

Description

Title of the Invention

HYDRAULIC COMPOSITION FOR CENTRIFUGAL MOLDING

Field of the Invention

[0001]

The present invention relates to a hydraulic composition for centrifugal molding, and a method for producing a cured article of a hydraulic composition.

Background of the Invention

[0002]

A centrifugal molding method has been known as a method for producing a hollow cylindrical concrete molded article, such as a pipe, a pile, and a pole. The centrifugal molding method is such a method that a kneaded concrete material is placed in a mold, and the concrete is compacted by pressing onto the inner surface of the mold with a centrifugal force formed by revolving the mold at high speed.

In the production of a concrete pile demanded to have a high strength in Japan, a high-strength admixture is added to the concrete, and steam curing is performed, for ensuring the strength capable of being shipped after 7 days from the kneading.

[0003]

JP-A 59-207863 describes a method for producing a centrifugal-molded article, in which in the production of a molded article through centrifugal molding, one or two or more selected from monooxycarboxylic acids and salts thereof are added, and the examples thereof describe that the concurrent use of a high-strength admixture provides a good condition in centrifugal compacting and a high strength.

JP-A 2010-100505 describes a high-strength concrete composition for centrifugal molding, containing a high early strength Portland cement, an admixture containing anhydrous gypsum and amorphous silica in a prescribed condition, a naphthalene dispersant, an aggregate, and water.

Summary of the Invention

[0004]

The present invention relates to a hydraulic composition for centrifugal molding, containing the following components A, B, C, and D, a cement, water, and an aggregate,

wherein the component A is contained in an amount of 0.03 part by mass or more and 0.15 part by mass or less, the component B is contained in an amount of 0.02 part by mass or more and 0.07 part by mass or less, the component C is contained in an amount of 0.5 part by mass or more and 1.0

part by mass or less, and the component D is contained in an amount of 0 part by mass or more and 8 parts by mass or less, per 100 parts by mass of the cement:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin,

component B: one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture.

[0005]

The present invention also relates to a method for producing a cured article of a hydraulic composition, containing the following steps 1 to 5:

step 1: kneading the following components A, B, C, and D, a cement, water, and an aggregate, so as to provide a hydraulic composition, wherein the component A in an amount of 0.03 part by mass or more and 0.15 part by mass or less, the component B in an amount of 0.02 part by mass or more and 0.07 part by mass or less, the component C in an amount of 0.5 part by mass or more and 1.0 part by mass or less, and the component D in an amount of 0 part by mass or more and 8 parts by mass or less, per 100 parts by mass of the cement, are kneaded:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin,

component B: one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture;

step 2: filling the hydraulic composition obtained in the step 1, in a mold;

step 3: compacting the hydraulic composition filled in the mold in the step 2, by applying a centrifugal force;

step 4: setting the hydraulic composition compacted in the step 3, in the mold; and

step 5: steam-curing the hydraulic composition set in the step 4, in the mold.

Detailed Description of the Invention

[0006]

It has been found that a high-strength admixture is effective for enhancing the strength of a cured article of a concrete for centrifugal molding, but when a high-strength admixture is used in a large amount, there is a possibility in the production site that a concrete product after curing is expanded and cracked on the surface thereof. It is

considered that the occurrence of the problems may be prevented by decreasing the amount of the high-strength admixture, but the strength of the cured article of the concrete for centrifugal molding may be insufficient. While the high-strength admixture is normally used in an amount of approximately 10% by mass based on the cement as described in the examples of JP-A 59-207863 and JP-A 2010-100505, it is desired that the amount thereof be decreased while exhibiting a sufficient strength.

[0007]

The present invention provides a hydraulic composition, such as a concrete and a mortar, which provides a cured article exhibiting a sufficient strength even in the case where the amount of the high-strength admixture used is decreased to prevent the problems of expansion and cracking.

[0008]

The present invention is expected to provide a hydraulic composition, such as a concrete and a mortar, which provides a cured article exhibiting a sufficient strength even in the case where the amount of the high-strength admixture used is decreased to prevent the problems of expansion and cracking.

[0009]

Although the mechanism of action in the present invention is unclear, it may be estimated that when the

amount of the high-strength admixture (component D) used is decreased to prevent the occurrence of expansion and cracking, the amount of ettringite formed is decreased and the 7-day strength is decreased, but it is expected that the use of one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin (component A) in combination with a particular oxycarboxylic acid or a salt thereof (component B) supplements the formation of ettringite, thereby ensuring the 7-day strength.

It is considered that the decrease of ettringite is caused by the heat curing and the coexistence of calcium hydroxide crystals. The component B has a function of micronizing and chelating calcium hydroxide, and thus it is expected that the reactivity of ettringite (abnormal hydration) is suppressed. It is also expected that component A facilitates the hydration of the pore phase in the initial wetting stage, thereby forming ettringite in a larger amount.

It is expected that the decrease of ettringite is suppressed by the synergistic effect of the two factors.

[0010]

Hydraulic Composition of Centrifugal Molding

Component A

The component A is one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin. The hydraulic composition for centrifugal molding of the present

invention contains the component A in an amount of 0.03 part by mass or more, and preferably 0.05 part by mass or more, and of 0.15 part by mass or less, and preferably 0.12 part by mass or less, per 100 parts by mass of the cement, from the standpoint of the 7-day strength of the cured article of the hydraulic composition (which may be hereinafter referred to as a 7-day strength).

[0011]

The average addition molar number of ethylene oxide of the ethylene oxide adduct of glycerin as the component A preferably exceeds 0, and is preferably 0.1 or more, from the standpoint of the 7-day strength. The average addition molar number is preferably 6 or less, more preferably 3 or less, further preferably 2 or less, and furthermore preferably 1.5 or less.

The component A is preferably glycerin from the standpoint of the 7-day strength.

[0012]

Component B

The component B is one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts thereof. The component B is preferably one or more compounds selected from tartronic acid and a salt thereof from the standpoint of the 7-day strength. The component B is preferably one or more compounds selected from gluconic acid

and a salt thereof from the standpoint of the 7-day strength and the availability.

The hydraulic composition for centrifugal molding of the present invention contains the component B in an amount of 0.02 part by mass or more, and preferably 0.03 part by mass or more, and of 0.07 part by mass or less, and preferably 0.06 part by mass or less, per 100 parts by mass of the cement, from the standpoint of the 7-day strength.

[0013]

Mass Ratio of Components A and B

The mass ratio A/B of the components A and B is preferably 1.5 or more, and more preferably 2.0 or more, and is preferably 3.5 or less, from the standpoint of the 7-day strength.

[0014]

Component C

The component C is a naphthalenesulfonic acid-formaldehyde condensate. The component C functions as a dispersant of the cement. The hydraulic composition for centrifugal molding of the present invention contains the component C in an amount of 0.5 part by mass or more, and preferably 0.7 part by mass or more, and of 1.0 part by mass or less, and preferably 0.9 part by mass or less, per 100 parts by mass of the cement, from the standpoint of the 7-day strength.

[0015]

The weight average molecular weight of the component C is preferably 1,000 or more, more preferably 3,000 or more, further preferably 4,000 or more, and furthermore preferably 5,000 or more, and is preferably 200,000 or less, more preferably 100,000 or less, further preferably 80,000 or less, and furthermore preferably 50,000 or less. The weight average molecular weight herein is measured by a gel permeation chromatography (GPC) method shown below.

[0016]

GPC Conditions

Column: G4000SWXL + G200SWXL (produced by Tosoh Corporation)

Eluent: 30 mM CH₃COONa/CH₃CN = 6/4 (pH 6.9)

Flow rate: 1.0 mL/min

Column temperature: 40°C

Detection: UV (280 nm)

Specimen size: 2 mg/mL, 0.01 mL

Standard substance for conversion: polystyrenesulfonic acid

[0017]

The component C used may be in a liquid form or a powder form. The component C used may be a commercially available product, and examples thereof include Mighty 150, produced by Kao Corporation.

[0018]

Examples of the production method of the component C include a method of providing a condensate through condensation reaction of naphthalenesulfonic acid and formaldehyde. The condensate may be neutralized. A water-insoluble matter by-produced in the neutralization may be removed. For example, the following production method can be exemplified. Firstly, for providing naphthalenesulfonic acid, 1 mol of naphthalene and from 1.2 to 1.4 mol of sulfuric acid are reacted at a temperature of from 150 to 165°C for from 2 to 5 hours to provide a sulfonated product. Subsequently, formalin is added dropwise to 1 mol of the sulfonated product to make from 0.95 to 0.99 mol of formaldehyde at a temperature of from 85 to 95°C over from 3 to 6 hours, and after completing the dropwise addition, the condensation reaction is performed at a temperature of from 95 to 105°C. Depending on necessity, water and a neutralizing agent are added to the condensate, and neutralization reaction is performed at a temperature of from 80 to 95°C. The neutralizing agent is preferably added in an amount from 1.0 to 1.1 times by mole the amount of each of naphthalenesulfonic acid and unreacted sulfuric acid. Water-insoluble matter formed through the neutralization may be removed, or preferably separated by filtration. An aqueous solution of a water-soluble salt of a

naphthalenesulfonic acid-formaldehyde condensate is obtained by the procedure. The aqueous solution can be used as it is as a naphthalene dispersant. Depending on necessity, the aqueous solution may be dried and formed into powder to provide a water-soluble salt of a naphthalenesulfonic acid-formaldehyde condensate in the form of powder, which may be used as a naphthalene dispersant in the form of powder. The drying and powder-forming may be performed by spray drying, drum drying, freeze drying, and the like. According to the aforementioned procedures, the naphthalenesulfonic acid-formaldehyde condensate can be obtained, and the target product may also be obtained by other conditions and methods.

[0019]

Component D

The component D is a high-strength admixture.

Examples of the component D include a high-strength admixture containing anhydrous gypsum. Examples of the high-strength admixture containing anhydrous gypsum include one containing anhydrous gypsum in an amount of 60% by mass or more.

The component D has a fineness degree (Blaine specific surface area) in a range of preferably 4,000 cm²/g or more, and more preferably 5,000 cm²/g or more, and of preferably 15,000 cm²/g or less, and more preferably 13,000 cm²/g or less.

[0020]

The high-strength admixture as the component D used may be a commercially available product, such as Denka Σ 1000, produced by Denka Co., Ltd., Super Mix, produced by Taiheiyo Materials Corporation, Noncleave, produced by Sumitomo Osaka Cement Co., Ltd., and Daimix, produced by Showa KDE Co., Ltd.

[0021]

The hydraulic composition for centrifugal molding of the present invention contains the component D in an amount of 0 part by mass or more, and from the standpoint of the 7-day strength, in an amount of preferably 1 part by mass or more, preferably 2 parts by mass or more, and more preferably 3 parts by mass or more, per 100 parts by mass of the cement. The hydraulic composition for centrifugal molding of the present invention contains the component D in an amount of 8 parts by mass or less, preferably 7 parts by mass or less, and more preferably 5 parts by mass or less, from the standpoint of the easiness in molding by centrifugal molding, and the avoidance of expansion and cracking after curing of the hydraulic composition.

[0022]

Cement

The cement used in the present invention is not particularly limited, and examples thereof include various cements, such as an ordinary Portland cement, a high early

strength Portland cement, an ultrahigh early strength Portland cement, a mixed cement, and an eco-cement (e.g., JIS R5214). Other hydraulic powder than the cement, such as a blast furnace slag, a fly ash, and a silica fume, may also be contained in the hydraulic composition for centrifugal molding.

[0023]

Aggregate

The hydraulic composition for centrifugal molding of the present invention contains an aggregate. Examples of the aggregate include a fine aggregate and a coarse aggregate, preferred examples of the fine aggregate include mountain sand, land sand, river sand, and crushed sand, and preferred examples of the coarse aggregate include mountain gravel, land gravel, river gravel, and crushed stone. A lightweight aggregate may be used depending on the purpose. The terminology of the aggregate is in accordance with "Concrete Soran" (Comprehensive Review of Concrete), June 10, 1998, Gijutsu Shoin Co., Ltd.

[0024]

Additional Components, Properties of Hydraulic Composition for Centrifugal Molding, etc.

The hydraulic composition for centrifugal molding of the present invention contains the component A, the component B, the component C, the component D, a cement, water, and an

aggregate. The hydraulic composition for centrifugal molding of the present invention may contain additional additives. Examples thereof include the following components.

AE agent: a resin soap, a saturated or unsaturated fatty acid, sodium hydroxystearate, lauryl sulfate, an alkylbenzenesulfonic acid and a salt thereof, an alkane sulfonate, a polyoxyalkylene alkyl (phenyl) ether, a polyoxyalkylene alkyl (phenyl) ether sulfate ester and a salt thereof, a polyoxyalkylene alkyl (phenyl) ether phosphate ester and a salt thereof, a protein material, an alkenyl succinate, an α -olefin sulfonate, etc.

Bubbling agent

Thickener

Silica sand

Foaming agent

Waterproofing material: a resin acid and a salt thereof, a fatty acid ester, fat and oil, silicone, paraffin, asphalt, wax, etc.

Blast furnace slag

Fluidizer

Defoamer: a dimethylpolysiloxane-based defoamer, a polyalkylene glycol fatty acid ester-based defoamer, a mineral oil-based defoamer, an oil and fat-based defoamer, an oxyalkylene-based defoamer, an alcohol-based defoamer, an

amide-based defoamer, etc.

Foam preventing agent

Rust preventing agent: a nitrite salt, a phosphate salt, zinc oxide, etc.

Water-soluble polymer: a cellulose compound, such as methyl cellulose and hydroxyethyl cellulose, a natural water-soluble polymer, such as β -1,3-glucan and xanthan gum, a synthetic water-soluble polymer, such as polyacrylamide, polyethylene glycol, and an ethylene oxide adduct of oleyl alcohol, a reaction product thereof with vinylcyclohexene diepoxide, and the like, etc.

Polymer emulsion: a polymer emulsion using such a monomer as an alkyl (meth)acrylate

[0025]

In the hydraulic composition for centrifugal molding of the present invention, the ratio of the content of water to the total of the content of the component D and the content of the cement in terms of (content of water)/(total content of component D and cement) $\times$ 100 (which is hereinafter referred to as W/P) is preferably 10% by mass or more from the standpoint of the kneading property, the workability, and the filling property in a mold, of a fresh concrete. The W/P is preferably 50% by mass or less, more preferably 40% by mass or less, and further preferably 35% by mass or less, from the standpoint of the improvement

effect of the smoothness on the inner surface and the appearance of the end surface of the centrifugal-molded article.

[0026]

In the case where the hydraulic composition for centrifugal molding of the present invention contains a fine aggregate (S) and a coarse aggregate (G), the ratio of the fine aggregate (s/a) is preferably 30% by volume or more, and more preferably 35% by volume or more, and is preferably 45% by volume or less, and more preferably 40% by volume or less, from the standpoint of the 7-day strength. The s/a is calculated from the volumes of the fine aggregate (S) and the coarse aggregate (G) according to $s/a = (S/(S+G)) \times 100$ (% by volume).

[0027]

The hydraulic composition for centrifugal molding of the present invention may contain a fine aggregate and a coarse aggregate. In this case, the fine aggregate is contained in an amount of preferably 450 kg or more, and more preferably 550 kg or more, and of preferably 950 kg or less, and more preferably 750 kg or less, per 1 m³ of an uncured concrete (fresh concrete). The coarse aggregate is contained in an amount of preferably 1,000 kg or more, and more preferably 1,050 kg or more, and of preferably 1,300 kg or less, and more preferably 1,200 kg or less, per 1 m³ of

an uncured concrete (fresh concrete).

[0028]

The hydraulic composition for centrifugal molding of the present invention has a slump value of preferably 0 cm or more and 8 cm or less from the standpoint of the reduction of sludge, and of preferably 0.5 cm or more, and more preferably 1 cm or more, and of preferably 6 cm or less, and more preferably 4 cm or less, from the standpoint of the enhancement of the filling property of the hydraulic composition in a mold and the reduction of sludge. The slump value is measured according to JIS A1101.

[0029]

The hydraulic composition of the present invention may be used as a concrete or a mortar.

[0030]

Method for producing Cured Article of Hydraulic Composition

The method for producing a cured article of a hydraulic composition of the present invention contains the following steps 1 to 5:

Step 1: kneading the following components A, B, C, and D, a cement, water, and an aggregate, so as to provide a hydraulic composition, in which the component A in an amount of 0.03 part by mass or more and 0.15 part by mass or less, the component B in an amount of 0.02 part by mass or more and 0.07 part by mass or less, the component C in an amount

of 0.5 part by mass or more and 1.0 part by mass or less, and the component D in an amount of 0 part by mass or more and 8 parts by mass or less, per 100 parts by mass of the cement, are kneaded:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin,

component B: one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture;

Step 2: filling the hydraulic composition obtained in the step 1, in a mold;

Step 3: compacting the hydraulic composition filled in the mold in the step 2, by applying a centrifugal force;

Step 4: setting the hydraulic composition compacted in the step 3, in the mold; and

Step 5: steam-curing the hydraulic composition set in the step 4, in the mold.

[0031]

The method for producing a cured article of a hydraulic composition of the present invention may further contain the following step 6 and may furthermore contain the following step 7:

Step 6: after the step 5, cooling the hydraulic composition and releasing from the mold; and

Step 7: curing the cured article of the hydraulic composition obtained in the step 6, at ordinary temperature and ordinary pressure.

[0032]

In the step 1, the component A, the component B, the component C, and the component D may be added separately from each other, or two or more thereof may be mixed in advance and then added. In the preparation of the hydraulic composition, such a method is preferred that the cement, the component D (in case of use), and the aggregate are mixed, and then a mixture containing water, the component A, the component B, and the component C is added thereto and mixed, since the component A, the component B, the component C, and the component D can be easily uniformly mixed in the preparation of the hydraulic composition.

[0033]

Examples of the specific method for the step 1 include a method, in which the cement, the component D (in case of use), and the aggregate are mixed, and a mixture containing water, the component A, the component B, and the component C is added thereto to satisfy the amount relationship, and kneaded to prepare the hydraulic composition.

[0034]

The preferred embodiments of the component A, the component B, the component C, and the component D used in the step 1 are the same as the preferred embodiments of the components in the hydraulic composition for centrifugal molding of the present invention.

The preferred ranges of the amounts of the component A, the component B, the component C, and the component D kneaded with respect to the cement in the step 1 are the same as the preferred ranges of the contents of the components in the hydraulic composition for centrifugal molding of the present invention.

Also in the step 1, the mass ratio A/B of the components A and B is preferably 1.5 or more, and more preferably 2.0 or more, and is preferably 3.5 or less, from the standpoint of the 7-day strength.

[0035]

In the step 1, a hydraulic composition having a W/P of preferably 10% by mass or more from the standpoint of the kneading property, the workability, and the filling property in a mold, of a fresh concrete, and of preferably 50% by mass or less, more preferably 40% by mass or less, and further preferably 35% by mass or less, from the standpoint of the improvement effect of the smoothness on the inner surface and the appearance of the end surface of the centrifugal-molded article, is obtained.

[0036]

Examples of the method for filling the hydraulic composition obtained in the step 1, in a mold in the step 2 include a method, in which the hydraulic composition after kneading is discharged from the kneading device, and poured into the mold by hand, followed by smoothing the surface thereof.

[0037]

In the step 3, the hydraulic composition thus filled in the mold is preferably compacted with a centrifugal force of 0.5 G or more. The centrifugal force in centrifugal molding is preferably 0.5 G or more and 30 G or less, and more preferably 25 G or less. The centrifugal force is preferably retained for at least 1 minute to a range of 15 G or more and 30 G or less, and more preferably 25 G or less, from the standpoint of the reduction of energy cost and the moldability.

[0038]

The compacting with a centrifugal force is performed, for example, with a centrifugal force of 0.5 G or more and 30 G or less, preferably for 5 minutes or more, more preferably 7 minutes or more, and further preferably 9 minutes or more, and preferably for 40 minutes or less. The compacting by retaining a high centrifugal force (which is generally 20 G or more) is preferably performed for 1 minutes

or more, more preferably 3 minutes or more, and further preferably 5 minutes or more, and preferably for 10 minutes or less, from the standpoint of compacting the molded article to have a smooth surface.

[0039]

The compacting with a centrifugal force may be performed by dividing into stages, and the centrifugal force G is preferably increased stepwise from the standpoint of the moldability. For example, in the case of five stages, the compacting performed includes (1) the first stage, in which a centrifugal force as the first speed of 0.5 G or more and less than 2 G is applied for 1 minute or more and 10 minutes or less, (2) the second stage, in which a centrifugal force as the second speed of 2 G or more and less than 5 G is applied for 1 minute or more and 10 minutes or less, (3) the third stage, in which a centrifugal force as the third speed of 5 G or more and less than 10 G is applied for 1 minute or more and 10 minutes or less, (4) the fourth stage, in which a centrifugal force as the fourth speed of 10 G or more and less than 20 G is applied for 1 minute or more and 10 minutes or less, and (5) the fifth stage, in which a centrifugal force as the fifth speed of 20 G or more and 30 G or less is applied for 1 minute or more and 10 minutes or less.

[0040]

In the step 4, the hydraulic composition obtained in the step 3 is set. Examples of the specific method therefor include a method of curing in the air for from 3 to 4 hours after kneading.

[0041]

In the step 5, the cured concrete in the mold obtained in the step 4 is steam-cured. The curing condition is preferably precuring performed by allowing to stand at room temperature (20°C) for from 1 to 4 hours and steam curing performed at a temperature of 60°C or more and 85°C or less. The step 5 and the step 6 may be performed under one sequence of temperature control.

As a specific curing condition, in the step 5, the temperature surrounding the mold is increased to a temperature of 60°C or more and 85°C or less at a temperature increasing rate of from 10°C or more and 30°C or less per 1 hour, and the temperature thus increased is retained for 2 hours or more and 8 hours or less, and in the step 6, the temperature is decreased to room temperature, for example, 20°C, at a temperature decreasing rate of 5°C or more and 20°C or less per 1 hour, followed by releasing the molded article from the mold.

One example of the preferred condition includes a method, in which the molded article is allowed to stand at room temperature, for example 20°C, for 3 hours, heated to

80°C at a temperature increasing rate of 20°C per hour, and retained for 6 hours (step 5), and is then cooled to room temperature at 10°C per hour, and after 20 hours or more and 30 hours or less, the molded article is released from the mold (step 6).

Autoclave curing at a prescribed temperature, for example, 180°C, may also be performed.

[0042]

In the step 7, the cured article of the hydraulic composition obtained in the step 6 is cured at ordinary temperature and ordinary pressure. Specifically, the cured article may be retained at 20°C under the atmospheric pressure.

[0043]

Examples of the method for producing a cured article of a hydraulic composition of the present invention include a method for producing a cured article of a hydraulic composition, in which the period of time from the start of the preparation of the hydraulic composition to the release from the mold is 8 hours or more and 30 hours or less. The start of the preparation of the hydraulic composition herein means the time when the cement comes firstly in contact with water.

The matters described for the hydraulic composition for centrifugal molding of the present invention may be

appropriately applied to the method for producing a cured article of a hydraulic composition of the present invention.

[0044]

The cured article of a hydraulic composition obtained by the production method of the present invention can be used as a centrifugal-molded concrete product, specific examples of which include a pile, a pole, and hume pipe. The cured article of a hydraulic composition obtained by the production method of the present invention is excellent in initial strength, and forms a decreased amount of sludge in the production thereof, thereby reducing the amount of waste products. Furthermore, the cured article is excellent in compacting, and thus the product has less unevenness on the inner surface and the end surface, is excellent in surface appearance, and has a smooth inner surface of the product, thereby avoiding failures during pile driving and failures of a cutting device during pile installation by inner excavation.

[0045]

Embodiments of the present invention will be shown below.

<1>

A hydraulic composition for centrifugal molding, containing the following components A, B, C, and D, a cement, water, and an aggregate,

wherein the component A is contained in an amount of 0.03 part by mass or more, and preferably 0.05 part by mass or more, and 0.15 part by mass or less, and preferably 0.12 part by mass or less, the component B is contained in an amount of 0.02 part by mass or more, and preferably 0.03 part by mass or more, and 0.07 part by mass or less, and preferably 0.06 part by mass or less, the component C is contained in an amount of 0.5 part by mass or more, and preferably 0.7 part by mass or more, and 1.0 part by mass or less, and preferably 0.9 part by mass or less, and the component D is contained in an amount of 0 part by mass or more, preferably 1 part by mass or more, preferably 2 parts by mass or more, and more preferably 3 parts by mass or more, and 8 parts by mass or less, preferably 7 parts by mass or less, and more preferably 5 parts by mass or less, per 100 parts by mass of the cement:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin, preferably glycerin,

component B: one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts thereof, preferably one or more compounds selected from gluconic acid, tartronic acid, and salts thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture.

[0046]

<2>

The hydraulic composition for centrifugal molding according to <1>, wherein the mass ratio A/B of the components A and B is 1.5 or more, and preferably 2.0 or more, and 3.5 or less.

[0047]

<3>

The hydraulic composition for centrifugal molding according to <1> or <2>, wherein the ratio of the content of water to the total of the content of the component D and the content of the cement in terms of $(\text{content of water})/(\text{total content of component D and cement}) \times 100$ is 10% by mass or more and 50% by mass or less, preferably 40% by mass or less, and more preferably 35% by mass or less.

[0048]

<4>

The hydraulic composition for centrifugal molding according to any one of <1> to <3>, wherein the hydraulic composition contains one or more additives selected from an AE agent, a bubbling agent, a thickener, silica sand, a foaming agent, a waterproofing material, a blast furnace slag, a fluidizer, a defoaming agent, a rust preventing agent, a water-soluble polymer, and a polymer emulsion.

[0049]

<5>

A method for producing a cured article of a hydraulic composition, containing the following steps 1 to 5:

step 1: kneading the following components A, B, C, and D, a cement, water, and an aggregate, so as to provide a hydraulic composition, wherein the component A in an amount of 0.03 part by mass or more, and preferably 0.05 part by mass or more, and 0.15 part by mass or less, and preferably 0.12 part by mass or less, the component B in an amount of 0.02 part by mass or more, and preferably 0.03 part by mass or more, and 0.07 part by mass or less, and preferably 0.06 part by mass or less, the component C in an amount of 0.5 part by mass or more, and preferably 0.7 part by mass or more, and 1.0 part by mass or less, and preferably 0.9 part by mass or less, and the component D in an amount of 0 part by mass or more, preferably 1 part by mass or more, preferably 2 parts by mass or more, and more preferably 3 parts by mass or more, and 8 parts by mass or less, preferably 7 parts by mass or less, and more preferably 5 parts by mass or less, per 100 parts by mass of the cement, are kneaded:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin, preferably glycerin,

component B: one or more compounds selected from

gluconic acid, tartronic acid, tartaric acid, and salts thereof, preferably one or more compounds selected from gluconic acid, tartronic acid, and salts thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture;

step 2: filling the hydraulic composition obtained in the step 1, in a mold;

step 3: compacting the hydraulic composition filled in the mold in the step 2, by applying a centrifugal force;

step 4: setting the hydraulic composition compacted in the step 3, in the mold; and

step 5: steam-curing the hydraulic composition set in the step 4, in the mold.

[0050]

<6>

The method for producing a cured article of a hydraulic composition according to <5>, wherein the mass ratio A/B of the components A and B in the step 1 is 1.5 or more, and preferably 2.0 or more, and 3.5 or less.

[0051]

<7>

The method for producing a cured article of a hydraulic composition according to <5> or <6>, wherein in the step 1, the ratio of the content of water to the total of the content

of the component D and the content of the cement in terms of (content of water)/(total content of component D and cement) × 100 is 10% by mass or more and 50% by mass or less, preferably 40% by mass or less, and more preferably 35% by mass or less.

[0052]

<8>

The method for producing a cured article of a hydraulic composition according to any one of <5> to <7>, wherein in the step 3, the hydraulic composition filled in the mold is compacted with a centrifugal force of 0.5 G or more and 30 G or less, and preferably 25 G or less.

[0053]

<9>

The method for producing a cured article of a hydraulic composition according to <8>, wherein in the step 3, the hydraulic composition filled in the mold is compacted with a centrifugal force retained for at least 1 minute to a range of 15 G or more and 30 G or less, and preferably 25 G or less.

[0054]

<10>

The method for producing a cured article of a hydraulic composition according to any one of <5> to <9>, wherein in the step 3, the hydraulic composition is compacted with a

centrifugal force that is changed stepwise, further the hydraulic composition is compacted with a centrifugal force that is increased stepwise, and furthermore the hydraulic composition is compacted by five stages including (1) the first stage, in which a centrifugal force as the first speed of 0.5 G or more and less than 2 G is applied for 1 minute or more and 10 minutes or less, (2) the second stage, in which a centrifugal force as the second speed of 2 G or more and less than 5 G is applied for 1 minute or more and 10 minutes or less, (3) the third stage, in which a centrifugal force as the third speed of 5 G or more and less than 10 G is applied for 1 minute or more and 10 minutes or less, (4) the fourth stage, in which a centrifugal force as the fourth speed of 10 G or more and less than 20 G is applied for 1 minute or more and 10 minutes or less, and (5) the fifth stage, in which a centrifugal force as the fifth speed of 20 G or more and 30 G or less is applied for 1 minute or more and 10 minutes or less.

[0055]

Examples

The following examples describe embodiments of the present invention. The examples exemplify the present invention and are not for limiting the present invention.

[0056]

Example 1 and Comparative Example 1

The following materials were used as the component A, the component B, the component C, and the component D. In the tables, materials that do not correspond to the component B are also described in the column of the component B for the sake of simplicity.

[0057]

Component A

Glycerin: purified glycerin, produced by Kao Corporation, purity: 99.0% or more

Component B

Sodium gluconate: first grade reagent, produced by Wako Pure Chemical Industries, Ltd., purity: 98% or more

Tartronic acid: produced by Sigma-Aldrich Corporation, purity: 99% or more

Tartaric acid: produced by Wako Pure Chemical Industries, Ltd., purity: 99% or more

Comparative oxycarboxylic acid

Citric acid: produced by Wako Pure Chemical Industries, Ltd., purity: 99.5% or more

Malonic acid: produced by Sigma-Aldrich Corporation, purity: 99% or more

Component C

Naphthalenesulfonic acid-formaldehyde condensate (which is referred to as NSF in the tables): Mighty 150, produced by Kao Corporation, weight average molecular

weight: 20,000 (The weight average molecular weight was measured by GPC under the aforementioned conditions)

[0058]

Component D

High-strength admixture D1: Super Mix, produced by Taiheiyo Materials Corporation (containing anhydrous gypsum in an amount of 60% by mass or more)

High-strength admixture D2: Denka Σ 1000, produced by Denka Co., Ltd. (containing anhydrous gypsum in an amount of 60% by mass or more)

[0059] Mortar Formulation

[Table 1]

W/P (% by mass)	Unit weight (kg/m ³)			
	W	C	S	Component D
23.6	392	1600	1400	64

[0060]

The components shown in Table 1 are as follows. The component D is that described above.

W: tap water in Wakayama City

C: ordinary Portland cement: mixed cement of ordinary Portland cement, produced by Taiheiyo Cement Corporation, and ordinary Portland cement, produced by Sumitomo Osaka Cement Co., Ltd. = 1/1 (mass ratio)

S: fine aggregate: mountain sand, produced in Joyo City

W/P shows the ratio (content of W)/(total content of C and component D) $\times 100$ (hereinafter the same).

[0061]

Production of Mortar

A mortar was produced according to the formulation condition shown in Table 1. Specifically, the component D, the cement (C), and the fine aggregate (S) were placed in a mortar mixer (Universal Mixer, Model 5DM-03-γ, produced by Dalton Co., Ltd.) and dry-mixed for 30 seconds, kneading water (W1) was added thereto, the mixture was kneaded by low-speed rotation for 60 seconds, kneading water (W2) containing the component A, the component B, and the component C was added thereto, and the mixture was finally kneaded by low-speed rotation for 240 seconds, thereby providing a mortar for centrifugal molding. The amount of W in Table 1 is the total of the amount of W1 and the amount of W2. The amount of W2 includes the amounts of the component A, the component B, and the component C. The mass ratio of the amount of W1 and the amount of W2 in terms of W1/W2 was 70/30.

The effective amounts (in terms of part by mass) of the component A, the component B, the component C, and the component D added per 100 parts by mass of the cement are as shown in Table 2.

A cured article can be produced by using the resulting

mortar for centrifugal molding and performing the steps 2 to 5 of the invention, or further performing the steps 6 and 7 of the present invention.

[0062]

Compressive Strength

According to JIS A1132, a mortar was filled in a cylindrical plastic mold (bottom diameter: 5 cm, height: 10 cm) by a two-layer filling method. After preprocessing at 20°C for 3 hours, the mortar was heated to 70°C at a rate of 20°C per hour, and steam-cured by retaining at 70°C for 4 hours. Thereafter, the mortar was naturally cooled to ordinary temperature, and cured in the air, thereby providing a mortar cured article. After 7 days, the cured articles each were measured for the compression stress of a cured article according to JIS A1108 to obtain the compressive strength. The results are shown in Table 2. The compressive strength obtained herein is in relation to the compressive strength of the cured article obtained by centrifugal molding.

[0063]

[Table 2]

	Component A		Component B		Mass ratio	Component C		Component D		7-Day compressive strength (N/mm ²)	
	Kind	Amount added (part by mass) *1	Kind	Amount added (part by mass) *1		Kind	Amount added (part by mass) *1	Kind	Amount added (part by mass) *1		
Comparative Example	1-1	0	none	0	-	NSF	0.8	D1	4	105	
	1-2	0.2	glycerin	0	-					108	
	1-3	0.1	glycerin	0	-					111	
	1-4	0.05	glycerin	0	-					109	
	1-5	0.03	glycerin	0	-					107	
	1-6	0	none	sodium gluconate	0.1					-	102
	1-7	0	none	sodium gluconate	0.05					-	106
	1-8	0	none	sodium gluconate	0.03					-	107
	1-9	0	none	sodium gluconate	0.01					-	105
	1-10	0	none	sodium gluconate	0.05					-	107
	1-11	0	none	tartronic acid	0.03					-	107
	1-12	0	none	tartronic acid	0.05					-	105
	1-13	0	none	tartronic acid	0.03					-	106
	1-14	0	none	citric acid	0.05					-	99
	1-15	0	none	citric acid	0.03					-	100
	1-16	0.1	glycerin	citric acid	0.03					-	101
	Example	1-17	0	none	malonic acid					0.05	-
1-18		0	none	malonic acid	0.03	-	101				
1-19		0.1	glycerin	malonic acid	0.03	-	105				
1-1		0.1	glycerin	sodium gluconate	0.03	3.33	118				
1-2		0.05	glycerin	sodium gluconate	0.03	1.67	116				
1-3		0.1	glycerin	sodium gluconate	0.05	2.00	115				
1-4		0.1	glycerin	tartronic acid	0.03	3.33	119				
1-5		0.05	glycerin	tartronic acid	0.03	1.67	117				
1-6		0.1	glycerin	tartronic acid	0.05	2.00	117				
1-7		0.1	glycerin	tartronic acid	0.03	3.33	115				
Comparative Example	1-20	0	none	0	-	NSF	0.8	D2	4	103	
Example	1-8	0.1	glycerin	sodium gluconate	0.03	3.33				117	

[0064] *1: part by mass per 100 parts by mass of the cement

[0065]

It is understood from the results in Table 2 that the concretes of Examples using the component A, the component B, the component C, and the component D are enhanced in 7-day compressive strength as compared to the concretes of Comparative Examples. Although approximately 10 parts by mass of the component D is ordinarily used per 100 parts by mass of the cement, the amount of the component D added in this test is decreased to 4 parts by mass per 100 parts by mass of the cement, but the concretes of Examples have a strength that is sufficient for shipment.

[0066]

Example 2 and Comparative Example 2

Mortars were produced and measured for compressive strength in the same manner as in Example 1 and Comparative Example 1 except that the mortar formulation was as shown in Table 3, and the amounts of the components A to D added were as shown in Table 4. The results are shown in Table 4. The components in Tables 3 and 4 are the same as in Example 1 and Comparative Example 1.

[0067] [Table 3]

W/P (% by mass)	Unit weight (kg/m ³)		
	W	C	S
23.6	392	1664	1400

[0068]

[Table 4]

		Component A		Component B		Mass ratio	Component C		Component D		7-Day compressive strength (N/mm ²)			
		Kind	Amount added (part by mass) *1	Kind	Amount added (part by mass) *1	A/B	Kind	Amount added (part by mass) *1	Kind	Amount added (part by mass) *1				
Comparative Example	2-1	none	0	none	0	-	NSF	0.8	none	0	96			
	2-2	glycerin	0.1	none	0	-					99			
	2-3	none	0	sodium gluconate	0.03	-					97			
Example	2-1	glycerin	0.1	sodium gluconate	0.03	3.33								104
	2-2	glycerin	0.1	tartronic acid	0.03	3.33								105

[0069] *1: part by mass per 100 parts by mass of the cement

[0070]

Example 3 and Comparative Example 3

Concrete Formulation

[0071] [Table 5]

W/P (% by mass)	Unit weight (kg/m ³)				
	W	C	S	G	Component D
22.7	130	550	620	1140	22

[0072]

Production of Concrete

A concrete was produced according to the formulation condition shown in Table 5. Specifically, the kinds and the amounts of the component A, the component B, the component C, and the component D shown in Table 6 were added and kneaded in a forced twin-shaft mixer for 4 minutes, thereby providing a concrete for centrifugal molding.

The effective amounts (in terms of part by mass) of the component A, the component B, the component C, and the component D added per 100 parts by mass of the cement are as shown in Table 6. The components in Tables 5 and 6 are the same as in Example 1 and Comparative Example 1. In Table 5, G shows a coarse aggregate, and small crushed stone (1505) was used therefor.

[0073]

Compressive Strength

The compression area was obtained from the average value of the thickness of the cured article. The cured article having been measured for thickness was measured for compression stress after 7 days from kneading according to JIS A1108. The compressive strength was obtained from the expression, $(\text{compressive strength}) = (\text{compression stress}) / (\text{compression area})$.

[0074]

Moldability

The concrete for centrifugal molding was placed in a mold for centrifugal molding (inner diameter: 20 cm × height: 30 cm), and centrifugally compacted by the first speed of 0.7 G for 3 minutes, the second speed of 5 G for 4 minutes, the third speed of 15 G for 2 minutes, and the fourth speed of 25 G for 3 minutes. Thereafter, after preprocessing at 20°C for 3 hours, the concrete was heated to 80°C at a rate of 18°C per hour, and steam-cured by retaining at 80°C for 8 hours. Thereafter, the concrete was naturally cooled to ordinary temperature, and cured in the air, thereby providing a concrete cured article. After releasing from the mold, the cured article was measured for the thickness (mm) of concrete at 4 positions of each of the upper part and the lower part thereof (8 positions in total), and evaluated according to the following standard.

AA: The difference between the maximum value and the

minimum value of the thicknesses at the 8 positions was less than 3 mm.

A: The difference between the maximum value and the minimum value of the thicknesses at the 8 positions was 3 mm or more and less than 5 mm (in the state where the paste layer on the inner surface was soft and accumulated in a certain amount on the lower part).

B: The difference between the maximum value and the minimum value of the thicknesses at the 8 positions was 5 mm or more and less than 7 mm.

C: The difference between the maximum value and the minimum value of the thicknesses at the 8 positions was 7 mm or more (in the state where the shape of the product was not able to be retained due to considerable droop or rock pocket).

A smaller difference between the maximum value and the minimum value of the thicknesses means excellent moldability due to the uniform molding.

[0075]

[Table 6]

		Component A		Component B		Mass ratio	Component C		Component D		7-Day compressive strength (N/mm ²)	Moldability
		Kind	Amount added (part by mass) *1	Kind	Amount added (part by mass) *1		Kind	Amount added (part by mass) *1	Kind	Amount added (part by mass) *1		
Comparative Example	3-1	none	0	none	0	—	NSF	0.8	D1	4	108	A
	3-2	glycerin	0.1	none	0	—					102	C
	3-3	none	0	sodium gluconate	0.03	—					105	C
Example	3-1	glycerin	0.1	sodium gluconate	0.03	3.33						

[0076] *1: part by mass per 100 parts by mass of the cement

Claims

[Claim 1]

A hydraulic composition for centrifugal molding, comprising the following components A, B, C, and D, a cement, water, and an aggregate,

wherein the component A is contained in an amount of 0.03 part by mass or more and 0.15 part by mass or less, the component B is contained in an amount of 0.02 part by mass or more and 0.07 part by mass or less, the component C is contained in an amount of 0.5 part by mass or more and 1.0 part by mass or less, and the component D is contained in an amount of 0 part by mass or more and 8 parts by mass or less, per 100 parts by mass of the cement:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin,

component B: one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture.

[Claim 2]

The hydraulic composition for centrifugal molding according to claim 1, wherein the mass ratio A/B of the

components A and B is 1.5 or more and 3.5 or less.

[Claim 3]

The hydraulic composition for centrifugal molding according to claim 1 or 2, wherein the ratio of the content of water to the total of the content of the component D and the content of the cement in terms of $(\text{content of water})/(\text{total content of component D and cement}) \times 100$ is 10% by mass or more and 50% by mass or less.

[Claim 4]

A method for producing a cured article of a hydraulic composition, comprising the following steps 1 to 5:

step 1: kneading the following components A, B, C, and D, a cement, water, and an aggregate, so as to provide a hydraulic composition, wherein the component A in an amount of 0.03 part by mass or more and 0.15 part by mass or less, the component B in an amount of 0.02 part by mass or more and 0.07 part by mass or less, the component C in an amount of 0.5 part by mass or more and 1.0 part by mass or less, and the component D in an amount of 0 part by mass or more and 8 parts by mass or less, per 100 parts by mass of the cement, are kneaded:

component A: one or more compounds selected from glycerin and an ethylene oxide adduct of glycerin,

component B: one or more compounds selected from gluconic acid, tartronic acid, tartaric acid, and salts

thereof,

component C: a naphthalenesulfonic acid-formaldehyde condensate, and

component D: a high-strength admixture;

step 2: filling the hydraulic composition obtained in the step 1, in a mold;

step 3: compacting the hydraulic composition filled in the mold in the step 2, by applying a centrifugal force;

step 4: setting the hydraulic composition compacted in the step 3, in the mold; and

step 5: steam-curing the hydraulic composition set in the step 4, in the mold.

[Claim 5]

The method for producing a cured article of a hydraulic composition according to claim 4, wherein the mass ratio A/B of the components A and B in the step 1 is 1.5 or more and 3.5 or less.

[Claim 6]

The method for producing a cured article of a hydraulic composition according to claim 4 or 5, wherein in the step 1, the ratio of the content of water to the total of the content of the component D and the content of the cement in terms of $(\text{content of water})/(\text{total content of component D and cement}) \times 100$ is 10% by mass or more and 50% by mass or less.