

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) A METHOD OF FORMING A STRUCTURAL SUPPORT FOR A PILE DRIVER INTO THE EARTH BY MEANS OF VIBRATION; AND A PILE ASSEMBLY

(71) We, N. V. TOT AANNEMING VAN WERKEN VOORHEEN H. J. NEDERHORST, of Turfmarkt 8, Gouda, Holland, a Dutch Company, 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:—

The invention relates to a method of forming a structural support for a pile driven into the earth by means of vibration; as well as to a pile assembly.

A foundation pile may only be driven into the earth by means of a vibrator when the cross-section of this pile is rather small. It is e.g. possible to vibrate a metal pile having a H-shaped cross-section into the earth. However, such a pile has only a small lower bearing surface so that its supporting capacity will have to be substantially derived from the friction between its upstanding side surface and the earth. When the upper layers of the earth insufficiently contribute to this friction, foundation piles which are adapted to be vibrated into the earth due to their small cross-section can only take up a small load. In case the upper layers of the earth are subject to subsidence e.g. because the ground level has previously been raised, the friction between the earth and the upstanding side surface of the foundation pile would even act on the pile in a downward direction, which makes the application of foundation piles which are adapted to be vibrated into the earth wholly impossible.

It is a first object of the present invention to provide a method of supporting a pile driven into the earth by means of vibration, wherein the ultimate supporting capacity of the pile is considerably increased.

According to one aspect of the present invention there is provided a method of forming a structural support for a pile

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driven into the earth by means of a vibrator, the method comprising the steps of positioning a supporting member underneath the pile before this pile is vibrated into the earth, said supporting member having a horizontal cross-section, which is larger than the horizontal cross-section of the pile, so that portions of the supporting member protrude sideways outside the pile, at least the protruding portions of said supporting member being provided with vertical openings, and of vibrating the pile into the earth and with the pile taking along the supporting member.

Here and in the following the term "supporting member" refers to a member having a horizontal cross-section which is larger than the cross-section of the pile.

The method as set forth in the last but one paragraph preferably further comprises the step of fixing said supporting member to the lower end of the pile before vibrating the pile into the earth.

In order to further increase the supporting capacity of the pile, at least one further supporting member as defined hereinabove may be connected to the lower portion of the pile at a distance above the lower end of the pile, the protruding portions of said further supporting member being provided with vertical openings, whereafter the pile is vibrated into the earth and the supporting members are taken along by the pile.

Due to the fact, that the (or each) supporting member which is driven into the earth together with the foundation element is provided with vertical openings, only a small resistance will be encountered as the earth may penetrate through the openings. Thus, the vibrator will be able to overcome this resistance even in the case that the overall surface of the supporting member(s) is large. Therefore, the supporting member(s) may be driven into a bearing layer of the earth without any difficulty.

SPECIFICATION AMENDED - SEE ATTACHED SLIP

According to another aspect of the present invention there is provided a pile assembly obtained with the method according to the present invention, the pile assembly comprising a pile and a supporting member arranged at the lower end of the pile, said supporting member having a horizontal cross-section larger than the horizontal cross-section of the pile, so that portions of the supporting member protrude sideways outside the pile, at least the protruding portions of said supporting member being provided with vertical openings.

The pile assembly as set forth in the preceding paragraph may further comprise at least one further supporting member connected to the lower portion of the pile at a distance above the lower end of the pile, said further supporting member having a horizontal cross-section which is larger than the horizontal cross-section of the pile, so that portions of the further supporting member protrude sideways outside the pile, at least the protruding portions of said further supporting member being provided with vertical openings.

The vertical openings in the or each supporting member preferably cover at least 80% of the total surface of the or each supporting member.

The invention will be described by way of example with reference to the accompanying drawing, which shows a perspective view of the lower portion of a pile assembly provided with two supporting members in accordance with the invention.

The pile assembly shown in the drawing by way of example comprises a pile 1 which is made of metal and is H-shaped in cross-section. The pile assembly further comprises a pile shoe which is positioned underneath the lower end of this pile 1 and which consists of a grid 2 composed of upstanding partitions. The grid 2 may be fixed to the lower end of the pile 1.

A second grid 2' which is similar to the grid 2 is fixedly connected to the pile 1 at a distance above the grid 2.

The surface of each of the grids 2,2' is large relative to the cross-section of the pile 1. Further, the openings of the grids 2,2' cover at least 80% of their overall surface.

The pile 1, together with the grids 2,2' is driven into the earth by means of a vibrator. As the earth can penetrate through the openings in the grids 2,2' only a small displacement of the earth will be necessary during this driving operation so that only a small resistance will be encountered. After the pile 1 has reached its required depth in the earth, the grids 2,2' act as supporting members.

The openings in the grids 2,2' may be arranged and dimensioned in such manner

that under the influence of a static load on the pile 1 a "bridging effect" will occur in the earth within these openings which is sufficient to transmit the forces onto the horizontal cross-section which is larger than grids 2,2'. These grids 2,2' will then substantially act as solid plate members.

The above-mentioned "bridging effect" is due to the compaction of the earth within each opening of grids 2 and 2', said compaction occurring when a static load is applied to the pile, whereby the pile is further driven into the earth by a very small distance. Thus the earth within the vertical openings forms bridges between the vertical walls of the vertical openings so that each supporting member or grid behaves as if no vertical openings are present.

In order to increase said compactness of the earth it is possible to inject a hardening fluid into the earth underneath the grid 2 and/or the earth below the grid 2' in order to obtain the required supporting capacity of the grids 2,2'.

Said hardening fluid is a liquid which hardens in the ground and interlinks the earth particles. A liquid on a water-glass base is normally applied in practice.

According to a modified embodiment, the supporting members may consist of perforated plates.

In the case that only one supporting member is used, this member will generally be positioned underneath the pile so as to act as a pile shoe. Of course, the number of the supporting members may be varied at will in dependence on the conditions of the earth or the required load capacity of the pile.

WHAT WE CLAIM IS:—

1. A method of forming a structural support for a pile driven into the earth by means of a vibrator, the method comprising the steps of positioning a supporting member underneath the pile before this pile is vibrated into the earth, said supporting member having a horizontal cross-section, which is larger than the horizontal cross-section of the pile, so that portions of the supporting member protrude sideways outside the pile, at least the protruding portions of said supporting member being provided with vertical openings, and of vibrating the pile into the earth and with the pile taking along the supporting member.

2. A method according to claim 1, further comprising the step of fixing said supporting member to the lower end of the pile before vibrating the pile into the earth.

3. A method according to claim 1 or 2, wherein at least one further supporting member is connected to the lower portion of the pile at a distance above the lower

10 zontal cross-section of the pile, so that portions of the supporting member protrude sideways outside the pile, at least the protruding portions of said supporting member being provided with vertical openings.

15 The pile assembly as set forth in the preceding paragraph may further comprise at least one further supporting member connected to the lower portion of the pile at a distance above the lower end of the pile, said further supporting member having a
20 horizontal cross-section which is larger than the horizontal cross-section of the pile, so that portions of the further supporting member protrude sideways outside the pile, at least the protruding portions of said
25 further supporting member being provided with vertical openings.

The vertical openings in the or each supporting member preferably cover at least 80% of the total surface of the or each
30 supporting member.

The invention will be described by way of example with reference to the accompanying drawing, which shows a perspective view of the lower portion of a pile
35 assembly provided with two supporting members in accordance with the invention.

The pile assembly shown in the drawing by way of example comprises a pile 1 which is made of metal and is H-shaped in cross-section. The pile assembly further comprises a pile shoe which is positioned underneath the lower end of this pile 1 and which consists of a grid 2 composed of upstanding partitions. The grid 2 may be fixed to the
45 lower end of the pile 1.

A second grid 2' which is similar to the grid 2 is fixedly connected to the pile 1 at a distance above the grid 2.

The surface of each of the grids 2,2' is
50 large relative to the cross-section of the pile 1. Further, the openings of the grids 2,2' cover at least 80% of their overall surface.

The pile 1, together with the grids 2,2' is driven into the earth by means of a vibrator. As the earth can penetrate through the openings in the grids 2,2' only a small displacement of the earth will be necessary during this driving operation so that only a
60 small resistance will be encountered. After the pile 1 has reached its required depth in the earth, the grids 2,2' act as supporting members.

The openings in the grids 2,2' may be
65 arranged and dimensioned in such manner

due to the compaction of the earth within each opening of grids 2 and 2', said compaction occurring when a static load is applied to the pile, whereby the pile is further driven into the earth by a very small distance. Thus the earth within the vertical openings forms bridges between the vertical
75 walls of the vertical openings so that each supporting member or grid behaves as if no vertical openings are present.

In order to increase said compactness of the earth it is possible to inject a hardening
85 fluid into the earth underneath the grid 2 and/or the earth below the grid 2' in order to obtain the required supporting capacity of the grids 2,2'.

Said hardening fluid is a liquid which
90 hardens in the ground and interlinks the earth particles. A liquid on a water-glass base is normally applied in practice.

According to a modified embodiment, the supporting members may consist of perforated plates.
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In the case that only one supporting member is used, this member will generally be positioned underneath the pile so as to act as a pile shoe. Of course, the number of the supporting members may be varied at will in dependence on the conditions of the earth or the required load capacity of the pile.
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WHAT WE CLAIM IS:—

1. A method of forming a structural support for a pile driven into the earth by means of a vibrator, the method comprising the steps of positioning a supporting member underneath the pile before this pile is vibrated into the earth, said supporting member having a horizontal cross-section, which is larger than the horizontal cross-section of the pile, so that portions of the supporting member protrude sideways outside the pile, at least the protruding portions of said supporting member being provided with vertical openings, and of vibrating the pile into the earth and with the pile taking along the supporting member.
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2. A method according to claim 1, further comprising the step of fixing said supporting member to the lower end of the pile before vibrating the pile into the earth.
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3. A method according to claim 1 or 2, wherein at least one further supporting member is connected to the lower portion of the pile at a distance above the lower
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