

Description

Title of Invention: RESIN COMPOSITION

Technical Field

[0001] The present invention relates to a resin composition, and more particularly, to a resin composition used in a surface protection method for concrete pieces.

Background Art

[0002] Concrete pieces sometimes flake off from a concrete structure due to the progression of neutralization by carbon dioxide, salt damage caused by permeation of chloride ions, or other deterioration with time. In order to prevent such flaking of concrete pieces, a method of covering the surface of concrete with a resin composition or a fiber sheet is known.

[0003] For example, in Patent Literature 1, for the purpose of improving workability of such a surface protection method, a flaking prevention method for concrete pieces, including forming a primer layer on the surface side of a concrete frame, then forming an elastic resin layer on the primer layer, and subsequently forming a reinforcement layer on the elastic resin layer, wherein the reinforcement layer is formed from a predetermined isocyanurate compound, a predetermined isocyanate

prepolymer, and a predetermined diamine compound is disclosed.

Citation List

Patent Literature

[0004] Patent Literature 1

Japanese Patent Laid-Open No. 2020-090566

Summary of Invention

Technical Problem

[0005] However, the isocyanurate compound is being designated as a deleterious substance or a toxic substance, and polyurea or polyurethane using an isocyanurate compound as a raw material has a problem from the viewpoint of toxicity. On that account, a resin composition using no isocyanurate compound has been desired as a resin composition used in a surface protection method.

[0006] Also, urethane that has been conventionally used for an intermediate coating layer in the surface protection method has low strength, and epoxy has low followability, and thus, they have problems as surface protective materials.

[0007] The present invention has been made in the light of the above problems, and it is an object of the present invention to provide a resin composition that has low

toxicity and can form a coating film excellent in strength and elongation.

Solution to Problem

[0008] That is to say, the present invention is as follows.

[1]

A resin composition comprising a modified silicone resin and a filler, wherein

a maximum stress is 5.0 N/mm^2 or more,

a breaking strain is 100% or more, and

an elastic modulus is 2.0 MPa or more,

as measured in accordance with JIS K 6251 on a cured product formed by curing the resin composition at 23°C and a relative humidity of 50% for 7 days.

[2]

The resin composition according to [1], wherein

an elongation stress of the resin composition, as measured in a compression mode in accordance with JIS K 6394 using parallel plates under the conditions of a gap of 1.5 mm, a strain of 0.5%, a temperature of 40°C, and an angular frequency of 0.1 rad/s, is 25 Pa or more.

[3]

The resin composition according to [1] or [2], wherein

the modified silicone resin comprises a straight-chain polymer A having two or more reactive silyl groups at each end, and

a content of the straight-chain polymer A is 10 to 90 mass% based on the total amount of the modified silicone resin.

[4]

The resin composition according to any one of [1] to [3], wherein

the modified silicone resin comprises a straight-chain polymer B having one reactive silyl group at each end, and

a content of the straight-chain polymer B is 10 to 90 mass% based on the total amount of the modified silicone resin.

[5]

The resin composition according to any one of [1] to [4], wherein

a content of the modified silicone resin is 20 to 99 mass% based on the total amount of the resin composition.

[6]

The resin composition according to any one of [1] to [5], wherein

an average particle diameter of the filler is 400 nm or less.

[7]

The resin composition according to any one of [1] to [6], wherein

a content of the filler is 1.0 to 15 mass% based on the total amount of the resin composition.

[8]

The resin composition according to any one of [1] to [7], wherein

the filler comprises one or more selected from the group consisting of silica, alumina, calcium carbonate, and a resin particle.

[9]

The resin composition according to any one of [1] to [8], for use in a surface protection method for concrete pieces.

[10]

A surface protection method for concrete pieces, having

a step of forming an intermediate coating layer on a surface of a concrete frame or a surface of another layer formed on the surface using the resin composition according to any one of [1] to [9].

Advantageous Effect of Invention

[0009] According to the present invention, a resin composition that has low toxicity and can form a coating film excellent in strength and elongation can be provided.

Brief Description of Drawings

[0010] [Figure 1] Figure 1 shows a view showing tensile characteristics in Examples.

[Figure 2] Figure 2 shows a view showing outline of a push-out test.

[Figure 3] Figure 3 shows a view showing results of a push-out test in Examples.

[Figure 4] Figure 4 shows a view showing outline of a crack followability test.

Description of Embodiments

[0011] Hereinafter, an embodiment of the present invention (referred to as the "present embodiment" hereinafter) will be described in detail, but the present invention is in no way limited thereto, and various modifications can be made without departing from the spirit of the present invention.

[0012] [Resin composition]

The resin composition of the present embodiment is a resin composition containing a modified silicone resin and a filler, wherein a maximum stress is 5.0 N/mm² or more, a breaking strain is 100% or more, and an elastic modulus is 2.0 MPa or more, as measured in accordance with JIS K 6251 on a cured product formed by curing the resin composition at 23°C and a relative humidity of 50% for 7 days.

[0013] (Maximum stress)

A maximum stress as measured in accordance with JIS K 6251 on a cured product formed by curing the resin composition at 23°C and a relative humidity of 50% for 7 days (referred to as "maximum stress" simply hereinafter) is 5.0 N/mm² or more, preferably 6.0 to 25 N/mm², more preferably 7.0 to 20 N/mm², still more preferably 7.5 to 18 N/mm², and still much more preferably 10 to 18 N/mm².
[0014] (Breaking strain)

A breaking strain as measured in accordance with JIS K 6251 on a cured product formed by curing the resin composition at 23°C and a relative humidity of 50% for 7 days (referred to as "breaking strain" simply hereinafter) is 100% or more, preferably 120% to 600%, more preferably 140% to 550%, still more preferably 160% to 500%, and still much more preferably 180% to 500%.
[0015] (Elastic modulus)

An elastic modulus as measured in accordance with JIS K 6251 on a cured product formed by curing the resin composition at 23°C and a relative humidity of 50% for 7 days (referred to as "elastic modulus" simply hereinafter) is 2.0 MPa or more, preferably 3.0 to 35 MPa, more preferably 4.0 to 30 MPa, still more preferably 5.0 to 25 MPa, and still much more preferably 6.0 to 20 MPa.
[0016] The strength and the elongation of the resulting coating film are effects exerted compositely by maximum stress, breaking strain and elastic modulus, and since the maximum stress, the breaking strain and the elastic

modulus are each the aforementioned lower limit value or more, the strength and the elongation of the resulting coating film are more improved. More specifically, even if the maximum stress and the elastic modulus are each the aforementioned lower limit value or more, if the breaking strain is deteriorated, the results show that the cured product (coating film) is easily broken in the push-out test described in the Examples, and the followability is not exerted in the crack followability test. Also, if the breaking strain is the aforementioned lower limit value or more but the maximum stress and the elastic modulus are deteriorated, the cured product (coating film) is easily broken in the push-out test.

[0017] The maximum stress, the breaking strain and the elastic modulus can be adjusted by the types or the contents of the modified silicone resin and the filler. More specifically, by using a modified silicone resin whose crosslinking density becomes high, the maximum stress and the elastic modulus tend to be more improved, or by using a modified silicone resin having a low crosslinking density and a more flexible backbone, the breaking strain tends to be more improved. In the present embodiment, the maximum stress, the breaking strain and the elastic modulus may be adjusted by using two or more modified silicone resins as described later.

[0018] The maximum stress, the breaking strain and the elastic modulus can be measured in accordance with JIS K

6251. In the measurement of the maximum stress, the breaking strain and the elastic modulus, the thickness of a No. 3 dumbbell is set to 1 mm, and the tensile speed is set to 100 mm/min.

[0019] (Elongation stress)

The elongation stress as measured in a compression mode in accordance with JIS K 6394 using parallel plates under the conditions of a gap of 1.5 mm, a strain of 0.5%, a temperature of 40°C, and an angular frequency of 0.1 rad/s (referred to as "yield elongation stress" simply hereinafter) is preferably 25 Pa or more, more preferably 30 to 800 Pa, still more preferably 35 to 700 Pa, and still much more preferably 40 to 600 Pa.

[0020] The composition of the present embodiment can be applied to places where dripping easily occurs due to gravity, such as walls and ceilings. The condition of an angular frequency of 0.1 rad/s corresponds to a speed at which dripping starts to occur when the composition is applied to, for example, ceiling, and due to the yield elongation stress, as measured under the above conditions, of 25 Pa or more, occurrence of dripping can be prevented. On that account, not only are handling properties improved but also a uniform coating film that has been suppressed in dripping and thereby suppressed in variation of strength or elongation can be obtained.

[0021] (Modified silicone resin)

The modified silicone resin in the present embodiment refers to a polymer having a reactive silyl group, and a substance wherein a reactive silyl group has been added to a polymer that becomes a main chain is included. The modified silicone resins may be used singly or may be used in combination of two or more.

[0022] Examples of the polymers to which a reactive silyl group is to be added include, but not limited to, polyether-based polymers, such as polyoxyethylene, polyoxypropylene, and polyoxybutylene; aliphatic hydrocarbon-based polymers, such as polyisoprene, polyisobutylene, and polybutadiene; acrylic polymers, such as poly(meth)acrylic acid and poly(meth)acrylate; and polyester-based polymers.

[0023] Among these, polyether-based polymers are preferable. Among the polyether-based polymers, polyoxyalkylenes are more preferable. Among the polyoxyalkylenes, polyoxypropylene is more preferable. By using such a polymer as a main chain, the breaking strain and the elastic modulus are more improved because flexibility of the main chain is high, so that the elongation of the resulting coating film tends to be more improved.

[0024] Although the backbone of the polymer may be straight-chain or may be branched, it is preferably straight-chain. By using such a modified silicone resin, an excessive increase in crosslinking density is

suppressed, and the breaking strain and the elastic modulus are more improved, so that the elongation of the resulting coating film tends to be more improved.

[0025] Examples of the reactive silyl groups include, but not limited to, an addition reactive silyl group, a condensation reactive silyl group, and a hydrolyzable silyl group. More specifically, groups wherein reactive groups, such as a hydrogen atom, a hydroxyl group, an alkoxy group, a halogen atom, an acyloxy group, an alkenyloxy group, an amide group, an oxime group, a ketoximate group, an amide group, an acid amide group, a mercapto group and an aminooxy group, have been linked to silicon atoms can be mentioned.

[0026] Examples of such reactive silyl groups include, but not limited to, groups represented by the following formula (1).



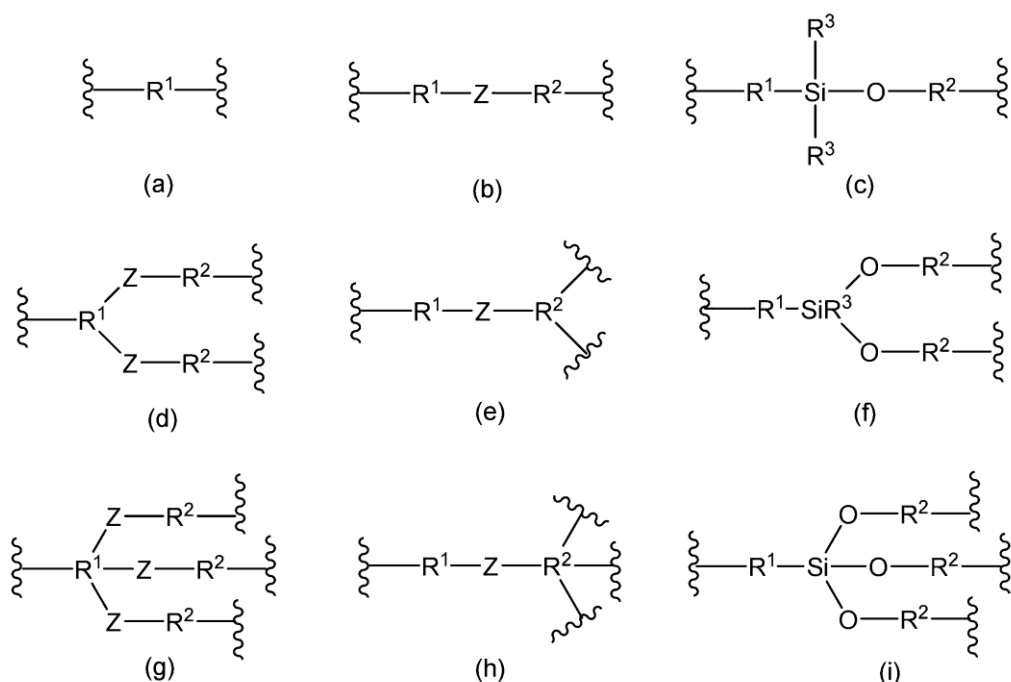
wherein each R independently represents an alkyl group having 1 to 20 carbon atoms, an aryl group having 6 to 20 carbon atoms, or an aralkyl group having 7 to 20 carbon atoms, each X independently represents a hydrogen atom, a hydroxyl group, an alkoxy group, a halogen atom, an acyloxy group, an alkenyloxy group, an amide group, an oxime group, a ketoximate group, an amide group, an acid amide group, a mercapto group, or an aminooxy group, a represents an integer of 1 to 3, b represents an integer of 0 to 2, and n represents an integer of 0 to 10.

[0027] Specific examples of the reactive silyl groups include, but not limited to, alkoxysilyl groups, such as a trimethoxysilyl group, a dimethoxymethylsilyl group, a dimethylmethoxysilyl group, a triethoxysilyl group, a diethoxymethylsilyl group, a dimethylethoxysilyl group, a dimethoxyphenylsilyl group, a diphenylmethoxysilyl group, a diethoxyphenylsilyl group, and a diphenylethoxysilyl group; and polymerized reactive silyl groups wherein these alkoxysilyl groups are linked to ends, such as dialkyl silicone, alkyl alkoxy silicone, dialkoxy silicone, diphenyl silicone, and alkoxy phenyl silicone. Among the reactive silyl groups, a dimethoxymethylsilyl group is preferable.

[0028] The linking position of the reactive silyl group in the polymer can be, for example, an end, a side chain, or an end and a side chain of the polymer that is a main chain though it is not particularly limited thereto. Among these, preferable is a modified silicone resin having a reactive silyl group at an end of the polymer that is a main chain. By using such a modified silicone resin, the distance between the crosslinking points and the number of crosslinking points are more easily controlled, and the maximum stress, the breaking strain and the elastic modulus can be more preferably adjusted, so that the strength and the elongation of the resulting coating film can be more improved.

[0029] The mode of linking of the reactive silyl group to an end of the polymer is not particularly limited, and the reactive silyl group ($-\text{SiX}_a\text{R}_{3-a}$) can be linked to an end of the polymer by an arbitrary linker L according to a method for modifying an end of the polymer with the reactive silyl group. Here, the linker L can be a portion that links an atom at an end of a repeating unit of the polymer to a silicon atom of the reactive silyl group represented by the formula (1). For example, when the polymer is polyoxyethylene, atoms at the ends of the repeating unit become an oxygen atom at one end and a carbon atom at the other end. When the polymer is an acrylic polymer and an initiator is added to an end of the polymer, the initiator portion is contained in the linker L.

[0030] Examples of such linkers L include, but not limited to, linking groups that may have a urethane linkage, a urea linkage, an ester linkage, an amide linkage, an ether linkage, and a siloxane linkage. Examples of such linking groups include groups represented by the following formulae (a) to (i).



wherein R^1 is a group linked to an end of the polymer and represents a single bond or a hydrocarbon group having 1 to 10 carbon atoms, each R^2 is a group linked to a reactive silyl group and independently represents a single bond or a hydrocarbon group having 1 to 10 carbon atoms, each Z independently represents a urethane linkage, a urea linkage, an ester linkage, an amide linkage, an ether linkage or a siloxane linkage, and each R^3 independently represents a hydrocarbon group having 1 to 10 carbon atoms.

[0031] The formulae (a) to (c) are each a straight-chain linker, the formulae (d) to (f) are each a bi-branched linker, and the formulae (g) to (i) are each a tri-branched linker. However, the linking group is not limited to the above, and straight-chain or bi- to penta-branched linking groups can be used. The number of

carbon atoms of the whole linking group is preferably 1 to 30, more preferably 1 to 20, and still more preferably 1 to 10. In the formula (a), R^1 is also linked to a reactive silyl group.

[0032] The number of reactive silyl groups linked to one end of the polymer is preferably 1 to 5. Among these, a modified silicone resin having two or more reactive silyl groups at each end (also referred to as a "straight-chain polymer A" hereinafter), a modified silicone resin having one reactive silyl group at each end (also referred to as a "straight-chain polymer B" hereinafter), or a combination of these is preferably used as the modified silicone resin. By using modified silicone resins having different numbers of reactive silyl groups in combination as above, the maximum stress, the breaking strain and the elastic modulus can be more preferably adjusted, and the strength and the elongation of the resulting coating film can be more improved.

[0033] As the straight-chain polymer A, a modified silicone resin having, at each end, two or more silicon atoms to each of which an alkoxy group is linked is preferable. By using such a straight-chain polymer A, the crosslinking density of the cured product is improved, and due to this, the maximum stress and the elastic modulus are more improved, so that the strength of the resulting coating film tends to be more improved.

[0034] A viscosity of the straight-chain polymer A at 25°C is preferably 100 to 7000 mPas, more preferably 500 to 5000 mPas, and still more preferably 1000 to 3000 mPas. Generally, as the molecular weight is decreased, the viscosity tends to be decreased, but by the viscosity in the aforementioned range, the crosslinking density of the cured product is improved, and due to this, the maximum stress and the elastic modulus are more improved, so that the strength of the resulting coating film tends to be more improved. The viscosity in the present embodiment can be measured by a conventional method using a Brookfield viscometer (B-type rotational viscometer). The viscosity in the present embodiment is measured under the conditions of 25°C and a number of revolutions of 10 rpm.

[0035] The straight-chain polymer A preferably uses, as a linker, a linking group having a siloxane linkage. By using such a modified silicone resin, the crosslinking density of the cured product is improved, and due to this, the maximum stress and the elastic modulus are more improved, and the strength of the resulting coating film tends to be more improved. The straight-chain polymer A may have or may not have a flexible group such as a urethane linkage. For example, if the polymer has a flexible group such as a urethane linkage, the breaking strain of the cured product is more improved, and the elongation of the resulting coating film tends to be more

improved, or if the polymer does not have a flexible group such as a urethane linkage, isocyanate that becomes a raw material for forming a urethane linkage is difficult to be mixed into the resin composition, so that a safer resin composition can be obtained.

[0036] A content of the modified silicone resin having two or more reactive silyl groups at each end, such as the straight-chain polymer A, is preferably 10 to 90 mass%, more preferably 20 to 85 mass%, and still more preferably 30 to 85 mass%, based on the total amount of the modified silicone resin. Since the content of the modified silicone resin having two or more reactive silyl groups at each end is in the aforementioned range, the maximum stress and the elastic modulus are more improved, and the strength of the resulting coating film tends to be more improved.

[0037] As the straight-chain polymer B, a modified silicone resin having, at each end, one silicon atom to which an alkoxy group is linked is preferable. Since such a straight-chain polymer B has a relatively low crosslinking density, the breaking strain of the cured product is more improved, and the elongation of the resulting coating film tends to be more improved.

[0038] The straight-chain polymer B may have a flexible group such as a urethane linkage. By using such a modified silicone resin, the breaking strain of the cured

product is more improved, and the elongation of the resulting coating film tends to be more improved.

[0039] A viscosity of the straight-chain polymer B at 25°C is preferably 7500 to 40000 mPas, more preferably 10000 to 45000 mPas, and still more preferably 20000 to 50000 mPas. Generally, as the molecular weight is increased, the viscosity tends to be increased, but by the viscosity in the aforementioned range, the crosslinking density of the cured product is decreased, and due to this, the breaking strain is more improved, so that the elongation of the resulting coating film tends to be more improved.

[0040] A content of the modified silicone resin having one reactive silyl group at each end, such as the straight-chain polymer B, is preferably 10 to 90 mass%, more preferably 15 to 80 mass%, and still more preferably 15 to 70 mass%, based on the total amount of the modified silicone resin. Since the content of the modified silicone resin having one reactive silyl group at each end is in the aforementioned range, the breaking strain of the cured produced is more improved, and the elongation of the resulting coating film tends to be more improved.

[0041] A content of the modified silicone resin is preferably 20 to 99 mass%, more preferably 25 to 99 mass%, and still more preferably 30 to 99 mass%, based on the total amount of the resin composition. By the content of

the modified silicone resin in the aforementioned range, the maximum stress, the breaking strain and the elastic modulus are more improved, and the strength and the elongation of the resulting coating film tend to be more improved.

[0042] (Filler)

Examples of the fillers include, but not limited to, an inorganic filler and an organic filler. The fillers may be used singly or may be used in combination of two or more.

[0043] Examples of the inorganic fillers include, but not limited to, silica; oxides, such as alumina, titanium oxide, and magnesium oxide; carbonates, such as calcium carbonate and magnesium carbonate; hydroxides, such as aluminum hydroxide and magnesium hydroxide; and inorganic fibers, such as glass fibers.

[0044] Examples of the organic fillers include, but not limited to, resin particles, such as acrylic beads; and organic fibers, such as cellulose fibers and synthetic resin fibers.

[0045] It is preferable to use one or more selected from the group consisting of silica, alumina, calcium carbonate and resin particles among these. By using such a filler, the yield elongation stress is more improved, and dripping tends to be suppressed.

[0046] An average particle diameter of the filler is preferably 400 nm or less, more preferably 1 to 200 nm,

still more preferably 1 to 100 nm, and still much more preferably 1 to 50 nm. By the average particle diameter in the aforementioned range, the yield elongation stress is more improved, and dripping tends to be suppressed. In the present embodiment, the average particle diameter refers to a primary particle diameter on the volume basis. The primary particle diameter can be measured by a laser diffraction scattering method.

[0047] A content of the filler is preferably 1.0 to 15 mass%, more preferably 1.5 to 10 mass%, and still more preferably 2.0 to 8.0 mass%, based on the total amount of the resin composition. By the content of the filler in the aforementioned range, the yield elongation stress is more improved, and dripping tends to be suppressed.

[0048] (Other components)

The resin composition of the present embodiment may contain other components in addition to the modified silicone resin and the filler. Examples of the other components include, but not limited to, a silicone resin other than the above modified silicone, a silane coupling agent, a curing catalyst, an organic pigment, an inorganic pigment, an ultraviolet light absorber, and a light stabilizer.

[0049] Examples of the silicone resins include, but not limited to, polydimethylsiloxane, polymethylphenylsiloxane, polydiphenylsiloxane, copolymers of these, and modified products of these.

Examples of the modified products include those wherein parts of methyl groups or phenyl groups have been subjected to alkyl modification, aralkyl modification, fluoroalkyl modification, polyether modification, amino modification, acrylic modification, epoxy modification or the like.

[0050] When the silicone resin is contained, a content of the silicone resin is preferably 45 to 75 mass%, more preferably 50 to 70 mass%, and still more preferably 55 to 65 mass%, based on the total amount of the resin composition.

[0051] Examples of the silane coupling agents include, but not limited to, aminosilane-based compounds, such as 3-aminopropyltrimethoxysilane, γ -aminopropyltriethoxysilane, and N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane; epoxysilane-based compounds, such as γ -glycidoxypropyltrimethoxysilane; vinylsilane-based compounds, such as γ -(meth)acryloxypropyltrimethoxysilane; cationic silane-based compounds, such as N- β -(N-vinylbenzylaminoethyl)- γ -aminopropyltrimethoxysilane hydrochloride; and phenylsilane-based compounds.

[0052] The silane coupling agent can function as a curing agent. When the silane coupling agent is contained, a content of the silane coupling agent is preferably 0.1 to 7.5 mass%, more preferably 0.5 to 5.0 mass%, and still

more preferably 1.0 to 3.0 mass%, based on the total amount of the resin composition.

[0053] The curing catalyst is not particularly limited as long as it catalyzes a reaction of a reactive silyl group, and examples thereof include a tin-based catalyst, a titanium-based catalyst, an aluminum-based catalyst, a zinc-based catalyst, an iron-based catalyst, and a phosphorus-based catalyst.

[0054] Examples of the ultraviolet light absorbers (UVA) include, but not limited to, a benzotriazole-based compound, a hydroxyphenyltriazine-based compound, and a polymer containing benzotriazole or benzophenone.

[0055] Examples of the light stabilizers (HALS) include, but not limited to, an N-OR type hindered amine-based compound, an N-R type hindered amine-based compound, and an N-H type hindered amine-based compound. Here, R represents a hydrocarbon group, and N-OR type or N-R type means a type wherein an OR group or an R group is linked to a nitrogen atom of a piperidyl skeleton. N-H type means a type wherein a hydrogen atom is linked to a nitrogen atom of a piperidyl skeleton.

[0056] [application]

The resin composition of the present embodiment can be preferably used for reinforcement, repairing or adhesion of an adherend, and particularly, it is preferably used in a surface protection method for concrete pieces. In the surface protection method in the

present embodiment, a flaking prevention method that is carried out for the purpose of preventing flaking of concrete, a protection method that is carried out for the purpose of blocking deterioration factors, such as salt, oxygen, moisture and light, etc. are included, and in any method, the composition of the present embodiment can be preferably used. The resin composition of the present embodiment capable of forming a coating film having excellent strength and elongation can be more preferably used in the flaking prevention method among these.

[0057] Particularly, the resin composition of the present embodiment can be preferably used for an intermediate coating layer in the surface protection method for concrete pieces. The intermediate coating layer is a layer having mechanical characteristics of a covering material in the surface protection method for concrete pieces, and is generally formed on a primer layer formed on a surface of a concrete frame. By using the composition for such applications, reinforcement or repairing of concrete can be carried out without using a toxic substance such as isocyanate.

[0058] Moreover, since the resin composition of the present embodiment is excellent in balance between strength and elongation, it can show good results also in a push-out test or a crack followability test, and flaking prevention treatment having higher reliability can be achieved.

[0059] [Surface protection method for concrete pieces]

The surface protection method for concrete pieces of the present embodiment has a step of forming an intermediate coating layer on a surface of a concrete frame or a surface of another layer formed on the surface using the above resin composition. In the surface protection method for concrete pieces of the present embodiment, if necessary, a primer layer may be formed on a surface of a concrete frame as another layer, or a top coating layer may be further formed on a surface of the intermediate coating layer.

[0060] By forming the primer layer, adhesion between the concrete frame and the intermediate coating layer tends to be more improved. Examples of resins contained in the primer layer include, but not limited to, an acrylic resin, an olefin resin, a vinyl acetate resin, a urethane resin, an epoxy resin, an aminated epoxy resin, a urea resin, a silicone resin, and modified resins of these.

[0061] Since the resin composition of the present embodiment is excellent also in adhesion to a concrete frame, it can be preferably used in a surface protection method in which a primer layer is not formed.

[0062] By forming the top coating layer, weathering resistance tends to be more improved. Examples of resins contained in the top coating layer include, but not limited to, a fluororesin, an acrylic resin, an acrylic silicone resin, an acrylic urethane resin, a urethane

resin, an olefin resin, a vinyl acetate resin, an ethylene-vinyl acetate copolymer resin, a silicone resin, and modified resins of these.

[0063] A method for forming each layer is not particularly limited, but for example, a method including applying a resin composition for forming each layer and then drying the composition at ordinary temperature or using drying equipment. When a layer is laminated, a layer that becomes an underlayer is dried, and then the next layer is formed. The drying time varies depending on the environmental conditions for coating, etc., but for example, it can be set to one day or more.

Examples

[0064] Hereinafter, the present invention will be described in more detail using examples and comparative examples. The present invention is in no way limited by the following examples.

[0065] [Example 1]

To 80 parts by weight of a modified silicone resin A (manufactured by Wacker Asahikasei Silicone Co., Ltd.; trade name: XB502; 25°C viscosity: 2000 mPas; modified silicone resin having, at each end, two or more silicone atoms to each of which a methoxy group has been linked; having a polyoxypropylene structure as a polyether-based polymer; having a dimethoxymethylsilyl group as a reactive silyl group), 20 parts by weight of a modified

silicone resin B (manufactured by Wacker Asahikasei Silicone Co., Ltd.; trade name: E30; 25°C viscosity: 30000 mPas; modified silicone resin having, at each end, one silicone atom to which a methoxy group has been linked; having a polyoxypropylene structure as a polyether-based polymer; having a dimethoxymethylsilyl group as a reactive silyl group) and 6 parts by weight of silica (manufactured by Wacker Asahikasei Silicone Co., Ltd.; trade name: H18; average particle diameter: 10 nm) were added, and they were stirred for 5 minutes. Further, 2 parts by weight of 3-aminopropyltrimethoxysilane were added, and they were stirred for 5 minutes, thereby preparing a resin composition.

[0066] [Example 2]

A resin composition was prepared by the same operations as in Example 1, except that the amount of the modified silicone resin A used was changed to 50 parts by weight, and the amount of the modified silicone resin B used was changed to 50 parts by weight.

[0067] [Example 3]

A resin composition was prepared by the same operations as in Example 1, except that the amount of silica used was changed to 3 parts by weight.

[0068] [Comparative Example 1]

A resin composition was prepared by the same operations as in Example 1, except that the amount of the

modified silicone resin A used was changed to 100 parts by weight, and the modified silicone resin B was not used.

[0069] [Comparative Example 2]

A resin composition was prepared by the same operations as in Example 1, except that the amount of the modified silicone resin A used was changed to 20 parts by weight, and the amount of the modified silicone resin B used was changed to 80 parts by weight.

[0070] [Comparative Example 3]

A resin composition was prepared by the same operations as in Example 1, except that silica was not used.

[0071] [Measurement of maximum stress, breaking strain and elastic modulus]

The resin composition obtained as above was molded into a sheet shape having a thickness of 1 mm, and the resulting sheet was allowed to stand still in an environment of 23°C and a relative humidity of 50% for 7 days to obtain a sheet-shaped cured product. This was punched out in a No. 3 dumbbell shape, and the resulting dumbbell was used for measurement of a maximum stress, a breaking strain and an elastic modulus described later. The maximum stress, the breaking strain and the elastic modulus were measured in accordance with JIS K 6251. In the measurement, the thickness of the No. 3 dumbbell was set to 1 mm, and the tensile speed was set to 100 mm/min.

The results are shown below. The tensile test results are shown in Figure 1.

[0072] [Table 1]

		Comparative Example 1	Example 1	Example 2	Comparative Example 2	Example 3	Example 4
Modified silicone	XB502	100	80	50	20	80	80
	E30	0	20	50	80	20	20
Filler	Fumed silica	6	6	6	6	3	0
Silane coupling agent	3- Aminopropyltrimethoxy silane	2	2	2	2	2	2
Tensile test (N=3 average)	Maximum stress [N/mm ²]	9.6	11.5	7.6	2.5	10.8	10.3
	Breaking strain [%]	43.4	285.1	351.3	362.2	278.3	245.2
	Elastic modulus [MPa]	23	9.5	3.4	1	9	9.2

[0073] [Push-out test]

A test substrate in a shape shown in Figure 2(a) was prepared in accordance with JSCE K 511, and a surface of the test substrate was coated with the resin composition prepared as above in a coating weight of 1.0 [kg/m²]. The substrate was allowed to stand still at 23°C and a relative humidity of 50% for 7 days to cure the composition, thereby preparing a coating film. The test substrate had a cylindrical drilled hole having a diameter of 100 mm and a depth of 55 mm on the side opposite to the coating film preparation surface.

[0074] The push-out test was carried out in accordance with JSCE K 533. Specifically, as shown in Figure 2(b), a columnar core portion surrounded by the drilled hole was loaded in the direction of the coating film preparation surface from the coating film non-preparation surface, and when a displacement of 10 mm was reached,

loading was temporarily discontinued. During the loading, a change of load (kN) with time, the load being applied at 5 mm/min, was monitored, and the peeling range given when a displacement of 10 mm was reached was marked.

This was repeated every 10 mm of displacement, and loading was carried out until the coating film was broken.

[0075] The loading was carried out at 1 mm/min before the remaining part of the core portion was fractured, and was carried out at 5 mm/min after the remaining part of the core portion was fractured.

[0076] In Figure 3, a change of load (kN) with time in the push-out test is shown. The same push-out test was carried out three times, and in Table 2, average values of measured maximum loads and maximum displacements are shown. As shown in Table 2 and Figure 3, in Comparative Example 1 in which the maximum stress and the elastic modulus were relatively high and the breaking strain was low, and in Comparative Example 2 in which the breaking strain was relatively high and the maximum stress and the elastic modulus were low, the cured product (coating film) was easily broken in the push-out test. On the other hand, it has been found that in Examples 1 and 2, the maximum load and the maximum displacement were much more improved than those in Comparative Examples 1 and 2 because the maximum stress, the elastic modulus and the breaking strain were each a predetermined value or more.

[0077] [Table 2]

		Comparative Example 1	Example 1	Example 2	Comparative Example 2
Push-out test	Maximum load [kN]	0.5	1.4	0.8	0.2
	Maximum displacement [mm]	5.5	84	87	11

[0078] [Crack followability test]

A test substrate in a shape shown in Figure 4(a) was prepared in accordance with JSCE K 511, and a surface of the test substrate was coated with the resin composition prepared as above in a coating weight of 1.5 [kg/m²]. The substrate was allowed to stand still at 23°C and a relative humidity of 50% for 7 days to cure the composition, thereby preparing a coating film. The test substrate had a cutting plane in the center, and the coating film was formed so as to go across the cutting plane.

[0079] The crack followability test was carried out in accordance with JSCE K 532. Specifically, as shown in Figure 4(b), the test substrate was pulled with a load cell (capacity 2 kN) in the long axis direction, and the test was carried out until the coating film was broken. A displacement given when the coating film was broken was measured.

[0080] This crack followability test was carried out three times, and in Table 3, an average value of measured displacements is shown. As shown in Table 3, it has been found that in Comparative Example 1 in which the maximum stress and the elastic modulus were relatively high and

the breaking strain was low, the cured product (coating film) was easily broken in the crack followability test. On the other hand, it has been found that in Examples 1 and 2, the displacement was much more improved than that in Comparative Example 1 because the maximum stress, the elastic modulus and the breaking strain were each a predetermined value or more.

[0081] [Table 3]

		Comparative Example 1	Example 1	Example 2
Crack followability test	Displacement [mm]	0.3	3.4	3.3

[0082] [Dripping evaluation]

First, using kinematic viscoelasticity measuring equipment (manufactured by TA Instruments, Inc., equipment name: RSA-G2), a yield elongation stress was measured in a compression mode in accordance with JIS K 6394 under the conditions of a gap of 1.5 mm, a strain of 0.5%, a temperature of 40°C and an angular frequency of 0.1 rad/s.

[0083] Subsequently, a test substrate was prepared in accordance with JSCE K 511, and the test substrate was kept in such a manner that the plane direction of the test substrate became parallel to the ground surface. A surface (lower surface) of the test substrate on the side opposite to the face of the substrate was coated with the resin composition prepared as above. In this state, the substrate was allowed to stand still at 23°C and a

relative humidity of 50% for 24 hours, and whether dripping occurred or not was confirmed.

[0084] The results are shown in Table 4. A resin composition that was free from occurrence of dripping was evaluated as ○, and a resin composition that suffered occurrence of dripping was evaluated as ×. As shown in Table 4, it has been found that occurrence of dripping was well correlated with the yield elongation stress.

[0085] [Table 4]

	Example 4	Example 3	Example 1
Yield elongation stress [Pa] (angular frequency: 0.1 rad/s)	24.7	39.8	368.7
Dripping evaluation	×	○	○

Industrial Applicability

[0086] The present invention has industrial applicability as a resin composition used in a surface protection method for concrete pieces, or reinforcement, repairing or adhesion of others.

Claims

[Claim 1]

A resin composition comprising a modified silicone resin and a filler, wherein

a maximum stress is 5.0 N/mm² or more,

a breaking strain is 100% or more, and

an elastic modulus is 2.0 MPa or more,

as measured in accordance with JIS K 6251 on a cured product formed by curing the resin composition at 23°C and a relative humidity of 50% for 7 days.

[Claim 2]

The resin composition according to claim 1, wherein an elongation stress of the resin composition, as measured in a compression mode in accordance with JIS K 6394 using parallel plates under the conditions of a gap of 1.5 mm, a strain of 0.5%, a temperature of 40°C, and an angular frequency of 0.1 rad/s, is 25 Pa or more.

[Claim 3]

The resin composition according to claim 1 or 2, wherein

the modified silicone resin comprises a straight-chain polymer A having two or more reactive silyl groups at each end, and

a content of the straight-chain polymer A is 10 to 90 mass% based on the total amount of the modified silicone resin.

[Claim 4]

The resin composition according to any one of claims 1 to 3, wherein

the modified silicone resin comprises a straight-chain polymer B having one reactive silyl group at each end, and

a content of the straight-chain polymer B is 10 to 90 mass% based on the total amount of the modified silicone resin.

[Claim 5]

The resin composition according to any one of claims 1 to 4, wherein

a content of the modified silicone resin is 20 to 99 mass% based on the total amount of the resin composition.

[Claim 6]

The resin composition according to any one of claims 1 to 5, wherein

an average particle diameter of the filler is 400 nm or less.

[Claim 7]

The resin composition according to any one of claims 1 to 6, wherein

a content of the filler is 1.0 to 15 mass% based on the total amount of the resin composition.

[Claim 8]

The resin composition according to any one of claims 1 to 7, wherein

the filler comprises one or more selected from the group consisting of silica, alumina, calcium carbonate, and a resin particle.

[Claim 9]

The resin composition according to any one of claims 1 to 8, for use in a surface protection method for concrete pieces.

[Claim 10]

A surface protection method for concrete pieces, having

a step of forming an intermediate coating layer on a surface of a concrete frame or a surface of another layer formed on the surface using the resin composition according to any one of claims 1 to 9.