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(54) METHOD FOR ANCHORING AN OBJECT TO THE GROUND

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Description

[0001] The invention relates to a method for anchoring an object to the ground with at least one pile that gets inserted into the ground.

[0002] From the state of the art various methods are known for inserting anchor piles into the ground.

[0003] For example NL-8403178 A1 discloses a method for drilling a screw injection type tension anchor pile into the ground. The screw injection type tension anchor pile described herein is presently well known as a "Leeuwanker". This "Leeuwanker" comprises a head section with a hollow steel tube section which comprises a spiral screw blade that extends as a drill portion over ca. 1 meter along an outer circumference of the hollow steel tube section. This head section is connectable to one or more smooth hollow steel tube sections of maximum 7 metres length by means of complementary threaded connections. Between windings of the spiral screw blade, outlet openings are provided which connect to a feed channel that is formed inside the hollow tube sections.

[0004] At present it is common practice to insert the "Leeuwanker" into the ground by means of first drilling the head section in rotation into the ground, then connecting one of the rod sections thereto, subsequently drilling the connected head and rod section further into the ground, then connecting another one of the rod sections thereto, subsequently drilling the expanded set of connected sections further into the ground, etc. This drilling is ended when a desired depth is achieved with the thus formed anchor pile. During the drilling, the spiral screw blade pulls the connected sections further into the ground. If desired a downwards pushing force can be added to a rotational momentum that gets exerted on the connected sections during drilling.

[0005] During a final stage of the drilling of the connected sections into the ground, grout gets pressurized into the feed channel. This grout gets injected around the head section into the ground via the outlet openings in the head section. The injected grout then gets mixed with ground particles by the spiral screw blade. After curing, this grout/ground mixture forms a rigid anchoring volume around the head section. After that, an object to be anchored can be coupled to a proximal end of the thus formed tension anchor pile.

[0006] The progress of the drilling of the connected sections into the ground is dependent on the resistance of the ground, the desired insertion depth for the anchor pile to be reached, obstructions that may be present in the ground, etc. In practice it sometimes appears that a desired insertion depth of for example more than 20 metres can hardly be reached, because a resistance for the anchor pile to get further drilled into the ground gets too high. Also it occurs that the drilling of the anchor pile to its desired depth takes a lot of time and/or requires great power from a heavy drill apparatus.

[0007] Another example for forming an anchor pile in the ground is disclosed in WO 2009/103149. Here a

method is described which starts with positioning a sonic drill apparatus at a desired location where the anchor pile needs to be formed into the ground. With this sonic drill apparatus a cased hole is formed into the ground. For this a hollow drill string with a removable or retrievable drill bit that is operatively connected to its distal end, is drilled into the ground while at the same time having a downwards pushing force exerted upon the string and while at the same time having a sonic vibration introduced in the string. The drill bit at its front side comprises a large opening. This opening serves two purposes. Firstly it is used to have a highly pressurized flushing fluid that gets injected via the inside of the hollow drill string flush away all the ground particles that have been drilled loose by the drill bit. The mixture of the flushing fluid and ground particles then gets transported to above ground along an outer side of the drill string. For this the drill bit is dimensioned larger than the drill string itself. A pile is then lowered into the cased hole. After that grout gets pumped into the hole. As soon as the hole is fully filled with the grout, the drill string including the drill bit gets pulled and/or vibrated out of the ground, such that it can be used again. For this being able to remove the drill string, the second purpose of the large opening of the drill bit becomes clear, because otherwise it would be impossible to remove the drill bit and drill string out of the ground again, since with this upwards movement it needs to be able to pass along the pile that has been lowered into the cased hole. After the drill string has been removed again, the grout gets time to cure inside the cased hole around the pile, such that after curing a founded anchor pile is formed.

[0008] A disadvantage with this is that the thus forming of the anchor pile is laborious, time-consuming and expensive. It is necessary to first drill a drill string into the ground which at the end needs to be removed again. Another disadvantage is that it is necessary to keep the hollow drill string completely empty of ground particles during the entire drilling process, because otherwise the pile cannot be lowered into the thus formed cased hole. Yet another disadvantage is that the flushed out ground particles need to be accumulated and transported away above ground. Also it is noted that a lot of grout is needed since the cased hole needs to be filled with it over its entire height. The tension strength of the thus formed founded anchor pile leaves to be improved because the grout does not get mixed with any circumventing ground particles. Finally it is noted that it is not possible to use the thus formed anchor pile until after the entire drill string has been removed and after the grout has fully cured.

[0009] The present invention aims to overcome those disadvantages at least partly or to provide a usable alternative. In particular the invention aims to provide a user-friendly and highly efficient method for anchoring an object to the ground with a truly reliable anchor pile that has been easily and swiftly inserted into the ground while at the same time resulting in a high tension strength.

[0010] This aim is achieved by a method according to

claim 1. The method for anchoring an object to the ground with at least one anchor pile that gets inserted into the ground, comprises the step of positioning a sonic drill apparatus at a position where the anchor pile is to be inserted into the ground. An assembly is provided of a head section and one or more rod sections, in which the rod sections are connectable to the head section and to each other while extending in a longitudinal direction for forming the anchor pile. The sections that together form the anchor pile are inserted into the ground. After a desired penetration depth has been reached for the head section, the object gets coupled to a proximal end of the connected sections of the anchor pile. According to the inventive thought the head section of the provided assembly comprises a drilling portion for drilling into the ground. Further, the inserting of the anchor pile into the ground comprises a drilling of the head section with its drilling portion in rotation directly into the ground by means of the sonic drill apparatus, after which one or more times one of the rod sections gets connected thereto such that the connected head and rod sections together can be drilled further into the ground by means of the sonic drill apparatus. During at least part of this drilling, a sonic vibration is introduced into the connected sections by means of the sonic drill apparatus.

[0011] Owing to the combined drilling action directly onto the connected sections together with the introduced sonic vibration frequency directly into the connected sections, during at least part of the drilling, it has surprisingly appeared possible to no longer first having to form a cased hole with the aid of a retrievable drill string. Thus large savings can be obtained in time and labour for forming the anchor or foundation piles. Also it has surprisingly appeared that it is no longer necessary to make use of a highly pressurized flushing liquid for transporting ground particles that have been drilled loose to above ground level. Furthermore it is advantageously no longer necessary to have large amounts of grout fill up an entire cased hole over an entire length of a pile inserted therein. Another advantage is that the thus formed anchor pile is able to deal with higher tension or compression forces compared to the above described state of the art anchor piles when having comparable lengths and cross-sectional dimensions. Certain aimed or desired insertion depths can more easily and much quicker be reached. For example for the abovementioned "Leeuwanker" it has occurred during tests that savings in time can be reached of about more than 50%. Also it has occurred during those tests that the drilling process for this type of anchor pile now requires substantially less power.

[0012] According to the invention, the inventive thought is used in combination with an injection type anchor pile, that is to say that the provided assembly then comprises hollow tube sections as rod sections, and that the head section then comprises one or more outlet openings. Those openings are connectable to a feed channel that arises inside the hollow tube sections when those sections are connected to each other. It is then possible,

during at least a final stage of the drilling of the connected sections into the ground, to feed a curable substance pressurized through this feed channel. The curable substance then gets injected via the one or more outlet openings into the ground to form a volume of a mixture of the curable substance and ground particles around the head section. According to the invention, the introduced sonic vibration then is used during this injection for compacting the mixture of the curable substance and ground particles around the head section after which the curing of the thus compacted mixture takes place. This compacting phase, advantageously helps to increase the strength of the thus formed anchor pile.

[0013] According to the invention, the head section is closed or substantially closed in the longitudinal direction at its front side. With this it is in particular meant that some or all of the one or more outlet openings can still be provided at this front side of the head section, as long as the rest of the feed channel towards the front side is blocked by front wall parts of the head section. Thus the introduced sonic vibrations can also efficiently be transferred to the ground directly underneath this front side of the head section, while at a same time it is prevented that (too large amounts of) ground particles get to enter the feed channel during the drilling/inserting process.

[0014] It is noted that US 2009/0101412 A1 already shows a method for drilling holes into the ground in which use can be made of a sonic drilling unit, and in which a drill string is used with a head section that comprises an earth-boring tool at its front side. However such a drill string is specifically destined to drill holes into the ground and after that immediately gets retracted out of the ground again. It is an expensive tool that is not destined or suitable to be left behind in the ground for use as an injection type anchor pile.

[0015] Further it is noted that US 2010/0101863 A1 already shows a method for obtaining ground samples at large depths in which use can be made of a sonic drilling unit, and in which a drill string is used with a head section that comprises a drill bit at its front side. However such a drill string is specifically destined to drill undisturbed ground samples out of the ground and after that immediately gets retracted out of the ground again. It is a specific sampling tool that is not destined or suitable to be left behind in the ground for use as an injection type anchor pile.

[0016] It is possible to keep the feed channel and outlet opening(s) filled with an amount of the curable substance, after the volume of the mixture of the curable substance and ground particles has been formed around the head section. This amount of the curable substance then can also cure inside the hollow tube sections and thus can further strengthen and reinforce the formed anchor or foundation pile.

[0017] In a variant it is however also possible to fill the feed channel and outlet opening(s) with an amount of non-curable substance, after the volume of the mixture of the curable substance and ground particles has been

formed around the head section. The non-curable substance then even may get to form a thin layer around that part of the head section where the one or more outlet openings are provided. The presence of the non-curable substance inside the feed channel and outlet opening(s) makes it possible to again make use of the feed channel and outlet opening(s) whenever this is desired. The feed channel and outlet opening(s) then have not gotten permanently blocked with cured substance, because the curable substance gets driven out of there before it starts to cure. It then remains possible to at a later stage have some kind of substance injected into the ground again via the feed channel and outlet opening(s). For example this can be desired during a later removal of the anchor or foundation pile out of the ground again, because then a filling substance can be fed via the feed channel and outlet opening(s) simultaneously with the removal. This filling substance then automatically gets to fill up the space that is left behind by the pile, and helps to prevent instabilities to arise in the surrounding ground layers.

[0018] The filling of the feed channel and outlet opening(s) with non-curable substance after the injection step with the curable substance has been completed, can be done by temporarily replacing the feeding of the curable substance to the feed channel by a feeding of the non-curable substance thereto. After an amount of the non-curable substance has entered that is larger than the volume of the feeding channel itself, it can be assumed that the non-curable substance has at least reached the outlet opening(s) and thus has substantially filled up the feed channel inside the hollow tube sections.

[0019] In a further embodiment, the invention can be used in combination with a screw injection type anchor, that is to say that the head section comprises a hollow tube section, and that the drilling portion of the head section comprises a spiral screw blade along at least part of an outer circumference of this hollow tube section. When sonically vibrated during the final stage of the drilling, the spiral screw blade then advantageously may help to further improve the mixing and compacting of the injected curable substance and ground particles.

[0020] Such a spiral screw blade in particular is designed with an outer radius that is at least 1.5 times larger than an outer radius of the hollow tube section, more in particular at least 2 times larger. This gives it sufficient downwards pulling force in the ground during drilling and/or sufficient grip in the ground during use as anchor pile.

[0021] The one or more outlet openings preferably are provided to lie in a circumferential wall of the tube section. The one or more outlet openings then can be directed substantially perpendicular to the longitudinal direction (radially outwardly) which helps to prevent ground particles to enter into the feed channel during drilling/inserting into the ground, and which also helps to properly direct the injection of the curable substance for forming the volume around the head section which volume then can get

compacted by means of the inserted sonic vibrations.

[0022] The one or more outlet openings preferably are provided to lie in between windings of the spiral screw blade. This has the advantage that during drilling the outlet openings lie somewhat protected in between those windings, which helps to prevent ground particles to enter into the feed channel via those outlet openings during drilling/inserting into the ground, and which also helps to properly direct the injection of the curable substance in between the windings where the sonic mixing with the ground particles needs to take place for forming the volume around the head section.

[0023] Preferably each outlet opening has a diameter of less than 10mm such that sufficient injection force for the substance to be injected can be achieved and/or such that it is largely prevented for ground particles to enter into the feed channel during drilling/inserting into the ground.

[0024] In a further embodiment the spiral screw blade extends along at least a front portion of a circumferential wall of the head section. Thus the sonic vibrations can start their positive effect right at the front of the pile. For example the spiral screw blade may get to extend along about 1 meter of the head section. Particularly for forming an anchor pile of the screw injection type, this has appeared optimal for being able to obtain the aimed compacted volume of injected substance and ground particles around and in-between the windings by means of the introduced sonic vibrations. In another example the spiral screw blade may get to extend along more than half a length of the head section.

[0025] In the alternative or in addition thereto, the rod sections may comprise screw thread along their entire outer circumference, that is to say along their entire or substantially their entire lengths in the longitudinal direction. This may help to further improve the strength of the anchor pile. The screw thread can also be used for connecting coupling organs to the rod sections for connecting them to each other.

[0026] The introduced sonic vibration preferably lies controllable by an operator in between 6,000-10,000 VPM. An operator then is able to each time choose a most optimum frequency in dependence of a progress he detects of the drilling of the connected sections into the ground. If for example the penetration resistance of the ground locally gets too high or the penetration speed temporarily gets too low, or the required power starts to get too high, then the operator may increase the sonic vibration frequency, whereas he can lower it again as soon as an obstructions that may be present in the ground is passed by the drilling portion and the penetration speed gets sufficiently high again.

[0027] In an embodiment, after a final stage of the drilling of the connected sections into the ground has ended, that is to say after the intended insertion depth has been reached, the connected sections can be rotated in place for a while, for example a few seconds or even a few minutes, without having those connected sections having

to further advance into the ground but while maintaining the sonic vibration into the connected sections. This may improve the abovementioned compacting and/or mixing of the ground particles around the anchor pile, and in particular around its head section where the curable substance may have been injected into the ground.

[0028] The thus formed anchor piles can be kept inside the ground. It is however also possible to remove them again.

[0029] Further advantageous embodiments are stated in the subclaims.

[0030] The invention shall be explained in more detail below with reference to the accompanying drawings, in which:

- Fig. 1a-c shows three steps of a first embodiment of the method according to the invention with a screw injection type anchor pile;
- fig. 2 schematically shows a lower part of a head section of the screw injection type anchor pile of fig. 1;
- Fig. 3a-b shows three steps of a second embodiment of the method according to the invention with a screw type anchor pile;
- Fig. 4 schematically shows a lower part of a head section of the screw type anchor pile of fig. 3;
- Fig. 5a-c shows three steps of a third embodiment of the method according to the invention with an injection type anchor pile;
- Fig. 6a-b schematically show a cutting head respectively a rod section equipped with such a cutting head of the injection type anchor pile of fig. 5.

[0031] In fig. 1 a mobile device has been indicated in its entirety with the reference numeral 1. It comprises a wheeled base 2 on top of which a guiding mechanism 3 is mounted such that it can be adjusted in angle. A sonic drill apparatus 5 can be moved up and down in a longitudinal direction x along the guiding mechanism 3.

[0032] In fig. 1a a head section 6 of an anchor pile to be formed gets placed inside the device 1 such that the sonic drill apparatus 5 may get to grip onto a proximal end of this head section 6. Furthermore the head section 6 is guided through a double clamping mechanism 7 that is positioned at a lower side of the guiding mechanism 3.

[0033] The head section 6 comprises a hollow tube section 8 that has a closed tip 9 in the longitudinal direction x at its front side. A spiral screw blade 10 extends along a front portion of a circumferential wall of the hollow tube section 8. Outlet openings 11 are provided in the circumferential wall of the tube section 8 of the head section 6. Those openings 11 lie in between windings of the spiral screw blade 10. The openings 11 connect to a feed channel inside the hollow tube section 8. See fig. 2.

[0034] The mobile device 1 with its guiding mechanism 3 and sonic drill apparatus 5 gets positioned such relative to an object 15, for example a deep wall, that needs to be anchored to the ground, that a desired position and

angle are obtained for directing the head section 6 relative to the ground. The head section 6 then gets drilled in rotation into the ground by means of the sonic drill apparatus 5, while at the same time a sonic vibration is introduced by means of the sonic drill apparatus 5 into the head section 6. For this the sonic drill apparatus 5 comprises a suitable vibration generator or oscillator, in particular one that is able to transmit longitudinal wave patterns at sonic vibration frequencies through the head section 6.

[0035] As soon as the head section 6 has been drilled far enough into the ground, the sonic drill apparatus 5 is released from the head section 6 and is moved up again along the guiding mechanism 3. Subsequently a hollow tube section 20 is placed in the device 1 such that its distal end can get connected by means of a screw connection 21 to the proximal end of the head section 6, and such that its proximal end can get gripped by the sonic drill apparatus 5. The connected sections 6 and 20 then together get drilled in rotation into the ground by means of the sonic drill apparatus 5, while at the same time the sonic vibration is introduced by means of the sonic drill apparatus 5 into the connected sections 6, 20. This is shown in fig. 1b.

[0036] This adding of a tube section 20 to the connected sections 6, 20 and then drilling it in combination with the introduced sonic vibration frequency into the ground can get repeated as many times as necessary until a desired end depth is reached by the head section 6.

[0037] During a final stage of this intermittent drilling process, a curable substance like for example grout, may get fed pressurized from above into the feed channel that is formed inside the hollow tube sections 6, 20. This substance then gets injected into the ground via the outlet openings 11, while at the same time getting mixed by the screw blade 10 with ground particles. Since this is merely done during the final stage of the drilling, a volume 22 of a mixture of the curable substance and ground particles is formed around merely a lower part of the head section 6. As soon as the sonic drilling is stopped then, this volume may start to cure and thus helps to anchor the connected sections 6, 20 extra strong to the ground. Owing to the sonic vibration on the one hand the connected sections 6, 20 can more easily get drilled into the ground, while on the other hand the volume 22 around the head section 6 gets compacted more during the final drilling stage.

[0038] Finally the proximal end of the uppermost tube section 20 gets connected with a suitable coupling 24 to the object 15 for anchoring it firmly to the thus formed anchor pile.

[0039] In fig. 3 the same device 1 is used for drilling another type of anchor pile with the aid of sonic vibration into the ground. For this a head section 30 is used that comprises a solid or hollow rod section of which a tip 31 is closed in the longitudinal direction x at its front side. See also fig. 4. A spiral screw blade 32 here extends like an auger along more than half the length of the rod sec-

tion. A solid or hollow rod section 33 gets connected to the head section by means of a screw connection 34, after which the sonic drilling is continued.

[0040] At the end of the drilling no curable substance gets injected into the ground with this type of anchor pile. Owing to the longer length of the spiral screw blade, it may already be sufficient for some ground conditions and purposes to obtain enough tension strength in the anchor pile without having to form a cured volume around its head section.

[0041] In fig. 5 the same device 1 is used for drilling an injection type anchor pile with the aid of sonic vibration into the ground. For this a head section 50 is used that comprises a cutting head 51 as drilling portion. The cutting head 51 is substantially fully closed in the longitudinal direction x at its front side. Only one or more slanted sideways directed outlet openings 53 are provided inside the cutting head 51. See fig. 6.

[0042] The cutting head 51 is connected to a hollow tube section 52 of the head section 50 such that the outlet openings 53 are connected to a feed channel inside the hollow tube section 52. The hollow tube section 52 at its outer circumference is equipped with a screw thread 53 that extends over the entire length of the section 52. The cutting head 51 is provided with complementary internal thread such that it can easily get connected to the section 52.

[0043] After the head section 50 has been drilled for its larger part into the ground at its aimed position and under its aimed angle, a hollow tube section 54 gets connected to the head section 50 by means of a screw connection 55, after which the sonic drilling of the connected sections 50, 54 is continued. The hollow tube section 54 at its outer circumference is also equipped with a screw thread 53 that extends over the entire length of the section 54. The screw connection 55 is provided with complementary internal thread such that it can easily get connected to both the sections 50, 54.

[0044] During the final stage of the drilling, curable substance gets injected into the ground via the outlet openings 53. Thus a curable volume 56 can advantageously be formed around the head section 50, which volume automatically gets compacted by the introduced sonic vibration frequency.

[0045] Besides the embodiments shown numerous variants are possible. For example the dimensions and shapes of the various components can be changed. Furthermore the various parts can be made out of all kinds of materials. For example the head sections and the rod sections are made out of steel or another suitable metal. They can however also be made out of a (reinforced) plastic material as long as the sections are strong enough to be able to deal with sonic vibrations that get introduced therein. Although it has appeared that it is already advantageous for increasing the penetration speed when the sonic vibration is introduced into the rod sections right from the beginning, it is noticed here that in an advantageous embodiment the sonic vibration is at least intro-

duced into the connected sections after they have reached a depth of more than 10.00 m or when the ground conditions become stiffer or harder than clay. This is probably because from that length on, standing resonant wave patterns can more easily start to form inside the connected sections.

[0046] Besides sonic drilling of the anchor piles into the ground, they can also be removed again from the ground by conveniently using the same or a larger type sonic drill apparatus.

[0047] Thus according to the invention an advantageous method is developed for forming anchor piles in the ground with the aid of introducing sonic vibration frequencies directly into connected rod sections of those anchor piles during the drilling process.

[0048] The cutting head 51 is connected to a hollow tube section 52 of the head section 50 such that the outlet openings 53 are connected to a feed channel inside the hollow tube section 52. The hollow tube section 52 at its outer circumference is equipped with a screw thread 53 that extends over the entire length of the section 52. The cutting head 51 is provided with complementary internal thread such that it can easily get connected to the section 52.

[0049] After the head section 50 has been drilled for its larger part into the ground at its aimed position and under its aimed angle, a hollow tube section 54 gets connected to the head section 50 by means of a screw connection 55, after which the sonic drilling of the connected sections 50, 54 is continued. The hollow tube section 54 at its outer circumference is also equipped with a screw thread 53 that extends over the entire length of the section 54. The screw connection 55 is provided with complementary internal thread such that it can easily get connected to both the sections 50, 54.

[0050] During the final stage of the drilling, curable substance gets injected into the ground via the outlet openings 53. Thus a curable volume 56 can advantageously be formed around the head section 50, which volume automatically gets compacted by the introduced sonic vibration frequency.

[0051] In fig. 7 the same device 1 is used for drilling a foundation type pile with the aid of sonic vibration into the ground. For this a head section 70 is used that comprises a cutting head 71 as drilling portion. The cutting head 71 is fully closed in the longitudinal direction x at its front side. See fig. 8.

[0052] The cutting head 71 is connected to a hollow tube section 72 of the head section 70.

[0053] After the head section 70 has been sonically drilled for its larger part into the ground at its aimed position and under its aimed angle, a hollow tube section 74 gets connected to the head section 70 by means of a screw connection 75, after which the sonic drilling of the connected sections 72, 74 is continued. The hollow tube sections 72 and 74 at their outer circumferences here have a smooth surface.

[0054] After the connected tube sections 72, 74 have

reached their aimed end depth, a reinforcement 77 gets inserted into the hollow space inside the tube sections 72, 74. After that the hollow space inside the tube sections 72, 74 gets filled with a curable substance like grout. If desired, a sonic vibration then can get introduced into the connected sections 72, 74 again for compacting the substance inside those sections 72, 74. After the substance has cured, the foundation pile is ready to get coupled to some kind of object for example by having an object like a building bearing with (part of) its weight upon it.

[0055] Besides the embodiments shown numerous variants are possible. For example the dimensions and shapes of the various components can be changed. Furthermore the various parts can be made out of all kinds of materials. For example the head sections and the rod sections are made out of steel or another suitable metal. They can however also be made out of a (reinforced) plastic material as long as the sections are strong enough to be able to deal with sonic vibrations that get introduced therein. Although it has appeared that it is already advantageous for increasing the penetration speed when the sonic vibration is introduced into the rod sections right from the beginning, it is noticed here that in an advantageous embodiment the sonic vibration is at least introduced into the connected sections after they have reached a depth of more than 10.00 m or when the ground conditions become stiffer or harder than clay. This is probably because from that length on, standing resonant wave patterns can more easily start to form inside the connected sections.

[0056] Besides sonic drilling of the anchor or foundation piles into the ground, they can also be removed again from the ground by conveniently using the same or a larger type sonic drill apparatus.

[0057] Thus according to the invention an advantageous method is developed for forming anchor or foundation piles in the ground with the aid of introducing sonic vibration frequencies directly into connected rod sections of those anchor or foundation piles during the drilling process. Also according to the invention an advantageous method is developed for removing anchor or foundation piles out of the ground with the aid of introducing sonic vibration frequencies directly into connected rod sections of those anchor or foundation piles during the upwards pulling process.

Claims

1. Method for anchoring an object (15) to the ground with at least one anchor pile that gets inserted into the ground, comprising the steps of:
 - positioning a sonic drill apparatus at a position where the anchor pile is to be inserted into the ground;
 - providing an assembly of a head section (6)

and one or more rod sections (20), in which the rod sections (20) are connectable to the head section (6) and to each other while extending in a longitudinal direction (x) for forming the anchor pile;

- inserting the anchor pile into the ground;

wherein the head section (6) comprises a drilling portion,

wherein the inserting of the anchor pile into the ground comprises a drilling of the head section (6) with its drilling portion in rotation directly into the ground by means of the sonic drill apparatus (5), repeatedly connecting one of the rod sections (20) thereto and then drilling the connected head and rod sections (6; 20) further into the ground by means of the sonic drill apparatus (5), wherein during at least part of this drilling, a sonic vibration is introduced into the connected sections (6; 20);

wherein the provided assembly comprises hollow tube sections as rod sections (6; 20), **characterized in that,**

the head section (6) is closed or substantially closed in a longitudinal direction (x) at its front side;

wherein the provided assembly comprises one or more outlet openings (11) in its head section (6) which openings (11) connect to a feed channel inside the hollow tube sections, wherein during at least a final stage of the drilling of the connected sections (6; 20) into the ground, a curable substance is fed pressurized through the feed channel, which curable substance gets injected via the one or more outlet openings (11) into the ground to form a volume (22) of a mixture of the curable substance and ground particles around the head section (6), and wherein the introduced sonic vibration is used during said final stage of the drilling for compacting the mixture of the curable substance and ground particles around the head section (6) after which the curing of the mixture takes place, and after which the object to be anchored to the ground is coupled to a proximal end of the connected sections (6; 20) of the anchor pile.

2. Method according to claim 1, wherein the head section (6) comprises a hollow tube section (8), and in which the drilling portion of the head section (6) comprises a spiral screw blade (10) along at least part of an outer circumference of the hollow tube section (8).
3. Method according to claim 2, wherein the one or more outlet openings (11) lie in between windings of the spiral screw blade (10).
4. Method according to claim 2 or 3, wherein the feed channel and one or more outlet openings (11) are filled with an amount of non-curable substance, after

the volume of the mixture of the curable substance and ground particles have been formed around the head section (6).

5. Method according to one of the preceding claims, wherein a spiral screw blade (10; 32) extends along at least a front portion of a circumferential wall of the head section (6; 30), in particular along more than half a length of the head section (6; 30). 5
6. Method according to one of the preceding claims, wherein the rod sections comprise screw thread (53) along their outer circumference. 10
7. Method according to one of the preceding claims, wherein a frequency of the introduced sonic vibration is controllable in between 6,000-10,000 VPM. 15
8. Method according to one of the preceding claims, wherein the sonic vibration is at least introduced after the connected sections (6; 20) have reached a depth of 10.00 m or when the ground conditions become stiffer or harder than clay. 20
9. Method according to one of the preceding claims, wherein the sonic vibration is introduced into the connected sections (6; 20) during at least a final stage of the drilling of the connected sections (6; 20) in rotation into the ground. 25
10. Method according to one of the preceding claims, wherein after a final stage of the drilling of the connected sections (6; 20) into the ground, the connected sections (6; 20) are rotated in place without having the connected sections (6; 20) further advancing into the ground and while maintaining the sonic vibration into the connected sections (6; 20). 30

Patentansprüche

1. Verfahren zum Verankern eines Objekts (15) am Boden mit mindestens einem Ankerpfahl, der in den Boden eingeführt wird, umfassend die Schritte: 35

- Positionieren einer Schallbohrvorrichtung an einer Position, an der der Ankerpfahl in den Boden eingesetzt werden soll;
- Bereitstellen einer Anordnung aus einem Kopfabschnitt (6) und einem oder mehreren Stababschnitten (20), wobei die Stababschnitte (20) mit dem Kopfabschnitt (6) und miteinander verbindbar sind, während sie sich in Längsrichtung (x) zum Bilden des Ankerpfahls erstrecken;
- Einbringen des Ankerpfahls in den Boden; 45

wobei der Kopfabschnitt (6) einen Bohrabschnitt umfasst,

wobei das Einsetzen des Ankerpfahls in den Boden ein Bohren des Kopfabschnitts (6) mit seinem Bohrabschnitt in Rotation direkt in den Boden mittels der Schallbohrvorrichtung (5), wiederholtes Verbinden eines der Stababschnitte (20) damit und dann Bohren des verbundenen Kopfabschnitts und der Stababschnitte (6; 20) weiter in den Boden mittels der Schallbohrvorrichtung (5) umfasst, wobei während mindestens eines Teils dieser Bohrung eine Schall-schwingung in die verbundenen Abschnitte (6; 20) eingeleitet wird;

wobei die vorgesehene Anordnung Hohlrohrabschnitte als Stababschnitte (6; 20) umfasst,

dadurch gekennzeichnet, dass

der Kopfabschnitt (6) an seiner Vorderseite in Längsrichtung (x) geschlossen oder im Wesentlichen geschlossen ist;

wobei die vorgesehene Anordnung eine oder mehrere Auslassöffnungen (11) in ihrem Kopfabschnitt (6) umfasst, welche Öffnungen (11) mit einem Zuführkanal innerhalb der Hohlrohrabschnitte verbunden sind, wobei während mindestens einer Endstufe des Bohrens der verbundenen Abschnitte (6; 20) in den Boden eine härtbare Substanz unter Druck durch den Zuführkanal zugeführt wird, die über eine oder mehrere Auslassöffnungen (11) in den Boden injiziert wird, um ein Volumen (22) eines Gemisches aus der härtbaren Substanz und Bodenpartikeln um den Kopfabschnitt (6) herum zu bilden, und wobei die eingeführte Schallschwingung während der Endstufe des Bohrens zum Verdichten der Mischung aus der härtbaren Substanz und Bodenpartikeln um den Kopfabschnitt (6) herum verwendet wird, woraufhin das Härten der Mischung stattfindet, und woraufhin das im Boden zu verankernde Objekt mit einem proximalen Ende der verbundenen Abschnitte (6; 20) des Ankerpfahls gekoppelt ist. 40

2. Verfahren nach Anspruch 1, wobei der Kopfabschnitt (6) einen Hohlrohrabschnitt (8) umfasst, und wobei der Bohrabschnitt des Kopfabschnitts (6) eine Spiralschraubenklinge (10) entlang mindestens eines Teils eines Außenumfangs des Hohlrohrabschnitts (8) umfasst. 45

3. Verfahren nach Anspruch 2, wobei die eine oder die mehreren Auslassöffnungen (11) zwischen den Wicklungen der Spiralschraubenklinge (10) liegen. 50

4. Verfahren nach Anspruch 2 oder 3, wobei der Zuführkanal und ein oder mehrere Auslassöffnungen (11) mit einer Menge an nicht härtbarer Substanz gefüllt werden, nachdem das Volumen der Mischung aus der härtbaren Substanz und Bodenpartikeln um den Kopfabschnitt (6) herum gebildet wurde. 55

5. Verfahren nach einem der vorhergehenden Ansprüche, wobei eine Spiralschraubenklinge (10; 32) sich

entlang mindestens eines vorderen Abschnitts einer Umfangswand des Kopfabschnitts (6; 30) erstreckt, insbesondere entlang mehr als einer halben Länge des Kopfabschnitts (6; 30).

6. Verfahren nach einem der vorhergehenden Ansprüche, worin die Stababschnitte Schraubgewinde (53) entlang ihres Außenumfangs umfassen. 5
7. Verfahren nach einem der vorhergehenden Ansprüche, wobei eine Frequenz der eingeleiteten Schall-schwingung zwischen 6.000-10.000 VPM steuerbar ist. 10
8. Verfahren nach einem der vorhergehenden Ansprüche, worin die Schallschwingung mindestens dann eingeleitet wird, nachdem die verbundenen Abschnitte (6; 20) eine Tiefe von 10,00 m erreicht haben oder wenn die Bodenverhältnisse steifer oder härter werden als Ton. 15 20
9. Verfahren nach einem der vorhergehenden Ansprüche, worin die Schallschwingung in die verbundenen Abschnitte (6; 20) während mindestens einer Endstufe des Bohrens der verbundenen Abschnitte (6; 20) in Rotation in den Boden eingeleitet wird. 25
10. Verfahren nach einem der vorhergehenden Ansprüche, wobei nach einer Endstufe des Bohrens der verbundenen Abschnitte (6; 20) in den Boden die verbundenen Abschnitte (6; 20) in Position rotiert werden, ohne dass die verbundenen Abschnitte (6; 20) weiter in den Boden vorrücken und unter Aufrechterhaltung der Schallschwingung in die verbundenen Abschnitte (6; 20). 30 35

Revendications

1. Procédé d'ancrage d'un objet (15) dans le sol avec au moins un pieu d'ancrage qui est inséré dans le sol, comprenant les étapes de : 40
 - positionnement d'un appareil de forage sonique à une position où le pieu d'ancrage doit être inséré dans le sol ; 45
 - fourniture d'un ensemble d'une sections de tête (6) et d'une ou plusieurs sections de tige (20), dans lequel les sections de tige (20) peuvent être raccordées à la section de tête (6) et les unes aux autres tout en s'étendant dans une direction longitudinale (x) pour former le pieu d'ancrage ; 50
 - insertion du pieu d'ancrage dans le sol ; 55

dans lequel la section de tête (6) comprend une partie de forage,
dans lequel l'insertion du pieu d'ancrage dans le sol

comprend un forage de la section de tête (6) avec sa partie de forage en rotation directement dans le sol au moyen de l'appareil de forage sonique (5), raccordant de manière répétée une des sections de tige (20) à celui-ci et puis forant les sections de tête et de tige raccordées (6 ; 20) davantage dans le sol au moyen de l'appareil de forage sonique (5), dans lequel pendant au moins une partie de ce forage, une vibration sonique est introduite dans les sections raccordées (6 ; 20) ; dans lequel l'ensemble fourni comprend des sections de tube creux en tant que sections de tige (6 ; 20),

caractérisé en ce que

la section de tête (6) est fermée ou sensiblement fermée dans une direction longitudinale (x) sur son côté avant ;
dans lequel l'ensemble fourni comprend une ou plusieurs ouvertures de sortie (11) dans sa section de tête (6), lesquelles ouvertures (11) se raccordent à un canal d'alimentation à l'intérieur des sections de tube creux, dans lequel pendant au moins une étape finale du forage des sections raccordées (6 ; 20) dans le sol, une substance durcissable et fournie sous pression à travers le canal d'alimentation, laquelle substance durcissable est injectée via les une ou plusieurs ouvertures de sortie (11) dans le sol pour former un volume (22) d'un mélange de la substance durcissable et de particules broyées autour de la section de tête (6), et dans lequel la vibration sonique introduite est utilisée pendant ladite étape finale du forage pour compacter le mélange de la substance durcissable et des particules broyées autour de la section de tête (6), après quoi le durcissement du mélange a lieu, et après quoi l'objet devant être ancré dans le sol est couplé à une extrémité proximale des sections raccordées (6 ; 20) du pieu d'ancrage.

2. Procédé selon la revendication 1, dans lequel la section de tête (6) comprend une section de tube creux (8), et dans lequel la partie de forage de la section de tête (6) comprend une lame de vis en spirale (10) le long d'au moins une partie d'une circonférence externe de la section de tube creux (8).
3. Procédé selon la revendication 2, dans lequel l'ouverture ou les ouvertures de sortie (11) se trouvent entre des enroulements de la lame de vis en spirale (10).
4. Procédé selon la revendication 2 ou 3, dans lequel le canal d'alimentation et une ou plusieurs ouvertures de sortie (11) sont remplis d'une quantité de substance non durcissable, une fois que le volume du mélange de la substance durcissable et des particules broyées a été formé autour de la section de tête (6).

5. Procédé selon l'une des revendications précédentes, dans lequel une lame de vis en spirale (10 ; 32) s'étend le long d'au moins une partie avant d'une paroi circonférentielle de la section de tête (6 ; 30), en particulier le long de plus de la moitié d'une longueur de la section de tête (6 ; 30). 5
6. Procédé selon l'une des revendications précédentes, dans lequel les sections de tige comprennent un filetage (53) le long de leur circonférence externe. 10
7. Procédé selon l'une des revendications précédentes, dans lequel une fréquence de la vibration sonore introduite est contrôlable entre 6000 et 10 000 VPM. 15
8. Procédé selon l'une des revendications précédentes, dans lequel la vibration sonore est au moins introduite après que les sections raccordées (6 ; 20) ont atteint une profondeur de 10,00 m ou lorsque les conditions du sol deviennent plus rigides ou dures que de l'argile. 20
9. Procédé selon l'une des revendications précédentes, dans lequel la vibration sonore est introduite dans les sections raccordées (6 ; 20) pendant au moins une étape finale du forage des sections raccordées (6 ; 20) en rotation dans le sol. 25
10. Procédé selon l'une des revendications précédentes, dans lequel après une étape finale du forage des sections raccordées (6 ; 20) dans le sol, les sections raccordées (6 ; 20) sont mises en rotation en place sans que les sections raccordées (6 ; 20) n'avancent davantage dans le sol et tout en maintenant la vibration sonore dans les sections raccordées (6 ; 20). 30
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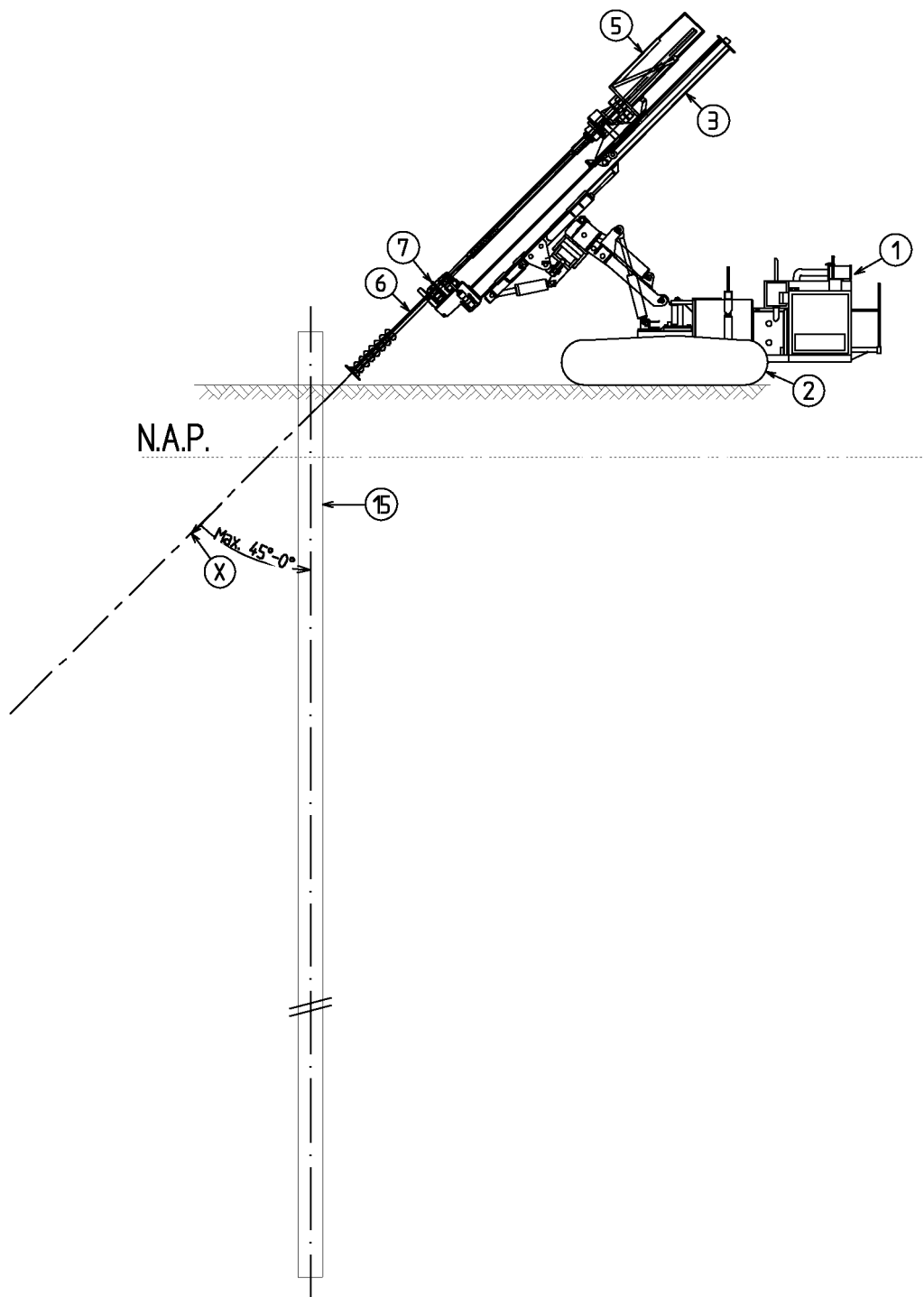


Fig. 1.a

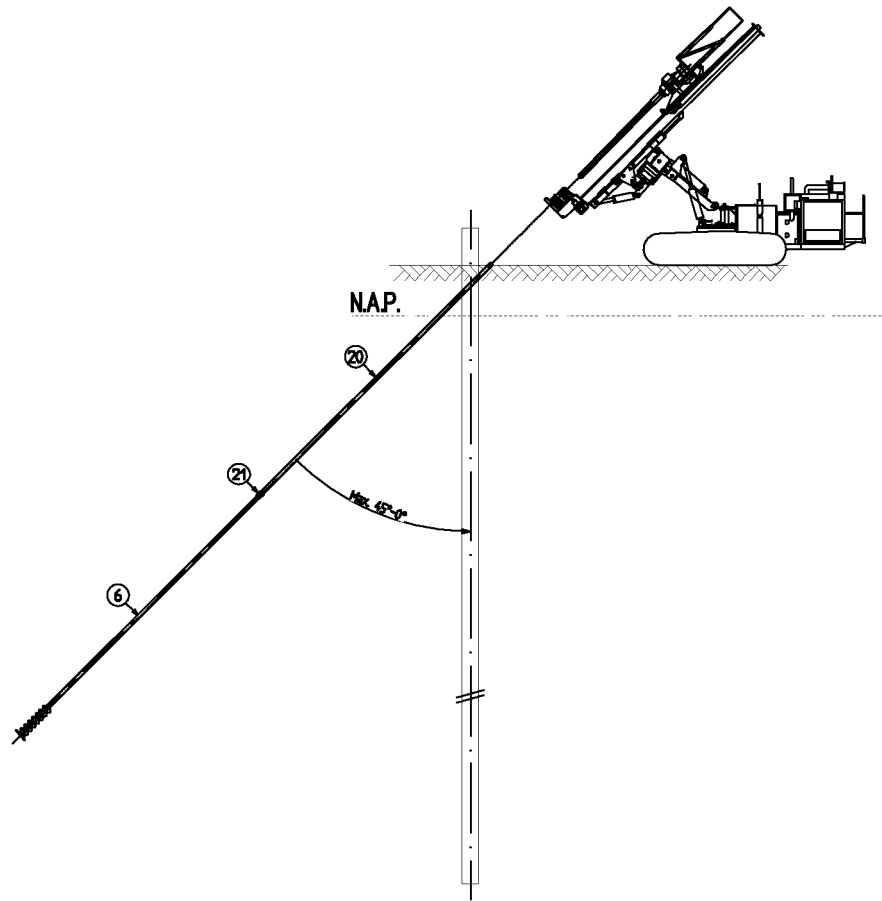


Fig. 1.b

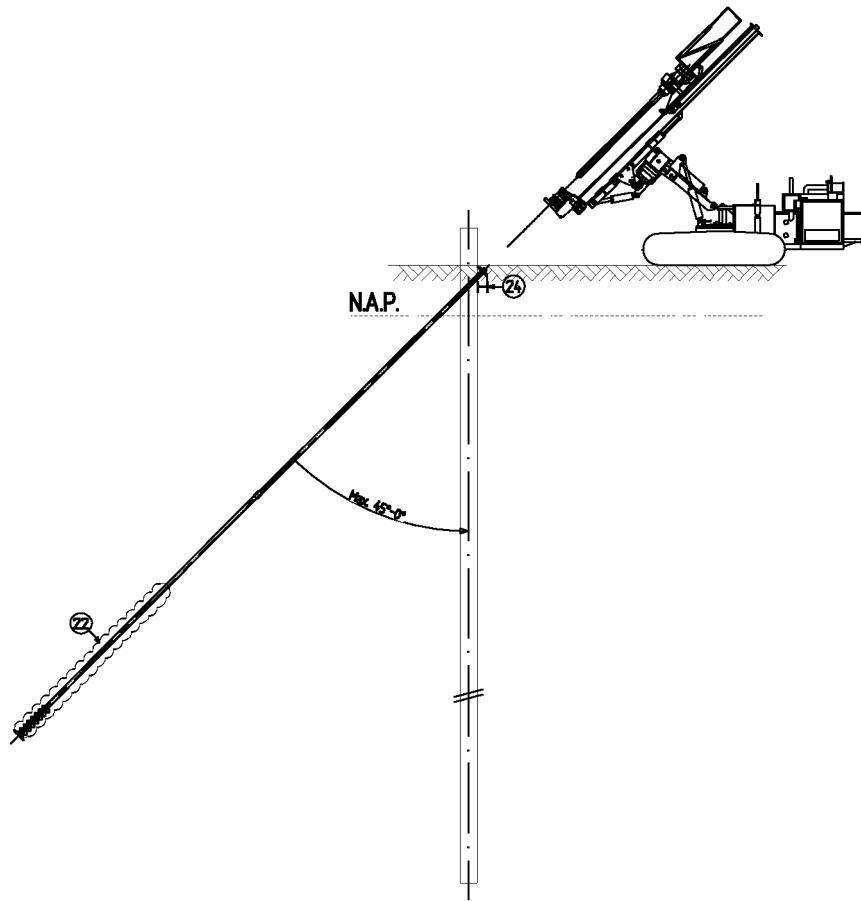


Fig. 1.c

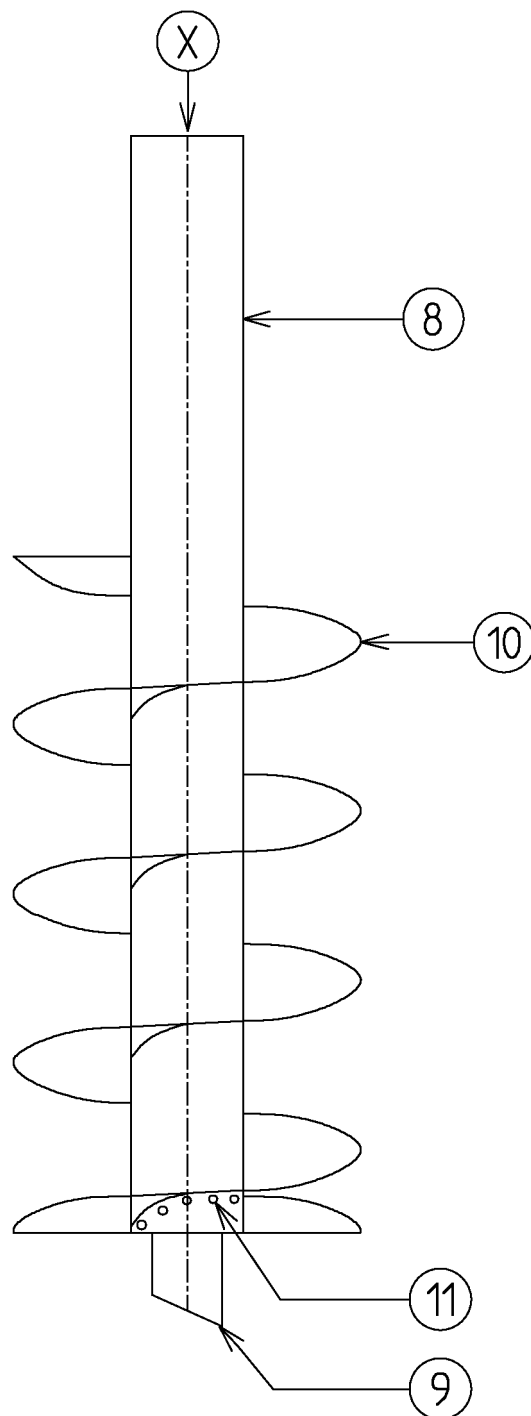


Fig. 2

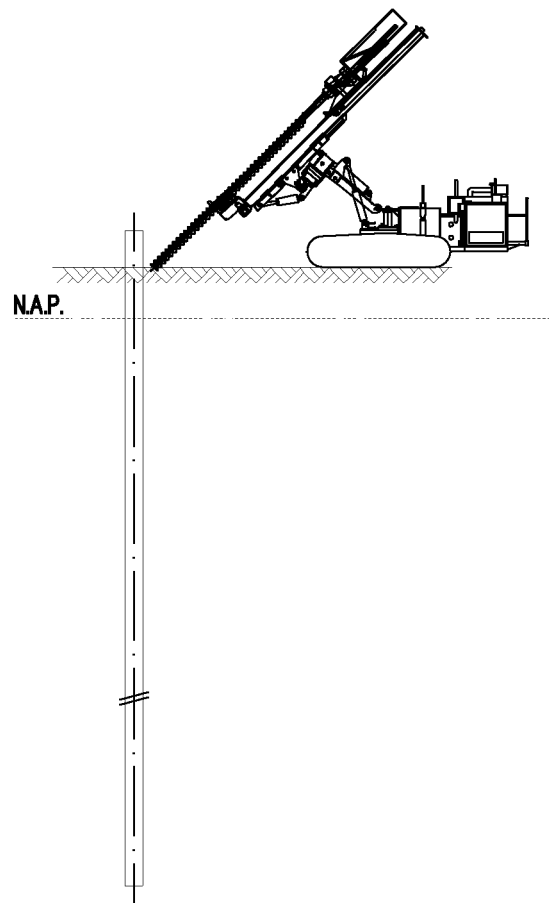


Fig. 3.a

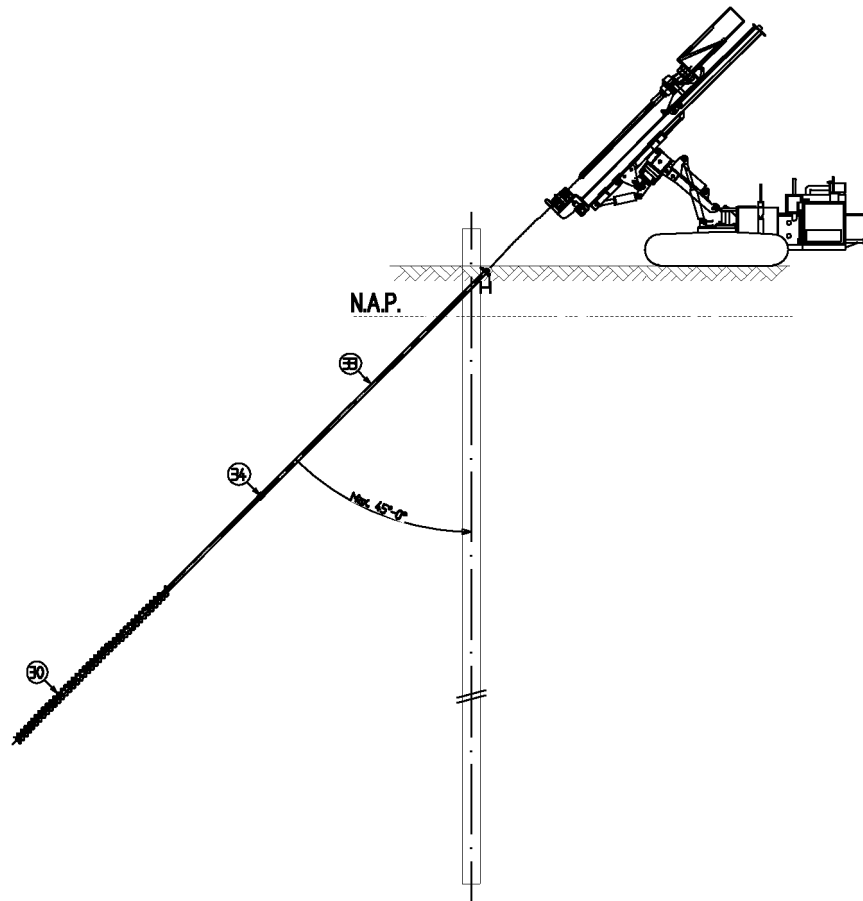


Fig. 3.b

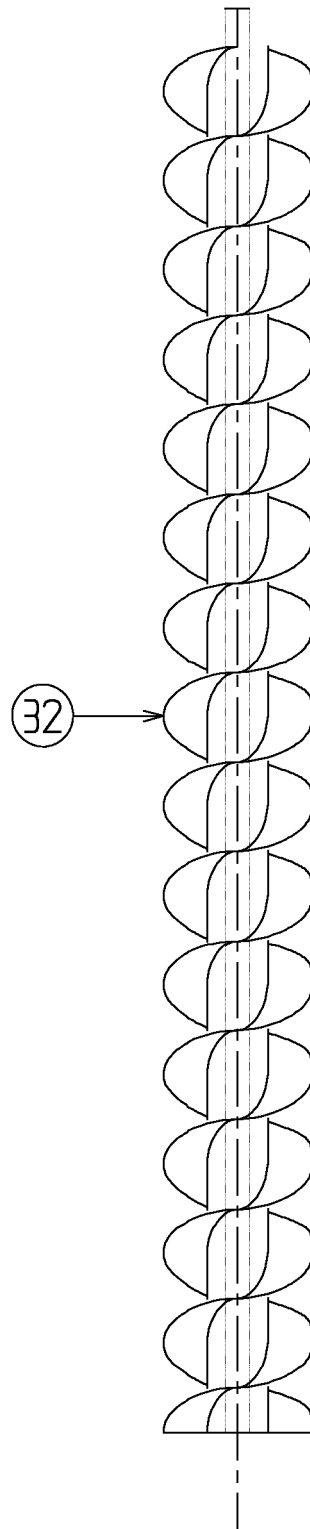


Fig 4

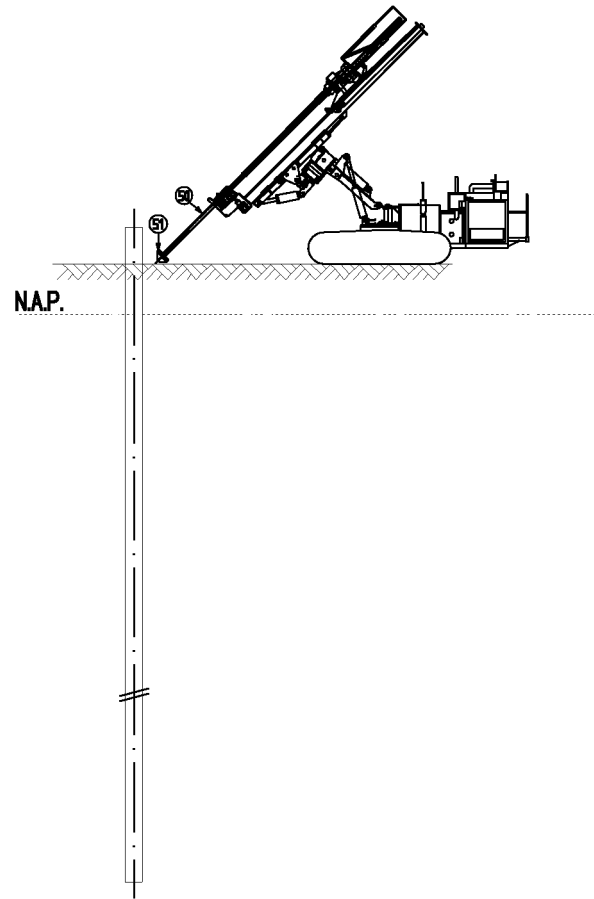


Fig. 5.a

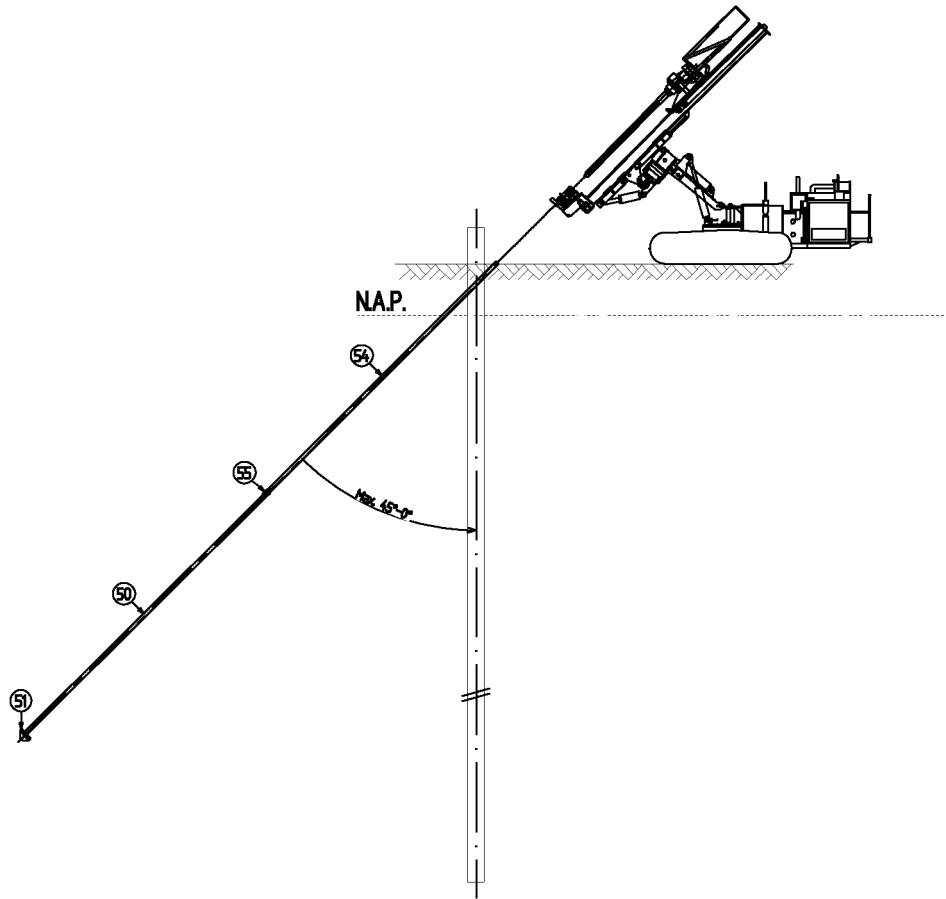


Fig. 5.b

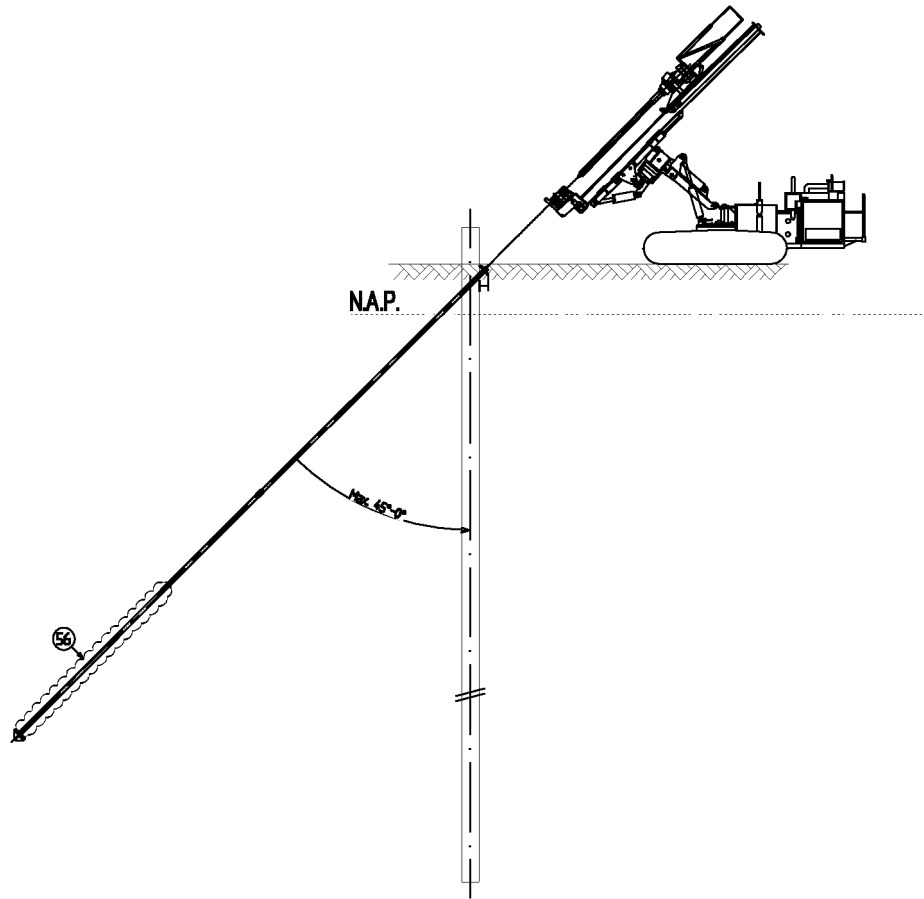


Fig. 5.c

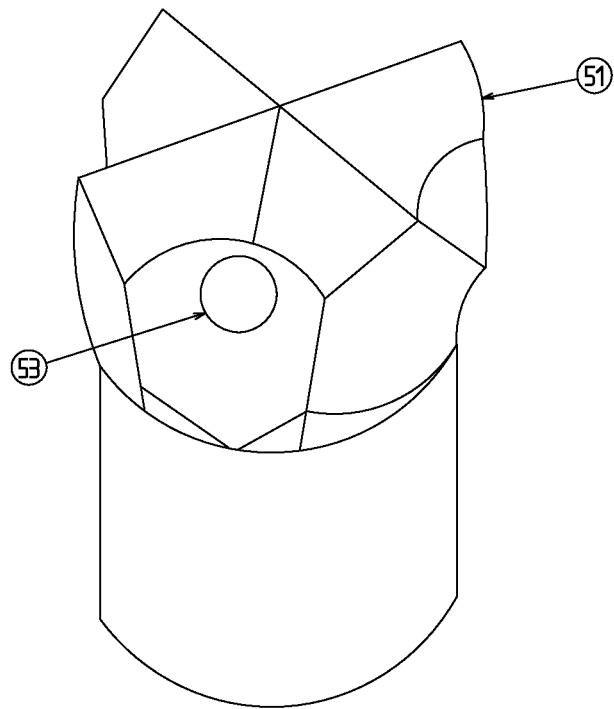


Fig. 6.a

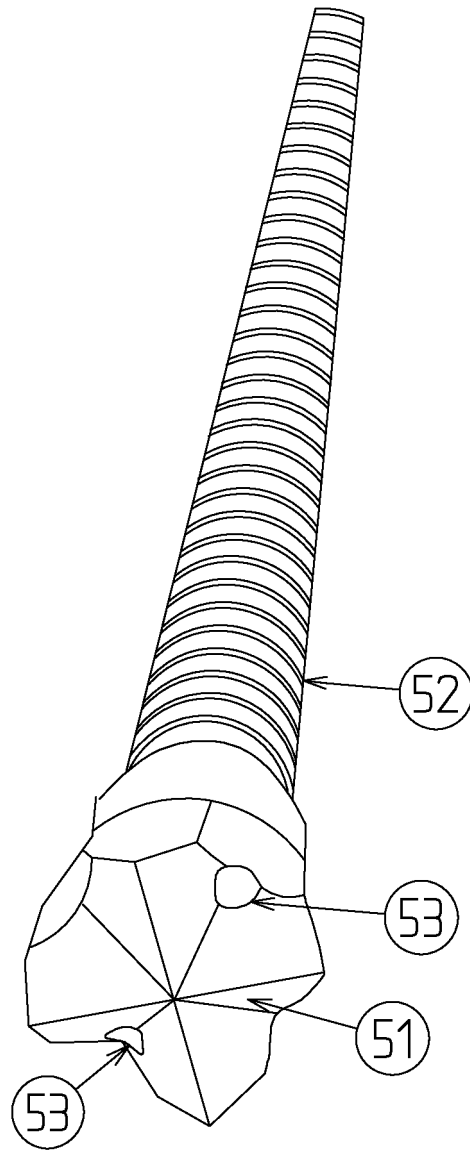
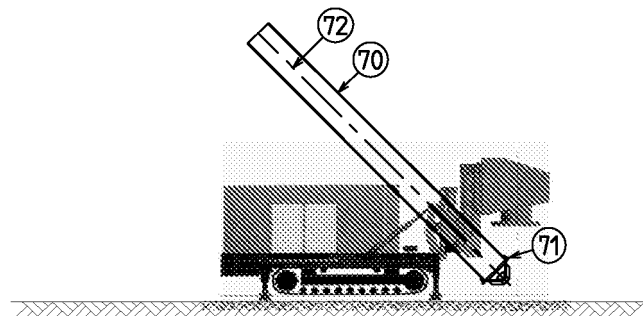


Fig. 6.b



N.A.P.

Fig. 7.a

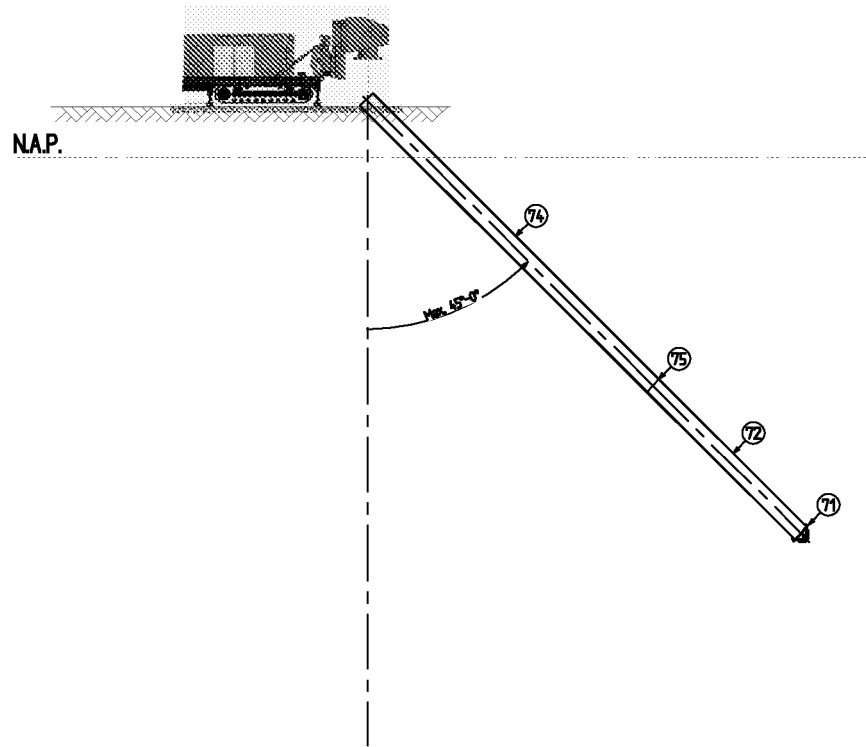


Fig. 7.b

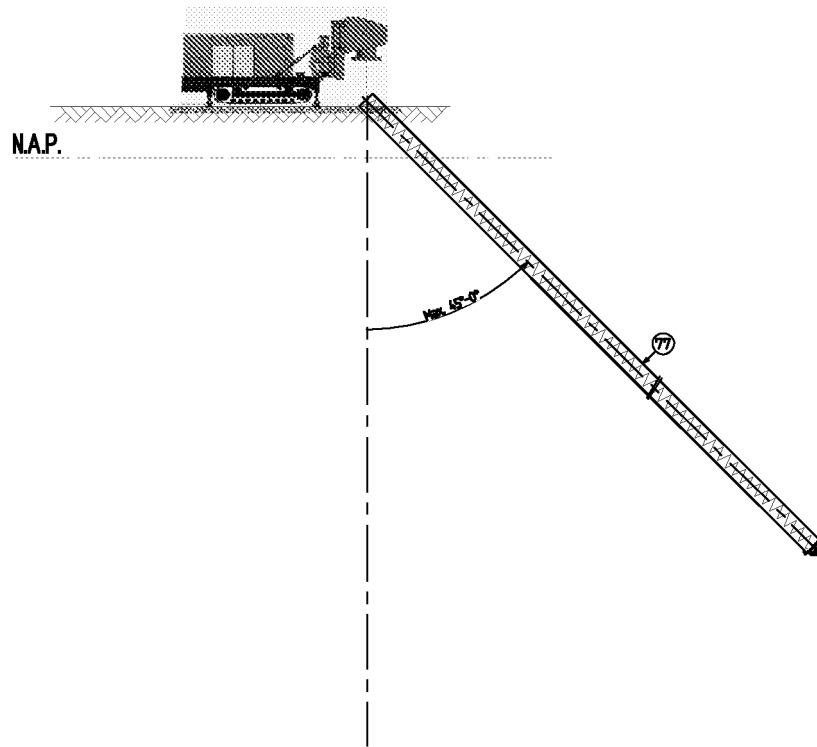


Fig. 7.c

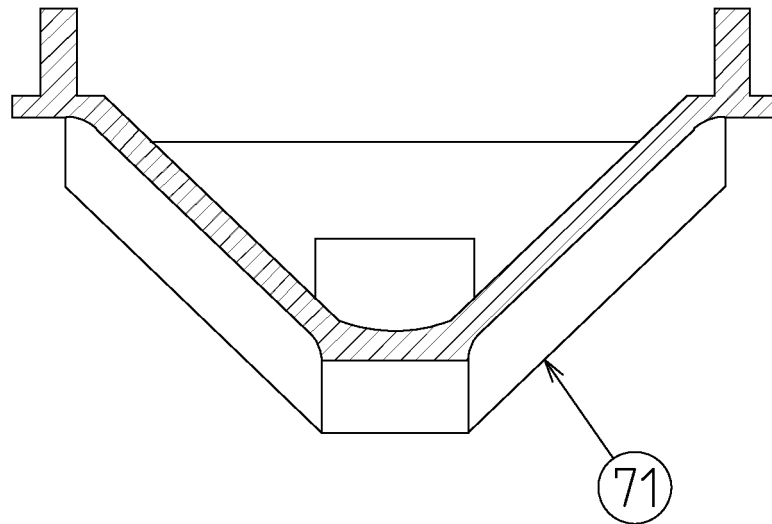


Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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