

DESCRIPTION
METHOD OF PREVENTING CONCRETE EXFOLIATION

TECHNICAL FIELD

5 The present invention relates to a method of preventing concrete exfoliation and a method of repairing concrete.

BACKGROUND ART

10 It is generally known that concrete degradation is caused by brine damage, neutralization, an alkali-aggregate reaction and frost damage. In recent years, problems such as a reduction in the strength of concrete considered to result from such a developing deterioration, and by extension the exfoliation of concrete pieces have come to the surface. Particularly, taking
15 the opportunity of the exfoliation accidents of the concrete pieces from the concrete structures such as elevated roads or elevated railroads, the countermeasures of preventing the exfoliation have been taken.

20 As a method of preventing the exfoliation of the concrete pieces, there is known a lining method, for example methods described in Takayuki Sato, Go Miyashita, "Method for Anti-spalling of Concrete Pieces", DNT COATING TECHNICAL REPORT (October, 2002), 10-15, website of DAI NIPPON TORYO CO., LTD., <http://www.dnt.co.jp/japanese/imagepdf/giho2-10.pdf>. and in
25 "Method for Anti-spalling of Concrete Pieces, Alpha V-net System", (April 15, 2002), website of ALPHA KOGYO K.K., <http://www.alpha-kogyo.co.jp/methods/alphav.htm>, in which glass clothes or vinylon triaxial mesh is interposed between laminated epoxy resin layers as reinforcing materials on outer
30 walls of concrete structures. However, these method required time and manpower to cut reinforcing materials of glass clothes or vinylon triaxial mesh in conformity with shapes of concrete structures and had a problem on construction that in asperities on or edge portions of the concrete structures, it became
35 difficult to bend a reinforcing material in conformity with

shapes of asperities or edges to adequately bring the reinforcing material into contact with the concrete surface. Further, in these methods, since a step of laminating multi-layer for interposing the above reinforcing material became necessary, a construction time became extended and economical loss thereby was a problem.

In order to resolve these problems, in recent years, a method not using reinforcing materials is developed. This is a method in which a high strength resin coating film is formed on the concrete surface in a short construction time by spray-applying, for example, ultra fast curable urethane resin or urea resin as lining using a special application apparatus. But, in this method, problems that a special application apparatus is required and perfect protective countermeasures against scattered mist during application are necessary because of a spray application method have remained.

On the other hand, there has been studied a method of preventing concrete exfoliation in which a urethane resin of two component reaction curable resin having a high set-to-touch property is applied on such outer walls of concrete structures with a trowel or a paddle. In this resin, there are occasions when the viscosity of resin just after mixing two components, at which the work of application can be conducted, is secured by means of an amount of filler to be blended. However, since properties of the obtained resin coating film are deteriorated, it was very difficult to attain compatibility between the workability of applying, the fast curability and the physical properties of a coating film such as securing the viscosity just after mixing enabling the work of application, securing an adequate time available for applying, attaining a set-to-touch property in several hours after applying and securing physical properties of a coating film required to materials for preventing exfoliation.

It is an object of the present invention to provide a method of preventing concrete exfoliation which uses a resin composition having excellent workability of applying with a trowel or a paddle because of being provided with sufficient viscosity from the instant following mixing and having a set-to-touch time of several hours or less, and can prevent the concrete pieces exfoliation even without using reinforcing materials, and a method of repairing concrete in which a location requiring repair can be readily found and repaired.

The present invention relates to a method of preventing concrete exfoliation comprising a step (1) of forming a high strength resin coating film by applying a resin composition to the surface of concrete, wherein the above-mentioned resin composition is obtained by mixing a component A containing polyol and aliphatic polyamine and a component B containing polyisocyanate, and the viscosity of the resin composition just after mixing is 15 Pa·s or larger, and the viscosity of the resin composition after a lapse of 10 minutes from the mixing is 1000 Pa·s or smaller, and a set-to-touch time is 1 to 4 hours in environment of 20°C, and the above-mentioned high strength resin coating film has tensile strength of 10 MPa or larger and percentage elongation of 30% or higher in environments of 20°C and 65% in humidity.

Preferably, the proportion of an amine equivalent of the aliphatic polyamine to a hydroxyl group equivalent of the polyol contained in the component A is 5 to 20%.

The above-mentioned aliphatic polyamine is preferably polyamine having at least two aliphatic amino groups in a molecule and has an amine equivalent of 80 to 300.

In the method of preventing concrete exfoliation of the present invention, a primer is preferably applied to the surface of concrete.

In the method of preventing concrete exfoliation of the present invention, a surface conditioner and a primer are preferably applied to the surface of concrete.

Preferably, the above-mentioned surface conditioner is resin mortar.

Preferably, the method of preventing concrete exfoliation of the present invention comprises a step (2) of applying a top coating composition after the step (1).

The present invention also relates to a method of repairing concrete comprising a step of making concrete-repairs on a location of displacement of a high strength resin coating film or a top coating film, and the high strength resin coating film is formed by the above-mentioned method of preventing concrete exfoliation.

Further, the present invention relates to a resin composition which is used in the above-mentioned method of preventing concrete exfoliation.

DETAILED DESCRIPTION OF THE INVENTION

The method of preventing concrete exfoliation of the present invention in which the resin composition is provided with sufficient viscosity just after mixing and the occurrence of its sagging is adequately inhibited even though it is used immediately. The reason why the sagging is inhibited like this is not clear, but the reason for this is assumed to be that by using the resin composition obtained by mixing a component A containing polyol and polyamine having a specific structure and a component B containing polyisocyanate, an urea reaction having a very high reaction rate occurs in an urethane reaction system having a relatively mild reaction rate and as a result of this a structural viscosity is generated and the viscosity of the resin composition becomes high immediately.

The present invention relates to the method of preventing concrete exfoliation which comprises the step (1) of forming a high strength resin coating film by applying a resin composition to the surface of concrete.

The high strength resin coating film used in the method of preventing concrete exfoliation of the present invention is

characterized by having tensile strength of 10 MPa or larger and percentage elongation of 30% or higher in environments of 20°C and 65% in humidity. When the above-mentioned tensile strength is smaller than 10 MPa or the above-mentioned percentage elongation is lower than 30%, the obtained high strength resin coating film cannot withstand the delamination or the displacement associated with the degradation of concrete and readily breaks. Preferably, the above tensile strength is 15 MPa or larger, or the above percentage elongation is 45% or higher.

The above tensile strength and percentage elongation can be determined by a tensile testing machine. As such a tensile testing machine, there can be given, for example, Autograph AG-100KNE (manufactured by SHIMADZU CORPORATION).

The tensile strength and the percentage elongation in the present invention are values to be obtained by measuring, more specifically, according to the following procedure. That is, a resin composition is applied to a polypropylene plate while spreading with a trowel in such a way that a film thickness is about 1 mm and cured for 7 days in environments of 20°C to prepare a plate for evaluating physical properties, and the resulting plate for evaluating physical properties is cut in the form of No. 2 dumbbell according to JIS K 6301-3 to prepare a sample. Measurements of tensile strength (MPa) and percentage elongation (%) are given by conducting a tension test of the prepared sample at a stretch speed of 100 mm/minute in environments of 20°C and 65% in humidity using a tensile testing machine.

As a resin composition for forming the above-mentioned high strength resin coating film, there is given a substance obtained by mixing a component A containing polyol and aliphatic polyamine and a component B containing polyisocyanate. The above-mentioned polyol, the above-mentioned aliphatic polyamine and the above-mentioned polyisocyanate are not particularly limited as long as those satisfy the above-mentioned tensile strength and percentage elongation. It is generally considered that the tensile strength and the percentage

elongation relates closely to each other. Generally, when the tensile strength is high, the percentage elongation becomes small and its resin coating film has hard and brittle properties. On the contrary, when the percentage elongation is large, the tensile strength becomes small and its resin coating film has flexible and weak properties. The above tensile strength and percentage elongation can be controlled by the curability of a resin composition and the molecular weight between crosslinked portions of a resin coating film to be obtained. That is, when the above curability is enhanced, generally, the tensile strength becomes large and the percentage elongation becomes small. On the other hand, when the above molecular weight between crosslinked portions is increased, generally, the percentage elongation becomes large and the tensile strength becomes small. Based on this concept, the constituents of the above resin composition can be changed.

Such polyol contained in the above-mentioned component A is not particularly limited and can include, for example, polyol having two or more hydroxyl groups in a molecule. The molecular weight of the above-mentioned polyol is preferably 300 or more and 10000 or less. And, a hydroxyl group equivalent of the above polyol is preferably 100 or more and 5000 or less. When the above-mentioned molecular weight and hydroxyl group equivalent are less than lower limits, respectively, the percentage elongation of the resin coating film to be obtained may be reduced and when those are more than upper limits, respectively, the tensile strength may be reduced.

As the above polyol, there can be given, specifically, polyether polyol or polyester polyol. As the above-mentioned polyether polyol, there can be given compounds obtained by performing addition polymerization of one species or two or more species of epoxides such as ethylene oxide, propylene oxide, butylene oxide and tetrahydrofuran to polyhydric alcohols such as ethylene glycol, propylene glycol, diethylene glycol, triethylene glycol, dipropylene glycol, trimethylene glycol,

1,3-butanediol, 1,4-butanediol, 1,5-pentanediol, 1,2-hexyl glycol, 1,10-decanediol, 1,2-cyclohexanediol, glycerin, 1,2,6-hexanetriol, 1,1,1-trimethylolethane,

1,1,1-trimethylolpropane and pentaerythritol. And, as the
5 above-mentioned polyester polyol, there can be given compounds obtained by reacting the above-mentioned polyhydric alcohols with polycarboxylic acid such as succinic acid, glutaric acid and adipic acid or dimethylester thereof, sebacic acid, phthalic anhydride, etc. Also, there can be given polyester which is
10 obtained by polymerizing a cyclic ester being lactone such as caprolactone together with polyol. These polyols may be used alone or as a mixture of two or more species.

And, such aliphatic polyamine contained in the above-mentioned component A is not particularly limited and can
15 include a substance as aliphatic compound having two or more amino groups in a molecule. In addition, the above-mentioned aliphatic polyamine also includes aliphatic polyamine having an aromatic ring in a molecule. The weight-average molecular weight of the above aliphatic polyamine is, for example, 160
20 or more and 1000 or less. And, an amine equivalent of the above aliphatic polyamine is preferably 80 or more and 300 or less. When the above amine equivalent is out of the above range, a sagging property and workability of applying of the above resin composition may be deteriorated.

25 As the above-mentioned aliphatic polyamine, there can be given, specifically, polyoxyalkylenepolyamine obtained by a method of reacting a terminal hydroxyl group of polyoxyalkylene polyol having at least two or more hydroxyl groups with ammonia under high temperature and high pressure conditions using a
30 hydrogenation-dehydrogenation catalyst. From the viewpoint of the viscosity just after mixing, the above aliphatic polyamine is preferably aliphatic diamine. As such aliphatic diamine which is commercially available, there can be given, for example, JEFFAMINE D-230 (produced by Sun Technochemicals Co., Ltd., amine
35 equivalent about 120), JEFFAMINE D-400 (produced by Sun

Technochemicals Co., Ltd., amine equivalent about 200).

As a preferable one of combinations of polyol and aliphatic polyamine contained in the above component A, there can be specifically given a combination of polyether polyol and aliphatic diamine from the viewpoint of the performance of the high strength film to be obtained and the viscosity of the resin composition to be obtained. Thereby, it is possible to provide sufficient viscosity immediately after mixing the component A and the component B.

In the above component A, it is preferred that the proportion of an amine equivalent of the above aliphatic polyamine to a hydroxyl group equivalent of the above polyol contained in the above component A is 5 to 20%. When this proportion is less than 5%, the viscosity just after mixing becomes low and sagging becomes apt to occur and therefore the workability of applying may be deteriorated. When it is more than 20%, the viscosity just after mixing becomes high and therefore applying the resin composition may become difficult, or a time available for applying becomes short and therefore the workability of applying may be deteriorated. The above proportion is more preferably 7 to 15%.

The above component A may contain pigment to the extent of not degrading performance of the high strength resin coating film to be obtained.

The above-mentioned pigment is not particularly limited and can include, specifically, coloring pigments like inorganic pigments such as chrome yellow, yellow iron oxide, iron oxide, carbon black, titanium dioxide, mica and the like and organic pigments such as azo chelate pigment, insoluble azo pigment, condensed azo pigment, phthalocyanine pigment, indigo pigment, perynone pigment, perylene pigment, dioxane pigment, quinacridone pigment, isoindoline pigment, metal complex pigment and the like, and extender pigments such as calcium carbonate, precipitated barium sulfate, clay, talk and the like.

Polyisocyanate contained in the above-mentioned

component B is not particularly limited and can include publicly known polyisocyanates. Specifically, there can be given aromatic polyisocyanate compounds, aliphatic polyisocyanate compounds and alicyclic polyisocyanate compounds.

5 As the above-mentioned aromatic polyisocyanate compound, there can be given, for example, liquid diphenylmethane diisocyanate or a partial prepolymer of diphenylmethane diisocyanate, obtained by modifying with carbodiimide, 2,4-trilene diisocyanate (2,4-TDI), diphenylmethane-4,4'-
10 diisocyanate (MDI), diphenylmethane-2,4'- diisocyanate, xylylene diisocyanate (XDI), crude trilene diisocyanate, polymethylenepolyphenyl isocyanate, and carbodiimidation modified products, products modified by biuret reaction and prepolymerization modified products thereof. Among others,
15 diphenylmethane-4,4'-diisocyanate, diphenylmethane-2,4'- diisocyanate, or prepolymers thereof or modified products thereof are preferred from the viewpoint of curability.

 As the above-mentioned aliphatic polyisocyanate compound and alicyclic polyisocyanate compound, there can be given, for
20 example, 4,4'-dicyclohexylmethane diisocyanate, isophorone diisocyanate, hexamethylene diisocyanate, and isocyanuration modified products, carbodiimidation modified products and prepolymerization modified products thereof.

 As the above polyisocyanate which is commercially
25 available, there can be given, for example, Millionate MLT (produced by NIPPON POLYURETHANE INDUSTRY CO., LTD.), Millionate MTL-S (produced by NIPPON POLYURETHANE INDUSTRY CO., LTD.) and Coronate MX (produced by NIPPON POLYURETHANE INDUSTRY CO., LTD.).

 The above resin composition has a set-to-touch time of
30 1 to 4 hours in environments of 20°C from the viewpoint of the reduction of a term of works. In addition, the set-to-touch time refers to the time elapsed before the resin coating film becomes a state of not getting fingerprints on it when the applied resin coating film is touched with a finger. A temperature in
35 measuring the above set-to-touch time is not particularly limited

and an ambient temperature in conducting the respective works can be employed. The resin composition used in the method of preventing concrete exfoliation of the present invention also has the above set-to-touch time in a temperature range of 10 to 30°C and therefore the degradation in the sagging property and the workability of applying are not found for temperatures in conducting the works.

5 In the method of preventing concrete exfoliation of the present invention, the above resin composition is obtained by mixing the above component A and the above component B before conducting the above step (1). The viscosity of the resin composition just after mixing is 15 Pa·s or larger. When the above viscosity just after mixing is smaller than 15 Pa·s, a sagging property in applying the resin composition is degraded. 10 The above viscosity just after mixing is preferably 18 Pa·s or larger and further preferably 30 Pa·s or larger.

And, the viscosity of the resin composition after a lapse of 10 minutes from the mixing is 1000 Pa·s or smaller. When the viscosity after a lapse of 10 minutes from the mixing is larger than 1000 Pa·s, the workability of applying becomes difficult. The above viscosity after a lapse of 10 minutes from the mixing is preferably 900 Pa·s or smaller and further preferably 500 Pa·s or smaller. In addition, in the present description, the terms "just after mixing" and "after a lapse of 10 minutes from the mixing" are respectively defined as "after a lapse of 1 minute from the completion of mixing and stirring the above component A and component B for 1 minute at a rotational speed of 1500 rpm with bench type Disper" and "after a lapse of 11 minutes similarly". 20

30 A method of measuring the above-mentioned viscosity is not particularly limited and can include a method using a viscometer such as a rotating viscometer of cone and plate type well known to those skilled in the art.

Further, more specifically, the viscosity of the resin composition in the present invention is a value obtained by 35

measuring the viscosity after lapses of 1 minute and 11 minutes from the mixing and stirring the resin composition at measuring conditions of 25°C, 3 degree angle cone and rotational speed of 0.5 rpm using a rotating viscometer of cone and plate type.

5 Preferably, a formulation ratio of the above component A and the above component B is set in such a way that a ratio of a hydroxyl group equivalent to an isocyanate equivalent is 1/1 to 1/1.5. When the formulation ratio ranges within the above range, a resin coating film having excellent physical properties
10 can be attained. The above range is more preferably 1/1.1 to 1/1.3.

 The method of preventing concrete exfoliation of the present invention comprises the step (1) of forming the above high strength resin coating film by applying the above resin
15 composition to the surface of concrete. The above-mentioned concrete is not particularly limited and can include, for example, a substance obtained by pouring and curing a mixture of water, cement, fine aggregate and coarse aggregate kneaded, which is well known to those skilled in the art. Preferably, the method
20 of preventing concrete exfoliation of the present invention is applied to the above concrete portion such as elevated portions of the road or the railroad and top portions of building outer walls, where there is a high possibility that an accident may occur due to the occurrence of exfoliation.

25 As the above method of applying the resin composition, there can be given a method of applying a resin composition while spreading with a paddle or a trowel.

 A film thickness or an application rate of the resin coating film in the above application of the resin composition is not
30 particularly limited and can be appropriately set depending on an area to be coated. In addition, in order to adequately exert effects of the present invention, it is preferred to set the above thickness of resin coating film at 0.75 to 2 mm.

35 A curing time until adequate physical properties of a coating film of the above resin composition are attained after

the application of the resin composition is generally 16 hours or more and in environments of 20°C, for example, it is 16 hours.

5 In the method of preventing concrete exfoliation of the present invention, the above surface of concrete is preferably one to which a primer is applied. By applying the primer to the above surface of concrete, the adhesion of the above high strength resin coating film to the above surface of concrete can be improved. As the above-mentioned primer, there can be given a substance having high adhesion to the above surface of
10 concrete, and as a commercially available product, there can be given Tough Guard R-M Primer (moisture curable urethane resin primer produced by Nippon Paint Co., Ltd.), Tough Guard R-W Primer (aqueous epoxy resin primer produced by Nippon Paint Co., Ltd.), etc.

15 A method of applying the above-mentioned primer is not particularly limited and can include, for example, brush application, roller application, spray application and the like. And, a film thickness or an application rate, and a drying time of the primer in the above application are not particularly
20 limited and can be appropriately set depending on the species of the above primer. For example, when Tough Guard R-M Primer is used, the application rate can be set at 0.15 kg/m² and the drying time at 20°C can be set at 30 minutes using roller application.

25 And, in the method of preventing concrete exfoliation of the present invention, the above surface of concrete may be one to which a surface conditioner and a primer are applied. By applying the above surface conditioner and the above primer to the above surface of concrete, asperities on the above surface
30 of concrete can be adjusted and the adhesion of the above high strength resin coating film to the above surface of concrete can be further improved. And, by applying the surface conditioner to the surface of concrete, peel strength can improved. As the above-mentioned surface conditioner, a
35 substance having high adhesion to the above surface of concrete

and the above primer can be given, and specifically cement, aggregate and resin mortar containing resin or the like can be given. As such a surface conditioner, which is commercially available, there can be given Tough Guard E-W Filler (epoxy resin polymer cement mortar surface conditioner produced by Nippon Paint Co., Ltd.), etc.

A method of applying the above-mentioned surface conditioner is not particularly limited and can include, for example, the same methods as the above-mentioned application methods of the resin composition. And, a film thickness or an application rate, and a drying time of the surface conditioner in the above application are not particularly limited and can be appropriately set depending on the species of the above surface conditioner. For example, when Tough Guard E-W Filler is used, the application rate can be set at 1.0 kg/m² and the drying time at 20°C can be set at 18 hours using applying while spreading with a trowel.

A method of applying the above primer, a film thickness or an application rate, and a drying time of the above primer are not particularly limited and can include substances described in the primer described above.

By thus forming the above high strength resin coating film on the surface of concrete, it is possible to prevent the concrete exfoliation.

Further, the method of preventing concrete exfoliation of the present invention may comprise the step (2) of forming a top coating film by applying a top coating composition after the above-mentioned step (1). By applying the above top coating composition, it is possible to prevent degradation by ultraviolet light or enhance an aspect. The above-mentioned top coating composition is not particularly limited and can include, for example, substances, which is well known to those skilled in the art, such as acrylic resin coating composition, urethane resin coating composition and fluorocarbon resin coating composition. It is preferred to use a substance having

elasticity referred to as a flexible type of these coating compositions so that it can follow the deformation of concrete. As such a top coating composition which is commercially available, there can be given, for example, Tough Guard UD top coat (urethane resin top coating composition produced by Nippon Paint Co., Ltd.).

A method of applying the above-mentioned top coating composition is not particularly limited and can include, for example, the same methods as the above-mentioned application methods of the primer. And, a film thickness or an application rate, and a drying time of the top coating composition in the above application are not particularly limited and can be appropriately set depending on the species of the above top coating composition. For example, when Tough Guard UD top coat is used, the application rate can be set at 0.12 kg/m^2 and the drying time at 20°C can be set at 18 hours in using roller application.

A method of repairing concrete of the present invention is characterized by making concrete-repairs on a location, where a displacement has taken place, of the high strength resin coating film or the top coating film further formed thereon, which has been formed by the above method of preventing concrete exfoliation.

The above-mentioned occurrence of a displacement is identified by visually checking the surface of the above high strength resin coating film or the above top coating film. Herein, the displacement refers to the quantity of vertical change relative to a plane of a coating film, and if the quantity of change is, for example, 10 mm, it is determined that a displacement of 10 mm takes place. The above concrete-repairs made on a location where a displacement has taken place is made by a method well known to those skilled in the art, for example repairing with remedial mortar after cutting off a resin coating film or a coating film of a location where a displacement has been observed in the above resin coating film or the above top coating film.

Further, the above repair is preferably made when the above displacement is 30 mm or smaller. When the displacement is larger than 30 mm, there is a possibility that the degradation in concrete proceeds excessively and reinforcement by repairs may become
5 difficult.

As for the concrete repaired by the above-mentioned method of repairing concrete, it is preferred that the above method of preventing concrete exfoliation is applied again to the surface of the repaired concrete after applying needed treatment
10 to the surface.

EFFECTS OF THE INVENTION

The method of preventing concrete exfoliation of the present invention is a method of forming a high strength resin
15 coating film having the specific physical properties of a coating film on the surface of concrete using a resin composition obtained by mixing a component A containing polyol and polyamine having a specific structure and a component B containing polyisocyanate. Therefore, viscosity is high from early stages after mixing the
20 components A and B and sagging does not occur even though the resin composition is used immediately. The reason for this is considered to be that since an urea reaction having a very high reaction rate occurs in an urethane reaction system having a relatively mild reaction rate, a structural viscosity is
25 generated and therefore the viscosity of the resin composition becomes high immediately.

The resin composition used in the method of preventing concrete exfoliation of the present invention has a high curing reaction rate and can conduct more simple and shorter
30 construction than conventional methods using glass clothes or triaxial mesh.

Further, since the method of repairing concrete of the present invention makes concrete-repairs on a location, where a displacement has taken place, of the high strength resin coating
35 film or the top coating film obtained by coating thereon, which

has been formed by the above method of preventing concrete exfoliation, a checking work and a repair work can be easily conducted.

5 BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the present invention will be described in detail by way of specific examples, but the present invention is not limited by the following examples. In addition, "part(s)" refers to "part(s) by weight".

10

Production Example 1: Production of component A-1

MITSERON B-500 GRAY coating composition solution
(produced by Mitsui Kinzoku Paints & Chemicals Co., Ltd., a coating composition solution comprising 54 parts of a polyol component in which a hydroxyl group equivalent is 625 g/eq and average number of functional groups is 2.7, 40 parts of pigment comprising titanium dioxide, silicon dioxide, mica and carbon black, and 3 parts of an additive, solids content 100%) 97 parts and 1 part of JEFFAMINE D-230 (aliphatic diamine produced by Sun Technochemicals Co., Ltd., an amine equivalent is 126 g/eq and average number of functional groups is 2.0, effective component 100%) were mixed and adequately stirred to obtain a component A-1.

25 Production Example 2: Production of component A-2 and component A-3

A component A-2 and a component A-3 were obtained by following the same procedure as in Production Example 1 except for mixing MITSERON B-500 GRAY coating composition solution and JEFFAMINE D-230 according to the formulation shown in Table 1.

Production Example 3: Production of component A-4

A component A-4 was obtained by following the same procedure as in Production Example 1 except for mixing MITSERON B-500 GRAY coating composition solution, JEFFAMINE D-230 and

titanium dioxide according to the formulation shown in Table 1.

Table 1

	Production Example (component)			
	1 (A-1)	2 (A-2)	3 (A-3)	4 (A-4)
MITSERON B-500 GRAY coating composition solution (part)	97.0	97.0	97.0	97.0
JEFFAMINE D-230 (part)	1.0	3.0	-	-
titanium dioxide (part)	0.0	0.0	0.0	20.0
Proportion of amine equivalent to hydroxyl group equivalent (%)	5	15	-	-

Example 1

A resin composition 1 was obtained by mixing and stirring 98 parts of the component A-1 obtained in Production Example 1 and 33 parts of MITSERON A-5000 curing agent (polyisocyanate produced by Mitsui Kinzoku Paints & Chemicals Co., Ltd., equivalent of isocyanate group 135, number of functional groups 2.7, solids content 100%) for 1 minute at a rotational speed of 1500 rpm with bench type Disper. After applying this resin composition 1 to a slate while spreading with a paddle, the set-to-touch time at 20°C was measured to give 2 hours.

The resulting resin composition 1 was applied to a polypropylene plate while spreading with a trowel in such a way that a film thickness is about 1 mm and cured for 7 days in environments of 20°C to prepare a plate for evaluating physical properties.

And, the resulting resin composition 1 was applied to the substrate sample 1 and the U-shaped lid sample, which have been prepared according to the following procedure, at an application rate of 1.4 kg/m² with a trowel and cured for 3 hours. Further, Tough Guard UD top coat (urethane resin top coating composition produced by Nippon Paint Co., Ltd.) was applied at an application rate of 0.12 kg/m² with a brush and cured for 7 days in environments

of 20°C to obtain a samples 1 for evaluation and a U-shaped lid for evaluation.

[Procedure of sample preparation]

5 The surfaces (smooth surface) of mortar substrates 1, 2
(JIS mortar, 70 × 150 × 20 mm) as a substrate and a U-shaped
lid specified in JIS A 5334 were ground with a disk sander. The
above JIS mortar and the above U-shaped lid were immersed for
24 hours in water of 20°C and then taken out and water on the
10 surface was removed with cotton waste.

To the surface of the resulting substrates 1, 2 and U-shaped
lid, Tough Guard E-W Filler (cement mortar-containing epoxy resin
surface conditioner produced by Nippon Paint Co., Ltd.) was
applied at an application rate of 1.0 kg/m² while spreading with
15 a trowel and cured for 16 hours in environments of 20°C.

Further, Tough Guard R-M Primer (moisture curable urethane
resin primer produced by Nippon Paint Co., Ltd.) was applied
at an application rate of 0.15 kg/m² with a brush and cured for
2 hours in environments of 20°C to obtain substrate samples 1,
20 2 and U-shaped lid samples.

Example 2 and Comparative Examples 1, 2

Resin compositions 2 to 4 were obtained by following the
same procedure as in Example 1 except for mixing the components
25 A-2 to A-4 obtained in Production Examples 2 to 4 and the MITSERON
A-5000 curing agent according to the formulation shown in Table
2, and then plates for evaluating physical properties, samples
1 for evaluation and U-shaped lids for evaluation were further
prepared. In addition, each of all set-to-touch times was 2
30 hours.

Further, as for Example 2, the resin composition 2 was
applied to the substrate sample 2, obtained by following the
same procedure of sample preparation as in example 1 using a
mortar substrate 2 (a mortar substrate formed by masking one
35 end portion of 50 mm in width on the side of shorter side of

the mortar substrate 1 with a masking tape) in place of a mortar substrate 1, by a method similar to the preparation method of the sample 1 for evaluation in Example 1 to prepare a sample 2 for evaluation.

5

Table 2

		Resin composition			
		1	2	3	4
Component A	A-1 (part)	98.0	-	-	-
	A-2 (part)	-	100.0	-	-
	A-3 (part)	-	-	97.0	-
	A-4 (part)	-	-	-	114.0
Component B	MITSERON A-5000 curing agent (part)	33.0	33.0	33.0	33.0

Example 3

10 A sample 1 for evaluation, a sample 2 for evaluation and a U-shaped lid for evaluation were prepared by following the same procedure as in Example 2 except for applying Tough Guard R-W Primer (water-borne epoxy resin primer produced by Nippon Paint Co., Ltd.) at an application rate of 0.04 kg/m² with a brush in place of Tough Guard R-M Primer in preparation of samples.

15

Example 4

20 A sample 1 for evaluation, a sample 2 for evaluation and a U-shaped lid for evaluation were prepared by following the same procedure as in Example 2 except for not applying Tough Guard E-W Filler in preparation of samples.

Example 5

25 A sample 1 for evaluation, a sample 2 for evaluation and a U-shaped lid for evaluation were prepared by following the same procedure as in Example 4 except for using Tough Guard R-W Primer in place of Tough Guard R-M Primer in preparation of samples.

Evaluation test

On each of the obtained resin compositions 1 to 4 and plates for evaluating physical properties, samples 1 for evaluation, samples 2 for evaluation and U-shaped lids for evaluation, the following evaluation tests were conducted. The evaluation results obtained were shown in Table 3.

(1) Viscosity

On each of the obtained resin compositions 1 to 4, the viscosity after lapses of 1 minute and 11 minutes from the completion of mixing and stirring was measured with a EH type viscometer (a rotating viscometer of cone and plate type manufactured by TOKIMEC INC., measuring conditions: 3 degree angle cone, rotational speed of 0.5 rpm, 25°C).

(2) Workability of applying

(a) Sagging property

Each of the obtained resin compositions 1 to 4 was applied to a JIS mortar standing vertically so as to be 5 mm in thickness by an area of 10 mm × 100 mm, and the presence or absence of sagging of each resin composition was evaluated.

(b) Time available for applying

The obtained resin compositions 1 to 4 were applied to a slate while spreading with a paddle, and the time before the work of applying the resin composition while spreading becomes difficulty was measured.

(3) Physical property of resin coating film

Each of the plates for evaluating physical properties obtained in Examples 1, 2 and Comparative Examples 1, 2 was cut in the form of No. 2 dumbbell according to JIS K 6301-3 to prepare a sample. Then, the tensile strength (MPa) and the percentage elongation (%) were measured by conducting a tension test with Tensiron UTM-10T (a tensile testing machine manufactured by Toyo Baldwin CO., LTD., stretch speed: 100 mm/minute) in environments

of 20°C and 65% in humidity.

(4) Adhesive property

(a) Adhesion

- 5 On each of the samples 1 for evaluation obtained in Examples 2 and 3 to 5, adhesion (MPa) was measured with an adhesive tester of BUILDING RESEARCH INSTITUTE-type according to JIS A 6916 paragraph 5.6 in environments of 20°C and 65% in humidity.

(b) Peel strength

- 10 On each of the sample 2 for evaluation obtained in Examples 2 and 3 to 5, peel strength (kg/mm) of 90 degree of SIGN peel was measured with Tensiron UTM-10T (stretch speed: 100 mm/minute) in environments of 20°C and 65% in humidity.

15 (5) Evaluation through punching shear test

- 20 On each of the U-shaped lids for evaluation obtained in Examples 1 to 5 and Comparative Examples 1 and 2, relationship of load vs. displacement and peel area were measured according to Standards "A method of a punching shear test of continuous fiber sheets adhesion" established by Expressway Research Institute, Japan Highway Public Corporation.

Table 3

	Example						Comparative Example	
	1	2	3	4	5		1	2
Resin composition	1	2	2	2	2		3	4
Viscosity	18	58	58	58	58		5	15
	300	350	350	350	350		240	460
Workability of applying	none	none	none	none	none		present	none
	20	20	20	20	20		20	20
Physical property of resin coating film	15.3	15.8	15.8	15.8	15.8		15.2	18.1
	60	65	65	65	65		63	12
Adhesive property	—	2.0<	2.0<	2.0<	2.0<		—	—
	—	0.35	0.35	0.03	0.03		—	—
"Punching shear test" according to JH	1.70	1.73	1.73	1.51	1.58		1.70	— ³⁾
	round	round	round	ellipse	ellipse		round	

1) maximum load in a displacement of 10 mm or more

2) shape of peel in a displacement of 30 mm

3) no data because of the occurrence of crack in a resin coating film before reaching a displacement of 10 mm

As is apparent from the results of Table 3, in the method of preventing concrete exfoliation of the present invention, the viscosity just after mixing is high and therefore sagging does not occur even though the resin composition is applied immediately, and the set-to-touch time is short and the physical properties of a coating film obtained are good and the adhesion to a substrate is excellent (Examples 1 to 5). Further, it was found that when the surface conditioner is applied to the surface of a substrate, a peeling property becomes high and the shape of peel from the punching shear test becomes round (Examples 4 and 5). And, a curing time is short. On the other hand, it was found that when the viscosity just after mixing is low, sagging occurs if applying the resin composition just after mixing (Comparative Example 1), and when the physical properties of a coating film are insufficient, the obtained resin coating film does not meet the Standards of Expressway Research Institute, Japan Highway Public Corporation.

INDUSTRIAL APPLICABILITY

The method of preventing concrete exfoliation of the present invention is useful for concrete structures like structures such as elevated roads or elevated railroads.

CLAIMS

1. A method of preventing concrete exfoliation comprising a step (1) of forming a high strength resin coating film by applying a resin composition to the surface of concrete,

wherein said resin composition is obtained by mixing a component A containing polyol and aliphatic polyamine and a component B containing polyisocyanate, and

the viscosity of the resin composition just after mixing is 15 Pa.s or larger, and the viscosity of the resin composition after a lapse of 10 minutes from the mixing is 1000 Pa.s or smaller, and a set-to-touch time is 1 to 4 hours in environment of 20°C, and

said high strength resin coating film has tensile strength of 10 MPa or larger and percentage elongation of 30% or higher in environments of 20°C and 65% in humidity, and

a film thickness of resin coating film is set at 0.75 to 2 mm.

2. The method of preventing concrete exfoliation according to Claim 1,

wherein the proportion of an amine equivalent of said aliphatic polyamine to a hydroxyl group equivalent of said polyol contained in the component A is 5 to 20%.

3. The method of preventing concrete exfoliation according to Claim 1 or 2,

wherein said aliphatic polyamine is polyamine having at least two aliphatic amino groups in a molecule and has an amine equivalent of 80 to 300.

4. The method of preventing concrete exfoliation according to any one of Claims 1 to 3,

wherein a primer is applied to the surface of concrete.

5. The method of preventing concrete exfoliation according to any one of Claims 1 to 3,

wherein a surface conditioner and a primer are applied to the surface of concrete.

5 6. The method of preventing concrete exfoliation according to Claim 5,
 wherein said surface conditioner is resin mortar.

 7. The method of preventing concrete exfoliation according to any one of Claims 1 to 6,
10 which comprises a step (2) of applying a top coating composition after the step (1).

 8. A method of repairing concrete,
 comprising a step of making concrete-repairs on a location
15 of displacement of a high strength resin coating film or a top coating film,
 wherein said high strength resin coating film is formed by the method of preventing concrete exfoliation according to any one of Claims 1 to 7.

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 9. A resin composition,
 which is used in the method of preventing concrete exfoliation according to any one of Claims 1 to 7.