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Test Report No. 1.1 / 13525 / 0036.0.1-2016e

General

Issued : 11 July 2017

Order by : **Dörken GmbH & Co. KG**
Wetterstraße 58
58313 Herdecke, GERMANY

Material : Composite consisted of a PEHD dimpled sheet (brown), a PP nonwoven (grey) and a PE sliding film (yellow) with a laminated nonwoven (white)
DELTA GEO DRAIN Quattro
(declaration by customer)

Order date : 15 January 2016 + 07 December 2016

Samples delivered : 15 December 2015

Tests	Standard	Issue	Results as Enclosure No.
1. Wide-width tensile test	DIN EN ISO 10319	09.2015	A1 - A2
2. Determination of the resistance to weathering	DIN EN 12224	11.2000	A3
3. Combined ageing for PE/PP (test for declared service life up to 25 years)	DIN EN 12447 DIN EN ISO 13438 DIN EN 13249 (Annex B)	03.2002 02.2005 2014	A4
4. Combined ageing for PE/PP (test for declared service life up to 50 years)	DIN EN 12447 DIN EN ISO 13438 DIN EN 13249 (Annex B)	03.2002 02.2005 2014	A5
5. Combined ageing for PP (test for declared service life up to 100 years)	DIN EN 12447 DIN EN ISO 13438 DIN EN 13249 (Annex B)	03.2002 02.2005 2014	A6
6. In-plane water flow capacity $q_{stress/gradient}$	DIN EN ISO 12958	08.2010	A7

The results apply exclusively to the specimens submitted.
The date of testing is reported on the enclosed enclosure/-es.
Results are reported to the accuracy given in the standards. In statistical evaluation, the measured accuracy is taken.

This test report contains 3 pages and 6 enclosure/-es (enclosure/-es A1 - A7).
It may not be published in parts.

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Summary of results

Date / Ref. : 11 July 2017 / fd

Order by : **Dörken GmbH & Co. KG , Wetterstraße 58 , 58313 Herdecke, GERMANY**

Material : Composite consisted of a PEHD dimpled sheet (brown), a PP nonwoven (grey) and a PE sliding film (yellow) with a laminated nonwoven (white)
DELTA GEO DRAIN Quattro
(declaration by customer)

Test		Standard	Unit	Mean $\bar{x}$	Standard-deviation s	Coef. of variation v in %
Wide-width tensile test		**DIN EN ISO 10319 09.2015**				
Tensile strength	MD		kN/m	23,6	2,16	9,2
	CMD		kN/m	21,6	0,63	2,9
Strain at maximum load	MD		%	36,5	2,39	6,5
	CMD		%	60,8	15,42	25,4

Test		Standard	Unit	Result
Determination of the resistance to weathering		**DIN EN 12224 11.2000**		
residual tensile strength	MD		%	64,7
residual strain	MD		%	48,0
residual tensile strength	CMD		%	89,2
residual strain	CMD		%	43,0
Combined ageing for PE/PP (test for declared service life up to 25 years)		**DIN EN 12447 03.2002 DIN EN ISO 13438 02.2005 DIN EN 13249 2014 (Annex B)**		
Residual tensile strength	MD		%	107,4
Residual strain	MD		%	114,0
Residual tensile strength	CMD		%	117,2
Residual strain	CMD		%	99,7
Combined ageing for PE/PP (test for declared service life up to 50 years)		**DIN EN 12447 03.2002 DIN EN ISO 13438 02.2005 DIN EN 13249 2014 (Annex B)**		
Residual tensile strength	MD		%	99,0
Residual strain	MD		%	113,0
Residual tensile strength	CMD		%	103,6
Residual strain	CMD		%	95,2

continued on page 3

tBU
Geschäftsführer:
Prof. Dr. Roland Hüttl

Amtsgericht Hamburg
HRB 130568
St.Nr.: 4673603268

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Summary of results

Date / Ref. : 11 July 2017 / fd

Order by : **Dörken GmbH & Co. KG , Wetterstraße 58 , 58313 Herdecke, GERMANY**

Material : Composite consisted of a PEHD dimpled sheet (brown), a PP nonwoven (grey) and a PE sliding film (yellow) with a laminated nonwoven (white)
DELTA GEO DRAIN Quattro
(declaration by customer)

Test		Standard		Unit	Result		
Combined ageing for PP (test for declared service life up to 100 years)		**DIN EN 12447 03.2002** **DIN EN ISO 13438 02.2005** **DIN EN 13249 2014 (Annex B)**					
Residual tensile strength	MD			%	105,2		
Residual strain	MD			%	106,9		
Residual tensile strength	CMD			%	115,3		
Residual strain	CMD			%	101,9		
Note: The residual tensile strength (mean of MD- and CMD-direction) is more than 50 %.							
In-plane water flow capacity $q_{stress/gradient}$		**DIN EN ISO 12958* 08.2010**			Hydraulic gradient		
					i = 0,1	i = 1,0	
Test direction:	MD	20 kPa		l/(m·s)	0,99	3,33	-
rigid/soft		50 kPa		l/(m·s)	0,85	2,88	-
		100 kPa		l/(m·s)	0,71	2,50	-
Note: soft surface aligned to nonwoven							

* test parameters according to standard: normal compressive stress: 20 kPa, 100 kPa, 200 kPa; gradient: 0,1, 1,0; test direction: MD and CMD; contact surfaces: soft/soft

Kiwa GmbH

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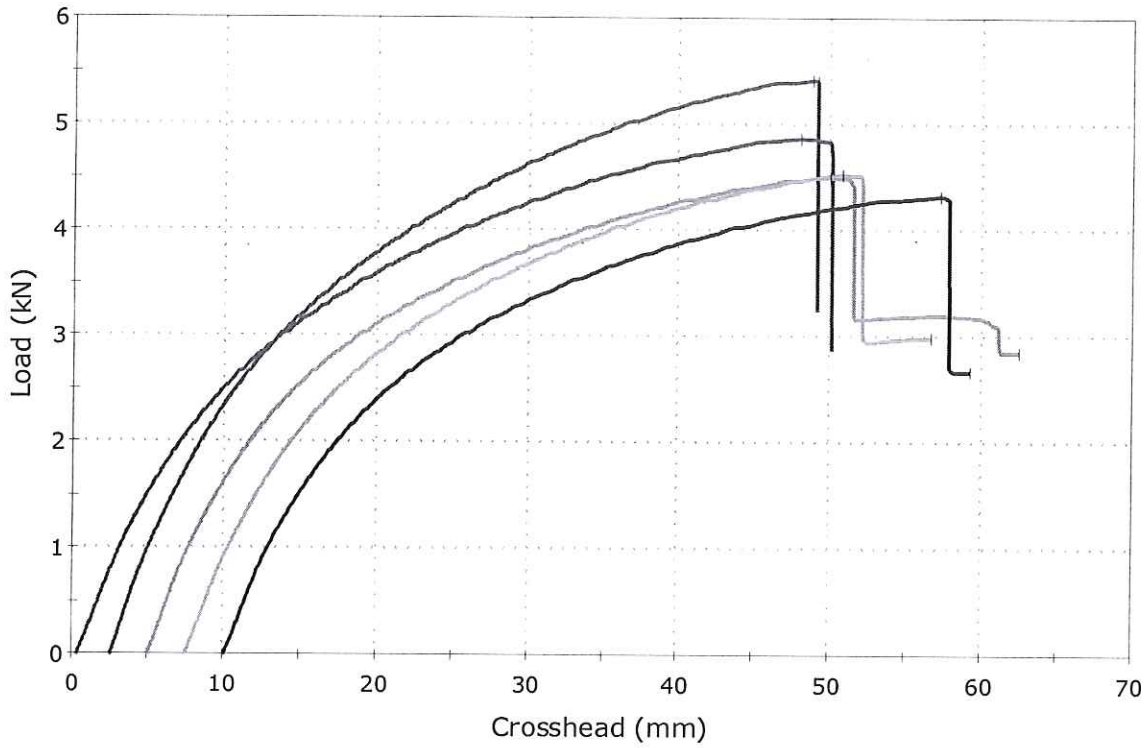
i.A. Schmale

i.A. Friederike Schmale
(Physiklaborantin, staff of test laboratory)

Kiwa GmbH - TBU

Test standard:	DIN EN ISO 10319 (09.2015)
Order number:	1.1/13525/0036.0.1-2016
Customer:	Dörken GmbH & Co. KG
Material:	DELTA GEO DRAIN Quattro
Test direction:	MD
Climate:	23°C / 49% rel. humidity
Date:	04.03.2016
Tester:	FD
Machine:	Instron 5567
Load cell:	30 kN
Extensometer (path):	standard Video Extensometer, Type 2663-822
Pre-load:	1% of Fmax.
Clamping system:	M-50-HJ-ME-2XL (100mm x 240mm)
Specimen width:	200,0 mm
LE:	100,0 mm
Remarks:	coated nonwoven to extensometer
Test condition:	dry

DIN EN ISO 10319

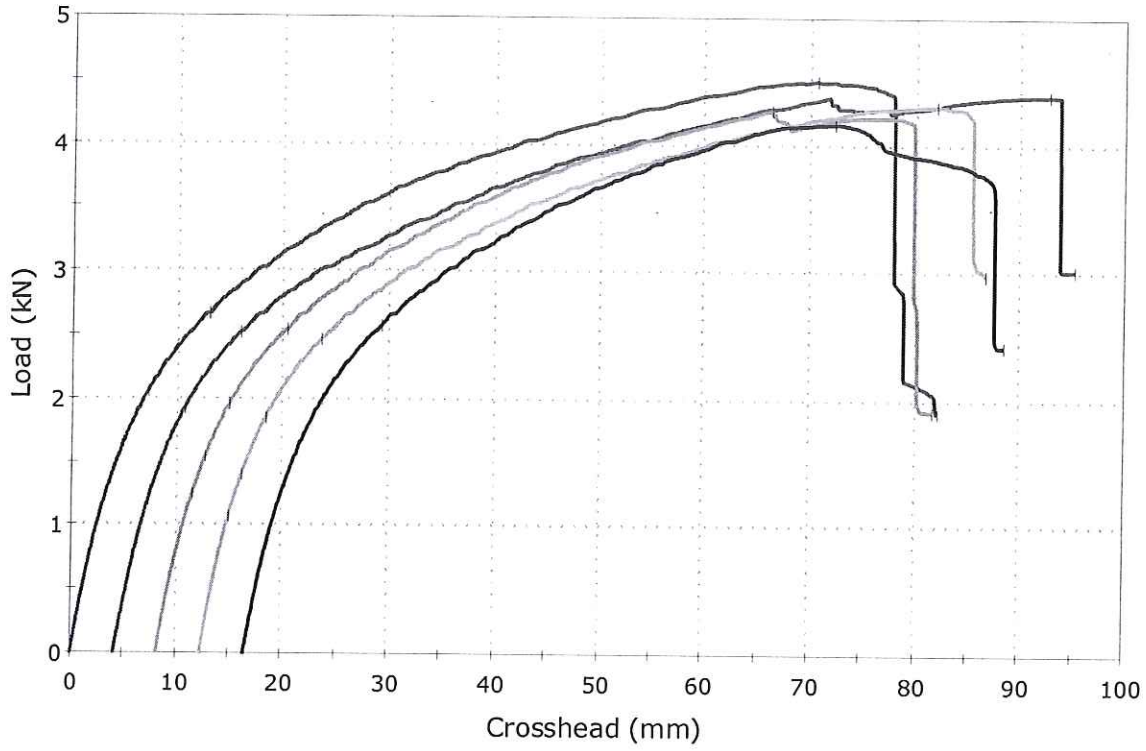


	max. Load (kN)	Fm (kN/m)	Am (%)	Test speed (%/min)
1	4,86	24,32	33,28	17,00
2	5,41	27,07	35,42	19,15
3	4,50	22,49	38,43	21,39
4	4,52	22,61	36,02	20,82
5	4,32	21,60	39,21	20,76
Mean	4,72	23,62	36,47	19,82
Standard deviation	0,43	2,16	2,39	1,79
Coef. of variation	9,16	9,16	6,54	9,02

Kiwa GmbH - TBU

Test standard:	DIN EN ISO 10319 (09.2015)
Order number:	1.1/13525/0036.0.1-2016
Customer:	Dörken GmbH & Co. KG
Material:	DELTA GEO DRAIN Quattro
Test direction:	CMD
Climate:	23°C / 49% rel. humidity
Date:	04.03.2016
Tester:	FD
Machine:	Instron 5567
Load cell:	30 kN
Extensometer (path):	standard Video Extensometer, Type 2663-822
Pre-load:	1% of Fmax.
Clamping system:	M-50-HJ-ME-2XL (100mm x 240mm)
Specimen width:	200,0 mm
LE:	100,0 mm
Remarks:	coated nonwoven to extensometer
Test condition:	dry

DIN EN ISO 10319



	max. Load (kN)	Fm (kN/m)	Am (%)	Test speed (%/min)
1	4,50	22,51	57,46	20,35
2	4,39	21,94	86,21	22,57
3	4,27	21,35	49,60	21,35
4	4,31	21,54	62,59	21,62
5	4,16	20,82	47,94	20,38
Mean	4,33	21,63	60,76	21,25
Standard deviation	0,13	0,63	15,42	0,93
Coef. of variation	2,93	2,93	25,38	4,37

Determination of the resistance to weathering
DIN EN 12224 (11.2000)

Test Report No. : **1.1/13525/0036.0.1-2016** Date: 24.05.2016
Company : **Dörken GmbH & Co. KG**
Material : **DELTA GEO DRAIN Quattro**
Operator : **hs/fd**

Test parameters

Weathering Tester	: UV tester, Type QUV / SPRAY
Luminous intensity	: 50 MJ/m²
Test cycle	: 5 h drycycle (50 ± 3 °C) 1 h wettcycle (25 ± 3°C black sensor panel)
Number of cycles	: 71
Test direction	: MD (machine direction) /CMD (cross machine direction)
Size of specimen	: MD: 60 x 300 mm /CMD: 60 x 300 mm
Duration	: 424 h (04-Apr-16 to 22-Apr-16)
Test method	: DIN EN ISO 10319 (09.2015)
Evaluation	: DIN EN 12226 (03.2012)

Results

MD Specimen No.		Tensile strength in N		Strain at max. Force in %	
		ref. specimen	exp. specimen	ref. specimen	exp. specimen
1		1190	830	41,9	23,0
2		1330	780	39,8	9,5
3		1150	820	40,5	40,1
4		1320	760	35,5	5,3
5		1190	810	34,7	14,3
Mean	$\bar{x}$	**1236**	**800**	**38,5**	**18,4**
Standard deviation	**s**	**82,9**	**29,2**	**3,19**	**13,79**
Coefficient of variation	**v**	**6,7%**	**3,6%**	**8,3%**	**74,8%**
residual strength/strain	**%**	**64,7**		**48,0**	

CMD Specimen No.		Tensile strength in N		Strain at max. Force in %	
		ref. specimen	exp. specimen	ref. specimen	exp. specimen
1		930	910	52,1	18,7
2		980	780	36,0	19,6
3		920	830	59,5	22,4
4		880	810	37,2	21,8
5		1010	880	62,6	23,9
Mean	$\bar{x}$	**944**	**842**	**49,5**	**21,3**
Standard deviation	**s**	**51,3**	**52,6**	**12,35**	**2,13**
Coefficient of variation	**v**	**5,4%**	**6,3%**	**25,0%**	**10,0%**
residual strength/strain	**%**	**89,2**		**43,0**	

Note : -

Combined durability test constisting of
Screening test method for determining the resistance to hydrolysis
DIN EN 12447 (03.2002)
and
Screening test method for determining the resistance to oxidation
DIN EN ISO 13438 (02.2005)

Test Report No. : **1.1/13525/0036.0.1-2016** Date: 15.06.2016
Company : **Dörken GmbH & Co. KG**
Material : **DELTA GEODRAIN Quattro**
Operator : **hs/ fd**

Test parameters

Test direction : MD (machine direction) and CMD (cross machine direction)
Size of specimen : 60 x 300 mm
Number of specimen : 5 reference (ref.) specimen in MD and CMD direction
5 exposed (exp.) specimen in MD and CMD direction
Raw material : PE / PP

Exposure conditions/ durations

Reference : no treatment
Test period 1 (DIN EN 12447) : Hydrolysis (deionised water, class 3)
Test temperature : 80 ± 1°C
Time of duration : 28 d (16.03.2016 - 13.04.2016)
Test period 2 (DIN EN ISO 13438) : Oxidation
Test temperature : 100 ± 1°C
Time of duration : 28 d (13.04.2016 - 11.05.2016)
Apparatus : Binder FED 115
Test method : DIN EN ISO 10319 (09.2015)
Evaluation : DIN EN 12226 (03.2012)

Results

Specimen No.	Tensile strength in N				Strain at max. tensile strength in %			
	Ref.	Exp.	Ref.	Exp.	Ref.	Exp.	Ref.	Exp.
	MD		CMD		MD		CMD	
1	1190	1280	930	1040	41,9	46,3	52,1	49,7
2	1330	1300	980	1140	39,8	45,9	36,0	59,9
3	1150	1390	920	1090	40,5	44,8	59,5	41,2
4	1320	1480	880	1090	35,5	42,3	37,2	47,9
5	1190	1190	1010	1170	34,7	40,0	62,6	47,9
Mean $\bar{x}$	1236	1328	944	1106	38,5	43,8	49,5	49,3
Standard deviation s	83	111	51	50	3,2	2,7	12,4	6,7
Coefficient of variation v	6,7%	8,3%	5,4%	4,5%	8,3%	6,1%	25,0%	13,7%
Residual strength/strain %	**107,4**		**117,2**		**114,0**		**99,7**	

Note : The test conditions (temperature and duration) were taken out of EN 13249 (annex B, durability aspects).

Combined durability test constisting of
Screening test method for determining the resistance to hydrolysis
DIN EN 12447 (03.2002)
and
Screening test method for determining the resistance to oxidation
DIN EN ISO 13438 (02.2005)

Test Report No. : **1.1/13525/0036.0.1-2016** Date: 15.06.2016
Company : **Dörken GmbH & Co. KG**
Material : **DELTA GEO DRAIN Quattro**
Operator : **hs/fd**

Test parameters

Test direction	: MD (machine direction) and CMD (cross machine direction)
Size of specimen	: 60 x 300 mm
Number of specimen	: 5 reference (ref.) specimen in MD and CMD direction
	5 exposed (exp.) specimen in MD and CMD direction
Raw material	: PE / PP

Exposure conditions/ durations

Reference	: no treatment
Test period 1 (DIN EN 12447)	: Hydrolysis (deionised water, class 3)
Test temperature	: 80 ± 1°C
Time of duration	: 28 d (16.03.2016 - 13.04.2016)
Test period 2 (DIN EN ISO 13438)	: Oxidation
Test temperature	: 100 ± 1°C
Time of duration	: 56 d (13.04.2016 - 08.06.2016)
Apparatus	: Binder FED 115
Test method	: DIN EN ISO 10319 (09.2015)
Evaluation	: DIN EN 12226 (03.2012)

Results

Specimen No.	Tensile strength in N				Strain at max. tensile strength in %			
	Ref.	Exp.	Ref.	Exp.	Ref.	Exp.	Ref.	Exp.
	MD		CMD		MD		CMD	
1	1190	1180	930	1000	41,9	38,7	52,1	45,4
2	1330	1180	980	1000	39,8	43,2	36,0	43,0
3	1150	1290	920	1010	40,5	47,4	59,5	44,2
4	1320	1260	880	990	35,5	43,4	37,2	56,0
5	1190	1210	1010	890	34,7	44,6	62,6	47,1
Mean $\bar{x}$	1236	1224	944	978	38,5	43,5	49,5	47,1
Standard deviation s	83	49	51	50	3,2	3,2	12,4	5,2
Coefficient of variation v	6,7%	4,0%	5,4%	5,1%	8,3%	7,3%	25,0%	11,0%
Residual strength/strain %	**99,0**		**103,6**		**113,0**		**95,2**	

Note : The test conditions (temperature and duration) were taken out of EN 13249 (annex B, durability aspects).

Combined durability test constisting of
Screening test method for determining the resistance to hydrolysis
DIN EN 12447 (03.2002)
and
Screening test method for determining the resistance to oxidation
DIN EN ISO 13438 (02.2005)

Test Report No. : **1.1/13525/0036.0.1-2016** Date: 10.08.2016
Company : **Dörken GmbH & Co. KG**
Material : **DELTA GEO DRAIN Quattro**
Operator : **hs/fd**

Test parameters

Test direction	: MD (machine direction) and CMD (cross machine direction)
Size of specimen	: 60 x 300 mm
Number of specimen	: 5 reference (ref.) specimen in MD and CMD direction
	5 exposed (exp.) specimen in MD and CMD direction
Raw material	: PE / PP

Exposure conditions/ durations

Reference	: no treatment
Test period 1 (DIN EN 12447)	: Hydrolysis (deionised water, class 3)
Test temperature	: 80 ± 1°C
Time of duration	: 28 d (16.03.2016 - 13.04.2016)
Test period 2 (DIN EN ISO 13438)	: Oxidation
Test temperature	: 100 ± 1°C
Time of duration	: 112 d (13.04.2016 - 03.08.2016)
Apparatus	: Binder FED 115
Test method	: DIN EN ISO 10319 (09.2015)
Evaluation	: DIN EN 12226 (03.2012)

Results

Specimen No.	Tensile strength in N				Strain at max. tensile strength in %			
	Ref.	Exp.	Ref.	Exp.	Ref.	Exp.	Ref.	Exp.
	MD		CMD		MD		CMD	
1	1190	1410	930	1110	41,9	41,9	52,1	56,0
2	1330	1230	980	1190	39,8	43,6	36,0	52,1
3	1150	1210	920	1050	40,5	34,2	59,5	45,4
4	1320	1310	880	1040	35,5	44,0	37,2	45,4
5	1190	1340	1010	1050	34,7	42,0	62,6	53,1
Mean $\bar{x}$	1236	1300	944	1088	38,5	41,1	49,5	50,4
Standard deviation s	83	82	51	63	3,2	4,0	12,4	4,8
Coefficient of variation v	6,7%	6,3%	5,4%	5,8%	8,3%	9,7%	25,0%	9,5%
Residual strength/strain %	**105,2**		**115,3**		**106,9**		**101,9**	

Note : The test conditions (temperature and duration) were taken out of EN 13249 (annex B, durability aspects).

Determination of water flow capacity in their plane
DIN EN ISO 12958 (08.2010)

Test Report No. : **1.1/13525/0036.0.1-2016** Date: 03.01.2017
Company : **Dörken GmbH & Co KG**
Material : **DELTA GEO DRAIN Quattro**
Operator : **bh**

Test parameters

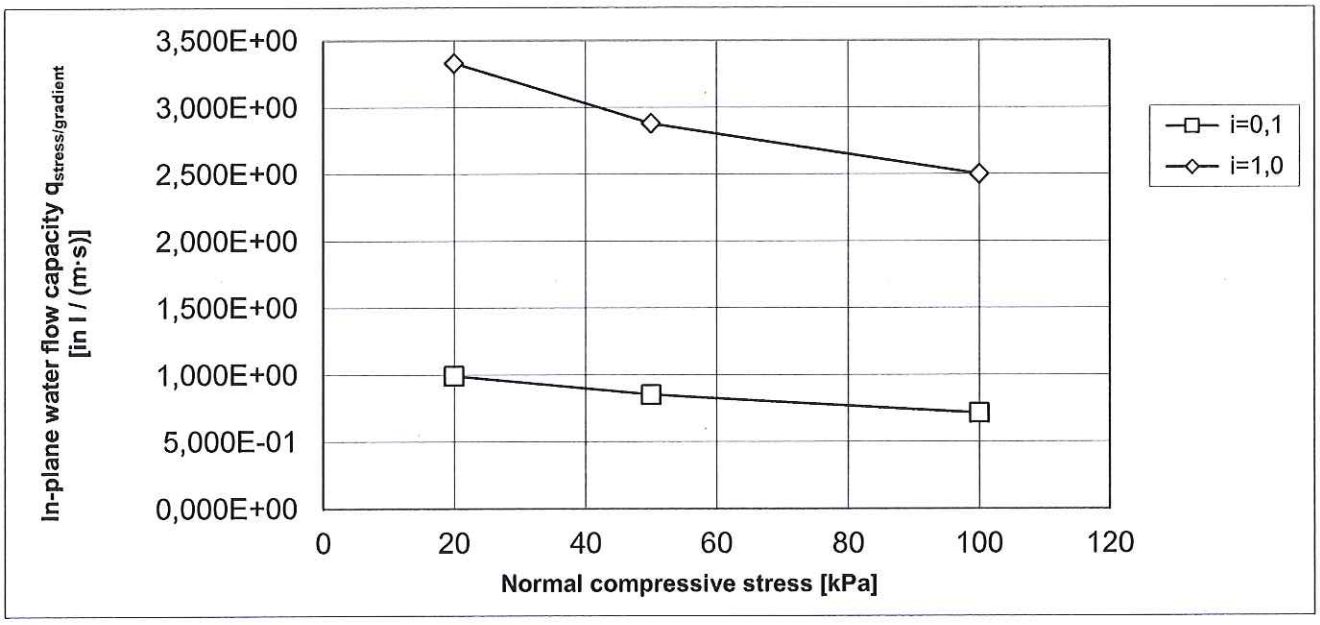
Normal compressive stress	: 20 kPa	50 kPa	100 kPa
Hydraulic gradient i	: 0,1	1,0	
Test direction	: MD		
Number of stacked specimens	: 1		
Contact surfaces	: rigid/soft		
Specimen L x B	: 300 mm x 200 mm		

MD - machine direction, CMD - cross machine direction

Results

Hydraulic gradient i	Test direction	Normal compressive stress [kPa] / Thickness (1 layer) [mm]			
		20 / -	50 / -	100 / -	- / -
		In-plane water flow capacity $q_{stress/gradient}$ [l / (m·s)]			
0,1	MD	9,93E-01	8,53E-01	7,14E-01	-
1,0		3,33E+00	2,88E+00	2,50E+00	-
		-	-	-	-

$1 m^2/s = 10^3$ l / (m · s)



Note: soft surface aligned to nonwoven