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UNDERPINNING SYSTEM AND METHOD OF CONSTRUCTING SAME

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2 Sheets-Sheet 2

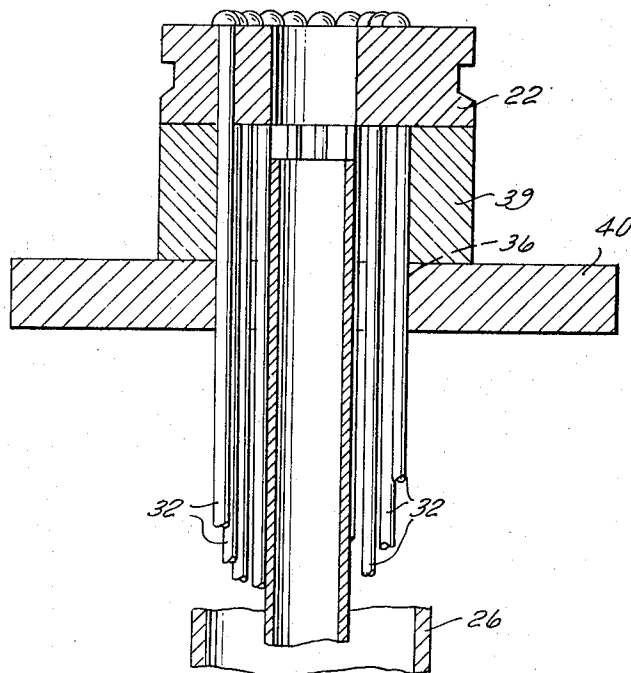


FIG. 4

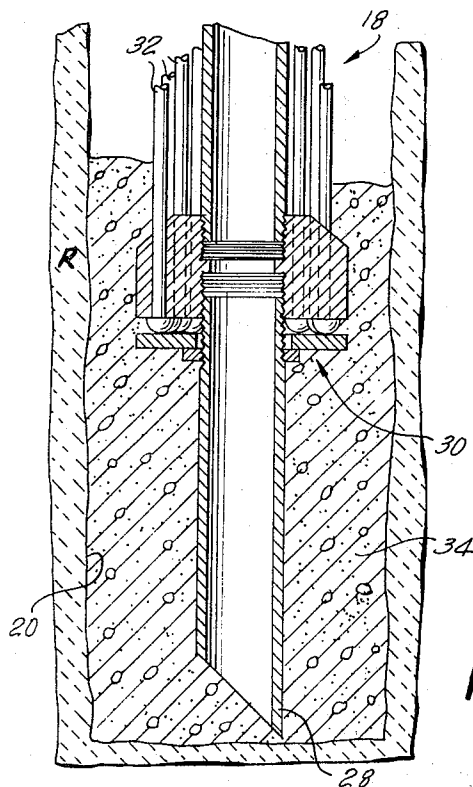


FIG. 5

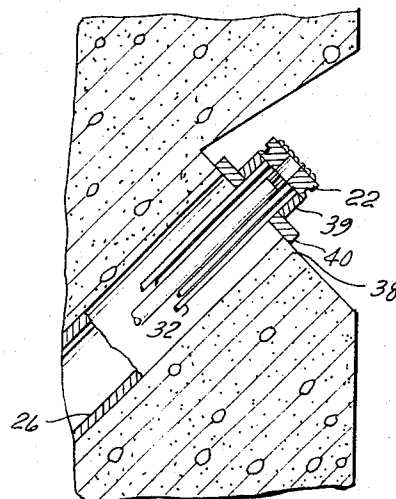


FIG. 6

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UNDERPINNING SYSTEM AND METHOD OF CONSTRUCTING SAME

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4 Claims. (Cl. 61—51)

This invention relates to an underpinning system and to a method of forming such a system, and this application is a continuation-in-part of my copending application, Serial No. 96,980, filed March 20, 1961, now Patent No. 3,226,933.

In the construction of large buildings and other such structures, it is generally necessary to excavate to a substantial depth to permit large foundations and/or the below ground level portion of the building or structure to be constructed. When excavations are made in normal types of earth such as sand, clay, gravel or combinations of these (as is usually the case), the banks of the excavated area tend to shear off along sloping planes of rupture, the exact angle of slope being dependent upon the nature and composition of the excavated material. In my copending application, Serial No. 96,980, filed March 20, 1961, a method and structure are disclosed which eliminate the necessity for bracing within the excavated area.

In the drawings:

FIGURE 1 is a sectional view along lines 1—1 of FIGURE 2 of an underpinning wall system with a tie-back construction;

FIGURE 2 is a view of the underpinning wall of FIGURE 1 along lines 2—2 of FIGURE 1;

FIGURE 3a is a sectional view of a rock socket with a mechanical type of anchor therein;

FIGURE 3b is a view similar to FIGURE 3a with a grouted anchor;

FIGURE 3c is a view similar to FIGURE 3a with still another type of grouted anchor;

FIGURE 3d is a view similar to FIGURE 3a with still another type of grouted anchor;

FIGURE 4 is a sectional view of an embodiment of an anchor head for holding a tie-back which is comprised of several wires of high tensile strength;

FIGURE 5 is a sectional view of a rock anchor for the tie-backs of FIGURE 4; and

FIGURE 6 is a fragmentary sectional view of the anchor head and pier arrangement.

The general method of construction of the present invention may best be understood by referring to my copending application wherein a complete sheeting wall is shown and described, the wall being constructed without the necessity of internal braces. However, the present invention is particularly applicable to the underpinning of adjacent structures during excavation operations.

Since the present invention is preferably used where there is a rock layer R not too far below ground level, the underpinning piers beneath the existing structure are first prepared and seated on the rock layer R.

With the piers in place, a series of casings or pipes are then driven into the soil, each casing being oriented at an angle of about 45° with the horizontal. The casings are placed by any conventional means such as jetting, drilling, etc., until the driving end of the casing becomes seated on the rock layer R.

With the casings seated on the rock layer, rock sockets are drilled in the layer R, each socket being substantially in line and extensive from the end of the casing. These sockets may be drilled by any suitable means, such as percussion, rotary or diamond drills which are well known in the art.

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With the sockets prepared anchors are then placed therein with high strength tendons attached thereto. Grout is next introduced into the rock sockets and the anchors are fixed in place. The grout is permitted sufficient time to set and harden, about three days or longer, before any considerable load is put on the tendons. To insure proper anchorage, a test load, substantially greater than the final load, is first placed on the tendons before final post-tensioning. For example, where a load of 133,000 pounds is to be finally placed on a tendon, an initial load of 200,000 pounds is first applied for about ten minutes before the load is reduced to 133,000.

If desired, mechanical anchors, such as cone type wedges, may be used in place of the grouted anchors. Such mechanical anchors are usually more expensive than the grouted type and in some cases they may take longer to place.

Since the present invention does not require any external bracing or support outside the structure line, this is particularly advantageous in a case where a building or a similar structure is to be built on a limited plot of land in a crowded city or industrial area. If the building is to abut against existing structures, care must be taken to insure that such structures are not disturbed by the excavation.

As shown in FIGURES 1 and 2, an existing structure 10 is adjacent to a new building 12 which is to extend below the elevation of the structure 10. Beneath the bottom of the footings 14 of the existing structure 10, a series of underpinning piers 16 are placed. These piers 16 rest on the rock layer R in much the same manner as soldier beams and downwardly inclined holes 27 are formed in the piers 16.

The piers 16 are held in place by means of a series of tendons 18. Each tendon 18 is anchored in a rock socket 20 by a suitable anchor and also connected to an anchor head 22 mounted on a recess in the face of the pier 16. Each tendon 18 is elongated and post-tensioned after it is in place.

If desired, sheeting 24 is provided between the piers 16 to hold back the overburden beneath the existing structure 10; or a continuous underpinning wall may be provided eliminating the necessity of sheeting between the piers, as in the case of the three piers 16 of the left-hand side of FIGURE 2.

With the present invention the driven tie-backs or tendons advantageously leave the area to be excavated for a new adjacent structure substantially clear and no unnecessary loss of building space need occur.

The tie-backs or tendons 18 may be composed of a number of high tensile strength wires or strands or a single high tensile strength rod or cable. When a number of wires are to be used, the tie-back may be of the type shown in FIGURES 4 and 5.

Referring to FIGURES 4 and 5, after the piers 16 are in place, a casing 26 is inserted downwardly and inwardly at an angle of about 45° through the holes 27 in the pier 16 and a rock socket 20 is drilled; a grout pipe 28 with an anchor 30 mounted near the end thereof is placed in the casing. Attached to the anchor 30 is a series of high tensile strength wires 32. The grout pipe 28 is extended to the bottom of the rock socket 20 and the anchor 30 and wires 32 are carried along with it. For convenience in installation, the grout pipe 30 may be in lengths of twenty feet, each length being connected to the preceding one as required.

Water is flushed through the pipe 28, which has an angularly cut end or any other suitable construction which permits ease in placing the grout, until the water runs from the top of the casing 26 or the hole 27, in a clear condition free of dirt. The supply of water is then shut off and the water in the casing and socket is allowed to

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settle and seek its own level. In some cases the use of water may not be necessary and it will be sufficient to use high pressure air which may be blown into the socket.

Grout 34 is then pumped through the grout pipe 28 and into the rock socket 20. The amount of grout 34 used for each tie-back should be sufficient to fill the rock socket 20, the grout pipe 28 and about 2 to 4 feet of the casing 26 above the rock socket 20. By placing at least this amount of grout in the socket 20, pipe 28 and casing 26, the anchor 30 is firmly and securely held in place.

The grout is allowed to set until the desired minimum strength is obtained before the wires 32, which had been drawn taut before grouting, are post-tensioned. The post-tensioning is accomplished by jacking the wires 32 against the pier 16.

As shown in FIGURES 4 and 6, a steel bearing plate 40 having a center hole 36 is placed on the inclined surface of a recess 38 cast in the exposed face of the pier 16 to permit the wires 32 and the grout pipe 28 to be inserted through the hole in the center of plate 40. The plate 40 is advantageously positioned so that it is normal to the line on which the casings 26 are driven and may serve as a bearing member to distribute the reaction against the tensile force of the wires 32 over the inclined face of the recess 38.

In jacking the wires 32, the anchor head 22 is drawn away from the pier 16 until a load in excess of the final post-tension load is achieved. This excess load is held for about ten minutes and then the load is reduced to the desired amount. At this time the anchor head 22 will be spaced from the pier since elongation of the wires 32 takes place during the loading operation. In order to maintain the elongation (and the accompanying developed load on the wires 32), spacer plates 39 are inserted between the anchor head 22 and the bearing plate 40 resting on the pier 16.

In the prior art where braces are used to shore up underpinning piers, particularly adjacent an excavated area, the braces are in compression while, in contrast, the tendons of the present invention are in tension. Since higher design stresses are permitted with tension members than with compression members, the size of the tendons is reduced compared to a brace which carries the same equivalent load as the tendon. In addition, long braces must be supported by secondary bracing or the design load must be sharply reduced. Accordingly, the present invention not only aids the builder during construction, but it also assists the designer by allowing him greater latitude since the allowable stresses are greater. In addition, the temporary underpinning support may be made into a permanent structure.

Various types of anchors will occur to those skilled in the art. In FIGURES 3a-d, four types of anchors are shown.

In FIGURE 3a, a mechanical anchor 42 is illustrated which is comprised of a cone and wedge combination of the expansion type. In this embodiment the rock socket has an oversize lower section 44 which is carefully drilled and underreamed. The anchor 42 is affixed to the tendon 18 and inserted into the lower section 44. The anchor 42 is comprised of a cone 46 fitted into split wedges 48 which mate with the surface of the cone 46. When tension is applied to the tendon 18, the cone 46 spreads the wedges apart and presses them into tight locking engagement with the walls of the lower socket section 44. The time to drill the section 44 and the cost of the cone and wedge

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combination have to be carefully considered before using this type of anchor in place of a grouted anchor.

Some additional grouted anchors are shown in FIGURES 3b, c and d. In FIGURE 3b a simple series of parallel strands 49 are shown.

In FIGURE 3c a series of wire tendons 50 are shown which are woven under and over a series of rings 52. The open structure about the rings provides very high holding power when the rock socket is filled with grout.

In FIGURE 3d a series of wire tendons 54 are shown which have been twisted together to provide additional bond surface and added holding power.

In addition to these anchors others such as buttons and nut and washer combinations may also be used.

The tendons may also be of various kinds. Besides solid rods and wires the tendons may be of strand, i.e., a series of wires helically twisted or of cable.

It is to be understood that the embodiments shown are illustrative of the present invention and are not to be a limitation thereof as other embodiments will occur to those skilled in the art which will be within the scope of the accompanying claims.

I claim:

1. An underpinning pier system for supporting undisturbed and in place a structure located above a rock layer, said system comprising a supporting pier positioned beneath and supporting the structure and extending to the rock layer, connecting means extending from the pier downwardly at an angle from the pier to the rock layer and inwardly beneath the structure, a rock socket drilled into the rock layer and a post-tensioned tendon extending through the connecting means, said tendon anchored in the rock socket and joined to the pier whereby the pier is stabilized and held against overturning when the area adjacent to the pier and the structure is excavated.

2. An underpinning pier system as defined in claim 1 and further including anchor means mounted on the pier and connected to the post-tensioned tendon.

3. An underpinning pier system as defined in claim 2 wherein said anchor means includes a bearing plate mounted on the pier and lying in a plane substantially normal to the axial plane along the extent of the post-tensioned tendon.

4. A method of underpinning an existing structure located above a rock layer comprising erecting an underpinning pier under said structure and extending downwardly to and in engagement with the rock layer, inserting connecting means from said pier downwardly and at an angle to said rock layer, preparing rock sockets in the rock layer adjacent the connecting means, setting anchors in the rock sockets, connecting tendons from said anchors to the underpinning pier through said connecting means, and post-tensioning said tendons whereby the underpinning pier is held in place without any bracing on the side opposite the rock anchors.

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