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"USE OF GEOTEXTILE PRODUCTS IN WATER CONTROL"

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As a method to demonstrate the uses of geotextile products in water control, this paper will deal with these uses in the construction of a earthern dam. Obviously, the geotextile products may be used in instances other than in the example, but this will serve to act as the general uses of geotextile products in water control.

Geotextiles have been in use since the 1950's and have gained increasing acceptance over the last ten years as can be seen from the the table below:

Sales of Geotextiles

1976	6,000,000 square yards
1977	15,000,000
1978	75,000,000
1980	102,000,000
1983	138,000,000
1985	210,000,000
1987	270,000,000

The main uses of geotextiles are:

1. Separation
2. Reinforcement
3. Drainage
4. Filtration

One or all of these functions may occur during the use of a geotextile. Geotextiles may perform one, two, three or all four of these functions.

These products are made mainly of polypropylene or polyester, but also may be nylon, polyethylene, or other polymers. The manner in which any of these polymers are extruded, woven or fabricated gives them different characteristics for different functions.

There are two main ways of fabricating these polymers into a usable product. These are; woven and nonwoven. This involves either weaving a fiber or tape at right angles to each other,(woven), or arranging a series of elements or threads in a random order (nonwoven).

Woven fabrics employ either individual extruded filaments, or slit tapes woven together to create a final product.

Nonwoven geotextiles employ either continuous filaments or staple fibers, joined together to give a homogenous product. The fibers are joined either by needle-punching, resin bonding, melt-bonding, or spun-bonding. Again, there are different qualities associated with different types of joining the fibers.

Rolls of standard geotextiles are approximately 3.5 - 5.3 meters wide and 70 - 150 meters long. The weight of each roll of geotextile will vary depending on the size of the roll and weight per square meter of the geotextile. Each of the woven and nonwoven geotextiles are available in different weights per square meter.

DESIGNING WITH GEOTEXTILES

The desired use of the geotextile will determine the applicable design method. It must be ascertained what qualities are required for the geotextile to perform adequately.

Physical properties that should be taken into consideration are:

1. Specific Gravity of the geotextile
2. Mass per unit area
3. Thickness

Mechanical properties that should be taken into consideration are:

1. Compressibility
2. Tensile Strength
3. Fatigue Strength
4. Burst Strength
5. Tear Strength

CONSTRUCTION METHODS AND TECHNIQUES

- Geotextiles, generally, are easily handled. They come in rolls that can normally be carried by one or two men. As mentioned previously, the materials that make up geotextiles are inert and do not affect the health of the people using them.

Areas where geotextiles can be used in relation to water control in the construction of an earthern dam are:

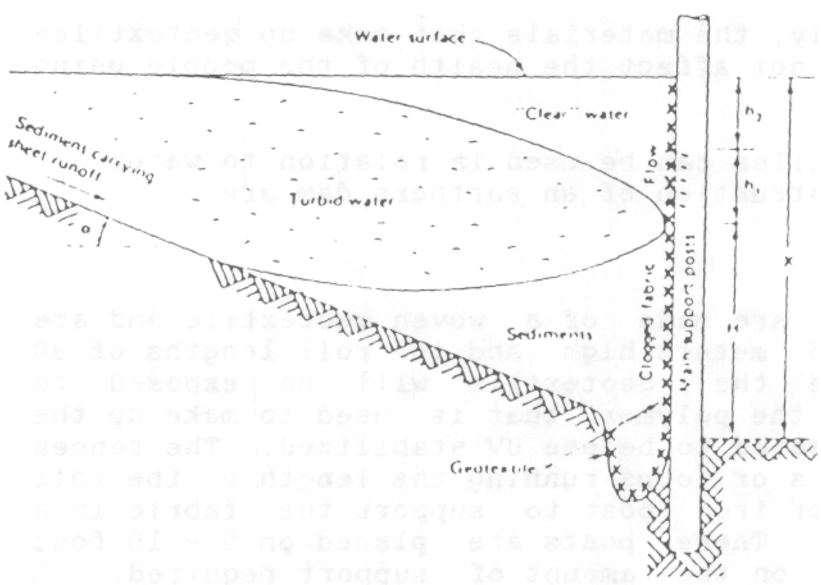
A) SILT FENCES

Silt fences are made of a woven geotextile and are approximately 1-1.5 meters high and in roll lengths of 30 meters. Because the geotextile will be exposed to ultraviolet rays, the polymer that is used to make up the silt fence, is treated to become UV stabilized. The fences usually have pockets or loops running the length of the roll to allow a wood or iron post to support the fabric in a vertical position. These poists are placed on 5 - 10 foot centers, depending on the amount of support required. A wire fence may also be placed behind the silt fence for extra support if required. The silt fence is embedded in an anchor trench to prevent run-off from undermining the silt fence.

Silt fences are used in areas where there is a potential for run-off from an excavation or site that has exposed bare soil during a construction process. The method that has been, and in some areas, IH still being used, is the use of straw or hay bales. The silt fencing has some obvious advantages over straw bale». These Include the ability to carry a large amount the silt fence to the application site with minimal equipment, the ease of installation, and the ability to clean the sediment that is held back by the silt fences.
If the silt Is allowed to be washed away without some method of entrapment, the silt will a) be lost forever in this location and b) will possibly pollute the environment around the site or anywhere downstream, if allowed to enter a water course.

As the silt fence holds back the silts and clays, from the turbid water, a layer of sedimentation is built up behind the fence. As this occurs the water runs through the fabric above the sediment, depositing additional sediment. This carries on up the silt fence until there is a possibility of over-topping of the fence and then the sediment is cleaned out from behind the fence. The diagram below illustrates the mechanism of this happening. Because there are various heights of fences available, it is advisable to obtain the one that would be applicable for your particular situation.

Designing for Filtration



Cross section of silt fence and suggested manner in which system functions

In the United States, the use of silt fencing Is common practice due mostly to legislation requiring the use of silt fences. In fact, the Water Quality Office of the Federal Environmental Protection Agency has issued "Water Quality Considerations for Construction and Dredging Operations", which states that, "Where silting and turbidity must be positively controlled because of the close proximity of the dredging operations to water intakes, resort areas, oyster beds, etc., a diaper or enclosure be provided for the cutter head and/or discharge pipe outlet to control the drift of suspended materials." This is an area where, very soon, we will be required to provide this protection in Canada as well.

B) RIP-RAP UNDERLAYMENT

Armored protection systems (rip-rap), generally incorporate an underlayment of a filtration and energy dissipation system. This can be a graded aggregate system. To replace this, nonwoven or woven monofilament geotextiles can be used under rip-rap to prevent loss of fines from the sub-base and to dissipate energy. With wave action or the raising and lowering of the water level (ponds or lakes behind a dam, tides, cooling ponds, water reservoirs), the geotextiles retain the fines in the base material. They do, however, allow water to pass through, either perpendicular, or along the plane of the fabric while retaining these fines. The movement of these fine soil particles is referred to as "piping" of the soil. With a properly designed geotextile, the piping action will not take place and will maintain the integrity of the base of the rip-rap.

This is an instance where the actual required specifications of the geotextile may not be the governing factor when finally purchasing the fabric. The installation process may dictate that the geotextile be heavier than was designed, just to withstand the rigors of the installation. Large size and sharp blast rock may be dumped from a height above the geotextile which may tend to tear or puncture a lighter geotextile. Ideally, the rip-rap should be "placed" on the geotextile, rather than "dumped". A sand cushion is sometimes placed under, and in some cases, over, the geotextile to protect it during installation or from abrasion of rip-rap due to possible movement of the rip-rap caused by wave action. The sand cushion can also act as a pore water dissipator when concrete blocks are placed directly on the fabric which does not allow the water to escape from the sub-base when there is a lowering of the water level.

The geotextile is normally rolled down the slope with an overlap on the side of the rolls of 0.6 meters or, in some instances, 25% of the roll width. The end of the rolls are also overlapped approximately 0.6 meters.

The equivalent opening *size* of the geotextile should be obtained to determine that is can function with the soil that it is going to be holding back.

C) PREFABRICATED DRAINS

- Geotextiles incorporated into a geocomposite can replace aggregate drains in certain instances. A geotextile (usually a nonwoven) is attached or joined with a prefabricated core. The core is fabricated from polyethylene or polypropylene and can have various configurations and thicknesses. This core can vary in shape from an "egg-crate" shape to a round drainage pipe. The two main types of drain are sheet drains or strip drains.

The sheet drains are used against walls where previously a graded aggregate filter was used. This involved placing aggregate behind the wall with the geotextile between the aggregate and the backfill. This was an easy thing to design, but not an easy thing to install. With the sheet drain, the core and the fabric can be placed very easily up against the wall and then the backfill can be placed against the prefabricated drain.

The strip drain can replace a trench or "French" drain. The strip drain usually comes in rolls and can be laid down in a trench. Prior to strip drains, the trench would be dug and a geotextile place in the trench, aggregate would then be put in this trench and the geotextile folded back over the aggregate. The aggregate was a method to create a void to allow water flow. With the strip drain, the requirement for, and therefore the handling and cost of the aggregate, can be eliminated.

In a dam situation, the prefabricated drain may be installed as a chimney drain. The sheet prefabricated drain can also be used to intercept water against fractured rock that is weeping.

Another application of prefabricated drains is the use of wick drains. The wick drains are used to dissipate pore pressure and accelerate consolidation. The wick drains are approximately 100 mm wide and 4 mm thick and come in rolls 250 - 300 meters long. They are installed using a crane and an installation mast using a hollow, rectangular steel tube called a mandrel. The wick is fed through the mandrel and pushed into the ground using the weight and the pulley system of the crane. The wick drains are pushed down to refusal, where a hard lens of soil (usually clay) is encountered, or to a previously designed depth. The mandrel is withdrawn, leaving the wick drain in place. This is repeated at spacings of 1.5 - 5.0 meters. A surcharge is then placed on the wicked area to achieve the desired

E) FLEXIBLE FORMING SYSTEMS

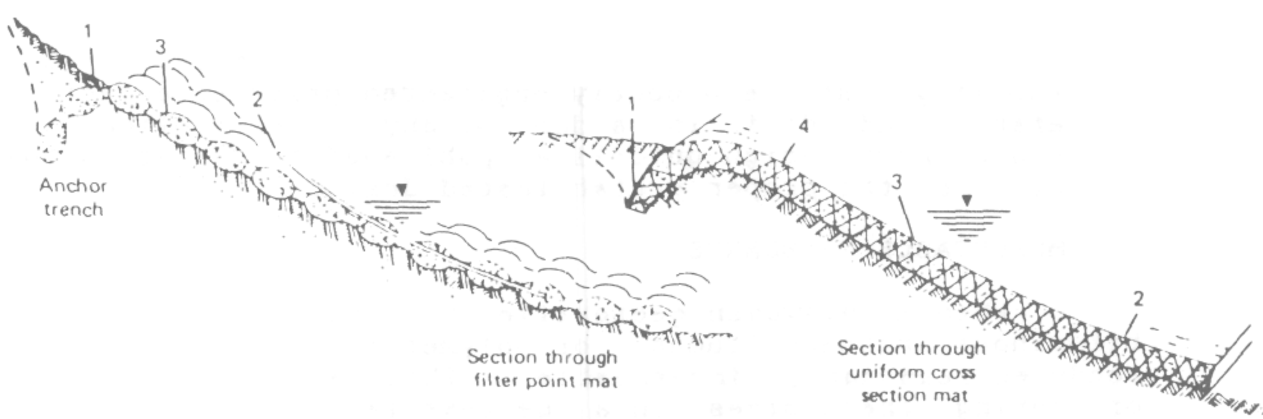
Geotextiles may be used as forms for grout mixes, bentonite, pumped soil, or anything that can be pumped or otherwise put into the form.

The advantage of the fabric is that it is flexible and allows the placement of the form where it may not be possible to place a rigid steel or wood form. This may involve the use of the fabric under an undermined bridge abutment or drop structure to prevent escape of grout installed to repair the damage caused by the scouring action of the water.

Another area where fabric formed concrete has an application is to replace rip-rap on shore of cooling ponds, rivers, in drainage channels, in culvert inlets, or as drop structures. This is done by using two layers of a geotextile (usually a woven nylon) that are joined by connecting threads. Weep holes or pore pressure equalization points can be put into the blanket to reduce uplift pressure. The geotextile can be almost any size or shape and when pumped with grout, resembles a large concrete "air mattress". There are various thicknesses and types to allow the designer to use the proper form for his application.

First, the geotextile is laid out on the area to be protected. Then it is keyed into an anchor trench. The grout is then pumped in, starting at the bottom, and working the way back up the slope.

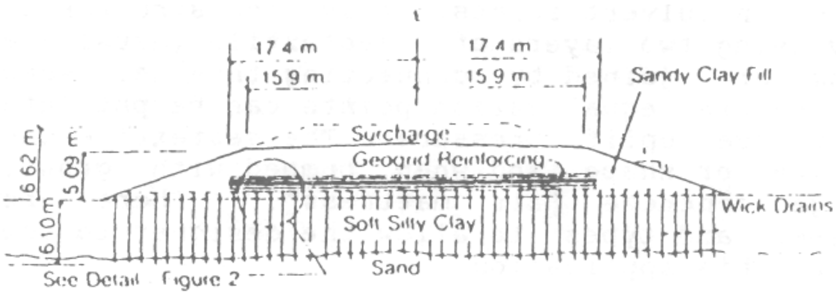
An articulated block system that has the fabric connected with a series of cables is also available. This allows for any settlement of the surface where the fabric formed concrete is placed. Even if there is settlement, the individual parts of the system will be tied together and will perform as designed with the allowable settlement. The diagram below shows usage of fabric formed concrete.



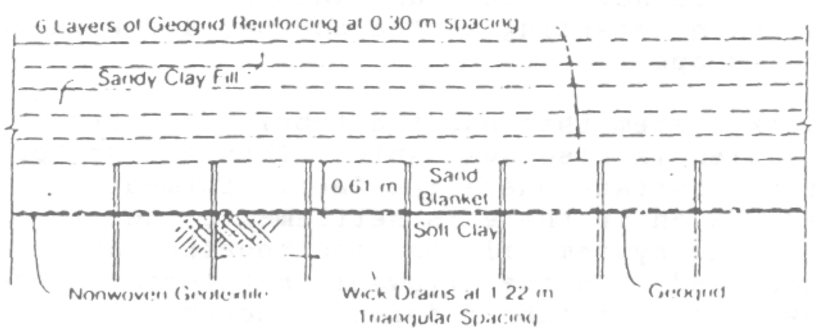
These areas of geotextile use are the main ones involving water control. There is tremendous amount of information settlement. This settlement time is substantially less than would have been achieved with Just a surcharge placed on the area. In some cases, the surcharge cannot be placed without the wick drains because of the potential for build-up of pore pressure in the structure.

This has been used on cooling pond dams to consolidate the dam to allow an Increase in the height of the dam to be built and to provide stability. Wick drains were used on the Dickenson dam in Red Lake, Ontario and at the Rafferty Dam in Saskatchewan, presently under construction.

The diagram below shows the use of wick drains as well as geotextiles and geogrids:



Typical section of reinforced embankment



Detail of embankment reinforcing and wick drains

All criteria such as crush strength, transmissivity. and permeability must be properly engineered prior to selecting a prefabricated drain in a dam or any other application. There are many design guidelines published to assist in the selection of the proper prefabricated drain.

D) IMPERMEABLE MEMBRANES

When a nonwoven geotextile is impregnated with a bituminous, rubber-bitumen, or polymeric mix, it can be rendered reasonably impermeable. This is done by spraying or pouring these mixes on a geotextile, usually after the geotextile has been placed on the final site.

available suppliers, trade organizations, manufacturers, industry publications, and engineering companies involved in geotextiles.

As mentioned at the outset of this paper, geotextile use has grown dramatically in the last decade. As people use them, more and more uses are determined. Also, as people use geotextiles and become more familiar with the advantages and characteristics of them, they tend to use them more often. This can represent the replacement of a previous system, or as a totally new use application for the user.

This paper dealt with the use of geotextile products in water control. Your awareness of the uses and quite possibly, economical solutions to some of your "challenges" can hopefully be met with geotextiles. These uses of geotextiles have been a result of evolution of uses of geotextiles. The awareness of these solutions should open the door to you to come up with even more solutions to some of your everyday situations that may incorporate the use of geotextiles.

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