

【DESCRIPTION】

【Invention Title】

FAST-CURING GROUT COMPOSITION FOR STEEL PIPE MULTI-STEP GROUTING METHOD, AND STEEL PIPE MULTI-STEP GROUTING METHOD USING SAME

【Technical Field】

The present invention relates to a fast-hardening grout composition for a steel pipe multistage grouting method, the fast-hardening grout composition including a sealing material having a 3-hour Vicat needle penetration of 10 mm or less and a main injection material capable of developing an early compressive strength of at least 2 MPa within 2 hours, whereby it is possible to maximize the reinforcement effect of soft ground and a tunnel and to dramatically reduce the overall construction time, and a steel pipe multistage grouting method using the same.

【Background Art】

When a tunnel is excavated in soft ground with low strength and self-supporting properties, water blocking and ground reinforcement are absolutely necessary before an excavation process in order to stabilize an excavation surface of the tunnel and prevent collapse. A grouting method is most widely for water blocking and ground reinforcement.

In particular, a grouting method for tunnel reinforcement is usually performed through a construction procedure of boring, steel pipe insertion, caulking, sealing, and grouting. That is, before tunnel excavation, a steel pipe is arranged and installed in an appropriate shape, a packer is installed in the steel pipe, and a grout composition is injected in multiple stages, whereby the steel pipe and the ground are integrated due to solidification of the ground by a main injection material, and the dispersion effect and reduction effect of overburden load and earth pressure applied to the tunnel excavation ground are obtained by the beam action of the steel pipe and the surrounding ground, and therefore safety of a blind end in a tunnel is secured. As a result, unwanted accidents, such as ceiling collapse, may be prevented, and stable excavation work based on excavation design may be performed.

In the steel pipe multistage grouting method, an injection hose is installed between a borehole wall and the steel pipe and a sealing material is injected in order to close a space between the borehole wall and the steel pipe after insertion of the steel pipe. After being injected, the sealing material is hardened into a gel, which integrates the steel pipe with the ground and prevents backflow of the main injection material.

If gelation initiation time of the sealing material is

delayed too much after injection, the main injection material and the sealing material may be mixed with each other, whereby the main injection material may not smoothly permeate the ground, and the main injection material may flow back immediately after injection of the main injection material. Also, if the gelation initiation time is too short, the sealing material may be excessively hardened, whereby the main injection material, which is post-injected, may not penetrate the sealing material, and therefore the main injection material may not permeate the ground. Therefore, the sealing process is a difficult process that requires optimal gelation and strength. In addition, the conventional sealing material requires a long curing time of 23 ± 1 hours in order to develop proper gelation strength, and there is a problem that the overall construction period is significantly delayed during the process. If the main injection material is injected without securing sufficient curing time and blasting and excavation are performed in order to comply with the construction period, deterioration in construction safety, such as fatal accidents, may occur.

Therefore, there is an urgent need to develop a fast-hardening grout composition for a steel pipe multistage grouting method capable of maximizing the reinforcement effect and reducing the overall construction time as much as possible through development of a sealing material that can

shorten gelation initiation time while securing appropriate gelation retention time such that smooth penetration of a main injection material is enabled, whereby excellent injection performance is secured, and through development of a main injection material that can set much earlier than the current curing time of about 18 ± 1 hours and can develop early compressive strength of at least 2 MPa, and a steel pipe multistage grouting method using the same.

【Disclosure】

【Technical Problem】

The present invention has been made in view of the above problems, and it is an object of the present invention to provide a fast-hardening grout composition for steel pipe multistage grouting method, the fast-hardening grout composition including a sealing material that can shorten gelation initiation time while securing appropriate gelation retention time and a main injection material that can develop early compressive strength by shortening curing time, whereby it is possible to maximize the reinforcement effect of soft ground and a tunnel and to dramatically reduce the overall construction time.

It is another object of the present invention to provide a steel pipe multistage grouting method using the fast-hardening grout composition for the steel pipe

multistage grouting method.

Various objects of the present invention to be achieved are not limited to the aforementioned objects, and other unmentioned objects will be clearly understood by those skilled in the art from the following description.

【Technical Solution】

In an embodiment, the present invention provides a fast-hardening grout composition for a steel pipe multistage grouting method including perforating a ground of a tunnel to be reinforced (S10), inserting a steel pipe into the perforation (S20), filling a sealing material between the steel pipe and the perforation (S30), gelling the filled sealing material (S40), filling the steel pipe inserted into the perforation with a main injection material including an injection material and a quick-setting material (S50), and hardening the filled main injection material (S60), wherein

the sealing material includes a sealing binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the sealing binder including 30 to 60 wt% of bentonite, 20 to 50 wt% of paper sludge incineration ash, 10 to 30 wt% of gypsum, 1 to 20 wt% of slaked lime, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator,

the main injection material includes an injection

material and a quick-setting material at a weight ratio of 1:0.8 to 1,

the injection material includes an injection binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the injection binder including 40 to 70 wt% of microcement, 5 to 30 wt% of calcium sulfoaluminate, 5 to 30 wt% of fly ash, 5 to 30 wt% of slag cement, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a retarder, and

the quick-setting material includes a quick-setting binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the quick-setting binder including 40 to 70 wt% of gypsum, 5 to 30 wt% of calcium aluminate, 5 to 30 wt% of C12A7, 5 to 30 wt% of blast furnace slag, 0.05 to 5 wt% of sodium hydrogen carbonate, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator.

The sealing binder may further include 0.1 to 10 wt% of plate-shaped graphite coated with alumina on the surface thereof, and

the plate-shaped graphite coated with alumina on the surface thereof may be prepared using a method including manufacturing a slurry by mixing 15 to 30 parts by weight of plate-shaped graphite having an average diameter of 1 to 10 μm and a thickness of 10 to 60 nm with 100 parts by weight of a solution including 0.03 to 0.9 mol/L of aluminum

alkoxide dissolved in an alcohol-based solvent and filtering the slurry to manufacture aluminum alkoxide-coated plate-shaped graphite, mixing 5 to 20 parts by weight of the manufactured aluminum alkoxide-coated plate-shaped graphite with 100 parts by weight of a solution including 0.03 to 0.5 mol/L of water dissolved in an alcohol-based solvent and coating the surface of plate-shaped graphite with alumina through hydrolysis reaction of the aluminum alkoxide, and removing the residual solution by filtering and drying to obtain alumina-coated plate-shaped graphite.

The injection binder may further include 0.1 to 10 wt% of a magnesium-sericite aggregate, which is an aggregate of magnesium and sericite, and

the magnesium-sericite aggregate may be prepared using a method including mixing 100 parts by weight of sericite with 15 to 25 parts by weight of $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, mixing 150 to 300 parts by weight of distilled water with the mixed sericite and $\text{MgCl}_2 \cdot \text{H}_2\text{O}$ and stirring the mixture for 5 to 30 hours, and centrifuging the stirred sericite, $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, and distilled water and extracting supernatant liquid to obtain a magnesium-sericite aggregate.

The magnesium-sericite aggregate may be prepared using the method further including mixing the obtained magnesium-sericite aggregate with neohesperidin at a ratio in parts by weight of 1:0.1 to 0.5 and crushing the mixture by ball

milling and drying the crushed magnesium-sericite aggregate at a temperature of 50 to 80°C.

In another embodiment, the present invention provides a steel pipe multistage grouting method using the fast-hardening grout composition for the steel pipe multistage grouting method, the steel pipe multistage grouting method including

perforating a ground of a tunnel to be reinforced (S10), inserting a steel pipe into the perforation (S20), filling a sealing material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method, between the steel pipe and the perforation (S30), gelling the filled sealing material (S40), filling the steel pipe inserted into the perforation with a main injection material including an injection material and a quick-setting material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method (S50), and hardening the filled main injection material (S60).

【Advantageous Effects】

A fast-hardening grout composition for a steel pipe multistage grouting method according to an embodiment of the present invention and a steel pipe multistage grouting method using the same have an effect in that a sealing material having a 3-hour Vicat needle penetration of 10 mm or less

is included, whereby it is possible to dramatically shorten gelation initiation time while securing appropriate gelation retention time, and therefore it is possible to enable smooth penetration of a main injection material and thus to secure excellent injection performance. In addition, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that a main injection material that can develop early compressive strength of at least 2 MPa within 2 hours is included, whereby it is possible for the main injection material to have excellent compressive strength while setting in a much shorter curing time than the current curing time of about 18±1 hours. Furthermore, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that it is possible to improve resistance to cracking due to premature hardening, to improve resistance to material separation, and to improve compensability to shrinkage. As a result, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that it is possible to maximize the reinforcement effect of soft ground and a tunnel and to dramatically reduce the overall construction time.

【Description of Drawings】

FIG. 1 is a schematic construction flowchart of a steel pipe multistage grouting method according to an embodiment of the present invention.

FIG. 2 is a photograph showing a blind end in a tunnel at which the steel pipe multistage grouting method according to the embodiment of the present invention is performed.

FIG. 3 is a view showing a continuous steel pipe installation in a longitudinal direction of a tunnel.

FIG. 4 is an experimental image for determining penetration of a main injection material after gelation of a sealing material according to Examples 1 to 3 of the present invention.

【Best Mode】

Hereinafter, embodiments of the present invention will be described in detail. However, the embodiments are provided by way of example, the present invention is not limited thereby, and the present invention is only defined by the category of the appended claims.

An embodiment of the present invention provides a fast-hardening grout composition for a steel pipe multistage grouting method including the steps of perforating the ground of a tunnel to be reinforced (S10), inserting a steel pipe into the perforation (S20), filling a sealing material between the steel pipe and the perforation (S30), gelling

the filled sealing material (S40), filling the steel pipe inserted into the perforation with a main injection material including an injection material and a quick-setting material (S50), and hardening the filled main injection material (S60), wherein

the sealing material includes a sealing binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the sealing binder including 30 to 60 wt% of bentonite, 20 to 50 wt% of paper sludge incineration ash, 10 to 30 wt% of gypsum, 1 to 20 wt% of slaked lime, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator,

the main injection material includes an injection material and a quick-setting material at a weight ratio of 1:0.8 to 1,

the injection material includes an injection binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the injection binder including 40 to 70 wt% of microcement, 5 to 30 wt% of calcium sulfoaluminate, 5 to 30 wt% of fly ash, 5 to 30 wt% of slag cement, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a retarder, and

the quick-setting material includes a quick-setting binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the quick-setting binder including 40 to 70 wt% of gypsum, 5 to 30 wt% of calcium aluminate, 5 to 30 wt% of

C12A7, 5 to 30 wt% of blast furnace slag, 0.05 to 5 wt% of sodium hydrogen carbonate, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator.

The fast-hardening grout composition for the steel pipe multistage grouting method according to the embodiment of the present invention and the steel pipe multistage grouting method using the same have an effect in that a sealing material having a 3-hour Vicat needle penetration of 10 mm or less is included, whereby it is possible to dramatically shorten gelation initiation time while securing appropriate gelation retention time, and therefore it is possible to enable smooth penetration of a main injection material and thus to secure excellent injection performance. In addition, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that a main injection material that can develop early compressive strength of at least 2 MPa within 2 hours is included, whereby it is possible for the main injection material to have excellent compressive strength while setting in a much shorter curing time than the current curing time of about 18 ± 1 hours. Furthermore, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that it is possible to improve resistance to cracking due to premature hardening, to improve resistance

to material separation, and to improve compensability to shrinkage. As a result, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that it is possible to maximize the reinforcement effect of soft ground and a tunnel and to dramatically reduce the overall construction time.

More specifically, the fast-hardening grout composition for the steel pipe multistage grouting method according to the embodiment of the present invention may be used in a steel pipe multistage grouting method including the steps of boring a perforation in the ground of a tunnel to be reinforced (S10), inserting a steel pipe into the perforation (S20), filling a sealing material between the steel pipe and the perforation (S30), gelling the filled sealing material (S40), filling the steel pipe inserted into the perforation with a main injection material including an injection material and a quick-setting material (S50), and hardening the filled main injection material (S60).

First, the fast-hardening grout composition for the steel pipe multistage grouting method according to the embodiment of the present invention includes a sealing material that is injected between the outside of the steel pipe and the perforation before injection of the main injection material so as to be expanded and filled, whereby it is possible to increase the friction force between the

steel pipe and the ground, and therefore it is possible to prevent drawing of the steel pipe, collapse of the perforation, and backflow due to injection pressure at the time of injection of the main injection material and to improve injection efficiency of the main injection material.

The sealing material should be present in a gelled state, not a fully solidified state, until the injection of the main injection material is completed. When conventional sodium silicate, which is usually used, is used as the sealing material, gelation initiation time may be shortened, but gelation retention time is also shortened, whereby the hardening speed also becomes very fast. When the main injection material is injected, therefore, the sealing material is already in a cured state and the main injection material is hardly injected. In order to dramatically shorten the gelation initiation time while securing an adequate gelation retention time in which the sealing material is densely and sufficiently injected into the ground and injection of the main injection material is not affected, it is preferable for the sealing material to include a sealing binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, wherein the sealing binder includes 30 to 60 wt% of bentonite, 20 to 50 wt% of paper sludge incineration ash, 10 to 30 wt% of gypsum, 1 to 20 wt% of slaked lime, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a

hardening accelerator. As a result, there is the effect of enabling smooth penetration of the main injection material and securing excellent injection performance.

More specifically, bentonite is mainly composed of montmorillonite, which is representative of the group of swelling clay minerals, and has the property of swelling as the result of increase in base spacing when in contact with water. As a result, the sealing material may be injected between the outside of the steel pipe and the perforation and may be filled while being expanded, whereby it is possible to exhibit the function of shrinkage compensation. In addition, excellent fluidity, prevention of material separation, and the thickening effect are achieved, whereby it is possible to secure appropriate gelation retention time.

In consideration of the above-mentioned improvement effect, it is preferable for bentonite to be contained in the sealing binder so as to account for 30 to 60 wt%.

The paper sludge incineration ash is a by-product generated in an incineration process of burning pulp and paper. Limestone powder is used as a filler to reduce the amount of pulp and improve the quality of paper during a paper manufacturing process. When excess limestone powder discharged in the form of sludge is burned in a boiler, limestone is decarboxylated, whereby the content of calcium oxide is high. The paper sludge incineration ash contains a

large amount of CaO , SiO_2 , and Al_2O_3 , which induce tissue densification, whereby it is possible to improve the strength and durability of the soft ground while dramatically shortening the gelation initiation time.

When the paper sludge incineration ash includes 55 to 85 wt% of CaO , 5 to 25 wt% of SiO_2 , and 1 to 20 wt% of Al_2O_3 and has a fineness of 3500 to 5500 cm^2/g , the above effects may be further improved.

In consideration of the above-mentioned improvement effect, it is preferable for the paper sludge incineration ash to be contained in the sealing binder so as to account for 20 to 50 wt%.

Gypsum is a monoclinic mineral with a chemical composition of $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, forming rhombohedral or columnar crystals, which is heated by a hydration reaction, and while expanding, the sealing material is injected and filled between the outside of the steel pipe and the perforation, and may exhibit the function of shrinkage compensation. In addition, gypsum has the function of shortening the gelation initiation time.

In consideration of the above-mentioned improvement effect, it is preferable for gypsum to be contained in the sealing binder so as to account for 10 to 30 wt%.

Slaked lime is an isometric white crystal, which may be mixed with gypsum and expanded such that the sealing material

is injected and filled between the outside of the steel pipe and the perforation, and may exhibit the function of shrinkage compensation. In addition, slaked lime has the function of shortening the gelation initiation time.

In consideration of the above-mentioned improvement effect, it is preferable for slaked lime to be contained in the sealing binder so as to account for 1 to 20 wt%.

The superplasticizer functions to improve injection efficiency by forming a lubricating film between particles, and a polycarbonate-based superplasticizer is preferably used. In consideration of the above-mentioned improvement effect and a material separation phenomenon, it is preferable for the superplasticizer to be contained in the sealing binder so as to account for 0.01 to 5 wt%.

The hardening accelerator, which shortens the gelation initiation time and minimizes expansion and contraction due to high reactivity thereof, is preferably made of at least one selected from the group consisting of lithium carbonate, sodium sulfate, magnesium sulfate, sodium carbonate, and a mixture thereof. In consideration of the above-mentioned improvement effect and strength characteristics after solidification, it is preferable for the hardening accelerator to be contained in the sealing binder so as to account for 0.01 to 5 wt%.

In addition, the sealing binder may further include 0.1

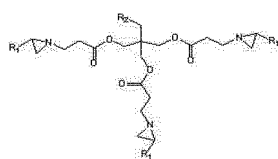
to 10 wt% of plate-shaped graphite coated with alumina on the surface thereof, whereby the horizontal area may be maximized, and therefore adequate gelation strength and gelation retention time may be secured. Furthermore, it is possible to dramatically shorten the gelation initiation time due to the alumina formed on the surface of graphite by coating, whereby it is possible to enable smooth penetration of the main injection material and thus to secure excellent injection performance.

More specifically, plate-shaped graphite coated with alumina on the surface thereof may be prepared using a method including the steps of manufacturing a slurry by mixing 15 to 30 parts by weight of plate-shaped graphite having an average diameter of 1 to 10 μm and a thickness of 10 to 60 nm with 100 parts by weight of a solution including 0.03 to 0.9 mol/L of aluminum alkoxide dissolved in an alcohol-based solvent and filtering the slurry to manufacture aluminum alkoxide-coated plate-shaped graphite, mixing 5 to 20 parts by weight of the manufactured aluminum alkoxide-coated plate-shaped graphite with 100 parts by weight of a solution including 0.03 to 0.5 mol/L of water dissolved in an alcohol-based solvent and coating the surface of plate-shaped graphite with alumina through hydrolysis reaction of aluminum alkoxide, and removing the residual solution by filtering and drying to obtain alumina-coated plate-shaped graphite,

whereby it is possible to further improve the above effect.

In addition, the sealing material may further include a compound represented by Formula 1 below and a compound represented by Formula 2 below, whereby excellent fluidity may be imparted, and therefore injection into the ground through the sealing material may be further improved. Furthermore, the sealing material is integrated with the ground after hardening, whereby it is possible to achieve excellent long-term strength.

[Formula 1]

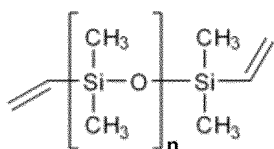


In the above formula,

R₁ is hydrogen or an alkyl group having a carbon number of 1 to 10, and

R₂ is a hydroxyl group or an alkyl group having a carbon number of 1 to 10.

[Formula 2]



In the above formula,

n is an integer of 1 to 10.

At this time, the compound represented by Formula 1 above and the compound represented by Formula 2 above are preferably mixed so as to account for 0.1 to 5 parts by weight based on 100 parts by weight of the mixing water of the sealing material in consideration of the above-mentioned improvement effect and the material separation phenomenon. In addition, the compound represented by Formula 1 above and the compound represented by Formula 2 above may be mixed at a weight ratio of 1:1, whereby it is possible to further improve the above-mentioned improvement effect.

Meanwhile, the fast-hardening grout composition for the steel pipe multistage grouting method according to the embodiment of the present invention includes a main injection material including an injection material that is discharged between the outside of the steel pipe and the perforation and is then injected into the ground through the sealing material in order to fill cracks in the ground and to consolidate the ground as the result of being supplied under pressure from the inside of the steel pipe and a quick-setting material configured to promote curing of the injection material.

At this time, the main injection material may include the injection material and the quick-setting material at a weight ratio of 1:0.8 to 1.

Preferably, the injection material includes an

injection binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, wherein the injection binder includes 40 to 70 wt% of microcement, 5 to 30 wt% of calcium sulfoaluminate, 5 to 30 wt% of fly ash, 5 to 30 wt% of slag cement, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a retarder. As a result, the injection material may easily pass through the sealing material and may be densely filled in the ground, whereby it is possible for the injection material to have excellent compressive strength while setting in a much shorter curing time than the current curing time of about 18 ± 1 hours.

More specifically, microcement is ultrafine cement with high fineness, which facilitates injection of the main injection material and enables development of excellent early compressive strength.

Preferably, microcement has a fineness of 6,000 to 10,000 cm^2/g and an average particle size of 1 to 10 μm .

In consideration of the above-mentioned improvement effect, it is preferable for microcement to be contained in the injection binder so as to account for 40 to 70 wt%.

Calcium sulfoaluminate may be mixed with cement to develop excellent early compressive strength. In addition, it is possible to prevent volume change and backflow of the injection material during the curing process, whereby it is possible to stably develop excellent compressive strength

within a short time.

Preferably, calcium sulfoaluminate includes at least 30 wt% of Al_2O_3 and a fineness of 4,500 to 8,000 cm^2/g .

In consideration of the above-mentioned improvement effect, it is preferable for calcium sulfoaluminate to be contained in the injection binder so as to account for 5 to 30 wt%.

The fly ash has the economic benefit of recycling an industrial by-product, has improved workability obtained by using high-fineness powder, long-term strength increased by latent hydraulic reaction, and the function of effectively filling voids.

In consideration of the above-mentioned improvement effect, it is preferable for the fly ash to be contained in the injection binder so as to account for 5 to 30 wt%.

Slag cement has the economic benefit of recycling an industrial by-product, has improved workability obtained by using high-fineness powder, long-term strength increased by latent hydraulic reaction, and the function of effectively filling voids.

In consideration of the above-mentioned improvement effect, it is preferable for slag cement to be contained in the injection binder so as to account for 5 to 30 wt%.

Meanwhile, the superplasticizer functions to improve injection efficiency by forming a lubricating film between

particles, and a polycarbonate-based superplasticizer is preferably used. In consideration of the above-mentioned improvement effect and the material separation phenomenon, it is preferable for the superplasticizer to be contained in the injection binder so as to account for 0.01 to 5 wt%.

The retarder functions to inhibit cement hydration reaction, thereby delaying setting or hardening. That is, the retarder prevents deterioration of workability due to excessively rapid setting, and at least one selected from the group consisting of citric acid, sodium citrate, tartaric acid, and a mixture thereof is preferably used. In consideration of the above-mentioned improvement effect and strength characteristics after hardening, it is preferable for the retarder to be contained in the injection binder so as to account for 0.01 to 5 wt%.

In addition, the injection binder may further include 0.1 to 10 wt% of a magnesium-sericite aggregate, which is an aggregate of magnesium and sericite, whereby it is possible to further improve injection into the ground through the sealing material as well as excellent strength development. Sericite has a small scaly or lobed structure having a small particle size, is fine-grained, provides excellent covering power to protect the composition, prevents the viscosity from decreasing rapidly to prevent solidification of the sealing material, may be injected into the ground through the sealing

material with excellent injection performance, may fill cracks in the ground after injection, and may be integrated with the ground to achieve excellent strength. In addition, sericite is aggregate with magnesium, whereby it is possible to further contribute to early strength improvement by promoting early hydration of latent hydraulic components.

The magnesium-sericite aggregate is preferably prepared using a method including the steps of mixing 100 parts by weight of sericite with 15 to 25 parts by weight of $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, mixing 150 to 300 parts by weight of distilled water with the mixed sericite and $\text{MgCl}_2 \cdot \text{H}_2\text{O}$ and stirring the mixture for 5 to 30 hours, and centrifuging the stirred sericite, $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, and distilled water and extracting supernatant liquid to obtain a magnesium-sericite aggregate.

In addition, the magnesium-sericite aggregate may be prepared using the method further including the steps of mixing the obtained magnesium-sericite aggregate with neohesperidin at a ratio in parts by weight of 1:0.1 to 0.5 and crushing the mixture by ball milling and drying the crushed magnesium-sericite aggregate at a temperature of 50 to 80°C. In this case, it is possible to further improve the above effect and to improve antioxidant performance.

In addition, the quick-setting material preferably includes a quick-setting binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, wherein the quick-setting

binder includes 40 to 70 wt% of gypsum, 5 to 30 wt% of calcium aluminate, 5 to 30 wt% of C12A7, 5 to 30 wt% of blast furnace slag, 0.05 to 5 wt% of sodium hydrogen carbonate, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator. As a result, sodium silicate, which is commonly used to promote hardening of the injection material, is not used, whereby it is possible to remedy an environmental problem, a durability deterioration problem, and a leaching problem. Furthermore, the quick-setting material is mixed with the injection material, whereby it is possible to develop high compressive strength in a short time while further shortening the hardening time of the injection material.

More specifically, gypsum is expanded by hydration reaction, whereby the main injection material is injected into the steel pipe, easily passes through the sealing material, and densely fills the ground. In addition, gypsum is mixed with the injection material to develop high compressive strength in a short time while shortening the hardening time. In consideration of the above-mentioned improvement effect, the hardening time, and the work performance, it is preferable for gypsum to be contained in the quick-setting binder so as to account for 40 to 70 wt%.

Calcium aluminate is mixed with the injection material to develop excellent early compressive strength.

Preferably, calcium aluminate, which is amorphous, includes 30 to 55 wt% of CaO, 15 to 55 wt% of Al₂O₃, 0.1 to 15 wt% of SiO₂, and 0.1 to 15 wt% of Fe₂O₃, and has a molar ratio of CaO/Al₂O₃ of 1.5 or more and a fineness of 3,000 to 7,000 cm²/g.

In consideration of the above-mentioned improvement effect, the hardening time, and the work performance, it is preferable for calcium aluminate to be contained in the quick-setting binder so as to account for 5 to 30 wt%.

C12A7 is mixed with calcium aluminate and the injection material to develop excellent early compressive strength.

Preferably, C12A7 has a fineness of 5,000 to 7,000 cm²/g.

In consideration of the above-mentioned improvement effect, the hardening time, and the work performance, it is preferable for C12A7 to be contained in the quick-setting binder so as to account for 5 to 30 wt%.

The blast furnace slag has the economic benefit of recycling an industrial by-product, has improved workability obtained by using high-fineness powder, long-term strength increased by latent hydraulic reaction, and the function of effectively filling voids.

In consideration of the above-mentioned improvement effect and the work performance, it is preferable for the blast furnace slag to be contained in the quick-setting binder so as to account for 5 to 30 wt%.

Sodium hydrogen carbonate is expanded, whereby the main injection material is injected into the steel pipe, easily passes through the sealing material, and densely fills the ground. In addition, sodium hydrogen carbonate is mixed with the injection material to develop high compressive strength in a short time while shortening the hardening time.

In consideration of the above-mentioned improvement effect and the work performance, it is preferable for sodium hydrogen carbonate to be contained in the quick-setting binder so as to account for 0.05 to 5 wt%.

The superplasticizer functions to improve injection efficiency by forming a lubricating film between particles, and a polycarbonate-based superplasticizer is preferably used. In consideration of the above-mentioned improvement effect and the material separation phenomenon, it is preferable for the superplasticizer to be contained in the quick-setting binder so as to account for 0.01 to 5 wt%.

The hardening accelerator, which shortens the hardening time and minimizes expansion and contraction due to high reactivity thereof, is preferably made of at least one selected from the group consisting of lithium carbonate, sodium hydroxide, and a mixture thereof. In consideration of the above-mentioned improvement effect and strength characteristics after hardening, it is preferable for the hardening accelerator to be contained in the quick-setting

binder so as to account for 0.01 to 5 wt%.

Another embodiment of the present invention provides a steel pipe multistage grouting method using the fast-hardening grout composition for the steel pipe multistage grouting method, the steel pipe multistage grouting method including the steps of:

perforating the ground of a tunnel to be reinforced (S10), inserting a steel pipe into the perforation (S20), filling a sealing material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method, between the steel pipe and the perforation (S30), gelling the filled sealing material (S40), filling the steel pipe inserted into the perforation with a main injection material including an injection material and a quick-setting material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method (S50), and hardening the filled main injection material (S60).

A schematic construction flowchart of the steel pipe multistage grouting method according to the embodiment of the present invention is shown in FIG. 1.

In addition, a photograph of a blind end in a tunnel at which the steel pipe multistage grouting method according to the embodiment of the present invention is performed is shown in FIG. 2.

In addition, a continuous steel pipe installation in a longitudinal direction of a tunnel is shown in FIG. 3.

In the step of perforating the ground of a tunnel to be reinforced (S10), the underground is perforated from a blind end in the tunnel, as shown in FIGs. 2 and 3, wherein perforation is performed such that the angle is widened toward the underground.

In the step of inserting a steel pipe into the perforation (S20), a steel pipe is manufactured to fit the diameter of the perforation hole. In general, unit steel pipes are assembly using a coupler, and the portion of the pipe that protrudes outside the perforation due to the length thereof is cut as needed. A center retaining member may be coupled to the periphery of the steel pipe such that the steel pipe can be installed in the center of the perforation hole in the perforation.

More specifically, the step of filling a sealing material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method, between the steel pipe and the perforation (S30) may include a sealing material injection hose installation step (S31), a packing installation step (S32), a caulking step (S33), and a sealing material filling step (S34).

First, in the sealing material injection hose installation step (S31), a sealing material injection hose

for injection of a sealing material is installed at an inlet side of the perforation in order to inject the sealing material such that a main injection material injected in a subsequent process does not leak.

The packing installation step (S32) is performed at the part corresponding to the inlet of the perforation outside the installed steel pipe. The position of the packing is the position at which a caulking portion can be formed by injection of a caulking material into the inlet of the perforation. The packing is preferably made of an elastic material, such as rubber, in order to improve sealing of the perforation.

In addition, the sealing material injection hose is coupled to the packing, and the sealing material injection hose installation step (S31) and the packing installation step (S32) may be performed as a single operation.

In the caulking step (S33), a caulking material may be injected between the inlet of the perforation and the packing.

In the sealing material filling step (S34), a sealing material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method, is injected through the installed sealing material injection hose such that a sealing portion is formed at a certain section inside the packing.

In the step of gelling the filled sealing material (S40),

the gelation initiation time is dramatically reduced to 3 hours or less while appropriate gelation retention time is secured, thereby enabling smooth penetration of the main injection material and securing excellent injection performance.

The step of filling the steel pipe inserted into the perforation with a main injection material including an injection material and a quick-setting material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method (S50) is performed in the formed sealing portion.

The step of hardening the filled main injection material (S60), the main injection material may develop early compressive strength of at least 2 MPa within 2 hours, whereby it is possible for the main injection material to have excellent compressive strength while setting in a much shorter curing time than the current curing time of about 18 ± 1 hours.

The fast-hardening grout composition for the steel pipe multistage grouting method according to the embodiment of the present invention and the steel pipe multistage grouting method using the same have an effect in that a sealing material having a 3-hour Vicat needle penetration of 10 mm or less is included, whereby it is possible to dramatically shorten gelation initiation time while securing appropriate

gelation retention time, and therefore it is possible to enable smooth penetration of a main injection material and thus to secure excellent injection performance. In addition, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that a main injection material that can develop early compressive strength of at least 2 MPa within 2 hours is included, whereby it is possible for the main injection material to have excellent compressive strength while setting in a much shorter curing time than the current curing time of about 18 ± 1 hours. Furthermore, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that it is possible to improve resistance to cracking due to premature hardening, to improve resistance to material separation, and to improve compensability to shrinkage. As a result, the fast-hardening grout composition and the steel pipe multistage grouting method have an effect in that it is possible to maximize the reinforcement effect of soft ground and a tunnel and to dramatically reduce the overall construction time.

Although the preferred embodiments of the present invention have been described in detail above, the present invention is not limited thereto, and various modifications may be made by a person having ordinary skill in the art within the scope of technical ideas of the present invention.

Manufacture of sealing material

<Example 1>

A slurried sealing material was manufactured by mixing 100 parts by weight of a sealing binder, obtained by mixing 47 wt% of bentonite, 27 wt% of paper sludge incineration ash, 15 wt% of gypsum, 10 wt% of slaked lime, 0.5 wt% of polycarbonate-based superplasticizer, and 0.5 wt% of a hardening accelerator (lithium carbonate) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently stirring the mixture.

At this time, the paper sludge incineration ash included 68.1 wt% of CaO, 15.7 wt% of SiO₂, and 7.3wt% of Al₂O₃ and had a fineness of 4350 cm²/g.

<Example 2>

A slurried sealing material was manufactured by mixing 100 parts by weight of a sealing binder, obtained by mixing 40 wt% of bentonite, 31 wt% of paper sludge incineration ash, 19.5 wt% of gypsum, 7 wt% of slaked lime, 1.5 wt% of plate-shaped graphite coated with alumina on the surface thereof, 0.5 wt% of polycarbonate-based superplasticizer, and 0.5 wt% of a hardening accelerator (lithium carbonate) with each other after introduction thereof into a forced mixer, with

120 parts by weight of mixing water and sufficiently stirring the mixture.

At this time, the paper sludge incineration ash was the same as that used in Example 1 above.

In addition, plate-shaped graphite coated with alumina on the surface thereof was prepared as follows. A slurry was manufactured by adding 200 g of plate-shaped graphite having an average diameter of 8.5 μm and a thickness of 38 nm to a solution including aluminum-tri-sec-butoxide (0.25 mol/L) dissolved in 1000 ml of ethanol and mixing the same under stirring for 1 hour. The slurry was filtered to remove the solution to manufacture plate-shaped graphite coated with aluminum alkoxide. Subsequently, 1000 ml of a solution including water (0.20 mol/L) dissolved in ethanol was added to 120 g of the manufactured aluminum alkoxide-coated plate-shaped graphite under stirring and mixed for 30 minutes to hydrolyze aluminum alkoxide on the surface of plate-shaped graphite. Subsequently, the residual solution was removed by filtering and drying was performed with hot air at 80°C for 2 hours, whereby alumina-coated plate-shaped graphite was prepared.

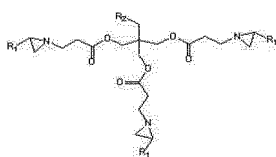
<Example 3>

A slurried sealing material was manufactured by mixing 100 parts by weight of a sealing binder, obtained by mixing

34 wt% of bentonite, 38 wt% of paper sludge incineration ash, 22 wt% of gypsum, 4 wt% of slaked lime, 1 wt% of plate-shaped graphite coated with alumina on the surface thereof, 0.5 wt% of polycarbonate-based superplasticizer, and 0.5 wt% of a hardening accelerator (lithium carbonate) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water, 0.5 parts by weight of a compound represented by Formula 1-1 below, and 0.5 parts by weight of a compound represented by Formula 2-1 below and sufficiently stirring the mixture.

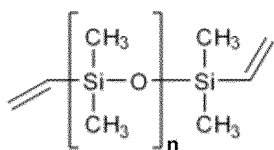
At this time, the paper sludge incineration material and plate-shaped graphite coated with alumina on the surface thereof were the same as those used in Example 2 above.

[Formula 1-1]



In the above formula, R_1 is a methyl group and R_2 is a hydroxyl group.

[Formula 2-1]



In the above formula, n is 5.

<Comparative Example 1>

A slurried sealing material for comparison was manufactured by mixing 100 parts by weight of a sealing binder, obtained by mixing 15 wt% of bentonite, 84 wt% of ordinary Portland cement, 0.5 wt% of polycarbonate-based superplasticizer, and 0.5 wt% of a hardening accelerator (lithium carbonate) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently stirring the mixture.

<Experimental Example 1>

Specimens of the sealing materials manufactured according to Examples 1 to 3 above and the sealing material for comparison manufactured according to Comparative Example 1 were prepared, and the time required for the penetration of a Vicat needle to reach 10 mm (based on the specification of the Korea Railroad Facilities Corporation) was measured as the gelation time.

In addition, the amount of penetration of the Vicat needle was measured 3 hours after injection of the sealing materials manufactured according to Examples 1 to 3 above and the sealing material for comparison manufactured according to Comparative Example 1.

The results of measurements are shown in Table 1 below.

[Table 1]

Classification	Example 1	Example 2	Example 3	Comparative Example 1
Gelation time (hour:min)	2:52	2:39	2:14	24:19
Amount of penetration of Vicat needle	9	8	8	25

It can be seen from Table 1 above that, for the sealing materials manufactured according to Examples 1 to 3 of the present invention, the gelation time and the amount of penetration of the Vicat needle after 3 hours, which was less than 10 mm, were much less than those of the sealing material for comparison manufactured according to Comparative Example 1. In addition, it can be seen that, when a test was performed to confirm the passage of the main injection material after gelation of the sealing materials according to Examples 1 to 3 of the present invention as shown in FIG. 4, the main injection material easily passed through each of the sealing materials manufactured according to Examples 1 to 3 of the present invention while the amount of penetration of the Vicat needle was less than 10 mm.

Therefore, the sealing material of the present invention can dramatically shorten gelation initiation time while

securing appropriate gelation retention time, thereby enabling smooth penetration of the main injection material and securing excellent injection performance.

Manufacture of main injection material

<Example 4>

A main injection material was prepared by stirring a separately prepared injection material and quick-setting material after introduction thereof into a forced mixer at a weight ratio of 1:1.

At this time, the injection material was manufactured by mixing 100 parts by weight of an injection binder, obtained by mixing 64 wt% of microcement (fineness: 6,780 cm²/g and average particle size: 4.7 μm), 12 wt% of calcium sulfoaluminate (fineness: 4,920 cm²/g and Al₂O₃ content: 32.7 μm), 11.8 wt% of fly ash, 12 wt% of slag cement, 0.1 wt% of a polycarbonate-based superplasticizer, 0.1 wt% of a retarder (citric acid) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently stirring the mixture so as to be slurried.

In addition, the quick-setting material was manufactured by mixing 100 parts by weight of a quick-setting binder, obtained by mixing 44 wt% of gypsum, 21 wt% of calcium aluminate, 18 wt% of C12A7 (fineness: 6,140 cm²/g), 16.1 wt% of blast furnace slag, 0.5 wt% of sodium hydrogen carbonate,

0.2 wt% of a polycarbonate-based superplasticizer, and 0.2 wt% of a hardening accelerator (sodium hydroxide) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently stirring the mixture so as to be slurried.

At this time, the calcium aluminate, which is amorphous, included 52.05 wt% of CaO, 27.86 wt% of Al₂O₃, 7.95 wt% of SiO₂, and 3.47 wt% of Fe₂O₃ and had a fineness of 4,140 cm²/g.

<Example 5>

A main injection material was prepared by stirring a separately prepared injection material and quick-setting material after introduction thereof into a forced mixer at a weight ratio of 1:1.

At this time, the injection material was manufactured by mixing 100 parts by weight of an injection binder, obtained by mixing 52 wt% of microcement (fineness: 6,780 cm²/g and average particle size: 4.7 μm), 24 wt% of calcium sulfoaluminate (fineness: 4,920 cm²/g and Al₂O₃ content: 32.7 μm), 7.8 wt% of fly ash, 14.5 wt% of slag cement, 1.5 wt% of an aggregate of magnesium and sericite, i.e. a magnesium-sericite aggregate, 0.1 wt% of a polycarbonate-based superplasticizer, 0.1 wt% of a retarder (citric acid) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently

stirring the mixture so as to be slurried.

At this time, the magnesium-sericite aggregate was prepared using a method including the steps of mixing 100 parts by weight of sericite with 22 parts by weight of $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, mixing 210 parts by weight of distilled water with the mixed sericite and $\text{MgCl}_2 \cdot \text{H}_2\text{O}$ and stirring the mixture for 19 hours, centrifuging the stirred sericite, $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, and distilled water and extracting supernatant liquid to obtain a magnesium-sericite aggregate, crushing the obtained magnesium-sericite aggregate by ball milling, and drying the crushed magnesium-sericite aggregate at a temperature of 70°C .

In addition, the quick-setting material was manufactured by mixing 100 parts by weight of a quick-setting binder, obtained by mixing 52 wt% of gypsum, 17 wt% of calcium aluminate, 18 wt% of C12A7 (fineness: $6,140 \text{ cm}^2/\text{g}$), 12.1 wt% of blast furnace slag, 0.5 wt% of sodium hydrogen carbonate, 0.2 wt% of a polycarbonate-based superplasticizer, and 0.2 wt% of a hardening accelerator (sodium hydroxide) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently stirring the mixture so as to be slurried.

At this time, calcium aluminate was the same as that used in Example 1 above.

<Example 6>

A main injection material was prepared by stirring a separately prepared injection material and quick-setting material after introduction thereof into a forced mixer at a weight ratio of 1:1.

At this time, the injection material and the quick-setting material were the same as those used in Example 5 above, wherein the magnesium-sericite aggregate was prepared using a method including the steps of mixing 100 parts by weight of sericite with 22 parts by weight of $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, mixing 210 parts by weight of distilled water with the mixed sericite and $\text{MgCl}_2 \cdot \text{H}_2\text{O}$ and stirring the mixture for 19 hours, centrifuging the stirred sericite, $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, and distilled water and extracting supernatant liquid to obtain a magnesium-sericite aggregate, mixing the obtained magnesium-sericite aggregate with neohesperidin at a ratio in parts by weight of 1:0.2 and crushing the mixture by ball milling, and drying the crushed magnesium-sericite aggregate at a temperature of 70°C.

<Comparative Example 2>

A main injection material was prepared by stirring a separately prepared injection material for comparison and quick-setting material for comparison after introduction thereof into a forced mixer at a weight ratio of 3:1.

At this time, the injection material for comparison was

manufactured by mixing 100 parts by weight of a binder, obtained by mixing 99.8 wt% of ordinary Portland cement, 0.1 wt% of a polycarbonate-based superplasticizer, and 0.1 wt% of a retarder (citric acid) with each other after introduction thereof into a forced mixer, with 120 parts by weight of mixing water and sufficiently stirring the mixture so as to be slurried.

In addition, soda silicate (water glass) was used as the quick-setting material for comparison.

<Experimental Example 2>

Specimens of the main injection materials manufactured according to Examples 4 to 6 above and the main injection material for comparison manufactured according to Comparative Example 2 were prepared, and the gel time and homogel strength were measured according to a cement strength test method of KS L ISO 679: 2006.

The results of measurements are shown in Table 2 below.

[Table 2]

Classification		Example 4	Example 5	Example 6	Comparative Example 2
Gel time (sec)		52	48	43	75
Homogel strength (MPa)	2 hours	2.64	3.37	3.72	0.11
	4 hours	3.87	4.67	5.02	0.18
	6 hours	4.57	5.42	5.74	0.23

	24 hours	6.78	7.94	8.33	1.25
	3 days	9.04	10.14	10.32	2.94
	7 days	9.87	10.72	10.87	3.12
	28 days	10.24	11.20	11.21	3.59

It can be seen from Table 2 above that each of the main injection materials manufactured according to Examples 4 to 6 of the present invention had shorter gel time and higher homogel strength than those of the main injection material for comparison manufactured according to Comparative Example 2. In the fast-hardening grout composition for the steel pipe multistage grouting method including the sealing material and the main injection material according to the present invention, therefore, it is possible to dramatically shorten the gelation initiation time and to develop early compressive strength of at least 2 MPa within 2 hours, whereby it is possible to achieve excellent compressive strength while achieving fast setting within a very short curing time, and therefore it is possible to reduce work time, to shorten the construction period, to reduce labor and construction costs, and to improve equipment efficiency.

As is apparent from the above description, those skilled in the art to which the present invention pertains will understand that the present invention may be practiced in

other specific forms without altering the technical ideas or essential features thereof. It should therefore be understood that the embodiments described above are all illustrative, not restrictive. The scope of the present invention should be construed to include all altered or modified forms derived from the meaning and scope of the appended claims and equivalents thereto, rather than the detailed description above.

【CLAIMS】

【Claim 1】 A fast-hardening grout composition for a steel pipe multistage grouting method comprising: perforating a ground of a tunnel to be reinforced (S10); inserting a steel pipe into the perforation (S20); filling a sealing material between the steel pipe and the perforation (S30); gelling the filled sealing material (S40); filling the steel pipe inserted into the perforation with a main injection material comprising an injection material and a quick-setting material (S50); and hardening the filled main injection material (S60), wherein

the sealing material comprises a sealing binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the sealing binder comprising 30 to 60 wt% of bentonite, 20 to 50 wt% of paper sludge incineration ash, 10 to 30 wt% of gypsum, 1 to 20 wt% of slaked lime, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator,

the sealing binder further comprises 0.1 to 10 wt% of plate-shaped graphite coated with alumina on a surface thereof,

the plate-shaped graphite coated with alumina on the surface thereof is prepared using a method comprising: manufacturing a slurry by mixing 15 to 30 parts by weight of

plate-shaped graphite having an average diameter of 1 to 10 μm and a thickness of 10 to 60 nm with 100 parts by weight of a solution comprising 0.03 to 0.9 mol/L of aluminum alkoxide dissolved in an alcohol-based solvent and filtering the slurry to manufacture aluminum alkoxide-coated plate-shaped graphite; mixing 5 to 20 parts by weight of the manufactured aluminum alkoxide-coated plate-shaped graphite with 100 parts by weight of a solution comprising 0.03 to 0.5 mol/L of water dissolved in an alcohol-based solvent and coating the surface of plate-shaped graphite with alumina through hydrolysis reaction of the aluminum alkoxide; and removing the residual solution by filtering and drying to obtain alumina-coated plate-shaped graphite,

the main injection material comprises an injection material and a quick-setting material at a weight ratio of 1:0.8 to 1,

the injection material comprises an injection binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the injection binder comprising 40 to 70 wt% of microcement, 5 to 30 wt% of calcium sulfoaluminate, 5 to 30 wt% of fly ash, 5 to 30 wt% of slag cement, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a retarder, and

the quick-setting material comprises a quick-setting binder and mixing water at a water-cement ratio (W/C) of 1.1 to 1.3, the quick-setting binder comprising 40 to 70 wt% of

gypsum, 5 to 30 wt% of calcium aluminate, 5 to 30 wt% of C12A7, 5 to 30 wt% of blast furnace slag, 0.05 to 5 wt% of sodium hydrogen carbonate, 0.01 to 5 wt% of a superplasticizer, and 0.01 to 5 wt% of a hardening accelerator.

【Claim 2】 The fast-hardening grout composition according to claim 1, wherein

the injection binder further comprises 0.1 to 10 wt% of a magnesium-sericite aggregate, which is an aggregate of magnesium and sericite, and

the magnesium-sericite aggregate is prepared using a method comprising:

mixing 100 parts by weight of sericite with 15 to 25 parts by weight of $\text{MgCl}_2 \cdot \text{H}_2\text{O}$;

mixing 150 to 300 parts by weight of distilled water with the mixed sericite and $\text{MgCl}_2 \cdot \text{H}_2\text{O}$ and stirring the mixture for 5 to 30 hours; and

centrifuging the stirred sericite, $\text{MgCl}_2 \cdot \text{H}_2\text{O}$, and distilled water and extracting supernatant liquid to obtain a magnesium-sericite aggregate.

【Claim 3】 The fast-hardening grout composition according to claim 2, wherein the magnesium-sericite aggregate is prepared using the method further comprising:

mixing the obtained magnesium-sericite aggregate with neohesperidin at a ratio in parts by weight of 1:0.1 to 0.5 and crushing the mixture by ball milling; and

drying the crushed magnesium-sericite aggregate at a temperature of 50 to 80°C.

【Claim 4】 A steel pipe multistage grouting method using the fast-hardening grout composition for the steel pipe multistage grouting method according to any one of claims 1 to 3, the steel pipe multistage grouting method comprising:

perforating a ground of a tunnel to be reinforced (S10);

inserting a steel pipe into the perforation (S20);

filling a sealing material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method, between the steel pipe and the perforation (S30);

gelling the filled sealing material (S40);

filling the steel pipe inserted into the perforation with a main injection material comprising an injection material and a quick-setting material, which is a part of the fast-hardening grout composition for the steel pipe multistage grouting method (S50); and

hardening the filled main injection material (S60).