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(54) Water resistant cast-in-place pile wall and method of constructing it

(57) The invention relates to a method of constructing a water resistant cast-in-place pile wall and the cast-in-place pile wall thus obtained. The wall is built up by providing a number of primary piles (302) and a number of secondary piles (312) which are intersecting. The wall is made watertight by providing a compression seal in the intersections. This compression seal is obtained by providing a liquid blocking means (320), which is positioned in a holding means (318), part of the armouring (314). Upon contact with water, the liquid blocking means swells and expands in the direction of the intersection, thus creating a compression seal. The compression seals are made at points in the intersection lines different from the end points of the intersection lines and are provided in the concrete piles before hardening of the secondary piles (312) occurs.

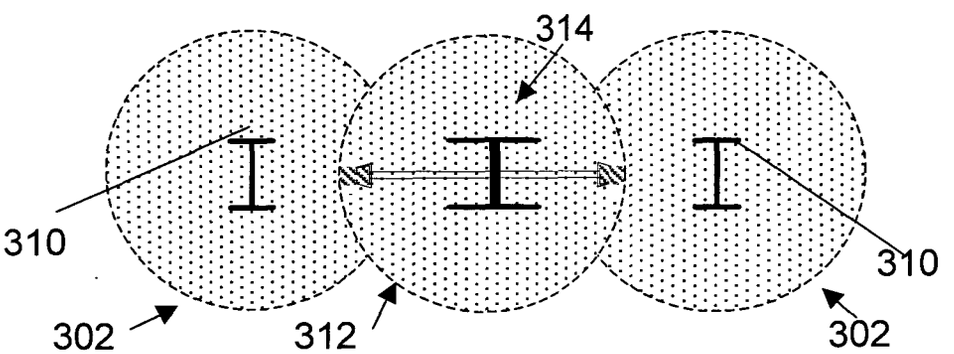

Fig. 3e

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Description

Technical field of the invention

[0001] The present invention relates to construction techniques for constructing a wall and to the resulting wall. More specifically, the invention relates to a cast-in-place pile wall for use as a retaining wall or floodwall for sustaining a difference in soil surface elevation, water elevation or water pressure from one side to another.

Background of the invention

[0002] In construction, pile walls are often used in difficult conditions. Typically, these walls can be used as a supporting or shoring structure e.g. if during construction the excavation is deep and the sides of the excavation hole exceed the angle of repose for the soil. Pile walls furthermore can be used as part of the foundation of a building. It is also known to use pile walls when a wall is to be constructed in a construction adjacent an existing construction, whereby the pile wall is constructed as close as possible to the existing wall of the existing construction. In these cases, pile walls are often used as active part of the building, i.e. not only for shoring or supporting reasons, but also to create walls for sunken or partially sunken rooms e.g. for construction of cellars, basements, underground parking spaces, garages etc. With a sunken or partially sunken room is meant that at least part of the room is situated under ground level or if construction is made in the water, under water level. Pile walls often replace diaphragm walls, cut off trench or cut off sheet pile walls, especially when the ground does not only consist of standard soil but when it also includes rigid inclusions. Whereas in general pile walls can be made of timber, steel or pre-cast concrete slabs driven side by side to retain earth and prevent water from seeping into an excavation, the present application is focussed on cast-in-place pile walls. With cast-in-place pile walls it is meant that the walls are not completely constructed from prefab piles, but that the piles are created by a cast-in-place process on the spot where the wall needs to be created. The present application thus is focussed on walls constructed by creating piles side by side in the ground, the piles having a certain intersection with neighbouring piles such that a wall is created. The piles typically are constructed on the spot by casting concrete in place. The use of cast-in-place concrete piles has the advantage that it is not necessary to drive the piles over their length into the ground by e. g. vibration, which may cause damage to adjacent buildings.

[0003] In many cases, but especially when the cast-in-place pile wall is used as active part of the construction used as wall for a sunken or partially sunken room, it is important that the pile wall is not only soil retaining, but that it is also completely water resistant. The lack of water resistance of concrete walls is a well known problem, that is e.g. addressed in the "Concrete Construction Engineering Handbook", edited by E.G. Nawy and published by CRC Press (1997). The permeability of concrete is mainly determined by the water/cement ratio and typically is in the range of 1.10^{-10} cm/s. This permeability can be influenced by addition of admixtures or by processing of the concrete afterwards such as curing in order to decrease the permeability of concrete. In this way it is possible, if the concrete is sufficiently thick such that the length of infiltration of the concrete is sufficiently high, to obtain a concrete wall that is substantially watertight. Nevertheless, in the construction of cast-in-place concrete pile walls, the wall is not made in a single piece and leakage may occur at the borders or seams of the different elements which create the wall.

[0004] A well known method of constructing a cast-in-place pile wall is shown in Fig. 1. A wall 100 is shown based on a cast-in-place pile wall comprising concrete piles 102, 104 constructed on-the-spot. The cast-in-place pile wall exists of overlapping piles 102, 104 that are formed in the ground. The piles 102, 104 are formed by drilling holes in the ground on primary positions, excavating the soil from the holes and inserting concrete such that primary piles 102 are formed, and repeating the same process for secondary piles 104. Primary piles 102 are not provided with armouring, or both primary piles 102 and secondary piles 104 are provided with an armouring or enforcement profile 106, 108, whereby the profile 106 of the primary piles 102 is typically substantially smaller than the profiles 108 of the secondary piles 104. The primary piles 102 and the secondary piles 104 are positioned such that the secondary piles 104 cut off parts of the primary piles 102, as shown in Fig. 1. This allows construction of retaining walls, but without providing walls that are completely watertight. Leaking occurs typically at the edges where the primary piles 102 and the secondary piles 104 intersect.

[0005] An often used solution for this problem is the construction of a watertight wall 110 next to the pile wall thus extending the infiltration length for water and obtaining a substantially watertight construction. Although this allows to solve the problem of water tightness, this nevertheless has the disadvantage that it is time consuming, that the amount of free space in the created room is reduced by building a thicker wall, which often is an important economical disadvantage, and that a lot of additional material is needed for this construction, thus leading to larger expenses and thus being an economical disadvantage as well.

Summary of the invention

[0006] It is an object of the present invention to provide a cast-in-place pile wall and a method of constructing a cast-in-place pile wall that is watertight without the need of additional space and time consuming constructions.

[0007] The above objective is accomplished by a

method and device according to the present invention.

[0008] The invention relates to a method for constructing a cast-in-place pile wall, comprising cast-in-place constructing at least one primary pile, cast-in-place constructing at least one secondary pile, the secondary pile intersecting with the primary pile at an intersection area having a first direction in the longitudinal direction of the secondary pile, and providing a liquid blocking means in the secondary pile, substantially in the first direction along the intersection area. It is an advantage of the present invention that the liquid blocking means is provided in the secondary pile, i.e. the liquid blocking means is present there when the secondary pile has hardened, so that no treatment such as water-tightening of the seams is necessary afterwards.

[0009] The method may furthermore comprise providing an armouring in the secondary pile. The armouring may comprise holding means for holding the liquid blocking means in the neighbourhood of the intersection area. The liquid blocking means may be brought in together with the armouring or it may be injected later on, but before hardening of the concrete. With "in the neighbourhood of the intersection area" is meant that the liquid blocking means is sufficiently close to the intersection area to seal it. The actual distance which may be used depends on the type and amount of liquid blocking means used.

[0010] The cast-in-place constructing at least one primary pile and at least one secondary pile may comprise cast-in-place constructing concrete piles.

[0011] Providing a liquid blocking means may comprise providing a hydrophilic liquid blocking means which expands and creates a compression seal at said intersection area. Providing a hydrophilic liquid blocking means may comprise providing a swelling strip in the holding means connected to an armouring prior to inserting the armouring in the secondary pile. Alternatively, or in combination therewith, providing a hydrophilic liquid blocking means may comprise providing an injectable liquid blocking material in the holding means connected to an armouring after said armouring has been inserted in the secondary pile.

[0012] The method may furthermore comprise providing an armouring in the primary piles.

[0013] The cast-in-place constructing of piles may comprise providing in the ground a hollow elongate element having substantially the volume of the pile to be constructed, excavating the hollow elongate element by removing soil from the hollow elongate element provided in the ground and filling said excavated hollow elongate element with concrete. The cast-in-place constructing may furthermore comprise curing the concrete. The concrete may be self-compacting concrete.

[0014] The invention also relates to a cast-in-place pile wall comprising at least one primary pile and at least one secondary pile intersecting with the at least one primary pile along an intersection area, wherein the at least one secondary pile comprises a liquid blocking means along the intersection area substantially in a longitudinal direction of the secondary pile. The at least one secondary pile may furthermore comprise an armouring. The armouring may include a holding means for holding the liquid blocking means in the neighbourhood of the intersection area so as to create a compression seal.

[0015] The at least one primary pile and the at least one secondary pile may be made of concrete. The concrete may be cured. The concrete may be self-compacting concrete.

[0016] The liquid blocking means may be a hydrophilic swelling strip. The liquid blocking means also may be an injected hydrophilic liquid blocking material.

[0017] The primary piles may comprise an armouring.

[0018] The invention furthermore relates to an armouring to be used in a cast-in-place pile wall according to the cast-in-place pile wall as described above.

[0019] It is an advantage of the present invention that in order to obtain a water tight cast-in-place pile wall, no additional wall needs to be provided next to the cast-in-place pile wall to obtain water tightness. It is a further advantage of the present invention that in this way the amount of space obtained for the constructed sunken room is significantly larger. It is also an advantage of the present invention that the amount of material needed to provide a water resistant cast-in-place pile wall is limited and that the time needed to construct a water resistant cast-in-place pile wale is limited.

[0020] Although there has been constant improvement, change and evolution of devices in this field, the present concepts are believed to represent substantial new and novel improvements, including departures from prior practices, resulting in the provision of more efficient and reliable methods and constructions of this nature. The teachings of the present invention permit the design of improved methods for constructing a cast-in-place pile wall and of an improved cast-in-place pile wall thus obtained.

[0021] These and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention. This description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

Brief description of the drawings

[0022]

Fig. 1 describes a schematic representation of a cross-sectional top view of (part of) a constructed cast-in-place pile wall based on concrete piles according to methods commonly known from the prior art.

Fig. 2 is a flow chart diagram of a sequence of different steps that may be comprised by a method for

constructing a cast-in-place pile wall according to a first embodiment of the present invention.

Fig. 3a to Fig. 3e is a schematic representation in cross sectional top view of the different steps of the method for constructing cast-in-place pile wall elements according to the first embodiment of the present invention.

Fig. 4 is a detailed cross sectional top view of a secondary pile and the corresponding armouring and water tightening means for use in a cast-in-place pile wall according to the first embodiment of the present invention.

Fig. 5 is a top view of a cast-in-place pile wall comprising primary and secondary piles according to an embodiment of the present invention.

Fig. 6 is a vertical cross-sectional view of the cast-in-place pile wall according to line VI-VI' in Fig. 5.

Fig. 7 is a top view of the armouring or reinforcement used in primary and secondary piles of the cast-in-place pile wall shown in Fig. 5.

Fig. 8 is a vertical cross-sectional view of the armouring or reinforcement used in primary and secondary piles, according to line VIII-VIII' in Fig. 7.

Fig. 9 is a detailed top view of a concrete secondary pile having an armouring or reinforcement for use in a cast-in-place pile wall according to a second embodiment of the present invention.

[0023] In the different figures, the same reference signs refer to the same or analogous elements.

Description of illustrative embodiments

[0024] The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

[0025] Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

[0026] It is to be noticed that the term "comprising", used in the claims, should not be interpreted as being restricted to the means listed thereafter; it does not exclude other elements or steps.. Thus, the scope of the expression "a device comprising means A and B" should not be limited to devices consisting only of components A and B. It means that with respect to the present invention, the only relevant components of the device are A and B.

[0027] In the present application the term "concrete" is used not strictly to refer to pure concrete. It also may be used to refer to an optimised mixture of polymer-modified concrete, polymer impregnated concrete, whereby the concrete afterwards is impregnated with polymer, polymer concrete, or any other concrete having admixtures to enhance the properties of concrete. Thus other additional components, often added to improve the quality of the concrete also may be present. The term concrete thus should be interpreted broad as referring to concrete or possibly adjusted concrete.

[0028] In the present application the terms "water stop", "water resistance", "water tightness" and so on should be interpreted in a very broad way, i.e. no restriction should be given to the chemical components present in the water and to possible contamination present in the water. The terms should be interpreted broad and could be replaced by "liquid stop", "liquid resistance", "liquid tightness" and so on.

[0029] In a first aspect, the present invention relates to a method for constructing a cast-in-place pile wall that is watertight. The method of construction will be described with reference to the flow chart shown in Fig. 2 indicating the different steps to be performed in the method 200 for constructing a cast-in-place pile wall that is watertight and with reference to Fig. 3a to Fig. 3e illustrating different steps of the method according to the first embodiment and Fig. 4 illustrating a more detailed top view of a secondary pile as constructed in the present invention.

[0030] The method comprises a fist step 202 of cast-in-place construction of a number of primary piles 302 in the ground. The exact method of cast-in-place construction is not limiting for the current application. A possible way of construction of the primary piles 302 may be first inserting a hollow elongate element 304, such as a tube, substantially vertically in the ground, removing the soil present within the hollow elongate element 304 and filling it with concrete 306. The hollow elongate elements 304 are inserted in the ground at modular distances A. With "modular distances" it is meant a distance A suitable for later constructing secondary piles in between the primary piles 302 so as to form a substantially continuous wall, i.e. such that primary piles 302 and later constructed secondary piles intersect. The hollow elongate elements 304 can be placed at modular distance A, e.g. by means of a matching plate or template (not shown in Fig. 3a) having suitable dimensions and suitable excisions or by measuring the distances between the central axis of the hollow elongate elements 304. Insertion of the hollow elongate elements 304 may be done by exerting downward forces onto the hollow elongate element 304, e.g. by means of high frequency vibrations, or by means of a combination of liquid such as water and a downward force. In this later case, e.g. water is made to flow into the hollow elongate element 304 to be introduced into the ground, which hollow elongate element 304 is erected on the ground. The

flowing of water weakens the resistance of the ground, and the hollow elongate element 304 is pushed substantially vertically into the ground, which may be done e.g. hydraulically, by applying a pushing force on the top side of the hollow elongate element 304 and/or by applying vibrations to the hollow elongate element 304. This way, the hollow elongate element 304 is pushed into the ground over a first distance. Thereafter, the hollow elongate element 304 is preferably brought deeper into the ground over a second distance without using the liquid, in order to avoid further weakening of the soil surrounding the hollow elongate element 304 and primary pile 302 to be constructed thus obtaining a better fixation of the hollow elongate element 304 and the primary pile 302. The total depth the hollow elongate element 304 is brought into the ground equals a summation of the first distance and the second distance, which is preferably deeper than the floor level of the sunken or partially sunken area to be built, for example about 1 m to 1.5 m deeper. The second distance may for example be in the range of 1 m to 1.5 m. If the hollow elongate elements 304 are cylindrical symmetrical, which is the most common situation, a typical way of driving the hollow elongate elements 304 in the ground is by using a spiral drilling equipment. Next, the soil is removed from inside the volume determined by the hollow elongate elements 304 and the volume is filled with concrete 306. The removal of the soil can be performed in any suitable way. For cylindrical symmetrical hollow elongate elements 304 this can be e.g. done by drilling the hollow elongate element 304 rotationally in a first direction in the ground whereas a spiral drill within the volume of the hollow elongate element 304 removes the soil from the volume of the hollow elongate element 304 by rotating in the opposite direction. The spiral drill thus allows to remove the soil from within the hollow elongate elements 304 as the latter are inserted substantially vertically into the ground. When an appropriate depth is obtained and all soil is removed from the volume determined by the hollow elongate elements 304, this volume is filled with a filling material or grout such as e.g. concrete. This can e.g. be performed by using a spiral drill having a hollow axis, through which concrete 306 can be inserted in the volume determined by the hollow elongate element 304. The concrete 306 is inserted under a suitable pressure to the end of the screw of the drill, such that the hollow volume determined by drilling the hollow elongate elements 304 in the ground is completely filled with concrete 306. In this way, primary concrete piles 302 are cast-in-place constructed in the ground. An illustration of two concrete primary piles 302 constructed in the ground is shown in top view in Fig. 3a.

[0031] Once the concrete primary piles 302 are constructed, and before the concrete 306 has been hardened completely, an armouring or reinforcement 310 is optionally inserted in the concrete 306 of the primary piles 302. This is illustrated in step 204 of the method 200 shown in Fig. 2. The available time to provide armouring or reinforcement 310 in the concrete primary piles 302 depends on the type of concrete 306 that is used. The material of profiles that can be used for providing an armouring or reinforcement 310 typically is metal such as e.g. steel, although other types of material also can be used, such as e.g. plastics material. The exact shape of the profile is not essential for the present invention, as long as it provides sufficient strength to the primary pile 302, depending on parameters such as diameter of the pile, length of the pile, quality of concrete used, environmental parameters. Typical profiles that can be used are I beams such as e.g. of the type IPE, IPEAA, JIS, as well as H-beams such as e.g. if the type HEA, HEB, JIS. Furthermore, tubes or pipes, C channel profiles, W section profiles or U channel profiles such as e.g. of the type UPE, UPN , UB/UC can be used. It will be obvious for a person skilled in the art that the exact shape of the armouring or reinforcement 310 used is non-limiting for the present invention. The length of the armouring or reinforcement 310 is adjusted such that it extends over a large part of the concrete primary piles 302, preferably at least over half of the length of the primary piles 302, more preferred at least over 75% of the length of the primary piles 302, still more preferred over substantially the complete length of the primary piles 302.

[0032] The concrete 306 used in the construction of the primary piles may either be self-compacting concrete (SCC), which is a special type of concrete that is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeneity, or it may be a more conventional type of concrete 306. In the latter case, the concrete typically is vibrated to improve the quality of the concrete 306, i.e. increase the density such that the water tightness of the concrete improves. Vibrating the concrete allows to reduce the number of air bubbles present in the concrete 306.

[0033] In a following step 206, secondary piles 312 are constructed in between the already constructed primary piles 302. The secondary piles 312 can be constructed in any suitable way for cast-in-place constructing a concrete pile such as e.g. any of the methods described above for the primary piles 302. The construction thus may comprise the insertion of a hollow elongate element, the removal of the soil present in the volume determined by the hollow elongate element and the filling of the volume with material or grout like e.g. concrete. Again either self-compacting concrete can be used or a more conventional type of concrete can be used which can be vibrated, possibly after insertion of the armouring or reinforcement. During the construction of the concrete secondary piles 312, part of the concrete primary pile 302 at the left and the right of the secondary pile 312 is removed and in this way the secondary piles 312 intersect with the primary piles 302. The intersection is large enough to avoid substantial diffusion of water

through the concrete. Thereby is meant that the modular distance by,which the primary piles 302 are separated from each other, together with the diameter of the primary piles 302 and the secondary piles 304 is such that the diameter of intersection, as defined by the distance B shown in Fig. 3c, also referred to as the minimum thickness of the cast-in-place pile wall, is significantly large such that it corresponds with a length of infiltration in the concrete that allows substantially no leakage of water directly through the concrete, if the concrete wall would be made of a single concrete piece. The minimum thickness for obtaining no leakage of water through vibrated concrete typically is about 280 mm. If the minimum thickness is 280 mm or larger, a full concrete wall can be water resistant.

[0034] As mentioned before, the exact shape of the cross section of the primary piles 302 and the secondary piles 312 is not limiting for the present invention. Typically the concrete piles constructed are cylindrical symmetrical and typical diameters used are between 420 mm and 520 mm, although the invention is not limited thereto. The larger the diameter of the concrete piles constructed, the larger the modular distance between the primary concrete piles can be with the intersection distance B or minimum thickness still being large enough.

[0035] In step 208, a special armouring or reinforcement 314 is introduced in the concrete secondary piles 312 before the concrete 306 of the secondary piles 312 has hardened completely. This is shown in Fig. 3d. A more detailed view of a concrete secondary pile is shown in Fig. 4, showing a top cross-sectional view of a secondary concrete pile with special armouring or reinforcement 314. The special armouring or reinforcement 314 comprises means for providing significant strength 316 (shown in Fig. 4) to the concrete secondary pile 312. The exact shape of the means for providing significant strength 316 is not critical nor limiting for the present invention. These means 316 may be any type of standard armouring or reinforcement means such as a standard profile which may be an I beam such as e.g. of the type IPE, IPEAA, JIS, as well as an H-beam such as e.g. if the type HEA, HEB, JIS. Furthermore, a tube or pipe, C channel profile, W section profile or U channel profile such as e.g. of the type UPE, UPN , UB/UC can also be used. It will be obvious for a person skilled in the art that other means for providing significant strength 316 can as well be used.

[0036] For each intersection with a primary pile 302 the special armouring or reinforcement 314 of the secondary pile 312 furthermore comprises a water stop means 320 (shown in Fig. 4) at a position near the intersection area between the primary pile 302 and the secondary pile 312. The position near the intersection area between the primary pile 302 and the secondary pile 312 is a position sufficiently close to the intersection area to seal that intersection area.

[0037] The water stop means 320 that can be used in the present invention will now be discussed in more detail. Typical water stop means that are applied are hydrophilic water stops. Exposure to water induces expansion of the material to create a compression seal. These hydrophilic water stops are suitable for substantially non-moving joints only, which is the case in the construction of cast-in-place pile walls. Typical examples of hydrophilic water stops are Hydrotite, Swellstop and Duro-seal water stops as available from Greenstreak Inc. or Superstop as available from e.g. RPM/Belgium N.V.

[0038] Holding means 318 for holding the water stop means 320 may be provided, for example on the armouring 314. The holding means 318 may be any type of holding means 318 suitable for comprising water stop means 320. Typical holding means 318 that may be used are C channel profiles or U channel profiles such as e.g. of the type UPE, UPN , UB/UC. As the water stop means 320 typically used will be water stop swelling means, the holding means 318 for providing a water stop means 320 should have significant strength to resist to the force developed during swelling of the water stop means 320. Part of this strength may be obtained due to the holding means 318 being connected to the means for providing significant strength 316 e.g. by means of interconnection means 322. The interconnection means 322 may be avoided depending on the size of the means for providing significant strength 316. The armouring or reinforcement 314 may be made of any suitable material such as metal like steel or plastic or a combination thereof. If the armouring or reinforcement is made of metal, it may be constructed from several separate metal profiles which can be welded together. In the case the armouring or reinforcement is made of plastic, the armouring or reinforcement can be made either by fixing several components together or by casting the complete armouring or reinforcement 314 in a single piece by injection moulding. An example of a special armouring or reinforcement 314 according to the present invention, with a means for providing significant strength 316 and a holding means 318 for comprising a water stop means 320 connected to the remaining part of the armouring or reinforcement 314 by means of an interconnection means 322 is shown in Fig. 4. In this figure, by way of example, a pile is shown wherein a special armouring or reinforcement 314 is provided comprising an I standard profile and two U profiles connected to the I standard profile by means of interconnection means 322 in the form of a plate. The interconnection means 322 may be any type of suitable interconnection means such as e.g. a bar or a plate. In the example shown, the interconnection means 322 comprises a plate which may be either a full plate connecting the holding means 318 and the means for providing significant strength 316 over substantially the whole intersection of the concrete piles, in which case it may provide an additional water stop for water leakage through possible cracks in the concrete or which may be a plate showing holes. In the later case no additional water stop function is provided,

but the strength of the constructed pile is larger as concrete from both sides of the plate is connected to each other. A further advantage of not using a full plate may be that the amount of material needed for constructing the special armouring or reinforcement 314 can be reduced. The U-profiles are suited for comprising a water stop means 320 such as e.g. a water stop swelling means like a swelling strip. Once provided in the holding means 318 the water stop means 320 are positioned in the neighbourhood of the intersection area between the primary and the secondary piles, at a small distance C from the intersection area with a neighbouring concrete primary piles 302 (not shown in Fig. 4). The distance C, or thus how far the "neighbourhood" extends, may be determined based on the degree of swelling of the water stop means 320 such that after full expansion of the water stop means 320 the water stop means 320 blocks the boundary of the piles at the intersection area between the secondary pile and the primary pile for water leaking. For a water stop swelling strip with a cross-section of 20 mm x 25 mm, the spacing from the intersection area typically is about 2.5 mm. The C shape or U shape of the holding means 318 and the strength of the connection of the holding means to the remaining part of the special armouring or reinforcement 314 is such that the expansion mainly occurs in the direction of the intersection between the primary pile 302 and the secondary pile 312. The armouring or reinforcement 314 is positioned such that the water stop means can be provided in the neighbourhood of the intersection area of the concrete piles.

[0039] Another possibility to provide a water stop means is obtained by, instead of providing a swelling strip of water stop material at the armouring or reinforcement 314 prior to inserting it into the pile formed, providing a channel in the special armouring or reinforcement 314 wherein a water stop material can be injected after the concrete secondary piles are cast and the special armouring or reinforcement 314 has been inserted. The water stop material used in the latter case again is a hydrophilic water stop material, but instead of a swelling strip, the water stop material now is a substance that is injectable. An example of a typical material that can be used is Polyurethane injection foam water stop available from Davco Construction Materials Pty Limited or DUROSEAL INJECT available from Greenstreak Inc.

[0040] The method 200 of providing a watertight cast-in-place pile wall thus comprises as a final step 210 the expansion of the water stop means 320 to block the intersection of the primary and secondary piles such that no water can leak through the intersection anymore. This expansion is a process that inherently occurs when introducing the hydrophilic water stop material into wet material such as e.g. wet concrete. The water stop materials have the advantage that no immediate swelling occurs during their first contact with water, e.g. present in the wet concrete. The swelling only occurs after a certain period of time, so that the swelling only occurs after the water stop means 320 is in the correct position. The water stop swelling means used thus has a kind of memory effect. The swelling of the water stop means 320 to its final position is illustrated in Fig. 3d and Fig. 3e.

[0041] It is an advantage of the present invention that the water stop means 320 is provided substantially in the concrete secondary pile as the latter allows a firm fixation of the water stop means (320) thus allowing to obtain a firm blocking of the boundary between the concrete piles. It is furthermore an advantage of the present invention that the water stop means 320 is provided somewhere along the intersection area of the concrete piles, in a direction perpendicular to the longitudinal direction of the piles, and not at the end points of the intersection area of the concrete piles, as this allows the water stop means (320) to be sealed substantially from the environment. With substantially sealed it is meant that only in the small boundary region of the intersection direct influence of the environment will be present. This avoids fast deterioration of the water stop means (320).

[0042] In a second aspect, the present invention also relates to a cast-in-place pile wall comprising concrete primary piles 302 and concrete secondary piles 312 which intersect with each other. This second embodiment will be described with respect to Fig. 5 to Fig. 8. The method of constructing the second embodiment preferably is the method described in the first embodiment of the present application, although the invention is not limited thereto. The concrete piles may have any suitable shape. Typically this shape is a cylindrical symmetrical shape, although the invention is not limited thereto. The piles may be circular, oval, square, rectangular in cross-section, or may have any suitable cross-sectional shape. The thickness of the wall formed, and the distance between neighbouring piles is not limiting for the present invention as long as it allows that the intersection between the concrete piles provides a minimum thickness of the cast-in-place wall such that the wall would be watertight if it consisted of a single piece of that thickness, i.e. if no boundary regions or regions where the concrete piles intersect would occur. Preferably, both primary and secondary piles are provided with an armouring or reinforcement 310, 314. Optionally one of either the primary piles 302 or the secondary piles 312 and its corresponding armouring or reinforcement 310 respectively 314 extends deeper into the ground than the other, to provide additional strength and stability to the cast-in-place wall, although the invention is not limited thereto. An example of a cast-in-place wall is shown in Fig. 5 in cross-sectional top view and in Fig. 6 in vertical cross-sectional view. It can be seen that the secondary piles 312 and the corresponding armouring or reinforcement 314 in this case extend deeper into the ground than the primary piles 302 and the corresponding armouring or reinforcement 310. The armouring or reinforcement for the different piles is illustrated in Fig. 7 in cross-sectional top view and in Fig. 8 in vertical cross-sectional view. It can be seen that the armouring

or reinforcement of the different piles comprises/is a means 310, 316 that provides strength to the concrete piles. This may e.g. be the central part of the armouring or reinforcement of the piles. It can be seen that the means for providing strength for the piles extending deeper in the ground are larger and thus provide more strength than the means for providing strength of the piles extending less deep. Nevertheless, the invention is not limited thereto and the size of the armouring or reinforcement may be equal for both piles or even smaller for the deepest extending piles. One of the piles furthermore comprises water stop means 320 at the inside of the pile, for example in holding means 318 in the neighbourhood of the intersection of the primary and secondary piles. The piles comprising these water stop means 320 are the secondary piles constructed in between the other type of piles, i.e. after the primary piles have been constructed. The piles comprising the water stop means 320 thus correspond with the piles having substantially their full diameter over their full cross-section. The water stop means 320 are preferably positioned in holding means 318 that may be connected to the remaining part of the armouring or reinforcement 314 so that swelling of the water stop means due to the hydrophilic behaviour of the water stop means does not substantially influence the position of the armouring or reinforcement 314. Therefore the armouring or reinforcement 314 furthermore may comprise interconnection means 322, although, depending on the size of the means providing significant strength 316, the holding means can also be directly connected to strength providing means 316. The armouring or reinforcement 314 is positioned such that the water stop means 320 can be provided in the neighbourhood of the intersection area of the piles, at points of the intersection area different from the end points of he intersection area. This is advantageous as it allows the water stop means 320 to be substantially only surrounded by the material of the holding means 318 and by concrete, thus sealing the water stop means 320 from at least a number of external environmental influences. The swelling of the water stop means occurs mainly in the direction of the intersection area between the primary piles and the secondary piles such that after complete swelling this intersection area is completely blocked by the water stop means 320 and no water leakage occurs through the boundary formed by the intersection area.

[0043] In a further aspect, the present invention also relates to a special armouring or reinforcement 314 which may be used in the method for constructing a cast-in-place pile wall and the cast-in-place pile wall thus obtained according to the present invention. As described in the description of the first aspect of the present invention, the special armouring or reinforcement 314 comprises means for providing significant strength 316 and holding means 318 for providing a water stop means 320 in the neighbourhood of the edges of a concrete pile intersecting with neighbouring concrete piles. The holding means 318 are preferably connected to the means for providing significant strength 316 by way of interconnecting means 322.

[0044] Other arrangements for accomplishing the objectives of the method and construction embodying the invention will be obvious for those skilled in the art. Whereas the water tightening means have been shown in the figures substantially in the centre of the concrete pile and in the centre region of the intersection area of two neighbouring piles, the water stop means can also be provided at another place of the intersecting part of the primary and secondary piles. This is illustrated in Fig. 9. The armouring 314 in this case comprises a means for providing significant strength 316 which may e.g. be U-shaped (as in Fig. 9) in cross-section or tubular (not represented in the drawings). The interconnecting means 322 thereby can but do not have to be flat plates. They may have any suitable shape that allows to firmly connect the holding means 318 with the armouring or reinforcement 314.

[0045] It is to be understood that although preferred embodiments, specific constructions and configurations, as well as materials, have been discussed herein for devices according to the present invention, various changes or modifications in form and detail may be made without departing from the scope and spirit of this invention.

Claims

1. A method for constructing a cast-in-place pile wall, the method comprising

   - cast-in-place constructing at least one primary pile (302),
   - cast-in-place constructing at least one secondary pile (312), the secondary pile (312) intersecting with the primary pile (302) at an intersection area having a first direction in the longitudinal direction of the secondary pile (312),
   - providing a liquid blocking means (320) in the secondary pile (312), substantially in the first direction along the intersection area.

2. A method according to claim 1, furthermore comprising providing an armouring (314) in said at least one secondary pile (312).

3. A method according to claim 2, wherein the armouring (314) comprises holding means (318) for holding the liquid blocking means (320) in the neighbourhood of the intersection area.

4. A method according to any of the previous claims, wherein cast-in-place constructing said at least one primary pile (302) and said at least one secondary pile (312) comprises cast-in-place constructing

concrete piles.

5. A method according to any of the previous claims, wherein providing a liquid blocking means (320) comprises providing a hydrophilic liquid blocking means which expands and creates a compression seal at said intersection area.

6. A method according to claim 5, wherein providing a hydrophilic liquid blocking means (320) comprises providing a swelling strip in holding means (318) connected to an armouring (314) prior to inserting the armouring (314) in the secondary pile (312).

7. A method according to claim 5 or 6, wherein providing a hydrophilic liquid blocking means (320) comprises providing an injectable liquid blocking material in holding means (318) connected to an armouring (314) after said armouring (314) has been inserted in the secondary pile (312).

8. A method according to any of the previous claims, wherein said method furthermore comprises providing an armouring (310) in said primary piles (302).

9. A method according to any of the previous claims wherein said cast-in-place constructing of piles comprises

- providing in the ground a hollow elongate element having substantially the volume of the pile to be constructed,
- excavating the hollow elongate element by removing soil from the hollow elongate element provided in the ground,
- filling said excavated hollow elongate element with concrete (306).

10. A method according to claim 9, wherein said cast-in-place constructing furthermore comprises curing said concrete (306).

11. A cast-in-place pile wall comprising at least one primary pile (302), and at least one secondary pile (312) intersecting with the at least one primary pile (302) along an intersection area, wherein the at least one secondary pile (312) comprises a liquid blocking means (320) along the intersection area substantially in a longitudinal direction of the secondary pile (312).

12. A cast-in-place pile wall according to claim 11, wherein the at least one secondary pile (312) furthermore comprises an armouring (314).

13. A cast- in-place pile wall according to claim 12, wherein the armouring (314) includes a holding means (318) for holding the liquid blocking means (320) in the neighbourhood of the intersection area so as to create a compression seal.

14. A cast-in-place pile wall according to any of claims 11 to 13, wherein the at least one primary pile and the at least one secondary pile are made of concrete.

15. A cast-in-place pile wall according to claim 14, wherein said concrete is cured.

16. A cast-in-place pile wall according to any of claims 14 or 15, wherein said concrete is self-compacting concrete.

17. A cast-in-place pile wall according to any of claims 11 to 16, wherein said liquid blocking means (320) is a hydrophilic swelling strip.

18. A cast-in-place pile wall according to any of claims 11 to 16, wherein said liquid blocking means (320) is an injected hydrophilic liquid blocking material.

19. A cast-in-place pile wall according to any of claims 11 to 18, wherein said primary piles (302) comprise an armouring (310).

20. An armouring (314) to be used in a cast-in-place pile wall according to any of claims 12 to 19.

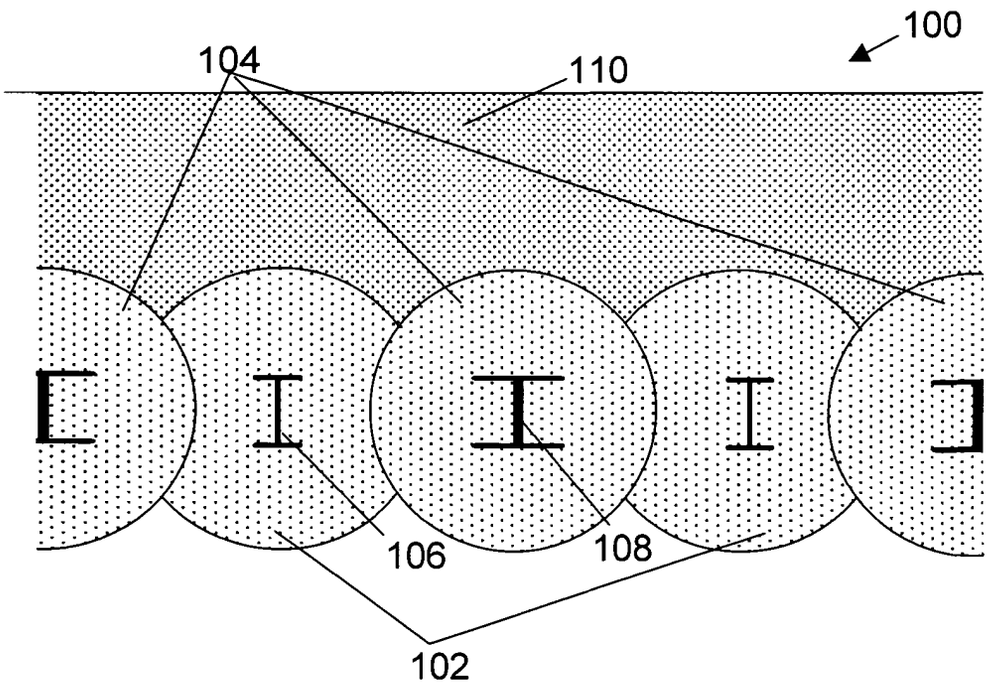

Fig. 1 – PRIOR ART

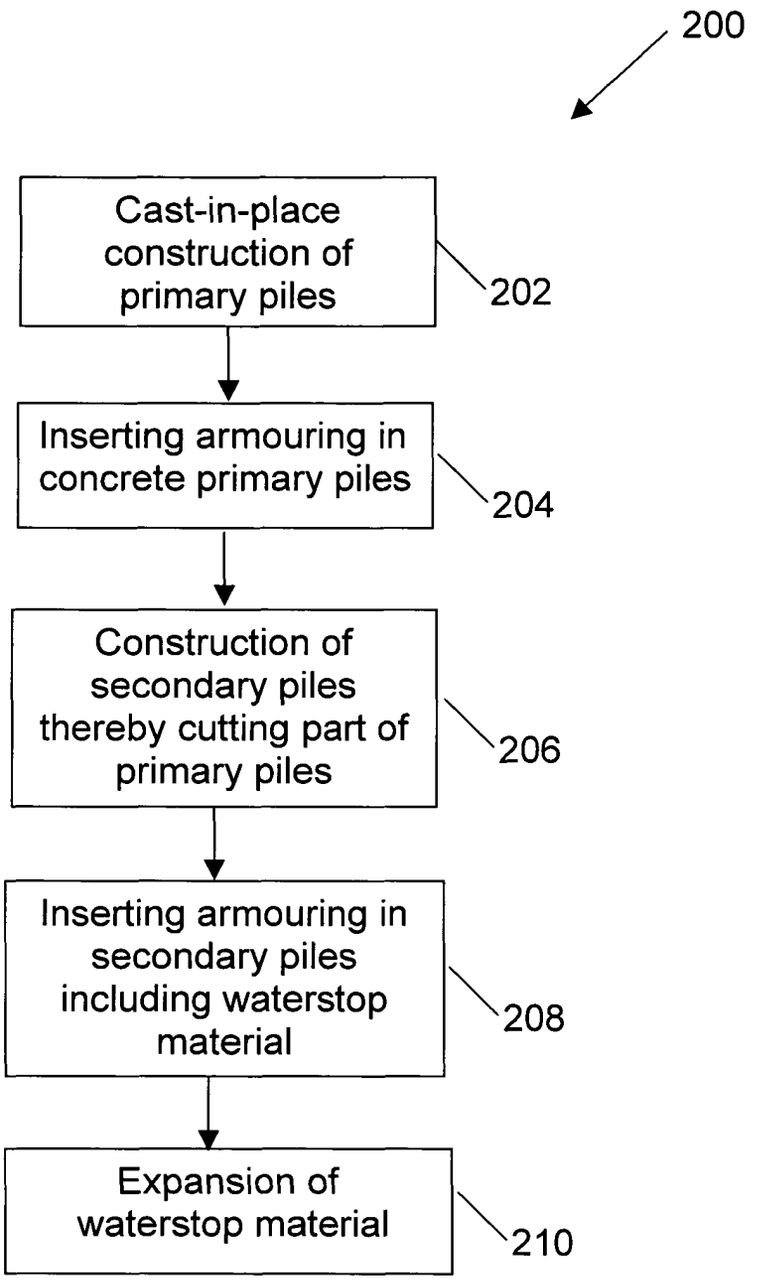
200
Cast-in-place construction of primary piles
202
Inserting armouring in concrete primary piles
204
Construction of secondary piles thereby cutting part of primary piles
206
Inserting armouring in secondary piles including waterstop material
208
Expansion of waterstop material
210

Fig. 2

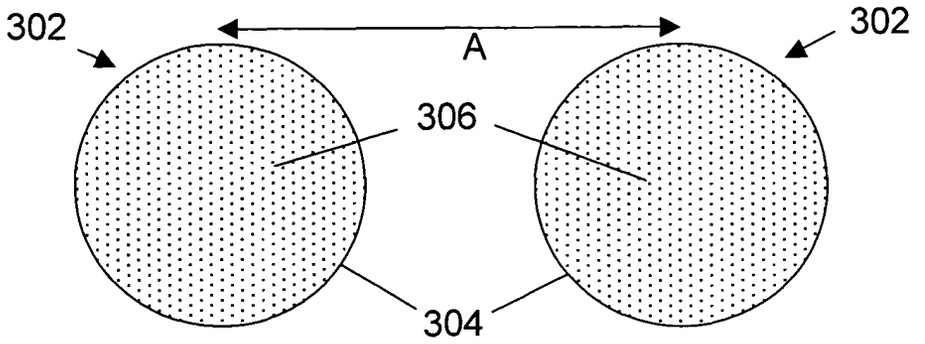

Fig. 3a

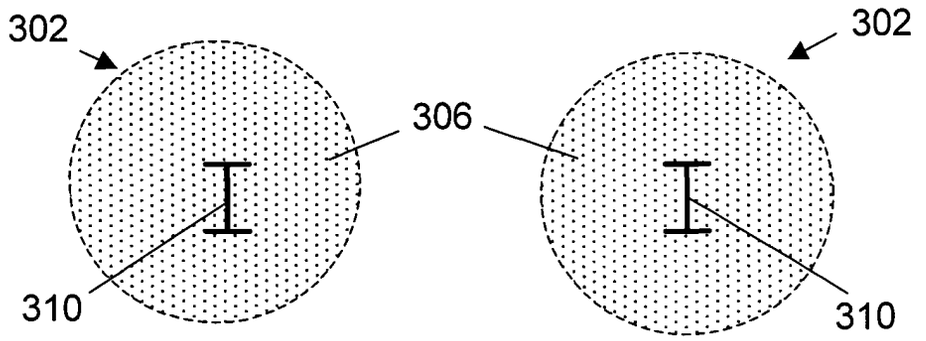

Fig. 3b

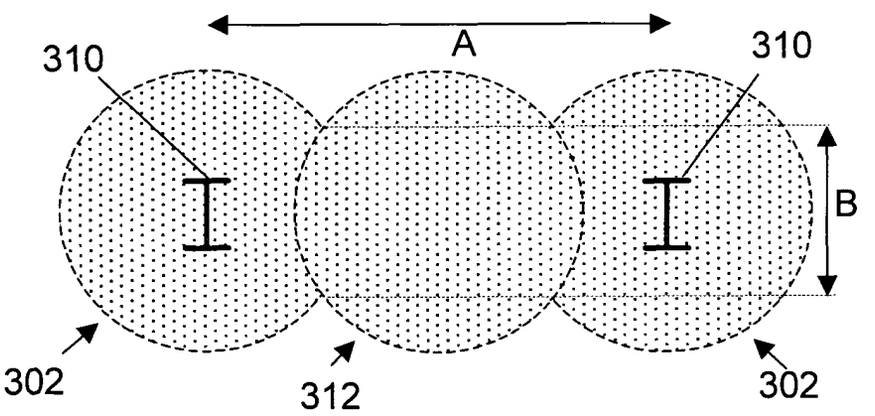

Fig. 3c

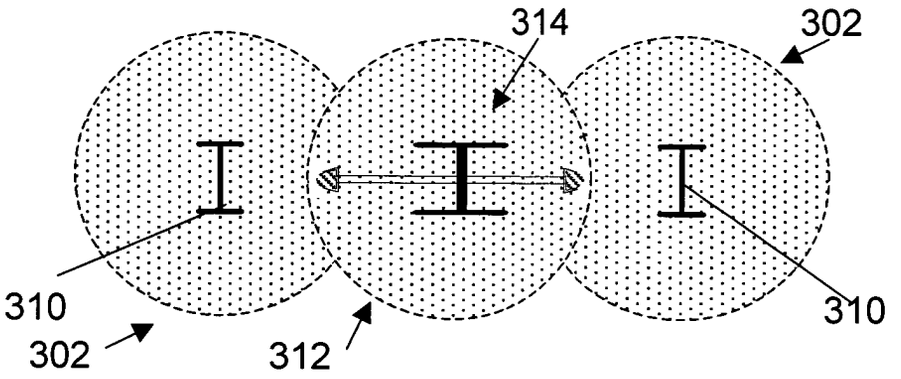

Fig. 3d

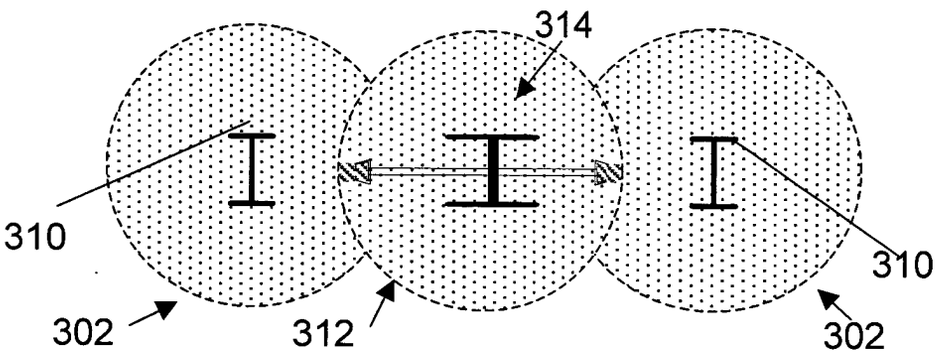

Fig. 3e

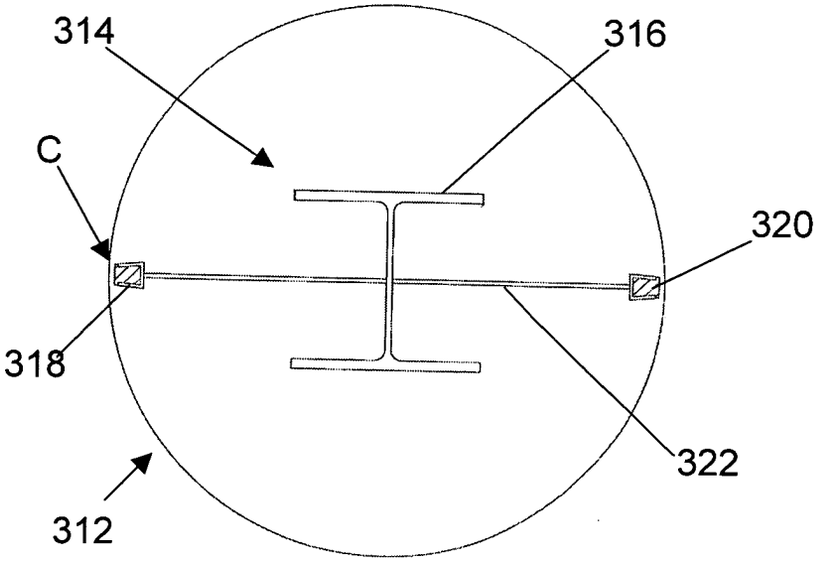

Fig. 4

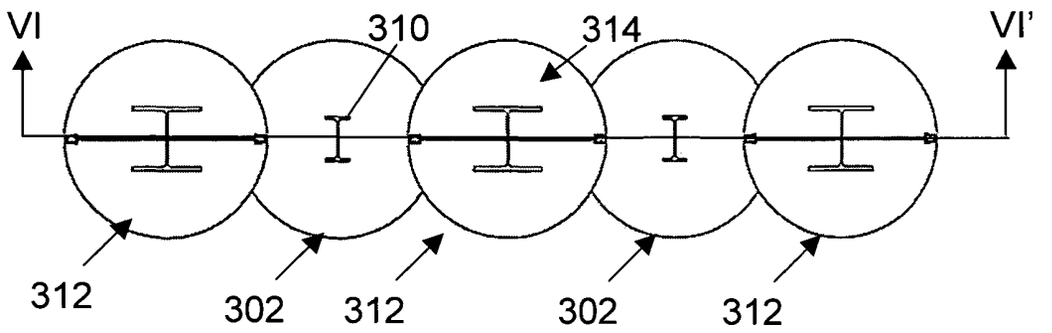

Fig. 5

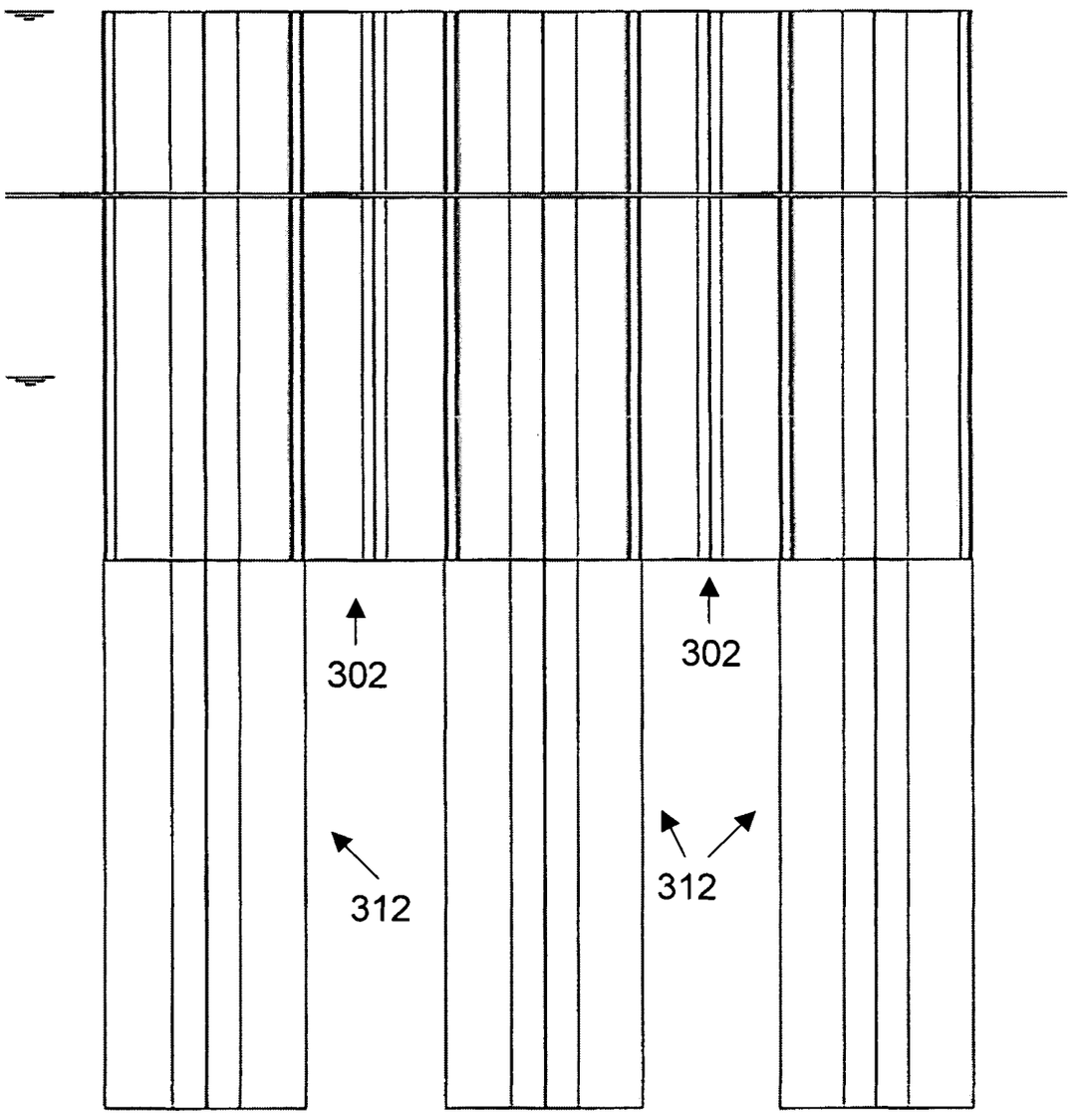

Fig. 6

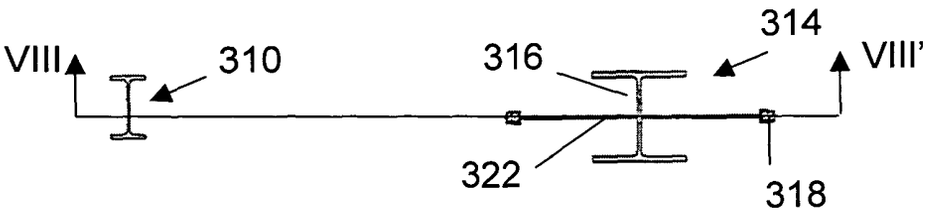

Fig. 7

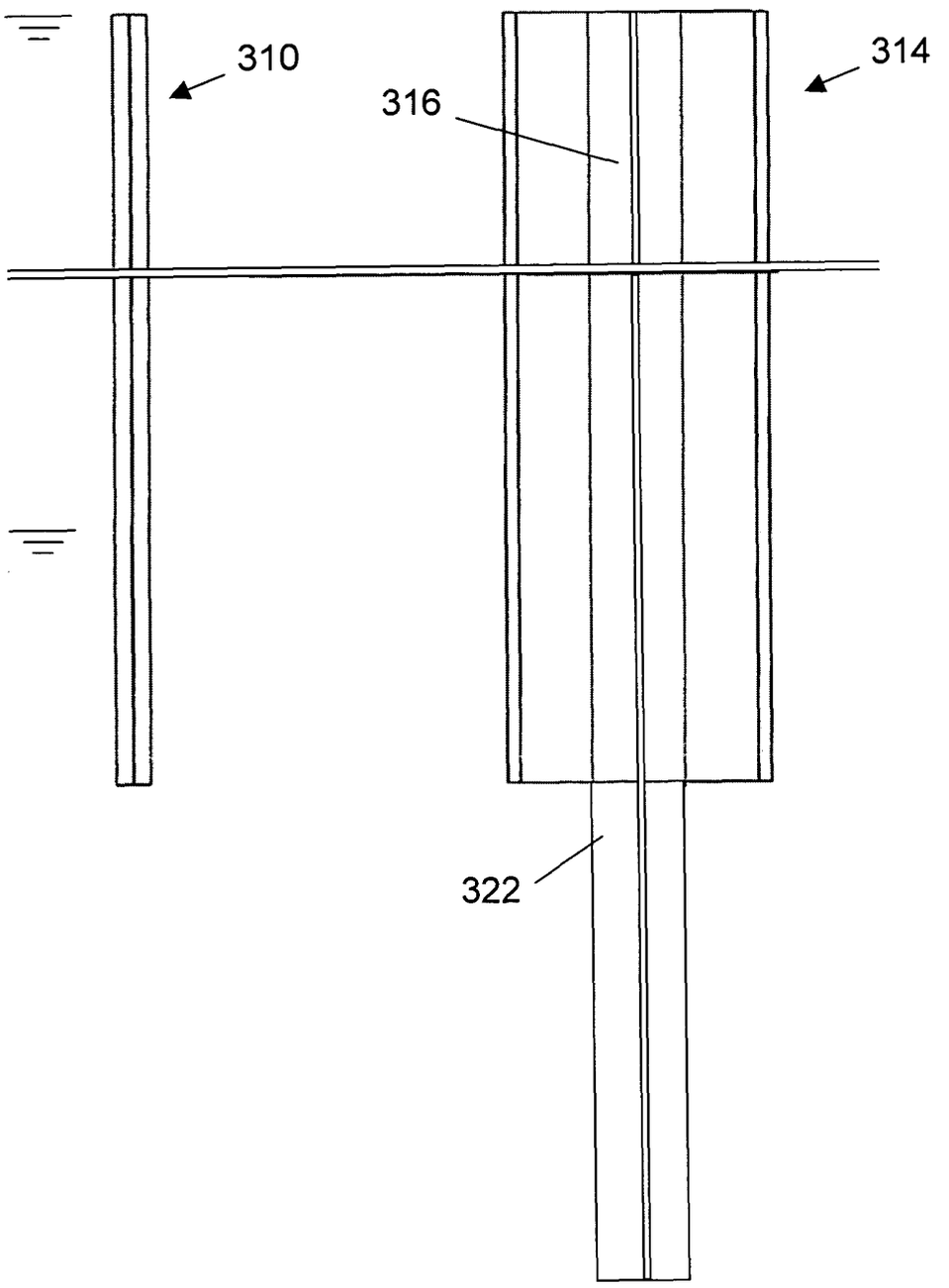

Fig. 8

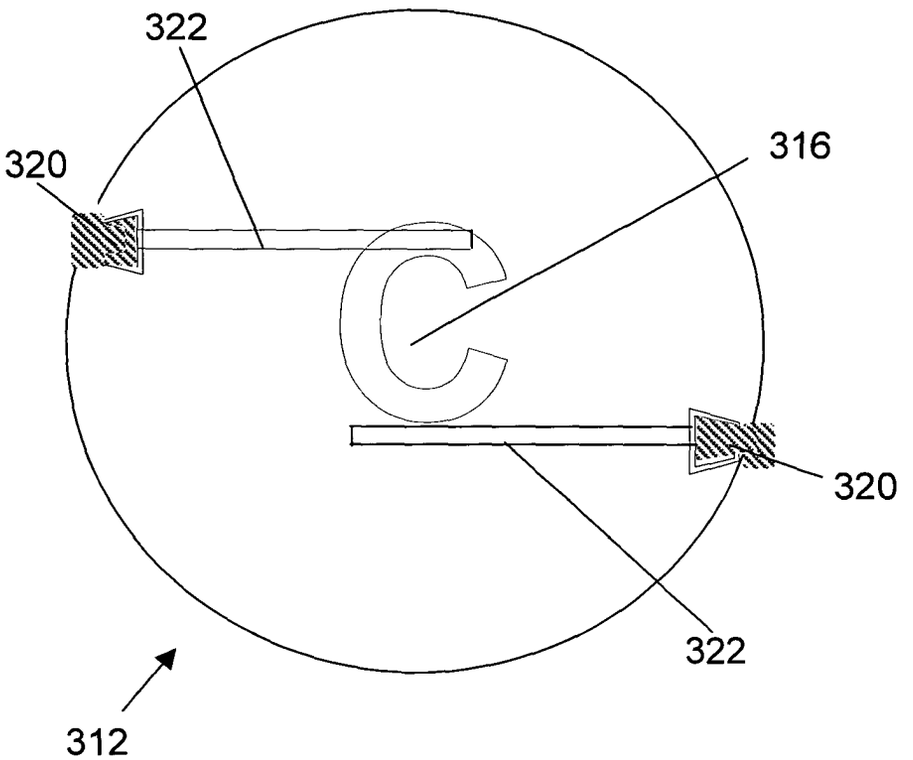

Fig. 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 44 7131

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	CH 527 972 A (WEY GINO INGENIEUR) 15 September 1972 (1972-09-15)	1,2,4, 9-12,14, 15,19,20	E02D19/06 E02D29/16
Y	* column 2, line 14 - column 4, line 12; figure 10 *	3,8,13	
Y	US 3 766 695 A (MORNER J) 23 October 1973 (1973-10-23) * abstract; figure 1 *	3,13	
Y	US 4 909 675 A (TAKI OSAMU) 20 March 1990 (1990-03-20) * figure 1 *	8	
A	EP 1 418 277 A (CHIAVEROTTI BVBA) 12 May 2004 (2004-05-12) * the whole document *	1-20	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 November 2004	Nilsson, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 44 7131

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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11-11-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CH 527972 A	15-09-1972	NONE	
US 3766695 A	23-10-1973	DE 2037370 A1	03-02-1972
		AT 305908 B	26-03-1973
		GB 1310393 A	21-03-1973
US 4909675 A	20-03-1990	CA 1320835 C	03-08-1993
EP 1418277 A	12-05-2004	BE 1015173 A5	05-10-2004
		EP 1418277 A1	12-05-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82