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(54) **SEGMENTAL BLOCK CONNECTION SYSTEM**

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(57) **ABSTRACT**

(21) Appl. No.: **10/912,351**

A block pad for being disposed between courses of blocks in a segmental retaining wall, the block pad having frictional properties for transferring tensile load from a soil reinforcing geosynthetic to the wall. The block pad further providing cushioning between block courses to minimize block cracking from bearing loads and wall settlement.

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Related U.S. Application Data

(62) Division of application No. 09/928,918, filed on Aug. 13, 2001.

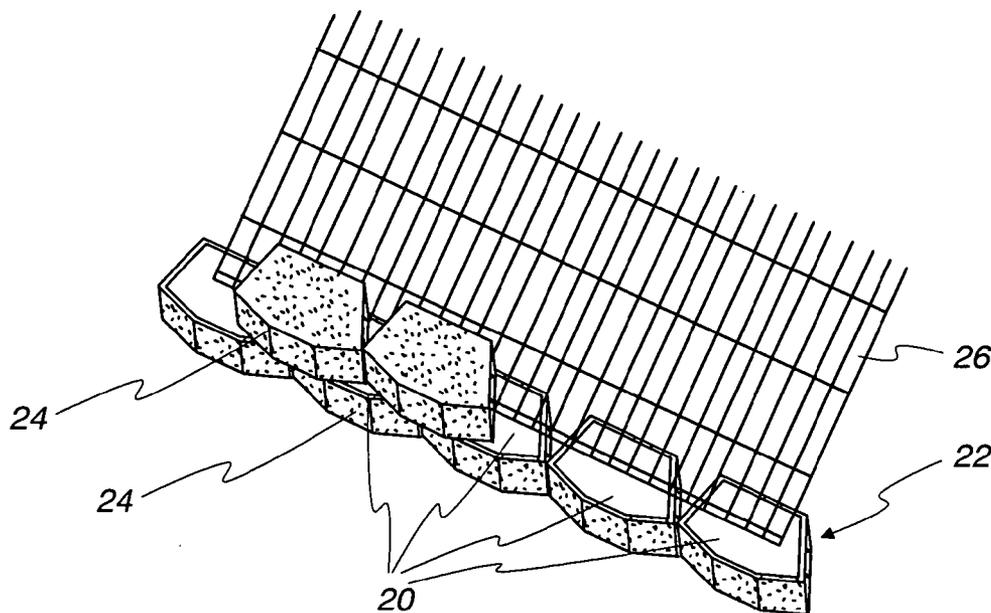


Fig. 1

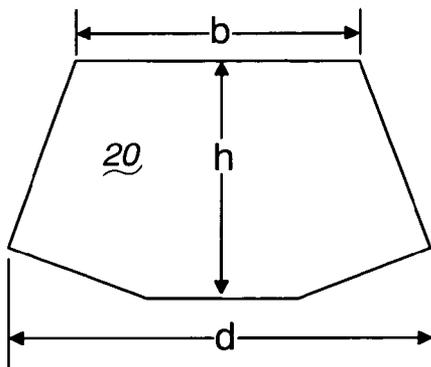


Fig. 2

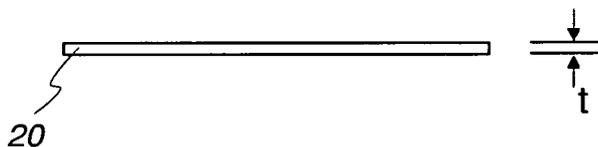
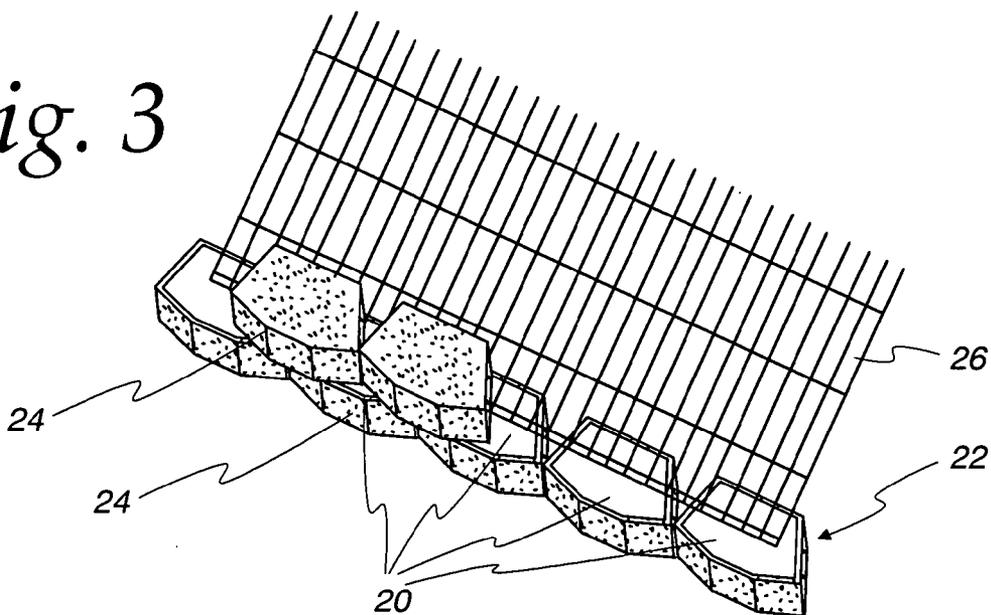


Fig. 3



SEGMENTAL BLOCK CONNECTION SYSTEM

[0001] This application is a divisional of application Ser. No. 09/928,918 filed Aug. 13, 2001, the disclosure of which is incorporated by reference herein.

FIELD AND BACKGROUND OF THE INVENTION

[0002] This invention relates generally to segmental retaining wall systems, and more specifically to a pad that is disposed between block layers and a geosynthetic reinforcement to enhance the connection between reinforcement and block in a segmental retaining wall.

[0003] Retaining wall blocks are typically stacked on top of one another to build a wall for retaining soil at a desired elevation. In addition to the blocks, reinforcing geosynthetics may be placed at different elevations within the backfill soil and between the blocks to interfere with shear planes within the soil mass that could cause wall failure and cause the soil behind the block face to act as a reinforced monolithic unit, not allowing a typical soil failure to occur. The geosynthetics are typically anchored by being sandwiched between blocks, with the overburden loads of the stacked block to apply normal force and capture the geosynthetic. Depending upon site conditions, the geosynthetics can be spaced at every block course or at greater intervals as needed.

[0004] In theory, anchoring a geosynthetic between blocks would provide adequate connection of the geosynthetic with the block facia, but if the mating block surfaces are not in uniform contact or are smooth, the tensioned geosynthetic can slip from between the blocks and the block-geosynthetic system fail to perform its maximum design strength.

[0005] In addition, the structural integrity of a reinforced segmental retaining wall can be jeopardized when individual blocks move laterally outward under the lateral soil loads in the wall. Such failure is more likely when the connection strength between the geosynthetic and the block is inefficient or when the blocks are non-uniform, which can cause loads to be concentrated to the point where the localized compressive strength of a block is exceeded. Settlement of a wall can also cause cracking of individual blocks.

[0006] Thus, there is a need for a segmental wall and geosynthetic reinforcement system that provides reliable and optimal connections between geosynthetics and the blocks of a wall. There is also a need for a segmental retaining wall that minimizes failure of individual blocks under localized bearing loads and wall differential settlement.

SUMMARY OF THE INVENTION

[0007] The block pad of the present invention overcomes inefficient connection problems when placed between upper and lower retaining wall blocks and the reinforcement geosynthetic. The block pad deforms to uniformly mate the surfaces of upper and lower blocks. This uniform mating improves the "grip" on a geosynthetic that is anchored between the blocks to ensure that there is optimal tension in the geosynthetic at the connection. Optimal tension results in smaller outward deflections in the wall and a better soil/block/reinforcement system. An added advantage of the

pad is that it cushions against concentrated bearing loads on lower blocks to prevent cracking that can occur when the wall settles.

[0008] One embodiment of the present invention is a pad made of a planar polymeric material inserted between courses of Segmental Retaining Wall (SRW) units (or blocks) placed as part of the retaining wall construction. The pad can be composed of any one of a number of materials, including but not limited to:

- [0009] a needlepunched nonwoven geotextile (continuous filament, or staple fiber),
- [0010] rubber or polymeric foam applied to a scrim (similar to a carpet non-stick pad), plastic sheet material, such as a PVC sheet,
- [0011] polypropylene,
- [0012] polyethylene,
- [0013] SBR rubber, or
- [0014] other compressible material.

[0015] This material is then cut to fit around the plan view shape of a specific block type, (Versalok, Keystone, Anchor block, etc.) over which the reinforcing pad is placed. The next block course is then placed over the pad, and construction continues in this manner until the desired wall height is achieved. The pad need not be inserted between every block or every course of blocks in the wall.

[0016] The insertion of the pad of this invention between block courses increases the connection strength of the segmental retaining wall block system, providing a more efficiently designed and constructed retaining wall.

[0017] A higher design efficiency results in less reinforcement being required and/or lower strength geosynthetics being used to reinforce the soil. Although the pads are an additional element in the wall system, the overall cost of the system is less because lower quantities or strengths of soil reinforcing geosynthetics are used.

[0018] In addition, the use of the block pads results in lower deformations to the wall system when the geotextile is under tensile load.

[0019] The present invention also has a cushioning effect from having the pad between block courses. This cushioning reduces block cracking from bearing loads and wall settlement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is a plan view of a reinforcing pad in accordance with the present invention.

[0021] FIG. 2 is an elevational view of the pad of FIG. 1;

[0022] FIG. 3 is a perspective view of a segmental retaining wall under construction and having multiple block courses, a geosynthetic reinforcement layer, and pads in accordance with the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0023] The following is a detailed description of the drawings. It is noted that the same reference numeral will be used to identify the same or similar elements in each figure.

[0024] Illustrated generally in FIG. 1, is a pad 20 in accordance with the present invention. The pad 20, as illustrated, has a plan shape intended to substantially match the plan shape of blocks to be used in building a segmental retaining wall. It should be noted that any shape of pad 20 will provide the benefits of the present invention, but preferably its shape substantially matches that of the blocks to be used in the wall.

[0025] As illustrated in FIG. 2, the pad 20 has a thickness that is determined based on the expected irregularities of the block to be used. Although depicted as a separate member, the pad 20 can be joined to the top or bottom surface of a block either before or after manufacture of the block. Such an arrangement may increase manufacturing costs of the block somewhat, but should reduce labor expenses in the actual construction of the wall.

[0026] The pads preferably have a thickness approximately equal to the thickness of the geosynthetic being anchored. Other pad thicknesses can be used, with the optimal pad thickness determined based on the characteristics of the blocks, the geosynthetic, the bearing loads of the wall, and the amount of settlement expected.

[0027] The improved connection between the wall and the geosynthetic is due to the interaction of the pad with the geosynthetic: specifically, a hard pad will not perform as well as a softer, more conforming pad. Also, the texture of the pad and geosynthetic affect performance. For example, a carpet non-skid foam pad performed better in testing, as compared with a nonwoven geotextile. The nonwoven fabric may have a better tendency to grip the geogrid, due to the many random fibers in the product. Further, a needlepunched nonwoven would be expected to perform better than say a flatter, calendared type nonwoven geosynthetic.

[0028] A maximum thickness of the pad 20 may be an issue if the thickness is so great that shear within the pad itself becomes a mode of failure. Thus, the pad 20 should not be so thick as to risk unbearable shear loads in the pad itself.

[0029] Also, the actual block geometry can affect performance. Tests reported in FIGS. 4 through 14 were performed on a flat topped block, without holes within the block body (see Keystone or Anchor for void space blocks). Thus, every block/grid system will be optimized with different pad materials. This is not unusual in the reinforced segmental block wall industry as long as improvements in wall performances can be demonstrated.

[0030] FIG. 3 illustrates the use of the pad 20 in the construction of a wall 22. The wall 22 is formed by a number of layers (or courses) of blocks 24. Disposed between the blocks is a geosynthetic 26 that extends into the soil to be reinforced. When properly tensioned, the geosynthetic 26 reinforces the soil to reduce the design loads on the retaining wall 22. As illustrated, the geosynthetic 26 is a grid, but other types of geosynthetics can be used in accordance with the present invention.

[0031] The block pad of the present invention has been tested and shown to improve

[0032] wall connection strength. Connection strength testing has been performed using three materials:

[0033] a PVC geomembrane sheet,

[0034] a nonwoven needlepunched fabric; and

[0035] a foamed scrim carpet skid resistant pad.

[0036] Testing was performed using the National Concrete Masonry Association (NCMA) test procedure ref. 1. This test method allows determination of the strength of a connection between a segmental block system and a reinforcement element.

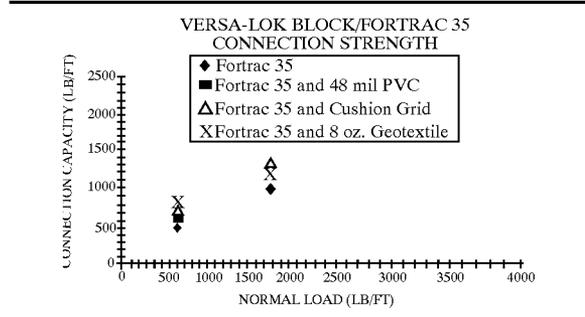
[0037] Connection strengths using the product, when compared with no intermediate interface, showed improvements of from 14% to 39% with an average of 26%. Testing was performed at two normal loads. Complete test results are provided in Tables 1 to 11.

TABLE 1

CONNECTION TEST RESULTS BLOCK TYPE: VERSA-LOK BLOCK GRID TYPE: Fortrac 35					
SERIES	WIDTH OF GEOGRID	Normal Load (lb/ft)	Wall Height (ft)	Number of Blocks	Peak Tensile Capacity (lb/ft)
1	3	600	5.0	10.0	630
2	3	1800	15.0	30.0	960
3	3	600	5.0	10.0	720
4	3	1800	15.0	30.0	1101
5	3	600	5.0	10.0	615
6	3	1800	15.0	30.0	1186
7	3	600	5.0	10.0	878
8	3	1800	15.0	30.0	1101

[0038]

TABLE 2



Note: Slipping and tearing of the geogrid occurred on all test series.

[0039]

TABLE 3

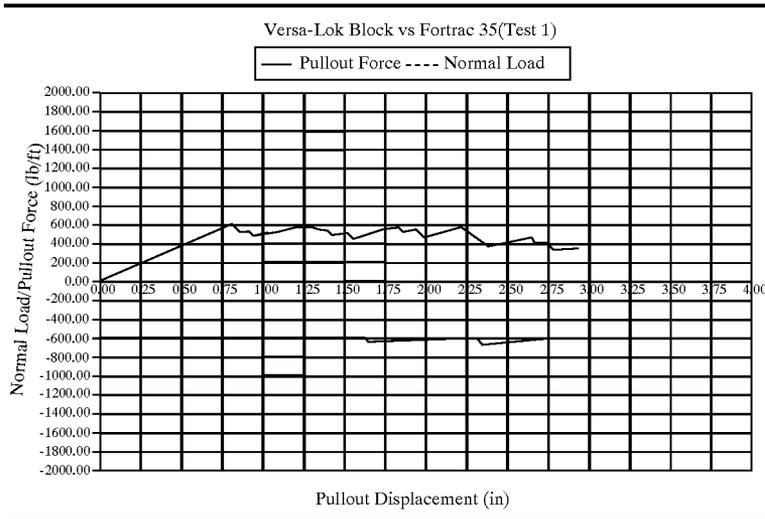
Versa-lok Block vs. Forrac 35				
Block	Grid	Material	Normal Load (lb/ft)	Pullout Force (lb/ft)
Versa-lok	Forrac 35	N/A	600	630
Versa-lok	Forrac 35	N/A	1800	960
Versa-lok	Forrac 35	40 mil PVC	600	720
Versa-lok	Protrac 35	40 mil PVC	1800	1101
Versa-lok	Forrac 35	Cushion Grid	600	815

TABLE 3-continued

Versa-lok Block vs. Forrac 35				
Block	Grid	Material	Normal Load (lb/ft)	Pullout Force (lb/ft)
Versa-lok	Forrac 35	Cushion Grid	1800	1188
Versa-lok	Forrac 35	8 oz Geotextile	600	878
Versa-lok	Forrac 35	8 oz Geotextile	1800	1101

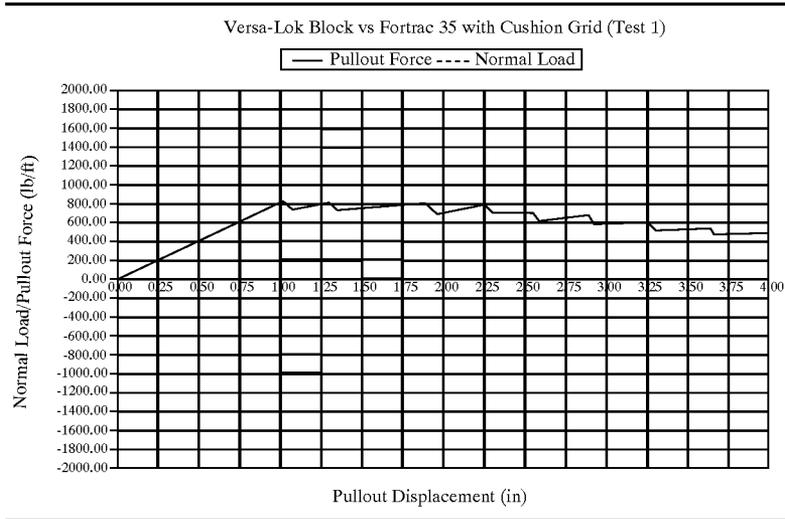
[0040]

TABLE 4



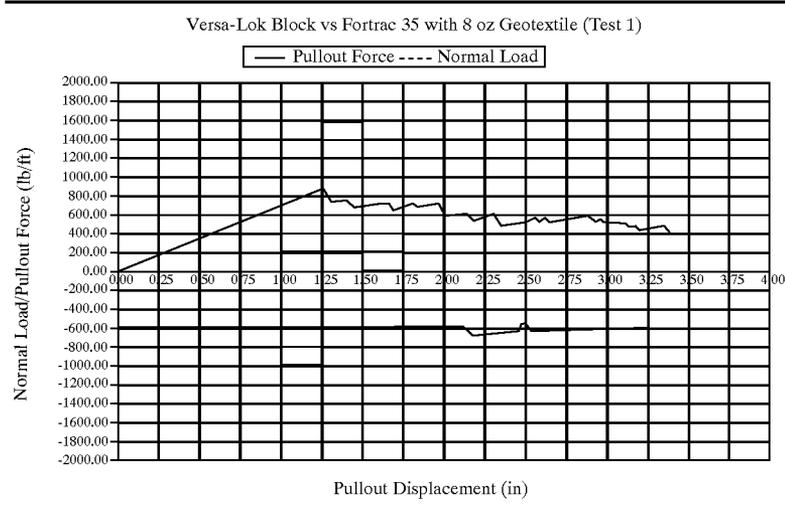
[0041]

TABLE 5



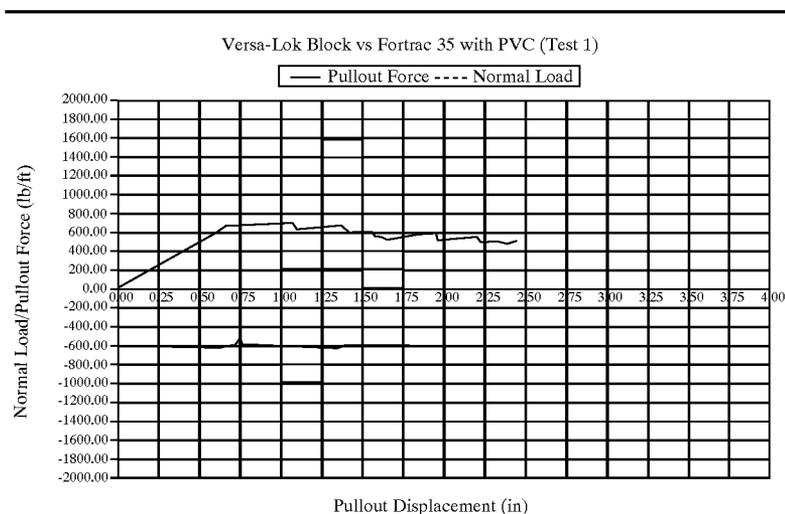
[0042]

TABLE 6



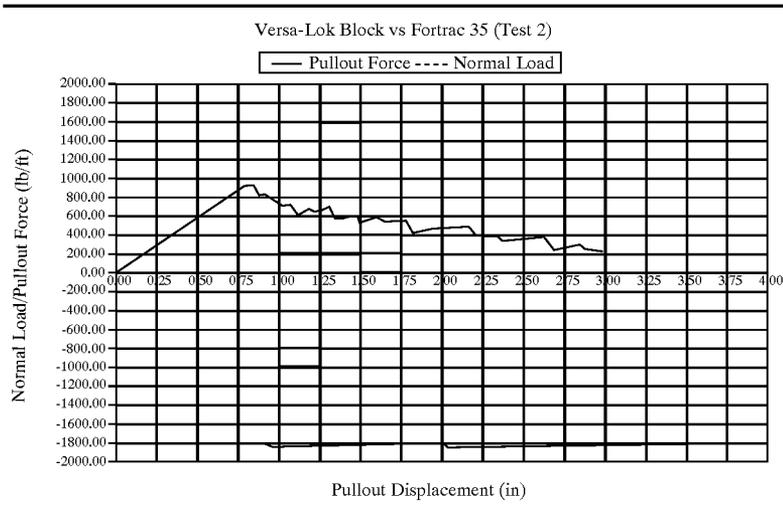
[0043]

TABLE 7



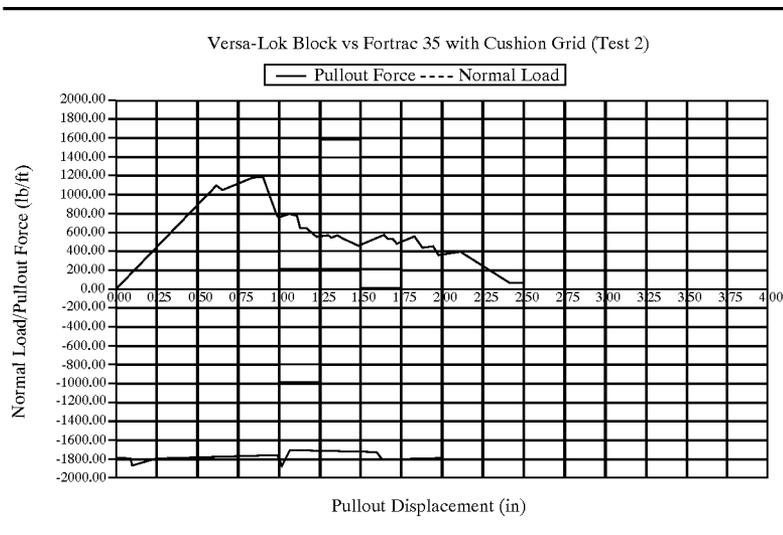
[0044]

TABLE 8



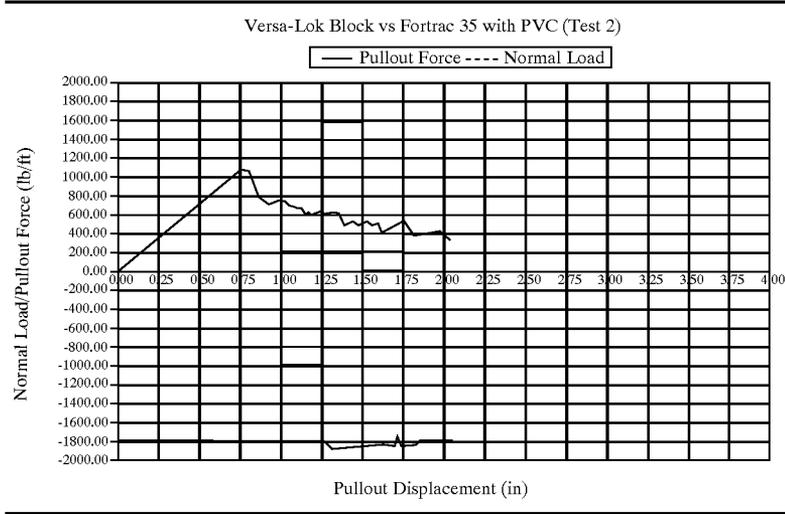
[0045]

TABLE 9



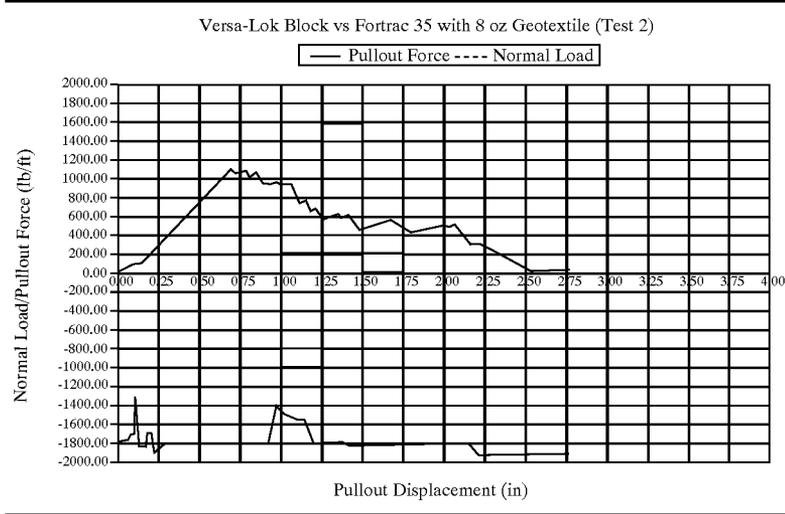
[0046]

TABLE 10



[0047]

TABLE 11



[0048] The use of the present invention benefits reinforced walls by optimizing available geosynthetic design strength, and by reducing deformations in the system connection when under load.

[0049] Utilizing the frictional reinforcement connection system of the present invention between blocks results in at least three specific benefits:

[0050] Lower quantities of geosynthetic, that has as a result of lowering the delivered cost of their system to the contractor;

[0051] Lower deformations to the wall system when the geosynthetic is under tensile load; and

[0052] A cushioning effect from having a “soft” pad between block courses to reduce cracking and failure of individual blocks.

[0053] This invention allows geosynthetics to be utilized to their fullest tensile strength. The result is the most efficient/low cost delivered strength for geosynthetic products. It is expected that geosynthetic producers will be driven to conduct testing with the present invention with their geosynthetic and use the improved results as a selling tool to contractors.

[0054] Further, the connection test results can be submitted to engineers and wall designers to assist in design efforts. A data file of block/grid/pad results to be used in design

(NCMA software) can be generated and include design data and other information regarding the use of the present invention.

[0055] The present invention is a relatively simple product to manufacture. A roll of material from a producer company in block type appropriate widths of master roll lengths is cut to the desired shape of the block to be reinforced. There are many cutter sources available, such as the Packlite Company of Atlanta, Ga. Also specific dies can be generated to allow cutting of the pad for each type of block.

[0056] The foregoing detailed description of the drawings is intended for clearness of understanding only and no unnecessary limitations therefrom should be read into the following claims.

1. A geosynthetically reinforced segmental retaining wall system, comprising:

- a plurality of stacked blocks;
- a geosynthetic soil reinforcing material disposed between adjoining stacked blocks; and
- a pad comprising a resilient material for being disposed between the stacked blocks, the pad for increasing the transfer of a tensile load from the geosynthetic soil reinforcing material to the segmental retaining wall by at least fourteen percent.

2. The wall system of claim 1, wherein the resilient material is shaped to substantially match the shape of a horizontal surface of the blocks.

3. The wall system of claim 1, wherein the resilient material consists of one or more of the following:

- polyvinyl chloride (PVC);
- a needlepunched nonwoven geotextile; or
- a polymeric foam applied to a scrim.

4. The wall system of claim 1, wherein the pad comprises:

- a resilient material that has a thickness sufficient to substantially fill voids and uneven surfaces between adjacent horizontal surfaces of retaining blocks.

5. The wall system of claim 1 wherein the pad is made of a material consisting of:

- a polymeric geomembrane, or a nonwoven needlepunched product, or a scrim with foam covering.

6. The wall system of claim 1, wherein the pad for insertion between the stacked blocks is shaped to fit the block shape and provides a frictional connection between a soil reinforcing geosynthetic and the wall.

7. The wall system of claim 1, wherein the pad provides an interlayer of dissimilar material to the concrete block that reduces cracking of the blocks once installed because of its thickness and compressibility.

8. A method for constructing a segmental block retaining wall comprising the steps of:

- stacking a plurality of blocks;
- disposing a geosynthetic soil reinforcing material between a pair of vertically stacked blocks; and

disposing a pad of resilient material between the pair of vertically adjoining stacked blocks and adjacent to the geosynthetic soil reinforcing material, wherein the pad increases the transfer of a tensile load from the geosynthetic soil reinforcing material to the segmental block retaining wall by at least fourteen percent as compared to a tensile load that would be transferred without the pad.

9. The method of claim 8, wherein the steps of:

- disposing the pad between the vertically stacked blocks results from the pad being formed integrally with one of the blocks.

10. The geosynthetically reinforced segmental retaining wall system of claim 1, wherein the pad is formed integrally with a block.

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