"Application of Geotextiles in Airport Paving"

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Abstract

This research is an attempt to produce fabric that used in airport paving. Two kinds of textile materials were used in this research (polyester and polypropylene) . Nonwoven construction was used for producing all samples. Some more results were reached concerns structures and materials for examples all samples have achieved expected results and sample was produced with polyester denier 6, puncture depth 12, 950 beats/min and weave bonding has achieved the best results.

I. Introduction

During the last three decades, textile has swept over new fields, specially in geotextiles. The expression Geotextiles refers to fabrics used in civil engineering which depend on joining between science of textile engineering, civil engineering and geo-engineering [(1)] which named as Geotextile. Geotextile are a member of a large family called geosynthetics and are defined by American Society for Testing Materials as " any permeable textile used mainly in civil engineering applications in conjunction with soil, rock, earth or other geotechnical engineering related material as an integral part of a manufactured project, structure or system".[(2)] These fabrics are mainly made of synthetic fibers , filaments, threads or tapes , and are constructed into woven , non woven or knitted fabrics .[(3,4)] Woven geotextiles , commonly are plain , basket, twill, satin, leno or triaxial weave , have high strength and high modulus in the principal directions, so they are preferred for many applications. The next major group of geotextiles is the nonwoven fabrics, which have enormous advantages. Unlike woven and nonwoven, knitted geotextiles involve interlocking a series of loops of yarn together. [(5)]

Geotextiles functions

In civil engineering structures a geotextiles perform mechanical functions such as separation, protection and reinforcement and hydraulic functions such as drainage and filtration either separately or simultaneously.

Application of Geotextiles

Geotextile play several important roles in hazardous or sanitary landfills, roads and airport paving, earth embankments, dams, coastline slope protection, streambed lining, sand and dune protection, foundation reinforcement, temporary walls, pipelines, erosion control structures, clay liners, reservoirs and tanks. Airport paving is considered one of the most important applications of geotextiles. Where geotextiles are placed between base course and sub-base course. [6-7] Because geotextiles are high tensile strength materials, and soil, in general are low tensile strength (but high compression strength) materials. Therefore geotextiles are ideal materials to increase soil quality and thus to increase soil structural stability, also geotextiles increase load –bearing capacity by providing tensile mechanism to the soil.

Airport paving

Airport pavements are designed to provide adequate support for the loads imposed by aircraft using that uses the airport. Airport paving must stability, durability and smoothness all year, all weather surfaces should be free from dust or particles and distribute. The pavement must be of adequate thickness and have sufficient stability.

The pavement structure consists of one or more layers of processed materials. Paving is divided, into two general types flexible and rigid. [8].

Flexible paving

This type consists a bituminous surface course, a base course of a suitable material, and usually a granular sub-base course. The design of flexible pavement is based on the results of sub-grade soil tests.

A flexible pavement consist of the following layers

1-surface course 2-base course 3-sub-base course .

Rigid paving

This type is made of Portland cement concrete, usually placed on a suitable sub-base course, which rests on a compacted sub grade [9]

II The experimental work

Two kinds of textile materials were used in this research, polyester and polypropylene fibers. Non woven construction was used for producing all samples, it depended on using cross- laid web with needle bonding and weave bonding processes for web bonding.

Table (1)
The specifications of the machine used for producing all samples

No	Property	Specifications
1	Model	ASSELIEN
2	Type	V 21
3	Company name	ASSELIEN
4	Year of manufacturing	1990
5	The manufactured country	France
6	Width of the machine	4 m

Table (2)
The specifications of samples, from 1 to 64 were produced in this research.

No	Property	Specifications
1	Type of fiber used	Polyester
2	Count of fiber	6 and 10 denier
3	Fiber length	64 mm
4	Web formation	Cross –laid
5	Web bonding	Needle and weave bonding
6	Weight (g/m^2)	600,900,1200 and 1500 (g/m^2)
7	Number of beats /min	650 and 950 beats /min
8	Puncture depth	8 and 12 mm

Table (3)
The specifications of samples, from 65 to 112 were produced in this research.

No	Property	Specifications
1	Type of fiber used	Polypropylene
2	Count of fiber	6 and 10 denier
3	Fiber length	64 mm
4	Web formation	Cross –laid
5	Web bonding	Needle and weave bonding
6	Weight (g/m^2)	600,900 and 1200 (g/m^2)
7	Number of beats /min	650 and 950 beats /min
8	Puncture depth	8 and 12 mm

Tests

In this part several tests were carried out in order to evaluate the produced fabrics, these tests were

The tensile strength of fabrics were determined according to the (ASTM-D 1682) (10)

The puncture strength of fabrics were determined according to the (ASTM-D 3787) (11)

The load dynamic of fabrics were determined according to the ISO 2094 & BS 4052 (12)

The tear strength of fabrics were determined according to the (ASTM.-D 4533) (13)

III-Results and Discussion

Results of experimental examination on the produced samples are presented in the following table and graphs. Results were statically analyzed for data listed.

Table (4) The results of the tests applied to the all samples

Tests	Load dynamic						Tensile strength				Elongation %				Punctur strength	
	Without load	With load	Compressibility ratio	Without load	With load	Compressibility ratio	Cross-machine direction		Machine direction		Cross-machine direction		Machine direction			
Number of beats /min	650			950			650	950	650	950	650	950	650	950	650	950
Weight / m^2	**Polyester denier 6 ,puncture depth 12, with needle bonding**															
600	5.14	4.42	14.007	4.58	3.65	20.30568	220	222	238	247	118	110	99	92	62	66
900	5.97	4.96	16.91792	5.81	4.98	14.28571	249	256	260	269	105	95	87	75	79	85
1200	6.9	5.88	14.78261	6.00	5.14	14.33333	305	317	319	326	99	87	74	71	—	—
1500	8.14	7.16	12.03931	7.96	6.92	13.06533	345	361	357	371	86	74	69	61	—	—
	Polyester denier 6 ,puncture depth 8, with needle bonding															
600	5.58	4.72	15.41219	5.21	4.63	11.13244	214	218	231	243	122	119	114	109	59	63
900	6.81	5.95	12.62849	5.98	5.12	14.38127	228	235	245	251	109	97	84	79	75	81
1200	7.63	6.41	15.98952	7.36	6.02	18.20652	244	256	297	299	102	83	77	73	—	—
1500	8.83	7.82	11.43828	8.24	7.12	13.59223	298	322	330	336	99	78	72	68	—	—
Polyester denier 10,puncture depth 12, with needle bonding																
600	5.51	4.63	15.97096	4.91	4.05	17.51527	209	216	226	239	129	124	116	111	60	64
900	6.71	5.96	11.17735	5.96	4.99	16.27517	225	229	237	244	111	107	103	101	77	83
1200	7.62	6.42	15.74803	6.56	5.78	11.89024	241	251	284	292	105	104	98	99	—	—
1500	8.25	7.13	13.57576	7.9	6.81	13.79747	296	311	326	330	97	95	93	88	—	—
Polyester denier 10 ,puncture depth 8, with needle bonding																
600	5.97	4.53	24.1206	5.27	4.68	11.19545	204	212	221	230	130	130	117	112	57	60
900	6.78	6.11	9.882006	6.31	5.52	12.51981	220	226	233	240	114	110	105	106	71	78
1200	8.25	7.52	8.848485	6.98	5.56	20.34384	239	248	276	282	107	105	103	101	—	—
1500	8.68	7.91	8.870968	7.73	6.24	19.27555	287	301	306	314	100	98	95	92	—	—
Polyester denier 6 ,puncture depth 12, with weave bonding																
600	5.87	5.13	12.60647	4.97	4.15	16.49899	234	246	275	295	111	103	93	86	87	94
900	6.83	6.11	10.54173	6.51	5.27	19.04762	267	281	301	319	99	88	81	72	—	—
1200	7.20	6.44	10.55556	6.92	6.10	11.84971	318	336	354	373	94	76	71	64	—	—
1500	8.95	8.01	10.50279	8.54	7.28	6.557377	365	379	394	406	81	71	65	55	—	—
Polyester denier 6 ,puncture depth 8, with weave bonding																
600	5.96	5.16	13.42282	5.62	4.85	13.70107	229	237	251	259	113	107	98	92	82	90
900	7.89	7.08	10.26616	7.32	6.56	10.38251	265	274	296	299	106	93	80	78	99	—
1200	8.72	7.84	10.09174	8.13	7.74	4.797048	297	312	331	345	100	82	72	70	—	—
1500	9.67	8.86	8.376422	9.45	8.86	7.830688	311	341	357	382	81	75	67	65	—	—
Polyester denier 10 ,puncture depth 12, with weave bonding																
600	6.79	5.99	11.78203	6.14	5.39	12.21498	225	231	243	286	115	107	102	94	81	88
900	7.98	6.98	12.53133	7.47	6.78	9.236948	255	269	286	302	105	99	91	86	93	98
1200	8.68	7.55	13.01843	7.76	5.99	22.80928	290	316	332	346	92	89	82	81	—	—
1500	9.87	8.94	9.422492	8.92	7.76	13.00448	311	325	338	386	87	81	77	73	—	—

Polyester denier 10 ,puncture depth 8, with weave bonding															
600	7.02	6.23	11.25356	6.98	6.12	12.32092	219	224	232	271	117	111	106	99	77	83
900	7.26	6.67	8.126722	6.87	5.99	12.80932	246	251	264	284	108	103	96	92	89	92
1200	8.55	7.62	10.87719	8.1	7.23	10.74074	281	297	318	330	98	94	87	85	—	—
1500	9.25	8.37	9.513514	8.92	8.3	6.950673	302	308	336	361	92	84	80	78	—	—
	Polypropylene denier 6 ,puncture depth 12, with needle bonding														
900	5.35	4.25	20.56075	5.11	4.32	15.45988	237	242	249	256	116	104	89	83	76	81
1200	6.53	5.69	12.86371	6.10	5.46	10.4918	295	304	312	319	108	96	84	79	95	98
1500	7.98	6.83	14.41103	7.23	6.17	14.66113	319	330	346	366	91	82	75	68	—	—
Polypropylene denier 6 ,puncture depth 8, with needle bonding															
900	6.01	5. 53	7.92	5.74	4.96	13.58885	220	229	238	244	129	126	116	112	72	78
1200	6.95	5.91	14.96403	6.94	5.91	14.8415	240	252	286	291	107	102	96	89	91	93
1500	8.14	7.33	9.95086	7.99	7.04	11.88986	291	314	317	324	101	86	79	71	—	—
Polypropylene denier 10 ,puncture depth 12, with needle bonding															
900	6.13	5.46	10.92985	5.54	4.57	17.50903	215	217	231	239	119	112	108	104	74	80
1200	7.03	6.24	11.23755	6.32	5.63	10.91772	229	241	253	276	110	107	106	101	92	95
1500	7.96	7.00	12.0603	7.39	6.28	15.0203	288	294	308	315	104	99	96	95	—	—
Polypropylene denier 10 ,puncture depth 8, with needle bonding															
900	6.51	5.62	13.67127	6.37	5.45	14.4427	211	223	228	234	121	117	112	109	69	72
1200	7.11	6.34	10.82982	6.66	5.78	13.21321	225	246	265	266	113	110	108	104	88	92
1500	8.35	7.39	11.49701	7.27	6.81	6.327373	268	274	300	307	108	101	98	96	—	—
Polypropylene denier 6 ,puncture depth 12, with weave bonding															
900	6.44	5.52	14.28571	6.11	5.23	14.40262	267	279	296	298	106	98	89	80	99	—
1200	6.97	6.12	12.19512	6.65	5.84	12.18045	321	327	331	346	100	85	82	76	—	—
1500	8.85	6.83	22.82486	8.31	7.25	12.75572	334	376	381	395	85	76	71	66	—	—
Polypropylene denier 6 ,puncture depth 8, with weave bonding															
900	7.46	6.35	14.87936	7.13	6.32	11.36045	261	272	289	294	109	99	95	87	96	99
1200	8.14	7.22	11.30221	7.96	7.00	12.0603	273	301	320	333	103	89	82	79	—	—
1500	9.15	8.26	9.726776	8.83	7.89	10.64553	298	324	342	375	91	78	76	69	—	—
Polypropylene denier 10 ,puncture depth 12, with weave bonding															
900	7.61	6.92	9.067017	7.38	6.64	10.0271	244	265	271	293	109	103	99	95	90	95
1200	8.12	7.24	10.83744	7.72	6.81	11.78756	286	301	315	332	98	92	92	87	98	—
1500	9.05	8.21	9.281768	8.56	7.64	10.74766	306	314	322	369	91	86	86	80	—	—
Polypropylene denier 10 ,puncture depth 12, with weave bonding															
900	8.13	7.45	8.364084	7.34	6.66	9.264305	240	245	259	273	111	106	102	101	87	91
1200	8.70	7.57	12.98851	7.91	7.00	11.50442	278	286	306	315	102	97	95	90	94	99
1500	9.07	8.27	8.8202	8.51	7.77	8.9656	296	309	317	352	84	88	89	82	—	—

Through this research, it was reached to the following results

1- It can be seen from the table (4) and figures from (1) to (6) that the more number of beats/min and puncture depth, the higher tensile strength and puncture strength the samples become. I can report that the increase in these factors increase friction areas which increase the consistence between the fibers by needle stress which increase the cutoff durability

2- It is obvious from the statistical analysis of the tensile strength and puncture strength results that there are direct relationship between fibers count, weight per m2 and tensile strength and puncture strength .I can state that the increase fibers in unit area, as well as cohesion spaces between fibers cause cutoff resistance

3-It is also clear that from the table (4) and diagrams from (9) to (10) that samples used weave bonding had recorded the highest rates of tensile strength and puncture strength, whereas samples used needle bonding have recorded the lowest rates. I can report that samples used weave bonding are considered a composite fabrics which have high durability.

4-It is also clear that from table (4) that an inverse relationship between fibers count, number of beats /min and puncture depth and the decrease ratio in fabric thickness, I can report that the increase in these factors cause the fabric to be more compacted which cause the decreasing in the fabric thickness under load.

5-It is also obvious from table (4) and diagram (11) that samples used the needle bonding have recorded the highest rates of compressibility under load, whereas samples used the weave bonding have the lowest rates .I can state that samples used weave bonding are composed fabric which cause decrease compressibility under load

6-It is also obvious from the statistical analysis that tensile strength in machine direction is higher than the tensile strength in cross machine direction. This is due to that carding machine make fibers straight in machine direction which cause an increase in the friction between fibers.

7-It can be seen from table (4) and figures (3) and (5) that the more number of beats/min and puncture depth, the lower elongation the samples become. I can report that the increase in these factors increase friction areas which increase the consistence between the fibers by needle stress to which cause decrease the elongation

8- It is obvious from the statical analysis of the elongation results that there are an inverse relationship between fibers count and weight /m^2 .I can state that the increase fibers in unit area, as well as cohesion spaces between fibers cause decrease the elongation

9-It is also clear that from the table (4) and diagram (10)that samples used weave bonding have recorded the lowest rates of elongation, whereas the samples made with needle bonding have recorded the highest rates. I can report that samples used weave bonding are considered a composite fabrics which have high durability.

10-It is also clear that from the figure (12) that sample produced with polyester denier 6, puncture depth 12, 950 beats/min and weave bonding has achieved the best results by Radar analysis (samples no 20)

11-Table (5) shows F test for all variables. It clear from this table polyester samples, that number of beat /min, weight /m^2 ,puncture depth , fibers count and bonding method, had a highly significant effect on fabrics properties ,as shown from α 1 to α 18 (α=>0.01). Polypropylene samples that fibers count, weight /m^2 and bonding method, had a highly significant effect on fabrics properties ,as shown from α 25 to α 30 (α=>0.01), whereas puncture depth and number of beats/min had a significant effect on fabrics properties ,as shown, from α 19 to α 24 (α=< 0.01).

12-All samples not tear and some samples not puncture as shown in table 4 (-)

Table (5)
F test for all variables were used in this research

No	F test	No	F test	No	F test
α 1	0.009094	**α 11**	0.002678	**α 21**	0.027664
α 2	0.009945	**α 12**	0.002869	**α 22**	0.050943
α 3	0.007285	**α 13**	0.003369	**α 23**	0.029319
α 4	0.008572	**α 14**	0.004118	**α 24**	0.031589
α 5	0.000143	**α 15**	0.000103	**α 25**	0.002752
α 6	0.000125	**α 16**	0.000199	**α 26**	0.001429
α 7	0.000137	**α 17**	0.009893	**α 27**	0.001341
α 8	0.000199	**α 18**	0.00311	**α 28**	0.000467
α 9	0.000108	**α 19**	0.016842	**α 29**	0.001118
α 10	0.000133	**α 20**	0.031589	**α 30**	0.001487

Table (6)
Shows regression equation and correlation coefficient for effect of weight /m^2 , bonding method, and number of beats /min on tensile strength and elongation for produced fabrics .

No	The variables	Regression equation	Correlation coefficient
Figure 4	650 beats/min	Y1 = 212.8+129X	0.99
	950 beats/min	Y 2= 187.5+137 X	0.99
Figure 5	650 beats/min	Y1 = -104.6-0.034 X	-0.99
	950 beats/min	Y2= -110.4-0.031 X	-0.98
Figure 9	Needle bonding	Y1 = 163.6+-0.098 X	0.97
	Weave bonding	Y 2= 200.009+105 X	0.98
Figure 10	Needle bonding	Y1= -131.67-0.038 X	-0.99
	Weave bonding	Y2 = -112-0.027 X	-097

Table (7)

Shows multi regression equation for effect of number of beats /min, fiber count , puncture depth and weight /m^2 ,on tensile strength and elongation for produced fabrics .

No	Multi regression equation
Figure 1	Z= 86.296+0.016X+0.734Y
Figure 2	Z = 236.78+0.27X-0.47Y
Figure 3	Z = -139.161-0.079 X-0.122Y+6.667-6XY
Figure 6	Z = 20.768+0.038X+38.459Y+0.001Y- 1.902Y^2
Figure 7	Z = -88.097+0.027X-6.97Y+0.002XY+0.613Y^2
Figure 8	Z =-122.525-0.087X+2.538Y+0.001XY-0.032Y^2

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