

PATENT SPECIFICATION

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(54) METHOD FOR CONNECTING PILES UNDER THE GROUND

(71) WE, NISHIMATSU CONSTRUCTION COMPANY, LIMITED, a Japanese Body Corporate of 20-10, 1-chome, Toranomon, 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 a method for connecting piles under the ground. More specifically, the invention relates to a method for connecting piles closely to one another in the radial direction under the ground to construct an underground structure such as a cofferdam.

Known prior techniques for connecting piles under the ground include, for example, the method shown in Figure 1 in which a plurality of piles 1 are driven at intervals each of which is smaller than the diameter of each pile, and then a pile 2 is driven between, and in contact with, two adjacent piles 1 with a certain contact width a , and the method shown in Figure 2 in which a plurality of piles 3 are driven at small intervals and a soil-hardening chemical is poured into spaces among the adjacent piles 3 from above the ground to form a hardened soil portion 5 with a certain width b between the two adjacent piles 3.

The first method however has the defect that when piles 1 or 2 are not driven perpendicularly, the contact width a between piles will not be constant over their entire length. Moreover, since the contact width a is generally small, it is difficult to make a sufficiently effective cofferdam. Application of the second method makes it possible to obtain a larger contact area than in the first method. But since the connecting part 5 is a hardened product resulting from the pouring of a chemical grout from the ground surface, both its hardness and its reliability of connection are low.

It is an object of this invention therefore to reduce the defects of these conventional methods in connecting piles under the ground in the radial direction, and to provide a method for connecting piles under the ground by which an underground dam having greater ability to check the flow of water can be constructed at a low cost.

This object can be achieved in accordance with the invention by a method which comprises driving a plurality of piles into the ground at predetermined intervals; excavating the spaces between adjacent driven piles to a predetermined depth by means of an auger having a concrete-jetting hole at the tip portion of its shaft, cutters capable of protruding from the auger blade, and hardener jetting holes near the tips of the cutters, the cutters not protruding during excavation; jetting concrete or mortar from the concrete jetting hole while the auger is being lifted thereby to fill the concrete or mortar in the cavity below the tip portion of the auger; and simultaneously jetting a hardener from the hardener jetting holes while rotating the auger with the cutters being maintained in the protruding state, and shaving off the soil around the cutters, thereby to mix the shaved soil with the jetted hardener and to make concreted soil in place.

The invention also provides an auger for use in such a method such auger having cutters movable to and from positions in which they protrude from the auger blade, holes for jetting hardener near the tips of the cutters, conduits for conducting hardener to said holes and a hole for jetting concrete at the tip portion of the shaft, the shaft being hollow.

Preferred embodiments of the method of this invention are described below with reference to the accompanying drawings in which:

Figures 1 and 2 are transverse sectional

views of underground dams in accordance with conventional methods;

Figure 3, 4 and 7 are vertical sectional views showing the steps of the method of this invention;

Figure 5 is a vertical sectional view showing the tip portion of an auger while it is excavating the ground or is out of operation;

Figure 6 is a top plan of the view in Figure 5;

Figure 8 is a vertical sectional view showing the state of the tip portion of an auger while it is being lifted; and

Figures 9 and 10 are plan and transverse sectional views of underground dams made by the method of this invention.

The first step of the method, as shown in Figure 3, is to drive mortar piles 7 into the ground 6 at intervals, and then, as shown in Figure 4, the spaces between the adjacent piles 7 are excavated by an auger 11 to provide holes 10 for forming piles in place. The details of the tip portion of the auger 11 at this time are shown in Figures 5 and 6. At the tip portion of a hollow shaft in the auger is provided a hole 12 for jetting concrete or mortar sent from above the ground, and in the periphery of a blade 13 of the auger, at least two protrudable cutters 14 are provided. These cutters are secured to the blade 13 by hinges 15 so that they are out of operation (in the unprotruding state) while the auger 11 is performing an excavating operation, and are in the open state (protruding state) by the pressure of the soil while the auger is being lifted (see Figure 8). At least one of the cutters 14 near the end of the shaft has a hole 18 for jetting out a hardener which is sent from above the ground through a conduit 16 and a flexible tube 17. While the auger 11 is performing an excavating operation supply of material to these holes 12 and 18 is controlled by a suitable electrical or mechanical means. The dimension and securing position of the protrudable cutters 14 may be suitably selected so that in operation, the tip of the cutter may contact the outside surface of a pile 7 to a desired degree and can shave it.

When the auger 11 has provided a space 10 for a cast-in-place pile in the state shown in Figure 4, it is lifted while it is rotating and simultaneously jetting out concrete from the hole 12 and mortar (hardener) from the hole 18. As a result, a concrete pile 8 is formed in the cavity left after the lifting of the auger 11 as shown schematically in Figure 7 and in detail in Figure 8, and around the pile is formed a concreted soil 9 which is a hardened mixture of the soil of the ground, shaved off by the protruding cutters 14 and the mortar (hardener) jetted out from near the tip of the cutter. Since the protruding cutter 14 is so constructed that in operation, its tip may contact the outside surface of the

pile 7, the concreted soil 9 is bonded to the pile 7 with a sufficient width c corresponding to the extent of contact of the cutter 14 with the outside surface of the pile 7, namely to the extent of shaving the outside surface of the pile 7. Thus, a strong connection between the pile 8 and the pile 7 is completed.

The piles to be connected are not limited to the driven concrete piles 7 described hereinabove, but may, for example, be cast-in-place concrete piles or driven steel piles. When a cast-in-place pile 7 is to be connected to a cast-in-place pile 8, it is desirable to form the pile 8 before the cast-in-place pile 7 formed is aged enough, for example within three days after pouring, because within this period, the outside surface of the cast-in-place pile 7 is still green and it is easy to bond the concreted soil 9 firmly to the pile 7.

Hardeners for making the concreted soil 9 may be not only a cement paste, but also any other materials which can increase the strength of the soil when mixed and thus enhance its ability to check the flow of water, for example water glass-type chemicals, bentonite, and suspended solids. From the standpoint of strength, the cement paste is most preferred.

In the drawings, the projectable cutters 14 are shown to be secured to the lowermost blade 13 of the auger 11, but the manner of securing is not limited to this specific embodiment. From the viewpoint of efficiency, however, it is preferred that the cutters should be secured to positions near the tip of the auger. Furthermore, the drawings show the cutters 14 as secured to the upper surface of the auger 13, but the mixing efficiency can be increased by providing another cutter at its lower surface. The drawings also show cutters 14 of the type which can be protruded by the pressure of the soil, but other types can also be employed. For example, the cutters may be ones which are closed (do not protrude) during the normal rotation of the auger, and open (protrude) during its reverse rotation; or they may be ones which are opened or closed by an electrical or mechanical control from above the ground.

Needless to say, the hardener-jetting hole 18 should be provided at a position near the tip of the cutter 14 which does not permit clogging. In the drawings, the jetting hole 18 is opened at the side surface of the cutter 14, but in another embodiment, it may be opened on the other surface or provide in other places separate from the cutter 14.

Example

The spaces among piles which had been driven at intervals of 55 cm into the ground composed of silt containing sand were excavated to a depth of 12 m by an auger having a diameter of 40 cm which was of the type

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shown in Figures 5 and 6. Then, while being rotated at a speed of 50 revolutions per minute, the auger was lifted at a rate of 50 cm per minute. During this time, concrete was jetted from jetting hole 12 at the shaft of the auger, and mortar, from jetting hole 18 of the protruding cutter.

The concrete used has a water/cement ratio of 50% and contained 400 kg/m³ of cement. It was applied by a discharging pump at a rate of 120 liters per minute. The mortar had a flow value of 17 seconds and a water/cement ratio of 55%, and consisted of 200 kg of cement, 100 kg of fly ash and 1.2 kg of an injecting aid. It was applied by a discharge pump at a rate of 120 liters per minute.

As a result, an underground dam was obtained in which mortar concrete piles having a 28-day compressive strength of 100 kg/cm² were connected to one another by concreted soil. This dam showed a satisfactory result in checking the flow of water.

The connected parts of piles have high strength because they are formed on concreted soil which consists of a mixture of the soil in place with a hardener (especially mortar). Furthermore, since the soil is mixed with the hardener, the connected parts can be formed with high reliability. The method of this invention can also increase the width of contact of concreted soil with driven piles, and thus reduce the number of piles per unit distance for constructing an underground dam.

WHAT WE CLAIM IS:

1. A method for connecting piles to one another in the radial direction under the ground, which comprises driving a plurality of piles into the ground at predetermined intervals; excavating the spaces between adjacent driven piles to a predetermined depth by means of an auger having a concrete jetting hole at the tip portion of its shaft, cutters capable of protruding from the auger blade, and hardener jetting holes near the tips of the cutters, the cutters not protruding during excavation jetting concrete or mortar from the concrete jetting hole while the auger is being lifted thereby to fill the concrete or mortar in the cavity below the tip portion of the auger; and simultaneously jetting a hardener from the hardener-jetting holes while rotating the

auger with the cutters being in the protruding state, and shaving off the soil around the cutters, thereby to mix the shaved soil with the jetted hardener and to form concreted soil in place.

2. The method of Claim 1 wherein the auger has at least two protrudable cutters secured to symmetrical positions around the auger blade.

3. The method of Claim 1 wherein the auger has at least two protrudable cutters which are secured to symmetrical positions at the upper surface of the auger blade by means of hinges so that they are maintained in the unprotruding state while the auger is performing an excavating operation into the ground, and are maintained in the protruding state by the pressure of the soil while the auger is being lifted.

4. A method for connecting piles under the ground substantially as hereinbefore described with reference to Figures 3 to 10 of the accompanying drawings.

5. A structure comprising piles interconnected by the method of any one of the preceding claims.

6. An auger for use in the method of any one of claims 1 to 4, such auger having cutters movable to and from positions in which they protrude from the auger blade, holes for jetting hardener near the tips of the cutters, conduits for conducting hardener to said holes and a hole for jetting concrete at the tip portion of the shaft, the shaft being hollow.

7. An auger according to Claim 6, wherein there are at least two protrudable cutters at symmetrical positions around the auger blade.

8. An auger according to Claim 7, wherein the cutters are hinged to the upper surface of the blade.

9. An auger for use in the method of any one of Claims 1 to 4 and constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 5, 6 and 8 of the accompanying drawings.

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shown in Figures 5 and 6. Then, while being rotated at a speed of 50 revolutions per minute, the auger was lifted at a rate of 50 cm per minute. During this time, concrete was jetted from jetting hole 12 at the shaft of the auger, and mortar, from jetting hole 18 of the protruding cutter.

The concrete used has a water/cement ratio of 50% and contained 400 kg/m³ of cement. It was applied by a discharging pump at a rate of 120 liters per minute. The mortar had a flow value of 17 seconds and a water/cement ratio of 55%, and consisted of 200 kg of cement, 100 kg of fly ash and 1.2 kg of an injecting aid. It was applied by a discharge pump at a rate of 120 liters per minute.

As a result, an underground dam was obtained in which mortar concrete piles having a 28-day compressive strength of 100 kg/cm² were connected to one another by concreted soil. This dam showed a satisfactory result in checking the flow of water.

The connected parts of piles have high strength because they are formed on concreted soil which consists of a mixture of the soil in place with a hardener (especially mortar). Furthermore, since the soil is mixed with the hardener, the connected parts can be formed with high reliability. The method of this invention can also increase the width of contact of concreted soil with driven piles, and thus reduce the number of piles per unit distance for constructing an underground dam.

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auger with the cutters being in the protruding state, and shaving off the soil around the cutters, thereby to mix the shaved soil with the jetted hardener and to form concreted soil in place.

2. The method of Claim 1 wherein the auger has at least two protrudable cutters secured to symmetrical positions around the auger blade.

3. The method of Claim 1 wherein the auger has at least two protrudable cutters which are secured to symmetrical positions at the upper surface of the auger blade by means of hinges so that they are maintained in the unprotruding state while the auger is performing an excavating operation into the ground, and are maintained in the protruding state by the pressure of the soil while the auger is being lifted.

4. A method for connecting piles under the ground substantially as hereinbefore described with reference to Figures 3 to 10 of the accompanying drawings.

5. A structure comprising piles interconnected by the method of any one of the preceding claims.

6. An auger for use in the method of any one of claims 1 to 4, such auger having cutters movable to and from positions in which they protrude from the auger blade, holes for jetting hardener near the tips of the cutters, conduits for conducting hardener to said holes and a hole for jetting concrete at the tip portion of the shaft, the shaft being hollow.

7. An auger according to Claim 6, wherein there are at least two protrudable cutters at symmetrical positions around the auger blade.

8. An auger according to Claim 7, wherein the cutters are hinged to the upper surface of the blade.

9. An auger for use in the method of any one of Claims 1 to 4 and constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 5, 6 and 8 of the accompanying drawings.

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