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(54) GROUTING STRUCTURE FILLED WITH SOLUBLE CRYSTAL AND CONSTRUCTION METHOD

(57) The present invention provides a grouting structure filled with soluble crystals and a construction method thereof, wherein the structure comprises a water-permeable section and a grouting section; a water-stop component is arranged between the water-permeable section and the grouting section; a permeable pipe is arranged in the water-permeable section; the permeable pipe is filled with solid soluble crystals; the water inlet of the drain pipe is arranged in the water-permeable section; the elevation of the water inlet of the drain pipe is higher than that of the water outlet of the drain pipe. The present structure is beneficial to increase the pressure of grouting, reduce cracks in the grouting section, and improve the sealing effect, thus enhancing the negative pressure effect of the water-permeable section, effectively supporting the water-stop component during grouting, preventing the slurry from entering the water-permeable section and the consequent interference in the formation of a negative pressure environment, avoiding blockage of the permeable pipe, and preventing large displacement of the water-stop component by squeezing. It is conducive to ensuring continuous drainage of the deep portion of the slope, and is of great significance in solving the problem of drainage treatment of

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large-scale landslide.

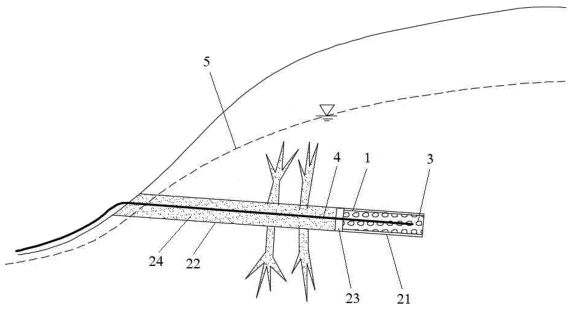

Fig 1

Description

Technical Field

[0001] The present invention relates to the technical field of slope drainage engineering, and in particular, to a grouting structure filled with soluble crystals and a construction method thereof.

Background

[0002] Rainfall infiltration is one of the important factors to change the mechanical parameters of the slope and induce landslides. Timely and effective drainage of the slope is an effective way to solve this problem. The existing drainage measures for slope mainly include surface drainage ditch, blind ditch, collecting well, horizontal drainage borehole, underground drainage hole, negative pressure drainage, etc.

[0003] The existing negative pressure drainage technology for slope mainly divides the slope boreholes into a water-permeable borehole section and a grouting seal borehole section, with a water-stop ring made of water-expanding rubber in between. As described in the Chinese Patent, publication No. CN107246019A, *SIDE SLOPE UNDERGROUND WATER DRILLING SELF-STARTING NEGATIVE PRESSURE DRAINAGE SYSTEM AND METHOD,* wherein a declination borehole grout into the grouting seal borehole section, and the reserved water-permeable borehole section is isolated from the outside atmosphere. The water inlet of the drain pipe is arranged in the permeable pipe, and the water outlet of such pipe extends out of the ground through the water-stop ring made of water-expanding rubber for drainage. Before the drainage process occurs, the pressure in the borehole will gradually increase with the infiltration of groundwater, leading to the natural outflow of the groundwater from the water outlet. When the drainage process takes place, because the drainage capacity of the drain pipe is greater than the flow rate of groundwater in the slope infiltrating into the cavity of the water-permeable borehole section and the air pressure in the permeable pipe is lower than the atmospheric pressure (a negative pressure is formed), the water in the soil around the permeable pipe continues to flow towards it, forcing the groundwater in the slope to flow rapidly towards the borehole to drain to the surface. At the same time, due to the negative pressure in the permeable pipe, the water in all directions around the permeable pipe will flow towards it, so the drainage range will increase, and such increased drainage range is more conducive to discharging the groundwater in the slope.

[0004] However, in the process of on-site construction, the difficulty of negative pressure drainage technology is that the water-permeable borehole section needs to maintain its permeability, and the slurry of the grouting seal borehole section cannot enter the water-permeable borehole section. If the pressure of grouting is high, the slurry will often break through the baffle structure such as the water-stop ring made of water-expanding rubber and enter the water-permeable borehole section, resulting in the failure of the borehole; if the pressure of grouting is small, the borehole section cannot be closed and the negative pressure cannot be formed. Accordingly, in order to solve the above problems, a new grouting technology is required.

Summary

[0005] For overcoming the deficiency of existing negative pressure drainage technology in controlling the pressure of grouting and the consequent failure in negative pressure drainage, an object of the present invention is to provide a grouting structure filled with soluble crystals and a construction method thereof.

[0006] Accordingly, in order to accomplish the above objects, the present invention provides the following technologies:

A grouting structure filled with soluble crystals, comprising a water-permeable section and a grouting section, wherein the water-permeable section is located at the lower part of a declination borehole, and the grouting section is situated at the upper part of the borehole; a water-stop component is arranged between the water-permeable section and the grouting section; a permeable pipe is arranged in the water-permeable section; the top of the permeable pipe is in contact with the water-stop component; a cavity is formed in the permeable pipe; the permeable pipe is filled with solid soluble crystals; the groundwater penetrates into the cavity through the permeable pipe; the water inlet of the drain pipe is arranged in the water-permeable section, and the water inlet of the drain pipe inserts into the permeable pipe after passing through the water-stop component; the water outlet of the drain pipe is located at the lower part of the slope; the elevation of the water inlet of the drain pipe is higher than that of the water outlet of the drain pipe, and the lift of the drain pipe is less than the height of the water column corresponding to the atmospheric pressure; the space between the drain pipe and the wall of the borehole of the grouting section is used for grouting.

[0007] The permeable pipe is a pipe with permeable holes on its pipe wall.

[0008] The lift of the drain pipe being smaller than the height of the water column corresponding to atmospheric pressure means the height difference between the water inlet of the drain pipe and the borehole orifice is smaller than the height of the water column corresponding to the local atmospheric pressure in order to perform negative pressure drainage.

[0009] The present invention provides a grouting structure filled with soluble crystals, wherein the permeable pipe is filled with the solid soluble crystals to support the water-stop component to a certain extent during grouting, contributing to the prevention of the slurry from entering the water-permeable section, and the water-stop com-

ponent from being squeezed to cause a large displacement; at the same time, grouting pressure will be increased to reduce the porosity of the grouting section and a better sealing can be achieved to ensure the negative pressure effect of the water-permeable section. The soluble crystals can dissolve, thereby changing the osmotic pressure of the surrounding soil, leading to the water flow from the surrounding soil to the permeable section and finally forcing the groundwater in the slope to be discharged to the surface; the cavity in the permeable pipe can facilitate the infiltration of groundwater after the soluble crystals dissolve. The present structure is beneficial to increase the pressure of grouting, reduce cracks in the grouting section, and improve the sealing effect, thus enhancing the negative pressure effect of the water-permeable section, effectively supporting the water-stop component during grouting, preventing the slurry from entering the water-permeable section and the consequent interference in the formation of a negative pressure environment, avoiding blockage of the permeable pipe, and preventing large displacement of the water-stop component by squeezing. It is conducive to ensuring continuous drainage of the deep portion of the slope, and is of great significance in solving the problem of drainage treatment of large-scale landslide.

[0010] Preferably, the soluble crystals comprise at least one of solid salt, solid sugar, solid alum and solid ice.

[0011] Different soluble crystals have different dissolution rates, and can be selected and matched according to actual needs. Among them, solid salt and solid alum, after dissolving, will form a certain residue in the water-permeable section and the drain pipe, contributing to the inhibition of growth of plants in the drain pipe and the water-permeable section, the effective avoidance of blockage, and the guarantee of effectiveness and continuity of the entire drainage system.

[0012] Preferably, the slurry of the grouting section is cement mortar or cement-sodium silicate slurry.

[0013] Preferably, the water-stop component includes a water-stop strip made of water-expanding rubber, a water-stop belt or sandbags.

[0014] Preferably, the bottom of the permeable pipe is provided with a pipe boot.

[0015] It is conducive to avoiding blockage at the bottom of the permeable pipe due to accumulation of sand and gravel and the consequent impact on drainage.

[0016] A construction method for a grouting structure filled with soluble crystals, using any of the above-mentioned grouting structures filled with soluble crystals, comprising the following steps:

a. drilling a declination borehole according to the geological survey, and making the water-permeable section of the borehole below the groundwater level line of the slope;

b. arranging a permeable pipe in the water-permeable section, and then inserting a drain pipe into the permeable pipe;

c. filling the permeable pipe with solid soluble crystals, and then installing a water-stop component to block the water-permeable section;

d. injecting slurry into the borehole to form a grouting section, and the completing the construction of the grouting structure.

[0017] Adopting a construction method of a grouting structure filled with soluble crystals recites in the present invention, wherein the permeable pipe is filled with solid soluble crystals to support the water-stop component, does not increase additional difficulty and cost, effectively improving the pressure of grouting in the grouting process, contributing to the improvement of grouting efficiency and avoidance of the damage to the water-stop component, and effectively ensuring the grouting effect, thereby guaranteeing the effective formation of a negative pressure environment for efficient operation of the drainage system and continuous drainage.

[0018] Preferably, after step d, the following steps are also included:

e. injecting water into the permeable pipe from the water outlet of the drain pipe;

f. drawing the solution out from the water outlet of the drain pipe and testing it after the soluble crystals are dissolved; stopping suction and completing the construction of the grouting structure when the concentration ρ of the soluble crystals in the solution meets the requirements.

[0019] It is beneficial to dissolve the soluble crystals at a rapid pace so as to perform drainage as soon as possible.

[0020] Preferably, in the step f, stop pumping when the concentration ρ of the soluble crystals is less than or equal to $1/2\ \rho_0$, wherein ρ_0 stands for the initial concentration of the soluble crystals.

[0021] Preferably, in the step e, inject water above 40° C.

[0022] To sum up, compared with the existing art, the beneficial effects of the present invention are:

1. The present structure is beneficial to increase the pressure of grouting, reduce cracks in the grouting section, and improve the sealing effect, thus enhancing the negative pressure effect of the water-permeable section, effectively supporting the water-stop component during grouting, preventing the slurry from entering the water-permeable section and the consequent interference in the formation of a negative pressure environment, avoiding blockage of the permeable pipe, and preventing large displacement of the water-stop component by squeezing. It is conducive to ensuring continuous drainage of the deep portion of the slope, and is of great significance in solving the problem of drainage treatment of large-scale landslide.

2. Adopting a construction method of a grouting structure filled with soluble crystals recites in the present invention, wherein the permeable pipe is filled with solid soluble crystals to support the water-stop component, does not increase additional difficulty and cost, effectively improving the pressure of grouting in the grouting process, contributing to the improvement of grouting efficiency and avoidance of the damage to the water-stop component, and effectively ensuring the grouting effect, thereby guaranteeing the effective formation of a negative pressure environment for efficient operation of the drainage system and continuous drainage.

Brief Description of Drawings

[0023]

FIG. 1 is a structure view of a grouting structure filled with soluble crystals of the present invention;
FIG. 2 is a view of drainage of a grouting structure filled with soluble crystals of the present invention.

[0024] Element Reference: 1-permeable pipe, 21-water-permeable section, 22-grouting section, 23-water-stop component, 24-slurry, 3-soluble crystals, 4-drain pipe, 5-groundwater level line.

Description of Embodiments

[0025] The present invention will be further described in detail below with reference to the accompanying drawings and specific embodiments. However, it shall not be construed that the scope of the above-mentioned subject matter of the present invention is limited to the following embodiments, as all technologies realized based on the content of the present invention belong to the scope of the present invention.

Embodiment 1

[0026] Referring to FIG. 1, a grouting structure filled with soluble crystals of the present invention, comprising a water-permeable section 21 and a grouting section 22, wherein the water-permeable section 21 is located at the lower part of a declination borehole, and the grouting section 22 is situated at the upper part of the borehole; a water-stop component 23 is arranged between the water-permeable section 21 and the grouting section 22; a permeable pipe 1 is arranged in the water-permeable section 21; the top of the permeable pipe 1 contacts the water-stop component 23; a cavity is formed in the permeable pipe 1; the permeable pipe 1 is filled with solid soluble crystals 3; the groundwater penetrates into the cavity through the permeable pipe 1; the water inlet of the drain pipe 4 is arranged in the water-permeable section 21, and the water inlet of the drain pipe 4 inserts into the permeable pipe 1 after passing through the water-stop component 23; the water outlet of the drain pipe 4 is located at the lower part of the slope; the elevation of the water inlet of the drain pipe 4 is higher than that of the water outlet of the drain pipe 4, the lift of the drain pipe 4 is less than the height of the water column corresponding to the atmospheric pressure; the space between the drain pipe 4 and the wall of the borehole of the grouting section 22 is used for grouting.

[0027] Specifically, the diameter of the borehole should be larger than 90mm, and the permeable pipe 1 can be a corrugated pipe, externally covered with filter cloth and internally supported by HDPE, preventing large particles such as coarse sand and gravel from entering; a pipe boot is set at the bottom of the permeable pipe 1; the pipe boot can be a HDPE pipe with a sealed bottom and an open top, and is sleeved on the bottom of the permeable pipe 1 (not shown in the FIG); the drain pipe 4 can be a PA pipe with a diameter of 4-8mm; the drain pipe 4 has good air tightness; the drainage capacity of the drain pipe 4 is greater than the flow rate of groundwater in slope infiltrating into the water-permeable section 21, facilitating natural drainage when the water head height of the cavity in the permeable pipe 1 is greater than the orifice elevation of the borehole as a result of elevated groundwater level, discharging groundwater of the slope in real time, and keeping the groundwater below the safe water level; the slurry 24 of the grouting section 22 is cement mortar or cement-sodium silicate slurry, cutting off the water-gas connection between the ground surface and the cavity of the water-permeable borehole section; the water-stop component 23 includes a water-stop ring made of water-expanding rubber, a water-stop belt or sandbags; after the water-stop component 23 is closed, the gap between the drain pipe 4 and the wall of the borehole of the grouting section 22 is closed by grouting.

[0028] The soluble crystals 3 comprise at least one of solid salt, solid sugar, solid alum and solid ice. The space between the permeable pipe 1 and the drain pipe 4 is filled with the soluble crystals 3, providing effective support for the water-stop component 23 during grouting. After that, groundwater will flow into or additional water will be added into the permeable pipe 1 over time, dissolving the soluble crystals 3 and then freeing the cavity in the permeable pipe 1 for drainage. Different soluble crystals 3 have different dissolution rates and can be selected according to actual needs. The present structure is beneficial to increase the pressure of grouting, reduce cracks in the grouting section, and improve the sealing effect, thus enhancing the negative pressure effect of the water-permeable section, effectively supporting the water-stop component during grouting, preventing the slurry from entering the water-permeable section and the consequent interference in the formation of a negative pressure environment, avoiding blockage of the permeable pipe, and preventing large displacement of the water-stop component by squeezing; besides, solid salt and solid alum, after dissolving, will form a certain residue in

the water-permeable section 21 and the drain pipe 4, contributing to the inhibition of growth of plants in the drain pipe 4 and the water-permeable section 21, the effective avoidance of blockage, and the guarantee of availability and continuity of the entire drainage system. solid salt and solid alum, after dissolving, will form a certain residue in the water-permeable section 21 and the drain pipe 4, contributing to the inhibition of growth of plants in the drain pipe 4 and the water-permeable section 21, the effective avoidance of blockage, and the guarantee of effectiveness and continuity of the entire drainage system.

Embodiment 2

[0029] The construction method of a grouting structure filled with soluble crystals according to the present invention adopts a grouting structure filled with soluble crystals as described in Embodiment 1, and includes the following steps:

a. drilling a declination borehole according to the geological survey, and making the water-permeable section 21 of the borehole below the groundwater level line 5 of the slope, that is, the position of the water-permeable section 21 is set according to the water level of the groundwater level line 5; the height difference between the bottom of the borehole and the orifice of the borehole is less than the height of the water column corresponding to the local atmospheric pressure, ensuring that the lift of the drain pipe 4 meets the requirements;

b. arranging a permeable pipe 1 in the water-permeable section 21, and then inserting a drain pipe 4 into the permeable pipe 1 with the port of the drain pipe 4 extending into the bottom of the permeable pipe 1;

c. filling the permeable pipe 1 with solid soluble crystals 3 until it is full, and then installing a water-stop component 23 to block the water-permeable section 21;

d. injecting slurry 24 into the borehole to form the grouting section 22 by the backward method can increase the pressure of grouting during grouting; the slurry 24 flowing into the surrounding soil to further ensure the sealing of the grouting section 22.

e. injecting water, such as water above 40° C, into the permeable pipe 1 from the water outlet of the drain pipe 4;

f. drawing the solution out from the water outlet of the drain pipe 4 and testing it after the soluble crystals 3 are dissolved; stopping suction and completing the construction of the grouting structure when the concentration ρ of the soluble crystals 3 in the solution meets the requirements.

[0030] In step f, the solubility of the soluble crystals 3 can be roughly obtained according to the amount of water injected and the amount of the soluble crystals 3. The prediction of reaching the predetermined solubility according to time is acceptable, and complete dissolution is not a must. The cavity in the permeable pipe 1 can be vacated more quickly with water injection, as such, the groundwater in the surrounding soil can penetrate into the permeable pipe 1.

[0031] In step f, the pumping is stopped when it is detected that the concentration ρ of the soluble crystals 3 is less than or equal to 1/2 ρ_0, wherein ρ_0 is the initial concentration of the soluble crystals 3 and can be can be roughly obtained according to the volume of the water-permeable section, the amount of water injected and the mass of the soluble crystals 3, or by referring to the concentration of the liquid extracted for the first time after a certain period of time. The aforementioned concentration requirements are mainly used to roughly grasp the dissolution of the soluble crystals 3.

[0032] Water injection is optional, that is, not to perform steps e and f, but to utilize the penetration of groundwater into the permeable section 21 to dissolve the soluble crystals 3. During the dissolution process, the osmotic pressure increases, the attraction to groundwater elevates, and then the infiltration of groundwater into the permeable pipe 1 is accelerated; at the same time, the solution will diffuse freely and the groundwater can still effectively dissolve the soluble crystals 3 when the groundwater needs to be drained.

[0033] When the soluble crystal 3 is solid ice it can be effectively melt since the soil has a temperature and there is no need to inject water; after the ice melts, the cavity in the permeable pipe 1 is vacated and there is no need to test the concentration.

[0034] As shown in FIG. 2, after the construction is completed, since the groundwater level line 5 in the slope is higher than the highest point of the drain pipe 4 (that is where the orifice of the borehole is located), the water head height of the water inlet of the drain pipe 4 is higher than that of the orifice of the borehole, discharging groundwater in the water-permeable section 21 by the drain pipe 4 under a water head difference, and triggering a drainage process. When the groundwater level drops below the highest point of the drain pipe 4, a siphon drainage process is started and negative pressure is generated in the water-permeable section 21. As such, the groundwater in the slope accelerates into the cavity, and after the groundwater in the cavity and the soil above the water-permeable section 21 in the slope is drained, an entire drainage process ends; wherein with cycles of rainfall infiltration, the drainage process circulates, effectively realizing continuous drainage of a deep portion of the slope, solving a problem of drainage treatment of large landslide, and ensuring the stability of the slope with low maintenance cost.

Claims

1. A grouting structure filled with soluble crystals, com-

prising: a water-permeable section (21) and a grouting section (22), wherein the water-permeable section (21) is located at the lower part of a declination borehole, and the grouting section (22) is situated at the upper part of the borehole; a water-stop component (23) is arranged between the water-permeable section (21) and the grouting section (22) ; a permeable pipe (1) is arranged in the water-permeable section (21) ; the top of the permeable pipe (1) is in contact with the water-stop component (23); a cavity is formed in the permeable pipe (1); the permeable pipe (1) is filled with solid soluble crystals (3) ; the groundwater penetrates into the cavity through the permeable pipe (1) ; the water inlet of the drain pipe (4) is arranged in the water-permeable section (21), and the water inlet of the drain pipe (4) inserts into the permeable pipe (1) after passing through the water-stop component (23); the water outlet of the drain pipe (4) is located at the lower part of the slope; the elevation of the water inlet of the drain pipe (4) is higher than that of the water outlet of the drain pipe (4), and the lift of the drain pipe (4) is less than the height of the water column corresponding to the atmospheric pressure; the space between the drain pipe (4) and the wall of the borehole of the grouting section (22) is used for grouting.

2. The grouting structure, as recited in claim 1, wherein the soluble crystals (3) comprise at least one of solid salt, solid sugar, solid alum and solid ice.

3. The grouting structure, as recited in claim 1, wherein the slurry (24) of the grouting section (22) is cement mortar or cement-sodium silicate slurry.

4. The grouting structure, as recited in any one of claims 1-3, wherein the water-stop component (23) includes a water-stop strip made of water-expanding rubber, a water-stop belt or sandbags.

5. The grouting structure, as recited in any one of claims 1-3, wherein the bottom of the permeable pipe (1) is provided with a pipe boot.

6. A construction method for a grouting structure filled with soluble crystals, wherein any grouting structure filled soluble crystals is applied in accordance with claims 1-5, comprises the following steps:

a. drilling a declination borehole according to the geological survey, and making the water-permeable section (21) of the borehole below the groundwater level line (5) of the slope;
b. arranging a permeable pipe (1) in the water-permeable section (21), and then inserting a drain pipe (4) into the permeable pipe (1);
c. filling the permeable pipe (1) with solid soluble crystals (3), and then installing a water-stop component (23) to block the water-permeable section (21) ;
d. injecting slurry (24) into the borehole to form a grouting section (22), and then completing the construction of the grouting structure.

7. The construction method, as recited in claim 6, wherein the following steps are included after step d:

e. injecting water into the permeable pipe (1) from the water outlet of the drain pipe (4);
f. drawing the solution out from the water outlet of the drain pipe (4) and testing it after the soluble crystals (3) are dissolved; stopping suction and completing the construction of the grouting structure when the concentration ρ of the soluble crystals (3) in the solution meets the requirements.

8. The construction method, as recited in claim 7, wherein the pumping is stopped when the concentration ρ of the soluble crystals (3) is less than or equal to $1/2\ \rho_0$ in the step f, wherein ρ_0 stands for the initial concentration of the soluble crystals.

9. The construction method, as recited in claim 7, wherein water above 40°C is injected in the step e.

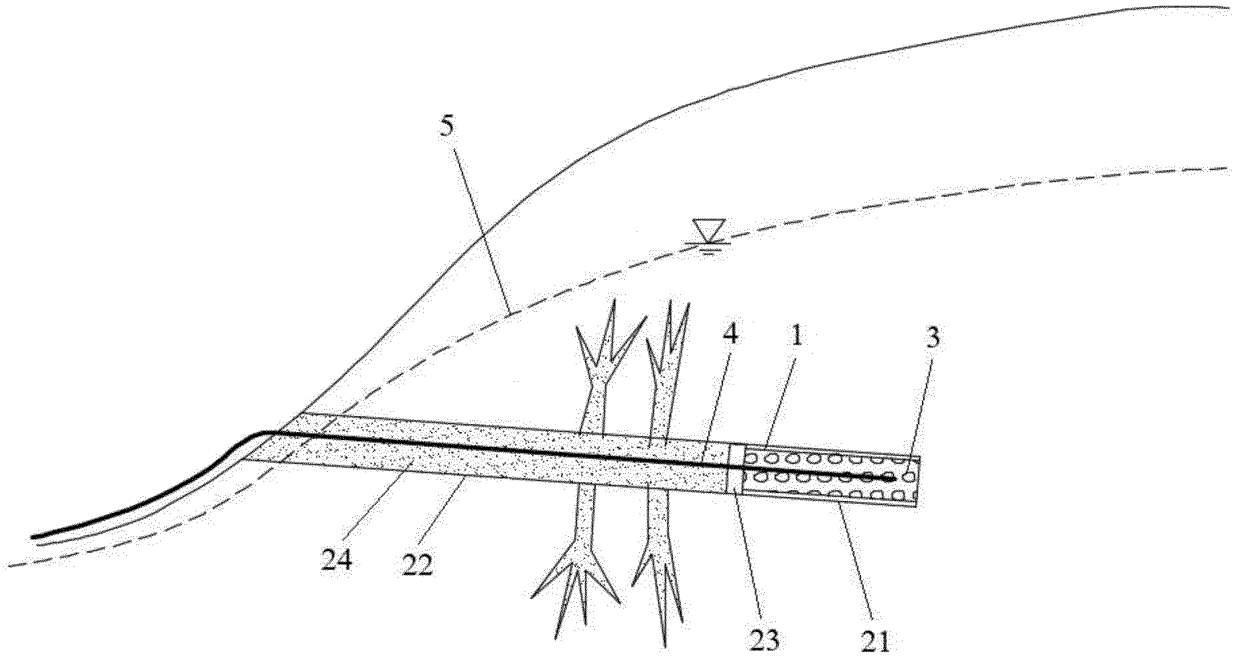

Fig 1

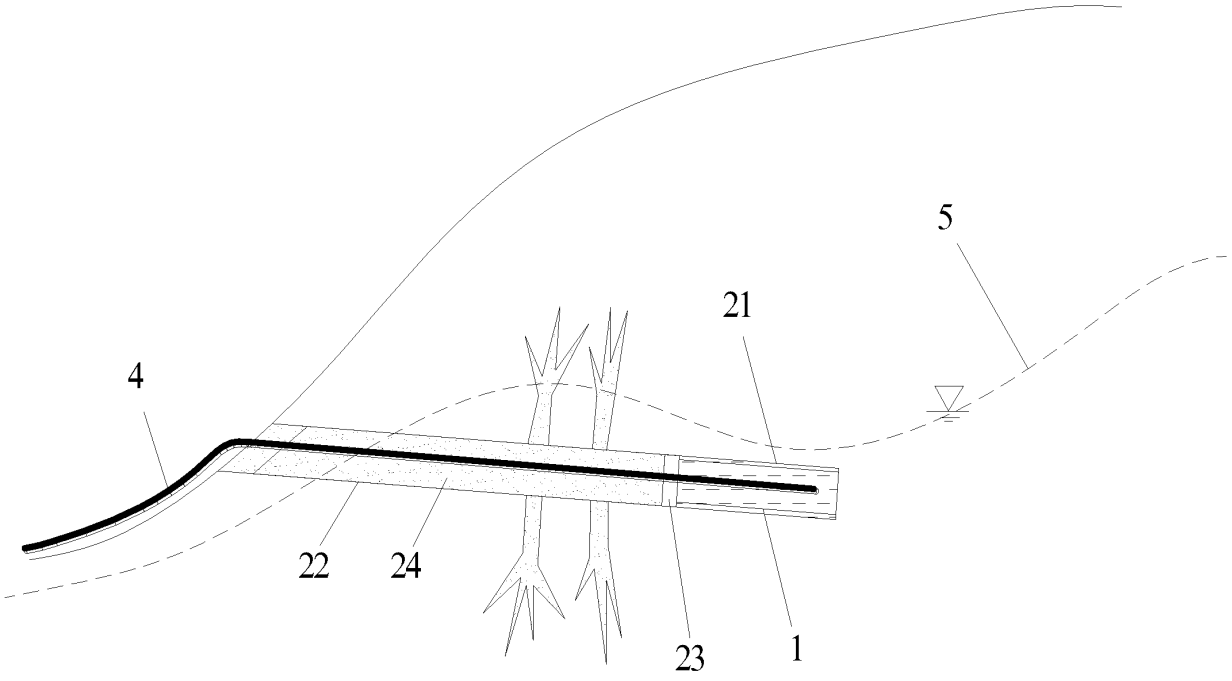

Fig 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/106035

A. CLASSIFICATION OF SUBJECT MATTER

E02D 17/20(2006.01)i; E02D 15/00(2006.01)i; E02D 3/10(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E02D,E21D,E21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, WPABSC, WPABS, DWPI, OETXT , 读秀, 超星科技数字图书馆: 中铁二院, 范雲鶴, 郑长青, 喻渝, 赵万强, 孙红月, 胖涛, 曹彧, 谭永杰, 刘金松, 刘洋, 尚岳全, 帅飞翔, 琚国全, 蒋立, 注浆, 透水, 透空, 注浆, 砂浆, 浆体, 灌浆, 排水, 可溶晶体, 冰, 明矾, 糖, 盐, 高程, 扬程, 支撑, 支承, 止水, 压力, 成孔, 成型, 腔, 堵塞, 封闭, 封孔, 钻孔, drill???, fill???, soluble, crystals, solid, salt?, sugar?, alum, ice , inject+, support+, drain, permeable, height, lift, seal???, jam, press+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 111794238 A (CHINA RAILWAY ERYUAN ENGINEERING GROUP CO., LTD.) 20 October 2020 (2020-10-20) claims 1-9	1-9
PX	CN 111810234 A (CHINA RAILWAY ERYUAN ENGINEERING GROUP CO., LTD.) 23 October 2020 (2020-10-23) claims 1-10	1-9
A	CN 107246019 A (ZHEJIANG UNIVERSITY) 13 October 2017 (2017-10-13) description, paragraphs 25-37, figure 1	1-9
A	CN 107237650 A (ZHEJIANG UNIVERSITY) 10 October 2017 (2017-10-10) entire document	1-9
A	CN 109629566 A (NINGXIA UNIVERSITY) 16 April 2019 (2019-04-16) entire document	1-9
A	CN 102635402 A (ZHEJIANG UNIVERSITY) 15 August 2012 (2012-08-15) entire document	1-9

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 September 2021	**15 October 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/106035

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 111425249 A (CHINA RAILWAY ERYUAN ENGINEERING GROUP CO., LTD.) 17 July 2020 (2020-07-17) entire document	1-9
A	CN 209780957 U (YUNNAN JIANTOU FOUNDATION ENGINEERING CO., LTD.) 13 December 2019 (2019-12-13) entire document	1-9
A	JP 2011179272 A (RAILWAY TECHNICAL RES. INST. et al.) 15 September 2011 (2011-09-15) entire document	1-9
A	US 2008080931 A1 (MELEGARI, C.) 03 April 2008 (2008-04-03) entire document	1-9

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/106035

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	111794238	A	20 October 2020	CN	111794238	B	04 May 2021
CN	111810234	A	23 October 2020	CN	111810234	B	29 June 2021
CN	107246019	A	13 October 2017	WO	2019000776	A1	03 January 2019
				US	2019153698	A1	23 May 2019
				CN	107246019	B	29 October 2019
				US	10577770	B2	03 March 2020
CN	107237650	A	10 October 2017	CN	107237650	B	11 February 2020
CN	109629566	A	16 April 2019	CN	109629566	B	06 April 2021
CN	102635402	A	15 August 2012		None		
CN	111425249	A	17 July 2020		None		
CN	209780957	U	13 December 2019		None		
JP	2011179272	A	15 September 2011	JP	5313192	B2	09 October 2013
US	2008080931	A1	03 April 2008	EP	1908884	A2	09 April 2008
				EP	1908884	A3	27 November 2013
				US	7455480	B2	25 November 2008
				IT	PC20060043	A1	03 April 2008

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 107246019 A **[0003]**