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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Cutter Bits and methods of Anchoring

We, NAVENBY LIMITED, a British Company, of 19, Acresfield, Bolton, Lancashire, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to cutter bits for forming anchor holes in clay, soil, rock or the like strata in order to provide for anchorages for structures such as pilings, walls and pillars, and methods of anchoring such structures.

An object of the present invention is to provide a cutter bit for undercutting or enlarging holes and also to provide a method of anchoring a retaining structure which is effective in a wide variety of strata conditions using such a cutter bit.

According to the present invention a cutter bit includes an outer tubular body, an inner bar axially slidably received in the tubular body, said inner bar having at least two axially extending slots longitudinally spaced apart, said tubular body having at least two pairs of diametrically opposed, axially extending slots respectively registering with the slots in the inner bar, and a cutter blade within each slot in the inner bar, each blade having a width not substantially less than the diameter of the outer body thereby the longitudinal side edges of the blades lie within the slots in the tubular body said blades being pivotally mounted to the tubular body one at one side and the other at the other side thereof and opposed side faces of the blades abutting longitudinal side faces of the slots in the tubular body and inner bar.

Also according to the present invention there is provided a method of anchoring a structure which retains a mass such as soil, clay, rock or the like, comprising the steps of forming an elongated hole in the mass, underreaming the hole by means of a cutter bit as set out in the preceding paragraph, passing an anchor shoe or the like along the hole to a position in which the anchor shoe or the like lies beyond the predetermined plane of rupture of the mass, said anchor shoe or the like having one or more covered rods or cables secured thereto for attachment to the retaining structure, passing a grout along the hole to form a securement for the anchor shoe or the like prior or subsequent to the passage of the latter along the elongated hole, filling the hole with grout, the covering on said rods or cables being of the type which does not bond with the grout so as to allow movement of the one or more rods or cables relative thereto, and attaching the one or more rods or cables to the retaining structure.

Embodiments of the present invention will now be described, by way of example with reference to the accompanying drawings in which:—

Figure 1 is a schematic side view of a hydraulically actuated cutter bit according to the present invention,

Figure 2 is a longitudinal sectional view of part of a cutter bit suitable for hydraulic actuation as above, or mechanical actuation by the mechanisms shown in Figure 4

Fig. 3 is a longitudinal sectional view of the hydraulic actuating parts of the cutter bit shown in Fig. 1, suitable for actuating the cutter bit shown in Fig. 2.

Fig. 4 is a longitudinal sectional view of an actuating head suitable for mechanically actuating the cutter bit shown in Fig. 2.

Fig. 5 is a longitudinal sectional view of a mechanism for mechanically oparating from the surface a cutter bit of the type shown in Fig. 2, and

Fig. 6 is a schematic view of an anchorage formed by a method of anchoring according to the present invention.

Referring to Figs. 1, 2 and 3, the cutter bit which is for forming and undercutting or

enlarging holes in cohesive soils or rock formations comprises a thick-walled metal tube 1 of circular cross-section into one end of which is screw-threaded a cutter 2 for cutting a hole in the soil or rock upon rotation of the tube 1.

Two pairs of diametrically opposed apertures 3 and 4 are formed in the wall of the tube 1, one pair of apertures 3 being spaced longitudinally from the other pair 4 (see especially Fig. 2).

Within the tube 1 is carried a longitudinally slidable metal bar 5 having an aperture 6 or 7 therethrough corresponding to each pair of apertures 3 or 4 in the tube. The hole cutter remote end of each aperture 6 or 7 in the bar 5 is formed with a cam face 8 or 9, respectively. Cutter blades 10 and 11 having sharpened cutter edge 12 (only one shown) and profiled follower faces 14 and 15 are located one in each aperture 6 or 7, respectively in the bar 5 with the profiled follower face 14 or 15 lying adjacent the cam face 8 or 9 of the bar 5. Each cutter blade is pivotally mounted through a pin 16 to the wall of the tube 1. The pivot point of one cutter blade is on the opposite side of the tube to that of the other cutter blade and its follower face is profiled in the opposite sense so that upon longitudinal movement of the bar 5 relative to the tube 1, the cam faces 8 and 9 engage their respective follower faces 14 and 15 on the cutter blades and push them from an inoperative position within the tube to an operative position in which they extend radially on opposite sides of the tube, the operative position of the cutter blade 11 being shown in dotted line in Fig. 2. The cutter blades 10 and 11 are shown in Fig. 2 with alternative profiles. The amount of movement of the blades is governed by movement of the metal bar 5 and a pin 17 carried by the bar 5 in a curved slot 18 in each cutter blade ensures positive retraction of the cutter blades, only one such pin 17 and slot 18 being illustrated in Fig. 2.

Referring to Fig. 3, the end of the tube 1 remote from the hole cutter 2 is closed by a hollow member 19 in which is located a hydraulic piston 20 longitudinally slidable relative to the tube 1. The metal bar 5 in the tube 1 is urged against one end of the piston 20 by a spring 21 mounted in the tube 1 at the opposite end of the bar 5 from the piston 20. The end of the piston 20 remote from the bar 5 forms one wall of a chamber 22 in the hollow member 19 to which hydraulic fluid can be supplied through a conduit 23 in the hollow member 19. An internally screw-threaded bore 24 is formed in the end of the hollow member 19 remote from the tube and serves to accommodate a screw-threaded end 25 of an arbor 26 (see Fig. 1). The arbor 26 is provided with a conduit 27 which provides communication between the conduit 23 in the hollow member 19 and a conventional external source of hydraulic fluid pressure (not shown). The arbor 26 is also provided with a pair of conduits 28 which connects a convenient external source of pressurised air with a pair of oval air pipes 29 carried in longitudinal recesses in the tube of the cutter bit and leading to the hole cutter 2 for the purpose of clearing the hole cutter 2 during drilling.

In operation, the cutter bit is rotated by the arbor 26 so as to rotate the hole cutter 2 in order to bore a hole in the soil or rock. Compressed air is passed down through the conduits 28 in the arbor and the air pipes 29 so as to prevent the hole cutter 2 from clogging. When the desired depth of hole is reached, drilling is stopped and hydraulic fluid under pressure is passed down into the cutter bit through the conduits 27 and 23 so as to shift the piston 20 and thus the metal bar 5 relative to the tube 1 against the action of the spring 21. Thus the cutter blades 10 and 11 are pivoted from their inoperative position to a position in which they extend radially from the tube 1. The arbor 26 is rotated and profile enlargement of the hole result. The length of this enlargement may be increased by slowly withdrawing the cutter bit from the bottom of the hole until the desired amount of material has been cut from the wall of the hole by the cutter blades. Then the hydraulic pressure on the piston 20 is released and the bar 5 moves under the action of the spring 21 to withdraw the cutter blades 10 and 11 into the tube 1, the movement of the cutter blades being controlled by the pin 17 located in the curved slot 18 in such cutter blade. With the cutter blades in their inoperative position, it is possible to withdraw the cutter bit prior to locating an anchor shoe or the like into the hole and anchoring it into position with cement or other grout.

In a second embodiment of the present invention, the hole cutter on the cutter bit is replaced by a solid head 30 (see Fig. 4) carried on the apertured metal bar 5 through the intermediary of a ball race 31, and the hydraulic circuitry is dispensed with. A resilient member 32 is mounted between the tube 1 and an extension 33 of the head 30 so as to urge an annular lip 34 on the extension 33 into engagement with an annular projection 35 on the apertured metal bar 5. In this way, the metal bar 5 is normally urged by the resilient member 32 into a position in which the cutter blades 10 and 11 are in their inoperative position. In use, the cutter bit attached to the end of the arbor 26 which in this case need not be provided with conduits 27 and 28 is passed down a previously cut hole until the solid head 30 engages with the soil or rock at the bottom of the hole. Pressure on the arbor 26 causes the tube 1 to move relative to the metal bar 5 against the action of the resilient member 32 and causes the cutter blades 10 and 11

to be pivoted into their operative position. The arbor 26 is rotated, whilst maintaining the pressure thereon, in order to rotate the cutter blades 10 and 11. Thus undercutting of the hole is effected. When it is desired to remove the cutter bit from the hole, the pressure on the arbor 26 is released, and the cutter blades 10 and 11 withdraw into the tube 1 under the action of the resilient member 32. Removal of the cutter bit is then possible.

Referring now to Fig. 5, the cutter bit shown in Fig. 2 can be operated by the mechanism which comprises a hollow arbor or drill tube 42 having secured to one end thereof the tube 1 of the cutter bit. To the other end of the hollow arbor or drill tube 42 is attached the output shaft 43 of a known type of drilling machine 44. Thus, rotation of the motor 44 causes rotation of the hollow arbor 42, cutter bit tube 1 and a hole cutter of the type shown in Fig. 1 in order to bore a hole in the soil or rock.

Within the hollow arbor 42 is carried a rod 45 which is longitudinally slidable relative to the arbor 42 and which is screw-threaded at one end for co-operation with a screw-threaded hole 46 in the hole cutter remote end of the metal bar 5. The rod 45 protrudes through a hole 47 through the drilling machine 44 and is attached beyond the machine to a device (not shown) of known form for applying a pulling force to the rod 45.

In operation, a hole is bored in the soil or rock by rotating the arbor 42, cutter bit and hole cutter by means of the drilling machine 44. When the hole has been bored to the required depth, the rod 45 in the arbor 42 is pulled by means of the device for applying a pulling force and the metal bar 5 in the cutter bit slides relative to the tube 1 until the cutter blades extend through the apertures in the cutter bit wall into their operative position as described with reference to Fig. 2. The arbor 42 is rotated and undercutting or enlarging of the hole is effected. Thereafter, the pulling force on the rod 45 is released and the cutter blades retract into the cutter bit tube to allow the cutter bit to be removed from the hole as previously described.

It will be appreciated that the rod may be inserted into the hollow arbor to co-operate with the metal bar of the cutter bit after the hole boring step has been completed.

It will be also appreciated that more than one rod or one or more wires may be employed, if desired, to operate the metal bar of the cutter bit.

It will be appreciated that the cutters may be provided with sharpened edges, teeth, stellite hardening tips or with a cover of a tungsten carbide matrix depending upon the type of strata to be cut.

In place of compressed air, water may be employed for preventing the cutters from clogging. Instead of hydraulic fluid, compressed air may be employed to operate the piston in the first embodiment.

It will be appreciated further that the number and shape of the cutter blades can be varied at will to suit the requirements of the anchorage, and, if desired, a single cutter can be employed.

A cutter bit according to the present invention is particularly suitable for forming an undercut hole in the method of anchoring described hereinafter with reference to Fig. 6.

Referring now to Fig. 6 the method of forming an anchorage for a piling 49 supporting a mass 50 of material of the type wherein a hole drilled in the mass 50 will maintain its diameter for some time, comprises the step of boring a downwardly inclined hole 51, preferably having a diameter of between 3 and 6 inches, into the mass 50 to extend from a predetermined position 52 related to the piling 49 to a position beyond the predetermined plane of rupture of the mass, the plane of rupture of the mass 50 being indicated by the dotted line 53. The boring tool is then removed from the hole 51 and a multi-barbed anchor shoe 54 is passed down the hole 51 until the whole of the anchor shoe lies beyond the plane 53 of rupture of the mass 50. Before being passed down the hole 52, a covered rod 55 is screwed into a screw-threaded bore in the rear end of the shoe, the rod 55 being of a predetermined length such that when the anchor shoe 54 is in its correct position the free end of the rod 55 can be connected with the piling 49. In this way the anchor shoe 54 can be precisely positioned relative to the predetermined plane 53 of rupture of the mass. A rigid grout tube (not shown) is inserted into the hole 52 over the rod 55 and is passed down until it contacts the anchor shoe 54. At the shoe contacting end of the grout tube is formed a flexible rubber covered spring steel cage (not shown) which, when forced against the anchor shoe 54, splays outwardly to seal the hole around the end of the grout tube. Cement grout 56 under a predetermined pressure is then passed down the tube and surrounds the anchor shoe 54 to locate it firmly within the stable mass of material beyond the plane 53 of rupture. During this stage, the tube is passed against the anchor shoe 54 to maintain the seal. The pressure applied to the cement grout 56 is determined by the physical properties of the material and determines the final shape of the anchorage.

When the pressure on the tube is released, the spring steel cage returns to a position which permits withdrawal of the tube from the hole. During withdrawal of the tube, cement grout is continued to be fed down the tube so as to fill the hole around the covered rod. The covering on the rod is of the type which will not bond with the cement, so that post-stressing of the rod is possible. The cement surrounding the rod increases the stability of

the mass in the zone supported by the piling.

In the case where the mass of material is such that the hole has to be maintained throughout the hole boring operation, the boring is carried out by a rotary flight auger which is arranged to be equalled or followed by a lining tube at a similar feed rate, the tube having a head with a cutting edge or suitable inserts and being rotated or oscillated to facilitate passage through the material. When the predetermined depth of hole is reached the flight auger is withdrawn and the anchor shoe with its associated covered rod is then inserted and the grouting operation commenced.

In drilling the hole there may be employed any one of the cutter bits described hereinbefore in order to increase the diameter of the hole at the location where the anchor shoe is to be disposed thus increasing the cross-sectional area of the hole at this location. After which the cutter bit is withdrawn from the hole and the anchor shoe and covered rod or cable are inserted in position and grout fed in prior or subsequent to the shoe insertion.

An alternative method of sealing the end of the grout tube with the hole is by using compounds which are mixed together at the section preceding the anchor shoe and which form a hard synthetic cement to seal the end of the tube with the hole. This method is particularly suited for use in plastic clays, when the grout tube is not removed but remains in the hole throughout the cement setting period to maintain pressure around the anchor shoe thus countering the flow of such clays.

A further method of sealing the end of the grout tube is effected by means of a spring steel cone on the end of the grout tube, which cone being arranged to splay outwardly to seal the hole upon application of pressure to the cement grout.

Under certain mass conditions, pressurised feeding of the cement grout is not required and in this case the hole at the end of the grout tube need not be sealed, the cement grout being merely poured down the grout tube to secure the anchor shoe in position.

Alternatively, under similar conditions, synthetic resins can first be fed into the hole and followed by the shoe or fabrication. Movement of the shoe or fabrication results in an intermixing of the resins to form a surrounding mass of synthetic grout.

It will be readily appreciated that one or more covered rods may be employed or alternatively one or more covered cables, depending upon the mass conditions and anchorage requirements.

The rods or cables will be covered by coating or wrapping processes, the material of the covering always being of the type which does not bond with the surrounding cement so as to allow rod or cable elongation freely as and when required. The thickness and type of the covering is variable according to the purpose of the anchorage i.e. temporary or permanent.

Dependent upon the conditions, a flexible grout tube may be employed in the place of a rigid tube. The anchor shoe may be replaced by a block or fabrication of a form suited to the properties of the mass being retained and the requirements of the anchorage, the form being indented or shouldered to obtain maximum anchorage strength. The rod or cable may be welded, swaged, cored or so otherwise affixed into the anchor shoe, block or fabrication as to ensure effective connection.

It is considered that the method of anchorage according to the present invention has the advantage that a maximum anchorage is obtained due to the design of the anchor shoe, block or fabrication, the position in which it is placed, the pressure of the cement grout or the shape of the undercut of the hole according to the physical properties of the mass being retained, and the fact that the rods or cables are free to elongate within the cement in order that post-stressing after the cement has set can be applied or allowed so that the cement covering the rods or cables functions as a compression pile which increases the stability of the system.

It will be apparent that any suitable type of grout may be employed in the place of cement grout, for example a synthetic plastics material grout.

WHAT WE CLAIM IS:—

1. A cutter bit including an outer tubular body, an inner bar axially slidably received in the tubular body, said inner bar having at least two axially extending slots longitudinally spaced apart, said tubular body having at least two pairs of diametrically opposed, axially extending slots respectively registering with the slots in the inner bar, and a cutter blade within each slot in the inner bar, each blade having a width not substantially less than the diameter of the outer body thereby the longitudinal side edges of the blades lie within the slots in the tubular body said blades being pivotally mounted to the tubular body one at one side and the other at the other side thereof and opposed side faces of the blades abutting longitudinal side faces of the slots in the tubular body and inner bar.

2. A cutter bit according to claim 1 wherein the blades are attached at corresponding ends to the outer tubular body.

3. A cutter bit according to claim 2 wherein a cam face for each blade, is formed at the end of the slot in the inner bar, which end is adjacent to the pivoted end of the respective cutter blade and a cam follower engageable by the respective cam face is formed on each blade adjacent to its pivoted end.

4. A cutter bit according to any preceding claim, wherein there is provided means to cause relative axial displacement between the outer tubular body and inner bar.

5. A cutter bit according to claim 4, wherein

the mass in the zone supported by the piling.

In the case where the mass of material is such that the hole has to be maintained throughout the hole boring operation, the boring is carried out by a rotary flight auger which is arranged to be equalled or followed by a lining tube at a similar feed rate, the tube having a head with a cutting edge or suitable inserts and being rotated or oscillated to facilitate passage through the material. When the predetermined depth of hole is reached the flight auger is withdrawn and the anchor shoe with its associated covered rod is then inserted and the grouting operation commenced.

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It will be readily appreciated that one or more covered rods may be employed or alternatively one or more covered cables, depending upon the mass conditions and anchorage requirements.

The rods or cables will be covered by coating or wrapping processes, the material of the covering always being of the type which does not bond with the surrounding cement so as to allow rod or cable elongation freely as and when required. The thickness and type of the covering is variable according to the purpose of the anchorage i.e. temporary or permanent.

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It is considered that the method of anchorage according to the present invention has the advantage that a maximum anchorage is obtained due to the design of the anchor shoe, block or fabrication, the position in which it is placed, the pressure of the cement grout or the shape of the undercut of the hole according to the physical properties of the mass being retained, and the fact that the rods or cables are free to elongate within the cement in order that post-stressing after the cement has set can be applied or allowed so that the cement covering the rods or cables functions as a compression pile which increases the stability of the system.

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2. A cutter bit according to claim 1 wherein the blades are attached at corresponding ends to the outer tubular body.

3. A cutter bit according to claim 2 wherein a cam face for each blade, is formed at the end of the slot in the inner bar, which end is adjacent to the pivoted end of the respective cutter blade and a cam follower engageable by the respective cam face is formed on each blade adjacent to its pivoted end.

4. A cutter bit according to any preceding claim, wherein there is provided means to cause relative axial displacement between the outer tubular body and inner bar.

5. A cutter bit according to claim 4, wherein

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the means to cause said axial displacement includes means at one end of the cutter bit for effecting relative movement of the relatively movable parts when the said end of the cutter bit is pressed against the bottom of a hole to be undercut.

6. A cutter bit according to claim 5, wherein the means for effecting relative movement comprises a solid head mounted on the remainder of the cutter bit through the intermediary of a ball-race.

7. A cutter bit according to any preceding claim, wherein conduit means are provided in the cutter bit for enabling a fluid to be passed into the vicinity of the cutter means during operation of the cutter bit in order to prevent clogging thereof.

8. A cutter bit substantially as hereinbefore described with reference to Figs. 1, 2 and 3 or Figs. 2 and 4 or Figs. 2 and 5 of the accompanying drawings.

9. A method of anchoring a structure which retains a mass such as soil, clay, rock or the like, comprising the steps of forming an elongated hole in the mass, underreaming the hole by means of a cutter bit as claimed in any one of claims 1 to 8, passing an anchor shoe or the like along the hole to a postion in which the anchor shoe or the like lies beyond the predetermined plane of rupture of the mass, said anchor shoe or the like having one or more covered rods or cables secured thereto for attachment to the retaining structure, passing a grout along the hole to form a securement for the anchor shoe or the like prior or subsequent to the passage of the latter along the elongated hole, filling the hole with grout, the covering on said rods or cables being of the type which does not bond with the grout so as to allow movement of the one or more rods or cables relative thereto, and attaching the one or more rods or cables to the retaining structure.

10. A method of anchoring substantially as hereinbefore described with reference to the accompanying drawings.

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