METHOD AND MEANS FOR SINKING FOUNDATION COLUMNS

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METHOD AND MEANS FOR SINKING FOUNDATION COLUMNS

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This invention relates to the formation of concrete foundation columns and particularly to a method and apparatus for sinking caissons for use in making such columns.

In some types of construction work, for example when the nature of the ground is such that the foundation columns can rest upon bed rock, it is common practice to drill or excavate the earth to facilitate the sinking of a caisson which serves as a form into which the concrete is poured.

In accordance with the present invention the caisson, such as a steel cylinder or shell, is caused to cut its own passage through the various strata of the soil and to sink to the required depth without requiring preliminary drilling or other preparation of the ground.

The principal objects of the invention are to provide an improved method and apparatus for accomplishing the above purpose: to provide a caisson of unitary construction which is capable of cutting its own passage into the ground; to improve the cutting and sinking characteristics of the caisson; to reduce the friction between the inner and outer surfaces of the caisson and the ground whereby the spinning and sinking of the caisson is facilitated; to provide means for controlling the rate of descent of the caisson during the sinking operation; and to conserve the lubricating material which flows upward around the outer surface of the caisson during the sinking operation. Other objects will be apparent as the nature of the invention is more fully disclosed.

A feature of the invention consists in permitting the construction of an entire caisson as a unit before the sinking operation is begun. In one embodiment the caisson has internal strengthening ribs and longitudinal channels for a fluid, such as water or a suspension of water and clay or other lubricating or cutting agent. Cutting teeth may be formed around the lower edge of the caisson and these teeth may be coated with a hard material such as tungsten carbide to reduce the wear and improve the cutting action.

In operation, the caisson is first raised to an upright or vertical position and is coupled to a suitable operating mechanism and a source of lubricating fluid such as water under pressure. The coupling is preferably arranged in a slightly eccentric or off-center position with respect to the caisson so as to give the caisson an eccentric motion when revolved. This eccentric motion serves to break the friction of the surrounding earth, to trowel and pack the earth walls, to provide a passage for the lubricating fluid and generally to improve the sinking operation. The rotating mechanism is mounted on a vertically movable drill carriage having supporting means adapted to support a predetermined part of the weight of the caisson whereby the rate of descent may be controlled.

Means are provided for introducing water or other lubricating fluid under pressure through the longitudinal channels to a point near the cutting edge, thence around the bottom of the shell and upwardly between the shell and the earth so as to loosen the earth and to lubricate the shell. Preferably the water is kept flowing to keep the mud relatively thin. Some material is thus washed out with the water. This liquid may be passed through one or more settling sumps so as to remove coarse particles that have been brought to the surface and to permit recovery and recirculation of the active lubricating constituents. Ordinarily it is best to provide a flow of water from the inside of the caisson to the cutting edge and thence to the surface by way of the outer face of the caisson. To provide such a condition the upper end of the caisson is closed tight. The water pressure within the caisson tends to lift the caisson so that the lower edge will not cut too fast. This lifting effect may be varied either by varying the water pressure or by varying weight on the top of the caisson.

These and other features and advantages of the invention will be described in connection with the accompanying drawings, in which:

Fig. 1 is a side elevation of an apparatus embodying the invention and illustrating the caisson at the start of the sinking operation;
Fig. 2 is a detail view of part of the apparatus of Fig. 1 showing means for raising the caisson into vertical position while attaching the driving mechanism;
Fig. 3 is a longitudinal section through the caisson taken on line 3—3 of Fig. 4;
Fig. 4 is a transverse section of the caisson taken on line 4—4 of Fig. 3;
Fig. 5 is a detail view of the cutting teeth;
Fig. 6 is a section taken on line 6—6 of Fig. 5;
Fig. 7 is a detailed sectional view of the caisson showing the strengthening ribs and the joint between adjacent sections of the shell;
Fig. 8 is a front elevation of the drill carriage showing the driving mechanism coupled to the caisson;
Fig. 9 is a section taken on line 8—8 of Fig. 8;
Fig. 10 is a top plan view of the caisson showing the top plate in position;
Fig. 11 is a detail view of the ring by which the top plate is coupled to the driving mechanism; Fig. 12 is a detail view of the coupling spider which is adapted to engage the ring of Fig. 11 for the above purpose; Fig. 13 is a sectional view, partly diagrammatic, of the lower part of the caisson, showing the od of the intermediate position after it has penetrated the earth to a certain extent but before reaching bed rock; and Fig. 14 is a section taken on line 14—14 of Fig. 13 showing the positioning frame and a portion of the channel which is provided for recovering the lubricating fluid.

In the drawings, Fig. 1 shows a framework mounted on a movable platform and carrying a vertically movable drill carriage which supports driving mechanism. This driving mechanism is coupled to the end of caisson which is to be sunk into the earth.

The caisson 5 is illustrated in Figs 3 to 7 as comprising a cylindrical steel shell formed, if desired, in a plurality of sections 5a, 5b (Fig. 7) which are placed end to end and are joined by suitable means such as a circumferential weld 6. A plurality of strengthening ribs 1 of circular channel type are disposed at convenient intervals along the interior of the shell 5 and are secured thereto as by welding. A pair of longitudinal angle members 8 are mounted within the shell, preferably not necessarily at opposite points on the circumference, to provide longitudinal channels 9 through which a fluid may be passed for lubricating purposes as hereinafter described. These angles preferably extend from the top of the shell 5 to a point near the lower edge thereof, one of the angles terminating near the lower edge than the other, so that, if an obstruction is encountered which damages one angle, the other angle will remain undamaged and will provide an uninterrupted channel through which fluid may continue to pass during the remainder of the sinking operation. The angles 8 may be secured to the shell 5 in any convenient manner as by welding 10 at convenient points along the rib 7. The ribs 7 may be cut to receive the angles 8 and may likewise be welded thereto if desired. In some instances it may be preferable to form the ribs 7 in two parts and to insert them into the shell after the angles 8 have been positioned.

A collar 10 secured to the bottom of shell 5 is provided with a plurality of teeth 12 which may be cut or otherwise formed therein as illustrated in Figs. 3, 5 and 6. This collar 10 may be of somewhat harder material than the shell 5 or the teeth may be covered with a coating of a hard substance such as tungsten carbide in a well known manner.

Successive teeth may be offset laterally like saw teeth as illustrated in Fig. 6 so as to facilitate the cutting operation and to cause the teeth to cut a passage somewhat wider than the shell itself, whereby sufficient clearance for the shell will be afforded and the upward flow of liquid will reduce the frictional resistance between the shell and the earth to a minimum.

At its upper end the shell 5 preferably carries an annular angle member 13 (Fig. 8) forming a peripheral flange to which the driving mechanism is secured as by bolts 15. This top plate carries a ring 16 containing a series of bayonet slots which are adapted to receive the coupling spider, to be described, by which the driving mechanism is coupled to the caisson. The ring 16 is preferably mounted somewhat eccentrically with respect to the top plate 14. In a shell having a diameter of, for example, six to eight feet it is sufficient to displace the center of ring 16 about a half inch. The degree of eccentricity, however, may be varied as desired in each particular instance.

The framework 1 comprises a pair of uprights 18 (Figs. 8, 9 and 9a) by which the carriage guide rails 20 upon which the drill carriage 3 is adapted to slide. Suitable strengthening and supporting members 21 and 22 may be provided to form a rigid truss for this purpose. The drill carriage 3 comprises a frame (Figs. 8 and 9) having top and bottom horizontal members 23 and 24, respectively, and vertical members 25 and 26. The form illustrated the rear vertical members 25 comprise channels which are adapted to engage opposite sides of the rails 20 so as to guide the vertical movement of drill carriage 3.

The drill carriage 3 supports a driving motor 27 (Fig. 8), which is connected by coupling 28 to a set of reduction gears mounted in housing 29. The final gear 30 of said set of reduction gears meshes with a gear 31 which is mounted on shaft 32 journaled in bearing 33 as shown in Fig. 9. Bearing 33 may be carried on cross member 34 forming a part of the frame of the drill carriage 3. The driving gears 41 may be carried on shaft 38 in position to engage bearings 39 so as to constitute a pair of thrust bearings for preventing longitudinal movement of said shaft.

The shaft 38 carries at its lower end a coupling spider 43 (Figs. 8 and 12) having a plurality of radially extending lugs 44 adapted to enter the bayonet slots 47 of the ring 16 carried by the top plate 14. This coupling spider is rigidly secured to shaft 38 and may bear against the lower bearing 39 to transmit upward thrust thereto. A pipe 45, adapted to carry lubricating fluid, is mounted on the two edges of the spider 43 and at its end is provided with a nipple 46 which enters the end of hollow shaft 38 through a suitable water-tight packing gland 47. The other end of pipe 45 is adapted to be connected to a flexible hose 48 as by a clamp 49. The hose 48 may lead to a suitable pumping mechanism, not shown, by which the liquid is withdrawn from a sump and forced upwardly through said hose and into the hollow shaft 38. The lower end of the shaft 38 may be provided with a pair of transverse bores 50 which may be connected by pipes 51 and flexible couplings 52 to a pair of vertical pipes 53 the lower ends of which communicate through apertures 54 with the upper ends of the longitudinal channels 9. The upper ends of channels 9 are preferably closed as by plates 55 so that fluid pressure may be maintained within said channels.

For suspending the drill carriage 3 from the framework there may be provided a plurality of sets of sheaves 57 and 58 which are adapted to receive a supporting cable 59. The cable 59 may extend between the sheaves 57 and 58, and sets of sheaves 59a and 59b may be provided. The framework 1 is supported by a beam 62, thence over pulleys 63 and 64 to a drum 65 which is connected to a suitable source of power, not shown, by which the vertical position of the carriage may be controlled. It is to be understood that the cable 59...
may comprise two sections both of which may be wound upon the drum 65, one of which may be passed between sheaves 77 and 69 and the other of which may be passed between sheaves 11 and 79, comprising a boom 67 (Figs. 1 and 2) which is mounted upon a stationary platform 68 carried by the framework 1 in a position suitable for the purpose. The position of the boom 67 may be controlled by a cable 69 extending between a set of pulleys 72, 73 and 74 carried by the framework 1 and by the boom as shown in Fig. 2. The cable 69 may pass over pulleys 72 and 66 and may be wound upon a drum 78 by which the position of the boom 67 is controlled. Another cable 75 is wound upon a drum 76 and is passed over pulleys 74, 73 and 72 carried by the framework 1 and between a pair of sheaves 70 and 78, the former carried by boom 67 and the latter being adapted to support a loop 80 for elevating and supporting the caisson. It is to be understood that any suitable sources of power may be used to operate the mechanism and 75 77 80

10 mechanism 4, a separate power source for operating comprising a plug 86 (Fig. 10) may be inserted in the ring 16 in back of one of the lugs 44 so as to prevent withdrawal of the lugs from the bayonet slots 17 so as to firmly secure the driving mechanism to the caisson. Locking means such as a plug 86 (Fig. 10) may be inserted in the ring 16 in back of one of the lugs 44 so as to prevent withdrawal of the lugs from the bayonet slots in the event of reverse rotation of the driving mechanism. The loop 80 and the cable 69 are now removed. The framework 1 is adapted to raise the drill carriage substantially above the top of the caisson for purposes of attachment. This construction also allows the top of the caisson to be sunk below the surface of the ground and below the end of the supporting framework 1.

With the parts in the position indicated, a suitably fluid such as water, or a mixture of water and clay, is pumped through the hose 46 and the hollow drive shaft 58 to the longitudinal channels 9 and central flood valve, whence it discharges at a point adjacent the cutting teeth 12 and serves to hydrate the soil to reduce the same to a semi-fluid state for elimination of resistance to sinking of the caisson. As the caisson sinks, the fluid passes through the lower edge of the shell and upwardly around the outer surface of the shell to the pit 82 and sump 83 causing the caisson to sink. The coarser particles may be separated out in the pit or in the sump and the mixture of water and clay may be collected and recirculated through the hose 46.

A plurality of settling sumps may be used if desired for separating the undesired material from the water and clay and for recovering the clay or lubricating substance. In all soil there is a certain amount of clay or similar lubricating material which, when the soil is hydrated and moved by water pressure, will remain in suspension until the velocity drops sufficiently to allow the larger particles to settle out. If the soil does not contain enough clay for this purpose an additional quantity may be placed in the sump from which the liquid is pumped. The hydrated soil and clay will find its way upward around the shell, lubricating the shell and carrying particles of soil which may be removed in the settling sumps.

Power may be applied to the motor 27 thereby causing the shell 8 to rotate slowly and causing the teeth 12 to cut their way into the earth. At the beginning of the operation the caisson may be supported partly or wholly by the drill carriage 3 as the fluid which is fed under the cutting edge reduces the resistance to motion when the platform permits the shell to lower so rapidly as to lose control of its downward course. As the operation proceeds, however, and more weight is desired in order to facilitate the sinking of the caisson the cable 58 may be manipulated to transfer an increasing amount of weight from the drill carriage 3 to the caisson and the weight of the carriage itself may be added if found necessary. As the caisson is rotated in the manner described above it is caused to move in a slightly eccentric path due to the eccentric position of the ring 16 with respect to the top plate 14. This
movement causes a momentary clearance 87 (Fig. 14) between one side of the caisson and the surrounding earth, which clearance progressively moves around the caisson as the position of the eccentric changes. The caisson accordingly has imparted thereto a transverse oscillatory motion with respect to the earth in addition to the movement of rotation. This movement causes the caisson to pack or trawl the lubricating material against the earth walls, thus solidifying the same whereby the earth is made more self-supporting and the friction on the surface of the caisson itself is reduced. Furthermore, this motion provides a passage for the liquid to pass upwardly around the surface of the caisson so as to lubricate the same for further reducing the friction of the surrounding earth. It will be noted that the liquid is thus assisted to move upwardly in a helical path around the outside of the shell as the operation of sinking the caisson progresses. The controlled liquid head within the shell insures the forcing of the solution up the rotating clearance to the surface carrying with it a portion of the hydrated core from within the shell. The liquid discharged from the ends of the channels produces a fan effect for jet adjacent to the cutting edge which facilitates the hydration of the soil and penetration of the teeth 12.

The structure is such that the cutting teeth 12 are able to cut through stone, rock and boulders as well as through the various strata of the soil. The eccentric motion of the caisson is particularly effective in cutting through boulders since the portion of the boulder remaining inside the caisson will necessarily be substantially smaller than the diameter of the caisson itself, which prevents the boulder from clogging up the caisson. A portion of the interior soil becomes hydrated and, due to the greater hydrostatic head within the caisson, passes upwardly around the side of the shell with the rising column of water and settles in the sump. Any remaining material will be removed after the caisson has been sunk to the desired depth, as by means of clam shell buckets or other excavating mechanism. It will be noted that the caisson normally is kept filled with water to a level above the ground level as illustrated in Fig. 13, thereby providing a controlled hydrostatic head which assists in forcing the water upwardly around the shell in the manner described above. This water is pumped out after the caisson has been sunk to the desired depth.

It is frequently desirable to cause the caisson to enter the bed rock a given distance. This is accomplished by continuing the above mentioned operation until the teeth 12 have cut themselves into the bed rock to the desired distance. Thereafter the operation may be stopped and a suitable sealing material such as concrete may be passed down the channels 9 to seal the bottom edges of the caisson in the bed rock. The driving mechanism may then be uncoupled, the ‘op plate removed and the caisson pumped out and then cleaned and filled with concrete to form the desired column.

In order to prevent an excessive shearing stress from being applied to the hollow shaft 38 and to the bearings 39, due to the eccentric movement of the shell, a certain amount of play is provided in the coupling device between the lugs 44 and the bayonet slots 41. This permits the caisson to become somewhat out of alignment with the driving shaft without damaging the driving mechanism.

During the major portion of the downward movement of the cylinder a very slow speed of rotation is maintained, until a point is reached where the resistance of the material is sufficient to retard the circulation of liquid, thereby slowing the downward movement of the cylinder. At this time the peripheral speed is increased in order to increase the cutting action and tend to keep the outer peripheral channel open for increased circulation. More weight may also be added if desired to relieve the stress on the cable 89.

It is to be understood that a cutting agent such as a shot may be supplied through the passages 8, if desired, to facilitate the cutting operation. The desirability of this will depend upon the nature of the strata through which the caisson is being sunk.

Inasmuch as the power required in this operation will remain substantially constant for a given type of soil, fluid and speed of revolution, the variations in power may be utilized to indicate the nature of the strata through which the caisson is moving at any particular time. In the case of an electric drive an ammeter may be used for this purpose and a fan effect for jet adjacent to the cutting edge which facilitates the hydration of the soil and penetration of the teeth 12.

The invention claimed is:
1. A caisson for use in making concrete foundations, comprising a cylindrical shell and driving means adapted to rotate said shell about an eccentric center whereby combined oscillatory and rotary motion is imparted thereto for causing the shell to cut a passage into the earth.
2. A caisson for use in making concrete foundation columns, comprising a cylindrical shell and a coupling member eccentric with respect to said shell, said member being adapted to be coupled to a driving means whereby a combined oscillatory and rotary motion is imparted to said shell for causing the shell to cut a passage into the earth.
3. A caisson for use in making concrete foundation columns, comprising a cylindrical shell, means eccentric to said shell adapted to be coupled to a driving means whereby a combined oscillatory and rotary motion may be imparted to said shell, and cutting means carried by said shell for causing said shell to cut a passage into the earth when rotated.
4. A caisson for use in making concrete foundation columns, comprising a cylindrical shell having cutting teeth at its lower edge and having internal longitudinal channels extending substantially from the top of said shell to a point adjacent 70_15

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said cutting teeth whereby a fluid may be discharged in position to assist the cutting operation, one of said channels terminating well above said cutting teeth so as to protect it from breakage by contact with a foreign object.

5. A caisson for use in making concrete foundation columns, comprising a cylindrical shell, driving mechanism therefor, and coupling means comprising a ring secured to said shell and having a plurality of bayonet slots formed therein, and a spider carried by said driving mechanism having lugs adapted to engage said bayonet slots for establishing a driving connection with said shell.

6. Apparatus for sinking a caisson for use in making concrete foundation columns, comprising a supporting frame, a plurality of vertical tracks carried by said frame, a vertically movable carriage suspended from said frame and slideable on said tracks, means to control the vertical movement of said carriage, driving mechanism mounted on said carriage, and means for coupling said driving mechanism to said caisson for imparting rotational movement thereto, said carriage being adapted to support part or all of the weight of said caisson during the driving operation.

7. Apparatus for sinking a caisson for use in making concrete foundation columns, comprising a supporting frame having a plurality of vertical tracks, a carriage suspended from said frame and movable on said tracks, driving mechanism mounted on said carriage and coupling means for securing said driving mechanism to said caisson, said coupling means being adapted to impart rotational movement to said caisson and to transfer a portion or all of the weight of said caisson to said carriage.

8. Apparatus for sinking a caisson for use in making concrete foundation columns, comprising a frame having a vertical track, a carriage movable on said track and a boom mounted on said frame, said boom operating independently of said carriage and being adapted for elevating the caisson into operative position.

9. Apparatus for sinking a caisson for use in making concrete foundation columns, comprising a supporting frame, a carriage movable vertically thereon, driving mechanism carried by said carriage, a boom mounted on said frame independently of said carriage, said boom being adapted for elevating the caisson to vertical position prior to attachment of the driving mechanism, and means for independently controlling the movement of said boom and of said carriage together with said caisson while converting said carriage to said caisson.

10. Method of sinking a caisson for use in making concrete foundation columns, which comprises rotating said caisson about an eccentric axis so as to produce a combination of rotary and oscillatory motion, whereby said caisson is caused to cut a passage into the earth and to oscillate in said passage for providing a passage between the outer surface of said caisson and the earth, which passage is continuously displaced around said caisson due to the eccentric movement thereof.

11. Method of sinking a caisson for use in making concrete foundation columns, which comprises rotating said caisson about an eccentric axis for causing the caisson to cut a passage into the earth, and supplying a fluid to said caisson at a point near the cutting edge under pressure such that the fluid passes around the cutting edge and flows upwardly to the surface of the ground around the outside of said caisson in a helical path.

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