

DESCRIPTION

Title of Invention

ANTICORROSION COVER MATERIAL, ANTICORROSION COVER LAYER, AND METHOD FOR PREVENTING CORROSION IN CONCRETE STRUCTURE

Technical Field

[0001]

The present invention relates to an anticorrosion cover material, an anticorrosion cover layer, and a method for preventing corrosion of a concrete structure.

Background Art

[0002]

In the sewerage, a hot-spring zone, and the like, hydrogen sulfide is generated by the effect of microorganisms or volcanic gas, and when water intervenes therein, sulfuric acid is produced. At such a site, corrosion of a concrete structure is a problem. When a concrete or other cement hardened bodies are brought into contact with sulfuric acid, the sulfuric acid reacts with calcium hydroxide in the concrete to produce gypsum dihydrate, and furthermore produce ettringite, resulting in expansion or degradation of the concrete.

As a method for repairing sites degraded due to sulfuric acid, a method is carried out in which the degraded site is removed by water jet and cross-section repair or unevenness adjustment is performed, followed by resin lining. As a repair material for use in this method, a material in which a polymer is blended with water-granulated blast furnace slag (PTL 1), a material containing alumina cement (PTLs 2 and 3), and a cement mortar in which a large amount of fine powder of water-granulated blast furnace slag, silica fume, or the like is mixed (PTL 4) are used. In addition, a material in which alumina cement and blast furnace slag fine powder are used, the material containing alumina cement particles of 5 μm or less in an amount of 25% by weight or less and containing a lithium salt (PTL 5), a material that contains a water-soluble organic compound having a sulfonic acid alkali metal salt as a substituent in an amount of 0.5 to 4 parts by mass relative to 100

parts by mass of cement (PTL 6), and the like are proposed.

[0003]

Known examples of resin components for use in resin lining include an epoxy resin, a bisphenol-type unsaturated polyester resin, a het acid-based unsaturated polyester resin, a bisphenol-type vinyl ester resin, a novolac-type vinyl ester resin, a brominated bisphenol-type vinyl ester resin, a silicone resin, a polyurethane resin, a polyurea resin, and an acrylic resin (NPL 1).

[0004]

In a method in which concrete is repaired with a cement-based material, followed by resin lining, multi-layer resin lining with a primer coating, an intermediate coating, an over coating, and the like is typically applied. Depending on the type of the resin, there is a case where an intermediate coating or an over coating is applied twice, and thus, many steps may be needed to form a final resin layer.

Citation List

Patent Literature

[0005]

PTL 1: JPH03-290348A

PTL 2: JP2003-89565A

PTL 3] JP2004-292245A

PTL 4] JP2000-128618A

PTL 5] JP2002-293603A

PTL 6] JP2003-292362A

Non-patent Literature

[0006]

NPL 1: “Gesuidou Konkurito Kouzoubutsu no Fusyoku Bousyoku Yokusei Gijutsu oyobi Bousyoku Gijutsu Manyuaru” written and edited by Tihou Kyoudou Houjin, Japan Sewage Works Agency, published by Ippan Zaidan Houjin, Sewerage Business Management Centre, pages 68 to 69, December, 2017

Summary of Invention

Technical Problem

[0007]

The present invention has an object to provide an anticorrosion cover material that facilitates repairing of a concrete structure degraded due to

sulfuric acid or the like and that is superior in durability, an anticorrosion cover layer in which the anticorrosion cover material is used, and a method for preventing corrosion of a concrete structure in which the anticorrosion cover material is used.

Solution to Problem

[0008]

As a result of intensive and extensive studies, the present inventors have found that an anticorrosion cover material that contains a (meth)acrylate monomer and a hydrophobic silica having a predetermined average particle diameter can solve the above problem, thus completing the present invention. The gist of the present invention is as follows.

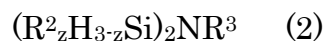
[1] An anticorrosion cover material containing a (meth)acrylate monomer and a hydrophobic silica,

the hydrophobic silica having an average particle diameter of 1 to 100 nm.

[2] The anticorrosion cover material according to the above [1], wherein the hydrophobic silica is at least one silica of a silica hydrophobized with an organosilane represented by the following general formula (1) and a silica hydrophobized with an organosilane represented by the following general formula (2):



wherein R^1 represents an alkyl group, x represents an integer of 1 to 3, y represents an integer of 0 to 3, and $x+y \leq 4$,

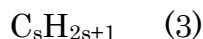


wherein R^2 represents hydrogen, an alkyl group, an alkenyl group, or a halogenated alkyl group, R^3 represents hydrogen, an alkyl group, or an alkali metal element, and z represents an integer of 1 to 3.

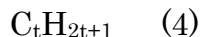
[3] The anticorrosion cover material according to claim 2, wherein the hydrophobic silica contains a silica hydrophobized with a first organosilane represented by the general formula (1) and a silica hydrophobized with a second organosilane represented by the general formula (1), the second organosilane being different from the first organosilane, wherein

in the general formula (1), R^1 of the first organosilane is an alkyl group represented by the following general formula (3), and R^1 in the second organosilane is an alkyl group represented by the following general formula

(4):



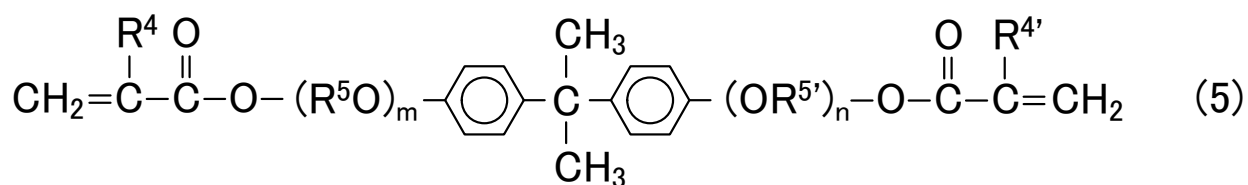
wherein s represents an integer of 1 to 5,



wherein t represents an integer of 6 to 12.

[4] The anticorrosion cover material according to any one of the above [1] to [3], wherein the (meth)acrylate monomer contains a di(meth)acrylate having a bisphenol A backbone.

[5] The anticorrosion cover material according to the above [4], wherein the di(meth)acrylate monomer having a bisphenol A backbone is a di(meth)acrylate having a bisphenol A backbone represented by the following general formula (5):



wherein R^4 and R^4' represent hydrogen or a methyl group, R^5 and R^5' represent an alkylene group optionally having a substituent, and m and n represent an integer of 1 to 20.

[6] The anticorrosion cover material according to any one of the above [1] to [5], wherein the anticorrosion cover material is of a two-agent type of a first anticorrosion cover material containing a polymerization initiator, the (meth)acrylate monomer, and the hydrophobic silica and a second anticorrosion cover material containing a decomposition accelerator which accelerates degradation of the polymerization initiator, the (meth)acrylate monomer, and the hydrophobic silica.

[7] The anticorrosion cover material according to any one of the above [1] to [6], wherein the anticorrosion cover material has a viscosity at 25°C of 1700 to 15,000 mPa·s and a thixotropy index at 25°C of 3.0 or more.

[8] The anticorrosion cover material according to any one of the above [1] to [7], wherein the anticorrosion cover material has a viscosity in the range of 0 to 25°C of 1700 to 15,000 mPa·s and a thixotropy index in the range of 0 to 25°C of 3.0 or more.

[9] An anticorrosion cover layer including

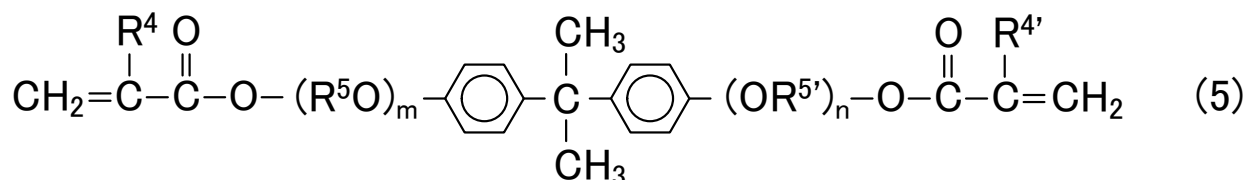
a substrate conditioning layer formed of a hardened body of an alumina cement composition that contains an alumina cement, a pozzolan material, and an aggregate, and

an anticorrosion cover material layer formed, on the substrate conditioning layer, of a hardened body of the anticorrosion cover material according to any one of the above [1] to [8].

[10] The anticorrosion cover layer according to the above [9], further containing a primer formed of a hardened body of a primer composition containing a (meth)acrylate monomer, the primer being interposed between the substrate conditioning layer and the anticorrosion cover material layer.

[11] The anticorrosion cover layer according to the above [10], wherein the (meth)acrylate monomer contained in the primer composition contains a di(meth)acrylate having a bisphenol A backbone.

[12] The anticorrosion cover layer according to the above [11], wherein the di(meth)acrylate having a bisphenol A backbone contained in the primer composition is a di(meth)acrylate having a bisphenol A backbone represented by the following general formula (5):



wherein R^4 and $\text{R}^{4'}$ represent hydrogen or a methyl group, R^5 and $\text{R}^{5'}$ represent an alkylene group optionally having a substituent, and m and n represent an integer of 1 to 20.

[13] The anticorrosion cover layer according to any one of the above [10] to [12], wherein the substrate conditioning layer has a porosity of 5 to 40% by volume and in an area in the vicinity of the primer of the substrate conditioning layer, pores of the substrate conditioning layer are filled with the hardened body of the primer composition.

[14] A method for preventing corrosion of a concrete structure, the method including a step of assembling a frame, a step of placing an alumina cement composition containing an alumina cement, a pozzolan material, and an aggregate into the frame to form a substrate conditioning layer, a step of removing the frame, and a step of applying the anticorrosion cover material

according to any one of the above [1] to [8] to form an anticorrosion cover material layer on the substrate conditioning layer.

[15] The method for preventing corrosion of a concrete structure according to the above [14], further including a step of applying a primer composition containing a (meth)acrylate monomer on the substrate conditioning layer to form a primer, the anticorrosion cover material being applied on the primer.

Advantageous Effects of Invention

[0009]

According to the present invention, it is possible to provide an anticorrosive cover material that facilitates repairing of a concrete structure degraded due to sulfuric acid or the like and that is superior in durability, an anticorrosive cover layer in which the anticorrosive cover material is used, and a method for preventing corrosion of a concrete structure in which the anticorrosive cover material is used.

Description of Embodiments

[0010]

[Anticorrosion cover material]

The anticorrosion cover material of the present invention contains a (meth)acrylate monomer and a hydrophobic silica having an average particle diameter of 1 to 100 nm. The hydrophobic silica is a silica having a surface hydrophobized with a treatment agent. By hydrophobizing the surface of the silica, it becomes easy to disperse the silica in the anticorrosion cover material, making it possible to enhance the thickening effect and the thixotropy effect of the silica. This results in facilitating thick application of the anticorrosion cover material. The anticorrosion cover material of the present invention can be applied into a thickness of 400 μm or more, for example, by one-time application using a roller. By using a (meth)acrylate monomer in the anticorrosion cover material, the sulfuric acid resistance of the anticorrosion cover material can be increased and at the same time, the durability thereof can be improved. In addition, it becomes easy to form a thick film of the anticorrosion cover material.

[0011]

(Hydrophobic silica)

The hydrophobic silica in the anticorrosion cover material of the present invention has an average particle diameter of 1 to 100 nm. When

the average particle diameter of the hydrophobic silica is less than 1 nm, it may be difficult to disperse the hydrophobic silica in the anticorrosion cover material. When the average particle diameter of the hydrophobic silica is larger than 100 nm, the surface area of the hydrophobic silica is small and thus the thickening effect and a thixotropy imparting effect of the hydrophobic silica are so weak that it may be difficult to thickly apply the anticorrosion cover material having a low viscosity. This results in greater trouble in repairing a degraded concrete structure. From this point of view, the average particle diameter of the hydrophobic silica is preferably 2 to 80 nm, more preferably 3 to 60 nm, and further preferably 5 to 50 nm. The average particle diameter of the hydrophobic silica is measured, for example, by a method in which the particle size distribution of the hydrophobic silica is measured using a laser diffraction/scattering particle size distribution analyzer (LS-13 320) manufactured by Beckman Coulter, Inc. and the particle diameter at a cumulative frequency of 50% by volume is taken as the average particle diameter of the hydrophobic silica, a method in which the hydrophobic silica is observed with a transmission electron microscope to directly measure the particle diameters and count the number of particles and the particle diameter at a cumulative frequency of 50% by number is taken as the average particle diameter of the hydrophobic silica, and the like. [0012]

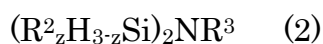
The hydrophobic silica in the anticorrosion cover material of the present invention is at least one silica of a silica hydrophobized with an organosilane represented by the following general formula (1) and a silica hydrophobized with an organosilane represented by the following general formula (2). It is considered that this can further increase the thickening effect and the thixotropy imparting effect of the hydrophobic silica to further facilitate thickly applying the anticorrosion cover material. As a result, it is further easier to repair a concrete structure. A silanol group present on the surface of the hydrophobic silica interacts with another silanol group present on the surface of another hydrophobic silica via a hydrogen bond so that the hydrophobic silica forms a three-dimensional network structure, resulting in an increased viscosity and an increased thixotropic property of the anticorrosion cover material. Then, by hydrophobizing a silica with an organosilane represented by the following general formula (1) and an

organosilane represented by the following general formula (2), the hydrophobic silica can be fully dispersed in the anticorrosion cover material. It is considered that, since the thus fully dispersed hydrophobic silica forms a three-dimensional network structure, the thickening effect and the thixotropy imparting effect of the hydrophobic silica are increased.

[0013]



In the general formula (1), R^1 represents an alkyl group, x represents an integer of 1 to 3, y represents an integer of 0 to 3, and $x+y \leq 4$.



In the general formula (2), R^2 represents hydrogen, an alkyl group, an alkenyl group, or a halogenated alkyl group, R^3 represents hydrogen, an alkyl group, or an alkali metal element, and z represents an integer of 1 to 3.

[0014]

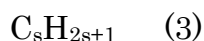
When the hydrophobic silica is a silica hydrophobized with an organosilane represented by the above general formula (1), from the viewpoint of imparting such a viscosity and thixotropic property that facilitate thickly applying the anticorrosion cover material to the anticorrosion cover material, the number of carbon atoms of the alkyl group as R^1 is preferably 1 to 12, more preferably 1 to 10, and further preferably 1 to 8. When the hydrophobic silica is a silica hydrophobized with an organosilane represented by the above general formula (2), from the viewpoint of imparting such a viscosity and thixotropic property that facilitate thickly applying the anticorrosion cover material to the anticorrosion cover material, R^2 is preferably hydrogen, an alkyl group having 1 to 3 carbon atoms, an alkenyl group, or a halogenated alkyl group having 1 to 3 carbon atoms, more preferably hydrogen or an alkyl group having 1 to 3 carbon atoms, and further preferably hydrogen or a methyl group. R^3 is preferably hydrogen, an alkyl group having 1 to 3 carbon atoms, or an alkali metal element, more preferably hydrogen or an alkyl group having 1 to 3 carbon atoms, and further preferably hydrogen.

[0015]

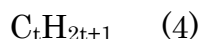
Although the hydrophobic silica can be used alone, two or more hydrophobic silicas are preferably combined so that such a viscosity and thixotropic property that facilitate thickly applying the anticorrosion cover

material with a low viscosity can be imparted to the anticorrosion cover material. In this case, the hydrophobic silica preferably contains a silica hydrophobized with a first organosilane represented by the general formula (1) and a silica hydrophobized with a second organosilane represented by the general formula (1), the second organosilane being different from the first organosilane.

In the above general formula (1), R^1 in the first organosilane is an alkyl group represented by the following general formula (3) and R^1 in the second organosilane is an alkyl group represented by the following general formula (4).



In the general formula (3), s represents an integer of 1 to 5.



In the general formula (4), t represents an integer of 6 to 12.

[0016]

From the viewpoint of imparting such a viscosity and thixotropic property that facilitate thickly applying the anticorrosion cover material to the anticorrosion cover material, preferably, s in the general formula (3) is an integer of 1 to 3 and t in the general formula (4) is an integer of 7 to 10, and more preferably, s in the general formula (3) is an integer of 1 to 2 and t in the general formula (4) is an integer of 8 to 9.

[0017]

The mass ratio of the silica hydrophobized with the first organosilane and the silica hydrophobized with the second organosilane is not particularly limited as long as such a viscosity and thixotropic property that facilitate thickly applying the anticorrosion cover material can be imparted to the anticorrosion cover material. The mass ratio of the silica hydrophobized with the first organosilane and the silica hydrophobized with the second organosilane is, for example, 5:95 to 95:5, preferably 30:70 to 90:10, and further preferably 50:50 to 85:15.

[0018]

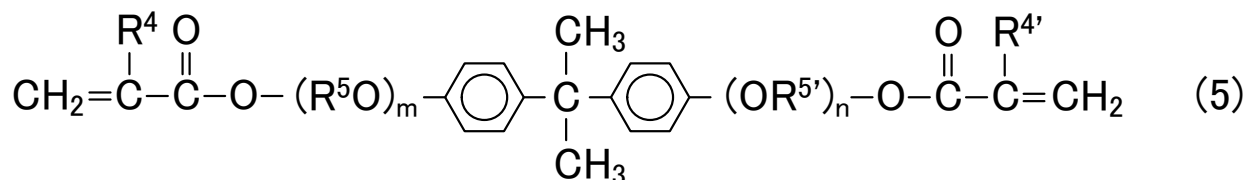
From the viewpoint of imparting such a viscosity and thixotropic property that facilitate thickly applying the anticorrosion cover material to the anticorrosion cover material, the content of the hydrophobic silica in the anticorrosion cover material is, relative to 100 parts by mass of the

(meth)acrylate monomer, preferably 0.5 to 20 parts by mass, more preferably 1 to 10 parts by mass, and further preferably 2 to 7 parts by mass.

[0019]

((Meth)acrylate monomer)

The (meth)acrylate monomer in the anticorrosion cover material of the present invention is preferably a di(meth)acrylate having a bisphenol A backbone. The di(meth)acrylate having a bisphenol A backbone is preferably a di(meth)acrylate having a bisphenol A backbone represented by the following general formula (5) (hereinafter sometimes referred to as (meth)acrylate monomer (A)). This can further improve the sulfuric acid resistance and durability of the anticorrosion cover material.



In the general formula (5), R^4 and $\text{R}^{4'}$ represent hydrogen or a methyl group, R^5 and $\text{R}^{5'}$ represent an alkylene group optionally having a substituent, and m and n represent an integer of 1 to 20. R^4 and $\text{R}^{4'}$ may be the same as or different from each other. R^5 and $\text{R}^{5'}$ may also be the same as or different from each other.

[0020]

From the viewpoint of further improving the sulfuric acid resistance and durability of the anticorrosion cover material, R^5 and $\text{R}^{5'}$ are preferably an alkylene group having 1 to 12 carbon atoms optionally having a substituent, more preferably an alkylene group having 2 to 4 carbon atoms optionally having a substituent, further preferably an ethylene group and a n -propylene group having a 2-hydroxy group ($-\text{CH}_2\text{CH}(\text{OH})\text{CH}_2-$). Preferably, $(m+n)$ is 2 to 10, and more preferably, $(m+n)$ is 2 to 4.

[0021]

Examples of the (meth)acrylate monomer (A) include bisphenol A-type EO2-modified di(meth)acrylate, bisphenol A-type EO(ethylene oxide)4-modified di(meth)acrylate, bisphenol A-type EO10-modified di(meth)acrylate, bisphenol A-type PO-modified di(meth)acrylate, and bisphenol A diglycidyl ether (meth)acrylic acid adduct. One of the (meth)acrylate monomers (A)

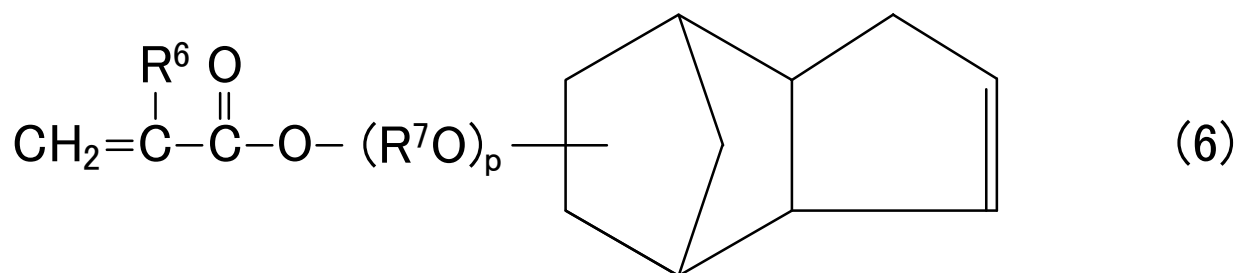
can be used alone or two or more thereof can be used in combination.

[0022]

Examples of commercially available (meth)acrylate monomers (A) include Miramer M-241 (manufactured by Miwon Specialty Chemical), Miramer M-2101 (manufactured by Miwon Specialty Chemical), Miramer PE210 (manufactured by Miwon Specialty Chemical), NK Ester BPE-100 (manufactured by SHIN-NAKAMURA CHEMICAL Co., Ltd.), NK Ester BPE-200 (manufactured by SHIN-NAKAMURA CHEMICAL Co., Ltd.), NK Ester BPE-500 (manufactured by SHIN-NAKAMURA CHEMICAL Co., Ltd.), NK Ester BPE-1300 (manufactured by SHIN-NAKAMURA CHEMICAL Co., Ltd.), Light Ester BP-2EMBR-MA (Kyoisha Chemical Co., Ltd.), FANCRYL FA-321M (manufactured by Hitachi Chemical Company, Ltd.), and FANCRYL FA-324A (manufactured by Hitachi Chemical Company, Ltd.).

[0023]

The anticorrosion cover material of the present invention preferably contains, as a (meth)acrylate monomer, in addition to the (meth)acrylate monomer (A), a (meth)acrylate having a dicyclopentenyl backbone (hereinafter sometimes referred to as (meth)acrylate monomer (B)). The (meth)acrylate having a dicyclopentenyl backbone is preferably a dicyclopentenylalkylene (meth)acrylate represented by the following general formula (6). This can further improve the sulfuric acid resistance and durability of the anticorrosion cover material. The (meth)acrylate monomer (B) also has an effect as a reactive diluent.



In the general formula (6), R^6 represents hydrogen or a methyl group, R^7 represents an alkylene group, and p represents an integer of 1 to 20.

[0024]

From the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material, R^6 is preferably a methyl group. R^7 is preferably an alkylene group having 1 to 12 carbon atoms, more preferably

an alkylene group having 1 to 4 carbon atoms, and further preferably an ethylene group. p is preferably an integer of 1 to 3, and more preferably 1.

[0025]

Examples of the (meth)acrylate monomer (B) include dicyclopentenylloxyethyl (meth)acrylate, dicyclopentenylloxy diethylene glycol (meth)acrylate, dicyclopentenylloxy triethylene glycol (meth)acrylate, and dicyclopentenylloxy propylene glycol (meth)acrylate. One of the (meth)acrylate monomers (B) can be used alone or two or more thereof can be used in combination. Among them, from the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material, dicyclopentenylloxyethyl (meth)acrylate is preferred.

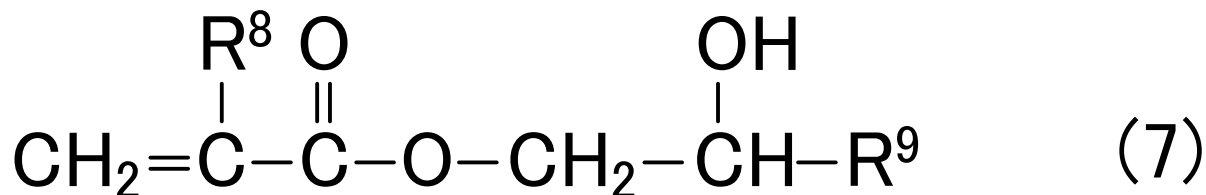
[0026]

The anticorrosion cover material of the present invention preferably contains, as a (meth)acrylate monomer, in addition to the (meth)acrylate monomer (A) and the (meth)acrylate monomer (B), a hydroxyalkyl (meth)acrylate (hereinafter sometimes referred to as (meth)acrylate monomer (C)). This can further improve the sulfuric acid resistance and durability of the anticorrosion cover material.

[0027]

Examples of the (meth)acrylate monomer (C) include 2-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, and glycerol mono(meth)acrylate. One of the (meth)acrylate monomers (C) can be used alone or two or more thereof can be used in combination. Among them, from the viewpoint of adhesiveness of the anticorrosion cover material, a 2-hydroxyalkyl (meth)acrylate represented by the following general formula (7) is preferred, and 2-hydroxyethyl (meth)acrylate is more preferred.

[0028]



In the general formula (7), R⁸ represents hydrogen or a methyl group and R⁹

represents hydrogen or an alkyl group.

[0029]

From the viewpoint of adhesiveness of the anticorrosion cover material, R⁸ is preferably a methyl group. R⁹ is preferably hydrogen or an alkyl group having 1 to 12 carbon atoms, more preferably hydrogen or an alkyl group having 1 to 5 carbon atoms, and further preferably hydrogen.

[0030]

From the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material, the content of the (meth)acrylate monomer (A) in the anticorrosion cover material is, based on 100 parts by mass of the total of the (meth)acrylate monomer (A), the (meth)acrylate monomer (B), and the (meth)acrylate monomer (C), preferably 20 to 80 parts by mass, and more preferably 40 to 70 parts by mass. On the other hand, from the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material, the content of the (meth)acrylate monomer (B) in the anticorrosion cover material is, based on 100 parts by mass of the total of the (meth)acrylate monomer (A), the (meth)acrylate monomer (B), and the (meth)acrylate monomer (C), preferably 10 to 50 parts by mass, and more preferably 20 to 40 parts by mass. From the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material, the content of the (meth)acrylate monomer (C) in the anticorrosion cover material is, based on 100 parts by mass of the total of the (meth)acrylate monomer (A), the (meth)acrylate monomer (B), and the (meth)acrylate monomer (C), preferably 5 to 35 parts by mass, and more preferably 10 to 20 parts by mass.

[0031]

The (meth)acrylate monomer in the anticorrosion cover material of the present invention may contain a (meth)acrylate monomer other than the (meth)acrylate monomer (A), the (meth)acrylate monomer (B), and the (meth)acrylate monomer (C) to the extent that the effect of the present invention is not impaired. From the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material, the content of the total of the (meth)acrylate monomer (A), the (meth)acrylate monomer (B), and the (meth)acrylate monomer (C) in the (meth)acrylate monomer in the anticorrosion cover material is preferably 80 to 100% by mass, more preferably 90 to 100% by mass, and further preferably 95 to 100% by mass.

[0032]

(Polymerization initiator)

The anticorrosion cover material of the present invention preferably contains a polymerization initiator for accelerating hardening of the (meth)acrylate monomer. The polymerization initiator generates free radicals to initiate polymerization of the (meth)acrylate monomer. Examples of the polymerization initiator include the following organic peroxides

[0033]

- (1) Ketone peroxides: methyl ethyl ketone peroxide, cyclohexanone peroxide, 3,3,5-trimethylcyclohexanone peroxide, methylcyclohexanone peroxide, methylacetoacetate peroxide, acetylacetone peroxide, etc.
- (2) Peroxyketals: 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, 1,1-bis(t-butylperoxy)cyclohexane, 2,2-bis(t-butylperoxy)octane, n-butyl-4,4-bis(t-butylperoxy)valerate, 2,2-bis(t-butylperoxy)butane, etc.
- (3) Hydroperoxides: t-butyl hydroperoxide, cumene hydroperoxide, diisopropylbenzene hydroperoxide, p-menthane hydroperoxide, 2,5-dimethylhexane-2,5-dihydroperoxide, 1,1,3,3-tetramethylbutyl hydroperoxide, etc.
- (4) Dialkyl peroxides: di-t-butyl peroxide, t-butyl cumyl peroxide, dicumyl peroxide, α,α' -bis(t-butylperoxy-m-isopropyl)benzene, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, 2,5-dimethyl-2,5-di(t-butylperoxy)hexyne-3, etc.
- (5) Diacyl peroxides: acetyl peroxide, isobutyl peroxide, octanoyl peroxide, decanoyl peroxide, laurinoyl peroxide, 3,3,5-trimethyl hexanoyl peroxide, succinic acid peroxide, benzoyl peroxide, 2,4-dichlorobenzoyl peroxide, m-toluoyl peroxide, etc.
- (6) Peroxydicarbonates: diisopropyl peroxydicarbonate, di-2-ethylhexyl peroxydicarbonate, di-n-propyl peroxydicarbonate, bis(4-t-butylcyclohexyl) peroxydicarbonate, di-2-ethoxyethyl peroxydicarbonate, dimethoxyisopropyl peroxydicarbonate, di(3-methyl-3-methoxybutyl) peroxydicarbonate, diallyl peroxydicarbonate, etc.
- (7) Peroxyesters: t-butyl peroxyacetate, t-butyl peroxyisobutylate, t-butyl peroxy-pivalate, t-butyl peroxyneodecanoate, cumyl peroxyneodecanoate, t-butyl peroxy-2-ethylhexanoate, t-butyl peroxy-3,3,5-trimethylhexanoate, t-butyl peroxy-laurate, t-butyl peroxybenzoate, di-t-butyl peroxyisophthalate,

2,5-dimethyl-2,5-di(benzoyl peroxy)hexane, t-butyl peroxy maleic acid, t-butyl peroxyisopropylcarbonate, cumyl peroxyoctoate, t-hexyl peroxyneodecanoate, t-hexyl peroxy pivalate, t-butyl peroxyneohexanoate, t-hexyl peroxyneohexanoate, cumyl peroxyneohexanoate, etc.

(8) Other organic peroxides: acetyl cyclohexylsulfonyl peroxide, t-butyl peroxyallyl carbonate, etc.

[0034]

One of the polymerization initiators can be used alone or two or more thereof can be used in combination. Among the polymerization initiators, in terms of the adhesiveness and hardening property, an organic peroxide is preferred. Among organic peroxides, a hydroperoxide is preferred. Among hydroperoxides, cumene hydroperoxide is preferred.

[0035]

The content of the polymerization initiator in the anticorrosion cover material is, relative to 100 parts by mass of the total content of the (meth)acrylate monomer, preferably 0.5 to 10 parts by mass, and more preferably 0.7 to 5 parts by mass.

[0036]

(Decomposition accelerator)

The anticorrosion cover material of the present invention preferably contains a decomposition accelerator in addition to the polymerization initiator. A decomposition accelerator plays a role in accelerating decomposition of the polymerization initiator to accelerate generation of free radicals, accelerating the hardening reaction of the anticorrosion cover material. This allows the anticorrosion cover material to securely harden under a normal temperature. Examples of the decomposition accelerator include the following compounds.

(1) Thiourea derivatives: diethylthiourea, dibutylthiourea, ethylene thiourea, tetramethylthiourea, mercaptobenzimidazole, benzoylthiourea, etc.

(2) Amines: N,N-diethyl-p-toluidine, N,N-dimethyl-p-toluidine, N,N-diisopropanol-p-toluidine, N,N-di(2-hydroxyethyl)-p-toluidine, triethylamine, tripropylamine, ethyldiethanolamine, N,N-dimethylaniline, ethylene diamine, triethanolamine, etc.

(3) Organic acid metal salts: cobalt naphthenate, copper naphthenate, zinc naphthenate, cobalt(II) bis(2-ethylhexanoate), iron(III) tris(2-

ethylhexanoate), etc.

(4) Organic metal chelate compounds: copper acetylacetonate, titanium acetylacetonate, manganese acetylacetonate, chromium acetylacetonate, iron acetylacetonate, vanadyl acetylacetonate, cobalt acetylacetonate, etc.

Another example of the decomposition accelerator is a condensation reaction product of an aldehyde and an amine. One of the decomposition accelerators can be used alone or two or more thereof can be used in combination. Among them, from the viewpoint of hardening property, an organic acid metal salt is preferred. Among organic acid metal salts, cobalt(II) bis(2-ethylhexanoate) is preferred.

As the decomposition accelerator, combination use of an amine and an organic acid metal salt is also more preferred. When an amine and an organic acid metal salt are used in combination, the ratio thereof (amine : organic acid metal salt) in terms of the mass ratio in 100 parts by mass of the total of the amine and the organic acid metal salt is preferably 1 to 45 : 55 to 99, and more preferably 5 to 15 : 85 to 95.

[0037]

The content of the decomposition accelerator in the anticorrosion cover material is, relative to 100 parts by mass of the total content of the (meth)acrylate monomer, preferably 0.5 to 10 parts by mass, and more preferably 1.0 to 5 parts by mass.

[0038]

(Silane coupling agent)

The anticorrosion cover material of the present invention can contain a silane coupling agent for the purpose of increasing the adhesiveness. Examples of the silane coupling agent include γ -chloropropyltrimethoxysilane, vinyltrimethoxysilane, vinyltrichlorosilane, vinyltriethoxysilane, vinyl-tris(β -methoxyethoxy)silane, γ -(meth)acryloxypropyltrimethoxysilane, β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -glycidoxypropyltrimethoxysilane, γ -mercaptopropyltrimethoxysilane, γ -aminopropyltriethoxysilane, N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane, N- β -(aminoethyl)- γ -aminopropylmethyldimethoxysilane, and γ -ureidopropyltriethoxysilane. Among them, in terms of adhesiveness, γ -(meth)acryloxypropyltrimethoxysilane is preferred.

The amount of the silane coupling agent used is, relative to 100 parts by mass of the total content of the (meth)acrylate monomer, preferably 0.01 to 20 parts by mass, and more preferably 0.05 to 5 parts by mass.

[0039]

(Other components)

In the anticorrosion cover material of the present invention, a component other than the above components can be used.

[0040]

The content of the other components in the anticorrosion cover material is, relative to 100 parts by mass of the total content of the (meth)acrylate monomer, preferably 50 parts by mass or less, and more preferably 30 parts by mass or less.

[0041]

(Two-agent type)

The anticorrosion cover material of the present invention may be of a one-agent type, but is preferably of a two-agent type of a first anticorrosion cover material containing the polymerization initiator, the (meth)acrylate monomer, and the hydrophobic silica and a second anticorrosion cover material containing the decomposition accelerator, the (meth)acrylate monomer, and the hydrophobic silica. The amine is preferably contained in the first anticorrosion cover material, and the thiourea derivative, the organic acid metal salt, and the organic metal chelate compound are preferably contained in the second anticorrosion cover material. By the anticorrosion cover material of the present invention being of a two-agent type, the workability of the anticorrosion cover material of the present invention is further improved. In addition, by the first anticorrosion cover material and the second anticorrosion cover material having almost the same composition, the permissible range of the blending ratio is expanded, and thus, the anticorrosion cover material can be used even at a workshop where blending at a strict blending ratio is difficult. Thus, the compositions of the first anticorrosion cover material and the second anticorrosion cover material are preferably almost the same except for the polymerization initiator and the decomposition accelerator. Specifically, it is preferred that, in the first anticorrosion cover material and the second anticorrosion cover material, the hydrophobic silica, the (meth)acrylate monomer (A), the (meth)acrylate

monomer (B), and the (meth)acrylate monomer (C) are respectively the same, and the content of the hydrophobic silica relative to 100 parts by mass of the (meth)acrylate monomer, and the content of the (meth)acrylate monomer (A), the content of the (meth)acrylate monomer (B), and the content of the (meth)acrylate monomer (C), based on 100 parts by mass of the total of the (meth)acrylate monomer (A), the (meth)acrylate monomer (B), and (meth)acrylate monomer (C), are respectively the same. Furthermore, generally, in the construction of corrosion prevention of the concrete structure, after materials are brought in, the materials are blended and kneaded to produce an anticorrosion cover material. Accordingly, by the anticorrosion cover material of the present invention being of a two-agent type, blending of the materials is easy by blending the first anticorrosion cover material and the second anticorrosion cover material and the anticorrosion cover material can be efficiently produced.

[0042]

(Viscosity)

The viscosity at 25°C of the anticorrosion cover material of the present invention is preferably 1,700 to 15,000 mPa·s. When the viscosity at 25°C of the anticorrosion cover material is 1,700 mPa·s or more, the anticorrosion cover material can be easily thickly applied. When the viscosity at 25°C of the anticorrosion cover material is 15,000 mPa·s or less, the anticorrosion cover material can be easily applied. From this point of view, the viscosity at 25°C of the anticorrosion cover material is more preferably 2,000 to 15,000 mPa·s, and further preferably 2,500 to 10,000 mPa·s. When the anticorrosion cover material of the present invention is of a two-agent type of a first anticorrosion cover material and a second anticorrosion cover material, the viscosity of the anticorrosion cover material of the present invention is the viscosity of an anticorrosion cover material obtained by mixing the first anticorrosion cover material and the second anticorrosion cover material. The viscosity of the anticorrosion cover material can be measured by a method described in the section of Examples given later.

[0043]

Viscosities in the range of 0 to 25°C of the anticorrosion cover material of the present invention are preferably 1,700 to 15,000 mPa·s. When viscosities in the range of 0 to 25°C of the anticorrosion cover material are

1,700 mPa·s or more, the anticorrosion cover material can be easily thickly applied even in a low temperature period. When viscosities in the range of 0 to 25°C of the anticorrosion cover material are 15,000 mPa·s or less, the anticorrosion cover material can be easily applied even in a low temperature period. From this point of view, viscosities in the range of 0 to 25°C of the anticorrosion cover material are more preferably 2,000 to 15,000 mPa·s, and further preferably 2,500 to 10,000 mPa·s.

[0044]

(Thixotropy index)

The thixotropy index at 25°C of the anticorrosion cover material of the present invention is preferably 3.0 or more. When the thixotropy index at 25°C of the anticorrosion cover material is 3.0 or more, the viscosity of the anticorrosion cover material decreases during applying the anticorrosion cover material and the anticorrosion cover material is easily applied, and the viscosity of the anticorrosion cover material after application increases to suppress dripping of the anticorrosion cover material. As a result, the anticorrosion cover material can be easily thickly applied. From this point of view, the thixotropy index at 25°C of the anticorrosion cover material is more preferably 3.3 or more, further preferably 3.5 or more. The upper limit of the thixotropy index at 25°C of the anticorrosion cover material is not particularly limited, but is, for example, 10.0 or less. When the anticorrosion cover material of the present invention is of a two-agent type of a first anticorrosion cover material and a second anticorrosion cover material, the thixotropy index of the anticorrosion cover material of the present invention is the thixotropy index of an anticorrosion cover material obtained by mixing the first anticorrosion cover material and the second anticorrosion cover material. The thixotropy index of the anticorrosion cover material can be measured by a method described in the section of Examples given later.

[0045]

Thixotropy indices in the range of 0 to 25°C of the anticorrosion cover material of the present invention are preferably 3.0 or more. When thixotropy indices in the range of 0 to 25°C of the anticorrosion cover material are 3.0 or more, the viscosity of the anticorrosion cover material decreases during applying the anticorrosion cover material even in a low temperature period and the anticorrosion cover material is easily applied, and the viscosity

of the anticorrosion cover material after application increases to suppress dripping of the anticorrosion cover material. As a result, the anticorrosion cover material can easily be thickly applied even in a low temperature period. From this point of view, the thixotropy index at 25°C of the anticorrosion cover material is more preferably 4.0 or more, and further preferably 5.0 or more. The upper limit of the thixotropy indices in the range of 0 to 25°C of the anticorrosion cover material is not particularly limited, but, for example, 10.0 or less.

[0046]

(Working life)

From the viewpoint of workability of the anticorrosion cover material of the present invention, the working life of the anticorrosion cover material of the present invention is preferably 15 to 75 minutes, and more preferably 30 to 50 minutes. The working life of the anticorrosion cover material can be measured by a method described in the section of Examples given later.

[0047]

(Hardening time)

From the viewpoint of workability of the anticorrosion cover material of the present invention, the hardening time of the anticorrosion cover material of the present invention is preferably 30 to 120 minutes, and more preferably 50 to 80 minutes. The hardening time of the anticorrosion cover material can be measured by a method described in the section of Examples given later.

[0048]

(Tensile shear adhesive strength)

From the viewpoint of the durability of the anticorrosion cover material of the present invention, the tensile shear adhesive strength of the anticorrosion cover material of the present invention is preferably 5 to 35 N/mm², and more preferably 10 to 30 N/mm². The tensile shear adhesive strength of the anticorrosion cover material can be measured by a method described in the section of Examples given later.

[0049]

[Anticorrosion cover layer]

The anticorrosion cover layer of the present invention includes: a substrate conditioning layer formed of a hardened body of an alumina cement

composition that contains an alumina cement, a pozzolan material, and an aggregate; and an anticorrosion cover material layer formed, on the substrate conditioning layer, of a hardened body of the anticorrosion cover material of the present invention. Thus, an anticorrosion cover layer that facilitates repairing of a concrete structure degraded due to sulfuric acid or the like and that is superior in sulfuric acid resistance and durability can be obtained.

[0050]

(Tensile adhesive strength)

From the viewpoint of the durability of the anticorrosion cover layer of the present invention, the tensile adhesive strength of the anticorrosion cover layer of the present invention is preferably 1.0 to 4.0 N/mm², and more preferably 1.5 to 4.0 N/mm². The tensile adhesive strength of the anticorrosion cover layer of the present invention can be measured by a method described in the section of Examples given later.

[0051]

(Sulfuric acid permeation depth)

From the viewpoint of the sulfuric acid resistance of the anticorrosion cover layer of the present invention, the sulfuric acid permeation depth of the anticorrosion cover layer of the present invention is preferably less than 0.3 mm, and more preferably less than 0.1 mm. The sulfuric acid permeation depth of the anticorrosion cover layer of the present invention can be measured by a method described in the section of Examples given later.

[0052]

(Anticorrosion cover material layer)

The anticorrosion cover material layer in the anticorrosion cover layer of the present invention is formed of a hardened body of the anticorrosion cover material of the present invention. Thus, a thick anticorrosion cover material layer can be easily formed. This facilitates easy repairing of a concrete structure degraded due to sulfuric acid or the like. In addition, the anticorrosion cover material layer can be superior in the sulfuric acid resistance and durability. Thus, the anticorrosion cover layer of the present invention can also be superior in the sulfuric acid resistance and durability.

[0053]

<Thickness>

The thickness of the anticorrosion cover material layer in the

anticorrosion cover layer of the present invention is, From the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover material layer, the thickness of the anticorrosion cover material layer in the anticorrosion cover layer of the present invention is preferably 0.4 mm or more, more preferably 0.5 mm or more, and further preferably 0.8 mm or more. Since, when the thickness of the anticorrosion cover material layer is not larger than necessary, the anticorrosion cover material is not wasted and the repairing of the concrete structure does not take a lot of trouble, the thickness of the anticorrosion cover material layer is preferably 2.0 mm or less, more preferably 1.5 mm or less, and further preferably 1.0 mm or less.

[0054]

(Substrate conditioning layer)

The substrate conditioning layer in the anticorrosion cover layer of the present invention is formed of a hardened body of an alumina cement composition. This can further improve the sulfuric acid resistance and durability of the anticorrosion cover layer. The alumina cement composition contains an alumina cement, a pozzolan material, and an aggregate.

[0055]

<Alumina cement>

The alumina cement in the alumina cement composition used in the substrate conditioning layer in the anticorrosion cover layer of the present invention is superior in the sulfuric acid resistance since the alumina cement forms a hardened body without generating slaked lime as a hydration product unlike Portland cement. The alumina cement is obtained from a clinker ground product containing monocalcium aluminate as a main mineral, and, for example, alumina cement No. 1, alumina cement No. 2, and the like can be used.

[0056]

The fineness of the alumina cement is preferably a Blain's specific surface area of 2,000 to 8,000 cm²/g in terms of the hydration activity.

[0057]

<Pozzolan material>

The pozzolan material in the alumina cement composition used in the substrate conditioning layer in the anticorrosion cover layer of the present invention is a substance that shows a pozzolan activity in response to an

alkali stimulation. Combination use of the pozzolan material with an alumina cement can suppress strength reduction due to phase transition of a hydrate to increase dripping resistance of the alumina cement composition during construction. Examples of the pozzolan material include water-granulated blast furnace slag, air-cooled blast furnace slag, converter slag, silica fume, and fly ash. One of the pozzolan materials can be used alone or two or more thereof can be used in combination.

[0058]

The fineness of the pozzolan material is preferably a Blain's specific surface area of 3000 cm²/g or more in terms of hydration activity. The amount of the pozzolan material used is generally, relative to 100 parts by mass of the alumina cement, preferably 60 to 200 parts by mass, and more preferably 80 to 150 parts by mass. The amount of silica fume is preferably 1 to 20 parts by mass relative to 100 parts by mass of the alumina cement.

[0059]

<Aggregate>

The aggregate in the alumina cement composition used in the substrate conditioning layer in the anticorrosion cover layer of the present invention is not particularly limited, and is generally a commonly available aggregate. Examples of the aggregate include silica sand aggregate, silica stone aggregate, lime stone aggregate, heavy aggregate, and light aggregate. One of the aggregates can be used alone or two or more thereof can be used in combination. An aggregate other than lime stone aggregate is preferably used in terms of acid resistant performance. Among aggregates other than lime stone aggregate, silica sand is preferred. By the alumina cement composition containing an aggregate, the strength of the substrate conditioning layer can be increased.

[0060]

The amount of the aggregate used is not particularly limited as long as it does not have an impact on the acid resistant performance and fluidity, but is preferably 100 to 400 parts by mass relative to 100 parts by mass of the total of the alumina cement and the pozzolan material.

[0061]

<Portland cement>

In order to more strongly exhibit the hardening property of the

pozzolan material contained in the alumina cement composition, the alumina cement composition may further contain portland cement. This can improve the strength of the substrate conditioning layer. The amount of the portland cement used is not particularly limited as long as it does not have an impact on the acid resistant performance and fluidity, but is preferably 25 to 70 parts by mass relative to 100 parts by mass of the alumina cement. When the alumina cement composition contains portland cement, for increasing the strength of the substrate conditioning layer, the alumina cement composition may further contain gypsum. The amount of the gypsum used is not particularly limited as long as it does not have an impact on the acid resistant performance and fluidity, but is preferably 50 to 150 parts by mass relative to 100 parts by mass of the portland cement. When the alumina cement composition contains portland cement, for accelerating hardening of the alumina cement composition, the alumina cement composition may further contain slaked lime. The amount of the slaked lime used is not particularly limited as long as it does not have an impact on the acid resistant performance and fluidity, but is preferably 5 to 50 parts by mass relative to 100 parts by mass of the portland cement.

[0062]

<Additive>

The alumina cement composition used in the substrate conditioning layer in the anticorrosion cover layer of the present invention can contain various additives to the extent that the additives have no negative impact on the performance of the substrate conditioning layer. However, a higher fatty acid-based admixture for the purpose of water proof, crack prevention, and the like possibly worsens adhesiveness between concrete and the substrate conditioning layer, and thus is preferably not used. A concrete curing agent obtained by dissolving a wax, a resin, a chlorinated rubber, or the like in a solvent also possibly worsens adhesiveness between concrete and the substrate conditioning layer, and thus is preferably not used.

[0063]

<Porosity>

The porosity of the substrate conditioning layer is preferably 5 to 40% by volume. When the porosity of the substrate conditioning layer is 5% by volume or more, the anticorrosion cover material or a primer composition as

described later can sufficiently permeate the substrate conditioning layer, and thus detachment of the anticorrosion cover material layer or the primer from the substrate conditioning layer is further suppressed. As a result, the sulfuric acid resistance and durability of the anticorrosion cover layer is further improved. When the porosity of the substrate conditioning layer is 40% by volume or less, permeation of an excessive amount of the anticorrosion cover material or a primer composition as described later into the substrate conditioning layer can be suppressed. When an excessive amount of the anticorrosion cover material or a primer composition as described later permeates the substrate conditioning layer, the amount of the anticorrosion cover material or the primer composition to be used for forming an anticorrosion cover material layer or a primer having a desired thickness becomes very large. From this point of view, the porosity of the substrate conditioning layer is more preferably 5 to 30% by volume. When the substrate conditioning layer has the porosity as described above, in an area in the vicinity of the anticorrosion cover material layer of the substrate conditioning layer or in an area in the vicinity of the primer thereof, pores in the substrate conditioning layer are filled with the hardened body of the anticorrosion cover material or the hardened body of the primer composition. The area in the vicinity of the anticorrosion cover material layer of the substrate conditioning layer is in the range of 0.5 mm or less from the interface between the substrate conditioning layer and the anticorrosion cover material layer. The area in the vicinity of the primer of the substrate conditioning layer is in the range of 2 mm or less from the interface between the substrate conditioning layer and the primer.

[0064]

<Thickness>

From the viewpoint of the sulfuric acid resistance and durability of the anticorrosion cover layer, the thickness of the substrate conditioning layer in the anticorrosion cover layer of the present invention is preferably 10 mm or more, more preferably 15 mm or more, and further preferably 20 mm or more. Since, when the thickness of the substrate conditioning layer is not larger than necessary, the alumina cement composition is not wasted and the repairing of the concrete structure does not take a lot of trouble, the thickness of the substrate conditioning layer is preferably 70 mm or less, more

preferably 60 mm or less, and further preferably 50 mm or less.

[0065]

<Compressive strength>

From the viewpoint of the durability of the anticorrosion cover layer, the compressive strength of the alumina cement composition used in the substrate conditioning layer in the anticorrosion cover layer of the present invention is preferably 30 to 90 N/mm², and more preferably 40 to 80 N/mm². The compressive strength of the alumina cement composition can be measured by a method described in the section of Example given later.

[0066]

(Primer)

The anticorrosion cover layer of the present invention preferably contains a primer interposed between the substrate conditioning layer and the anticorrosion cover material layer. This allows for suppression of detachment of the anticorrosion cover material layer from the substrate conditioning layer. As a result, the sulfuric acid resistance and durability of the anticorrosion cover layer are further improved. The primer is formed of a hardened body of a primer composition containing a (meth)acrylate monomer.

[0067]

The (meth)acrylate monomer contained in the primer composition is preferably the same as the (meth)acrylate monomer used in the anticorrosion cover material. This can further increase the adhesiveness between the primer and the anticorrosion cover material layer. As a result, the sulfuric acid resistance and durability of the anticorrosion cover layer are further improved. As with the (meth)acrylate monomer used in the anticorrosion cover material, the primer composition also preferably contains a polymerization initiator and a decomposition accelerator. As with the (meth)acrylate monomer used in the anticorrosion cover material, the primer composition may also contain other components. As with the (meth)acrylate monomer used in the anticorrosion cover material, the primer composition is also preferably of a two-agent type of a first primer composition containing the polymerization initiator and the (meth)acrylate monomer and a second primer composition containing the decomposition accelerator and the (meth)acrylate monomer.

[0068]

Since the (meth)acrylate monomer, the polymerization initiator, and the decomposition accelerator contained in the primer composition are the same as the (meth)acrylate monomer, the polymerization initiator, and the decomposition accelerator used in the anticorrosion cover material, description of the (meth)acrylate monomer, the polymerization initiator, and the decomposition accelerator contained in the primer composition is omitted. The (meth)acrylate monomer, the polymerization initiator, and the decomposition accelerator contained in the primer composition are preferably the same as the (meth)acrylate monomer, the polymerization initiator, and the decomposition accelerator used in the anticorrosion cover material of the anticorrosion cover material layer provided adjacent to the primer.

[0069]

<Thickness>

From the viewpoint of suppressing detachment of the anticorrosion cover material layer from the substrate conditioning layer, the thickness of the primer is preferably 50 to 250 μm , more preferably 80 to 200 μm , and further preferably 100 to 150 μm .

[0070]

<Viscosity>

From the viewpoint of workability of the primer composition, the viscosity at 25°C of the primer composition is preferably 50 to 1000 mPa·s, and more preferably 100 to 500 mPa·s. The viscosity at 25°C of the primer composition can be measured by a method described in the section of Example given later.

[0071]

(Working life)

From the viewpoint of workability of the primer composition, the working life of the primer composition is preferably 10 to 50 minutes, and more preferably 20 to 30 minutes. The working life of the primer composition can be measured by a method described in the section of Example given later.

[0072]

(Hardening time)

From the viewpoint of workability of the primer composition, the

hardening time of the primer composition is preferably 15 to 85 minutes, and more preferably 30 to 50 minutes. The hardening time of the primer composition can be measured by a method described in the section of Example given later.

[0073]

(Construction period)

One of functions that have a negative impact on the performance of the anticorrosion cover layer is the construction period, such as a rainy period, a high temperature period, and a low temperature period. In particular, the low temperature period has a negative impact on the hardening, performance, and the like of a resin, and thus is not preferred as the construction period. However, since the anticorrosion cover layer of the present invention can maintain a high performance even in a low temperature period (for example, a construction environment of a temperature of 0 to 15°C), the anticorrosion cover layer can be constructed even in a low temperature period.

[0074]

[Method for preventing corrosion of a concrete structure]

The method for preventing corrosion of a concrete structure of the present invention includes a step (A) of assembling a frame, a step (B) of placing the alumina cement composition into the frame to form a substrate conditioning layer, a step (C) of removing the frame, and a step (D) of applying the anticorrosion cover material of the present invention to form an anticorrosion cover material layer on the substrate conditioning layer. Thus, an anticorrosion cover layer superior in sulfuric acid resistance and durability can be easily formed and repairing of a concrete structure degraded due to sulfuric acid or the like can be easily performed.

[0075]

(Step (A))

In the step (A), a frame is assembled. By using a frame, construction of corrosion prevention can be performed on a concrete structure with a high degree of damage in reinforcing steel bars which requires a relatively larger scale repairing. For example, when corrosion prevention is performed on a wall surface inside a manhole, a cylindrical frame as described in JP-A-2015-71939 can be used.

[0076]

(Step (B))

In the step (B), the alumina cement composition is placed into the frame to form a substrate conditioning layer. For example, when corrosion prevention is performed on a wall surface inside a manhole, the alumina cement composition is injected into a void between the cylindrical frame and the manhole interior wall surface, and is hardened to form a substrate conditioning layer. Placement of the alumina cement composition is required to be performed so that separation of the materials occurs as small as possible and no defect in construction is formed on the placed substrate conditioning layer. After the alumina cement composition is placed, compaction with a vibrator may be performed. This allows for formation of a dense solid substrate conditioning layer with few air bubbles and pores. The alumina cement composition can be fully spread over the periphery of a reinforcing steel bar and into every corner of the frame.

[0077]

(Step (C))

In the step (C), the frame is removed. The frame is required to be removed after a strength required for the substrate conditioning layer to receive its own weight and a load applied in the construction is reached. In order to determine the time when the required strength of the substrate conditioning layer is reached, for example, the compressive strength of a standard test piece that is cured in the same state as for the substrate conditioning layer may be measured. It is preferred that a part of the frame that receives a relatively low load is removed first, and then, the remaining important part is removed. For example, the horizontal part of the frame is preferably removed later than the vertical part thereof.

[0078]

(Step (D))

In the step (D), the anticorrosion cover material of the present invention is applied to form an anticorrosion cover material layer on the substrate conditioning layer. In order to secure the sulfuric acid resistance in the whole anticorrosion cover material layer, it is important to secure an even construction thickness and to form no pinholes. Thus, the anticorrosion cover material is preferably elaborately applied using a roller, a metal trowel, a dedicated coating machine, or the like. Since the anticorrosion cover

material of the present invention can be thickly applied even with a low viscosity, a uniform application thickness can be achieved and generation of pinholes can be suppressed. A desired layer thickness of the applied anticorrosion cover material is to be secured. Since the anticorrosion cover material of the present invention can be easily thickly applied, a desired layer thickness of the anticorrosion cover material is easily secured. For securing the durability of the anticorrosion cover material layer, appropriate curing is preferably performed so that the anticorrosion cover material layer is not damaged until the state of the anticorrosion cover material layer that withstands the use is achieved after completion of application of the anticorrosion cover material. The curing period of the anticorrosion cover material layer is, for example, 1 to 7 days.

[0079]

(Step (E))

The method for preventing corrosion of a concrete structure of the present invention may further contain a step (E) of applying a primer composition containing a (meth)acrylate monomer on the substrate conditioning layer to form a primer. In this case, in the step (D), the anticorrosion cover material is applied on the primer. Thus, a primer can be formed between the substrate conditioning layer and the anticorrosion cover material layer. The primer composition is applied on the substrate conditioning layer, for example, using a brush, a roller, or the like. The primer composition is preferably applied on a dry substrate conditioning layer. For example, the surface water content of the surface of the substrate conditioning layer on which the primer composition is to be applied is preferably 7% or less.

[0080]

(Footsteps in manhole)

Footsteps (metal foot holders) in a manhole have possibly been corroded due to a corrosive gas, such as hydrogen sulfide. Thus, in construction of corrosion prevention of an interior wall surface of a manhole, footsteps in the manhole are preferably replaced. From this point of view, the method for preventing corrosion of a concrete structure of the present invention may include a step of removing old footsteps before the step (A), and a step of attaching new footsteps after the step (D). Old footsteps can be

removed, for example, by cutting. New footsteps can be attached, for example, by a twindrill method recommended by the Twindrill Association.

[0081]

(Step of removing corrosive part)

The method for preventing corrosion of a concrete structure of the present invention may include a step of removing a corrosive part of the concrete structure before the step (A). For example, until a healthy concrete surface is exposed, a corrosive part may be removed by an ultrahigh pressure water treatment. The pressure of water used in the ultrahigh pressure water treatment is, for example, 150 to 200 MPa. Whether a healthy concrete surface is exposed can be determined, for example, by a phenol phthalein method.

[0082]

(Treatment of reinforcing steel bar)

In the method for preventing corrosion of a concrete structure of the present invention, a treatment of a reinforcing steel bar in the concrete structure may be performed before the step (A) and after removing the corrosive part of the concrete structure. For example, in the treatment of a reinforcing steel bar, after flowing rust is removed using a sandblast, an electrical tool, or the like and the reinforcing steel bar is cleaned with air blast or high-pressure water, a rust preventive may be applied on the reinforcing steel bar.

[0083]

(Repairing of cross section)

When a defect, such as a crack, is present on a cross section of a concrete appearing after removal of a corrosive part of a concrete structure, the defect causes a defect of the anticorrosion cover layer. Thus, the cross section of the concrete is preferably repaired prior to the step (A). For example, V-cutting is performed along the crack of the concrete using a grinder or the like. Then, a primer may be applied on the V-cut part, followed by filling with a sealant. Filling with a sealant may be performed after construction of the anticorrosion cover layer.

[0084]

[Use]

The present invention is suitable for corrosion suppression technique

and corrosion prevention technique of a sewerage concrete structure. The present invention allows for prolongation of the service life of a sewerage concrete structure as much as possible. Sewerage facilities are, for example, composed of a sewer pipe, a pump station, a disposal station, and the like. Among the facilities, since the present invention allows for easy repairing of a concrete structure, the present invention is more suitable for the corrosion suppression technique and corrosion prevention technique of a concrete structure of a sewer pipe with a small working space, and is further suitable for the corrosion suppression technique and corrosion prevention technique of a manhole of a sewer pipe. The corrosive environment in a manhole of a sewer pipe generally has a yearly average hydrogen sulfide gas concentration of 10 ppm or more and less than 50 ppm, and is such a corrosive environment that causes a notable concrete corrosion (Classification II of corrosive environment described in page 47 of NPL 1). This is an environment such that, if this corrosive environment was left as it was, a concrete would be corroded in several years (about 4 mm/year in yearly average corrosion rate) and the corrosion would reach a reinforcing steel bar. However, according to the present invention, even in such a severe corrosive environment, the service life of the sewerage concrete structure can be prolonged as much as possible.

Examples

[0085]

The present invention will be described in detail below with reference to Examples and Comparative Examples. It should be noted that the present invention is not to be limited to the following examples.

[0086]

Each anticorrosion cover material of Examples and Comparative Examples was subjected to the following evaluations.

(Viscosity, thixotropy index)

Viscosities of each anticorrosion cover material were measured with a Brookfield viscometer (rotor No.5) under a condition of a spindle rotation speed of 20 rpm in a temperature range of 0 to 35°C.

Viscosities respectively under conditions of a spindle rotation speed of 2 rpm and a rotation speed of 20 rpm were measured, and the thixotropy index was calculated based on the following formula.

<Calculation formula of thixotropy index>

Thixotropy index = viscosity at rotation speed of 2 rpm / viscosity at rotation speed of 20 rpm

Viscosities of the primer composition used in the primer of each anticorrosion cover layer of Examples and Comparative Examples were measured in the same manner.

[0087]

(Hardening time, working life)

25 g of the agent A and 25 g of the agent B for each anticorrosion cover material were weighed out, and were mixed to prepare a mixture liquid, and then, the temperature of the mixture liquid was measured with a thermocouple. Then, the time when the temperature of the liquid was the highest was taken as the hardening time. In addition, the working life was calculated based on the following formula.

< Calculation formula of working life>

Working life = hardening time $\times$ 0.6

The hardening time and the working life of the primer composition used in the primer of each anticorrosion cover layer of Examples and Comparative Examples were measured in the same manner.

[0088]

(Tensile shear adhesive strength)

The tensile shear adhesive strength of each anticorrosion cover material was measured according to JIS K6850. Specifically, two SS400 steel plates (100 mm $\times$ 25 mm $\times$ 1.6 mm thickness) having a surface treated with sand blast and degreased with acetone were provided. An anticorrosion cover material was applied on one SS400 steel plate in an area of from an end to 12.5 mm in the longitudinal direction. The two SS400 steel plates were bonded to each other so that the part with the anticorrosion cover material applied of the one SS400 steel plate overlapped only a part in an area of from an end to 12.5 mm in the longitudinal direction of the other SS400 steel plate (the adhesion area: 3.125 cm²), thus preparing a tensile shear adhesive strength test piece. Then, the anticorrosion cover material on the tensile shear adhesive strength test piece was cured at a temperature of 23°C and a humidity of 50% for one day. Grips of a tensile tester were attached on the non-overlapped sides of the two SS400 steel plates in the tensile shear

adhesive strength test piece. The prepared test piece was measured for the tensile shear adhesive strength with a tensile tester in an environment of a temperature of 23°C and a humidity of 50% under a condition of a tensile rate of 10 mm/min.

[0089]

(Applicability)

A mold frame of 140 mm × 195 mm × 20 mm was attached to a concrete plate, and an alumina cement composition was placed therein to prepare a test specimen. Immediately after the frame was removed, the test specimen was made to stand upright, and was cured at a temperature of 20°C and a humidity of 60% for one day. A primer composition was applied on the surface of the cured test specimen in an application amount of 150 g/m² and was cured for 30 minutes to form a primer on the surface of the test specimen. An anticorrosion cover material was applied on the surface of the primer in an application amount of 500 g/m², and was cured at a temperature of 20°C and a humidity of 60% for one day to harden the anticorrosion cover material. The appearance of the hardened anticorrosion cover material was visually evaluated, and the thickness of the coating was measured using a wet gage. The case where a coating with a thickness of 0.4 mm or more could be formed without liquid dripping and where no crease, unevenness, and detachment were seen in the appearance was determined as good. Meanwhile, the case where there was liquid dripping, the case where a coating with a thickness of 0.4 mm or more could not be formed, or the case where there was at least one defect of crease, unevenness, and detachment in the appearance was determined as no good.

[0090]

The alumina cement composition used in the substrate conditioning layer of each anticorrosion cover layer of Examples and Comparative Examples was subjected to the following evaluations.

(Compressive strength, porosity)

According to JIS R5201, the compressive strength of the alumina cement composition was measured. Specifically, the alumina cement composition was placed into a mold frame of 40 mm × 40 mm × 160 mm to prepare a test specimen. After removing the frame on the next day, the test specimen was cured in water of 20°C for 27 days, and the test specimen of a

material age of 28 day was measured for the compressive strength. According to ASTM-C-642, the porosity of the test specimen was measured. [0091]

Each anticorrosion cover layer of Examples and Comparative Examples was subjected to the following evaluations.

(Average particle diameter)

Using a laser diffraction/scattering particle size distribution analyzer (LS-13 320) manufactured by Beckman Coulter, Inc., the particle size distribution of the hydrophobic silica was measured, and the particle diameter at a cumulative frequency of 50% by volume was taken as the average particle diameter of the hydrophobic silica.

(Blain's specific surface area)

The Blain's specific surface area was measured according to JIS R5201.

(Adhesiveness)

According to JIS A7502-2:2015 "Gesuidou Kouzoubutsu no Konkurito Fussyoku Taisaku Gijutsu Dai 2 bu: Bousyoku Sekkei Hyoujun (Corrosion protection technology of sewerage concrete structures-Part 2: Design standards for prevent sulfuric acid corrosion), Fuzokusyo L (Kitei) Hippari Siken (Siito Rainingu Kouhou oyobi Morutaru Rainingu Kouhou)", the adhesiveness of the anticorrosion cover layer was measured. Specifically, a mold frame of 280 mm × 280 mm × 20 mm was attached on a concrete plate (300 mm × 300 mm × 60 mm), an alumina cement composition was placed therein to form a substrate conditioning layer. After removing the frame on the next day, the substrate conditioning layer was cured in water of 20°C for 27 days. A primer composition was applied on the surface of the cured substrate conditioning layer in an application amount of 150 g/m², and was cured for 30 minutes to form a primer on the surface of the substrate conditioning layer. An anticorrosion cover material was applied on the surface of the primer in an application amount of 500 g/m², and was cured and hardened in an environment of a temperature of 25°C and a humidity of 50% for one day to form an anticorrosion cover material layer, thus forming an anticorrosion cover layer on the surface of the concrete plate. Using a concrete cutter, a cut with a size of 40 mm × 40 mm and a depth to the concrete plate was made in the surface of the anticorrosion cover layer to prepare a

test piece for tensile adhesive strength test. Using an adhesive (DENKA HARDLOC II Acrylic Resin Mortar Daina N, manufactured by Denka Company Limited), a steel jig for top tension was bonded to the surface of the anticorrosion cover layer. Then, using a Ken-ken type (Ken-ken: Building Research Institute) adhesion tester, the maximum tensile load was measured in an environment of a temperature of 23°C and a humidity of 50%, and then the tensile adhesive strength was calculated based on the following formula. The fracture surface of the test piece was also observed to specify the fracture site.

<Tensile adhesive strength>

$$\sigma_t = T/1600$$

σ_t : tensile adhesive strength (N/mm²)

T: maximum tensile load(N)

[0092]

(Sulfuric acid resistance test)

According to “Bousyoku Hifukusou no Shinseki Shiken c) Morutaru Rainingu Kouhou no Baai” in JIS A7502, a sulfuric acid resistance test was performed. Specifically, an alumina cement composition was placed into a mold frame of 75 mmφ × 150 mm, and the frame was removed on the next day, followed by curing in water of 20°C for 27 days to prepare an alumina cement hardened body. A primer composition was applied on the entire surface of the alumina cement hardened body in an application amount of 100 g/m², and was cured for 30 minutes to form a primer on the surface of the alumina cement hardened body. An anticorrosion cover material was applied on the surface of the primer in an application amount of 500 g/m², and was cured and hardened in an environment of a temperature of 25°C and a humidity of 50% for one day to form an anticorrosion cover material layer on the surface of the primer, thus preparing a test specimen for sulfuric acid resistance test. The prepared test specimen was immersed in a test liquid (5% aqueous sulfuric acid solution). The whole of the test liquid was replaced every 7 days in the first 4 weeks and then, every 4 weeks. After 112 days of immersion, the test specimen was taken. Then, after the test specimen was washed with water, the appearance of the test piece was visually evaluated. The case where there was no crease, unevenness, detachment, and fracture was determined as good. Meanwhile, the case

where there was at least one defect of crease, unevenness, detachment, and fracture was determined as no good.

[0093]

(Sulfuric acid permeation depth)

According to “Bousyoku Hifuku Sou no Ryusan Shintou Fukasa no Sokutei Houhou (Morutaru Rainingu Kouhou)” in JIS A7502, the sulfuric acid permeation depth was measured. Specifically, the test specimen after the sulfuric acid resistance test was cut in half in the direction perpendicular to the axis direction of the cylinder. A 1% phenolphthalein solution was sprayed on the circular cut section. The length in the diameter direction of a part that was colored red in the test piece was measured at 5 sites with a caliper. The average was subtracted from the initial value (75 mm) and the result was multiplied by 1/2 to calculate the sulfuric acid permeation depth. In an area of the test specimen where sulfuric acid permeated, the pH value of the test specimen decreases, and thus the area where sulfuric acid permeated does not give a color with phenolphthalein.

[0094]

Anticorrosion cover materials, alumina cement compositions, and primer compositions were prepared as described below.

(Anticorrosion cover material)

Using materials shown in Table 1 and Table 2, anticorrosion cover materials were prepared to measure physical properties. The results are shown in Table 1 and Table 2.

[0095]

(Alumina cement composition)

Using materials shown in Table 3, alumina cement compositions were prepared to measure physical properties. The results are shown in Table 3.

[0096]

(Primer composition)

Using materials shown in Table 4, primer compositions were prepared to measure physical properties. The results are shown in Table 4.

[0097]

(Anticorrosion cover layer)

Using each anticorrosion cover material, alumina cement composition, and primer composition, an anticorrosion cover layer was formed to measure

physical properties. The results are shown in Table 5.

[0098]

(Materials)

((Meth)acrylate monomer)

M-241: bisphenol A-type EO4-modified dimethacrylate: in the general formula (5), R^4 and $R^{4'}$ are a methyl group, R^5 and $R^{5'}$ are an ethylene group, and $m+n$ is about 4: manufactured by Miwon Specialty Chemical

PE210: bisphenol A glycidyl ether acrylic acid adduct: in the general formula (5), R^4 and $R^{4'}$ are hydrogen, R^5 and $R^{5'}$ are a *n*-propylene group having a 2-hydroxy group, and m and n are 1: manufactured by Miwon Specialty Chemical

FANCRYL FA512M: dicyclopentenylloxyethyl methacrylate, in the general formula (6), R^6 is a methyl group, R^7 is an ethylene group, and p is about 1: manufactured by Hitachi Chemical Company Ltd.

2HEMA: 2-hydroxyethylmethacrylate, in the general formula (7), R^8 is a methyl group, and R^9 is hydrogen: manufactured by Mitsubishi Chemical Corporation

(Silica)

AEROSIL R-972: silica hydrophobized with dimethyldichlorosilane (in the general formula (1), R^1 is a methyl group, x is 2, and y is 2): average particle diameter 16 nm, manufactured by Evonik Japan

AEROSIL R-805: silica hydrophobized with octylsilane (in the general formula (1), R^1 is an octyl group (number of carbon atoms: 8), x is 1, and y is 0): average particle diameter 12 nm, manufactured by Evonik Japan

AEROSIL R-812: silica hydrophobized with hexamethyldisilazane (in the general formula (2), R^2 is a methyl group, R^3 is hydrogen, and z is 3): average particle diameter 7 nm, manufactured by Evonik Japan

AEROSIL RX-50: silica hydrophobized with hexamethyldisilazane (in the general formula (2), R^2 is a methyl group, R^3 is hydrogen, and z is 3): average particle diameter 40 nm, manufactured by Evonik Japan

FB-5D: fused silica, average particle diameter 5 μm , manufactured by Denka Company Limited

AEROSIL 380: hydrophilic fumed silica, average particle diameter 7 nm, manufactured by Evonik Japan

(Inorganic thixotropic agent)

Esben WX: organic bentonite obtained by modifying a crystal surface of montmorillonite with a quaternary ammonium cation, manufactured by Hojun Co., Ltd.

(Polymerization initiator)

Kayacumene H: cumene hydroperoxide, manufactured by KAYAKU NOURYON CORPORATION

(Decomposition accelerator)

Co-12E: cobalt(II) bis(2-ethylhexanoate), manufactured by Tokyo Fine Chemical CO.,LTD.

(Silane coupling agent)

SILQUEST A-174: γ -methacryloxypropyltrimethoxysilane, manufactured by Momentive Performance Materials Japan

(Hardening accelerator)

PT-2HE: N,N-di(2-hydroxyethyl)-p-toluidine, manufactured by Morin Chemical Industries Co., Ltd.

(Alumina cement)

Alumina cement No. 1: alumina cement, Blain's specific surface area 4800 cm²/g, manufactured by Denka Company Limited

(Portland cement)

Ordinary cement: Portland cement, manufactured by Denka Company Limited

(Pozzolan material)

Blast furnace slag: water-granulated blast furnace slag, commercial product, Blain's specific surface area 6100 cm²/g

Silica fume, commercial product

(Others)

Gypsum: commercial product

Slaked lime, commercial product

Silica sand, commercial product

[0099]

Table 1

Classification	Material name	Chemical name	Example 1		Example 2		Example 3		Example 4		Example 5	
			Anticorrosion cover material 1		Anticorrosion cover material 2		Anticorrosion cover material 3		Anticorrosion cover material 4		Anticorrosion cover material 5	
			Agent A	Agent B	Agent A	Agent B	Agent A	Agent B	Agent A	Agent B	Agent A	Agent B
(Meth)acrylate monomer	M-241	Bisphenol A-type EO4-modified dimethacrylate (parts by mass)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	PE210	Bisphenol A diglycidyl ether acrylic acid adduct (parts by mass)	22.0	22.0	10.0	10.0	22.0	22.0	22.0	22.0	22.0	22.0
	FA-512M	Dicyclopentenylloxyethyl methacrylate (parts by mass)	23.0	23.0	35.0	35.0	23.0	23.0	23.0	23.0	23.0	23.0
	2HEMA	2-Hydroxyethyl methacrylate (parts by mass)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Silica	AELOSIL R-972	Hydrophobized fumed silica (average particle diameter: 16 nm) (parts by mass)	4.0	4.0	3.0	3.0	-	-	-	-	-	4.0
	AELOSIL R-805	Hydrophobized fumed silica (average particle diameter: 12 nm) (parts by mass)	1.0	1.0	2.0	2.0	-	-	--	-	-	1.0
	AELOSIL R-812	Hydrophobized fumed silica (average particle diameter: 7 nm) (parts by mass)	-	-	-	-	3.0	3.0	-	-	-	-
	AELOSIL RX-50	Hydrophobized fumed silica (average particle diameter: 40 nm) (parts by mass)	-	-	-	-	-	-	7.0	7.0	-	7.0
	FB-5D	Fused silica (average particle diameter: 5 μ m) (parts by mass)	-	-	-	-	-	-	-	-	-	-
	AELOSIL 380	Hydrophilic fumed silica (average particle diameter: 7 nm) (parts by mass)	-	-	-	-	-	-	-	-	-	-
Inorganic thixotropic agent	Esben WX	Quaternary ammonium cation-modified organic bentonite (parts by mass)	-	-	-	-	-	-	-	-	-	-
Polymerization initiator	Kayacumene H	Cumene hydroperoxide (parts by mass)	3.0	-	3.0	-	3.0	-	3.0	-	-	1.5
Decomposition accelerator	Co-12E	Cobalt(II) bis(2-ethylhexanoate) (parts by mass)	-	3.0	-	4.0	--	3.0	-	3.0	-	1.5 ^{*1)}
Other components	A-174	γ -Methacryloxypropyltrimethoxysilane (parts by mass)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	PT-2HE	N,N-Di(2-hydroxyethyl)-p-toluidine (parts by mass)	-	-	0.35	-	-	-	-	-	-	-

(continued)

Table 1 (continued)

Ratio of agent A and agent B (by mass)		Example 1	Example 2	Example 3	Example 4	Example 5
Properties	Viscosity (mPa·s)	0°C	1 : 1	1 : 1	1 : 1	-
		5°C	-	8,500	-	-
		15°C	-	6,800	-	-
		25°C	14,600	5,100	-	-
		35°C	8,900	2,700	10,300	12,800
	Thixotropic index (T.I.)	6,100	-	-	-	-
		0°C	-	3.7	-	-
		5°C	-	4.0	-	-
		15°C	3.1	4.7	-	-
		25°C	3.7	5.5	7.7	3.0
	Working life (min)	35°C	4.3	-	-	-
		5°C	-	41	-	-
	Hardening time (min)	25°C	39	-	38	39
		-	-	68	-	-
Tensile shear adhesive strength (N/mm ²)	65		-	63	65	65
	19.3		21.9	18.4	19.6	18.9
	Applicability	5°C	good	-	good	good
25°C		good	-	good	good	good

*1) added immediately before use
[0100]

Table 2

Classification	Material name	Chemical name	Comparative Example 1		Comparative Example 2		Comparative Example 3		Comparative Example 4	
			Anticorrosion cover material 6 Agent A	Anticorrosion cover material 6 Agent B	Anticorrosion cover material 7 Agent A	Anticorrosion cover material 7 Agent B	Anticorrosion cover material 8 Agent A	Anticorrosion cover material 8 Agent B	Anticorrosion cover material 9 Agent A	Anticorrosion cover material 9 Agent B
(Meth)acrylate monomer	M-241	Bisphenol A-type EO4-modified dimethacrylate (parts by mass)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	PE210	Bisphenol A diglycidyl ether acrylic acid adduct (parts by mass)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
	FA-512M	Dicyclopentenylxyethyl methacrylate (parts by mass)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
	2HEMA	2-Hydroxyethyl methacrylate (parts by mass)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	AELOSIL R-972	Hydrophobized fumed silica (average particle diameter: 16 nm) (parts by mass)	-	-	-	-	-	-	-	-
Silica	AELOSIL R-805	Hydrophobized fumed silica (average particle diameter: 12 nm) (parts by mass)	-	-	-	-	-	-	-	-
	AELOSIL R-812	Hydrophobized fumed silica (average particle diameter: 7 nm) (parts by mass)	-	-	-	-	-	-	-	-
	AELOSIL RX-50	Hydrophobized fumed silica (average particle diameter: 40 nm) (parts by mass)	-	-	-	-	-	-	-	-
	FB-5D	Fused silica (average particle diameter: 5 μ m) (parts by mass)	5.0	5.0	-	-	-	-	-	-
	AELOSIL 380	Hydrophilic fumed silica (average particle diameter: 7 nm) (parts by mass)	-	-	5.0	5.0	-	-	-	-
Inorganic thixotropic agent	Esben WX	Quaternary ammonium cation-modified organic bentonite (parts by mass)	-	-	-	-	-	-	5.0	5.0
Polymerization initiator	Kayacumene H	Cumene hydroperoxide (parts by mass)	3.0	-	3.0	-	3.0	-	3.0	-
Decomposition accelerator	Co-12E	Cobalt(II) bis(2-ethylhexanoate) (parts by mass)	-	3.0	-	3.0	-	3.0	-	3.0
Other components	A-174	γ -Methacryloxypropyltrimethoxysilane (parts by mass)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	PT-2HE	N,N-Di(2-hydroxyethyl)-p-toluidine (parts by mass)	-	-	-	-	-	-	-	-

(continued)

Table 2 (continued)

Ratio of agent A and agent B (by mass)		Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Properties	Viscosity (mPa·s)	0°C	-	-	-
		5°C	-	-	-
		15°C	-	-	-
		25°C	1,500	300	500
		35°C	-	-	-
	Thixotropic index (T.I.)	0°C	-	-	-
		5°C	-	-	-
		15°C	-	-	-
		25°C	1.1	9.6	2.0
		35°C	-	-	-
	Working life (min)	5°C	-	-	-
		25°C	34	24	43
	Hardening time (min)	-	-	-	-
		57	59	40	71
[0101]	Tensile shear adhesive strength (N/mm ²)		15.1	21.7	13.6
	Applicability	5°C	-	-	-
		25°C	no good (liquid dripping, short film thickness)	no good (liquid dripping, short film thickness)	no good (liquid dripping, short film thickness)

Table 3

Classification	Material name	Alumina cement composition 1	Alumina cement composition 2
Alumina cement	Alumina cement No. 1 (parts by mass)	18.5	14.0
Portland cement	Ordinary cement (parts by mass)	-	8.0
Pozzolan material	Blast furnace slag (parts by mass)	15.0	15.0
Others	Silica fume (parts by mass)	1.5	2.0
	Gypsum (parts by mass)	-	9.0
	Slaked lime (parts by mass)	-	2.0
	Silica sand (parts by mass)	65.0	50.0
Properties	Porosity (%)	14.5	6.5
	Compressive strength (N/mm ²)	60.3	73.8

[0102]

Table 4

Classification	Material name	Chemical name	Primer composition 1	
			Agent A	Agent B
(Meth)acrylate monomer	M-241	Bisphenol A-type EO4-modified dimethacrylate (parts by mass)	40.0	40.0
	FA-512M	Dicyclopentenylxyethyl methacrylate (parts by mass)	23.0	23.0
	2HEMA	2-Hydroxyethyl methacrylate (parts by mass)	15.0	15.0
	PE210	Bisphenol A diglycidyl ether acrylic acid adduct (parts by mass)	22.0	22.0
Polymerization initiator	Kayacumene H	Cumene hydroperoxide (parts by mass)	3.0	-
Decomposition accelerator	Co-12E	Cobalt(II) bis(2-ethylhexanoate) (parts by mass)	-	3.0
Silane coupling agent	A-174	γ -Methacryloxypropyltrimethoxysilane (parts by mass)	1.5	1.5
Ratio of agent A and agent B (by mass)			1 : 1	
Properties	Viscosity (mPa·s) 25°C		300	
	Working life (min) 25°C		24	
	Hardening time (min) 25°C		40	

[0103]

Table 5

	Anticorrosion cover layer				Properties		
	Anticorrosion cover material	Alumina cement composition	Primer composition	Anticorrosion cover material construction temperature	Adhesiveness		Sulfuric acid permeation depth (mm)
					Tensile adhesive strength (N/mm ²)	Fracture site	
Example 6	Anticorrosion cover material 1	Alumina cement composition 1	Primer composition 1	25°C	3.5	Cohesive failure of alumina cement composition	good <0.1
Example 7	Anticorrosion cover material 2	Alumina cement composition 1	Primer composition 1	5°C	3.4	Cohesive failure of alumina cement composition	good <0.1
Example 8	Anticorrosion cover material 3	Alumina cement composition 1	Primer composition 1	25°C	4.0	Cohesive failure of alumina cement composition	good <0.1
Example 9	Anticorrosion cover material 4	Alumina cement composition 1	Primer composition 1	25°C	3.2	Cohesive failure of alumina cement composition	good <0.1
Comparative Example 5	Anticorrosion cover material 6	Alumina cement composition 1	Primer composition 1	25°C	3.4	Cohesive failure of alumina cement composition	no good 0.5
Comparative Example 6	Anticorrosion cover material 7	Alumina cement composition 1	Primer composition 1	25°C	3.2	Cohesive failure of alumina cement composition	no good 0.3
Comparative Example 7	Anticorrosion cover material 8	Alumina cement composition 1	Primer composition 1	25°C	3.6	Cohesive failure of alumina cement composition	no good 0.7
Comparative Example 8	Anticorrosion cover material 9	Alumina cement composition 1	Primer composition 1	25°C	3.9	Cohesive failure of alumina cement composition	no good 0.4
Example 10	Anticorrosion cover material 1	Alumina cement composition 1	-	25°C	2.8	Cohesive failure of alumina cement composition	good <0.1
Example 11	Anticorrosion cover material 1	Alumina cement composition 2	Primer composition 1	25°C	3.0	Interfacial failure of concrete and alumina cement composition	good <0.1
Comparative Example 9	-	Alumina cement composition 1	-	-	-	-	- 1.7
Comparative Example 10	-	Alumina cement composition 2	-	-	-	-	- 2.2

[0104]

The anticorrosion cover materials of Examples 1 to 5 which contained a (meth)acrylate monomer and a hydrophobic silica having an average particle diameter of 1 to 100 nm showed a good applicability. On the other hand, the anticorrosion cover material of Comparative Example 1 which contained a non-hydrophobized silica having an average particle diameter more than 100 nm could not be thickly applied. In the anticorrosion cover material of Comparative Example 2 which contained a non-hydrophobized silica, the silica could not be uniformly dispersed and unevenness occurred. The anticorrosion cover material of Comparative Example 3 which contained no hydrophobic silica caused liquid dripping and could not be thickly applied. In the anticorrosion cover material of Comparative Example 4 in which an organic bentonite which is one of inorganic thixotropic agents was blended instead of a hydrophobic silica, the thickening effect and the thixotropic property imparting effect were small to cause liquid dripping and the anticorrosion cover material could not be thickly applied.

The primer compositions of Examples 6 to 11 could be applied in a thickness of 100 μm without liquid dripping.

[0105]

The anticorrosion cover layers of Examples 6 to 11 which included a substrate conditioning layer formed of a hardened body of an alumina cement that contains an alumina cement, a pozzolan material, and an aggregate and an anticorrosion cover material layer formed of a hardened body of the anticorrosion cover material of the present invention on the substrate conditioning layer were found to be superior in the sulfuric acid resistance. In addition to the superior sulfuric acid resistance, the tensile adhesive strength is also high, and thus, it is found that the anticorrosion cover layers of Examples 6 to 11 are superior in durability. By comparing the anticorrosion cover layer of Example 6 with the anticorrosion cover layer of Example 10, it is found that when a primer is provided, the sulfuric acid resistance is improved and thus, the durability is further improved. From the anticorrosion cover layer of Example 7, it is found that, by the anticorrosion cover layer of the present invention, a superior anticorrosion cover layer can be constructed also in a low temperature period. On the other hand, the anticorrosion cover layers of Comparative Examples 5 to 8 whose anticorrosion cover material layer was not an anticorrosion cover material layer formed of a hardened body of the anticorrosion cover material

of the present invention had a poor sulfuric acid resistance. The anticorrosion cover layers of Comparative Examples 9 and 10 which contained no anticorrosion cover material layer had a poor sulfuric acid resistance. The anticorrosion cover layers of Comparative Examples 5 to 8 have a high tensile adhesive strength but have a poor sulfuric acid resistance, and thus it is found that the anticorrosion cover layers of Comparative Examples 5 to 8 have a poor durability.

CLAIMS

[Claim 1]

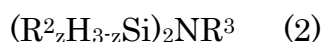
An anticorrosion cover material comprising a (meth)acrylate monomer and a hydrophobic silica,
the hydrophobic silica having an average particle diameter of 1 to 100 nm.

[Claim 2]

The anticorrosion cover material according to claim 1, wherein the hydrophobic silica is at least one silica of a silica hydrophobized with an organosilane represented by the following general formula (1) and a silica hydrophobized with an organosilane represented by the following general formula (2):



wherein R^1 represents an alkyl group, x represents an integer of 1 to 3, y represents an integer of 0 to 3, and $x+y \leq 4$,

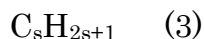


wherein R^2 represents hydrogen, an alkyl group, an alkenyl group, or a halogenated alkyl group, R^3 represents hydrogen, an alkyl group, or an alkali metal element, and z represents an integer of 1 to 3.

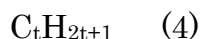
[Claim 3]

The anticorrosion cover material according to claim 2, wherein the hydrophobic silica comprises a silica hydrophobized with a first organosilane represented by the general formula (1) and a silica hydrophobized with a second organosilane represented by the general formula (1), the second organosilane being different from the first organosilane, wherein

in the general formula (1), R^1 of the first organosilane is an alkyl group represented by the following general formula (3), and R^1 of the second organosilane is an alkyl group represented by the following general formula (4):



wherein s represents an integer of 1 to 5,



wherein t represents an integer of 6 to 12.

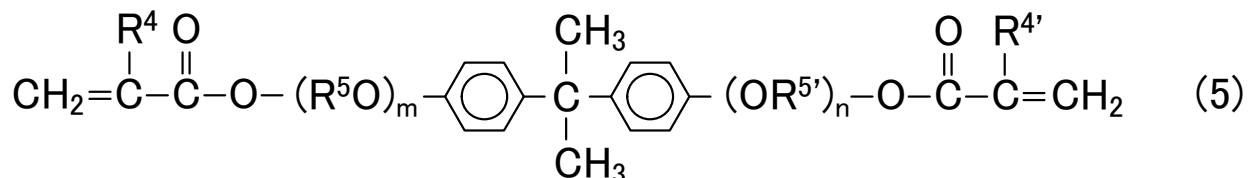
[Claim 4]

The anticorrosion cover material according to any one of claims 1 to 3, wherein the (meth)acrylate monomer comprises a di(meth)acrylate having a

bisphenol A backbone.

[Claim 5]

The anticorrosion cover material according to claim 4, wherein the di(meth)acrylate monomer having a bisphenol A backbone is a di(meth)acrylate having a bisphenol A backbone represented by the following general formula (5):



wherein R^4 and R^4' represent hydrogen or a methyl group, R^5 and R^5' represent an alkylene group optionally having a substituent, and m and n represent an integer of 1 to 20.

[Claim 6]

The anticorrosion cover material according to any one of claims 1 to 5, which is of a two-agent type of a first anticorrosion cover material containing a polymerization initiator, the (meth)acrylate monomer, and the hydrophobic silica and a second anticorrosion cover material containing a decomposition accelerator which accelerates decomposition of the polymerization initiator, the (meth)acrylate monomer, and the hydrophobic silica.

[Claim 7]

The anticorrosion cover material according to any one of claims 1 to 6, wherein the anticorrosion cover material has
a viscosity at 25°C of 1,700 to 15,000 mPa·s, and
a thixotropy index at 25°C of 3.0 or more.

[Claim 8]

The anticorrosion cover material according to any one of claims 1 to 7, wherein the anticorrosion cover material has
a viscosity in the range of 0 to 25°C of 1,700 to 15,000 mPa·s, and
a thixotropy index in the range of 0 to 25°C of 3.0 or more.

[Claim 9]

An anticorrosion cover layer comprising
a substrate conditioning layer formed of a hardened body of an alumina cement composition that contains an alumina cement, a pozzolan material, and an aggregate, and
an anticorrosion cover material layer formed, on the substrate

conditioning layer, of a hardened body of the anticorrosion cover material according to any one of claims 1 to 8.

[Claim 10]

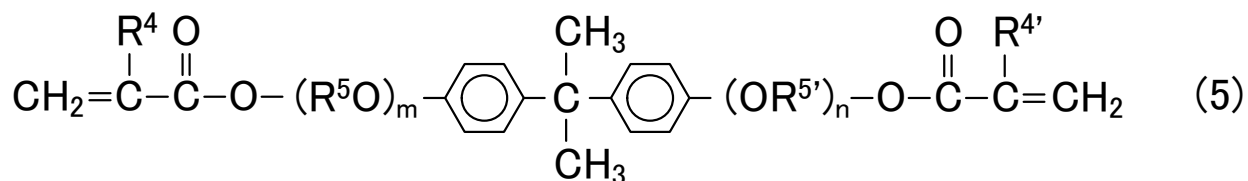
The anticorrosion cover layer according to claim 9, further comprising a primer formed of a hardened body of a primer composition containing a (meth)acrylate monomer, the primer being interposed between the substrate conditioning layer and the anticorrosion cover material layer.

[Claim 11]

The anticorrosion cover layer according to claim 10, wherein the (meth)acrylate monomer contained in the primer composition comprises a di(meth)acrylate having a bisphenol A backbone.

[Claim 12]

The anticorrosion cover layer according to claim 11, wherein the di(meth)acrylate having a bisphenol A backbone contained in the primer composition is a di(meth)acrylate having a bisphenol A backbone represented by the following general formula (5):



wherein R^4 and $\text{R}^{4'}$ represent hydrogen or a methyl group, R^5 and $\text{R}^{5'}$ represent an alkylene group optionally having a substituent, and m and n represent an integer of 1 to 20.

[Claim 13]

The anticorrosion cover layer according to any one of claims 10 to 12, wherein the substrate conditioning layer has a porosity of 5 to 40% by volume, and

in an area in the vicinity of the primer of the substrate conditioning layer, pores of the substrate conditioning layer are filled with a hardened body of the primer composition.

[Claim 14]

A method for preventing corrosion of a concrete structure, the method comprising

a step of assembling a frame,

a step of placing an alumina cement composition containing an alumina cement, a pozzolan material, and an aggregate into the frame to form

a substrate conditioning layer,

a step of removing the frame, and

a step of applying the anticorrosion cover material according to any one of claims 1 to 8 to form an anticorrosion cover material layer on the substrate conditioning layer.

[Claim 15]

The method for preventing corrosion of a concrete structure according to claim 14, further comprising a step of applying a primer composition containing a (meth)acrylate monomer on the substrate conditioning layer to form a primer,

the anticorrosion cover material being applied on the primer.