Oct. 28, 1969 E. R. COLLE 3,474,626

METHOD AND MEANS FOR PROTECTING BEACHES

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FIG. 1

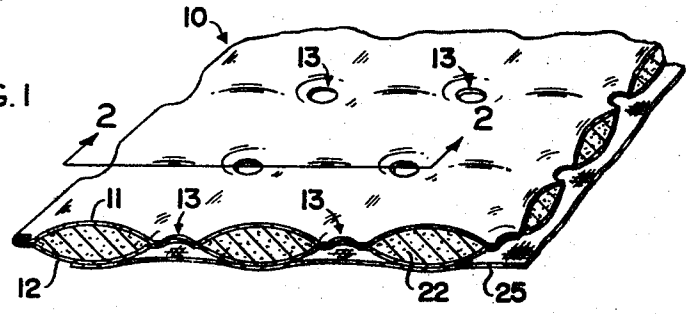
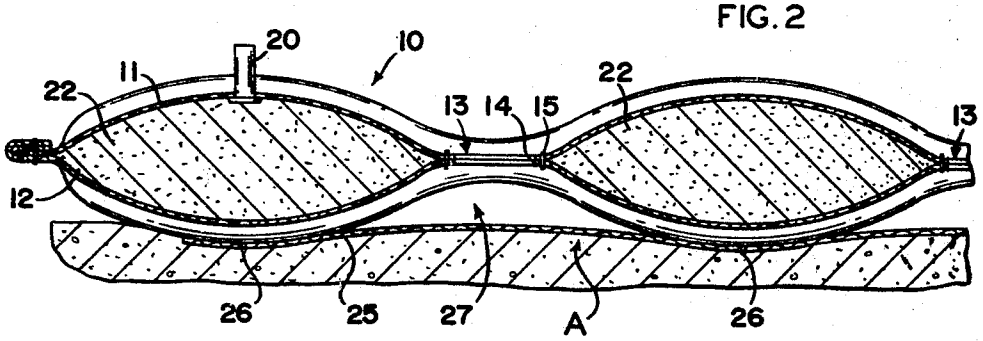


FIG. 2



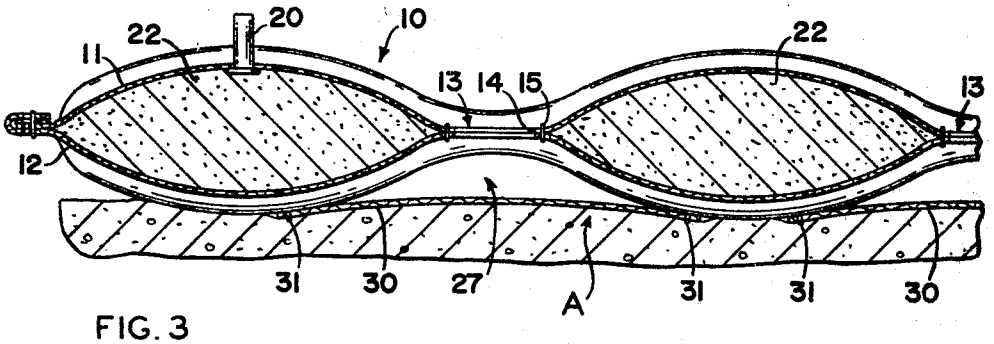


FIG. 3

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METHOD AND MEANS FOR PROTECTING BEACHES

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ABSTRACT OF THE DISCLOSURE

A protective mat and filter cloth assembly comprising an apertured concrete filled fabric envelope together with a filtering cloth or fabric attached to the envelope below the apertures to protect the surface of beaches, rivers or canal banks, dunes, revetments, groins or the like against the effect of erosion and scour by water and wind.

DISCLOSURE

This invention relates to the art of protecting shorelines and, more particularly, to an improved mat arrangement for such a shoreline.

It is well known in the art to protect beaches or similar surfaces from the erosive effects of wind and water by assembling fabric envelopes in the form of tubes, bags, or the like, separately or interconnected, filling these fabric envelopes with sand or similar particulate material, and placing the filled envelopes on the surface to be protected. The particulate nature of the filling material permits this protective device to conform intimately to the surface to be protected which is most desirable. The sand filled envelopes may also be placed upon, with or without mechanical attachment, a layer of fabric directly on the surface to be protected, which fabric acts as a filter to restrain the soil while permitting the free passage of water outwardly from the soil.

There are several objections to this technique. The fabric envelopes are first susceptible to mechanical damage, as by abrasion, permitting the escape of the filling material. The weighting effect of the sand filled envelope is thus lost and the fabric is soon displaced or destroyed by the action of the moving water. The filter fabric itself may also be so damaged, permitting the erosion of underlying soil. Furthermore, the fabrics employed both as sand containers and as surface filter fabrics, rarely, if ever perform as ideal filters as they must do in order to permit this technique to perform successfully. The flexing action on the fabrics caused by the moving water invariably permits the escape of some solid particles, both from the hand filling material and from the underlying soil to be protected. Loss of solids releases tension on the fabrics, permitting more severe flexing with consequent distortion of the fabric yarns, increase in porosity, loss of additional solids, and so on until the structure eventually loses its effectiveness.

Beaches are also commonly protected by placing over them a layer of filter fabric and weighting the fabric down with heavy stones, commonly known as rip-rap. To be effective, the stones must be of such a size that the smallest stone will be moved but slightly as a result of the most severe wind and water action anticipated in the design of the structure. The stone must be of such quality that it is relatively undamaged by such severe forces. Stone of this size and quality is often prohibitively expensive. The weight and shape of the stones also tends to damage the underlying filter fabric.

To overcome the problems associated with such rip-rap and filter cloth protection, concrete blocks have been used. These block may be designed so that they interlock

permitting them to act in unison as a weighting means while at the same time articulating at the interlocking edges, permitting the whole mat to flex and follow the contour of the underlying soil. Manufacture of these blocks is relatively inexpensive. Installation on dry land is easily accomplished. Installation under water, however, where they are especially needed, is very difficult and expensive. The fabric cloth must first be placed and secured in position under moving water while the concrete blocks are carefully assembled thereon. The blocks must fit tightly enough that they do not become disengaged as a result of water action, yet not so tightly that uplift forces, as by wave action, cannot be relieved by water passing freely from beneath the blocks and upwardly through the interlocking joints. Problems involved in such precise installation under open moving water are economically insurmountable.

As an alternative, the blocks may be interconnected with flexible steel cables with the entire block and cable assembly being placed over a filter cloth. However, in order to avoid loss of strength in the flexible steel cables by rust and corrosion, these cables must be manufactured of corrosion resistant metal, such as stainless steel. This steel is very expensive. Furthermore, the articulation of the block and cable assembly, with frequent flexing of the cables, may cause fatigue failure in the cables. If only a few of the cables in such an assembly are destroyed, the effectiveness of the entire assembly is lost. Furthermore, installation procedures of such a block and cable assembly are quite expansive, requiring enormous precasting and prefabricating installations as well as very heavy placing equipment. While the technique is suitable to very large installations, such as the banks of the Mississippi River, it is completely unsuited to small installations, areas where shallow draft handling barges must be used, or to ocean beaches where the severely corrosive effects of salt water prohibits use.

Interlocking concrete blocks on top of filter cloth provide adequate weight and protection against scour, but provide exposure of filter cloth to open water only in the relatively small area between blocks. Uplift forces thus act almost entirely on the blocks, tending to lift and displace them. Rip-rap on filter cloth provides better filter cloth exposure and so less uplift on the stones. However, the individual stones provides less mass resistance to uplift, since they do not interlock, and additionally, the stones tend to tear and distort the filter cloth fabric, thereby reducing its effectiveness.

An ideal filter cloth installation would be one in which the cloth was held down tightly to the underlying soil with sufficient weight to avoid disturbance by moving water and in which the cloth was completely protected against erosion by water bearing solids, but yet exposed the maximum possible surface area of the cloth to free water in order to avoid, in as far as possible, the development of uplifting hydrostatic pressure on the weighting means. In practice, these conditions cannot be achieved using construction techniques and materials heretofore known.

It is the principal object of this invention to provide a filter cloth installation which more nearly approaches the ideal condition described above.

More specifically, an object of this invention is to provide a filter cloth installation in which the filter cloth is protected from damage due to the erosive action of water with suspended solids.

A further object of this invention is to provide a filter cloth installation in which the filter cloth is held in position by an overlying weight with the weight exposing a maximum surface area of the cloth.

Another object of the invention is to provide a weighted filter cloth installation with the weight on the cloth being resistant to uplift.

Still another object of the invention is to provide a protective structure for a shoreline which structure includes a filter cloth that restrains movement of the underlying soil and assists in positioning the protective structure on the shoreline.

More specifically the present invention makes use of a relatively new technique for producing and installing beach protective structures in combination with the known technique of employing an underlying filter cloth. The two techniques are combined in such a way that the effect of each is enhanced with the combined effect being substantially superior to the effect which might have been anticipated.

The aforementioned new technique for producing and installing erosion control structures for beaches and the like includes preparing a series of interconnected fabric envelopes, the fabric being usually water permeable, positioning these envelopes on the surface to be protected, and injecting a flowable hardenable slurry into the envelopes. The slurry is usually composed of portland cement, sand, and water. The envelopes are usually made of two layers of nylon fabric, with or without interior reinforcing members, which are woven, sewed, or otherwise attached together at regularly spaced intervals. The points at which the two layers are attached often serve as filter points, permitting relief of hydrostatic uplifting pressure.

In accordance with the principles of this invention, it is contemplated that a fabric envelope will be constructed in accordance with the above-described new technique and employed in a novel manner in combination with a filter cloth. Thus, it is contemplated that the filter cloth will be attached to the lower layer of fabric at convenient intervals with the filter cloth being stretched across the surface to be protected. In this manner, an open network of channels is formed beneath the tie points with the water immediately above the filter cloth being sheltered and having free access through the tie points to the open water above the envelope. The points of attachment between the filter cloth and the envelope are selected such that the filter cloth lies flat when the envelope is inflated by the injected slurry.

More specifically, this invention contemplates an assembly for use in protecting shorelines and the like which comprises two large continuous sheets of flexible material with the sheets being joined around their entire outer periphery to form an enclosed interior space between the two sheets. A plurality of aligned openings are formed through the two sheets and the openings are joined around their periphery to define a fully enclosed interior space between the sheets. A third layer of flexible material is provided and secured to at least portions of the exterior surface of at least one of the two sheets. In accordance with the preferred embodiment, the third layer comprises a third sheet of material with the area of the third sheet being less than the area of the sheet to which it is attached.

Also in accordance with the principles of this invention, an improved method of protecting beaches has been devised. This method contemplates the joining together of two large sheets of flexible material around their entire outer periphery. The two sheets are also joined together at a plurality of spaced points intermediate the edges of the sheets with at least some of the spaced points including openings through the two sheets. A third layer of flexible material is positioned against one of the two sheets with the third layer extending across the openings. The third layer is attached to the one sheet to form an assemblage of three layers of material with the assemblage then being positioned on the surface to be protected and a hardenable flowable slurry is injected between the two sheets.

A better understanding of the invention can be achieved by reference to the following description and attached drawings.

FIGURE 1 is a perspective view of an erosion control structure produced in accordance with this invention.

FIGURE 2 is a cross-sectional view taken along section lines 2—2 of FIGURE 1.

FIGURE 3 is a sectional view similar to FIGURE 2 showing a modification of the invention.

Referring now to the drawings wherein one form of the invention is illustrated, there is shown in FIGURE 1 a fabric envelope or form indicated generally by the reference numeral **10**. This envelope comprises two layers of fabric material, preferably at least in part porous, including an upper fabric layer **11** and a lower fabric layer **12**. The two fabric layers are joined together by tie points **13** at spaced intervals across the surface of the fabric layers. As shown, the tie points **13** comprise aligned openings **14** through the two layers **11** and **12** with the openings **14** being stitched **15** around the periphery of the openings to provide a fully enclosed interior space in the envelope. It will be appreciated that these tie points may be formed by other means as well with the sole requirement being that the tie points provide a fully enclosed interior with at least some of the tie points providing openings through the fabric envelope. Other convenient methods of forming the tie points include the use of an especially open type of woven connection, such as a basket or leno weave. The two fabric layers may also be sewn together and the fabric in the sewn area pierced at close intervals and fixed in this open screen-type configuration with adhesive. A further alternate method of forming the tie points is through the use of a mechanical attachment, such as a grommet, removing the fabric within at least some of the grommets and inserting in its place a metal or fiber screen. All of these expedients provide the basic requirements of the formation of openings through the two layers of fabric with the enclosed interior space of the envelope being preserved.

The fabric envelope **10** further includes a conduit through which material may be supplied to the interior of the envelope. This conduit may take any one of a number of different forms but is illustrated in FIGURE 2 as a tube **20** which is inserted between the individual strands of the fabric. The tube **20** may be detachably secured to a hose which is connected to a pump for inflating the envelope with particulate material.

In the preferred form of the invention it is contemplated that a flowable, hardenable, cementitious slurry **22** will be pumped through the tube **20** to the interior of the envelope, thereby to inflate the envelope, as illustrated in FIGURES 1 and 2. Reinforcing means, not shown, such as reinforcing rods or fabric webbing, may be incorporated within the hardened cement **22**. The envelope thus inflated has a mattress-like structure and forms a mat which is adapted to rest on surfaces such as canal or river banks, ocean beaches, dunes, revetments, groins, or such other surfaces as it may be desired to protect against the effect of erosion and scour by water and wind.

As stated above, the fabric within the tie point area **13** is removed, in whole or in part, or is slit, perforated, or otherwise treated in such a way as to permit the free flow therethrough of water with or without suspended solids. A third layer of fabric comprising a filter cloth **25** is attached to at least the lower fabric layer **12** in such a way as to restrain soil lying beneath the structure while permitting the passage of water upwardly through the soil particles, through the filter, and thence through the tie point openings **14**. The filter cloth **25** is joined to the lower fabric layer **12** at convenient intervals, as by stitching at fastening points **26**. These fastening points **26** are shown in FIGURE 2 as being located at the diagonal midpoints of the tie points **13**, although the filter cloth **25** may be attached at less frequent intervals and at other locations, as by means of continuous seams parallel to the rows of tie points **13**.

When mortar **22** is injected into the interconnected fabric envelopes formed by fabric layers **11** and **12**, the mattress-like structure formed will have a smaller surface area than did the fabric layers **11** and **12** before

mortar injection. This reduction in surface area may range from as little as 5% to as much as 30%, depending on the fabric construction and the mortar injection pressure. For convenience of installation as well as for improving effectiveness, as will later become apparent, it has been found convenient to cut the filter cloth **25** to such a dimension and attach it to the fabric layer **12** such that the filter cloth **25** is flat when the fabric layers **11** and **12** are contracted as a result of mortar injection. In this manner, the filter cloth **25** aids in positioning the envelope accurately before inflation.

For example, if fabric layers **11** and **12** are woven of 850 denier filament nylon, 20 x 20 count, and are attached by means of 1½" diameter tie points **13** on 8" centers, and if mortar is injected at a pressure of about 10 p.s.i., it has been determined that the mortar filled fabric envelope will contract approximately 20% in area. Accordingly, it is convenient to use 20% less area of filter cloth **25** than fabric layer **12**. Since the area between the filter points before inflation with mortar will contract in this case from 64 in.^{2} to 80% of 64 in.^{2} or about 51 in.^{2}, the filter cloth **25** is attached to the fabric layer **12** on 8" centers measured along the fabric layer **12** and on approximately 7" centers ($\sqrt{5}/\cong 7$) as measured along filter cloth **25**. If more widely spaced attachment points are used, the same ratio would apply.

Advantages of this fabric assembly become more apparent when reference is made to FIGURE 2 in which it will be observed that an open network of channels **27** is formed beneath the mortar filled fabric envelopes, these channels lying directly beneath the line of open tie points **13**. The channels interconnect, one with another, intersecting beneath tie points **13**. The filter cloth **25** thus is stretched tightly and held fixedly in position on the surface A of the ground to be protected. A maximum area of this surface A is exposed to sheltered water immediately above the filter cloth **25** and this water in turn has free access through open tie points **13** to the open water above the protective mortar and fabric structure, while at the same time the filter cloth **25** is well protected from damage as would otherwise occur from the erosive action of water with suspended solids.

A modified form of the invention is shown in FIGURE 3 wherein, in leu of a continuous sheet of material, the filter cloth is formed by a plurality of strips **30**. Each strip is stitched **31** to the bottom sheet **12** and positioned to underlie the openings **14**. It will be appreciated that the stitches **31** may be placed at points on the sheet **12** such that, upon inflation of the envelope, each strip is stretched tightly in the manner of sheet **25**.

For constructing the fabric envelopes, it is preferred to use nylon yarns because of their high strength to cost ratio and also because of their excellent resistance to the strong alkalis which are present in portland cement mortar. It is also preferred that at least part of the yarn be producer bulked filament nylon, known by the tradename Cordura, because of its improved bond to portland cement mortar and because of its excellent filtering characteristics in restraining cement and other solid particles of the injected slurry while allowing vehicle water of the slurry to pass therethrough, thereby causing rapid stiffening and high strength of the hardened mortar as is well known. Cordura also exhibits improved abrasion resistance over unbulked filament nylon and for this reason is particularly preferred in the upper fabric layer which is exposed to the erosive effects of water borne solids.

When the upper and lower fabric layers are woven together, it has been found that one particularly good fabric construction consists of 850 denier filament nylon in the warp, 965 denier Cordura nylon in the filling, the two fabric layers being woven together at 8" centers to form 1½" sq. filter points. A 1" diameter hole is formed in the center of each filter point by means of a heated punch which not only removes the fabric within the 1" circle but also fuses together the yarns around the periphery of the 1" circle. Where the upper and lower layers of the fabric envelope are woven separately and later joined, as by means of sewing, it is preferred that the upper fabric layer be woven of 965 Cordura nylon in both warp and fill and the lower layer of fabric be woven of 850 denier filament nylon in both warp and fill. The two fabric layers are joined together by tie points on 8" centers, the tie points being former by sewing 1½" diameter circles, a 1" hole being formed in the middle of each tie point as described above. In either of the two above described examples, a 20 x 20 count provides both economy and adequate strength.

For the lower filter cloth fabric, it is preferable to use a more open weave, for example a 12 x 12 count. Since fabric of such an open weave is relatively unstable and subject to distortion, a leno weave rather than a plain weave in manufacture of this fabric is preferred. The fabric, either plain or leno weave, may be resin dipped to cement the intersection points of the yarns and so achieve improved fabric stability. While a nylon yarn is normally preferred in the construction of this filter fabric for the reasons described above, the use of polypropylene yarn may occasionally be preferred by reason of its greater elasticity and so better conformance to an irregular underlying ground surface.

It will, of course, be apparent to those skilled in the art that a variety of fabric constructions may be employed under special circumstances, all without departing from the spirit of this invention. In a like manner, a variety of materials may be used to form the weighting and stiffening means overlying the filter cloth and the following example of one type of hardenable slurry is cited for purposes of illustration only.

For a protective structure on an ocean beach exposed to severe winds and waves, where optimum strength and durability of the mortar fill is required, a mortar composed of 2 parts cement, 1 part pozzolanic quality fly ash, 3 parts mason sand, all by bulk volume, together with 13 gallons of water and a water reducing agent such as calcium lignosulfanate which is normally employed in the amount of one-quarter lb. per 94 lb. sack of cement has proven satisfactory.

It is believed apparent that the above-described assembly provides an improved filter cloth and protective mat installation in accordance with the objects of the invention. Thus, the fabric envelope, together with the filter cloth attached to the lower layer of the envelope, may be assembled on dry land. Thereafter, the entire assembly may be placed beneath the water with the filter cloth **25** defining the effective area of the mat when the envelope is inflated. The concrete material by which the filter cloth **25** is retained in engagement with the soil may then be injected into the interior of the envelope **10**, thus avoiding the necessity of attempting to position unwieldly stones or cement blocks beneath the surface of the water. As the form **10** is inflated, the filter cloth **25** is stretched tightly against the surface of the soil which it is intended to protect and the weight of the injected cement retains the cloth accurately in position. The filter cloth **25** is entirely protected by the cement weight above the cloth with the openings **14** in the mat providing sheltered channels of water which do not have an adverse effect on the cloth **25**. Moreover, the openings **14** permit the relief of hydrostatic uplift pressure which may tend to displace the cement mat while at the same time permitting the passage of water through the soil beneath the cloth without detrimental displacement of the soil.

Changes or modifications in the above-described assembly will suggest themselves to those having ordinary skill in the art and changes or modifications such as these are intended to be included within the spirit and scope of the invention as defined by the appended claims.

Having thus disclosed my invention, I claim:

1. An assembly for use in protecting shorelines and the like comprising:
two large continuous sheets of flexible material,
said sheets being joined around their entire outer periphery to form an enclosed interior space between the two sheets adapted to receive a flowable material therein,
a plurality of aligned openings through said two sheets,
means joining said two sheets around the periphery of each opening,
a third layer of flexible material, and
means securing said third layer to at least portions of the exterior surface of at least one of said two sheets with said third layer extending across at least some of said openings.

2. The assembly of claim 1 wherein said third layer is joined to at least one of said two sheets at points spaced from the openings through said two sheets.

3. The assembly of claim 1 wherein said third layer comprises a third sheet of material with the area of said third sheet being less than the area of at least one of said two sheets.

4. The assembly of claim 1 wherein said material is a loose woven fabric material.

5. The assembly of claim 1 wherein said third layer comprises a third sheet of material with the points of securement between said third sheet and said one sheet being spaced apart a greater distance as measured along the surface of said one sheet than the distance as measured along said third sheet.

6. The assembly of claim 1 wherein the space between said two sheets of material is filled with a hardenable, cementitious slurry.

7. The assembly of claim 1 wherein said thrid layer comprises a plurality of strips of material.

8. A method of protecting beaches and the like comprising the steps of:

joining together two large sheets of flexible material around their entire outer periphery,
joining together said two sheets at a plurality of spaced points with at least some of said spaced points including openings therethrough,
positioning a third layer of flexible material against one of said two sheets with said third layer extending across the openings,
attaching said third layer to said one sheet to form an assemblage of three layers of material,
positioning the assemblage on the surface to be protected, and
injecting a hardenable, flowable slurry between the two sheets.

9. The method of claim 8 wherein said third layer comprises a third sheet having less area than the area of said one sheet.

10. The method of claim 8 wherein said third layer comprises a third sheet, and wherein the step of attaching includes the attachment of said third sheet at points spaced from the openings,
the spaced points being determined by measuring a greater distance along said one sheet than along said third sheet.

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