DESCRIPTION

FORMWORK FOR CONCRETE FORMING AND METHOD FOR PRODUCING SAME

Field

[0001] The present invention relates to a formwork for concrete forming mainly used in construction and civil engineering fields and a method for producing the same, and in particular to a formwork for concrete forming, in which the formwork has excellent release property, can be used repeatedly, and more reliably decreases air bubbles causing air voids on the surface of concrete and a method for producing the same.

Background

[0002] Conventionally, formworks made of woods, metals and plastics have been used for producing concrete members and concrete products having predetermined shapes and dimensions by placing concrete. At the time of placing concrete into the formwork, generally, a release agent is applied to the formwork in advance so that the formwork can be easily removed after curing the concrete. An oily release agent made of light oil or a mixture of machine oil with light oil has been used for a long time, while a release agent made by mixing vegetable oils, fatty acid esters, or organic acids as additives has been developed and used nowadays. An aqueous formwork remover made by emulsifying or dispersing mineral oil into water using an anionic surfactant has been developed. Generally, it has been said that the aqueous formwork remover provides a whiter finished concrete surface and less air bubbles (air bubbles in contact with the surface of the formwork) that cause air voids on the concrete surface than the oily release agent. It has been said that the aqueous formwork remover provides weaker adhesion force to the formwork and a poorer release property than the oily release agent.

Recently, however, an aqueous formwork remover having an excellent release property has been developed (for example, refer to Patent Literatures 1 and 2)

[0003] Freshly mixed concrete contains aggregates such as cement, sand, crushed stone, and gravel and water for mixing and kneading the aggregates and has fluidity. At the time of forming, vibration is usually applied in order to compact the freshly mixed concrete poured into a formwork. The air entrained at this time or the air contained in the concrete may generate air bubbles on the formwork surface.

[0004] When the surface of the concrete is observed at the stage where curing of the concrete is completed and the formwork is removed, what is called air voids may be observed due to curing while the air bubbles become air reservoir. These air voids are generated as a result of insufficient elimination of the air bubbles from the concrete.

[0005] The air voids on the surface of the concrete not only impair the appearance but also reduce durability and deteriorate the finish of coating when the coating is applied, and thus cause serious problems from a practical viewpoint. Particularly, for unfinished concrete, to which the surface finish of concrete is not carried out, whether the quality of the concrete is good is often determined based on the surface finish and thus significant decrease in the air voids is required in usual concrete construction. As conventional techniques relating to this, for example, formworks for forming a concrete described in Patent Literatures 3 to 5 have been known.

[0006] However, effects of the conventional techniques that are said to be effective in decreasing the air bubbles on the surface depend on the state of the formwork being

the substrate, a type of concrete, and a placing method and thus it can be said that these conventional formworks may actually fail to exhibit sufficient effects. Consequently, as conventional techniques so as to address these problems, a tool that eliminates air bubbles on the concrete surface has been developed (for example, refer to Patent Literature 6). However, this tool has difficulty in the timing of the construction and may rather impair appearance. A method for eliminating the air bubbles on the surface by applying an antifoaming agent to the formwork (for example, refer to Patent Literature 4) or a curing sheet for a concrete formwork with a smooth surface having a contact angle to water of 45° or less (for example, refer to Patent Literature 7) have been developed. However, the effects of these are not clear.

Citation List

Patent Literature

[0007] Patent Literature 1: Japanese Laid-open Patent Publication No. 5-293812

Patent Literature 2: Japanese Laid-open Patent Publication No. 11-19915

Patent Literature 3: Japanese Laid-open Patent Publication No. 2008-179047

Patent Literature 4: Japanese Laid-open Patent Publication No. 2006-137101

Patent Literature 5: Japanese Laid-open Patent Publication No. 6-317011

Patent Literature 6: Japanese Patent No. 3768188

Patent Literature 7: Japanese Utility Model Application Laid-open No. 5-16219

Summary

Technical Problem

[0008] In recent years, whether the quality of concrete

is good has been increasingly determined based on the surface finish and thus establishment of reliable decrease technique of air bubbles causing air voids on the concrete surface has been required.

[0009] The present invention has been made in view of the above problems and an object of the present invention is to provide a formwork for concrete forming, in which the formwork enables excellent release performance to be retained, can be used repeatedly, and reliably decrease air bubbles causing air voids on the concrete surface to improve the designability of the concrete surface after forming and a method for producing the same.

Solution to Problem

[0010] In order to solve the above-described problems and achieve the object, a formwork for concrete forming according to the present invention includes a water-repellent layer having a contact angle to water of 130° or larger on at least a part of the formwork surface.

[0011] Here, the concrete formed with the formwork for concrete forming according to the present invention means concrete in the broad sense including a cement-based material containing cement such as mortar and cement paste.

[0012] Moreover, in the above-described present invention, another formwork for concrete forming is characterized in that the water-repellent layer has a contact angle to water of 150° or larger.

[0013] Moreover, in the above-described present invention, another formwork for concrete forming is characterized in that the water-repellent layer includes a porous layer of hydrophobic oxide fine particles.

[0014] Moreover, in the above-described present invention, another formwork for concrete forming includes a porous layer formed from hydrophobic oxide fine

particlesover at least a part of a formwork surface.

[0015] Moreover, in the above-described present invention, another formwork for concrete forming is characterized in that an average primary particle diameter of the hydrophobic oxide fine particles is 3 nm to 100 nm.

[0016] Moreover, in the above-described present invention, another formwork for concrete forming is characterized in that the hydrophobic oxide fine particles are made of a hydrophobic silica.

[0017] Moreover, in the above-described present invention, another formwork for concrete forming is characterized in that the hydrophobic silica has trimethylsilyl groups on the surface of the hydrophobic silica.

[0018] Moreover, in the above-described present invention, another formwork for concrete forming is characterized in that the porous layer includes a three-dimensional network structure.

[0019] Moreover, in the above-described present invention, another formwork for concrete forming further includes a filled particle containing layer arranged between the formwork surface and the porous layer.

[0020] Moreover, in the above-described present invention, another formwork for concrete forming further includes a basecoat layer arranged between the formwork surface and the porous layer.

[0021] Moreover, a method for producing the above-described formwork for concrete forming according to the present invention includes providing a porous layer formed from hydrophobic oxide fine particles over at least a part of the formwork surface.

[0022] Moreover, another method for producing the above-described formwork for concrete forming according to the

present invention includes providing a water-repellent layer on at least a part of the formwork surface.

[0023] Moreover, a concrete according to the present invention is produced by using the above-described formwork for concrete forming.

Advantageous Effects of Invention

[0024] The formwork for concrete forming according to the present invention is a formwork for forming a concrete and includes a water-repellent layer having a contact angle to water of 130° or larger on at least a part of the formwork surface. Consequently, the surface tension of the formwork surface significantly increases due to the water-repellent layer and thus, when air bubbles entrained in the concrete are in contact with the surface of the water-repellent layer at the time of placing, the air bubbles tend to spread along the surface. As a result, the air bubbles on the concrete surface become thinner and flatter than air bubbles formed when a conventional formwork is used. These air bubbles move upwards by small vibration and are removed from the concrete surface easily. According to the present invention, therefore, the advantageous effects of more reliable decrease in the air bubbles causing the air voids on the concrete surface is obtained.

[0025] Another formwork for concrete forming according to the present invention is a formwork for forming a concrete and includes a porous layer formed from hydrophobic oxide fine particles over at least a part of the formwork surface. Consequently, the formwork enables the excellent release performance to be retained over a long period of time. As a result, opposite to the conventional formworks, the formwork does not require application of a release liquid to the formwork surface in

each use and can be used repeatedly. Use of the formwork for concrete forming of the present invention provides effects of forming a smooth concrete surface after forming and significantly decreasing generation of pits such as air voids to improve the designability of the concrete surface.

Brief Description of Drawings

[0026] FIG. 1 is a sectional view illustrating a first embodiment of a formwork for concrete forming according to the present invention.

FIG. 2 is a schematic perspective view of a model formwork used in experiments.

FIG. 3 includes photographic views comparing generation states of air voids on the concrete surface of Experiment Number 1.

FIG. 4 includes photographic views comparing generation states of air voids on the concrete surface of Experiment Number 2.

FIG. 5 includes photographic views comparing generation states of air voids on the concrete surface of Experiment Number 3.

FIG. 6 includes photographic views comparing generation states of air voids on the concrete surface of Experiment Number 4.

FIG. 7 is an exploded perspective sectional view illustrating a constitution example of a conventional painted plywood for a formwork.

FIG. 8 includes exploded perspective sectional views illustrating a constitution example of a painted plywood for a formwork to which the present invention is applied.

FIG. 9 is a sectional view illustrating a second embodiment of a formwork for concrete forming according to the present invention.

FIG. 10 is a view illustrating the advantage of the

second embodiment of the formwork for concrete forming according to the present invention.

FIG. 11 includes photographic views comparing generation states of air voids on the concrete surface of Experiment Number 5.

FIG. 12 includes sectional views illustrating a formwork for concrete forming of a third embodiment according to the present invention. FIG. 12(1) is a view just after placing concrete and FIG. 12(2) is a view after vibration.

FIG. 13 includes explanation views of a contact angle α to water. FIG. 13(1) is a view when the contact angle is an acute angle and FIG. 13(2) is a view when the contact angle is an obtuse angle.

FIG. 14 is a sectional view illustrating a modified example of the third embodiment of the present invention.

FIG. 15 includes photographic views illustrating a placing state of concrete when polyvinyl chloride plates are used as a formwork body being a substrate of the third embodiment of the present invention.

FIG. 16 includes photographic views illustrating concrete surfaces after the removal of the formwork when polyvinyl chloride plates are used as the formwork body being a substrate of the third embodiment of the present invention.

FIG. 17 includes photographic views illustrating concrete surfaces after the removal of the formwork when painted plywoods are used as the formwork body being a substrate of the third embodiment of the present invention.

FIG. 18 includes photographic views illustrating concrete surfaces after the removal of the formwork when painted plywoods are used as the formwork body being a substrate of the third embodiment of the present invention.

FIG. 19 is a photographic view illustrating a concrete surface after the removal of the formwork when painted plywoods to which FLUOROSURF (registered trademark) is applied by brush painting are used.

FIG. 20 is a photographic view illustrating a concrete surface after the removal of the formwork when polyvinyl chloride plates to which NeverWet is applied by spray coating are used.

Description of Embodiments

[0027] Hereinafter, embodiments of the formwork for concrete forming and the method for producing the same according to the present invention will be described in detail with reference to the drawings. These embodiments, however, do not limit the present invention.

[0028] (First embodiment)

The first embodiment of the present invention will be described.

FIG. 1 is a schematic sectional view illustrating the first embodiment of the present invention. As described in this view, the formwork for concrete forming 10 according to the present embodiment is a formwork for forming a concrete and includes a formwork body 12, and, from a formwork surface 20 of the formwork body 12, includes a basecoat layer 14, a filled particle containing layer 16, and a porous layer 18 formed from hydrophobic oxide fine particles in this order.

[0029] The present invention essentially includes the porous layer 18 on the outermost surface of the formwork surface 20 at the side in contact with the concrete. The basecoat layer 14 and the filled particle containing layer 16 may be included if necessary. A plurality of basecoat layers may be used or any layers other than the basecoat layer 14 may be included as long as the advantageous

effects of the present invention are not impaired.

[0030] [Formwork body]

The material of the formwork body 12 is not limited as long as the material may be a material commonly used and can be selected from, for example, woods, metals, synthetic resins, natural resins, and a composite materials thereof. Generally, woods and painted plywoods are preferably used from the viewpoint of cost and versatility. The shape, the size, and the like of the formwork body 12 can be adequately designed depending on a target formed concrete product. When a groove is intended to be formed on a formed product, a jointer may also be included. When the jointer is included, the jointer constitutes a part of the formwork body 12. Consequently, the formwork body 12 in this case includes the jointer. When the jointer is included, a porous layer formed from the hydrophobic oxide fine particles may be provided on the surface of the jointer.

[0031] Undercoating, sealing coating, primer coating, coloring coating and the like may be adequately applied to the surface of the formwork body 12. In the present invention, the coating film formed by such coating is called the basecoat layer 14. By including the basecoat layer 14 between the formwork surface 20 and the porous layer 18, the unevenness correction of the formwork surface 20, the adhesion improvement of the porous layer 18 and the filled particle containing layer 16, and the durability improvement of the formwork body 12 can be achieved.

[0032] [Basecoat layer]

For the formation of the basecoat layer 14, a known application (coating) method using known undercoating agents, sealing agents, primers, and coloring agents can be employed, and thus the formation is not described in detail

here. The filled particle containing layer 16 will be described later.

[0033] [Porous layer]

The porous layer 18 is formed at least a part (the outermost surface at the side in contact with concrete) of the formwork surface 20. The hydrophobic oxide fine particles that are a raw material for forming the porous layer 18 are not limited as long as the fine particles have a hydrophobic property. The hydrophobic oxide fine particles may also be fine particles provided with the hydrophobic property by surface treatment. For example, fine particles provided with a hydrophobic surface state by applying surface treatment to hydrophilic oxide fine particles with a silane coupling agent and the like may also be used. The type of the oxide is not limited as long as the fine particles have the hydrophobic property. For example, at least one of silica (silicon dioxide), alumina, titania, and the like may be used. As these fine particles, known fine particles or commercially available fine particles may also be used.

[0034] Examples of the silica may include "AEROSIL R972", "AEROSIL R972V", "AEROSIL R972CF", "AEROSIL R974", "AEROSIL RX200", "AEROSIL RX300", "AEROSIL NX90G", and "AEROSIL RY200" (product names, these products are manufactured by Nippon Aerosil Co., Ltd.), "AEROSIL R202", "AEROSIL R805", "AEROSIL R812", and "AEROSIL R812S" (product names, these products are manufactured by Evonik Degussa GmbH), "SYLOPHOBIC-100", "SYLOPHOBIC-200" and "SYLOPHOBIC-603" (product names, these products are manufactured by Fuji Silysia Chemical, Ltd.). Here, AEROSIL and SYLOPHOBIC are registered trademarks.

[0035] Examples of the titania may include "AEROXIDE TiO_2 T805" (product name, manufactured by Evonik Degussa

GmbH). Examples of the alumina may include fine particles having the hydrophobic property prepared by treating "AEROXIDE Alu C" (product name, manufactured by Evonik Degussa GmbH) and the like with a silane coupling agent. Here, AEROXIDE is a registered trademark.

[0036] Among them, hydrophobic silica fine particles can be preferably used. In Particular, from the viewpoint of obtaining a more excellent water-repellent property, hydrophobic silica fine particles having trimethylsilyl groups on the surfaces are preferable. Examples of the corresponding commercially available products may include "AEROSIL RX200", "AEROSIL RX300", and "AEROSIL NX90G" (product names, these products are manufactured by Nippon Aerosil Co., Ltd.), "AEROSIL R812", "AEROSIL R812S", and "AEROSIL R8200" (product names, these products are manufactured by Evonik Degussa GmbH).

[0037] Although the particle size of the hydrophobic oxide fine particles is not limited, the average primary particle diameter is preferably 3 nm to 10 μm, more preferably 3 nm to 100 nm, and most preferably 5 nm to 50 nm. By setting the average primary particle diameter within the above range, gas such as air can be retained in voids existing in the aggregates. As a result, the porous layer can exhibit an excellent release property. This aggregated state is also retained after concrete is attached to at least a part (the outermost surface at the side in contact with concrete) of the formwork surface 20 and thus the porous layer can exhibit the excellent release property. In Particular, by using the hydrophobic oxide fine particles having an average primary particle diameter of 3 nm to 100 nm, the formwork for concrete forming 10 having a three-dimensional network structure surface can be obtained.

[0038] The porous layer 18 of the hydrophobic oxide fine particles formed on the outermost surface of the formwork surface 20 is preferably the porous state having the three-dimensional network structure. The thickness of the porous layer 18 is preferably about 0.1 μm to about 500 μm and more preferably about 0.5 μm to about 20 μm. By forming the porous layer 18 in the porous state as described above, the layer can contain much air and thus the porous layer can exhibit a more excellent release property.

[0039] In the present invention, the measurement of the average primary particle diameter can be carried out with a scanning electron microscope (FE-SEM). When the resolution of the scanning electron microscope is insufficient, the measurement may be carried out using other electron microscope such as a transmission electron microscope together. Specifically, when the particle shape is a spherical shape, the diameter of the particle is determined to be the particle diameter, whereas when the particle shape is a non-spherical shape, the average value of the longest diameter and the shortest diameter of the particle is determined to be the particle diameter. The average of the particle diameters of 50 particles randomly selected from the observation with the scanning electron microscope and the other electron microscopes is determined to be the average primary particle diameter.

[0040] Although the specific surface (measured by BET method) of the hydrophobic oxide fine particles are not particularly limited, usually 50 m^2/g to 300 m^2/g is preferable and 100 m^2/g to 300 m^2/g is more preferable.

[0041] At the time of application to at least a part (the outermost surface at the side in contact with concrete) of the formwork surface 20, the hydrophobic oxide fine particles can be directly attached (a dry method) or

can be attached by applying a dispersion liquid prepared by dispersing the hydrophobic oxide fine particles into a solvent (a wet method). In the present invention, the wet method is preferable from the viewpoint of easily obtaining a uniform coating film (hydrophobic oxide fine particle layer) industrially and, in addition, easily obtaining the three-dimensional network structure.

[0042] When the dispersion liquid described above is used, the solvent to be used for the dispersion liquid can be adequately selected from organic solvents such as alcohol (ethanol), cyclohexane, toluene, acetone, IPA, propylene glycol, hexylene glycol, butyl diglycol, pentamethylene glycol, normal-pentane, normal-hexane, and hexyl alcohol. At this time, a slight amount of a dispersing agent, a coloring agent, an anti-settling agent, a viscosity modifier, and the like may be used together. The dispersed amount of the hydrophobic oxide fine particles to the solvent is usually about 10 g/L (liter) to about 300 g/L and preferably about 30 g/L to about 100 g/L.

[0043] The method for applying the dispersion liquid is not particularly limited. For example, printing methods (inkjet printing, screen printing, and gravure printing), a dropping method, and the like can be employed in addition to application methods by a spray, a brush, a roller, immersion, and the like. After application, the applied dispersion liquid may be adequately dried at room temperature to about 150°C.

[0044] Usually, the amount to be attached when the hydrophobic oxide fine particles are applied to the formwork surface 20 can be adequately determined depending on a desired release property and the like. Based on the solid content standard, the amount to be attached may be about 0.1 g/m^2 to about 100 g/m^2 and preferably about 0.5

g/m^2 to about 20.0 g/m^2. By determining the amount within the range described above, the porous layer can obtain a more excellent release property over a long period of time and, in addition, is more advantageous in terms of reduction in detachment of the hydrophobic oxide fine particles, cost, and the like.

[0045] [Filled particle containing layer]

The filled particle containing layer 16 is preferably included between the formwork surface 20 and the porous layer 18. The filled particle containing layer 16 is a layer in which filled particles are dispersed in a matrix. By including the filled particle containing layer 16, the release property of the formwork for concrete forming 10 can be retained over a longer period of time. As the filled particles, filled particles containing at least one of organic components and inorganic components can be employed. The amount to be attached when the filled particle containing layer 16 is included between the formwork surface 20 and the porous layer 18 is, for example, about 0.1 g/m^2 to about 100 g/m^2 and preferably about 1.0 g/m^2 to about 20.0 g/m^2 based on the solid content as a standard. By determining the amount within the range described above, the filled particle containing layer can obtain a more excellent adhesion property of the hydrophobic oxide fine particles over a long period of time and, in addition, is more advantageous in terms of reduction in detachment of the hydrophobic oxide fine particles applied onto the filled particle containing layer 16, durability, and the like. The method for attaching the filled particle containing layer 16 is not particularly limited. For example, a printing method, a dropping method, and the like can be employed in addition to application methods by a spray, a brush, a roller, immersion, and the

like. At the time of attachment (application), the matrix described below can be diluted with an adequate solvent. After the attachment, the applied filled particle containing layer can be adequately dried at room temperature to about 150°C.

[0046] As the inorganic components, for example, 1) metals such as aluminum, copper, iron, titanium, silver, and calcium or alloys or intermetallic compounds containing these metals, 2) oxides such as silicon oxide, aluminum oxide, zirconium oxide, titanium oxide, and iron oxide, 3) inorganic acid salts or organic acid salts such as calcium phosphate and calcium stearate, 4) glasses, and 5) ceramics such as aluminum nitride, boron nitride, silicon carbide, and silicon nitride can be preferably used.

[0047] As the organic components, for example, organic polymer components (or resin components) such as acrylic-based resins, urethane-based resins, melamine-based resins, amino resins, epoxy resins, polyethylene-based resins, polystyrene-based resins, polypropylene-based resins, polyester-based resins, cellulose-based resins, vinyl chloride-based resins, polyvinyl alcohols, ethylene-vinyl acetate copolymers, ethylene-vinyl alcohol copolymers, ethylene-ethyl acrylate copolymers, polyacrylonitriles, and polyamides can be preferably used.

[0048] Other than the filled particles made of the inorganic components or the filled particles made of the organic components, particles including both of the inorganic components and the organic components can be used as the filled particles of the present invention. Among them, in particular, at least one of the particles such as acrylic resin particles, polyethylene-based resin particles, hydrophilic silica particles, calcium phosphate particles, carbon powder, calcined calcium particles, non-calcined

calcium particles, and calcium stearate particles can be more preferably used.

[0049] The average particle diameter of the filled particles (based on measurement by a laser diffraction particle size distribution meter) is preferably about 0.3 μm to about 100 μm, more preferably 1 μm to 50 μm, further preferably 5 μm to 30 μm, and most preferably 20 μm to 30 μm. The filled particles having an average particle diameter of less than 0.3 μm are not suitable from the viewpoint of a handling property, unevenness formation, and the like, whereas the filled particles having an average particle diameter of more than 100 μm are not suitable from the viewpoint of detachment of the filled particles and dispersibility. The shape of the filled particles is not limited. For example, the shape may be any of a spherical shape, a spheroid shape, an irregular shape, teardrop shape, a flat shape, a hollow shape, a porous shape, and the like.

[0050] As the matrix constituting the filled particle containing layer 16 and binding the filled particles, thermoplastic resins, thermosetting resins, rubbers, elastomers, and waxes can be employed. The contained amount of the filled particles in the matrix can vary depending on the material of the matrix, the type of the filled particles, desired physical properties, or the like. Generally, the contained amount is preferably 1% by weight to 80% by weight and more preferably 3% by weight to 50% by weight based on the solid content weight standard.

[0051] A method for containing the filled particles (a method for dispersing the filled particle into the matrix) is not particularly limited. Generally, a method for formulating the filled particles in the raw material for forming the matrix (for example, a composition containing a

thermoplastic resin) and other methods are included. The method for mixing may be either dry mixing or wet mixing.

[0052] When the matrix is the thermoplastic resin, the main components of the thermoplastic resin layer generally include 1) the thermoplastic resin or a monomer or an oligomer constituting the thermoplastic resin, 2) a solvent, and 3) a crosslinking agent if necessary, and the like and thus the filled particles may be added and mixed in the mixture of these components. As the thermoplastic resin, a known thermoplastic resin can be employed. For example, acrylic resins, polystyrenes, ABS resins, vinyl chloride resins, polyethylene resins, polypropylene resins, polyamide-based resins, polycarbonates, polyacetals, fluorine-based resins, silicone resins, and polyester-based resins and, in addition, blended resins of these resins, copolymers containing a combination of monomers constituting these resins, and modified resins can be used.

[0053] When the matrix is the thermosetting resin, for example, phenolic resins, urea resins, melamine resins, unsaturated polyester resins, epoxy resins, and silicon resins can be employed. When the matrix is the elastomer, for example, PVC-NBR blended elastomers and urethane-based elastomers can be employed.

[0054] According to the formwork for concrete forming 10 according to the present invention that is configured as described above, the formwork enables the excellent release performance to be retained over a long period of time, opposite to conventional formworks, does not require application of a release liquid to the formwork surface in each use, and is able to be used repeatedly after forming concrete (what is called diversion). Use of the formwork for concrete forming of the present invention provides effects of forming a smooth concrete surface after forming

and significantly decreasing generation of pits such as air voids to improve the designability of the concrete surface.

[0055] (Second embodiment)

The second embodiment of the present invention will be described. In the following description, the detailed description of the overlapped description parts of the first embodiment will be omitted, and only the different parts will be described in detail.

[0056] FIG. 9 is a schematic sectional view of the formwork for concrete forming of the second embodiment of the present invention. As seen from FIG. 9, what is significantly different from the first embodiment is that the basecoat layer 14 in the first embodiment is replaced to an adhesion layer 22 and a resin film 24.

[0057] As the adhesion layer 22, for example, isocyanate-based (urethane-based), polyethyleneimine-based, polybutadiene-based, poly-acrylic, polyester-based, epoxy-based, polyvinyl acetate-based, cellulose-based, and other adhesives or pressure-sensitive adhesives can be used. Although the applied amount of the adhesion layer 22 is not particularly limited, the applied amount is preferably about 1 g/m^2 to about 200 g/m^2 as an after-drying weight.

[0058] As the resin film 24, for example, films or sheets of resins such as low-density polyethylenes, medium-density polyethylenes, high-density polyethylenes, linear-low-density polyethylenes, polyesters, polypropylenes, polyvinyl chlorides, nylons, and an ethylene-propylene copolymers or, films or sheets of resins such as polyvinylidene chlorides, polyvinyl alcohols, and an ethylene-vinyl acetate copolymer saponification product can be used. These materials can be used singly or in combination. The thickness of the films or sheets is not particularly limited. The thickness is usually about 9 μm

to about 500 μm and desirably about 20 μm and about 100 μm.

[0059] In the second embodiment, the same formwork body 12, porous layer 18, and filled particle containing layer 16 in the first embodiment can be used in a similar way. In the second embodiment, the basecoat layer and any layers can be also included between the formwork surface 20 and the porous layer 18.

[0060] As an advantage of the second embodiment, as illustrated in FIG. 10, the formwork body 12 and the other components (from the adhesion layer 22 to the porous layer 18) are separately produced and laminated at a construction field or a workplace near a construction field, whereby the formwork for concrete forming of the present invention can be rapidly completed. As a method for laminating, when a hot melt-type adhesive or a thermosensitive-type adhesive is used for the adhesion layer 22, lamination can be carried out by heating with a pressing iron or the like. When a dry laminate-type adhesive or a pressure sensitive-type adhesive is used for the adhesion layer 22, complete lamination can be carried out by applying pressure after lamination. It goes without saying that a laminated body of the resin film 24 to the porous layer 18 can be laminated at the construction field or the workplace using a two-component curable adhesive or a pressure-sensitive adhesive.

[0061] (Verification of advantageous effects of present invention through experiment)

Subsequently, verification of the advantageous effects of the present invention through experiments will be described.

[0062] [Verification of advantageous effects of first embodiment]

First, experiments carried out in order to verify the

advantageous effects of the first embodiment and verified results will be described.

[0063] FIG. 2 is a schematic perspective view of a model formwork used in the present experiments. Illustration of the bottom part and the right and left side parts of the formwork are omitted. As illustrated in this view, in this experiment, a freshly mixed concrete is poured into the model formwork configured by two plates P (vertical dimension 300 mm and horizontal dimension 300 mm) oppositely placed back and forth at a distance of 100 mm and the freshly mixed concrete is cured to form a concrete.

[0064] As the material of the model formwork that corresponded to the first embodiment of the present invention, plates formed by applying one filled particle containing layer to a painted plywood (Imported Product B) and applying a porous layer thereon, plates formed by applying four filled particle containing layers to a plywood for concrete formwork and applying a porous layer thereon, plates formed by applying only a porous layer to an intermediate product of a pained plywood, and plates formed by applying one filled particle containing layer to a steel plate and applying a porous layer thereon were used. The porous layer in this experiment was a layer formed by applying an ethanol dispersion in which hydrophobic silica particles having an average primary particle diameter of 7 nm were dispersed and thereafter heating and drying the applied dispersion at around 120°C. A three-dimensional network structure was observed as a result of the observation using FE-SEM. The filled particle containing layer is a layer formed by applying a lacquer (main component: polyester-based resin) in which acrylic-based resin beads (average particle diameter 20 μm) were dispersed and thereafter heating and drying the applied

dispersion at around 120°C.

[0065] On the other hand, Imported Product A, Imported Product B, Imported Product C, Domestic Product A, Domestic Product B (these products are painted plywoods), and steel plates to which an oily release agent was applied were used for comparison.

[0066] Materials used for forming concretes in this experiment are listed in Table 1.

[0067]

Table 1

Type	Material name	
Cement	Normal Portland cement	N
	Moderate heat Portland cement	M
Fine aggregate	Pit sand	S1
	Lime crushed sand	S2
Coarse aggregate	Crushed stone 2005 (limestone)	G
Water	Tap water	W
Additive	AE Water reducing agent (high performance type)	AD1
	High performance water reducing agent	AD2

[0068] Formulations of concretes used in this experiment are listed in Table 2.

[0069]

Table 2

Exper-iment Number	Formu-lation	Nominal strength	Slump (cm)	Slump flow (cm)	Water/ Cement ratio (%)	Unit amount (kg/m³)						Added ratio of additives to cement (%)	
						Cement		Water	Fine aggre-gate		Coarse aggre-gate		
						N	M	W	S1	S2	G	AD1	AD2
1	Normal 24 18 20N	24	18	-	60.0	308	0	185	519	346	926	0.7	0
2	Normal 42 18 20N	42	18	-	41.3	412	0	170	457	305	983	0	0.9
3	High strength 60 60 20M	60	-	60	31.7	0	536	170	462	308	915	0	1.4
4	Normal 24 12 20N	24	12	-	60.0	287	0	172	475	316	1053	0.7	0

[0070] In Table 3, each of test results of slumps (JIS A 1101: 2005), slump flows (JIS A 1150: 2007), air contents (JIS A 1128: 2005), concrete temperatures (JIS A 1156: 2006), bleeding amounts/bleeding ratios (JIS A 1123: 2012), and compression strength (JIS A 1108: 2006) of the concretes used in this experiment are listed. Here, the result of the compression strength test is obtained by measuring the test samples that are cured in a standard manner for a material age of 28 days.

[0071]

Table 3

Experiment Number	Formulation	Slump (cm)	Slump flow (cm)	Air content (%)	Concrete temper-ature (°C)	Breeding amount (cm^3/cm^2)	Breeding ratio (%)	Compression strength (N/mm^2) Standard curing 28 days
1	Normal 24 18 20N	18.0	-	4.2	21	0.224	4.82	28.6
2	Normal 42 18 20N	18.0	-	3.9	21	0.034	0.77	58.3
3	High strength 60 60 20M	-	63.5	2.5	22	0	0	80.6
4	Normal 24 12 20N	12.5	-	4.5	21	0.165	3.79	30.5

[0072] FIGS. 3 to 6 are photographic views comparing generation state of air voids on the concrete surfaces of Experiment Numbers 1 to 4, respectively. Here, in each view of FIGS. 3 to 5, (1) to (5) are Comparative Examples and (6) corresponds to the present invention. As illustrated in FIGS. 3 to 5, it is found that every sample corresponding to the present invention barely generates air voids on the concrete surface compared with generation of the air voids of Comparative Examples.

[0073] FIG. 6 corresponds to Experiment Number 4. The formulation of Experiment Number 4 is often used for members for civil engineering applications. In FIG .6, (1) and (2) are Comparative Examples and (3) to (6) correspond to the present invention. As illustrated in FIG. 6, it is found that every sample corresponding to the present invention barely generates air voids on the concrete surface compared with generation of the air voids of the Comparative Examples.

[0074] Consequently, according to the present invention, a smooth concrete surface after forming is formed, generation of pits such as air voids are significantly decreased, and the designability of the concrete surface can be improved.

[0075] [Application examples of first embodiment]

Subsequently, the application example of the formwork for concrete forming and the method for producing the same according to the first embodiment will be described. The formwork for concrete forming according to the present embodiment is applicable to a commercially available common painted plywood for a formwork. FIG. 7 is an exploded perspective sectional view illustrating a schematic constitution of a common painted plywood for a formwork as an example. As illustrated in this view, a common painted

plywood for a formwork 30 includes a formwork body 32, a primer layer 34, an undercoating layer 36, a middle-coating layer 38, and a top-coating layer 40. Here, the primer layer 34 may have a substrate enhance function, the undercoating layer 36 may have an unevenness adjustment function, the middle-coating layer 38 may have a durability function, and the top-coating layer 40 may have a release function.

[0076] FIG. 8 includes views illustrating aspects in which the present embodiment is applied to the common painted plywood for a formwork of FIG. 7. In the example illustrated in FIG. 8(1), the painted plywood for a formwork is constituted including a water-repellent coating layer 42 instead of the top-coating layer 40 in FIG. 7. Other layers (the formwork body 32, the primer layer 34, the undercoating layer 36, and the middle-coating layer 38) except the water-repellent coating layer 42 are the same as the painted plywood for a formwork 30 illustrated in FIG. 7. Here, the water-repellent coating layer 42 corresponds to the porous layer 18 of the formwork for concrete forming 10 according to the present embodiment, in which the porous layer is formed from the hydrophobic oxide fine particles. The primer layer 34, the undercoating layer 36, and the middle-coating layer 38 correspond to the basecoat layer 14 of the formwork for concrete forming 10 according to the present embodiment.

[0077] The production method of the formwork for concrete forming according to the present embodiment is a method for producing a formwork for concrete forming and includes the step of providing a porous layer formed from hydrophobic oxide fine particles over at least a part of the formwork surface. Consequently, when the painted plywood for a formwork illustrated in FIG. 8(1) is prepared,

that the water-repellent coating layer 42 is applied in addition to the primer layer 34, the undercoating layer 36, and the middle-coating layer 38 to the formwork body 32 by application and the like corresponds to the implementation of the present invention.

[0078] In the example of FIG. 8(2), the water-repellent coating layer 42 and a durability layer 44 having a durability function are included instead of the top-coating layer 40 and the middle-coating layer 38 in FIG. 7. Other layers (the formwork body 32, the primer layer 34, and the undercoating layer 36) except these layers are the same as the layers of the painted plywood for a formwork 30 illustrated in FIG. 7. As described above, the water-repellent coating layer 42 corresponds to the porous layer 18 that is formed from the hydrophobic oxide fine particles of the formwork for concrete forming 10 according to the present embodiment. The durability layer 44 corresponds to the filled particle containing layer 16 of the formwork for concrete forming 10 according to the present embodiment. The primer layer 34 and the undercoating layer 36 correspond to the basecoat layer 14 of the formwork for concrete forming 10 according to the present embodiment. Consequently, when the painted plywood for a formwork illustrated in FIG. 8(2) is prepared, that the durability layer 44 and the water-repellent coating layer 42 are applied in addition to the primer layer 34 and the undercoating layer 36 to the formwork body 32 by application and the like corresponds to the implementation of the present invention.

[0079] The application of the water-repellent coating layer 42 and other layers to the formwork body 32 and the like can be carried out not only in the production factory of the painted plywood for a formwork and the production

factory of precast concrete but also in the process before and after formwork assembly at the concrete casting field. As described above, the present invention can be applicable for the commercially available common painted plywood for a formwork and thus the same action and effect as those described above can be obtained.

[0080] [Verification of advantageous effects of second embodiment]

Subsequently, the experiment (Experiment Number 5) carried out in order to verify the advantageous effects of the second embodiment and verified results will be described. This experiment is carried out using the model formwork in FIG. 2 used in the verification experiment of the first embodiment.

[0081] The materials used for the concrete formed in Experiment Number 5 are the same as the materials listed in Table 1.

[0082] The formulation of the concrete used in Experiment Number 5 is listed in Table 4.

[0083]

Table 4

Experiment Number	Formulation	Nominal strength	Slump (cm)	Slump flow (cm)	Water/Cement ratio (%)	Unit amount (kg/m^3)						Added ratio of additives to cement (%)	
						Cement		Water	Fine aggregate		Coarse aggregate		
						N	M	W	S1	S2	G	AD1	AD2
5	Normal 30 8 20N	30	8	-	50.8	335	0	170	609	159	1033	0.8	0

[0084] In Table 5, each of test results of a slump (JIS A 1101: 2005), an air content (JIS A 1128: 2005), and a concrete temperature (JIS A 1156: 2006) of the concrete used in Experiment Number 5 are listed.

[0085]

Table 5

Experiment Number	Formulation	Slump (cm)	Air content (%)	Concreate temperature (°C)
5	Normal 30 8 20N	10.0	5.0	13

[0086] The material of the model formwork in Experiment Number 5, corresponding to the second embodiment of the present invention, is formed by laminating a laminated body of polyethylene terephthalate (PET) film (thickness 75 μm (FIG. 11(1)) or 50 μm (FIG. 11(2)), the filled particle containing layer, and the porous layer to the painted plywood (Imported Product B) using an epoxy-based adhesive. The porous layer of Experiment Number 5 was a layer formed by applying an ethanol dispersion in which hydrophobic silica particles having an average primary particle diameter of 7 nm were dispersed and thereafter heating and drying the applied dispersion at around 120°C. A three-dimensional network structure was observed as a result of the observation using FE-SEM. The filled particle containing layer is a layer formed by applying a lacquer (main component: blended resin of acrylic-based resin and vinyl chloride-vinyl acetate copolymer resin) in which acrylic-based resin beads (average particle diameter 20 μm) were dispersed and thereafter heating and drying the applied dispersion at around 120°C. As a blank of Experiment Number 5 (FIG. 11(3)), the painted plywood (Imported Product B) was used without modification.

[0087] FIG. 11 includes photographic views comparing generation states of air voids on the concrete surface of Experiment Number 5. (3) is Comparative Example and (1) and (2) correspond to the present invention. As illustrated in FIG. 11, it is found that every sample corresponding to the present invention barely generates air voids on the concrete surface compared with generation of the air voids of Comparative Examples.

[0088] (Third embodiment)

Subsequently, the third embodiment of the present invention will be described. In the following description, the detailed description of the overlapped description parts of the first embodiment will be omitted, and only the different parts will be described in detail.

[0089] FIG. 12 includes schematic sectional views illustrating a formwork for concrete forming of a third embodiment according to the present invention. As illustrated in this view, the formwork for concrete forming 100 according to the present embodiment is a formwork for forming a concrete 1 and includes the formwork body 12 and a water-repellent layer 50 provided on the formwork surface 20 of the formwork body 12. The water-repellent layer 50 is a layer having a water-repellent surface having a contact angle α to water of 130° or larger and more desirably a layer having a super-water-repellent surface having a contact angle α to water of 150° or larger.

[0090] Here, the water repellency means a property that represents the difficulty in wetting with water and, as illustrated in FIG. 13, the contact angle α of a waterdrop placed on a solid surface (in the present invention, the surface of the water-repellent layer 50) is an indicator of the water repellency. Generally a contact angle α of 90°

or larger is determined to be water-repellent, a contact angle α of 110° to 150° is determined to be high-water-repellent, and a contact angle α of 150° or larger is determined to be super-water-repellent. It is said that the highest limit of the contact angle α is 120° even when the surface free energy of a material is reduced. In order to achieve the contact angle α of larger than 120°, a special surface morphology is required to be processed.

[0091] According to the above constitution, the surface tension of the formwork surface 20 becomes significantly high by the water-repellent layer 50, whereby, as illustrated in FIG. 12(1), an air bubble 2 is easy to spread along the surface of the water-repellent layer 50 when the air bubble 2 entrained in concrete 1 at the time of placing is in contact with the surface. Consequently, the air bubble 2 on the surface of the concrete becomes thinner and flatter along the surface than the air bubble formed when a conventional formwork is used. As illustrated in FIG. 12(2), the air bubble 2 moves upwards by small vibration applied from the outside of the formwork body 12 and is easily removed from the concrete surface. According to the present invention, therefore, the air bubbles causing the air voids on the concrete surface can be more reliably decreased.

[0092] As illustrated in FIG. 14, the water-repellent layer 50, for example, can be constituted by the basecoat layer 14 provided on the formwork body 12, the filled particle containing layer 16 provided on the basecoat layer 14, and the super-water-repellent porous layer 18 provided on the filled particle containing layer 16. The porous layer 18, for example, is formed of the hydrophobic oxide fine particles and placed on the outermost surface of the

formwork surface 20 at the side in contact with concrete 1.

[0093] The basecoat layer 14 and the filled particle containing layer 16 may be included if necessary and a plurality of undercoat layers 14 may be used or any layers other than the basecoat layer 14 may be included.

[0094] According to the formwork for concrete forming 100 constituted as described above, the surface tension of the formwork surface 20 becomes significantly high by the water-repellent layer 50, whereby an air bubble is easy to spread along the surface of the water-repellent layer 50 when the air bubble entrained in concrete at the time of placing is in contact with the surface. Consequently, the air bubble 2 on the surface of the concrete becomes thinner and flatter along the surface than the air bubble formed when a conventional formwork is used. The air bubble moves upwards by small vibration externally applied and is easily removed from the concrete surface. According to the present invention, therefore, the advantageous effects of more reliable decrease in the air bubbles causing the air voids on the concrete surface is obtained. Consequently, the designability of the concrete surface can be improved. According to the formwork for concrete forming 100 of the present invention, the formwork enables the excellent release performance to be retained over a long period of time, does not require application of a release liquid to the formwork surface in each use as a conventional formwork, and is able to be used repeatedly after forming concrete (what is called diversion).

[0095] [Verification of advantageous effects of third embodiment]

Subsequently, the experiment carried out in order to verify the advantageous effects of the third embodiment and verified results will be described.

[0096] In this experiment, concrete is poured using formworks having different contact angles and the finish states of the concrete surfaces are observed and compared.

[0097] As the formwork having a water-repellent layer, a formwork formed by uniformly applying a filled particle containing layer on the substrate (formwork body) having a contact angle (contact angle to water, the following is the same) of about 80° and processing the surface so that the predetermined contact angles can be obtained by changing the concentration of the hydrophobic oxide fine particles that are applied onto the filled particle containing layer was used. For the formwork body being the substrate of the formwork, polyvinyl chloride plates and painted plywoods were used.

Experiment cases (Experiment Numbers 6 and 7) of the present experiments are listed in Table 6.

[0098]

Table 6

Experiment Number	Formulation of concrete	Substrate of formwork	Contact angle α
6	Normal 33 18 20N	Polyvinyl chloride plate	80° (no treatment), 120°, 130°, and 150°
7	Normal 30 18 20N	Painted plywood	80° (no treatment), 90°, 110°, 120°, 130°, 140°, 150°, and more than 150°

[0099] The materials used for concrete formed in the present experiments are the same as the materials listed in Table 1. Formulations of concretes used in the present experiments are listed in Table 7. In Table 8, each of test results of slumps (JIS A 1101: 2005), air contents (JIS A 1128: 2005), and concrete temperatures (JIS A 1156: 2006) are listed as the test results of the freshly mixed

concretes.

[0100]

Table 7

Experiment Number	Formu-lation	Nominal strength	Slump (cm)	Water/ Cement ratio (%)	Unit amount (kg/m^3)						Added ratio of additives to cement (%)	
					Cement		Water	Fine aggre-gate		Coarse aggre-gate		
					N	M	W	S1	S2	G	AD1	AD2
6	Normal 33 18 20N	33	18	50.8	335	0	170	506	338	964	0	1.0
7	Normal 30 18 20N	30	18	53.6	318	0	170	519	346	959	0	1.0

[0101]

Table 8

Experiment Number	Formulation	Slump (cm)	Air content (%)	Concreate temperature (°C)
6	Normal 33 18 20N	18.0	4.6	16
7	Normal 30 18 20N	20.0	5.9	14

[0102] <Case of polyvinyl chloride plates: Experiment Number 6>

FIG. 15 includes photographic views illustrating placing states of concrete when polyvinyl chloride plates are used as a formwork body. FIG. 15(1) illustrates the case of polyvinyl chloride plates to which no surface treatment is carried out (the contact angle of the surface is 80°) and FIGS. 15(2) to 15(4) illustrate the cases of polyvinyl chloride plates having water-repellent layers (the contact angles of the water-repellent layers are 120°, 130°, and 150°). FIGS. 15(3) and 15(4) correspond to the present invention. FIG. 16 includes photographic views illustrating concrete surfaces after the removal of the formwork of polyvinyl chloride plates and FIGS. 16(1) to 16(4) correspond to FIGS. 15(1) to 15(4), respectively.

[0103] As illustrated in FIG. 15, in the case of the polyvinyl chloride plates, concrete was not attached to the formwork by the advantageous effects of water-repellant property of the formwork surface at the time of placing when the contact angle was 130° or larger. As illustrated in FIG. 16, it was observed that the surface air bubbles changed into flat air bubbles along the surface of the formwork when the contact angle was 130°. When the contact angle was 150°, the surface air bubbles were barely

observed.

[0104] <Case of painted plywoods: Experiment Number 7>

FIGS. 17 and 18 illustrate concrete surfaces after the removal of the formwork when painted plywoods are used as a formwork body. FIG. 17(1) illustrates the case of the painted plywoods to which no surface treatment is carried out (the contact angle of the surface is 80°) and FIGS. 17(2) to 17(4) illustrate the cases of painted plywoods having water-repellent layers (the contact angles of the water-repellent layers are 90°, 110°, and 120°). FIGS. 18(1) to 18(4) illustrate the cases of painted plywoods having water-repellent layers (the contact angles of the water-repellent layers are 130°, 140°, 150° and larger than 150°). FIGS. 18(1) to 18(4) correspond to the present invention.

[0105] As illustrated in FIGS. 17 and 18, in the cases of the painted plywoods, although a clear result was not obtained when the contact angle was 130°, it was observed that the surface air bubbles changed into flat air bubbles along the surface of the formwork when the contact angle was 140°. When the contact angle was 150° or larger, the surface air bubbles were barely observed.

[0106] According to the above observation results, generation of the surface air bubbles can be decreased by applying water-repellant finishing of the formwork surface of the formwork body having a contact angle α to water of 130° or larger and more preferably 150° or larger, compared with generation of the surface air bubbles when the conventional formwork is used. According to the third embodiment of the present invention, therefore, the air bubbles causing the air voids on the concrete surface can be more reliably decreased.

[0107] Just for reference, the concrete surface after the removal of the formwork is illustrated in FIG. 19 in the case when the formwork prepared by applying FLUOROSURF (registered trademark) (manufactured by FluoroTechnology Co., LTD.), which is a super-water-repellent material, to painted plywoods with brush application is used. The concrete surface after the removal of the formwork is illustrated in FIG. 20 in the case when the formwork prepared by applying NeverWet (manufactured by NeverWet LLC.), which is a super-water-repellent spray, to polyvinyl chloride plates with spray application is used. Both FLUOROSURF (registered trademark) and NeverWet have the super-water-repellent function. As illustrated in FIG. 19 and FIG. 20, it was observed that, although a decrease effect in the surface air bubbles was recognized, FLUOROSURF or NeverWet was detached from the formwork during concrete placing and thus the effect appeared to be less effective. After the removal of the formworks, the water-repellent effect was observed to be disappeared and not to remain on the formwork surfaces.

[0108] [Method for producing formwork for concrete forming]

The production method of the formwork for concrete forming according to the third embodiment of the present invention is a method for producing a formwork for concrete forming and the method includes the step of providing a water-repellent layer having a contact angle to water of 130° or larger and more desirably 150° or larger on at least a part of a formwork surface. Consequently, when the formwork illustrated in FIG. 12(1) or FIG. 14 is prepared, that the water-repellent layer 50 is applied to the formwork body 12 by application and the like corresponds to the implementation of the present invention.

[0109] The application of the water-repellent layer 50 to the formwork body 12 can be carried out not only in the production factory of the formwork plates and the production factory of precast concrete but also in the process before and after formwork assembly at the concrete casting field. As described above, the present invention can be applicable for the commercially available common formwork plates and thus the same action and effect as those described above can be obtained.

[0110] As described above, the formwork for concrete forming according to the present invention is a formwork for forming a concrete and is provided with a water-repellent layer having a contact angle to water of 130° or larger on at least a part of the formwork surface. Consequently, the surface tension of the formwork significantly increases due to the water-repellent layer and thus, when air bubbles entrained in the concrete are in contact with the surface of the water-repellent layer at the time of placing, the air bubbles tend to spread along the surface. As a result, the air bubbles on the concrete surface become thinner and flatter than air bubbles formed when a conventional formwork is used. These air bubbles move upwards by small vibration and are easily removed from the concrete surface. According to the present invention, therefore, the air bubbles causing the air voids on the concrete surface can be more reliably decreased.

[0111] Another formwork for concrete forming according to the present invention is a formwork for forming a concrete and is provided with a porous layer formed from hydrophobic oxide fine particles over at least a part of the formwork surface. Consequently, the formwork enables the excellent release performance to be retained over a long period of time. As a result, opposite to conventional

formworks, the formwork does not require application of a release liquid to the formwork surface in each use and is able to be used repeatedly. Use of the formwork for concrete forming of the present invention forms a smooth concrete surface after forming and significantly decreases generation of pits such as air voids to improve the designability of the concrete surface.

Industrial Applicability

[0112] As described above, the formwork for concrete forming and the method for producing the same according to the present invention are useful for the formwork for forming a concrete used in construction and civil engineering fields, are particularly suitable to retain the release property to be able to be used repeatedly, and are suitable to improve the designability of the concrete surface after forming by reliably decreasing air bubbles that cause air voids on the concrete surface.

Reference Signs List

[0113] 10, 100 Formwork for Concrete Forming

12 Formwork Body

14 Basecoat Layer

16 Filled Particle Containing Layer

18 Porous Layer

20 Formwork Surface

22 Adhesion Layer

24 Resin Film

50 Water-repellent Layer

CLAIMS

1. A formwork for concrete forming, comprising:

a water-repellent layer having a contact angle to water of 130° or larger on at least a part of a formwork surface.

2. The formwork for concrete forming according to claim 1, wherein the water-repellent layer has a contact angle to water of 150° or larger.

3. The formwork for concrete forming according to claim 1 or 2, wherein the water-repellent layer comprises a porous layer, the porous layer comprising hydrophobic oxide fine particles.

4. A formwork for concrete forming, comprising:

a porous layer formed from hydrophobic oxide fine particles over at least a part of a formwork surface.

5. The formwork for concrete forming according to claim 3 or 4, wherein an average primary particle diameter of the hydrophobic oxide fine particles is 3 nm to 100 nm.

6. The formwork for concrete forming according to any one of claims 3 to 5, wherein the hydrophobic oxide fine particles comprises a hydrophobic silica.

7. The formwork for concrete forming according to claim 6, wherein the hydrophobic silica comprises trimethylsilyl groups on the surface thereof.

8. The formwork for concrete forming according to any one of claims 3 to 7, wherein the porous layer comprises a

three-dimensional network structure.

9. The formwork for concrete forming according to any one of claims 3 to 8, comprising a filled particle containing layer arranged between the formwork surface and the porous layer.

10. The formwork for concrete forming according to any one of claims 3 to 9, further comprising a basecoat layer arranged between the formwork surface and the porous layer.

11. A method for producing the formwork for concrete forming according to any one of claims 3 to 10, the method comprising:

providing a porous layer formed from hydrophobic oxide fine particles over at least a part of the formwork surface.

12. A method for producing the formwork for concrete forming according to any one of claims 1 to 3, the method comprising:

providing a water-repellent layer on at least a part of the formwork surface.

13. A concrete produced by using the formwork for concrete forming according to any one of claims 1 to 10.