



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
10.10.2018 Bulletin 2018/41

(51) Int Cl.:
E01B 1/00 (2006.01)

(21) Application number: **17290051.6**

(22) Date of filing: **07.04.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

- **Peuchlestrade, Anthony**
F-38291 Saint-Quentin-Fallavier Cedex (FR)
- **Jonnekin, Arnaud**
F-38291 Saint-Quentin-Fallavier Cedex (FR)
- **Watt, Olivier**
F-38291 Saint-Quentin-Fallavier Cedex (FR)

(71) Applicant: **Holcim Technology Ltd.**
8645 Jona (CH)

(74) Representative: **Keschmann, Marc**
Haffner und Keschmann Patentanwälte GmbH
Schottengasse 3a
1010 Wien (AT)

(72) Inventors:
• **Guillon, Emmanuel**
F-38291 Saint-Quentin-Fallavier Cedex (FR)

(54) **TRACK BED AND METHOD OF STABILIZING A TRACK BED**

(57) A track bed (1) for a railroad track, comprising track ballast (3) made from particulate matter and a multitude of railroad ties (4) supported on the track ballast (3), wherein at least one region (6) of the track ballast (3) is stabilized by means of a bonding agent that bonds together particles of the particulate matter, wherein the

bonding agent is based on a hydraulic binder, in particular cement, and that the bonding agent leaves free voids between the bonded particles so that the track ballast (3) has a water draining capability in said at least one stabilized region (6).

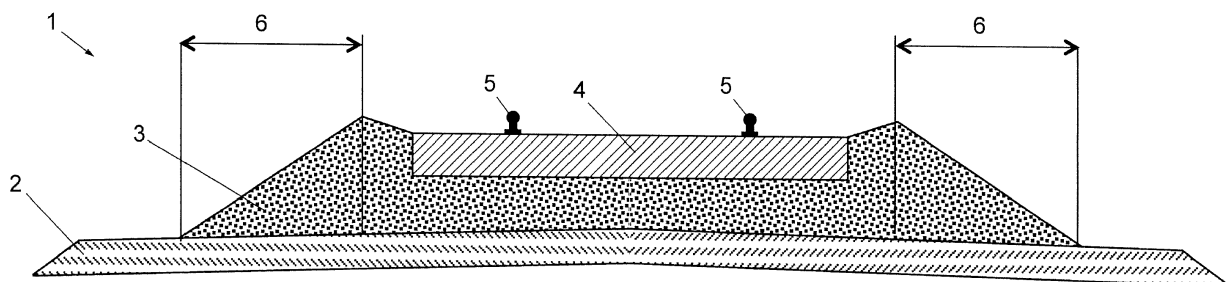


Fig. 1

Description

[0001] The invention refers to a track bed for a railroad track, comprising track ballast made from particulate matter and a multitude of railroad ties supported on the track ballast, wherein at least one region of the track ballast is stabilized by means of a bonding agent that bonds together particles of the particulate matter.

[0002] Further, the invention refers to a method of stabilizing a track bed for a railroad track, said track bed comprising track ballast made from particulate matter and a multitude of railroad ties supported on the track ballast.

[0003] Track ballast forms the track bed, upon which railroad ties are laid. The track ballast is packed between, below and around the ties and is typically made of crushed stone. With regard to the shape of the particles, it is important that the stones are irregularly cut and have relatively sharp edges, so that they properly interlock and grip the ties in order to fully secure them against movement.

[0004] The mechanical strength of the track ballast is essential for the stability of the railroad track bed. Since ballast consists of granular material, its strength and failure properties are determined by the frictional contact interactions between the ballast particles. There have been many attempts to improve the mechanical stability of track ballast so as to improve its lifetime and reduce maintenance operations.

[0005] Some solutions comprise cohering the individual particles of the particulate matter into a coherent elastic structure with a polymeric bonding agent. For example, it is known from EP 1 619 305 B1 to foam up the cavities of a ballast bed of a railway track with polyurethane (PU). For this, the reactants isocyanate, polyol and additives are mixed up as foaming agent and introduced into the cavities of the ballast bed where they react to form polyurethane foam.

[0006] Alternatively, it is also known to spray or pour polymeric resins onto the surface of the track ballast. This solution is effective technically, but is complex to implement because of the exposure of the workers and the environment to reactive and often harmful chemicals. This requires particular precautions on the jobsite to protect the workers, and to minimise that excess product is released into the environment, which would typically contaminate ground water. Furthermore, the resins that are used are relatively expensive.

[0007] The advantages of binding the individual particles of the particulate matter of the track ballast into a coherent structure by means of a bonding agent comprise enhanced track stability, resistance to rock displacement and improved riding qualities. With these advantages, however, a major drawback has been the inability to release the ballast from its consolidated condition for repairs to the road bed without major destruction of the consolidated material. Further, the particulate matter, once removed from the track for maintenance purposes, cannot be easily recycled due to its material composition comprising the polymeric bonding agent.

[0008] Therefore, the invention aims at providing improvements in stabilizing track ballast and to overcome the drawbacks of the prior art solutions as described above.

[0009] To solve these and other objects, the invention according to a first aspect thereof provides a track bed for a railroad track, comprising track ballast made from particulate matter and a multitude of railroad ties supported on the track ballast, wherein at least one region of the track ballast is stabilized by means of a bonding agent that bonds together particles of the particulate matter, characterized in that the bonding agent is based on a hydraulic binder, in particular cement, and that the bonding agent leaves free voids between the bonded particles so that the track ballast has a water draining capability in said at least one stabilized region.

[0010] By using a bonding agent that is based on a hydraulic binder, a strong bond can be achieved between the individual particles of the particulate matter of the track ballast. Hydraulic binders are widely used in the constructional industry and are known in a great number of different variations and mixtures so that the invention makes available a proven technology for stabilizing track ballast. The handling of hydraulic binders at the jobsite is safe and does not require specific safety measures. Neither the workers nor the environment is exposed to harmful chemicals. Furthermore, hydraulic binders are much less expensive than polymers, such as polyurethane foam or resins.

[0011] Another advantage is that the bonding agent is mineral-based instead of organic-based so that the coherent structure consisting of the particulate matter (in particular crushed stone) and the bonding agent is altogether a mineral material that can easily be recycled.

[0012] Furthermore, using a bonding agent based on a hydraulic binder enables the stabilisation of the track ballast without modifying the actual track design.

[0013] According to the invention, the bonding agent leaves free voids between the bonded particles so that the track ballast has a water draining capability in said at least one stabilized region. Therefore, the bonding agent is applied in such a way that fluid flow can occur through the track ballast so that rainwater can drain, in particular towards the outer sides of the track ballast. The draining capability requires that the voids arranged between the particles of the particulate matter are interconnected resulting in a certain degree of open porosity of the track ballast.

[0014] In order to keep the water draining capability of the track ballast, a certain amount of bonding agent should not be exceeded, since the bonding agent would otherwise completely fill the voids between the particles, which in turn would impair the draining capability. According to a preferred embodiment, the stabilized region has a mass ratio of bonding agent to track ballast of 1:10 - 1:20, in particular about 1:12.

[0015] Hydraulic binders are substances used in construction that set in the presence of water and harden. By adhering to the particles of the track ballast, the bonding agent based on a hydraulic binder binds the particles together. According to a preferred embodiment, the bonding agent is a hardened cement slurry, in particular a hardened cement paste or cement mortar. A cement paste is a mixture of cement and water as well as optionally admixtures.

[0016] Preferably, the hydraulic binder is a Portland cement binder, wherein the Portland cement preferably is a cement of the type CEM I, CEM II or CEM III.

[0017] In order to provide stabilisation to the track ballast, it is not necessary to have all the particles of the entire track ballast bonded with each other. Rather, stabilizing only specific regions of the track ballast may be sufficient, in particular with a view to stabilising the track ballast when it is already placed with railroad ties already being supported on the track ballast and rails fixed to the ties. Further, the bonding of particles is not desired directly below the railroad ties, because the particles should remain free in this region to move in order to provide a lateral confinement of the structure.

[0018] Therefore, according to a preferred embodiment, the track ballast comprises a central region located below said railroad ties and side regions arranged on both sides of said central region, wherein only the side regions are stabilized by said bonding agent. In particular, the side regions correspond to the outer slopes of the track ballast on either side of the ties. The track ballast in the central region can be easily replaced and/or compacted without breaking the bonding in the side regions.

[0019] According to a second aspect the invention provides a method of stabilizing a track bed for a railroad track, said track bed comprising track ballast made from particulate matter and a multitude of railroad ties supported on the track ballast, wherein particles of the particulate matter are bonded together by means of a bonding agent that is based on a hydraulic binder, in particular cement, said bonding agent being applied to the particles of the particulate matter so as to leave free voids between the bonded particles so that the track ballast has a water draining capability.

[0020] Preferably, the bonding agent comprises or consists of a cement slurry, in particular a cement paste or a cement mortar.

[0021] Preferably, the hydraulic binder is a Portland cement binder. Portland cement as used in the invention may be any type of Portland cement, whatever its chemical composition is. Suitable cements used in the invention preferably are the cements described according to the European EN 197-1 Standard of April 2012 or mixtures thereof, preferably cement of the types CEM I, CEM II, CEM III, CEM IV or CEM V. Preferably, the Portland cement preferably is a cement of the type CEM I, CEM II or CEM III.

[0022] In another embodiment, the hydraulic binder contains high amounts of aluminate phases, namely where the cumulated alumina content of the binder is between 10wt.-% and 50wt.-%. These aluminate phases can be provided by a specific cement, such as a calcium sulfoaluminate cement, a calcium aluminate cement, or a specific binder such as that described in EP 1781579. In a preferred embodiment, such a binder can be a mixture of 50wt.-% CEM I, 25wt.-% gypsum, and 25wt.-% calcium aluminate cement, such as Ciment Fondu produced by Kerneos.

[0023] Preferably, the track ballast comprises a central region located below said railroad ties and side regions arranged on both sides of said central region, wherein the bonding agent is only applied to the particles of the side regions.

[0024] The bonding agent can be applied to the track ballast in various ways. According to a first alternative, which is preferred, the bonding agent is poured or sprayed onto the track ballast from above in at least one region to be stabilized. Preferably, compressed-air spraying is used, which allows to deeply spray bonding agents having different fluidity. The bonding agent that is poured or sprayed onto the surface of the track ballast will also be distributed within the track ballast under the influence of gravity.

[0025] According to a second alternative, the bonding agent is mixed with the particles of said particulate matter and the resulting mixture is placed as track ballast on a track formation. This embodiment can be suitable for the construction of new lines, or for when the aggregates of the ballast are replaced in large maintenance operations.

[0026] In order to safeguard that the bonding agent, in particular when it is sprayed or poured onto the track ballast, effectively impregnates the bed of track ballast and bind the particles throughout the depth of the bed on the one hand and does not clog the voids between the particles on the other hand, the bonding agent should have a low viscosity and/or a high flowability when being applied. In this connection, a preferred embodiment provides that the flowability of the bonding agent, at the time of application, is 2-7 seconds, preferably 2-4 seconds, with a specific funnel test method that is identical to the method described in ASTM D6910/D6910M-09, and with two modifications:

- The funnel's dimensions used are: internal top cone diameter: 149 mm, internal bottom cone diameter: 17.3 mm, bottom tube height 30.3 mm, total height 190 mm (comprising cone and bottom tube).
- The time measured to characterize the flowability corresponds to the flow of 0.6 L of the product, and not 1 L as in ASTM D6910/D6910M-09.

[0027] Alternatively, the flowability may also be expressed in terms of the spread of the slurry, wherein a preferred embodiment provides that the bonding agent has an initial spread of at least 90 mm, measured according to a test

method inspired from EN 12350-8 referring to the testing of fresh concrete/self-compacting concrete, wherein the dimensions are adjusted for slurries (height 57 mm, internal diameter at top: 21 mm, internal diameter at bottom: 37 mm), 5 min after mixing.

[0028] The adjustment of the rheological properties of the bonding agent, in particular depending on the application method (pouring or spraying), may be achieved by methods known to the person skilled in the art, such as admixture selection and dosage and/or water to cement ratio variations.

[0029] In order to increase the flowability of the bonding agent, the Portland cement, according to a preferred embodiment of the invention, has a specific surface (Blaine) of 3000 - 10000 cm²/g, preferably 3500 - 6000 cm²/g.

[0030] Preferably, the bonding agent has a water/binder ratio of 0.4 to 0.6, where the mass of binder includes the Portland cement and, if any, mineral particles, such as slag, fly ash, silica fume, natural or synthetic pozzolans, limestone fillers, siliceous fillers, calcined clays, or mixtures thereof.

[0031] Preferably, the bonding agent, in particular the cement paste or the cement mortar, comprises a water reducer, in particular a plasticiser or super-plasticiser, such as a polycarboxylate based or a polynaphthalene sulfonate based water reducer. A water reducer makes it possible to reduce the amount of mixing water for a given workability by typically 10-15% or to increase flowability for a given water/binder ratio. By way of example of water reducers, mention may be made of lignosulphonates, hydroxycarboxylic acids, carbohydrates, and other specific organic compounds, for example glycerol, polyvinyl alcohol, sodium alumino-methyl-siliconate, sulfanilic acid and casein.

[0032] Super-plasticisers belong to a new class of water reducers and are capable of reducing water contents of mixing water, for a given workability, by approximately 30% by mass. By way of example of a superplasticizer, the PCP super-plasticisers without an anti-foaming agent may be noted. The term "PCP" or "polyoxy polycarboxylate" is to be understood according to the present invention as a copolymer of acrylic acids or methacrylic acids and their esters of polyoxyethylene (POE).

[0033] Preferably, the cement slurry comprises 0.05 to 1%, more preferably 0.05 to 0.7% of a water reducer, a plasticiser or a superplasticizer, percentage expressed by mass relative to the dry cement mass.

[0034] The setting time can be adjusted depending on the requirements. A fast setting mortar is for example suitable in maintenance operations that are carried out during night time maintenance slots of existing lines, and when the railway tracks need to be reopened the following morning. The reduction of the setting times is then carried out by using known strong set time accelerators regularly purchased from admixture suppliers. These products may be formulations based on calcium or sodium nitrates, nitrites, chlorides, thiocyanates, or aluminium sulphates.

[0035] Preferably, the bonding agent used in the invention comprises 0.05 to 2.5 wt.-% of an accelerator, expressed as dry mass relative to dry cement mass.

[0036] According to an embodiment of the invention, other additives may be added to the bonding agent. Such additives may be setting retarders, coloured pigments, film forming agents, hydrophobic agents or de-polluting agents (for example zeolites or titanium dioxide), latex, organic or mineral fibres, mineral additions or their mixtures.

[0037] According to an embodiment of the invention, the bonding agent used in the invention may further comprise mineral particles. Preferably, the bonding agent may comprise 15 to 75% of mineral particles, more preferably from 15 to 65%, most preferably from 20 to 55%, the percentages being expressed by mass relative to the dry mass of cement.

[0038] The suitable mineral particles have a maximum particle size of 200 micrometres are selected from calcium carbonate, silica, ground glass, solid or hollow glass beads, glass granules, expanded glass powders, silica aerogels, silica fume, slags, ground sedimentary siliceous sands, fly ash or pozzolanic materials or mixtures thereof.

[0039] The mineral particles used according to the invention may be slags (for example, as defined in the European NF EN 197-1 Standard of April 2012, paragraph 5.2.2), pozzolanic materials (for example as defined in the European NF EN 197-1 Standard of April 2012, paragraph 5.2.3), fly ash (for example, as described in the European NF EN 197-1 Standard of April 2012, paragraph 5.2.4), calcined schists (for example, as described in the European NF EN 197-1 Standard of April 2012, paragraph 5.2.5), material containing calcium carbonate, for example limestone (for example, as defined in the European NF EN 197-1 Standard paragraph 5.2.6), silica fume (for example, as defined in the European NF EN 197-1 Standard of April 2012, paragraph 5.2.7), siliceous additions (for example, as defined in the "Concrete" NF P 18-509 Standard), metakaolin or mixtures thereof.

[0040] Fly ash is generally pulverulent particles comprise in fume from thermal power plants which are fed with coal. Fly ash is generally recovered by electrostatic or mechanical precipitation.

[0041] Slags are generally obtained by rapid cooling of molten slag resulting from melting of iron ore in a blast furnace.

[0042] Silica fume may be a material obtained by the reduction of very pure quality quartz by the coal in electric arc furnaces used for the production of silicon and alloys of ferrosilicon. Silica fume is generally formed of spherical particles comprising at least 85% by mass of amorphous silica.

[0043] The pozzolanic materials may be natural siliceous and/or silico-aluminous materials or a combination thereof. Among the pozzolanic materials, natural pozzolans can be mentioned, which are generally materials of volcanic origin or sedimentary rocks, and natural calcined pozzolans, which are materials of volcanic origin, clays, shale or thermally-activated sedimentary rocks.

[0044] With regard to the amount of bonding agent used to bond the particles of the particulate matter with each other, a preferred embodiment provides that the bonding agent is poured or sprayed onto the track ballast in an amount of 40-70, preferably 50-70, more preferably 55-65, litres per m² of track ballast surface and per m of track ballast thickness.

[0045] Preferably, the bonding agent is poured or sprayed onto the track ballast in such an amount that a homogeneous bed of said bonding agent is formed at the bottom of the track ballast, said bed preferably having a height of 5-20 mm. In this embodiment the bonding agent is applied in excess so that the bonding agent forms a bed at the bottom of the track ballast so as to increase the stability of the ballast. In this particular embodiment, the fluidity of the bonding agent must be so high that the voids between the particles remain at least partially free from the bonding agent so that the track ballast remains permeable to water.

[0046] According to a preferred embodiment of the invention, the flexural strength of the bonding agent after having set and hardened is selected to be 1-5 MPa, in particular 1-2 MPa (measured on prisms having a dimension of 4*4*16 cm according to EN 196-01 24h after mixing). In this way, the cohesion provided by the bonding agent is enough to stabilize the track ballast, but not too high, so that ballast replacing machines are able to break the bonding points and allow the replacement of treated ballast.

[0047] The appropriate thickness of a layer of track ballast depends on the size and spacing of the ties, the amount of traffic on the line, and various other factors. The thickness of the track ballast preferably is greater than 150 mm. With high-speed railway lines the thickness of the track ballast may be up to 500 mm.

[0048] The invention will now be described in more detail with reference to an exemplary embodiment illustrated in Fig. 1. Fig. 1 shows a cross section of a track bed 1 for a railroad track. The track bed 1 comprises a sub-ballast layer 2 and track ballast 3 made from particulate matter. A multitude of railroad ties 4 are supported on the track ballast 3, wherein rails 5 are fixed to the railroad ties 4. In side regions 6 of the track ballast a bonding agent based on a hydraulic binder has been applied so that the particles of the track ballast are bonded together.

[0049] The invention will also be described in more detail with reference to the following examples.

Example 1

[0050] This example illustrates the bonding capacity of the bonding agent of the present invention and the possibility to bond a specific given thickness of the track ballast by depositing the suitable quantity of bonding agent per unit area of ballast.

[0051] The following materials were used for the test:

- Bonding agent: A Portland cement mortar with the following composition:

- CEM I 52.5 R (Lafarge France Le Teil plant): 750 parts by weight
- Limestone filler (BL 200): 375 parts by weight
- Sand with a particle size of 0-1 mm: 833 parts by weight
- Water: 420 parts by weight

The cement mortar was prepared by mixing the cement, the filler and the sand in a Perrier planetary mixer during 15 sec. Thereafter, water was added to the mixture during a time period of 30 sec and the mortar was mixed during 2 minutes at a slow speed.

The fresh cement mortar has the following properties:

- Slump flow (method inspired from EN 12350-8 referring to the testing of fresh concrete/self-compacting concrete, wherein the dimensions are adjusted for slurries (height 57 mm, internal diameter at top: 21 mm, internal diameter at bottom: 37 mm) 5 min after mixing): 110 mm
- Modified Marsh Funnel: 2.5 seconds The cement mortar once hardened had a 24h compressive strength of 6 MPa and a 24h flexural strength of 1 MPa (measured on prisms having a dimension of 4*4*16 cm according to EN 196-01 24h after mixing).

- Ballast: Glensanda Ballast 35-65 having particle sizes of 35-65 mm. 23 +/-1 kg of ballast was placed in a bucket (30 cm deep, 30 cm diameter) and compacted 30 seconds on a vibrating table. The ballast height after compaction was obtained by the average value of 4 height measurements (H1). The effective mass of ballast was measured (M1). The apparent specific weight of the ballast (R1) and the ballast porosity (P1) were calculated.

[0052] A given mass of bonding agent (M3) was deposited homogeneously at the top surface of the ballast and then sealed in order to prevent any water loss which may cause weight measurement artefacts. This sealing was done purely for the purpose of this test. 24 hours after the application, the bonded ballast was unmoulded and the mass of the bonded

EP 3 385 446 A1

ballast (including the bonding agent) was measured (M2). The fraction of the ballast bonded was evaluated first by calculating $(M2-M3)/M1$.

[0053] If any, the excess of bonding agent was quantified by determining the height of the bonding agent layer (H2) at the bottom of the bucket. The volume of excess bonding agent per surface unit was calculated: $H2/P1$ Three tests were performed, wherein the test differed primarily in the mass of the bonding agent (M3) used.

[0054] The results are shown in the following table:

Test	Test 1	Test 2	Test 3
Ballast Mass M1 (kg)	22	23.55	22.44
Ballast Height H1 (cm)	22	23	22
Specific weight R1 (kg/m ³)	1415	1449	1443
Porosity (-)	46%	44%	44%
Mass of treated ballast M2 (kg)	23.06	25.78	25.56
Mass of bonding agent applied M3 = M2 - M1 (kg)	1.06	2.23	3.12
Volume of bonding agent per unit area of ballast (L/m ²)	7.5	15.7	22
Mass of bonded ballast with bonding agent M4 (kg)	10.32	25.52	25.34
Mass of bonded ballast without bonding agent M5 = M4 - M3 (kg)	9.26	23.29	22.22
Wt.-% of ballast bonded	42	99	99
Depth of bonding (cm)	9	23	22
Thickness of excess bonding agent H2 (cm)	0	0.5	2
Volume of excess bonding agent in the bucket (L)	0	0.13	0.63
Volume of excess bonding agent per surface unit (L/m ²)	0	1.8	8.9

[0055] Test 2 shows that with the application of 15.7 L/m² of bonding agent a thickness of 23 cm of ballast is bonded. An homogeneous layer of 5mm of bonding agent is found at the bottom of the bucket.

[0056] Test 1 shows that with a lower amount of bonding agent per surface unit the depth of bonding is reduced to 9cm. The percentage of ballast bonded is surprisingly closely proportional to the amount of bonding agent deposited (42% versus 47% = $7.5/15.7$).

[0057] Test 3 shows that with an amount of 22 L/m² of bonding agent all ballast is fully bonded. A homogeneous layer of 2 cm of bonding agent is measured at the bottom of the bucket.

[0058] It is observed that in tests 2 and 3 the bonding agent was deposited in excess. When subtracting this excess volume and normalize it by the thickness of ballast bonded, one can calculate the minimal volume of bonding agent needed per ballast layer thickness unit:

- For Test 2: $(15.7-1.8)/0.23 = 60.7$ L/m²/m, i.e. 60.7 litres of bonding agent per surface unit and per metre (depth) of ballast.
- For Test 3: $(22-8.9)/0.22 = 59.7$ L/m²/m, i.e. 59.7 litres of bonding agent per surface unit and per metre (depth) of ballast.

Example 2

[0059] In example 2 a number of different cement slurries were prepared that are suitable as bonding agent according to the invention.

[0060] Table 1 illustrates the impact of different types of binder:

Table 1

Raw material (kg)	Mix1	Mix2	Mix3	Mix4	Mix5	Mix6	Mix7
CEM I 52.5 R	750			375		487	
CEM II/A 42.5 R		750					

EP 3 385 446 A1

(continued)

Raw material (kg)	Mix1	Mix2	Mix3	Mix4	Mix5	Mix6	Mix7
CEM III/A 42.5 N			750				
Finer CEM I 52.5 R					375		
Aluminate Cement							375
Limestone Filler				375	375		375
Fly Ash						262	
0-1 Sand	805	833	833	833	833		833
Water	460	420	420	420	420	460	420
Slump-Flow (mm)	105	105	100	110	95	105	110
Modified Marsh Funnel	2.4	2.5	2.5	2.5	3	2.6	2.5
24h compressive strength (MPa)	17	12	6.7	6	4.8	8.4	5.7
24h flexural strength (MPa)	5.5	3.5	2.2	1	1.6	2.9	2.2

[0061] Table 2 illustrates the impact of different types of sand:

Table 2

Raw material (kg)	Mix 4	Mix 8	Mix 9
CEM I 52.5 R	375	375	550
Limestone Filler	375	375	550
0-1 Sand	833		
0-2 Sand		833	
Water	420	420	620
Slump-Flow (mm)	110	105	115
O'Funnel	2.5	2.4	2
24h compressive strength (MPa)	6	6.1	5
24h flexural strength (MPa)	1	2.3	2

[0062] Table 3 illustrates the impact different types of admixtures:

Table 3

Raw material (kg)	Mix10	Mix11	Mix12	Mix13	Mix14	Mix15
CEM I 52.5 R	375	375	375	375	375	375
Limestone Filler	375	375	375	375	375	375
0-1 Sand	833	1048	833	833	833	736
Superplasticizer		2				
Accelerator			7.5			
Fibres				2.25		
Latex					40	
Thickening agent						0.2

EP 3 385 446 A1

(continued)

Raw material (kg)	Mix10	Mix11	Mix12	Mix13	Mix14	Mix15
Water	420	330	420	420	401	450
Slump-flow (mm)	110	115	110	105	100	95
O'Funnel	2.5	6	2.7	2.6	2.9	2.6
24h compressive strength (MPa)	6	12	6.8	6.2	4.5	4.3
24h flexural strength (MPa)	1	4	2.4	2.3	1.1	0.9

[0063] In the above examples, the following materials were used:

Materials	Source
GEM I 52.5 R	Lafarge France, Le Teil plant
CEM II/A 42.5 R	Lafarge France Val D'Azergues plant
CEM III/A 42.5 N	Holcim Croatia, Adria Cement Koromacno plant
Finer CEM I 52.5 R	Lafarge France, Le Teil plant, blaine fineness 6000 m ² /g
Aluminate Cement	Mixture of 50wt.-% CEM I 52.5 R, 25wt.-% gypsum, 25wt.-% calcium aluminate cement (Ciment Fondu from Kerneos),
Limestone Filler	Omya BL 200
Fly Ash	Cordemais plant
0-1 Sand	Sibelco BE 01
0-2 Sand	EN Normalized sand
Superplasticizer	Chryso Premia 180
Accelerator	CaCl ₂
Fibres	Chryso Syntec 12
Latex	Waker Etonis
Thickening agent	CP Kelco - Kelco-crete

[0064] In the above examples, the bonding agent was prepared by the following method: The cement mortar was prepared by mixing the cement, the filler and the sand in a Perrier planetary mixer during 15 sec. Thereafter, water and additives were added to the mixture during a time period of 30 sec and the mortar was mixed during 2 minutes at a slow speed.

[0065] The material properties were measured as follows:

The slump flow was measured with a method inspired from EN 12350-8 referring to the testing of fresh concrete/self-compacting concrete, wherein the dimensions are adjusted for slurries (height 57mm, internal diameter at top: 21mm, internal diameter at bottom: 37mm) 5 min after mixing. The flow time was measured by the modified Marsh funnel test, using the protocol described above.

[0066] The compressive strength and the flexural strength were measured on prisms having a dimension of 4*4*16 cm according to EN 196-01 24h after mixing.

Claims

1. A track bed for a railroad track, comprising track ballast made from particulate matter and a multitude of railroad ties supported on the track ballast, wherein at least one region of the track ballast is stabilized by means of a bonding

agent that bonds together particles of the particulate matter, **characterized in that** the bonding agent is based on a hydraulic binder, in particular cement, and that the bonding agent leaves free voids between the bonded particles so that the track ballast has a water draining capability in said at least one stabilized region.

- 5 **2.** A track bed according to claim 1, **characterized in that** the bonding agent is a hardened cement slurry, in particular a hardened cement paste or cement mortar.
- 3.** A track bed according to claim 1 or 2, **characterized in that** the hydraulic binder is a Portland cement binder, wherein the Portland cement preferably is a cement of then type CEM I, CEM II, CEM III, or aluminate cement.
- 10 **4.** A track bed according to claim 1, 2 or 3, **characterized in that** the track ballast comprises a central region located below said railroad ties and side regions arranged on both sides of said central region, wherein only the side regions are stabilized by said bonding agent.
- 15 **5.** A track bed according to any one of claims 1 to 4, **characterized in that** the stabilized region has a mass ratio of bonding agent to track ballast of 1:10 - 1:20, in particular about 1:12.
- 6.** Method of stabilizing a track bed for a railroad track, said track bed comprising track ballast made from particulate matter and a multitude of railroad ties supported on the track ballast, wherein particles of the particulate matter are'

20 bonded together by means of a bonding agent that is based on a hydraulic binder, in particular cement, said bonding agent being applied to the particles of the particulate matter so as to leave free voids between the bonded particles so that the track ballast has a water draining capability.
- 7.** Method according to claim 6, **characterized in that** the bonding agent comprises or consists of a cement slurry, in

25 particular a cement paste or cement mortar.
- 8.** Method according to claim 6 or 7, characterize in that the hydraulic binder is a Portland cement binder, wherein the Portland cement preferably is a cement of the type CEM I, CEM II, CEM III, or aluminate cement.
- 30 **9.** Method according to claim 6, 7 or 8, **characterized in that** the bonding agent is poured or sprayed onto the track ballast in at least one region to be stabilized.
- 10.** Method according to claim 6, 7 or 8, **characterized in that** the bonding agent is mixed with the particles of said particulate matter and the resulting mixture is placed as track ballast on a track formation.
- 35 **11.** Method according to any one of claims 6 to 10, **characterized in that** the track ballast comprises a central region located below said railroad ties and side regions arranged on both sides of said central region, wherein the bonding agent is only applied to the particles of the side regions.
- 40 **12.** Method according to any one of claims 6 to 11, **characterized in that** the flowability of the bonding agent, at the time of application, is 2-7 seconds, preferably 2-4 seconds, when measured according to a spread test method inspired from the method described in ASTM D6910/D6910M-09, where the dimensions of the funnel are adapted for slurries (internal top cone diameter: 149 mm, internal bottom cone diameter: 17.3 mm, bottom tube height: 30.3 mm, total height: 190 mm (comprising cone and bottom tube)) and where the time measured to characterize the

45 flowability corresponds to the flow of 0.6 L of the product.
- 13.** Method according to any one of claims 6 to 12, **characterized in that** the bonding agent has an initial slump of at least 90 mm, measured according to a spread test method inspired from EN 12350-8 referring to the testing of fresh concrete/self-compacting concrete, wherein the dimensions are adjusted for slurries (height 57 mm, internal diameter

50 at top: 21 mm, internal diameter at bottom: 37 mm) 5 min after mixing.
- 14.** method according to any one of claims 6 to 13, **characterized in that** the Portland cement has a specific surface (Blaine) of 3000 - 10000 cm²/g, preferably 3500 - 6000 cm²/g.
- 55 **15.** Method according to any one of claims 6 to 14, **characterized in that** the bonding agent, in particular the cement paste, cement slurry or cement mortar, comprises a water reducer, in particular a plasticiser or superplasticiser, such as a polycarboxylate based or a polynaphthalene sulfonate based water reducer.

EP 3 385 446 A1

16. Method according to any one of claims 6 to 15, **characterized in that** the bonding agent is poured or sprayed onto the track ballast in an amount of 40-70, preferably 50-70, more preferably 55-65, litres per m² of track ballast surface and per m of track ballast thickness.

5 17. Method according to any one of claims 6 to 16, **characterized in that** the bonding agent is poured or sprayed onto the track ballast in such an amount that a homogeneous bed of said bonding agent is formed at the bottom of the track ballast, said bed preferably having a height of 5-20 mm.

10

15

20

25

30

35

40

45

50

55

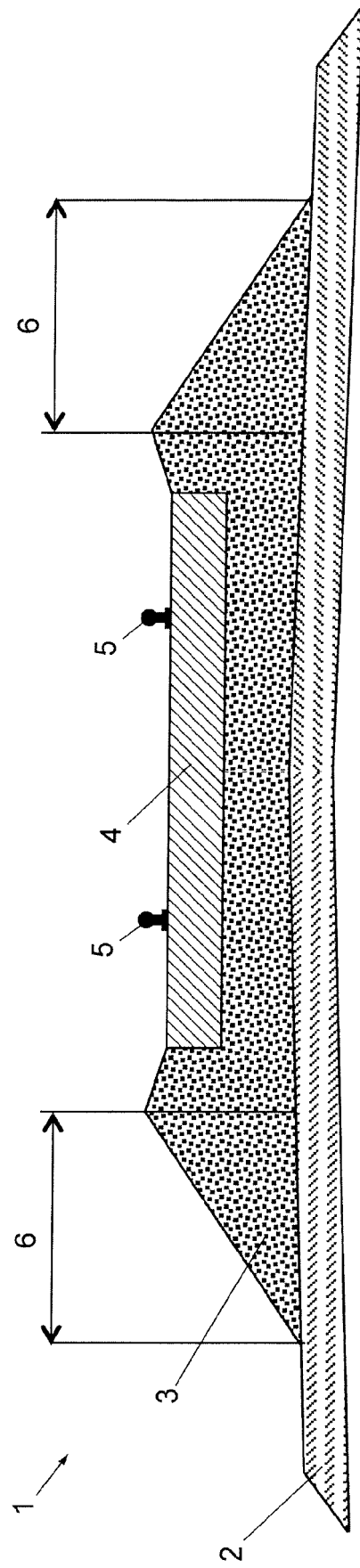


Fig. 1



EUROPEAN SEARCH REPORT

 Application Number
 EP 17 29 0051

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 4 451 180 A (DUVAL HENRY H [US]) 29 May 1984 (1984-05-29) * column 6, line 34 - column 7, line 37; figures 1-9 *	1-11, 14-17 12,13	INV. E01B1/00
X A	DE 199 29 283 A1 (GUDEHUS GERD [DE]; AUGUSTIN SVEN [DE]) 28 December 2000 (2000-12-28) * column 2, lines 22-37; claims 1,6; figures 1-3 *	1,2,4,6, 7,9-11 3,5,8, 12-17	
X A	DE 44 23 542 A1 (HEINRICH CRONAU GMBH HOCH TIEF [DE]) 11 January 1996 (1996-01-11) * column 3, lines 43-61; claims 1,17,18; figures 1,2 *	1,2,5-7, 9,10,16, 17 3,4,8,11	
A	US 3 656 690 A (HANIG SIEGFRIED) 18 April 1972 (1972-04-18) * column 2, lines 30-45; figures 1,2 *	1-17	
A	US 3 841 554 A (BENNETT R) 15 October 1974 (1974-10-15) * claims 1,2,6; figures 1-3 *	1-17	TECHNICAL FIELDS SEARCHED (IPC) E01B
A,D	EP 1 619 305 B1 (MSB MAN GMBH [DE]) 6 May 2009 (2009-05-06) * column 11, paragraph [0056] - column 12, paragraph [0061]; figures 1-4 *	1-17	
A,D	EP 1 781 579 A2 (LAFARGE SA [FR]) 9 May 2007 (2007-05-09) * page 8, paragraph [0073]; claims 7,11-16; table 5 *	3,5,8, 14,15	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 September 2017	Examiner Fernandez, Eva
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 1
 EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 29 0051

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-09-2017

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4451180 A	29-05-1984	NONE	
DE 19929283 A1	28-12-2000	NONE	
DE 4423542 A1	11-01-1996	NONE	
US 3656690 A	18-04-1972	BE 747648 A1 DE 1914712 A1 FR 2039789 A5 GB 1296759 A US 3656690 A	31-08-1970 15-10-1970 15-01-1971 15-11-1972 18-04-1972
US 3841554 A	15-10-1974	NONE	
EP 1619305 B1	06-05-2009	AT 430837 T EP 1619305 A2 ES 2326125 T3	15-05-2009 25-01-2006 01-10-2009
EP 1781579 A2	09-05-2007	AT 434592 T BR PI0513507 A CA 2574532 A1 CN 101023043 A CN 102745918 A CN 102765892 A EG 25879 A EP 1781579 A2 ES 2327254 T3 FR 2873366 A1 JP 5123661 B2 JP 2008506628 A KR 20070043854 A MA 28744 B1 PT 1781579 E RU 2360874 C2 SI EP1781579 T1 UA 86424 C2 US 2007266903 A1 US 2010132590 A1 WO 2006018569 A2 ZA 200701333 B	15-07-2009 06-05-2008 23-02-2006 22-08-2007 24-10-2012 07-11-2012 23-09-2012 09-05-2007 27-10-2009 27-01-2006 23-01-2013 06-03-2008 25-04-2007 02-07-2007 12-10-2009 10-07-2009 31-10-2009 27-04-2009 22-11-2007 03-06-2010 23-02-2006 30-07-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 1619305 B1 [0005]
- EP 1781579 A [0022]