

DESCRIPTION

Title of Invention

GROUT MATERIAL, GROUT MORTAR, AND CURED BODY

Technical Field

[0001]

The present invention relates to a grout material used mainly in the civil engineering and construction fields, grout mortar, and a cured body using the grout mortar.

Background Art

[0002]

A grout material has been used for improving the workability and the fillability of mortar and concrete, so as to perform grout work smoothly.

The major applications thereof include the construction of underground structures, the installation of bridge bearings, the installation of equipments, the filling of gaps of walls and posts in earthquake-resistant reinforcement, and the like, and for filling the gaps of structures for integration, there are such demands as (1) the required fluidity corresponding to the filling space, the filling method, and the like, (2) the non-shrinkage property causing no bleeding, sinkage, nor voids after filling, and (3) the required strengths corresponding to the use condition of the structure (see, for example, NPL 1).

[0003]

A cement cured body decreases in volume through hydration or drying of cement, and therefore there is a danger of occurrence of cracks and decrease in adhesion capability to the existing structure. The occurrence of cracks not only impairs the appearance but also causes a danger of adverse effects on the stability, the waterproof capability, and the water tightness of the structure.

In view of the above, an expanding material has been used for the purpose of compensation of the shrinkage of cement, thereby suppressing the occurrence of cracks and retaining the adhesion capability to the structure, and examples thereof include a calcium sulfonate aluminate-based expanding material (i.e., a hauyne-based expanding material) containing $3\text{CaO} \cdot 3\text{Al}_2\text{O}_3 \cdot \text{CaSO}_4$ (hauyne), CaSO_4 , and CaO as major components, and a lime-based expanding material containing free

lime as a major component, and also include expanding materials containing free lime, a hydraulic substance, and a gypsum material.

[0004]

A grout material is proposed that has a small temperature dependency, a significantly high effect of retaining the fluidity and the fillability, and has an effect of enhancing the strength imparted for a long time, by combining cement and an expanding material, and also a particular water reducing agent (see, for example, PTL 1).

Furthermore, a high strength grout material is proposed that retains an excellent fluidity, suppression of bubbles, a suitable change rate in length, and a volume expansion rate (see, for example, PTL 2).

[0005]

However, the ordinary grout material containing an expanding material is invaded by water from the outside in storing beyond the quality assurance period, is lowered in effect of retaining the fluidity and in expanding capability particularly at a high temperature, and may have a danger of occurrence of cracks in the cured body due to corrosion of a reinforcing steel bar through the brine damage, and the decrease in adhesion capability to the structure.

Under the circumstances, there is a demand of securing the integration with the structure and the durability through an increased adhesion strength to the reinforcing steel bar.

Citation List

Patent Literatures

[0006]

PTL 1: Japanese Patent No. 3,894,780B

PTL 2: WO 2007/029399

Non-patent Literature

[0007]

NPL 1: Shin Cement-Concrete-ko Konwa Zairyo (New Admixture Materials for Cement and Concrete), pp. 304-307, KASAI Yoshio and SAKAI Etsuo, Gijutsu Shoin, Co., Ltd., January 15, Heisei-19 (2007)

Summary of Invention

Technical Problem

[0008]

An object of the present invention is to provide a grout material that is enhanced in fluidity, brine damage resistance, adhesion strength to a reinforcing steel bar, and rust inhibiting rate of a reinforcing steel bar, thereby enhancing the durability, grout mortar, and a cured body.

Solution to Problem

[0009]

The present invention has been made for solving the problem. As a result of various efforts performed by the present inventors for solving the problem, it has been found that a grout material prepared by combining a particular fine aggregate can enhance the fluidity, the brine damage resistance, the adhesion strength to a reinforcing steel bar, and the rust inhibiting rate of a reinforcing steel bar, thereby enhancing the durability, and thus the present invention has been completed. The substance of the present invention is as follows.

[1] A grout material containing cement, an expanding material, a gas foaming substance, a water reducing agent, and a fine aggregate, the grout material having an amount of chlorine of 3 ppm or more and 1,800 ppm or less.

[2] The grout material according to the item [1], wherein the expanding material contains ternesite, and has a content of the ternesite of 0.05 part by mass or more and 20 parts by mass or less per 100 parts by mass of the expanding material.

[3] The grout material according to the item [1] or [2], wherein the fine aggregate has a chemical composition having a proportion of CaO of 85% by mass or more and a proportion of SiO₂ of 0.2% by mass or more and 15% by mass or less.

[4] The grout material according to any one of the items [1] to [3], wherein the fine aggregate has a reduction in fineness modulus by the "test for resistance to abrasion of coarse aggregate by the Los Angeles machine" according to JIS A1121 of 70% or more and 100% or less.

[5] The grout material according to any one of the items [1] to [4], wherein the fine aggregate has a chemical composition having a proportion of K₂O of 40 ppm or more and 3,000 ppm or less, a proportion of SO₃ of 40 ppm or more and 3,000 ppm or less, a proportion of Fe₂O₃ of 0.1% by mass or more and 3.0% by mass or less, and a proportion of Al₂O₃ of 0.1% by mass or more and 3.0% by mass or less.

[6] The grout material according to any one of the items [1] to [5], wherein the grout material has a content ratio of the fine aggregate of 40 parts by mass or more and 300 parts by mass or less per 100 parts by mass of the cement.

[7] A grout mortar containing the grout material according to any one of the items [1] to [6] and water kneaded with each other.

[8] A cured body containing the grout mortar according to the item [7].

Advantageous Effects of Invention

[0010]

The present invention can provide a grout material that is enhanced in fluidity, brine damage resistance, adhesion strength to a reinforcing steel bar, and rust inhibiting rate of a reinforcing steel bar, thereby enhancing the durability, grout mortar, and a cured body.

Description of Embodiments

[0011]

The present invention will be described in detail below.

The parts and percentages in the description herein each are based on mass unless otherwise indicated.

The grout mortar referred in the description herein is a comprehensive term for a paste containing no coarse aggregate and mortar containing a fine aggregate.

[0012]

The grout material of the present invention contains cement, an expanding material, a gas foaming substance, a water reducing agent, and a fine aggregate, and has an amount of chlorine of 3 ppm or more and 1,800 ppm or less.

In the grout material of the present invention, the amount of chlorine contained is focused, and it has been found that the amount of chlorine influences the adhesion strength of the grout material and a reinforcing steel bar. Specifically, in the case where the amount of chlorine contained in the grout material is less than 3 ppm, the adhesion strength to a reinforcing steel bar is lowered. In the case where the amount of chlorine contained in the grout material exceeds 1,800 ppm, the rust inhibiting effect is lowered.

The amount of chlorine contained in the grout material is preferably 30 ppm or more, more preferably 40 ppm or more, further preferably 50 ppm or more,

still further preferably 100 ppm or more, and particularly preferably 130 ppm or more, from the standpoint of enhancing the adhesion strength to a reinforcing steel bar. The amount of chlorine contained in the grout material is necessarily 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, and further preferably 1,400 ppm or less, from the standpoint of enhancing the rust inhibiting effect of a reinforcing steel bar for enhancing the durability.

[0013]

The amount of chlorine contained in the grout material can be regulated, for example, by adding an admixture containing chlorine in the production of the grout material. The amount of chlorine can be measured by the method described in the examples described later.

[0014]

The cement used in the present invention is not particularly limited, examples of which include various types of cement, such as ordinary, high early strength, ultrahigh early strength, low heat, and moderate heat, various types of mixed cement obtained by mixing blast furnace slag, fly ash, silica fume or the like to the above cement, environment friendly cement (eco-cement) produced from municipal waste incineration ash and sewage sludge incineration ash as a raw material, and commercially available fine particle cement, and various types of cement and various types of mixed cement having been micronized may also be used. Cement obtained by increasing or decreasing the amount of the component that is ordinarily used in cement (such as gypsum) may also be used.

In the present invention, ordinary Portland cement or high early strength Portland cement is preferably selected from the standpoint of the high fluidity, the brine damage resistance, the adhesion strength to a reinforcing steel bar, and the rust inhibition thereof.

[0015]

The cement used in the present invention preferably has a Blaine specific surface area value of 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, and further preferably 3,000 cm²/g or more and 4,500 cm²/g or less, from the standpoint of the production cost and the strength exhibiting capability.

The Blaine specific surface area value is obtained according to JIS R5201 (physical testing methods for cement).

[0016]

The expanding material used in the present invention is not particularly limited, and any material that can form an expansive hydrate to suppress the bleeding may be used.

Expanding materials containing free lime, free magnesia, calcium ferrite, an ettringite-based material, a lime-based material, or an ettringite-lime-based complex material have been known, and an expanding material containing free lime is preferred from the standpoint of the long-term stability, while not particularly limited. Examples of the expanding material containing free lime include a free lime-anhydrous gypsum-based material, a free lime-hydraulic compound-based material, and a free lime-hydraulic compound-anhydrous gypsum-based material.

The expanding material used in the present invention preferably contains ternesite. Ternesite is a mineral represented by $5\text{CaO} \cdot 2\text{SiO}_2 \cdot \text{SO}_3$, and accelerates the hydraulic reaction. Furthermore, ternesite substantially does not engage in the reaction, and therefore is expected to function like a filler to improve the fluidity retaining capability. Accordingly, the effect of retaining fluidity can be held event at a high temperature.

The content of ternesite is preferably 0.05 part by mass or more and 20 parts by mass or less, more preferably 0.1 part by mass or more and 18 parts by mass or less, and further preferably 0.5 part by mass or more and 15 parts by mass or less, per 100 parts by mass of the expanding material. Ternesite contained in an amount within the range can improve both the curing acceleration and the fluidity retaining capability.

In the present invention, a free lime-hydraulic compound-anhydrous gypsum-based material is preferably used, and the material having a free lime content exceeding 40% is particularly preferred, due to the good expanding capability thereof.

Examples of the hydraulic compound herein include one kind or two or more kinds of hauyne, calcium ferrite, calcium aluminoferrite, calcium silicate, calcium aluminate. In the present invention, an expanding material and a non-explosive demolition agent that are commercially available may be used as the expanding material.

The expanding material and the non-explosive demolition agent are available from various companies, and examples thereof include "Denka CSA #20"

and "Denka Power CSA", produced by Denka Co., Ltd., "Expan", "Hyper Expan", "N-EX", and "Bristar", produced by Taiheiyo Materials Corporation, and crushed materials thereof.

[0017]

The grain size of the expanding material used in the present invention is not particularly limited, and is, in terms of Blaine specific surface area value, preferably 2,000 cm²/g or more and 25,000 cm²/g or less, more preferably 2,200 cm²/g or more and 15,000 cm²/g or less, and further preferably 2,400 cm²/g or more and 10,000 cm²/g or less. In the case where the Blaine specific surface area value of the expanding material is the lower limit value or more, the bleeding can be suppressed. In the case where the Blaine specific surface area value of the expanding material is the upper limit value or less, the sufficient expansion capability can be obtained.

[0018]

The content ratio of the expanding material used in the present invention is preferably 0.5 part by mass or more and 20 parts by mass or less, more preferably 1.0 part by mass or more and 18 parts by mass or less, and further preferably 2 parts by mass or more and 15 parts by mass or less, per 100 parts by mass of the cement. In the case where the content ratio of the expanding material is the lower limit value or more, the effect of suppressing cracks can be easily obtained. In the case where the content ratio of the expanding material is the upper limit value or less, the strength exhibiting capability can be improved. In the case where the content ratio of the expanding material is in the range, the grout material satisfying the effects of the present invention, i.e., the grout material that has high fluidity and brine damage resistance, and excellent adhesion strength to a reinforcing steel bar and rust inhibition thereof, can be easily obtained.

[0019]

The gas foaming substance used in the present invention is used for the purpose of suppressing sinkage and shrinkage due to bleeding of the grout material that is in the non-cured state after executing the grout mortar. The gas foaming substance used in the present invention may be any material that generates gas after kneading with water, with no particular limitation.

[0020]

Examples of the gas foaming substance include an oily substance, such as a vegetable oil and a mineral oil. Examples of the gas foaming substance also

include a powder substance, such as flaky aluminum powder surface-treated with stearic acid and aluminum powder produced by the atomizing method. Examples of the gas foaming substance also include a nitrogen gas foaming substance generating nitrogen gas under an alkali atmosphere, such as an azo compound, a nitroso compound, and a hydrazine derivative. Examples of the gas foaming substance also include a percarbonate salt, such as sodium percarbonate, potassium percarbonate, and ammonium percarbonate, a perborate salt, such as sodium perborate and potassium perborate, a permanganate salt, such as sodium permanganate and potassium permanganate, and a peroxide substance, such as hydrogen peroxide.

The gas foaming substance used in the present invention is preferably aluminum powder surface-treated with stearic acid or the like due to the large sinkage suppressing effect thereof.

[0021]

The nitrogen gas foaming substance used as the gas foaming substance used in the present invention contains a compound that generates nitrogen gas through reaction with an alkali formed in kneading the cement contained in the grout material with water, and may by-produce a gas, such as carbon monoxide, carbon dioxide, and ammonia.

The nitrogen gas foaming substance used in the present invention is not particularly limited, as far as the substance can be used for integrating with the structure, for suppressing the sinkage and shrinkage of the uncured grout mortar, and for enhancing the crack resistance in standing in a dry condition.

[0022]

The content ratio of the gas foaming substance is preferably 0.0001 part by mass or more and 1 part by mass or less, more preferably 0.0005 part by mass or more and 0.5 part by mass or less, and further preferably 0.001 part by mass or more and 0.2 part by mass or less, per 100 parts by mass of the cement. In the case where the content ratio of the gas foaming substance is the lower limit value or more, the sufficient initial expansion effect can be imparted. In the case where the content ratio of the gas foaming substance is the upper limit value or less, the strength exhibiting capability is improved.

[0023]

The water reducing agent used in the present invention assists the dispersion of the materials and also has a function imparting fluidity to the

kneaded grout mortar.

[0024]

The water reducing agent used in the present invention is not particularly limited, examples of which include a naphthalene-based water reducing agent, a melamine-based water reducing agent, an aminosulfonic acid-based water reducing agent, and a polycarboxylic acid-based water reducing agent, and one kind or two or more kinds of the water reducing agent among these may be used in the present invention.

As for specific examples of the water reducing agent, examples of the naphthalene-based water reducing agent include "Rheobuild SP-9 Series", a trade name, produced by NMB, Ltd., and "Mighty 2000 Series", a trade name, produced by Kao Corporation, and "Sunflow HS-100", a trade name, produced by Nippon Paper Industries, Co., Ltd. Examples of the melamine-based water reducing agent include "Sikament 1000 Series", a trade name, produced by Sika, Ltd., and "Sunflow HS-40", a trade name, produced by Nippon Paper Industries, Co., Ltd. Examples of the aminosulfonic acid-based water reducing agent include "Parik FP-200 Series", a trade name, produced by Fujisawa Pharmaceutical Co., Ltd. Examples of the polycarboxylic acid-based water reducing agent include "Rheobuild SP-8 Series", a trade name, produced by NMB, Ltd., "Darex Super 100 PHX", a trade name, produced by Grace Chemicals K.K., and "Chupol HP-8 Series" and "Chupol HP-11 Series", trade names, produced by Takemoto Oil & Fat Co., Ltd.

The water reducing agent includes ones in a powder form. Specifically, examples of the naphthalene-based water reducing agent include "Mighty 100", a trade name, produced by Kao Corporation, "Sanyo Levelon P", a trade name, produced by Sanyo Chemical Industries, Ltd., and "CellufLOW 110P", a trade name, produced by DKS Co., Ltd. Examples of the melamine-based water reducing agent include "Melment F10M", produced by BASF Pozzoloth, Ltd. Examples of the polycarboxylic acid-based water reducing agent include "Quinflow 750", a trade name, produced by Mitsubishi Kasei Corporation, and "CAD 9000P", a trade name, produced by Kao Corporation.

[0025]

The content ratio of the water reducing agent in terms of solid content is preferably 0.1 part by mass or more and 2 parts by mass or less, more preferably 0.2 part by mass or more and 1.8 parts by mass or less, and further preferably 0.3 part by mass or more and 1.0 part by mass or less, per 100 parts by mass of the

cement. In the case where the content ratio of the water reducing agent is the lower limit value or more, the sufficient fluidity can be obtained. In the case where the content ratio of the water reducing agent is the upper limit value or less, the materials can be suppressed from being separated.

[0026]

The chemical composition of the fine aggregate used in the present invention preferably has a proportion of CaO of 85% by mass or more and a proportion of SiO₂ of 0.2% by mass or more and 15% by mass or less. In the case where the chemical composition of the fine aggregate has a proportion of CaO and a proportion of SiO₂ within the ranges, the grout material that has high fluidity and neutralization resistance, and excellent adhesion strength to a reinforcing steel bar and rust inhibition thereof can be obtained.

The proportion of CaO is preferably 87% by mass or more, more preferably 89% by mass or more, and further preferably 91% by mass or more. The upper limit of the proportion of CaO is not particularly limited, and is preferably 99% by mass or less, and 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, and further preferably 0.4% by mass or more and 10% by mass or less.

For allowing the chemical composition of the fine aggregate within the aforementioned range and the range described later, the fine aggregate may be prepared by mixing silica sand, calcite, scapolite as a metamorphic rock, quartz and potassium feldspar as igneous rocks, and the like. The chemical composition is regulated to the range of the present invention by mixing the rocks under confirmation by fluorescent X-ray diffraction. The chemical composition of the fine aggregate used in the present invention is calculated as oxide conversion.

[0027]

The fine aggregate used in the present invention preferably has a chemical composition containing K₂O, SO₃, Fe₂O₃, and Al₂O₃. In the case where the fine aggregate contains K₂O, SO₃, Fe₂O₃, and Al₂O₃, high fluidity and neutralization resistance, and adhesion strength to a reinforcing steel bar and rust inhibition thereof can be obtained.

The proportion of K₂O 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, and still further 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, and still further preferably 70 ppm or more and 2,000 ppm or less.

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

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

[0028]

The fine aggregate used in the present invention preferably has a reduction in fineness modulus by the "test for resistance to abrasion of coarse aggregate by the Los Angeles machine" according to JIS A1121 of 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, and still further preferably 85% or more and 97% or less. In the case where the reduction in fineness modulus of the fine aggregate is the lower limit value or more, the adhesion force to a reinforcing steel bar can be enhanced. In the case where the reduction in fineness modulus of the fine aggregate is the upper limit value or less, the brine damage resistance can be enhanced. In the description herein, the "fineness modulus of the fine aggregate" is a value that is obtained from the result of sieving, and is an index showing an approximate value of the size of the fine aggregate. In the description herein, the "reduction in fineness modulus of the fine aggregate" means the reduction rate of the fineness modulus after the test in the comparison between the fineness modulus before the test for resistance to abrasion of coarse aggregate by the Los Angeles machine and the fineness modulus after the test.

For allowing the reduction in fineness modulus of the fine aggregate within the aforementioned range, the fine aggregate may be prepared by mixing silica sand, calcite, scapolite as a metamorphic rock, quartz and potassium feldspar as igneous rocks, and the like. The reduction in fineness modulus of the fine aggregate is regulated to the range of the present invention by mixing the rocks under confirmation by the test for resistance to abrasion of coarse aggregate by the Los Angeles machine.

The production region and the origin of the fine aggregate are not particularly limited, as far as the reduction in fineness modulus of the fine aggregate is in the range.

[0029]

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, and further preferably 100 parts by mass or more and 200 parts by mass or less, per 100 parts by mass of the cement. In the case where the content ratio of the fine aggregate is the lower limit value or more, the heat generation amount can be reduced to suppress the shrinkage, thereby suppressing cracks from occurring. In the case where the content ratio of the fine aggregate is the upper limit value or less, the grout material that has high fluidity and brine damage resistance, and excellent adhesion strength to a reinforcing steel bar and rust inhibition thereof can be obtained.

[0030]

The grout material of the present invention may contain siliceous fine powder along with the cement, the expanding material, the gas foaming substance, the water reducing agent, and the fine aggregate, from the standpoint of improving the strength exhibiting capability, enhancing the acid resistance, securing the usable time, and furthermore improving the dimensional stability.

[0031]

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

The kind of the silica fume is not limited, and silica fume containing ZrO_2 in an amount of 10% or less as an impurity, and acidic silica fume are preferably used from the standpoint of the fluidity. The acidic silica fume means silica fume that provides a supernatant showing acidity of pH 5.0 or less in adding 1 g of the silica fume in 100 cc of pure water, followed by stirring.

[0032]

The powder fineness of the siliceous fine powder is not particularly limited, and is generally in a range of 3,000 cm^2/g or more and 9,000 cm^2/g or less in terms of Blaine value for granulated blast furnace slag and fly ash, and in a range of 20,000 cm^2/g or more and 300,000 cm^2/g or less in terms of BET specific surface area for silica fume.

[0033]

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, and further preferably 3 parts by mass or more and 10 parts by mass or less, per 100 parts by mass of the cement. In the case where the content ratio of the siliceous fine powder is the lower limit value or more, the strength exhibiting capability can be improved, the acid resistance can be enhanced, the usable time can be secured, and the dimensional stability can be improved. In the case where the content ratio of the siliceous fine powder is the upper limit value or less, the fluidity can be enhanced, the adhesion force to a reinforcing steel bar and the rust inhibition thereof can be enhanced.

[0034]

In the present invention one kind or two or more kinds of a setting modifier, an air entraining agent, a rust inhibitor, a water repellent, an antibacterial agent, a colorant, an anti-freezing agent, an admixture material, such as limestone fine powder, air-cooled blast furnace slag fine powder, sewage sludge incineration ash and molten slug thereof, municipal waste incineration ash and molten slug thereof, and pulp sludge incineration ash, an anti-foaming agent, a thickener, a shrinkage reducer, a fibrous substance, such as steel fibers, vinylon fibers, carbon fibers, and wollastonite fibers, a polymer, a clay mineral, such as bentonite and sepiolite, and an anion exchanger, such as hydrotalcite, may be used in such a range that does not adversely affect the performance and substantially does not impair the object of the present invention.

[0035]

The grout material of the present invention is not particularly limited in mixing method of the materials, and the materials may be mixed in the execution thereof, or a part or the whole thereof may be mixed in advance.

The mixing device used may be any device, and for example, a tilting mixer, an omni mixer, a Henschel mixer, a V-type mixer, and a Nauta Mixer may be used.

[0036]

The grout mortar of the present invention contains the grout material of the present invention described above and water, and obtained by kneading the grout material and water.

The amount of water to be kneaded in the present invention is not particularly limited since the amount thereof vary depending on the object and

purpose in use and the content ratios of the materials, and 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, and further preferably 16 parts by mass or more and 60 parts by mass or less, per 100 parts by mass of the grout material. In the case where the amount of water to be kneaded is the lower limit value or more, the fluidity can be suppressed from being decreased, and the heat generation amount can be suppressed from being increased significantly. In the case where the amount of water to be kneaded is the upper limit value or less, the strength exhibiting capability can be secured.

[0037]

In the present invention, the kneading method of the grout material and water is not particularly limited, and a hand mixer having a rotation number of 900 rpm or more, an ordinary high-speed grout mixer, or a twin screw forced mixer is preferably used.

[0038]

The kneading with a hand mixer or a high-speed grout mixer is preferably performed, for example, in such a manner that the prescribed amount of water is placed in advance in a vessel, such as a bucket canister, or the mixer, and then the grout mortar composition is placed therein while rotating the mixer, followed by kneading for 3 minutes or more. The kneading with a forced mixer is preferably performed, for example, in such a manner that the grout mortar composition is placed in advance in the mixer, and then the prescribed amount of water is placed therein while rotating the mixer, followed by kneading for at least 4 minutes or more. In the case where the kneading time is less than the prescribed period of time, the suitable fluidity of the grout mortar cannot be obtained in some cases due to the shortage in kneading.

The kneaded grout mortar is generally delivered to the construction site under pressure and filled with a hand injection gun, a diaphragm type hand pump, a squeeze type mortar pump, or the like, thereby forming a cured body of the grout mortar of the present invention.

Examples

[0039]

The present invention will be further described with reference to experimental examples of the present invention shown below, but the present

invention is not limited thereto.

[0040]

[Experimental Example 1]

A grout material was prepared by regulating 11.1 parts by mass of an expanding material, 0.0025 part by mass of a gas foaming substance, 0.5 part by mass of a water reducing agent, and 166.7 parts by mass of a fine aggregate contained in 100 parts by mass of cement. Subsequently, a chlorine-containing admixture (material name: sodium chloride) was mixed therein to prepare a grout material.

23 parts by mass of water per 100 parts by mass of the resulting grout material were kneaded to prepare grout mortar.

The grout mortar thus prepared was measured for the chlorine concentration, the fluidity, the chloride ion submergence depth, the adhesion strength, and the rusting rate of a reinforcing steel bar. The results are shown in Table 1.

[0041]

<Materials Used>

- Cement: Test cement (Commercially available pure chemicals were used as the preparation materials of the cement factory and for regulating the chemical composition, and anhydrous gypsum as a pure chemical was used for regulating the SO₃ amount) having a chlorine amount of 1.5 ppm and a Blaine value of 3,450 cm²/g

- Expanding material: The expanding material was produced in such a manner that a CaO material, an Al₂O₃ material, an SiO₂ material, and a CaSO₄ material were blended, mixed, and pulverized, and then fired at 1,200°C to synthesize a clinker, which was pulverized with a ball mill to a Blaine specific surface area of 3,000 cm²/g. The mineral composition of ternesite was obtained through calculation based on the chemical composition obtained by fluorescent X-ray and the identification result of the powder X-ray diffraction. The content of ternesite per 100 parts by mass of the expanding material is shown in Table 1.

- Gas foaming substance: Flaky aluminum powder surface-treated with stearic acid, commercially available product

- Setting modifier: A mixture of 25 parts of citric acid as first-class reagent and 75 parts of potassium carbonate as first-class reagent

- Water reducing agent: A naphthalene-based water reducing agent,

commercially available product ("Celluflow 110P", produced by DKS Co., Ltd.)

- Water: Tap water

- Fine aggregate: The test was performed by using the composition of the fine aggregate shown in Table 1. The chemical composition of the fine aggregate was measured by fluorescent X-ray diffraction. For preparing the chemical composition, silica sand (from Aichi prefecture), calcite (CaCO_3), scapolite ($(\text{Na,Ca,K})_4\text{Al}_4\text{Si}_9\text{O}_{24}(\text{Cl,CO}_3,\text{SO}_4)$) as a metamorphic rock, quartz (SiO_2) and potassium feldspar (KAlSi_3O_8) as igneous rocks were mixed to prepare the chemical composition.

[0042]

<Measured Items>

- Chlorine concentration: The grout mortar thus prepared was measured for the chlorine concentration according to JIS R5202.

- Fluidity: The fluidity was measured according to JSCE-F 541 in terms of J_{14} funnel falling value under an environment of 30°C immediately after kneading and 30 minutes thereafter.

- Chloride ion submergence depth: The material subjected to underwater curing at 20°C until a material age of 28 days according to JIS A1171 was immersed in a brine solution defined in JIS A6205, Appendix 1 (Brine immersion test method of reinforcing steel bar), 3.2.1 (Brine solution) at 20°C, and then taken out therefrom after 28 days. The specimen after immersing in the brine solution was fractured into two pieces, a 0.1% fluorescein sodium aqueous solution and a 0.1 mol/L silver nitrate solution were sprayed on the cross sectional surface thereof, and the part emitting fluorescent light was designated as the chlorine ion submergence depth.

- Adhesion strength: The adhesion strength to a reinforcing steel bar was obtained by withdrawing a round bar steel having a diameter of 19 mm embedded to a depth of 16 cm. The material was cured by sealed curing at 20°C, and the test was performed at a material age of 28 days.

- Rusting rate of reinforcing steel bar: The grout mortar filled on a round bar steel having a diameter of 19 mm embedded to a depth of 18 cm to a covering depth of 10 mm was subjected to underwater curing at 20°C until a material age of 28 days, and then immersed in a brine solution defined in JIS A6205, Appendix 1 (Brine immersion test method of reinforcing steel bar), 3.2.1 (Brine solution) at 30°C for 1 week. Thereafter, the specimen was taken out therefrom, and allowed

to stand still indoors under an environment at 30°C for 1 week. The immersion and the standing still were repeated every 1 week, and the test was performed for 182 days. After completing the test, the round steel bar was taken out, and after removing rust with a 10% diammonium citrate solution, measured for the weight (m_2) of the round steel bar after the test, and the rusting rate of the reinforcing steel bar was calculated based on the change from the weight (m_1) of the round steel bar before the test according to the following expression.

$$\text{Rusting rate of reinforcing steel bar (\%)} = ((m_1 - m_2) / m_1) \times 100$$

[0043]

Table 1

No.	CaO % by mass	SiO ₂ % by mass	Chlorine ppm	Ternesite % by mass	Fluidity		Chloride ion submergence depth mm	Adhesion strength N/mm ²	Rusting rate of reinforcing steel bar %	Note
					Immediate sec	After 30 min sec				
1-1	91	4.8	1.5	5	8.9	15.3	4.6	3.4	12	Comparative Example
1-2	91	4.8	3	5	8.2	12	3.9	4.7	8	Example
1-3	91	4.8	50	5	8.3	11.8	3.8	4.9	6	Example
1-4	91	4.8	200	5	8.2	11.5	3.7	5.2	4	Example
1-5	91	4.8	1800	5	8.4	12.1	4	4.9	9	Example
1-6	91	4.8	2000	5	9.2	16.1	5.4	3.6	15	Comparative Example
1-7	10	83	200	5	8.9	12.6	4	4.0	9	Example
1-8	85	4.9	210	5	8.7	12.7	3.9	4.8	5	Example
1-9	92	0.2	210	5	8	11.9	3.9	4.8	6	Example
1-10	91	4.8	190	5	8.2	11.5	3.7	5.2	4	Example
1-11	90	15	200	5	8.5	12.3	3.8	4.9	6	Example
1-12	91	4.8	190	0.1	8.2	12.6	3.7	5.2	4	Example
1-13	91	4.8	210	20	8.2	10.4	3.9	5.4	4	Example

[0044]

It was confirmed from the results in Table 1 that the use of the particular amount of chlorine contained and the fine aggregate having the particular chemical composition achieved the high fluidity, the effect of retaining the fluidity, the brine damage resistance, the adhesion strength to a reinforcing steel bar, and the suppression of rusting rate of a reinforcing steel bar.

[0045]

[Experimental Example 2]

The same procedures as in Experimental Example 1 were performed except that the fine aggregates shown in Table 2 were blended to prepare grout mortar. The results are shown in Table 2. The ternesite in the expanding material used was 5 parts by mass per 100 parts by mass of the expanding material.

The test for resistance to abrasion of fine aggregate by the Los Angeles machine was performed in the following manner. 5 kg of the fine aggregate and 6 iron balls were placed in the Los Angeles machine. The iron balls had an average diameter of approximately 46.8 mm and a mass of 390 to 445 g per one ball. Subsequently, the Los Angeles machine was operated by 500 rotations (30 rpm). Subsequently, the fine aggregate taken out from the Los Angeles machine was sieved with metal meshes of 5 mm, 2.5 mm, 1.2 mm, 0.6 mm, 0.3 mm, and 0.15 mm. The fineness modulus (R_1) of the fine aggregate before subjecting to the Los Angeles machine and the fineness modulus (R_2) of the fine aggregate after subjecting to the Los Angeles machine were compared, and the reduction in fineness modulus after the test was calculated according to the following expression.

$$\text{Reduction in fineness modulus} = R_2/R_1$$

[0046]

Table 2

No.	CaO % by mass	SiO ₂ % by mass	Chlorine ppm	reduction in fineness modulus %	Fluidity		Chloride ion submergence depth mm	Adhesion strength N/mm ²	Rusting rate of reinforcing steel bar %	Note
					Immediate sec	After 30 min sec				
2-1	86	3.1	190	70	8.9	12.6	4.1	4.8	6	Example
2-2	89	3.9	200	85	8.4	12.1	3.9	5	5	Example
2-3	91	4.8	210	93	8.5	11.8	3.9	5.1	4	Example
1-4	91	4.8	200	98	8.2	11.5	3.7	5.2	4	Example
2-4	89	4.9	200	100	9.0	12.3	4.1	5	5	Example

[0047]

It was confirmed from the results in Table 2 that the use of the particular amount of chlorine contained and the fine aggregate having the particular chemical composition and the reduction in fineness modulus within the particular range achieved the high fluidity, the brine damage resistance, the adhesion strength to a reinforcing steel bar, and the suppression of rusting rate of a reinforcing steel bar.

[0048]

[Experimental Example 3]

The same procedures as in Experimental Example 1 were performed except that the fine aggregates shown in Table 3 were blended to prepare grout mortar. The results are shown in Table 3.

[0049]

Table 3

No	CaO % by mass	SiO ₂ % by mass	Chlorine ppm	K ₂ O ppm	SO ₃ ppm	Fe ₂ O ₃ % by mass	Al ₂ O ₃ % by mass	Fluidity		Chloride ion submergence depth mm	Adhesion strength N/mm ²	Rusting rate of reinforcing steel bar		Note
								Immediate sec	After 30 min sec					
3-1	90	4.9	190	40	1000	0.6	0.8	8.5	12.1	3.8	5.1	6		Example
1-4	91	4.8	200	940	930	0.7	0.8	8.2	11.5	3.7	5.2	4		Example
3-2	89	0.1	160	3000	940	0.2	1.2	8.2	11.7	3.7	4.9	5		Example
3-3	90	4.8	210	930	40	1.1	0.3	8.4	12.1	3.8	5.1	5		Example
3-4	92	4.2	190	890	3000	0.3	1.2	8.4	12.0	3.8	4.9	6		Example
3-5	90	4.9	200	930	1000	0.1	0.7	8.3	11.8	3.9	5	5		Example
3-6	91	4.8	190	940	930	0.7	0.6	8.2	11.5	3.7	5.2	4		Example
3-7	91	5	160	780	900	3	0.5	8.5	12.2	3.9	5.2	6		Example
3-8	90	5.1	170	930	900	0.6	0.1	8.4	12	3.8	4.8	6		Example
3-9	90	4.5	180	890	940	0.5	3	8.3	11.8	3.9	4.8	5		Example

[0050]

It was confirmed from the results in Table 3 that the use of the particular amount of chlorine contained and the fine aggregate having the particular chemical composition achieved the high fluidity, the brine damage resistance, the adhesion strength to a reinforcing steel bar, and the suppression of rusting rate of a reinforcing steel bar.

Industrial Applicability

[0051]

The grout material of the present invention contains the particular amount of chlorine and uses the particular fine aggregate, thereby can provide grout mortar enhanced that is in fluidity, brine damage resistance, adhesion strength to a reinforcing steel bar, and rust inhibiting rate of a reinforcing steel bar, thereby enhancing the durability, and thus can be used in a wide variety of fields including the reinforcing construction method of a bridge pier with a steel plate lining, the filling construction method of a large shoe seat, the anchoring material for a reinforcing steel bar, the miscellaneous gap filling, the reparation of a cross section of concrete, the self-leveling flooring, and the like, and also the civil engineering and construction fields, and the like.

CLAIMS

[Claim 1]

A grout material comprising cement, an expanding material, a gas foaming substance, a water reducing agent, and a fine aggregate, the grout material having an amount of chlorine of 3 ppm or more and 1,800 ppm or less.

[Claim 2]

The grout material according to claim 1, wherein the expanding material contains ternesite, and has a content of the ternesite of 0.05 part by mass or more and 20 parts by mass or less per 100 parts by mass of the expanding material.

[Claim 3]

The grout material according to claim 1 or 2, wherein the fine aggregate has a chemical composition having a proportion of CaO of 85% by mass or more and a proportion of SiO₂ of 0.2% by mass or more and 15% by mass or less.

[Claim 4]

The grout material according to any one of claims 1 to 3, wherein the fine aggregate has a reduction in fineness modulus by the "test for resistance to abrasion of coarse aggregate by the Los Angeles machine" according to JIS A1121 of 70% or more and 100% or less.

[Claim 5]

The grout material according to any one of claims 1 to 4, wherein the fine aggregate has a chemical composition having a proportion of K₂O of 40 ppm or more and 3,000 ppm or less, a proportion of SO₃ of 40 ppm or more and 3,000 ppm or less, a proportion of Fe₂O₃ of 0.1% by mass or more and 3.0% by mass or less, and a proportion of Al₂O₃ of 0.1% by mass or more and 3.0% by mass or less.

[Claim 6]

The grout material according to any one of claims 1 to 5, wherein the grout material has a content ratio of the fine aggregate of 40 parts by mass or more and 300 parts by mass or less per 100 parts by mass of the cement.

[Claim 7]

A grout mortar comprising the grout material according to any one of claims 1 to 6 and water kneaded with each other.

[Claim 8]

A cured body comprising the grout mortar according to claim 7.