June 7, 1966 L. MENARD 3,254,492

CASTING OF PILES IN SITU

Filed Oct. 9, 1962 2 Sheets-Sheet 1

FIG. 1

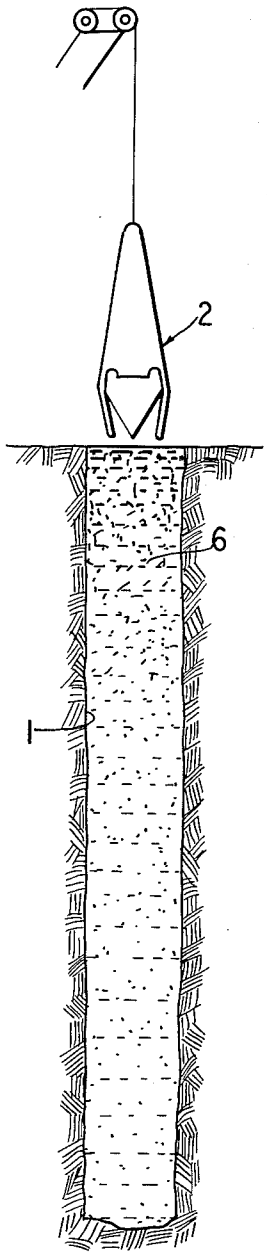


FIG. 1a

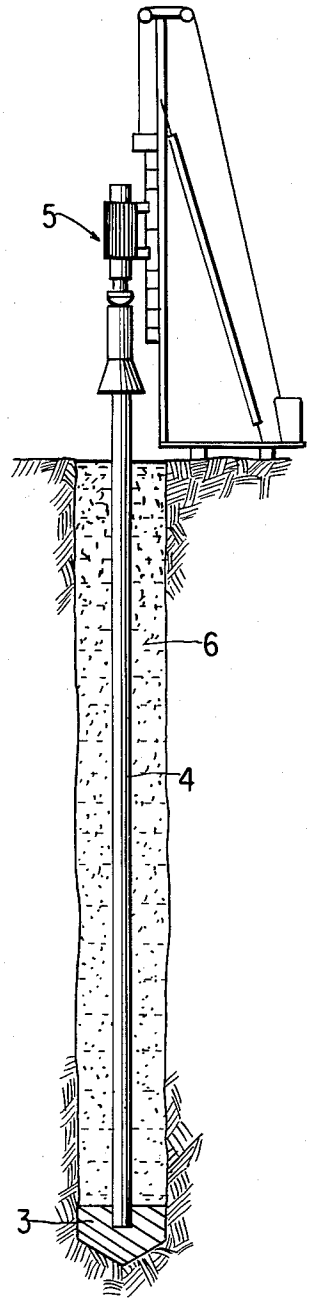
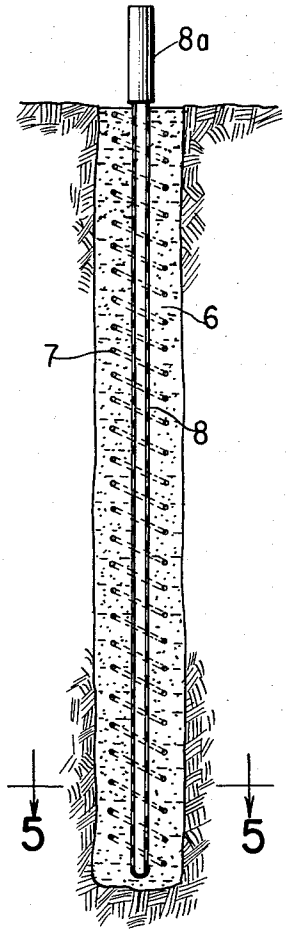


FIG. 2



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FIG. 3

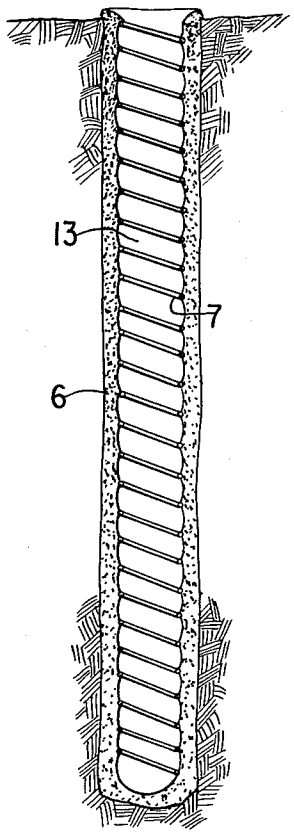


FIG. 4

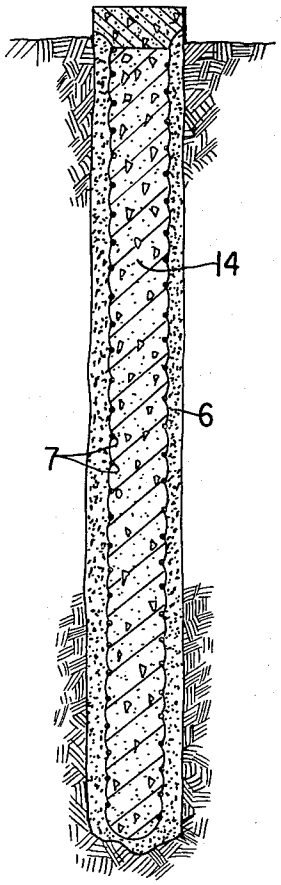


FIG. 5

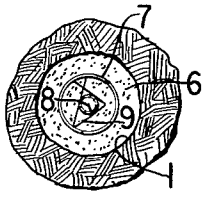
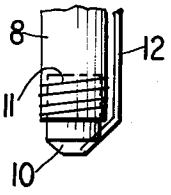


FIG. 6



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CASTING OF PILES IN SITU

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Claims priority, application France, Oct. 13, 1961, 875,875
7 Claims. (Cl. 61—53.52)

This invention relates to the casting of piles in situ and has for object to facilitate the operation of in situ casting; to enable an improved grade of concrete to be used, and to render the support for the pile more efficient.

It is known that the strength of the support of a pile cast in situ depends on two main factors, namely the mechanical characteristics of the supporting soil and the construction of the supporting shaft. In the case of heterogenous soils with yielding strata and, more particularly, in alluvial strata traversed by underground streams, the process of concrete casting is particularly intricate.

Moreover it is sometimes necessary to protect the green concrete by a jacket consisting of a steel tube or by rings of precast concrete. This jacket is normally heavy and has the disadvantage of reducing the lateral grip between the pile and the earth.

It is an object of the present invention to effect an improvement in the grip between the pile and the soil whilst effectively protecting the pile during setting.

It is another object of the invention to provide for ready inspection or test of the walls of the hole for soundness before final casting of the pile therein.

The method of making a pile according to the invention is carried out in the following way. A hole is bored of a diameter equal to the nominal diameter of the pile and the wall of the hole is supported by a lining formed by pouring into it, in proportions with the boring, liquid mortar or grout. Once the boring of the hole is completed, a radially expensible bag of approximately the same length as the pile is introduced axially into the hole and filled with pressure fluid to cause radial dilation. The pressure is maintained until the grout has set, whereupon the bag is deflated to separate it from the lined wall of the hole and it is withdrawn. The resultant cylindrical cavity is filled with concrete.

The positioning and inflation of the expansible bag according to this invention enables a hole to be formed concentrically with the axis of the pile which, after setting of the wall lining, will be filled with concrete of good quality. The concrete can therefore be poured dry and under conditions which are very favourable for its structural strength. Furthermore, a rapid examination can be made of the central hole (inspection for leakage, etc.) to establish the continuity and satisfactory quality of the wall lining.

Inflation of the bag enables the cement or grout to be squeezed dry, and its mechanical characteristics to be thereby improved. It increases the grip between the grout and the surrounding virgin soil due to the prestressing thus exerted and maintained during the period of setting of the grout. Finally, this grout consolidates the soil itself in the zone around the pile, and this in turn improves the mechanical characteristics of the latter.

Preferably, a pervious metal cage is inserted into the hole at the same time as the bag, and surrounding the latter, this cage being of a diameter equal to the maximum permissible diameter of the bag when inflated. It may, for example, be formed by rolling panels of expaned metal into a helix of a diameter slightly less than that of the hole in order primarily to keep the bag in position, and to allow grout to pass therethrough.

The use of the helical cage is not essential in itself but does improve the efficiency of the process. Without it, the maximum internal pressure in the bag would be limited by the resistance of that stratum of the soil which has the weakest compressibility characteristic, and there would be a risk of forming bulges in the wall lining which could lead to bursting of the bag.

In one method of carrying out the invention the grout which is poured into the hole in step with the progress of the boring has added thereto a small percentage of a clay for the purpose of rendering the mixture thixotropic and thereby avoiding the necessity for the use of shuttering. However, the use of an external shuttering may sometimes be necessary, in which case the latter will be located in the usual manner and withdrawn after introduction of the inflatable bag and before inflation thereof.

Conveniently, before withdrawing the bag, it is reduced to its nominal diameter and further grout is run in all round the bag—for example by pumping it down to the bottom of the hole—then reinflating the bag to force the new grout against the wall, this operation being carried out several times if necessary.

Finally, the process according to the present invention can be completed by the formation of one or more indentations at the base or at intermediate points along the length of the pile. Each indentation is formed when the cylindrical cavity has been formed and before this cavity is filled with load-bearing concrete. To form the indentations, an expansible bag can be lowered to the desired depth, or any other expansion means can be used such as conventional mechanical devices like a rock splitter, or an expander formed, for example, by two half-shells spread apart by screw jacks. The indentations mentioned above will be filled with the concrete poured into the cylindrical cavity and will enable the grip of the concrete on the soil or the grout liner, or both, to be increased.

Advantageously, a liquid such as water is used to inflate the bag and it is preferred that the bag should be lowered into the bore with a water content sufficient to cause slight expansion. Its introduction into the bore is facilitated by the presence of the helical cage, although various other means can be used to this end. For example, a conical plug may be secured to the lower end of the bag, the end of a rigid bar approximately of equal length to that of the pile being releasably attached to this plug. As soon as the end of the bag has reached the bottom of the hole the rod can be detached from the plug and withdrawn from the hole.

One practical example of the use of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIGURES 1–4 show successive steps in the construction of a lined hole;

FIGURE 5 is a section on the line 5—5 of FIGURE 2 showing the engagement of the bag and its cage after insertion into the hole; and

FIGURE 6 is a schematic partial view of a modified lower end of the bag.

In casting a pile in situ according to the present invention a hole **1** is bored to the nominal diameter of the pile. This can be achieved, for example, either by the use of a mechanism **2** (FIGURE 1*a*) such as a bucket, or by driving a concrete nosepiece **3** (FIGURE 1*b*) with successive stem elements, beams, or like driving elements **4** under the action of a pile driver **5**.

As the depth of the hole increases, its walls are supported by pouring a thick cement grout **6** to which is preferably added a percentage of bentonite or similar clayey substance so as to render the mixture thixotropic. The grout is introduced in the appropriate manner, for example by pumping directly to the bottom of the bore. To this end, a simple hand-operated mud pump is sufficient, although, if required, an external shuttering (not shown) may also be used.

When the bore has reached its full depth, a radially inextensible metal cage **7** (FIGURE 2) and a radially expansible bag **8** are inserted axially into the hole. The cage is advantageously formed by a helix which allows the grout to pass through when the latter, under the action of the expanding bag, is progressively compressed against the wall leaving the centre of the hole free. The cage **7** must also prevent the bag located within it from local dilation beyond a predetermined limit. For example, the cage can be made of wire 5 mm. in diameter wound into a helix of 4 to 6 cm. pitch. Panels of expanded metal or mesh rolled into a helix can also be used, and this represents an inexpensive form of cage.

The bag **8** to be placed inside the cage is comp'etely flexible, and this facilitates its carriage and use. It is preferably of standard length—for example, 6, 12 or 18 feet—and the length of the bag is chosen so as to be only slightly greater than that of the pile, for example less than 6 feet longer. Expansion of the excess length of the bag after insertion in the bore hole is then prevented by surrounding it with a collar **8***a* (FIGURE 2) which is inextensible and of slightly larger diameter than the deflated bag.

In order to introduce the bag into the hole, it is filled with liquid, preferably water, which causes it to expand slightly. If, as in the example shown, a cage **7** is used, this latter can be used to assist the introduction of the bag with its water filling. For example, as shown in FIGURE 5, the bag **8** is lightly held by deformable cross-bars or steadies **9** fixed to the cage **7**. As will be understood, these steadies must be able to deflect when the bag is inflated.

If, on the other hand, no cage is use, it will be convenient to insert the bag **8** into the hole with the aid of a device such as that shown in FIGURE 6. In this arrangement, the bottom end of the bag is fixed to a generally conical tip **10** to which it is bound or otherwise secured as shown at **11**. The tip **10** has an oblique hole into which is inserted the crank end of a rigid rod **12** having a length at least equal to the depth of the hole, it is then possible to insert the bag filled with water with the assistance of the rigid rod and, when the conical tip **10** reaches the bottom of the hole, to disengage the rod **12** and withdraw it.

Pressure is introduced into the bag by any convenient form of pump for delivering water thereinto and the volume of the bag is measured in terms of pressure. Under the action of the liquid pressure, the grout is pressed against the earth and progressively squeezed dry. Pressure is maintained until the grout has set (from 2–24 hours according to its composition).

After the grout has set, the bag is deflated either by opening it to release the fluid, or by pumping out the fluid or, when the fluid is water, and especially in the case of very long piles, by pumping in air under pressure. The bag is then withdrawn leaving a central cavity **13** (FIGURE 3) which can then be tested for soundness.

It is equally possible, before withdrawing the bag, to collapse it to its nominal diameter (approximately that at which it was inserted when full of water) to add grout around the bag—as by pumping it from the bottom of the hole—and then to reinflate the bag to compress the new grout against the wall of the hole.

Finally, the central cavity **13** is filled with concrete **14** to the required specification, with or without reinforcement, and a pile is obtained with the properties set out above.

The process according to the invention results in various technical and economic advantages. It ensures the provision of a continuous column formed from concrete of as uniformly good a quality as in the superstructure of the building owing to the presence of the protective wall of grout. Whilst, soil movements and underground streams can lead to erosion or deterioration of the wall, just as in an ordinary pile, these attacks will be less serious because of the prestressing of the wall lining, and moreover they are immediately detectable after the withdrawal of the bag. An early opportunity is therefore provided for remedying the defects before pouring the load-carrying concrete into the cavity.

Furthermore, the process according to the invention leads to a very significant increase in the grip between the pile and the ground by increasing the normal forces on the wall and by the consolidation of the surrounding soil. This advantage is particularly noticeable in the case of piles for which lateral grip constitutes an important element in their load-carrying capacity, and also in the case of anchorages.

On the other hand, settlements are reduced owing to the increase in the modulus of deformation of the ground on the lateral wall and at the foot of the pile.

Another advantage of the process according to the invention resides in the fact that the pressurising of the bag and the drop in pressure due to soil collapse provides a pressure measurement on a large scale of the mechanical characteristics of the ground as described in French Patent No. 1,117,983 of January 19, 1955.

Other advantages, especially in the economic field, are as follows:

(1) The rapid setting of the lining which inflation of the bag produces, can be turned to good account by using a free flowing neat cement or grout which can be poured very easily from some central mixing point;

(2) The possibility of avoiding the use of shuttering due to the use of a thixotropic grout. It must be noted, nevertheless, that the use of external shuttering might sometimes be necessary, in which case the external shuttering will be introduced in the usual manner but withdrawn after introduction of the expansible bag and before inflation thereof;

(3) The ease of placing the main body of concrete, which can be poured and compacted by vibration;

(4) Stronger union at the head of the pile with the supported structure.

I claim:

1. A process for constructing piles cast in situ comprising the steps of forming a hole of a diameter equal to the nominal diameter of the pile, pouring liquid grout into said hole as its formation proceeds, inserting axially into said hole filled with said grout to its full depth when formed a completely flexible and resiliently extensible, radially expansible element and a pervious metal cage, said element having a length approximately equal to the depth of said hole, said pervious metal cage surrounding said element and having a diameter less than that of said hole and equal to the maximum permissible expanded diameter of said element, expanding said element under radial pressure whereby said radially expansible element is expanded approximately equally radially, maintaining said pressure until said grout sets to form a lining for said hole, releasing said radial pressure to cause said expansible element to pull away from said lining, removing said element and filling the cavity left thereby with load-bearing concrete.

2. The process of claim **1** wherein said liquid grout is a thixotropic mixture containing a small proportion of a clayey substance.

3. The process of claim **1** wherein said cage is an open metal helix whose pitch is selected to prevent excessive local bulging of said element under said radial pressure in yielding ground.

4. A process for constructing piles cast in situ comprising the steps of forming a hole of a diameter equal to the nominal diameter of the pile, pouring liquid grout into said hole as its formation proceeds, inserting axially into said hole filled with said grout to its full depth when formed a completely flexible and resiliently extensible radially expansible element and a pervious metal cage, said element having a length slightly in excess of the depth of said hole, said pervious metal cage surrounding said

element and having a diameter less than that of said hole and equal to the maximum permissible diameter of said element, expanding said element under radial pressure whereby said radially expansible element is expanded approximately equally radially, maintaining said pressure until said grout sets to form a lining for said hole, releasing said radial pressure to cause said expansible element to pull away from said lining, removing said element and filling the cavity left thereby with load-bearing concrete.

5. The process of claim 4 wherein the excess length of said element is enclosed in a non-expansible collar whereby the radial expansion of said element under pressure is confined to the depth of said hole.

6. A process for construction piles cast in situ comprising the steps of forming a hole of a diameter equal to the nominal diameter of the pile, pouring liquid grout into said hole as its formation proceeds, inserting axially into said hole filled with said grout to its full depth when formed a partially expanded, completely flexible and resiliently extensible, radially expansible element and a pervious metal cage, said element having a length approximately equal to the depth of said hole, said pervious metal cage surrounding said element and having a diameter less than that of said hole and equal to the maximum permissible diameter of said element, said element supported within said cage by deformable transverse studs capable of yielding under radial expansion of said element, expanding said element under radial pressure whereby said radially expansible element is expanded approximately equally radially, maintaining said pressure until grout sets to form a lining for said hole, releasing said radial pressure to cause said expansible element to pull away from said lining, removing said element and filling the cavity left thereby with load-bearing concrete.

7. The process of claim 6 wherein said expansion is effected by water pressure.

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