ABSTRACT OF THE DISCLOSURE

A soil retaining structure and method of forming same adapted for use in preventing lateral sliding of a ground formation adjacent an excavation, which structure includes a plurality of spaced apart, long, slender pile elements arranged in a three-dimensional network.

It happens quite often that new underground tunnels have to pass in close vicinity of existing structures. It becomes, therefore, of great importance to prevent the slightest loosening of the ground which surrounds the foundations of the concerned structures and provide for their protection.

For this purpose, grouting techniques have been extensively used, though the results obtained have not always appeared to be very satisfactory. In fact, the efficiency of this method is usually of difficult preliminary valuation and in certain circumstances, in soil formations of low permeability, may even be completely inadequate; quite often, when the grout runs out of control by invading outside areas, this method may lead to unforeseen failures.

Thus, it is an object of the present invention to make available to the construction industry a new procedure which will achieve reliable protection of the foundations of structures which are in close proximity of excavations to be executed.

The procedure according to the invention consists of placing into the ground, in the vicinity and along the foundations of existing structures to be protected, a three-dimensional "network" formed by resisting small sized piles distributed in various directions. The individual pile elements may be preformed and either driven directly into the subsoil or placed within pre-bored holes. Alternatively, the pile elements may be concrete cast in situ with care being taken to prevent spreading of concrete beyond the confines of a previously prepared bore hole. By forming the "network" with well defined pile elements, there is less likelihood of producing undesirable fractures within the subsoil.

The pattern and the number of piles contained in the "network" will depend upon the nature of the soil-formations, the size of the excavations, the distance of the nearby existing structures, their particular conditions and so on. The "network" of piles functions to trap the ground meshed therein so as to create a subsurface soil-pile gravity or retaining wall between an excavation and the foundation of the structure to be protected. Presence of the subsurface retaining wall has been found to effectively prevent loosening of soil beneath the foundation of an existing aboveground structure which otherwise would be experienced due to the natural tendency of such subsoll to slide horizontally or downwardly toward the excavation.

Preferably, the network of piles is created prior to starting an excavation or tunnelling operation. However, the invention also has utility in preventing further deterioration of subsoil conditions adjacent existing excavations or to prevent landslides adjacent naturally occurring depressions or cavities in the ground.

A schematic drawing, without limiting the present invention, is given in table I to illustrate the above described procedure.

FIG. 1 represents the vertical section of the three-dimensional network structure in close vicinity of the building to be protected and the future underground tunnel. FIG. 2 represents the top view. The letters have the following meanings:

E = existing building
N = street level
P = connecting beam
S = three-dimensional network
T = underground tunnel to be built
a,a',b,b',c,c',d,d',e,e' = piles forming the three-dimensional network.

FIG. 1 clearly shows that the construction of the underground tunnel T in close vicinity of the building E might have endangered its stability without the previous strengthening of the ground located between the building and the tunnel by means of the three-dimensional network S which, therefore, acts as a retaining wall with respect to the ground situated under the foundations of the building.

The small size piles a,b,c,d,e' will be usually placed into the ground either by percussion or rotary methods. In certain particularly subsoil conditions, when the waterproofing of the boreholes is required, the rotary method will be applied using special drilling muds consisting of bentonite, clay, cements, etc. Any spread-out of water through the boreholes into the surrounding ground is thus practically avoided during either the drilling or the concreting. In fractured formations, special additives may be added to the drilling muds to increase their plugging efficiency.

During the drilling, a casing tube will be progressively driven into the borehole for its entire length, to avoid any caving-in.

When the casing has reached the desired depth a steel bar will be placed and the concreting through the casing will follow. A special device, if needed, will be used for the concreting under pressure. During the concreting the casing will be progressively withdrawn.

The above said retaining structure can also be used for landslide protection.

The piles a,a',b,b',c,c',d,d',e,e' of the retaining structure S may also consist of precast concrete elements placed into the ground by percussion or into previously drilled boreholes.

Such operation may be completed by a partial or total grouting before, during or after the placing of the elements themselves.

The precast concrete elements may also be replaced by wooden, iron or other elements. While the present invention has been particularly described with reference to excavations, such as tunnels, occurring adjacent to an existing buildings, I wish to be not so limited. Accordingly, in the appended claims I have used the more generic term cavity to include not only exposed and subsurface excavations, such as tunnels, but naturally occurring holes in the ground.

What is claimed is:

1. A method of forming a laterally supporting retaining wall imbedded in a subsoil adapted to prevent loosening and lateral displacement of subsoil including the steps of: imbedding a plurality of relatively spaced apart generally vertically extending pile elements within said subsoil, positioning said pile elements in a plurality of planes to form a three-dimensional network of pile elements, posi-
tioning at least some of the pile elements of said network inclined vertically with respect to other pile elements, and enmeshing subsoil among the piles of said network for laterally supporting the subsoil against lateral displacement thereof.

2. A method according to claim 1, wherein the step of imbedding a plurality of relatively spaced apart generally vertically extending pile elements within said subsoil further includes the step of forming a plurality of preformed pile elements into said subsoil.

3. A method according to claim 1, wherein the step of imbedding a plurality of relatively spaced apart generally vertically extending pile elements within said subsoil further includes the steps of forming bore holes in said subsoil, and casting said pile elements in situ within said bore holes.

4. A method according to claim 3, wherein the step of forming bore holes in said subsoil further includes the step of sealing the side walls of said bore holes during formation thereof to prevent passage of fluid therethrough prior to casting in situ.

5. A method according to claim 3, wherein the step of forming bore holes in said subsoil further includes the steps of providing casing tubes in said bore holes for strengthening the side walls during formation thereof, and progressively withdrawing said casing tubes during casting in situ.

6. A laterally supporting retaining wall adapted to prevent loosening of subsoil comprising: a plurality of relatively spaced apart pile elements imbedded in the subsoil, at least some of said pile elements being located in a plurality of planes to form a network of pile elements, at least some of said pile elements being vertically inclined with respect to other adjacent pile elements, and subsoil enmeshed in said network of piles, said network of piles cooperating with said subsoil enmeshed therein to define said laterally supporting retaining wall.

7. The structure according to claim 6, wherein said pile elements are formed of material chosen from the group including precast concrete, wood, and steel.

8. The structure according to claim 6, wherein said pile elements comprise concrete cast in situ.

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U.S. Cl. X.R.

61—42, 50, 53.52