Reuse of ribbon archs as reinforcement element in retaining walls with face made by concrete blocks

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ABSTRACT: This papper shows a retaining wall construction with face made of concrete blocks without grouting utilization, and stability analysis. It reused polyester ribbon as reinforcement element in soil for minimize building cost of this kind of building and decrease environmental impact, the reuse of polyester ribbon reduces waste production of difficult decomposition. A prototype was built in order to prove that is possible and practicable the building of this type of structure and the execution was based in parameters applied in soil reinforcement program. The prototype was built with a factor of safety of 2, for agree to the stability for execution of permanent buildings, and was applied overload on the structure made of soil, verified the expected good behavior of the retaining wall, supporting an overload of 24 kN. Besides, tensile strenght tests on the ribbon used in the building allowed compare the value adopted as real resistence value reached by the ribbon tested and them these data comproved the experiment efficiency.

Keywords: Retaining wall, geosynthetics, support, arching tape, polypropylene, reinforced soil.

1 INTRODUCTION

The increasing need to use urban spaces in regions with the necessary gradients increases every day. Such constructions are often carried out through traditional knowledge such as reinforced concrete, cyclic concrete, masonry, gabions, wire mesh, among others. The use of geosynthetics (geogrids and geotextiles) as a soil reinforcement element in containment structures through reinforced landfills increases geotechnical engineering with techniques to solve such problems.

As a process of industrialization and improvement of the quality of life, the plastic bring all the inherent benefits of the product: lightness, strength and durability; if discarded incorrectly, causes disruption to the environment. In order to give the final destination more adequate, invoking the main characteristics of plastics, strength and durability, the use of arcing ribbons as reinforcement element in retaining walls was evaluated.

2 METHODOLOGY

The idea for the development of this work originated from the observation of a considerable number of arching tapes that are dumped into the environment. These tapes have high strength and can be found easily in construction sites, transportation company areas or even in industrial areas, as they are used to "tie" or wrap boxes, concrete blocks, among other uses. They can be found in several colors (Figure 1), widths and strengths, which provides in relation to the latter, several possibilities of applications of this material as a reinforcing element in the soil. In addition, they can be of the smooth or rough type (Figure 2), providing greater interaction with the soil.

Figure 1. Tapes in various colors and widths.

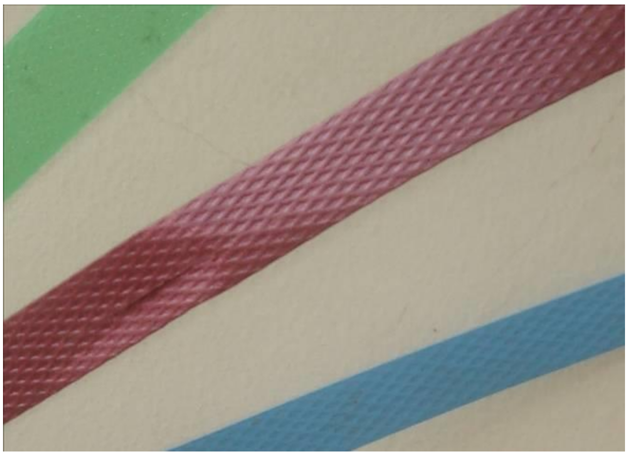

Figure 2. Detail of the arching tape rugged.

The need to develop methods to reduce environmental impact was also an important ally to improve the idea of building a retaining wall reusing archery ribbons, as well as promoting the "recycling" of this material of difficult decomposition in the environment, still promotes the realization of a containment structure with application in several places, making more accessible to the population of low income due to the decrease of the cost with the material.

Figures 3 and 4 show arch discs discarded on construction sites and road margins.

The use of the face of the wall in concrete blocks was another solution adopted for the analysis of reducing the cost of retaining walls works.

The application of overload at the top of the wall aimed to induce and evaluate the movement of the wall, thus allowing to measure the deformation.

Figure 3. Discarded tapes in the works of Águas Claras, Federal District (DF).

Figure 4. Discarded tapes on the banks of the National Park of Brasília / DF.

3 CHACARATERIZATION OF AREA AND UTILIZED MATERIALS

3.1 *Arching tapes*

A sample of the arcing tape used in the execution of the experiment was sent to Maccaferri do Brasil, a unit in Camaçari, Bahia, to perform tensile strength (kN) and strain (%) tests. Figures 5 and 6 show some moments of performing this test.

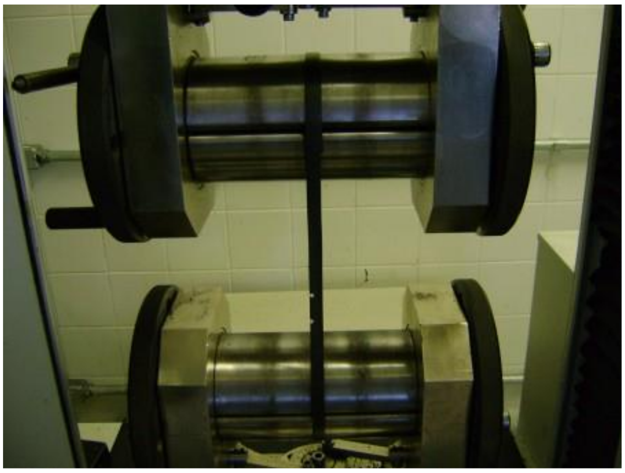

Figure 5. Execution of the tensile test on the arching ribbons.

Figure 6. View of the broken tape in the tensile test.

The tapes used in the test were considered to be high strength and were only 13 mm wide.

The sample was collected according to the procedures of NBR 12593, with monitoring done by Maccaferri quality department and certified by competent parts.

The tensile tests were carried out on 6 samples of the arching ribbons. After the test, the data obtained according to Tables 1 and 2 were presented.

For the data entry in the equipment, the original values of the width and thickness of the samples were used. Thus, at the end of the test, the equipment provides the values of the maximum strength, tensile strength, strain obtained, tensile strength at 2; 5; 10 and 12%.

Table 1. Results of the tensile tests.

Samples	Maximum breaking strength (kN)	Maximum tensile stress (kN/m)	Stretching at max. force (%)
1	0,9	71,07	25,53
2	0,91	72,6	25,13
3	0,9	71,8	26,13
4	0,89	70,62	23,8
5	0,92	72,67	25,38
6	0,84	66,78	18,34
Average	0,89	70,92	24,05
Standard Deviation	0,03	2,19	2,9
Coefficient of variation	3,14	3,08	12,07

Table 2. Results of the tensile tests.

Samples	Tensile strength			
	2%	5%	10%	12%
1	16,48	31,46	50,24	56,06
2	16,22	31,56	50,96	57,29
3	15,72	30,91	50,07	55,9
4	16,18	32,03	51,78	57,27
5	16,92	33,27	52,93	59,07
6	16,29	31,29	50,57	56,13
Average	16,3	31,75	51,09	56,95
Standard Deviation	0,39	0,83	1,09	1,21
Coefficient of variation	2,41	2,61	2,13	2,12

3.2 *Description of the study site*

The site used for the construction of the reinforced wall was in a work in Águas Claras / DF, located near Avenida Araucárias (Figures 7 and 8).

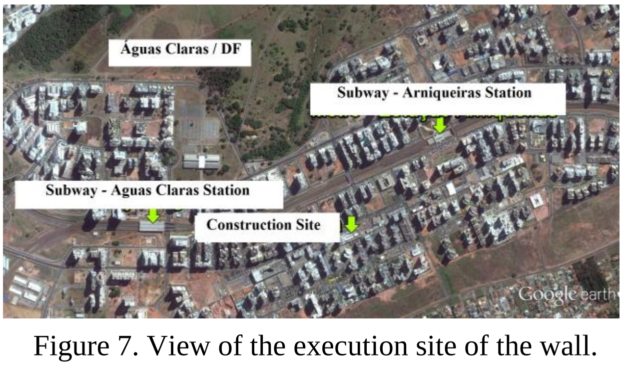

Figure 7. View of the execution site of the wall.

Figure 8. View of the execution site of the wall.

The wall was built next to the drilling hole SP9 indicated in figure 9, and the soil found from the fourth meter of the drilling hole (Table 3) was a moist purple silt and, from that point was the execution of the wall containment.

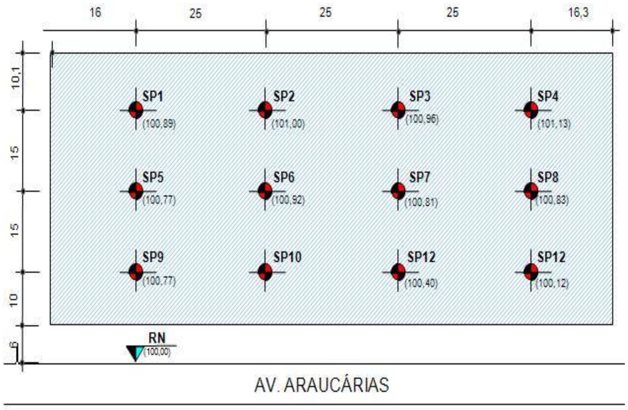

Figure 9. Drilling hole location plan.

Table 3. Summary of the SPT 09.

SPT Nº 09		
Survey summary		
Depth (m)	N/30	Soil Description
1	7	Clay silt
2	7	Clay silt
3	11	Clay silt
4	12	Purple silt moist
5	32	Purple silt moist
6	39	Purple silt moist
7	40	Purple silt submerged
8	55/11	Purple silt submerged

4 CONSTRUCTION OF THE RETAINING WALL WITH USE OF ARCING TAPES, AS A REINFORCEMENT AND FACE ELEMENT IN CONCRETE BLOCKS

4.1 *Retaining wall dimensioning*

After previous analyzes and reinforced wall dimentioning (Table 4 and figure10), using the reinforced slope geogrid sizing program (Abramento, 1998) using local soil resistance parameters (estimated based on SPT soil survey report) and of the resistance data of the arching tape, the section to be executed was defined (Figure 12).

Table 4. Dimensioning of the reinforced wall.

Pre-dimensioning of retaining walls and slopes					
Geometry and load					
H	2,2 m	β	90 º	q	0 kPa
Soil parameters		Natural soil		Foundation soil	
C1	0 kPa	C2	40 kPa	Cf	5 kPa
γ1	18 kN/m³	γ2	20 kN/m³	γf	18 kN/m³
φ1	20 º	φ2	39 º	φf	20 º
Friction angle					
Landfill - reinforcement		17 º	Foundation - reinforcement		18 º
Safety Factors			Reduction Factor		
FSφ Landfill	1	FS anchorage	1	Reinforcement	4

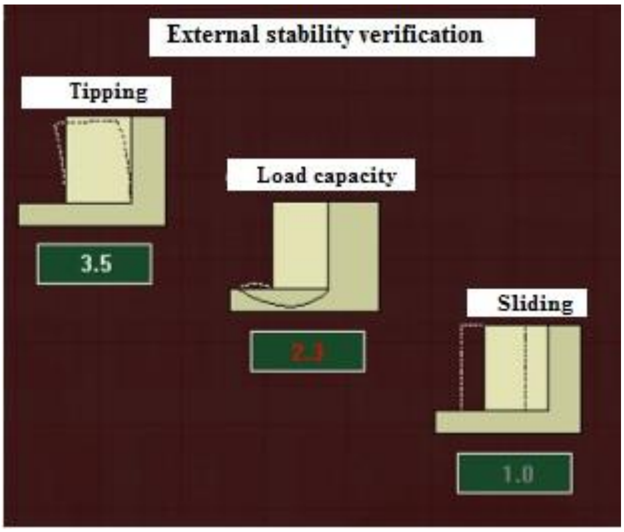

Figura 10. Prior stability verification.

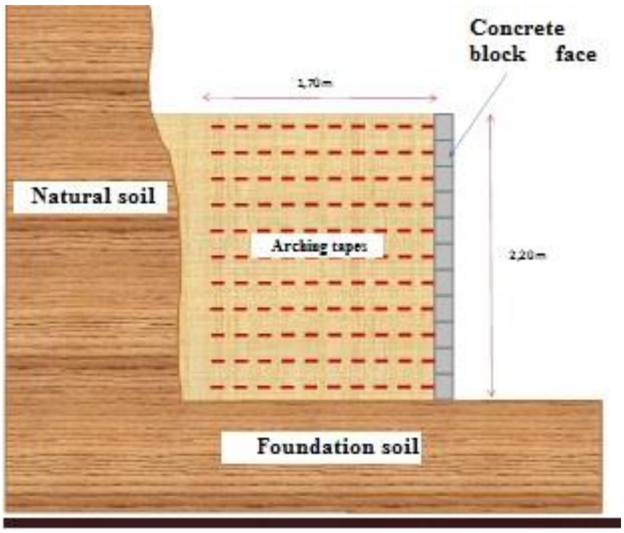

Figure 11. Reinforced wall section with arching tape

4.2 *Reinforced wall execution*

The execution of the reinforced wall, started with remotion of the surplus soil, then the slope was lateralized that laterally side the wall on the inner side, right side (Figure 12), using manual equipment, type pick.

Figura 12. Remoção de terra e regularização da área utilizada para a construção do protótipo.

The area of 2.5 x 2.9 m, which served as the basis for the landfill and construction of the wall was compacted with mechanical equipment, type compactor frog. Then, a greased HDPE geomembrane was fixed in the contacts with the sides of the wall to be executed, in order to avoid lateral interactions with the adjacent soils (Figure 13).

After leveling the ground, the first row of concrete blocks was set, with the bottoms (bottom) broken, for proper fittings with PVC pipes, as fasteners of the arching tape. (Figures 5 to 16).

Figura 13. Aplicação de graxa na geomembrana de PEAD disposta verticalmente.

Figure 14. Realization of the first layer of the entrance wall with arching tape and facing of concrete blocks.

Figure 15. Fixing detail of PVC pipes, arcing tape and concrete block.

Figure 16. Views of the mooring of PVC pipes.

After the completion of this step, the landfill of the posterior layers was performed (Figures 17 to 19).

Figure 17. Application of the arching tapes in the second layer.

Figure 18. Realization of the third layer.

Figure 19. Finalization of the prototype.

4.3 *Application of overloading on the reinforced wall*

After the finalization of the retaining wall, and without major visual deformations in the interval of 1 (one) day, an overload of 1.50 meters of compacted soil is carried out on the finished containment structure (Figure 20).

Figure 20. A wooden structure, mounted on a retaining wall, to contain a soil load (overload).

5 RESULTS AND ANALYZES

5.1 *Face deformation measurements*

To measure the deformations, a wooden jig was mounted in front of the retaining wall (Figure 21), to enable measurements of the deformations in the wall.

Figure 21. View of the wooden jig mounted in front of the wall.

The measurements showed little variation during the execution of the wall, so that the vertical alignment underwent minor adjustments during the laying of the blocks. However, when the overload was applied, considerable deformations were observed. This is due to the fact that in the sizing this increase of load was not predicted.

Figure 22 shows the maximum deformations, measured on the face of the wall, at 0.0 m (at the foot of the wall), 0.80 m high, 1.60 m high and at the crest; after the execution of the overhead of 1,50 m of height of ground placed on the wall constructed with arching ribbons.

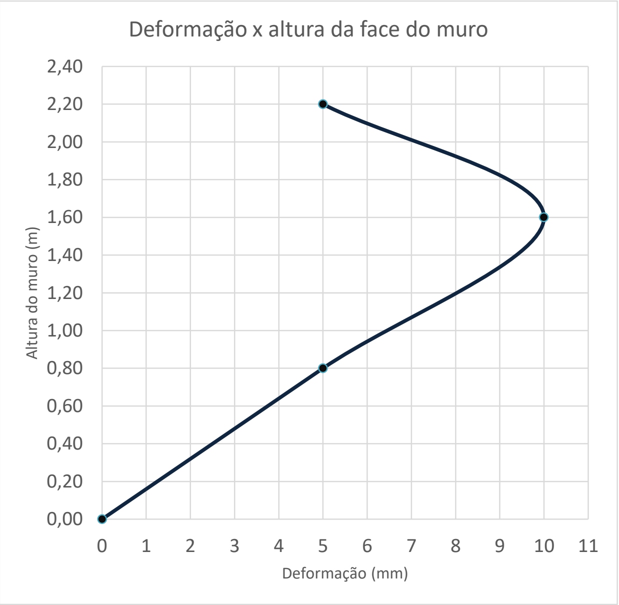

Figure 22. Measured deformation on the face of the wall.

6 CONCLUSIONS

This work aimed to present and analyze an alternative technique in the construction of a containment structure with the reuse of polyester tapes as a reinforcement element in order to minimize the execution cost, but also the environmental impact due to the production of garbage and of the difficult decomposition of this product when launched in nature. The studies carried out showed that:

• In general, the feasibility of using arcing ribbons as reinforcement element in retaining walls can be stated.

• Deformability measurements showed little variation during wall execution.

• The deformations measured on the face of the wall proved to be considerable when the overload was applied, due to the fact that this increase in load was not predicted in the design, showing that it is necessary to evaluate the safety factor when applying load on the crest of the containment system.

ACKNOWLEDGEMENTS

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