

IMPROVEMENTS IN OR RELATING TO PILES AND ANCHORAGES

5 This invention relates to a method of providing  
bored cast-in-situ piles in boreholes and to a device  
for use therein.

10 Piles are commonly used as foundation members for  
supporting engineering structures such as buildings,  
bridges, viaducts, retaining walls and quay walls.  
Piles can be pre-formed piles which are constructed in  
advance and subsequently driven into the ground at a  
desired location using a suitable hammer.  
Alternatively, piles can be cast-in-situ in a pre-bored  
hole of the required size and depth by filling the hole  
15 with concrete and with steel reinforcements.

20 With cast-in-situ piles there is generally a need  
when forming the hole to provide some form of support  
to the sides of the hole to prevent soil and loose rock  
from falling in and causing collapse of the hole. Two  
methods of providing such support are in general use.  
In the first method, a steel lining tube is introduced  
as the hole is formed and the lining tube is then  
withdrawn as concrete is introduced into the hole. In  
25 the second method, the hole is kept filled with a mud  
made from bentonite clay during the drilling of the  
hole and the mud is displaced from the hole as concrete  
is introduced into the base of the hole in forming the  
pile.

30 Piles carry the load of the eventual structure in  
two ways. Firstly, the load is held by lateral  
friction acting on the circumference of the pile, the  
frictional force being transferred to the soil down the  
35 length of the pile. Secondly, the load is carried by  
end-bearing, the load being carried down the pile shaft

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to the soil underlying the foot of the pile. The relative importance of these two load carrying modes depends upon the individual soil properties at a particular location and on the depth and dimension of the piles.

The support provided by the lining tube or by the use of bentonite clay is sufficient to stop collapse of the hole from occurring and to limit the disturbance to the soil surrounding the pile. However some disturbance of the soil nevertheless takes place during forming of the hole and consequently the lateral frictional resistance of the pile is reduced below that which could be achieved if there were no disturbance.

Such disturbance takes two forms. Firstly, there is physical loosening of the soil. This is the main type of disturbance in sand and gravel and other soils of such type. Secondly, there is taking up of water and swelling of the soil which is the main form of disturbance with clay and similar fine particle soils.

EP-A-0 179 836 offers a solution to any tendency for hole collapse to take place with piling members which are to be driven into the ground or merely inserted into a pre-bored hole therein. A spreading mandrel member is introduced into the hole so as to expand a hollow fragmented piling member portion outward into the ground. A holding means holds the piling member portion in its expanded disposition. EP-A-0 179 836 offers no solution for dealing with the problem of soil disturbance when casting piles in-situ and moreover the main thrust of the teaching of EP-A-0 179 836 is in connection with the use of driven piles where the disturbance effects are less.

According to one aspect of the present invention, there is provided a method for the production of a cast-in-situ pile in a previously produced borehole which comprises the steps of (a) introducing into a borehole a sleeve which consists of two or more segments connected by expandable gaskets and which has means for expanding it radially provided at intervals along its length, (b) introducing into the borehole at the same time as or after the sleeve is introduced a steel reinforcement for the pile, (c) introducing concrete for forming the pile into the borehole either before the sleeve is introduced into the borehole or after the sleeve is introduced so as to lie around the sleeve and the steel reinforcement and (d) expanding the sleeve to force wet concrete being disposed there around against the sides of the borehole.

In a second aspect, this invention provides a sleeve for introduction into a borehole, the sleeve consisting of two or more segments which together make up a closed circumference, which segments are connected by expandable gaskets which allow the circumference to be increased while maintaining a closed body, means being housed in the sleeve, preferably at intervals along the length thereof, for expanding the sleeve radially.

The segments of the sleeve itself may be formed from metal, in particular steel, or even from plastics or other material. The sleeve may be of circular, square, rectangular or other suitable section, for example hexagonal. The diameter of the sleeve (effective diameter for non circular sections) will be selected according to the diameter of the pile to be produced.

5 The sleeve may be emplaced over the full depth of the borehole in which a pile is to be produced or over some selected section only as may be determined by the particular requirements at the location of production of a pile.

10 The gasket may be constructed of metal, for example steel, or of plastics material, in particular neoprene rubber and may be initially flat or deformed as necessary to allow it to be accommodated within the borehole during its introduction thereinto and for it to expand by the required amount without itself undergoing damage or without damage to the borehole taking place.

15 The means for expanding the sleeve outwardly and increasing its circumference provided at intervals along its length may take the form of inflatable bags utilising either gas or liquid for achieving inflation, i.e. pneumatic or hydraulic bags, or by means of  
20 pistons driven by hydraulic force or by any other suitable means. Otherwise use of a continuous pneumatic or hydraulic bag extending the length of the sleeve within which it is positioned is to be  
25 contemplated.

30 The effects of the sleeve expansion which takes place when using the sleeve are threefold. Firstly pressure is applied to the wet concrete to compact it. Secondly, loosened soil around the periphery of the pile will be compacted by the expansion of the sleeve and the concrete. This will increase the ability of the pile produced to transfer lateral friction by force from the pile to the surrounding undisturbed ground.  
35 Thirdly, softened soil around the periphery of the pile will be consolidated by the pressure applied. This

will also increase the ability of the pile to transfer lateral friction to the surrounding ground.

5       Once the concrete has set, the sleeve will be  
retracted to its original circumference and withdrawn  
from the hole leaving a hollow pile in-situ. Removal of  
the sleeve is assisted if, to break its intimate  
contact with the concrete, the sleeve additionally  
10       comprises two or more arrays of segments spaced apart  
along the length of the sleeve and connected by  
expandable gaskets which allow the length of the sleeve  
to be varied, means being housed in the sleeve for  
expanding the sleeve longitudinally. Again, piston  
15       means can be used within the sleeve for effecting  
expansion and contraction of the sleeve longitudinally.

20       The void existing down the centre of the pile  
provides a means of introducing instruments for, for  
example, measuring the integrity of the pile shaft and  
the amount of improvement which has been made to the  
soil. If any faults are found in the integrity of the  
pile, they may be repaired by means of grouting or by  
means of special equipment introduced down the void.  
The void may also be used to access the base of the  
25       pile to effect improvement to the ground below the base  
of the pile by means of grouting or any other soil  
improvement method. Eventually, the void may be filled  
with additional concrete with possibly elements such as  
steel reinforcing bar or steel columns, if required,  
30       emplaced therein for casting of concrete thereabouts or  
the void may be left open.

35       For a better understanding of the invention, and  
to show how the same may be carried into effect,  
reference will now be made by way of example only to  
the accompanying drawings wherein:-

Figure 1 is a longitudinal section through a pile section under construction produced by the method of this invention;

5           Figure 2 is a longitudinal section through a completed pile produced by the method of this invention.

10           Figure 3 shows a sleeve embodying this invention expanded to a square cross-section;

          Figure 4 shows a sleeve embodying the invention expanded to a circular cross-section;

15           Figure 5 shows a sleeve embodying the invention in longitudinal section with provision of a means for the expansion thereof at intervals along its length, and

20           Figure 6 shows to an enlarged scale a portion circled in Figure 5 of the section of Figure 5.

          Referring to Figure 1 there is shown a borehole 100 in which is provided a steel reinforcement 2 and a sleeve 3 embodying the invention as they will be  
25           disposed prior to introducing concrete into the borehole. Subsequently, concrete will be introduced at the foot of the borehole 100 to surround the steel reinforcement 2 and the sleeve 3. While the concrete is still fluid, the sleeve 3 is expanded to ensure that  
30           the pile produced is in intimate contact with the borehole.

          The section through the borehole shown in Figure 2 shows the sleeve 3 now removed to leave a void 300  
35           extending within a body 1 of cast concrete extending above ground level 101 and containing steel

reinforcement 2 therein.

Referring to Figure 3 of the drawings, here the central sleeve consists of four panels 4 each connected by a longitudinal gasket 5. The panels of the sleeve are also connected to each other via pistons 6 carrying hydraulic rams 9 and acting in two directions at right angles to each other under hydraulic pressure applied by a piston driver 7 served by a hydraulic hose 8. The gaskets themselves may be steel plates slidable with respect to the panels with which they are associated so that, however much the sleeve is expanded within the confines of a square borehole, a square cross-section of sleeve will be maintained.

Figure 4 shows a structure which is equivalent to that of Figure 3 but where the panels 4 are of arcuate form. Like reference numerals here indicate like parts to those in Figure 3.

Finally, Figure 5 shows the disposition of additional hydraulic rams or pistons 10 at intervals along the length of a sleeve 3 embodying the invention. Positions of sets of pistons 6 are paired and one ram 10 is circled and shown to a larger scale in Figure 6. The pistons act on the sleeve 3 to assist in separating it from the completed pile and are protected by a circumferential gasket 11 which is similar to the longitudinal gasket 5. The pile produced on casting will accordingly be keyed into the wall of borehole thereby enhancing the frictional gripping of the pile by its surrounding borehole wall while the sleeve can readily be removed when casting of the pile has taken place.

The embodiments shown in the drawings are only

examples of embodiments encompassed by the invention. They generally show hydraulic rams acting on segment panels of a sleeve structure. They can also act on the gaskets so it is the expansion of the gaskets which  
5 gives rise to overall expansion of the sleeve rather than displacement of segment panels, such displacement being accommodated by the expandibility of the gaskets.



CLAIMS

1. A method for the production of a cast-in-situ pile in a previously produced borehole which comprises the steps of (a) introducing into a borehole a sleeve which consists of two or more segments connected by expandable gaskets and which has means for expanding it radially provided at intervals along its length, (b) introducing into the borehole at the same time as or after the sleeve is introduced a steel reinforcement for the pile, (c) introducing concrete for forming the pile into the borehole either before the sleeve is introduced into the borehole or after the sleeve is introduced so as to lie around the sleeve and the steel reinforcement and (d) expanding the sleeve to force wet concrete being disposed there around against the sides of the borehole.

2. A method according to claim 1, wherein the segments of the sleeve are formed of steel or plastics material.

3. A method according to claim 1 or 2, wherein the gaskets are formed of plate elements on the exterior of a framework of segments of the sleeve and the expansion results in travel of the gasket panels outwardly over the outer surface of the segments to increase overall the cross-section of the sleeve.

4. A method according to claim 1 or 2, wherein the gaskets are formed of resilient material and are expanded as the segments are forced outwardly from their initial position when the concrete has been introduced between sleeve and borehole.



5. A sleeve for introduction into a borehole, the sleeve consisting of two or more segments which together make up a closed circumference, which segments are connected by expandable gaskets which allow the circumference to be increased while maintaining a closed body, means being housed in the sleeve for expanding the sleeve radially.

6. A sleeve as claimed in claim 5 wherein the segments are formed of metal or plastics material.

7. A sleeve as claimed in claim 6 or 7, wherein the gaskets are formed of panel members able to slide laterally over the longitudinally extremities of the segments of the sleeve in achieving expansion of the sleeve.

8. A sleeve as claimed in claim 6 or 7, wherein the gaskets are formed of plastics material which is deformable as expansion of the sleeve occurs in use.

9. A sleeve as claimed in any one of claims 5 to 8 wherein means for expanding the sleeve circumferentially are provided at intervals along the length thereof.

10. A sleeve as claimed in any one of claims 5 to 9, which includes pneumatic or hydraulic bags for achieving local expansion of the sleeve.

11. A sleeve according to any one of claims 5 to 9 which includes piston means within the sleeve which is drivable to effect expansion of the sleeve.

12. A sleeve as claimed in any one of claims 5 to 8, which includes a pneumatic or hydraulic bag



-11-

extending therein along substantially the length thereof.

5 13. A sleeve according to anyone of claims 5 to 9 which additionally comprises two or more arrays of segments spaced apart along the length of the sleeve and connected by expandable gaskets which allow the length of the sleeve to be varied, means being housed in the sleeve for expanding the sleeve longitudinally.

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14. A sleeve according to claim 13, which includes piston means within the sleeve for effecting expansion and contraction of the sleeve longitudinally.