



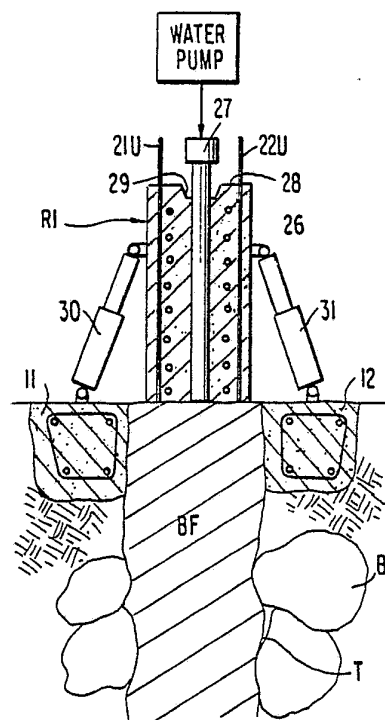
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(54) Title: METHOD AND APPARATUS FOR CONSTRUCTING REINFORCED CONCRETE WALLS IN THE EARTH

(57) Abstract

Reinforced concrete walls are constructed in difficult ground by casting a pair of guide walls (11, 12) and the trench excavation for the wall is carried out between the two guide walls (11, 12). Initially, backfilling is of a plastic erodable mixture. At the surface forms (23, 24) are set for casting the reinforced structures which are to form the concrete wall and hollow pipes (26) are embedded at spaced intervals. Water is injected into the pipes (26) gradually washing the erodable backfill material and facilitating the descent of the cast section (R1). As the wall section (R1) is lowered, the next wall section (R2) is formed and concreted in sequence. As each wall section is formed, the next pipe pipe section (226) is coupled to the protruding sections and the next reinforcing elements (221, 222) are secured to the protruding reinforcing bars (21, 22) of the element that has been lowered. The sequences continues until the whole structure has reached the design depth.



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METHOD AND APPARATUS FOR CONSTRUCTING
REINFORCED CONCRETE WALLS IN THE EARTH

BACKGROUND OF THE INVENTION:

Construction of shafts having smooth walls, particularly where the ground conditions are hard and rocky and where conventional slurry walls would be irregular and possibly misaligned, and in the presence of a high water table is difficult. The present invention utilizes the known slurry wall excavation techniques, combined with cement bentonite trench in sinking of caissons in a unique way for constructing reinforced concrete walls in difficult or rocky ground particularly with respect to the problem of sinking circular shafts when ground conditions are hard and in the presence of a high water level. The invention allows the construction of such a wall where continuity of horizontal reinforcement in the shaft is desired.

According to the invention, the system for sinking a large hollow shaft comprises forming two reinforced concrete guide walls spaced apart a distance larger than the nominal wall thickness of the final concrete structure. The excavation is then performed, preferably in panel sections with the backfill consisting essentially of erodable plastic mixtures such as cement-bentonite, sand-cement-bentonite or similar materials which have no large aggregates. A form supported on the guide walls is constructed over the slurry wall for segments of the final structure leaving embedded six inch pipes, for example, at one meter intervals with pipes coupling extending and ends of vertical reinforcement bars out of the poured concrete. As the forms for the section are removed above ground, hydraulic jacks are placed on the concrete element, segment or ring and are anchored to the guide walls. Then water is injected into alternate ones of the pipes, washing the erodable backfill and from beneath



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the hardened concrete and facilitating the descent of the toroidal section (in the case of a circular shaft) of the wall which is pull, supported or guided as need may be by jacks. As one section is lowered, the next is formed and
5 concreted and the sequence continues until the whole structure has reached design depth, which may be a bearing stratum or rock. The material of the backfill is washed out of alternate ones of the pipes, so that as water is injected in one pipe, soil, water and bentonite e.g. the temporary
10 backfill, exits from the next pipe. As the structure reaches design depth, the pipes may then all be used as grout pipes to extend a drill curtain below the bottom of the wall, seal the space between the structure and rock, and grout any void left around the structure by washing of backfill.

15 BRIEF DESCRIPTION OF THE DRAWINGS:

The above and other objects, advantages and features of the invention will become more apparent when considered with the following specification taken with the accompanying drawings wherein:

20 Figure 1 is a perspective view illustrating the construction of a wall with an erodable backfill mixture in accordance with the invention,

Figure 2 is a sectional view illustrating the forming of slurry walls with the steel reinforced concrete toroidal
25 section with a system of pipes, typically six inch diameter pipes spaced at one meter intervals with the pipe coupling and vertical elements of the steel reinforcing bars extending above the poured concrete,

Figure 3 illustrates the use of jacks to lower the
30 element or segment which has been cast above the ground into the trench as the water is injected into the pipes washing the erodable backfill material,

Figure 4 illustrates the construction of the toroidal ring in sections and the sequence according to the invention.



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As shown in Figure 1, a strong pair of spaced, steel reinforced, concrete guide walls 11 and 12 are constructed and spaced apart a distance D which is larger than the nominal thickness of the final concrete wall structure. In this preferred embodiment, the invention is illustrated as being applied to a circular shaft, but it will be appreciated that it can be applied to shafts of any cross sections such as rectangular, hexagonal, oval shafts and the like and, certain aspects of the invention can be applied to forming straight walls e.g. walls which do not close upon themselves and do not form shafts. Preferably, the excavation is carried out in sections so as to form panel sections and can be carried out using well known slurry excavation techniques as disclosed in Veder patent 3,310,952 and also disclosed in the text "3 The I.C.O.S. Company In The Underground Works" (1968), incorporated herein by reference.

Techniques that are especially useful in excavating in difficult soils where there are large boulders and the like are disclosed in the above noted patent and text. Chissels, rotary bits and the like may be used to excavate through the rock. In a preferred aspect of this portion of the invention, the slurry trench is excavated to the final depth. According to this aspect of the invention, the construction is done in panels and the backfill consists of a plastic erodable mixture with no large aggregates, such as a cement-bentonite mixture, sand-cement-bentonite or a similar backfill material. It is noted that the use of a pair of spaced apart concrete guide walls is not new, having been utilized by the assignee hereof for many years in constructing numerous steel reinforced concrete underground cut-off wall structures. That is to say, the structure illustrated in Figure 1 and the manner of forming same is not per se deemed to be novel according to the present invention.



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As shown in Figure 2, the guide walls 11 and 12 are provided with steel reinforcements 14 and 15. The excavation of the trench T having a thickness or width D to the full depth of the wall and may be carried out by a number of slurry trench excavation techniques disclosed in the text "3 The I.C.O.S. Company In The Underground Works". In the present case, the excavation of trench T is formed in panel sections P1, P2, P3...PN with the excavation in part being carried out by clam shells where the earth is amenable to clam shell bucket excavation and when the boulders and massive rock blocks are encountered, they are removed by chissels, rotary drills and the like, all of which are well known in the art.

In the present case, as each panel section P1, P2, P3...PN is excavated, it is backfilled with a plastic erodable mixture such as cement-bentonite, sand-cement-bentonite or similar such backfill with no large aggregates. (In relatively shallow walls, the excavation can be done by a backhoe in a cement-bentonite slurry mixture so that the erodable backfill is in place as earth is excavated). After completion of the last panel wall section PN, an initial final concrete wall construction is constructed above the trench which is maintained full of the erodable plastic mixture. This is done by erecting steel reinforcement cages in the form of an annulus, and in Figure 2, it is indicated by two annular rings 21, 22 which are cross connected by other steel reinforcing bars not shown. Annular forms 23, 24 are set up around the form and a series of pipes, in this case approximately six inches in diameter and embedded at about one meter intervals with a pipe coupling 27 extending out above the level of the concrete are provided. The lower edge of annular forms 23, 24 may be open so the concrete is cast on or initially interfaces with the erodable mixture.



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However, the lower edge of the initial casting forms can be closed with a metal plate or mesh so the first concrete ring is installed in the form with a mesh, not shown at the lower edges of initial casting which, in conjunction with the upper surface of the erodable backfill to permit the installation of the concrete in the form. It will be noted that the upper ends 21U and 22U of the vertical runs of the steel reinforcing cage 21 and 22 project above the level of the concrete with pipe coupling 27. As shown in Figure 3, the upper edge 28 of the concrete is shaped so as to provide an annular trough or groove 29 so as to provide an interlocking joint or section when the next concrete element or annulus is cast.

As shown in Figure 3, after the forms have been removed, hydraulic jacks 30, 31 are secured to the annular concrete ring R1, there being a plurality of such jacks spaced around the ring R1 and extending between the guide walls 11 and 12 and fastens to the external and internal surfaces of ring R1. It will be appreciated that conventional anchors or lifting rings are embedded in the concrete ring R1 and locked to the reinforcement cage 21, 22. Water is then injected into the alternate ones of pipes 26 and with the eroded portions of the erodable backfill withdrawn or exited from an adjacent pipe 26. As the upper layers of the erodable backfill material are removed, the jacks 30 and 31 lower the toroidal sections of the wall R1 into the trench T. After one toroidal section R1 is lowered, the next ring R2 is formed as shown in Figure 4. A second reinforcing cage 221, 222 is erected with the lower ends of the reinforcing bars secured to the upper ends 21U and 22U of the initial annular reinforcing cage and a second pipe section 226 is fastened to the coupling 27 of the first annular ring R1. Jacks are again applied (not shown in Figure 4) and the pumping of water and the material of the backfill washing out by



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means of alternate pipes 26 is resumed. The construction of the annular rings R1, R2, R3...RN continues to the final design depth. When the structure has reached its design depth, the pipes 26 can be used as grout pipes to extend a
5 drill curtain below the bottom of the trench T. The joint J between each annular ring section can be specially fabricated to be absolutely water tight because the joint is fabricated above ground and is exposed when the forms of the upper ring section R2 are removed and prior to the
10 erosion of the backfill in the Trench T. Of course, since the wall segments are above ground, they can be coated with further waterproofing materials, such as bituminous or tar compounds, etc. The grouting can fill any contact space between the structure and rock and the grout can fill any
15 void left around the structure by the washing of the backfill.

In Figures 2 and 4, the water pump and the means for removing the water carrying eroded backfill, respectively, are diagrammatically illustrated.

20 Thus, there has been disclosed and described a method and apparatus for constructing underground concrete wall, particularly hollow circular shafts in grounds where a conventional slurry wall would be irregular and possibly misaligned and in the presence of a high water table. It allows
25 continuity or horizontal reinforcement in the shaft which is a definite advantage under certain design conditions.

While there has been disclosed and described a preferred embodiment of the invention, it will be appreciated that various modifications and adaptations of the basic
30 underlying philosophy of the invention without departing from the spirit thereof and it is intended that such modifications, departures and adaptations be incorporated in the claims appended hereto.

WHAT IS CLAIMED IS:



CLAIMS

1. A method of constructing a reinforced concrete wall in the ground comprising:

I. forming a pair of concrete guide walls spaced apart along the line of said wall, the spacing between said guide walls being greater than the width of the reinforced concrete walls to be constructed,

II. excavating a trench between said pair of guide walls and backfilling said trench with an erodable mixture capable of sustaining the excavation walls,

III. placing forms along said wall and above the surface of said trench and spaced apart the width of said reinforced concrete wall, installing steel reinforcement between said forms and casting concrete between said forms from the surface of said erodable mixture and filling said forms to thereby form an initial concrete wall section,

IV. after the concrete has set in said section, lowering said section into the trench while eroding said erodable backfill material, said section being lowered to a level wherein a portion thereof projects the upper level of said trench,

V. forming at least one further wall section directly on said first wall section by placing forms therealong, and

VI. after the concrete has set in said at least one further concrete section, lowering the said one section while eroding said backfill material to the final depth of said concrete wall.

2. The invention defined in Claim 1, wherein the steel reinforcement in said first section is coupled to the steel reinforcement in said at least one further concrete section.



3. The invention defined in Claim 1, including
2 placing a series of vertical pipes in said wall section
3 and coupling said series of pipes in said first wall
4 section with a like series of aligned pipes in said second
5 wall section.

4. The invention defined in Claim 1, including
2 forming a groove in the upper surface of said first wall
3 section so as to form a locking seal with said at least
4 one further concrete section.

5. The invention defined in Claim 1, wherein con-
2 crete wall is formed endless and said steel reinforcement
3 is formed endless and continuous in any horizontal plane.

6. The invention defined in Claim 3, wherein step IV
2 includes injecting water into selected ones of said vertical
3 pipes and withdrawing injected water and erodable backfill
4 material from selected others of said vertical pipes.

7. The invention defined in Claim 3, wherein step IV
2 includes injecting water into alternate ones of said vertical
3 pipes and withdrawing water and eroded backfill from at
4 least some of the remaining vertical pipes.

8. The invention defined in Claim 3, including:
2 VII. injecting a grout below the lower most concrete
3 wall section through said vertical pipes.

9. Apparatus for constructing a reinforced concrete
2 wall in the earth comprising a first plurality of substan-
3 tially vertical pipes, concrete wall forming means for said
4 pipes are embedded, said concrete wall forming means being
5 positioned over a trench in the earth filled with an erodable



6 backfill material, a second plurality of substantially
7 vertical pipes embedded in said concrete wall forming
8 means, water supply means connected to said first plurality
9 of pipes for introducing water therein to erode said erod-
10 able backfill material, and means connected to said second
11 plurality of pipes for removing water and eroded backfill
12 material from said trench.

10. Apparatus as defined in Claim 9, including a
2 pair of spaced apart guide means defining said trench and
3 jack means between said guide means and said concrete walls
4 for lowering said concrete wall into said trench as said
5 backfill is eroded.



FIG. 1

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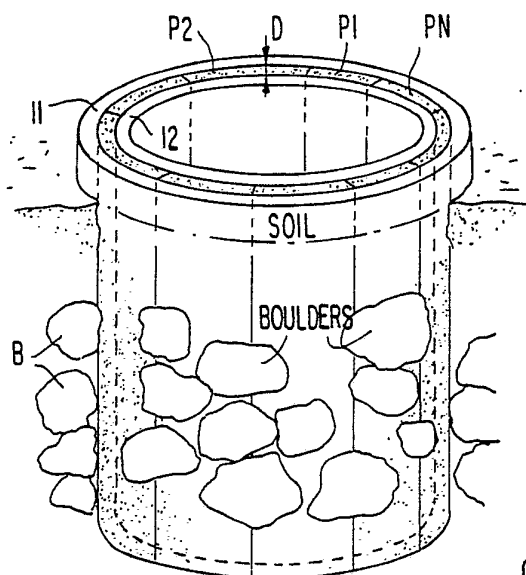


FIG. 2

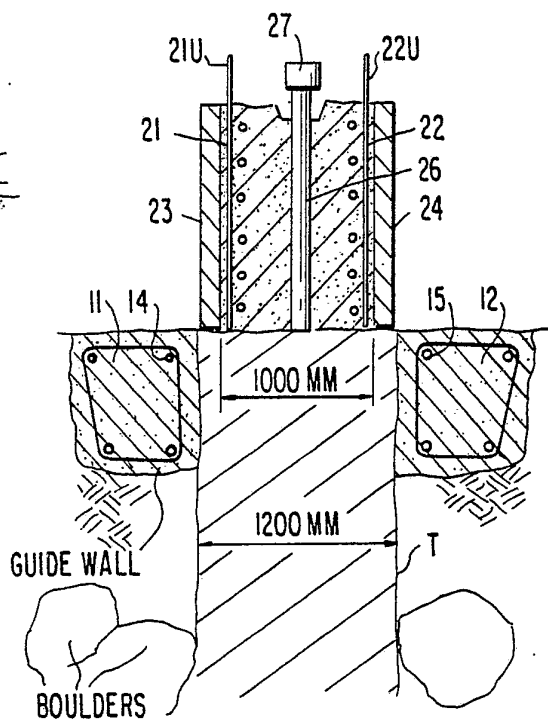
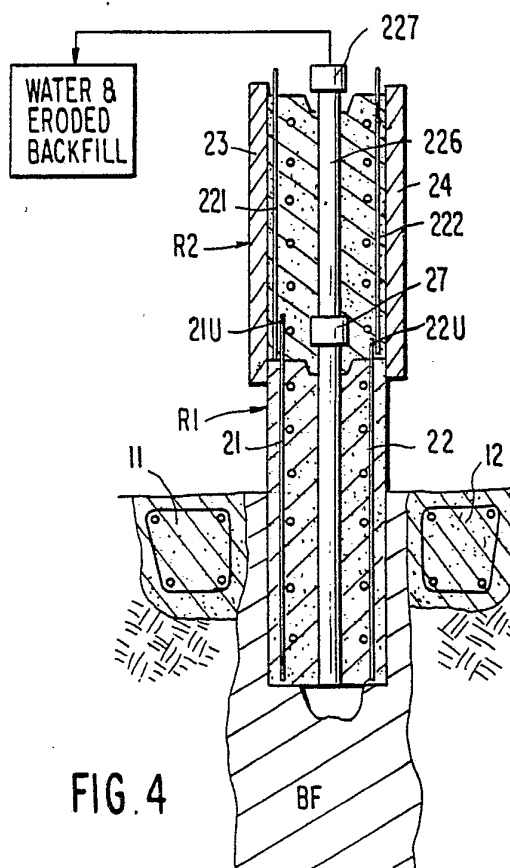
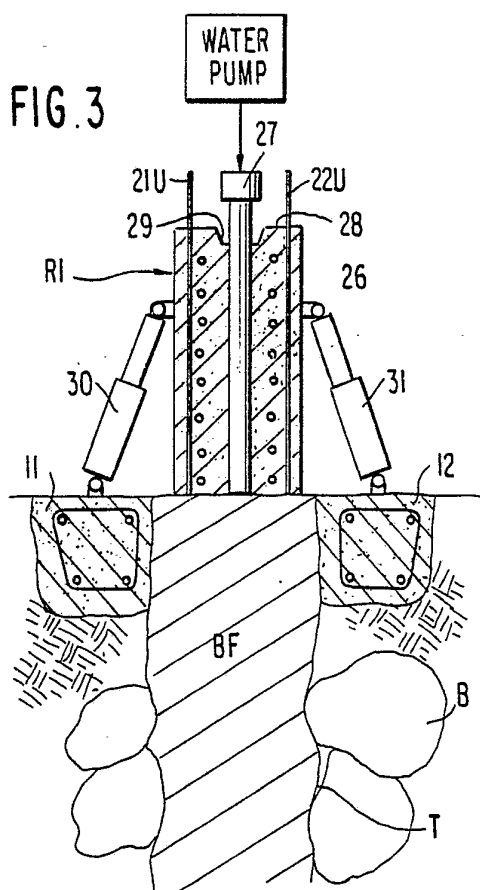


FIG. 3



INTERNATIONAL SEARCH REPORT

International Application No PCT/US84/00297

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl. 3 E02D 5/18		
U.S. Cl. 405/267		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
U.S	405/133, 134, 150, 151, 222, 233, 266-268, 286, 249/1, 10, 11, 51, 52/169.13, 742	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category [*]	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	US, A, 3,293,865, published 27 December 1966 Loofbourow et al. See Figure 2 and Col. 4, lines 30-52	1,2,4,5
Y	US, A, 2,329,223, published 14 September 1943, Schmidt See figure 1	3,8
Y	JP, A, 57-155424, Published 25 September 1982, See figure 1	1,2,4,5
Y	SU, A, 624,989, published 29 September 1978, Mirochnik See figure 1	6,7,9,10
Y	Su, A, 950,857, published 25 August 1982, Yakovenko See figure 2	1,2,4,5
A	US, A, 2,791,886, published 14 May 1957, Veder See claim 4	6,7,9,10
A	US, A, 3,100,381, published 13 August 1963 Case et al	1,2,5,6,7, 9,10
A	US, A, 3,402,559, published 24 September 1968, Fukushima	3,8
A	US, A, 3,464,665, published 2 September 1969, Schoewert	4
[*] Special categories of cited documents: ¹⁵ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
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