DEVICE AND METHOD FOR IMPROVED PILE CASTING

Inventor: Basem Hazzan, Akko (IL)

Correspondence Address:
SALTAMAR INNOVATIONS
1 Mathewson Road
Barrington, RI 02806 (US)

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ABSTRACT
This invention deals with a device and a method for an improved concrete pile casting in swelling soils by substantially lowering or eliminating heave forces created in active soils from affecting said piles by surrounding selectable parts of the pile by an easily deformable material for lowering the horizontal and the vertical soil movement effect, and by providing a low friction surface for further lowering vertical forces effect. This inventive device and method further facilitates subsequent operations by permitting an easy and seamless casting of columns and by ensuring a clean and smooth pile surface for a better adhesion of new concrete to an old one, as well as preventing cement dough seepage to surrounding soil and concrete segregation.
DEVICE AND METHOD FOR IMPROVED PILE CASTING

FIELD OF THE INVENTION

[0001] This invention deals with a device for the neutralization, i.e. the lowering or the elimination, of heave forces acting on piles sunk in certain types of expansive soils and for the improvement of the properties of cast in situ piles.

BACKGROUND OF THE INVENTION

[0002] Certain types of soils, such as clay and marl, swell when absorbing water and shrink when this water is exuded. Water is usually absorbed by soils during the rainy season and exuded by evaporation and the like during the dry season. The shrinkage leads to cracks which can be several meters deep and ten centimeters wide, depending on many factors. The soil depth in which this phenomenon occurs is called the active depth hereinbelow, and may not be uniform. In a rainy season following a dry one, water tends to flow into the cracks and leads to soil swelling, which also closes the cracks, and in the following dry season the soil shrinks to create cracks. Thus an annual soil shrinkage-swelling cycle occurs. Also, water from other sources, such as water used during construction or for irrigation could flow into soil cracks during a dry season and cause soil swelling. Both the soil shrinkage and the soil swelling lead to soil movements. These movements cause substantial pressures, stresses and forces, called heave pressures, which may reach, according to various sources, 20 to 80 tonnes/m**2. The heave forces tend to decrease with depth, the soil depth in which the forces and movements exist, or are still significant is called active soil depth. As the soil movement is three dimensional, so are the heave forces, which have both horizontal and vertical components. A conventional designation of the vertically pointing heave forces is positive, if pointing upward. Vertically forces pointing downward are commonly designated negative skin friction, and are caused by fill settlement. The heave forces act on piles and the like built in active soils, and the pressures, summed over the pile circumference, are known to cause severe structural damage. The term “pile” as used hereinbelow refers mainly to founding piles and to other piles in contact with soil along at least part of their lengths and circumferences, such as retaining walls piles. The vertical heave forces act on underground structural elements such as piles and the like either by creating friction forces, which are upward or downward pointing, or by applying pressure on non vertical, horizontal or inclined, surfaces of these elements. The vertical heave forces exceed the design load acting on the pile by low-rise buildings and may exceed the load acting on the pile, in higher/heavier buildings, especially during mid-construction, when the design load is not yet applied. Desiccation of the soil in the active depth causes pile settlement. This heave or settlement may be differential among piles, thus leading to cracks in the supported structure. The horizontal forces may bend, shear and tilt the piles, cracking them and any supported structures. Either way, damage to the piles and to the supported structures often ensues. The advantage of neutralizing the heave forces is, therefore, obvious. It should be pointed out that the seasonal soil moisture contents variation tends to be lower for the soil underneath a structure, which is not exposed to weather conditions and relatively protected temperature changes, and higher for an exposed soil which is affected by the weather conditions. Thus, piles may be subjected to circumferentially varying pressures.

[0003] Another soil phenomenon handled by this inventive device and method is the collapse of the walls of boreholes bored in certain types of soils, such as sand and fill, into the borehole before or during the casting of the pile. The soil layer in which this collapse may occur, such as sand and fill, may be called unstable or active layer, and its depth is called the active depth. Such collapse fills parts of the borehole with soil and may cause pile shortening, partial concrete filling along some pile sections or even concrete discontinuity with negative structural consequences.

[0004] Still another problem caused by the collapse of soil around the bore head is that a roughly inverted conical depression is formed in the collapsed soil region at the upper part of the soil around the bore mouth, and, when filled by concrete, forms a mushroom shaped pile. This effect is particularly harmful in swelling soils. Heave forces acting on such mushroom, in addition to their effects elsewhere, may raise the pile, cause tension forces, crack it and the supported structure and lead to other problems.

[0005] Yet another problem is the seepage of concrete dough into porous soil such as fill, in contact with the concrete. This seepage weakens the concrete. The seepage and the segregation are further aggravated by compacting the concrete, a process often required.

[0006] Six problems addressed and solved or alleviated by this invention are listed below:

[0007] 1. The creation of vertical and horizontal heave forces on founding piles.

[0008] 2. The creation of negative skin friction or heave forces on founding piles.

[0009] 3. The collapse of soil such as fill soil at the upper part of a borehole and the created mushroom like depression, and the forces created by the settling of the soil.

[0010] 4. The creation of heave forces acting on partly or fully embedded piles of retaining walls, such as basement walls, the cleaning of the piles prior to the application of anti moisture materials and the sealing of the gaps between the piles.

[0011] 5. The problem of the seam between the top part of a pile and an aboveground column extending away from it.

[0012] 6. The seepage of cement dough into a porous soil such as fill soil and the resulted weakening of the concrete, or segregation. This problem is aggravated when the top part of the concrete is compacted.

[0013] No device or method for economically fully solving the abovementioned problems have been developed so far, although partial attempt is shown in GB Patent 2283266 to Sloma.

[0014] One conventional way of attempting to overcome the abovementioned problems is by extending the piles to substantially greater depths than the ones required in the absence of heave forces. Such extension is always expensive and often impractical, as bedrock or water table may be encountered. Of course, this conventional way does not eliminate the heave forces reaching the pile and leading to tension stresses. These stresses might lead to pile cracking or failure and require added reinforcement. This inventive device eliminates, or greatly reduces, the need for such pile extension. Another conventional way used is the building of a so called membrane around the structure, the membrane being several meters wide and made of impermeable materials such as
concrete or asphalt, to prevent or to lower the moisture fluctuations near the piles. This conventional solution, as the previous one, is expensive and often impractical.

The manner in which this inventive device solves the abovementioned problems is shown below in this document.

SUMMARY OF THIS INVENTION

Three concentric sleeves of the same length are the essential elements of this invention:

An inner sleeve which serves as a mold for the upper part of a pile, and is preferably fairly rigid and water impermeable, encompassed by:

A filling sleeve, made of a thick, highly deformable, low modulus material, encompassed by:

An outer sleeve, made of a thin sheet having low friction coefficient between it and might be formed of two layers.

The inner sleeve also supports its weight and that of the other two sleeves. The filling sleeve is intended to be deformed by the horizontal and the vertical forces created by the soil movements, therefore passing only a small part of the potential soil forces to the pile. The low friction between the outer sleeve and the encompassed sleeve, passes only a small part of the vertical forces created by the soil movements to the filling sleeve and to the pile.

The sleeve dimensions and materials are to be selected according to the particular conditions of each project.

A BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a partly exploded oblique view of this inventive device.

FIG. 2 is a sectional view of a pile incorporating this inventive device and of heave forces acting thereon.

FIG. 3 is a sectional view of a pile incorporating this inventive device and of different heave downward forces acting thereon.

FIG. 4 is a sectional view of a pile incorporating this inventive device and of still different heave downward forces acting thereon.

FIG. 5 is a view of section 5-5 in FIG. 2.

FIG. 6 is a view of section 6-6 in FIG. 3.

FIG. 7 is a view of section 7-7 in FIGS. 2, 3.

FIG. 8 is a view of section 8-8 in FIG. 4.

FIG. 9 is a sectional view of a reinforced wall incorporating this inventive device.

FIG. 10 is a view of section 10-10 of FIG. 9.

FIG. 11 is a sectional view of another embodiment of this inventive device.

FIG. 12 is a view of section 12 of FIG. 11.

DETAILED DESCRIPTION OF THIS INVENTION

FIG. 1 is a view depicting some of the elements of this inventive device, and should be preferably viewed in conjunction with FIGS. 2, 3, 4, 9 and 11.

FIG. 1 depicts 12, a relatively thick and rigid inner sleeve having an inner diameter, a thickness, and a length, said thickness could be typically 1 to 5 mm but is not limited to this range. Several of many possible materials for 12 are polypropylene, PVC, HDPE and cardboard, 14 is a filling sleeve of a preferably relatively low density, low elastic modulus, highly deformable material such as a plastic or other foam, of which the widely used low density polystyrene foam (Styrofoam™) is a typical example, an outer sleeve 13 is of a relatively thin and preferably smooth, low friction coefficient material for sliding on 14, each of sleeves 12, 13, 14 having substantially the same length and two extremities, sleeve 12 is encompassed by sleeve 14 and sleeve 14 is encompassed by sleeve 13. Two sealing rings 15, a bottom one (shown) and a top one (not shown) hold 13, 12 and 14 together.

The manner in which this inventive device neutralizes the heave forces that affect piles and the like, is elaborated in the following explanation of FIG. 2. As this explanation is valid also for the embodiments shown in FIGS. 3, 4, 9 and 11, this explanation is not repeated in full when FIGS. 3, 4, 9, 11 are described.

FIG. 2 is a cross sectional view of a pile 29 utilizing this inventive device 21, wherein 230 is a borehole, bored through an active zone 210 including moisture induced swelling soil and 211, a zone of collapsed soil, said collapse often occurs at the top of the borehole, said collapsed soil might lead to concrete segregation, active zone 210 extending between levels 217 and 218, and stable zone 212, including only stable soil, extending below level 218 down and including the bottom part 225 of borehole 230, for a pile 29 to be made by casting concrete 216 therein, 27 is a reinforcement cage of pile 29 in borehole 230. This embodiment of the inventive device 21 of this invention includes inner sleeve 22, filling sleeve 24, outer sleeve 23, and a bottom and a top sealing rings 25 similar to elements 12, 14, 15, respectively, and to their encompassing relationships, as shown in FIG. 1. In addition, the inventive device 21 includes at least three rod spacers 26 encompassed by 22, separating 22 from 27 to provide adequate gap between 27 and 22 for concrete 216. Filling sleeve 24 is compressed by at least some of the horizontal soil movements in zone 210 and sheared by at least some of the vertical soil movements of 210. Sleeve 24 is made of material of low elastic modulus, or low yield point, so that relatively large soil movements lead to low horizontal terms or vertical loading of the pile, thus lowering horizontal terms heave forces. The materials and finishes of filling sleeve 24 and the outer sleeve 23 are selected so that the friction coefficient between 23 and 24 is small. Alternatively, sleeve 23 may be made of two layers—only one layer shown here—in contact with each other. The low friction coefficient is between the two layers of 23 or a layer of 23 and 24. Said two layers could be created, by way of an example only, by folding in two a sheet of the material used for making 23. A low friction coefficient between 23 and an inner element lowers the heave forces acting on that inner element and transmitted to pile 29. A protective and water impermeable membrane 28 for decreasing the moisture contents fluctuations in 210 and 211, may be added. In this embodiment, device 21 extends above ground to make an upward extension of pile 29 extending by length 224 above 28. Extending 29 by 224 permits the use of the extended part of 29 as an aboveground structural element without any seam between the underground and the above ground parts of 29. The absence of seams is desirable in general, and particularly important where earthquake resistance is required. Arrows 213 represent the horizontal forces acting on 21 as a result of the soil pressure and arrows 214 represent the positive heave forces. The compression of filling sleeve 24 neutralizes the forces represented by 213 while the low friction along 23, between two 23 sheets or between 23 and 24 and shearing within 24 neutralizes the effect of the
forces represented by 214 on the pile. Sleeve 23 may be made, by way of an example only, of polyethylene or P.V.C. Other materials of suitable properties may be used.

[0038] Therefore, this embodiment 21 of the inventive design incorporates five elements: an inner sleeve 22, an outer sleeve 23, a filling sleeve 24, at least one spacer 26, and sealing rings 25. Top and bottom sealing rings 25 may be used for fastening one or two extremities of 23 to the respective extremity or extremities of 24 and 22. In this inventive design, elements 22, 23, 24 are required and elements 25, 26 are optional. Membrane 28 may be added to lower moisture fluctuations around pile 29.

[0039] It should be understood that the term cylinder and terms derived therefrom also refer to a sheet bent along approximately to circular arc of any angle, but typically between somewhat below 180 degrees and somewhat above 360 degrees, or a tubular shell extending from 360 degrees and below.

[0040] Sleeve 22 may be made of a flexible sheet bent to a cylindrical arcuate shape, its flexibility pushing sleeves 23, 24 against borehole 230, the are formed by 22, 23, 24 may be 360 degrees or somewhat above it, as shown in this embodiment, to form at least part of this inventive device, or it may be any other angle, such as somewhat less than 180 degrees, as shown by in FIG. 9.

[0041] Sleeve 21 may also be made by encompassing tube or pipe forming 22 by tube or pipe forming 24 and encompassing by a sleeve or sheet 23, or by any desired combination of bent sheets and tubes.

[0042] Sleeve 21, or any number of its constitutive parts such as 22, 23, 24, 25, 26, may be held in place before the lining the concrete by any means such as by tying it to 27 at a desirable place, securing it to 29 or by other means known in the trade.

[0043] Means other than 26 for separating 22 and 27 could be used, and membrane 28 may not be necessary or practical in many circumstances.

[0044] The designation of the elements in the subsequent Figs. that are similar to 22, 23, 24, 25, 26 in FIG. 2 is increased by 10 or by multiples of 10. As their functionality is the same as in this Fig., it is described only briefly in other Figs.

[0045] It is known that fill soil such as 211 in FIG. 2, absorbs the cement dough that seeps into it, and causes segregation of the concrete. The segregation weakens the concrete. This inventive device, by preventing cement dough seepage therethrough, prevents the concrete weakening caused by it.

[0046] The inventive device shown and claimed in this document may be made of any materials suitable for its conditions of use, such as the particular environmental conditions and the applied forces. For example, while plastic materials may often be used for the parts illustrated in the embodiments of this document, other materials such as cardboard, wood, steel which may be painted or galvanized, and many others, may also be used, the materials listed in this paragraph being strictly exemplary and presented as non-limiting list only, are not an exhaustive list and do not limit the scope of this invention. The dimensions shown in this document are also exemplary and non-limiting only, different dimensions and materials may be used if deemed desirable or necessary. Sleeves 22,23,24 may be made by cutting and bending sheets of the respective materials in situ, by cutting tubes, or any or all of them may be prepared elsewhere, and brought to the construction site ready for assembly.

[0047] Also, while a single unit of this inventive device is shown in the accompanying figures, a number of inventive devices, preferably mounted one on top of each other, may be used for a single pile without limiting the scope of this invention. Furthermore, this inventive device may be used only for the underground parts of a pile while a different device or method may be used for any aboveground parts of a pile, which are not subject to moisture induced and other soil effects.

[0048] It is to be understood that there is not a clear and constant separation level, such as 218 in FIG. 2, shown between zones 210 and 212, 218 being merely an approximation, below which the effects of the soil moisture fluctuations are considered to be sufficiently small.

[0049] It is also to be understood that the borehole diameter may be increased in parts such as the borehole section that receives this inventive device, so that the pile diameter is constant, although in the embodiments shown in this document the borehole diameter is constant and the pile diameter is reduced by twice the sleeves 22, 23, 24 thicknesses where encompassing the sleeve.

[0050] FIG. 3 is similar to FIG. 2, except that the heave forces shown are negative, that is, downward pointing, due to a different type of soil in the active zone. The numbering of elements in FIG. 3 is usually that of FIG. 2, augmented by 100.

[0051] FIG. 3 is a cross sectional view of a pile 39 utilizing this inventive device 31, wherein 330 is a borehole, bored through an active zone 310 including moisture induced swellting soil and 311, a zone of collapsed soil that might lead to a mushroom creation. Active zone 310 extending between levels 317 and 318, and stable zone 312, including only stable soil, extending below level 318 downward and including bottom part 325 of borehole 330, for a pile 39 to be made by casting concrete 316 therein. 37 is a reinforcement cage of pile 39. This embodiment of the inventive device 31 of this invention includes inner sleeve 32, filling sleeve 34, outer sleeve 33, and a bottom and a top sealing rings 35 similar to elements 12, 14, 13, 15, respectively, and to their encompassing relationships, as shown in FIG. 1. In addition, the inventive device 31 includes at least one spacer rod 36 encompassed by 32, separating 32 from 37 to provide adequate gap between 37 and 32 for concrete 316. A protective and water impermeable membrane 38 for decreasing the moisture contents fluctuations in 310 and 311 may be added. In this embodiment, device 31 extends aboveground to make an upward extension of pile 39 extending by length 324 above 38. This extension prevents the falling down of disturbed bored soil into the borehole before or/and during pile casting. Arrows 313 represent the horizontal forces acting on 31 as a result of the soil pressure and arrows 314 represent the negative heave forces. The yielding of 34 neutralizes 313 while the low friction along 33 neutralizes 314.

[0052] Therefore, this embodiment 31 of the inventive design incorporates six elements: an inner ring 32, an outer sleeve 33, a filling sleeve 34, at least one spacer 36, sealing rings 35. In this inventive design, elements 32, 33, 34 are required and elements 35, 36 are optional. Membrane 38 may be added to lower moisture fluctuations.

[0053] Means other than 36 for separating 32 and 37 could be used, and membrane 38 may not be necessary or practical in many circumstances.

[0054] FIG. 4 is a cross sectional view of a pile 49 utilizing this inventive device 41, wherein 430 is a borehole, bored
through an active zone 410 including moisture affected fill soil, active zone 410 extending between levels 417 and 418, and stable zone 412 including only stable soil, zone 410 extending below level 418 downward and including bottom part 425 of borehole 430, for a pile 49 to be made by casting concrete 416 therein, and 47 is a reinforcement cage of pile 49. This embodiment of the inventive device 41 of this invention includes inner sleeve 42, filling sleeve 44, outer sleeve 43, and a bottom and a top sealing rings 45, similar to elements 12, 14, 13, 15, respectively, and to their encompassing relationships, as shown in FIG. 1. In addition, the inventive device 41 includes at least one spacer rod 46 encompassed by 42, separating 42 from 47 to provide adequate gap between 47 and 42 for concrete 416. A protective and water impermeable membrane 48 that decreases the moisture contents fluctuations in 410 may be added. In this embodiment, device 41 extends aboveground to make an upward extension of pile 49 extending by length 424 above 48. Arrows 413 represent the forces acting on 41 as a result of the soil pressure and arrows 414 represent the negative heave forces. The yielding of 44 neutralizes 413 while the low friction along 43 neutralizes 414.

Therefore, this embodiment 41 of the inventive design incorporates five elements: an inner ring 42, an outer sleeve 43, a filling sleeve 44, at least one spacer 46, sealing rings 45. In this inventive design, elements 42, 43, 44 are required and elements 45, 46 are optional. Membrane 48 may be added.

Means other than 46 for separating 42 and 47 could be used, and membrane 48 may not be necessary or practical in many circumstances.

FIG. 5, a view of cross section 5-5 of FIG. 2 in active zone 510, includes inner sleeve 52, filling sleeve 54 and outer sleeve 53 surrounding reinforcement cage 57 and spaced away from it by spacers 56. In this embodiment, the spacers are in the form of at least three rods, said rods are vertically disposed to separate 52 from 57. Borehole 530 in soil 510 surrounds 53 and exerts horizontal heave pressures 513 and vertical heave pressures, not shown, said pressures are not necessarily circumferentially uniform.

FIG. 6, a view of cross section 6-6 of FIG. 3 in fill and active soil 611, includes inner sleeve 62, filling sleeve 64 and outer sleeve 63 surrounding reinforcement cage 67 and spaced away from it by spacers 66. In this embodiment, the spacers are in the form of at least three rods, said rods are vertically disposed to separate 62 from 67. Borehole 630 in soil 610 surrounds 63 and exerts heave pressures 613, and negative friction forces, not shown, as a result of the fill settlement, said pressures and forces are not necessarily circumferentially uniform.

FIG. 7, a view of cross section 7-7 of FIGS. 2 and 3 in stable soil 712, includes borehole 730 in soil 712 defining pile size of cast concrete 716. 716 includes reinforcement cage 77, said cage is spaced away from 730 by vertical rod spacers 76.

FIG. 8, a view of cross section 8-8 of FIG. 4 in fill and active soil 811, includes inner sleeve 82, filling sleeve 84 and outer sleeve 83 surrounding reinforcement cage 87 and spaced away from it by vertical spacer rods 86. Soil 811 surrounds 83 and exerts heave pressures 813 and negative friction forces, not shown, said pressures and forces are not necessarily circumferentially uniform.

FIG. 9 is a cross section through a reinforced wall supporting soil 921 and including four identical piles 109 incorporating a different embodiment of this inventive device, four being an illustrative number only, and any other number of piles above one may be used.

A number of boreholes 930 for piles 99 are bored in soil 921 which may be fill, active or both, and reinforcement cages 97 are inserted therein. A relatively rigid inner sleeve 92, filling sleeve 94, preferably made of deformable, low modulus material, and a relatively rigid outer sleeve 93 are inserted into each borehole 930, grooves are cut through said sleeves and inserts 920, preferably in contact with cages 97 are inserted into grooves 922. Spacers 920 are made or rubber or other suitable material to be easily removable, as elaborated hereinbelow. One side of each one of grooves 922 is positioned to define the contact area of support wall 923, to be cast later, with soil 921, said defining sides of said grooves being preferably coplanar. Additional spacers, not shown, separating 92 from 97, may be added. Concrete 916 is cast in boreholes 930 to form piles 99. Soil 921 is then dug out in the support wall side of piles 99, the left side in this exemplary figure, and the portions of 92, 93, 94 in that support wall side as well as 920 are removed, exposing clean pile surfaces and grooves 922 in piles 99. Concrete 911 to form wall 923 is then cast. There is no need to clean the exposed parts of piles 99, and grooves 922 ensure a good contact between wall 923 and piles 99. Furthermore, much better water sealing properties are obtained by the penetration of the concrete of 911 into grooves 922 of piles 99.

FIG. 10 is a view of cross section 10-10 of the cast retaining wall 1023 including pile 109 extending upward of 1025 to top wall level 1024, and wall concrete 1011, 1017, the original soil level and 1010, the soil level at the exposed side of wall 1023, 1013 are heave or other soil forces acting on wall 1023, 102, 103, 104 are the inner, outer and the filling sleeves, respectively, 1020 is a groove for improving the adherence of wall 1023 to piles 109 and increasing its strength and rigidity.

FIG. 11 is a cross sectional view of a pile 119 utilizing this inventive device 111, wherein 1130 is a borehole, bored through an active fill zone 1110 including moisture induced swelling soil and 1111, a zone of collapsed soil that might lead to concrete segregation. Active zone 1110 extending between levels 1117 and 1118, and stable zone 1112, including only stable soil, extending below level 1118 downward and including bottom part 1125 of borehole 1130, for a pile 119 to be made by casting concrete 1116 therein. 117 is a reinforcement cage of pile 119. This embodiment of the inventive device 111 of this invention includes inner sleeve 112, filling sleeve 114, outer sleeve 113, and a bottom and a top sealing rings 115 similar to elements 12, 14, 13, 15, respectively, and to their encompassing relationships, as shown in FIG. 1. In addition, the inventive device 111 includes at least one spacer ring rod 116 encompassed by 112, separating 112 from 117 to provide adequate gap between 117 and 112 for concrete 1116. A protective and water impermeable membrane 118 for decreasing the moisture contents fluctuations in 1110 and 1111 may be added. In this embodiment, device 111 extends aboveground to make an upward extension of pile 119 extending @ 1124 above 38 to form a structural column seamlessly and continuously cast above pile 119 for better structural properties in general and improved earthquake resistance in particular. Arrows 1113 represent the horizontal heave forces acting on 111 as a result of the soil swelling, and arrows 1114 represent the vertical
heave forces. The deformation of 114 neutralizes 1113 while the low friction along 113 neutralizes 1114.  

Therefore, this embodiment 111 of the inventive design incorporates five elements: an inner sleeve 112, an outer sleeve 113, a filling sleeve 114, spacers 116, and sealing rings 115. In this inventive design, elements 112, 113, 114 are required and elements 115, 116 are optional. Membrane 118 may be added to lower moisture fluctuations.

Means other than 36 for separating 32 and 37 could be used, and membrane 118 may not be necessary or practical in many circumstances.

FIG. 12, a view of cross section 12-12 of FIG. 11 outside of soil 1110, includes inner sleeve 112, filling sleeve 124 and outer sleeve 123 surrounding reinforcement cage 127 and spaced away from it by spacers 126. In this embodiment, the spacers are in the form of at least three rods, said rods are vertically disposed to separate 122 from 127.

It will be appreciated by persons skilled in the art, that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention is defined by the appended claims and includes both combinations and sub-combinations of the various features described hereinabove as well as variations and modifications thereof which would occur to persons skilled in the art upon reading the foregoing description.

1. A device for in-situ casting of at least partly underground concrete pile within a borehole having a mouth, said borehole having a reinforcing cage at least partially disposed therein, said device comprising:

A cylindrical inner sleeve mountable within said borehole for casting said pile, said inner sleeve having a length, an upper extremity and a lower extremity, and dimensioned to at least partially surround said reinforcement cage;

A filling sleeve having an upper extremity and a lower extremity and having substantially the same length as the length of said inner sleeve, said filling sleeve dimensioned to circumferentially encompass said inner sleeve, said filling sleeve being substantially deformable and made of material having a low elastic modulus;

An outer sleeve having an upper extremity and a lower extremity and having substantially the same length as said inner and filling sleeves, said outer sleeve dimensioned to circumferentially encompass said filling sleeve, said outer sleeve and said filling sleeve having a low coefficient of friction therebetween, wherein said lower extremities of said inner filling and outer sleeves are substantially coplanar when deployed within said borehole for affecting said casting.

2. A device according to claim 1 further comprising a sealing ring, said sealing ring dimensioned to be coupled at least to an extremity of said filling sleeve and to a matching extremity of said outer sleeve.

3. A device according to claim 1 further comprising a spacer for spacing apart said inner sleeve and said cage.

4. A device according to claim 1 wherein said outer sleeve comprises at least two essentially congruent layers.

5. A device according to claim 1 wherein any of said sleeves comprises a bent sheet.

6. A device according to claim 1 wherein at least one of said inner sleeve and filling sleeve is expandable for securing said outer sleeve to said borehole wall.

7. A device according to claim 1 wherein any of said sleeves comprises a tube.

8. A device according to claim 1 wherein any of said sleeves comprises polymeric material.

9. A device according to claim 1 wherein said inner sleeve comprises of cardboard.

10. A device according to claim 1 wherein said inner sleeve comprises of metal.

11. A method for in-situ casting of at least partly underground concrete pile within a borehole, said borehole having a reinforcing cage therein and having a mouth, said method comprising any sequence of the steps of:

inserting a cylindrical inner sleeve mountable within said borehole for casting said pile, said sleeve having a length, said sleeve surrounding at least a part of said cage;

inserting a filling sleeve having substantially the same said length, said filling sleeve made of substantially low elastic modulus and substantially deformable material;

inserting an outer sleeve having substantially the same said length, wherein each sleeve having a top extremity and a bottom extremity, and wherein said top extremities are coplanar and said bottom extremities are coplanar, wherein said outer sleeve encompasses said filling sleeve, said filling sleeve encompasses said inner sleeve, and only said bottom extremities are below said mouth, said outer sleeve having a low friction coefficient at the interface between itself and its encompassed sleeve.

12. A method according to claim 11 further comprising the step of attaching a sealing ring extending between an extremity of said filling sleeve and said outer sleeve.

13. A method according to claim 11 further comprising the step of inserting a spacer, said spacer being inserted between said inner sleeve and said cage for spacing apart said inner sleeve from said cage.

14. A method according to claim 11 wherein said outer sleeve comprises at least two substantially congruent layers.

15. A method according to claim 11 wherein any of said sleeves is formed of a bent sheet.

16. A method according to claim 11 further comprising the step of elastically bending at least one of said inner sleeve and said filling sleeve to expand and secure said outer sleeve to said borehole wall.

17. A method according to claim 11 wherein any of said sleeves is formed of a tube.

18. A method according to claim 11 wherein any of said sleeves comprises polymeric material.

19. A method according to claim 11 wherein said inner sleeve is formed of cardboard.

20. A method according to claim 11 wherein said inner sleeve is formed of metal.

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