An extraction/grouting device which includes a fluid conduit having a longitudinal extent and a cutting nozzle in fluid communication with the fluid conduit. The cutting nozzle provides an at least partially lateral spray relative to the longitudinal extent. At least one guide is connected to the fluid conduit.
SOIL EXTRACTION/GROUTING DEVICE
CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a non-provisional application based upon U.S. provisional patent application Ser. No. 60/687,943, entitled “SOIL EXTRACTION/GROUTING DEVICE”, filed Jun. 7, 2005.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a soil extraction/grouting device, and, more particularly, to a soil extraction/grouting device which can be used to improve the density/stability of soils, and which can thereby stabilize the soils and overlying structures and/or lift and stabilize a structure which has become unstable or has sunk because of underlying soil conditions.

[0004] 2. Description of the related art

[0005] It is often desirable to densify soils for the purpose of stabilizing the soils. Soft soils, such as sand and mixtures which include sand, are unstable and will often allow a structure to sink or crack due to lack of uniform support of the foundation.

[0006] One method of densifying soil is to pump a low slump cementitious or chemical grout into the ground through a pipe driven beforehand. If a cementitious grout is used, it is placed under a high pressure so that it compacts the soil as it displaces it. Chemical grouts on the other hand, typically increase a soil’s density by expanding or hardening in a porous soil after they are in place, but will not raise a structure.

[0007] The low slump technique, called compaction grouting, is used to raise a foundation, or a segment thereof if settlement has not been uniform. To do so, the grout pressure is increased and focused on the soils in direct support of the foundation. A difficulty with the procedure is that if the soil condition is not uniform, and few are, the grout tends to flow laterally in fingers through the most porous soil. When this is the case, a relatively large volume of material must often be placed at high pressures before there is adequate confinement to exert pressure within the targeted soil.

[0008] Another difficulty is that if the targeted soil is relatively dense, it will not be wholly penetrable. As a result, a particular area may not yield the profile desired to direct the maximum hydraulic force vertically. If for example, the strata permits only 20% penetration of the soil in direct support of a foundation, the grout pressure must be five times as great as would be required if the grout pressure could be fully directed on the soil directly beneath the foundation.

[0009] Piers and piles are known which systems are primarily used for residential and light commercial applications. Installations require engineers to design their installation, and building permits, because piers change the design function of the structure by raising the structures footings off the soil. The voids created beneath the footing allow water to accumulate and migrate under the footing compromising the load bearing capacities of unsupported areas. Jacking a structure with pilings or piers causes point loading of a foundation, a situation for which the foundation is not designed. This point loading often causes foundations to crack. Jacking systems are also often limited to concrete structures, and are not useable with most block, stone, and brick foundations. These systems require excavation to the depth of the footing for installation often with medium heavy duty equipment. The procedure requires days to install, disruption, slab removal, and is usually limited to concrete structures. Pier and pile loads are also much less than the structure itself could carry as designed, even if on competent soil.

[0010] Compaction grouting is known which process is most applicable to stabilization of fine grained soils and can also be used to raise structures which have settled. Its primary use is for soil densification and foundation raising. Due to the lack of lateral confinement, compaction grouting is generally not effective nearer than about 15 foot (4.6 m) of the surface or an unrestrained down slope. Although densification and raising are obtainable through compaction grouting, it is limited to a single soil condition, expensive, requiring extensive investigation, planning, engineering, and with varying results. It too has difficulty lifting masonry, brick or stone foundations due to the possibility of causing potential damage.

[0011] Known chemical grouts typically increase a soil’s density by expanding or hardening in a porous soil after they are in place, but will not raise a structure. Known methods/devices of densifying a soil by simply pumping grout into the soil has the disadvantages of being very dependent on the porosity of the soil, which can require very high grout pressure to produce an adequate hydraulic lift, and/or require a relatively large volume of grout material.

[0012] Other disadvantages of conventional methods are that the results, feasibility, pressure application, performance, duration, costs, difficulty, disruption, material consumptions, and grout volumes are dictated by soil conditions.

[0013] What is needed in the art is extraction/grouting device which can be used efficiently and effectively to provide support a variety of structures.

SUMMARY OF THE INVENTION

[0014] The present invention provides an extraction/grouting device which can be used efficiently and effectively to provide support for a variety of structures.

[0015] The invention comprises, in one form thereof, an extraction/grouting device which includes a fluid conduit having a longitudinal extent and a cutting nozzle in fluid communication with the fluid conduit. The cutting nozzle provides an at least partially lateral spray relative to the longitudinal extent. At least one guide is connected to the fluid conduit.

[0016] The invention comprises, in another form thereof, an extraction/grouting device which includes a fluid conduit having a longitudinal extent and a cutting nozzle in fluid communication with the fluid conduit. The cutting nozzle provides an at least partially lateral spray relative to the longitudinal extent. A backthruster nozzle is in fluid communication with the fluid conduit. The backthruster nozzle provides an at least partially longitudinal spray relative to the longitudinal extent.
The invention comprises, in yet another form thereof, a method of extraction and grouting, including the steps of: driving a casing terminated in a sacrificial point in a soil, the casing being in proximity to a structure; separating the casing from the sacrificial point by moving the casing upwardly from the sacrificial point; inserting an extraction/grouting device in the casing, the extraction/grouting device including a fluid conduit having a longitudinal extent, a cutting nozzle in fluid communication with the fluid conduit, the cutting nozzle providing an at least partially lateral spray relative to the longitudinal extent, and at least one guide connected to the fluid conduit; mechanically forming a cavity in the soil above the sacrificial point using the nozzle and a cutting fluid; and extracting an excavated soil from the cavity.

An advantage of the present invention is that it can be used to raise a structure.

Another advantage of the present invention is that it is not dependent on the porosity of the soil in which it is acting on.

Yet another advantage of the present invention is that it requires less grout pressure for the same amount of hydraulic lift, when compared to other methods/devices.

Yet another advantage of the present invention is that it requires less grout for the same amount of hydraulic lift, when compared to other methods/devices.

Yet another advantage of the present invention is that there is minimal disruption of surrounding soils and structures since is not required.

Yet another advantage of the present invention is that there is minimal duration of the extraction/grouting process since excavation starting from the soil surface is not required.

Yet another advantage of the present invention is that work can be performed from inside or outside of a particular structure.

Yet another advantage of the present invention is that all cutting fluids are generally confined to the discharge hose to minimize mess and cleanup.

Yet another advantage of the present invention is that installations are performed in ½ to ¼ the time of other methods/devices.

Yet another advantage is that other methods/devices often require primary, secondary, and tertiary grouting where the present invention does not.

Yet another advantage of the present invention is that the pipe and/or casing may also be left in place to expedite ongoing operations.

Yet another advantage of the present invention is that all soil types can be compacted to greater densities to increase anticipated greater load requirements.

Yet another advantage of the present invention is that grouts can be contained to specific locations keeping material volumes low, prices down, limited duration for installation, and faster results in densification and raising.

Yet another advantage of the present invention is that densification and raising results are predictable, particularly with structures in excess of 2 ½ inches in thickness.

Yet another advantage of the present invention is that, because of the grouts' containment, higher soil densities are achieved, with higher corresponding load lifting capabilities, which consequently allows a structure to function as designed.

Yet another advantage of the present invention is that the process/device according to the present invention can lift stone, brick, cinder block and other foundations, uniformly and without point loading as with pier or piles.

Yet another advantage of the present invention is that structures other than buildings, such as roads and pipelines, can be lifted.

Yet another advantage if the present invention is far less likely to cause lateral damage to surrounding structures or utilities than conventional methods devices due to the forces being directed more vertically, and not laterally.

Yet another advantage of the present invention is that lifting and other pressures are easily controlled and do not require extensive site investigation planning or soil analysis.

Yet another advantage of the present invention is that results, feasibility, pressure application, performance, duration, costs, difficulty, disruption, material consumptions, and grout volumes are not dictated by soil conditions.

Yet another advantage of the present invention is that it allows a user to dictate with predictable results because of the containment of a grout in a preconceived preconstructed location.

Yet another advantage of the present invention is that is it can be used in/around very loosely cohesive soils such as sandy and/or silty soils.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIGS. 1-7B are fragmentary and partially cross-sectional side views illustrating an embodiment of a device and method according to the present invention;
[0043] FIG. 8 is a cross-sectional view taken along section line 8-8 in FIG. 1;

[0044] FIGS. 9-14 are fragmentary and partially cross-sectional side views illustrating another embodiment of a device and method according to the present invention which can be used with a directional boring machine, or other drilling machine, to lift and support a road, for example;

[0045] FIGS. 15-20 are partially cross-sectional side views illustrating another embodiment of a device and method according to the present invention;

[0046] FIG. 21 is fragmentary side view of an embodiment of an extraction/grouting device used in FIGS. 16-19;

[0047] FIG. 22 is fragmentary perspective view of the device of FIG. 21;

[0048] FIGS. 23-25 are fragmentary and partially cross-sectional side views illustrating another embodiment of a device and method according to the present invention; and

[0049] FIGS. 26-27 are fragmentary and partially cross-sectional side views illustrating another embodiment of a method according to the present invention, wherein a pipeline can be lifted and supported.

[0050] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate one preferred embodiment of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[0051] Referring now to the drawings, and more particularly to FIG. 1, there is shown an compaction grouting, jet packer or extraction/grouting device 10 which generally includes a fluid conduit 12 having a longitudinal extent 14, a cutting nozzle 16 in fluid communication with fluid conduit 12, where cutting nozzle 16 provides an at least partially lateral spray 18 relative to longitudinal extent 14. At least one guide 20 is connected to fluid conduit 12. A backthruster nozzle 21 can be in fluid communication with fluid conduit 12, where backthruster nozzle 21 provides at least partially longitudinal spray 23 relative to longitudinal extent.

[0052] Extraction/grouting device 10 can densify soils 22 for the purpose of stabilizing the soil, particularly when the soil supports a structure 24. Referring to FIGS. 2-7B, the present invention can drive or drills a pipe or casing 26 with a sacrificial point 28 into the ground. Casing 26 is then retracted a distance from sacrificial point 28, which may be as little as a few inches for example, to open the end of pipe 26, by leaving sacrificial point 28 at the furthest drill point, to expose surrounding soil. If necessary when working with very loose soils such as sand, a pre-grouting can be performed in the scenario of FIG. 3 for example where a chemical grout is discharged down casing 26 to increase the cohesiveness of soil 22, which then allows extraction/grouting device 10 to create a cavity. A chemical grout, or grout of the contractor choosing, dependent upon the soil condition or desired results, is pumped through the casing into the soils, prior to set-up or following set-up, dependent upon material selection. Extraction/grouting device 10 is inserted into the casing and jets the cavity within the grouted soil mass. Alternatively, the method according to the present invention can pre-grout soil 22 after cavity 30 is formed using particularly fluid conduit 12 and nozzle 16 to inject the chemical grout. The pre-treating can include powdered clay, foam, and/or sodium silicate, for example.

[0053] Extraction/grouting device 10 can be inserted into pipe 26 to the vicinity just above sacrificial point 28. Water is pumped through fluid conduit 12, which can be a flexible hose and/or high pressure hose and/or pipe, or some combination thereof including appropriate couplings, connected to a source of water or other cutting fluid and a pump or air compressor (not shown). Cutting nozzle 16 can be a rotating nozzle that shoots radial spray 18, thereby eroding surrounding soils. Hose 12 is of a smaller diameter than pipe 26, and is directed in pipe 26 via at least one guide 20, so that debris soil and water 36 are forced up pipe 26 and into a discharge channel 38 and exiting through discharge outlet 40 and discharge hose 41, and the debris removal can be facilitated by backthruster nozzle 21. During the extraction operation a cap 42 at the top 44 of pipe 26 inhibits fluids from leaking out of the top of the pipe and raises or lowers jet packer 10 within pipe 26 thereby adjusting the height of the soil cavity 30.

[0054] Following this extraction process, compressed air can be forced through extraction/grouting device 10 to purge the remaining soil and water from cavity 30. After the packer is removed, a grout 46, such as a cementitious or other grout, is pumped into cavity 30 under pressure to densify the surrounding soils, and the increasing pressures and material volumes can raise a structure if necessary.

[0055] The present invention provides a device for and process of mechanically forming a wafer-like cavity 30 in a selected location within a soil to be compacted. Typically, this is performed a few feet beneath a foundation 48. When a grout is pumped into cavity 30, it immediately begins to densify the soil, pressing it against foundation 48. The hydraulic forces exerted against the soil by the grout are not reduced by impenetrable material, as it has been removed.

[0056] Some grout 46 may seep into the adjacent soil, but the pressure within cavity 30 is the highest pressure. Because of the full grout bearing provided by the clean hydraulic pond, the pressure required is much less than if the pond were limited to a 20% exposure, as can be the ease in known methods.

[0057] Extraction grouting of the present invention is a process and system by which a soil can be removed from deep within the ground without excavation starting from the surface of the soil, as with a backhoe, for example. Soils are removed in pre-determined locations and volumes for the purpose of replacing them with various grout compositions, including cementitious, to increase soil densities or to raise whole or partial elements of a structure. One use of the present invention is to densify soils in order to increase their load bearing capacities and stability beneath settled structures to inhibit further settlement or raise the settled segment.

[0058] In one embodiment, the present invention provides steel pipe or casings 26 varying in diameter from two inches to five inches which are driven or drilled into the soils
beneath structure 24. Depending upon the application and results desired, depths can range from just a few feet below the structure to much greater depths. Dependant upon the cavity size desired, soil types or weight of the structure to be raised, a single, double or quadruple tipped nozzle 16 can be employed. Nozzles 16 can be self rotating or manually rotated from the surface.

[0059] The water pressures and volumes are adjusted depending upon cavity 30 requirements and soil conditions. A true cavity or void is created by the present invention, not a slurry or mixed soil in its place. The soils are extracted and replaced with other products. Soils removed do not have to be reintroduced into the cavity. Increasing pressures and material volumes can raise a structure. In contaminated soils the water and soils extracted are recovered in a holding tank for disposal or re-mixed and reintroduced into the cavity as part of the grout.

[0060] Couplings 50 can be added as required by the application. Guide 20 can maintain fluid conduit or hose 12 approximately coaxial with casing 26. Each guide 20 can include a plurality of spokes 52 (FIG. 8) extending radially between fluid conduit 12 and casing 26. Cap 42 can provide a seal between end 44 and fluid conduit 12.

[0061] As shown particularly in FIGS. 9-14, the present invention can include a canister 54 for insertion into pipe 26, where canister 54 includes a deformable container 56. Deformable container 56 can help contain grout 46 in a specified area, thereby increasing the hydraulic lift efficiency of the present invention. Canister 54 can be held in place by cleats 57 while deformable container 56 expands into cavity 30.

[0062] In the embodiment of FIGS. 15-22, a directional boring machine 58, or other drilling machine, can be used to form a hole 60 under road 61, which can be as small as a few inches in diameter or up to 24" in diameter, and the cavity or hole 60 can be filled with a bentonite slurry 63 or similar product. Extraction/grouting device 62 includes cutting nozzle 64 and backthrust nozzle 66 connected to fluid conduit 66. Extraction/compaction device 62 can further include an at least partially cylindrical sled 68 attached to a water hose 66 and a cable. Extraction/grouting device 62 is pulled into hole 60 within a specified grout zone 70. The rotating center nozzle 64 can wash the soils or mix them as a grout solution is injected through rotating nozzle 64. The slurry in front of extraction/grouting device 62 allows extraction/grouting device 62 to move easily through the bored hole 60. The slurry also helps inhibit the collapse of the soils in front of the sled. Using the heavy slurry also inhibits the jetted soils under pressure from migrating forward along extraction/grouting device 62 to the front of the extraction/grouting device 62. At least one guide 72, in the form of annular aprons, for example, help maintain the contour of the hole as well as inhibiting debris forward migration along the tube. Backthrust nozzle 74 forces debris away from extraction/grouting device 62 as well as pushing extraction/grouting device 62 forward. Flow rates for either nozzle can be adjusted from the surface. This embodiment can be particularly useful when laying a pipeline under an existing road, for example.

[0063] In another embodiment (FIGS. 23-25), extraction/grouting device 10 is used to loosen and displace the soils as a second pipe 76 below extraction pipe 26 pumps a redi-mix grout or other product into the loosened soils. As the redi-mix grout or other grout (i.e. foam, soil, resin, urethane, etc.) is pumped into the loosened soils just below (a foot or so) extraction/grouting device 10 so that it forces the loosened soils up extraction pipe 26. This replacement product can form a much stronger column because the products injected are not mixed with the indigenous soils. The procedure can also be used to remove contaminant in the ground or to inject enzymes into soils for remediation. The process can also be used for installing anchors above and below water. Both pipes can be retrieved at a synchronized speed.

[0064] The process according to the present invention can also be used to wash a soil to remove silts, clays, or peat. Washing the impurities from a soil allows the remaining sandy soils to be more easily permeated. Various products can then be injected for lower costs and greater strengths. Washing can be performed as many times as needed to create the desired permeable condition. Following the completion of the washing efforts a product can be installed either through a manchette tube or a driven pipe device or through the nozzle as it rotates.

[0065] In yet another embodiment (FIGS. 26-27), the present invention can be used for pipeline 78 raising without excavation using compaction grouting according to the present invention. A sagging pipeline is raised into designed position without excavation while the remaining pipeline is uniformly supported. Grout mass 80 expands uniformly, displacing, densifying and compacting weak soil.

[0066] While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

What is claimed is:

1. An extraction/grouting device, comprising:
   a fluid conduit having a longitudinal extent;
   a cutting nozzle in fluid communication with said fluid conduit, said cutting nozzle providing an at least partially lateral spray relative to said longitudinal extent; and
   at least one guide connected to said fluid conduit.

2. The extraction/grouting device of claim 1, wherein said cutting nozzle is a rotating nozzle providing an at least partially radial spray.

3. The extraction/grouting device of claim 1, further including a casing, said fluid conduit being within said casing.

4. The extraction/grouting device of claim 3, wherein said at least one guide is between said casing and said fluid conduit, said at least one guide maintaining at least one channel between said fluid conduit and said casing.

5. The extraction/grouting device of claim 4, further including a discharge outlet connected to both said casing and said at least one channel.
6. The extraction/grouting device of claim 4, wherein said at least one guide maintains said fluid conduit approximately coaxial with said casing.

7. The extraction/grouting device of claim 4, wherein each of said at least one guide includes a plurality of spokes extending radially between said fluid conduit and said casing.

8. The extraction/grouting device of claim 3, further including a cap at one end of said casing, said cap providing a seal between said end and said fluid conduit.

9. The extraction/grouting device of claim 3, further including a canister for insertion into said casing, said canister including a deformable container.

10. The extraction/grouting device of claim 1, wherein said fluid conduit is a high pressure flexible hose.

11. The extraction/grouting device of claim 1, further including an approximately cylindrical sled connected to said fluid conduit.

12. The extraction/grouting device of claim 11, wherein said at least one guide comprises at least one annular apron on a perimeter of said cylindrical sled.

13. The extraction/grouting device of claim 1, further including a backthruster nozzle in fluid communication with said fluid conduit, said backthruster nozzle providing an at least partially longitudinal spray relative to said longitudinal extent.

14. An extraction/grouting device, comprising:

   a fluid conduit having a longitudinal extent;
   a cutting nozzle in fluid communication with said fluid conduit, said cutting nozzle for providing an at least partially lateral spray relative to said longitudinal extent; and
   a backthruster nozzle in fluid communication with said fluid conduit, said backthruster nozzle providing an at least partially longitudinal spray relative to said longitudinal extent.

15. The extraction/grouting device of claim 14, wherein said cutting nozzle is a rotating nozzle providing an at least partially radial spray.

16. The extraction/grouting device of claim 14, further including a casing, said fluid conduit being within said casing.

17. The extraction/grouting device of claim 16, wherein said at least one guide is between said casing and said fluid conduit, said at least one guide maintaining at least one channel between said fluid conduit and said casing.

18. The extraction/grouting device of claim 17, further including a discharge outlet connected to both said casing and said at least one channel.

19. The extraction/grouting device of claim 17, wherein said at least one guide maintains said fluid conduit approximately coaxial with said casing.

20. The extraction/grouting device of claim 17, wherein each of said at least one guide includes a plurality of spokes extending radially between said fluid conduit and said casing.

21. The extraction/grouting device of claim 16, further including a cap at one end of said casing, said cap providing a seal between said end and said fluid conduit.

22. The extraction/grouting device of claim 16, further including a canister for insertion into said casing, said canister including a deformable container.

23. The extraction/grouting device of claim 14, wherein said fluid conduit is a high pressure flexible hose.

24. The extraction/grouting device of claim 14, further including an approximately cylindrical sled connected to said fluid conduit.

25. The extraction/grouting device of claim 24, wherein said at least one guide comprises at least one annular apron on a perimeter of said cylindrical sled.

26. A method of extraction and grouting, comprising the steps of:

   driving a casing terminated in a sacrificial point into a soil, the driven casing being in proximity to a structure;
   separating said casing from said sacrificial point by moving said casing upwardly from said sacrificial point;
   inserting an extraction/grouting device in said casing, said extraction/grouting device including a fluid conduit having a longitudinal extent, a cutting nozzle in fluid communication with said fluid conduit, said cutting nozzle providing an at least partially lateral spray relative to said longitudinal extent, and at least one guide connected to said fluid conduit;
   mechanically forming a cavity in said soil above said sacrificial point using said nozzle and a cutting fluid; and
   extracting an excavated soil from said cavity.

27. The method of claim 26, wherein said extracting step occurs simultaneously with said mechanically forming step.

28. The method of claim 27, wherein said excavated soil is extracted through at least one channel between said fluid conduit and said casing.

29. The method of claim 26, further including the step of pneumatically purging at least a part of said cavity of a remaining said excavated soil by conducting a compressed air through said fluid conduit and said nozzle.

30. The method of claim 26, further including the step of pre-grouting with a chemical grout prior to said mechanically forming step.

31. The method of claim 26, further including the step of pre-grouting said cavity with a chemical grout.

32. The method of claim 31, wherein said chemical grout is sprayed into said cavity using said fluid conduit and said nozzle.

33. The method of claim 26, further including the step of removing said extraction/grouting device from said casing.

34. The method of claim 33, further including the step of pumping a grout through said casing and into said cavity under a pressure.

35. The method of claim 34, further including the step of densifying soils surrounding said cavity.

36. The method of claim 35, further including the step of raising said structure.

37. The method of claim 36, further including the steps of inserting a canister into said casing, said canister including a deformable container, and pumping a grout through said casing and into both said cavity and said deformable container, said deformable container containing said grout within said cavity.

38. The method of claim 26, wherein said structure is a building.

39. The method of claim 26, wherein said structure is a road.
40. The method of claim 26, wherein said structure is a pipeline.

41. A method of extraction and grouting, comprising the steps of:

- drilling a hole in a soil, said hole being at least partially under a structure;
- filling said hole with a slurry;
- pulling an extraction/grouting device into said hole and a grouting zone in proximity to said hole, said extraction/grouting device including a fluid conduit having a longitudinal extent, a cutting nozzle in fluid communication with said fluid conduit, said cutting nozzle providing an at least partially lateral spray relative to said longitudinal extent; and at least one guide connected to said fluid conduit, and a backthruster nozzle in fluid communication with said fluid conduit, said backthruster nozzle providing an at least partially longitudinal spray relative to said longitudinal extent; and at least one of washing said soil and mixing said soil with a grout through said rotating nozzle.

42. The method of claim 41, wherein said extraction/grouting device includes an approximately cylindrical sled connected to said fluid conduit, said at least one guide comprises at least one annular apron on a perimeter of said cylindrical sled.

43. The method of claim 42, further including the steps of forcing debris away from said sled and pushing said sled using said back thruster muzzle.

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