Evaluation of geomat physical properties after 6 years submitted to the real field conditions in the of Arroio Passo da Mangueira channel.

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ABSTRACT
The channel works was constructed as a superficial revetment and protection of the Arroio Passo da Mangueira banks. The channel solution was used in the lower part (1/3 of the height), and the base of the bank was used gabion mattress with concrete. For the rest of the bank it was adopted an application of geomats for control erosion, with grassy vegetation grouped with other vegetations of 50mm until 150mm of height. After six years of the application, were made tests with the material to verify the degradation of the phisycal properties of the geomat submitted to the reals conditions. In this case, was noted a small physical degradation of the geomat, and the bank presents a excellent natural coverage.

1. INTRODUCTION

The erosion surface process can occur in both urban and rural areas and has often and severely affected several regions of the country. Although it is a natural process, erosion can be accelerated by anthropic action, resulting in dangerous consequences for the environment, such as loss of agricultural areas, degradation and water contamination, destruction of infrastructure works (roads, streets, channels, among others).

For erosion control, simple and flexible techniques can be employed, such as simple planting of vegetation, or more complex solutions, such as rigid concrete structures. The application of geosynthetics can be present in the entire range of solutions, but to adjust the technique to local conditions and to the agents that trigger erosive processes are necessary (slope, soil type, rainfall, use and occupation of the soil, etc).

In this case, two solutions were applied to the same work, in order to guarantee the geotechnical stability of the channel banks and to stabilize hydraulically the wet perimeter of the section, because of the shear stresses from the flow, a Reno® mattress was made lower third (1/3) of the channel where there would be constant water due the natural water flow regime. In the upper two thirds (2/3), where the presence of water would be sporadic and only in periods of floods, Macmat 16.1 geomantas were performed with grass planting (Figure 1).

The Arroi Passo da Mangueira channel was originated from an agreement between the City Hall of Porto Alegre city and the WMS Supermercados do Brasil Company, the latter would be responsible for doing some improvements to the surroundings of its establishment, located at Avenida Sertório, 6600, Sarandi neighborhood, Porto Alegre - RS. For this purpose, the company Pedraccon - Mineração e Paveamento had been contracted to do the work, specifically for the segment in question, the company EAT - Engenharia e Consultoria Ltda was contracted to develope the Arroio Passo da Mangueira channel design.

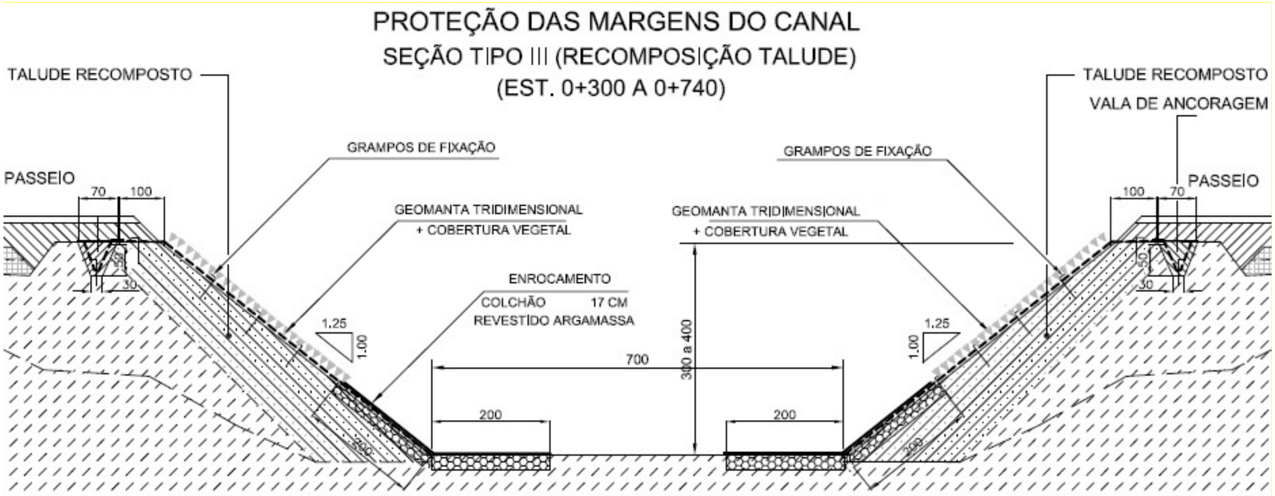

Figure 1. Transversal secction of the project - EAT – Engenharia e Consultoria Ltda

2. GEOSYNTHETICS FOR EROSION CONTROL

Among the simple and flexible erosion control techniques are the surface protection barriers. When installed on cut or embankment slopes, they tend to guarantee the integrity of the area by protecting against the dynamics of the erosion process, which often occurs through the detachment of soil particles through raindrops or the shear stress.

The surface protection barriers can be produced with temporary materials (TERMs - Temporay Erosion and Revegation Materials), for example straw and coconut fibers, jute, etc., and / or with woods known as permanent (PERMs - Permanent Erosion and Revegation Materials). In the latter case, geomantas are included, which are the object of this study.

The simple purpose of the TERMs type surface protection barriers is to provide adequate conditions for the reconstitution of vegetation, retaining soil humidity, acting as a source of organic matter and temporary surface protection of the land, since they are degradable. After its degradation of TERMS, the vegetation developed in the area will be responsible for surface protection (Theisen, 1992, apoud Verdematti, 2015).

In the case of simple protection barriers of the PERMs type, in addition to providing surface protection against erosion processes permanently, the geomants, as they have elements in relief, present better performance (stability) on the installation surface, adhering to the retention capacity of the topsoil, even in conditions of runoff on the surface, and greater solidarity with the raticular system of vegetation, as its development proceeds (Theisen, 1992, apoud Verdematti, 2015).

2.1 Relevant properties

For geosynthetics to perform the erosion control function, they must basically attend the following requirements:

- Retain fines from the underlying soil or transported erodible materials;
- Resist the flow velocities and shear stresses caused by surface water flow.

In order to guarantee the continuity of the mentioned performance it is important to check the mechanical and hydraulic properties of the proposed surface protection. Geomats over 10 mm thick, associated with rich vegetation, can support velocities until 4.0 m / s in a maximum time of 20 hours (Theisen, 1992, apoud Verdematti, 2015).

Other physical characteristics that can be evaluated in the geomat is its tensile strength. In addition to its own weight, the cover soil layer generates tensile efforts on the geomat, but the system must be competent to the point that it does not allow the geomat to rupture, compromising the continuity of the surface protection allowing an erosive process. The minimum characteristics that the material must meet in production are shown in table 1.

Table 1. Minimum properties of the geomat

Property	Value	Unit
Grammage	500	g/m²
Thickness	16	mm
Tensile strength – wide band – (Longitudinal)	3,39	kN/m
Medium Elongation (Longitudinal)	81,38	%
Tensile strength – wide band – (Transversal)	0,73	kN/m
Medium Elongation (Transversal)	48,40	%

3. WORK CHARACTERIZATION

Along the stretch, for the intervention, it was possible to observe that the local soil was heterogeneous and composed, in general, of a layer of sandy-silty embankment and a layer of sandy clay (figure 2). The clay layer showed dissection cracks and localized instability. the embankment slope suffered an erosive process at its base, which could start a global rupture.

Figure 2. Current situation of the Passo da Mangueira initial stretch of the on Rua Dona Alzira, Porto Alegre.

3.1 Analysis of geotechnical stability

The geotechnical stability verification of the slopes was made in order to evaluate if the channel solution with trapezoidal section would be technically feasible. Soil parameters were adopted through a correlation performed with percussion drilling tests performed “in loco”.

The safety factor adopted for the section subjected to raised water table was 1.3 and 1.5 for the lowered water table. The modeling of the channel section was carried out in the SLIDE 6 - Rocscience Geotechnical Engineering Software (Figure 3), where the safety factors found exceed the established limits.

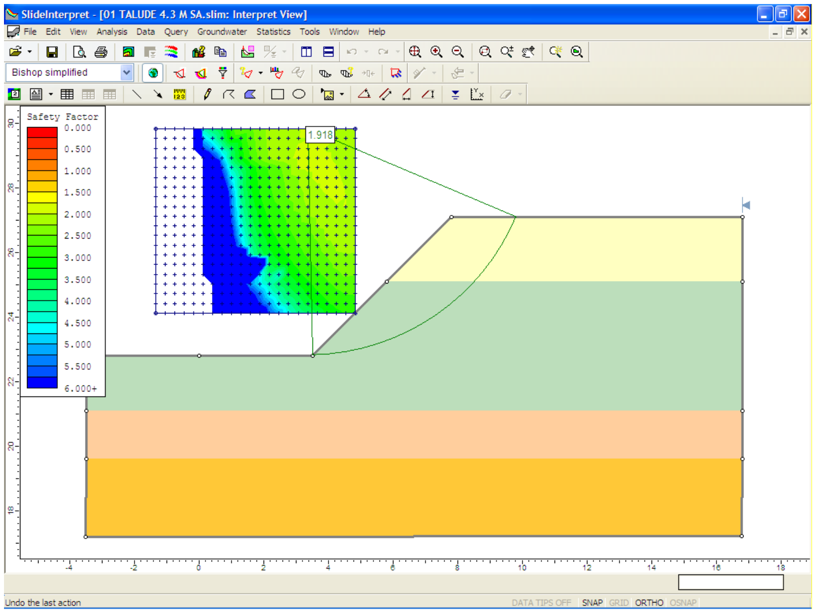

Figure 3. Stable slope - SF =1,918 (without water action)

3.2 Revetment determination

Based on the hypothesis that the trapezoidal channel slope was geotechnically stable, it was necessary to do the hydraulic checks.

With the hydraulic verification of the channel, a trapezoidal section was determined, with 7 meters of base and slopes 1: 1.25, stabilized. The parameters for the design were obtained from the PDDrU- Master Plan for Urban Drainage, Passo das Pedras and Mangueira Basin, 2002, developed by IPH, for the Porto Alegre City Hall.

The criteria for sizing and selecting the most suitable solution generally consider the velocity and shear stress parameters. For such checks, the input data in Table 2 were considered.

Table 2. Input data

Parameter	Value	Unit
Longitudinal channel slope	0,0014	m/m
Banks slope	1:1,25	(V:H)
Flow to TR=25 anos	39,00	m³/s
Maximum flow	76,50	m³/s
Velocity	2,38	m/s
Water depth	3,16	M
Natural soil Sandy clay. w / sand <50%	0,50	D50

An allowable velocity for the natural soil of 0.50 m/s was considered to avoid the soil sediment erosion, however with the estimated acting stream velocity of 2.38 m/s, it required a superficial protection against the action of the flow. At the bottom (1/3 of the channel height) and base of the embankment, mattress-type gabions with a mortar face were used, a solution that would protect part of the bed against the flow shear stresses and would also facilitate the maintenance of the channel. For the remainder of the slope (upper 2/3), the application of a geomat for erosion control was adopted, with subsequent application of rich vegetation of the grass type of pivoting root intercropped with legumes between 50 mm and 150 mm high.

3.3 Geomat application

For the geomat execution the first step was to clean the slope by removing trunks, boulders or any obstacle that could obstruct the coils of the geosynthetic, making it uniform and regularizing it. This cleaning was performed with the aid of heavy equipment and with subsequent manual thinning. In Figure 6, it is possible to verify the regularized slope and the beginning of the execution of the coating in mattress-type gabions at the base of the channel gutter.

Figure 4. Regularized slope

Prior to the installation of the geomat, a channel was spaced at least 1.0m from the top of the slope, with the main function of anchoring the geomat on the slope in addition to being also responsible for the upper drainage (Figure 5).

The channel was executed before the development of the geomat over the slope, with a height and depth of 0.30m, and with the same longitudinal extension of the section to be protected. The upper end of the geomat was placed inside the channel and fixed with clamps. After the first fixation of the geosynthetic, the channel was filled with the soil that was removed from it and compacted manually.

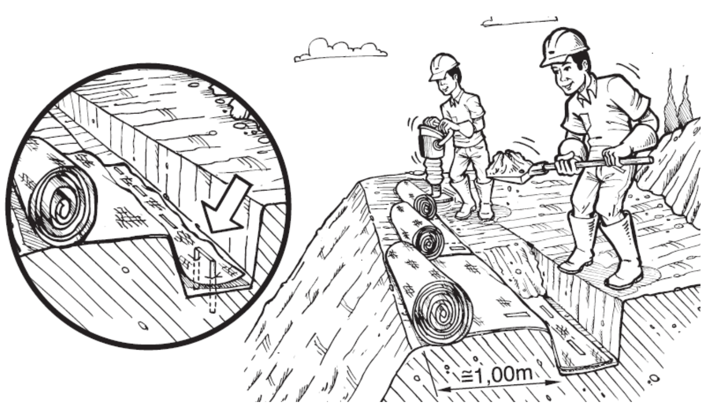

Figure 5. Anchoring trench

Once anchored, the geomat is unrolled from top to bottom and with 30 cm overlaps at the ends of the rollers (Figure 6).

Figure 6. Geomat application

To keep the geomanta in direct contact with the slope, anchoring clamps were applied along the bank at a rate of 3.25 clamps/m², spaced according to Figure 7.

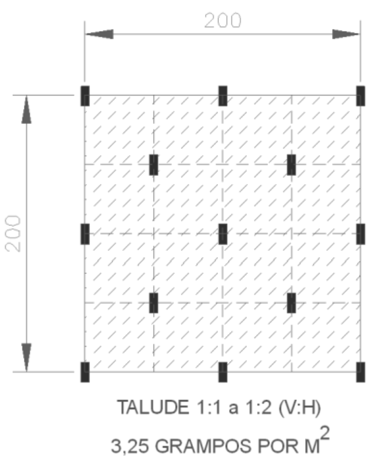

Figure 7. Fixing clamp density

The fixing clamps ensured a better uniformity and contact of the geosynthetic with the slope. By this criterion, it is assessed that even though the slope is free of irregularities, a visual inspection was carried out on the site after the application of the geomat over the slope, checking the need for additional clamping of points in the points that did not present an adequate fixation. Figure 8 shows the type of clamp to be applied to each section.

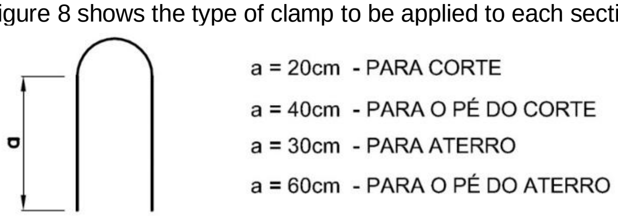

Figure 8. Clamp type

For the vegetation correct development on the geomat it is necessary to do a seeding on the material. In this case, it was opted for hydro-sowing, through the blasting of the seeds in the dosage, fertilization and correct hydration, thus dispensing the cover soil on the geomat. This procedure was adopted because it is faster than the traditional sowing process, and its application is more indicated in large areas to be sown.

The work started on April 5, 2013 and ended on October 9 of the same year. In total, only 23 days worked for the installation of the geomat were considered, representing an average productivity of 310.00 m²/day for a team of five men, that is, 62.00 m²/man/day.

Figure 9. View of the work completed in August / 2014.

4. GEOMANTA TESTS AFTER 6 YEARS

One of the most frequent questions related to geomat is related to its durability on site. The geomat being a solution classified as permanent (Brazilian Geosynthetics Manual, 2015), must have characteristics that guarantee the integrity of the surface protection system throughout the life of the work, unlike the temporary solutions that after the initial period of the work, already to degrade leaving in this way the responsibility of superficial protection only with the vegetation that has developed in this period.

The geomat (PERMs) exposed to ultraviolet rays, can generate a dryness of the polymer making the material brittle. Added to this degradation factor to the traction demand generated by the weight itself and the cover soil layer, they can favor the rupture of the geomat during the life of the work. Thus, it is important to evaluate the integrity of the geomat exposed in real field conditions, because in a case of early degradation the geomat would no longer adhere to the capacity of retaining topsoil in runoff of water on the surface, and would not contribute to solidarity with the raticular vegetation system.

In order to check the completeness of the geomat, a sample was removed of approximately 1m² of the material present in the upper margins of the Passo da Mangueira stream. This sample was tested on the following items:

- Grammage;
- Thickness;
- Wide band traction resistance (Longitudinal - coil development);
- Medium elongation (Longitudinal - coil development);
- Wide band traction resistance (transversal to the coil);
- Medium elongation (transversal to the coil).

Table 3 shows the material specification values, used with production reference and the values obtained in the test made in 2019, that is, 6 years after the work carried out where the geomat was exposed and real field conditions. The weight of the specification has a value of 500 g / m² (minimum) while the weight obtained by the sample taken from the work has a value of 600 g / m². The thickness of the geomat remained basically stable, with the specification value being 16mm, while the value obtained in the 2019 test is approximately 16.46mm.

The longitudinal tensile strength varied from 3.39kN/m (production reference), against the 2019 test result of 1.93kN/m, that is, there was a reduction of approximately 43% in the longitudinal tensile strength. The mean longitudinal elongation also showed a loss of approximately 9%, since the specification value was 81.38% and the value obtained in the test in 2019 was 74%. The result found in the transversal direction of the geomanta showed a small loss in terms of tensile strength, less than 5%. Regarding stretching, there was an increase from 48.2% to 62%.

Table 3. Comparison of the initial values of the geomanta and the values obtained in the 2019 trial.

Property	Min.Value	Value test 2019	Unit
Grammage	500	600	g/m²
Thickness	16	16,46	mm
Wide band (longitudinal) tensile strength	3,39	1,93	kN/m
Medium Elongation (Longitudinal)	81,38	74	%
Wide band (transverse) tensile strength	0,73	0,69	kN/m
Medium elongation (transversal)	48,40	62	%

The reduction in tensile strength and elongation results were expected due to the exposure of the material to weathering, especially to UV rays. It should also be noted that the longitudinal tensile strength as well as the elongation in this sense, were the properties evaluated that suffered the greatest reduction. It is believed that this reduction was due to the fact that it is the same direction in which the geomat is subjected to traction efforts due to the material's own weight and the soil cover applied over it. This state of tension associated with exposure to UV's is possibly conditioning the degradation of the material.

The speed of the geosynthetics degradation process exposed to real field conditions is difficult to predict, since they depend on the solar incidence over the material throughout its service life. In addition to understanding this phenomenon, it is necessary to associate geomat exposure to the surface with this scenario, since it may be less or more exposed, depending on the soil and / or vegetation cover that is over it during the service period.

5. CONCLUSION

In view of the work developed that presents an application of geomat as a superficial coating of the upper bank of Arroio Passo da Mangueira, and subsequent laboratory testing of the sample of geomat taken from the work itself, 6 years after its respective application, it can be concluded that the applied material presented results superior to the reference ones, like for example, thickness, weight, transversal elongation. On the other hand, although expected, it presented results below those of reference regarding strength and longitudinal elongation. Finally, it should be noted that the solution has met the expectations of the work so far, since the vegetation on the bank has been successfully developed, as well as the applied geomat does not show any breaks along its development on the slope.

6. BIBLIOGRAPHIC REFERENCE

Prado, J. A., Donassollo, A. e Costa Jr., J. R. C. (2015). *Canalização do Arroio Passo da Mangueira com Geomanta*. IX Congresso Brasileiro de Geotecnia Ambiental e VIII Congresso Brasileiro de Geossintéticos – REGEO 2015. Brasília, DF, BR, 1.

MACCAFERRI DO BRASIL. (2009). *Revestimentos de Canais e Cursos de Água*. Jundiaí, SP, BR.

MACCAFERRI DO BRASIL. (2010) *Comics de instalação*. Jundiaí, SP, BR.

Vertematti, J. C., et al. (2015). *Manual Brasileiro de Geossintéticos*. 2 ed. Blucher. São Paulo, SP, BR.