(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 278 075 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.01.2011 Bulletin 2011/04

(21) Application number: **09163915.3**

(22) Date of filing: **26.06.2009**

(51) Int Cl.:
E02D 3/12 *(2006.01)* ***E02D 5/46*** *(2006.01)*
E02D 5/66 *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR

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(54) Soil stabilization column, rotary device and manufacturing method of such column

(57) The present invention relates to reinforcement of underground foundation, and in particular to a soil stabilization column comprising an essentially cylindrical portion comprising a mixture of soil and a stabilizing agent, and a center portion extending at least partly along the essentially cylindrical portion and comprising a cured load bearing stabilizing slurry, wherein the essentially cylindrical portion and the center portion are arranged concentrically to each other. The present invention further relates to a rotary device and method for forming such soil stabilization column.

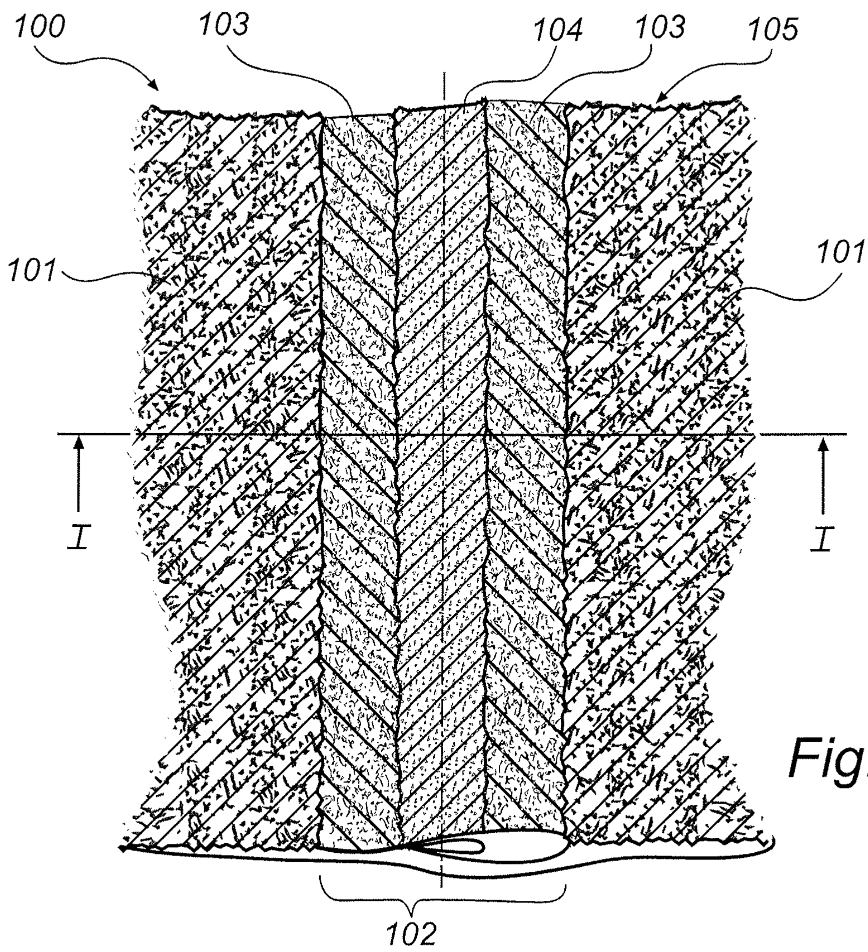

Fig.1

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Description

Field of the Invention

[0001] The present invention relates to reinforcement of underground foundation, and in particular to a soil stabilization column and a rotary device and method for forming such soil stabilization column.

Background Art

[0002] The subsurface properties of ground and soil structures, for example soil foundations for roads, buildings, etc., are often inadequate for supporting loads. Therefore, it is desirable to strengthen or reinforce the load bearing capacity of the ground by soil improvement or by introducing prefabricated piles that are driven into the ground.

[0003] A known technique of soil improvement is to introduce a dry soil consolidating agent into the ground by means of a rotatable shaft. Accordingly, a rotatable shaft is at its end arranged with a boring tool which during a turning motion is driven into the ground. Dry consolidating agent is added into the ground by blowing/injecting consolidating agent through a channel in the shaft and out through an outlet, or nozzle, of the boring tool. During the turning motion, while the shaft and boring tool are being withdrawn from the ground, the consolidating agent is ejected and mixed with the surrounding soil in the shape of a column. Commonly, consolidating agent such as cement and/or lime is used which together with existing or added water in the soil column hardens such that the expected soil improvement is achieved. However, resulting properties of the reinforced column, such as shear and compression strengths, are limited, although quite better than the unimproved soil. Normally, the abovementioned technique of introducing dry soil consolidating agent into the ground entail soil improvements up to a depth of 20 meters, and the soil improvements of the top portions of the improved soil column are often of low quality due to poor initial soil conditions, such as a dry crust or lack of water due to the ground-water table being located a certain distance below the existing ground level.

[0004] Another technique for increasing the load bearing capacity of the ground is to introduce solid piles into the ground. Prefabricated piles may be driven into the ground by using a pile driver, or a cast-in-place pile is manufactured by casting a pile in a predrilled casing which is provided in the ground with the use of a drilling rig. In the case of unstable ground, cast-in-place manufacturing involving a drilling rig is cumbersome and a driven prefabricated pile is typically used. The prefabricated pile technique entails prefabricating e.g. a conventional concrete pile off-site, transport the pile to the site, and by force drive the pile into the ground using a pile driver, which results in time consuming manufacturing, expensive handling, and a noisy construction site. This type of pile typically has low frictional coupling with the surrounding soil since it is formed of a prefabricated element and relatively slender, thus having moderate skin surface. Furthermore, when used in unstable soil, a prefabricated pile is disadvantageous in that it is probable to deform and experience column buckling, typically due to lack of subsurface lateral support. The technique requires a high number of prefabricated piles to be placed close together in order to be used with soft soils, which imply expensive and time consuming production.

Summary of the Invention

[0005] The object of the present invention is to eliminate or at least to alleviate the above mentioned drawbacks by the use of a soil stabilization column with improved load bearing properties, and to provide a method for manufacturing said soil stabilization column. These and other objects are met by the subject matter provided in the independent and dependent claims.

[0006] The invention is based on the realization that by providing a soil stabilizing column comprising a mixture of soil and stabilizing agent and a concentric center portion of a cured stabilizing slurry, the load bearing properties and the manufacturing of the soil stabilization column are considerably improved and facilitated.

[0007] According to a first aspect thereof, the invention relates to an in situ soil stabilization column, comprising an essentially cylindrical portion comprising a mixture of soil and a stabilizing agent, and a center portion extending at least partly along the essentially cylindrical portion and comprising a cured load bearing stabilizing slurry, wherein the essentially cylindrical portion and the center portion are arranged concentrically to each other.

[0008] The present invention is advantageous in that a soil stabilization column with a center portion of cured load bearing stabilizing slurry provides a stable and strong center portion which, in turn, provides improved load bearing properties, such as improved shear and compression strengths. Hence, the soil stabilizing column may support increased loads, which, for example, allows for production of soil foundations or stabilized embankments with increased height, load bearing capacity, and stability.

[0009] The soil stabilization column is further advantageous in that it has improved subsurface friction properties between the different portions of the column and the surrounding soil due to its in situ production, which, in turn, increase the load bearing capacity of the column. The center portion of the soil stabilization column is arranged concentrically with the mixture of soil and stabilizing agent which provides high verticality along the column, both at low, or shallow, and high, or deep, depths. For example, high verticality provides an even distribution of friction forces between the center portion and the mixture of soil and stabilizing agent at low, or shallow, depths and at high, or deep, depths along the subsurface column. The soil stabilization column also allows for improved transfer of load forces into friction forces. For instance, the load bearing elements of the soil stabilization column, such as the center portion, are gradually coupled to the surrounding soil which improves the load bearing capacity and an even distribution of internal load bearing forces of the column and the surrounding soil is provided. In other words, the column is gradually integrated with the surrounding soil which increases the load bearing capacity e.g. provided by the frictional forces between the center portion, the mixture of soil and stabilizing agent, and the surrounding soil.

[0010] The mixture of soil and stabilizing agent of the soil stabilization column according to the invention provides increased load bearing capacity, improved soil properties, and serves as a support for the center portion. For example, this means that the mixture of soil and stabilizing agent support the center portions such that the soil stabilization column is less prone to suffer from deformations, such as buckling or cracking, which increases its durability.

[0011] In an embodiment of the soil stabilization column, the center portion is essentially cylindrical which allows for a suitable column that is advantageous in that e.g. the load bearing capacity along the full length of the center portion is improved and essentially uniform. An essentially cylindrical center portion also improves the load bearing properties of the column in terms of reducing cracking, buckling, or other deformations of the center portion. In addition, the center portion is supported by the mixture of soil and stabilizing agent which further reduces the risk of deformations of the center portion.

[0012] According to one embodiment of the present invention, the essentially cylindrical portion encircle the center portion of the soil stabilization column. Hence, the cured center portion is arranged inside the cylindrical portion of a soil and stabilizing agent mixture such that the center portions forms a semisolid, or solid, cylindrical center portion of the soil stabilization column. In other words, in a cross-section of the soil stabilization column, the essentially cylindrical portion of a soil and stabilizing agent mixture forms a surrounding shell formation which surrounds the center portion of cured stabilizing slurry. This is advantageous in that a composite soil stabilizing column is formed, wherein the center portion of cured load bearing stabilizing slurry is provided with a supportive casing of a mixture of soil and stabilizing agent.

[0013] Advantageously, in an embodiment, the center portion of the soil stabilization column comprises cured cement or concrete which enables a cost efficient soil stabilization column which is of high strength and durability. The center portion soil stabilization slurry may also comprise grout, or mortar, or other compositions comprising a mixture of water, cement and sand. The slurry mixture may also comprise fine gravel or fly ash, and according to an embodiment of the soil stabilization column, the cured stabilizing slurry comprises filler material, or aggregate.

[0014] According to a second aspect thereof, the invention relates to a method for forming an in situ composite soil stabilization column, comprising inserting a rotary device into the ground so as to define an essentially cylindrical soil formation, providing a stabilizing agent in the soil formation by ejection from the rotary device, mixing the stabilizing agent with the soil formation by rotating the rotary device, providing a curing stabilizing slurry in a center portion of the soil formation by ejection from the rotary device, such that the center portion and the soil formation are concentrically arranged.

[0015] The method for forming a soil stabilization column is advantageous in that the formed soil stabilization column has improved load bearing properties, wherein, for example, the subsurface friction properties between the different portions of the column and the surrounding soil is improved, as described above. The method further allows for efficient manufacturing of the soil stabilization column which minimizes the process steps necessary for manufacturing. The same rotary device is used for arranging the essentially cylindrical soil formation of a mixture of soil and stabilizing agent and for concentrically providing the stabilizing slurry in a center portion of the soil stabilizing column. Hence, only one rotary device is required for the manufacturing of a soil stabilization column which allow for simple and efficient operation. Also, the method allows for a soil stabilization column, and method for manufacturing the column, wherein the concentric verticality between the different portions of the column are considerably improved. Moreover, the method allows for time efficient manufacturing, for example due to low handling requirements and efficient manufacturing process, which reduces manufacturing and handling costs.

[0016] According to an embodiment of the method for forming a soil stabilization column, the step of providing the stabilizing agent further comprises ejecting the stabilizing agent from a first outlet, or first nozzle, of said rotary device. The first outlet may be formed for ejecting the stabilizing agent and used for improved ejection wherein the distribution of soil stabilizing agent in the soil formation is controlled. Furthermore, by ejecting the soil stabilizing agent from the first outlet the mixing of the stabilizing agent with the soil formation is facilitated. For example, the first outlet is arranged to guide and eject the soil stabilizing agent in an essential radial direction of the soil formation during rotation of the rotary device.

[0017] In yet an embodiment of the method for forming a soil stabilization column, the step of providing a curing stabilizing slurry comprises ejecting the curing stabilizing slurry from a second outlet, or second nozzle, of said rotary device. Advantageously, by providing the curing stabilizing slurry from an outlet of the rotary device, the control of the ejection process is improved wherein the center portion is aligned with the soil formation of the soil stabilizing column. For example, the second outlet is arranged to eject the slurry in the center of the soil formation and may be arranged in a downward direction.

[0018] According to one embodiment of the invention, the step of providing a stabilizing agent further comprises ejecting said stabilizing agent in a radial outer portion of said soil formation. In other words, the stabilizing agent is provided in an outer region of the essentially cylindrical soil formation, wherein the outer region forms a supportive casing for the center portion. For example, the stabilizing agent is ejected at an intended radial length of the soil formation and mixed into the surrounding soil of the soil formation. By forming an outer region of the soil stabilizing column comprising a mixture of soil and soil stabilizing agent, wherein the outer region is integrated with the soil, or ground, and has the shape of a hollow cylinder, the center portion of the soil stabilizing column located in the center of the cylinder is uniformly supported. Accordingly, the method efficiently provides a soil stabilizing column having improved overall strength and durability, as well as improved transfer of load bearing forces into the surrounding soil and ground. Alternatively, according to another embodiment of the method, the ejection of the soil stabilizing agent is not limited to an outer region of the soil formation. For example, the soil stabilizing agent may be ejected and mixed into the main part of the soil formation, wherein the main part comprises the center portion region and the outer region.

[0019] The step of mixing the stabilizing agent may in an embodiment of the invention further comprise mixing by means of extension of said rotary device. In other words, the method comprise mixing the stabilizing agent by the use of mixers, or extensions, which are arranged on the rotary device, and which mixers, or extensions, mix the surrounding soil in the soil formation during rotation of the rotary device. This allows for the ejected soil stabilizing agent to be properly mixed and integrated with the soil such that an improved column is realized. The soil stabilizing agent may also be ejected, or injected into the soil formation and properly mixed with soil in the injection. For example, mixing during injection of the soil stabilizing agent may be achieved by high pressure injection.

[0020] According to an embodiment of the invention, the stabilizing agent and/or the curing stabilizing slurry is ejected during retraction, or withdrawal, of the rotary device from the soil. That is, when the rotary device is retracted or withdrawn from the subsurface position in the ground to towards the surface. Hence, the rotary device is inserted and forced down into the soil, or ground, to a desired depth usually during rotation. During insertion, the soil is loosened and the prepared for mixing with stabilizing agent due to the rotary action of the rotary device. At the desired depth the ejection from the rotary device of soil stabilizing agent and curing stabilizing slurry is initiated and maintained while the rotary device during a rotation motion is retracted from the ground. As described, the stabilizing agent and/or the curing stabilizing slurry is ejected during the retraction motion. In one embodiment, the soil stabilizing agent is ejected during the retraction of the rotary device which is advantageous in that the soil will be loosened up, disaggregated, during insertion of the rotary device. In yet an embodiment, the curing stabilizing slurry is ejected during retraction of the rotary device, and the stabilizing agent may be injected during insertion of the rotary device which means that the ejection of the two different mediums will essentially comprise two separate ejection processes. Also, the ejection of the stabilizing agent and the curing stabilizing slurry may in one embodiment of the invention be simultaneous, i.e. both ejection processes are performed at the same time during retraction of the rotary device, which allows for time efficient production.

[0021] According to one embodiment, the steps of the method are performed either in a consecutive order, for example as mentioned above or according to appended claims, or generally simultaneously. Furthermore, the method for forming a soil stabilization column may advantageously be achieved in a one-stroke procedure, in which the soil stabilization column is formed during one stroke, or one cycle. Hence, steps such as, but not limited to, inserting the rotary device into the ground, providing soil stabilizing agent, mixing the stabilizing agent, providing curing stabilizing slurry, may be realized in a one-stroke, or generally simultaneous, procedure wherein the rotary device is inserted and retracted from the ground. In other words, a one-stroke method for forming a soil stabilization column is provided. By realizing abovementioned consecutive order, generally simultaneous or one-stroke method embodiments, the method is further improved for example in terms of cost and manufacturing time efficiency.

[0022] According to a third aspect thereof, the present invention relates to a rotary device for forming an in situ soil stabilization column by boring into the ground, which rotary device comprises a bore tip arranged at a forward end of the rotary device, a first channel for transporting a stabilizing agent, which first channel has a first outlet for ejecting the stabilizing agent, means for mixing the stabilizing agent with soil, and a second channel for transporting a curing stabilizing slurry, which second channel has a second outlet for ejecting the curing stabilizing slurry in a radially centered portion of a formed soil stabilization column.

[0023] The rotary device, or rotary tool, for forming a soil stabilization column according to the present invention is advantageous in that it allows for efficient manufacturing of a soil stabilization column with improved load bearing capacity, wherein, for example, the subsurface friction properties between the different portions of the column and the surrounding soil is improved, as described above. Hence, the device is advantageous in that it is arranged to provide a soil stabilization column having a center portion of stabilizing slurry in a mixture of soil and stabilizing agent. The rotary device further allows for fast production with low additional handling requirements, such as alignment of the device or lengthy equipment adjustments or equipment changes. Furthermore, the rotary device provides a soil stabilization columns with considerably improved verticality, wherein the center portion of curing stabilizing slurry is aligned in the center of the soil stabilizing column along the main part of the length, or depth, of the soil stabilizing column. Hence, improved load bearing capacity is ensured and provided essentially along the complete length soil stabilizing column.

[0024] According to an embodiment of the invention, the first outlet of the rotary device is arranged in an outer radial position of the rotary device. In other words, the first outlet is arranged in a position which is located at an, in a radial direction, outer portion of rotary device, wherein the outlet may be arrange to face the surrounding, or circumjacent, soil in a radial direction. The arrangement of the first outlet in an outer radial position of the rotary device enables the stabilizing agent to be transported and ejected into the soil. For example, the arrangement is advantageous in that a mixture of soil and soil stabilizing agent may be realized which provides an improved supportive casing surrounding the center portion of the soil stabilizing column.

[0025] The second outlet may, in an embodiment of the invention, be arranged in an essentially radially centered position of the rotary device. in other words, the second out let is arranged in a position which is centrically located on the rotary device, wherein the outlet may be arranged in a downward direction. For example, the second outlet may be advantageously be centrically arranged at the bore tip of the rotary device. By arranging the second outlet in a center position of the rotary device the rotary device is arranged such that ejection of the curing stabilizing slurry is arranged in a center portion of the soil stabilizing column.

[0026] According to one embodiment, the second outlet comprises a valve which controls the ejection of the curing stabilizing slurry. By controlling the ejection the insertion process of the rotary device may be improved and an optimized level of ejection of curing stabilizing agent in the center portion may be realized. According to an embodiment, the second outlet comprise a fall down valve. The fall down valve may be arranged at the bore tip of the rotary device which allows for proper insertion of the rotary device into the ground and for efficient ejection of the curing stabilizing slurry when the rotary tool at a intended depth is retracted, or withdrawn. In yet an embodiment, a fall-down valve arrangement comprises the bore tip itself.

[0027] The means for mixing the stabilizing agent may, in an embodiment of the invention, comprise at least one radial projection of the rotary device. Hence, the means for mixing may comprise an mixer, arm, wing, guide, or other type of projecting member which is attached to the rotary device, wherein the means for mixing rotate along with the rotational motion of the rotary device and at least partly extend in the radial direction of the rotary device. Hence, the soil, or ground, is mixed during rotation of the rotary device and stabilizing agent that is introduced in the soil will be mixed with the soil. For example, the rotary device may be provided with radially projecting arms, wherein the arms may be tilted, or inclined, and given a pitch which improved the insertion, or boring, of the rotary device into the soil, or ground.

[0028] Other objectives, features, and advantages of the present invention will appear from the following detailed disclosure, from the attached dependent claims as well as from the drawings.

Brief Description of Drawings

[0029] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings. It is to be understood that the drawings are not true to scale and dimensions other than those illustrated in the drawings are equally possible within the scope of the invention. It is also to be noted that the dimensions of some details in the drawings may be exaggerated in comparison with other details.

Fig 1 is a side view of a portion of an embodiment of the soil stabilization column arranged in the ground.

Fig 2 is a cross-sectional view taken at I-I of an embodiment of the soil stabilizing column.

Fig 3a to 3d schematically illustrate an embodiment of the soil stabilizing column and the steps of an method embodiment for forming the soil stabilizing column.

Fig 4 illustrate a schematic set up including a machine forming an soil stabilizing column.

Fig 5 is a first cross-sectional view of an embodiment of the rotary tool according to the present invention.

Fig 6 is a second cross-sectional view of an embodiment of the rotary tool.

Detailed Description of Embodiments of the Invention

[0030] Fig 1 is a side view of an embodiment of the soil stabilizing column 100 which may be formed in situ in the soil 101, or ground, for stabilization and in order to improve the load bearing capacity. The soil stabilization column 100 comprises an essentially cylindrical portion 102 which defines the extension of the soil stabilizing column 100 relative the surrounding soil 101 in a radial direction, wherein the depth, or length, of the soil stabilization column 100 is typically measured from the soil surface 105. The essentially cylindrical portion 102 of the soil stabilization column 100 comprises a mixture 103 of soil and stabilizing agent, and a center portion 104 comprising a cured load bearing stabilizing slurry. The center portion 104 is formed in the center of and extends along the essentially cylindrical portion 102. In more detail, the soil stabilizing column 100 is formed of the essentially cylindrical portion 102 comprising the mixture 103 of soil and stabilizing agent, and the center portion 104 of cured slurry, wherein the mixture 103 is arranged in an radially outer portion of the essentially cylindrical portion 102. Thereby, the mixture 103 forms a supportive case, or shell, surrounding the center portion 104. Furthermore, as illustrated, the center portion 104 and the essentially cylindrical portion 102 are arranged concentrically to each other, wherein the longitudinal axis of center portion 104 substantially coincide with the axis of the essentially cylindrical portion 102 along the full depth, or length, of the center portion 104. As illustrated in Fig 1, the interface between the mixture 103 and the surrounding soil 101 may typically be somewhat rough, wherein the interface will depend on the composition of soil and stabilizing agent. For example, the concentration of stabilizing agent in the mixture 103 may be gradually lower in a radial direction towards the surrounding soil 101, which imply that the essentially cylindrical portion 102 is gradually integrated with, or into, the surrounding soil 101. In addition, the interface between the center portion 104 and the mixture 103 may to some extent be a rough interface in which the mixture 103 of soil and stabilizing agent and the center portion 104 of cured slurry are integrated, or mixed, with each other. In other words, the interfaces between the surrounding soil 101 and the mixture 103, and the mixture 103 and the center portion 104, may be somewhat coarse, wherein the interfaces may be overlapping. For example, this allows for improved load bearing properties, such as improved load distribution and load transfer between the different portions of the soil stabilizing column 100 and the surrounding soil 101.

[0031] Fig 2 illustrates a cross-sectional view of the embodiment of the soil stabilizing column as described with reference to Fig 1. The soil stabilization column 200 is depicted as a produced soil stabilization column surrounded by soil, or regular ground, 201. A center portion 204 of a cured stabilizing slurry which forms a solid and load bearing center of the soil stabilizing column 200 is provided. The soil stabilization column 200 further comprises a mixture 203 of soil and stabilizing agent, which mixture 203 is annularly arranged around the center portion 204. Hence, the center portion 204 is surrounded by the mixture 203, wherein the mixture, in turn, is surrounded by soil 201. The soil stabilizing column 200 comprises the essentially cylindrical portion 202 which forms the general shape of the soil stabilizing column 200 and defines it as a substantially distinct unit separated from the surrounding soil. However, the soil stabilization column 200 is to some extent integrated with the surrounding soil, wherein, for example, the mixture 203 is formed of both soil and stabilizing agent. In other words, at least some of the soil which is comprised in the mixture 203 is taken from the original non-stabilized soil, or ground.

[0032] The width of the soil stabilizing column, typically defined by the width, or diameter, of the essentially cylindrical portion 102 and 202, may normally be between 10 cm and about 150 cm, wherein the dimension of the center portion 104 and 204, defined by the diameter, may normally be between 5 cm and about 100 cm. Generally, suitable dimensions for the soil stabilization column 100 may depend on the general conditions of the soil prior to stabilization, and the load bearing and dimensional requirements of the stabilized soil.

[0033] Fig 3a to Fig 3d schematically illustrate an embodiment of the soil stabilizing column 300, a schematic embodiment of a rotary device 330 for forming the soil stabilizing column 300, and steps of an embodiment of a method for forming the soil stabilizing column 300. The rotary device 330 is arranged for being inserted into the ground and comprises a forward end and a longitudinal shaft. The rotary device 330 is further provided with mixing blades 331 and outlets, or nozzles, for ejecting stabilizing agent and stabilizing slurry. According to illustrated embodiment of the method for forming a soil stabilizing column 300, with reference to Fig 3a, the rotary tool 330 is initially arranged in a resting position above the non-processed soil 306. In Fig 3b, the rotary device 330 has been inserted into the soil by forcing and rotating the rotary tool 330 in a downward direction, wherein the rotary device is bored into the soil. While the rotary device 330 is driven into the soil the rotary device 330 and the mixing blades 331 form an essentially cylindrical soil formation 307, wherein the soil formation 307 essentially defines the location, or region, where the soil stabilization column 300 will be formed. Also, while the rotary device 330 is inserted in the soil, the rotary device 330 and the mixing blades loosen, or disaggregate, the soil in the soil formation 307 such that the soil will be easier to mix with a stabilizing agent at a later stage in the method. The insertion of the rotary device 330 and the rotary shaft further displaces soil in the center of the soil formation 332, wherein the displaced soil is typically displaced in an outward, or radial, direction, being in essence a sliding formwork for later added curing stabilizing slurry. The rotary device 330 is typically inserted into the soil to an intended depth, as illustrated in Fig 3b. For example, the intended depth may be of various distances ranging from about 0.5 meters to about 50 meters, or preferably between 2 meters to 30 meters. When the intended depth is reached, the rotary device 330 is, with reference to Fig 3c, retracted, or withdrawn, in an upward motion. During retraction the method for forming the soil stabilizing column 300 comprises providing a stabilizing agent in the soil formation 307 by ejection of stabilizing agent from the rotary device 330. In more detail, the stabilizing agent is provided by transporting, or pumping, the stabilizing agent in a first channel in the rotary shaft which is connected to a first channel in the rotary device 330. The first channel of the rotary device 330 further comprises an outlet, wherein the stabilizing agent is ejected, or pumped, through the outlet and into the soil formation 332. The ejection of the stabilizing agent is performed during the retraction and rotation motion of the rotary device 330, wherein the stabilizing agent is mixed with the soil in the soil formation 332 such that a mixture 303 is achieved, as illustrated in Fig 3c. For example, the mixing of the stabilizing agent with the soil formation is achieved by rotating the rotary device, wherein the mixing blades 331 of the rotary device 330 ensure complete and efficient mixing of the mixture 303. During retraction of the rotary device 330 the method for forming the soil stabilizing column 300 further comprises providing a curing stabilizing slurry in the center portion of the soil formation. In more detail, a void, or cavity, in the center portion of the soil formation is formed, or revealed, when the rotary device 330 is retracted, and the provision of the curing stabilizing slurry is achieved by ejection of curing stabilizing slurry from the rotary device 330. The curing stabilizing slurry may be provided by transporting, or pumping, the stabilizing agent in a second channel in the rotary shaft which second channel is connected to a second channel in the rotary device 330. The second channel of the rotary device 330 is arranged with an outlet, wherein the curing stabilizing slurry is ejected, or pumped, through the outlet and into the soil formation 332. The ejection of the curing stabilizing slurry is performed during the retraction and rotation motion of the rotary device 330, wherein the curing stabilizing slurry forms a load bearing center portion 304 of the soil stabilization column 303, as illustrated in Fig 3c and Fig 3d, and wherein the center portion 304 and the mixture 303 of the soil in the soil formation 307 and stabilizing agent are concentrically arranged. In other words, with reference to Fig 3c, the method comprises forming a composite soil stabilization column 300 comprising a center portion 304 of curing slurry surrounded by a mixture 303 of soil and stabilization agent, wherein the longitudinal axis of the center portion coincides with the axis of the mixture 303 at all depth along the center portion 304. As illustrated in Fig 3d, the rotary device has been fully retracted to the soil surface 305, and a complete composite soil stabilizing column 300 has been achieved in the soil. The composite soil stabilizing column 300 is surrounded by soil 301 which to some extend may be radially compressed compared to its initial non-processed state. The compression of the soil 301 may be achieved during insertion of the rotary device 330 due to the radial displacement of soil in the center portion of the soil formation 307. As a result, the compression of the soil 301 may further improve the load bearing capacity and the structural stability of the composite soil stabilization column 300. Accordingly, the method for forming the soil stabilizing column 300 may further comprise ejecting the stabilizing agent in a radial outer portion of the soil formation 307. Hence, the stabilizing agent may be ejected in the outer circumferential portion of the soil formation 307 geometrically separated from the center portion. This means that the mixture 303 comprising soil and stabilizing agent will be essentially arranged separated from the center portion, such that composite column is achieved. Furthermore, the curing stabilizing slurry may in an embodiment be ejected and arranged in the center portion 304 of the soil formation 307 only. Accordingly, two separate and distinct portions, namely the center portion 304 and the mixture 303, of the soil stabilizing column 300 are realized.

[0034] In another embodiment of the method for forming the soil stabilizing column 300, the stabilizing agent is ejected and mixed into the soil formation 307 while the rotary device is inserted, or bored, into the ground. In other words, in a first step, the mixture 303 is provided while the rotary device 330 is performing a downward motion, and, in a following step, the center portion 304 comprising curing stabilizing slurry is provided, or ejected, while the rotary device 330 is retracted.

[0035] With reference to Fig 3a to Fig 3d, the soil stabilization column may be formed in one-stroke, or one cycle. Hence, the method for forming a soil stabilization column is performed in one stroke, or generally simultaneously, which one-stroke comprises one cycle of insertion and retraction of the rotary device 330 in the ground.

[0036] Fig 4 shows a machine arrangement for forming the soil stabilizing column according to the present invention as described with reference to Fig 1, Fig 2 and Fig 3a to Fig 3d. The machine 470 is provided with a mast, or leader, 471 onto which a schematic rotary device 430 and a rotary shaft 432 is arranged. A stabilizing slurry supply 472 is provided and connected to a swivel unit 476 via a slurry conduit 473. In addition, a stabilizing agent supply 474 is provided and connected to the swivel unit 476 via a stabilizing agent conduit 475. The supplies 472 and 474 are arranged to pump stabilizing slurry and stabilizing agent via the conduits 473 and 475 to the swivel unit 476, respectively. The swivel unit 476 connects the conduits 473 and 475 to the rotary shaft 432, and the stabilizing agent and the stabilizing slurry is further guided to the rotary device 430 by two separate transportation channels in the rotary shaft 432. The mast, or leader, 471 is arranged for inserting the rotary device 430 and the rotary shaft 432 into the ground, wherein a rotary drive unit 477 is arranged on the mast, or leader, for providing a rotational motion to the rotary device 430 via the rotary shaft 432.

[0037] Fig 5 and Fig 6 illustrate two different cross-sectional views of an embodiment of the rotary device 530 and 630, respectively, wherein Fig 6 illustrates the rotary device 630 rotated 90 degrees along its axis relative the view in Fig 5. With reference to Fig 5, a bore tip 533 is arranged at a forward end of the rotary device 530, which boor tip 533 facilitates the process of inserting, or boring, the rotary device 530 into the soil. During insertion, soil is typically displaced and guided in a radial direction relative the axis of the rotary device 530 by slide portions 534. A first channel 535 for transporting the stabilizing agent is provided inside a the rotary shaft 532. The first channel 534 extends inside the cylindrical body 536 of the rotary device 530, and is provided with a first outlet 537 through the wall of the cylindrical body 536. As illustrated, a second channel 538 for transportation of curing stabilizing slurry is formed in the rotary shaft 532. The second channel 538 leads into the inside of the cylindrical body 537 and the slurry is further guided towards the forward end of the rotary device. The second channel 538 is provided with a second outlet 539 located at the forward end of the rotary device 530, wherein the second outlet 539 is arranged for ejecting the stabilizing slurry in a radially centered portion of a formed soil stabilizing column. A fall-down valve 540 is arranged at the forward end, or bore tip, for controlling the ejection of curing stabilizing slurry from the second channel 538. The fall-down valve is closed during insertion of the rotary device 530 due to the force exerted from surrounding soil, and falls down by its own weight and possibly the pressure from the slurry, such that the second channel is opened, when the rotary device is retracted. Alternatively, the valve may also be a controllable valve which may be closed and opened by a machine operator or a control unit. As further shown in Fig 5, the rotary device 530 is equipped with mixing blades 531 for mixing the stabilizing agent with surrounding soil. The mixing blades 531 extend from the cylindrical body 536 of the rotary device in a direction normal to the axis of the rotary device 530.

[0038] In Fig 6, the same embodiment of the rotary device 630 is illustrated as described with reference to Fig 5. As can been seen in the figure, two additional sets of mixing blades 631 are shown and is formed of extending arms, or wings, which project from the cylindrical body 636 of the rotary device 630. Also, two support bars 641 for holding and supporting the arrangement of the fall-down valve 640, are illustrated, wherein the curing stabilizing agent is free to pass through, or between, the support bars. As further illustrated, the first channel 635 is formed of a pipe inside the rotary shaft 632 and is arranged with an outlet 637. The outlet 637 is arranged in level, along the axis of the rotary device, with a par of mixing arms 630. Hence, efficient and direct mixing of the ejected stabilizing agent during manufacturing of a soil stabilizing column may be achieved. As further illustrated in fig 6, the second channel 638 is located in the rotary shaft 632, and leads through rotary device 630 to the fall-down valve.

[0039] According to the present invention, the stabilizing agent may be of various types. For example, the stabilizing agent is a dry form of stabilizing agent, a soil consolidating agent, or a binder agent. Typically the stabilizing agent interact with the ambient water content in the soil, wherein the soil and stabilizing agent consolidates to form a stabilized portion in the soil. The stabilizing agent may be transported to and ejected from the rotary device via pressurized air, which means that the ejection of stabilizing agent may controlled by controlling a pneumatic system arranged to work together with the stabilizing agent supply 474, as shown in Fig 4. For example, the stabilizing agent is a lime cement powder which is blown out, or ejected, from the rotary device and mixed into the soil according to the present invention. The curing and load bearing stabilizing slurry may, according to the present invention, be of various types, such as different compositions comprising a mixture of water and cement to form concrete. For example, a curing water and binder slurry, cement, grout, or other types of curing solutions, or chemical suspensions, of binder agent mixed in a thicker liquid may be used. The curing soil stabilizing slurry may be transported to and ejected from the rotary device via pump arrangement typically located at the curing stabilizing slurry supply 472, as shown in Fig 4. This allow for control of the ejection of the slurry by controlling the pump arrangement. Additionally, the rotary tool may be arranged with controlling valves which may be used to control the ejection of the stabilizing agent or curing stabilizing slurry from the rotary device of the present invention. The rotary tool may also be driven into the ground without rotation if the ground is very loose.

[0040] The invention has mainly been described above with reference to a number of explicitly disclosed embodiments. However, as is readily appreciated by the skilled person in the art, embodiments other than the ones disclosed above are equally possible with the scope of the invention, as defined by the appended claims.

Claims

1. An in situ soil stabilization column, comprising
an essentially cylindrical portion comprising a mixture of soil and a stabilizing agent, and
a center portion extending at least partly along said essentially cylindrical portion and comprising a cured load bearing stabilizing slurry,
wherein said essentially cylindrical portion and said center portion are arranged concentrically to each other.

2. A soil stabilization column according to claim 1, wherein said center portion is essentially cylindrical.

3. A soil stabilization column according to any one of the preceding claims, wherein said essentially cylindrical portion encircle said center portion.

4. A soil stabilization column according to any one of the preceding claims, wherein said center portion comprises in situ cured cement or concrete.

5. A soil stabilization column according to any one of the preceding claims, wherein said cured stabilizing slurry comprises a fill material or aggregate.

6. A method for forming an in situ composite soil stabilization column, comprising
inserting a rotary device into the ground so as to define an essentially cylindrical soil formation,
providing a stabilizing agent in said soil formation by ejection from said rotary device,
mixing said stabilizing agent with said soil formation by rotating said rotary device,
providing a curing stabilizing slurry in a center portion of said soil formation by ejection from said rotary device,
such that said center portion and said soil formation are concentrically arranged.

7. A method according to claim 6, in which said step of providing a stabilizing agent comprises ejecting said stabilizing agent from a first outlet of said rotary device.

8. A method according to claim 6 or 7, in which said step of providing a curing stabilizing slurry comprises ejecting said curing stabilizing slurry from a second outlet of said rotary device.

9. A method according to any one of claims 6 to 8, in which said step of providing a stabilizing agent comprises ejecting said stabilizing agent in a radial outer portion of said soil formation.

10. A method according to any one of claims 6 to 9, in which said step of mixing said stabilizing agent comprises mixing by means of extensions of said rotary device.

11. A method according to any one of claims 6 to 10, in which said stabilizing agent and/or said curing stabilizing slurry is ejected during retraction of said rotary device.

12. A method according to any one of claims 6 to 11, wherein the steps of the method are performed either in a consecutive order as mentioned in the claims, or generally simultaneously.

13. A rotary device for forming an in situ soil stabilization column by boring into the ground, said rotary device comprising
a bore tip arranged at a forward end of said rotary device,
a first channel for transporting a stabilizing agent, having a first outlet for ejecting said stabilizing agent,
means for mixing said stabilizing agent with soil,
a second channel for transporting a curing stabilizing slurry, having a second outlet for ejecting said curing stabilizing slurry in a radially centered portion of a formed soil stabilization column.

14. A rotary device according to claim 13, wherein said first outlet is arranged in an outer radial position of said rotary device.

15. A rotary device according to claim 13 or 14, wherein said second outlet is arranged in an essentially radially centered position of said rotary device.

16. A rotary device according to any one of claims 13 to 15, wherein said second outlet comprises a fall-down valve.

17. A rotary device according to any one of claims 13 to 16, wherein said fall-down valve is arranged at said bore tip.

18. A rotary device according to any one of claims 13 to 17, wherein said means for mixing comprises at least one radial projection of said rotary device.

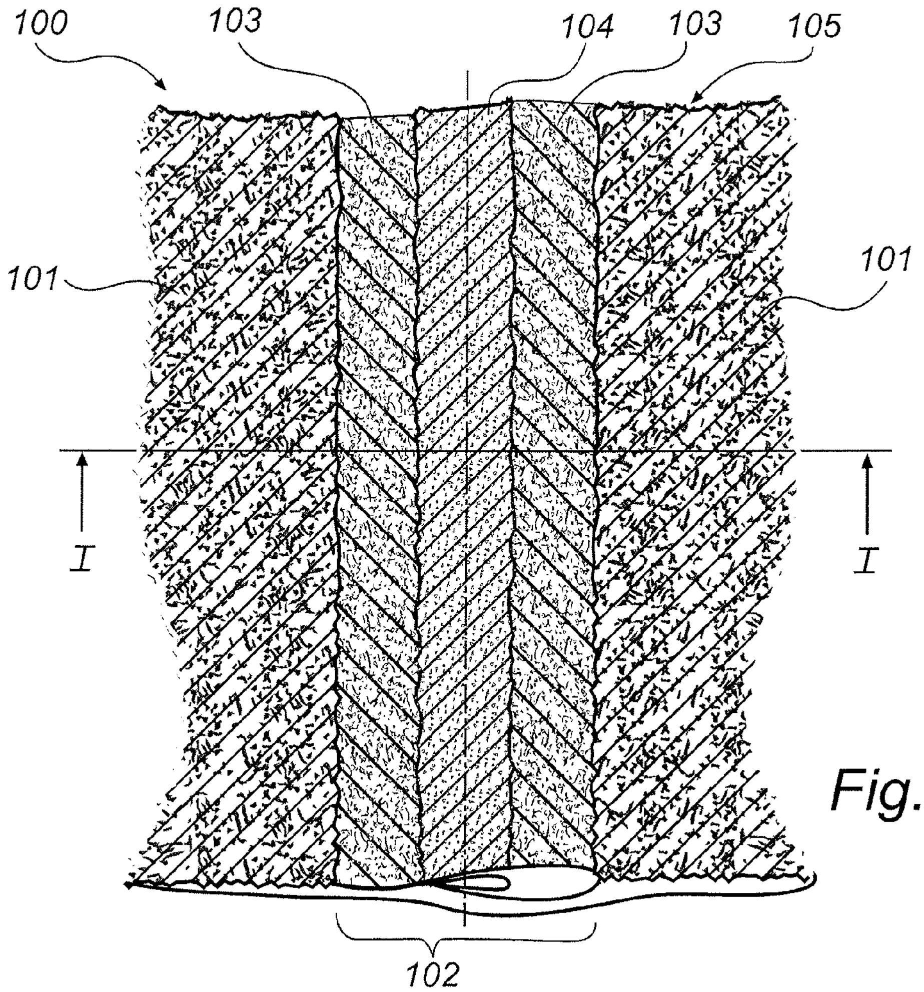


Fig.1

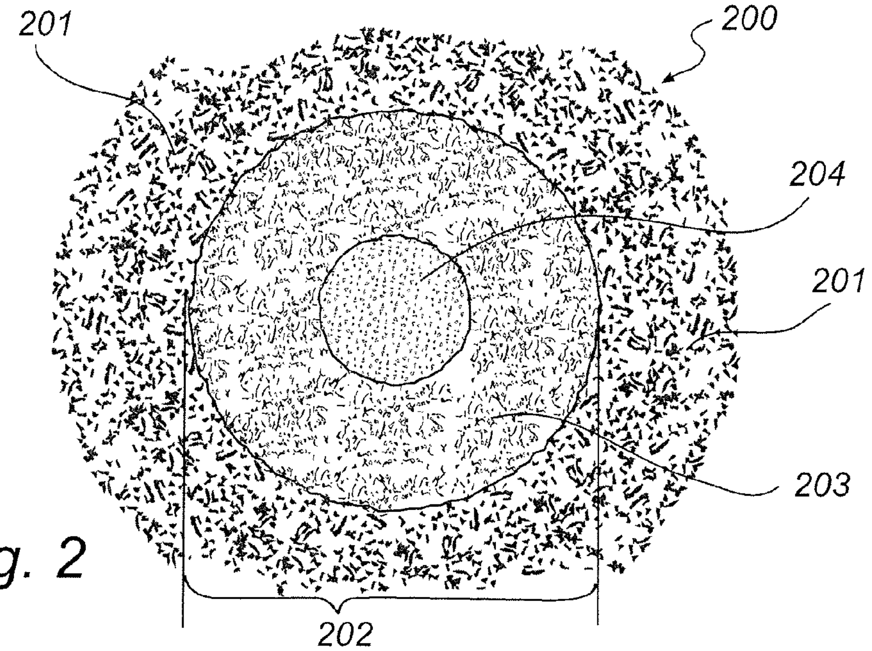


Fig. 2

Fig.3a

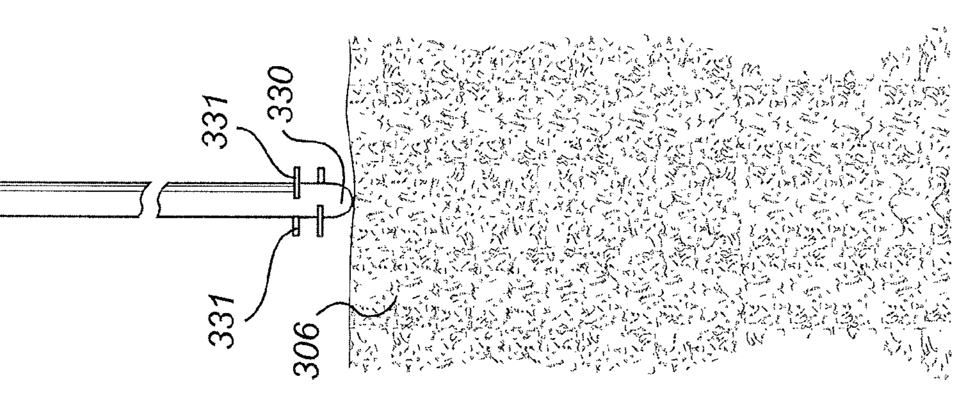


Fig.3b

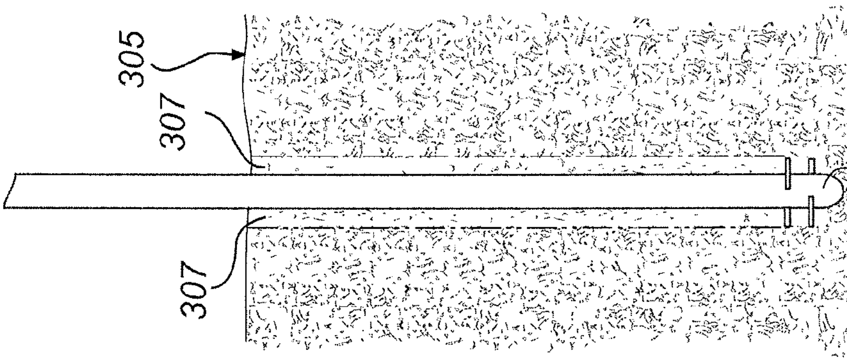


Fig.3c

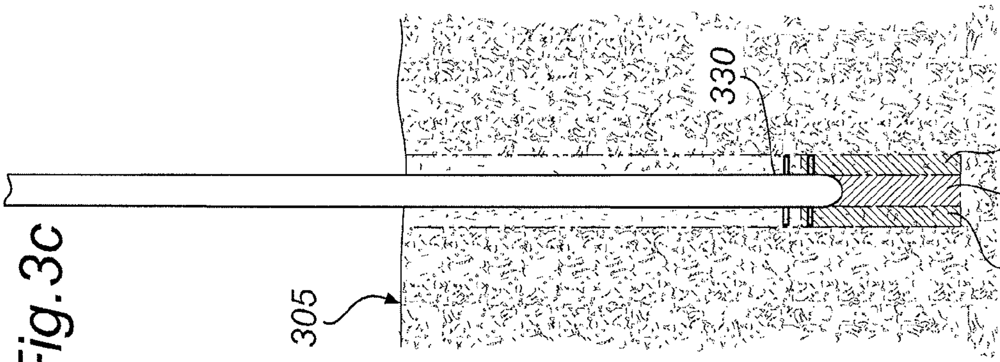
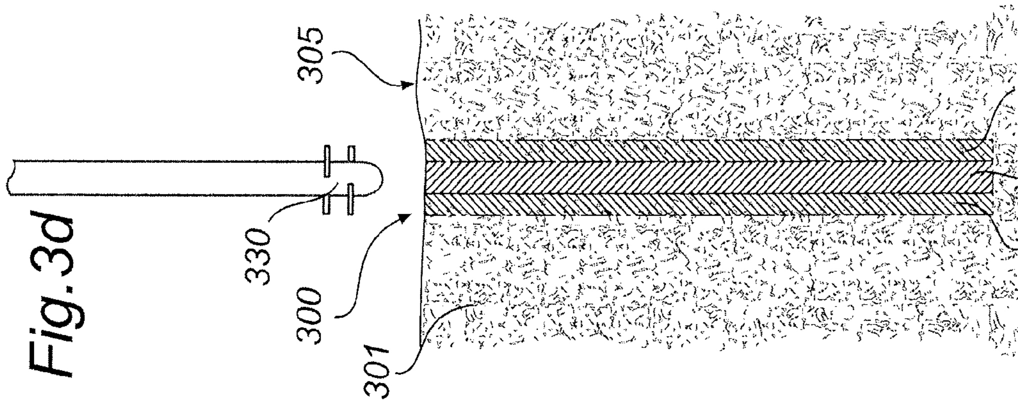


Fig.3d



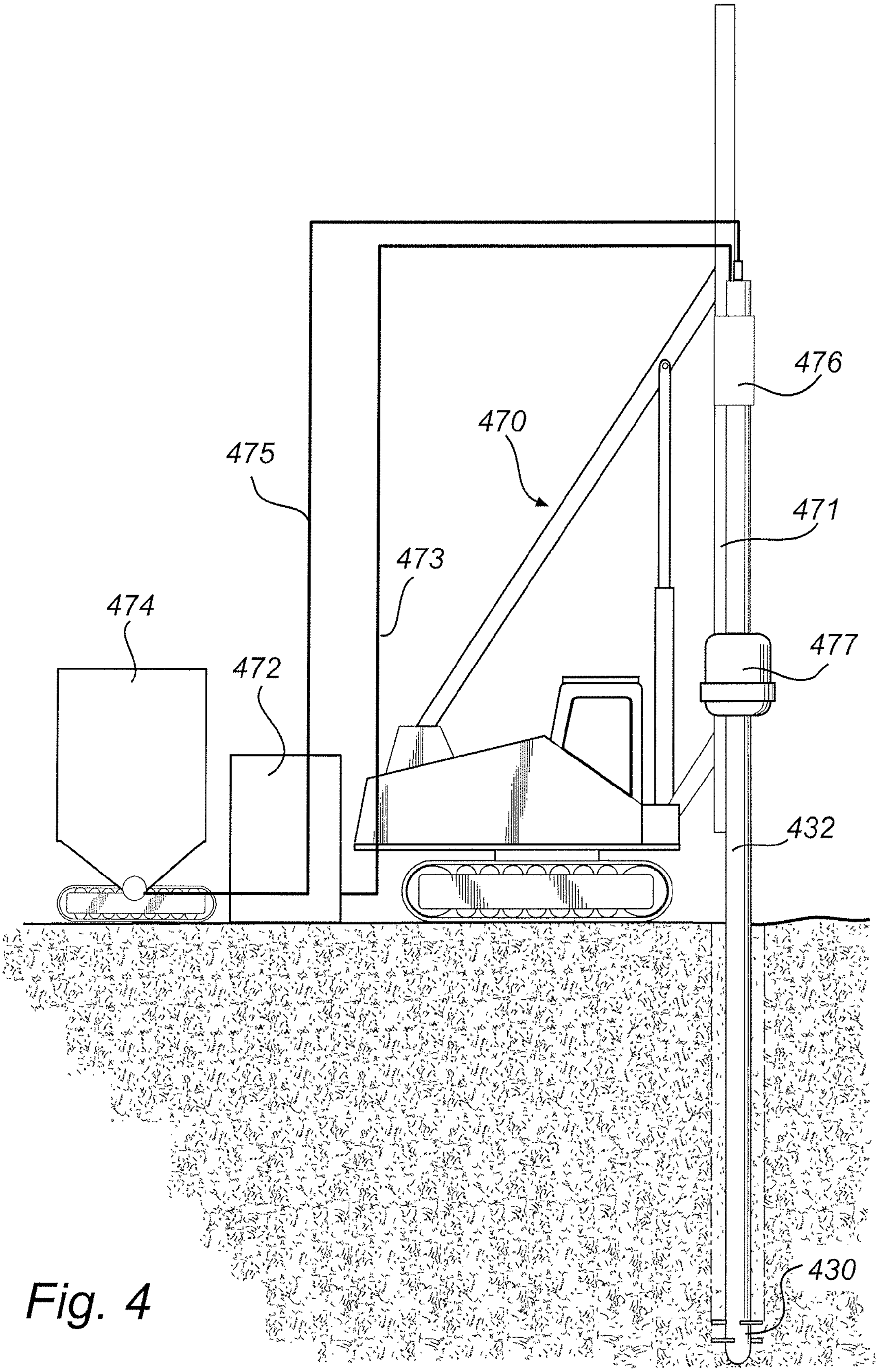


Fig. 4

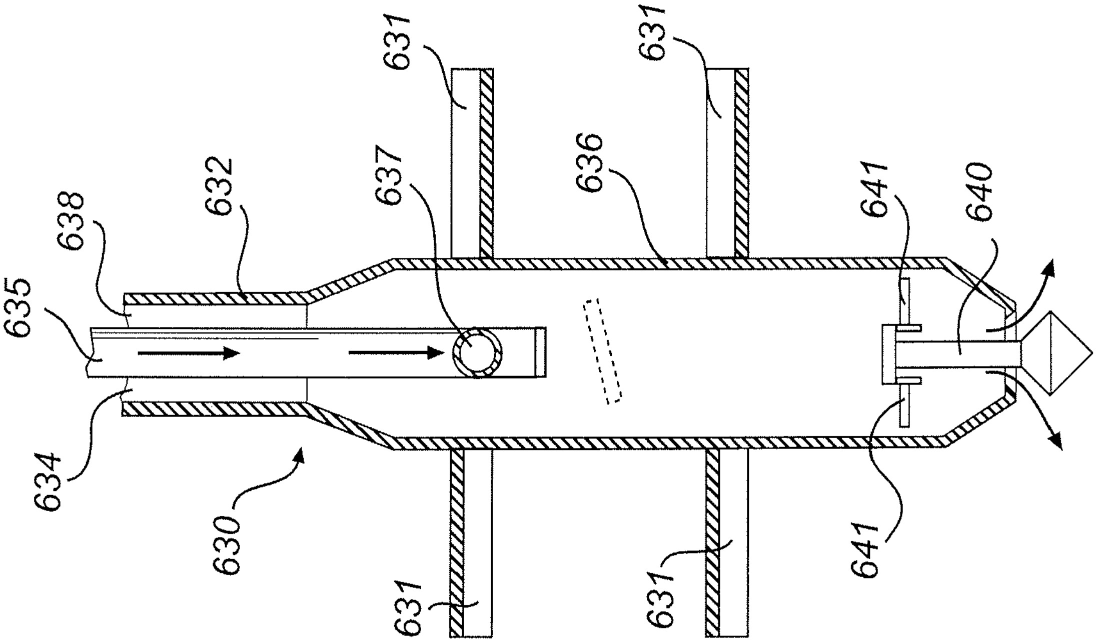


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Fig. 6

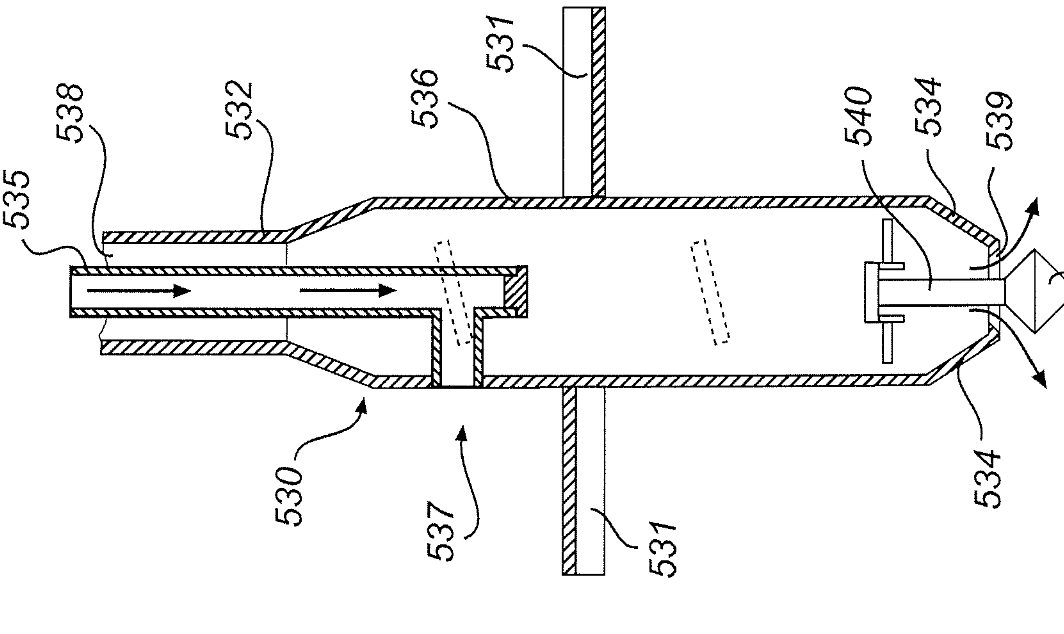

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Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 09 16 3915

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2008/138390 A1 (SMET LUC MARIA HUGO CORNEEL [BE]) 20 November 2008 (2008-11-20) * page 6, line 13 - page 7, line 10; figure 4 * -----	1-18	INV. E02D3/12 E02D5/46 E02D5/66
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			E02D

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	22 January 2010	Geiger, Harald

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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