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Constructive Elements for River Bank Defense Structures Using Woven Geotextiles**Éléments constructifs pour la protection des berges utilisant des géotextiles tissés**

The present paper brings forth for the river banks protection reinforcing works a non-conventional solution in which use is made, in the achievement of the protection toe, of gabion-bag type structural elements made of geotextiles and filled with local soil. The advantage of such a solution lies in the fact that unprocessed local materials are used. Economically the selection of this solution is entirely justifiable in the cases when the rockfill has to be transported from long distances. A full-scale test had been performed during the spring of 1980. Since then several high floods have been recorded on that river. The observations concerning the work revealed the fact that a good arrangement and interlocking of the prefabricated elements in the protective toe had been achieved and maintained. During both the construction and the operation the geotextile the gabion-bags had been made of had a satisfactory behaviour comparable to that resulting from the laboratory tests.

L'article présente une solution non traditionnelle pour l'exécution d'un massif de protection, des éléments de construction du type "gabions-sacs" remplis à terre, réalisés par des géotextiles. L'avantage offert par une telle solution réside en l'utilisation des matériaux locaux. Telles solutions sont justifiées dans les circonstances où les enrochements doivent être transportés aux grandes distances. Une expérimentation à l'échelle naturelle a été exécutée au printemps de l'année 1980. Dès lors on a enregistré quelques crues sur la rivière. Les observations effectuées sur cet ouvrage ont montré qu'on a réalisé et maintenu un bon rangement et joint par l'interpénétration des éléments prefabricqués en massif. Les géotextiles utilisées comme matériaux de confection pour de "gabions-sacs" ont eu un comportement satisfaisant tant à la mise en oeuvre que pendant l'exploitation, comparable à ceux résultats par les essais de laboratoire.

INTRODUCTION

The use of woven geotextiles in the river banks protection structures is no longer a novelty (1). In the various solutions that had been experimented and applied the technical and economical obvious advantages offered by this new construction material had been emphasized.

The present paper shows the results of the authors' studies orientated on the utilization of geotextiles in the execution of the prefabricated elements to replace the riprap in the classical protection toes from the river bank protection-reinforcing works (4).

The prefabricated elements have a cylindrical shape and are of the gabion-bag type. The solution has in view their filling with local soil directly on the site.

Thus, for certain cases a new solution is obtained having indices of efficiency superior to those of the traditional ones. This is due to i) the elimination of unavailable or more expensive materials (such as the rock fill, cement, wire net, a.s.o.); ii) the diminution of fuel consumption in the transport of materials; iii) construction facility; iii) increased productivity

UTILIZABLE GEOTEXTILES

For the achievement of the structural gabion-bag type elements of the geotextile confection material must meet the following conditions;

- durability to physical environmental factors action taking into account the specific conditions

determined by the structural elements permanent or temporary immersion;

- chemical and biological unreactiveness;
- adequate breaking, tearing and bursting strength during the earthfilling manipulation, construction and operation;
- adequate permeability to air and water so that under the severe construction circumstances when the gabion-bags are thrown from the bank into water bursting should be avoided and the earthfill quick saturation should be allowed providing a good arrangement and interlocking of the elements in the structure;
- thinness and marked flexibility so that no difficult problems are met during the fabrication.

The tests concerning the behaviour of some fabrics made of polyamide, polyesters and polypropylene performed on samples subjected to artificial ageing under conditions specific to the river banks protection and reinforcing works led to the conclusion that in point of durability, the fabrics made of polypropylene have the best behaviour. As far as the material is concerned the authors had chosen the geotextiles ALFA-Hessian-type fabrics-obtained from fibrillated polypropylene foil yarns.

Due to the yarns roughness this type of fabric manifests a good dimensional stability and unweaving strength. The fibrillated yarn also gives the fabric a certain elasticity increasing its crushing strength

As a result of the performed tests the fabrics selected for this utilization have been executed in two

variants ; ALFA M and ALFA G.(2).As related to denseness they cover the entire granulometric domain of soils of the sand and gravel type that usually can be taken into consideration as filling materials.

Dimensional defining characteristics as well as the mechanical ones of the ALFA geotextiles utilizable as confection materials for the earth filled bag-type gabions are presented in table 1.

TABLE 1 - ALFA Geotextiles Technical Data

Characteristic	Variants	
	ALFA M	ALFA G
Denseness yarns/10 cm(no)	warp 56	100
	weft 55	55
Linear density of yarns λ (tex)	warp 229	268
	weft 229	268
Mass μ (g/m ²)	240	292
Breaking strength F _G (N)	warp 1300	3800
	weft 1440	1950
Breaking elongation ε (%)	warp 16	28
	weft 17	13

GEOTEXTILES CAPACITY TO RETAIN THE GRAINED MATERIAL

One of the main conditions to be observed by the geotextile the prefabricated materials are to be made of is its capacity to satisfactorily retain the earthfill constituent particles.

The tests to establish the geotextile capacity to retain the grained material had been performed by filtering a soil suspension with two experimental variants :
 - under constant hydraulic head H = 0,1 m ;
 - under more severe conditions supposing the grained material forced passing by suction.

On the basis of the obtained results the authors considered that for the presumed utilisation the geotextiles must meet the following conditions :

- 25% is the maximum percentage of soil particles (d) that 90% pass through (P90) or 10% remain on (R10) the geotextile; this means:

$$d_{25} \geq P_{90} \quad \text{or} \quad d_{25} \geq R_{10}$$

- 25% is the minimum percentage of the soil particles that are 50% retained on (R50) or 50% pass through (P50) the geotextiles; this means :

$$d_{75} \geq R_{50} \quad \text{or} \quad d_{75} \geq P_{50}$$

For the above mentioned conditions the limitation of the ALFA M geotextile granulometric domain of utilization is presented in fig.1.

The validity of the granulometric utilization domain thus established had been demonstrated on a physical model in an experimental arrangement in which the earth filled gabion-bag type elements had been impelled in a water basin. The geotextile capacity to retain the earthfill particles had been determined for various velocities of movement (values ranging between 1 ... 5 m/s)

The tests had been performed with earthfill corresponding and noncorresponding to the granulometric utilization domain recommended for the respective geotextile. Admitting that the geotextile restrictive effect cannot be absolute a retention capacity of 80% had been considered as satisfactory.

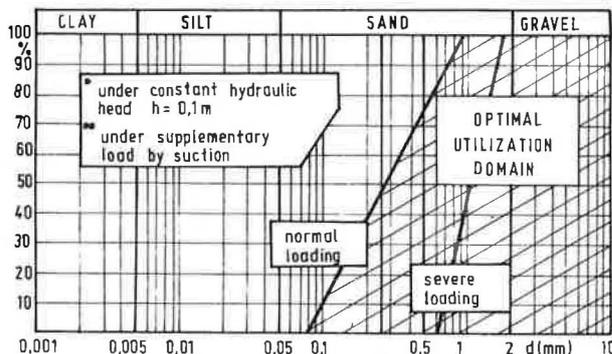


Fig.1 - ALFA M geotextile granulometric domain of efficient utilization

The results obtained for the ALFA M geotextiles (fig.2) led to the following observations :

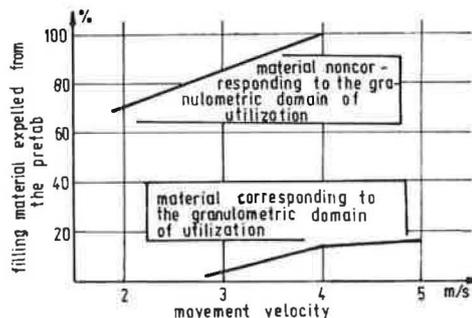


Fig.2 - Checking up of the utilization domain of ALFA M geotextile

- the geotextiles capacity to retain the earthfill depends on the movement velocity ;
- this capacity is clearly differentiated being satisfactory for earth comprised in the granulometric utilization domain and un-satisfactory for not included earth.

From the above presented facts it follows that by determining the geotextile granulometric utilization domain a possibility had been created allowing a correct selection of the filling material for the gabion-bags.

PERMEABILITY TO WATER

Woven geotextiles permeability to water had been determined with a Darcy apparatus (3) under a hydraulic head H = 0.10 m. As for woven geotextiles the hydraulic gradient cannot be determined the testing results have been expressed in apparent velocities (table 2)

TABLE 2 - ALFA Geotextiles Permeability to Water

Geotextile	Apparent velocity (m/sec)
ALFA M	0.154
ALFA G	0.019

CONDITIONS FOR THE RIVER BANKS PROTECTION WORKS
ACHIEVEMENT WITH PREFABS OF THE GABION-BAG TYPE

Structural elements used in river banks protection can be made in any location along the river by earth-filling the geotextile bags

The execution consists of two major operations ;

- bags earthfilling;
- river bank protection work implementation.

Studies performed on hydraulic model (4) for the achievement of protection toe from elements of the gabion-bags type replacing the classical solution with rock-fill showed that :

- it is necessary and sufficient that the replacing structural elements should have the same weight as the stone blocks used for the rockfill protection toe;

- the gabion-bags dimensions should not render their placing difficult;

- prefabs can be achieved as individual elements, bounded by two or by three;

- in comparison with the classical solution of riprap the gabion-bags diminish the roughness coefficient increasing the local velocities by 10-13%.

Observing the conditions imposed by the elements stability in the protection toe the prefabs weight should also be taken into consideration so that their placing does not become too difficult. Due to this fact the double-linked prefabs are preferable as they can be more easily manipulated with any type of crane.

The gabion-bags dimensional elements should also guarantee a corresponding interlocking of elements in the protection toe. The performed studies showed that a good interlocking of these elements is attained at a 70% - 80% filling.

The geotextile specific consumption is determined by the elements diameter and length. The possibility of the prefabs dimensional optimization consequently results.

The execution is recommended to be performed during low level periods of the river as in the case of the traditional rockfill protection toe construction.

NATURAL SCALE EXPERIMENTATION

The experiment aimed at achieving a protection toe of piling gabion-bags included in the usual works of protection and reinforcing on a regulated river section.

The protection toe placed on a fascine work is 1.55 m high and has a 1.30 m crestwidth and a 1:1.5 inclination of slope the geotextile used for the achievement of the gabion-bags being ALFA M.

The prefabricated elements have been used in one or linked by two, each in two dimensional variants (table 3 - case 1 and 2).

Bags dimensions have been chosen taking into consideration the site actual placing possibilities.

For filling the bags earth from the bank and river ballast had been used, the operation being performed on the bank in the site neighbourhood.

The geotextile of tubular shape, previously sewn had been sectioned in accordance with the bags length.

TABLE 3 - Technical Data Regarding the Gabion-bags
Dimensional Characteristics and Works Efficiency Indices

Characteristic		Experimental variants	
		simple bags	double-linked bags
Bag diameter (m)	case 1	0.4	0.6
	case 2	0.4	0.6
Bag length (m)	case 1	1.20	1.50
	case 2	2.00	2.00
Geotextile consumption (linear m/bag)	case 1	2.00	2.60
	case 2	2.80	3.10
Number of bags per cubic meter of structure	case 1	6.00	2.25
	case 2	3.50	1.50
Geotextile consumption per cubic meter of structure (m ²)	case 1	14.4	10.5
	case 2	11.9	8.4
Average time necessary for the complete achievement of a prefab (minutes)		3	4
Average time necessary for the prefabs placing (min)		5	4
Specific productivity obtained with 1 crane and 2 workers (m ³ of work/hour)			cca.3

The operations necessary in the achievement of prefabs consisted in the bags earth filling and their consecutive coupling at the bottom, at the center (for double-linked bags) and at the top.

The filled bags had been stored on the river bank in a position favourable to their further manipulation with the crane (photo 1).

The placing had been achieved by linking several bags with a cable attached to the crane (photo 2) workers' intervention being moderate. Special care had been taken in laying the last layer of prefabs so that the pile of bags in the protection toe should observe the work dimensional elements.

The observations made during the implementation allow the following remarks :

- the geotextile had a good resistance to the severe mechanical strains to which it was subjected during the prefabs lifting and launching;

- launching the prefabs from the bank with the crane achieves a good arrangement and interlocking of elements in the protective toe (photo 3);

- the productivity obtained in achieving the works is satisfactory and comparable to that obtained from classical works (table 2).

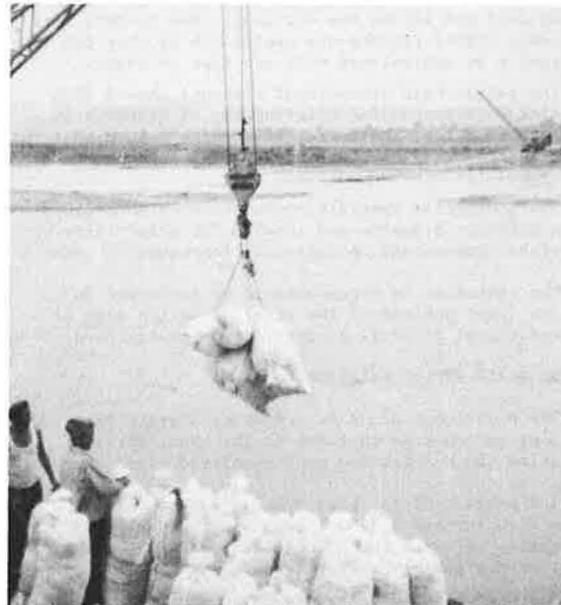
RESULTS

The full-scale experimentation had been performed during the spring of 1980. Since then several high floods had been registered on the river.

The observations made in time concerning the works showed that :

- a good arrangement and interlocking of elements in the work had been performed;
- the bank experimental protection had a good behaviour at high-water levels and for high flow velocities;
- the protection structure underwent no important settling in time and no geometric modification to damage the bank protection;
- the geotextile used as confectioning material for the prefabricated elements had a good behaviour comparable to the laboratory tests results.

The experimental works are still under permanent observation in order to provide data on the behaviour in operation conditions.



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