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COMPLETE SPECIFICATION

Process of Forming a Tubular Pile Foundation

We, NIPPON CONCRETE KOGYO KABUSHIKI KAISHA, a Japanese Corporation, of 8—3, 1-chome, Shimbashi, Minato-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the forming of pile foundations and has as its object the provision of a foundation process by means of which foundations required to withstand heavy loads, for example, bridge piers set in the sea or in a river, can be formed easily in a short time.

According to the present invention there is provided a process of forming a tubular pile foundation comprising a first step including the substeps of arranging a set of pipe piles vertically and in a circle, applying rods and/or wires to the circular arrangement of pipe piles to form a tubular reinforcement structure, inserting the reinforcement structure in the annular space in a first double-walled tubular mould, and placing concrete in the mould to form a first tubular pile section; a second step including the substeps of securely connecting the bottom ends of another set of pipe piles with the respective top ends of pipe piles of said first tubular section, the two sets being in aligned abutting relation with each other, applying rods and/or wires to the second set of pipe piles to form a second tubular reinforcement structure, setting up a second double-walled tubular mould on the top of said first tubular pile section in aligned relation to said first mould and placing concrete in the annular space of the second tubular mould to form a second tubular pile section integral with the first tubular pile section, and repeating such substeps to form further tubular pile sections to obtain an integral pile structure of a desired length;

and a third step of setting up said tubular pile structure in the sea, a river or the like by letting it down vertically through the water surface until it reaches the bottom ground.

For a better understanding of the present invention, reference will now be made to the accompanying drawings which illustrate the various stages of a foundation process, and in which:

Figs. 1 and 1a illustrate two different forms of pipe pile, Fig. 1 representing a vertical axial cross section of a concrete pipe pile reinforced with tensioned rods and/or wires, and Fig. 1a representing a side elevation, partly in cross section, of a steep pie pile;

Fig. 2 is a vertical axial cross section of a double-walled tubular mould in which concrete is placed with the pipe piles vertically arranged in the annular space between the inner outer walls of the mould;

Fig. 3 is a plan view of the same, partly in transverse cross section, taken along the line III—III in Fig. 2;

Fig. 4 is a vertical axial cross section showing a second tubular concrete section formed integral with the first tubular concrete section of Figs. 2 and 3 by welding the bottom ends of similar pipe piles to the top ends of the respective pipe piles embedded in the first tubular concrete section and placing concrete in a similar double-walled tubular mould mounted on the first tubular concrete section;

Figs. 5 and 6 illustrate the different stages of the step of letting down a tubular concrete structure formed to a predetermined length by the previous steps vertically through the water and the muddy deposit to the supporting ground;

Fig. 7 is a vertical axial cross section showing how the precast tubular concrete sections are joined at the work site to obtain a desired length of tubular structure; and

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Fig. 8 is a side elevation, partly in section, showing how pressure water is led through the pipe piles to jet out from their bottom ends as the tubular concrete structure is let down through the underwater muddy deposit to the supporting ground.

Referring to the drawings and first to Fig. 1, there is shown one form of pipe pile usable in the fabrication of foundations which is a prestressed concrete pipe pile including end plates of iron 11 and 12 having central openings 11a and 12a, respectively, and a multitude of pretensioned wires 13 extending between the end plates. The wires 13 are anchored by their expanded ends 14. Another form of pipe pile is shown in Fig. 1a, which is of steel.

In the first step of the process, a number of pipe piles of the form illustrated in Fig. 1 or Fig. 1a are vertically arranged in a circle, as shown in Figs. 2 and 3. Then, rods and/or wires are applied to the circular arrangement of pipe piles in a spiral or circumferential fashion and joined together by connecting wires either manually or by welding to form a tubular basket-like reinforcement structure including the pipe piles 1. This reinforcement structure is placed in a double-walled tubular mould in the annular space between its inner and outer walls 4 and 40. As observed from Fig. 2, the pipe piles 1 in the reinforcement are of such length that their top ends extend above the top of the tubular mould 4—40. Subsequently, concrete 5 is placed in the mold to form a first tubular section A.

In the second step of the process, first, a set of similar pipe piles 1 are arranged, as shown in Fig. 4, on the tubular section A with the bottom end plate 11 of each of these pipe piles placed in contact with the adjacent end plate 12 of the corresponding embedded pipe pile 1. The piles are in aligned relation to each other and the adjacent end plates 11 and 12 are welded together. Transverse and connecting rods and/or wires are applied to the second set of pipe piles 1, now integral with the first set, in the same manner as described above to form another tubular basket-like reinforcement structure. A second tubular double-walled mould 4—40 is mounted on the tubular section A to surround the reinforcement structure and again concrete is placed in the mould to form a second tubular concrete section B integral with and similar to the first section A.

The procedure described above is repeated a required number of times to obtain a large-diameter tubular pile structure of a desired length. In this manner, tubular pile structures can be fabricated on land which range in length from about 20 to 30 meters and in diameter from about 3 to 8 meters. One example of such tubular pile structure 6 is

shown in Fig. 5, which includes three tubular sections A, B and C.

Description will next be made of the third step of the process with reference to Figs. 5 and 6, in which step the tubular pile structure 6 is set on the supporting ground at the bottom of a sea or a river by letting down such structure vertically through the water. During this step, when the structure 6 being let down reaches the surface H of the muddy deposit lying below the water surface S before reaching the bottom ground X, as shown in Fig. 5, the structure may be axially extended by substantially the same procedure described hereinbefore.

For example, referring to Fig. 6, tubular sections D and E are the ones connected at the work site with the consecutive top section C or D of the pile structure 6 before the bottom section A of the structure 6 is set in the ground at an appropriate depth as a pile foundation to support a desired superstructure 8.

If necessary, such superstructure 8 can be built on the tubular pile foundation 6 through the medium of hydraulic jacks 7, as shown in Fig. 6. As will be readily noted, the jacks can serve to help level the superstructure 8 as the tubular pile foundation 6 sinks into the ground X during the course of settling. In this case, when the process of settling has practically ceased, concrete is placed in the region of jacks 7 to complete the foundation work.

Again in the third step, when the tubular pile structure 6 is let down through the muddy deposit H to the supporting ground X, as shown in Fig. 5, the letting down of the structure 6 can be facilitated by expelling the mud at its bottom. As will be readily understood, the sets of pipe piles 1 of prestressed concrete or 1a of steel, embedded in the successive tubular sections A, B and C, are vertically aligned with each other, forming multiple-length pipe piles each defining a continuous hole 10 extending vertically through the tubular pile structure 6, as shown in Fig. 8. Thus jets of water can be formed to expel the neighboring mud at the bottom of the descending structure 6, as indicated by the arrows P in Fig. 8, by feeding pressure water into the holes 10 at their top end.

Further, although the tubular concrete structure, for example, shown in Fig. 4, is fabricated at the work site by the procedure explained with reference to Fig. 2, 3 and 4, it may also be fabricated by precasting individual tubular concrete sections A and B, each including for reinforcement a number of pipe piles 1 exposed at both top and bottom, as shown in Fig. 7. In use of such precast sections, they are placed one on another in vertical alignment and the adjoining ends 11 and 12 of the vertically aligned pipe piles are interconnected as by welding. Subsequently,

an annular joint 30 of concrete is cast between the precast section A and B, encircling the welded pipe joint, thereby to form an integral concrete structure.

5 WHAT WE CLAIM IS:—

1. A process of forming a tubular pile foundation comprising a first step including the substeps of arranging a set of pipe piles vertically and in a circle, applying rods and/or
10 wires to the circular arrangement of pipe piles to form a tubular reinforcement structure, inserting the reinforcement structure in the annular space in a first double-walled tubular mould, and placing concrete in the mould
15 to form a first tubular pile section; a second step including the substeps of securely connecting the bottom ends of another set of pipe piles with the respective top ends of pipe piles of said first tubular section, the two
20 sets being in aligned abutting relation with each other, applying rods and/or wires to the second set of pipe piles to form a second tubular reinforcement structure, setting up a second double-walled tubular mould on the
25 top of said first tubular pile section in aligned relation to said first mould and placing concrete in the annular space of the second tubular mould to form a second tubular pile section integral with the first tubular pile
30 section, and repeating such substeps to form further tubular pile sections to obtain an integral tubular pile structure of a desired length; and a third step of setting up said tubular pile structure in the sea, a river or
35 the like by letting it down vertically through the water surface until it reaches the bottom ground.

2. A process of forming a pile foundation as set forth in claim 1, in the third step of
40 which the tubular pile structure is axially extended as it is let down vertically through the water surface by connecting an additional set of similar pipe piles to the top of the respective pipe piles extending above the top

of said tubular pile structure, applying rods 45 and/or wires to the additional set of pipe piles to form a further reinforcement structure, setting up a double-walled tubular mould on the top of said tubular structure in aligned
50 relation thereto with the further reinforcement structure located in the annular space in the last-mentioned tubular mould, placing concrete in the latter to form a tubular extension pile section integral with the existing
55 tubular pile structure, and repeating the formation of such tubular extension pile section a desired number of times to obtain an extended tubular pile structure reaching the bottom ground.

3. A process of forming a tubular pile foundation as set forth in claim 1 in the third
60 step of which water under pressure is fed into the set of aligned pipe piles to jet out at the bottom ends of the pipe piles thereby to expel any neighboring muddy deposit to
65 aid the tubular pile structure in descending to the bottom ground.

4. A process of forming a tubular pile foundation as set forth in claim 2 including
70 a further step of arranging on the top end surface of the extended tubular pile structure a number of hydraulic jacks operable to keep level the superstructure built thereon in spite of any possible settling of the tubular pile structure under the load of the superstructure, and
75 placing concrete about the jacks to set the level of the superstructure when the settling has practically ceased.

5. A process of forming a tubular pile foundation, the process being substantially as
80 hereinbefore described with reference to the accompanying drawings.

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2. A process of forming a pile foundation as set forth in claim 1, in the third step of which the tubular pile structure is axially extended as it is let down vertically through the water surface by connecting an additional set of similar pipe piles to the top of the respective pipe piles extending above the top

of said tubular pile structure, applying rods and/or wires to the additional set of pipe piles to form a further reinforcement structure, setting up a double-walled tubular mould on the top of said tubular structure in aligned relation thereto with the further reinforcement structure located in the annular space in the last-mentioned tubular mould, placing concrete in the latter to form a tubular extension pile section integral with the existing tubular pile structure, and repeating the formation of such tubular extension pile section a desired number of times to obtain an extended tubular pile structure reaching the bottom ground.

3. A process of forming a tubular pile foundation as set forth in claim 1 in the third step of which water under pressure is fed into the set of aligned pipe piles to jet out at the bottom ends of the pipe piles thereby to expel any neighboring muddy deposit to aid the tubular pile structure in descending to the bottom ground.

4. A process of forming a tubular pile foundation as set forth in claim 2 including a further step of arranging on the top end surface of the extended tubular pile structure a number of hydraulic jacks operable to keep level the superstructure built thereon in spite of any possible settling of the tubular pile structure under the load of the superstructure, and placing concrete about the jacks to set the level of the superstructure when the settling has practically ceased.

5. A process of forming a tubular pile foundation, the process being substantially as hereinbefore described with reference to the accompanying drawings.

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