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(54) Benævnelse: **FUNDERINGSPÆL MED ET I DET VÆSENTLIGE CYLINDRISK SKAFT**

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Description

The invention concerns a driven pile comprising a substantially cylindrical shaft, wherein the shaft provides a first pile end and a second pile end, wherein a socket is arranged on the driven pile in the region of the second pile end, wherein the socket or the driven pile has an abutment in the region of the second pile end so that a further driven pile can be inserted with a first pile end as far as a maximum insertion depth defined by the abutment.

Driven piles of the kind set forth in the opening part of this specification are already part of the state of the art and are shown for example in WO 2013026510 A1 or also in
US 4 569 617 A. Driven piles are driven into the bedrock by a driving apparatus. The term bedrock is used for example to denote the ground. When the first driven pile has been driven into the bedrock a further driven pile can be inserted into the upper end of the driven pile which has already been driven in. The further driven pile is joined to the first driven pile by the action of force which is also implemented by the driving apparatus. In the state of the art that join is made by frictional engagement and force-locking engagement. The state of the art however does not always guarantee that the force for separating two or more driven piles is greater than the initial joining force which has been applied with the driving apparatus. In other words the tensile force which the driven piles which are driven into each other can carry is too low for many areas of use. An increase in that tensile force above a value of the joining force applied for joining the piles is only possible with difficulty. Other systems operate for example with the incorporation of additional components like for example spreader elements to increase the tensile force between the individual piles by the tip of the driven piles being widened. In that case however cracks can occur, which in turn give rise to problems in regard to the tensile force and strength and stability of the connected driven piles and complicate the system.

The object of the invention is to avoid the above-described disadvantages and to provide a driven pile which is improved over the state of the art.

According to the invention that object is attained by the characterising portion of claim 1.

The fact that the socket and/or the driven pile in the region of the second pile end in the interior provides or provide at least one undercut portion extending at least substantially as far as the abutment ensures that, after a further driven pile has been inserted and driven in, under the effect of a force, it is joined in positively locking relationship to the driven pile which has been previously driven into place, by virtue of the undercut configuration. By virtue of that join the arrangement comprising interconnected driven piles can withstand very high tensile forces in comparison with the state of the art. In addition no further components like spreader elements are required.

Further advantageous embodiments are defined in the appendant claims.

Further details and advantages of the present invention will be described more fully hereinafter by means of the specific description with reference to the embodiments by way of example illustrated in the drawings in which:

Figure 1 shows a detail view of two joined driven piles,
Figures 2a and 2b show cross-sections of the driven pile, and
Figures 3a through 3c show individual steps in joining the driven piles.

Figure 1 shows a sectional view of two driven piles 1 (not illustrated in their entirety). The driven piles 1 are formed from a substantially cylindrical shaft 2 providing a first pile end 1a and a second pile end 1b. As shown in Figure 1 the first pile end 1a fits in the socket 3 of a further pile 1. In that case the first pile end 1a is driven into the socket 3 as far as the abutment 9. At the second pile end 1b the socket 3 has a substantially constant socket wall thickness WMcon. Starting from the first pile end 1b along the maximum insertion depth T which is defined by the abutment 9 the socket wall thickness varies from the constant socket wall thickness WMcon to the variable socket wall thickness WMvar. That variation in the wall thickness affords an undercut portion 8 which extends at a maximum angle α in the interior of the socket 3 of between 1.5° and 3° measured relative to a longitudinal axis L. In other words that undercut portion 8 is provided by the change in the cross-section of the socket 3 from a substantially circular cross-section Qk at the second pile end 1b to a cross-section Qa which deviates from a circular cross-section Qk and which is disposed at the inner abutment 9. Figure 1 shows a section A-A which is described more fully in Figure 2b and shows the change in cross-section from the cross-section Qk to Qa as a plan view. The driven pile 1 which is of a substantially tubular configuration, with its shaft 2, is of a substantially constant shaft wall thickness Ws at least along its maximum insertion depth T, starting from the first pile end 1a. In this embodiment that shaft wall thickness Ws is less than the socket wall thickness WMvar and WMcon. Due to the smaller shaft wall thickness Ws the shaft 2 is deformed, and not the region of the socket 3, that is formed by the greater socket wall thicknesses WMvar and WMcon. In other words, the driven pile 1 is more easily deformable at least in the region along the insertion depth T by virtue of the smaller shaft wall thickness Ws and/or also a softer material structure, than the remaining region of the driven pile 1. The material from which the driven pile 1 is made is at least partially and preferably completely ductile cast steel or ductile cast iron. The abutment 9 is a contact surface which is in the form of a kind of shoulder substantially perpendicular to the longitudinal axis L of the driven pile 1. By virtue of the configuration in the form of a shoulder the first pile end 1a can no longer penetrate more deeply into the driven pile 1 upon coming into contact with the abutment 9. By virtue of the upsetting of the shaft 2 under the effect of force the shaft 2 must adapt to the contour of the undercut portion 8 in the region thereof. That takes place along the insertion depth T. As a result, that involves a very gentle uniform deformation of a round cross-section to a cross-section with a plurality of or even only one undercut portion 8. The gentle uniform deformation ensures that no cracks are formed in the shaft 2. In accordance with that principle driven piles 1 can be anchored in a suitable bedrock in a condition of being secured together without using individual components to resist tensile forces or – if necessary also individually - .

Figure 2a shows the second pile end 1b of the socket 3. The socket wall thickness is constant in the region of the second pile end 1b. The circular cross-section Qk thus forms a constant socket wall thickness WMcon. Subsequently the first pile end 1a of a further pile 1 is introduced internally into that constant socket cross-section WMcon until it reaches the abutment 9 under the action of the force involved and is upset there. The first pile end 1a is not shown in Figure 2a.

Figure 2b shows the section A-A which was shown in Figure 1 in the side view of the arrangement comprising two driven piles 1. The variable socket wall thickness WMvar occurs with increasing insertion depth T (shown in Figure 1) from the constant socket wall thickness WMcon shown in Figure 2a. The change in the socket wall thickness from WMcon to WMvar affords the undercut configuration 8. In this embodiment the undercut configuration 8 is produced by a trilobular configuration. In other words the cross-section Qa which differs from a substantially circular cross-section Qk is provided by the shape of a trilobular configuration, three undercut regions 8a, 8b and 8c being produced by the trilobular configuration. A cross-sectional shape other than a trilobular configuration is also possible in the production of at least one undercut portion 8. The end of the undercut portion 8 in the interior of the socket 3 and/or the driven pile 1 is afforded by the abutment 9. The variable socket wall thickness WMvar can be both greater in its thickness than the constant socket wall thickness WMcon and also smaller than same. This provides that when the first pile end 1a is being driven in the diameter of the shaft 2 is portion-wise stretched and also compressed. As a result the periphery of the shaft 2 is completely retained upon upsetting of the shaft 2 in the region of the undercut portion 8, even if the diameter of the shaft 2 is expanded portion-wise and reduced elsewhere. By virtue of that deformation of the circular cross-section for example to a trilobular configuration or a polygonal configuration, the periphery is not changed upon portion-wise alteration of the shaft 2 in the region of the first pile end 1a. This very careful variation in cross-section at the shaft 2 prevents cracks being formed – cracking would lead to a reduction in the tensile strength of joined driven piles.

Figure 3a shows portions of a driven pile 1 which is placed with its first pile end 1a over the second pile end 1b of a further driven pile 1 with a socket 3. It is possible to see the undercut portion 8 and the abutment 9. The shaft diameter DSA of the shaft 2 is almost the same as the opening cross-section of the socket 3 at the second pile end 1b.

Figure 3b shows how the shaft 2 of the pile 1 is introduced into the socket 3 of a further driven pile 1. In this case the shaft 2 begins to adapt to the inside wall of the socket 3. A slight change in cross-section or a portion-wise change in the shaft diameter DSA at the shaft 2 begins.

Figure 3c shows how the shaft 2 of the driven pile 1 was placed in the socket 3 of a further driven pile 1. The shaft diameter DSA' has adapted portion-wise to the inside dimensions of the socket 3. By virtue of upsetting of the shaft 2 by the co-operation of the abutment 9 and the undercut portion 8 the shaft diameter DSA is increased or reduced in size relative to the adapted shaft diameter DSA'. After connection of the at least two driven piles 1 by upsetting in the undercut portion 8 a filling material 10, preferably concrete or concrete emulsion, is introduced in order to prevent subsequent return deformation of the shaft 2 under a tensile loading after the filling material 10 has hardened.

Referring to Figures 3a, 3b and 3c it can be seen that the method of joining at least two driven piles 1 comprises at least the following steps:

- driving a driven pile 1 into a bedrock with a driving apparatus, wherein the driven pile 1 is driven with the first pile end 1a leading into the bedrock,
- inserting a further driven pile 1 with the first pile end 1a into the socket 3 of the preceding driven pile 1, that is provided with an undercut portion 8, and driving it in by means of a driving apparatus,
- driving in to the required depth of the arrangement of driven piles 1, wherein in the driving-in operation the first pile end 1a adapts to the internal contour of the socket 3 by crack-free deformation, wherein tensile securing is afforded by virtue of the at least one undercut portion 8 – which is preferably afforded by the change in cross-section from a substantially circular cross-section to the cross-section in the form of a trilobular configuration - ,
- possibly inserting further driven piles 1 and driving them in as described in the preceding steps, and
- filling the arrangement of driven piles 1 with a filling material 10, preferably concrete or concrete emulsion, for impeding return deformation of the first pile end 1a which is deformed by virtue of the undercut portion 8.

Patentkrav

1. Funderingspæl (1) omfattende et i det væsentlige cylindrisk skaft (2), hvor skaftet (2) tilvejebringer en første pælende (1a) og en anden pælende (1b), hvor en muffe (3) er indrettet på funderingspælen (1) i regionen af den anden pælende (1b), hvor muffen (3) eller funderingspælen (1) har et anslag (9) i regionen af den anden pælende (1b) så at en yderligere funderingspæl (1) kan indsættes med en første pælende (1a) så langt som en maksimumdybde (T) defineret af anslaget (9),
kendetegnet ved at

- muffen (3) og/eller

- funderingspælen (1) i regionen af den anden pælende (1b) tilvejebringer i det indre mindst en underskåret del (8) der strækker sig mindst i det væsentlige til anslaget (9).

2. Funderingspæl som beskrevet i krav 1, **kendetegnet ved at** den underskårne del (8) er tilvejebragt ved ændringen i tværsnittet af muffen (3) fra et i det væsentlige ringformet tværsnit (Qk) ved den anden pælende (1b) til et tværsnit (Qa) ved det indre anslag (9), der afviger fra det cirkulære tværsnit.

3. Funderingspæl som beskrevet i krav 2, **kendetegnet ved at** tværsnittet (Qa) der afviger fra et i det væsentlige ringformet tværsnit (Qk) er i form af en trilobular konfiguration, hvor tre underskæringsregioner (8a, 8b, 8c) produceres af den trilobulare konfiguration.

4. Funderingspæl som beskrevet i krav 1 eller krav 2, **kendetegnet ved at** den underskårne del (8) strækker sig ved en maksimumvinkel (a) i det indre af muffen (3) på mellem 1,5° og 3° målt i forhold til en langsgående akse (L).

5. Funderingspæl som beskrevet i mindst et af de foregående krav, **kendetegnet ved at** funderingspælen (1) i det væsentlige er rørformet, hvor skaftet (2) har en i det væsentlige konstant akselvægtykkelse (Ws) i regionen mindst langs dens maksimumindsætningsdybde (T) startende fra den første pælende (1a).

6. Funderingspæl som beskrevet i et af kravene 1 til 5, **kendetegnet ved at** muffen (3) ved den anden pælende (1b) har en i det væsentlige konstant muffevægtykkelse (WMcon), startende fra den anden pælende (1b) langs maksimumindsætningsdybden (T) er af en variabel muffevægtykkelse (WMvar) i henhold til den underskårne del (8).

7. Funderingspæl som beskrevet i et af kravene 1 til 6, **kendetegnet ved at** anslaget (9) er tilvejebragt af en kontaktflade indrettet i det væsentlige vinkelret på den langsgående akse (L) af funderingspælen (1).

8. Funderingspæl som beskrevet i et af kravene 1 til 7, **kendetegnet ved at** funderingspælen (1) mindst delvist og fortrinsvis fuldstændigt består af duktilt formbart støbestål eller støbejern.

9. Funderingspæl som beskrevet i et af kravene 1 til 8, **kendetegnet ved at** funderingspælen (1) er lettere deformerbar mindst i regionen langs indsætningsdybden (T) i henhold til den mindre akselvægtykkelse (WS) og/eller en blødere materialestruktur, end den resterende region af funderingspælen (1).

10. Fremgangsmåde til samling af mindst to funderingspæle (1) som beskrevet i et af kravene 1 til 9, hvor fremgangsmåden omfatter følgende trin:

- nedramme en funderingspæl (1) i en undergrund med en nedramningsindretning, hvor funderingspælen (1) nedrammes med den første pælende (1a) forrest i undergrunden,

- indsætte en yderligere funderingspæl (1) med den første pælende (1a) ind i muffen (3) af den foregående funderingspæl (1), der er forsynet med en underskåret del (8), og nedramme ved hjælp af en nedramningsindretning,

- nedramme til den ønskede dybde af anordningen af funderingspæle (1), hvorved nedramning af den første pælende (1a) tilpasses til den indre kontur af muffen (3),

- eventuel indsætning af yderligere funderingspæle (1) og nedramning som beskrevet i de foregående trin, og

- fylde anordningen af funderingspæle (1) med et fyldstofmateriale (10) for at hindre returdeformation af den første pælende (1a) der er deformeret i henhold til den underskårne del (8).

Fig. 1

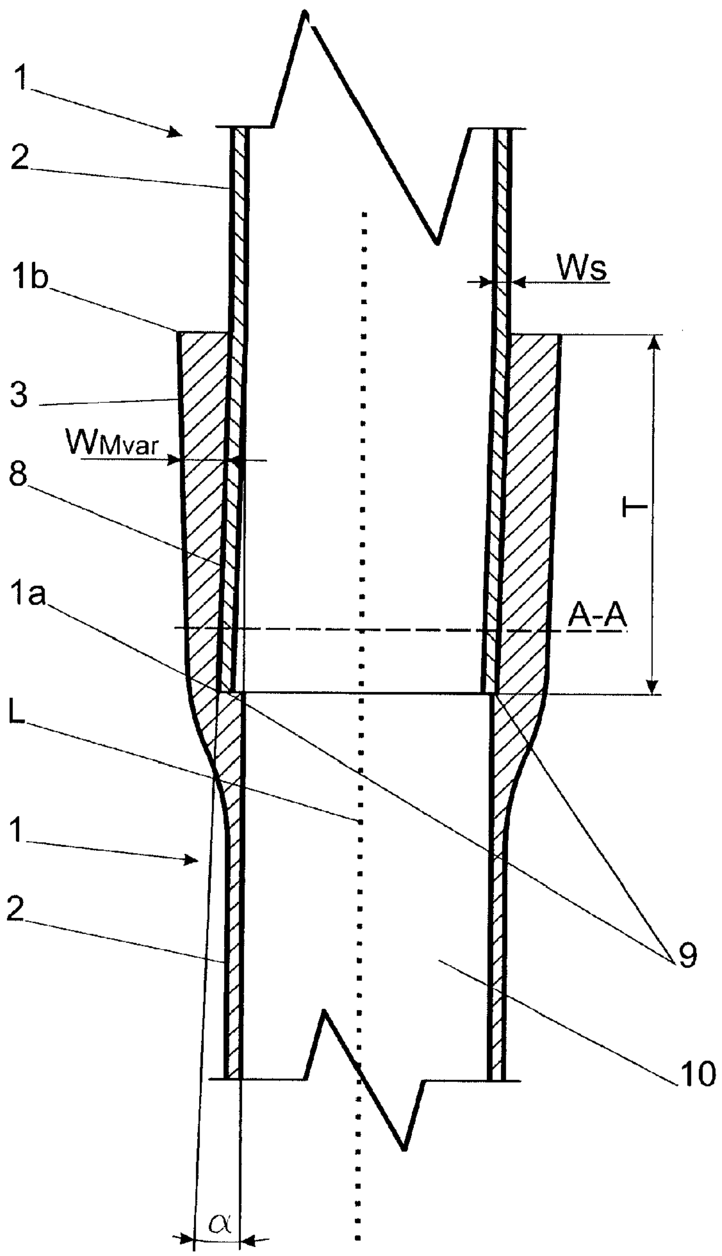

Fig. 2a

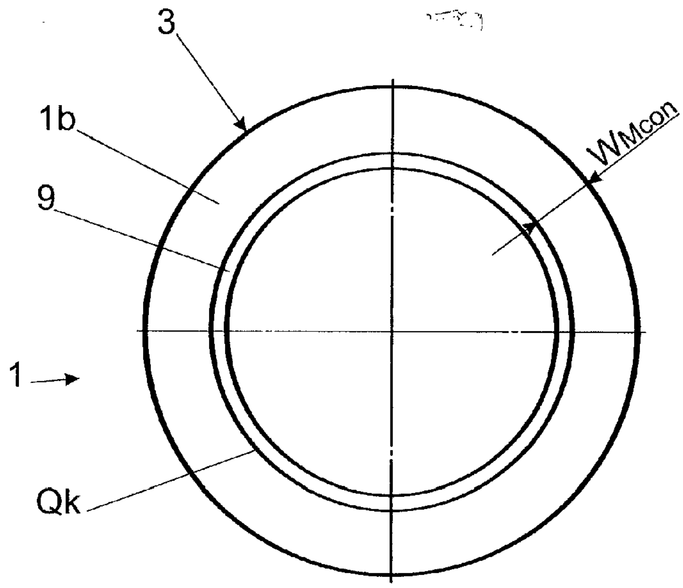

Fig. 2b

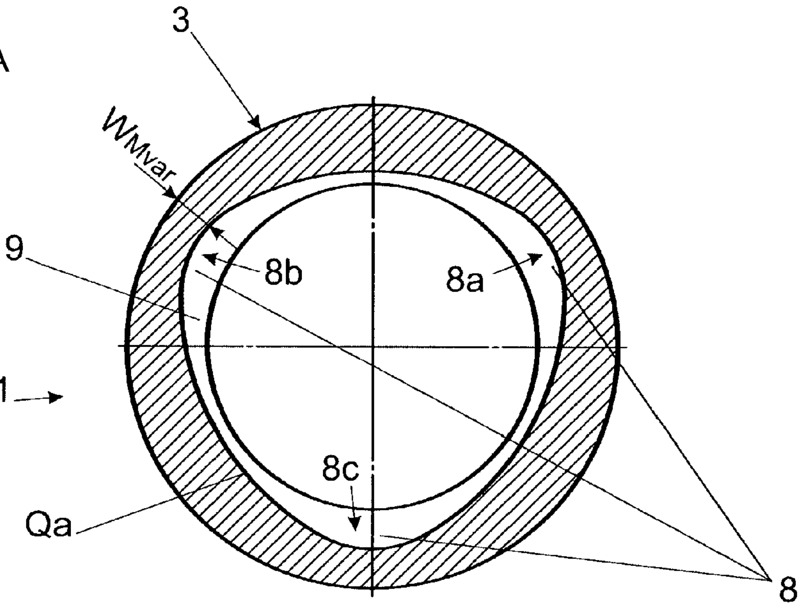

Fig. 3c

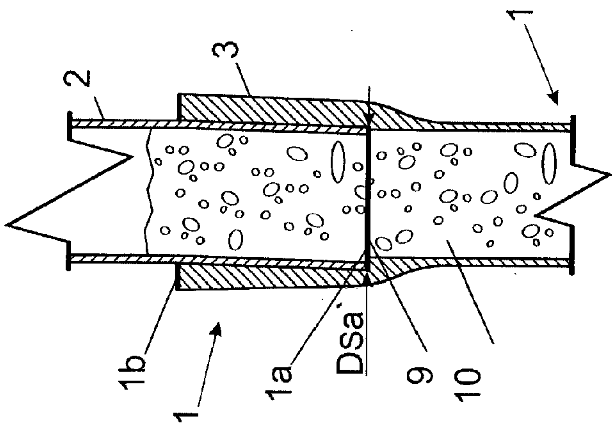

Fig. 3b

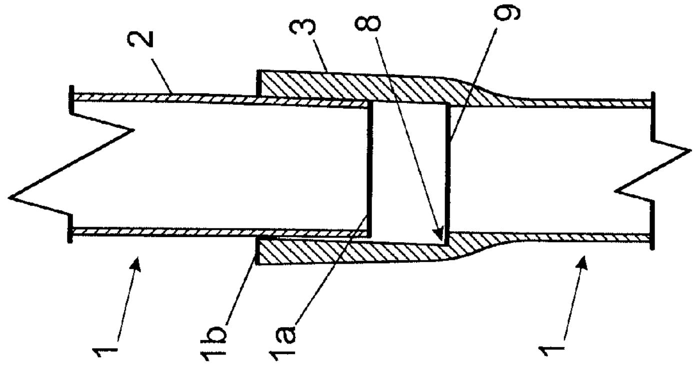

Fig. 3a