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Studying the shape of geotextile tube

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***Abstract*— Geotextile tubes are severally more and more used in maritime field as systems of beaches protection against coastal erosion. The predicting of their dimensions is very important, because these dimensions govern the stability against several site conditions of wave and current. There are many studies to calculate dimensions of geotextile tubes, but they require the running of a computer program and this limit their access to large public designers. The most popular is the approach presented by Leshchinsky et al. (1996) in the program GeoCoPS 2.0 In this paper, a new numerical approach was established to calculate dimensions of geotextile tubes regarding the degree of filling F_A (%). The results were presented in a computer program. The approach developed is based on same relationship used by Leshchinsky and other authors and iterations of all parameters. At the conclusion of this paper formulas, depending only on F_A (%), to calculate dimensions of filled geotextile tube are proposed.**

Keywords*— *Geotextile tubes, coastal erosion, degree of filling, predicting of dimensions, computer program

I. INTRODUCTION

When a geotextile tube is empty and lying flat on the ground surface, its width is equal to half its circumference. When it is fully filled (degree of filling 100%), it has a circular shape with a radius R100% = circumference/2.π). In practice, a degree of filling of between 60% and 85% can only be obtained [2].

The shape of geotextile tube is obtained where the underside of the cross-section is flat, the sides approximate quadrants of a circle and the upper side approximates a (half) ellipse [2].

With a certain degree of filling F_A (%), theses conventions and notations are considered:

B: width Contact with subsoil (m);

W: Total width of geotextile tube (m);

H: Height of geotextile tube (m);

r: Radius of quadrant circle (m);

a: Major axis of the half ellipse (m);

b: Minor axis of the half ellipse (m);

c: Focal length of the half ellipse (m);

L: Circumference of geotextile tube (m);

A: Area of geotextile tube (m²);

P_0: Initial pressure (pumping pressure) (Kpa);

F_A: Degree of filling regarding to the area (%);

F_H: Degree of filling regarding to the height (%);

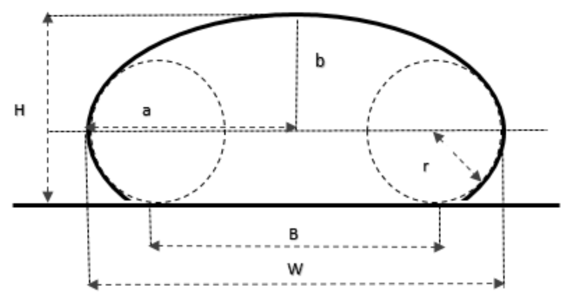

Fig. 1. Cross section view of geotextile tube: convention and notation

In literature, the degree of filling FA (%) is expressed as a percentage of the theoretical cross-sectional area of a 100% filled geotextile tube: $F_A = \frac{A}{A_{100\%}}$. However, in practice, the degree of filling is usually related to the theoretical height of the tube at 100% filling FH. Because it is more easy to measure the height than the area of the cross-sectional witch is impossible to measure during filling phase: $F_H = \frac{H}{H_{100\%}} = \frac{H}{2R_{100\%}}$

II. ASSUMPTIONS

The following assumptions are considered in the establishment of the program:

- The problem is tow-dimensional (i.e plane strain) in nature. The geotextile tube is long and all cross-sections are perpendicular to the long axis are identical in terms of geometry and materials. Hence, the pressure loss due to drainage through the geotextile tube during filling and possible material segregation is ignored.

- The geotextile shell in thin, flexible and has negligible weight per unit length;
- No shear stresses develop between the material filling and geotextile.

The geotextile tensile force T along the circumference of geotextile tube must be constant, since there is no shear stress between filling material and geotextile, and it is equal to that develop in the quadrants of circle: T=P.r

With P is the pressure in geotextile at the contact between the quadrant circle and the subsoil: $P=P_0+\gamma H$

The pressure along the base B in geotextile is constant and equal to P, the equilibrium of forces in the base B gives the following formula: $P\times B=\gamma\times A$.

III. METHODOLOGY AND PROGRAM ESTABLISHED

A computer program was established for the determination of the shape of geotextile tube. It is basing in the principle of iteration.

This program is based on degree of filling and the circumference as inputs and gives F_H ; a ; b ; r as intermediary results, and H ; B ; W ; T as final results.

According to [1], we have:

$$a = \frac{2H + B}{4} + \frac{B^2}{8H + 4B} \quad \textbf{(1)}$$

$$b = \frac{2H + B}{4} - \frac{B^2}{8H + 4B} \quad \textbf{(2)}$$

$$r = \frac{2H - B}{4} + \frac{B^2}{8H + 4B} \quad \textbf{(3)}$$

$$L = B + \pi r + \frac{\pi}{2}\sqrt{2(a^2 + b^2)} \quad \textbf{(4)}$$

$$A = \frac{\pi}{2}ab + Br + \frac{\pi}{2}r^2 \quad \textbf{(5)}$$

$$W = B + 2.r \quad \textbf{(6)}$$

The program is based on three major steps to follow, they are described below.

A. Step 1: initial values

a) Take the first approximation for F_{H0} as $F_{H0} = \frac{F_A}{1.5}$ and $B_0 = R_{100\%}$

b) Calculate : $H_0 = 2.R_{100\%}.F_{H0}$

c) Calculate r_0 ; a_0 ; b_0 ; A_0 and W_0 by equations above

B. Step 2: intermidiate values

a) For each i in the serie , we calculate L_i , r_i , a_i , b_i , H_i , A_i , B_i, $L_{i recalculated}$, F_{Ai}, $F_{Ai\ recalculated}$ and F_{Hi} as follow:

$$L_i = L$$

$$F_{Ai} = F_A$$

$$F_{Ai\ recalculated} = \frac{A_i}{A_{100\%}}$$

$$F_{Hi} = F_{Hi-1} + \frac{F_{Ai} - F_{Ai-1\ recalculated}}{100}$$

$$H_i = 2.R_{100\%}.F_{Hi}$$

$$B_i = B_{i-1}\left(1 + \frac{L_{i-1} - L_{i-1\ recalculated}}{L}\right)$$

$$L_{i\ recalculated} = B_i + \pi r_i + \frac{\pi}{2}\sqrt{2(a_i^2 + b_i^2)}$$

$$r_i = \frac{H_{i-1}^2}{2H_{i-1} + B_i} ;$$

$$a_i = \frac{2H_{i-1} + B_i}{4} + \frac{B_i^2}{8H_{i-1} + 4B_i} ;$$

$$b_i = \frac{2H_{i-1} + B_i}{4} - \frac{B_i^2}{8H_{i-1} + 4B_i} ;$$

$$A_i = \frac{\pi a_i b_i}{2} + B_i r_i + \pi\frac{r_i^2}{2} ;$$

b) We compare for each i :

- $F_{Ai\ recalculated}$ and F_{Ai} and F_{Ai-1}
- $L_{i\ recalculated}$ and L_i and L_{i-1}
- F_{Hi} and F_{Hi-1} ; B_i and B_{i-1} ; r_i and r_{i-1} ; a_i and a_{i-1} ; b_i and b_{i-1} ; A_i and A_{i-1} ; W_i and W_{i-1}

C. Last Step: difinitive results

We repeat the step 2 until we obtain theses equalities, with an error marge of 10^{-6})

- $F_{Ai\ recalculated} = F_{Ai} = F_{Ai-1} = F_A$
- $L_{i\ recalculated} = L_i = L_{i-1} = L$
- $F_{Hi} = F_{Hi-1}$; $H_i = H_{i-1}$; $B_i = B_{i-1}$; $r_i = r_{i-1}$; $a_i = a_{i-1}$; $b_i = b_{i-1}$; $A_i = A_{i-1}$ and $W_i = W_{i-1}$

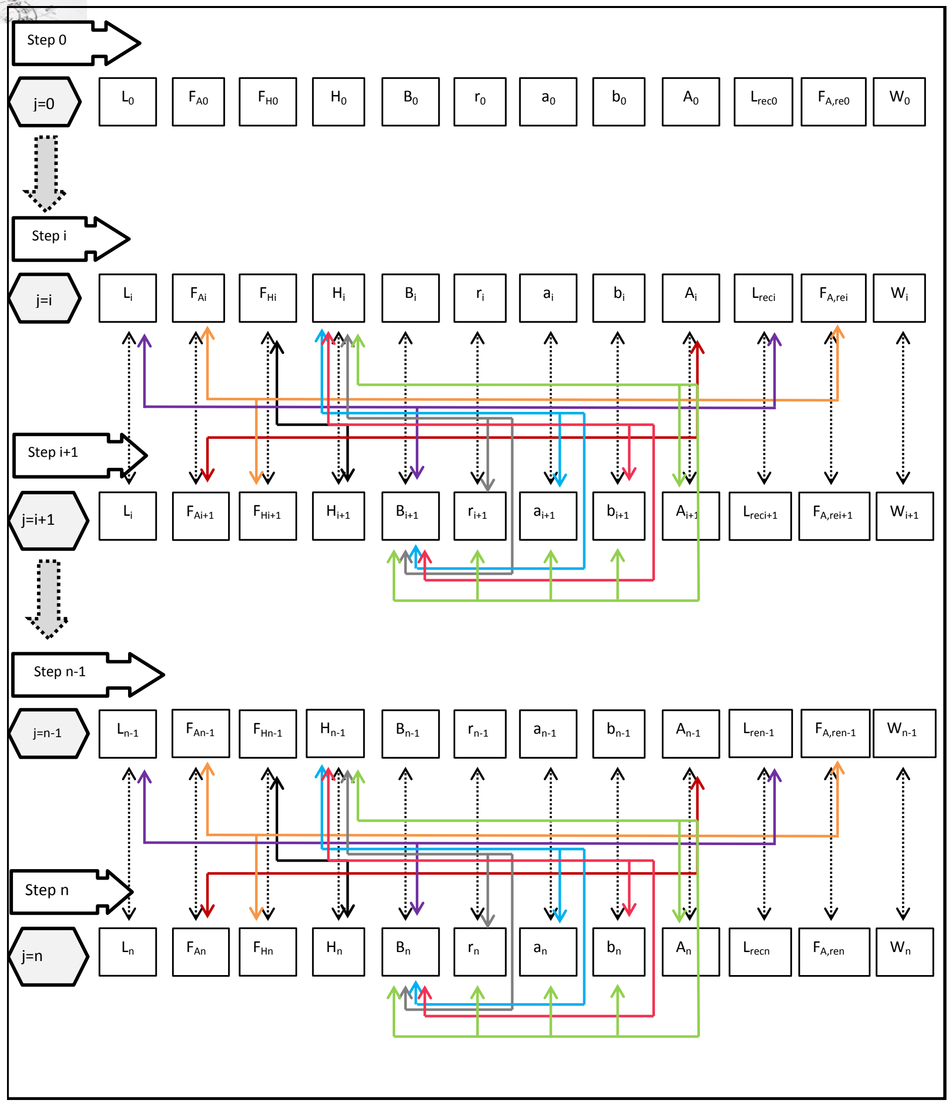

Fig. 2. SGTPP-FA: Algorithm for determination of the shape of a filled geotextile tube based on F_A

IV. RESULT AND DISCUSSION

A. *Degree of filling FH as a function of degree of filling F_A*

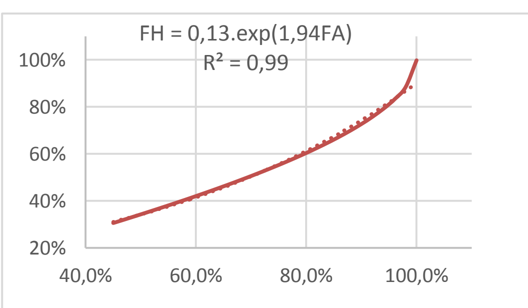

Fig. 3. Degree of filling F_H as a function of degree of filling F_A

$$F_H = 0.13 R_{100\%}.\exp(1.94.F_A)$$

B. *Height of tube as a function of degree of filling FA*

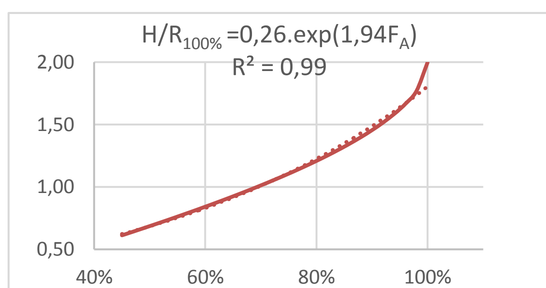

Fig. 4. Height of geotextile tube as a function of degree of filling F_A

$$H = 0.26 R_{100\%}.\exp(1.94 F_A)$$

This equation is obtained from results of the established program for degree of filling FA between 45% and 98% and with a very small error marge between -2% and 2%.

C. *Width of tube B as a function of degree of filling F_A*

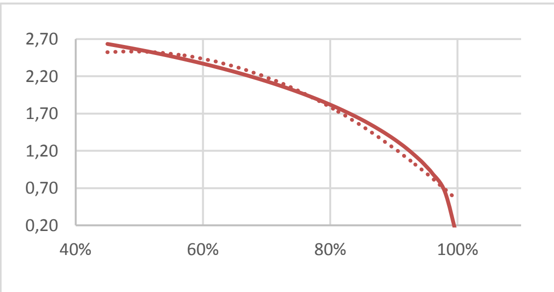

Fig. 5. Width of geotextile tube as a function of degree of filling F_A

The exponential of $B/R_{100\%}$, is expressed as shown in graph below (fig 6):

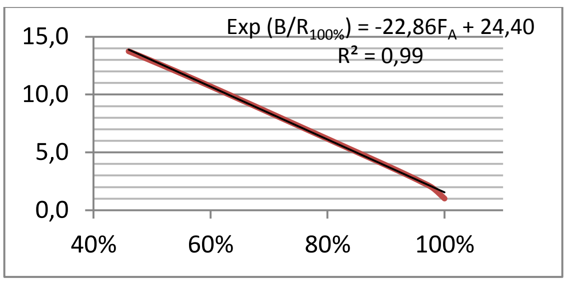

Fig. 6. The exponential of the Width of geotextile tube as a function of degree of filling F_A

$$B = R_{100\%}.Ln(24.40 - 22.86F_A)$$

This equation is obtained from results of the established program for degree of filling F_A between 45% and 98% and with a very small error marge between -2% and 2%.

D. *Total Width of tube W as a function of degree of filling F_A*

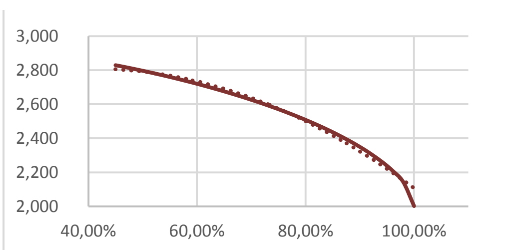

Fig. 7. Total width of geotextile tube as a function of degree of filling F_A

The natural logarithm of $W/R_{100\%}$ is shown in figure 8:

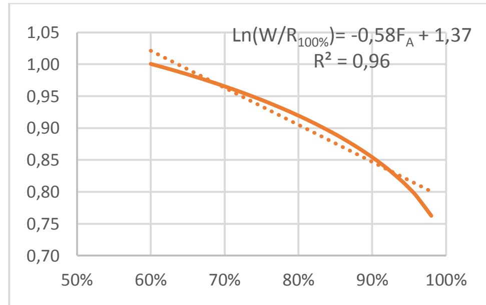

Fig.8. The natural logarithm of the total Width of geotextile tube as a function of degree of filling F_A

$$W = R_{100\%}.Exp(1.37 - 0.58F_A)$$

This equation is obtained from results of the established program for degree of filing F_A between 45% and 100% and with a very small error marge between -1% and 1%.

E. *Radius of the quadrant circle of tube r as a function of degree of filling FA*

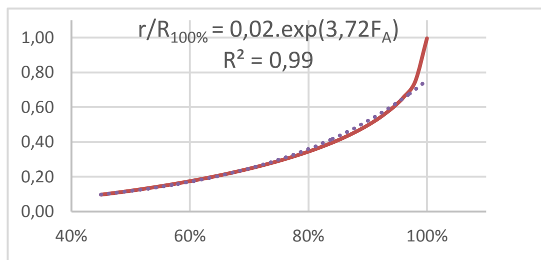

Fig. 9. Radius of the quadrant circle of geotextile tube as a function of degree of filling F_A

$$r = 0.02R_{100\%}.\exp(3.71F_A)$$

This equation is obtained from results of the established program for degree of filing FA between 45% and 98% and with a very small error marge between -2% and 5%.

F. *Pumping pressure $P_{0\ as}$ a function of degree of filling FA*

We have $P.B = \gamma.A$

And $P = P_0 + \gamma.H$

So $\frac{P_0}{\gamma} = \frac{A}{B} - H$

And $\frac{P_0}{\gamma.R_{100\%}} = \frac{\pi.F_A}{B/R_{100\%}} - H/R_{100\%}$

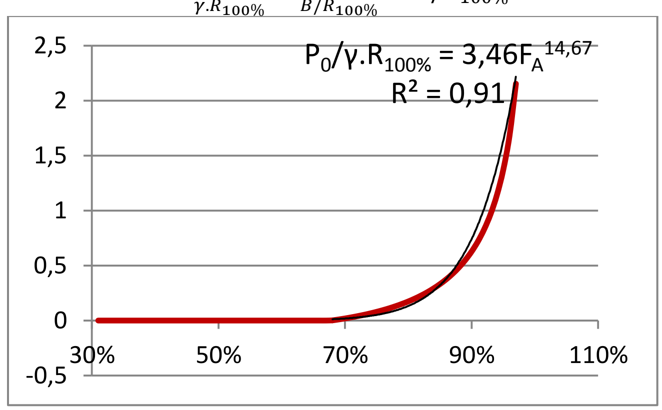

Fig. 10. Pumping pressure P_0 as a function of degree of filling F_A

$$\frac{P_0}{\gamma.R_{100\%}} = 3.46.F_A^{14.67}\ for\ F_A \geq 67\%$$

$$P_0 \cong 0\ for\ F_A < 67\%$$

For a degree of filling of 100% the pumping pressure reaches infinity, the establishes program gives à value of 200 for the term $\frac{P_0}{\gamma.R_{100\%}}$.

For a degree of filling less than 67%, the program gives a value null for P0, This mean that for obtaining a degree of filling of less than 67%, we don't need pratically any initial pumping pressure P0. In practice, that is that it is not necessary to have any sofisticated materail to obtain a degree of filling of less than 67%.

V. Comparison with Existing Methods

Different results obtained from the established program SGTDF-F_A were compared with three most existing popular methods in literature. Leshchinsky et al. 1996 (computer program GeoCoPS) [3] [4] [5] Silvester (1986) [7] and A.Bezuijen and E.W.Vastenburg (2013) [2].

As exposed in tables and figures below, the comparison highlights that there is a very good agreement between SGTDF-FA and the three methods.

A. *Comparison with A.Bezuijen and E.W.Vastenburg (2013)*

It is demonstrated from the established computer program that with a certain degree of filling F_A (%) of the geotextile tube, the degree of filling F_H (%), relative radius of curvature $r/R_{100\%}$, relative width $B/R_{100\%}$, relative total width $W/R_{100\%}$ and relative height $H/R_{100\%}$ have the same values regardless of the circumference L. Tables 1 to 3 show the comparison between the values of W, H and r for the established computer program and recommendations of A.Bezuijen and E.W.Vastenburg. There is a very good agreement between the two methods.

TABLE 1
COMPARISON OF TOTAL WIDTH W OF THE ESTABLISHED PROGRAM AND A.BEZUIJEN AND E.W.VASTENBURG [2]

F_A (%)	$W/R_{100\%}$ (-)		
	Bezuijen & Vastenburg	**Amallas**	**Difference (%)**
100%	2.00	2.00	0%
95%	2.28	2.24	2%
90%	2.40	2.35	2%
85%	2.49	2.44	2%
80%	2.56	2.51	2%
75%	2.63	2.57	2%
70%	2.69	2.63	2%
65%	2.74	2.68	2%
60%	2.79	2.72	3%

The table 1 shows that there is a very good numerical agreement for the total width of geotextile tube W between the values calculated from the established program and those prescribed by A.Bezuijen and E.W.Vastenburg.

TABLE 2
COMPARISON OF HEIGHT H OF THE ESTABLISHED PROGRAM AND A.BEZUIJEN AND E.W.VASTENBURG [2]

FA (%)	$H/R_{100\%}$ (-)		
	Bezuijen & Vastenburg	**Amallas**	**Difference (%)**
100%	2.00	2.00	0%
95%	1.59	1.62	-2%
90%	1.42	1.45	-2%
85%	1.29	1.32	-2%
80%	1.17	1.21	-3%
75%	1.07	1.11	-3%
70%	0.98	1.01	-3%
65%	0.89	0.92	-4%
60%	0.81	0.84	-4%

The table 2 shows that there is a very good numerical agreement for the height of geotextile tube H between the values calculated from the established program and those prescribed by A.Bezuijen and E.W.Vastenburg.

TABLE 3
COMPARISON OF RADIUS OF CURVATURE OF THE ESTABLISHED PROGRAM AND A.BEZUIJEN AND E.W.VASTENBURG [2]

FA (%)	$r/R_{100\%}$ (-)		
	Bezuijen & Vastenburg	**Amallas**	**Différence (%)**
100%	1,00	1,00	0%
95%	0,70	0,62	11%
90%	0,58	0,50	15%
85%	0,50	0,41	18%
80%	0,43	0,34	20%
75%	0,37	0,29	21%
70%	0,32	0,25	23%
65%	0,28	0,21	26%
60%	0,24	0,17	27%

The table 3 shows that there is generally a numerical agreement for the radius of curvature of geotextile tube r between the values calculated from the established program and those prescribed by A.Bezuijen and E.W.Vastenburg.

B. Comparison with Leshchinsky et al. 1996 (computer program GeoCoPS)

TABLE 4
COMPARISON OF SGTPP-FA AND GEOCOPS : (FOR Γ = 20 KN/M^3 AND L=3.6M) [4] [8]

	Inputs				Results					
N	**P^* (Kpa)**		**F_A^{**} (%)**	**Source**	**H (m)**	**B (m)**	**W (m)**	**Area (m²)**	**P_0 (Kpa)**	**T (KN/m)**
1	**P**	44.6		**GeoCoPS**	1.00	0.46	1.27	1.04	-	17.4
	P_0	24.6								

			98	**Amallas**	1.01	0.36	1.23	1.02	31.5	19.5
2	**P**	30.2		**GeoCoPS**	0.91	0.64	1.32	1.00	-	9.7
	P_0	12								
			93	**Amallas**	0.89	0.65	1.31	0.96	11.1	9.8
3	**P**	22.2		**GeoCoPS**	0.82	0.83	1.38	0.94	-	5.8
	P_0	5.8								
			88	**Amallas**	0.80	0.84	1.37	0.91	5.5	5.7
4	**P**	18.1		**GeoCoPS**	0.75	0.95	1.42	0.90	-	4.2
	P_0	3.1								
			83	**Amallas**	0.74	0.97	1.41	0.86	3.0	4.0
5	**P**	13.7		**GeoCoPS**	0.63	1.15	1.52	0.81	-	2.4
	P_0	1.1								
			75	**Amallas**	0.63	1.15	1.48	0.77	0.9	2.2
6	**P**	11.6		**GeoCoPS**	0.55	1.25	1.56	0.74	-	1.7
	P_0	0.6								
			68	**Amallas**	0.55	1.26	1.52	0.70	0.1	1.5

(*):Pumping pressure P_0 is given by formula: $P_0=P-\gamma.H$

(**): F_A is calculated using the formula

$$F_A = 0.5138\, ln\left(\frac{H}{2.R_{100\%}}\right)+1.052,$$ which is obtained from equation in figure 3.

The table 4 shows that there is a very good agreement for results obtained from the established program and those calculated by the program GeoCoPS.

C. Comparison with Silvester (1986)

TABLE 5
COMPARISON OF SGTPP-FA AND AND SILVESTER : (FOR Γ = 20 KN/M^3 AND L=3.6M) [4] [7]

	Inputs				**Results**					
N	**P* (Kpa)**		**FA** (%)**	**Source**	**H (m)**	**B (m)**	**W (m)**	**Area (m^2)**	**P_0 (Kpa)**	**T (KN/m)**
1	**P**	44.6		**Silvester**	1.00	0.48	1.27	1.05	-	17.5
	P0	24.6								
			98.2	**Amallas**	1.01	0.36	1.23	1.02	36.5	19.5
2	**P**	30.2		**Silvester**	0.90	0.65	1.32	0.99	-	10.1
	P0	12.2								
			93.4	**Amallas**	0.89	0.67	1.31	0.96	11.8	9.6
3	**P**	22.2		**Silvester**	0.80	0.82	1.38	0.95	-	5.8
	P0	6.2								
			88.0	**Amallas**	0.79	0.88	1.38	0.90	5.5	5.5
4	**P**	18.1		**Silvester**	0.70	0.94	1.43	0.89	-	4.2
	P0	4.1								
			83.4	**Amallas**	0.69	1.04	1.44	0.83	3.1	3.5
5	**P**	13.7		**Silvester**	0.60	1.05	1.50	0.81	-	2.8
	P0	1.7								
			74.5	**Amallas**	0.60	1.19	1.49	0.74	0.8	2.1
6	**P**	11.6		**Silvester**	0.51	1.21	1.55	0.74	-	2.0
	P0	1.4								
			67.5	**Amallas**	0.52	1.31	1.54	0.67	0.1	1.4

(*):Pumping pressure P_0 is given by formula:

$$P_0=P-\gamma.H$$

(**): F_A is calculated using the formula :

$F_A = 0.5138\, ln\left(\frac{H}{2.R_{100\%}}\right)+1.052$, which is obtained from equation in figure 3.

The table 5 shows that there is a very good agreement for results obtained from the established program and those calculated given by Silverster (1986).

VI. CONCLUSION

This paper proposes for the first time in literature formulas for calculation of geotextile tube's dimensions. It is demonstrated that these formulas present a perfect agreement with the presented program SGTPP-FA and with most popular existing methods. This let designers and geotextile tubes manufacturers use these formulas without further resort to having computer programs.

REFERENCES:

[1] Y.Amallas and Y.Ajdor (2018): New approach for predicting shape of geotextile tubes base on degree of filling FA. Journal of Theoretical and Applied Information Technology. ISSN: 1992-8654, E-ISSN: 1817-3195. 15th December 2018 -- Vol. 96. No. 23 – 2018. 7812-7821.

[2] A.Bezuijen and E.W.Vastenburd (2013). Geosystems: design rules and applications.*1st edition CRC Press/Belkama.*

[3] Leshchinsky, D., et al., 1996. Geosynthetic tubes for confining pressurized slurry: some design aspects. *Journal of Geotechnical Engineering, 682–690.*

[4] D. Leshchinsky and O. Leshchensky. GeoCoPS (2.0): Supplemental note. *ADAMA Engineering, Inc. 33 The Horseshoe. Newark, Delaware 19716, USA.*

[5] Adama Eng., 1996. GeoCoPS—Geotextile Tubes Contained Pressurized Slurry. *Computer Program. ADAMA Engineering, Newark, Delaware.*

[6] Kazimirowicz, K., 1994. Simple analysis of deformation of sand-sausages. *Fifth International Conference on Geotextiles, Geomembranes and Related Products, Vol. 2, Hydraulic Applications and Related Research, Singapore, 1994, pp. 775–778.*

[7] Silvester, R. 1986. Use of grout-filled sausages in coastal structures. *Journal of Waterway port Costal and Ocean Engineering, ASCE. 112(1). 95-114*.

[8] Liu, G. S. 1981. Design criteria of sand sausages for beach defences. *The 19th Congress of International Association for Hydraulic Research, New Delhi, India. Subject B(b), paper No. 6. 123-131*.

[9] P. van Steeg, E. Vastenburg, A. Bezuijen, E. Zengerink and J. de Gijt. Large-scale physical model tests on sand-filledgeotextile tubes and containers under wave attack. CSt2011p0021.

[10] Ir. P. van Steeg, Ing. E.W. Vastenburg : Deltares, 2010. Large scale physical model tests on the stability of geotextile tubes, Deltares report 1200162-000, February 2010, Delft.

[11] Bezuijen A., K.W. Pilarczyk (2012). Gesynthetics in hydraulic and coastal engineering filters, revetments and sand filled structures . Proc. EuroGeo 5, Valencia, pp 65-80

[12] Pilarczyk (2000): Geosynthetics and geosystems in hydraulic and coastal engineering. A.A. Balkema, Rotterdam, the Netherlands.

[13] Y.Amallas and Y Ajdor : Protection of Monika beach against coastal erosion by geotextile tubes. International Journal of Emerging Technology and Advanced Engineering. Volume 8, Issue 11, November 2018. pp 120-128.