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(54) Title: PRECAST CONCRETE RETAINING WALL

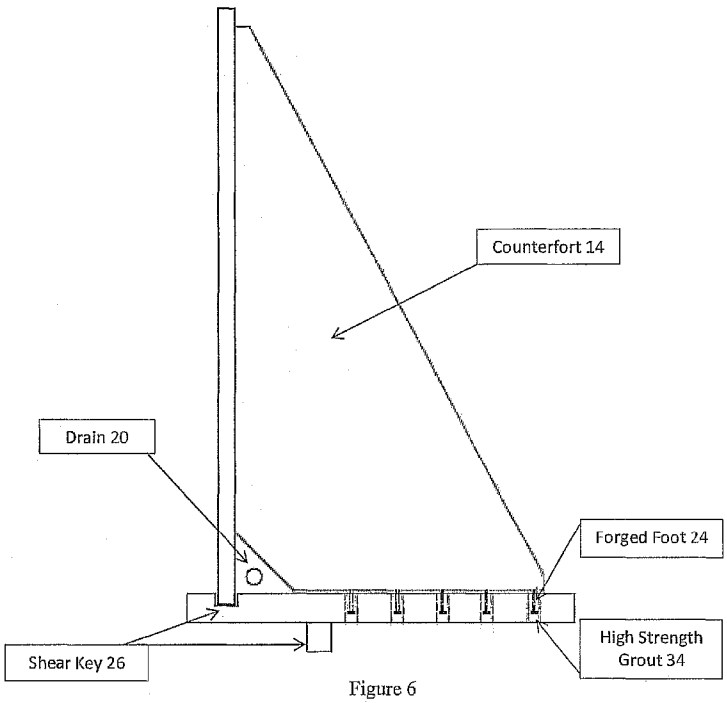

Figure 6

(57) Abstract: A retaining wall (10) comprises a precast concrete face panel (12) with integral counterfort (14) connected to the rear of the facing and a precast concrete base (16) supporting the facing (12) and the counterfort (14). The counterfort (14) comprises a reinforced concrete slab having a substantially vertical front portion at a substantially right angle to a base portion, and a rear portion running from substantially the top of the counterfort to the rear of the base portion thereof The face and counterfort module (11) is connected to the base module (15) through the use of rebar and openings which are fixedly attached together using a high strength group.

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PRECAST CONCRETE RETAINING WALL

FIELD OF THE INVENTION

[0001] The present invention pertains generally to retaining walls. Specifically, the invention relates to an apparatus and method of installation for a completely precast concrete retaining wall of the type typically used alongside highways and railways.

BACKGROUND OF THE INVENTION

[0002] Various retaining wall systems have been developed for use in retaining soil on an embankment. In a conventional retaining wall design, one of the major design criteria that must be considered is the pressure exerted on the foundation at the front of the base (toe) of the retaining wall system. This becomes particularly limiting in tall vertical walls with sloping backfill. Conventionally designed cantilevered walls reduce the pressure at the toe by providing a lever arm perpendicular to and behind the wall face upon which the vertical load of the backfill acts, creating a moment opposite in direction to the moment due to the horizontal force of the backfill material on the wall face. This moment is increased for design purposes by increasing the area of the cantilever arm subject to the vertical loads by increasing the size or length of the moment arm until a suitable toe pressure is reached and a suitable factor of safety against overturning is reached.

[0003] Many different schemes for increasing the opposing moment force, i.e., the vertical force on the lever arm, have been employed and are well known in the art. Some ways that the industry has tried to oppose the moment force are through using a gravity wall, piling wall, mechanically stabilized earth wall, cantilever wall or an anchored wall. Figures 1 and 2 show examples of a prior art retaining wall.

[0004] A major disadvantage of the prior art is that many of the tieback elements, including straps, anchors, and/or stems, must extend too far behind the face to engage the wall panels in order to produce a margin of safety which is sufficient to overcome the overturning moment. In these situations, there is frequently insufficient room to introduce stabilizing members of adequate length between the front of the wall and the stable earth or rock mass created by excavation. Consequently, a considerable cut must be made into the soil behind the retaining wall in comparison to the height of the soil retained for conventional static, leverage retaining wall systems in order to meet suitable margins of safety. This design constraint effectively limits the height of a wall to single tiers 10 to 12 feet high.

[0005] Cast-in-place cantilever retaining walls are a proven method of retaining earth. These retaining walls typically consist of a vertical wall on top of a horizontal base. These walls work by utilizing the same soil they are retaining at the face of the wall to also anchor the base below. The walls are very commonly designed for up to approximately twenty feet tall retained earth, which is the height difference from the high elevation to the low elevation. For walls over twenty feet, one way to keep the sections from getting too massive is to utilize counterforts. Counterforts are also vertical but perpendicular to the face extending at an angle from the top of face to the base.

[0006] While counterforts have been a great innovation to the industry, a disadvantage of prior art counterforts is that they can require special forming and labor which can be expensive when performed on site. Inside a plant, the sections can be pre-manufactured in a controlled environment at less cost. There is prior art that consists of a face with counterforts, but it still relies on a final pour on-site to fill a base shell which is substantially open. This cast-in-place base can take a significant amount of time to cure and can be costly to

form and place the rebar in situ. These prior art retaining walls also require labor intensive temporary shoring to hold the face upright until the cast-in-place base has cured.

[0007] Another prior art product has a precast base and precast wall, but fails to include a counterfort for support. This is disadvantageous as the wall heights grow, since the lever arm to resist the overturning moment is confined within the planes of the base and face. Not only does this lead to unpractical, inefficient reinforcement design and panel thickness, but it requires a large number of expensive and labor intensive mechanical splice sleeve connections at the critical juncture between the face and base. Another disadvantage to not having a counterfort is that the wall needs to be temporarily braced during installation, which adds both cost and time.

[0008] There is also prior art of pre-manufactured upside-down, T-shaped retaining walls with small scale counterfort ribs. The disadvantage of these walls is that they require specific forms and therefore are not customizable. Also their installation allows for less flexibility due to the fixed connection between the base and face of these T-shaped retaining walls. Further, due to how this system needs to be formed, it makes it difficult to add textured aesthetics to the face of the wall. This system is also limited in retained height due to the challenge of handling such a large, one-piece unit. At a certain height, these retaining walls are also limited in size due to shipping limitations.

SUMMARY OF THE INVENTION

[0009] The present invention provides an apparatus and method for constructing a retaining wall which allows for taller walls and shorter bases by pre-manufacturing parts of the wall to be transported to and assembled at the site. Using pre-manufactured assembly components will save both on installation and transportation costs. Generally, a precast, substantially solid, rectangular or trapezoidal base is set on grade at the job site, and a face panel

with an integral counterfort is set upright on the base with a connection joining them together. Temporary shoring is not required with this assembly. As soon as the face panel and counterfort are set on the base, it can withstand temporary wind loads immediately. The invention is also flexible in that the height or width of any of the individual components can vary over a wide range. All of the pieces of the assembly can easily be made to custom sizes.

BRIEF DESCRIPTION OF THE DRAWINGS

[00010] In describing the prior art and preferred or illustrative embodiments, reference is made to the accompanying drawings. It should be understood, however, that the application is not limited to the precise arrangements and instrumentalities shown therein:

[00011] FIG. 1 represents a perspective view of a prior art retaining wall.

[00012] FIG. 2 represents a perspective view of a prior art retaining wall.

[00013] FIG. 3 represents a perspective view of a retaining wall comprising a first embodiment of the present invention.

[00014] FIG. 4 represents a plan view of the embodiment of Figure 3.

[00015] FIG. 5 represents a front elevation view of the embodiment of Figure 3.

[00016] FIG. 6 represents a right elevation view of the embodiment of Figure 3.

[00017] FIG. 7 represents a close-up view of a connection between a base and face panel with an exposed end of rebar fixed into an opening in a base with grout.

[00018] FIG. 8a represents a plan view of a retaining wall comprising a second embodiment of the present invention using H-Piles beneath the base.

[00019] FIG. 8b represents a front view of a retaining wall comprising a second embodiment of the present invention using H-Piles beneath the base.

[00020] FIG. 8c represents a right side view of a retaining wall comprising a second embodiment of the present invention using H-Piles beneath the base.

[00021] FIG. 8d represents a perspective view of a retaining wall comprising a second embodiment of the present invention using H-Piles beneath the base.

[00022] FIG. 9a represents a plan view of a retaining wall comprising a third embodiment of the present invention using H-Piles beneath a pocket in the base.

[00023] FIG. 9b represents a front view of a retaining wall comprising a third embodiment of the present invention using H-Piles beneath a pocket in the base.

[00024] FIG. 9c represents a right side view of a retaining wall comprising a third embodiment of the present invention using H-Piles beneath a pocket in the base.

[00025] FIG. 9d represents a perspective view of a retaining wall comprising a third embodiment of the present invention using H-Piles beneath a pocket in the base.

[00026] FIG. 10a represents a plan view of a retaining wall comprising a fourth embodiment of the present invention using a barrier located on top of the face panel.

[00027] FIG. 10b represents a front view of a retaining wall comprising a fourth embodiment of the present invention using a barrier located on top of the face panel.

[00028] FIG. 10c represents a right side view of a retaining wall comprising a fourth embodiment of the present invention using a barrier located on top of the face panel.

[00029] FIG. 10d represents a perspective view of a retaining wall comprising a fourth embodiment of the present invention using a barrier located on top of the face panel.

[00030] FIG. 11a represents a plan view of a retaining wall comprising a fifth embodiment of the present invention using a barrier located on the rear side of the face panel.

[00031] FIG. 11b represents a front view of a retaining wall comprising a fifth embodiment of the present invention using a barrier located on the rear side of the face panel.

[00032] FIG. 11c represents a right side view of a retaining wall comprising a fifth embodiment of the present invention using a barrier located on the rear side of the face panel.

[00033] FIG. 11d represents a perspective view of a retaining wall comprising a fifth embodiment of the present invention using a barrier located on the rear side of the face panel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[00034] While embodiments of this invention can take many different forms, specific embodiments thereof are shown in the drawings and will be described herein in detail with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention, and is not intended to limit the invention to the specific embodiment illustrated.

[00035] Referring to the drawings in detail, wherein like numerals indicate like elements throughout, there is shown in FIGS. 3-7 a preferred embodiment of a retaining wall in accordance with the various aspects of present invention. While retaining wall systems are commonly used in retaining soil, it should be understood that the present invention can be used in many different applications including retaining other materials such as sand, pebbles or rocks.

[00036] Figure 3 illustrates a perspective view of an embodiment of wall 10 embodying principles of the present invention. The retaining wall 10 of the present invention is made of precast concrete in two discrete, modular parts.

[00037] Wall 10 comprises a precast concrete face panel 12 with an integral counterfort piece 14 and a precast base piece 16. A first precast modular part 11 is a generally

flat front face panel 12 with an integral counterfort 14 extending from the rear side of the panel 18. The face panel is typically not completely "flat" because it has surface ornamentation so that for example it appears to be a stone or brick or other ornamentation wall. The panel 12 can have a common height of twenty feet. The counterfort 14 which extends from the rear side of the panel 18 is unitary with the face panel 12. The face panel 12 will preferably have at least two counterforts 14 spaced apart evenly from ends of the face 12. The counterfort 14 has a flat bottom, so that in side view, the counterfort 14 is generally a right triangle. However, it should be understood that many different embodiments of the shape of the counterfort have been envisioned. For instance, when viewed from the side, the counterfort 14 could be a generally rectangular shape or be made of a shape that is generally rectangular and then transitions to a triangular shape. Many different combinations are claimed and disclosed herein. A side view of an embodiment of the retaining wall 10 is shown in Fig. 6.

[00038] Unless the wall is designed to retain water, it is important to have proper drainage behind the wall in order to limit the pressure to the wall's design value. Therefore an opening for drainage is preferably provided or the wall can be constructed using the dry stone building method so that the wall can be self-draining. Drainage materials will reduce or eliminate the hydrostatic pressure and improve the stability of the material behind the wall. Therefore, as seen in Fig. 6, the counterfort 14 may also have an opening 20 for drainage near the bottom front corner of the counterfort 14. Face panel 12 may also have a weep hole for drainage towards the bottom.

[00039] The front face panel 12 may have more than one counterfort 14 providing support. The counterfort 14 extends perpendicularly from the face panel 12, and its base extends rearward (illustratively thirteen feet). The top of the "triangle" may be squared off to have a

horizontal top ledge (illustratively of six inches), with a bottom edge (illustratively of ten feet). The bottom edge may also be squared off.

[00040] Reinforcing bars (rebar) 22 can be cast within the counterfort 14. Preferably, there will be more longitudinal, approximately vertical steel reinforcements incorporated in the lower part of the counterfort securing that part of the wall 10 where overturning forces are greatest. Furthermore, such rebars 22 are preferably in greater concentration at the rear of the counterfort 14 where they can best resist tensile forces, although reinforcements will normally also run approximately vertically at intermediate positions nearer the facing panel 12. Rebars can also be added within the base 16 for additional strength.

[00041] These rebars 22 act as a tensioning device within the concrete helping to meet design loads. In one embodiment, the rebars 22 extend through the bottom of the counterfort 14. The rebars 22 can also terminate in an "L" or "backwards L" configuration. This helps the exposed portions of the rebars 22 act as anchors. Another option is to utilize a forged foot 24 at the free end, where the bar (illustratively one inch diameter) terminates in a horizontal disk (illustratively two and a half inch diameter). However, it should be understood that the rebar 22 can terminate in a number of differing configurations.

[00042] A second precast modular part 15 comprises a base 16 which is illustratively one foot thick. The base 16 is generally a rectangular or trapezoidal shaped platform and typically is set on grade. Because the base 16 is a platform, it is generally solid with no substantial openings other than small openings for grout fill. The base 16 is precast concrete and therefore does not require that the base 16 be cast in-situ at the construction site.

[00043] In one embodiment, a shear key 26 can be made between the face 12 or counterforts 14 and the base 16. This shear key can be a depression in the base 16 and sized to

accept the bottom 30 of the front face panel 12. Once the bottom 30 of the face 12 is set into place, the voids between the shear key 26 and bottom 30 of the face panel 12 can be filled with grout to solidify the connection.

[00044] A shear key 26 can also extend down from the base 16 into the ground. This could be a pre-manufactured shear key or there can be exposed rebar extending down from the base 16 to be later poured with concrete in the field. In another embodiment, the base 16 can be precast with a front lip which protrudes from the end of the base 16 near the face panel 12.

[00045] In one embodiment, the base 16 has at least one opening 32 sized to accept the downward-extending rebar 22 ends from the counterfort 14. This opening 32 can be sized to accept more than one rebar 22 end. In a preferred embodiment, the base has a single row or multiple rows of openings 32, illustratively four and a half inches in diameter, to receive multiple downward-extending rebar 22 ends from the counterfort 14. This connection point between the counterfort 14 and base 16 is shown more closely in Fig 5. As shown in this Figure, rebar 22 can terminate in forged foot anchor 24.

[00046] The connection between the first module 11 and second module 15 is made by inserting an end of a piece of rebar of one module into an opening in the other module and then sealing the connection with grout. For the purposes of this disclosure, a method of connecting the modules will be described where the first module has protruding rebar and the second module has openings. However, it should be understood to one of ordinary skill in the art that the connection described herein can be reversed with the second module 15 having rebar extending from its top surface and connecting with openings within the bottom surface of the first module 11.

[00047] To connect the first module 11 and second module 15, an installer would place the second module 15 into a substantially horizontal position. The installer would then raise the first module 11 above the second module 15 and align the exposed ends of the rebars 22 of the first module 11 with the openings 32 on the second module 15. The installer would then lower the first module 11 on top of the second module 15 such that the exposed ends of the rebar 22 of the selected first module are placed within the openings in the second module. One advantage of this arrangement is that once the first module 11 is placed on the second module 15, no temporary shoring is required to hold the face upright until the grout connection between the first module 11 and second module 15 has cured.

[00048] By lowering the first module 11 onto the second module 15, the anchor 24 is simultaneously lowered into an opening 32 in the base 16. This opening 32 can be a straight cylindrical shape, tapered or formed using a corrugated pipe. It can extend partially or all the way through the base 16. It shall be understood that those of ordinary skill in the art can use a number of different sizes and shapes for the opening 32. Before the first module 11 is completely set on the second module 15, an installer can use one or more shims 36 to make the front face panel 12 plumb in both the vertical and horizontal directions. An installer can also use shims 36 to rotate the face 12 to any desired angle.

[00049] Once the installer has installed the shims 36 and is satisfied with the placement of the first 11 and second modules 15, the anchor 24 can finally be set into the opening 32. The shims 36 elevate the first module 11 above the second module 15 enough so that an installer can pump a high strength grout 34 into the opening 32. This high strength grout 34 fills the void remaining in the opening 32 and bonds itself to the concrete base 16 and the anchor 24. This results in a shear cone in the base to resist the pullout of the rebar 22, ultimately

connecting the two precast modular pieces 11, 15. Once the face 12 and counterfort 14 are connected to the base 16 with grout 34, the connection is complete. An installer can then backfill the area behind the retaining wall 10.

[00050] In a typical installation, multiple retaining walls 10 are placed adjacent to one another to form a continuous wall. To allow for flexibility between adjacent walls 10, an installer can place a shear key or use ship laps between adjacent modules. This interface between adjacent walls can either be grouted or not grouted. A product such as butyl mastic joint sealant or wrap can also be used to seal the vertical joint between adjacent faces 12.

[00051] If circumstances require extra precautions to keep the base 16 from sliding once it is backfilled and any surcharge loads are applied, several measures can be taken. One option is that the bottom of the base 16 can be textured or roughened to increase friction between the base 16 and subsurface ground beneath the base. An alternative is that the base 16 can be set on shims and have various holes or ports 38 in the base 16 so that flow-able grout can be pumped through the base 16 and into the void created by the shims underneath. This grout will serve to increase the frictional force between the base 16 and subsurface.

[00052] If there are poor soil conditions under the base, then H-piles 40 can be driven into the ground and the base 16 set on top of these piles 40 for added stability. Figure 8 shows an embodiment of the present invention with piles 40 driven into the earth underneath the base 16. If desired, a pocket 42 can be created in the base 16 to allow the pile 40 to extend up into the base 16 and then the connection can be filled with grout. Figure 9 shows images of pocket 42 formed in base 16. Alternatively, the piles 40 could extend up into the grouted area between the subsurface and the base 16 and then this void would be filled with grout. Still a fourth alternative method would be to utilize a cast-in-place pile cap which can be poured prior

to setting the base 16. This pile cap is typically a thick concrete mat that rests on concrete, steel or timber piles that are driven into the unstable ground to provide a suitable stable foundation.

[00053] In another embodiment, a vehicle impact barrier 44 can be formed and cast-in-place on top of the wall 10 or behind the wall 10. Figure 10 shows an embodiment of the retaining wall 10 with a vehicle impact barrier 44 attached on top of the wall 10. Figure 11 shows an alternative embodiment of the retaining wall 10 with a vehicle impact barrier 44 attached to the rear side of the panel 18. To create a cast-in-place impact barrier, will use a face panel 12 that has exposed rebar extending out of the face 12. This rebar will extend vertically out of the top surface of the face panel 12 if a user wishes to have the impact barrier 44 formed on top of the face 12. However if a user prefers that the impact barrier 44 be formed on a rear surface 18 of the face 12, then the rebar will extend horizontally out of the rear surface 18. In either scenario, an installer can cast an impact barrier 44 around the exposed rebar to form the cast-in-place barrier 44 at the desired location. Another embodiment of this impact barrier eliminates the need for in situ casting because a pre-manufactured, pre-cast barrier can also be formed integrally with the face 12 at the factory. The pre-cast concrete barrier can be precast in a number of different desired locations. However, in a preferred embodiment, the pre-cast concrete barrier is located on top of the face 12.

[00054] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[00055] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same,

equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[00056] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

I claim:

1. A precast concrete retaining wall assembly comprising:

a first module comprising a precast concrete face panel and at least one integral counterfort, wherein said first module includes reinforcement bars; and

a second module comprising a substantially solid precast concrete base platform, wherein said second module includes reinforcement bars.

2. The precast concrete retaining wall of claim 1 wherein the first module has a bottom surface and at least one reinforcement bar within said first module has an exposed end which extends beyond the bottom surface of said first module; and further wherein the second module has a top surface and at least one opening within the top surface of the base sized to accept at least one exposed end of said reinforcement bar.

3. The precast concrete retaining wall of claim 1 wherein said second module has a top surface and at least one reinforcement bar within said base has an exposed end which extends beyond the top surface of the base; and further wherein the first module has a bottom surface and at least one opening within the bottom surface of the first module sized to accept at least one exposed end of said reinforcement bar.

4. The precast concrete retaining wall of claim 1 wherein the integral counterfort is generally triangular when viewed from a side elevation view.

5. The precast concrete retaining wall of claim 1 wherein the integral counterfort is generally rectangular when viewed from a side elevation view.

6. The precast concrete retaining wall of claim 1 wherein the integral counterfort has a top portion and a bottom portion and said counterfort is generally rectangular at the top portion and then generally triangular at the bottom portion when viewed from a side elevation view.

7. The precast concrete retaining wall of claim 1 wherein there are multiple integral counterforts attached to the face panel.

8. The precast concrete retaining wall of claim 1 wherein the base further comprises a shear key sized to accept a bottom surface of said face panel.

9. The precast concrete retaining wall of claim 1 wherein the base further comprises a lip protruding from a top surface of the base.

10. The precast concrete retaining wall of claim 1 wherein the base further comprises at least one grout pour opening which extends completely through said base.

11. The precast concrete retaining wall of claim 1 wherein the base further comprises a textured bottom surface.

12. The precast concrete retaining wall of claim 1 wherein the base further comprises a shear key on a bottom surface of the base.

13. The precast concrete retaining wall of claim 1 wherein the face panel further comprises a precast concrete impact barrier attached to and located above a top surface of said face panel.

14. A method for installing a precast concrete retaining wall assembly which includes a first module comprising a precast concrete face panel and at least one integral counterfort, wherein said first module includes reinforcement bars, and a second module made of a precast concrete base, wherein said second module includes reinforcement bars and wherein one of said first module or second module further comprises a plurality of said reinforcement bars, each with an exposed end portion protruding from an outer surface and the other module further comprises at least one opening sized to receive said exposed end portion of said reinforcement bars, the method comprising the steps of:

placing the second module into a generally horizontal position;

placing the face of the first module in a generally vertical position and raising said first module above said second module;

aligning the exposed ends of the reinforcement bars of the selected first or second module with the at least one opening of the other module;

placing at least one shim on top of the second module;

moving the first module on top of the second module such that the exposed ends of the reinforcement bars of the selected first or second module are placed within the openings in the other module;

adding grout into said openings; and

backfilling the space behind the precast concrete retaining wall assembly.

15. The method of claim 14 further comprising having grout openings in the base and further comprising the steps of placing shims underneath the base and then pumping grout through the base and into a void created by the shims placed underneath the base.

16. The method of claim 14 further comprising the step of creating texture on a bottom surface of the base.

17. The method of claim 14 further comprising the step of creating a shear key on a bottom surface of the base.

18. The method of claim 14 further comprising the step of not using temporary shoring to resist temporary loads during installation.

19. The method of claim 14 further comprising the step of driving at least one pile or drilled shaft under the base.

20. The method of claim 14 further comprising having at least one grout opening in the base;

creating at least one pocket in a bottom of the base sized to cover at least one pile or drilled shaft;

driving said at least one pile or drilled shaft under the base; and

pumping grout through said at least one grout opening in the base.

21. The method of claim 14 further comprising having a shear key in the base sized to accept the face panel; and

grouting the shear key into the base after the first module has been placed on the second module.

22. The method of claim 14 further comprising grouting any gaps between the interface of the first module and second module.

23. The method of claim 14 further comprising placing one or more of either a butyl mastic joint sealant or wrap, a shear key, or ship lap between adjacent retaining walls.

24. The method of claim 14 further comprising having at least one exposed reinforcement bar extend vertically from a top surface of the face panel; and

further comprising the step of casting in place an impact barrier around said at least one exposed reinforcement bar.

25. The method of claim 14 further comprising having at least one exposed reinforcement bar extend horizontally from a location adjacent to a top surface of the face panel; and

further comprising the step of casting in place an impact barrier around said at least one exposed reinforcement bar.

26. A precast concrete retaining wall assembly comprising:

a first module comprising a precast concrete face having opposed top and bottom surfaces, opposed side surfaces, opposed front and rear surfaces, and at least one integral

counterfort integrally attached to the rear surface of the face, wherein said counterfort further comprises at least one side surface and at least a bottom surface, wherein said first module further includes reinforcement bars; and

a second module comprising a precast concrete base having opposed top and bottom surfaces, opposed side surfaces and opposed front and rear surfaces, wherein said second module further includes reinforcement bars.

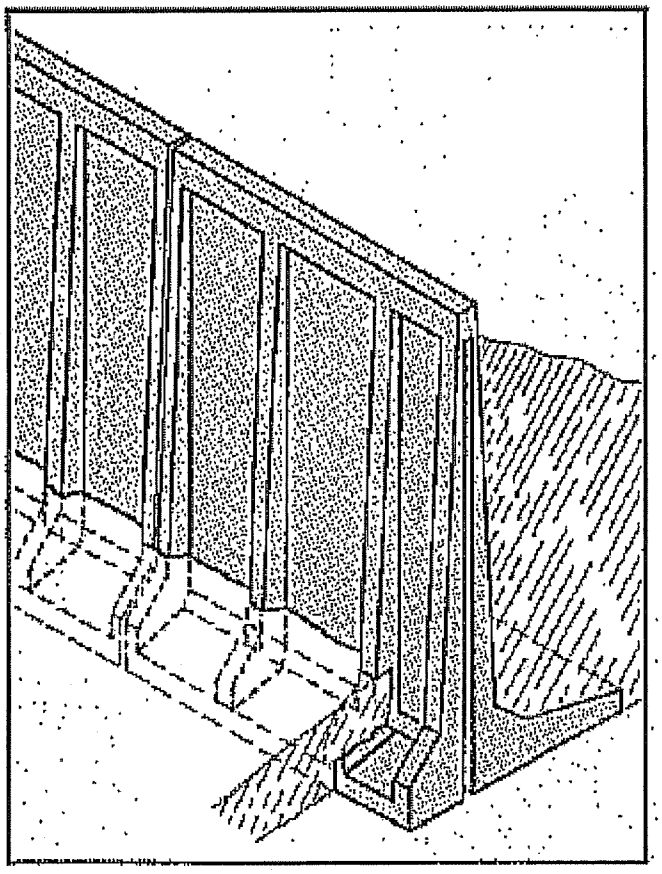


Figure 1 (Prior Art)

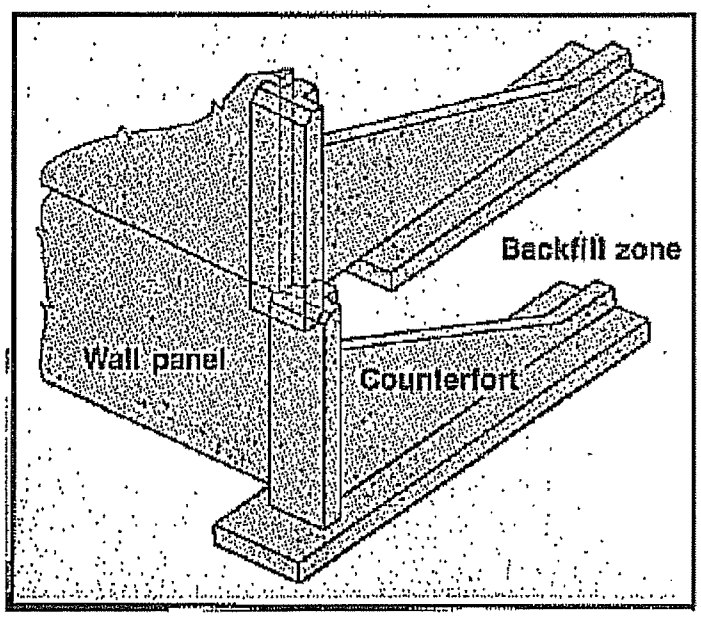


Figure 2 (Prior Art)

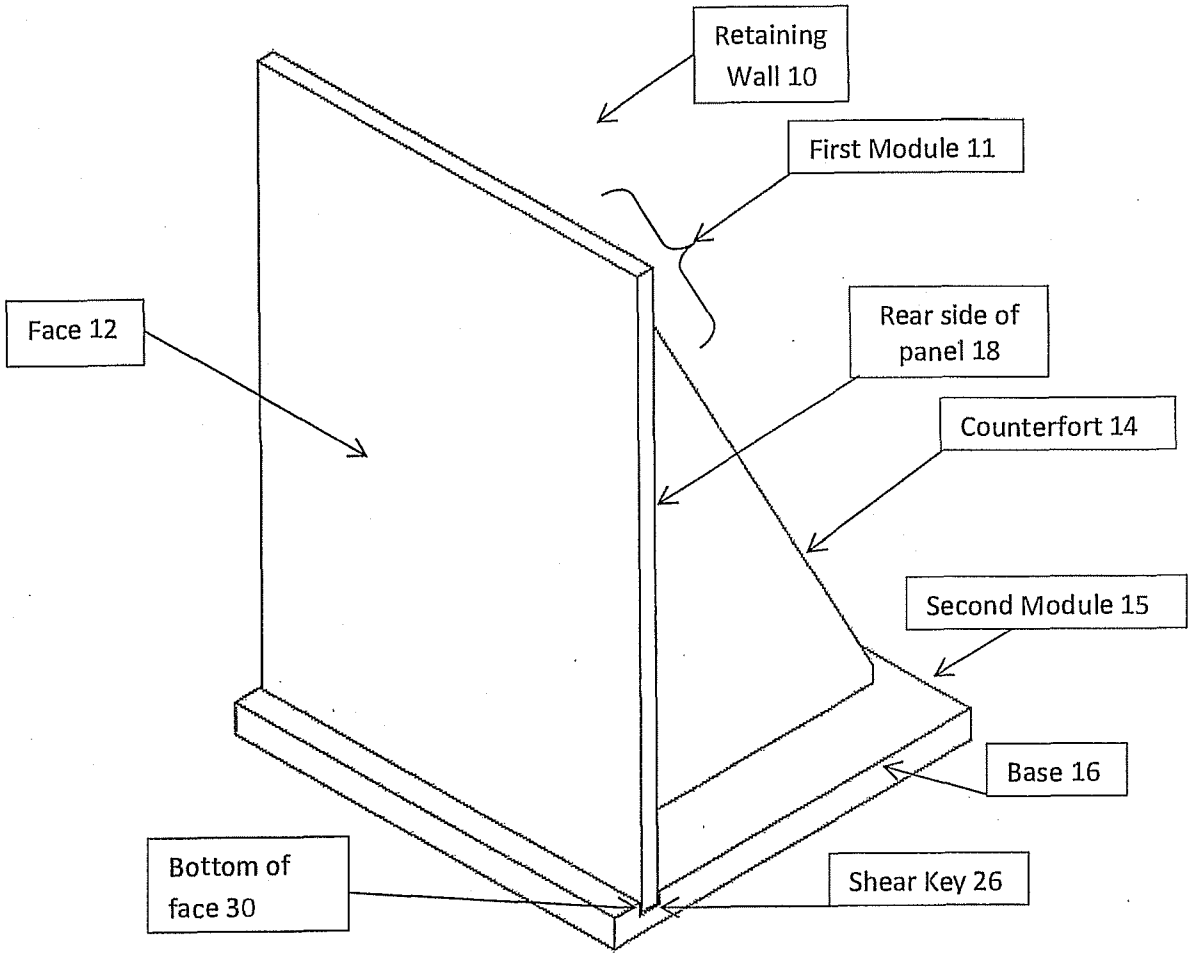


Figure 3

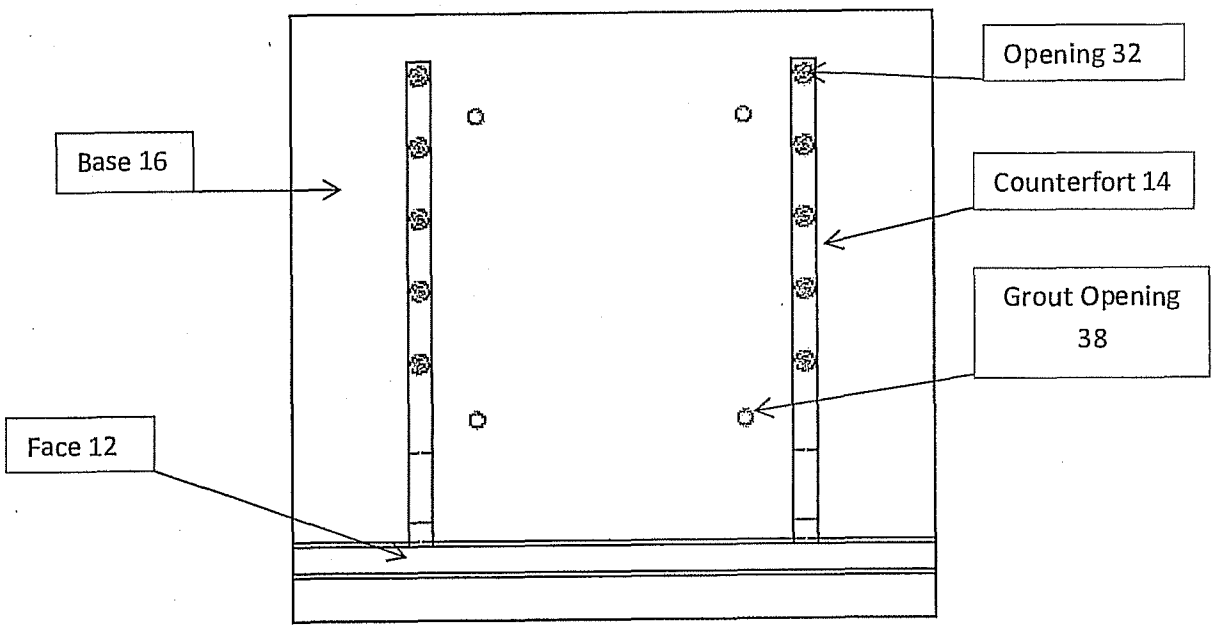


Figure 4

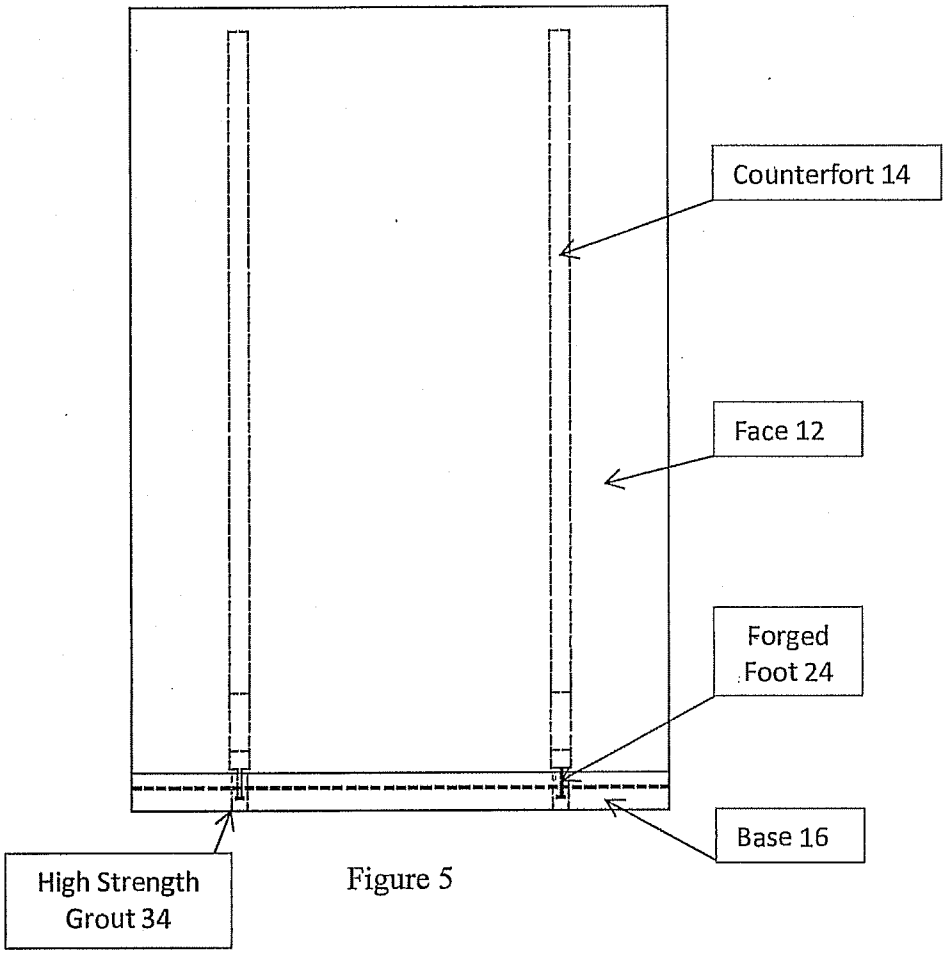

Counterfort 14
Face 12
Forged Foot 24
Base 16
High Strength Grout 34

Figure 5

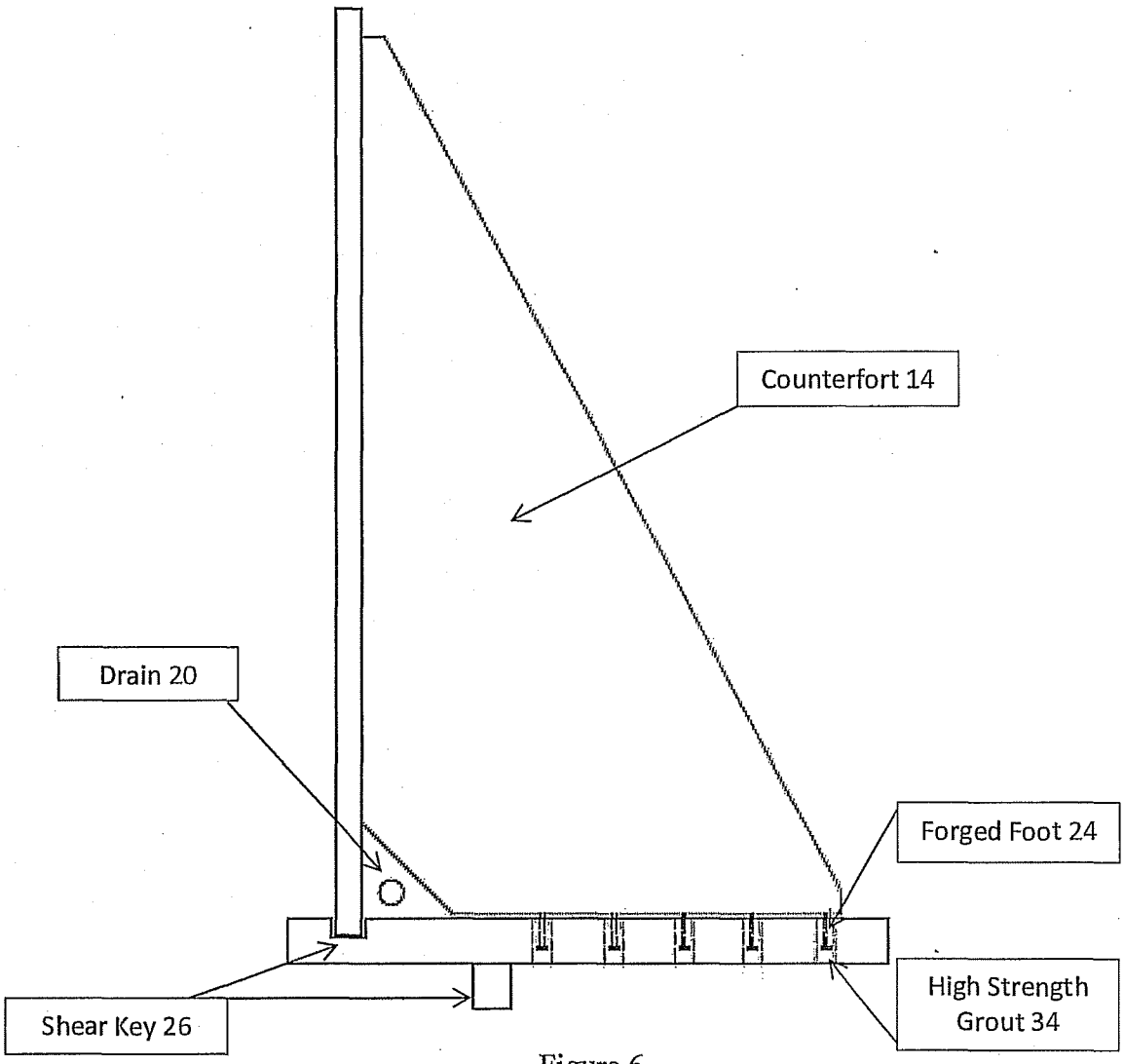


Figure 6

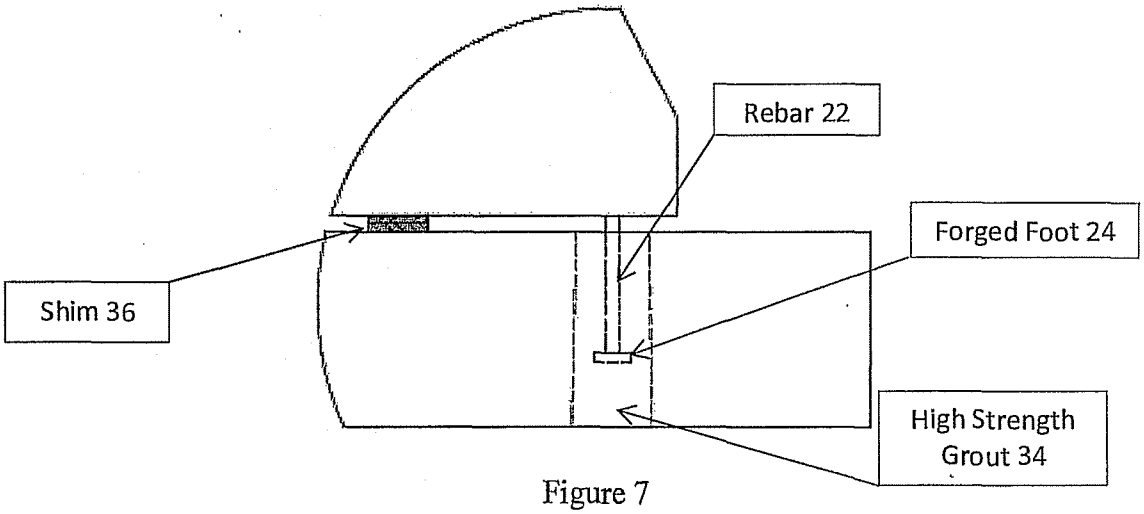


Figure 7

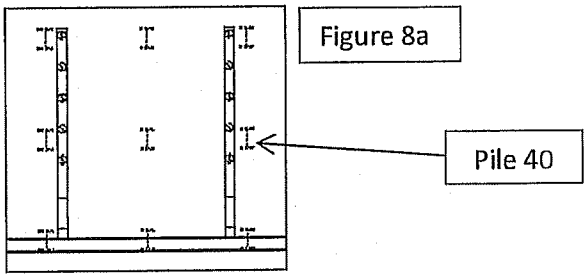
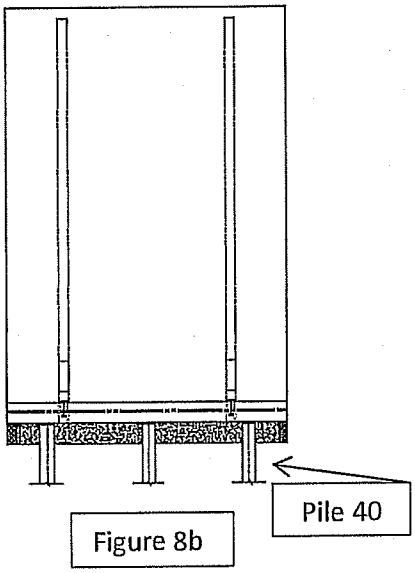


Figure 8a
Pile 40


Pile 40
Figure 8b

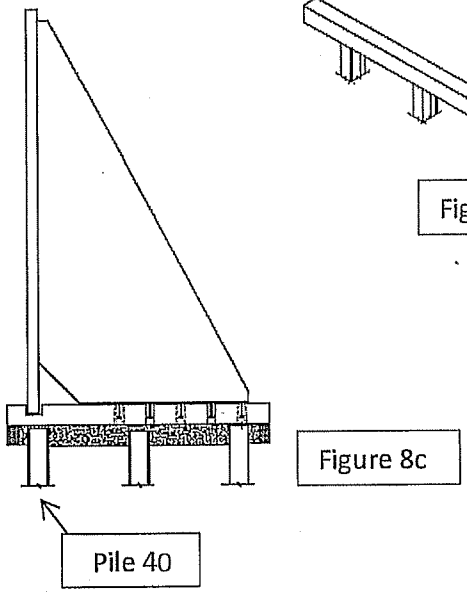


Figure 8c
Pile 40

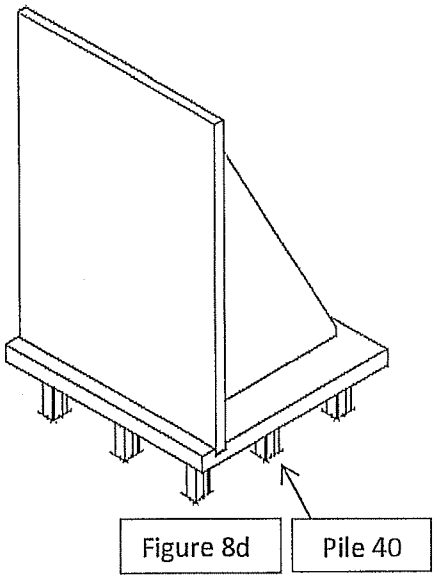


Figure 8d
Pile 40

Figure 8

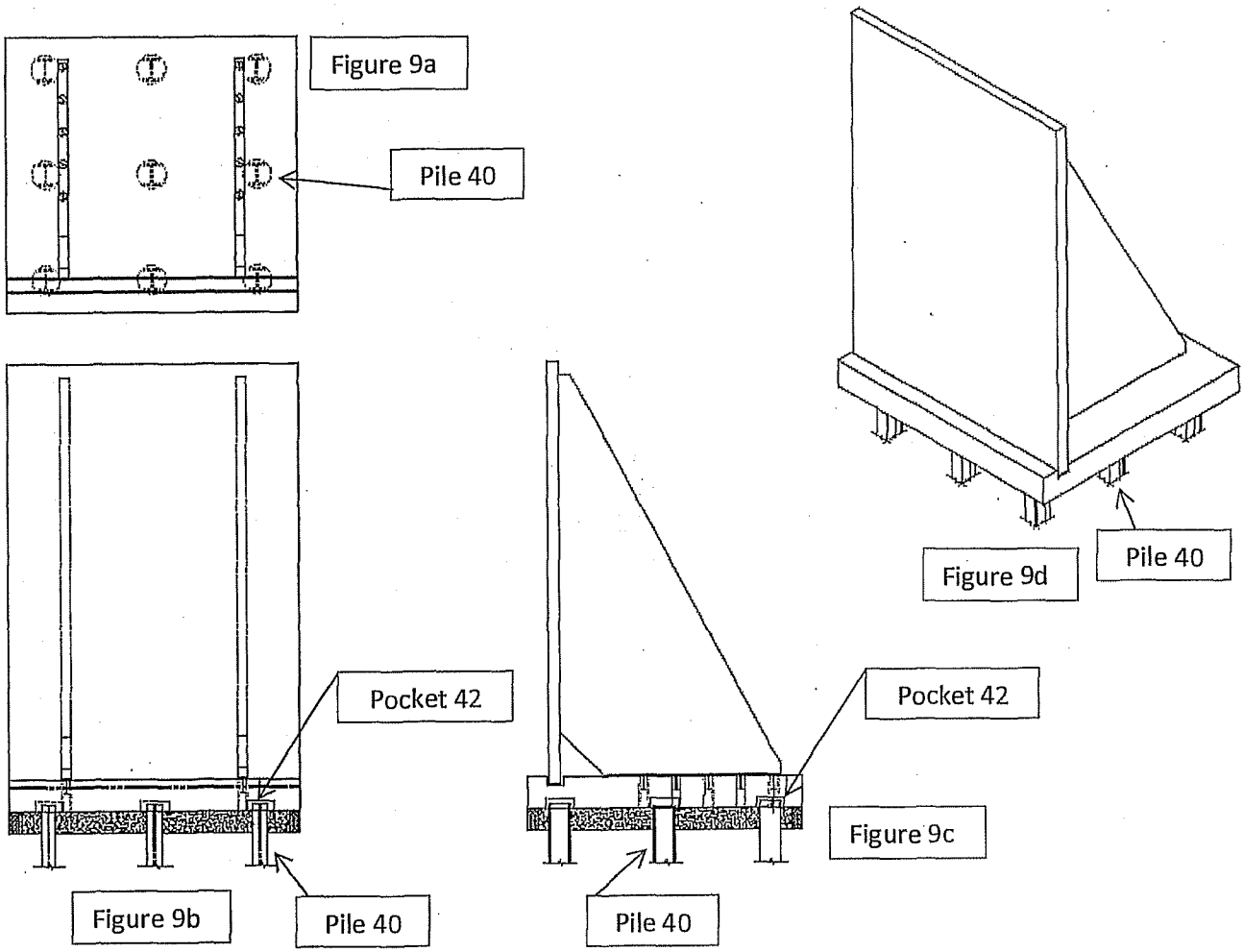


Figure 9a
Pile 40
Figure 9d
Pile 40
Pocket 42
Figure 9b
Pile 40
Pocket 42
Figure 9c
Pile 40

Figure 9

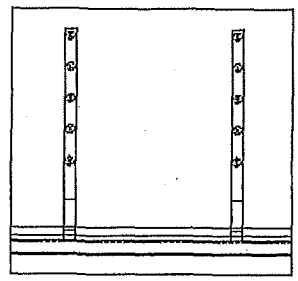


Figure 10a

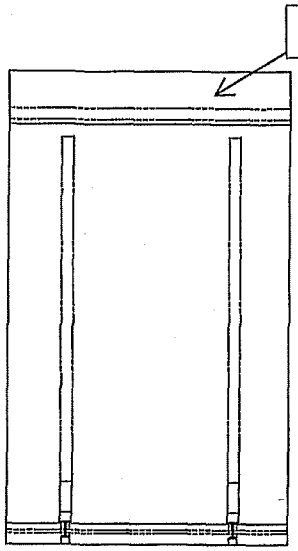


Figure 10b

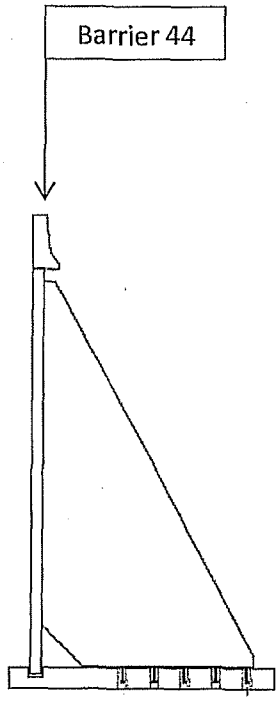


Figure 10c

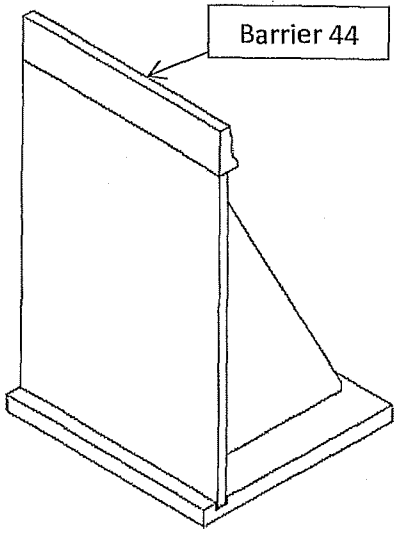


Figure 10d

Figure 10

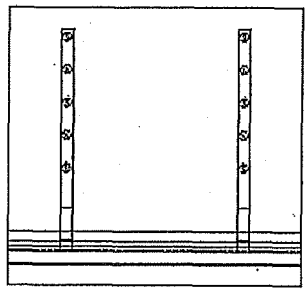


Figure 11a

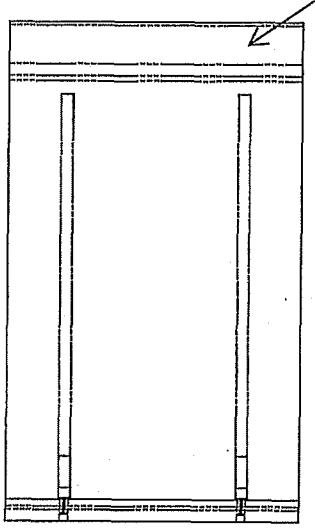


Figure 11b

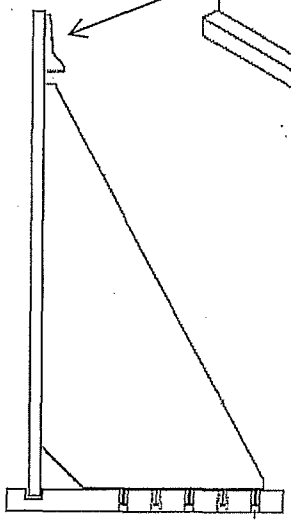


Figure 11c

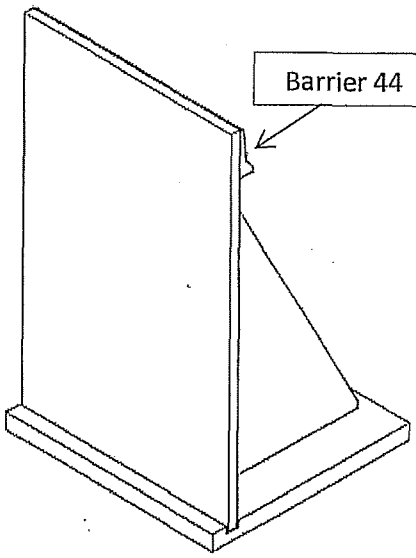


Figure 11d

Figure 11