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Canevari

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[54] **CAPILLARY DEVICE**

[75] Inventor: **Gerard P. Canevari,** Cranford, N.J.

[73] Assignee: **Esso Research and Engineering Company,** Linden, N.J.

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Related U.S. Application Data

[63] Continuation of Ser. No. 40,923, May 27, 1970, abandoned.

[52] **U.S. Cl.** **61/10,** 61/35

[51] **Int. Cl.** **E02b 11/00**

[58] **Field of Search** 61/11, 10, 12, 13, 35, 61/36

[56] **References Cited**

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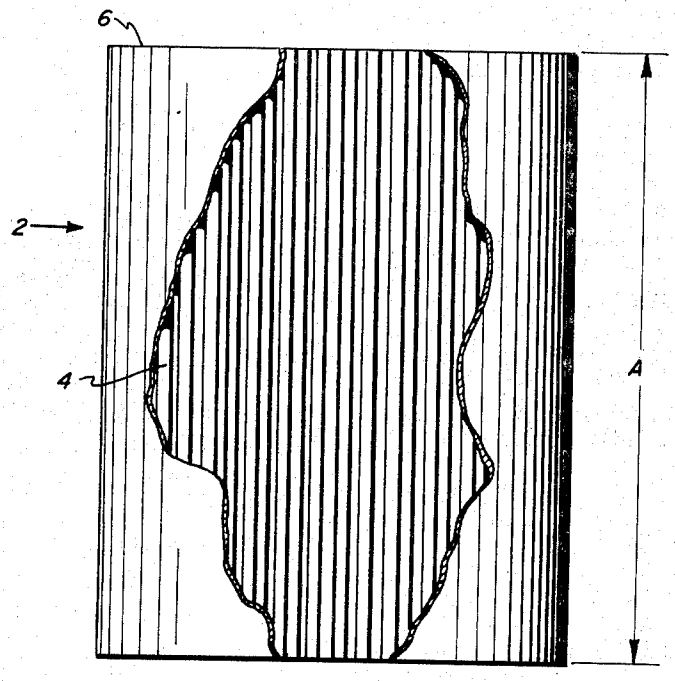
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Primary Examiner—Jacob Shapiro
Assistant Examiner—Alex Grosz
Attorney, Agent, or Firm—M. Bressler; H. N. Wells

[57] **ABSTRACT**

A device for sorbing large amounts of liquid by capillary action. The device comprises a multiplicity of cylindrically shaped particles. Each particle comprises a plurality of capillary sized passageways which run the length of the particle. The particles each sorb an amount of liquid, by capillary action, equal to the volume of the capillary passageways. The particles may be used in any application requiring the sorption and retention of liquids. These particles have particular application to sorbing and retention of water from muddy soils so as to improve the load-bearing characteristics of the soil.

2 Claims, 2 Drawing Figures



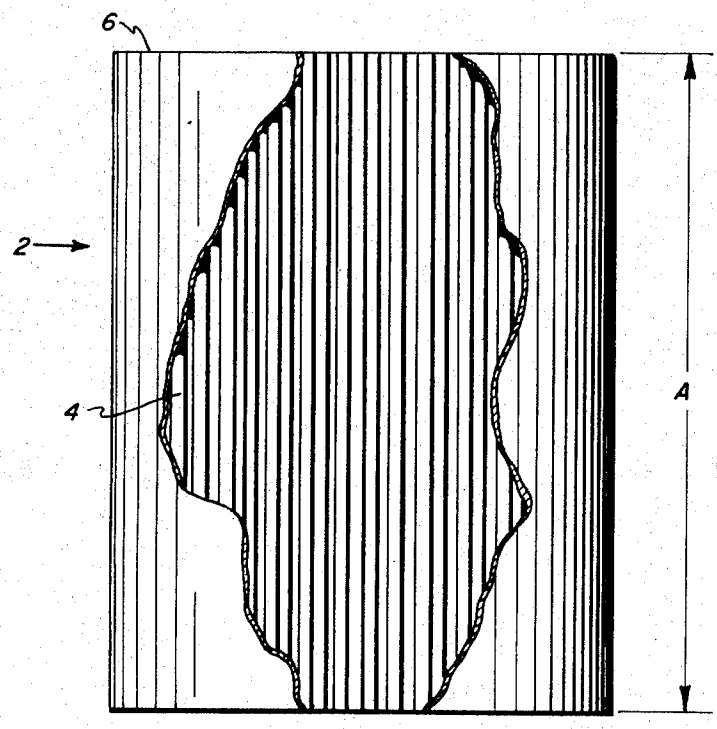


Fig. 1

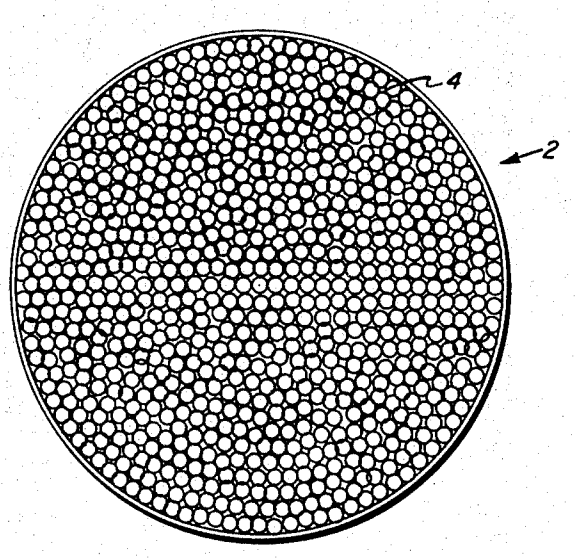


Fig. 2

G. P. Canevari *INVENTOR*

BY Donald F. Cullen ATTORNEY

CAPILLARY DEVICE

This is a continuation, of application Ser. No. 40,923 filed May 27, 1970, now abandoned.

BACKGROUND OF THE DISCLOSURE

The instant invention is directed to a device which sorbs and retains large quantities of liquid per unit volume by means of capillary action. Specifically, the instant invention is directed to a device which sorbs and retains large quantities of liquid by means of a plurality of contiguous capillary passageways disposed within its interior. More specifically, the instant invention is directed to a method for improving the load-bearing ability of swampy or wet soil by disposing a multiplicity of said capillary devices in said soil.

It is well known in the prior art that capillary action can be used to draw a liquid into a very narrow diameter tube. However, due to the difficulty in expense of construction, most capillary tubes are employed mainly in the laboratory for specific laboratory functions and, moreover, each capillary tube usually only comprises a single hollow opening. It is highly unusual to find a small capillary member, which shall be called a "capillette" for convenience, comprising more than a single capillary tube therein.

It should be apparent to those skilled in the art that a capillette would have great utility as a liquid removing and retaining device if such a capillette could be made in sufficient quantity so that large quantities of water can be retained therein. Unfortunately, in the prior art no such capillettes were available.

The basic reason for not having a plurality of capillaries within a capillette is related to the difficulty of construction and thus the prohibitive cost of such articles. In order to even dispose a single capillary passageway within a small capillary member requires a great deal of fabricating skitt. To dispose more than one tube within a small diameter capillary member requires even greater skill. In order to dispose a sufficient number of longitudinal contiguous passageways throughout a capillette requires skills beyond those presently possessed in the art. Moreover, even if such a plurality of capillary tubes could be disposed within a capillette, the cost of constructing such a capillette would be prohibitive. As a result, there is very little, in the prior art, for effecting low-cost liquid removal by means of capillary action. This is unfortunate since liquids removed into capillary spaces are effectively retained. Unlike a sponge, it is very difficult to squeeze liquids out of a capillary space.

The failure of the prior art to provide for efficient removal of liquids has barred the development of a low-cost means for improving the load-bearing capacity of swampy soils. This technique would be of invaluable assitance in the stabilization of large areas of poor load-bearing soils which does not justify the expense of conventional large-scale load-improvement methods used in the soil mechanics art. An excellent example is the use of capillary removal of water from swampy soil in which pipelines are disposed. In operations of this kind, the removal of excess water due to heavy rains, swamps, muskeg, and the like, with resultant improvement in load bearing, could result in successful operations such as ditching, excavation and backfill at relatively low cost.

SUMMARY OF THE INVENTION

The instant invention is directed to an apparatus having excellent liquid sorbing and retention characteristics. The apparatus of the instant invention is characterized by small articles having a plurality of contiguous longitudinal capillary passageways therein which fill up with retained liquid and are held by capillary action.

The instant invention is further directed to a method for improving the load-bearing characteristics of wet soils by means of disposing a multiplicity of these articles in an area where heavy structures are to be disposed. The articles sorb large amounts of water in the article's capillary passageways where they are held by strong capillary forces.

In accordance with the instant invention, a capillary device is provided having a length of ⅛ to 2 inches and a cross-sectional area of 0.015 to 3 sq. inches and further being characterized by comprising a plurality of contiguous capillary passageways passing in the longitudinal direction over the entire length of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood by reference to the accompanying drawings of which:

FIG. **1** is an elevation view, partially in section, of the capillary device of the instant invention;

FIG. **2** is a plan view of the capillary device of the instant invention.

DETAILED DESCRIPTION

The device of the instant invention is depicted in FIGS. **1** and **2**. In FIGS. **1** and **2** the unique capillette of the instant invention is designated generally at **2**. The length of the capillette of the instant invention, as illustrated in FIG. **1**, is denoted by the dimension A. Preferably, this length A is ⅛ to 2 inches. More preferably, the dimension A is ¼ to 1-½ inches. Most preferably, the dimension A is ¼ to ½ inch. The cross-sectional area of the capillary device **2** of the instant invention is denoted in FIG. **1** by **6**. In a preferred embodiment, the cross-sectional area **6** is 0.015 to 3 sq. inches. More preferably, the cross-sectional area denoted by **6** is 0.05 to 1.75 sq. inches. Most preferably, the cross-sectional area **6** is 0.05 to 20 sq. inches. In a preferred embodiment, the capillary device **2** is cylindrically shaped. Thus, in FIG. **2** the device **2** is illustrated as a circular body. It should be appreciated that a square, rectangular, triangular shape, or any other shaped cross-sectional area may be substituted without any loss of effectiveness. The capillary device **2** is further characterized by a plurality of contiguous capillary passageways **4** which run the length of the device **2**. Thus, each of the longitudinally disposed passageways **4** has a length equivalent to that of the dimension A. Each capillary passageway **4** has a diameter in the range of 5 to 50 microns. More preferably, the diameter of the passageways **4** is in the range of 5 to 40 microns. Most preferably, the passageway **4** diameter is 10 to 30 microns. There are approximately 80,000 to 2,500,000 of these passageways 4 per sq. inch of cross-sectional area. Most preferably, there are 150,000 to 2,400,000 passageways 4 per sq. inch of cross-sectional area. Most preferably, there are 220,000 to 2,000,000 passageways 4 per sq. inch of cross-sectional area.

It should be appreciated that the diameter and length and number of the contiguous passageways **4** is critical to the effectiveness of the instant invention. Each device **2** has as its major application, the sorption of liquid into the capillary passageways **4.** To this extent, any cellular material would suffice. However, in addition to the sorption of liquid, the instant device **2** has a second function, the holding of liquid under loading conditions. This requirement of the instant invention bars the employment of sponge-like cellular materials since these materials are not effective to retain liquid under the pressure of heavy loads. Liquids held in capillary tubes, however, have the ability to withstand these high pressures. This requirement in the device **2** will become more apparent from the disclosure below. It should be re-emphasized that in order for the device **2** to perform its function as a high liquid-sorbing device with excellent holding capacity under heavy loading pressures, the number and size of the capillary passageways **4** must be at least within the minimum number recited above.

In a preferred embodiment, the device **12** of the instant invention can be manufactured by the processing of a readily available kind of plant obtainable in nature. This variety of plant is found in marshes and other wet ground and is characterized by long stalks containing a large number of tiny capillaries. One specific example of such a plant is commonly called "cattails." Such a plant is inexpensive and, as far as is known, unused for any commercial purpose at present. Plants of the type typified by cattails may be processed into an article of manufacture of the kind illustrated at **2** in FIGS. **1** and **2** by cutting off the stems of the plants, and thence slicing the stems into lengths in the range described above for the dimension A, and thereafter dried.

Alternatively, the device **2** of the instant invention may be produced by conventional manufacturing means. Typically, conventionally manufactured capillary devices employ glass as the material of construction. It should be appreciated that the cost of normal manufacturing means to produce the device **2** of the instant invention is much higher than the cost of using naturally growing plants such as cattails.

The capillary device **2** of the instant invention has as a principal application, the sorption and retention of liquids under high loading conditions. Specifically, these devices **2** are directed to the sorption and retention of water from wet soils in which heavy loads are to be disposed. Thus, large numbers of these devices **2** are spread out over a relatively large area of wet soil. The devices **2** sorb water into the capillary passageways **4.** The soil now supports ditching and pipelaying equipment along the right of way of the pipeline. Upon applying these heavy loads onto the soil, the capillary device **2** does not release its water which is retained in the capillary passageways **4.**

EXAMPLE I

In order to evaluate the water-removal capability of the capillary device **2** of the instant invention, a laboratory sample of wet soil was designed comprising a capped jar in which 50 grams of clean sand were disposed and to which 40 cu. centimeters of water were added. Various capillary devices were added to this sand-water slurry and after a soak period of 24 hours, the mixture was drained through filter paper. Seven tests were made. One of these tests was a control wherein no capillary device was added to the sample. Three of the tests involved the addition of 28 percent by volume of a capillary device comprising dried cattails of the kind described above. In one of the cases, the length "A" was ¾ in. Two experiments involved the use of 28 vol. percent of cattails with a length "A" of ¼ to ½ in. In one of these cases, an active surfactant, 1 percent Aerosol Ot, was added to the water. It should be appreciated that a surfactant such as Aerosol Ot drastically lowers the surface tension of the water and, as can be seen in the table below, appreciably lowers water retention. This proves that the sorbing effect is due to capillary pressure since the capillary pressure is directly proportional to the surface tension of the liquid divided by the capillary radius. Thus, due to lowered surface tension there was a marked reduction in water sorbed. The glass capillaries used had a capillary diameter of 0.9 mm, which was the smallest capillary available in the laboratory in which the test was run. It should be understood that the percentage volume is based on the sand volume.

Table I which appears immediately below is a summary of the laboratory results of the seven tests. A measure of the effectiveness of each of these capillary devices is the amount of free water drained from the sample after 24 hours of contact with the capillary device. The less free water drained, the more effective the device, since the remainder of the water is retained within the capillaries.

TABLE I

Sample	Free Water Drained From Sample After 24 Hours
Control (50 grams sand + 40 cc. water)	21 cc.
28 Vol. % Cattails (¾" cut)	3 cc.
28 Vol. % Cattails (½–½" cut)	0 cc.
28 Vol. % Cattails (¼–½" cut)	13 cc.
with 1% Aerosol Ot in water	
10 Vol. % Glass Capillaries (½" cut)	19 cc.
50 Vol. % Glass Capillaries (½" cut)	16 cc.

It is apparent from the data of Table I that a capillary device manufactured from cattails is far more effective than the readily available commercial capillaries that are presently on the market. Further, it is clear that cattails in the length of ¼ to ½ in. are most effective. Finally, the addition of a surfactant which reduces surface tension of water clearly indicates that capillary force is the phenomena by which the water is retained in the capillary device.

EXAMPLE II

The tests described above in Example I clearly establish that capillary action is an effective means to remove free water from soils. Thus, a second test was performed to determine the load-bearing properties of soils which were treated with the capillary devices of the instant invention. In this case, soil was obtained from marsh lands. The shear strengths of the various test samples were measured in a laboratory by a vane shear apparatus developed for these tests. The vane shear apparatus includes vane blades (½ × ½ inch) which are rotated in the sample and the shear strength is calculated from the energy (in.-lbs) that is accumulated in a torsion spring. Three tests were run, including one test which was a control in which no capillary device was used to sorb water. The data resulting from these tests appear immediately below in Table II.

TABLE II

Sample	Vane Shear Strength, PSI
Control — Marsh Soil	0.1
10 Vol. % Cattails	1.0
20 Vol. % Cattails	4.3

It should be understood that the volume percentages of the capillary devices are based on the total marsh soil sample volume. The results of these tests, as manifested by the vane shear strength in pounds per sq. inch, indicate the addition of 10 percent by volume of cattail capillary devices increases the strength of the soil ten times. Doubling the volume of cattails to 20 vol. percent increases the load-bearing strength of the untreated soil by a multiple of 43 times.

While the above-described preferred embodiment illustrates the invention in detail, it should be understood that the instant invention in its broadest aspects is not limited to its preferred embodiment. Other embodiments using capillary devices which do not depart from the scope and spirt of this invention should be understood to be covered by the invention as defined by the claims.

What is claimed is:

1. A process for increasing the load-bearing characteristics of wet soils by sorbing and retaining water therefrom comprising disposing in the wet soil onto which heavy loads are to be disposed a plurality of predried capillary devices having capillary passageways of diameter and length such that removal of water therefrom by external pressure is substantially resisted by capillary forces, said devices having a length of ⅛ to 2 inches and 80,000 to 2,500,000 passageways per square inch of cross section, each passageway having a diameter in the range of 5–50 microns drawing water from said soil into said capillary devices, and retaining the water in said capillary devices by capillary forces, thereby increasing the load-bearing capacity of said soil without removing water therefrom.

2. A wet soil stabilizing device for sorbing water from wet soils and retaining said water when subjected to pressure thereby increasing the load-bearing capacity of said soils, said stabilizing device comprising a plurality of contiguous water-free capillary passageways passing in the longitudinal direction over the entire length of the device, said passageways being open at their ends to permit access of said water to said passageways thereby withdrawing said water from contact with said soil, said passageways being of sufficiently small diameter and length for retaining said water within said stabilizing device by capillary action when subjected to external pressure, said devices having a length of ⅛ to 2 inches and 80,000 to 2,500,000 passageways per square inch of cross section, each passageway having a diameter in the range of 5 to 50 microns.

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