استفاده از آزمايش كيفي فرآورده‌هاي بافته شده انكـــــا به عنوان مواد كنترل كننده فرسايش

نوشته: علي وصال*

Qualitative Test of Enka Fabricated Products as an Erosion Control Material

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چكيده

مهندسان ومعماران درحال جستجوي روشها ومواد جديدي هستند تا عملكرد را اصلاح نموده وهزينه راكاهش دهند. خاكهاي فرسايش پذير، نيازها وتقاضاهاي طراحي ورشد محيطي اين تحقيق را نسبتا مشكل نموده‌اند. مواد ساختماني بافته شده يا فابريك (Geotextile) به طور وسيعي در تثبيت زمين، زهكشي وكنترل فرسايش مي‌توانند مورد استفاده قرار گيرند. اين امر باعث صرفه جويي ميليونها دلار در هزينه ساخت و تعمير و نگهداري مي‌شود. مواد كنترل كننده فرسايش، به گونه‌اي طراحي مي‌شوند كه تقاضاهاي كاربردي ويژه‌اي را برآورد كنند.

در اين تحقيق، كنترل فرسايش توسط مواد انكا(Enka) و نيز توسط خاك معمولي (بدون استفاده ازمواد انكا) در كانالي باعرض 2/7 متر در آزما يشگاه آب يوتا مورد آزمايش قرار گرفت. روشها و عملكردهاي اجرايي آزمايش به طور خلاصه در مقاله ذكر شده است. نتايج آزمايش در جدولها و شكلهايي با استفـــاده از نرم افزارهاي ماكرو سافت ارائه شده است. بر اساس اين نتايج، اين مواد در نگهداري خاك در مقابل فرسايش كارآمدتر ازخاك كنترل نشده هستند.

كليد واژه‌ها: فرسايش، كنترل فرسايش، تثبيت، مواد ساختماني بافته شده يا ژئوتكستايل

Abstract

Engineers and Builders are continuing to search for new methods and materials to improve performance and to reduce construction costs. Problem soils, demanding design requirements and growing environmental concerns, can make this search rather difficult. Construction fabrics can extensively be used in ground stabilization, drainage and erosion control to save millions of dollars in construction and maintenance. Each erosion control product is designed to meet the demands of a specific application.

The erosion control test with Enka products as an erosion control material and the bare soil were performed in 2.7 m wide channel at Utah Water Laboratory. The procedures and test performances are briefly stated in the paper. Test results are presented in tables and figures using Microsoft Excel program and SPSS software package. According to the results, it is concluded that these products are highly efficient in keeping the soil more stable against the erosion than the bare soil itself.

Key words: Erosion, Erosion control, Stabilize, Construction fabrics

Introduction

Erosion control and revegetation mats(ECRM) are synthetic webs, which provide a flexible ground cover and retard erosion while allowing natural vegetation to establish. Simplicity of installation makes ECRM a cost-effective alternative to riprap, concrete and asphalt linings for permanent erosion control. ECRM products are especially suited for areas where traditional mulching techniques do not work because of severe erosive forces, as in steep slopes, ditches and banks. Erosion control products provides a cost-effective, easily installed alternative to heavy armor-protection in many applications including ditches for roadway and parking lot run-off, storm and irrigation channels, pipe and culvert outlets, roadway slopes, bridge abutments, and building sites.

The Enka product as an erosion control material was tested for its capability of retarding the erosion against the forces acting on it. It was found that for the range of flows and velocities tested, the products have responded reasonably well. The Enka products, one of the Mirafi erosion control fabrics are generally preferred especially by designers of armored erosion protection systems.

Test facilities and procedures

Test Section Layout

High velocity flow tests were conducted in an indoor concrete flume at the Utah water Research Laboratory. The flume, which is 2.4m wide, 2m deep, and 178m long, is supplied with water under 11.7m of head from a nearby reservoir through a 90cm diameter pipe. A spreader at the outlet end of the supply pipe uniformly distributes water over the 2.7m width of the channel. A plywood partition and end gates in the flume provides two test sections, each measuring 1.2m in width and 16.7m in length. A 6.67m long plywood lined smooth approach to the test section allows turbulence in the high velocity water flows to subside before they reach the soil and test materials. The bottom of each channel is positioned approximately 60cm above the floor of the concrete flume so that water can flow underneath, and so draining of the soil masses can be more quickly accomplished. The floors of the channels are slotted and covered with drainage fabric which allows water to drain through but retains the soil. Soil is compacted into the channels on top of the drainage fabric to a depth of 45cm, and the materials to be tested are installed on the soil surface. Figure 1 is a sketch of flume and test channels.

Channel Preparation

Soil used in these tests is classified as sandy loam, and has the following approximate composition : sand =56 % , silt =29.5 %, clay =14.5 %, and organic matter = 0.84%. Soil was added to the channels in layer and uniformly compacted with a gasoline-driven, hand-operated compactor. Final compaction in the channels was approximately 90% of standard Proctor density. Soil eroded during each test was replaced with new soil that was compacted in preparation for every new test.

A test consists of a series of runs, each at a different velocity, with cross –sectional measurements of the channel being made after each run. The products being tested were then left in place during the entire test, then were removed and soil was added to the channel and compacted for the next test.

Installation of Test Materials

Utah is experiencing its sixth year of drought so the water supply for laboratory tests is limited during the summer months. Thus, it was possible to run only one high-velocity channel at a time, and the south one was selected. It was filled with soil, compacted, and an expandable plastic mat was installed .It was stretched to a 1.175m width to fit the channel, and stapled into place. The first test utilized five layers of the mat with the slits in the top, bottom, and center layers opened in the direction of flow, and those on the other two layers opened against the flow.

Material for the second run was identical to that in the first, but only three layers were installed instead of five. Slits on the top and bottom layers opened with the flow, and the middle one was against.

Figure 2 shows the placement and method of anchoring the mat and side curtains. Side curtains were of woven drainage fabric, and were placed to prevent the premature failure of channel edges due to side- wall effects.

Test materials were anchored at their upper ends in trenches according to the pattern shown in Figure 3. The three layers of material were anchored with 2.5cm wide by 15cm long wire staples according to the pattern shown in Figure 4.

Measurement Facilities

A four-wheel measurement cart mounted on steel rails was positioned over the test channel. Velocity measurements of the flows in the channel were made from this cart, using a Montedero Whitney electromagnetic velocity probe, which has a full- scale range of 0-6m/s with an accuracy of ± 1% and a resolution of 0.003mm/s.

Contour measurements for determining depths of soil eroded in the test channel were also made from this cart, using a modified point gage mounted on an instrument carriage on rails. These measurements were made after every run at 30cm intervals across the channel and at 150cm intervals along the channel for the entire 15m length.

Discharge of flows in the channel were measured with a Nusonics Ultrasonic Flow-meter which has an advertized accuracy of ±2 percent of reading for flows between 0.034m³/s and 0.341m³/, and of ±1 percent of reading for flows over 0.341m³/s. Flow depths needed for positioning the velocity probe were made with a small diameter metal rod calibrated in inches.

Test Procedures

Testing procedures includ running each selected velocity of flow for 30 minutes before advancing to the next higher velocity. During each run, velocity measurements were taken along the centerline of the channel at five different locations: the first at station 0 where the flow enters the test section, and the other four along the channel at stations 1.5, 3.0, 4.5, 6.0, 7.5, 9.0, 10.5, 12.0,13.5,15.0 After each 30 minutes run, profile measurements were made at 30 cm intervals across the width of the channel, and at 1.5m intervals along its length.

Results Recorded

Results of the tests were recorded in narrative, tabular, and graphical forms and include the following:

1.Velocities – along the centerline of the channel at stations 0, 1.5,3.0,4.5,6.0,7.5,9.0,10.5,12.0,13.5,15.0 m.

2. Erosion depth –at 30cm intervals across the width of the channel and

5ft. along its length.

3. Time – duration of each individual run.

Criteria for Erosion Control Fabric Selection

Sufficient fabric strength is required to resist damage during installation and subsequent service life. In addition, where the mandates that the fabric act as a filter, selection of appropriate Mirafi fabrics should be based on established filter criteria.

Hand placement and careful equipment operations, e.g. minimum drop heights from clam shells or crane buckets, result in relatively low installation stresses. Back dumping from either slope top or bottom and subsequent spreading imposes high stresses on the fabric. Rounded stones, such as river gravels typically used for gabion fill, result in lower fabric stresses than do angular rocks, e.g. quarry shot rock. An erosion blanket fabric may be subjected to significant stresses and abrasive forces such as severe storms and high velocity water current during its service life. Experience provides the best guidelines to determine which Mirafi fabrics are the best suited to meet the specific project strength requirements. Correlating experience to fabric properties, the U.S. Army Corps of Engineers (Corps) generally requires that fabrics used in armored erosion protection systems maintain those strength properties indicated in ref. (3).

Results and Discussions

The velocities measured along the channel for each run and the station in which these measurements recorded are shown in Table 1. For each run the velocities vary at the stations along the channel according to table 1. Duration of each run is shown in this table. During each run, velocity measurements were taken along the centerline of the channel at five different locations: the first at station 0 where the flow enters the test section, and the other four along the channel at stations 1.5,3.0,.4.5,6.0,7.5,9.0,10.5, 13,15m . The entrance velocities for run 1,2,3,4,5 are 1.34, 3.14, 3.35, 4.9 and 3.43 m/s, respectively.

After each 30 minutes run, profile measurements were made at 30cm intervals across the width of the channel, and at 1.5m intervals along its length.

As mentioned above, the duration is 0.5 hr for all runs except run 5 which is 48 hr. The erosion depths measured at three points across the width of channel and averaged at each station are recorded and shown in Table 2 for bare soil and Table 3 for Enka Products. The graphs 1 and 2 which correspond to these tables are illustrated . These tables and graphs that are prepared and drawn by Microsoft Excel program. It can be deduced from the tables and graphs the trend for erosion depths is not in the direction of declining or uprising. For Enka product , the tend line has a smoothly shaped slope . This is due to stable soil under the erosion mat which has no or might have slight movement along the channel. However, The graph and tables for bare soil highlighting the severe erosion and soil movement. The trend line through the erosion depth points is random and has no special pattern. This may be due to the fact that the soil from the beginning of channel is transported by water along the channel during the test and deposited farther along the channel bed . According to Table 1, the velocities in run 5 are almost double. The bare soil cannot tolerate and yields to bed shear stress caused by high velocity water current. We could not test run 5 for bare soil. Because high velocity water could wash the whole soil and destruct the channel bed as well. If we prolonged run 4 test for bare soil, most of the bed soil would wash away and come up with severe bed erosion. On the contrary, the Enka product could reasonably tolerate water stress especially for high water velocities as in run 5 and stabilize the channel bed soil against erosion.

Conclusion and Recommendation

Erosion Blanket test of Enka products were conducted in the 2.4m wide channel at Utah Water Laboratory. The test results which compare the erosion depths of bare soil and Enka erosion mat confirm the efficiency, good quality and performance of the products. The construction fabrics could reasonably stabilize the bed soil and protect channel against erosive forces even in run 5 which was conducted with high velocity current. One can infer from the graphs and tables that could not be drawn when dealing with bare soil erosion test particular trend a for erosion depths points. There is no ascending or descending orders in the tendency lines which drawn thru the points. However, the trend line through erosion depths for Enka fabrics erosion test has the smooth slope. The tendency line through erosion depths for bare soil test illustrates no particular pattern and almost randomly shaped. This can interpreted as the movement of the soil by water along the channel and its deposition farther in the course of the channel . Furthermore, the resistance of the bare soil against low velocity water is noticeable. The bare soil can reasonably tolerate low velocity current.

It should be noted that bed shear stress computation is highly recommended and essential for future study when dealing with erosion blanket tests in the flume.

The installation recommendations are intended as general guidelines for installing Enka fabrics as an integral part of erosion protection systems. Site conditions may warrant the use of different and /or additional installation procedures.

1- Prepare the slope by grading it as smooth as possible. Inspect the prepared slope for loose or unstable soil; replace such soils where needed.

2- Unroll the Erosion control fabric directly onto the prepared slope. Unroll the fabric perpendicular to the primary erosive force is generally preferred. Experience dictates that fabric sections should be overlapped in the direction of anticipated water flow. A minimum overlap width of 60 cm is suggested. Overlaps may be eliminated if all fabric sections are either factory or field sewn. If large armor is used without a bedding material, a greater overlap width may be required to prevent lap separation caused by moving water.

3- pins or nails may be required during windy periods to prevent the fabric sections from floating.

4- Mirafi fabrics should be toed- in at the top of the slope. Additionally, it should be toe-wrapped or toed-in at the slope bottom. Backfill soil used to fill the toe-in trenches should be no more permeable than the soil removed from the trenches.

5- Fabric rolls are less likely to move by water or current forces if a heavy solid bar is inserted through a hem in the fabric end. The hem may be prepared by fabric sewing or by factory sewing at Mirafi Inc. prior to placement.

It should be noted that the type of erosion protection system selected varies with the application, source and magnitude of erosive forces, and economics. For any given application, current or run-off velocities, wave impact forces, and ice forces (if appropriate) determine the size armor required for effective erosion control. In turn, the type of armor protection, slope angle, protected soil characteristics as well as filtration requirements dictate the specific type of erosion control fabric that is required for an effective erosion protection systems.

Table 1- Velocity measurements along the channel

Run 1 (.5 hr)		Run 2 (.5 hr)		Run 3 (.5 hr)		Run 4 (.5 hr)		Run 5 (48 hr)	
Station (m.)	Velocity (m/s)	Station (m .)	Velocity (m/s)	Station (m.)	Velocity (m/s)	Station (m.)	Velocity (m/s)	Station (m.)	Velocity (m/s)
0.0	1.35	0.0	3.14	0.0	3.35	0.0	4.90	0.0	3.43
0.15	1.22	5.0	2.70	5.0	3.08	5.0	5.03	5.0	3.78
0..3		10.0		10.0		10.0		10.0	
0.45	1.31	15.0	1.97	15.0	2.20	15.0	4.33	15.0	1.80
0.60		20.0		20.0		20.0		20.0	
0.75		25.0		25.0		25.0		25.0	
0.90	1.40	30.0	1.68	30.0	1.80	30.0	3.18	30.0	2.10
1.05		35.0		35.0		35.0		35.0	
1.20		40.0		40.0		40.0		40.0	
1.35	1.62	45.0	1.89	45.0	1.73	45.0	2.60	45.0	2.77
1.50		50.0		50.0		50.0			

Table 2- Erosion depth measurements for Bare Soil

Station	Run 1	Run 2	Run 3	Run 4
0.0	-3.69	-13.60	-21.99	-25.80
1.5	-3.69	-12.99	-21.00	-25.50
3.0	-3.06	-13.56	-18.69	-24.60
4.5	-3.00	-9.12	-12.12	-22.80
6.0	-2.61	-6.30	-9.36	-10.20
7.5	-1.59	-8.82	-6.31	-10.80
9.0	-0.66	-12.27	-10.23	-18.00
10.5	-1.41	-11.40	-11.94	-17.10
12.0	-0.75	-11.70	-6.00	-10.50
13.5	-1.11	-12.30	-3.00	-9.72
15.0	-1.11	-12.63	-7.50	-17.40

Table 3- Erosion Depth measurements for Enka Fabrics

station	Run 1	Run 2	Run 3	Run 4	Run 5
0.0	-0.900	-1.200	-2.400	-3.000	-7.800
1.5	-0.900	-1.500	-2.400	-3.300	-8.193
3.0	-1.800	-1.800	-2.100	-3.900	-8.070
4.5	-2.400	-2.100	-1.800	-2.550	-8.040
6.0	-1.200	-0.600	-1.500	-3.000	-7.950
7.5	-0.600	-0.600	-1.200	-2.100	-7.500
9.0	-1.200	-0.900	-1.650	-1.500	-7.200
10.5	0.300	0.000	-1.200	-1.200	-6.900
12.0	0.000	0.000	-0.600	-1.800	-7.500
13.5	-0.600	-0.600	-1.200	-2.400	-6.600
15.0	-0.600	-0.600	-1.200	-2.400	-6.600

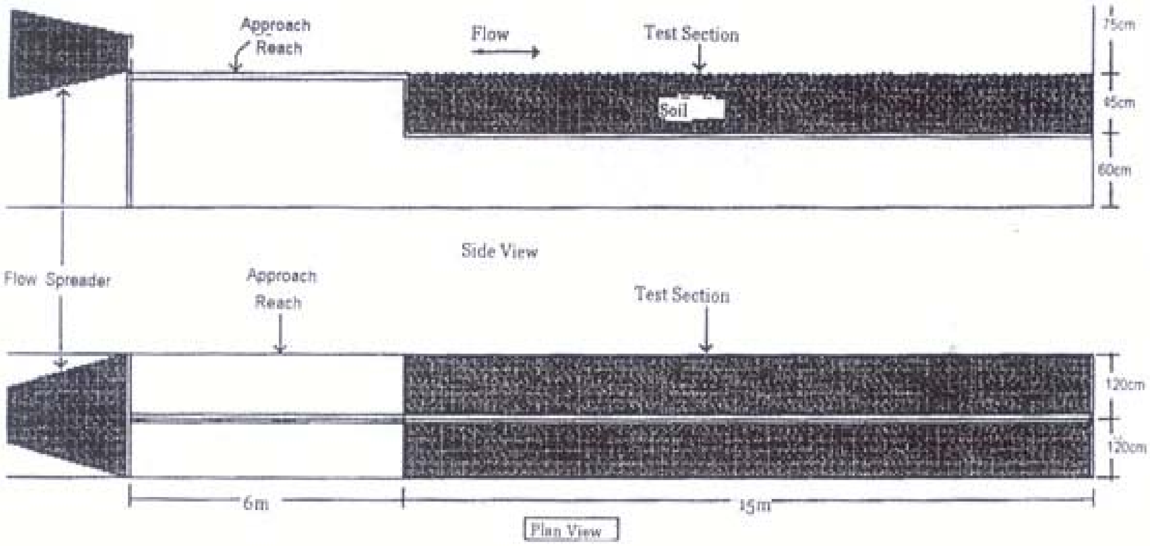

Figure-1 -Sketch of flume and test channels

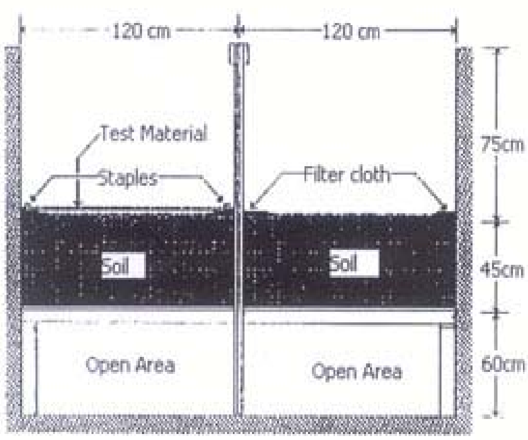

Figure 2-Flume cross section showing anchoring of materials and side curtains

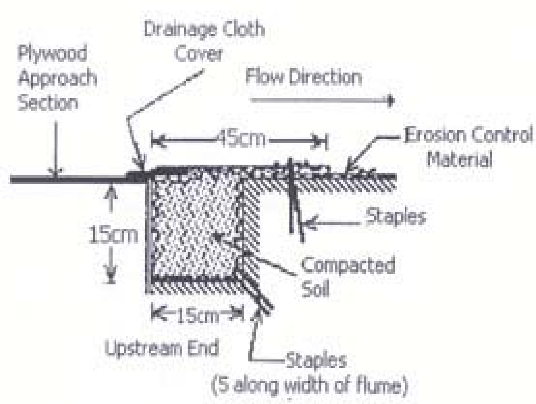

Figure 3- Head trench for anchoring test materials

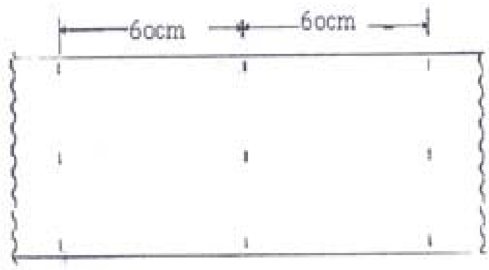

Figure 4- Staple pattern for 3 layers of materials

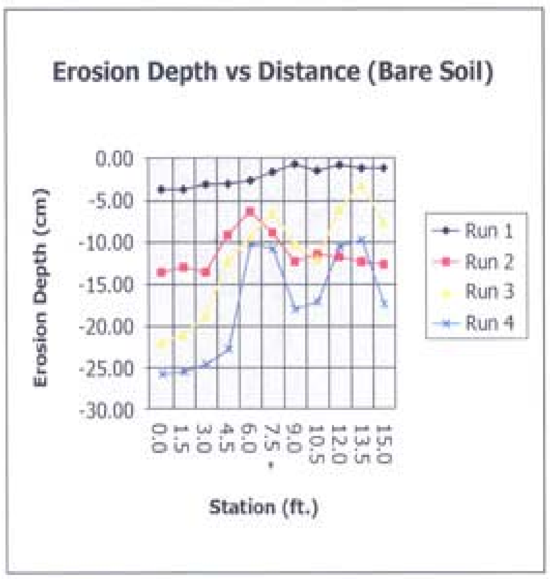

Figure5- Erosion depth versus distance for bare soil

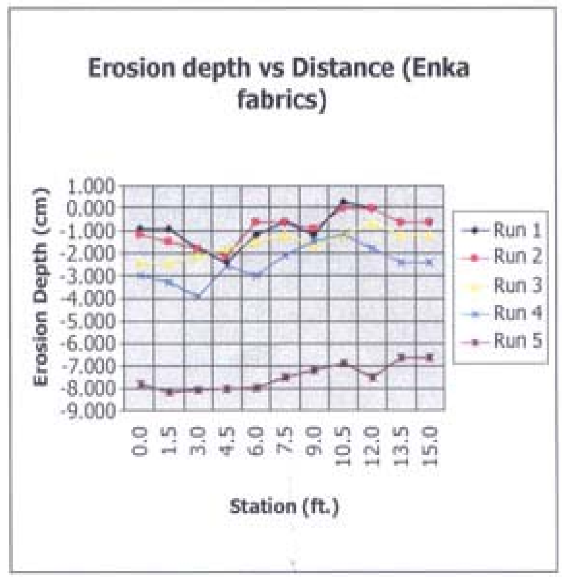

Figure 6- Erosion depths versus distance for Enka Fabrics

References

Design of Roadside Channel with Flexible Linings, FHWA-IP-87-7 (HEC-15), (1987)

Federal Highway Administration ,1985- Geotextile Engineering Manual, March 1985, 917 pp.

Giroud, J.P. ,1985- Geotextile and Geomembranes , Definitions , Properties and Design, third edition, Industrial Federal Association International, St.Paul, Minnesota.

Hydraulic Manual-Volume 2-Erosion and Sediment Control Manual, Oregon Department of Transportation, December,(1999).

Koemer,R.M. & Soong, T.Y.,1997- The Evolution of Geosynthetics , Civil Engineering , ASCE, 67(7), 62-64.

Van Santvoort, G.P.T.M., ed. ,1995- Geosynthetics in Civil Engineering, A.A. Balkema, Rotterdam.

Transportation Research Board ,1980- Erosion Control During Construction-Manual on Principles and Practices, National Cooperative Highway Research Program Report 221.

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