Jan. 12, 1960 J. T. HAZAK 2,920,456

CONCRETE PILES AND METHODS FOR FORMING AND INSTALLING SAME

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Fig. 1.

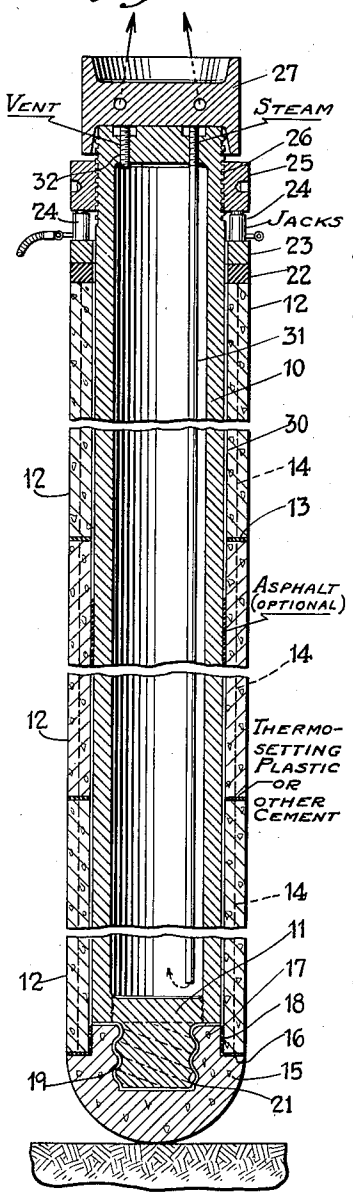


Fig. 2.

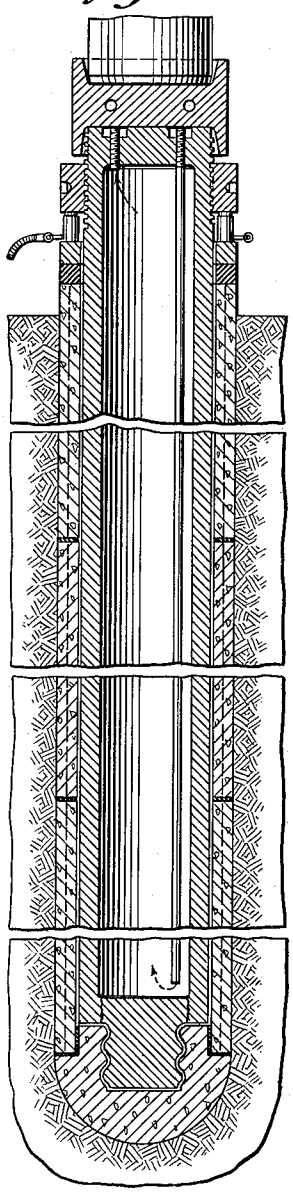
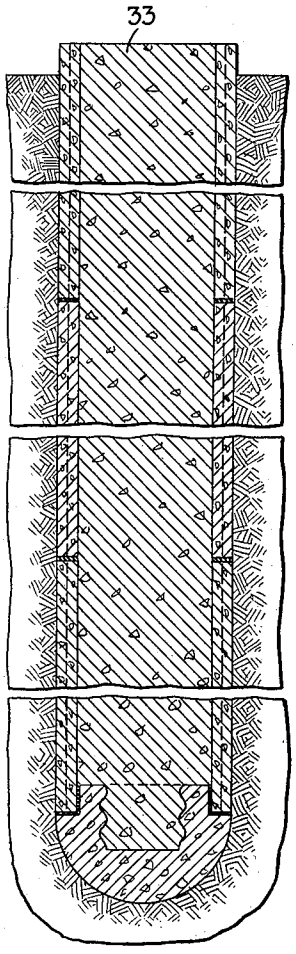


Fig. 3.



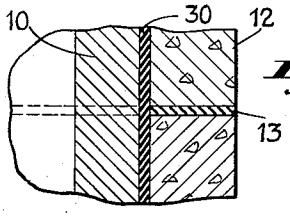


Fig. 4.

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Fig. 5.

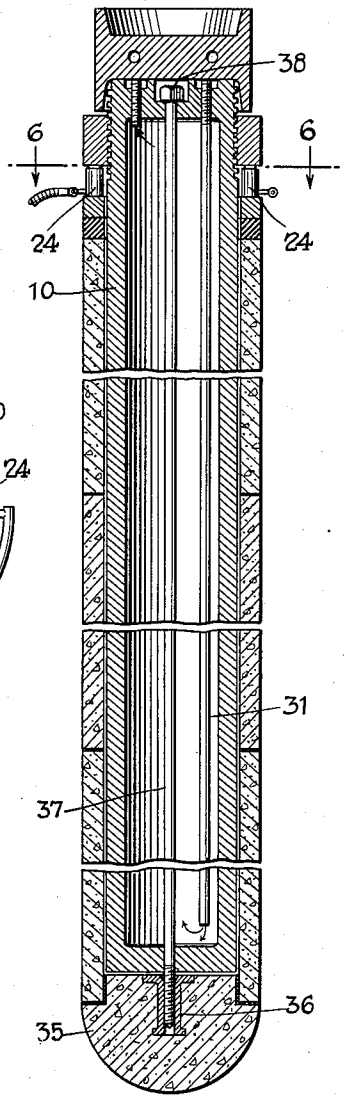


Fig. 6.

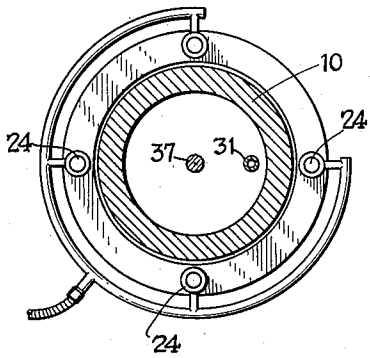
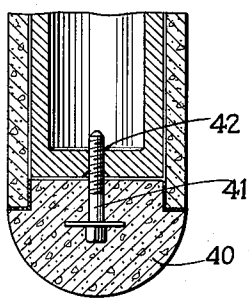


Fig. 7.



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CONCRETE PILES AND METHODS FOR FORMING AND INSTALLING SAME

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Application April 24, 1956, Serial No. 580,347

8 Claims. (Cl. 61—57)

This invention relates to concrete piles and methods for making and installing same.

One method for making concrete piles which has been extensively used for many years, is to drive a steel shell into the earth by the use of a driving mandrel therein, such mandrel thereafter being removed and concrete being poured into the shell to complete the pile. Another method has been to form a concrete tube made up of a series of end-to-end sections, the sections having aligned holes in their walls in which so-called prestressing wires are installed under heavy tension to subject the series of sections to longitudinal compression sufficient to enable the concrete tube to withstand the severe impacts from a pile driver. Such concrete tubes after being driven in the earth may also be filled with concrete.

But both of the above-described methods, as well as others which have heretofore been used, involve the use of considerable amounts of expensive steel, such steel being made necessary essentially so that the shell structure while being driven will be able to resist cracking or shattering due to tensions and reactions resulting from the heavy impacts of the pile driving hammer. But once the pile is in place, in the usual case there is little or no further need for permanent steel reinforcement thereof because the loads which the pile has to carry are generally largely vertical compressive loads which concrete is well able to withstand. While sometimes a relatively small amount of reinforcement is desirable in concrete members to be used as piles, to insure that same will not become easily broken upon handling and placing them in position under a driving hammer, yet the greatest need for steel reinforcement of the concrete is during the driving only, and thus if the steel remains permanently a part of the pile, its value is thereafter largely wasted.

According to the present invention, a concrete pile construction and method of making and installing same is provided, such that little or no metal reinforcement needs to remain as a part thereof after the pile has been driven and completed. Such method in its preferred form comprises surrounding a rigid pile driving mandrel means with a precast concrete pile shell which may, if desired, be formed of a series of precast concrete sections sealed or cemented together end to end and with a concrete or metal boot member which closes the bottom end. The lower end of such shell is suitably detachably secured with respect to the lower end of the mandrel means. Then force is applied to the upper end of the concrete shell to subject the shell to prestressing, that is, heavy compressive stressing preferably throughout the length of the shell or the greater part thereof. Such force may be applied for example by suitable jacking means interposed to react between the upper end of the concrete shell and suitable protruding portions on the upper end of the mandrel means. The assembly comprising the concrete shell and mandrel means is then placed in upstanding position beneath the follower of a pile driving hammer, for example, at the desired location for driving the pile, and then the assembly is driven into

the earth to the required depth by impacts from the hammer, which do not endanger the concrete of the shell or tend to cause cracking thereof, in view of the fact that the shell is under heavy compressive stress. After the assembly has been driven, the jacking means, or whatever is used for applying the prestressing force, may be released to allow the mandrel means to be suitably manipulated or released at its lower end, whereupon the mandrel means may be withdrawn and the pile is completed by pouring concrete into the remaining shell.

Various further and more specific objects, features and advantages of the invention will appear from the detailed description given below taken in connection with the accompanying drawings which form a part of this specification and illustrate merely by way of example, preferred forms of the invention. The invention consists in such novel features, arrangements and combinations of parts and method steps as may be shown and described herein.

In the drawings:

Fig. 1 is a vertical sectional view of an assembly comprising a mandrel means surrounded by a concrete shell with a boot at the bottom, the assembly being here shown in position ready for driving into the earth;

Fig. 2 is a view similar to Fig. 1 but showing the assembly after it has been driven;

Fig. 3 is a vertical sectional view of the concrete shell and boot after same has been driven and the mandrel means therein has been replaced by concrete;

Fig. 4 is a detailed enlarged sectional view showing the manner of sealing together end-to-end sections of the concrete shell and showing a portion of the mandrel means therein;

Fig. 5 is a view similar to Fig. 1, but illustrating a somewhat modified embodiment of the invention;

Fig. 6 is a horizontal sectional view taken substantially along line **6—6** of Fig. 5; and

Fig. 7 is a vertical sectional view of the bottom portion of a further alternative embodiment of the invention.

Referring to Fig. 1 in further detail, the mandrel means is here shown at **10** in the form of a heavy cylindrical steel cylinder closed at its top and bottom ends. One of such ends, for example the bottom end, may be closed as by a removable plug **11** which may be screwed in place or otherwise affixed.

The mandrel means is surrounded by a precast concrete shell **12** which preferably, although not necessarily, may be made as shown, of a series of sections arranged end to end, the ends being sealed and preferably cemented together as at **13**. To accomplish such sealing and cementing, suitable means of known form may be used, for example polyester cement materials adapted to become set when put in place, by the action of a suitable catalyst. If preferred, other suitable known materials may be used such as synthetic resinous thermosetting cement. It is desirable that the ends of the concrete sections be permanently sealed together so that the concrete shell will be waterproof. Usually but not necessarily a small amount of steel reinforcing may be embedded in each section of the shell in the form of relatively small wires or rods as indicated by the dotted lines **14**. Such reinforcement need only be sufficient to prevent the concrete from cracking due to tension forces when the sections are being handled or manipulated and put in place on the mandrel means. If exceptional strength of the shell is desired during driving or handling, or for any other reason, the reinforcing wires may extend through aligned holes throughout the series of concrete sections and be grout bonded in place under heavy tension in the manner disclosed in U.S. patent to Maxwell M. Upson No. 2,706,498, granted April 19, 1955.

With the form of the invention shown in Fig. 1,

the bottom end of the shell is closed by a boot means 15. This boot means may be formed of various materials such as concrete, in which event it may be provided with a peripheral flange formation as at 16 for engaging the lower end of the lowermost shell section 12, a portion of the boot as at 17 extending up into such shell section in close-fitting relation thereto and being also cemented thereto as indicated at 18. The boot as shown is formed with a central cavity 19 internally threaded with coarse threads as shown to engage corresponding threads as at 21 formed on a protruding lower end portion of the bottom closure member 11 of the mandrel means. A threaded connection is thus provided between the lower end of the mandrel means and the boot means for preventing the boot means from moving downwardly with respect to the mandrel means when the concrete shell is being prestressed in the manner hereinafter described. But it will be apparent that the mandrel means may be readily removed from the boot by turning the mandrel means about its axis when it is desired to detach and remove the mandrel means from the shell as further hereinafter described.

The upper end surface of the upper concrete section 12 is preferably surmounted by one or more annular cushion rings as at 22 formed for example of thermoset laminated synthetic plastic material. Such ring or rings in turn may be surmounted by a metal jacking ring 23 upon which a plurality of hydraulic jacks as at 24 are mounted. The jacks in turn may be surmounted by a metal reaction ring 25 adjustably secured with respect to the body of the mandrel as by the provision of coarsely threaded engaging surfaces as at 26. It will be understood that other possible forms of engaging means between the adjustably secured reaction ring 25 and the mandrel might be used.

The mandrel means, as shown in Fig. 1, is positioned beneath a so-called follower 27 of a pile driving hammer assembly.

After the parts are in place as shown in Fig. 1, the jacks 24 are operated to apply heavy pressure to the concrete shell sections, such pressure reacting against the reaction ring 25. Such pressure should be sufficient to subject the concrete shell throughout to heavy compression comparable to the pressures achieved in concrete members for construction purposes generally of corresponding cross-sections when prestressed by heavily tensioned wires.

Usually the mandrel cylinder 10 should be of a size to fit the concrete shell sections quite closely or with very little clearance. In some cases it may be desirable to fill the clearance space between the mandrel and the concrete sections with some material which can be softened by heating, for example asphalt, as indicated at 30. This will tend to give the concrete shell firm support against the mandrel when driving the assembly. After the assembly has been driven and it is desired to remove the mandrel, it may be heated as by introducing steam or other hot fluid through a pipe 31, the air and excess steam being vented through an outlet vent 32.

When the concrete shell has been properly prestressed as above described, the assembly is driven into the earth as indicated in Fig. 2 by a pile driving hammer. Thereupon the above-mentioned asphalt or the equivalent if used is melted by heating as aforementioned. The mandrel means may then be turned to release the threaded connection at 19, 21. Then the mandrel means may be lifted up out of the concrete shell. Finally a mass of concrete as indicated at 33 in Fig. 3, may be poured in to fill the shell for completing the pile.

The embodiment shown in Fig. 5 is similar to that of Fig. 1, except for the manner in which the lower end of the mandrel means is detachably connected to the boot. As shown in Fig. 5, the boot means 35 may be cast with an internally threaded metal member 36 therein, adapted to receive a rod 37 threaded at its lower end

and extending up to a suitable head portion on the rod at 38. It will be apparent that with this arrangement, after the concrete shell and boot have been applied to the mandrel means, the rod 37 may be turned to secure threaded engagement with the member 36 to thus detachably retain the boot member with respect to the mandrel means. Then when it is desired to remove the mandrel means, the rod 37 may be unscrewed, leaving the mandrel free to be upwardly withdrawn.

A somewhat different embodiment is shown in Fig. 7 wherein the boot member 40 is formed with an upwardly protruding bolt 41 cast in place therein for threaded engagement in an aperture as at 42 within the bottom end of the mandrel. In operation, this arrangement may be used in a manner similar to that of the arrangement of Fig. 1.

The above-described methods and arrangements have the advantage that the concrete shell as driven remains in intimate contact with the ground at all times without any clearance space, thus preserving the ground pressures as is desirable to avoid causing settling of adjacent structures or objects. Furthermore, after the mandrel is withdrawn, it will be apparent that the remaining shell may be visually inspected to assure that it is in satisfactory condition before filling same with concrete. And since the shell sections are tightly sealed and cemented together, the shell will in effect be the equivalent of a single piece which will be quite water-tight.

If desired, the mandrel means can be left in the shell until all other piles in the immediate neighborhood have been driven, thus assisting in supporting the shell against pressures of adjacent pile driving operations until the driving stresses have had a chance to equalize themselves.

Ordinarily it will be possible to withdraw the mandrel means without using any jacking or hammering apparatus, but if desired, after the bottom end of the mandrel means has been released from the boot, the jacks 24 may be used to force the mandrel means upwardly at the start of the withdrawal operation.

The concrete shell sections may be cast by any desired well known processes and without the necessity of the use of the mandrel means therein until the shells are ready to be driven. Thus for the usual construction job, a comparatively small number of mandrels will be required and as a matter of fact, only one single mandrel may be needed.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. Method for forming and installing concrete pile shells in the earth which comprises the following combination of steps: surrounding a pile-driving mandrel means with a precast concrete pile shell having a boot at its lower end; detachably securing such boot against downward movement with respect to the lower end of the mandrel means; applying jacking force reacting between the upper end of the shell and the upper end of the mandrel means to subject the shell longitudinally to compressive stressing and with consequent tensioning of the mandrel means; driving the assembled mandrel means and prestressed shell into the earth by impacts applied to the upper end of the mandrel means; releasing such force; releasing the lower end of the mandrel means with respect to the boot; and withdrawing the mandrel means.

2. Method for forming and installing concrete pile shells in the earth which comprises the following combination of steps: providing pile driving mandrel means having reaction means at the upper end thereof, a precast

concrete pile shell, and a member having a laterally extending surface; assembling the aforesaid members whereby said mandrel means is surrounded by said precast concrete pile shell and said member having a laterally extending surface is secured to the lower end of said mandrel means with said surface in supporting engagement with the lower end of said shell; applying force reacting between the upper end of said shell and the reaction means at the upper end of the mandrel means to subject said shell longitudinally to compressive stressing between the upper end of the shell and the laterally extending surface and with consequent tensioning of the mandrel means; driving the assembly into the earth by impacts applied to the upper end of the mandrel means; releasing such force; releasing the lower end of the mandrel means from said member having a laterally extending surface; and withdrawing said mandrel means.

3. A concrete pile shell and driving assembly comprising in combination: a rigid mandrel for receiving pile driver impacts at its upper portion; a concrete pile shell surrounding said mandrel; means having a laterally extending surface engaging the lower end of said shell and being relesably secured to the lower end of said mandrel; a reaction member secured to the upper portion of the mandrel for receiving and applying upwardly directed jacking forces to the mandrel; and jacking means between the upper end of the shell and the reaction member for supplying said forces in downward reaction against the upper end of the shell, whereby the mandrel is subjected to tension and the shell to compression between said laterally extending surface and said jacking means to prestress the shell during driving.

4. An assembly in accordance with claim 3, and in which said means having a laterally extending surface is a boot means secured to the lower end of the shell and covering the lower end of the mandrel, and in which the lower end of the mandrel and said boot means are formed with interengaging threaded portions.

5. An assembly in accordance with claim 3, and in which said laterally extending surface is provided by boot means covering the lower end of the assembly, and in which a rod is provided within the mandrel extending down from the upper end thereof, said rod having portions releasably engaging said boot means upon turning said rod relatively to said boot means.

6. An assembly in accordance with claim 3 and in which a layer of heat-softenable material is interposed between the mandrel and the shell and means is provided

for supplying heat to the interior of the mandrel for softening said material to facilitate removal of the mandrel from the shell.

7. A concrete pile shell driving assembly comprising in combination: a rigid pile shell driving mandrel; a concrete pile shell surrounding said mandrel and including boot means at the bottom thereof having a surface engaging the lower end of the shell; means releasably securing said boot means to the lower end of the mandrel; reaction ring means surrounding the upper end of the mandrel and having coacting portions which are relatively adjustable for vertically adjusting the ring means with respect to the mandrel; and jacking means between the reaction ring means and the upper end of the shell whereby said jacking means is positioned to apply compression forces to the shell to prestress the same during driving.

8. A concrete pile shell and driving assembly comprising in combination: a rigid mandrel for receiving pile driver impacts at its upper portion; a concrete pile shell surrounding said mandrel; means having a laterally extending surface engaging the lower end of said shell and being releasably secured to the lower end of said mandrel; a cushion ring surmounting the upper end of said shell; a reaction member secured with respect to the upper portion of the mandrel for receiving and applying upwardly directed jacking forces to the mandrel, and jacking means between said cushion ring and said reaction member for supplying said forces in downward reaction against said cushion ring and thence against the upper end of the shell, whereby the mandrel is subjected to tension and the shell to compression between said laterally extending surface and said cushion ring to prestress the shell during driving.

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