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Turzillo

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[54] **MEANS FOR STABILIZING STRUCTURAL LAYER OVERLYING EARTH MATERIALS IN SITU**

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Related U.S. Application Data

[62] Division of Ser. No. 15,355, March 2, 1970, which is a division of Ser. No. 755,273, Aug. 26, 1968.

[52] **U.S. Cl.** **61/63,** 61/35, 61/53.64, 175/292, 175/394, 259/145

[51] **Int. Cl.** **E02d 27/48**

[58] **Field of Search** 61/53.5, 53.64, 63, 35; 175/394, 292; 259/145

[56] **References Cited**

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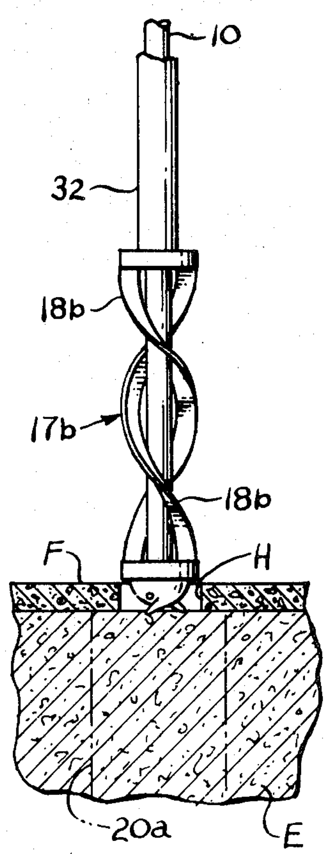
[57] **ABSTRACT**

Method and means for providing solid columnar support under structural layer, overlying earth materials of an earth situs. Expansible agitator means projected through relatively small diameter hole in overlying layer and expanded to agitate and loosen earth materials to define elongated body thereof of greater peripheral size than hole. Self-hardenable fluid pumped through hole into loosened earth, is allowed to harden after removal of contracted agitator means through small hole. Resultant rigid, composite column underlies area of structural layer surrounding hole for the solid support of same.

3 Claims, 8 Drawing Figures



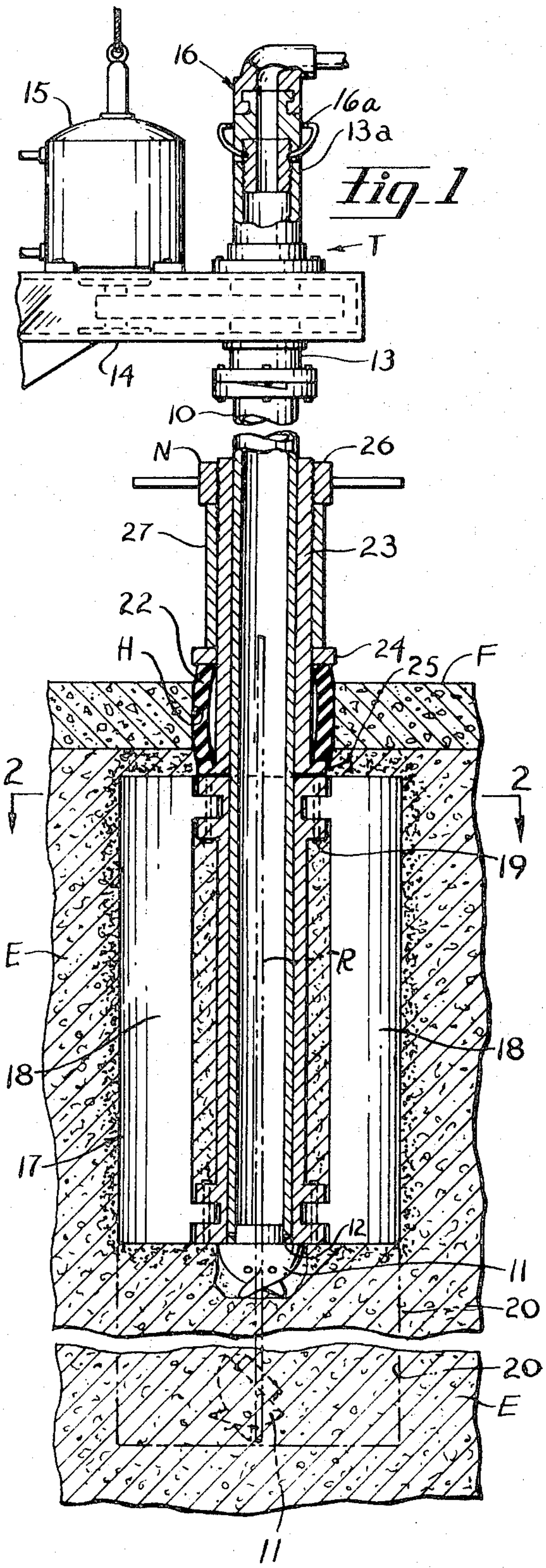


Fig. 1

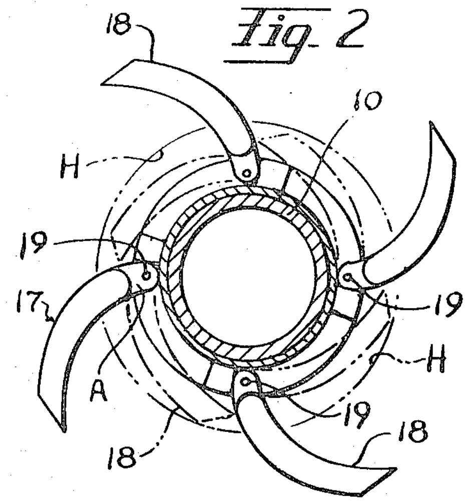


Fig. 2

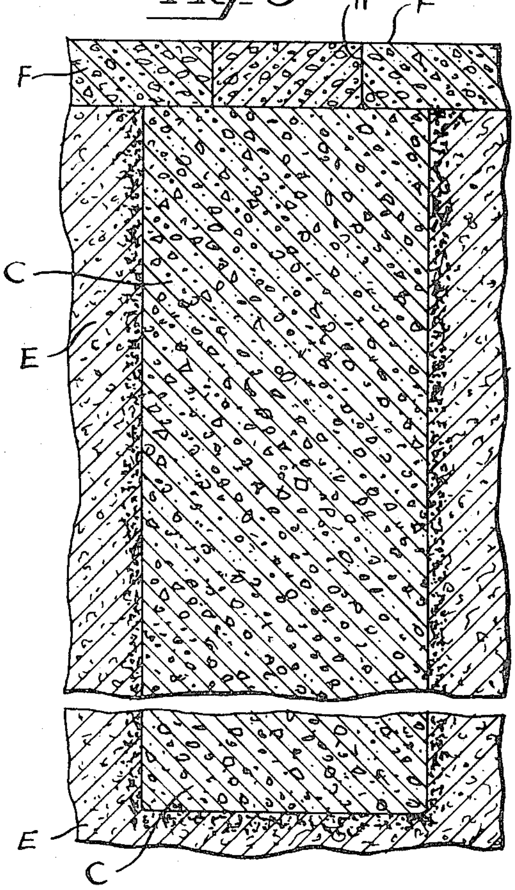


Fig. 3

Fig. 4

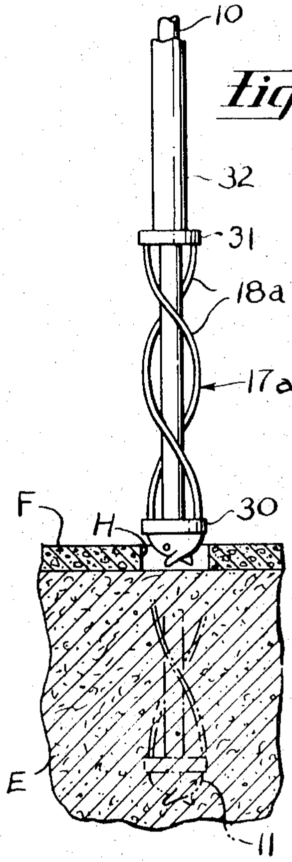


Fig. 5

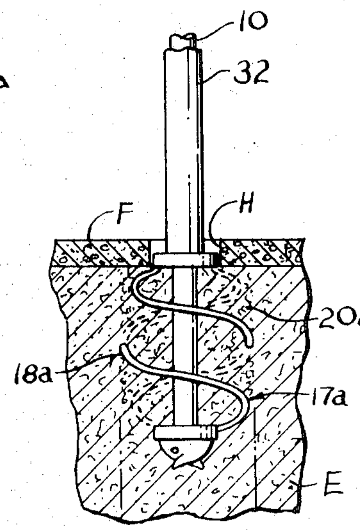


Fig. 6

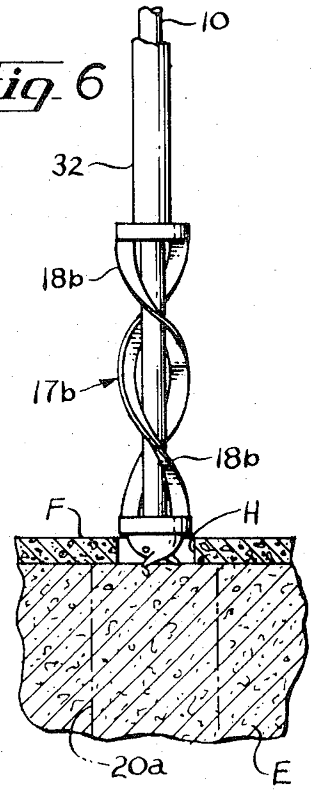


Fig. 7

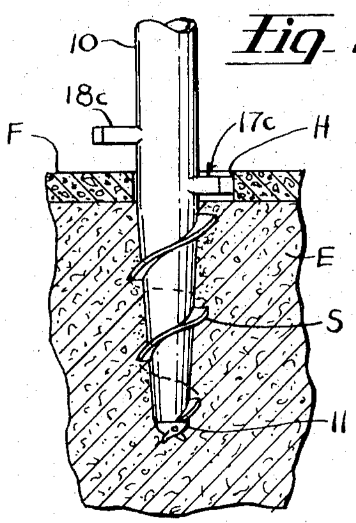
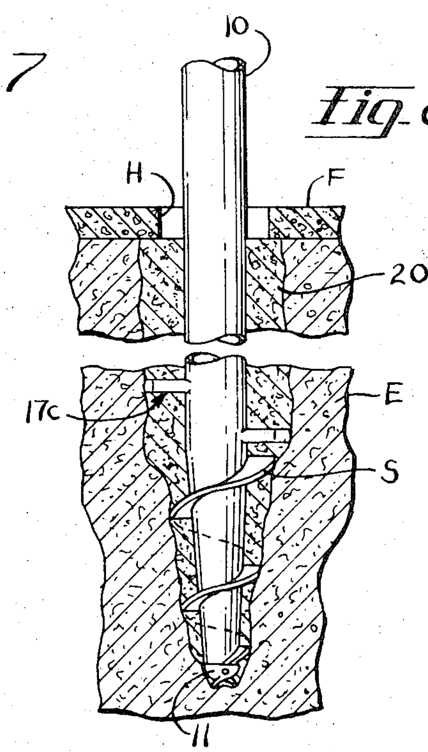


Fig. 8



MEANS FOR STABILIZING STRUCTURAL LAYER OVERLYING EARTH MATERIALS IN SITU

This is a divisional application Ser. No. 15,355, filed Mar. 2, 1970, which in turn was divided out of application now of United States application Ser. No. 755,273, filed August 26, 1968.

BACKGROUND OF INVENTION

Heretofore a number of methods and means have been available for stabilizing porous earth means in situ. The known related methods, however, have had limited uses and/or limited results for various reasons. Some of these methods are in the class of so-called chemical grouting, in which porous earth materials, such as sandy soil, have chemicals injected into the same to make the same less migrant for excavation purposes. Other methods were utilized to force hardenable fluids into the subsoil to fill cavities, voids, and pores existing or created in the same, so that only unpredictably limited areas of the subsoil could be depended upon for any substantial degree of increased load-bearing capacity.

In one known method of treating a porous earth situs, a pilot hole was drilled several feet into the earth, and cleared of loose material as by flushing with water. After forcing pressurized air into the hole to drive out the flushing water, hardenable fluid repair material was forced into voids in the region surrounding the hole. When this repair material hardened, the process was repeated until the subsoil was similarly treated to desired depth. In other words, only originally available voids were filled with repair material to form an irregular-shaped body of rather unpredictable load-bearing capacity, and the aforesaid pilot hole, drilled to the full depth of the formed irregular-shaped body, was required to be filled with filler material by a series of additional operations. Moreover, the last-mentioned method was impractical, if not unduly expensive, for providing a solid supporting column under a footer, floor, or the like, overlying an earth situs.

SUMMARY OF INVENTION

In use of the method and means of the present invention to provide a solid columnar support under a sagging concrete floor or like slab or layer over an earth situs, hole, smaller than the diameter of the required supporting column, is drilled in said slab. A boring tool provided with an expansible agitator means is then pushed through the hole and drilled into the earth below the slab. When the agitator means clears the slab, it is expanded, so that with requisite rotation of the tool the earth is loosened and thoroughly agitated to a requisite extent below the slab, to define a generally cylindrical-shaped body of loose earth, the operation being aided by outward compaction of the solid by the rotated agitator means.

Hydraulic self-hardenable cement mortar or chemical mortar, under pressure, is now pumped through a passage in the tool shaft to mix thoroughly with the loosened earth. Before the mortar hardens, however, the agitator means is contracted to allow removal of the boring tool through the small slab opening. Upon hardening of the mixture of mortar and earth, the cylindrical body thereof overlying the hole in the slab will support the slab, with or without elevating the slab, depending upon the requirements. The hole in the slab can be filled in with concrete if desired.

A general object of the present invention is to provide improved method and means for providing a solid columnar support under sagging floor or like slab overlying earth of a situs, without necessarily requiring use of conventional heavy drilling and pile-forming equipment, and whereby the cost of the operation will be relatively low and the need for total or substantial replacement of sagging slabs can be avoided.

Other objects of the invention will be manifest from the following brief description and the accompanying drawings.

Of the accompanying drawings:

FIG. **1** is a fragmentary vertical cross-section, partly broken away, illustrating improved means for providing solid columnar support in an earth situs, under a floor or like slab overlying earth materials of the situs.

FIG. **2** is a horizontal cross-section taken substantially on the line **2—2** of FIG. **1**, but with the drilling tool apart from the situs.

FIG. **3** is a fragmentary vertical cross-section corresponding to FIG. **1**, but illustrating the completed columnar support provided in the situs by the method of the invention.

FIG. **4** is a view corresponding in part of FIG. **1**, but illustrating use of a modified form of earth agitating means for practicing the method of the invention, in an initial step of the method.

FIG. **5** is a view corresponding to FIG. **4**, but illustrating use of the agitating means in a more advanced stage of the method.

FIG. **6** is a view corresponding to FIG. **5**, but illustrating use of another form of expansible agitator means for use in the method.

FIG. **7** is a view corresponding generally to FIGS. **4** and **6** but illustrating initial step in the method for use of further modified form of agitator means.

FIG. **8** is a view corresponding to FIG. **7** but illustrating a further advanced step in the method performed by the agitator means.

Referring to FIGS. **1** and **2** of the drawings, there is illustrated suitable apparatus for practicing the method of the present invention, as for providing reinforcing support for a sagging structural layer supported by earth E of a situs, such as a concrete floor or slab F. As shown in FIG. **1**, the improved apparatus may include a tool T including an elongated hollow metal shaft **10**, provided with an apertured closure member **11**, which may be in the form of a drill bit of known type, releasably affixed on the inner end of the shaft, as by means of break-away pins **12**. Shaft **10** may be of a single length of tubing, or of a plurality of sections thereof coupled together in known manner. In any event, the shaft **10** may be mounted for rotation in a number of ways, such as by affixing the shaft at its upper end to a connector **13** rotatably mounted in a carriage **14** of a known form of drilling rig (not shown), for rotation by a hydraulically, electrically, or air operable motor **15.** An upward extension **13*a*** of rotatable connector **13** may have thereon a removable swivel connector **16** communicating with suitable source of fluid hydraulic cement mortar or other self-hardenable cementitious material, such as chemical mortar, under pressure. The swivel connector **16** is removable from the extension **13a**, for disconnecting the latter from said source, as well as for inserting reinforcing devices down the hollow shaft **10** in practice of the method to be described later.

Suitably mounted on the lower end of the shaft **10**, may be expansible and retractable agitator means **17**, such as a plurality of radially outwardly curvate blades **18** each pivoted about an axis **19** to swing between a stopped, expanded condition shown in full lines in FIGS. **1** and **2** in which there is a space A, of substantial flow area between the inner edge of the blade and rod **10**, and contracted condition thereof shown in chain-dotted lines in FIG. **2.** In said contracted condition, the lower end of the clockwise rotating rod **10** with agitator means **17** thereon is readily insertable downwardly through the hole H in slab F, and into the earth below the slab. Reverse rotation against the earth materials, however, causes the blades to expand outwardly due to resistence of the earth materials against concave inner portions of the blades, and continued reverse rotation is effective to cause the blades to agitate and loosen the earth materials to define a cylindrical body **20** thereof of greater transverse cross-section than that of hole H, as indicated by chain-dotted lines in FIG. **1.** The length or depth of body **20** is determined by the total stroke of axial movement or reciprocation of the agitator means **17** below slab F. The requisite loosening action of the earth is aided by impaction of the soil radially beyond the circular path of the ends of the blades **18.** Free movement of the loosened earth materials in either direction is, in any event, facilitated by provision of the aforementioned spaces A between the blades and shaft **10.**

After formation of the earth body **20**, the churning action of the expanded blades **18** may be utilized to mix in fluid cementitious material, such as self-hardenable hydraulic cement or chemical mortar, pumped through swivel **16**, shaft **10**, and the apertured closure or drill bit **11.** The pressurized fluid material may be retained below slab F by radially outward expansion of a rubber sleeve **22** against the wall of the hole H. For this purpose, the rubber sleeve **22** is retained on a metal tube **23**, axially slidably mounted on shaft **10**, between relatively movable and fixed stop rings **24** and **25** on tube **23**, respectively. A nut **26** threaded on metal tube **23**, is selectively rotatable against a metal sleeve **27** on tube **23**, axially to compress the rubber sleeve for said radial expansion thereof. While mixture of mortar and earth of the formed cylindrical body thereof is still fluid, the nut **26** is backed away to permit removal of the tool with agitator means **17**, in collapsed condition, through the hole H.

In use of the apparatus described in connection with FIGS. **1** and **2**, to form a hardened columnar support C beneath the concrete slab F, as shown in FIG. **3**, the steps of the method may be as follows:

First, a hole H is drilled in the floor, slab or surface layer F, to be of smaller diameter than that of the required column to be formed under the same, then the carriage **14** of a drilling rig (not shown) is moved to pass the rotating rod **10**, with the contracted agitator means **17** thereon, downwardly through the hole H, until all of the agitator means is worked within the earth beneath the slab. At this point, the rubber sleeve **27**, may be expanded to seal the hole H, as shown in FIG. **1**, in which case the shaft **10** is freely rotatable and axially shiftable within the now fixedly positioned metal tube **27.**

Now, with the agitator means **17** so positioned in the earth E, the direction of rotation of the shaft **10** is reversed to expand the blades **18**, as shown in full lines in FIGS. **1** and **2**, by pressure of the earth against the concave inner sides of the blades. Continued rotation of the agitator means, while reciprocating the shaft **10**, is effective to form a cylindrical body **20** of loosened earth to selective depth, as indicated in chain-dotted lines in FIG. **1**, and generally of diameter substantially greater than the opening H in slab F. The material of the body **20** will be more loose and porous than before due to compaction of soil into the surrounding earth.

After the body **20** of substantially loose and porous earth has been formed to required depth, indicated in chain-dotted lines in FIG. **1**, fluid, self-hardenable cementitious material, such as hydraulic cement mortar under pressure, is pumped through the swivel connector **16**, shaft **10**, and apertured drill bit **11**, into the loosened earth material of body **20** thereof formed by the agitator means. With continued rotation and vertical reciprocation of the expanded agitator means **17**, as described above, the fluid mortar is thereby thoroughly mixed with the loosened earth materials into a fluid, self-hardenable mass. While this mass is still fluid, the shaft, **10** may be elevated with the agitator means in contracted condition thereon, to withdraw the same through the small hole H in slab F. Because the fluid is supplied under pressure, the intruded body **20** may be extended to raise and/or level the slab F.

Prior to such withdrawal of the agitator means, however, rigid reinforcing devices, such as one or more elongated rigid reinforcing elements R, may be projected downwardly through the shaft **10** to knock out the bit or closure member **11.** The swivel connector **16** is adapted to be temporarily disconnected from shaft extension **13***a* for this purpose, as described above. After the reinforcing device or elements R have been so positioned, the aforesaid additional pumping of fluid into the intruded body **20** is accomplished if or as necessary to elevate the slab P.

Upon hardening of the concrete body **20**, it forms a solid cylindrical concrete column or pile C, the upper end of which overlies or spans the hole H to provide requisite strong support for the slab F, as shown in FIG. **3.** The hole H may be filled in with concrete to the upper level of the slab.

Referring to FIGS. **4** and **5**, there is illustrated a modified form of agitator means **17***a* mounted on shaft **10**, the same including a plurality of spiral elements **18***a* of strong spring steel wire, extended between a relatively fixed collar **30** at the lower end of shaft **10** and a relatively movable collar **31** non-rotatably carried by a sleeve **32** which is axially shiftable on shaft **10.** Sleeve **32** is axially shiftable, as by manual or other means, radially to expand or contract the spiral elements **18***a* with reference to said shaft as shown in FIGS. **5** and **4**, respectively. That is, in the above described practice of the method of the invention, the contracted agitator **17***a* is insertable through hole H, and then can be expanded and rotated with the shaft **10**, as shown in FIG. **5**, to form a cylindrical body **20***a* of loose earth, as before, with or without fluid sealing the hole H. The results are otherwise substantially as described above in connection with FIG. **3.**

FIG. **6** is a view corresponding to FIG. **4**, but showing a modified form of agitator means **17***b*, wherein the spiral blades **18***b* are of thin, flexible strips of flat springy metal, adapted radially to expand and contract, generally as illustrated in FIG. **5** and **4**, respectively.

FIG. **7** is a view corresponding to FIG. **4**, illustrating another modified form of agitator means **17***c*, including a tapered spiral screw S on the inner end of shaft **10**, adapted to pass through hole H in off-center relationship, progressively to pass axially staggered cutting teeth **18***c*, one at a time, until all of the cutting teeth are below slab F, for agitating and mixing the earth materials as before (see FIG. **5**). The use is otherwise generally as for the method described above in connection with FIGS. **1**, **2**, and **3**, the agitator means being removed through the hole H in the same progressive manner as described for insertion thereof.

In any of the methods described above the self-hardenable fluid material pumped into earth body **20** may be other than hydraulic cement mortar. For example, well-known chemical grouts may be pumped into the earth body **20** in proportions which produce very stiff gels from dilute, properly catalyzed, aqueous solutions.

Other modifications of the invention may be resorted to without departing from the spirit thereof or the scope of the appended claims.

What is claimed is:

1. Apparatus for providing reinforcing support for a structural layer overlying earth material of an earth situs comprising: a boring tool removably insertable through an opening in the structural layer; agitator means on said tool operable to agitate and loosen the earth material beneath the structural layer to define a body thereof of greater transverse cross-section than that of the opening, inwardly of said layer; and means for passage of pressurized self-hardenable cementitious material inwardly of the opening to mix with the loosened earth, for forming the body into a column adapted to harden and support the structural layer; and said agitator means being at least one spiral element expansible and contractable on the tool by changing the axial extent thereof on the tool.

2. Apparatus as in claim **1**, wherein said at least one spiral element is of springy metal.

3. Apparatus as in claim **1**, said agitator means including flexible spiral elements of springy material, and means reciprocable on said shaft to distend and extend the spiral elements axially of the shaft, and thereby correspondingly to change the effective diameter of the formed column.

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