

DESCRIPTION

Title of Invention

ULTRA RAPID HARDENING GROUT MATERIAL, ULTRA RAPID HARDENING GROUT MORTAR, AND HARDENED BODY

Technical Field

[0001]

The present invention relates to an ultra rapid hardening grout material, an ultra rapid hardening grout mortar, and a hardened body, which are used mainly in the civil engineering and construction industry.

Background Art

[0002]

An ultra rapid hardening grout mortar having an ultra rapid hardening property, a self-filling property and a self-leveling property is a material indispensable for a rational execution.

The ultra rapid hardening grout mortar exhibits a necessary strength at a material age of 3 hours, and exhibits, after hardening, a proper expandability. Therefore, the ultra rapid hardening grout mortar is an attractive material which is capable of early performing a firm integration with a structure, and various kinds thereof are proposed (for example, refer to PTLs 1 to 6).

[0003]

However, the conventional ultra rapid hardening grout mortar has a problem in terms of low carbonation resistance in some cases. Further, there is an object to further enhance the bond strength to a reinforcing bar for ensuring integration with a structure and durability.

For imparting carbonation resistance, it is reported (in PTL 7, for example) that the combined use with a polymer emulsion or a specific powder-like drying shrinkage-reducing agent provides an effect of further enhancing the carbonation resistance.

However, the use of the polymer emulsion is indispensable, thereby causing a problem in terms of cost, while carbonation resistance is imparted. Furthermore, the effect of enhancing the bond strength to a reinforcing bar is not confirmed.

Citation List

Patent Literature

[0004]

PTL 1: JPH11-021160A

PTL 2: JPH11-139859A

PTL 3: JP2006-104013A

PTL 4: US4,142,909B

PTL 5: JP2007-001828A

PTL 6: JP5113496B

PTL 7: JP2008-169085A

Summary of Invention

Technical Problem

[0005]

An object of the present invention is to provide an ultra rapid hardening grout material, which contains a specific chlorine content and can enhance durability by further enhancing carbonation resistance, bond strength to a reinforcing bar, and a rust prevention rate of the reinforcing bar; an ultra rapid hardening grout mortar; and a hardened body.

Solution to Problem

[0006]

The present invention is carried out to solve the above problem, and the present inventors have piled up various efforts and have found that an ultra rapid hardening grout material having a specific chlorine amount can further enhance fluidity, carbonation resistance, bond strength to a reinforcing bar, and a rust prevention rate of the reinforcing bar to thereby enhance durability, thus achieving the present invention. The summary of the present invention is as follows.

[1] An ultra rapid hardening grout material, including cement, calcium aluminate, gypsum, a gas foaming substance and a fine aggregate, and having a chlorine content of 3 ppm or more and 1,800 ppm or less.

[2] The ultra rapid hardening grout material according to [1], wherein chemical components of the fine aggregate have a CaO proportion of 85% by mass or more, and a SiO₂ proportion of 0.2% by mass or more and 15% by mass or less.

[3] The ultra rapid hardening grout material according to [1] or [2], wherein

decrease of fineness modulus of the fine aggregate according to JIS A 1121: "Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine" is 70% or more and 100% or less.

[4] The ultra rapid hardening grout material according to any of [1] to [3], wherein chemical components of the fine aggregate have a K_2O proportion of 40 ppm or more and 3,000 ppm or less, a SO_3 proportion of 40 ppm or more and 3,000 ppm or less, a Fe_2O_3 proportion of 0.1% by mass or more and 3.0% by mass or less, and a Al_2O_3 proportion of 0.1% by mass or more and 3.0% by mass or less.

[5] The ultra rapid hardening grout material according to any of [1] to [4], wherein the content ratio of the fine aggregate is 40 parts by mass or more and 300 parts by mass or less with respect to 100 parts by mass of the cement.

[6] An ultra rapid hardening grout mortar, which is obtained by mixing the ultra rapid hardening grout material according to any of [1] to [5] and water.

[7] A hardened body, which is formed by using the ultra rapid hardening grout mortar according to [6].

Advantageous Effects of Invention

[0007]

According to the present invention, an ultra rapid hardening grout material, which contains a specific chlorine content and can enhance durability by further enhancing carbonation resistance, bond strength to a reinforcing bar, and a rust prevention rate of the reinforcing bar, an ultra rapid hardening grout mortar, and a hardened body can be provided.

Description of Embodiments

[0008]

In the following, the present invention is described in detail.

Note that "parts" or "%" in the present specification is on a basis of mass, unless indicated otherwise.

Further, the term "ultra rapid hardening grout mortar" described in the present specification is a collective term including a paste not containing a coarse aggregate, and a mortar containing a fine aggregate.

[0009]

The ultra rapid hardening grout material of the present invention includes cement, calcium aluminate, gypsum, a gas foaming substance, and a fine

aggregate, and the content of chlorine is 3 ppm or more and 1,800 ppm or less.

Focusing on the content of chlorine contained in the ultra rapid hardening grout material in the present invention, it has been found out the content of chlorine affects the bond strength between the ultra rapid hardening grout material and the reinforcing bar. Namely, in the case where the content of chlorine contained in the ultra rapid hardening grout material is less than 3 ppm, the bond strength to a reinforcing bar is lowered, and, in the case where the content of chlorine contained in the ultra rapid hardening grout material is more than 1,800 ppm, the rust prevention effect is lowered.

From the viewpoint of enhancing the bond strength to a reinforcing bar, the content of chlorine contained in the ultra rapid hardening grout material is preferably 30 ppm or more, more preferably 40 ppm or more, further preferably 50 ppm or more, further more preferably 100 ppm or more, particularly preferably 130 ppm or more. Moreover, from the viewpoint that enhancing an effect of preventing rust of the reinforcing bar due to carbonation to enhance the durability, the content of chlorine contained in the ultra rapid hardening grout material is required to be 3 ppm or more and 1,800 ppm or less, and is preferably 1,600 ppm or less, more preferably 1,500 ppm or less, further preferably 1,400 ppm or less.

[0010]

The content of chlorine contained in the ultra rapid hardening grout material can be adjusted, for example, by adding an admixture containing chlorine in preparing the ultra rapid hardening grout material. Incidentally, the content of chlorine can be measured according to the method described in Examples described later.

[0011]

The cement to be used in the present invention is not limited particularly, and examples thereof include various cements such as an ordinary cement, a high-early-strength cement, an ultra high-early-strength cement, a low-heat cement, and a moderate-heat cement, various blended cements prepared by blending the above-described cements with a blast furnace slag, a fly ash, a silica fume or the like, an environmentally conscious type cement (ecocement) produced by using a municipal refuse ash or a sewage sludge incineration ash as a raw material, and a commercially available fine particle cement. The various cements or the various blended cements may be processed into fine powder and then used. Further, those adjusted by increasing or decreasing the content of the component being used

ordinarily in the cement (for example, gypsum) may be used.

In the present invention, from the viewpoint of high fluidity, carbonation resistance, bond strength to a reinforcing bar, and rust prevention, it is preferred to select the ordinary portland cement or the high-early-strength portland cement.
[0012]

From the viewpoint of production cost or strength developing property, the Blaine's specific surface area (hereinafter, also referred to Blaine value) of the cement to be used in the present invention is preferably 2,500 cm²/g or more and 7,000 cm²/g or less, more preferably 2,750 cm²/g or more and 6,000 cm²/g or less, further preferably 3,000 cm²/g or more and 4,500 cm²/g or less.

The Blaine's specific surface area can be obtained according to JIS R 5201 (Physical testing methods for cement).
[0013]

The calcium aluminate (CA) to be used in the present invention is a collective term including compounds mainly containing CaO and Al₂O₃, and examples thereof include amorphous compounds mainly containing a CaO component and an Al₂O₃ component, and crystalline calcium aluminates such as CaO·2Al₂O₃, CaO·Al₂O₃, 12CaO·7Al₂O₃, 11CaO·7Al₂O₃·CaF₂, and 3CaO·3Al₂O₃·CaF₂.

The molar ratio of CaO/Al₂O₃ of the CA is preferably in a range of 0.75 to 3, more preferably in a range of 1 to 2. In the case where the molar ratio of CaO/Al₂O₃ is 0.75 or more, sufficient initial strength developing property is exhibited. In the case where the molar ratio of CaO/Al₂O₃ is 3 or less, sufficient fluidity and usable time are achieved.

Incidentally, the calcium aluminate is preferably amorphous. In the case of using the crystalline calcium aluminate, there may be some cases where sufficient strength development is not exhibited.
[0014]

As a method of obtaining the CA, exemplified is a method of heat-treating a CaO raw material, a Al₂O₃ raw material, and the like in a rotary kiln, an electric furnace, or the like.

Examples of the CaO raw material to be used in producing the CA include calcium carbonate such as lime stone or conch, calcium hydroxide such as slaked lime, and calcium oxide such as quicklime.

Examples of the Al₂O₃ raw material include bauxite, an industrial by-

product called as aluminum residual ash, and the like.

[0015]

In the case of obtaining the CA industrially, there are some cases where the obtained CA contains impurities. Examples thereof include SiO_2 , Fe_2O_3 , MgO , TiO_2 , MnO , Na_2O , K_2O , Li_2O , S, P_2O_5 , and F, and the presence of these impurities is not problematic particularly, as long as the object of the present invention is not substantially inhibited. Specifically, as long as the total amount of the impurities falls within a range of 10% or less, the presence of these impurities is not problematic particularly.

[0016]

The particle size of the CA is not limited particularly, and in general, the Blaine value is preferably from 3,000 to 9,000 cm^2/g , more preferably from 4,000 to 8,000 cm^2/g . The Blaine value of the CA being 3,000 cm^2/g or more, sufficient initial strength developing property is exhibited, and the Blaine value of the CA being 9,000 cm^2/g or less, the fluidity and the usable time are easily ensured.

[0017]

In the present invention, it is preferred to use the CA having an ignition loss of 1% or more, and it is more preferred to use the CA having an ignition loss of 2% or more. The ignition loss of the CA being 1% or more, the fluidity and the usable time are easily ensured and the occurrence of spots is restrained.

A method of adjusting the ignition loss to 1% or more is not limited particularly, and examples thereof include a method of supplying water or hygroscopic moisture, a method of supplying carbon dioxide, and the like.

[0018]

The gypsum to be used in the present invention is a term collectively including gypsums such as anhydrous gypsum, gypsum hemihydrate, and gypsum dihydrate, and is not limited particularly. In view of the strength developing property, it is preferred to use anhydrous gypsum or gypsum hemihydrate, and it is more preferred to use anhydrous gypsum.

[0019]

The particle size of the gypsum is not limited particularly, and in general, the Blaine value is preferably from 3,000 to 9,000 cm^2/g , more preferably from 4,000 to 8,000 cm^2/g . The Blaine value of the gypsum being 3,000 cm^2/g or more, the dimensional stability is good, and the Blaine value of the gypsum being 9,000 cm^2/g or less, the fluidity is easily ensured.

[0020]

The preferred mix proportion of each material per 100 parts by mass of a binder composed of the cement, the CA, and the gypsum is as follows: from 50 to 98 parts by mass of the cement, from 1 to 25 parts by mass of the CA, and from 1 to 25 parts by mass of the gypsum. In the case where the mix proportion falls within the range described above with respect to each material, an ultra rapid hardening grout material achieving the effects of the present invention, namely, an ultra rapid hardening grout material having a high fluidity and being excellent in the carbonation resistance, the bond strength to a reinforcing bar, and the rust prevention, can be obtained.

[0021]

Here, with respect to the mix proportion of the CA or the gypsum per 100 parts by mass of the rapid hardening component composed of the CA and the gypsum, it is preferred that the mix proportion of the CA is from 30 to 70 parts by mass, and the mix proportion of the gypsum is from 70 to 30 parts by mass, and it is more preferred that the mix proportion of the CA is from 40 to 60 parts by mass, and the mix proportion of the gypsum is from 60 to 40 parts by mass. In the case where the mix proportion of the CA is 30 parts by mass or more and the mix proportion of the gypsum is 70 parts by mass or less, the property of developing the initial strength is sufficient and the dimensional stability is good. In the case where the mix proportion of the CA is 70 parts by mass or less and the mix proportion of the gypsum is 30 parts by mass or more, the usable time is easily ensured.

[0022]

The mix proportion of the rapid hardening component is preferably from 2 to 50 parts by mass, more preferably from 10 to 40 parts by mass, with respect to 100 parts by mass of the cement. In the case where the mix proportion of the rapid hardening component is less than 2 parts by mass, being not less than the initial strength developing property, the segregation resistance is good. In the case where the mix proportion of the rapid hardening component is 50 parts by mass or less, an ultra rapid hardening grout material having a high fluidity and being excellent in the carbonation resistance, the bond strength to a reinforcing bar, and the rust prevention, can be obtained.

[0023]

The gas foaming substance to be used in the present invention is one to be

used for an object of restraining subsidence or shrinkage due to bleeding of the ultra rapid hardening grout material not solidified yet after the ultra rapid hardening grout mortar is applied. The gas foaming substance to be used in the present invention is not limited particularly, as long as the substance generates gas after being mixed with water.

[0024]

As the gas foaming substance, an oily substance such as vegetable oil or mineral oil is exemplified. Further, examples of the gas foaming substance include powder substance such as a phosphorus-piece aluminum powder subjected to surface treatment with stearic acid, and aluminum powder produced by an atomization method. Furthermore, examples of the gas foaming substance include a nitrogen gas foaming substance capable of forming foams of a nitrogen gas under an alkali atmosphere, such as an azo compound, a nitroso compound and a hydrazine derivative. Moreover, examples of the gas foaming substance include percarbonates such as sodium percarbonate, potassium percarbonate, and ammonium percarbonate, perborates such as sodium perborate and potassium perborate, permanganates such as sodium permanganate and potassium permanganate, and peroxides such as hydrogen peroxide.

As the gas foaming substance to be used in the present invention, it is preferred to use aluminum powder subjected to surface treatment with stearic acid, since the subsidence-restricting effect is large.

[0025]

The nitrogen gas foaming substance to be used as the gas foaming substance to be used in the present invention includes a compound which generates a nitrogen gas through a reaction with an alkali generated by the cement contained in the ultra rapid hardening grout material at the time when the ultra rapid hardening grout material is mixed along with water. As a byproduct, gas such as carbon oxide, carbon dioxide, or ammonia may be generated.

The nitrogen gas foaming substance to be used in the present invention is not limited particularly, as long as the substance is useful for integrating with a structure, restraining the subsidence or shrinkage of the ultra rapid hardening grout material not solidified yet, or enhancing the crack resistance on being placed under a dry condition.

[0026]

The content ratio of the gas foaming substance is 0.0001 parts by mass or

more and 1 part by mass or less, more preferably 0.0005 parts by mass or more and 0.5 parts by mass or less, further preferably 0.001 parts by mass or more and 0.2 parts by mass or less, with respect to 100 parts by mass of the cement. In the case where the content ratio of the gas foaming substance is not less than the lower limit described above, the sufficient initial expansion effect is imparted. In the case where the content ratio of the gas foaming substance is not more than the upper limit described above, the strength developing property is good.

[0027]

With respect to the chemical components of the fine aggregate to be used in the present invention, it is preferred that the proportion of CaO is 85% by mass or more and the proportion of SiO₂ is 0.2% by mass or more and 15% by mass or less. With respect to the chemical components of the fine aggregate, in the case where the proportion of CaO and the proportion of SiO₂ fall within the respective ranges described above, an ultra rapid hardening grout material having a high fluidity and being excellent in the carbonation resistance, the bond strength to a reinforcing bar, and the rust prevention, can be obtained.

The proportion of CaO is preferably 87% by mass or more, more preferably 89% by mass or more, further preferably 91% by mass or more. The upper limit of the proportion of CaO is not limited particularly, and is preferably 99% by mass or less, more preferably 98.5% by mass or less.

The proportion of SiO₂ is preferably 0.25% by mass or more and 13% by mass or less, more preferably 0.3% by mass or more and 11% by mass or less, further preferably 0.4% by mass or more and 10% by mass or less.

The fine aggregate is prepared by mixing with silica sand, calcite, scapolite, which is metamorphite, quartz, which is an igneous rock, potash feldspar, or the like such that the chemical components of the fine aggregate fall within the ranges described above or later. Each rock is mixed, confirming by fluorescent X-ray diffraction, such that the chemical components fall within the ranges of the present invention. Incidentally, the chemical components of the fine aggregate are those calculated with conversion in terms of an oxide.

[0028]

The fine aggregate to be used in the present invention preferably includes, as the chemical components, K₂O, SO₃, Fe₂O₃, and Al₂O₃. The inclusion of K₂O, SO₃, Fe₂O₃, and Al₂O₃ in the fine aggregate can contribute to a high fluidity, carbonation resistance, bond strength to a reinforcing bar, and a rust prevention.

The proportion of K_2O is preferably 40 ppm or more and 3,000 ppm or less, more preferably 50 ppm or more and 2,500 ppm or less, further preferably 60 ppm or more and 2,250 ppm or less, further more preferably 70 ppm or more and 2,000 ppm or less.

The proportion of SO_3 is preferably 40 ppm or more and 3,000 ppm or less, more preferably 50 ppm or more and 2,500 ppm or less, further preferably 60 ppm or more and 2,250 ppm or less, further more preferably 70 ppm or more and 2,000 ppm or less.

The proportion of Fe_2O_3 is preferably 0.1 or more and 3.0% by mass or less, more preferably 0.13 or more and 2.5% by mass or less, further preferably 0.15 or more and 2.0% by mass or less.

The proportion of Al_2O_3 is preferably 0.1 or more and 3.0% by mass or less, more preferably 0.13 or more and 2.5% by mass or less, further preferably 0.15 or more and 2.0% by mass or less.

[0029]

With respect to the fine aggregate to be used in the present invention, the decrease of fineness modulus according to JIS A 1121: "Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine" is preferably 70% or more and 100% or less, more preferably 75% or more and 99% or less, further preferably 80% or more and 98% or less, further more preferably 85% or more and 97% or less. In the case where the decrease of fineness modulus is not less than the lower limit, the bond strength to a reinforcing bar is enhanced. In the case where the decrease of fineness modulus is not more than the upper limit, the carbonation resistance is enhanced, which contributes to reducing the rust development of a reinforcing bar which is attributable to carbonation. In the present specification, the term "fineness modulus of the fine aggregate" is a value obtainable from the result obtained by performing a sieve analysis, and is an index showing an approximate value of the size of the fine aggregate. In the present specification, the term "decrease of fineness modulus of the fine aggregate" is a ratio of decrease of fineness modulus of the fine aggregate after test according to "Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine", which is obtained by comparing fineness modulus of the fine aggregate before the test with fineness modulus of the fine aggregate after the test.

In order that the decrease of fineness modulus of the fine aggregate falls within the range described above, the fine aggregate is prepared by mixing with

silica sand, calcite, scapolite, which is metamorphite, quartz, which is an igneous rock, potash feldspar, or the like. Each rock is mixed to make adjustments, confirming by "Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine", such that the decrease of fineness modulus of the fine aggregate falls within the range of the present invention.

The producing area or origin of the fine aggregate is not limited particularly, as long as the decrease of fineness modulus of the fine aggregate falls within the range described above.

[0030]

The content ratio of the fine aggregate is preferably 40 parts by mass or more and 300 parts by mass or less, more preferably 75 parts by mass or more and 250 parts by mass or less, further preferably 100 parts by mass or more and 200 parts by mass or less, with respect to 100 parts by mass of the cement. In the case where the content ratio of the fine aggregate is not less than the lower limit described above, the heat generation amount can be decreased, and the shrinkage is restrained so that a crack can be restrained. Further, in the case where the content ratio of the fine aggregate is not more than the upper limit described above, an ultra rapid hardening grout material having a high fluidity and being excellent in the carbonation resistance, the bond strength to a reinforcing bar, and the rust prevention, can be obtained.

[0031]

The ultra rapid hardening grout material of the present invention may contain a siliceous fine powder, along with the cement, calcium aluminate, gypsum, the gas foaming substance, and the fine aggregate, from the viewpoint of providing good dimensional stability, besides improving the strength developing property, enhancing the acid resistance, and ensuring the usable time.

[0032]

Examples of the siliceous fine powder include a latent hydraulic substance such as fine powder of granulated blast furnace slag, and a pozzolan material such as fly ash or silica fume, and among them, silica fume is preferred.

The kinds of silica fume are not limited, and in view of the fluidity, the use of silica fume containing ZrO_2 in an amount of 10% or less as impurities or acidic silica fume is more preferred. The acidic silica fume is one which satisfies the requirement that 1 g of silica fume is put in a pure water of 100 cc and stirred, and the supernatant liquid exhibits an acidity having a pH of 5.0 or less.

[0033]

The fineness of the siliceous fine powder is not limited particularly, but in general, the fine powder of granulated blast furnace slag or the fly ash has a Blaine value of 3,000 cm²/g or more and 9,000 cm²/g or less, and the silica fume has a BET specific surface area of 20,000 cm²/g or more and 300,000 cm²/g or less.

[0034]

The content ratio of the siliceous fine powder is preferably 1 part by mass or more and 20 parts by mass or less, more preferably 2 parts by mass or more and 15 parts by mass or less, further preferably 3 parts by mass or more and 10 parts by mass or less, with respect to 100 parts by mass of the cement. The content ratio of the siliceous fine powder being not less than the lower limit described above, it is possible to improve the strength developing property, enhance the acid resistance, ensure the usable time, and provide good dimensional stability. The content ratio of the siliceous fine powder being not more than the upper limit described above, it is possible to enhance the fluidity and enhance the bond strength to a reinforcing bar and the rust prevention effect.

[0035]

One or two or more of admixtures such as an expansive additive, a water-reducing admixture, a set adjusting admixture, an AE (air-entraining) admixture, a rust preventative, a water repellent, an antibacterial agent, a colorant, an anti-freezing admixture, a fine powder of lime stone, a fine powder of air-cooled blast-furnace slag, a sewage sludge incineration ash or a molten slag thereof, a municipal wastes incineration ash or a molten slag thereof, and a pulp sludge incineration ash; an anti-foaming agent; a thickener; a shrinkage reducing agent; fibrous substances such as steel fiber, vinylon fiber, carbon fiber, and wallastonite fiber; polymers; clay minerals such as bentonite and sepiolite; and anion exchangers such as hydrotalcite; and the like may be used, as long as the object of the present invention is not substantially inhibited.

[0036]

With respect to the ultra rapid hardening grout material of the present invention, a method of mixing the respective materials is not limited particularly, and the respective materials may be mixed at the time of applying, or part or whole thereof may be mixed in advance before applying.

As the mixing equipment, any existing equipment, for example, a tilting barrel-type mixer, an OM mixer (omni-mixer), a Henschel mixer, V-shaped rotating

mixer, or a Nauta® mixer, can be used.

[0037]

The ultra rapid hardening grout mortar of the present invention includes the above-described ultra rapid hardening grout material of the present invention and water, and one obtained by mixing the ultra rapid hardening grout material and water.

The amount of water to be mixed in the present invention varies depending on the object of the use and application, and the content ratio of each component, and therefore, is not limited particularly, but is preferably 10 parts by mass or more and 70 parts by mass or less, more preferably 14 parts by mass or more and 65 parts by mass or less, further preferably 16 parts by mass or more and 60 parts by mass or less, with respect to 100 parts by mass of the ultra rapid hardening grout material. The amount of water to be mixed being not less than the lower limit described above, it is possible to restrain the decrease of the fluidity and an extreme increase of the heat generation amount. The amount of water to be mixed being not more than the upper limit described above, it is possible to ensure the strength developing property.

[0038]

In the present invention, although a method of mixing the ultra rapid hardening grout material and water is not limited particularly, it is preferred to use a hand mixer with a rotation number being 900 rpm or more, an ordinary high-speed grout mixer, or a twin-screw type revolving-paddle mixer.

[0039]

With respect to mixing with a hand mixer or a high-speed grout mixer, it is preferable that water having a prescribed amount is put, in advance, in a container such as a pail can, or a mixer, then the ultra rapid hardening grout mortar composition is charged in the mixer being rotated, and mixed, for 3 minutes or more. With respect to mixing with the revolving-paddle mixer, for example, it is preferable that the ultra rapid hardening grout mortar composition is charged in the mixer in advance, and water having a prescribed amount is put in the mixer being rotated, and mixed, for at least 4 minutes or more. In the case where the mixing time is less than the prescribed time, the shortage in mixing may cause some cases where the ultra rapid hardening grout mortar can not have an appropriate fluidity.

The mixed ultra rapid hardening grout mortar is generally pressure fed to

a part to be applied with a hand-operation type injection-gun, a diaphragm hand-pump, or a mortar pump of squeeze-type etc., and filled and applied therein, thereby providing a hardened material prepared by using the ultra rapid hardening grout mortar of the present invention.

Examples

[0040]

In the following, the present invention is further illustrated based on the experimental examples of the present invention, but the present invention is not limited thereto.

[0041]

[Experimental Example 1]

An ultra rapid hardening grout material was prepared such that the prepared material included 15 parts by mass of the CA, 15 parts by mass of the gypsum, 0.05 parts by mass of the gas foaming substance, 0.5 parts by mass of the water-reducing admixture, and 166.7 parts by mass of the fine aggregate, with respect to 100 parts by mass of the cement. Subsequently, an admixture containing chlorine (material name: sodium chloride) was mixed therein to thereby prepare an ultra rapid hardening grout material.

An ultra rapid hardening grout mortar was prepared by mixing 100 parts by mass of the ultra rapid hardening grout material and 23 parts by mass of water.

The chlorine concentration, fluidity, depth of carbonation, bond strength, and rust development rate of a reinforcing bar of the prepared ultra rapid hardening grout mortars were measured. The results are described in Table 1.

[0042]

<Materials Used>

- Cement: cement prepared experimentally (by using mixed raw materials prepared by a cement plant, various commercially available pure chemicals for adjusting the chemical components, and pure chemicals of calcium sulfate anhydride for adjusting the SO_3 amount), chlorine amount: 1.5 ppm, Blaine value: 3,450 cm^2/g
- CA: molar ratio of $\text{CaO}/\text{Al}_2\text{O}_3$: 1.70, ignition loss: 1.0%, crystalline, main components: $\text{CaO} \cdot \text{Al}_2\text{O}_3$ and $12\text{CaO} \cdot 7\text{Al}_2\text{O}_3$, Blaine value: 5,000 cm^2/g
- Gypsum: calcium sulfate anhydride, commercial product, Blaine value: 4,000 cm^2/g

- Gas foaming substance: azodicarbonamide, commercial product
- Water-reducing admixture: naphthalene-based water-reducing admixture, commercial product (Selflow 110P manufactured by DKS Co. Ltd.)
- Water: tap water
- Fine aggregate: The components for the fine aggregate shown in Table 1 were used for the test. The measurement of the chemical components of the fine aggregate was carried out by a fluorescent X-ray diffraction. For adjusting the chemical components, silica sand (produced in Aichi Prefecture), calcite (CaCO_3), scapolite ($(\text{Na}, \text{Ca}, \text{K})_4\text{Al}_4\text{Si}_9\text{O}_{24}(\text{Cl}, \text{CO}_3, \text{SO}_4)$), which is a metamorphite, quartz (SiO_2), which is an igneous rock, or potash feldspar (KAlSi_3O_8) was mixed to adjust the chemical components.

[0043]

<Measurement Items>

- Chlorine Concentration: With respect to the prepared ultra rapid hardening grout mortars, the chlorine concentration was measured according to JIS R 5202.
- Fluidity: The efflux value through J_{14} funnel was measured under a 30°C atmosphere according to JSCE-F 541 immediately after mixing and 30 minutes after mixing.
- Depth of Carbonation: After being aged in water at 20°C until a material age of 28 days, accelerated carbonation was performed for 12 weeks under an atmosphere having a temperature of 30°C , a relative humidity of 60%, and a carbon dioxide gas concentration of 5%. After the accelerated carbonation, an alcohol solution containing 1% phenolphthalein was sprayed on the cross section of the mortar, and the depth of carbonation was confirmed by measuring the depth from the surface to the colored part to thereby evaluate the carbonation resistance.
- Bond strength: Bond strength to a reinforcing bar at the time of drawing out a round steel having a diameter of 19 mm with an embedding depth of 16 cm was evaluated. For curing, sealed curing at 20°C was carried out, and the test was conducted at a material age of 28 days.
- Rust Development Rate of Reinforcing Bar: A round steel having a diameter of 19 mm with an embedding depth of 18 cm was filled with an ultra rapid hardening grout mortar such that the cover was 10 mm, and subjected to underwater curing at 20°C until a material age of 28 days, and then, accelerated carbonation was carried out for 12 weeks under an atmosphere having a temperature of 30°C , a relative humidity of 60%, and a carbon dioxide gas concentration of 5%. During

the accelerated carbonation test, the test specimen was taken out every 3 weeks, and immersed in water for one day under an atmosphere having a temperature of 20°C, and thus, the accelerated carbonation test was carried out. After the test was finished, the round steel was taken out and the rust was removed with a 10% diammonium hydrogen citrate solution, and then the weight (m_2) of the round steel after the test was measured, and the rust development rate of a reinforcing bar, which is based on the change from the weight (m_1) of the round steel before the test, was calculated according to the following expression.

$$\text{Rust Development Rate of Reinforcing Bar (\%)} = [(m_1 - m_2)/m_1] \times 100$$

[0044]

Table 1

No.	CaO	SiO ₂	Chlorine	Fluidity	Depth of Carbonation	Bond Strength	Rust Development Rate of Reinforcing Bar	Note
	% by mass	% by mass	ppm	sec	mm	N/mm ²	%	
1-1	91	4.8	1.5	7.9	5.1	3.5	6	Comparative Example
1-2	91	4.8	3	8.2	4.3	4.7	0	Example
1-3	91	4.8	200	8.2	4.1	5.2	0	Example
1-4	91	4.8	1800	8.4	4.4	4.9	1	Example
1-5	91	4.8	2000	9.2	5.3	3.6	7	Comparative Example
1-6	10	83	200	8.9	4.8	4.0	4	Example
1-7	85	4.9	210	8.7	4.3	4.8	0	Example
1-8	92	0.2	210	8	4.5	4.8	2	Example
1-9	91	4.8	190	8.2	4.1	5.2	0	Example
1-10	90	15	200	8.5	4.5	4.9	2	Example

[0045]

It has been confirmed from the results shown in Table 1 that by the use of the fine aggregate having the specific chlorine concentration and the specific chemical components, the high fluidity, carbonation resistance and bond strength to a reinforcing bar, and the restraintment of the rust development rate of a reinforcing bar are possible.

[0046]

[Experimental Example 2]

Ultra rapid hardening grout mortars were prepared in the same manner as in Experimental Example 1 except for mixing the respective fine aggregates shown in Table 2. The results are shown in Table 2.

With respect to the test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine, first, 5 kg of the fine aggregate and 6 iron balls were charged in the Los Angeles machine. The average diameter of the iron balls was about 46.8 mm, and the mass of each iron ball fell within a range of from 390 to 445 g. Next, rotation by the Los Angeles machine was performed 500 times (30 rotations/minute). Then, the fine aggregate collected from the Los Angeles machine was subjected to sieving with net sieves made of metal each having a sieve mesh of 5 mm, 2.5 mm, 1.2 mm, 0.6 mm, 0.3 mm, or 0.15 mm. Comparing the fineness modulus (R_1) of the fine aggregate before charging in the Los Angeles machine and the fineness modulus (R_2) of the fine aggregate after charging in the Los Angeles machine, the decrease of the fineness modulus after the test was calculated according to the following expression.

$$\text{Decrease of Fineness Modulus} = R_2 / R_1$$

[0047]

Table 2

No.	CaO	SiO ₂	Chlorine	Decrease of Fineness Modulus	Fluidity	Depth of Carbonation	Bond Strength	Rust Development Rate of Reinforcing Bar	Note
	% by mass	% by mass	ppm	%	sec	mm	N/mm ²	%	
2-1	86	3.1	190	70	8.7	5.0	4.3	2	Example
2-2	89	3.9	200	85	8.2	4.1	4.2	1	Example
2-3	91	4.8	210	93	8.2	4.1	5.2	0	Example
1-3	91	4.8	200	98	8.2	4.1	5.1	0	Example
2-4	89	4.9	200	100	9.1	4.9	4.2	2	Example

[0048]

It has been confirmed from the results shown in Table 2 that by the use of the fine aggregate having the specific chlorine concentration, the specific chemical

components, and the decrease of fineness modulus which falls within the specific range, the high fluidity, carbonation resistance and bond strength to a reinforcing bar, and the restraintment of the rust development rate of a reinforcing bar are possible.

[0049]

[Experimental Example 3]

Ultra rapid hardening grout mortars were prepared in the same manner as in Experimental Example 2 except for mixing the respective fine aggregates shown in Table 3. The results are shown in Table 3.

[0050]

Table 3

No.	CaO	SiO ₂	Chlorine	Decrease of Fineness Modulus	K ₂ O	SO ₃	Fe ₂ O ₃	Al ₂ O ₃	Fluidity	Depth of Carbonation	Bond Strength	Rust Development Rate of Reinforcing Bar	Note
	% by mass	% by mass	ppm	%	ppm	ppm	% by mass	% by mass	sec	mm	N/mm ²	%	
3-1	90	4.9	190	83	40	1000	0.6	0.8	8.5	4.5	4.8	1	Example
1-3	91	4.8	200	85	940	930	0.7	0.8	8.2	4.1	5.2	0	Example
3-2	89	0.1	200	84	3000	940	0.2	1.2	9.1	4.4	4.9	1	Example
3-3	90	4.8	180	86	930	40	1.1	0.3	8.8	4.3	5.1	1	Example
3-4	92	4.2	200	87	890	3000	0.3	1.2	8.7	4.6	4.9	1	Example
3-5	90	4.9	180	88	930	1000	0.1	0.7	8.9	4.4	4.9	1	Example
3-6	91	5	190	87	780	900	3	0.5	8.6	4.6	4.8	1	Example
3-7	90	5.1	190	86	930	900	0.6	0.1	8.8	4.4	4.8	0	Example
3-8	90	4.5	200	88	890	940	0.5	3	8.5	4.5	4.9	1	Example

[0051]

It has been confirmed from the results shown in Table 3 that by the use of the fine aggregate having the specific chlorine concentration, the specific chemical components, and the decrease of fineness modulus which falls within the specific range, the high fluidity, carbonation resistance and bond strength to a reinforcing bar, and the restraintment of the rust development rate of a reinforcing bar are possible.

Industrial Application

[0052]

The ultra rapid hardening grout material of the present invention has the specific chlorine concentration, and therefore, provides an ultra rapid hardening grout mortar exhibiting an enhanced fluidity, carbonation resistance, bond strength to a reinforcing bar, and rust prevention rate of a reinforcing bar, and enhanced durability. The ultra rapid hardening grout mortar can be widely utilized for a bridge pier reinforcing construction method with steel plate lining, a large shoe seat filling method, an anchoring material for reinforcing steel, the other gap filling, repairing section of concrete, a self-leveling floor material, anchoring to reinforcing steel or the like, application for civil engineering and construction, and the like.

CLAIMS

[Claim 1]

An ultra rapid hardening grout material, comprising cement, calcium aluminate, gypsum, a gas foaming substance and a fine aggregate, and having a chlorine content of 3 ppm or more and 1,800 ppm or less.

[Claim 2]

The ultra rapid hardening grout material according to claim 1, wherein chemical components of the fine aggregate have a CaO proportion of 85% by mass or more, and a SiO₂ proportion of 0.2% by mass or more and 15% by mass or less.

[Claim 3]

The ultra rapid hardening grout material according to claim 1 or 2, wherein decrease of fineness modulus of the fine aggregate according to JIS A 1121: "Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine" is 70% or more and 100% or less.

[Claim 4]

The ultra rapid hardening grout material according to any one of claims 1 to 3, wherein chemical components of the fine aggregate have a K₂O proportion of 40 ppm or more and 3,000 ppm or less, a SO₃ proportion of 40 ppm or more and 3,000 ppm or less, a Fe₂O₃ proportion of 0.1% by mass or more and 3.0% by mass or less, and a Al₂O₃ proportion of 0.1% by mass or more and 3.0% by mass or less.

[Claim 5]

The ultra rapid hardening grout material according to any one of claims 1 to 4, wherein the content ratio of the fine aggregate is 40 parts by mass or more and 300 parts by mass or less with respect to 100 parts by mass of the cement.

[Claim 6]

An ultra rapid hardening grout mortar, which is obtained by mixing the ultra rapid hardening grout material according to any one of claims 1 to 5 and water.

[Claim 7]

A hardened body, which is formed by using the ultra rapid hardening grout mortar according to claim 7.