EROSION CONTROL USEING GEOTEXTILES

Ana-Maria CIUBOTARIU[1], Lavinia RUSU[2], Crina TIRON[3], Radko KOVAR[4], Costea BUDULAN[5], Marina ROMAN [6]
[1,3,4] *Technical University of Liberec, Faculty of Textile Engineering, Department of Textile Technology, Liberec, Czech Republic*
[2,5,6] *Technical University of Iasi, Faculty of Textile Engineering, Iasi, Romania*
ciubotariu.anamaria@gmail.com

Abstract
Erosion is caused by a group of physical and chemical processes by which the soil or rock material is loosened, detached and transported from one place to another by running water, waves, wind, moving ice or other geological factors and bank erosion agents. The geo-textile serves as an anti-erosion factor when it prevent land degradation, most likely to occur under the influence of environment factors. The requirements imposed to a geo-textile that should provide an anti-erosion function are diverse in relation to the context in which they are used . Usually are required the permeability and retention capabilities, but for some works it is necessary to have also adequate strength characteristics. The anti-erosion function of a geo-textile could be temporary or permanent. The raw materials for the temporary applications are mainly natural polymers such as flax, hemp, jute, sisal, coir (coconut fibre), cotton. This paper presents the properties of the materials, design method and procedure and applications.
Key words: anti-erosion, geo-textile, jute, tensile strength;

1. Introduction

Erosion means the wearing away of the land surface by water, wind, ice, gravity, or other geological agents. Erosion is caused by a group of physical and chemical processes by which the soil or rock material is loosened, detached, and transported from one place to another by running water, waves, wind, moving ice, or other geological factors and bank erosion agents.[1]

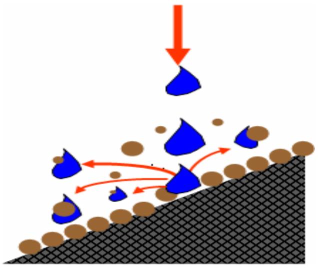
The following terms are used to describe different types of water erosion:

- Accelerated erosion- Erosion much more rapid than normal or geologic erosion, primarily as a result of the activities of man.
- Channel erosion- The erosion process whereby the volume and velocity of flow wears away the bad or banks of a well-defined channel.
- Gully erosion- The erosion process whereby runoff water accumulates in narrow channels and, over relatively short periods, removes the soil to considerable depths, raining from 1 to 2 feet to as much as 75 to 100 feet.
- Rill erosion- An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soil.
- Splash erosion- the spattering of small soil particles caused by the impact of raindrops on wet soil. The loosend and spattered particles may or may not be subsequently removed by surface runoff.
- Sheet erosion- the gradual remove of a fairly uniform layer of soil from the land surface by runoff water.

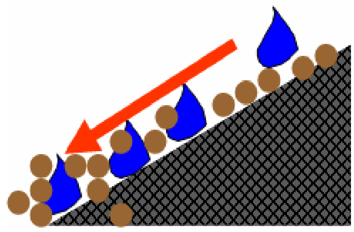
The main forms of surface erosion are:

- Primary erosion / splash erosion (to impact) - is due to dynamic action of raindrops or sprinkler irrigation (see figure 1.a.);
- Secondary erosion / sheet erosion - is due to water leakage that occurs at land surface under the influence of thin and continue layers of water (see figure 1.b.);

- Linear erosion / rill erosion - by drip or gutters- is the most frequent and is manifested by concentrating water flow in natural micro-depressions on the slope in a series of gullies; it represents the boundary between the surface erosion and depth erosion.[2]



a).Primary erosion (to impact)



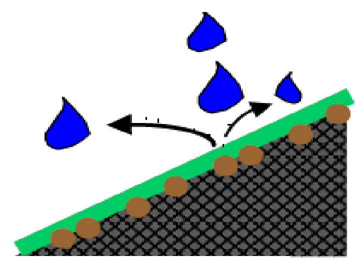
b).Secondary erosion (sheet)

Figure1.

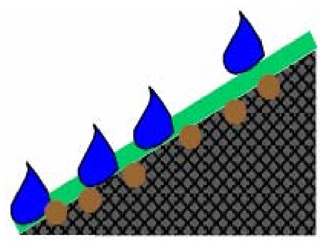
A rapidly developing area for geo-textiles is in the erosion control industy where they are employed for short-term effects. This usage differs from the other applications of geo-textiles in that they are laid on the surface and not buried in the soil. The main aim is to control erosion whilst helping to establish vegetation which will control erosion naturally. The geo-textile is then surplus to requirements and can degrade, enriching the soil. Geo-textiles can reduce runoff, retain soil particles and protect soil which has not been vegetated, from the sun, rain and wind. They can also be used to suppress weeds around newly planted trees. Erosion control can be applied to riverbanks and coastlines to prevent undermining by the ebb and flow of the tide or just by wave motion.[3]

In erosion control, the geo-textile protects soil surfaces from the tractive forces of moving water or wind and rainfall erosion. Geo-textiles can be used in ditch linings to protect erodible fine sands or cohesionless The geo-textiles is placed in the ditch and is secured in place by stakes or is covered with rock or gravel to secure the geo-textile, shield it from ultraviolet light, and dissipate the energy of the flowing water (see figure 2.a. and 2.b).

Geo-textiles are also used for temporary protection against erosion on newly seeded slopes. After the slope has been seeded, the geo-textile is anchored to the slope holding the soil and seed in-place until the seed germinate and vegetative cover is established. The erosion control function can be thought of as a special case of the combination of the filtration and separation functions.[1]



a).Primary erosion eliminated with geotextile



b). Secondary erosion eliminated with geotextile

Figure 2

An anti-erosion material must solve these problems :
- a minimal dynamic impact of rainwather ;
- a minimal mobility of soil particles ;
- to provide and improve the development process of plant.

2. Essential proprieties of geo-textiles

The three main proprieties which are required and specified for a geo-textile are its mechanical responses, filtration ability and chemical resistance. These are the properties that produce the required working effect. They are all developed from the combination of the physical from of the polymer fibers, their textile construction and the polymer chemical characteristics.

Mechanical responses include the ability of a textile to perform work in a stressed environment and its ability to resist damage in an arduous environment. Usually the stressed environment is known in advance and the textile is selected on the basis of numerical criteria to cope with the expected imposed stresses and its ability to absorb those stresses over the proposed lifetime of the structure without straining more than a predetermined amount.

The general properties of chemical fibers compared to natural fibers still tend to fall into distinct categories. Natural fibers posses high strength, modulus and moisture uptake and low elongation and elasticity. Regenerated cellulose fibers have low strength and modulus, high elongation and moisture uptake and poor elasticity. Synthetic fibers have high strength, modulus and elongation with a reasonable amount of elasticity and relatively low moisture uptake.

Natural fibers can be of vegetable, animal or mineral origin. Vegetable fibers have the greatest potential for use in geo-textiles because of their superior engineering properties, for example animal fibers have a lower strength and modulus and higher elongation than vegetable fibers. Mineral fibers are very expensive, brittle and lack strength and flexibility.
Over years, the natural fibers like jute, flax, hemp, cotton, sisal, abaca, coir are used mainly for control of surface soil erosion and the specification of the most common materials that are used for the purpose are given in table 1.

Table 1. Specification of jute geo-textiles for control of surface soil erosion by rain and wind

Type	***Weight (g/m²)***	***Thickness (mm)***	***Strip strength (kN/m)***		***Elongation at break (%)***		***Open area (%)***
			MD	CD	MD	CD	
Woven	292	2	10	10	10	10	70
Woven	500	5	10	7.5	10	10	55
Woven	730	6	10	10	10	10	30

MD-Machine direction CD-Cross direction

Specialty of the products is as below:

1. Highly flexible and easily takes shape of soil contour.
2. Open space in between threads helps grow vegetation fast and healthily. Detached soil particles of the open areas by raindrops are arrested in between the threads of the fabric in firm contact with the soil surface.
3. The threads across the slope work as miniature check dams, which reduce velocity of runoff while excess flows along the threads down the slope.
4. After degradation, the geo-textiles become part of soil and enhance water absorption capacity of the soil.

3. Functions

Functional requirements for geo-textiles used for erosion control are presented in Table 2

Table 2. Functional requirements for geo-textiles used for erosion control

Geo-textile functions	
Tensile strength	ii
Elongation	ii-iii
Chemical resistance	i
Biodegradability	iii
Flexibility	iii
Friction properties	ii
Interlock	i
Tear resistance	ii
Penetration	ii
Puncture resistance	i-ii
Permeability	ii
Resistance to flow	iii
Water	iii
UV light	iii
Climate	iii
Quality assurance & control	i

iii- highly important; ii-important; i-moderately important.

Some typical mechanical data for different natural fibers are shown in Table 3.

Table 3. Mechanical properties of different natural fibers

Fiber	***Density (g/cm³)***	***Young's modulus (GPa)***	***Tensile strength (MPa)***	***Elongation at break (%)***
Cotton	1.5-1.6	5.5-12.6	287-597	7-8
Jute	1.3	26.5	393-773	1.5-1.8
Flax	1.5	27.6-46.9	345-1035	2.7-3.2
Ramie	-	61.4-128	400-938	3.6-3.8
Sisal	1.5	9.4-22	511-635	2-2.5

Jute is readily biodegradable and ideally suited for the initial establishment of vegetation that in turn provides a natural erosion prevention facility. By the time natural vegetation has become well established the jute has started to rot/break down and disappear (6-12 months), without polluting the land.

Some research has been directed towards reducing the degradation rate of jute, which can be made almost rot-proof by treating the fabric with a mixture of oxides and hydroxides of cobalt and manganese with copper pyroborate.

4. Manufacturing process

On the basis of manufacturing techniques, geo-textiles can be broadly classified into three basic categories, namely, woven, knitted and non-woven. A combination of these with or without other materials like nets or grids is termed as composites. At present knitted fabrics are rarely used as geo-textiles, woven fabrics have an excellent tensile strength but provide poor abrasion resistance and dimensional stability and, except for uncalandered monofilaments, it has low coefficient of permeability. Further, woven fabrics have little or no ability to transmit water within their plane and have poor surface frictional characteristics.[4]

High strength woven geo-textiles have also been used for separation and stabilization in the construction of embankments, dikes, coffer dams and breakwaters. A high strength geo-textile can also be manufactured into a geo-textile tube. These tubes are typically filled with sand and have been used effectively as breakwaters or to rebuild an eroded shoreline.

Non-woven fabrics, particularly needle punched, have the unique ability to elongate locally to resist damage, better permeability and frictional resistance though their tensile strength is much lower than that of woven fabrics.[4]

Geo-nets are the most recently introduced members of the geo-synthetics family. They are also used to prevent surface erosion with the advantage that they does not absorb moisture and they do not change size.

The design of the anti-erosion systems it generally starts from their main function, to limit the soil loss through erosion to an acceptable value. For example an acceptable value for the agricultural purposes is 10 tons/ha/year. This value can be applied to other engineering fields. Material loss by erosion can be evaluated using the universal equation of Wishmeier [5]:

$$E = R \times K \times L \times S \times P \times C \qquad (1)$$

Where:
E- the average of the annual soil loss (mass/ area);
R- index of rain erosion (depending on the intensity and duration of rain, mass, diameter and velocity of rain drops);
K- index of land erodability;
L- slope length;
S- slope angle;
P- site conditions factor (usually equal to 1, except the case when the site is terraced)
C- type of crop factor.

5. Conclusion

Geo-textiles have contributed to the erosion control industry for over 60 years. The type of geo-textile used is based on an installation's functional requirement. Geo-textiles are available in a variety of structures and composition designed to meet a wide range of applications. It was observed that jute geo-textile controlled soil erosion more effectively than by the conventional method and retained soil nutrients as well as soil moisture in the dry season.

6. References

1. Headquarters departments of the army and air force Washington, *Engineering use of geo-textiles,* Technical manual No.5-818-8, 20 July 1995, page 6.
2. Polyfelt Geosynthetics, *Controlul eroziunii solului,* www.envirofelt.com;
3. Peter R Rankilor, *Handbook of technical textiles,*
4. Dr.M K Talukdar, *Product development in Geosynthetics,* 18th National Convention of Textile Engineers, Kolkata, 2005, page 6-11;
5. A. Găzdaru, V Feodorov, S Manea, L. Batali, *Geosinteticele în construcții,* Edidura Academiei Române, Bucureşti, 1999, 214-216.