<table>
<tr><td rowspan="2">Patent Right</td><td>Date</td><td>October 30, 2024</td><td rowspan="2">Court</td><td rowspan="2">Intellectual Property High Court, Second Division</td></tr>
<tr><td>Case number</td><td>2023 (Gyo-Ke) 10132</td></tr>
<tr><td colspan="5">- A case in which, with regard the decision made by the JPO on the opposition to the patent for an invention titled "Ground consolidation material and ground improvement method," the court rescinded the part of the decision that revoked the patent, on the grounds that there are errors in the JPO's determination regarding an inventive step in Corrected Inventions 1, 2, and 4 to 7 to which the patent pertains.</td></tr>
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Case type: Rescission of Patent Revocation Decision

Result: Granted

References: Article 29, paragraph (2) of the Patent Act

Related rights, etc.: Patent No. 6961270

Revocation Decision: Opposition No. 2022-700328

Summary of the Judgment

1. In this case, with regard to the decision made by the JPO (the "JPO Decision") on the opposition to the patent for an invention titled "Ground consolidation material and ground improvement method," for which the Plaintiff is the patentee, the Plaintiff seeks rescission of the part of the decision that revoked the patent pertaining to Claims 1, 2, and 4 to 7 of the Patent after the correction. The issue of the case is whether an inventive step is found in the patented invention.

2. In the JPO Decision, the JPO determined that all of Corrected Inventions 1, 2, and 4 to 7 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 5, 6, and 9 Documents.

3. In this judgment, the court stated that: it cannot be found that Corrected Invention 1 could have been easily made by a person ordinarily skilled in art based on the Cited Invention as well as Exhibit Ko 5, 6, and 9 Documents; and it should also be said that the other Corrected Inventions (Corrected Inventions 2 and 4 to 7), which cite the matters specifying Corrected Invention 1, could not have been easily made by a person ordinarily skilled in art at the time of the filing of the application for the Patent. In conclusion, the court determined that there are errors in the determination in the JPO Decision regarding an inventive step in the Corrected Inventions. The determination by the court regarding an inventive step in Corrected Invention 1 is as summarized below.

4. The difference between Corrected Invention 1 and the invention described in Exhibit

Ko 1 Document (the Cited Invention) is examined as follows. Exhibit Ko 1 Document describes the chemical liquid for injection into the ground for obtaining a consolidated body that has the same composition as the ground consolidation material based on Corrected Invention 1, but it does not describe any matters concerning the ground improvement method, such as the definition of the first gelation time, the explanation of the function and effect thereof, or the procedures and conditions for injection. Therefore, a question arises as to whether a person ordinarily skilled in the art, at the time of the filing of the application for the Patent, could have easily conceived of the injection conditions of said ground consolidation material having the configuration of Corrected Invention 1 in the ground improvement method using said ground consolidation material.

The ground consolidation materials used in the ground improvement method of Corrected Invention 1 and that of the Cited Invention are both a suspension (suspension-type grout) containing water glass and particulate slag as active ingredients. Its principle of consolidation is based on the hydraulic property of the slag in that "the alkaline component in the low-molar-ratio silica solution stimulates the latent hydraulic property of the particulate slag and solidifies, and the silica component in the low-molar-ratio silica solution reacts with the calcium component in the particulate slag and gelates, so that the silica gel connects the consolidated portions formed by the slag in the earth and sand to form a unified consolidated body." On the other hand, the ground consolidation materials described in Exhibit Ko 5, 6, and 9 Documents are "active hybrid silica colloid" (Exhibit Ko 5), "solution-type active silica grout" (Exhibit Ko 6), or "durable silica grout (Exhibit Ko 9) (solution-type grout), and their principle of consolidation is based on the pH of the ground in that: "As the injection liquid permeates between soil particles, the pH of its region of contact with the soil shifts toward neutral and gelation progresses" (Exhibit Ko 5) or "The injected acid liquid begins to consolidate when it reacts with the alkaline component in the soil and becomes almost neutral" (Exhibit Ko 6). Thus, the ground consolidation material of Corrected Invention 1 and that of the Cited Invention have different principles of consolidation.

With regard to the injection conditions in the ground improvement method, Exhibit Ko 5, 6, and 9 Documents explain the magma action method in which: as for the injection material (solution-type grout), since the injected acid liquid begins to consolidate when it reacts with the alkaline component in the soil and becomes almost neutral, the gel time of the solution is measured for the state in which it is injected into the ground; and if the injection time of the liquid is set to be longer than the soil gelation time (GTso), the subsequent injection liquid permeates and consolidates while overcoming the tip surface of the preceding injection liquid that is turning into a gel, or pushing the injection liquid that is turning into a gel toward the outer circumference. However, the magma action method describes the injection conditions only when an acid liquid reacts with the alkaline component in the soil and consolidates, and it cannot be said to be naturally applicable as the conditions for injection of the ground consolidation material of Corrected Invention 1 and the Cited Invention that consolidates due to the hydraulic property of the slag in the liquid. Since the principle of consolidation is different, it cannot be immediately said that these inventions can achieve the task of forming a large-diameter, high-strength consolidated body under the same injection conditions just because they are in the same technical field of ground improvement. There are no descriptions in Exhibit Ko 5, 6 and 9 Documents that suggest that the magma action method can be applied to a suspension-type grout, which has a different principle of consolidation. Therefore, it should be said that a person skilled in the art could not have easily conceived of the injection conditions according to the properties of the suspension-type grout of Corrected Invention 1 and the Cited Invention (first gelation, pseudoplasticity, and second gelation).

Judgment rendered on October 30, 2024
2023 (Gyo-Ke) 10132 Case seeking rescission of patent revocation decision
Date of conclusion of oral argument: August 21, 2024

# Judgment

Plaintiff: Kyokado Engineering Co., Ltd

Defendant: Commissioner of the Japan Patent Office

## Main text

1. With regard to the decision made by the Japan Patent Office (JPO) on October 3, 2023, for the case of Opposition No. 2022-700328, the part of the decision that revoked the patent pertaining to Claims 1, 2, and 4 to 7 of Patent No. 6961270, is hereby rescinded.
2. The Defendant shall bear the court costs.

## Facts and reasons

No. 1 Claim
Same as the main text
No. 2 Outline of the case
1. In this case, with regard to the decision made by the JPO on the opposition to the patent for which the Plaintiff is the patentee, the Plaintiff seeks rescission of the part of the decision that revoked the patent. The issue of the case is whether an inventive step is found in the patented invention.
2. Progress of procedures at the JPO, etc.
(1) The Plaintiff filed a patent application on October 19, 2020, for an invention titled "Ground consolidation material and ground improvement method," and obtained registration of the establishment of a patent (Patent No. 6961270; number of claims: 12; hereinafter the "Patent") on October 15, 2021. The gazette in which the Patent appeared (Exhibit Ko 10) was published on November 5, 2021.
(2) An opposition to the Patent (pertaining to Claims 1 to 7) was filed on April 20, 2022, and the JPO examined it as Opposition No. 2022-700328.
(3) As the Plaintiff received a notice of grounds for revocation (advance notice of decision; Exhibit Ko 14) on November 2, 2022, it filed a request for correction and other documents (Exhibits Ko 16-1 to 16-3) on January 26, 2023, seeking to correct the claims, etc. of the Patent (hereinafter the "Correction"; Claim 3 was deleted).

(4) On October 3, 2023, the JPO approved the Correction and made a decision on the opposition to revoke the patent pertaining to Claims 1, 2, and 4 to 7 of the Patent (hereinafter the "Decision"). A certified copy of the JPO Decision was served upon the Plaintiff on October 13, 2023.

(5) On November 9, 2023, the Plaintiff filed this action to seek rescission of the part of the JPO Decision that revoked the Patent.

3. Statements of the claims

The statements of Claims 1, 2, and 4 to 7 of the Patent after the Correction are as described in Attachment "Corrected Invention" (the inventions stated in the respective claims are referred to as "Corrected Invention 1" and the like according to their claim numbers, and are collectively referred to as the "Corrected Inventions").

4. Summary of the JPO Decision

With regard to the determination as indicated in the JPO Decision, the Plaintiff cites the part of the determination relating to an inventive step in each of the Corrected Inventions as the grounds for rescission in this lawsuit. The summary of the reasons for that part of the determination is as follows.

(1) It is found that the invention described in Attachment "Cited Invention" (hereinafter the "Cited Invention") is described in Exhibit Ko 1 Document, a publication distributed prior to the filing of the patent application for the Patent (primary cited document; Unexamined Patent Application Publication No. 1995-166163).

(2) Whether Corrected Invention 1 involves an inventive step

A. Common feature and differences between Corrected Invention 1 and the Cited Invention

(Common feature)

"A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2$/g to 20,000 $cm^2$/g, wherein:

said ground consolidation material is composed of:

1. water glass

1) molar ratio of water glass: 1.68 to 2.31

2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%

3) blending ratio of water glass (40 L- to 160 L)/400 L

2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material

1) particulate slag: Braine value 4,000 to 20,000 $cm^2$/g, average particle size of 2 μm

to 10 μm
2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which f the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material retains permeability and then exhibits pseudoplasticity, retains pseudoplasticity, and comes to rest, and then solidifies, and it solidifies after the injection is completed"

(Difference 1)

"In the case of Corrected Invention 1, the "first gelation" and the "second gelation" are defined as follows: 'said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies… wherein: 1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred; 2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1); 3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2).' On the other hand, in the case of the Cited Invention, the chemical liquid for injection into the ground reaches a state being equivalent to 'pseudoplastic' during the process until consolidation, but it is not specified as exhibiting the 'first gelation' and the 'second gelation.'"

(Difference 2)

"In the case of Corrected Invention 1, 'the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation.' On the other hand, the Cited Invention is not specified as performing the injection described above."

B. Whether a person ordinarily skilled in the art could have easily conceived of the differences

(A) Regarding Difference 1, the "first gelation" and "second gelation" defined in Corrected Invention 1 are the phenomena that also occur in the Cited Invention, to which the patentee has given specific names, and giving such names does not give rise to any specific technical meaning. Therefore, Difference 1 is not a substantial difference, or it is something that a person ordinarily skilled in the art could have achieved as appropriate.

(B) Regarding Difference 2, the relevant documents (Exhibit Ko 5 Document [YONEKURA Ryozo and SHIMADA Shunsuke, *Yakueki chūnyū no chōki taikyūsei to kōkyū gurauto honsetsu chūnyū kōhō no sekkei sekō–Kankyōhozengata ekijōka taisakukō to hinshitsu kanri–* (Long-term durability of chemical injection and design and construction by permanent grout injection method–Environmental preservation-type liquefaction countermeasure work and quality control–), published on October 31, 2016], Exhibit Ko 6 Document [Coastal Development Institute of Technology, *Engan Gijutsu (Coastal Technology) Library* No. 33, *Shintō koka shori kōhō gijutsu manuaru* (Permeable grouting method technical manual) (revised edition), published in October 2018], and Exhibit Ko 9 Document [Unexamined Patent Application Publication No. 2018-193550, published on December 6, 2018]) contain statements such as "magma action method" and "making the soil gelation time shorter than the injection time." Accordingly, a person ordinarily skilled in the art would attempt to adopt an injection method such as the magma action method also in the Cited Invention in order to reduce the inflow into regions other than the injection target or into water. Therefore, in order to realize the magma action method in the Cited Invention, a person ordinarily skilled in the art could have easily performed the injection of the ground consolidation material into the ground over a time longer than the "gel time" or "soil gelation time (GTso).

The "gel time" described in Exhibit Ko 6 Document and the "soil gelation time (GTso)" described in Exhibit Ko 9 Document are considered to be equivalent to the "time required to reach the first gelation" as defined in Corrected Invention 1 or the time corresponding to the state of being more hardened. Therefore, in the course of injection of the ground consolidation material of the Cited Invention into the ground, if the material is injected into the ground over a time longer than the soil gelation time (GTso), this will result in the structure of Corrected Invention 1 in which "a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation."

In addition, the "chemical liquid for injection into the ground" in the Cited Invention has a property in that "it is easy to adjust a relatively long gelation time, is excellent in permeability because of maintaining a low viscosity until reaching gelation, and is therefore particularly suitable for injection into a water-permeable ground such as sandy soil," and that this property has commonality with the "permeation and gelling properties" of "active hybrid silica" in Exhibit Ko 5 Document or the properties of "silica grout" that "permeates and consolidates" in Exhibit Ko 9 Document. Considering these, the effect of Corrected Invention 1 of "enabling a ground improvement method to achieve a large consolidation diameter while reducing the deviation to outside the injection area" is within the range of matters that could have been predicted from the Cited Invention as well as the matters described in Exhibit Ko 5 Document and Exhibit Ko 9 Document.

C. Accordingly, Corrected Invention 1 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 5, 6, and 9 Documents.

(3) Whether Corrected Invention 2 involves an inventive step

A. Common feature and differences between Corrected Invention 2 and the Cited Invention

(Common feature and Differences 1 and 2)

Same as the common feature and Differences 1 and 2 as mentioned in (2) A. above.

(Difference 3)

"Corrected Invention 2 is specified as follows: 'said ground consolidation material exhibits flow characteristics and solidification characteristics, which consist of the first gel time and the second gel time as described below'; and 'flow characteristics: 1) first gel time (GT1): 10 minutes or more (20°C) where the first gel time refers to the time after blending until reaching the abovementioned first gelation, which is the point in time when gel begins to adhere to the P-funnel by the P-funnel method (the time when fluidity starts to decrease); the time until the first gel time is defined as the permeability retention time (T1), and the viscosity is 10 seconds or less by the P-funnel method or 10 mPa-s or less by a viscometer; and 2) second gel time (GT2): 10 minutes or more

(20°C) where the first gel time refers to the time until when, after the first gel time, the material exhibits pseudoplasticity, and its viscosity becomes equal to or greater than the viscosity in the first gel time by P-funnel method or equal to or greater than the viscosity until the first gel time by a viscometer, and the material finally does not regain fluidity even when stirred; or in other words, the time required to reach the abovementioned second gelation after the abovementioned first gelation.' On the other hand, the Cited Invention is not specified as such."

B. Whether a person ordinarily skilled in the art could have easily conceived of the differences

As mentioned in (2) B. above, Differences 1 and 2 could have been easily achieved by a person ordinarily skilled in the art. Regarding Difference 3, the "first gel time" and the "second gel time" specified in Corrected Invention 2 are only specific names given by the patentee to the phenomena that also occur in the Cited Invention, and giving names as such does not give rise to any specific technical meaning. Therefore, Difference 3 is not a substantial difference, or it is something that a person ordinarily skilled in the art could have achieved as appropriate.

C. Accordingly, Corrected Invention 2 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 5, 6, and 9 Documents.

(4) Whether Corrected Invention 4 involves an inventive step

A. Common features and differences between Corrected Invention 4 and the Cited Invention

(Common feature and Differences 1 and 2)

Same as the common feature and Differences 1 and 2 as mentioned in (2) A. above.

(Difference 4)

"Corrected Invention 4 is specified as follows: 'Ground improvement method' which is characterized in that 'the injection of said ground consolidation material is performed by injecting the ground consolidation material with the first gel time shorter than the injection time of an injection volume per one stage in a predetermined injection region, through which the subsequent ground consolidation material repeatedly overcomes and flows outside the gelation region where the preceding ground consolidation material has become pseudoplastic, thereby expanding the permeated area, and thus expanding the consolidated region while reducing the deviation to the outside of the predetermined region'; 'wherein "one stage" is defined as the length of the injection target at the injection depth assigned to one inlet of the injection pipe, where the material is injected from an injection pipe installed in the ground.' On the other hand, the Cited Invention is not specified as performing the injection described above."

B. Whether a person ordinarily skilled in the art could have easily conceived of the differences

As mentioned in (2) B. above, Differences 1 and 2 could have been easily achieved by a person ordinarily skilled in the art. Regarding Difference 4, Corrected Invention 4 is interpreted as defining the "injection of the ground consolidation material" in the magma action method by limiting it to "one stage." As mentioned in (2) B. above, in the course of injection by the magma action method in the Cited Invention, a person ordinarily skilled in the art could have easily performed the injection of the "chemical liquid for injection into the ground" with the soil gelation time (GTso) shorter than the injection time of an injection volume per one stage, and thereby would have arrived at the structure based on Difference 4.

C. Accordingly, Corrected Invention 4 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 5, 6, and 9 Documents.

(5) Whether Corrected Invention 5 involves an inventive step

A. Common features and differences between Corrected Invention 5 and the Cited Invention

(Common feature and Differences 1 and 2)

Same as the common feature and Differences 1 and 2 as mentioned in (2) A. above.

(Difference 5)

"Corrected Invention 5 is specified as follows: 'when an injection volume per one stage is V, an injection time required for injecting V is T, and the first gel time of said ground consolidation material is GT1, the injection of said ground consolidation material is performed by continuously injecting the material in the first gel time shorter than T to inject the injection volume V per one stage, and the injection of said ground consolidation material is completed by injecting the injection volume V per one stage through repeating the process in which the subsequent ground consolidation material continuously repeats overcoming and permeating outside of the pseudoplasticity region created by the preceding ground consolidation material.' On the other hand, the Cited Invention is not specified as performing the injection described above."

B. Whether a person ordinarily skilled in the art could have easily conceived of the differences

As mentioned in (2) B. above, Differences 1 and 2 could have been easily achieved by a person ordinarily skilled in the art. Regarding Difference 5, Corrected Invention 5 is interpreted as limiting the "injection of the ground consolidation material into the ground" by the magma action method to the injection of the "injection volume per one stage defined as V" for the "time required for injecting V defined as T." As mentioned in (2) B. above, in the course of injection by the magma action method in the Cited Invention, a person ordinarily skilled in the art could have easily performed the injection of the injection volume V per one stage by using the "chemical liquid for injection into the ground" with the soil gelation time (GTso) shorter than the injection time, and this would lead to the structure based on Difference 5.

C. Accordingly, Corrected Invention 5 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 5, 6, and 9 Documents.

(6) Whether Corrected Invention 6 involves an inventive step

A. Common features and differences between Corrected Invention 6 and the Cited Invention

(Common feature and Differences 1 and 2)

Same as the common feature and Differences 1 and 2 as mentioned in (2) A. above.

(Difference 6)

"Corrected Invention 6 is specified as follows: 'said ground consolidation material is adjusted in terms of one or more of the gel time, permeability, strength or bleeding, depending on (1) the amount of water glass, (2) the molar ratio of water glass, (3) the blending ratio of slag, or (4) the specific surface area of slag.' On the other hand, the Cited Invention is not specified as such."

B. Whether a person ordinarily skilled in the art could have easily conceived of the differences

As mentioned in (2) B. above, Differences 1 and 2 could have been easily achieved by a person ordinarily skilled in the art. Regarding Difference 6, Exhibit Ko 1 Document (Table 5 under paragraph [0056], etc.) states that the gelation time and strength can be changed by changing the amount of water glass, the molar ratio of water glass, the blending ratio of slag, and the specific surface area of slag. Therefore, a person ordinarily skilled in the art could have easily adjusted the gelation time and strength based on these results.

C. Accordingly, Corrected Invention 6 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 1, 5, 6, and 9 Documents.

(7) Whether Corrected Invention 7 involves an inventive step

A. Common features and differences between Corrected Invention 7 and the Cited Invention

(Common feature and Differences 1 and 2)

Same as the common feature and Differences 1 and 2 as mentioned in (2) A. above.

(Difference 7)

"Corrected Invention 7 is specified as follows: 'said ground consolidation material is adjusted in terms of gelation and strength by adding one or more of cement, gypsum, slaked lime, pozzolan, clay, acid, alkali, or salt.' On the other hand, the Cited Invention is not specified as such."

B. Whether a person ordinarily skilled in the art could have easily conceived of the differences

As mentioned in (2) B. above, Differences 1 and 2 could have been easily achieved by a person ordinarily skilled in the art. Regarding Difference 7, Exhibit Ko 1 Document (paragraph [0081]) states that "the gelation time, permeability, and consolidation strength can be adjusted so as to be best suited to the injection target ground by using the abovementioned water glass and slag-based material and adding to and mixing with it cement, lime… or calcium elution adjusting agent." Therefore, Difference 7 could have been easily achieved by a person ordinarily skilled in the art.

C. Accordingly, Corrected Invention 7 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 1, 5, 6, and 9 Documents.

No. 4 Decision of the court

1. The court finds that there are errors in the determination in the JPO Decision in which the JPO denied an inventive step in each of the Corrected Inventions. It cannot be found that Corrected Invention 1 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as Exhibit Ko 5, 6, and 9 Documents, nor can it be found as such for the other Corrected Inventions which cite the matters specifying Corrected Invention 1. As the grounds for rescission of the JPO Decision as argued by the Plaintiff are well-founded, it is appropriate to rescind the JPO Decision.

The reasons for this conclusion are as follows.

2. Concerning the Corrected Inventions

According to the statements in the detailed explanation of the invention, etc. in the description of the Patent (after the Correction) (Patent No. 6961270; Exhibit Ko 10), the outline, etc. of the Corrected Inventions is as follows.

(1) Each of the Corrected Inventions relates to a ground consolidation material and ground improvement method designed to form a large-diameter, high-strength consolidated body by injecting a suspension containing water glass and particulate slag

as active ingredients into the ground ([0001]; unless otherwise specified, the numbers in square brackets [ ] indicate the paragraph numbers in the description of the Patent).

(2) Conventionally, a high-pressure injection method has been used to form a high-strength consolidated body in the ground by high-pressure injection of a cement-based injection liquid. As this method had a problem of producing a large amount of waste soil, a technology was desired to form a consolidated body by injecting a solidification material into spaces between large soil particles while maintaining the existing soil as it is ([0002][0003]). There was also a conventional ground improvement method by which particulate cement or slag-based cement is injected into the ground to obtain high strength, but it was difficult to form a large, unified, consolidated body ([0004]). Even by applying technologies such as a suspension-type grout in which water glass and cement are mixed or a grout in which slaked lime and slag are mixed with water glass, it was impossible to simultaneously satisfy the conditions of low viscosity, long gelation time, and high strength ([0005] to [0009]).

It was difficult to form a consolidated body with a large consolidation diameter by injecting a conventional suspension-type grout into the soil due to the following characteristics: [i] it is difficult to simultaneously obtain low viscosity and high strength in a long gel time; [ii] since large bleeding occurs and the blended solution and the suspension are separated in the ground, the consolidated components of the suspension are not connected to each other, making it difficult to obtain a unified consolidated body; [iii] even when the suspension is divided into fine particles, the particles reassemble electrically, causing clogging and failing to consolidate a wide area; and [iv] it is difficult to obtain permeation and consolidation properties sufficient to form a large-diameter consolidated body by injecting a large injection volume per one stage at a low pressure with a large injection hole interval ([0019]).

(3) The Corrected Inventions are intended to solve the abovementioned problems, and their purpose is to provide a ground consolidation material and a ground improvement method capable of forming a large-diameter high-strength consolidated body by injecting a suspension containing water glass and particulate slag as active ingredients into the ground ([0020]).

Said ground consolidation material is a ground consolidation material used to consolidate the ground by injecting into the ground a suspension containing water glass with a molar ratio in the range of 1.5 to 2.8 and particulate slag with a specific surface area of 4,000 $cm^2/g$ to 20,000 $cm^2/g$ as active ingredients, which is characterized in that the fluidity of said suspension consists of: (1) a process in which the suspension retains permeability, (2) a process in which permeability then rapidly decreases and the suspension reaches a pseudoplastic state, (3) a process in which the suspension retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the suspension reaches a consolidated state ([0021]). In addition, the suspension injected into the ground can expand the consolidated region through a repeated process in which the preceding suspension that retains permeability gelates, its fluidity decreases, and it forms a pseudoplastic zone, and then the subsequent suspension that retains permeability overcomes said pseudoplastic zone to expand the permeated area, and then forms a pseudoplastic zone ([0027]). Said ground improvement method is characterized in that a suspension as a ground consolidation material as described above is injected into the ground to consolidate the ground. The fluidity of said suspension is expressed in that the suspension undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it solidifies after undergoing the first gelation and retaining pseudoplasticity, and the injection of said suspension into the ground can be performed over a time longer than the time required to reach said first gelation ([0031][0033]).

The Corrected Inventions have been made to invent a suspension-type grout with the first gel time and second gel time using low-molar-ratio water glass and particulate slag, and the use of its characteristics for injection into the ground has made it possible to provide a ground improvement method that achieves a large consolidation diameter while reducing the deviation to outside the injection area. In addition, since the grout causes less bleeding and the silica solution in the supernatant liquid gelates, the consolidated components of the particulate slag are connected to each other, enabling ground improvement with a unified consolidated body ([0042][0043]). The strength of the suspension according to the Corrected Inventions is uniquely determined by the content of slag ([0044]).

(4) When the suspension-type grout according to the Corrected Inventions is used, the alkaline component in the low-molar-ratio silica solution stimulates the latent hydraulic property of the particulate slag and solidifies, and the silica component in the low-molar-ratio silica solution reacts with the calcium component in the particulate slag and gelates, so that the silica gel connects the consolidated portions formed by the slag in the earth and sand to form a unified consolidated body. In addition, since this suspension does not rely solely on the particle size of the slag, and the silica solution also contributes to the consolidation of the ground, there is no need to make the cement and slag microparticulate to the extent that they reaggregate electrically. Furthermore, the suspension is superior in permeability compared to particulate cement-based liquid because the slag permeates together with the silica solution due to the gelation function

showing a longer gelation time and the lubricity between soil particles caused by the silica solution ([0048] - [0050]).

In the Corrected Inventions, it has been found that: the abovementioned suspension-type grout retains permeability with an almost constant viscosity for a sufficiently long time, then it exhibits pseudoplasticity due to the rapid increase in viscosity and the decrease in permeability; and, following this first gel time and exhibiting flow characteristics while retaining pseudoplasticity, said suspension-type grout shows the second gel time when it reaches a solidified state in which it does not flow again even when stirred. This suspension has a characteristic in that it flows when force is applied to it (when it is stirred) during the sufficiently long time after exhibiting pseudoplasticity. Accordingly, it has been found that when this suspension is injected into the ground, the subsequent permeable suspension overcomes the pseudoplastic zone formed by the preceding suspension during the pseudoplasticity retention time and permeates to the outside of the zone, and by repeating this process, a large-diameter consolidated body is formed. The Corrected Inventions have been thus completed ([0057][0058]).

(Table 5)

Examples of water glass used (physical property value of water glass made by adjusting JIS-compliant water glass with NaOH and diluting it with water)

| | Type (i) adjusted | Type (i) adjusted | Type (ii) adjusted | Type (iii) adjusted |
|---|---|---|---|---|
| Name of water glass used | Water Glass A | Water Glass B | Water Glass C | Water Glass D |
| Specific gravity | 1.352 | 1.343 | 1.452 | 1.399 |
| Silicon dioxide | 21.64% | 21.64% | 28.10% | 28.93% |
| Sodium oxide | 10.73% | 11.06% | 11.75% | 9.34% |
| Molar ratio | 2.08 | 2.02 | 2.47 | 3.20 |

(5) In the experiment performed as embodiment of the Corrected Inventions, the materials used were water glass A (molar ratio 2.08), water glass B (molar ratio 2.02), water glass C (molar ratio 2.47) and water glass D (molar ratio 3.20) (Table 5) prepared using the JIS standard water glass as a base, as well as those prepared by adding NaOH to adjust molar ratio, and they are blended with slag (water-granulated slag, composition $SiO_2$: 33.02%, CaO: 41.94%, $Al_2O_3$: 12.83%, MgO: 8.61%, and $Fe_2O_3$:

0.37%) in varying amounts (Table 9). ([0081] to [0085], [0094], [0095]).

(Table 9)

## Composition of suspension (per 400 L)

| Composition No. | Molar ratio | Water Glass A | Slag Kg | Water L | $SiO_2$ (%) |
|---|---|---|---|---|---|
| 1 | 2.08 | 100 | 50 | Remainder | 7.3 |
| 2 | 2.06 | | | | |
| 3 | 2.02 | | | | |
| 4 | 1.96 | | | | |
| 5 | 2.08 | | 75 | | |
| 6 | 2.06 | | | | |
| 7 | 2.02 | | | | |
| 8 | 1.96 | | | | |
| 9 | 1.86 | | | | |
| 10 | 1.77 | | | | |
| 11 | 1.68 | | | | |
| 12 | 2.08 | | 100 | | |
| 13 | 2.06 | | | | |
| 14 | 2.02 | | | | |
| 15 | 1.96 | | | | |
| 16 | 2.08 | | 150 | | |
| 17 | 2.06 | | | | |
| 18 | 2.02 | | | | |
| 19 | 1.96 | | | | |

| Composition No. | Molar ratio | Water Glass C | Slag Kg | Water L | $SiO_2$ (%) |
|---|---|---|---|---|---|
| 42 | 2.47 | 100 | 75 | Remainder | 7.3 |
| 43 | 2.43 | | | | |
| 44 | 2.31 | | | | |
| 45 | 2.47 | | 100 | | |
| 46 | 2.43 | | | | |
| 47 | 2.31 | | | | |

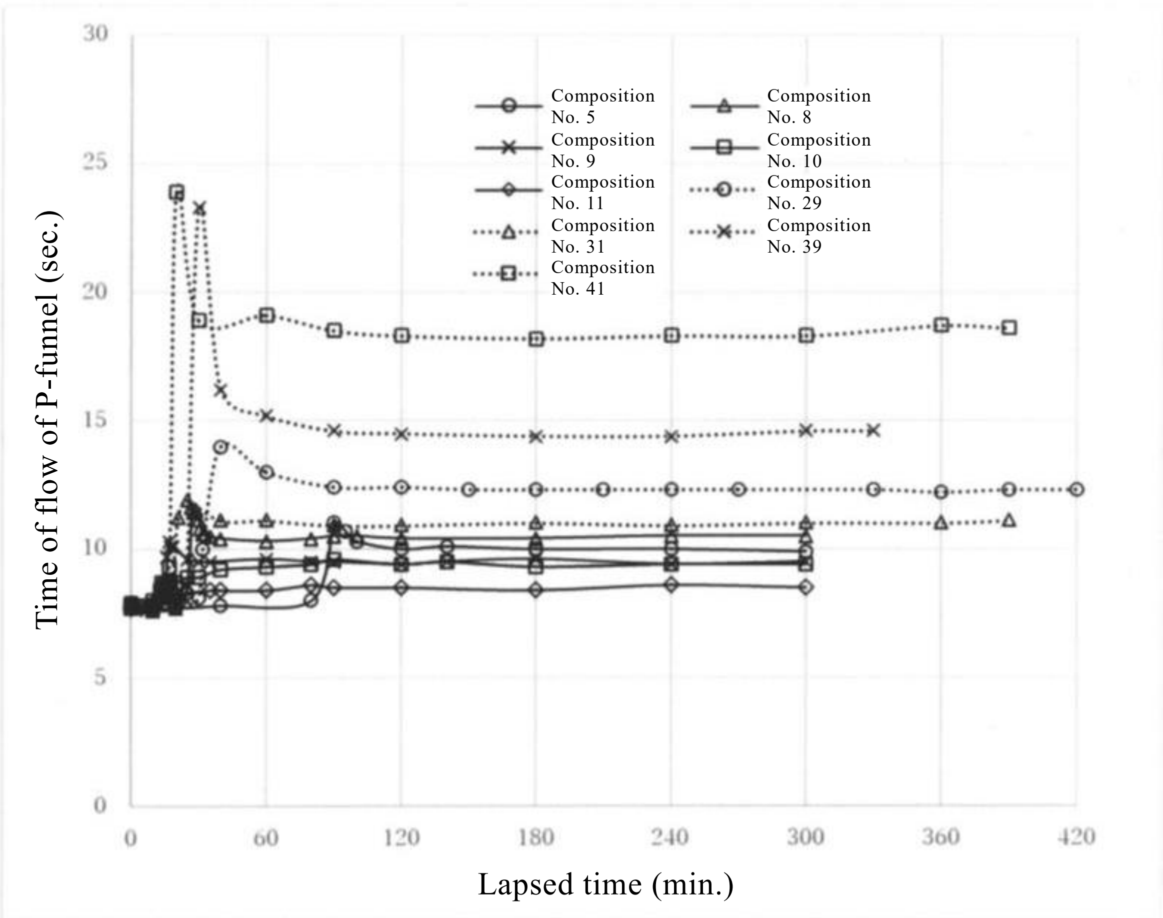
| Composition No. | Molar ratio | Water Glass B | Slag Kg | Water L | $SiO_2$ (%) |
|---|---|---|---|---|---|
| 20 | 2.02 | 100 | 50 | Remainder | 7.3 |
| 21 | 2.00 | | | | |
| 22 | 1.96 | | | | |
| 23 | 1.91 | | | | |
| 24 | 2.02 | | 75 | | |
| 25 | 2.00 | | | | |
| 26 | 1.96 | | | | |
| 27 | 1.91 | | | | |
| 28 | 2.02 | | 100 | | |
| 29 | 2.00 | | | | |
| 30 | 1.96 | | | | |
| 31 | 1.91 | | | | |
| 32 | 2.02 | 40 | | | 2.9 |
| 33 | 2.00 | | | | |
| 34 | 1.96 | | | | |
| 35 | 2.02 | 160 | | | 11.7 |
| 36 | 2.00 | | | | |
| 37 | 1.96 | | | | |
| 38 | 2.02 | 100 | 150 | | 7.3 |
| 39 | 2.00 | | | | |
| 40 | 1.96 | | | | |
| 41 | 1.91 | | | | |

| Composition No. | Molar ratio | Water Glass D | Slag Kg | Water L | $SiO_2$ (%) |
|---|---|---|---|---|---|
| 48 | 3.20 | 100 | 75 | Remainder | 7.3 |
| 49 | 3.14 | | | | |
| 50 | 2.93 | | | | |
| 51 | 3.20 | | 100 | | |

In testing the gel time of the blended solution, the gel time by the P-funnel method was defined as the time when the viscosity of the blended solution began to change rapidly, i.e., when a gel began to adhere to the container wall opening of the P-funnel, and the time until this point after blending was defined as the first gel time. The suspension was then slowly stirred in a poly jug and poured into the P-funnel, while keeping it in a fluid state, and the time of flow was measured repeatedly ([0090] [0096]).

According to the test results, after blending, the time of flow along with the lapse of time showed an almost constant value, but at a certain point, the slag began to aggregate and the time of flow suddenly became longer, at which point the suspension began to adhere to the funnel wall (first gel time). After reaching the peak, the time of flow became shorter, gradually became longer over time, or showed an almost constant value. After reaching the peak, the time of flow became shorter, but not shorter than before it reached the peak (Figure 4) (paragraphs [0097] and [0098]).

(Figure 4)



(Table 10)

Relationship between the molar ratio and each physical property (the specimen stirred in the first gelation)

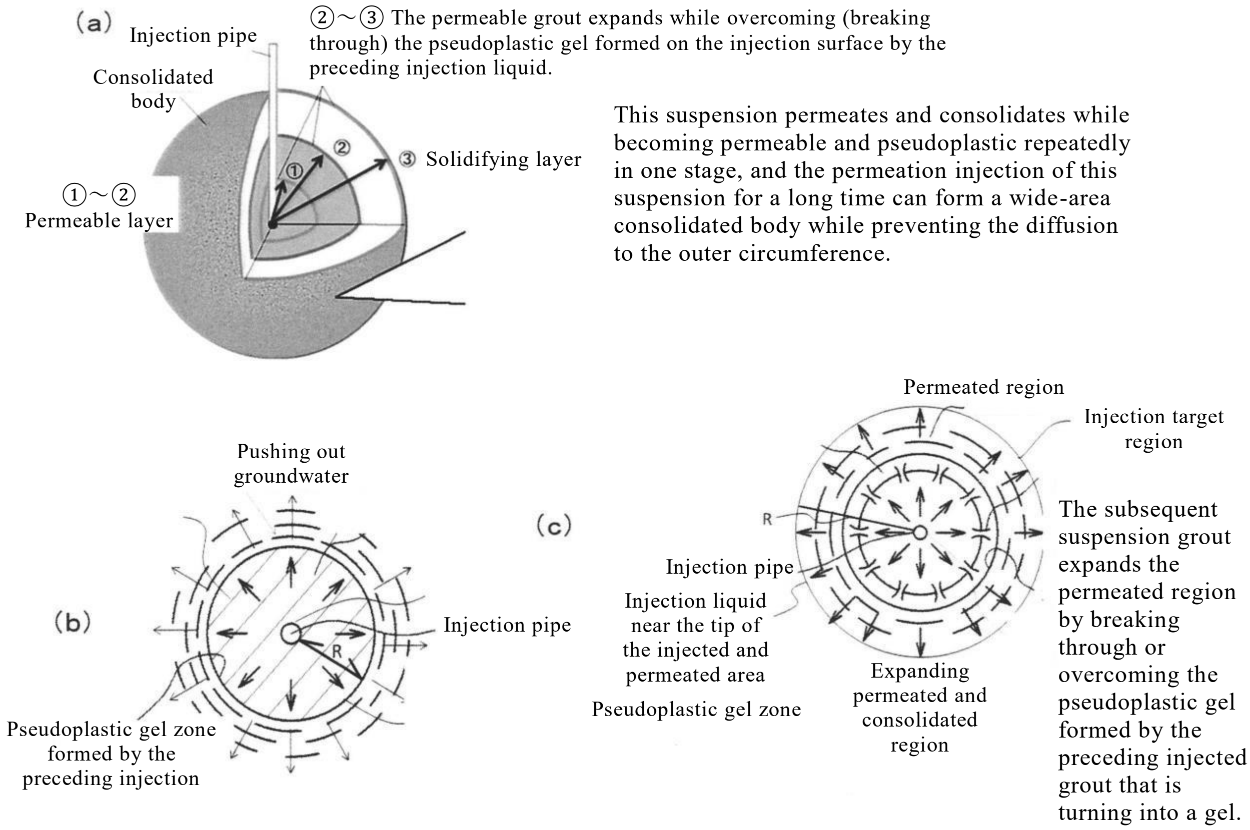
| Composition No. | Amount of Water Glass A L | Amount of slag kg | Molar ratio | First gel time (min.) | Bleeding rate (%, one day) | Homogel strength (MN/m²) |
|---|---|---|---|---|---|---|
| 5 | 100 | 75 | 2.08 | 59 | 0.2 | 1.08 |
| 8 | | | 1.96 | 23 | 1.5 | 0.21 |
| 9 | | | 1.86 | 16 | 2.1 | 0.31 |
| 10 | | | 1.77 | 13 | 3.1 | 0.32 |
| 11 | | | 1.68 | 13 | 7.1 | 0.49 |
| Composition No. | Amount of Water Glass B L | Amount of slag kg | Molar ratio | First gel time (min.) | Bleeding rate (%, one day) | Homogel strength (MN/m²) |
| 20 | 100 | 50 | 2.02 | 45 | 1.0 | 0.40 |
| 21 | | | 2.00 | 30 | 1.0 | 0.49 |
| 22 | | | 1.96 | 30 | 0.9 | 0.64 |
| 23 | | | 1.91 | 22 | 0.9 | 0.39 |
| 24 | | 75 | 2.02 | 36 | - | - |
| 25 | | | 2.00 | 38 | 0.7 | 0.92 |
| 26 | | | 1.96 | 31 | 1.4 | 0.42 |
| 27 | | | 1.91 | 20 | - | - |
| 28 | | 100 | 2.02 | 43 | 0.6 | 4.63 |
| 29 | | | 2.00 | 36 | 0.2 | 4.45 |
| 30 | | | 1.96 | 27 | 0.6 | 4.44 |
| 31 | | | 1.91 | 17 | 0.4 | 4.35 |
| 32 | 40 | | 2.02 | 300 or more | 43.9 | - |
| 33 | | | 1.96 | 300 or more | 40.8 | - |
| 34 | | | 1.88 | 130 | 4.1 | 2.54 |
| 35 | 160 | | 2.02 | 23 | 0.5 | 5.50 |
| 36 | | | 2.00 | 21 | 0.5 | 6.53 |
| 37 | | | 1.98 | 19 | 0.6 | 6.15 |
| 38 | 100 | 150 | 2.02 | 86 | 0.0 | 5.05 |
| 39 | | | 2.00 | 36 | 0.0 | 5.25 |
| 40 | | | 1.96 | 29 | 0.0 | 4.45 |
| 41 | | | 1.91 | 23 | 0.5 | 5.56 |
| Composition No. | Amount of Water Glass C L | Amount of slag kg | Molar ratio | First gel time (min.) | Bleeding rate (%, one day) | Homogel strength (MN/m²) |
| 42 | 100 | 75 | 2.47 | 230 | 38.2 | - |
| 43 | | | 2.43 | 200 | 38.5 | - |
| 44 | | | 2.31 | 200 | 34.8 | - |
| 45 | | 100 | 2.47 | 120 | 34.1 | 3.88 |
| 46 | | | 2.43 | 160 | 20.4 | 4.02 |
| 47 | | | 2.31 | 180 | 14.1 | 3.78 |
| Composition No. | Amount of Water Glass D L | Amount of slag kg | Molar ratio | First gel time (min.) | Bleeding rate (%, one day) | Homogel strength (MN/m²) |
| 48 | 100 | 75 | 3.20 | 300 or more | - | - |
| 49 | | | 3.14 | 300 or more | 62.2 | - |
| 50 | | | 2.93 | 300 or more | 58.2 | - |
| 51 | | 100 | 3.20 | 220 | 40.2 | 0.01 |
| 52 | | 150 | 2.93 | 58 | 3.1 | |
| 53 | | | 2.81 | 50 | 3.3 | |
| 53 | | | 2.70 | 57 | 3.5 | |

Note) Homogel strength: material age 28 days

From the above test, it was found that said suspension has a property in which its viscosity increases rapidly at a certain point and it becomes pseudoplastic, and then it solidifies. After the first gelation, the suspension was stirred continuously and its viscosity was measured. The viscosity gradually decreased, and after one hour following the first gelation, the time of flow remained almost the same. In Composition No. 29, regelation (a phenomenon in which re-peaking occurs) was not observed even after the suspension was stirred continuously for a maximum of seven hours, but after being left to rest, the suspension solidified and was no longer able to be stirred (second gel time). In other compositions, since the viscosity showed a constant value after about 300 minutes, stirring was stopped, and then it was confirmed that the suspension solidified. The first gel time remained almost the same even when the blending ratio of slag and the molar ratio were changed. However, when the amount of water-glass was reduced as in Compositions No. 32 to 34, the first gel time increased rapidly and the amount of bleeding also increased. (Table 10) ([0099] to [0102]).

The unique characteristic of the fluidity of the suspension based on the Corrected Inventions is as follows. The suspension maintains permeation fluidity (the P-funnel flow time is short) by stirring, and then its fluidity rapidly begins to become low (the P-funnel flow time is long). The time when it exhibits pseudoplasticity is defined as the first gel time. After the peak, the fluidity decreases, and the suspension maintains pseudoplastic flow. Thereafter, when the stirring is stopped, the suspension reaches a point at which it lost fluidity even if force is applied to it (even if it is stirred) (the second gel time). If the suspension is injected during the first gel time, sufficient permeability can be obtained, less bleeding is caused after injection, and a predetermined strength can be obtained. Furthermore, even after the preceding injection liquid reaches the first gel time, the subsequent permeable injection liquid repeatedly overcomes and permeates the pseudoplastic region formed during the first gel time and reaches a pseudoplastic state. After a predetermined volume is injected, the whole substance solidifies over time. Even in the pseudoplastic region, sufficient strength similar to that in the permeated region of the first gel time is maintained (Fig. 10) ([0118] to [0120]).

(Figure 10)




3. Concerning Ground for Rescission 1 (an error in the determination on an inventive step in Corrected Invention 1 based on the Cited Invention)

(1) Corrected Invention 1

As mentioned in No. 2. 3. above, Corrected Invention 1 is an invention described in Claim 1 of the Patent.

(2) Matters stated in Exhibit Ko 1 Document

A. Exhibit Ko 1 Document is a publication of the patent application for an invention titled "Chemical liquid for injection into the ground" published on June 27, 1995 (Unexamined Patent Application Publication No. 1995-166163). Exhibit Ko 1 Document contains the following statements.

B. The present invention relates to a chemical liquid for injection into the ground, which is intended to obtain a high-strength consolidated body, for which it is easy to adjust a gelation time over a wide range, in particular, a relatively long gelation time, and which is excellent in permeability because of maintaining a low viscosity until reaching gelation, and is therefore particularly suitable for injection into a water-permeable ground such as sandy soil (paragraph [0001] in Exhibit Ko 1 Document; hereinafter the paragraphs in Exhibit Ko 1 Document are described as "Exhibit Ko 1 [ ]").

In the examples of the invention, the following materials are used. As water glass, five types of water glass having different molar ratios as indicated in Table 1 were used. According to Table 1, Water Glass No. 3 contains $SiO_2$ at 27.36% and $Na_2O$ at 14.05%, and its molar ratio is 2.01. As slag, four types of water-granulated slag having different specific surface areas and average particle sizes as indicated in Table 2 were used, with a composition of $SiO_2$ at 33.02%, CaO at 41.94%, $Al_2O_3$ at 12.83%, MgO at 8.61%, and $Fe_2O_3$ at 0.37%. According to Table 2, Slag No. 4 has a specific surface area of 10,200 $cm^2/g$ and an average particle size of 6.0 μm (Exhibit Ko 1 [0045] to [0049]).

(Table 1)

| Water Glass No. | $SiO_2$ (%) | $Na_2O$ (%) | Molar ratio |
|---|---|---|---|
| 1 | 28.75 | 10.03 | 2.96 |
| 2 | 28.05 | 10.05 | 2.76 |
| 3 | 27.36 | 14.05 | 2.01 |
| 4 | 25.17 | 17.11 | 1.54 |
| 5 | 24.94 | 18.86 | 1.37 |

(Table 2)

| Slag No. | Specific surface area ($cm^2/g$) | Average particle size (μm) |
|---|---|---|
| 1 | 4,200 | 13.0 |
| 2 | 5,300 | 9.7 |
| 3 | 8,300 | 8.0 |
| 4 | 10,200 | 6.0 |

Regarding water glass and slag-type solution, the composition, gelation time, viscosity and unconfined compressive strength of the type composed of the water glass indicated in Table 1 and the slag indicated in Table 2 were examined. In the case of the injection liquid indicated as Example No. 12 in Table 5, which is blended so that it contains 292 g of Water Glass No. 3 in Table 1, 125 g of Slag No. 4 in Table 2, and 583 g of water out of the total amount of 1,000 g, and $SiO_2$ in water glass is 8%, the gel time at 20°C is 22 minutes, the viscosity after 2 minutes is 6.3 CPS, the viscosity after 20 minutes is 35 CPS, and then it solidifies, and its unconfined compressive strength becomes 15.5 $kgf/cm^2$ after 7 days and 30.0 $kgf/cm^2$ after 49 days. The test results indicated in Table 5 show that the examples in which the used water glass has a molar ratio of about 1.5 to 2.8, the used slag has an average particle size of 10 μm or less, and a specific surface area of 5,000 $cm^2/g$ or more, or in particular, 8,000 $cm^2/g$ or more, exhibit extremely remarkable effects (Exhibit Ko 1 [0055] to [0059]).

Furthermore, according to the results of the permeation test of the chemical liquid of the Cited Invention using the injection apparatus, it can be seen that the injection liquid in which Water Glass No. 3 (molar ratio 2.01) in Table 1 and Slag No. 4 in Table 2 are blended is most excellent in terms of permeability and consolidation strength. The results of this test also indicate that when the water glass with a molar ratio of 2.8 or more is used, permeation is insufficient due to the separation of the slag. In addition, when the water glass with a molar ratio of 1.5 or less is used, consolidation at the top of the consolidated body is insufficient due to high viscosity. However, excellent permeation results were obtained in all cases within the scope of the invention described in Exhibit Ko 1 Document (Exhibit Ko 1 [0070] to [0078]).

Therefore, according to the technical matters that can be understood from the statements in Exhibit Ko 1 Document, the following effects can be found. 1. In a chemical liquid for injection into the ground composed of water glass and slag, by using the water glass with a molar ratio in the range of about 1.5 to 2.8 and the particulate slag with an average particle size of about 10 μm or less and a specific surface area of about 5,000 $cm^2/g$ or more, or preferably about 8,000 $cm^2/g$ or more, it is possible to obtain a consolidated body that becomes consolidated with certainty by taking a relatively long gel time while maintaining low viscosity and maintains high strength for a long time (Exhibit Ko 1 [0084]). 2. If a water glass and slag-type solution mentioned in 1. above is used as a base, and cement and lime, especially, cement and lime with an average particle size of about 10 μm or less and a specific surface area of about 5,000 $cm^2/g$ or more, or preferably about 8,000 $cm^2/g$ or more, are added, the viscosity slightly increases due to blended lime, but the gelation time can be adjusted to be accelerated, which makes it possible to increase strength (Exhibit Ko 1 [0085]). 3. By using a water glass and slag-type solution mentioned in 1. above as a base and adding a calcium elution adjusting agent, the strength slightly decreases but the viscosity decreases and the gelation time can be adjusted to be delayed, which makes it possible to improve permeability (Exhibit Ko 1 [0086]).

C. Cited Invention

In addition to the above, in light of the content of the examples described in Exhibit Ko 1 Document, it is found that the Cited Invention as described in Attachment "Cited Invention" is described in Exhibit Ko 1 Document, as mentioned in No. 2. 4. (1) above.

(3) Comparison between Corrected Invention 1 and the Cited Invention

A. When Corrected Invention 1 is compared with the Cited Invention, their common feature and difference are as follows.

(Common feature) As described in No. 2. 4. (2) above, that is:

A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, wherein:

said ground consolidation material is composed of:

1. water glass

1) molar ratio of water glass: 1.68 to 2.31

2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%

3) blending ratio of water glass (40 L to 160 L)/400 L

2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material

1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 μm to 10 μm

2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material retains permeability and then exhibits pseudoplasticity, retains pseudoplasticity, and comes to rest, and then solidifies, and it solidifies after the injection is completed.

(Difference: Underlined by the court)

Corrected Invention 1 is specified as follows: a ground improvement method wherein: "said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies"; "the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed"; "wherein: 1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred; 2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1); 3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2)." On the other hand, the Cited Invention is not specified as a ground improvement method in terms of the injection conditions such as those underlined above in the case where the injection liquid retains permeability and then exhibits pseudoplasticity, comes to rest, and then solidifies.

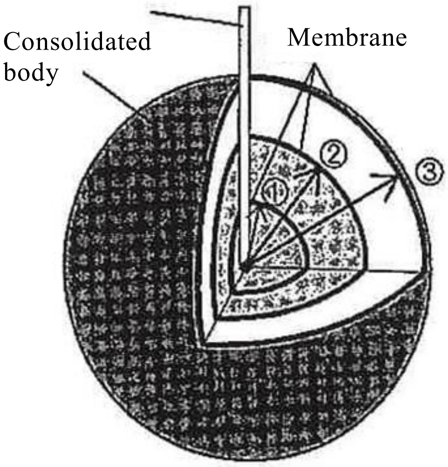
B. As mentioned in No.3. 1. above (Defendant's Arguments), the Defendant asserts Differences 1 and 2 as the differences between Corrected Invention 1 and the Cited Invention in the same manner as determined in the JPO Decision. However, since Differences 1 and 2 are understood collectively as constituting the Plaintiff's ground improvement method combined with the related injection conditions, it is appropriate to find the difference between these inventions to be as described in A. above. Therefore, the Defendant's argument cannot be accepted.

(4) Determination on the differences

A. Matters stated in the relevant documents

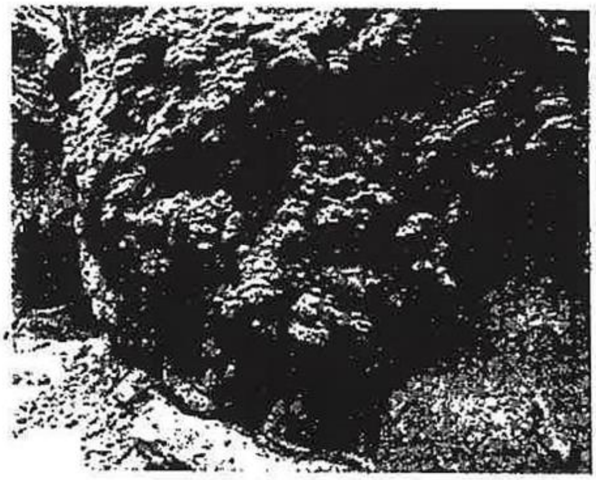
(A) Exhibit Ko 5 Document (YONEKURA Ryozo and SHIMADA Shunsuke, *Yakueki chūnyū no chōki taikyūsei to kōkyū gurauto honsetsu chūnyū kōhō no sekkei sekō– Kankyōhozengata ekijōka taisakukō to hinshitsu kanri–* (Long-term durability of chemical injection and design and construction by permanent grout injection method– Environmental preservation-type liquefaction countermeasure work and quality control–) , published on October 31, 2016) contains the following statements: "As the injection liquid permeates between soil particles, the pH of its region of contact with the soil shifts toward neutral and gelation progresses (omitted), and the injection material expands the consolidated region while overcoming it (magma action method) (Figure 6.1.5, Photo 6.1.1…). As a result, groundwater maintains an almost neutral region (omitted). Using such permeation and gelling properties, this construction method reduces the inflow into regions other than the injection target or into water. Active hybrid silica colloid in which small silica particles are combined with active silica colloid as a base can strengthen the ground at levels from low strength to high strength through early strength development achieved by adjusting the silica concentration. It is applicable to mega-earthquake countermeasures and measures to strengthen the deep underground in the future (omitted)." (pages 106 and 107). This document also describes the "magma action method" using the injection material composed of "active hybrid silica colloid in which small silica particles are combined with active silica colloid as a base," in which "as the injection material permeates between soil particles, the pH of its region of contact with the soil shifts toward neutral and gelation progresses," a neutral membrane (pseudo-gel membrane) is formed on the injection surface (Figure 6.1.5), and "the injection liquid overcomes it and expands the consolidated region."

(Figure 6.1.5)




Conceptual figure of the magma action method

(Photo 6.1.1)



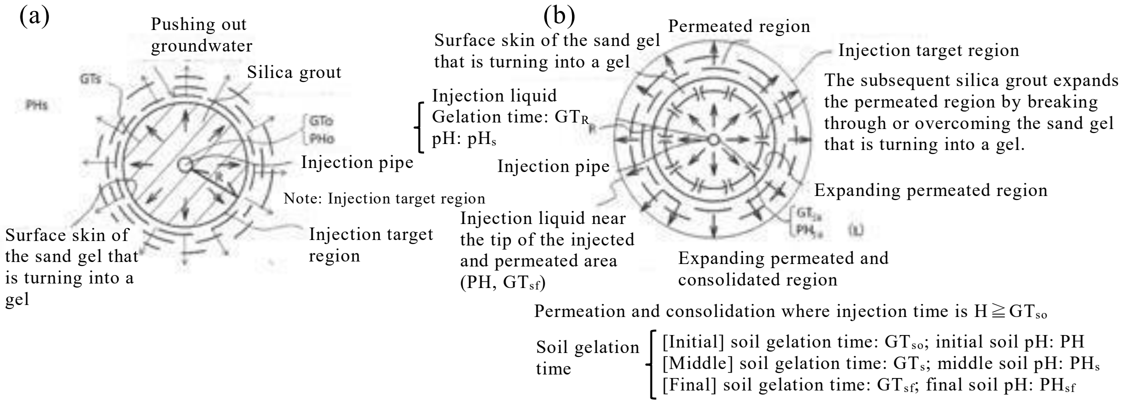
Injection and permeation through overcoming the gel by the magma action method

(B) Exhibit Ko 6 Document (Coastal Development Institute of Technology, *Engan Gijutsu (Coastal Technology) Library* No. 33, *Shintō koka shori kōhō gijutsu manuaru* (Permeable grouting method technical manual) (revised edition), published in October 2018) states as follows: "1) Gel time"; "The gel time of solution-type active silica grout differs between the state in which it is homogel and the state in which it is injected into the ground. The injected acid liquid begins to consolidate when it reacts with the alkaline component in the soil and becomes almost neutral. Therefore, the gel time of the liquid is measured for the state in which it is injected into the ground."; "The ground can be improved homogenously by adjusting the soil gel time to be shorter than the injection time of one spherical improvement body" (page 57).

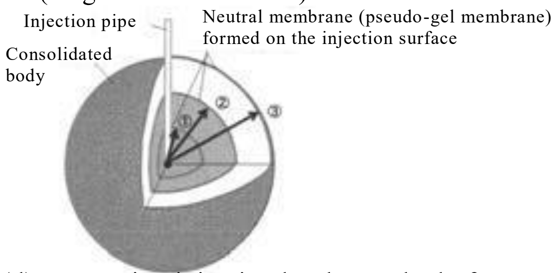
(C) Exhibit Ko 9 Document is a publication of the patent application for an invention titled "Durable silica grout and ground improvement method using durable silica grout" published on December 6, 2018 (Unexamined Patent Application Publication No. 2018-193550).

The invention described in Exhibit Ko 9 Document focuses on the fact that durable ground improvement is the maintenance of a predetermined improvement effect for a period during which durability is required, and provides a "reliable durable ground improvement method using a non-alkaline silica solution which addresses the injection purpose at the time of injection design by combining the injection material, construction method, management method, and other matters to enable quantitative evaluation of durability" (paragraph [0019] in Exhibit Ko 9 Document; hereinafter the paragraphs in Exhibit Ko 9 Document are described as "Exhibit Ko 9 [　　]").

(Figure 17)

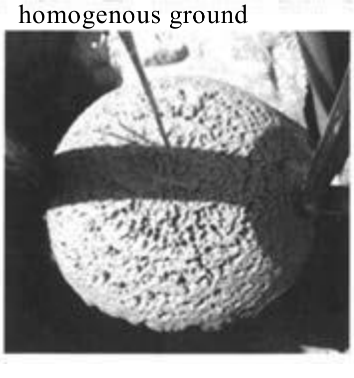



(b) Conceptual figure of the method of permeation and consolidation through overcoming the gel (magma action method)




(d) Permeation injection by the method of permeation and consolidation through overcoming the gel (Figure 84(b))

(c) Demonstration of the permeation and consolidation properties of silica solution in the homogenous ground




"Durable silica grout" (Claim 1) is created as a "composition which uses a silica solution from which alkali, which is a deteriorating factor of a silica gel, is removed, has properties of permeating and consolidating over a wide area without deviating from a predetermined injection region, and enables the consolidated ground to maintain necessary durability for a predetermined period (Exhibit Ko 9 [0029])", so as to obtain durability according to the injection purpose.

Furthermore, "durable silica grout" (Claim 8) is supposed to have the composition described in Claim 1, and is assumed to "penetrate and consolidate without deviating to the outside of a predetermined injection region" (Exhibit Ko 9 [0079]) by the "magma action method" in "Figure 17," in a manner that "as shown in Figure 17, even if the injection time is longer than the soil gelation time (GTso), the injection liquid permeates and consolidates while overcoming the tip surface that is turning into a gel, or pushing the injection liquid that is turning into a gel toward the outer circumference (Exhibit Ko 9 [0114]).

Regarding the magma action method, Exhibit Ko 9 Document states as follows: "It has been found that if the soil gelation time (GTso) is kept shorter than the injection time (H) for heterogeneous and various grounds by using an acidic silica liquid, and with a setting of flash setting ≤GTo≤10000 min. (GTo≥H≥GTso), the injection liquid permeates between soil particles, while becoming semi-gel but not becoming veined regardless of the dilution by groundwater or the heterogeneity of the ground, and expands the consolidated region." (Exhibit Ko 9 [0076], Figure 17); "It has been found that if a silica grout in the acidic region is injected by taking a longer injection time (H) than the soil gelation time (GTso), the pH increases and the gelation time decreases, and the injection area expands while the injection liquid is in a state of turning into a gel and kept within the injection region, thereby ensuring that the predetermined region can be consolidated (Figure 17)." (Exhibit Ko 9 [0077]); "(c) It has been found that in the ground with relatively homogeneous ground conditions, if the pH of the acidic silica injection material is more neutral than the pH of the injection liquid, the acidic silica injection material gelates while being held in the predetermined region even if it does not reach gelation by the time the injection of the predetermined volume is completed (GTo>GTso>H) (Table 11, Table 12, Figure 17(e), Figure 84(a).); In this case, the silica grout permeates and consolidates almost based on the permeation theory shown in Figures 11 to 14, whether spherical or cylindrical permeation. It has been found that such permeation and consolidation properties can be obtained by using non-alkaline silica grout, and by effectively combining the flow characteristics and gelling properties of a non-alkaline silica grout, which are caused by its mutual reaction with the soil, with the construction method, the injection hole pitch, the stage length, the number of stages, the injection rate, the injection time, and the soil gelation time for point injection, cylindrical injection, or multipoint injection, and the formulations. This enables the silica grout to permeate and gelate in the predetermined region using the phenomenon in which, where the preceding silica grout is in a semi-gel state in the ground, the subsequent silica grout consolidates while pushing the preceding silica grout toward the outer circumference or overcoming it. (Table 12(b), *2, *3"; "In *2 and *3, GTso is smaller than H, but the silica grout solidifies while overcoming the preceding silica grout as indicated in Figure 17(b)." (Exhibit Ko 9 [0078]); "This is similar to a phenomenon in which the magma erupting onto the ground loses fluidity as it cools down, and the magma following one after another overcomes the preceding one and solidifies over a wide area (Figure 17)." (Exhibit Ko 9 [0079]).

Claims 26 and 27 state that the silica grouting or chemical injection in the "silica grouting according to Claims 1 to 16 and injection management method used for any of (omitted)" refers to "injection of silica injection liquid, or suspension-type injection liquid containing silica," thus assuming the use of "not only the injection of silica liquid but also a suspension-type grout containing silica and performing gelation in which cement and slag are primary ingredients" (Exhibit Ko 9 [0210]). This may be because the use of a suspension-type injection liquid enables the grout to "permeate and consolidate without deviating to the outside of a predetermined injection region" even "under heterogeneous ground conditions or under the influence of fluidity of groundwater" (Exhibit Ko 9 [0084]) or "in the ground prone to deviation or ground with large voids" (Exhibit Ko 9 [0085]).

B. Based on the above, the court examines the differences.

As mentioned in (2) C. and (3) A. above, Exhibit Ko 1 Document describes the chemical liquid for injection into the ground for obtaining a consolidated body that has the same composition as the ground consolidation material based on Corrected Invention 1, but it does not describe any matters concerning the ground improvement method, such as the definition of the first gelation time, the explanation of the function and effect thereof, or the procedures and conditions for injection. Therefore, a question arises as to whether a person ordinarily skilled in the art, at the time of the filing of the application for the Patent, could have easily conceived of the injection conditions of said ground consolidation material having the configuration of Corrected Invention 1 in the ground improvement method using said ground consolidation material.

As mentioned in No. 4., 2. above, the ground consolidation materials used in the ground improvement method of Corrected Invention 1 and that of the Cited Invention are both a suspension (suspension-type grout) containing water glass and particulate slag as active ingredients. Its principle of consolidation is based on the hydraulic property of the slag in that "the alkaline component in the low-molar-ratio silica solution stimulates the latent hydraulic property of the particulate slag and solidifies, and the silica component in the low-molar-ratio silica solution reacts with the calcium component in the particulate slag and gelates, so that the silica gel connects the consolidated portions formed by the slag in the earth and sand to form a unified consolidated body." On the other hand, the ground consolidation materials described in Exhibit Ko 5, 6, and 9 Documents are "active hybrid silica colloid" (Exhibit Ko 5), "solution-type active silica grout" (Exhibit Ko 6), or "durable silica grout (Exhibit Ko 9) (solution-type grout), and their principle of consolidation is based on the pH of the ground in that: "As the injection liquid permeates between soil particles, the pH of its region of contact with the soil shifts toward neutral and gelation progresses" (Exhibit Ko 5) or "The injected acid liquid begins to consolidate when it reacts with the alkaline component in the soil and becomes almost neutral" (Exhibit Ko 6). Thus, the ground consolidation material of Corrected Invention 1 and that of the Cited Invention have different principles of consolidation.

With regard to the injection conditions in the ground improvement method, Exhibit Ko 5, 6, and 9 Documents explain the magma action method in which: as for the injection material (solution-type grout), since the injected acid liquid begins to consolidate when it reacts with the alkaline component in the soil and becomes almost neutral, the gel time of the solution is measured for the state in which it is injected into the ground; and if the injection time of the liquid is set to be longer than the soil gelation time (GTso), the subsequent injection liquid permeates and consolidates while overcoming the tip surface of the preceding injection liquid that is turning into a gel, or pushing the injection liquid that is turning into a gel toward the outer circumference. However, the magma action method describes the injection conditions only when an acid liquid reacts with the alkaline component in the soil and consolidates, and it cannot be said to be naturally applicable as the conditions for injection of the ground consolidation material of Corrected Invention 1 and the Cited Invention that consolidates due to the hydraulic property of the slag in the liquid. Since the principle of consolidation is different, it cannot be immediately said that these inventions can achieve the task of forming a large-diameter, high-strength consolidated body under the same injection conditions just because they are in the same technical field of ground improvement. There are no descriptions in Exhibit Ko 5, 6 and 9 Documents that suggest that the magma action method can be applied to a suspension-type grout, which has a different principle of consolidation. Therefore, it should be said that a person skilled in the art could not have easily conceived of the injection conditions according to the properties of the suspension-type grout of Corrected Invention 1 and the Cited Invention (first gelation, pseudoplasticity, and second gelation).

As mentioned above, the injection management method according to Claims 26 and

27 in Exhibit Ko 9 Document assumes the use of "a suspension-type grout containing silica and performing gelation" (Exhibit Ko 9 [0210]), and its configuration covers "durable silica grout" under Claim 8, which permeates and consolidates by the magma action method (Exhibit Ko 9 [0079]). However, Exhibit Ko 9 Document only describes that the conditions under which the "suspension-type grout" can be used are "under heterogeneous ground conditions or under the influence of fluidity of groundwater" (Exhibit Ko 9 [0084]) or "in the ground prone to deviation or ground with large voids (Exhibit Ko 9 [0085]), and it does not contain any description explaining how the "suspension-type grout containing silica and performing gelation" solidifies, or whether it solidifies while undergoing processes of the "first gelation," the exhibition of "pseudoplasticity," and the "second gelation." Even for the "suspension-type grout" under Claims 26 and 27 which includes the configuration under Claim 8, the relationship with the magma action method is not clear. Therefore, the descriptions mentioned above cannot be understood as suggesting that the injection conditions, etc. in Exhibit Ko 9 Document can be applied to a suspension-type grout.

C. The Defendant argues as follows. In the JPO Decision, the JPO determined that the "gel time" described in Exhibit Ko 5, 6, and 9 Documents is considered to be equivalent to the "time required to reach the first gelation" as defined in Corrected Invention 1 or corresponding to the state of being more hardened, and therefore that, by injecting the ground consolidation material of the Cited Invention into the ground over a time longer than the soil gelation time (GTso), a person ordinarily skilled in the art would have arrived at the matters specifying Corrected Invention 1. However, as mentioned above, the suspension-type grout of Corrected Invention 1 and the solution-type grout in Exhibit Ko 5, 6 and 9 Documents, both of which are to be used as a ground consolidation material, have different principles of consolidation. The gelation time of the solution-type grout is affected by the alkaline component in the soil, whereas that of the suspension-type grout is determined solely by its components. Therefore, it cannot be said that the "gel time" and the "time required to reach the first gelation" are equivalent, nor that, by injecting the ground consolidation material of the Cited Invention into the ground over a time longer than the soil gelation time, a person ordinarily skilled in the art would have arrived at the matters specifying Corrected Invention 1. Consequently, the Defendant's argument cannot be accepted.

The Defendant argues that the principle or mechanism of consolidation applied in Corrected Invention 1 and that described as a technical matter in Exhibit Ko 5, 6 and 9 Documents are the same in that when the preceding ground consolidation material is "turning into a gel," the subsequent ground consolidation material expands the injection region while overcoming it and consolidates. However, while the solution-type grout consolidates due to the pH of the ground into which it is injected, the suspension-type grout consolidates due to the hydraulic property of the slag in the grout. Based on this fact, the Corrected Inventions solve the problem with the conventional technology by which it was difficult to form a large-diameter consolidated body using a suspension-type injection material. Even if the phenomenon occurring in the process of forming a large-diameter consolidated body and the conditions for injection of the chemical liquid required to achieve this process turn out to be similar, it should be said that the details of the gelation, expansion of the injection region, and solidification mechanism according to the characteristics of respective chemical liquids are not the same. Therefore, the Defendant's argument cannot be accepted.

The Defendant argues that: based on Exhibit Ko 5, 6, and 9 Documents, a person ordinarily skilled in the art could have understood the mechanism of the magma action method described above; and as Exhibit Ko 9 Document states that a solution-type grout and a suspension-type grout can be used in the same way, a person ordinarily skilled in the art could have easily caused the magma action in the Cited Invention, which relates to a suspension-type grout, by continuing the injection longer than the gelation time. However, as mentioned above, Exhibit Ko 9 Document cannot be understood as containing any statement that suggests that the technical matters relating to a solution-type grout, such as injection conditions, can be applied to a suspension-type grout. Thus, the Defendant's argument lacks a premise to be based upon.

(5) Summary

According to the above, it cannot be found that Corrected Invention 1 could have been easily made by a person ordinarily skilled in the art based on the Cited Invention as well as the technical matters described in Exhibit Ko 5, 6, and 9 Documents. Therefore, there is an error in the determination in the JPO Decision regarding an inventive step in Corrected Invention 1, and Ground for Rescission 1 argued by the Plaintiff is recognized.

4. Concerning Grounds for Rescission 2 to 5 (errors in the determination on an inventive step in Corrected Inventions 2, and 4 to 7 based on the Cited Invention)

The Corrected Inventions except for Corrected Invention 1 (Corrected Inventions 2 and 4 to 7) cite the matters specifying Corrected Invention 1. As mentioned above, Corrected Invention 1 could not have been easily made by a person ordinarily skilled in the art at the time of the filing of the application for the Patent, and therefore, it should be said that the Corrected Inventions except for Corrected Invention 1 also could not have been easily made by a person ordinarily skilled in the art at the time of the filing of the application for the Patent.

Consequently, there are errors in the determination in the JPO Decision regarding an inventive step in the Corrected Inventions except for Corrected Invention 1, and Grounds for Rescission 2 to 5 argued by the Plaintiff are recognized.

No. 5 Conclusion

As discussed above, there are errors in the determination in the JPO Decision regarding an inventive step in the Corrected Inventions, and the Plaintiff's claim is well-grounded and therefore upheld. Accordingly, the judgment is rendered as indicated in the main text.

Intellectual Property High Court, Second Division
Presiding judge: SHIMIZU Hibiku
Judge: KIKUCHI Eri
Judge: RAI Shinichi

(Attachment)

Corrected Invention

[Claim 1]

A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, which is characterized in that:

said ground consolidation material is composed of:

1. water glass

1) molar ratio of water glass: 1.68 to 2.31

2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%

3) blending ratio of water glass (40 L to160 L)/400 L

2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material

1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 μm to 10 μm

2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies; the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed;

wherein:

1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity

rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred;
2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1);
3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2).
[Claim 2]
A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, which is characterized in that:
said ground consolidation material is composed of:
1. water glass
1) molar ratio of water glass: 1.68 to 2.31
2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%
3) blending ratio of water glass (40 L to160 L)/400 L
2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material
1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 μm to 10 μm
2) blending ratio: (50 kg to 150 kg)/400 L;
the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;
said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it

retains pseudoplasticity, comes to rest, and then solidifies; the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed;

wherein:

1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred;

2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1);

3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2);

said ground consolidation material exhibits flow characteristics and solidification characteristics, which consist of the first gel time and the second gel time as described below:

flow characteristics:

1) first gel time (GT1): 10 minutes or more (20°C)

where the first gel time refers to the time after blending until reaching the abovementioned first gelation, which is the point in time when gel begins to adhere to the P-funnel by the P-funnel method (the time when fluidity starts to decrease); the time until the first gel time is defined as the permeability retention time (T1), and the viscosity is 10 seconds or less by the P-funnel method or 10 mPa-s or less by a

viscometer; and
2) second gel time (GT2): 10 minutes or more (20°C)
where the first gel time refers to the time until when, after the first gel time, the material exhibits pseudoplasticity, and its viscosity becomes equal to or greater than the viscosity in the first gel time by P-funnel method or equal to or greater than the viscosity until the first gel time by a viscometer, and the material finally does not regain fluidity even when stirred; or in other words, the time required to reach the abovementioned second gelation after the abovementioned first gelation.

[Claim 3]

Deleted

[Claim 4]

A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, which is characterized in that:

said ground consolidation material is composed of:

1. water glass
1) molar ratio of water glass: 1.68 to 2.31
2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%
3) blending ratio of water glass (40 L to 160 L)/400 L
2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material
1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 μm to 10 μm
2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies; the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed;

wherein:

1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred;

2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1);

3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2);

the injection of said ground consolidation material is performed by injecting the ground consolidation material with the first gel time shorter than the injection time of an injection volume per one stage in a predetermined injection region, through which the subsequent ground consolidation material repeatedly overcomes and flows outside the gelation region where the preceding ground consolidation material has become pseudoplastic, thereby expanding the permeated area, and thus expanding the consolidated region while reducing the deviation to the outside of the predetermined region;

wherein "one stage" is defined as the length of the injection target at the injection depth assigned to one inlet of the injection pipe, where the material is injected from an injection pipe installed in the ground.

[Claim 5]

A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, which is characterized in that:

said ground consolidation material is composed of:

1. water glass

1) molar ratio of water glass: 1.68 to 2.31

2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%

3) blending ratio of water glass (40 L to160 L)/400 L

2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material

1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 μm to 10 μm

2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies; the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed;

wherein:

1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred;

2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel

begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1);
3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2);

wherein, when an injection volume per one stage is V, an injection time required for injecting V is T, and the first gel time of said ground consolidation material is GT1, the injection of said ground consolidation material is performed by continuously injecting the material in the first gel time shorter than T to inject the injection volume V per one stage, and the injection of said ground consolidation material is completed by injecting the injection volume V per one stage through the process in which the subsequent ground consolidation material continuously repeats overcoming and permeating outside of the pseudoplasticity region created by the preceding ground consolidation material.

[Claim 6]

A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, which is characterized in that:

said ground consolidation material is composed of:

1. water glass
1) molar ratio of water glass: 1.68 to 2.31
2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%
3) blending ratio of water glass (40 L to 160 L)/400 L
2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material
1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 µm to 10 µm
2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies; the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed;

wherein:

1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred;

2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1);

3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2);

wherein said ground consolidation material is adjusted in terms of one or more of the gel time, permeability, strength or bleeding, depending on (1) the amount of water glass, (2) the molar ratio of water glass, (3) the blending ratio of slag, or (4) the specific surface area of slag.

[Claim 7]

A ground improvement method for consolidating the ground by injecting into the ground a ground consolidation material containing, as active ingredients, water glass with a molar ratio in the range of 1.68 to 2.31 and particulate slag with a Blaine value of 4,000 $cm^2/g$ to 20,000 $cm^2/g$, which is characterized in that:

said ground consolidation material is composed of:

1. water glass

1) molar ratio of water glass: 1.68 to 2.31

2) $SiO_2$ content in the water glass-blended solution: 2.9 to 11.7 w/v%

3) blending ratio of water glass (40 L to160 L)/400 L

2. particulate slag and its blending ratio per 400 L of a suspension as a ground consolidation material

1) particulate slag: Braine value 4,000 to 20,000 $cm^2/g$, average particle size of 2 µm to 10 µm

2) blending ratio: (50 kg to 150 kg)/400 L;

the fluidity of said ground consolidation material consists of: (1) a process in which the material retains permeability, (2) a process in which permeability then rapidly decreases and the material reaches a pseudoplastic state, (3) a process in which the material retains the pseudoplastic state, and (4) a process in which pseudoplasticity is lost and the material reaches a consolidated state;

said ground consolidation material undergoes the first gelation in which it retains permeability and then exhibits pseudoplasticity, and the second gelation in which it retains pseudoplasticity, comes to rest, and then solidifies; the injection of said ground consolidation material into the ground is performed through the process in which the injection region is expanded while the subsequent ground consolidation material that retains permeability repeatedly overcomes or breaks through the region where the preceding ground consolidation material that retains permeability has become pseudoplastic, and the material solidifies when the injection is completed; and a predetermined volume is injected into the ground over a time longer than the time required to reach the first gelation, and the material solidifies after the injection is completed;

wherein:

1) pseudoplasticity refers to fluidity of a material from a state of permeability in which the material permeates between soil particles, to the first gelation in which fluidity rapidly decreases, and then to the second gelation in which the material does not permeate between soil particles but remains fluid when stirred, and finally does not regain fluidity even when stirred;

2) the first gelation refers to a process from a state of permeability in which the material permeates between soil particles, to a state in which fluidity rapidly decreases and gel

begins to adhere to the P-funnel by the P-funnel method; the time required to reach the first gelation is referred to as the first gel time (GT1);

3) the second gelation refers to a process in which the material exhibits pseudoplasticity after the first gelation, and the viscosity decreases, or does not decrease but slightly increases, or decreases but remains equal to or greater than the viscosity up to the first gelation by the P-funnel method and the viscosity up to the first gelation by a viscometer, and the material is solidified without regaining fluidity after stirring is stopped; the time required to reach the second gelation after the first gelation is referred to as the second gel time (GT2);

wherein said ground consolidation material is adjusted in terms of gelation and strength by adding one or more of cement, gypsum, slaked lime, pozzolan, clay, acid, alkali, or salt.

(Attachment)

Cited Invention

A ground improvement method for consolidating the ground by injecting into the ground a chemical liquid for injection into the ground, which is intended to obtain a high-strength consolidated body, for which it is easy to adjust a relatively long gelation time, and which is excellent in permeability because of maintaining a low viscosity until reaching gelation, and is therefore particularly suitable for injection into a water-permeable ground such as sandy soil, wherein:

the chemical liquid for injection into the ground is composed of:

water glass having a molar ratio of 2.01 and containing $SiO_2$ at 27.36% and $Na_2O$ at 14.05%, and

slag that is water-granulated slag having a specific surface area of 10,200 $cm^2/g$ and a composition of $SiO_2$ at 33.02%, CaO at 41.94%, $Al_2O_3$ at 12.83%, MgO at 8.61%, and $Fe_2O_3$ at 0.37%;

$SiO_2$ in the water glass-blended solution is 8%,

the blending ratio of water glass is 292 g/1,000 g,

the average particle size of the slag is 6.0 μm, and

the blending ratio of slag is 125 g/1,000 g; and

the chemical liquid for injection into the ground has a gelation time of 22 minutes at 20°C, a viscosity of 6.3 CPS after 2 minutes, a viscosity of 35 CPS after 20 minutes, and then it solidifies, and its unconfined compressive strength becomes 15.5 $kgf/cm^2$ after 7 days and 30.0 $kgf/cm^2$ after 49 days.