

PATENT SPECIFICATION

(11) 1273 094

DRAWINGS ATTACHED

- (21) Application No. 32432/70 (22) Filed 3 July 1970
 (31) Convention Application No. 6910661 (32) Filed 10 July 1969
 (31) Convention Application No. 6910665 (32) Filed 10 July 1969 in
 (33) Netherlands (NL)
 (45) Complete Specification published 3 May 1972
 (51) International Classification E02D 5/28
 (52) Index at acceptance

E1H 1D 2X



(54) A METAL FOUNDATION PILE FOR A BUILDING STRUCTURE

(71) We, N.V. TOT AANNEMING VAN
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 pany, 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 metal founda-
 tion pile for a building structure.

When metal foundation piles with a small
 cross-section and a great length have to be
 driven into the earth by vibration, the
 problem occurs that only a restricted strength
 of blow of the vibrator and therefore only a
 partial utilization of the vibrator weight is
 admissible in view of the rather small moment
 of inertia of the piles, as otherwise the
 danger of buckling would exist.

According to the present invention there is
 provided a metal foundation pile for a build-
 ing structure, comprising a plurality of spaced
 upright parallel metal bars, a plurality of
 horizontally extending elongated metallic
 cross-members interconnecting said metal
 bars, said cross-members each having end
 portions welded to two adjacent ones of said
 metal bars and being vertically spaced from
 each other, and pile shoe means positioned
 underneath the metal bars.

In a preferred embodiment of the present
 invention, a common pile shoe is positioned
 underneath the bars, the pile shoe comprising
 a plurality of interconnected members defin-
 ing a lattice structure.

In another preferred embodiment of the
 present invention, a plurality of pile shoes
 separate from each other are each positioned
 underneath a respective one of said metal
 bars, each pile shoe comprising a plurality
 of interconnected members defining a lattice
 structure.

Preferably each bar consists of at least one
 rolled billet with a rectangular cross-section.

Preferably, semi-manufactured products are
 used as bars, which leads to an important de-
 crease of the costs of the foundation pile.

Further, mill scale of the rolled billets may
 already give some protection against
 corrosion, while a further corrosion resistant
 layer may be applied at low cost due to a
 favourable ratio between the outer surface
 of the cross-section of the billets. Due to
 this favourable ratio between the outer surface
 and the cross-section, a downwardly directed
 force of friction on the foundation pile, which
 may sometimes occur, may be considerably
 reduced.

Preferably the rolled billets have a maxi-
 mum cross-section of $10 \times 10 \text{ cm}^2$, as such
 cross-section still allows the foundation pile
 to be vibrated into the earth without any
 difficulty.

Foundation piles in accordance with the
 invention may have a very great length. For
 this purpose a plurality of rolled billets may
 be positioned one above the other and may
 be coupled by means of intermediate coupling
 members.

The invention will be described with re-
 ference to the accompanying drawings, in
 which:—

Figure 1 is a front view of a first founda-
 tion pile in accordance with the invention.

Figure 2 is a cross-section along the line
 II—II in Figure 1.

Figure 3 is a top view of the foundation
 pile of Figure 1, wherein the pile shoe is
 omitted.

Figure 4 is a front view of a modified
 foundation pile in accordance with the in-
 vention.

Figure 5 is a cross-section along the line
 V—V in figure 4.

Figure 1 shows a first metal foundation
 pile in accordance with the invention. This
 foundation pile is composed of three parallel
 metal bars 1 with a square cross-section.
 These bars 1 have their axes disposed at
 the longitudinal edges of an imaginary
 regular trilateral right prism and are inter-
 connected by means of cross-members 2,
 each of these members being a metal strip.
 The width of these cross-strips 2 extends in

the longitudinal direction of the foundation pile. The cross-strips 2 are welded with their end portions to the bars 1 concerned. The distance between successive cross-strips 2, which interconnect the same two bars 1, amounts to 1—2 m in the lower portion of the foundation pile, but may be considerably larger, e.g. 5 m, in the upper portion of the foundation pile.

A common pile shoe 3 is mounted underneath the bars 1. This pile shoe 3 comprises a plurality of interconnected members defining a lattice structure of hexagonal external shape and is welded to the three bars 1.

The three interconnected bars 1, together with the underlying pile shoe 3, are vibrated into the earth, during which operation no danger of buckling exists despite the small cross-section of the bars 1.

This is because the required cross-section of the foundation pile is spread over a plurality of bars, which are interconnected by means of cross-members, so that the foundation pile itself as well as the single bars obtain a rigidity which is such, that no buckling occurs any more, when the maximum strength of blow of the vibrator and thus the total vibrator weight is applied, or even when a downwardly directed tensile force is exerted on the vibrator.

The metal foundation pile shown in Figures 4 and 5 differs from the foundation pile according to the Figures 1 to 3 in that a separate pile shoe 4 is mounted underneath each bar 1. Each pile shoe 4 again comprises a plurality of interconnected members defining a lattice structure of circular external shape.

Although the forms of foundation pile as shown in the drawings comprise each three bars 1, it will be understood that a larger number of metal bars inter-connected by metal cross-strips may be employed, which bars have their axes disposed at the longitudinal edges of an imaginary regular multi-lateral right prism.

Further, the foundation pile may be built up of a plurality of elements, which are positioned one above the other and are coupled with each other. Each of these elements consists of a plurality of parallel metal bars 1, which are interconnected by metal cross-strips 2.

Tests were made with a foundation pile according to the invention on a site, in which earth layers having a cone resistance of 200—300 kg/cm² occur at a depth of 6—15 m. It was found that a foundation pile according to the invention with a length of 18 m and with a single lattice shoe having an overall surface of 3000 cm², could be completely vibrated into the earth within 3—4 minutes.

An important advantage of each of the above-described foundation piles consists in

that only a slight earth displacement is necessary when the pile is driven into the earth. This enables the distance between adjacent piles to be much smaller than would be possible when solid piles with the same bearing capacity are used. The pile separation distance may for instance be 80—100 cm when foundation piles in accordance with the invention are used, while this distance would have to be 150—180 cm if solid piles (not in accordance with the invention) were used. This is of particular importance in the foundation of a high building structure such as a factory chimney, when a large number of foundation piles has to be driven into the earth closely to each other.

Due to the simple shape of the cross-section of each of the above-described foundation piles, it is possible to apply a corrosion resistant layer at low costs.

A foundation pile in accordance with the invention may be used as a tensile pile. In that case the foundation pile and the pile shoe, and successive elements of the foundation pile when the same is composed of a plurality of elements positioned one above the other, should be rigidly interconnected.

Preferably, in the foundation pile of the invention, each bar consists of at least one rolled billet with a rectangular cross-section. As this material may be obtained at a low price, the costs of the foundation pile are considerably decreased.

WHAT WE CLAIM IS:—

1. A metal foundation pile for a building structure, comprising a plurality of spaced upright parallel metal bars, a plurality of horizontally extending elongated metallic cross-members interconnecting said metal bars, said cross-members each having end portions welded to two adjacent ones of said metal bars and being vertically spaced from each other, and pile shoe means positioned underneath the metal bars.

2. A foundation pile according to claim 1, wherein a common pile shoe is positioned underneath the bars, the pile shoes comprising a plurality of interconnected members defining a lattice structure.

3. A foundation pile according to claim 1, wherein a plurality of pile shoes separate from each other are each positioned underneath a respective one of said metal bars, each pile shoe comprising a plurality of interconnected members defining a lattice structure.

4. A foundation pile according to claims 1, 2 or 3, wherein said cross-members consist of cross-strips, the width of which extends in the longitudinal direction of the bars.

5. A foundation pile according to any one of the preceding claims, wherein the distance between successive cross-members, which interconnect the same two bars, amounts to



the longitudinal direction of the foundation pile. The cross-strips 2 are welded with their end portions to the bars 1 concerned. The distance between successive cross-strips 2, which interconnect the same two bars 1, amounts to 1—2 m in the lower portion of the foundation pile, but may be considerably larger, e.g. 5 m, in the upper portion of the foundation pile.

A common pile shoe 3 is mounted underneath the bars 1. This pile shoe 3 comprises a plurality of interconnected members defining a lattice structure of hexagonal external shape and is welded to the three bars 1.

The three interconnected bars 1, together with the underlying pile shoe 3, are vibrated into the earth, during which operation no danger of buckling exists despite the small cross-section of the bars 1.

This is because the required cross-section of the foundation pile is spread over a plurality of bars, which are interconnected by means of cross-members, so that the foundation pile itself as well as the single bars obtain a rigidity which is such, that no buckling occurs any more, when the maximum strength of blow of the vibrator and thus the total vibrator weight is applied, or even when a downwardly directed tensile force is exerted on the vibrator.

The metal foundation pile shown in Figures 4 and 5 differs from the foundation pile according to the Figures 1 to 3 in that a separate pile shoe 4 is mounted underneath each bar 1. Each pile shoe 4 again comprises a plurality of interconnected members defining a lattice structure of circular external shape.

Although the forms of foundation pile as shown in the drawings comprise each three bars 1, it will be understood that a larger number of metal bars interconnected by metal cross-strips may be employed, which bars have their axes disposed at the longitudinal edges of an imaginary regular multi-lateral right prism.

Further, the foundation pile may be built up of a plurality of elements, which are positioned one above the other and are coupled with each other. Each of these elements consists of a plurality of parallel metal bars 1, which are interconnected by metal cross-strips 2.

Tests were made with a foundation pile according to the invention on a site, in which earth layers having a cone resistance of 200—300 kg/cm² occur at a depth of 6—15 m. It was found that a foundation pile according to the invention with a length of 18 m and with a single lattice shoe having an overall surface of 3000 cm², could be completely vibrated into the earth within 3—4 minutes.

An important advantage of each of the above-described foundation piles consists in

that only a slight earth displacement is necessary when the pile is driven into the earth. This enables the distance between adjacent piles to be much smaller than would be possible when solid piles with the same bearing capacity are used. The pile separation distance may for instance be 80—100 cm when foundation piles in accordance with the invention are used, while this distance would have to be 150—180 cm if solid piles (not in accordance with the invention) were used. This is of particular importance in the foundation of a high building structure such as a factory chimney, when a large number of foundation piles has to be driven into the earth closely to each other.

Due to the simple shape of the cross-section of each of the above-described foundation piles, it is possible to apply a corrosion resistant layer at low costs.

A foundation pile in accordance with the invention may be used as a tensile pile. In that case the foundation pile and the pile shoe, and successive elements of the foundation pile when the same is composed of a plurality of elements positioned one above the other, should be rigidly interconnected.

Preferably, in the foundation pile of the invention, each bar consists of at least one rolled billet with a rectangular cross-section. As this material may be obtained at a low price, the costs of the foundation pile are considerably decreased.

WHAT WE CLAIM IS:—

1. A metal foundation pile for a building structure, comprising a plurality of spaced upright parallel metal bars, a plurality of horizontally extending elongated metallic cross-members interconnecting said metal bars, said cross-members each having end portions welded to two adjacent ones of said metal bars and being vertically spaced from each other, and pile shoe means positioned underneath the metal bars.

2. A foundation pile according to claim 1, wherein a common pile shoe is positioned underneath the bars, the pile shoes comprising a plurality of interconnected members defining a lattice structure.

3. A foundation pile according to claim 1, wherein a plurality of pile shoes separate from each other are each positioned underneath a respective one of said metal bars, each pile shoe comprising a plurality of interconnected members defining a lattice structure.

4. A foundation pile according to claims 1, 2 or 3, wherein said cross-members consist of cross-strips, the width of which extends in the longitudinal direction of the bars.

5. A foundation pile according to any one of the preceding claims, wherein the distance between successive cross-members, which interconnect the same two bars, amounts to



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1—2 m in at least the lower portion of the foundation pile.

comprises three bars which form the edges of an imaginary trilateral prism.

6. A foundation pile according to any one of the preceding claims, wherein each bar consists of a rolled billet with a rectangular cross-section.

10. A foundation pile according to any one of claims 1—8, characterised in that the bars form the edges of an imaginary multi-lateral prism.

7. A foundation pile according to claim 6, wherein said rolled billet has a maximum cross-section of $10 \times 10 \text{ cm}^2$.

11. A foundation pile substantially as herein before described with reference to Figures 1 to 3 of the accompanying drawings.

8. A foundation pile according to claim 6 or 7, wherein a plurality of rolled billets are positioned one above the other and are coupled by means of intermediate coupling members.

12. A foundation pile substantially as hereinbefore described with reference to Figures 4 and 5 of the accompanying drawings.

9. A foundation pile according to any one of the preceding claims, wherein the pile

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1972.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.