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- **VAN SEUMEREN, Johannes Antonius**
3601 NA MAARSSSEN (NL)
- **de GROOT, Franciscus Marie**
4131 PM VIANEN (NL)
- **EIJKELKAMP, Alphonsus Gerardus Maria**
6987 EM GIESBEEK (NL)
- **EIJKELKAMP, Hugo Jaap**
6901 MA ZEVENAAR (NL)

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(74) Representative: **EP&C**
P.O. Box 3241
2280 GE Rijswijk (NL)

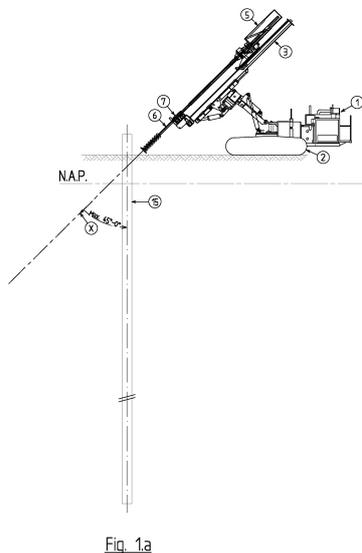
(71) Applicant: **High Five Solutions B.v.**
4131 PM Vianen (NL)

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(72) Inventors:
• **VAN LEEUWEN, Marinus Teunis, jr**
3451 BL VLEUTEN (NL)

(54) **METHOD FOR REMOVING AN ANCHOR OR FOUNDATION PILE OUT OF THE GROUND**

(57) A method for removing an anchor or foundation pile out of the ground comprises the steps of positioning a drill apparatus at a position where the anchor or foundation pile is to be removed from out of the ground and where it is coupled to an object for anchoring and/or founding the object to the ground, which anchor or foundation pile comprises an assembly of a head section and one or more rod sections connected to each other, decoupling a proximal end of the connected sections from the object, and removing the connected sections out of the ground by means of an upwards pulling force, while repeatedly disconnecting one of the rod sections therefrom. According to the invention the drill apparatus is a sonic drill apparatus, wherein during at least part of the removing of the connected sections of the anchor or foundation pile out of the ground, a sonic vibration is introduced into the connected sections.



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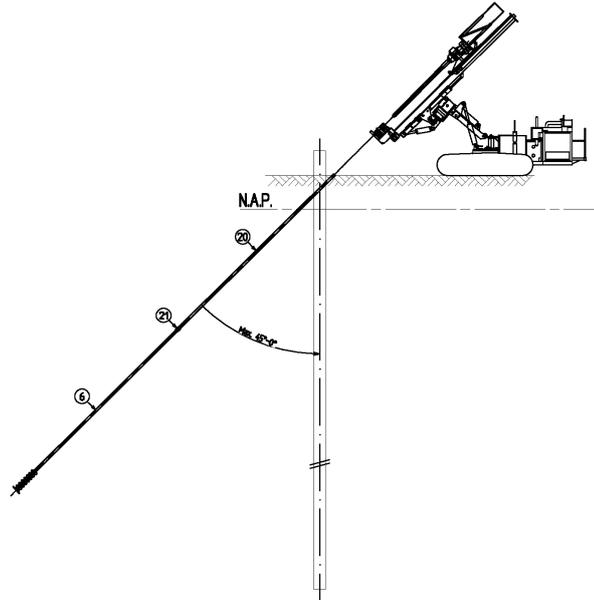


Fig. 1.b

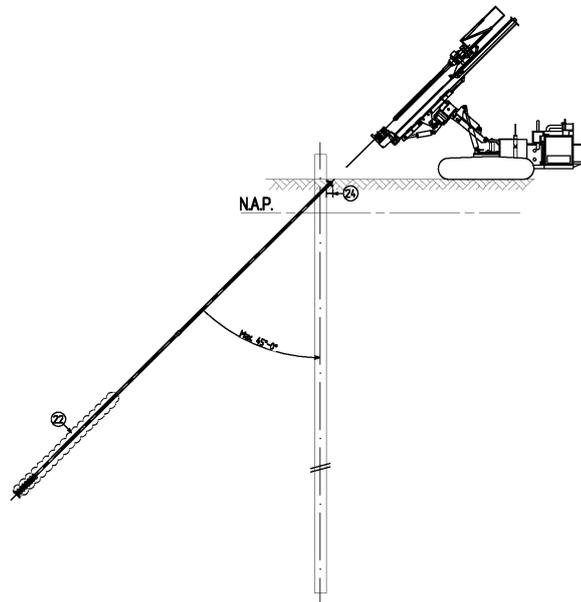


Fig. 1.c

Description

[0001] The invention relates to a method for removing an anchor or foundation pile out of the ground again after it has been used for anchoring and/or founding an object to the ground.

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

[0003] For example NL-8403178 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] It is further disadvantageous that such expensive anchor or foundation piles sometimes need to be left behind in the ground after they have served their temporary anchoring or founding purpose. This is costly and not good for the environment. It is not always possible to quickly and easily remove them again. In particular for

injection type anchor or foundation piles, more in particular for screw injection type anchor or foundation piles, it sometimes has appeared impossible to remove anchor or foundation piles out of the ground because state of the art methods appeared unfit. Also it sometimes appeared that the rod sections as well as the head section could only be removed from out the ground again damaged and not clean. In the case of (screw) injection type anchors or foundation piles, the cured substance that originally was formed as a volume around at least part of the pile, appeared to stay in the way of this.

[0010] 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 removing an anchor or foundation pile out of the ground after they have been used for anchoring and/or founding an object to the ground, more in particular for removing a truly reliable anchor or foundation pile that previously has been easily and swiftly inserted into the ground while at the same time resulting in a high tension strength.

[0011] This aim is achieved by a method for removing an anchor or foundation pile out of the ground according to claim 1. This method comprises the step of positioning a drill apparatus at a position where the anchor or foundation pile is to be removed from out of the ground and where it is coupled to an object for anchoring and/or founding that object to the ground. With this the anchor or foundation pile comprises an assembly of a head section and one or more rod sections connected to each other. The method further comprises the step of decoupling a proximal end of the connected sections from the object. Subsequently the method comprises the step of removing the connected sections out of the ground by means of an upwards pulling force, while repeatedly disconnecting one of the rod sections therefrom. According to the inventive thought the drill apparatus is a sonic drill apparatus, wherein during at least part of the removing of the connected sections of the anchor or foundation pile out of the ground, a sonic vibration is introduced into the connected sections.

[0012] Formed anchor or foundation piles no longer need to be kept inside the ground. It is now also well possible to quickly and easily remove them again. For this the method comprises the steps of decoupling the proximal end of the connected sections from the object, and removing the connected sections out of the ground by means of the upwards pulling force exerted thereupon by means of the sonic drill apparatus, while repeatedly disconnecting one of the rod sections therefrom. During at least part of the removing of the connected sections out of the ground, the sonic vibration then may be introduced into the connected sections. Owing to this sonic vibration frequency that gets introduced into the head section, it has for (screw) injection type anchor or foundation piles even appeared possible to loosen cured substances like grout from their head sections again, making it possible to retract them out of the ground with a lower

pulling force. This is advantageous because it is now no longer necessary to leave the expensive anchor or foundation piles behind in the ground after they have served their temporary anchoring or founding purpose. This is cost-saving and better for the environment.

[0013] It is noted that the invention also relates to a removing of anchor or foundation piles out of the ground that have been formed in other manners than with the aid of sonic vibrations according to the invention of the co-pending European patent application No. 15 837 147.6. Also for such other types of anchor or foundation piles it has appeared that they can be quickly and easily be removed from out of the ground again by means of making use of a sonic drill apparatus. The removing method then may comprise steps of decoupling a proximal end of connected sections forming an anchor or foundation pile from an object, and removing those connected sections out of the ground by means of an upwards pulling force exerted thereupon by means of a sonic drill apparatus, while repeatedly disconnecting one of rod sections therefrom, wherein during at least part of the removing of those connected sections out of the ground, a sonic vibration gets introduced into the connected sections. In particular for injection type anchor or foundation piles, more in particular for screw injection type anchor or foundation piles, this advantageously has appeared to make it possible to even remove anchor or foundation piles out of the ground again that no one thought possible and/or for which state of the art methods had already appeared unfit. Tests have shown that the rod sections as well as the head section can thus be removed from out the ground again undamaged and substantially clean. In the case of (screw) injection type anchors or foundation piles, substantially all the cured substance that originally was formed as a volume around at least part of the pile, appeared to stay behind in the ground in sonically broken apart pieces.

[0014] In a particular embodiment, during the removing of the connected sections out of the ground by means of the upwards pulling force, the connected sections may be rotated by the sonic drill apparatus in a same rotational direction as during the previous drilling of the connected sections into the ground. This rotational movement in the same rotational direction has the advantage of helping to further loosen ground particles and/or cured substances like grout from the anchor or foundation pile, without accidentally prematurely disconnecting the connected sections from each other before they have reached positions above ground level.

[0015] In another embodiment, when it is desired to remove hollow tube sections of a (screw) injection type anchor or foundation pile out of the ground, a substance gets fed to a feed channel that extends through those hollow tube sections and that connects to one or more outlet openings in its head section. Thus the space that is left behind during the removing of the sections can get automatically filled up again with this substance, for example bentonite or another suitable filling substance. In

order to be able to do this, the feed channel and outlet opening(s) preferably have been kept free from cured substance during insertion of the pile into the ground. As described above this can be done by having the feed channel and outlet opening(s) filled with an amount of non-curable substance at the end of the inserting of the anchor or foundation pile into the ground.

[0016] The invention particularly is suitable for a removing of anchor or foundation piles out of the ground that have been formed with the aid of sonic vibrations according to the invention of the co-pending European patent application No. 15 837 147.6. With this the insertion method for anchoring and/or founding an object to the ground with at least one anchor or foundation pile that gets inserted into the ground, comprises the step of positioning a sonic drill apparatus at a position where the anchor or foundation 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 or foundation 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 or foundation pile. According to the inventive thought of the co-pending European patent application No. 15 837 147.6, the head section of the provided assembly comprises a drilling portion for drilling into the ground. Further, the inserting of the anchor or foundation 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.

[0017] 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 or foundation 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.

[0018] In a preferred embodiment according to the invention of the co-pending European patent application No. 15 837 147.6, the inventive thought can be used in combination with an injection type anchor or foundation 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 of the co-pending European patent application No. 15 837 147.6, the introduced sonic vibration then can be 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 can take place. This compacting phase, advantageously helps to increase the strength of the thus formed anchor or foundation pile.

[0019] 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.

[0020] 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 the later removal of the anchor

or foundation pile out of the ground again with the removal method according to the present invention, 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 the hole from prematurely collapsing and/or helps to prevent instabilities to arise in the surrounding ground layers.

[0021] 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.

[0022] In a further embodiment, the invention of the co-pending European patent application No. 15 837 147.6 can be used in combination with a screw injection type anchor or foundation pile, 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.

[0023] 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 or foundation pile.

[0024] 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.

[0025] 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 vol-

ume around the head section.

[0026] 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.

[0027] In a preferred embodiment 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.

[0028] 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 or foundation 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. Particularly for forming an anchor or foundation pile of the non-injection type, this has appeared more than sufficient for forming an aimed compacted volume of ground particles around and in-between the windings by means of the introduced sonic vibrations.

[0029] In the alternative, the provided assembly may also comprise solid bar sections as rod sections. This can be used when it is not deemed necessary to inject a curable substance like grout around the head section into the ground. The abovementioned spiral screw blade can also be provided along such a solid bar section.

[0030] 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.

[0031] 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 obstruction that may be present in the ground is passed by the drilling portion and the penetration speed gets sufficiently high again.

[0032] 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 or foundation pile, and in particular around its head section where the curable substance may have been injected into the ground.

[0033] Further advantageous embodiments are stated in the subclaims.

[0034] 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 for forming a screw injection type anchor pile into the ground according to the invention of the co-pending European patent application No. 15 837 147.6 that can also be removed again from the ground by conveniently using the same or a larger type sonic drill apparatus according to the present invention;
- 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 for forming a screw injection type anchor pile into the ground according to the invention of the co-pending European patent application No. 15 837 147.6 that can also be removed again from the ground by conveniently using the same or a larger type sonic drill apparatus according to the present invention;
- 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 for forming an injection type anchor pile into the ground according to the invention of the co-pending European patent application No. 15 837 147.6 that can also be removed again from the ground by conveniently using the same or a larger type sonic drill apparatus according to the present invention;
- 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;
- Fig. 7a-c shows three steps of a fourth embodiment

of the method for forming a foundation pile into the ground according to the invention of the co-pending European patent application No. 15 837 147.6 that can also be removed again from the ground by conveniently using the same or a larger type sonic drill apparatus according to the present invention; and

- Fig. 8 schematically shows a cross-section through the cutting head of the foundation type pile of fig. 7.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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 section. 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.

[0044] 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.

[0045] 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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.

[0050] The cutting head 71 is connected to a hollow tube section 72 of the head section 70.

[0051] 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 50 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.

[0052] 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.

[0053] 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 ad-

vantageous 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.

[0054] According to the invention, after the 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.

[0055] Thus 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.

[0056] The invention can further be embodied by one or more of the following clauses:

1. Method for anchoring and/or founding an object to the ground with at least one pile that gets inserted into the ground, comprising the steps of:

- positioning a sonic drill apparatus at a position where the pile is to be inserted into the ground;
- providing an assembly 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 pile;
- inserting the pile into the ground; and
- coupling the object to a proximal end of the connected sections of the pile,

characterized in that.

the head section comprises a drilling portion, wherein the inserting of the 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, repeatedly connecting one of the rod sections thereto and then drilling the connected head and rod sections further into the ground by means of the sonic drill apparatus, wherein during at least part of this drilling, a sonic vibration is introduced into the connected sections.

2. Method according to clause 1, wherein the provided assembly comprises hollow tube sections as rod sections, wherein the provided assembly comprises one or more outlet openings in its head section which openings connect to a feed channel inside the hollow tube sections,

wherein during at least a final stage of the drilling of the connected sections 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 into the ground to form a volume of a mixture of the curable substance and ground particles around the head section, 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 after which the curing of the mixture takes place.

3. Method according to clause 2, wherein the head section comprises a hollow tube section, and in which the drilling portion of the head section comprises a spiral screw blade along at least part of an outer circumference of the hollow tube section.

4. Method according to clause 3, wherein the one or more outlet openings lie in between windings of the spiral screw blade.

5. Method according to one of the preceding clauses, wherein a spiral screw blade extends along at least a front portion of a circumferential wall of the head section, in particular along more than half a length of the head section.

6. Method according to clause 1, wherein the provided assembly comprises solid bar sections as rod sections.

7. Method according to one of the preceding clauses, wherein the rod sections comprise screw thread along their outer circumference.

8. Method according to one of the preceding clauses, wherein a frequency of the introduced sonic vibration is controllable in between 6,000-10,000 VPM.

9. Method according to one of the preceding clauses, wherein the sonic vibration is at least introduced after the connected sections have reached a depth of 10.00 m or when the ground conditions become stiffer or harder than clay.

10. Method according to one of the preceding clauses, wherein the sonic vibration is introduced into the connected sections during at least a final stage of the drilling of the connected sections in rotation into the ground.

11. Method according to clause 10, wherein after the final stage of the drilling of the connected sections into the ground, the connected sections are rotated in place without having the connected sections further advancing into the ground and while maintaining

the sonic vibration into the connected sections.

12. Method according to one of the preceding clauses, wherein the head section is closed or substantially closed in a longitudinal direction at its front side.

13. Method for removing an anchor or foundation pile out of the ground, in particular for removing an anchor or foundation pile that was inserted into the ground by a method according to one of the preceding clauses, comprising the steps of:

- positioning a sonic drill apparatus at a position where the anchor or foundation pile is to be removed from out of the ground and where it is coupled to an object for anchoring and/or founding the object to the ground, which anchor or foundation pile comprises an assembly of a head section and one or more rod sections connected to each other;
- decoupling a proximal end of the connected sections from the object;
- removing the connected sections out of the ground by means of an upwards pulling force, while repeatedly disconnecting one of the rod sections therefrom,

wherein during at least part of the removing of the connected sections out of the ground, a sonic vibration is introduced into the connected sections.

14. Method according to clause 13, wherein during the removing of the connected sections out of the ground by means of the upwards pulling force, the connected sections are being rotated by means of the sonic drill apparatus, in particular in a same rotational direction as during a previous drilling of the connected sections into the ground.

Claims

1. Method for removing an anchor or foundation pile out of the ground, comprising the steps of:
 - positioning a drill apparatus at a position where the anchor or foundation pile is to be removed from out of the ground and where it is coupled to an object (15) for anchoring and/or founding the object (15) to the ground, which anchor or foundation pile comprises an assembly of a head section (6) and one or more rod sections (20) connected to each other;
 - decoupling a proximal end of the connected sections (6; 20) from the object (15); and
 - removing the connected sections (6; 20) out of the ground by means of an upwards pulling force, while repeatedly disconnecting one of the

rod sections (6; 20) therefrom,

characterized in that,

the drill apparatus is a sonic drill apparatus (5), wherein during at least part of the removing of the connected sections (6; 20) of the anchor or foundation pile out of the ground, a sonic vibration is introduced into the connected sections (6; 20).

2. Method according to claim 1, wherein the anchor or foundation pile to be removed is an injection type anchor or foundation pile that comprises hollow tube sections as rod sections (6; 20), that 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, and that has a cured volume (22) of a mixture of an injected curable substance and ground particles around the head section (6),
 - wherein the sonic vibration that gets introduced into the connected sections (6; 20) loosens the cured volume (22) from their head section (6) again, in particular by means of having substantially all the cured substance that originally was formed as the cured volume (22) around at least part of the anchor or foundation pile to get sonically broken apart into pieces and stay behind in the ground.
3. Method according to claim 2, wherein the anchor or foundation pile to be removed is a screw injection type anchor or foundation pile, wherein the head section (6) further comprises a hollow tube section (8) and a drilling portion, 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),
 - wherein the cured volume (22) of the mixture of the injected curable substance and ground particles lies around and in-between windings of the spiral screw blade (10),
 - wherein the sonic vibration that gets introduced into the connected sections (6; 20) loosens the cured volume (22) from around and in-between the windings again, in particular by means of having substantially all the cured substance that originally was formed as the cured volume (22) around and in-between the windings to get sonically broken apart into pieces and stay behind in the ground.
4. Method according to claim 2 or 3, wherein the injection type anchor or foundation pile to be removed has its feed channel and one or more outlet openings (11) kept free from cured substance during insertion of the anchor or foundation pile into the ground by having the feed channel and one or more outlet openings (11) filled with an amount of non-curable substance at the end of the inserting of the anchor or foundation pile into the ground.

- 5. Method according to one the preceding claims 2-4, wherein during the removing of the hollow tube sections of the injection type anchor or foundation pile out of the ground, a filling substance gets fed via the feed channel and the one or more outlet openings (11) simultaneously with the removal for filling up a space that is left behind by the anchor or foundation pile during the removing of the hollow tube sections. 5

- 6. Method according to one of the preceding claims, wherein during the removing of the connected sections (6; 20) of the anchor or foundation pile out of the ground by means of the upwards pulling force, the connected sections (6; 20) are being rotated by means of the sonic drill apparatus (5). 10 15

- 7. Method according to claim 6, wherein during the removing of the connected sections (6; 20) of the anchor or foundation pile out of the ground by means of the upwards pulling force, the connected sections (6; 20) are being rotated by means of the sonic drill apparatus (5) in a same rotational direction as during a previous drilling of the connected sections (6; 20) into the ground. 20 25

- 8. 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. 30

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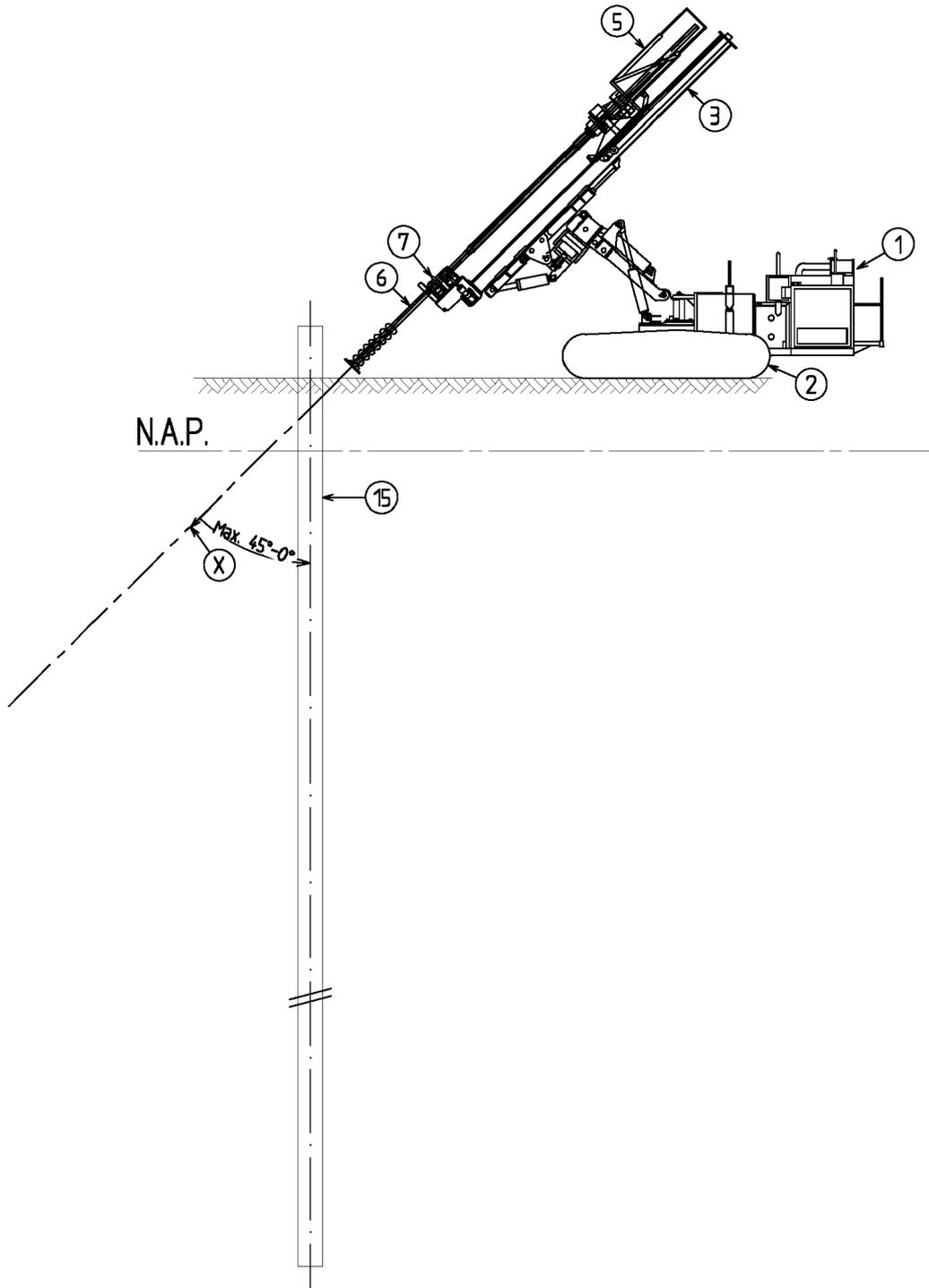


Fig. 1.a

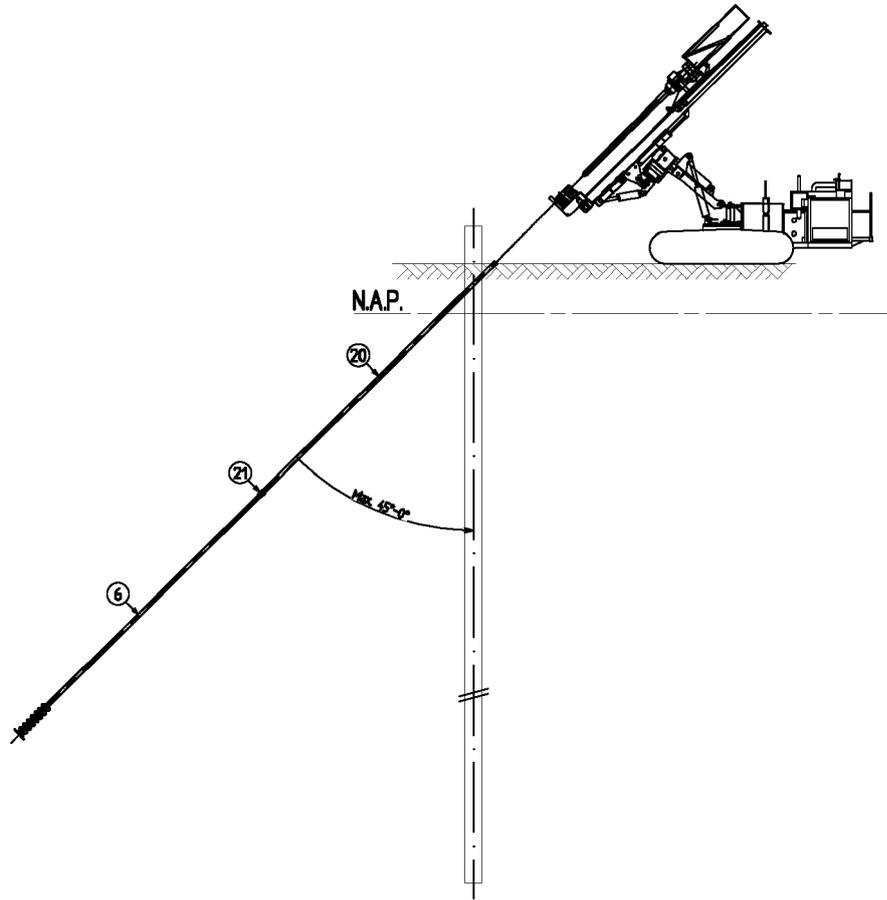


Fig. 1.b

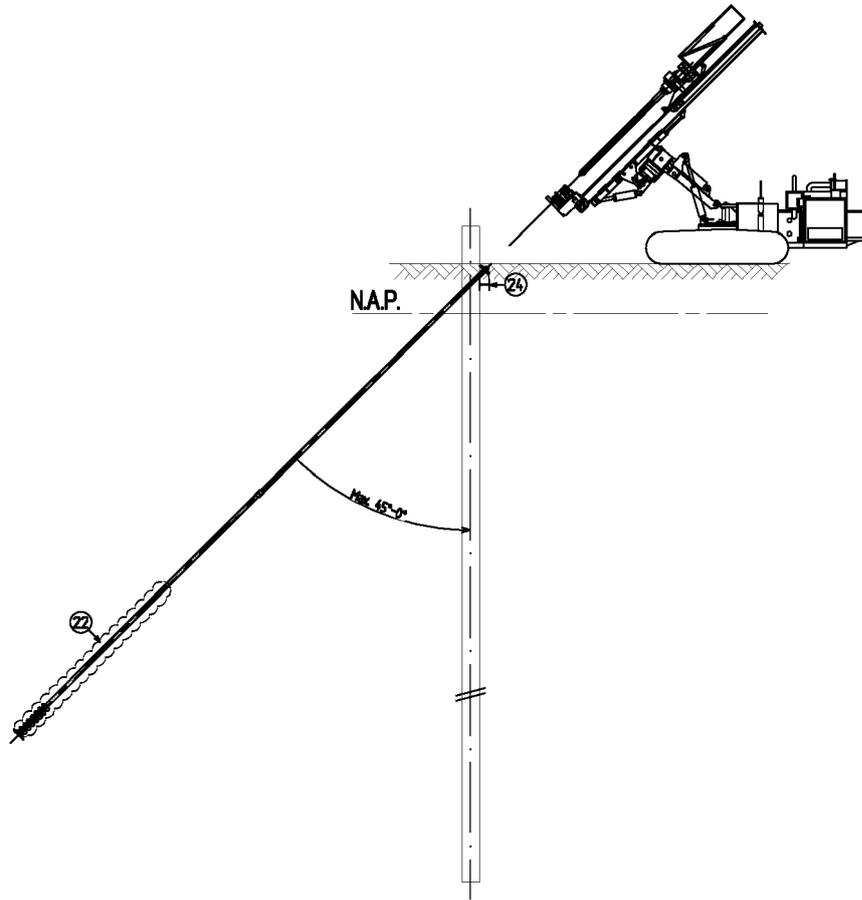


Fig. 1.c

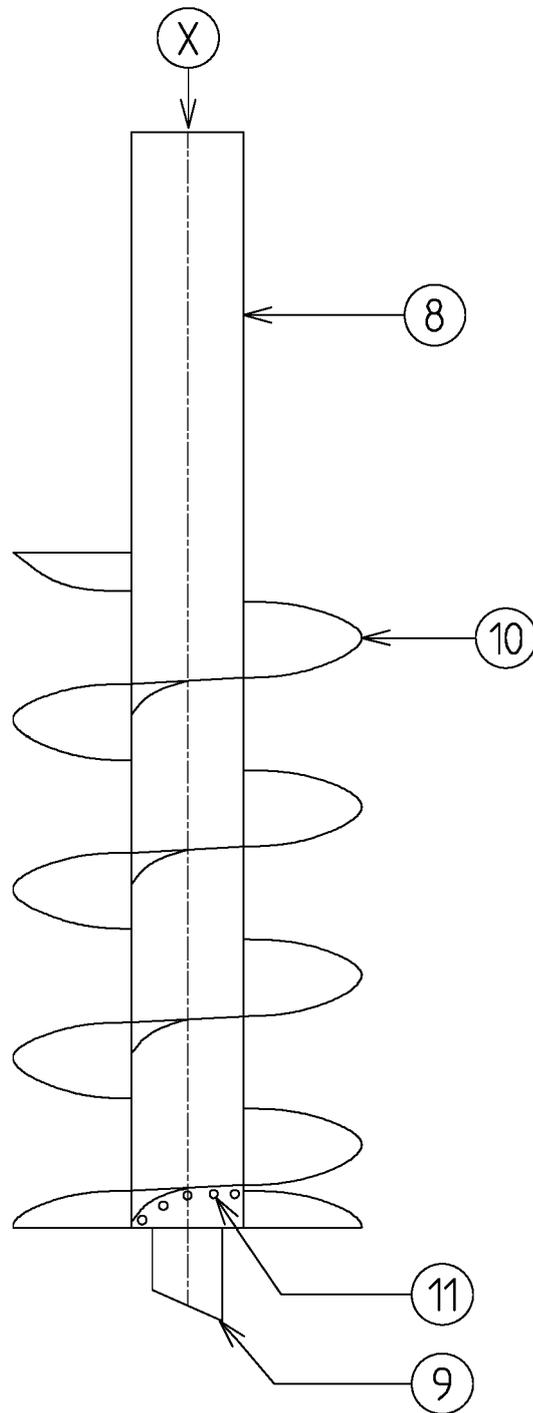


Fig. 2

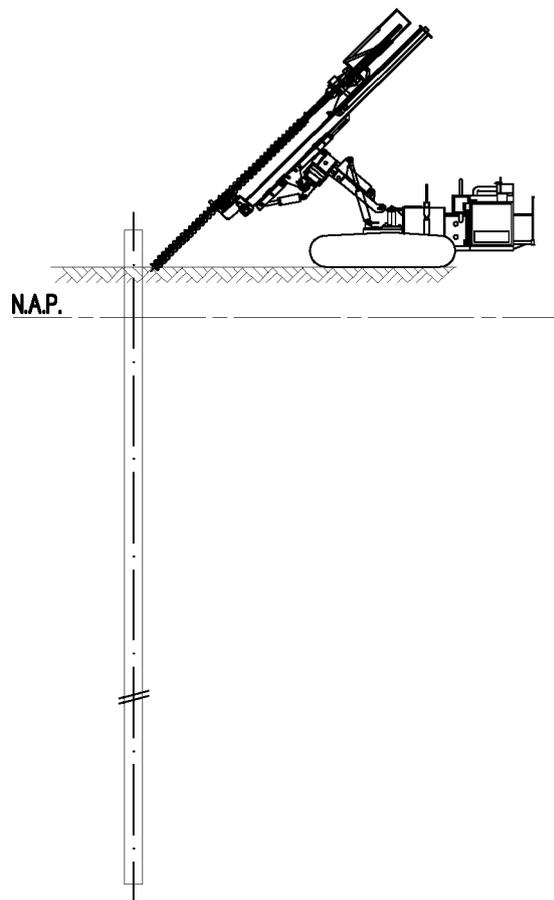


Fig. 3.a

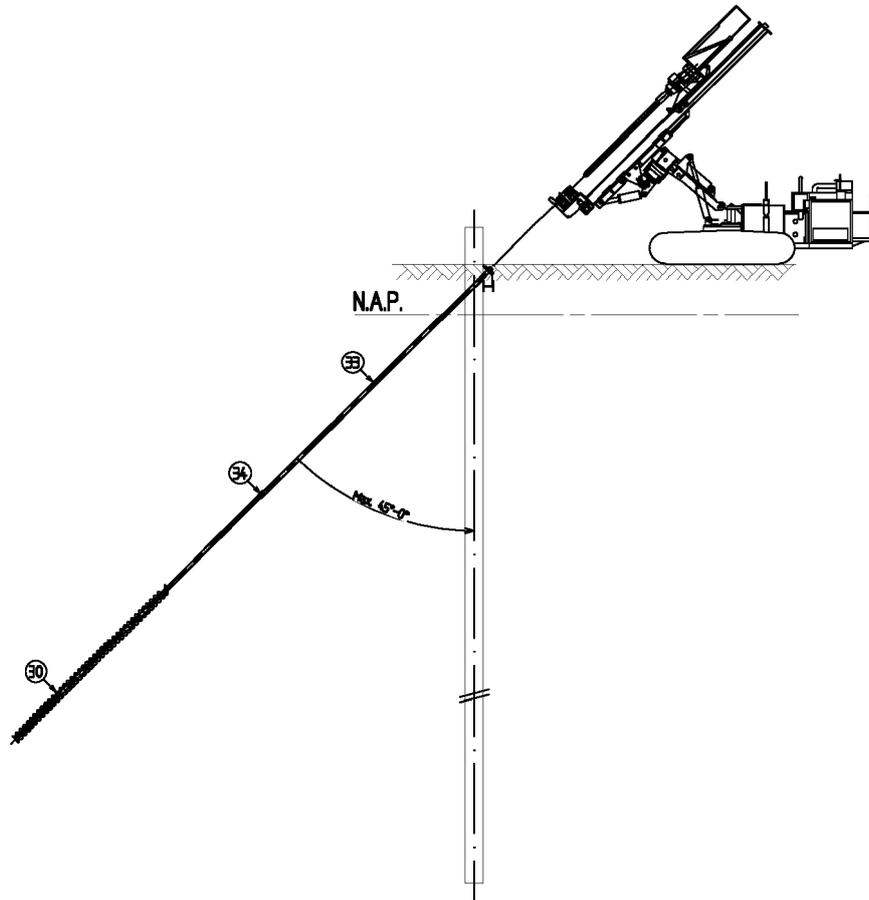


Fig. 3.b

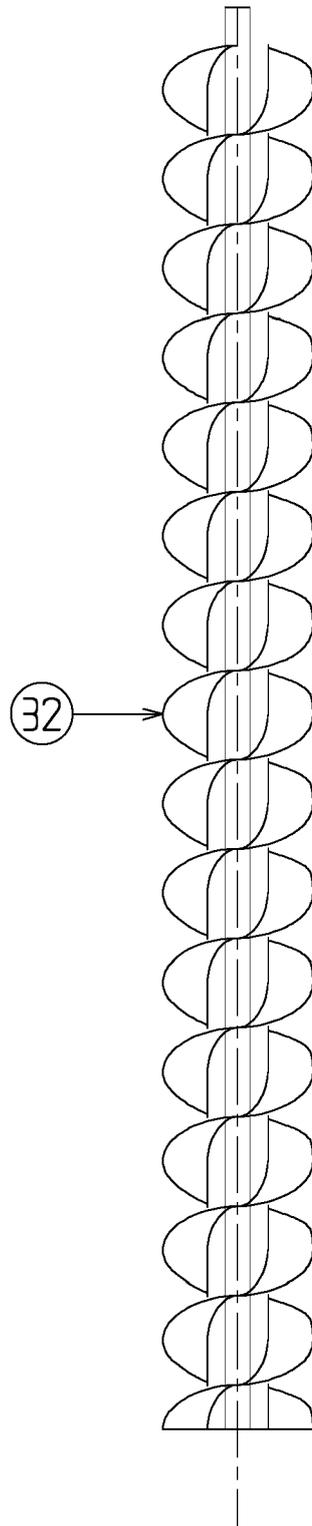


Fig 4

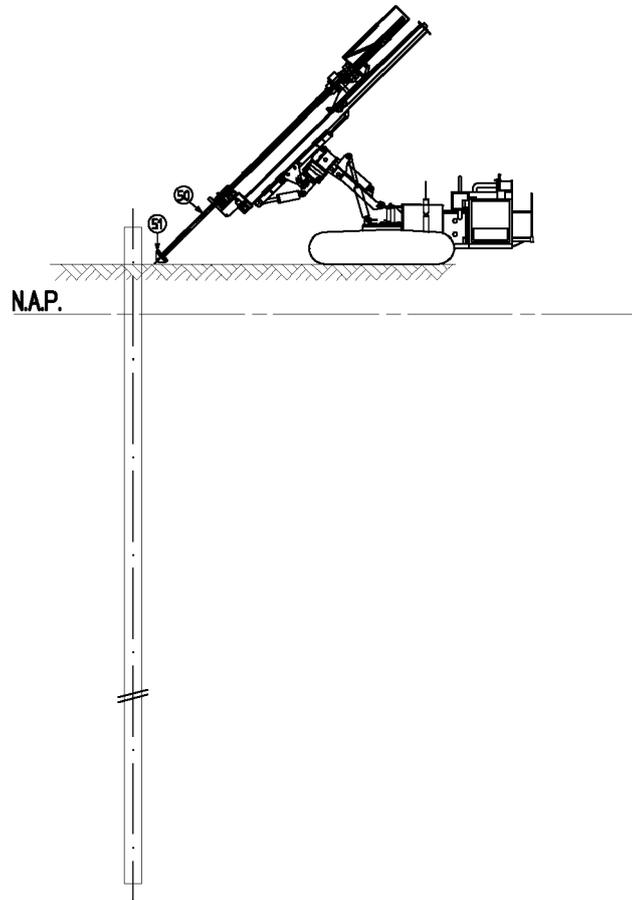


Fig. 5.a

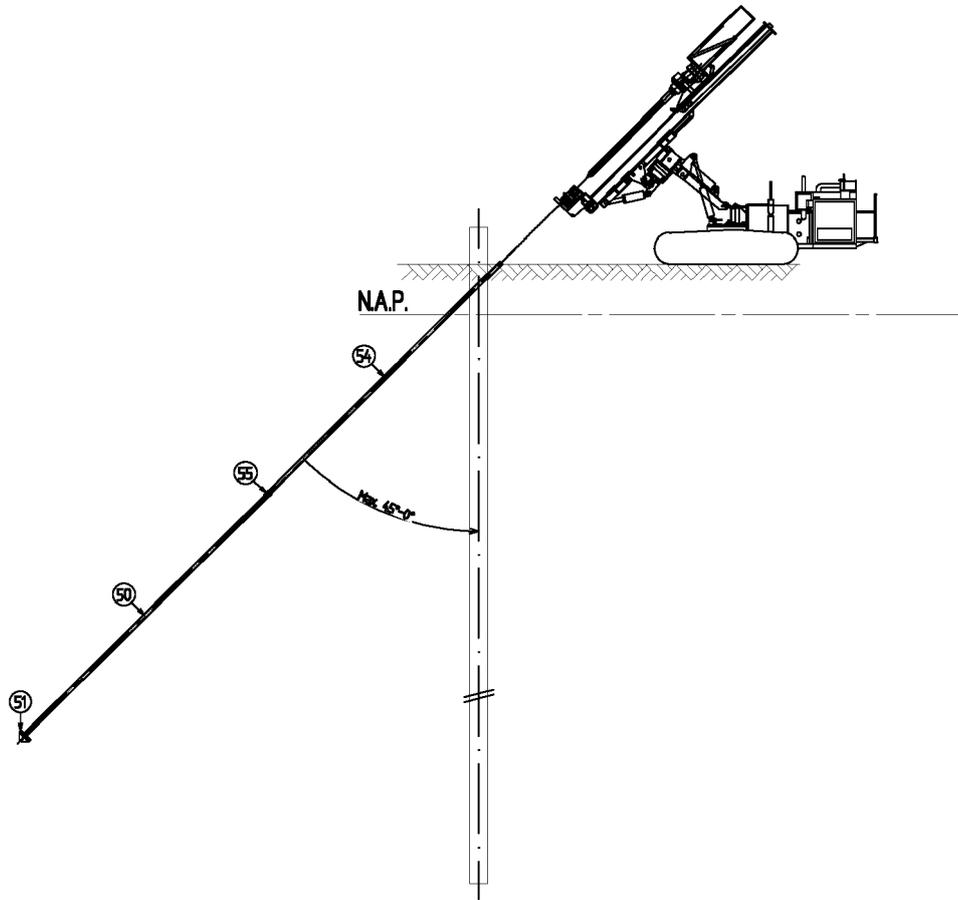


Fig. 5.b

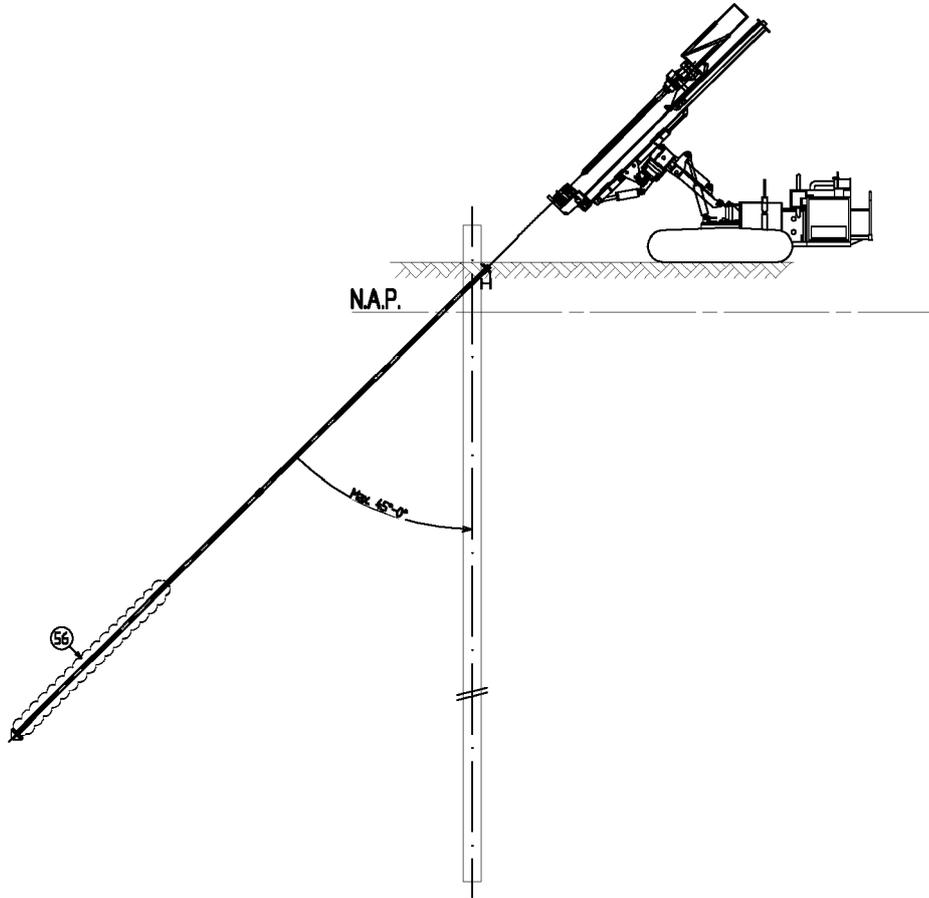


Fig. 5.c

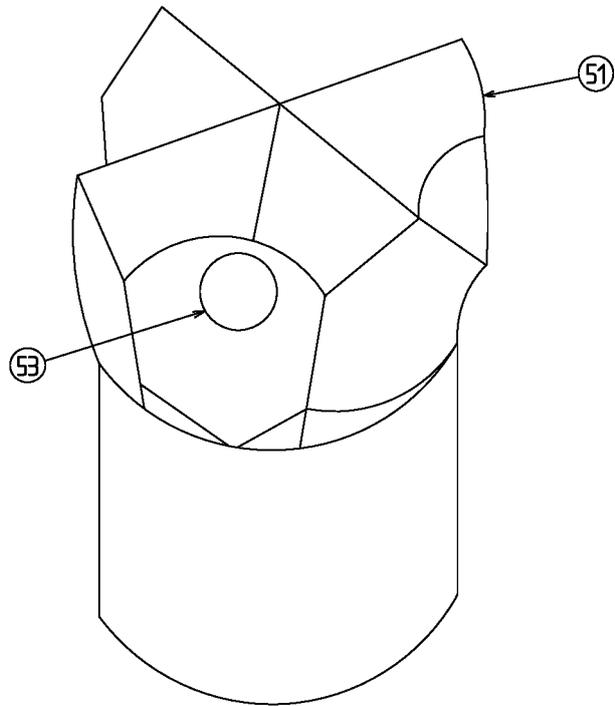


Fig. 6.a

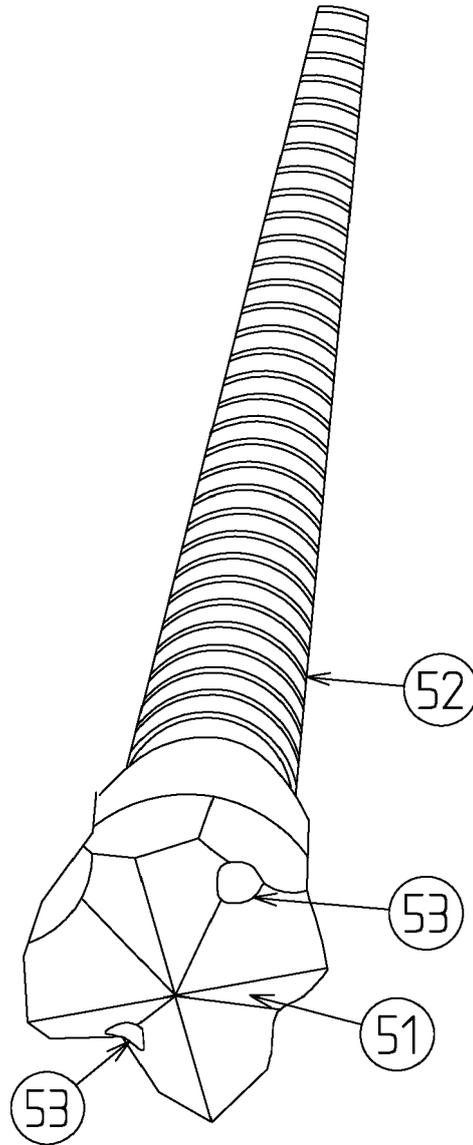
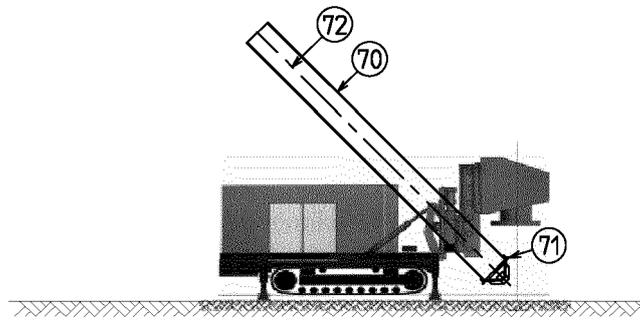


Fig. 6.b



N.A.P.

Fig. 7.a

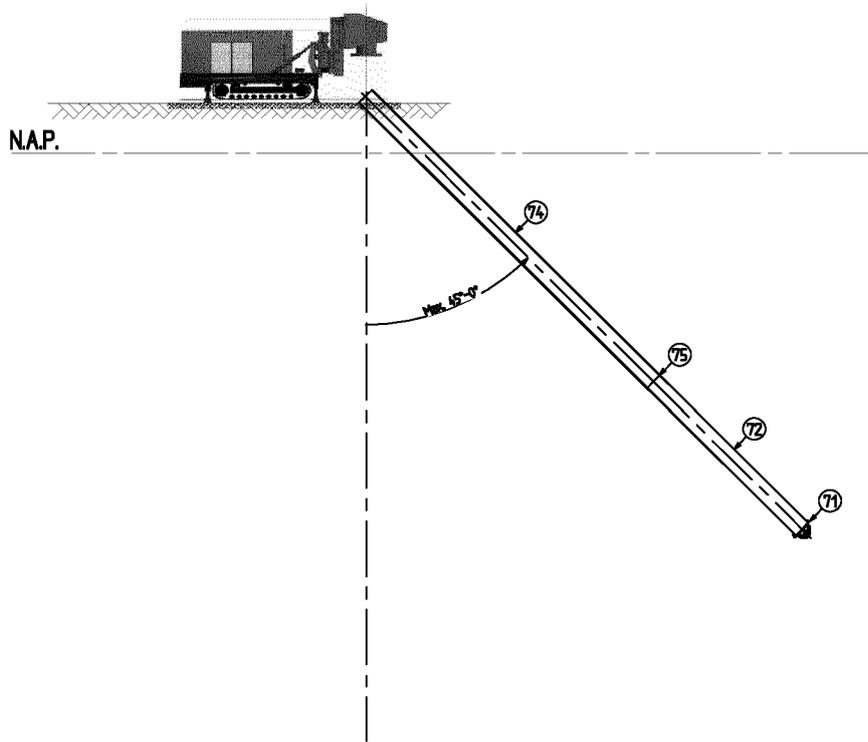


Fig. 7.b

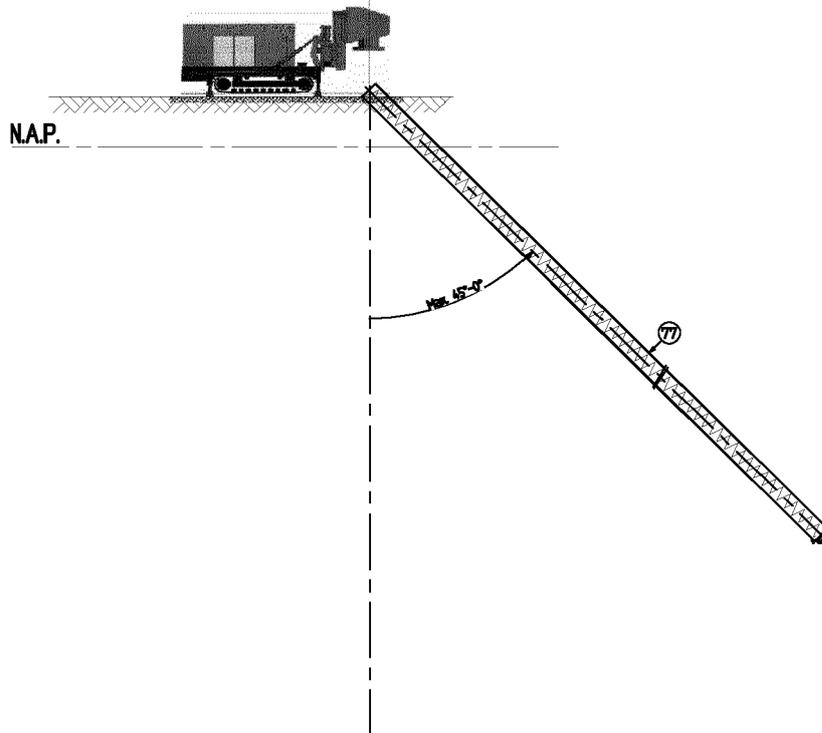


Fig. 7.c

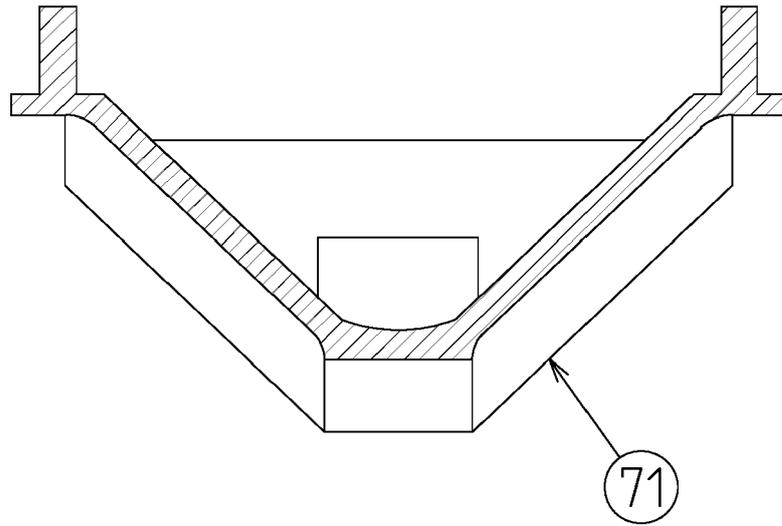


Fig. 8



EUROPEAN SEARCH REPORT

Application Number
EP 19 17 5074

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A	US 2009/101412 A1 (HARTUNG MARKUS [DE] ET AL) 23 April 2009 (2009-04-23) * the whole document *	1-8	
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			E02D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 June 2019	Examiner Geiger, Harald
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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