement material for a corridor of a guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and 35 parts of water; a void ratio of the large-void asphalt mixture matrix is 16%; the grouting material has a final strength of 40 MPa, a 2-hour strength of 13 MPa, and a fluidity of 12 s;

the powder in the grouting material includes 69 parts of cement, 4 parts of polyester latex,

17 parts of lime powder, 1.5 parts of a polycarboxylate-type superplasticizer, 5.5 parts of a graphene reinforcing agent, and 3 parts of a shrinkage reducing admixture;

the large-void asphalt mixture matrix includes 100 parts of aggregates, 3.8 parts of polyurethane asphalt, 0.6 parts of a surface-active binder, and 0.3 parts of polymer fibers, and the surface-active binder is an amphiphilic block copolymer;

the large-void asphalt mixture matrix also includes block-shaped conductive metal aggregates, the volume of which accounts for 20% of the total volume of the road surface, and the particle size distribution of the metal aggregates is (4.75-9.5cm):(9.5-13.5cm)=2:5; and

the synthetic gradation of the aggregates in the asphalt mixture matrix is shown in Table 3.

**Table 3 Synthetic gradation of aggregates in asphalt mixture matrix (Embodiment 2)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 93   | 40  | 15   | 9    | 8    | 7   | 6   | 6    | 5     |

**[0042]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 180°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 0.6-5 mm.

#### **[0043] Comparative Embodiment 4**

**[0044]** The polyester latex and graphene reinforcing agent in the grouting material of Embodiment 2 are removed, and the mass fraction of the active filler lime powder is increased

to 26.5 parts. All other conditions remain the same as those in Embodiment 2.

**[0045] Embodiment 3**

**[0046]** A pavement material for a corridor of a guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and 30 parts of water; a void ratio of the large-void asphalt mixture matrix is 18%; the grouting material has a final strength of 38 MPa, a 2-hour strength of 30 MPa, and a fluidity of 14 s;

the powder in the grouting material includes 90 parts of cement, 2 parts of terpolymer elastomer latex, 2 parts of pozzolanic powder, 1 part of an aliphatic-type superplasticizer, 2 parts of a metal-organic framework material and carbon nanotube mixture reinforcing agent (in a ratio of 1:1), 1 part of a fiber stabilizer, and 2 parts of conductive particles; the particle size range of the conductive particles in the grouting material is 0-1.18 mm;

the large-void asphalt mixture matrix includes 100 parts of aggregates, 5.5 parts of epoxy asphalt, 0.4 parts of a surface-active binder, and 0.4 parts of steel fibers, and the surface-active binder is an amphiphilic block copolymer;

the large-void asphalt mixture matrix includes block-shaped conductive metal aggregates, the volume of which accounts for 13% of the total volume of the road surface, and the particle size distribution of the metal aggregates is (4.75-9.5cm):(9.5-13.5cm)=2:5; and

the synthetic gradation of the aggregates in the asphalt mixture matrix is shown in Table 4.

**Table 4 Synthetic gradation of aggregates in asphalt mixture matrix (Embodiment 3)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 84   | 44  | 17   | 12   | 8    | 5   | 4   | 4    | 4     |

**[0047]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 180°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 2-5 mm.

#### **[0048] Comparative Embodiment 5**

**[0049]** The block-shaped conductive metal aggregates included in the large-void asphalt mixture matrix in Embodiment 3 are removed, and the proportion of common aggregates with the same particle size is increased by 13% in volume, where the proportion is  $(4.75-9.5\text{cm}):(9.5-13.5\text{cm})=2:5$ ; and the conductive particles are removed from the grouting material, and the mass fraction of cement is increased to 92 parts. All other conditions remain the same as those in Embodiment 3.

#### **[0050] Embodiment 4**

**[0051]** A pavement material for a corridor of an guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and 32 parts of water; a void ratio of the large-void asphalt mixture matrix is 15%; the grouting material has a final strength of 36 MPa, a 2-hour strength of 18 MPa, and a fluidity of 11 s;

the powder in the grouting material includes 67 parts of cement, 3 parts of acrylic polymer latex, 20 parts of blast furnace slag, 2 parts of a polyoxyethylene-type superplasticizer, 1 part of a nano-silicon reinforcing agent, 2 parts of a heat-absorbing stabilizer, and 5 parts of conductive particle; the particle size range of the conductive particles in the grouting material is 0.15-0.3 mm;

the large-void asphalt mixture matrix includes 100 parts of aggregates, 4.6 parts of high-viscosity modified asphalt, 0.6 parts of a surface-active binder, and 0.4 parts of basalt fibers, and the surface-active binder is an amphiphilic block copolymer;

the large-void asphalt mixture matrix includes block-shaped conductive metal aggregates, the volume of which accounts for 15% of the total volume of the road surface, and the particle size distribution of the metal aggregates is  $(4.75-9.5\text{cm}):(9.5-13.5\text{cm})=2:5$ ; and

the synthetic gradation of the aggregates in the asphalt mixture matrix is shown in Table 5.

**Table 5 Synthetic gradation of aggregates in asphalt mixture matrix (Embodiment**

4)

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 95   | 12  | 10   | 7    | 5    | 4   | 3   | 2    | 1     |

**[0052]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 180°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 2-5 mm.

**[0053] Comparative Embodiment 6**

**[0054]** A pavement material for a corridor of a guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and 32 parts of water; a void ratio of the large-void asphalt mixture matrix is 15%; the grouting material has a final strength of 36 MPa, a 2-hour strength of 18 MPa, and a fluidity of 11 s;

the powder in the grouting material includes 67 parts of cement, 3 parts of acrylic polymer latex, 20 parts of blast furnace slag, 2 parts of a polyoxyethylene-type superplasticizer, 1 part of a nano-silicon reinforcing agent, 2 parts of a heat-absorbing stabilizer, and 5 parts of conductive particle;

the large-void asphalt mixture matrix includes 100 parts of aggregates, 4.6 parts of high-viscosity modified asphalt, 0 part of a surface-active binder, and 0 part of fibers, and the surface-active binder is an amphiphilic block copolymer; and

the large-void asphalt mixture matrix includes block-shaped conductive metal aggregates, the volume of which accounts for 15% of the total volume of the road surface, and the particle size distribution of the metal aggregates is (4.75-9.5cm):(9.5-13.5cm)=2:5.

**Table 6 Synthetic gradation of aggregates in asphalt mixture matrix (Comparative Embodiment 6)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 95   | 12  | 10   | 7    | 5    | 4   | 3   | 2    | 1     |

**[0055]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 180°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 2-5 mm. That is, the surface-active binder and fibers are removed from the large-void asphalt mixture matrix in Embodiment 4.

#### **[0056] Embodiment 5**

**[0057]** A pavement material for a corridor of an guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and 29 parts of water; a void ratio of the large-void asphalt mixture matrix is 22%; the grouting material has a final strength of 45 MPa, a 2-hour strength of 26 MPa, and a fluidity of 13 s;

the powder in the grouting material includes 70 parts of cement, 17 parts of active mineral powder, 2.5 parts of a polycarboxylate-type superplasticizer, 6 parts of a nano silicon oxide

reinforcing agent, 0.5 parts of an expansion agent, and 4 parts of conductive particle; the particle size range of the conductive particles in the grouting material is 1.5 mm;

the large-void asphalt mixture matrix includes 100 parts of aggregates, 3.2 parts of rubber asphalt and 0.3 parts of steel fibers;

the large-void asphalt mixture matrix includes block-shaped conductive metal aggregates, the volume of which accounts for 27% of the total volume of the road surface, and the particle size distribution of the metal aggregates is (4.75-9.5cm):(9.5-13.5cm)=2:5; and

the synthetic gradation of the aggregates in the asphalt mixture matrix is shown in Table 7.

**Table 7 Synthetic gradation of aggregates in asphalt mixture matrix (Embodiment 5)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 70   | 13  | 5    | 4    | 3    | 3   | 3   | 2    | 1     |

**[0058]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 180°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 2-5 mm.

#### **[0059] Embodiment 6**

**[0060]** A pavement material for a corridor of a guided rubber-tyre tram system in this embodiment includes a grouting material and a large-void asphalt mixture matrix; the grouting material is prepared from following components in parts by weight: 100 parts of powder and

31 parts of water; a void ratio of the large-void asphalt mixture matrix is 20%; the grouting material has a final strength of 40 MPa, a 2-hour strength of 20 MPa, and a fluidity of 11 s;

the powder in the grouting material includes 81 parts of cement, 7 parts of polyester latex, 9.6 parts of fly ash, 1.3 parts of a sulfonate-type superplasticizer, 1 part of a metal-organic framework material reinforcing agent, and 0.1 parts of a fiber stabilizer;

the large-void asphalt mixture matrix includes 100 parts of aggregates, 3.2 parts of base asphalt, 0.6 parts of a surface-active binder, and 0.3 parts of lignin fibers, and the surface-active binder is an amphiphilic block copolymer;

there are conductive particles or metal aggregates; and

the synthetic gradation of the aggregates in the asphalt mixture matrix is shown in Table 8.

**Table 8 Synthetic gradation of aggregates in asphalt mixture matrix (Embodiment 6)**

|                      |     |      |     |      |      |      |     |     |      |       |
|----------------------|-----|------|-----|------|------|------|-----|-----|------|-------|
| Sieve hole size (mm) | 16  | 13.2 | 9.5 | 4.75 | 2.36 | 1.18 | 0.6 | 0.3 | 0.15 | 0.075 |
| Passing rate (%)     | 100 | 74   | 11  | 6    | 5    | 3    | 3   | 3   | 2    | 1     |

**[0061]** A paving method of the pavement material for the corridor of the guided rubber-tyre tram system includes the following steps:

1) laying an asphalt mixture matrix: putting asphalt mixture materials into an asphalt mixing plant pugmill, and mixing at 180°C for 55 s; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C;

2) preparing grouting material liquid: putting grouting powder and water into a mixer and mixing for 90 s at a stirring speed of not less than 200 r/min; and

3) grouting: pumping the grouting material onto a surface of the laid asphalt mixture matrix, allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 2-5 mm.

**[0062]** Cores are drilled from, or specimens are prepared with the materials obtained from the aforementioned embodiments and comparative embodiments, and the resulting specimens are

subjected to performance tests. The test results are shown in Table 9.

**Table 9 Test results of various embodiments and comparative embodiments**

| <b>Item</b>              | <b>Dynamic stability (cycles/mm)</b> | <b>Marshall stability (kN)</b> | <b>Semi-circular bending (SCB) fracture energy (J/m<sup>2</sup>)</b> | <b>Four-point fatigue life (600µm, 15°C)</b> | <b>Vehicle body voltage</b> |
|--------------------------|--------------------------------------|--------------------------------|----------------------------------------------------------------------|----------------------------------------------|-----------------------------|
| Embodiment 1             | 30981                                | 19.4                           | 3928                                                                 | 1.03 million cycles                          | Absence                     |
| Comparative Embodiment 1 | 36287                                | 21.3                           | 583                                                                  | 0.45 million cycles                          | Absence                     |
| Comparative Embodiment 2 | 35238                                | 17.4                           | 628                                                                  | 0.32 million cycles                          | Absence                     |
| Comparative Embodiment 3 | 28763                                | 15.2                           | 873                                                                  | 0.35 million cycles                          | Absence                     |
| Embodiment 2             | 42845                                | 18.5                           | 3203                                                                 | 1.21 million cycles                          | Absence                     |
| Comparative Embodiment 4 | 26289                                | 12.1                           | 1487                                                                 | 0.63 million cycles                          | Absence                     |
| Embodiment 3             | 48279                                | 17.3                           | 3220                                                                 | 1.18 million cycles                          | Absence                     |
| Comparative Embodiment   | 45637                                | 18.5                           | 2929                                                                 | 1.06 million cycles                          | Presence                    |

|                                |       |      |      |                        |          |
|--------------------------------|-------|------|------|------------------------|----------|
| 5                              |       |      |      |                        |          |
| Embodiment<br>4                | 39498 | 18.3 | 3674 | 1.06 million<br>cycles | Absence  |
| Comparative<br>Embodiment<br>6 | 36552 | 16.9 | 1098 | 0.87 million<br>cycles | Absence  |
| Embodiment<br>5                | 35276 | 17.4 | 3257 | 1.25 million<br>cycles | Absence  |
| Embodiment<br>6                | 43821 | 20.9 | 3098 | 1.19 million<br>cycles | Presence |

**[0063]** It can be seen from Table 9 that there are significant differences in rutting resistance, bearing capacity and fatigue resistance among the materials prepared by changing the compositions of the grouting material and the asphalt mixture matrix or the contents of all components thereof. The materials prepared in the embodiments exhibit excellent rutting resistance, high bearing capacity, and good fatigue endurance, and have good durability under the conditions of heavy load, channelization, and multi-axis traffic.

**[0064]** According to the present invention, the elastomer latex added to the grouting material can effectively enhance the flexibility of the grouting material, which enables collaborative deformation with the asphalt mixture matrix under heavy load conditions, thus reducing the risk of cracking. The surface-active binder added to the asphalt mixture matrix has a significant enhancing effect on the adhesion at a cement-asphalt interface, and thus can greatly improve the crack resistance. Furthermore, the paving method of the pavement material for the corridor pavement of the guided rubber-tyre tram system according to the present invention is simple and does not require additional special machinery, thus being suitable for large-scale promotion and application.

**[0065]** Although the present invention has been illustrated and described with reference to specific embodiments, those skilled in the art will understand that various changes in form and details may be made herein without departing from the spirit and scope of the present invention as defined by the appended claims and their equivalents.

## CLAIMS

1. A pavement material for a corridor of a guided rubber-tyre tram system, characterized by comprising a grouting material and a large-void asphalt mixture matrix;

the grouting material is prepared from the following components in parts by weight: 100 parts of powder and 28-35 parts of water, wherein the powder in the grouting material is prepared from the following components in parts by weight:

50-90 parts of cement,  
0-10 parts of elastomer latex,  
5-22 parts of an active filler,  
0-3 parts of a superplasticizer,  
0-6 parts of a reinforcing agent,  
0-3 parts of a stabilizer, and  
0-5 parts of conductive particles;

the large-void asphalt mixture matrix is prepared from the following components in parts by weight:

100 parts of aggregates,  
3.2-5.5 parts of asphalt,  
0-0.6 parts of a surface-active binder, and  
0.2-0.4 parts of fibers;

a void ratio of the large-void asphalt mixture matrix being 10-28%; and

a synthetic gradation of the aggregates in the large-void asphalt mixture matrix being as follows:

100% passing rate of the aggregate through 16 mm sieve holes,  
70-100% passing rate of the aggregate through 13.2 mm sieve holes,  
10-50% passing rate of the aggregate through 9.5 mm sieve holes,  
5-25% passing rate of the aggregate through 4.75 mm sieve holes,  
4-20% passing rate of the aggregate through 2.36 mm sieve holes,  
3-18% passing rate of the aggregate through 1.18 mm sieve holes,  
3-16% passing rate of the aggregate through 0.6 mm sieve holes,  
3-14% passing rate of the aggregate through 0.3 mm sieve holes,  
2-12% passing rate of the aggregate through 0.15 mm sieve holes,  
1-10% passing rate of the aggregate through 0.075 mm sieve holes, wherein  
a total percentage of the aggregates with different particle sizes is 100%.

2. The pavement material for the corridor of the guided rubber-tyre tram system according

to claim 1, characterized in that the grouting material has a final strength of 35-45 MPa, a 2-hour strength of 10-30 MPa, and a fluidity of 10-14 s.

3. The pavement material for the corridor of the guided rubber-tyre tram system according to claim 1, characterized in that a weight ratio of the grouting material to the large-void asphalt mixture matrix is (10-30):(70-90).

4. The pavement material for the corridor of the guided rubber-tyre tram system according to claim 1 or 2, characterized in that the elastomer latex in the grouting material is selected from a mixture of any one or more of epoxy emulsion, polyester latex, terpolymer elastomer latex, and acrylic polymer, wherein

the terpolymer elastomer latex is selected from a mixture of any one or more of chlorotrifluoroethylene-vinylidene fluoride copolymer elastomer latex, vinylidene fluoride-perfluoropropylene copolymer elastomer, and vinylidene fluoride-tetravinylidene fluoride-perfluoropropylene.

5. The pavement material for the corridor of the guided rubber-tyre tram system according to claim 1 or 2, characterized in that the active filler in the grouting material is selected from a mixture of any one or more of blast furnace slag, pozzolanic powder, fly ash, lime powder, and active mineral powder;

the superplasticizer is selected from a mixture of any one or more of sulfonate-type, polycarboxylate-type, aliphatic-type, and polyoxyethylene-type superplasticizers;

the reinforcing agent is selected from a mixture of any one or more of active mineral powder, nano-diatomite, nano-silica, metal-organic framework materials, carbon nanotubes, graphene, and nano-silicon;

the stabilizer is selected from a mixture of any one or more of fibers, an expansion agent, a shrinkage reducing admixture, and a heat-absorbing stabilizer; and

the conductive particles are metal conductive particles with particle sizes of less than 1.18 mm.

6. The pavement material for the corridor of the guided rubber-tyre tram system according to claim 1 or 2, characterized in that the asphalt in the large-void asphalt mixture matrix is selected from a mixture of any one or more of base asphalt, styrene-butadiene-styrene (SBS)-modified asphalt, high-viscosity modified asphalt, rubber asphalt, epoxy asphalt, and polyurethane asphalt;

the surface-active binder is an amphiphilic block copolymer; and

the fibers are selected from a mixture of any one or more of lignin fibers, polymer fibers, steel fibers, and basalt fibers.

7. The pavement material for the corridor of the guided rubber-tyre tram system according to claim 1 or 2, characterized in that the large-void asphalt mixture matrix further comprises conductive particles; the conductive particles are mixed into the aggregates as block materials, and a total volume of the conductive particles in the grouting material and the aggregates accounts for 10-27% of that of the pavement material; and

the particle size distribution of the conductive particles in the aggregates is (4.75-9.5cm):(9.5-13.5cm)=2:5.

8. A paving method of the pavement material for the corridor of the guided rubber-tyre tram system according to any one of claims 1 to 7, characterized by comprising the following steps:

(1) laying a large-void asphalt mixture matrix: putting all material components of the large-void asphalt mixture matrix into an asphalt mixing plant pugmill according to parts by mass, and mixing at 160-180°C for 40-55 s to obtain an asphalt mixture; spreading the mixed asphalt mixture on a road surface with a loose paving coefficient of 1.1-1.25, and rolling for compaction with a steel wheel road roller, with a first pass being static compaction, second to fourth passes being vibratory compaction, and fifth to sixth passes being static compaction; performing final rolling when the temperature drops to 70-90°C to obtain the laid large-void asphalt mixture matrix;

(2) preparing a grouting material: putting powder and water into a mixer according to parts by mass, and mixing for 90 s at a stirring speed of not less than 200 r/min to obtain the grouting material;

(3) grouting: pumping the grouting material obtained in step (2) onto a surface of the asphalt mixture matrix laid in step (1), allowing grout to be 1-2 cm higher than the road surface, and maintaining this state for 10 min; and removing laitance on the surface of the asphalt mixture matrix when no obvious bubbles are observed on a grout surface, with an exposed aggregate depth on the surface being 0.6-5 mm.

9. The paving method according to claim 8, characterized in that a surface-active binder used in step (1) is added in two ways: one is to uniformly mix the surface-active binder into molten asphalt, and the other is to spray the surface-active binder at a mass of 0.05-0.2kg/(cm<sup>2</sup>) onto the laid asphalt mixture matrix at 40-90°C.

10. Use of the pavement material for the corridor of the guided rubber-tyre tram system according to any one of claims 1 to 7 in pavements for automatic tracking or autonomous driving vehicles.