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(54) Method for providing a slab-shaped underground structure

Verfahren zur Bereitstellung einer fliesenförmigen Bodenstruktur

Procédé pour fournir une structure souterraine en forme de dalle

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Description

[0001] The present invention relates to a method for providing a slab-shaped underground structure.

[0002] A method is known from the prior art for providing a slab-shaped base surface in a construction pit. The construction pit is composed of vertical walls and has a horizontal base surface. The vertical walls can be provided in a conventional manner by vibrating or ramming sheet piling into the ground.

[0003] Various methods are known for providing the horizontal base surface. In one conventional method, the ground is first excavated and groundwater pumped off, following which a concrete base surface is provided. The drawback of this method is that it is labour-intensive and results in a considerable degree of disruption for the existing environment.

[0004] With another conventional method for providing a horizontal base surface in the ground, spheres of water glass are injected into the ground. From ground level, injection pipes are introduced into the ground in accordance with a fixed pattern of equilateral triangles. The distal ends of the injection pipes are situated at the same vertical position in the ground. After the injection pipes have been positioned, a sphere of water glass is injected into the ground by passing water glass through the injection pipe. By controlling the injection pressure, it is possible to ensure that the water glass spreads in all directions in the ground and thus creates a spherical shape. As the injection pipes are close together due to the triangular configuration, the spheres of water glass will connect with one another during injection. Once sufficient water glass has been injected, a slab-shaped base surface will have formed under the distal ends of the injection pipes. The injection pipes can be removed and re-used for a subsequent piece of slab-shaped base surface.

[0005] One drawback of this conventional method is that the ground above the slab-shaped base surface has to be completely and uniformly perforated with injection pipes. The presence of any obstacles in the ground prevents the injection pipes from being provided at a regular distance. A further drawback is the fact that damage is caused on the ground surface and the existing plants are damaged due to the installation of the injection pipes. Another significant drawback is the fact that this conventional method cannot be used if there are buildings on the ground surface.

[0006] WO94/25688 discloses a method for sealing off ground sites and a device for carrying out this method. The ground site is in particular a waste dump, wherein a waste body is disposed in the ground. In a first step of the method, a drilling operation is arranged, wherein a controllable drill head is used to make a plurality of drilling holes underneath the waste body. The controllable drill head is introduced into the ground at a starting point and drilled through the ground over a curved line to an end point at ground level. In a next step of the method, the drill head is withdrawn through the drill hole, wherein a

setting substance is injected to form a slab-shaped underground structure. Directional injections are made while the drill head is withdrawn.

[0007] From the prior art, there is therefore a great demand for a method providing a slab-shaped underground structure which at least partially overcomes the above drawbacks. For example within the field which relates to the reinforcement of dikes, there is a great demand for a method for providing a so-called polder caisson. The polder caisson is a basin-type structure which is provided underground on the landside of the dikes. The basin-type structure has vertical walls and a horizontal base surface. The vertical walls and the horizontal base surface are poorly permeable to water and therefore not entirely water-tight. The polder caisson serves as a water-control structure. The polder caisson is furthermore provided with a drainage facility.

[0008] The object of the polder caisson is to control water pressures in the water-bearing sand layer and in the compressible layer on the landside of the dikes, immediately behind the dike, in such a manner that these become independent of the water level. The polder caisson provides an interruption in the shear plane between the water-bearing sand layer and the ground layer above the latter. Furthermore, the polder caisson acts as a deadweight which contributes to the strength of the dike. Another advantageous effect of the polder caisson is that the distance along which the seepage water has to travel is increased as it has to pass under the polder caisson. This further improves the strength of the dike.

[0009] Constructing the polder caisson can partly be carried out using conventional methods. The vertical walls may, for example, be constructed by digging trenches which are filled with a mixture of cement and bentonite. The horizontal base surface could be constructed by means of the conventional method, as described above with the aid of spheres of water glass. However, due to buildings on the dike and the considerable damage to the flora and fauna which this method can cause, the method is not always desirable and cannot always be used. Thus, there is a great demand for a method which can be performed for reinforcing dikes in situations where buildings are present on the dike.

[0010] It is an object of the present invention to at least partly overcome one of the abovementioned drawbacks and/or to provide a usable alternative. In particular, it is an object of the invention to provide a method for providing a slab-shaped underground structure, in which detrimental effects on the environment and on existing buildings are avoided as much as possible.

[0011] This object is achieved using the method for providing a slab-shaped underground structure according to claim 1. The method according to the invention comprises various steps. In a first step, an earth-drilling device is set up for introducing a drill pipe with a controllable drill bit into the ground at an entry point. Preferably, the drill pipe with drill bit is introduced into the ground at an angle of inclination of at least 5° to at most 40° with

respect to the ground level.

[0012] Subsequently, a first controlled bore hole is drilled from the entry point through the ground to an exit point. The expression a controlled bore hole is understood to mean that the bore hole is drilled using a controllable drill bit. A controllable drill bit for drilling into the ground is known, for example, from US2004238222.

[0013] During drilling, a plurality of drill pipes can be connected to one another. Preferably, a drill pipe has a length of at most 5 metres, but in particular at most 3 metres and a diameter of at least 50 mm and at most 250 mm.

[0014] After the bore hole has been drilled, the injection of a hardening substance, such as grout or water glass, can begin. When the drill bit has reached the exit point, an injection head is connected to one end of the drill pipe for injecting a hardening substance. The injection head is pulled through the bore hole and at the same time a hardening substance is injected into the ground around the bore hole over at least part of the bore hole. This results in a body made of hardening substance being formed at the location of the bore hole. Preferably, the injection head is coupled to the drill bit or exchanged for the drill bit at the end of the drill pipe at the exit point. From the exit point, the injection head can then be retracted through the bore hole.

[0015] Preferably, the drill pipes are retracted from the bore hole in a rotating manner using the earth-drilling device. Thus, the friction between the drill pipes and the surrounding earth will be relatively low.

[0016] By injecting a hardening substance, a hardened body is formed over at least a part of the bore hole. When the injection head is retracted in a rotating manner, a cylindrical hardened body is formed.

[0017] After the first bore hole has been created, a second controlled bore hole is drilled substantially parallel to the first bore hole, a hardening substance being injected into the ground around the bore hole over at least part of the second bore hole.

[0018] The centre-to-centre distance between the first and second bore hole should be chosen in such a manner that the hardening substances in the ground around the bore holes come into contact with one another. Preferably, the centre-to-centre distance between the second bore hole and the first bore hole is at most 100 cm, but more preferably at most 80 cm. The bodies of hardening substance will then merge with one another, so that eventually one large hardened body is obtained.

[0019] It is advantageous with the method according to the invention that providing the slab-shaped structure is achieved quickly, in particular when compared to the above-described conventional method in which spheres of water glass are injected. Injecting spheres of water glass is carried out in a slow manner in order to distribute the water glass in the ground as evenly as possible. It is only by slow injection that a spherical shape can be achieved. According to the invention, the hardening substance can be injected into the bore holes in a continuous

process. An even distribution of the hardening substance is less important, so that a great deal of time can be saved. It is possible to form a substantial part of the slab-shaped structure to be produced in a short time.

[0020] Another significant advantage of the method according to the invention is the fact that the method can be used in situations where a slab-shaped structure has to be provided under existing buildings. The bore holes can be drilled in a controlled manner under the existing buildings from the entry point. Thus, the method does not have a detrimental effect on the existing buildings, flora and fauna on ground level. Due to the fact that large distances of, for example, 100 m can be crossed by means of controlled drilling, the buildings on a dike do not present an obstacle when constructing a polder caisson in order to reinforce said dike.

[0021] A further advantage is the fact that the method according to the invention uses less material and equipment. Compared to the conventional method using spheres of water glass, it is possible to achieve savings of approximately 80% on material. In addition, the amount of equipment required with the method according to the invention can be greatly reduced. The conventional method using spheres of water glass requires approximately two injection pipes per square metre, while with the method according to the invention, the amount of equipment required, such as drill pipes, depends mainly on the length of the bore holes to be produced.

[0022] In one preferred embodiment of the method according to the invention, the bore holes are injected with a hardening substance according to a fixed pattern. When forming a slab-shaped structure, the bore holes are substantially parallel to one another. In an embodiment of the method according to the invention, the adjacent bore holes can be injected simultaneously or successively. However, intermediate bore holes are preferably injected later. Initially, the hardening substance is injected into bore holes which are relatively far from one another. The bore hole itself and the ground around the bore hole will retain the hardening substance. The hardening substance is injected in such a manner that a neighbouring bore hole is not filled with the hardening substance. Subsequently, the neighbouring bore holes themselves are injected with the hardening substance. As this takes place at a later stage, the body of hardening substance from the neighbouring, intermediate bore holes will expand so as to merge with the previously produced bodies of hardening substance. As a result thereof, a slab-shaped structure can advantageously be produced in a controlled manner.

[0023] In a further particular embodiment of the method according to the invention, the injection pressure is measured when the hardening substance is being injected into the intermediate bore holes at a later stage. This serves as a measure for the leaktightness of the slab-shaped structure to be produced. When the injection pressure is high, this is an indication that bodies of hardening substance are expanding so as to merge with one

another.

[0024] Preferably, a water glass mixture is injected while the injection head is retracted through the bore hole. This is advantageous as the water glass mixture is environmentally friendly and as a mixture of water glass and, for example, a hardener, may offer the required water-inhibiting properties of the slab-shaped structure.

[0025] Preferably, the bore hole is flushed with bentonite while it is being drilled. Bentonite is a natural clay, whose main ingredient is the mineral montmorillonite. Bentonite has excellent suspension, supporting, stabilizing and plastering properties, which make it eminently suitable for the method according to the invention.

[0026] In one preferred embodiment of the method according to the invention, a storage pit is provided near the entry point and/or near the exit point for collecting flushing liquid during drilling. This is advantageous as the materials used during drilling, flushing and injecting, such as water glass, grout and bentonite, can be collected in the storage pit, which can be emptied in an environmentally friendly way after the various operations have been carried out.

[0027] Preferably, various process parameters are measured with a method according to the invention. During drilling, for example, the liquid pressure and the liquid flow rates to the storage pit can be measured. It is likewise advantageous to measure the volume of injected liquid during injection of hardening substance. Thus, it is possible to closely monitor progress of the process while the method is carried out and to intervene in the process in time, for example as a result of setting a monitoring function.

[0028] Furthermore, the invention relates to an injection head which is particularly suitable for use with the method according to the invention, in which the injection head comprises a line which is provided with a reamer. Preferably, the injection head can be fitted to an end of a drill pipe. When the bore hole has been drilled, the drill bit and the associated controlling measuring system can be removed and the injection head can be fitted. Subsequently, the injection head can be pulled through the bore hole. The reamer is axially connected to the injection head. When the injection head is being pulled through the bore hole, the reamer ensures that this takes place in a smooth manner. Preferably, a flushing line is connected to the reamer for lubrication and maintaining the bore hole.

[0029] In a preferred embodiment, the injection head according to the invention is provided with a rotation locking member. This rotation locking member prevents any undesirable rotation of the injection head inside the bore hole. The injection head may be connected to the drill pipes by means of a swivel when these are retracted in a rotating manner through the bore hole. The rotation locking member may be provided with electronic means, a rotation sensor, such as a gyroscope, and a radio detection measuring system which is coupled to a computer program in order to ensure that the injection head has

the correct angular displacement with respect to the bore hole. By preventing a rotation of the injection head, no cylindrical body of hardened substance will be produced around the bore hole, but only a slab-shaped body of hardened substance will be created. As a result, the injected hardened substance is provided in a more efficient manner in order to form a slab-shaped structure and a significant saving on material can be achieved.

[0030] Preferably, the injection head comprises at least one radially extending nozzle, but more preferably, the injection head according to the invention comprises at least two nozzles situated opposite one another. Advantageously, a slab-shaped body can expediently be formed from the hardening substance by means of this injection head.

[0031] Furthermore, the invention relates to the use of the method according to the invention for reinforcing a dike by constructing a polder caisson, as defined in claim 10.

[0032] Further preferred embodiments are defined in the other subclaims.

[0033] The invention will be described in more detail below with reference to the attached drawings which show a practical embodiment of the invention, but should not be seen as limiting, in which:

Fig. 1 shows a diagrammatic representation of a slab-shaped underground structure provided under existing buildings;

Fig. 2 shows a number of bore holes in cross section, in which a hardened body has formed around the bore holes;

Fig. 3 shows a number of bore holes in cross section, in which a flat hardened body is obtained by using a non-rotating injection head; and

Fig. 4 shows a diagrammatic detail view of the end of a drill pipe with an injection head according to the invention attached thereto.

[0034] Fig. 1 diagrammatically shows a site for applying the method according to the invention, in which buildings are present on the ground level. This may, for example, be an area on the landside of the dikes. Under the buildings 1, a bore hole 2 has been drilled from the entry point A to the exit point B. A controllable drill bit has been used in order to produce the bore hole 2. At the entry point A, an earth-drilling device is set up in order to introduce a drill pipe with the controllable drill bit attached thereto into the ground. Preferably, the angle of inclination at which the drill pipe with drill bit is introduced is between 6° and 36°. Depending on the circumstances on the site, a bore hole can have a length of at most 1000 metres. When constructing a polder caisson, it may, for example, be desirable to provide a slab-shaped structure having a width of at least 15 metres and a length of at least 100 metres. The depth of the bore hole can be adjusted as desired. In the case of a polder caisson, it may for example be desirable to construct this at a depth of

3 metres in the water-bearing sand layer. This can be achieved using the method according to the invention. If the drill bit has reached the exit point B according to the method according to the invention, the coupled drill pipes can be retracted. During the retraction, hardening substance is injected over at least part of the bore hole, which results in the body of hardening substance 3. By successively drilling and injecting substantially parallel to the first bore hole, with the bodies of hardening substance merging with one another, a slab-shaped structure is obtained according to the method according to the invention.

[0035] Fig. 2 shows a cross-sectional view of various bore holes which have been drilled substantially parallel to one another. The bore holes are numbered I, II and III. The bore holes may be drilled and injected in the order I, II, III, but it is advantageous to initially skip in each case one bore hole. According to the invention, the bore holes I and III are then drilled and injected first, after which bore hole II is drilled and injected. The hardened bodies 3 around the bore holes 2 are obtained by rotating the injection head while pulling it through the bore hole. This results in a cylindrical hardened body 3 having a circular cross section.

[0036] The cylindrical hardened body around bore hole II is created after the bodies 3 around bore holes I and II have hardened. Fig. 2 shows that the hardened body 3 around bore hole II has expanded so as to merge with the hardened bodies 3 around bore holes I and III. By providing the body of hardening substance in the intermediate bore hole II later, it is possible to ensure more reliably that the slab-shaped structure obtained is leak-tight. In order to check that this is the case, it is possible to check the injection pressure while the hardening substance is being injected into the intermediate bore hole 2. When the injection pressure is high, this is an indication that the hardening substance can spread less readily around the bore hole II. This means that the hardening substance flows onto the hardened bodies 3 around the bore holes I and III.

[0037] Fig. 3 shows a cross-sectional view of 5 bore holes I, II, III, IV, V. The bore holes have been produced according to the method according to the invention. The bore holes I - V are substantially parallel to one another and are injected with a hardening substance. Analogously to the method described with reference to Fig. 2, the bore holes II and IV are in this case injected with a hardening substance at a later stage. Thus, the bodies of hardening substance around the bore holes II and IV have expanded so as to merge with the hardened bodies around bore holes I, III and V.

[0038] Compared to the hardened bodies as illustrated in Fig. 2, the hardened bodies around the bore holes here do not have a circular cross section. In cross section, the hardened bodies around the bore holes have a width which is approximately twice the height. As a result thereof, the hardened bodies around the bore holes are more slab-shaped. Advantageously, these slab-shaped hard-

ened bodies are more expedient for producing the final slab-shaped structure. As a result thereof, the hardening substance, such as water glass, is handled effectively.

[0039] By means of the method according to the invention, it is possible to produce an underground polder caisson having a wall thickness of 0.2 metres and a width of 15 metres. The bore holes 2 are provided at a centre-to-centre distance "a" of at most 100 cm, but preferably at most 80 cm. The slab-shaped hardened bodies 3 have been produced by passing the injection head through the bore hole without rotation. By not rotating the injection head with respect to the bore hole, the hardening substance is injected in a fixed direction over at least part of the bore hole. In order to fix the angular displacement of the injection head with respect to the bore hole, electronic means may be used, such as a radio-detection system, a gyroscope, etc., such as are used in the controllable drill bit.

[0040] In order to produce the slab-shaped hardened body 3, as illustrated in Fig. 3, use can be made of two nozzles situated opposite one another in the injection head.

[0041] Fig. 4a shows a top view of an end of a drill pipe 4 with a transmitter housing 5 and an injection head 7 having two pairs of nozzles 8 situated opposite one another connected thereto. Hardening substance can be injected into the bore hole and the surrounding earth via the nozzles 8. The direction of flow of the injected hardening substance is substantially axial in the longitudinal direction of the bore hole towards the connection with the drill pipe.

[0042] The transmitter housing 5 serves to check the displacement of the injection head 7. A transmitter is provided in the transmitter housing which can measure the displacement of the injection head. Preferably, the transmitter housing comprises a swivel which ensures that the injection head 7 does not have to rotate along with the drill pipe 4. Furthermore, the transmitter housing preferably comprises a reamer when the drill pipes are retracted through the bore hole in a rotating manner. A line may be connected to the reamer for the supply of a flushing agent.

[0043] Fig. 4b shows a side view of the end as illustrated in Fig. 4a. The injection head 7 is slab-shaped in the shape of a triangle. At one corner, the injection head 7 is fitted to the transmitter housing 5.

[0044] Many variants are possible in addition to the embodiments illustrated in the drawings without departing from the scope of protection of the invention as defined in the claims.

[0045] In one variant of the illustrated embodiment of the method according to the invention, a curved slab-shaped structure having, for example, vertical strip parts, can be formed instead of a flat horizontal slab-shaped structure. The pattern of the bore holes determines the ultimate cross section of the structure. It is possible to provide all types of conceivable shapes of structure, such as tubular tunnel structures, using the method according

to the invention.

[0046] Thus, the invention provides a method by means of which a slab-shaped underground structure can expediently be formed. It is particularly advantageous that the method according to the invention has only a minimal effect on the existing environment and that the method can even be used in the case of existing buildings.

Claims

1. Method for providing a slab-shaped underground structure comprising the following steps:

- setting up an earth-drilling device for introducing a drill pipe (4) with a controllable drill bit into the ground at an entry point;
- drilling a first controlled bore hole (2) from the entry point (A) through the ground to an exit point (1B);
- connecting an injection head (7) to one end of the drill pipe (4) for injecting a hardening substance (3);
- drilling a second controlled bore hole substantially parallel to the first bore hole, a hardening substance being injected into the ground around the bore hole over at least part of the second bore hole; and
- retracting the drill pipe (4) in a rotating manner through the first bore hole (2) and pulling the injection head (7) through the bore hole, and at the same time injecting a hardening substance (3) into the ground around the bore hole over at least part of the bore hole, **characterized in that** the method comprises the step of:
- connecting the injection head (7) by means of a swivel to the drill pipe.

2. Method according to claim 1, in which the centre-to-centre distance (a) between the second bore hole and the first bore hole after the bore holes have been drilled is at most 100 cm.

3. Method according to claim 1 or 2, in which a number of adjacent bore holes (I, II, III) are injected according to a fixed pattern in order to form the slab-shaped structure, with intermediate (II), substantially parallel bore holes being injected later.

4. Method according to claim 3, in which the injection pressure is measured while the hardening substance (3) is being injected into the intermediate bore hole.

5. Method according to one of the preceding claims, in which a water glass mixture is injected while the injection head (7) is retracted through the bore hole.

6. Method according to one of the preceding claims, in which a storage pit is provided near the entry point (A) and/or near the exit point (B) for collecting flushing liquid during drilling.

7. Method according to one of the preceding claims, in which a bore hole (2) is drilled having a length of between 30 and 1000 metres.

8. Method according to one of the preceding claims, in which process parameters are measured.

9. Method according to one of the preceding claims, in which the bore hole (2) is flushed with bentonite while it is being drilled.

10. Use of the method according to one of claims 1-9 for reinforcing a dike for constructing a polder caisson.

Patentansprüche

1. Verfahren zum Bereitstellen einer tafelförmigen unterirdischen Struktur, das die folgenden Schritte umfasst:

- Aufstellen einer Erdbohrvorrichtung zum Einleiten eines Bohrgestänges (4) mit steuerbarem Bohrkopf in den Boden an einem Eintrittspunkt;
- Bohren eines ersten gesteuerten Bohrlochs (2) von dem Eintrittspunkt (A) durch den Boden bis zu einem Austrittspunkt (1B);
- Verbinden eines Einspritzkopfes (7) mit einem Ende des Bohrgestänges (4) zum Einspritzen einer aushärtenden Substanz (3);
- Bohren eines zweiten gesteuerten Bohrlochs im Wesentlichen parallel zu dem ersten Bohrloch, wobei über wenigstens einen Teil des zweiten Bohrlochs eine aushärtende Substanz in den Boden um das Bohrloch herum eingespritzt wird; und
- drehendes Herausziehen des Bohrgestänges (4) über das erste Bohrloch (2) und Herausziehen des Einspritzkopfes (7) über das Bohrloch bei gleichzeitigem Einspritzen einer aushärtenden Substanz (3) über wenigstens einen Teil des Bohrlochs in den Boden um das Bohrloch herum,

dadurch gekennzeichnet, dass das Verfahren die folgenden Schritte umfasst:

- Verbinden des Einspritzkopfes (7) mit dem Bohrgestänge mittels eines Schwenkkopfes (swivel).

2. Verfahren nach Anspruch 1, wobei der Mittenabstand (a) zwischen dem zweiten Bohrloch und dem

ersten Bohrloch nach dem Bohren der Bohrlöcher maximal 100 cm beträgt.

3. Verfahren nach Anspruch 1 oder 2, wobei in eine Anzahl benachbarter Bohrlöcher (I, II, III) entsprechend einem festen Muster eingespritzt wird, um die tafelförmige Struktur auszubilden, wobei in im Wesentlichen parallele Zwischen-Bohrlöcher (II) später eingespritzt wird. 5
4. Verfahren nach Anspruch 3, wobei der Einspritzdruck gemessen wird, während die aushärtende Substanz (3) in das Zwischen-Bohrloch eingespritzt wird. 10
5. Verfahren nach einem der vorangehenden Ansprüche, wobei ein Wasserglas-Gemisch eingespritzt wird, während der Einspritzkopf (7) über das Bohrloch herausgezogen wird. 15
6. Verfahren nach einem der vorangehenden Ansprüche, wobei in der Nähe des Eintrittspunktes (A) und/oder des Austrittspunktes (B) eine Lagergrube zum Auffangen von Spülfluid beim Bohren vorhanden ist. 20
7. Verfahren nach einem der vorangehenden Ansprüche, wobei ein Bohrloch (2) mit einer Länge zwischen 30 und 1000 Meter gebohrt wird. 25
8. Verfahren nach einem der vorangehenden Ansprüche, wobei Prozessparameter gemessen werden. 30
9. Verfahren nach einem der vorangehenden Ansprüche, wobei das Bohrloch (2) mit Bentonit gespült wird, während es gebohrt wird. 35
10. Einsatz des Verfahrens nach einem der Ansprüche 1-9 zum Verstärken eines Deichs beim Bauen eines Polder-Senkkastens. 40

Revendications

1. Procédé pour fournir une structure souterraine en forme de dalle comprenant les étapes suivantes consistant à : 45
 - mettre en place un dispositif de forage du sol pour introduire une tige de forage (4) avec un trépan contrôlable dans le sol au niveau d'un point d'entrée ; 50
 - forer un premier trou de forage contrôlé (2) depuis le point d'entrée (A), au travers du sol, jusqu'à un point de sortie (1B) ;
 - connecter une tête d'injection (7) à une extrémité de la tige de forage (4) pour injecter un produit durcisseur (3) ; 55
 - forer un deuxième trou de forage contrôlé sen-

siblement parallèle au premier trou de forage, un produit durcisseur étant injecté dans le sol autour du trou de forage sur au moins une partie du second trou de forage, et

- rétracter la tige de forage (4) de manière rotative au travers du premier trou de forage (2) et tirer la tête d'injection (7) au travers du trou de forage, et en même temps, injecter un produit durcisseur (3) dans le sol autour du trou de forage sur au moins une partie du trou de forage,

caractérisé en ce que le procédé comprend l'étape consistant à :

- connecter la tête d'injection (7), au moyen d'une articulation, à la tige de forage.
2. Procédé selon la revendication 1, dans lequel la distance de centre à centre (a) entre le deuxième trou de forage et le premier trou de forage après que les trous de forage aient été forés, est au maximum de 100 cm.
 3. Procédé selon la revendication 1 ou 2, dans lequel on injecte dans un certain nombre de trous de forage adjacents (I, II, III) selon un modèle fixe afin de former la structure en forme de dalle, avec des trous de forage sensiblement parallèles intermédiaires (II) qui sont injectés plus tard.
 4. Procédé selon la revendication 3, dans lequel la pression d'injection est mesurée pendant que le produit durcisseur (3) est injecté dans le trou de forage intermédiaire.
 5. Procédé selon l'une quelconque des revendications précédentes, dans lequel un mélange de silicate de sodium est injecté pendant que la tête d'injection (7) est rétractée au travers du trou de forage.
 6. Procédé selon l'une quelconque des revendications précédentes, dans lequel un puits stockage est prévu à proximité du point d'entrée (A) et/ou à proximité du point de sortie (B) pour collecter du liquide de rinçage au cours du forage.
 7. Procédé selon l'une quelconque des revendications précédentes, dans lequel un trou de forage (2) est foré en ayant une longueur comprise entre 30 et 1000 mètres.
 8. Procédé selon l'une quelconque des revendications précédentes, dans lequel les paramètres de processus sont mesurés.
 9. Procédé selon l'une quelconque des revendications précédentes, dans lequel le trou de forage (2) est rincé avec de la bentonite pendant qu'il est en cours

de forage.

10. Utilisation de la méthode selon l'une quelconque des revendications 1 à 9 pour le renforcement d'une digue pour la construction d'un caisson de polder.

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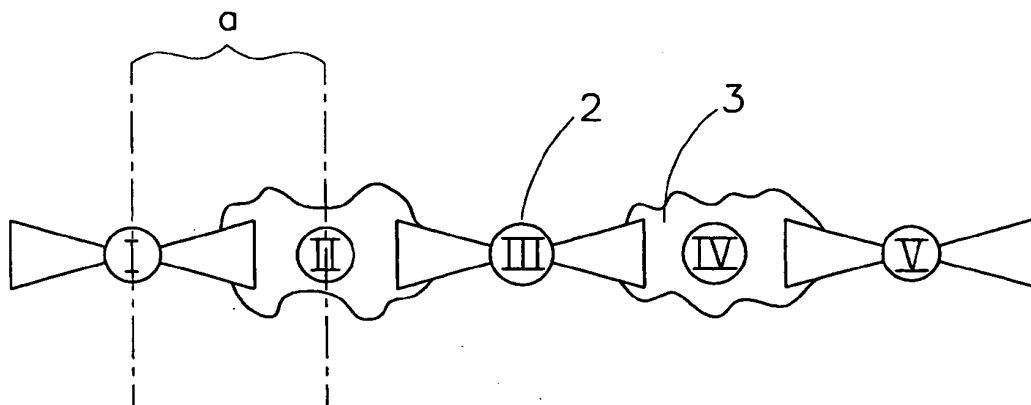
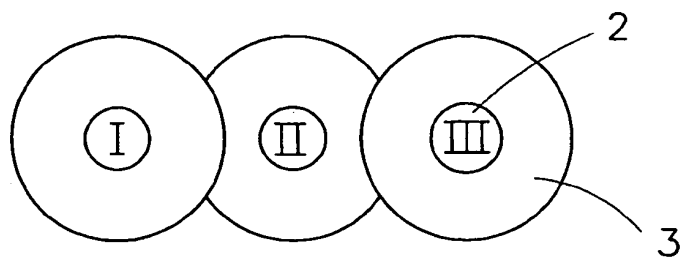
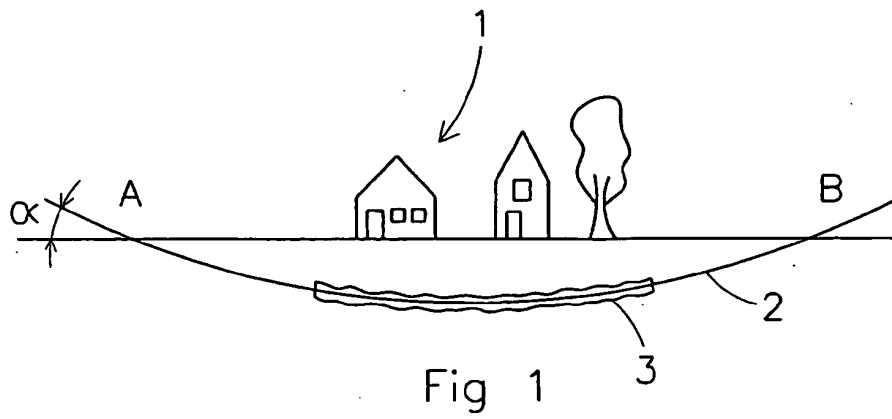
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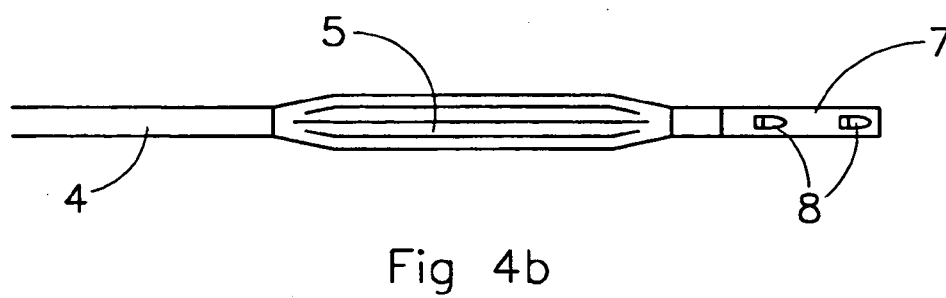
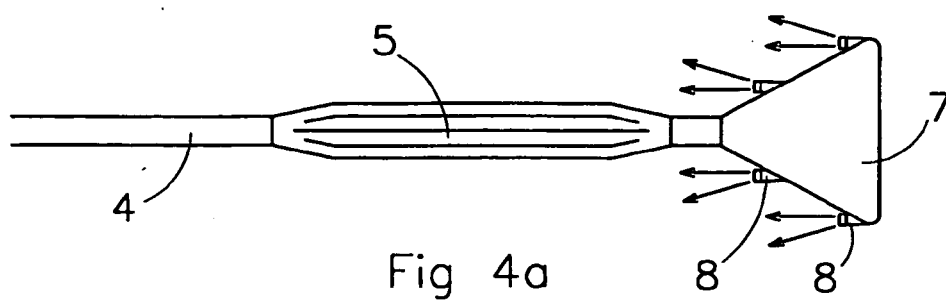
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REFERENCES CITED IN THE DESCRIPTION

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