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Neiman et al.(10) **Pub. No.: US 2019/0003142 A1**(43) **Pub. Date: Jan. 3, 2019**(54) **BLOCK RETAINING WALL WITH
MICRO-PILE SOLDIER PILES**(71) Applicant: **H&K Group, Inc.**, Skippack, PA (US)(72) Inventors: **Cory Neiman**, Oley, PA (US); **Michael
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York**, Sellersville, PA (US)(73) Assignee: **H&K Group, Inc.**, Skipjack, PA (US)(21) Appl. No.: **16/016,200**(22) Filed: **Jun. 22, 2018****Related U.S. Application Data**(60) Provisional application No. 62/525,866, filed on Jun.
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(57)

ABSTRACT

A retaining wall system includes a plurality of large mass retaining blocks formed with vertically oriented openings passing therethrough for the installation of micro-pile soldier piles. The retaining blocks can be formed of pre-cast concrete and stacked vertically so that the vertical openings are aligned for the installation of micro-pile soldier piles through the stacked retaining blocks and into the bedrock below the retaining blocks. The micro-pile soldier piles can include a steel casing that is installed through the aligned vertical openings to terminate at the bedrock with grout filling the steel casing except for optional reinforcement. The retaining blocks can be formed with cutout key openings that allow concrete to be inserted to provide a key interlock between adjacent retaining blocks to further stabilize the retaining wall. The retaining wall can also include a row of waler blocks that incorporate a pair of tie-back anchors for each waler block.

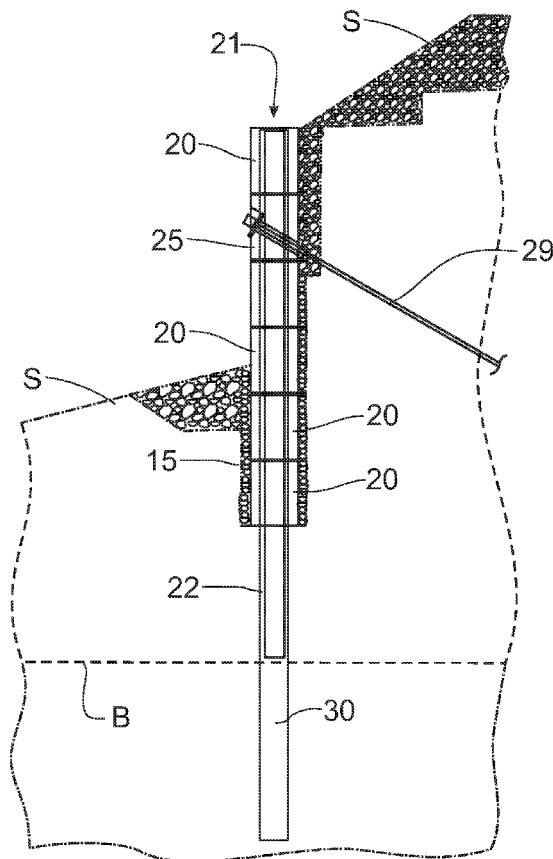


Fig. 1

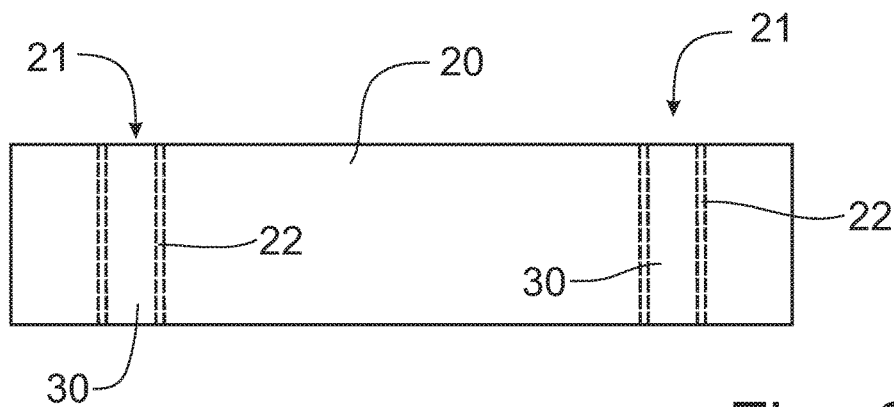
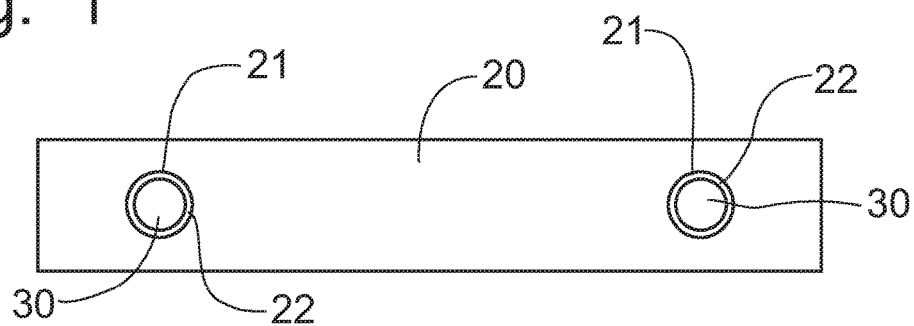


Fig. 2

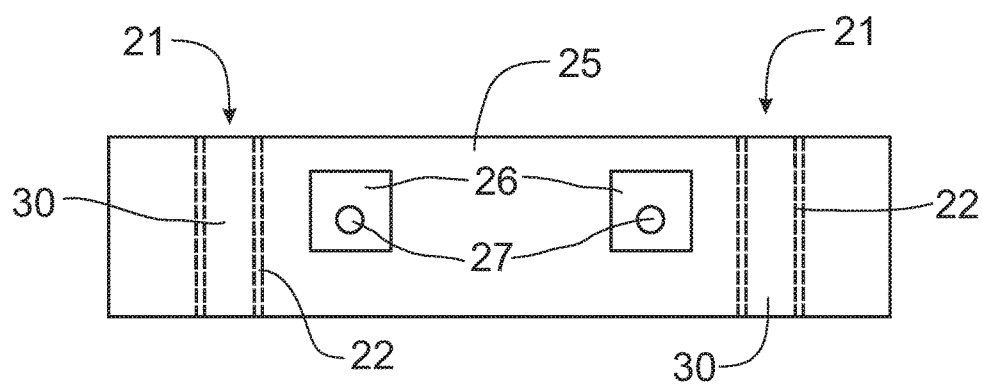


Fig. 3

Fig. 4

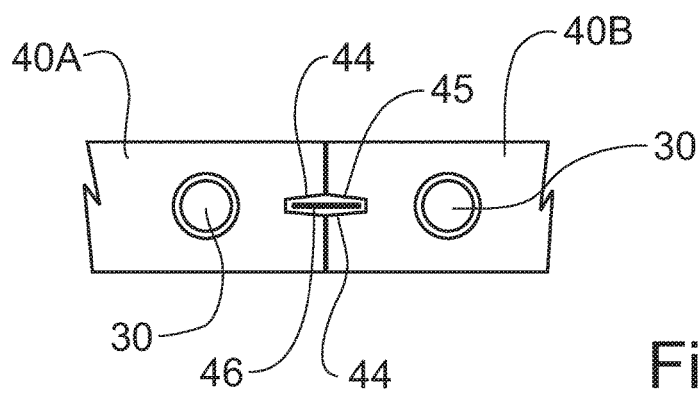
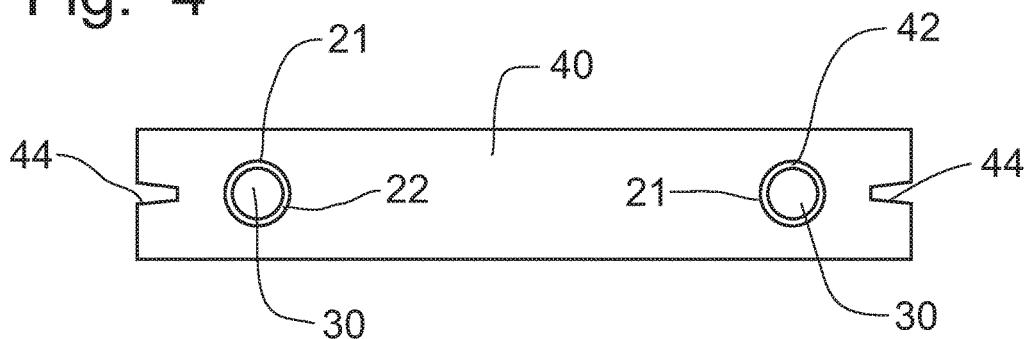


Fig. 5

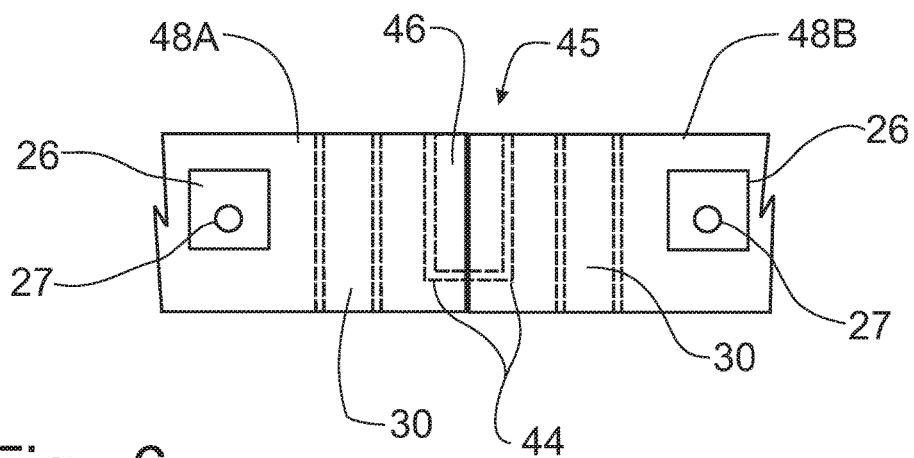


Fig. 6

Fig. 5A

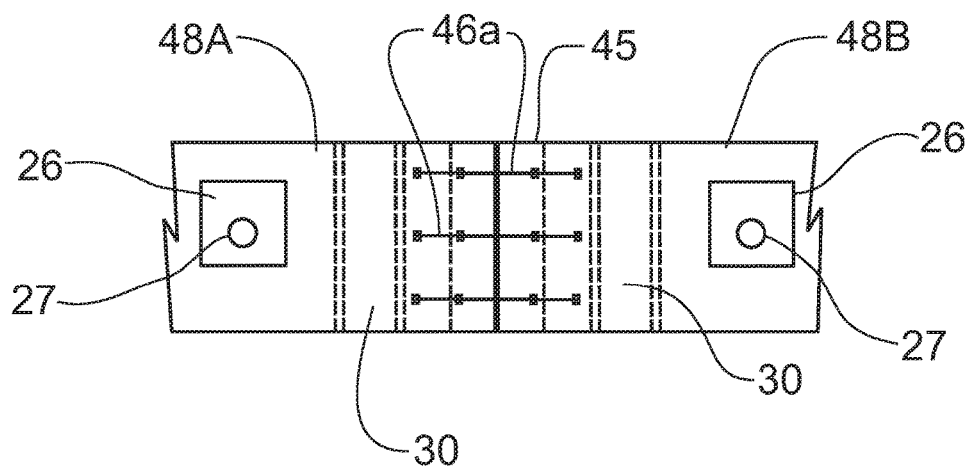
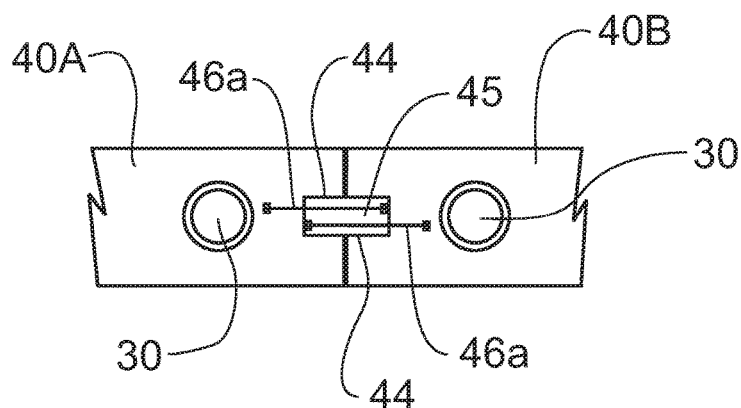


Fig. 6A

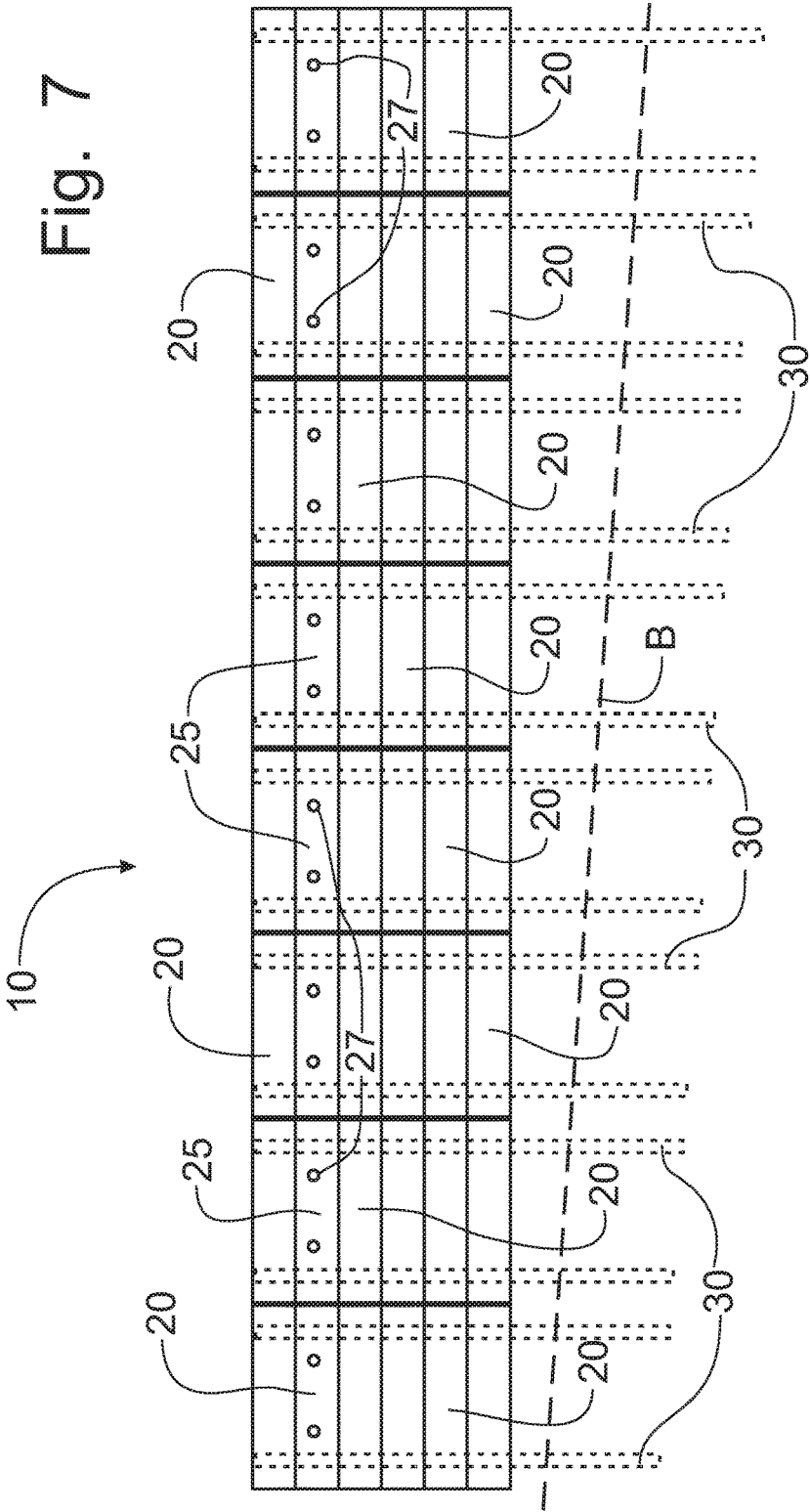
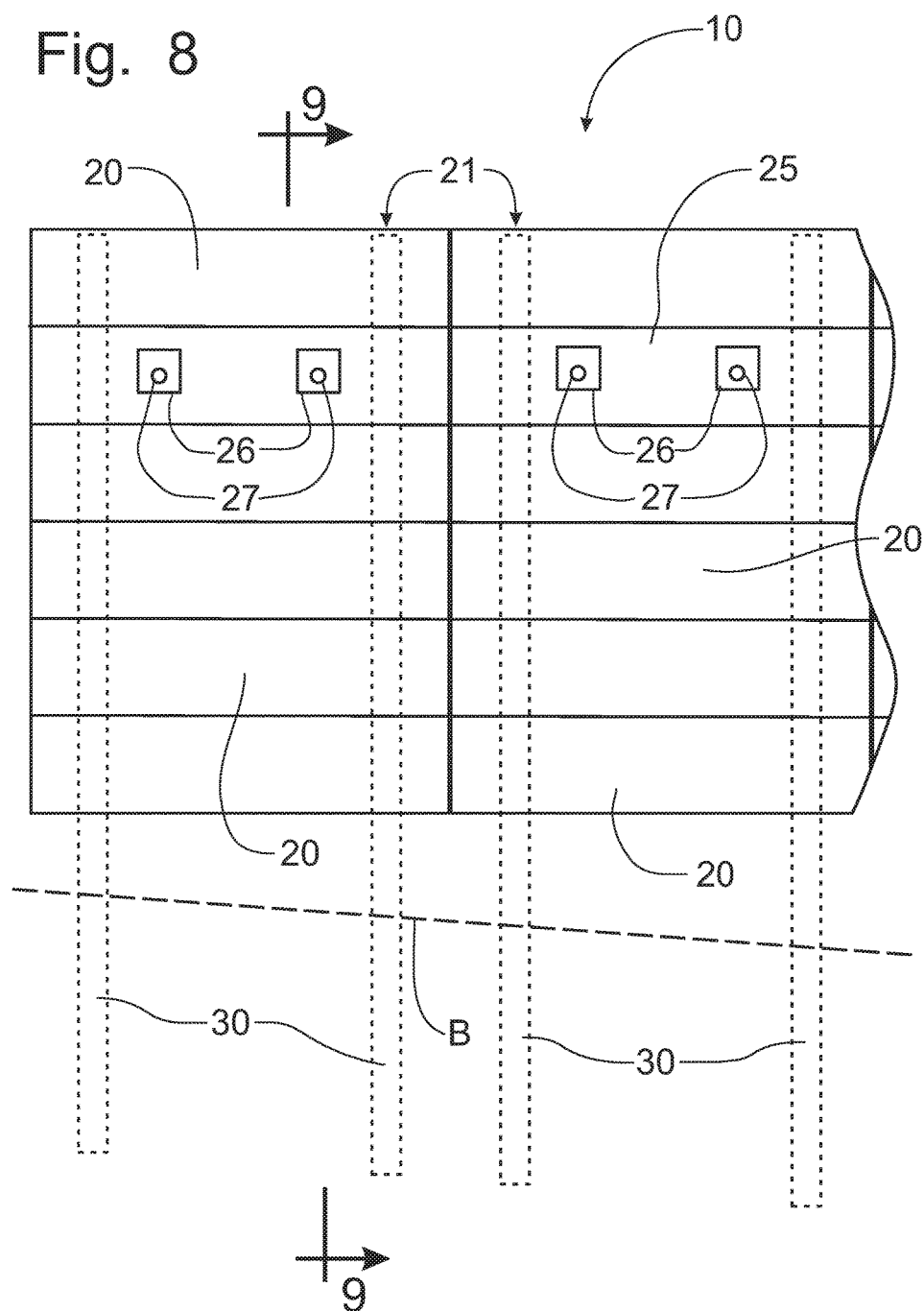
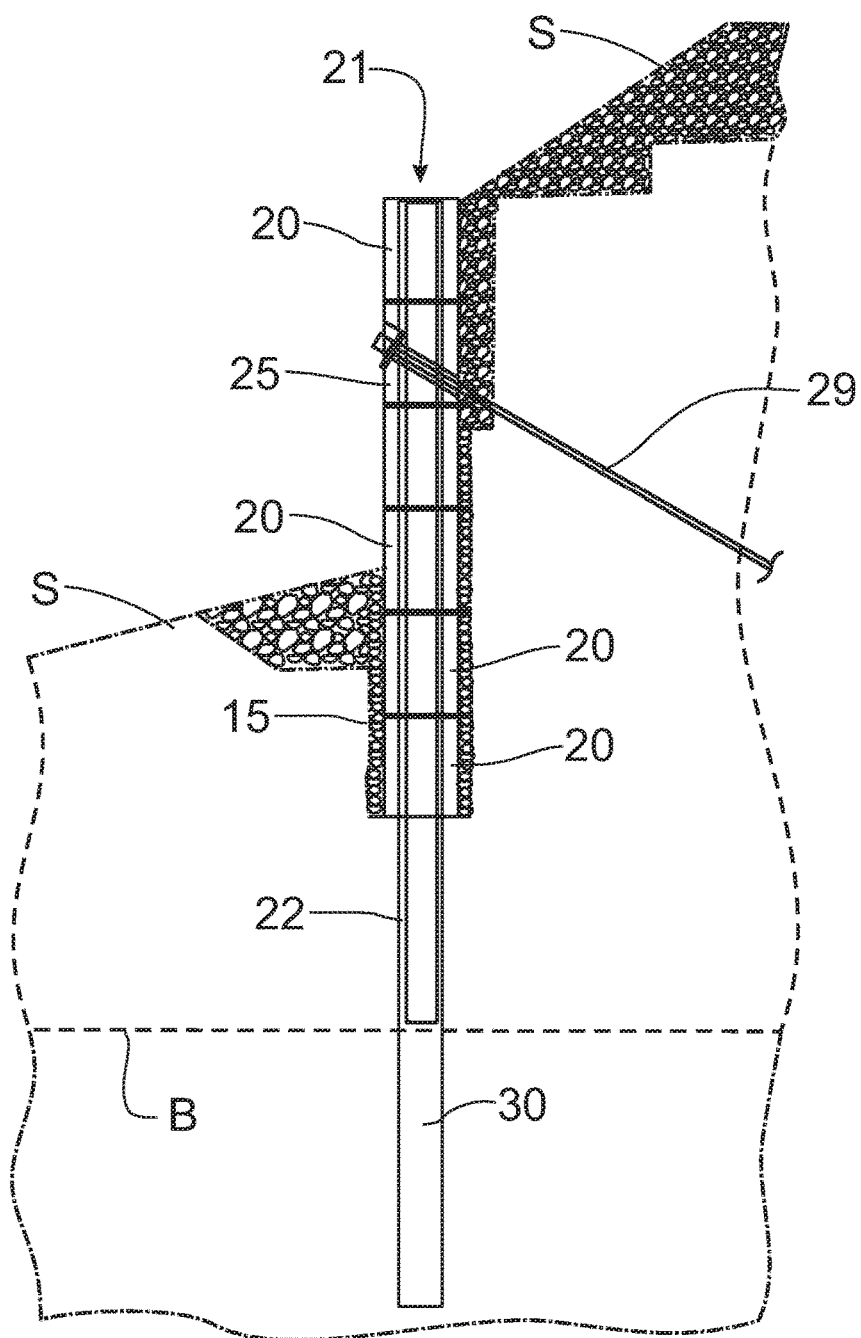
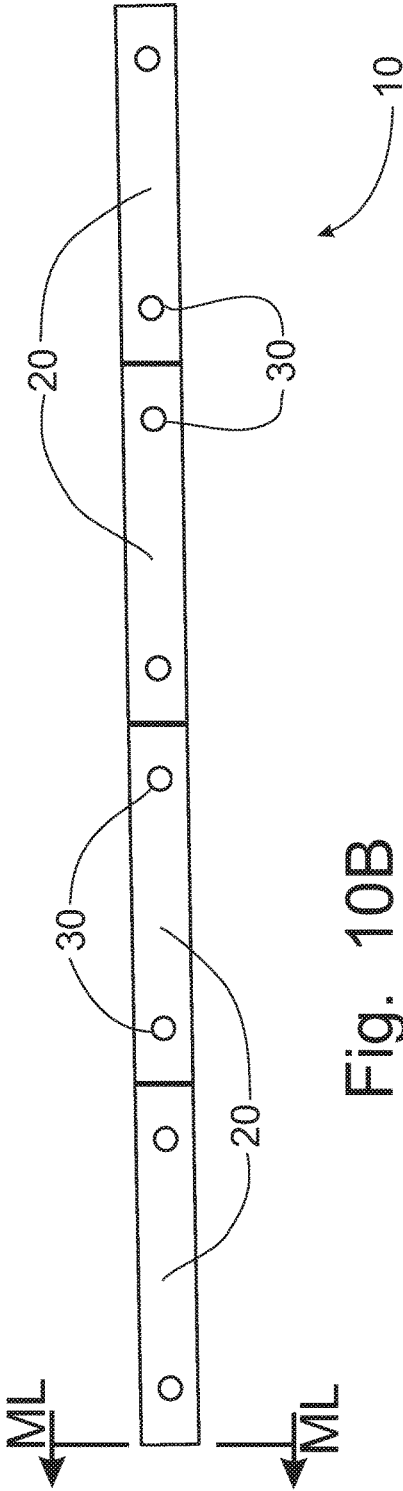
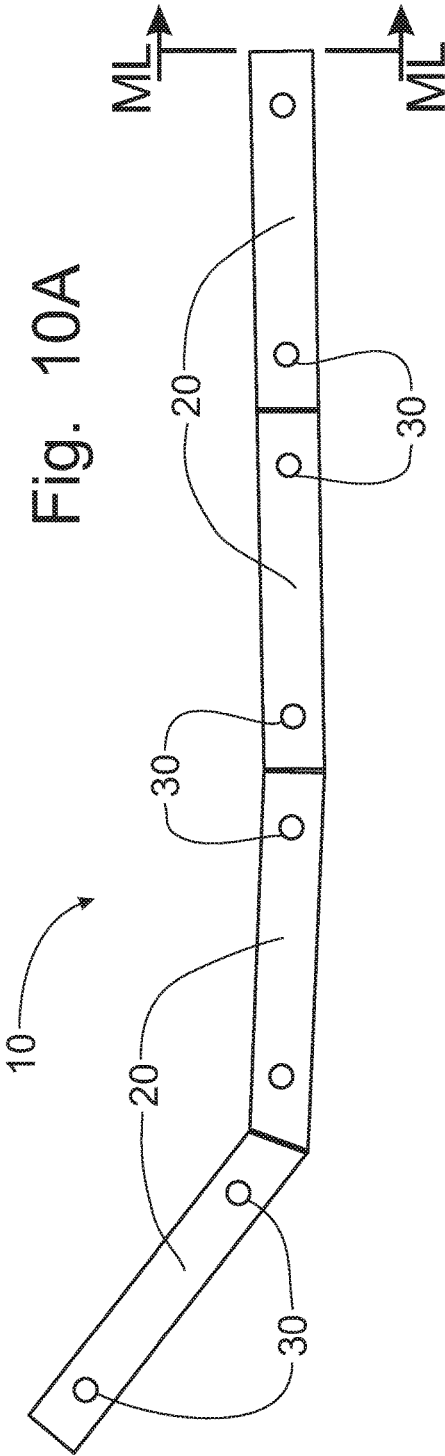


Fig. 8







BLOCK RETAINING WALL WITH MICRO-PILE SOLDIER PILES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims domestic priority on U.S. Provisional Patent Application Ser. No. 62/525,866, filed Jun. 28, 2017, the content of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates generally to a configuration of a retaining wall system, and, more particularly, to a retaining wall formed with large retaining wall blocks incorporating micro-pile soldier piles and tie-back anchors.

BACKGROUND OF THE INVENTION

[0003] Retaining walls have been utilized to retain material behind the wall, such as soil, and are well known in the construction industry. Retaining walls have been formed from concrete, reinforced concrete, concrete blocks, stone-filled baskets, and many other configurations. As a basic operating principle, the mass of the retaining wall must be greater than the forces exerted by the material behind the wall trying to tip the retaining wall forwardly. To assist in maintaining the position of the retaining wall, tie-backs anchors are frequently utilized to prevent the wall from moving. Tie-back anchors are connected to the retaining wall and extended into the material behind the retaining wall so that the tie-back anchors must move through the material in order for the retaining wall to be tipped forwardly by the mass of the material behind the retaining wall.

[0004] Micro-piles are small diameter pillars formed as drilled and grouted friction piles where each friction pile includes steel elements that are bonded into the bearing soil or rock, usually with cement grout. Typically, micro-piles are drilled into bedrock, with steel casing being advanced as the hole is drilled to and into the bedrock. The drill pipe is removed, which leaves the steel casing embedded in bedrock. Cementitious grout is pumped or pressure fed into the steel casing from the bottom up. The steel casing is then lifted to top of bedrock to allow bonding between the cementitious grout and the bedrock structure, thus bonding the micro-pile to the bedrock. Excess steel casing is cut from the tops of micro-pile and then capped according to design.

[0005] It would be desirable to combine the technologies of large mass block structures with micro-pile formation and, if needed, tie-back anchors to provide a retaining wall system providing flexibility in use within the construction industry. It would also be desirable to provide a method of constructing a retaining wall utilizing large mass retaining blocks and micro-pile soldier piles and tie-back anchors, if needed.

SUMMARY OF THE INVENTION

[0006] It is an object of this invention to overcome the disadvantages of the prior art by using micro-pile soldier piles for a retaining wall formed from retaining blocks.

[0007] It is another object of this invention to provide a retaining wall formed from large mass retaining blocks retained by micro-pile soldier piles.

[0008] It is a feature of this invention that the retaining wall can include a row or multiple rows of waler blocks formed to incorporate tie-back anchors.

[0009] It is another feature of this invention that the retaining wall system can include a pair of tie-back anchors engaged with each waler block.

[0010] It is an advantage of this invention that each micro-pile soldier pile includes a steel casing extending through vertically aligned openings in the large mass retaining wall blocks.

[0011] It is another advantage of this invention that the steel casing terminates below the bottom of the micro-pile opening in the blocks to extend into the bedrock structure beneath the retaining wall structure.

[0012] It is still another feature of this invention that each large mass retaining wall block can be formed with a cutout key opening in the laterally opposing ends thereof.

[0013] It is still another advantage of this invention that each said cutout key opening can be filled with concrete to form a key between adjacent retaining wall blocks in each respective row of the retaining wall blocks.

[0014] It is yet another advantage of this invention that the key between adjacent retaining wall blocks enhances the stability of the retaining wall.

[0015] It is still another advantage of this invention that the key can be reinforced with reinforcement bars extending between the adjacent retaining wall blocks.

[0016] It is still another advantage of this invention that the key can be reinforced with a steel plate placed within the key which is then filled with concrete.

[0017] It is yet another advantage of this invention that the large mass retaining blocks can be formed as pre-cast concrete.

[0018] It is still another object of this invention to provide a method of forming a retaining wall system by forming a plurality of retaining wall blocks formed with a pair of laterally opposed vertically oriented openings extending through the height of each said retaining wall block into which micro-pile soldier piles can be installed.

[0019] It is a further feature of this invention that the placement of the retaining wall blocks into row configurations establishes multiple, vertically spaced, layers of retaining wall blocks with vertically aligned openings therein for the installation of the micro-pile soldier piles through all of the rows of retaining wall blocks of the retaining wall.

[0020] It is a further advantage of this invention that the micro-pile soldier piles can extend into bedrock located beneath the retaining wall blocks.

[0021] It is still a further advantage of this invention that the pre-cast concrete retaining blocks can have a uniform shape.

[0022] It is a yet another object of this invention to provide a retaining wall system which is durable in construction, inexpensive of manufacture, carefree of maintenance, easy to construct, and simple and effective in use.

[0023] These and other objects, features and advantages are accomplished according to the instant invention by providing a retaining wall system in which a plurality of large mass retaining blocks are formed with vertically oriented openings passing therethrough for the installation of micro-pile soldier piles. The retaining blocks can be formed of pre-cast concrete and stacked vertically so that the vertical openings are aligned for the installation of micro-pile soldier piles through the stacked retaining blocks and into

the bedrock below the retaining blocks. The micro-pile soldier piles can include a steel casing that is installed through the aligned vertical openings to terminate at the bedrock with grout filling the steel casing except for optional reinforcement. The retaining blocks can be formed with keys that interlock into adjacent retaining blocks to further stabilize the retaining wall. The retaining wall can also include a row or multiple rows of waler blocks that incorporate a pair of tie-back anchors for each waler block.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The advantages of this invention will become apparent upon consideration of the following detailed disclosure of the invention, especially when taken in conjunction with the accompanying drawings wherein:

[0025] FIG. 1 is a top plan view of a large mass retaining wall block incorporating the principles of the instant invention;

[0026] FIG. 2 is a side elevational view of the large mass retaining wall block shown in FIG. 1;

[0027] FIG. 3 is a side elevational view of a waler block for use in conjunction with a tie-back anchor;

[0028] FIG. 4 is a top plan view of an alternative configuration of a large mass retaining wall block having notches formed in the end walls to permit insertion of a key to integrate adjacent blocks thereto;

[0029] FIG. 5 is a top plan view of portions of two adjacent large mass retaining wall blocks as depicted in FIG. 4, but having a steel plate and concrete key formed therebetween;

[0030] FIG. 5A is a top plan view of two adjacent large mass retaining wall blocks similar to that of FIG. 5, but depicted an alternative configuration of the key openings being formed with reinforcing bars extending from opposing sides of the concrete retaining wall block;

[0031] FIG. 6 is a side elevational view of portions of two adjacent large mass retaining wall waler blocks with an inserted concrete key, similar to that depicted in FIG. 5;

[0032] FIG. 6A is a side elevational view of the alternative key opening configuration shown in FIG. 5A but applied to a waler block as depicted in FIG. 6;

[0033] FIG. 7 is a front elevational view of a portion of a retaining wall system incorporating the principles of the instant invention, the top of the bedrock being indicated by a dashed line;

[0034] FIG. 8 is an enlarged portion of the retaining wall system shown in FIG. 8;

[0035] FIG. 9 is a cross-sectional view through the retaining wall system according to lines 9-9 of FIG. 8;

[0036] FIG. 10A is a top plan view of a portion of a retaining wall system matching with FIG. 10B along the match line; and

[0037] FIG. 10B is a top plan view of an adjacent portion of the retaining wall depicted in FIG. 10A and matching thereto at the match line.

DETAILED DESCRIPTION OF THE INVENTION

[0038] Referring now to the drawings, a retaining wall system combining the technologies of large mass retaining wall blocks, micro-pile soldier piles, and tie-back anchor systems. The basic large mass retaining wall block 20 is best seen in FIGS. 1 and 2. While the retaining wall block 20 can

be formed in essentially any shape and using many different materials, the preferred configuration is to form the retaining wall block 20 from concrete as a parallelepiped having rectangular faces. The size of the concrete retaining wall blocks 20 can be determined according to a specific final design, but a representative size would be a concrete block that is approximately thirteen (13') feet long, about three (3') feet high and about twenty-six (26") inches in depth. A concrete retaining wall block 20 of this suggested size would weigh approximately 13000 pounds and provide a substantial retaining wall block 20.

[0039] In the formation of the concrete retaining wall block 20, two vertically oriented openings 21 through the concrete retaining wall block 20. The openings 21 will provide the ability to form micro-pile soldier piles 30 during the installation of the retaining wall blocks 20 and the formation of the retaining wall system 10, as will be described in greater detail below. For concrete retaining wall blocks 20 of the size suggested above, a possible opening 21 size, subject to the specifications of the final design, would be approximately 13 inches in diameter, with placement centered between the front and rear faces, and the center of the opening 21 being approximately 24 inches inboard of each respective end of the retaining wall block 20. The vertical orientation of the openings 21 would extend through the entire vertical height of the retaining wall blocks 20.

[0040] An alternative configuration of the retaining wall block is shown in FIG. 3 as a retaining wall waler block 25. The configuration of the waler block 25 is essential identical to the retaining wall block 20 described above, but has added features to accommodate the installation of a tie-back anchor 29, if the tie-back anchor 29 is appropriate according to the final design of the retaining wall system 10. In the waler block 25, the front face of the waler block 25 is formed with a cutout wedge 26 through which a hole 27 is formed to permit insertion of the tie-back anchor 29, as will be described in greater detail below. As is depicted in FIG. 3, the cutout wedge 26 is preferably located further from the respective end of the waler block 25 than the opening 21 passing therethrough so that the cutout wedge 26 does not interfere with the vertical opening 21 or the formation of the micro-pile soldier pile 30 as will be described in greater detail below.

[0041] Yet another configuration of the retaining wall block is best seen in FIGS. 4-6 in which the opposing ends of the retaining wall block 40 are formed with cutout key openings 44 extending from the top surface of the retaining wall block 40 to the bottom surface. The cutout key openings 44 enable adjoining retaining wall blocks 40 to be connected together via a concrete key 45, which would enhance the effective strength of the retaining wall system 10 as compared to a retaining wall system 10 constructed from the basic retaining wall blocks 20. As depicted in FIG. 6, the cutout key openings 44 can be formed at the time of formation of the retaining wall blocks 40. When two adjacent retaining wall blocks 40A, 40B are placed into position, the cutout key openings 44 align and can be reinforced by the placement of a steel plate 46 within the aligned key openings 44 and non-shrink grout (preferably), or optionally Class A concrete, placed into the aligned key openings 44 to form the reinforced key 45 and connect the now adjoining retaining wall blocks 40A, 40B.

[0042] An alternative to the use of a steel plate to provide reinforcements is depicted in FIGS. 5A and 6A, wherein the

key openings 44 can be formed with reinforcing bars 46a, such as #4 rebar, extending from opposing sides of the concrete retaining wall block 40. Then when two adjacent retaining wall blocks 40A, 40B are placed into position, the reinforcement bars 46a from one retaining wall block 40A will extend into the cutout key opening 44 of the adjacent retaining wall block 40B. Then, the insertion of non-shrink grout or Class A concrete into the adjacent cutout key openings 44 will create the reinforced key 45 connecting the now adjoining retaining wall blocks 40A, 40B. Alternatively, the reinforcement bars 46a could be inserted into the cutout key openings 44 after the retaining wall block 40 has been formed and grouted into place before forming the key 45. As can be seen in FIG. 6A, the alternatively configured retaining wall blocks 40 can be utilized for waler blocks 48A, 48B as well.

[0043] Referring now to FIGS. 7-10B, the retaining wall system 10 can best be seen. The retaining wall blocks 20 (which could also be the alternative configuration of retaining wall blocks 40) are pre-formed, perhaps at the job site, and placed into position vertically stacked so that the openings 21 are aligned in a vertical manner. In certain retaining wall designs, it may be necessary to dig an excavation trench 15 into the existing soils and install a trench box (not shown) to protect the excavated trench 15 as the excavation of the trench 15 proceeds. The pre-formed concrete retaining wall blocks 20 are then placed into the bottom of the excavated trench 15 and stacked as indicated above so that the openings 21 are vertically aligned.

[0044] Once two or more rows of concrete retaining wall blocks 20 have been placed into the excavated trench and properly stacked with the openings 21 aligned properly, the trench can be backfilled to stabilize the concrete retaining wall blocks 20. Then, a steel casing 22 can be inserted into each set of aligned openings 21 such that the steel casing 22 rests on the bottom of the trench. A drill (not shown) can then be inserted through the elevated top of the steel casing 22 and a hole drilled through the subsoil into the bedrock B, preferably eight (8') feet into the bedrock B, or the depth determined by the design of the system, which results in the lowering of the steel casing 22 into the bedrock B. At this point, the steel casing 22 should be projecting out of the concrete retaining wall blocks 20 to a height corresponding to the finished grade of the retaining wall 10. The remaining layers of concrete wall retaining blocks 20 can then be stacked with the openings 21 being aligned with the upwardly projecting steel casings 22 and lowered to the layer below.

[0045] Once the retaining wall blocks 20 and waler blocks 25 have been properly stacked, the tie-back anchors 29 should be installed through the waler blocks 25 and partially tensioned. The micro-pile soldier piles 30 can then be formed by pumping or pressure feeding cementitious grout into the opening of the steel casing 22 to fill the steel casing 22 from the bottom upwardly. Because the micro-pile soldier piles 30 are being used to resist the bending moment applied by the backfill behind the retaining wall 10, the preferred method of forming the soldier piles 30 would be to leave the steel casing 22 resting on the bedrock at the bottom of the drilled hole, rather than elevate the steel casing 22 above the bedrock so that the cementitious grout can bond with the bedrock as is typical with micro-piles. Once the micro-pile soldier piles 30 have been formed and preferably capped at

the top, the tie-back anchors 29 can be fully tensioned and the retaining wall 10 backfilled to the finished grade.

[0046] Alternatively, the drilling of the holes through the subsoil and into the bedrock B can be done after the concrete retaining wall blocks 20 have been properly stacked. The steel casing 22 can be inserted through each set of aligned openings 21 to the bottom of the trench, whereupon the drill can be inserted into the steel casing 22 and drilled through the subsoil and approximately 8 feet into the bedrock B, as noted above. The tie-back anchors 29, if any, can be installed and partially tensioned, followed by the placement of the cementitious grout into the steel casings 22 to fill the steel casings from the bottom up. The micro-piles are then capped and the tie-back anchors 29 fully tensioned, followed by the backfilling of the retaining wall 10 to the finished grade.

[0047] In the formation of the micro-pile soldier piles 30, one or more reinforcement bars or other reinforcement structure (not shown) can be lowered into the casing 22 to the bottom of the micro-pile opening in the bedrock B, to provide additional capacity for the micro-pile 30. Then, cementitious grout is pumped or pressure fed into the micro-pile opening to fill the micro-pile opening from the bottom upwardly. Grout is also placed into the annular space between the steel casing and the retaining wall blocks 20, as well as between the casing and the underlying soil. The micro-pile soldier piles 30 can then be capped according to the engineering design. The tie-back anchors can be fully tensioned, and the soils S around the retaining wall system 10 can be finished to grade with R-3 slope protection or other materials.

[0048] If the design of the retaining wall 10 requires the installation of tie-back anchors 29, the installation of a row or layer of waler blocks 25 instead of the normal retaining wall blocks 20, would be provided with appropriate additional rows of retaining wall blocks 20 placed on top thereof with the vertical openings 21 of all rows of blocks 20, 25 being aligned. The tie-back anchors 29 are typically installed into the waler blocks 25 before any remaining retaining wall blocks 20 are placed on top of the waler blocks 25 and then partially tensioned. After the installation of the remaining blocks 20 and subsequent backfill, the tie-back anchors 29 can be fully tensioned.

[0049] As an alternative to the above-identified installation procedure, the retaining wall system 10 can be constructed as noted above with respect to forming the excavation trench 15 and the placement of retaining wall blocks 20 in the bottom of the excavation trench 15 with subsequent vertically spaced rows of retaining wall blocks 20 being positioned in a manner that will align the openings 21 in the respective vertically spaced retaining wall blocks 20. The rows of retaining wall blocks 20 should extend vertically to the designated bottom elevation for the design of the retaining wall system 10. As the rows of retaining wall blocks 20 are placed, the annular space between the blocks 20 and the trench box should be filled with AASHTO #57 gravel.

[0050] Formation of a retaining wall system 10 as described above provides a convenient method for the construction of a retaining wall 10 for a construction site, and provides substantial flexibility in the design of the retaining wall system 10. For example, the sizes of the retaining wall blocks 20 can be varied as deemed appropriate for the retaining wall design. The micro-pile soldier piles

30 can installed with greater convenience and flexibility than the conventional soldier piles used for retaining wall construction.

[0051] It will be understood that changes in the details, materials, steps and arrangements of parts which have been described and illustrated to explain the nature of the invention will occur to and may be made by those skilled in the art upon a reading of this disclosure within the principles and scope of the invention. The foregoing description illustrates the preferred embodiment of the invention; however, concepts, as based upon the description, may be employed in other embodiments without departing from the scope of the invention.

Having thus described the invention, what is claimed is:

1. A retaining wall system, comprising:
 - a plurality of retaining wall blocks stacked vertically in rows, each said retaining wall block having a pair of vertical openings extending therethrough, said vertical openings being positioned proximate to the opposing lateral ends of each respective retaining wall block, said retaining wall blocks being stacked in a manner that the vertical openings of the vertically spaced retaining wall blocks are vertically aligned; and
 - a micro-pile soldier pile formed in each set of the vertically aligned openings extending through the rows of retaining wall blocks, each said micro-pile soldier pile extending through all of said rows of retaining wall blocks and into the underlying soil and bedrock below said retaining wall blocks, each said micro-pile soldier pile being formed with a casing member inserted through the vertically aligned openings and the insertion of cementitious grout into the casing member.
2. The retaining wall system of claim 1 wherein at least one row said retaining wall blocks comprises a row of waler blocks formed to receive tie-back anchors, said retaining wall system further comprising a pair of tie-back anchors engaged with each said waler block.
3. The retaining wall system of claim 2 wherein the casing member of each said micro-pile soldier pile includes a steel casing extending through the vertically aligned openings in said retaining wall blocks.
4. The retaining wall system of claim 3 wherein said steel casing terminates at the bottom of the micro-pile opening within the bedrock structure.
5. The retaining wall system of claim 1 wherein each said retaining wall block is formed with a cutout key opening in the laterally opposing ends thereof, each said cutout key opening being filled with concrete to form a key between adjacent retaining wall blocks in each respective row of said retaining wall blocks.
6. The retaining wall system of claim 5 wherein said key is also formed with reinforcement bars extending between the adjacent retaining wall blocks.
7. The retaining wall system of claim 5 wherein said key is also formed with a steel plate spanning between the key openings in the adjacent blocks.
8. The retaining wall system of claim 1 wherein said retaining wall blocks are formed as pre-cast concrete.
9. A method of forming a retaining wall system comprising the steps of:
 - forming a plurality of retaining wall blocks as pre-cast concrete with a uniform shape, each said retaining wall block being formed with a pair of laterally opposed

vertically oriented openings extending through the height of each said retaining wall block;

placing the retaining wall blocks into row configurations establishing multiple, vertically spaced, layers of retaining wall blocks, each said vertical spaced layer of retaining wall blocks being positioned in a manner that the vertically oriented openings therein are aligned vertically with the vertically oriented openings of the retaining wall block immediately below; and

installing micro-pile soldier piles into each of the vertically aligned openings, each said micro-pile soldier pile extending through all of the rows of retaining wall blocks and into bedrock located beneath said retaining wall blocks.

10. The method of claim 9 further comprising the steps of:
 - positioning a row of waler blocks within said rows of retaining wall blocks, each said waler block having a pair of cutout wedges and corresponding holes passing through front and rear faces of each said waler block; and
 - inserting a tie-back anchor into each respective cutout wedge and hole.
11. The method of claim 9 wherein said step of installing micro-pile soldier piles comprises the step of:
 - drilling through said vertically aligned openings to establish a drilled opening into bedrock located below said retaining wall system in alignment with said vertically aligned openings.
12. The method of claim 11 wherein said step of installing micro-pile soldier piles further comprises the steps of:
 - inserting a steel casing through said vertically aligned openings terminating in said drilled opening in the bedrock; and
 - filling said steel casing with cementitious grout.
13. The method of claim 12 wherein said step of installing micro-pile soldier piles further comprises the step of:
 - inserting reinforcement into said steel casing to be encased into said cementitious grout.
14. The method of claim 12 wherein said step of forming a plurality of retaining wall blocks comprises the steps of:
 - creating a key in a side of each said retaining wall block to be engaged with an adjacent retaining wall block to enhance the stability of the retaining wall system.
15. The method of claim 14 wherein said step of creating a key comprises the steps of:
 - providing a cutout key opening in adjacent sides of retaining wall blocks at corresponding locations; and
 - filling the aligned cutout key openings with concrete to create an interlocking key between the adjacent retaining wall blocks.
16. The method of claim 15 wherein said step of creating a key further comprises the step of placing within the aligned key openings a steel reinforcement spanning between the two aligned key openings.
17. A retaining wall system, comprising:
 - a plurality of large mass retaining wall blocks stacked vertically in rows, each said retaining wall block having a pair of vertical openings extending therethrough, said vertical openings being positioned proximate to the opposing lateral ends of each respective retaining wall block, said retaining wall blocks being stacked in a manner that the vertical openings of the vertically spaced retaining wall blocks are vertically aligned;

a row of said retaining wall blocks forming a row of waler blocks having a pair of tie-back anchors incorporated into each said waler block, each said waler block having a pair of cutout wedges and corresponding holes passing through front and rear faces of each said waler block with each said tie-back anchor engaged into each respective cutout wedge and passing through said corresponding hole; and

a micro-pile soldier pile formed in each of the vertically aligned openings extending through the rows of retaining wall blocks and extending through all of said rows of retaining wall blocks and into the underlying soil and bedrock below said retaining wall blocks, each said micro-pile soldier pile being formed with a steel casing member inserted through the vertically aligned openings and extending into said bedrock and with an insertion of cementitious grout into the steel casing member.

18. The retaining wall system of claim **17** wherein each said retaining wall block is formed with a cutout key opening in the laterally opposing ends thereof, each said cutout key opening being filled with concrete to form a key between adjacent retaining wall blocks in each respective row of said retaining wall blocks.

19. The retaining wall system of claim **18** wherein said key is also formed with reinforcement bars extending between the adjacent retaining wall blocks.

20. The retaining wall system of claim **17** wherein each said retaining wall block is formed as pre-cast concrete.

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