Jadwiga Malkiewicz,
Robert Drobina

Faculty of Materials and Environmental Sciences,
Institute of Textile Engineering
and Polymer Materials
University of Bielsko-Biała,
ul. Willowa 2, 43-309 Bielsko-Biała, Poland
E-mail: jmalkiewicz@ath.bielsko.pl

Estimate of the Properties of Underlay Geocomposites Cooperating with other Geosynthetics in Geotechnical Buildings

Abstract
In the following article the authors present production technology for modern geocomposites obtained by mechanical needle-punching technology and spun-lace technology. The influence of the mass per unit area on mechanical parameters as well as that of the mass per unit area and load on hydraulic parameters were analysed. It enabled the authors to find out what mass per unit area is the most advantageous for geocomposites as underlays in hydrotechnical buildings.

Key words: *geosynthetics, geotextiles, geononwoven, geocomposite, underlay.*

Introduction

A geocomposite in geotechnics is a product combined in a production facility, in which the geotextile constitutes at least one component (PN-EN ISO 10318:2007). According to Wesołowski [1], it is a material manufactured of at least two geosyntetic products combined with each other the following ways: mechanically (stitching through, needling), thermally (welding) or chemically (glue) used in contact with the ground, rocks and other geotechnical materials in engineering constructions [1]. The major incentive to manufacture composites is the willingness to obtain a material which combines the best properties of separate geotextiles and related products. The composition of the composite depends on the role which the composite is bound to serve in certain constructional solution [2]. The composites are used as underlays in order to reinforce subgrades, railway sub soils, building yards and car parks, stabilise and protect against the erosion of slopes, construct retaining walls and standalone walls out of the ground, strengthen river channels, shores, landfills, etc. [3]. These geocomposites are useful in buildings to prevent water erosion processes. Constructions built using geotextiles often serve very important functions [4], that is why these constructions have to operate together with carefully selected geotextiles which are to separate, filter, protect, drain and also strengthen [5, 6].

According to the authors in [4], spun-lace geotextiles, which have not been used in geotechnics so far, can be combined with mechanically - needled geotexiles to create a modern geocomposite characterised by a combination of the properties of the materials mentioned. Mechanically needled geononwovens have very good hydraulic properties obtained thanks to their spatial structure and considerable porosity. Moreover they show smaller tensile strength and static puncture resistance and considerable elongations at the maximum load [4]. However, hydrodynamically needled geotextiles show considerable tensile strength with a relatively small mass per unit area. Using these materials as separate layers in earthen structures and in hydrotechnical buildings makes it possible to make a choice between functional properties and using additional layers of building materials [7].

Plan of experiment

The design of the experiment was based on assumptions contained in publications by the following authors [8 - 13]. Polypropylene geotextiles manufactured by two different methods – mechanical needling ($M_p = [200\ 300\ 400]^T g/m^2$) and hydrodynamic needling ($M_p = [100\ 200]^T g/m^2$) in order to obtain the construction of a geotextile geocomposite were taken into account arbitrarily. The geononwovens were combined into a geocomposite by mechanical needle-punching [7, 14].

As for the choice of machines indispensable to carry out tests, the following criteria were taken into account: the possibility of carrying out production tests and future mass production of the geocomposite, the possibility of processing raw materials of different chemical and physical properties, the possibility of manufacturing geotextiles of a vast variety of basis weight and the most possible width of the finished product.

Technological tests were carried out using the following units [7, 14]:

1. Unit AQUAJET – a unit aimed at obtaining nonwovens by Spun–lace needle punching technology, where delicate water needles directed at a fibre web under high pressure are the element combining the fibres in the fibre web. The width of the finished product is 320 cm, the scope of the basis weight for the unit is 30 – 220 g/m^2, the possibility of processing fibres of thickness amounting to 1.7 – 6.7 dtex and length 38 – 60 mm, the possibility of processing different types of raw material (PET, PP, PE, PCV, and blend of raw materials).
2. Unit FEHRER – aimed at the production of geotextiles by mechanical needle punching technology on one side and on both sides. The needle punching of the fibre web is performed by steel needles with cuts, causing the

Malkiewicz J, Drobina R. Estimate of the Properties of Underlay Geocomposites Cooperating with other Geosynthetics in Geotechnical Buildings.
FIBRES & TEXTILES in Eastern Europe 2013; 21, 2(98): 111-116.

Table 1. Basic parameters of the process of manufacturing geocomposites; D - needled punched geononwovens, S - spun-laced nonwoven, K - geocomposite.

Item number	Parameter	Needle punched geononwoven	Spun-laced nonwoven	Geocomposite
1	Raw materials	PP100% 15dtex/60mm	PP 100% 2.2dtex/40mm	PP100% 15dtex/60mm Spun-laced nonwoven
2	Preparation of raw material	Equipment for precisely defining the percentage of fibres		
3	Process of manufacturing	FEHRER unit	AQUAJET unit	FEHRER unit
4	Speed, m/min	3.0	7-9	3
5	Type of needles	FOSTER F 206/3B	-	FOSTER F 206/3B
6	Depth of needling, mm	10	-	10
7	Amount of needling, pi/cm^2	30	-	30
8	Mass per unit area after needling, g/m^2	D/200 D/300 D/400	S/100 S/200	K/300 – 328.8 K/400 – 414.4 K/500 – 521.2 K/600 – 610.7
9	Width after needling, cm	320	320	320

drawing of fibres in the cross machine direction. The width of the finished product is 320 cm, the scope of basis weight for this unit 70 – 1000 g/m^2, the possibility of processing fibres of thickness amounting to 1.7 – 110 dtex and length 38 – 87 mm, the possibility of processing different types of raw materials, such as PET, PP, PCV, PE, and blend of raw materials.

Generally the plan of the experiment consisted of two stages which include ***Table 1***):

1) manufacturing mechanically needled geotextile and hydrodynamically needled geotextile.
2) obtaining a geocomposite (M_p=[300 400 500 600]^{T}g/m^2) from the mechanically needled geotextile and hydrodynamically needled geotextile.

Obtaining geocomposites by combining components of appropriate mass per unit area was suggested. The following percentage of the components was chosen arbitrarily:

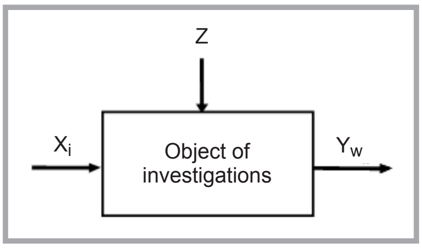

Figure 1. *Object of investigations; x_i- input variables, Y_w – output variable, Z – non-measurable disturbances.*

- D/200 + S/100 = K/300, where the needle-punched geotextile constitutes approximately - 66%,
- D/300 + S/100 = K/400, where the needle-punched geotextile constitutes approximately - 75%,
- D/300 + S/200 = K/500, where the needle-punched geotextile constitutes approximately - 66%,
- D/400 + S/200 = K/600, where the needle-punched geotextile constitutes approximately - 66%.

Methods of data analysis

As a result of the experiment conducted, aimed at establishing a modern geocomposite in the form of an underlay, supplementary characteristics were determined approximating the real characteristics of the object of the investigations. The form of the supplementary characteristics, also called the mathematical model or the function of regress, was determined separately for every output variable $y_w \in Y_w$ (see ***Figure 1***).

The output of the object as a function of the input: x_1, x_2 and non-measurable disturbances – Z were determined as follows:

$$\hat{y}_w = f(x_1, x_2, b_0, b_1, b_2, \dots b_k) \quad (1)$$

where:

- x_1 *i* x_2 - settings,
- *b* – coefficients of function of regress,
- k = 1, 2, 3, ... , k - number of coefficients of regression equation.

In order to obtain a useful regress equation and also satisfy the requirements of the significance at a determined probability level (α = 0.05) the following condition must be met:

$$F_{calc} = F(K'; N - K' - 1) \geq F_{crit}, \quad (2)$$

where:

F_{crit} - the critical values of F-Snedecor's statistics determined for *K'* and *N* - *K'* - 1 degrees of freedom at significance level α = 0.05.

This condition can be met by the models including the different numbers of *K'* coefficients occurring in the equation of regress. Sometimes the choice of "the best equation of regress is needed", which was taken into account during the analysis:

- increases in squares of coefficients of determination - R^2,
- values of F-Snedecor's statistics - $F(K'; N - K' - 1)$,
- values of partial statistics of the terms of regress equations - $F_{crit.}(K'; N - K' - 1)$.

Methods of investigation

Investigations were conducted in accordance with the scope and kind of testing of geotextiles properties adjusted to the function which these materials fulfill in the construction, mainly as drainage, filtration and separation layer. Physical and mechanical properties of the geotextiles were characterised by the following parameters: mass per unit area (PN-EN ISO 9864), thickness at a particular pressure: 2, 20, 200 kPa (PN-EN ISO 9863), tensile strength, elongation at maximum load (PN-EN ISO 10319) , static puncture resistance - the CBR method (PN-EN ISO 12236), and dynamic puncture resistance - cone drop test (PN-EN ISO 13433). The hydraulic properties were characterised by the water flow capacity (PN-EN ISO 11058), water permeability in the plane (PN-EN ISO 12958), and characteristic opening size (PN-EN ISO 12956). All parameters were determined according to ISO harmonised standards for functions drainage, filtration and separation [7, 15].

Results of the research on mechanical properties

The main aim of the research was to determine the influence of mass per unit area on basic mechanical and hydraulic properties and find out what mass per unit area is most advantages for the geocomposites applied as underlays in geotechnical buildings.

Statistical parameters of mechanical properties of the geononwovens are shown in ***Table 2***.

Table 2. Statistical parameters of mechanical properties of the geononwovens.

Parameter		M_p, g/m^2	e_{2kPa}, mm	e_{20kPa}, mm	e_{200kPa}, mm	F_{rMD}, kN/m	F_{rXMD}, kN/m	E_{MD}, %	E_{XMD}, %	F_{CBR}, kN	F_D, mm
D/200	x	**210.8**	**2.54**	**1.81**	**1.0**	**7.3**	**12.2**	**119.2**	**109.1**	**1.3**	**22.4**
	$V_{\%}$	0.28	1.89	1.18	3.65	1.23	0.82	0.34	0.42	2.64	3.12
	u	8.51	0.03	0.02	0.03	0.11	0.12	0.50	0.57	0.04	0.57
D/300	x	**316.5**	**3.01**	**2.23**	**1.23**	**13.8**	**19.9**	**120.2**	**115.2**	**2.2**	**18.0**
	$V_{\%}$	1.12	6.21	4.04	5.05	0.69	0.49	0.09	0.38	4.7	2.62
	u	8.51	0.09	0.03	0.04	0.12	0.12	0.14	0.55	0.13	0.59
D/400	x	**406.8**	**3.21**	**2.81**	**1.8**	**16.9**	**25.9**	**130.1**	**121**	**3.2**	**12.0**
	$V_{\%}$	0.32	1.09	2.66	4.15	0.48	1.24	0.37	0.22	5.43	3.93
	u	8.51	0.02	0.05	0.05	0.10	1.40	0.60	0.33	0.22	0.59
S/100	x	**111.2**	**1.04**	**0.84**	**0.7**	**6.3**	**7.2**	**47.2**	**56**	**0.32**	**25**
	$V_{\%}$	0.57	10.4	6.83	2.17	4.67	2.32	0.86	1.01	6.87	1.4
	u	8.51	0.08	0.04	0.01	0.37	0.3	0.51	0.7	0.03	0.52
S/200	x	**195.6**	**1.29**	**1.14**	**0.8**	**11.23**	**11.23**	**54.5**	**77.2**	**1.91**	**22**
	$V_{\%}$	0.35	1.94	7.44	3.9	0.46	0.97	1.72	0.51	0.57	1.31
	u	8.51	0.02	0.06	0.02	0.06	0.15	1.16	0.49	0.01	0.39

Note for ***Tables 2*** and ***3***: D - needled punched geononwovens, S - spun-laced nonwoven, K - geocomposite, M_p = mass per unit area, e_{2kPa} = thickness at pressure 2 kPa, e_{20kPa} = thickness at pressure 20 kPa, e_{200kPa} = thickness at pressure 200 kPa, F_{rMD} = tensile strength in machine direction, F_{rXMD} = tensile strength in cross machine direction, E_{MD} = elongation at maximum load in machine direction, E_{XMD} - elongation at maximum load in cross machine direction F_{CBR} - static puncture resistance, F_D - dynamic puncture resistance, statistics: $\overline{X}$ - mean value, $V_{\%}$ coefficient of variation, U – mean error.

Statistical parameters of mechanical properties of the geocomposites are shown in ***Table 3***.

Table 3. Statistical parameters of mechanical properties of the geocomposites.

Parameter		M_p, g/m^2	e_{2kPa}, mm	e_{20kPa}, mm	e_{200kPa}, mm	F_{rMD}, kN/m	F_{rXMD}, kN/m	E_{MD}, %	E_{XMD}, %	F_{CBR}, kN	F_D, mm
K/300	x	**328.8**	**3.16**	**2.72**	**1.59**	**6.0**	**6.3**	**89.8**	**82.8**	**2.1**	**18.2**
	$V_{\%}$	0.10	1.19	3.52	5.09	0.95	0.58	0.30	0.23	3.44	2.32
	u	8.51	0.03	0.07	0.006	0.07	0.05	0.34	0.24	0.09	0.52
K/400	x	**414.4**	**3.62**	**2.64**	**1.77**	**6.9**	**8.5**	**95.7**	**92.7**	**2.4**	**17.4**
	$V_{\%}$	0.04	1.25	0.83	1.79	1.8	1.36	0.49	0.51	2.83	2.97
	u	8.51	0.03	0.02	0.02	0.14	0.14	0.59	0.59	0.08	0.64
K/500	x	**521.2**	**4.2**	**3.1**	**2.1**	**8.1**	**8.9**	**97.5**	**95.3**	**3.1**	**14.0**
	$V_{\%}$	0.16	2.69	3.86	4.23	0.98	0.77	0.19	0.03	1.10	3.37
	u	8.51	0.08	0.09	0.06	0.10	0.08	0.23	0.04	0.04	0.59
K/600	x	**610.7**	**4.4**	**3.6**	**2.4**	**9.6**	**9.1**	**99.1**	**96.8**	**3.8**	**12.1**
	$V_{\%}$	0.06	1.78	2.48	1.28	0.82	0.07	0.40	0.18	2.08	2.61
	u	8.51	0.06	0.06	0.02	0.10	0.08	0.49	0.22	0.10	0.39

In the next part, the influence of changes in the mass per unit area of the composites on their mechanical properties was checked. In order to show changes in mechanical properties of the composites in the function of changing their mass per unit area, substitute characteristics were determined -

$$\hat{e} = f(M_p), \hat{F}_r = f(M_p), \hat{E} = f(M_p),$$

$$\hat{F}_{CBR} = f(M_p), \hat{F}_D = f(M_p)$$

approximated with straight lines. Coefficients of the regression function, the coefficient of the multidimensional correlation and computational statistics – $F_{calc.}$ and critical statistics Fisher – Snedecor's F_{crit} are shown in the diagrams.

However, substitute characteristics for elongation at the maximum load and movement at static puncture were not established.

Analysing the data shown in ***Table 3*** and the diagram shown in ***Figure 2***, it can be assumed that the more parameter – M_p increases, the more the thickness of the composite at a pressure amounting to 2 and 200 kPa increases linearly. Substitute characteristics at a pressure of 20 kPa were not established.

Analysing the data shown in ***Table 3*** and the diagram shown in ***Figure 3***, it can be assumed that the more parameter – M_p increases, the more the tensile strength measured in the machine direction – F_{rMD} of the geocomposites increases linearly. Substitute characteristics were not found in the cross machine direction.

Analysing the data shown in ***Table 3*** and diagram shown in ***Figure 4*** (see page 110), it can be assumed that the more parameter – M_p increases, the more the static puncture resistance of the composites F_{CBR} increases linearly.

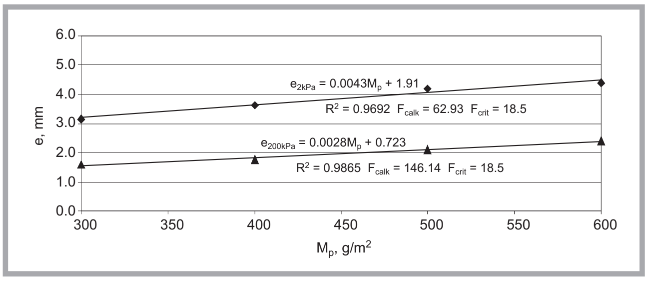

Figure 2. *Influence of changes in the mass per unit area – M_p on the thickness – e of the geocomposites at a pressure amounting to 2 kPa and 200 kPa.*

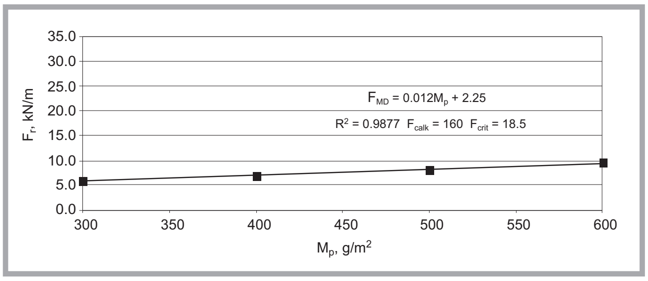

Figure 3. *Influence of changes in the mass per unit area on the tensile strength measured in the machine direction– $F_{rMD.}$.*

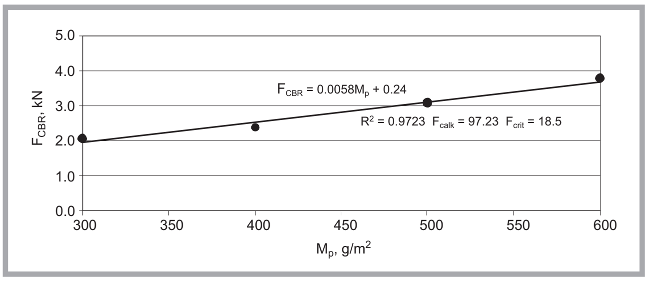

Figure 4. Influence of changes in the mass per unit area – M_p on the static puncture resistance F_{CBR} of the geocomposites.

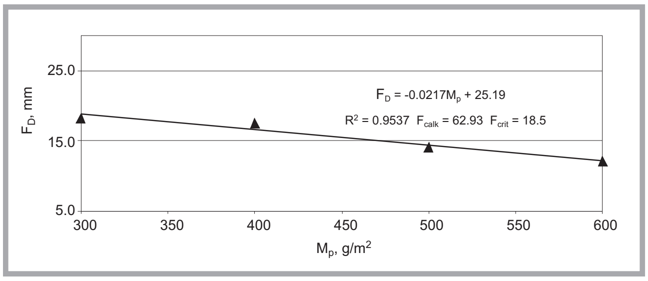

Figure 5. Influence of changes in the mass per unit area – M_p on the dynamic puncture resistance of the geocomposites – F_D.

Analysing the data shown in ***Table 3*** and diagram shown in ***Figure 5***, it can be assumed that the more parameter M_p increases, the more the dynamic puncture resistance of the geocomposites – F_D decreases linearly.

*Table 4. Parameters of hydraulic properties of the geononwovens, *) Methods of investigation.*

Parameter		D/200	D/300	D/400	S/100	S/200
Water flow capacity in their plane q_{ng} l/m·s						
Flow direction - **MD**						
where i = 0.1, at load:	2 kPa	2.5×10^{-3}	4.2×10^{-3}	4.5×10^{-2}	1.1×10^{-3}	1.8×10^{-3}
	20 kPa	1.3×10^{-3}	2.8×10^{-3}	3.7×10^{-3}	4.5×10^{-4}	7.9×10^{-4}
	50 kPa	7.9×10^{-4}	1.7×10^{-3}	1.6×10^{-3}	2.5×10^{-4}	4.4×10^{-4}
	100 kPa	3.9×10^{-4}	1.3×10^{-3}	1.2×10^{-3}	1.6×10^{-4}	2.8×10^{-4}
where i = 1, at load:	2 kPa	2.1×10^{-3}	6.9×10^{-3}	1.4×10^{-2}	3.9×10^{-3}	5.1×10^{-3}
	20 kPa	1.7×10^{-3}	3.3×10^{-3}	3.7×10^{-3}	1.4×10^{-3}	1.2×10^{-3}
	50 kPa	1.6×10^{-3}	2.3×10^{-3}	2.7×10^{-3}	5.4×10^{-4}	5.1×10^{-4}
	100 kPa	1.3×10^{-4}	2.0×10^{-3}	1.5×10^{-3}	2.3×10^{-4}	3.3×10^{-4}
Flow direction - **XMD**						
where **i = 0.1**, at load:	2 kPa	1.9×10^{-3}	1.5×10^{-2}	1.8×10^{-2}	6.8×10^{-4}	$4,2 \times 10^{-3}$
	20 kPa	1.3×10^{-3}	2.8×10^{-3}	2.5×10^{-3}	4.2×10^{-4}	1.8×10^{-3}
	50 kPa	8.1×10^{-4}	1.4×10^{-3}	2.0×10^{-3}	3.8×10^{-4}	1.1×10^{-3}
	100 kPa	7.7×10^{-4}	9.2×10^{-4}	1.1×10^{-3}	2.2×10^{-4}	9.8×10^{-4}
where i = 1, at load:	2 kPa					
	20 kPa	7.6×10^{-3}	1.2×10^{-2}	1.8×10^{-2}	4.4×10^{-3}	3.1×10^{-3}
	50 kPa	1.7×10^{-3}	3.1×10^{-3}	3.7×10^{-3}	1.6×10^{-3}	1.8×10^{-3}
	100 kPa	6.8×10^{-4}	1.3×10^{-3}	2.5×10^{-3}	1.1×10^{-3}	1.4×10^{-3}
		2.4×10^{-4}	1.2×10^{-3}	1.5×10^{-3}	7.1×10^{-4}	8.1×10^{-4}
Water permeability in the plane without load VI_{H50} m/s		2.3×10^{-2}	2.2×10^{-2}	2.1×10^{-2}	2.4×10^{-2}	2.1×10^{-2}
Characteristic opening size 0_{90} mm		0.110	0.095	0.089	0.090	0.089

*Table 5. Parameters of hydraulic properties of the geocomposites, *) Methods of investigation.*

Parameter		K/300	K/400	K/500	K/600
Water flow capacity in their plane q_{ng} l/m·s					
Flow direction - **MD**					
where i = 0.1, at load:	2 kPa	4.5×10^{-3}	4.8×10^{-3}	5.1×10^{-3}	5.7×10^{-3}
	20 kPa	1.3×10^{-3}	3.8×10^{-3}	4.2×10^{-3}	4.5×10^{-3}
	50 kPa	5.5×10^{-4}	1.4×10^{-3}	1.5×10^{-3}	2.9×10^{-3}
	100 kPa	3.9×10^{-4}	1.2×10^{-3}	1.1×10^{-3}	1.8×10^{-3}
where i = 1, at load:	2 kPa	7.8×10^{-3}	9.28×10^{-3}	8.7×10^{-3}	9.5×10^{-3}
	20 kPa	3.8×10^{-3}	5.4×10^{-3}	5.4×10^{-3}	6.4×10^{-3}
	50 kPa	1.6×10^{-3}	4.2×10^{-3}	3.8×10^{-3}	4.5×10^{-3}
	100 kPa	9.1×10^{-4}	3.6×10^{-3}	3.1×10^{-3}	3.2×10^{-3}
Flow direction - **XMD**					
where **i = 0.1**, at load:	2 kPa	5.6×10^{-3}	6.2×10^{-3}	6.8×10^{-3}	7.1×10^{-3}
	20 kPa	2.2×10^{-3}	4.5×10^{-3}	4.7×10^{-3}	6.1×10^{-3}
	50 kPa	9.8×10^{-4}	3.1×10^{-3}	3.9×10^{-3}	$2,8 \times 10^{-3}$
	100 kPa	5.2×10^{-4}	9.2×10^{-4}	3.7×10^{-3}	2.4×10^{-3}
where i = 1, at load:	2 kPa	6.1×10^{-3}	9.8×10^{-3}	1.2×10^{-2}	9.7×10^{-3}
	20 kPa	3.4×10^{-3}	5.2×10^{-3}	6.3×10^{-3}	7.1×10^{-3}
	50 kPa	1.9×10^{-3}	3.1×10^{-3}	4.2×10^{-3}	4.8×10^{-3}
	100 kPa	9.7×10^{-4}	2.9×10^{-3}	3.1×10^{-3}	3.4×10^{-3}
Water permeability in the plane without load VI_{H50} m/s		3.0×10^{-2}	2.3×10^{-2}	2.1×10^{-2}	1.9×10^{-2}
Characteristic opening size 0_{90} mm		0.100	0.095	0.089	0.081

Results of the research on hydraulic properties

Parameters of hydraulic properties of the geononwovens are shown in ***Table 4***, whereas of the geocomposites are shown in ***Table 5***.

Analysing the data shown in ***Table 5*** and the diagram in ***Figure 6.a***, for the machine direction MD it can be assumed that the more load – N_H increases, regardless of the mass per unit area value, the more the water flow capacity in the plane of product – q_{ng} of the geocomposite decreases. Further load growth – N_H influences changes in the water flow capacity parameter in the plane of product – q_{ng}. Composites of a mass per unit area amounting to Mp = 500 – 600 g/m^2 at load N_H = 2 – 20 kPa are characterised by the biggest water flow capacity. As for functioning as drainage and filtration (roads, car parks, etc.), lighter geocomposites can be used with a mass per unit area – M_p = 300 – 400 g/m^2 without lowering their water flow capacity, which is a great advantage of these geocomposites. Whereas for the cross machine direction XMD (***Figure 6.b***), it can be assumed that in the range of load N_H = 20 – 50 kPa, regardless of the mass per unit area value – M_p , the water flow capacity in the plane of product – q_{ng} of the geocomposite decreases. Further increase in the load – N_H influences changes in the water flow capacity in the plane of product – q_{ng}. Geomposites at load – N_H = 2 – 50 kPa are characterised by the biggest water flow capacity. As for functioning as filtration and drainage, when aimed at roads, car parks, etc., composites of a mass per unit area M_p = 300 – 400 g/m^2 can be used, which can be at a maximum load amounting to 50 kPa. proving very well that the components out of which the geocomposite aimed at functioning in soil conditions is made of were carefully selected.

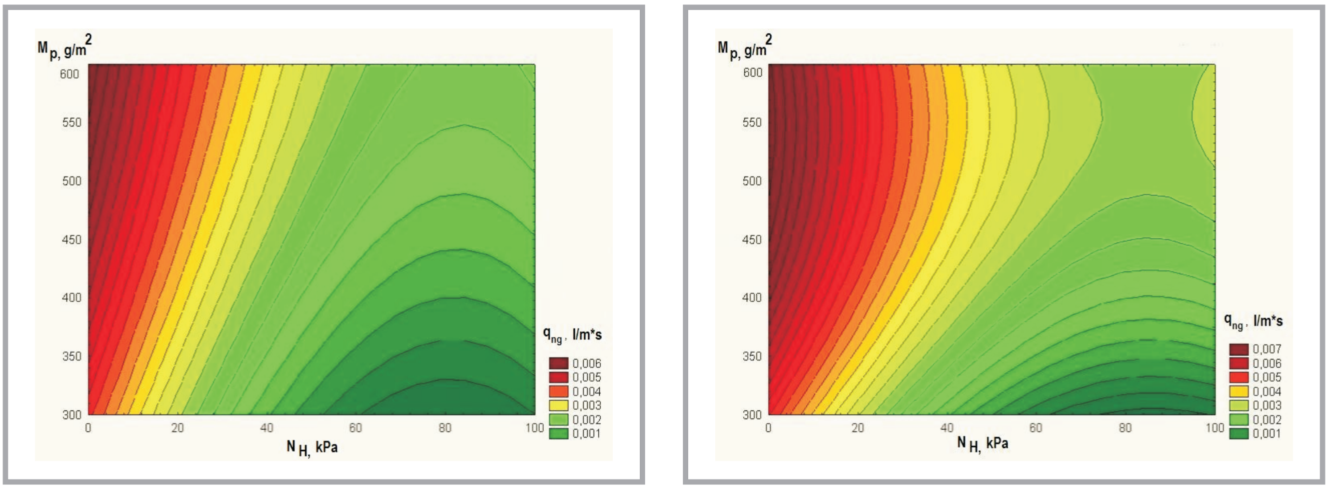

Figure 6. *Diagram of water flow capacity regression of the geocomposites –* $\hat{q}_{g} = f(N_H; M_p)$ *where i = 0.1* $_{MD}$*;* $R^2 = 0.937$*; R = 0.968;* $F_{calc} = 29.80$*;* $F_{crit} = 3.33$*,* $\hat{q}_{g} = f(N_H; M_p)$ *where i = 0.1* $_{XMD}$*;* $R^2 = 0.92$*; R = 0.96;* $F_{calc} = 23.56$*;* $F_{crit} = 3.33$*.*

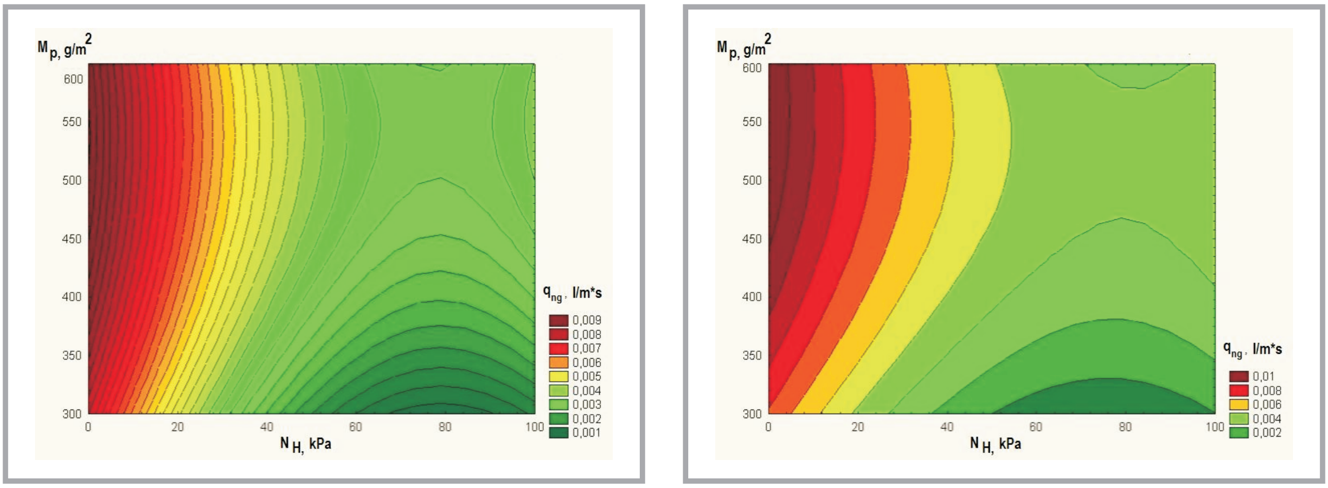

Figure 7. *Diagram of water flow capacity regression function of the geocomposites -* $\hat{q}_{g} = f(N_H; M_p)$ *where i = 1* $_{MD}$*;* $R^2 = 0.932$*; R = 0.965;* $F_{calc} = 27.46$*;* $F_{crit} = 3.33$*,* $\hat{q}_{g} = f(N_H; M_p)$ *where i = 1* $_{XMD}$*;* $R^2 = 0.909$*; R = 0.953;* $F_{calc} = 20.108$*,* $F_{crit} = 3.33$*.*

Analysing data shown in ***Table 5*** and the diagram in ***Figure 7.a***, for the machine direction MD, it can be assumed that in the scope of load – N_H = 20 – 50 kPa, regardless of the mass per unit area value – M_p, the water flow capacity in the plane of product – q_{ng} of the geocomposite decreases. The composites at load N_H = 2 – 20 kPa are characterised by the biggest water flow capacity. As for functioning as filtration and drainage aimed at roads, car parks, etc., geocomposites of mass per unit area amounting to – M_p = 300 – 400 g/m^2 can be used, which can be loaded to 50 kPa, proving very well that the components out of which the geocomposite aimed at functioning in soil conditions is made of have been carefully selected. Whereas for the cross machine direction XMD (***Figure 7.b***), it can be assumed that in the load range N_H = 20 – 50 kPa, regardless of the mass per unit area, the water permeability decreases. A further load increase influences the change in the water flow capacity parameter in the plane of product – q_{ng}. Geomposites at load N_H = 1 – 20 kPa are characterised by the biggest water flow capacity. As for functioning as filtration and drainage aimed at roads, car parks, etc., geocomposites of mass per unit area – M_p = 300 – 475 g/m^2 can be used, which can be loaded to 20 kPa, proving very well that the components out of which the composite aimed at functioning in soil conditions is made of were carefully selected.

Analysing the data shown in ***Table 5***, it can be assumed that water permeability in the plane without a load, expressed by transmissivity – V_{H50} m/s, decreases together with an increase in the mass per unit area – M_p, whereas the characteristic opening size – 0_{90} decreases together with an increase in the mass per unit area, which directly influences the drainage and filtration function of the geotextile.

As for the result of the statistical analysis of mechanical and hydraulic properties of the geocomposites, it was found that for functioning as drainage, filtration and separation, lighter geocomposites, meaning of smaller mass per unit area in the range of 300 – 400 g/m^2 , can be used without lowering mechanical and hydraulic properties.

Conclusions

1. The technological identification carried out enabled the creation of materials of smaller basis weight that meet requirements concerning geotextiles to be used as an underlay in different kinds of engineering objects without worsening their properties.

2. The statistical modelling carried out enabled to define the influence of the mass per unit area on forming mechanical parameters such as thickness, tensile strength, elongation at maximum load and resistance to static and dynamic puncture.
3. As for hydraulic properties, it can be realised that the more the mass per unit area decreases, the more the water permeability in the plane without a load and characteristic opening size increases, whereas the flow capacity, load and mass per unit area influence the water flow capacity in the plane significantly.
4. The geocomposite suggested combines the properties of mechanically-needled and hydrodynamically-needled geotextiles, thanks to which, together with a smaller mass per unit area, underlay materials of very high mechanical and hydraulic parameters are obtained that meet requirements concerning geotextile materials aimed at functioning with the ground.

References

1. Wesołowski A, Krzywosz Z, Brandyk T. Geosynthetics in building construction. Publisher: SGGW – Warszawa, 2000, pp. 47-48.
2. Maślanka K, Pielichowski J. Geosynthetics in engineering and environmental. Publisher: Thesis 2006, pp. 12-23.
3. Malkiewicz J. Estimation of geotextiles for cooperation with geogabions in erosion control construction. *Science Nature Technologies* 2011; 5; 4: 72.
4. Malkiewicz J, Drobina R. Technological identification of spun-lace technology. Inżynieria Morska i Geotechnika (2) 2011 130 – 139.
5. Bolt A, Duszyńska A. Zasady doboru geosyntetyków w projektowaniu warstw filtracyjnych i separacyjnych. Geotechnika w budowie składowisk odpadów - Pułtusk, November, 1997.
6. Duszyńska A. Zastosowanie geosyntetyków w budownictwie i inżynierii środowiska. Seminarium Geosyntetyczne Gdańsk, October, 2009: 54-69.
7. Malkiewicz J, Bartkowiak E. Influence of mechanical needle punching on chosen properties of nonwoven geotextiles. *Inżynieria Morska i Geotechnika* 2010; 5: 624 – 634.
8. Józkowicz I, Drobina R, Lewandowski S. The comparative analysis of the ring spinning both classic and compact , Part II: The Verification of Created Models. *Fibres & Textiles in Eastern Europe* 2010; 18; 5 (82): 28-34.
9. Lewandowski S, Drobina R, Józkowicz I. Comparative analysis of the ring spinning process both classic and compact, Theoretical reflections, Part I: Elaboration of the statistical model based on the multiple regression. *FIBRES & TEXTILES in Eastern Europe* 2010; 18; 4 (81): 20-24.
10. Lewandowski S, Drobina R. Identification of Spliced Wool Combed Yarn Joints by Networks Realized Regression tasks and Multiple Regression. *Fibres & Textiles in Eastern Europe* 2008; 16; 5 (70): 33-39.
11. Lewandowski S, Drobina R. Prediction of Properties of Unknotted Spliced Ends of Yarns Using Multiple Regression and Artificial Neural Networks. Part II: Verification of Regression Models, Verification of Models Realized Regression Tasks. *Fibres & Textiles in Eastern Europe* 2008; 16; 6 (71): 20-27.
12. Drobina R, Włochowicz A, Machnio MS. Multi Criterion Assessment of Pneumatically Spliced Worsted Wool Ring Spun Yarns. *Fibres & Textiles in Eastern Europe* 2008; 16; 5 (70): 17-23.
13. Drobina R, Włochowicz A, Machnio MS. Fatigue curves elaborated for selected worsted wool yarns. *Fibres & Textiles in Eastern Europe* 2007; 15 (69); 5 - 6 (64 - 65): 54–58.
14. Bartkowiak E, Malkiewicz J. Parameters and the usable properties of needled geotextiles made of staple fibres against a background of properties of other geotextiles. In: *Geosyntetyki i tworzywa sztuczne w geotechnice i budownictwie inżynieryjnym*, Częstochowa,11–13 May 2006, pp. 321-461.
15. Malkiewicz J. The role of the modern opinion of geotextiles in building construction, p. II. *Przegląd włókienniczy – Włókno, Odzież, Skóra* 2012; 1: 17-21.

Received 06.03.2012 Reviewed 10.10.2012