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EROSION CONTROL STRUCTURE

Abstract

A system including a closed loop or partially closed loop structure, including tied blocks, positioned at or adjacent to a toe of a slope.

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Background/Summary

[0001] This application claims priority to U.S. Provisional Application Ser. No. 63/552,335 filed on Feb. 12, 2024 and entitled Erosion Control Structure, the entire contents of which are hereby incorporated by reference. [0002] The present disclosure is directed to an erosion control structure, and more particularly, to an erosion control structure that can include tied blocks.

BACKGROUND

[0003] Erosion control structures are typically used to limit the bulk movement and/or entrainment of dirt and/or soil. Such erosion control structures are often desired to be located on inclined surfaces or substrates. In particular, such erosion control structures may often be located at the bottom of the inclined surface or substrate, adjacent to a shoreline or sharp drop-off, where the erosion control structure can serve as a lip or anchor. In these cases the erosion control structure can enable a build up of soil and vegetation above and behind the erosion control structure.

[0004] Erosion of shorelines and the like present numerous challenges including erosion and downstream pollution of waterways, safety concerns for human and animal entrance and egress, undesirable aesthetics, and increased maintenance costs. Typically, the bank adjacent to a lake, pond, stream, river or other waterway is unstable at the interface of the bank and the water level, commonly known as the toe of the slope. In particular in some cases the toe of a slope may collapse due to oversaturation with water, and/or may erode due to water or wave action.

[0005] Existing erosion control structures that are positioned on inclines and/or at shorelines can be difficult and expensive to manufacture and deploy, and/or may not be sufficiently effective to retain soil to provide the desired build up above/behind the erosion control structure. Other existing erosion control structures that are used on flat surfaces can have similar challenges.

SUMMARY

[0006] In one embodiment the present disclosure is directed to an erosion control structure that can be located on an incline and/or at a shoreline, and that can operate as a lip or anchor to provide a build up of soil and vegetation behind the erosion control structure. In other embodiments the erosion control structure can be used on flat surfaces. The erosion control structure is relatively quick and easy to assemble, and can provide a strong and long-lasting anchor/support that is relatively inexpensive to procure and install. More particularly, in one embodiment the invention is directed to a system including a closed loop or partially closed loop structure, including tied blocks, positioned at or adjacent to a toe of a slope.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. **1** is a perspective view of one embodiment of an erosion control structure;

[0008] FIG. **2** is a side view of a portion of the erosion control structure of FIG. **1**, in a flat/unrolled state, and positioned on a ground surface;

[0009] FIG. **3** is a top view of a tied block mat which can be used to make part of the erosion control structure of FIG. **1**;

[0010] FIG. **4** is a perspective view of a portion of the tied block mat of FIG. **3**;

[0011] FIG. **5** is a side view of another erosion control structure, shown positioned at a toe of a slope;

[0012] FIG. **5**A shows the erosion control structure of FIG. **5**, with soil infill located therein;

[0013] FIG. **6** is a side view of another embodiment of the erosion control structure, shown positioned at a toe of a slope, with soil built up above/behind the erosion control structure;

[0014] FIG. **7** is a side view of another embodiment of the erosion control structure;

[0015] FIG. **8** is a perspective view of another embodiment of the erosion control structure, shown positioned at the toe of a slope;

[0016] FIG. **9** is a side view of another embodiment of the erosion control structure;

[0017] FIG. **10** is a perspective view of the erosion control structure of FIG. **10**, shown positioned at the toe of a slope and at/adjacent to a body of water;

[0018] FIG. **11** is a side view of another embodiment of the erosion control structure;
[0019] FIG. **12** is a side view of another embodiment of the erosion control structure;
[0020] FIG. **13** is a side view of another embodiment of the erosion control structure;
[0021] FIG. **14** is series of perspective views showing one method for forming an erosion control structure;
[0022] FIG. **15** is a side view of another embodiment of the erosion control structure;
[0023] FIG. **16** is a perspective view of an erosion control structure, positioned in a channel/ditch; and
[0024] FIG. **17** is a side cross section taken along line **17-17** of FIG. **16**.

DETAILED DESCRIPTION

[0025] One embodiment of an erosion control structure, generally designated **10** shown in FIG. **1**, can in one case be made of or include a closed loop structure (or substantially or partially closed loop structure) of tied block **12**, that is (in one case) wrapped about/positioned about a core or core material **14**. The structure **10** can in one case be termed a concrete block erosion roll ("CBER"). As shown in FIGS. **2-4**, in one embodiment the closed loop structure **12**/tied block structure **12**, when laid flat, includes or takes the form of an array of blocks **16** that are coupled to an adjacent, flexible grid/mesh material **18**. In the illustrated embodiment each block **16** has a truncated pyramid shape, having a base **20** on its underside, the base **20** having a bottom surface **21** and, in one case, four rectangular surfaces **23** extending about a perimeter of the base **20** (see FIG. **4**). Each block **16** can have with four angled sides **22** extending away from the base **20** (upwardly from the base **20**, when laid flat in the configuration of FIGS. **2-4**). Each side **22** is inclined inwardly (moving in a bottom-to-top direction) relative to the associated block **16**. Each block **16** can have a flat, square top surface **24** positioned at a top of each side **22**, oriented parallel to the base **20**/bottom surface **21**.

[0026] In one embodiment each block **16** can have a size of between about two inches and about eighteen inches square at the base **20**, have a height of between about one inch and about ten inches, and have a spacing therebetween of between about one inch and about three inches. Each block **16** can be made of cast concrete, but if desired can be made of other materials included but not limited to clay, plastics, polymers, fiberglass, composite materials, rubber, synthetic rubber, cement (including hydraulic cement), cement mixed with gravel, sand and/or other aggregates, combinations of these materials and the like. In addition, it should be understood that each block **16** can have various other shapes besides the truncated pyramid shape shown in the figures, including for example in one case a generally rectangular prism shape (including cubes or cuboids), pyramids, or the like.

[0027] The grid/mesh material **18** can take any of a wide variety of shapes and forms, and in one case is a geogrid, such as a geosynthetic material used to reinforce soils and ground surfaces, and which can resist tensile forces. The grid/mesh material **18** can be made of or include plastic and/or polymer material, such as polypropylene, and more particularly biaxial polypropylene yarn, which may in one case be coated with a polymer to provide resistance to degradation due to exposure to ultra-violet radiation and weathering. In one case a suitable grid/mesh material **18** is FORNIT® 30/30 biaxial geogrid, manufactured by HUESKER Synthetic GmbH of Gescher, Germany. The grid/mesh material **18** can also or instead take the form of other tensile elements such as rope, wire, cable, or string made of polymers, plastic, metal, cotton, or other materials.

[0028] While each block **16** can be relatively rigid, the grid/mesh material **18** may have sufficient flexibility to enable the mesh material **18** to be folded about itself, and to enable the tied block structure **12** to be rolled into, and assume, the rolled/generally tubular or cylindrical shape shown in FIG. **1**. The grid/mesh material **18** can have or define a grid of strands **25** that are arranged perpendicular to each other, or are arranged at other angles, to define gaps **26** therebetween (see FIGS. **3** and **4**). In one case the gaps **26** are at least about ¼″ square (or have an average surface area of at least about 0.0625 square inches) about so that liquids and small particulates can pass therethrough, and in one case the gaps **26** are about 1.35″ square.

[0029] The grid/mesh material **18** can be coupled to the blocks **16** to form the tied block structure **12**. In one embodiment, the grid/mesh **18** is embedded in a lower portion of each block **16**, adjacent to and parallel to the base **20**/bottom surface **21** of each block **16**. In particular, in one case, when the blocks **16** are made of concrete and/or a hardenable paste, the grid/mesh **18** can be embedded in each block **16** during the formation of the blocks **16**, for example when each block **16** is made of liquid/slurry concrete. The concrete blocks **16** can then be allowed to cure and harden, anchoring each block **16** to the grid/mesh **18**.

[0030] In another embodiment, the grid/mesh **18** includes or takes the form of a three-dimensional mat of interconnected fibers, where the "three-dimensional" mat can have an open weave or mesh component having a loft or thickness that is at least about 5 mm in one case and/or less than about 25 mm. In this case the grid/mesh **18** can be a geotextile and/or loop matting that has outwardly protruding filaments that can project into the base **20** of each block **16** when the block **16** is curing, to thereby bond the grid/mesh **18** and the blocks **16**. In this case the grid/mesh **18** can be placed against the blocks **16** when the blocks **16** are curing, rather than being deeply embedded in to the blocks **16**, details of which can be found in U.S. Pat. No. 11,198,231, the entire contents of which are incorporated by reference herein. However if desired the blocks **16** can be coupled to the grid/mesh **18** by various other means and mechanisms, including adhesives, via the use of mechanical fasteners, and the like.

[0031] The core **14**, if utilized, can define, be located at and/or overlap with a geometric center of the erosion control structure **10**, and can take a variety of forms and be made from various materials. In one embodiment the core **14** is made of or includes structural core material **13** such as excelsior (e.g. wood shavings) and/or wood wool, such as Curlex CL Blankets by American Excelsior Co. of Rice Lake, Wisconsin. However it should be understood that the core material **13** can be made of any of a wide variety of materials, including natural/organic materials such as straw, wood fibers, hay, mulch, compost, and/or synthetic materials such as lightweight synthetic fibers, fiberglass, shredded or small pieces of rubber, polymers, styrofoam, or the like. The core **14** can in one case include a netting or mesh material **15** (see FIGS. **1** and **5**) that retains the core material **13** in the desired shape, or alternatively the core **14** can include the core material **13** that is dimensionally stable and thus does not need any netting or mesh material **15**. Further alternatively, the core material **13** can simply be located/retained loose inside/at a center of the tied block structure **12**, without using the netting or mesh material **15** (see FIG. **7**). The core **14**/core material **13** can be made of a material that is sufficiently strong to support the tied block structure **12** in a closed loop shape or substantially/partially closed loop shape, and resist degradation when exposed to external environmental conditions, for at least about twelve months in one case.

[0032] Regardless of the material chosen, the core **14** (i.e. including the core material **13** and/or outer netting **15**) in one embodiment is made of water and/or soil permeable material, and/or the core **14** may as a whole be water and/or soil permeable. In addition, the core **14** can be made of material having, and/or as a whole have, a relatively small density and/or weight. In particular, the core **14** can in some cases merely operate as a structural placeholder to retain the tied block structure **12** in the closed (or substantially/partially closed) loop shape. In that case it can be desired to reduce the weight/density of the core **14** to reduce the weight/density of the erosion control structure **10**, which provides ease of transportation, handling and placement.

[0033] Accordingly in one case the core **14** is made of a material different from the tied block structure **12** and/or the blocks **16**, and has a density at least 50% less than a density of the material of the blocks **16**, and at least about 75% less in another case. However, if desired the core **14** can also have a density equal to or greater than the density of the blocks **16**, for example where it is desired for a relatively dense core **14** to add additional weight and stability to the structure **10**.

[0034] In order to provide sufficient weight reduction and/or cost savings, in some case the core **14** may be relatively large. In particular, the core **14** can in one case have a volume that is or constitutes at least about 10% of a volume of the erosion control structure **10**/closed loop structure

12, or have a volume that is at least about 20% of a volume of the erosion control structure **10**/closed loop structure **12** in another case, or at least about 30% in yet another case. However, in other cases the core **14** can provide a smaller volume, and indeed in alternate embodiments described in greater detail below the erosion control structure **10** may not include a core **14** at all.

[0035] FIG. **1** shows the core **14** in the form of a single, generally tubular or cylindrical component. However the core **14** can have any of a wide variety of shapes and structures. For example, in the embodiment of FIG. **6**, the core **14** includes two core portions **14***a*, **14***b*, each taking the form of a tube or cylinder positioned side-by-side, and located inside the closed loop structure **12**. Thus core **14** can thus include and/or be made of one, two, three or more core portions, and have any of a wide variety of shapes.

[0036] The erosion control structure **10** can include an outer liner **28** extending at least partially about an outer surface of the tied block structure **12**. In particular as shown in FIG. **1** the liner **28** extends about, and covers, of an outer surface area of the tied block structure **12**, extending from a bottom center (6 o'clock) position of the tied block structure **12**, to a top center (12 o'clock) position of the tied block structure **12**, and thus extends about 180 degrees about the tied block structure **12** in the illustrated embodiment. Thus the liner **28** may not extend about an entirety of the closed loop structure **12** (e.g. extends less than 360 degrees), for reasons which will be described in greater detail below.

[0037] In the embodiment of FIG. **5**, the liner **28** extends about, and covers, of an outer surface area of the tied block structure **12**, extending from a position slightly offset from, in the downstream direction) bottom center (about a 7 o'clock position) of the tied block structure **12**, but in contact with the substrate **34**, to a midheight position (3 o'clock) position, and thus extends about **270** degrees about the tied block structure **12**. The liner **28** can extend about/cover at least 30% of an outer surface area of the tied block loop structure **12** in one case (e.g. extending about 120 degrees in end view), leaving up to 70% of the outer surface area (e.g. about 60 degrees) uncovered. Conversely, in another case the liner **28** does not extend about/cover at least about 30% (e.g. about 120 degrees) of the outer surface area of the tied block loop structure **12**. In another case the liner **28** can extend about/cover at least 50% of an outer surface area of the tied block loop structure **12** (e.g. extending about **180** degrees in end view), leaving up to 50% of the outer surface area (e.g. about 60 degrees) uncovered.

[0038] The liner **28** can be water permeable in one case (e.g. have openings or pores **3**A or

[0039] greater in average diameter (or average effective diameter, where an effective diameter can be used for non-circular openings, where the effective diameter of a non-circular opening is a diameter that provides the same surface area as the surface area of the non-circular opening) in one case) and soil impermeable in one case (e.g. the liner can have openings or pores 0.002 mm or less in average diameter (or average effective diameter) in one case, or 0.020 mm or less in average diameter (or average effective diameter) in another case, or 0.050 mm in average diameter (or average effective diameter) in yet another case). Alternatively the liner **28** can be both water impermeable and soil impermeable, or even water permeable and soil permeable if desired.

[0040] The liner **28** can be loosely held in place against the tied blocks **12**, or can be glued, affixed or cast into the tied block structure **12**. In another case the liner **28** is integrally coupled and/or formed with the tied block structure **12**. The liner **28** can include or take the form of a geotextile, textile, a film or matting including polymers/plastics, jute, hemp, straw, PVA, cotton, ferrous or non-ferrous material.

[0041] With reference to FIGS. **1** and **6** for example, the erosion control structure **10** can include an plurality of elongated support members **30** coupled to the tied block/closed loop structure **12**, and extending away therefrom. In one case the elongated support members **30** are coupled to or terminate adjacent to a radially outer surface of the tied block structure **12** and/or the mesh material **18** and/or the liner **28**. The support members **30** can take the form of straps, ropes, chains, cables or the like that can transmit tension forces. Each support member **30** can have a length of at least about three feet in one case, and at least about six feet in another case. Various support members **30** can be spaced along the axial length of the structure **10**, such as at a spacing between one foot and ten feet along the length of the structure **10** in one embodiment.

[0042] In order to form the erosion control structure **10**, a flat of tied block mat **12**, such as shown in FIGS. **2** and **3**, can be provided, and as also shown in FIG. **14**A. A core **14** (if desired) can then be placed on the tied block mat **12** as shown in FIG. **14**B. The mat **12** can then rolled about the core **14**, and about axis **31** (FIGS. **2**, **3** and **14**B) such that the flat layer of tied block **12** is rolled or coiled about the core **14** in a generally circular or generally spiral/helical shape, as shown in FIG. **14**C. It is noted that the mat **12** can be rolled about axis **31** (extending parallel to the greatest length of the mat **12**), which can be perpendicular to the axis **33** (extending perpendicular to the greatest length of the mat **12** in one case) (FIG. **3**) about which the tied block mat **12** can be rolled during storage/shipping. Rolling up the mat **12** about the lengthwise axis **31** can enable the structure **10** to have a relatively long length, such as at least about ten feet long in one case, or at least about twenty feet long in another case. However, if desired, the mat **12** can be rolled about axis **33**, or other axes to create the structure **10**. It is also noted that although the figures show the mat **12** rolled such that the top surfaces **24** of the blocks **16** are positioned radially inwardly, the mat **12** can be rolled in the opposite direction such that the “top” surfaces **24** of the blocks **16** are positioned/face radially outwardly. Once formed the structure **10** can, in one case, have a height between twenty inches and sixty inches, a width between twenty inches and sixty inches, and a length between three feet and fifty feet.

[0043] The tied block mat **12** can have the liner **28** coupled thereto (positioned thereunder, as shown in FIG. **2**) and underlying at least an entire surface area of the tied block mat **12**, prior to rolling up the mat **12**, which can result in the structure shown in FIGS. **7-11** after the tied block mat **12** rolled. In an alternative embodiment, the liner **28** may not be coupled to the mat **12** prior to rolling, and instead the liner **28** can be placed on the mat **12** after rolling (or the liner **28** may underline only a portion of the tied block mat **12** prior to rolling), which can result in the structure shown in FIGS. **1**, **5**, **5**A and **6**. In yet another embodiment, as shown in FIG. **12**, the structure **10** can be entirely encased within a (tubular) sleeve of liner material **28**, such that the liner **28** encapsulates the structure **10** therein.

[0044] When a core **14** is utilized, in some cases it may be desired to limit the number of layers of the tied block mat **12** that is rolled about the core **14**. In particular, in the embodiment shown in FIG. **1** the tied block mat **12** is rolled about itself generally only once, with a limited overlap (between about 15 degrees and about 90 degrees in one case) to ensure the tied block mat **12** forms a closed loop, and remains in the closed loop. Thus in the illustrated embodiment at least about 50% of the structure **10** (measured in the circumferential direction) has only a single layer (in the radial direction) of tied block mat **12**, and the tied block mat **12** does not form more than two layers in radial direction at any location. However in other cases the structure **10** can have multiple layers of tied block mat **12**, overlapping in the radial direction as will be described in greater detail below.

[0045] Once the structure **10** is formed, it can be lifted and moved to the desired location, such as at the toe **32** of a slope/substrate **34** (which can be soil, or local grade) as shown in FIGS. **5**, **5**A and **6**. The toe **32** of the slope **34** can be a bottom edge of the slope **34**, and can in some cases be positioned at or adjacent to a body of water **36**. In one case, the structure **10** can be positioned adjacent to the toe **32** of the slope such that the structure **10** is entirely positioned on the slope/substrate **34**, and the leading/downstream edge of the of the structure **10** is spaced away from the toe **32** by not more than an effective diameter of the structure **10**, or in another case is spaced from the toe **32** by no more than 2× the effective diameter, or in another case no more than 5× the effective diameter.

[0046] When positioned adjacent to a body of water **36**, in one case a lower-most portion, upper-most portion, or center of each structure **10** is located no more than about three inches above the body of water **36**, or alternatively and the leading/downstream edge **43** of the structure **10** in contact with the substrate **34** is spaced away from the body of water **36** by not more than an effective diameter of the structure **10**, or in another case is spaced from the body of water **36** no more than 2× the effective diameter, or in another case no more than 5×, or in another case no more than **10**x, the effective diameter. In some cases the water **36** can at least temporarily reach to the center, or higher, of the structure **10**, as shown in FIG. **6**, although the level of the water **36** can rise and fall due to irrigation, precipitation or evaporation, and in addition the level of water **36** can be adjusted by temporarily draining water during the installation process.

[0047] The structure **10** can be lifted and moved into position onto the substrate **34** via the support members **30** in one case, and carried out using mechanical equipment such as fork lifts, excavators, or the like. The structure **10** can have some flexibility along its longitudinal direction, and thus can be positioned as desired to conform to the curvature of a given toe **32** desired. Once the structure **10** is roughly positioned at the toe **32** the support members **30** can be pulled to position the structure **10** in the desired location and/or height and at the desired curvature. In addition, multiple structures **10** can be positioned longitudinally end-to-end along the toe **32** and provide continuous erosion control along the toe **32**.

[0048] Once the structure **10** is positioned at the desired location to, each support member **30** can be pulled taut in the uphill direction, and then anchored in place in the underlying (soil) substrate **34**. For example, as shown in FIGS. **6**, **8** and **10**, an anchor **40** (such as a steel t-post, a plastic or wood stake, percussion or screw earth anchor, or other types of soil anchor) can be passed through each support member **30** and into the substrate **34** to anchor the structure **10** in place. Thus each support member **30** can be coupled to the closed loop structure **12** at a lower end of the support member **30**, and be coupled to the substrate **34** at an upper end thereof. Instead of being coupled to the substrate **34**, each support member **30** and/or anchor **40** can also or instead be coupled to a hardened material/substrate, such as a concrete wall or a wooden bulkhead. In addition, if desired percussion driven earth anchors (not shown) can be driven through the structure **10** in and into the substrate **34** to further anchor the structure(s) **10** in place.

[0049] As noted above, the liner **28** can in some cases be positioned to not cover at least part of the upper or upstream portion of the structure **10** (e.g. “upper” or “upstream” with regard to the slope of the substrate **34** and/or the flow of water from precipitation flowing down the substrate **34**), and to cover at least part of the lower or downstream portion of the structure **10**, and in one case covers the downstream-most portion of the structure **10** that is in contact with the substrate **34**. In one case the liner **28** does not cover the upstream-most portion **45** of the structure that is in contact with the substrate **34** (e.g. the approximately 5 o'clock location of the structure of FIG. **5**). Once the structure **10** is positioned and anchored in place, in one case soil and/or water, such as wet soil and/or spoil dredged from the floor of bed or an adjacent body of water **36**, can be scooped, pumped, or otherwise placed immediately uphill of the structure **10**. Alternatively water and/or soil can be transported to the site of the structure **10** from a different location. In either case the water and/or soil can then enter the structure **10** from the uphill side, and fill/permeate the core **14**, or other volume inside the structure **10**/closed loop structure **12**, shown as soil infill **37** in FIG. **5**A. In particular, soil can become embedded in the core **14** and/or portions of the tied block **12**, trapped by the fibers or other materials of the core **14**. When the liner **28** is water permeable and soil impermeable, introduced water can freely flow out of the core **14**/structure **10** and through the liner **28**, leaving the trapped soil **37** behind. In one case, the soil **37** located in the structure **10** fills at least about 10% of an inner volume of the structure **10**, or at least about 20% in another case, to ensure sufficient weight inside the structure **10**.

[0050] Water/soil can be continued to be added to the upstream of the structure **10** as desired until the structure **10** is saturated with soil in the desired amount. In the embodiment of FIG. **6**, the structure **10** has been essentially immersed in soil to create the backfilled area **39**. In an alternative embodiment, water and/or soil are not mechanically added during the placement/assembly process, and instead the structure **10** can (if desired) rely upon the natural migration of water/soil over time to introduce soil into the core **14**/structure **10**. The trapped soil **37** adds weight the structure **10**, helping to anchor and stabilize the structure **10**. In this manner, additional anchoring weight and volume of the structure **10** is provided on-site by existing, available materials (namely, soil), and the structure **10** does not need to be pre-loaded with anchoring weight and volume. Thus the ability to providing anchoring mass and weight on-site enables a reduction in transportation and manufacturing costs.

[0051] As noted above, the liner **28** can be located on the lower or downstream side of the structure **10**, covering the associated outer surface, and not located on the upper or upstream side of the structure **10**, not covering the associated outer surface. By not positioning the liner **28** on the upstream side of the structure **10**, soil is free to enter and infiltrate the core **14** and other portions of the structure **10**. Conversely, by positioning the liner **28** on the lower side of the structure **10**, when the liner **28** is soil impermeable, soil is trapped in the core **14** and other inner portions of the structure **10**. When the liner **28** is water permeable, water can flow through the core **14**, leaving the soil behind.

[0052] Once the structure **10** is located and sufficiently anchored in place, if desired the volume above and upstream of the structure **10** can be backfilled with soil or other backfill material, in one case adding backfill **39** up to the top of the structure **10**, as shown in FIG. **6**. The backfilled area **39** and/or the upper surface of the structure **10** can then be seeded with vegetation (such as grasses) to provide further stability, if desired.

[0053] In an alternative embodiment, as shown in FIGS. **7** and **8**, the structure **10** can have a generally flat and planar, or sheet-like, extension portion **42** or extension portions **42**, **44**, that are positioned on the substrate **34**, and extend above and/or below the structure **10**. In the embodiment of FIGS. **7** and **8** the structure **10** includes an upper extension portion **42**. Thus when the structure **10** is used adjacent to a toe slope **32**, the upper extension portion **42** can extend in the upper or upstream direction, on adjacent dry land, and conform to the underlying substrate. In the embodiment of FIG. **8** the structure **10** includes both an upper extension portion **42** and a lower extension **44** portion that extends below/downstream of the structure, on and conforming to the bed/floor of the adjacent body of water **36** in one case.

[0054] The extension portions **42**, **44** can each be generally flat, planar, flexible mats that conform to the underlying substrate **34** and act as scour aprons, reducing erosion by reducing scouring action at those locations covered by the extension portions **42**, **44**. The extension portions **42**, **44** can also help to secure the structure **10** in place due to friction, and/or soil that is positioned on and/or above the extension portions **42**, **44** and/or by placing anchors through the extension portions **42**, **44**. In the illustrated embodiment, each extension portion **42**, **44** is not shown as including any blocks **16** thereon. However it should be understood that blocks **16** can be positioned on one or both of the extensions portions **42**, **44**, on all or part thereof, and coupled to the underlying flexible mat portion. The use of such blocks **16** can provide erosion control and/or provide a habitat that encourages growth of marine plants and animals.

[0055] Each extension portion **42**, **44** can extend away from the tied block structure **12** in the upper/lower direction at least about two feet in one case, or at least about six feet in another case, and less than about thirty feet in one case. In the illustrated embodiment each extension portion **42**, **44** has the same length, along the central axis of the structure **10**, as the tied block mat **12**, but the extension portions **42**, **44** can have a greater or lesser length as desired.

[0056] Each extension portion **42**, **44** can be made of a variety of materials. In one case as shown in FIG. **7** one or each extension portion **42**, **44** is made of the same material as the liner **28**, and can be integrally/seamless formed with or coupled to the liner **28** extending around the tied block mat **12**. In another embodiment one or each extension portion **42**, **44** is made of the same material as the grid/mesh **18**, and can be integrally/seamless formed with or coupled to the grid/mesh **18** forming part of the tied block mat **12**. However the extension portions **42**, **44** can be made of any of a wide range of materials, and can be coupled to the tied block mat **12** and/or liner **28** as desired.

[0057] In order to form the structure **10** with the extension portion **42** and/or **44**, the process can begin with a generally flat layer of tied block mat **12** shown in FIG. **14**A, which includes the liner **28** having a portion positioned below part of the tied block mat **12**, and a portion **42** extending beyond the tied block mat **12**. The core **14**, if utilized, can then be positioned on the tied block mat **12** as shown in FIG. **14**B. Next the tied block mat **12** can be rolled about the core **14**, as shown in FIG. **14**C into a generally circular or spiral shape. The portion **42** of the liner **28** extending beyond the tied block mat **12** can then be used as an extension portion **42**, as shown for example in FIGS. **7** and **8**.
[0058] In addition, in another embodiment, the structure **10** can include extension portions (not shown) that extend in the longitudinal direction parallel to the central axis, rather than radially (uphill and/or downhill). The longitudinally extending extension portion can be positioned below longitudinally-adjacent structures **10** to help to provide continuous erosion control and prevent soil loss between adjacent structures **10**.
[0059] In another alternate embodiment shown in FIGS. **9** and **10**, the liner **28** extends about the structure **10**/tied block mat **12** at least 360 degrees, in a helical configuration in end view to form a closed loop or a tubular structure. In this embodiment the liner **28**, when the liner **28** is soil impermeable, may somewhat block the entrance of soil into the core **14** (if utilized) compared to the embodiment of, for example, FIGS. **5** and **5**A. However in the embodiments of FIGS. **9** and **10** soil may still find its way into the core **14**/center of the structure **10** and be retained therein. In other cases however the structure **10** may be sufficiently weighty and the structure **10** may not necessarily need the core **14** to become saturated with soil.
[0060] In yet another alternate embodiment, as shown in FIG. **11**, the structure **10** does not include the core **14**. In this case the structure **10** can still act as an erosion control structure, can be still be filled up with soil at the time of installation, or over time if desired, to remain anchored in place. Alternatively the structure **10** may not necessarily need to be filed with soil. In yet another embodiment, as shown in FIG. **13**, the structure **10** can form closed loop structure, but the closed loop may not be entirely formed by the tied block mat **12**. For example, in this case the tied block mat **12** may extend only about 180 degrees (or at least about 180 degrees in one case) (e.g. from about the 6 o'clock position to about the 12 o'clock position, or on the downstream side of the substrate **34**/toe **32**), and straps or other tensile elements **46** can extend the remaining amount (**180** degrees in this case) and are coupled to the tied block mat **12**/liner **28** at both ends thereof. In addition, in one case the structure **10** may not form an entirely closed loop (e.g. can extend less than 360 degrees), but can instead form a partially and/or substantially closed loop, extending at least about 180 degrees in one case, or at least about 220 degrees in one case, or at least about 270 degrees in another case, or at least about 300 degrees in yet another case, and the structure **10** may be able to retain its substantially closed loop shape due to the weight of the tied block mat **12** and/or anchoring components.
[0061] In another embodiment shown in FIG. **15**, the structure **10** is positioned on a flat or generally flat substrate or ground surface **34**. An anchoring structure **48**, such as rebar, can be passed entirely through the structure **10** and embedded in the ground surface **34** to help retain the structure **10** in place. In addition, the liner **28** (either with or without blocks **12** thereon) can extend upstream (relative to the direction of expected water flow) as an extension portion **42**, and an upstream location of the extension portion **42**/liner **28** can be held in place via an anchor **40**. In this configuration the structure **10** can operate as a rock dam, located at the toe of a slope and/or at a generally flat location to retain soil and/or prevent erosion.
[0062] In some of the embodiments described and shown above, the structure **10** is oriented such that its central axis **31** is parallel (or generally parallel, accounting for natural variances in the slope **34** and the flexible shape/positioning of the structure **10**) to a length of the toe **32** of the slope **34**. In the embodiment of FIGS. **16** and **17**, the structure **10** is oriented such that its central axis **31** is oriented perpendicular (or generally perpendicular, accounting for natural variances in the slope **34**

and the flexible shape/positioning of the structure **10**) to the toe **32** of the slope **34** (or, more specifically, perpendicular to two opposed slopes **34** (including a second or “supplemental” slope **34** as shown). In particular in this embodiment the structure **10** is located in, and spans the length of, channel/ditch **50** (collectively termed a “channel” herein). The structure **10** of this embodiment can include a downstream extension portion **42**, which can be made of the grid/mesh material **18**. In one case the structure **10** includes a plurality of support members **30** spaced along its length, where each support member **30** is coupled to the underlying substrate by an anchor **40**, to secure the structure **10** in place.

[0063] In the embodiment of FIGS. **16** and **17** (as best shown in FIG. **17**), the structure **10** is positioned on top of an underlying mat **52** of tied block **12**, that is arranged in a flat orientation. In this case the mat **52** of tied block **12** can have the same qualities and characteristics of tied block **12** as described and shown above. However it should be understood that the structure **10** shown in FIGS. **16** and **17** can be positioned directly on a ground surface, without the mat **52** positioned thereunder. Moreover it should be understood that any of the structures **10** described and shown above can have a mat **52** of tied block **12** positioned thereunder.

[0064] The structure **10** of FIGS. **16** and **17** can be positioned in the channel **50** and operate as an energy dissipater, to dissipate the energy of liquids, such as water, flowing through the channel **50**, by slowing the speed of the flowing liquid. The structure **10** of FIGS. **16** and **17** can also serve as a sediment filter, for example trapping sediment in the core **14** or otherwise within the structure **10**. The structure **10** can entire span the channel **50**, or at least the bottom-most portions thereof, and extend up the sides **34** of the channel **50** an extent sufficient to accommodate the desired or expected height of fluid flowing down the channel **50**.

[0065] Thus as can be seen the structures **10** disclosed herein can be formed in any of a wide variety of configurations. The structure **10** can be easily transported to the installation location, is easily assembled, and provides a stable, anchored structure that can operate as a lip or anchor to provide a build up of soil and vegetation behind the structure, or provide other stabilization qualities.

[0066] Having described the invention in detail and by reference to the various embodiments, it should be understood that modifications and variations thereof are possible without departing from the scope of the claims of the present application.

Claims

1. A system comprising: a closed loop or partially closed loop structure, including tied blocks, positioned at or adjacent to a toe of a slope.

2. The system of claim 1 wherein the toe of the slope is positioned at or adjacent to a bottom of an inclined surface, wherein the toe of the slope is positioned at or adjacent to a body of water, and wherein the loop structure is positioned such that a downstream edge of the loop structure is spaced away from the toe of the slope by not more than **10** times an effective diameter of the loop structure.

3. The system of claim 1 further comprising a core material, and wherein the loop structure is positioned about the core material.

4. The system of claim 3 wherein the core material is water permeable and soil permeable.

5. The system of claim 3 wherein the core material is located at a center of the system, wherein the core material has a density less than a density of the blocks of the loop structure, and wherein the core material has a volume that constitutes at least about 10% of a volume of the loop structure.

6. The system of claim 1 wherein the system includes a liner at least partially extending about the loop structure, wherein the liner is water permeable and soil impermeable.

7. (canceled)

8. (canceled)

9. The system of claim 6 wherein the liner does not cover an upstream-most portion of the loop structure that is in contact with the slope.
10. The system of claim 6 wherein the liner does not extend about an entirety of the loop structure.
11. (canceled)
12. The system of claim 6 wherein the liner forms a closed loop extending about the loop structure.
13. The system of claim 1 wherein the tied block structure includes an array of truncated pyramidal blocks that coupled together other via a flexible mesh material, and wherein the blocks are concrete.
14. The system of claim 1 wherein the loop structure takes the form a generally flat layer of tied block that is coiled in at least one of a generally circular or generally spiral shape, and wherein the tied block does not form more than two layers of tied block in a radial direction.
15. (canceled)
16. The system of claim 1 wherein the loop structure extends less than 360 degrees.
17. The system of claim 1 wherein soil fills at least about 10% of an inner volume of the loop structure.
18. The system of claim 1 further comprising a generally sheet-like extension portion coupled to the loop structure, positioned at least one of upstream or downstream of the loop structure, and conforming to an underlying substrate, wherein the system includes a liner at least partially extending about the loop structure, and wherein the extension portion is made of the same material as the liner.
19. (canceled)
20. (canceled)
21. (canceled)
22. The system of claim 1 wherein the structure has a central axis oriented generally parallel to a length of the toe of the slope.
23. The system of claim 1 wherein the structure has a central axis oriented generally perpendicular to a length of the toe of the slope.
24. (canceled)
25. (canceled)
26. A system comprising: a water permeable core material; and a closed loop or partially closed loop structure, including tied blocks, positioned about the core material.
27. The system of claim 26 wherein the core material has a density less than a density of the blocks of the loop structure, and wherein the core material has a volume at least about 10% of a volume of the loop structure, wherein the system further includes a liner at least partially extending about the loop structure, wherein the liner is water permeable and soil impermeable, and wherein the liner is positioned about only least part of the loop structure.
28. (canceled)
29. (canceled)
30. (canceled)
31. The system of claim 27 wherein the loop structure is positioned on an inclined surface, wherein at least part of a downstream outer surface of the loop structure is covered by the liner, and wherein at least part of an upstream outer surface of the loop structure is not covered by the liner.
32. A system comprising: a closed loop or partially closed loop structure, including tied blocks, positioned about a core having a volume at least about 10% of a volume of the loop structure.
33. The system of claim 32 wherein the core is water permeable, and wherein the system further includes a water permeable, soil impermeable liner at least partially extending about the loop structure.
34. A system comprising: a closed loop or partially closed loop structure, including tied blocks; and a water permeable, soil impermeable liner at least partially extending about the loop structure.
35. The system of claim 34 wherein the liner extends about at least 30% but less than 100% of an

outer surface area of the loop structure, wherein the system further includes a water permeable core material, and wherein the loop structure is positioned about the core, and wherein the core material has a density less than a density of the blocks of the loop structure, and has a volume at least about 10% of a volume of the loop structure.

36. (canceled)

37. A method comprising: placing a closed loop structure, or partially closed loop structure, including tied blocks, on a toe of a slope.

38-42. (canceled)