

Debond Foundation Pile

Field of the Invention

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The present invention relates broadly to a method of constructing a debond foundation pile, and to a debond foundation pile structure.

Background

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Standard foundation piles, such as foundation concrete bore piles, are installed into the ground of construction sites to support buildings and structures as desired. A skin friction force typically acts along the full length of the concrete pile in contact with the soil, whilst an end bearing force acts on the bottom end of the concrete pile. Both these forces stabilize the structure of the foundation pile.

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Underground constructions, such as tunnels for train tracks or roads, are on the increase to provide greater convenience for the travelling public. Building authorities, such as the Singapore Land Transport Authority (LTA), do not allow standard foundation bore piles to be constructed near a tunnel. Another situation in which standard foundation bore piles may not be adequate is in places where poor ground conditions are experienced, as can for example typically be the case where pillars for a viaduct are to be constructed. In such construction sites, only debond foundation bore piles are allowed to be constructed.

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In order to prevent negative loading of the surrounding ground onto a structure via the foundation pillar and vice versa in such construction sites, debond foundation bore piles are designed such that the skin frictional force does not act over the full length of the bore pile, rather only on a desired working length.

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Conventionally, debond foundation piles are constructed using a number of long steel casings of different diameters and lengths which are permanently placed in the ground, to separate the skin of the foundation pile from the surrounding soil.

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In such cases, the number of steel casings consumed can be substantial if many piles are to be constructed. This is an unnecessary wastage of material resources, which will result in high construction costs, especially since the cost of steel is high.

Another known arrangement involves wrapping up the debond length of a steel cage with thick plastics sheets. Additional steelwork must typically be carried out on the standard steel cage. Also, it is difficult to wrap multi-typically layers of thick plastic sheets over the length of the steel cages and to keep poured concrete from escaping at the edges and joints under pressure.

Summary of the invention

In accordance with a first aspect of the present invention, there is provided a method of constructing a debond foundation pile, the method comprising the steps of boring a first hole having a diameter larger than a diameter of the foundation pile into the ground up to a debond length depth; inserting an inner casing having a diameter substantially equal to the diameter of the foundation pile inside the first hole such that an annulus space is defined between an outer surface of the inner casing and the wall of the first hole, and such that a bottom portion of the annulus space is substantially sealed; providing a debond material sleeve into the annulus space; forming the foundation pile inside the inner casing to a desired combined working and debond lengths depth; and extracting the inner casing.

The boring of the first hole may comprise inserting an outer casing having a diameter substantially equal to the diameter of the first hole into first hole for guiding an auger during continued boring of the first hole to the desired debond length depth, for stabilising an opening of the first hole, or both; and extracting the outer casing after the forming of the foundation pile inside the inner casing.

The debond length may be chosen such that the first hole is self standing.

The outer casing may extend along the depth of the first hole.

One or more sacrificial centralizer elements may be positioned between the outer surface of the inner casing and the wall of the first hole.

One or more of the sacrificial centralizer elements may be formed integrally with the inner casing.

5 A foundation bore pile may be formed inside the inner casing. The working length may be chosen such that a second hole formed during the forming of the foundation bore pile inside the inner casing is self standing.

10 A driven concrete foundation pile may be formed inside the inner casing.

 A driven steel beam foundation pile may be formed inside the inner casing.

 The material for the debond sleeve may comprise a mixture of a debond material and a release agent.

15 The material for the debond sleeve and a material for the foundation bore pile may have substantially the same material densities.

20 The inner casing, the outer casing, or both, may be re-usable after extraction.

 In accordance with a second aspect of the present invention, there is provided a debond foundation pile structure comprising a foundation pile formed in the ground; and a debond sleeve structure formed in the ground and arranged directly on an
25 outer surface of the foundation pile.

 The foundation pile may comprise a foundation bore pile. The foundation pile may comprise a driven concrete foundation pile. The foundation pile may comprise a driven steel beam foundation pile.

30 In accordance with a third aspect of the present invention, there is provided a debond foundation pile constructed utilising the method as defined in the first aspect.

Brief description of the drawings

The invention is herein described by way of non-limiting examples, with reference to the accompanying drawings, in which:-

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Figures 1 to 3 are schematic, cross-sectional view drawings illustrating construction of an in-situ debond sleeve foundation bore pile with re-usable steel casings in accordance with an example embodiment.

Detailed Description

The construction of a debond bore pile having a debond sleeve formed in-situ and using re-usable steel casings in an example embodiment will now be described with reference to Figures 1, 2 and 3. Turning initially to Figure 1, an outer steel casing 3 having a
15 suitable outer diameter is inserted into the bore hole 3a after an initial boring, in order to stabilise the opening of the bore hole 3a and to guide a subsequent oversized boring. Oversized auger boring of the hole 3a inside the outer casing 3 is continued until a depth equal to the desired debond length 4 is reached.

20 A hole 3a is then bored downwards from the ground level 10 using a predefined oversized auger at the construction site location identified by numeral 1. The term "oversized" here refers to the fact that bore 3a is of a larger diameter compared with the diameter of the foundation pile being constructed. In typical examples, the diameter of a foundation bore pile may be between about 600mm and 2500mm, and the diameter of the bore
25 hole 3a in such examples may be about 200mm to 400mm larger than the diameter of the foundation bore pile. It is noted that in different embodiments, the bore hole 3a may not be self standing, and longer outer casings may be used in such embodiments.

The depth of oversized auger bored ("overbored") hole 3a can range from about
30 10m to 30m in example embodiments, and the hole 3a is self standing, on good ground in the example embodiment. A self standing hole does not require any additional steel casing support along the depth of the hole. Subsequently, an inner steel casing 2 having a diameter which is smaller than the diameter of the outer casing 3, and having a desired length, is co-axially inserted inside the oversized hole
35 3a, thereby forming an annulus space 5. The inner casing 2, in the example

embodiment, comprises sacrificial centralizer ribs 6a at a bottom portion of the inner casing which extend across the annulus space 5 and engage the wall of the hole 3a.

The inner steel casing 2 is designed according to the size of the desired foundation pile.

5 The length of the inner casing 2 is greater than the debond length 4 of the foundation pile and when inserted, the top end of the inner casing 2 extends beyond the top of the oversized hole 3a. Additional sacrificial centralizer elements 6b are positioned around the inner casing 2 inside the annulus space 5 near the top portion of the inner casing 2. The bottom end 9 of the inner casing 2 extends into the soil 8.

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As illustrated in Figure 2, a mixture of debond material and release agent 12 is poured or pumped into the annulus space 5. The debond material may e.g. comprise granite chips in sand (Aggregate Sand) or copper slat, and the release agent may e.g. comprise drilling mud, bentonite, polymer or oil-based products. The debond material and release agents in the example embodiment are chosen to ensure easy non-stick removal of steel casings from the ground and to provide frictionless surface contact between the foundation pile skin and the soil at a desired debond length. The bottom portion 12a of the annulus space 5 is automatically plugged because the bottom end 9 of the inner casing 2 extends into the soil as described above, to prevent concrete from seeping in at a later stage. A cast in-situ debond sleeve material 12, having a predefined length equal to the debond length 4 of the bore pile, is thus constructed in the ground.

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The in-situ debond sleeve material 12 is temporarily supported by inner casing 2.

25 Next, the size of the auger is changed according to a desired diameter of the inner casing 2 and boring inside the inner casing 2 is continued to a depth until the bottom 16 of a desired working length 28 is reached.

The depth of the inner hole 19 is chosen to make the bore self standing, on good ground, without having the need for any additional casing support, in the example embodiment. In typical examples, the working length 28 may be from about 6m to 40m.

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After the inner hole 19 is bored, a standard steel cage assembly 20 is lowered inside the inner casing 2 until the bottom part of the assembly 20 touches the bottom portion 16 of the hole 19. The steel cage assembly 20 is held in position from the

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top by braces (not shown). The steel cage assembly 20 is aligned to be centered in the hole 19, in the example embodiment.

5 While the steel cage assembly 20 is held in position, a wet concrete mixture 22 is poured or pumped into the hole 19 up to the brink of the inner casing 2, through trimming pipes (not shown). After this step, the bracing (not shown) is cut away to release the steel cage assembly 20. The concrete mixture may be of any desired grade in respective embodiments.

10 In the example embodiment, while the concrete mixture 22 is wet, the inner casing 2 is gradually extracted, e.g. by using a service crane (not shown), for reuse. In the process, the sacrificial centralizers 6a are automatically dislodged. The sacrificial centralizers 6b are removed after the inner casing 2 is extracted, in the example embodiment.

15 Upon removal of the inner casing 2, the wet concrete 22 meets the in-situ debond sleeve 25, as shown in Figure 3. The wet concrete 22 and the debond sleeve 25 do not displace each other at the interface 27, as their material densities are similar, in the example embodiment. It will be appreciated by a person skilled in the art that other techniques may be used to substantially prevent displacement at the interface 27 in
20 different embodiments, such as using sacrificial material sheets, which may e.g. disintegrate during drying of the wet concrete 22 and the debond material 25.

After the concrete 22 has set, the positioning casing 3 is also removed for reuse. A complete in-situ debond sleeve 25 directly arranged on the foundation bore pile (set
25 concrete 22) is thus formed.

In different embodiments, different construction procedures can be employed for the pile construction inside of the inner casing (compare with the casing 2 in Figure 1). For example, rather than employing standard bore pile construction procedures as
30 described above with reference to Figure 2 and 3, driven concrete or steel beam foundation piles techniques may be employed to a desired working lengths. In such embodiments, the inner casing 2 is similarly removed upon completion of the construction of the driven concrete or steel beam foundation piles, allowing the in-situ debond sleeve to be formed directly around the driven concrete or steel beam
35 foundation piles.

The in-situ debond sleeve in the example embodiment resembles a long sleeve axial bearing that effectively eliminates skin friction forces between a desired debond length of the foundation bore pile surface and the soil.

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The guide or positioning steel casing 3 and inner steel casing 2 in the example embodiment may be reused for constructing other debond piles. This results in materials cost savings when compared with conventional permanent steel double casing constructions.

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As the debond sleeve 25 is cast in-situ and involves flexible processes which can suit different construction sites, the example embodiment may require less resources to cast in-situ debond sleeve in the ground as against the conventionally used pre-wrap steel cage construction off-site.

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The finished product quality of the in-situ debond sleeve foundation pile in terms of e.g. preventing negative loading in the example embodiment was found to be comparable to permanent steel casing constructions, and superior to pre-wrap type.

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The method of constructing a debond foundation bore pile as described in the example embodiment may be more economical and easier to construct when compared to conventional methods, and may increase productivity, efficiency and reduction in overall construction costs.

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The debond sleeve in example embodiments can be made from common construction materials such as e.g. comprise granite chips in sand (Aggregate Sand) or copper slat for the debond material, and e.g. comprise drilling mud, bentonite, polymer or oil-based products for the release agent. The debond sleeve has a good mechanical strength to withstand the wet concrete and surrounding soil pressure.

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The in-situ debond foundation pile construction with re-usable steel casings in example embodiments can be applied for foundation piles of all diameters.

It will be appreciated by a person skilled in the art that numerous variations and/or
35 modifications may be made to the present invention as shown in the specific

embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A method of constructing a debond foundation pile, the method comprising the steps of:

5 boring a first hole having a diameter larger than a diameter of the foundation pile into the ground up to a debond length depth;

inserting an inner casing having a diameter substantially equal to the diameter of the foundation pile inside the first hole such that an annulus space is defined between an outer surface of the inner casing and the wall of the first hole, and such
10 that a bottom portion of the annulus space is substantially sealed;

pouring a debond sleeve material into the annulus space;

forming the foundation pile inside the inner casing to a combined working and debond lengths depth; and

extracting the inner casing.

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2. The method as claimed in claim 1, wherein the boring of the first hole comprises inserting an outer casing having a diameter substantially equal to the diameter of the first hole into first hole for guiding an auger during continued boring of the first hole to the debond length depth, for stabilising an opening of the first
20 hole, or both; and extracting the outer casing after the forming of the foundation pile inside the inner casing.

3. The method as claimed in claims 1 or 2, wherein the debond length is chosen such that the first hole is self standing.

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4. The method as claimed in claims 1 or 2, wherein the outer casing extends along the depth of the first hole.

5. The method as claimed in any one of claims 1 to 4, wherein one or
30 more sacrificial centralizer elements are positioned between the outer surface of the inner casing and the wall of the first hole.

6. The method as claimed in claim 5, wherein one or more of the sacrificial centralizer elements are formed integrally with the inner casing.

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7. The method as claimed in any one of claims 1 to 6, wherein a foundation bore pile is formed inside the inner casing.

5 8. The method as claimed in any one of claim 7, wherein the working length is chosen such that a second hole formed during the forming of the foundation bore pile inside the inner casing is self standing.

9. The method as claimed in any one of claims 1 to 6, wherein a driven concrete foundation pile is formed inside the inner casing.
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10. The method as claimed in any one of claims 1 to 6, wherein a driven steel beam foundation pile is formed inside the inner casing.

11. The method as claimed in any one of claims 1 to 10, wherein the debond sleeve material comprises a mixture of a debond material and a release agent.
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12. The method as claimed in any one of claims 1 to 11, wherein the debond sleeve material and a foundation bore pile material have substantially the same material densities.
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13. The method as claimed in any one of claims 1 to 12, wherein the inner casing, the outer casing, or both, are re-usable after extraction.

25 14. A debond foundation pile structure comprising
a foundation pile formed in the ground; and
a debond sleeve structure formed in the ground and arranged directly
on an outer surface of the foundation pile.

30 15. The foundation pile as claimed in claim 14, wherein the foundation pile comprises a foundation bore pile.

16. The foundation pile as claimed in claim 14, wherein the foundation pile comprises a driven concrete foundation pile.
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17. The foundation pile as claimed in claim 14, wherein the foundation pile comprises a driven steel beam foundation pile.

18. A debond foundation pile constructed utilising the method as
5 claimed in any one of claims 1 to 13.