Appendix-I

Table 1: Kapok fibre nonwoven fabric - Design of Experiment (RSM - CCD)

Sr. No	**Sample Code**	**Blend % (Kapok / Modal)**	**Carded Web Mass (g/m^2)**	**Stroke Frequency (/Min)**	**Needle Depth (mm)**
1	K1	50/50	400	150	10
2	K2	40/60	300	200	7.5
3	K3	40/60	500	200	7.5
4	K4	60/40	300	200	7.5
5	K5	60/40	500	200	7.5
6	K6	40/60	300	200	12.5
7	K7	40/60	500	200	12.5
8	K8	60/40	300	200	12.5
9	K9	60/40	500	200	12.5
10	K10	50/50	400	250	5
11	K11	30/70	400	250	10
12	K12	50/50	200	250	10
13	K13	50/50	400	250	10
14	K14	50/50	400	250	10
15	K15	50/50	400	250	10
16	K16	50/50	400	250	10
17	K17	50/50	400	250	10
18	K18	50/50	400	250	10
19	K19	50/50	400	250	10
20	K20	50/50	600	250	10
21	K21	70/30	400	250	10
22	K22	50/50	400	250	15

Table 1: Kapok fibre nonwoven fabric - Design of Experiment (RSM - CCD)

Sr. No	**Sample Code**	**Blend % (Kapok / Modal)**	**Carded Web Mass (g/m^2)**	**Stroke Frequency (/Min)**	**Needle Depth (mm)**
23	K23	40/60	300	300	7.5
24	K24	40/60	500	300	7.5
25	K25	60/40	300	300	7.5
26	K26	60/40	500	300	7.5
27	K27	40/60	300	300	12.5
28	K28	40/60	500	300	12.5
29	K29	60/40	300	300	12.5
30	K30	60/40	500	300	12.5
31	K31	50/50	400	350	10

Table 2: Sound absorption coefficient value of Kapok samples

Sr. No	**Sample Code**	**Sound Absorption Coefficient Value (α) at different Frequency**								
		250 Hz	**500 Hz**	**1000 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**	**5000 Hz**	**6300 Hz**
1	K1	0.01	0.20	0.19	0.37	0.50	0.61	0.72	0.74	0.78
2	K2	0.01	0.04	0.13	0.28	0.37	0.53	0.54	0.57	0.63
3	K3	0.03	0.07	0.18	0.35	0.47	0.59	0.63	0.69	0.74
4	K4	0.13	0.15	0.20	0.34	0.51	0.63	0.70	0.74	0.79
5	K5	0.15	0.22	0.28	0.45	0.51	0.66	0.74	0.81	0.86
6	K6	0.01	0.05	0.15	0.29	0.39	0.54	0.55	0.59	0.65
7	K7	0.05	0.08	0.18	0.38	0.50	0.61	0.65	0.71	0.78
8	K8	0.13	0.17	0.19	0.31	0.51	0.67	0.71	0.77	0.81
9	K9	0.17	0.21	0.29	0.41	0.53	0.69	0.80	0.83	0.87
10	K10	0.15	0.20	0.27	0.40	0.51	0.57	0.69	0.73	0.75
11	K11	0.02	0.05	0.18	0.36	0.50	0.59	0.62	0.65	0.72
12	K12	0.01	0.18	0.20	0.29	0.49	0.53	0.65	0.69	0.73

Table 2: Sound absorption coefficient value of Kapok samples

Sr. No	**Sample Code**	**Sound Absorption Coefficient Value** (α) **at different Frequency**								
		250 Hz	**500 Hz**	**1000 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**	**5000 Hz**	**6300 Hz**
13	K13	0.18	0.23	0.32	0.53	0.50	0.65	0.74	0.77	0.79
14	K14	0.17	0.25	0.33	0.51	0.53	0.65	0.76	0.77	0.87
15	K15	0.19	0.23	0.33	0.53	0.52	0.67	0.77	0.78	0.85
16	K16	0.18	0.25	0.27	0.52	0.54	0.65	0.79	0.80	0.81
17	K17	0.15	0.24	0.29	0.54	0.58	0.63	0.79	0.79	0.81
18	K18	0.17	0.23	0.27	0.51	0.53	0.69	0.74	0.78	0.85
19	K19	0.18	0.25	0.33	0.51	0.52	0.68	0.76	0.81	0.87
20	K20	0.20	0.26	0.34	0.55	0.57	0.69	0.81	0.83	0.89
21	K21	0.27	0.34	0.49	0.57	0.67	0.82	0.85	0.89	0.93
22	K22	0.18	0.24	0.33	0.51	0.53	0.68	0.75	0.80	0.84
23	K23	0.02	0.06	0.16	0.31	0.40	0.55	0.57	0.63	0.69
24	K24	0.04	0.09	0.19	0.42	0.51	0.64	0.71	0.73	0.80
25	K25	0.16	0.19	0.29	0.40	0.52	0.69	0.74	0.79	0.82
26	K26	0.20	0.23	0.30	0.50	0.54	0.69	0.77	0.84	0.89
27	K27	0.02	0.07	0.17	0.33	0.41	0.57	0.59	0.67	0.71
28	K28	0.07	0.10	0.21	0.44	0.52	0.67	0.75	0.76	0.78
29	K29	0.20	0.21	0.30	0.50	0.57	0.71	0.78	0.82	0.83
30	K30	0.21	0.24	0.33	0.54	0.59	0.76	0.84	0.88	0.91
31	K31	0.19	0.25	0.34	0.53	0.55	0.67	0.78	0.80	0.85

Table 3: Milkweed fibre nonwoven fabric- Design of Experiment (RSM - CCD)

Sr. No	**Sample Code**	**Blend % (Milkweed / Modal)**	**Carded Web Mass (g/m^2)**	**Stroke Frequency (/Min)**	**Needle Depth (mm)**
1	M1	50/50	400	150	10
2	M2	40/60	300	200	7.5

Table 3: Milkweed fibre nonwoven fabric- Design of Experiment (RSM - CCD)

Sr. No	**Sample Code**	**Blend % (Milkweed / Modal)**	**Carded Web Mass (g/m^2)**	**Stroke Frequency (/Min)**	**Needle Depth (mm)**
3	M3	40/60	500	200	7.5
4	M4	60/40	300	200	7.5
5	M5	60/40	500	200	7.5
6	M6	40/60	300	200	12.5
7	M7	40/60	500	200	12.5
8	M8	60/40	300	200	12.5
9	M9	60/40	500	200	12.5
10	M10	50/50	400	250	5
11	M11	30/70	400	250	10
12	M12	50/50	200	250	10
13	M13	50/50	400	250	10
14	M14	50/50	400	250	10
15	M15	50/50	400	250	10
16	M16	50/50	400	250	10
17	M17	50/50	400	250	10
18	M18	50/50	400	250	10
19	M19	50/50	400	250	10
20	M20	50/50	600	250	10
21	M21	70/30	400	250	10
22	M22	50/50	400	250	15
23	M23	40/60	300	300	7.5
24	M24	40/60	500	300	7.5
25	M25	60/40	300	300	7.5
26	M26	60/40	500	300	7.5
27	M27	40/60	300	300	12.5
28	M28	40/60	500	300	12.5
29	M29	60/40	300	300	12.5

Table 3: Milkweed fibre nonwoven fabric- Design of Experiment (RSM - CCD)

Sr. No	**Sample Code**	**Blend % (Milkweed / Modal)**	**Carded Web Mass (g/m^2)**	**Stroke Frequency (/Min)**	**Needle Depth (mm)**
30	M30	60/40	500	300	12.5
31	M31	50/50	400	350	10

Table 4: Sound absorption coefficient value of Estabragh (Milkweed) samples

Sr. No.	**Sample Code**	**Sound Absorption Coefficient Value (α) at different Frequency**								
		250 Hz	**500 Hz**	**1000 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**	**5000 Hz**	**6300 Hz**
1	M1	0.07	0.10	0.15	0.23	0.41	0.48	0.56	0.70	0.80
2	M2	0.05	0.06	0.15	0.20	0.34	0.46	0.51	0.64	0.76
3	M3	0.06	0.09	0.16	0.24	0.40	0.49	0.59	0.70	0.77
4	M4	0.07	0.05	0.14	0.21	0.35	0.54	0.58	0.65	0.75
5	M5	0.10	0.14	0.23	0.32	0.49	0.62	0.65	0.77	0.84
6	M6	0.06	0.06	0.16	0.22	0.38	0.47	0.56	0.68	0.78
7	M7	0.09	0.11	0.18	0.24	0.41	0.50	0.60	0.71	0.79
8	M8	0.09	0.10	0.18	0.28	0.43	0.57	0.60	0.68	0.80
9	M9	0.11	0.17	0.25	0.34	0.50	0.68	0.68	0.79	0.89
10	M10	0.06	0.09	0.11	0.23	0.40	0.53	0.59	0.71	0.81
11	M11	0.03	0.05	0.11	0.19	0.31	0.45	0.53	0.60	0.71
12	M12	0.02	0.07	0.12	0.18	0.34	0.44	0.51	0.64	0.74
13	M13	0.10	0.12	0.16	0.26	0.44	0.50	0.62	0.76	0.83
14	M14	0.09	0.11	0.17	0.26	0.47	0.49	0.64	0.75	0.85
15	M15	0.07	0.11	0.16	0.27	0.41	0.48	0.65	0.77	0.81
16	M16	0.06	0.10	0.14	0.25	0.43	0.50	0.62	0.78	0.83
17	M17	0.07	0.12	0.14	0.28	0.41	0.51	0.61	0.74	0.84
18	M18	0.07	0.10	0.17	0.27	0.44	0.50	0.64	0.72	0.83
19	M19	0.09	0.11	0.13	0.24	0.44	0.51	0.63	0.76	0.85

Table 4: Sound absorption coefficient value of Estabragh (Milkweed) samples

Sr. No.	**Sample Code**	**Sound Absorption Coefficient Value** (α) **at different Frequency**								
		250 Hz	**500 Hz**	**1000 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**	**5000 Hz**	**6300 Hz**
20	M20	0.17	0.20	0.26	0.36	0.56	0.63	0.74	0.82	0.91
21	M21	0.11	0.13	0.23	0.30	0.48	0.59	0.68	0.76	0.89
22	M22	0.11	0.13	0.19	0.24	0.43	0.51	0.63	0.75	0.84
23	M23	0.06	0.08	0.13	0.18	0.33	0.44	0.51	0.63	0.74
24	M24	0.08	0.10	0.18	0.27	0.44	0.51	0.62	0.73	0.80
25	M25	0.09	0.11	0.14	0.25	0.41	0.56	0.60	0.63	0.79
26	M26	0.14	0.18	0.24	0.36	0.50	0.68	0.69	0.80	0.90
27	M27	0.07	0.07	0.14	0.21	0.40	0.49	0.54	0.66	0.79
28	M28	0.07	0.10	0.17	0.25	0.40	0.51	0.61	0.73	0.81
29	M29	0.10	0.13	0.17	0.24	0.42	0.58	0.59	0.69	0.81
30	M30	0.16	0.21	0.28	0.37	0.52	0.69	0.70	0.81	0.93
31	M31	0.10	0.10	0.18	0.28	0.47	0.56	0.66	0.75	0.86

Appendix-II

Table:1 Kapok fibre nonwoven fabric physical properties

Sr. No	Sample Code	Fabric GSM (g/m^2)	Thickness (mm)	Air permeability ($m^3/m^2/hr$)	Porosity (%)
1	K1	331	3.47	350	89.45
2	K2	291	2.57	425	88.98
3	K3	459	4.05	220	88.98
4	K4	279	2.73	615	86.93
5	K5	487	4.17	310	85.05
6	K6	289	2.35	395	88.03
7	K7	455	3.90	390	88.66
8	K8	264	2.46	470	86.27
9	K9	469	3.89	260	84.56
10	K10	315	3.32	370	89.53
11	K11	342	3.81	360	92.21
12	K12	151	1.64	910	89.82
13	K13	330	3.86	450	90.57
14	K14	322	3.05	390	88.34
15	K15	373	3.27	360	87.40
16	K16	356	3.59	395	89.06
17	K17	300	3.11	340	89.33
18	K18	286	3.02	365	89.51
19	K19	350	3.49	470	88.91
20	K20	542	4.73	222	87.35
21	K21	358	3.46	590	84.30
22	K22	391	3.55	285	87.84

Table:1 Kapok fibre nonwoven fabric physical properties

Sr. No	Sample Code	Fabric GSM (g/m^2)	Thickness (mm)	Air permeability ($m^3/m^2/hr$)	Porosity (%)
23	K23	267	2.76	365	90.59
24	K24	459	4.64	220	90.38
25	K25	315	3.45	555	88.31
26	K26	469	4.61	295	86.99
27	K27	291	2.86	475	90.12
28	K28	482	4.79	215	90.20
29	K29	261	2.41	625	86.17
30	K30	474	4.35	300	86.08
31	K31	370	3.21	375	87.27

Table:2 Milkweed fibre nonwoven fabric physical properties

Sr. No	**Sample Code**	**Fabric GSM (g/m^2)**	**Thickness (mm)**	**Air permeability ($m^3/m^2/hr$)**	**Porosity (%)**
1	M1	328	3.31	445	91.81
2	M2	284	2.47	415	90.96
3	M3	438	3.75	325	90.81
4	M4	253	2.28	510	90.34
5	M5	391	3.52	315	90.32
6	M6	279	2.76	595	92.06
7	M7	390	3.61	350	91.50
8	M8	272	2.24	555	89.43
9	M9	419	3.83	335	90.47
10	M10	365	3.14	370	90.39
11	M11	378	3.10	405	90.86
12	M12	187	2.09	785	92.62
13	M13	354	3.09	510	90.51

Table:2 Milkweed fibre nonwoven fabric physical properties

Sr. No	**Sample Code**	**Fabric GSM** (g/m^2)	**Thickness (mm)**	**Air permeability** ($m^3/m^2/hr$)	**Porosity (%)**
14	M14	366	3.65	355	91.71
15	M15	348	3.31	335	91.30
16	M16	372	3.45	335	91.10
17	M17	345	3.34	425	91.45
18	M18	355	3.43	370	91.44
19	M19	370	3.66	375	91.66
20	M20	490	4.78	265	91.53
21	M21	351	3.32	340	90.25
22	M22	360	3.01	530	90.13
23	M23	296	2.99	440	92.21
24	M24	502	4.25	320	90.72
25	M25	283	2.33	545	89.42
26	M26	409	3.83	350	90.70
27	M27	284	2.89	515	92.27
28	M28	427	3.82	325	91.20
29	M29	275	2.51	560	90.46
30	M30	381	3.61	415	90.82
31	M31	338	2.72	635	89.72

Appendix-III

Regression Analysis:

Table:1 Estimated regression coefficient and corresponding p-value for kapok fibre non-woven fabric

Term	Coef	SE Coef	T Value	P Value
Constant	0.5354	0.00428	125.06	< 0.001
X_1	0.11694	0.00462	25.29	< 0.001
X_2	0.06824	0.00462	14.76	< 0.001
X_3	0.04509	0.00462	9.75	< 0.001
X_4	0.02472	0.00462	5.35	< 0.001
X_5				
250	-0.36849	0.00575	-64.04	< 0.001
500	-0.31269	0.00575	-54.34	< 0.001
1000	-0.23366	0.00575	-40.61	< 0.001
2000	-0.05785	0.00575	-10.05	< 0.001
2500	0.01989	0.00575	3.46	0.001
3150	0.15183	0.00575	26.39	< 0.001
4000	0.22634	0.00575	39.34	< 0.001
5000	0.26409	0.00575	45.89	< 0.001
$X_1 * X_1$	-0.03517	0.00847	-4.15	< 0.001
$X_2 * X_2$	-0.06905	0.00847	-8.15	< 0.001
$X_3 * X_3$	-0.05961	0.00847	-7.04	< 0.001
$X_4 * X_4$	-0.05683	0.00847	-6.71	< 0.001
$X_1 * X_2$	-0.0308	0.0113	-2.72	0.007
$X_1 * X_3$	0.0136	0.0113	1.2	0.231
$X_1 * X_4$	0.0064	0.0113	0.56	0.573

Term	Coef	SE Coef	T Value	P Value
X_1 * X_5				
250	0.0164	0.0131	1.25	0.212
500	0.0197	0.0131	1.51	0.133
1000	0.0022	0.0131	0.17	0.865
2000	-0.0278	0.0131	-2.12	0.035
2500	-0.0294	0.0131	-2.25	0.025
3150	-0.0119	0.0131	-0.91	0.362
4000	0.0122	0.0131	0.93	0.351
5000	0.0172	0.0131	1.32	0.189
X_2 * X_3	-0.0042	0.0113	-0.37	0.713
X_2 * X_4	0.0042	0.0113	0.37	0.713
X_2 * X_5				
250	-0.0166	0.0131	-1.27	0.206
500	-0.0299	0.0131	-2.29	0.023
1000	-0.0141	0.0131	-1.08	0.283
2000	0.0359	0.0131	2.75	0.007
2500	-0.0141	0.0131	-1.08	0.283
3150	-0.0066	0.0131	-0.5	0.616
4000	0.0176	0.0131	1.35	0.18
5000	0.0109	0.0131	0.84	0.404
X_3 * X_4	0.0131	0.0113	1.15	0.25
X_4 * X_5				
250	0.0049	0.0131	0.38	0.708
500	-0.0201	0.0131	-1.54	0.126
1000	0.0091	0.0131	0.69	0.489
2000	0.0341	0.0131	2.61	0.01
2500	-0.0143	0.0131	-1.09	0.277
3150	-0.0051	0.0131	-0.39	0.697
4000	0.0007	0.0131	0.06	0.955
5000	-0.0009	0.0131	-0.07	0.944
X_4 * X_5				

Term	Coef	SE Coef	T Value	P Value
250	-0.0097	0.0131	-0.74	0.458
500	-0.0114	0.0131	-0.87	0.385
1000	-0.0072	0.0131	-0.55	0.581
2000	0.0061	0.0131	0.47	0.641
2500	-0.0056	0.0131	-0.42	0.671
3150	0.0136	0.0131	1.04	0.299
4000	0.0078	0.0131	0.59	0.553
5000	0.0061	0.0131	0.47	0.641

Following equation indicate the regression equation of NAC (α) versus kapok fibre blend%, carded web mass, stroke frequency, needle depth and its interactive effect at a various frequency (Hz).

Regression equation of sound absorption coefficient at different frequency level

Frequency 250 Hz

$$\begin{aligned} NAC(\alpha) = & -1.497 + 0.01620X_1 + 0.002035X_2 + 0.002962X_3 + 0.0371X_4 \\ & - 0.000088X_1 * X_1 - 0.000002X_2 * X_2 - 0.000006X_3 * X_3 \\ & - 0.002273X_4 * X_4 - 0.000008X_1 * X_2 + 0.000007X_1 * X_3 \\ & + 0.000064X_1 * X_4 - 0.000000X_2 * X_3 + 0.000004X_2 * X_4 \\ & + 0.000026X_3 * X_4 \end{aligned} \tag{6.1}$$

Frequency 500 Hz

$$\begin{aligned} NAC(\alpha) = & -1.357 + 0.01637X_1 + 0.001969X_2 + 0.002712X_3 + 0.0367X_4 \\ & - 0.000088X_1 * X_1 - 0.000002X_2 * X_2 - 0.000006X_3 * X_3 \\ & - 0.002273X_4 * X_4 - 0.000008X_1 * X_2 + 0.000007X_1 * X_3 \\ & + 0.000064X_1 * X_4 - 0.000000X_2 * X_3 + 0.000004X_2 * X_4 \\ & + 0.000026X_3 * X_4 \end{aligned} \tag{6.2}$$

Frequency 1000 Hz

$$NAC(\alpha) = -1.347 + 0.01549X_1 + 0.002048X_2 + 0.003004X_3 + 0.0376X_4$$

$$
\begin{aligned}
&- \ 0.000088X_1 * X_1 - \ 0.000002X_2 * X_2 - \ 0.000006X_3 * X_3 \\
&- \ 0.002273X_4 * X_4 - \ 0.000008X_1 * X_2 + \ 0.000007X_1 * X_3 \\
&+ \ 0.000064X_1 * X_4 - \ 0.000000X_2 * X_3 + \ 0.000004X_2 * X_4 \\
&+ \ 0.000026X_3 * X_4
\end{aligned} \tag{6.3}
$$

Frequency 2000 Hz

$$
\begin{aligned}
NAC(\alpha) = &- 1.285 + 0.01399X_1 + 0.002298X_2 + \ 0.003254X_3 + \ 0.0402X_4 \\
&- \ 0.000088X_1 * X_1 - \ 0.000002X_2 * X_2 - \ 0.000006X_3 * X_3 \\
&- \ 0.002273X_4 * X_4 - \ 0.000008X_1 * X_2 + \ 0.000007X_1 * X_3 \\
&+ \ 0.000064X_1 * X_4 - \ 0.000000X_2 * X_3 + \ 0.000004X_2 * X_4 \\
&+ \ 0.000026X_3 * X_4
\end{aligned} \tag{6.4}
$$

Frequency 2500 Hz

$$
\begin{aligned}
NAC(\alpha) = &- 0.959 + 0.01391X_1 + 0.002048X_2 + \ 0.002771X_3 + \ 0.0379X_4 \\
&- \ 0.000088X_1 * X_1 - \ 0.000002X_2 * X_2 - \ 0.000006X_3 * X_3 \\
&- \ 0.002273X_4 * X_4 - \ 0.000008X_1 * X_2 + \ 0.000007X_1 * X_3 \\
&+ \ 0.000064X_1 * X_4 - \ 0.000000X_2 * X_3 + \ 0.000004X_2 * X_4 \\
&+ \ 0.000026X_3 * X_4
\end{aligned} \tag{6.5}
$$

Frequency 3150 Hz

$$
\begin{aligned}
NAC(\alpha) = &- 0.947 + 0.01478X_1 + 0.002085X_2 + \ 0.002862X_3 + \ 0.0417X_4 \\
&- \ 0.000088X_1 * X_1 - \ 0.000002X_2 * X_2 - \ 0.000006X_3 * X_3 \\
&- \ 0.002273X_4 * X_4 - \ 0.000008X_1 * X_2 + \ 0.000007X_1 * X_3 \\
&+ \ 0.000064X_1 * X_4 - \ 0.000000X_2 * X_3 + \ 0.000004X_2 * X_4 \\
&+ \ 0.000026X_3 * X_4
\end{aligned} \tag{6.6}
$$

Frequency 4000 Hz

$$
\begin{aligned}
NAC(\alpha) = &- 0.984 + 0.01599X_1 + 0.002206X_2 + \ 0.002921X_3 + \ 0.0406X_4 \\
&- \ 0.000088X_1 * X_1 - \ 0.000002X_2 * X_2 - \ 0.000006X_3 * X_3 \\
&- \ 0.002273X_4 * X_4 - \ 0.000008X_1 * X_2 + \ 0.000007X_1 * X_3
\end{aligned}
$$

$$+\ 0.000064X_1 * X_4 -\ 0.000000X_2 * X_3 +\ 0.000004X_2 * X_4$$
$$+\ 0.000026X_3 * X_4 \tag{6.7}$$

Frequency 5000 Hz

$$\begin{aligned} NAC(\alpha) = & -0.938 + 0.01624X_1 + 0.002173X_2 +\ 0.002904X_3 +\ 0.0402X_4 \\ & -\ 0.000088X_1 * X_1 -\ 0.000002X_2 * X_2 -\ 0.000006X_3 * X_3 \\ & -\ 0.002273X_4 * X_4 -\ 0.000008X_1 * X_2 +\ 0.000007X_1 * X_3 \\ & +\ 0.000064X_1 * X_4 -\ 0.000000X_2 * X_3 +\ 0.000004X_2 * X_4 \\ & +\ 0.000026X_3 * X_4 \end{aligned} \tag{6.8}$$

Frequency 6300 Hz

$$\begin{aligned} NAC(\alpha) = & -0.833 + 0.01545X_1\ + 0.002202X_2 +\ 0.002829X_3 + 0.0391X_4 \\ & -\ 0.000088X_1 * X_1 -\ 0.000002X_2 * X_2 -\ 0.000006X_3 * X_3 \\ & -\ 0.002273X_4 * X_4 -\ 0.000008X_1 * X_2 +\ 0.000007X_1 * X_3 \\ & +\ 0.000064X_1 * X_4 -\ 0.000000X_2 * X_3 +\ 0.000004X_2 * X_3 \\ & +\ 0.000026X_3 * X_4 \end{aligned} \tag{6.9}$$

Table:2 Estimated regression coefficient and corresponding p-value for physical properties of kapok fibre nonwoven fabric

Term	**Coef**	**SE Coef**	**T-Value**	***P*-Value**
Constant	0.5729	0.0182	31.4	<0.001
A	-0.1119	0.0851	-1.31	0.19
B	0.4364	0.0854	5.11	<0.001
C	0.3328	0.0692	4.81	<0.001
D	-0.1846	0.0256	-7.21	<0.001
E				
250	-0.378	0.0175	-21.62	<0.001
500	-0.312	0.0175	-17.84	<0.001
1000	-0.226	0.0175	-12.93	<0.001
2000	-0.0751	0.0175	-4.29	<0.001

Term	**Coef**	**SE Coef**	**T-Value**	***P*-Value**
2500	0.0348	0.0175	1.99	0.048
3150	0.1514	0.0175	8.66	<0.001
4000	0.2219	0.0175	12.69	<0.001
5000	0.2673	0.0175	15.29	<0.001
A*A	-0.923	0.284	-3.25	0.001
B*B	-0.86	0.186	-4.63	<0.001
C*C	0.3584	0.0786	4.56	<0.001
D*D	-0.1734	0.0336	-5.16	<0.001
A*B	1.881	0.491	3.83	<0.001
A*C	0.384	0.153	2.51	0.013
A*D	-0.675	0.166	-4.07	<0.001
A*E				
250	-0.0434	0.0718	-0.6	0.546
500	-0.049	0.0718	-0.68	0.495
1000	0.008	0.0718	0.11	0.911
2000	-0.0097	0.0718	-0.14	0.892
2500	0.0548	0.0718	0.76	0.446
3150	0.0153	0.0718	0.21	0.832
4000	-0.0283	0.0718	-0.39	0.694
5000	-0.0046	0.0718	-0.06	0.949
B*C	0.157	0.153	1.03	0.305
B*D	0.646	0.141	4.59	<0.001
B*E				
250	0.004	0.0556	0.07	0.942
500	0.0059	0.0556	0.11	0.916
1000	-0.0111	0.0556	-0.2	0.842
2000	0.0193	0.0556	0.35	0.729
2500	-0.0395	0.0556	-0.71	0.478
3150	-0.0125	0.0556	-0.23	0.822
4000	0.0392	0.0556	0.71	0.481
5000	0.0246	0.0556	0.44	0.658

Term	Coef	SE Coef	T-Value	*P*-Value
C*D	0.0077	0.0532	0.14	0.885
C*E				
250	-0.0254	0.034	-0.75	0.456
500	-0.0037	0.034	-0.11	0.914
1000	0.014	0.034	0.41	0.682
2000	-0.0317	0.034	-0.93	0.353
2500	0.028	0.034	0.82	0.411
3150	-0.0026	0.034	-0.08	0.938
4000	-0.0017	0.034	-0.05	0.961
5000	0.0133	0.034	0.39	0.697
D*E				
250	-0.0284	0.0249	-1.14	0.256
500	-0.0158	0.0249	-0.63	0.528
1000	-0.0009	0.0249	-0.04	0.971
2000	0.0227	0.0249	0.91	0.363
2500	0.0396	0.0249	1.59	0.113
3150	0.0026	0.0249	0.1	0.917
4000	-0.0126	0.0249	-0.5	0.615
5000	-0.013	0.0249	-0.52	0.602

Following equation indicate the regression equation of NAC (α) versus kapok fabric GSM, thickness, air permeability, porosity and its interactive effect at different frequency level.

Regression equation of sound absorption coefficient at different frequency level

Frequency 250 Hz

$$\begin{aligned} NAC(\alpha) = & -76.6 + 0.0703A - 8.95B - 0.00584C + 1.869D - 0.000024A*A \\ & - 0.3484B*B + 0.000003C*C - 0.01109D*D + 0.00614A*B \\ & + 0.000006A*C - 0.000874A*D + 0.000288B*C + 0.1040B*D \end{aligned}$$

$$+ 0.000006C * D \tag{6.10}$$

Frequency 500 Hz

$$\begin{aligned} NAC(\alpha) = & -76.8 + 0.0703A - 8.95B - 0.00577C + 1.872D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * C + 0.1040B * D \\ & + 0.000006C * D \end{aligned} \tag{6.11}$$

Frequency 1000 Hz

$$\begin{aligned} NAC(\alpha) = & -77.2 + 0.0705A - 8.96B - 0.00572C + 1.876D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A\ * D + 0.000288B * C + 0.1040B * D \\ & + 0.000006\ \textit{Air permeability}\ *\ \textit{Porosity}\ (\%) \end{aligned} \tag{6.12}$$

Frequency 2000 Hz

$$\begin{aligned} NAC(\alpha) = & -77.5 + 0.0705A - 8.94B - 0.00585C + 1.882D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * C + 0.1040B * D \\ & + 0.000006C * D \end{aligned} \tag{6.13}$$

Frequency 2500 Hz

$$\begin{aligned} NAC(\alpha) = & -77.9 + 0.0708A - 8.98B - 0.00568C + 1.886D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * D + 0.1040B * D \\ & + 0.000006C * D \end{aligned} \tag{6.14}$$

Frequency 3150 Hz

$$\begin{aligned} NAC(\alpha) = & -76.9 + 0.0706A - 8.96B - 0.00577C + 1.876D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * C + 0.1040B * D \end{aligned}$$

$$+ 0.000006C * D \tag{6.15}$$

Frequency 4000 Hz

$$\begin{aligned} NAC(\alpha) = & -76.5 + 0.0704A - 8.93B - 0.00577C + 1.873D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * C + 0.1040B * D \\ & + 0.000006C * D \end{aligned} \tag{6.16}$$

Frequency 5000 Hz

$$\begin{aligned} NAC(\alpha) = & -76.5 + 0.0705A - 8.93B - 0.00573C + 1.872D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * C + 0.1040B * D \\ & + 0.000006C * D \end{aligned} \tag{6.17}$$

Frequency 6300 Hz

$$\begin{aligned} NAC(\alpha) = & -76.8 + 0.0708A - 8.97B - 0.00574C + 1.877D - 0.000024A * A \\ & - 0.3484B * B + 0.000003C * C - 0.01109D * D + 0.00614A * B \\ & + 0.000006A * C - 0.000874A * D + 0.000288B * C + 0.1040B * D \\ & + 0.000006C * D \end{aligned} \tag{6.18}$$

Table:3 Estimated regression coefficient and corresponding p-value for milkweed fibre nonwoven fabric

Term	**Coef**	**SE Coef**	**T-Value**	***P*-Value**
Constant	5.63	1.62	3.48	0.001
Y_1	0.4432	0.0615	7.2	<0.001
Y_2	7.11	1.78	4.01	<0.001
Y_3	2.63	2.27	1.16	0.246
Y_4	-0.1575	0.0615	-2.56	0.011
Y_5				
250	-0.695	0.142	-4.89	<0.001

Term	**Coef**	**SE Coef**	**T-Value**	***P*-Value**
500	-0.501	0.142	-3.53	0.001
1000	-0.54	0.142	-3.8	<0.001
2000	-0.131	0.142	-0.92	0.358
2500	0.178	0.142	1.25	0.213
3150	0.256	0.142	1.8	0.073
4000	0.486	0.142	3.42	0.001
5000	0.476	0.142	3.35	0.001
Y_1*Y_1	-0.00467	0.00131	-3.57	<0.001
Y_2*Y_2	1.718	0.723	2.38	0.018
Y_3*Y_3	-0.28	1.03	-0.28	0.782
Y_4*Y_4	-0.00175	0.00131	-1.34	0.182
Y_1*Y_2	0.3019	0.0411	7.34	<0.001
Y_1*Y_3	0.1264	0.049	2.58	0.011
Y_1*Y_4	0.00312	0.00175	1.79	0.076
Y_1*Y_5				
250	-0.01227	0.00404	-3.04	0.003
500	-0.0081	0.00404	-2	0.046
1000	-0.00727	0.00404	-1.8	0.073
2000	0.00023	0.00404	0.06	0.954
2500	0.00356	0.00404	0.88	0.379
3150	0.02315	0.00404	5.73	<0.001
4000	0.00315	0.00404	0.78	0.437
5000	-0.00477	0.00404	-1.18	0.239
Y_2*Y_3	3.06	1.15	2.66	0.008
Y_2*Y_4	-0.0865	0.0411	-2.1	0.037
Y_2*Y_5				
250	-0.3645	0.095	-3.84	<0.001
500	-0.1882	0.095	-1.98	0.049
1000	-0.1295	0.095	-1.36	0.174
2000	0.0664	0.095	0.7	0.485
2500	0.1447	0.095	1.52	0.129

Term	Coef	SE Coef	T-Value	*P*-Value
3150	0.0566	0.095	0.6	0.552
4000	0.2132	0.095	2.24	0.026
5000	0.2426	0.095	2.55	0.011
Y_3*Y_4	-0.0875	0.049	-1.79	0.076
Y_3*Y_5				
250	-0.017	0.113	-0.15	0.882
500	-0.017	0.113	-0.15	0.882
1000	-0.18	0.113	-1.59	0.113
2000	-0.04	0.113	-0.36	0.723
2500	0.03	0.113	0.26	0.792
3150	0.088	0.113	0.78	0.437
4000	0.088	0.113	0.78	0.437
5000	-0.064	0.113	-0.56	0.575
Y_4*Y_5				
250	-0.00134	0.00404	-0.33	0.74
500	-0.00051	0.00404	-0.13	0.9
1000	0.00366	0.00404	0.9	0.367
2000	-0.00384	0.00404	-0.95	0.343
2500	0.00116	0.00404	0.29	0.775
3150	-0.00343	0.00404	-0.85	0.398
4000	-0.00093	0.00404	-0.23	0.819
5000	0.00199	0.00404	0.49	0.623

Regression Analysis:

Following equation indicate the regression equation of NAC (α) versus milkweed fibre blend%, carded web mass, stroke frequency, needle depth and its interactive effect at a various frequency (Hz).

Regression equation of sound absorption coefficient at different frequency level

Frequency 250 Hz

$$NAC(\alpha) = 0.126 - 0.00198Y_1 - 0.000760Y_2 - 0.000335Y_3 + 0.01483Y_4 - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \quad (6.19)$$

Frequency 500 Hz

$$NAC(\alpha) = 0.097 - 0.00156Y_1 - 0.000685Y_2 - 0.000335Y_3 + 0.01516Y_4 - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \quad (6.20)$$

Frequency 1000 Hz

$$NAC(\alpha) = 0.157 - 0.00148Y_1 - 0.000660Y_2 - 0.000451Y_3 + 0.01683Y_4 - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \quad (6.21)$$

Frequency 2000 Hz

$$NAC(\alpha) = 0.178 - 0.00073Y_1 - 0.000577Y_2 - 0.000351Y_3 + 0.01383Y_4 - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_3 \quad (6.22)$$

Frequency 2500 Hz

$$NAC(\alpha) = 0.281 - 0.00039Y_1 - 0.000543Y_2 - 0.000301Y_3 + 0.01583Y_4 - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \quad (6.23)$$

Frequency 3150 Hz

$$\begin{aligned} NAC(\alpha) = {} & 0.313 + 0.00156Y_1 - 0.000581Y_2 - 0.000260Y_3 + 0.01399Y_4 \\ & - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 \\ & + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 \\ & - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \end{aligned} \tag{6.24}$$

Frequency 4000 Hz

$$\begin{aligned} NAC(\alpha) = {} & 0.456 - 0.00044Y_1 - 0.000514Y_2 - 0.000260Y_3 + 0.01499Y_4 \\ & - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 \\ & + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 \\ & - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \end{aligned} \tag{6.25}$$

Frequency 5000 Hz

$$\begin{aligned} NAC(\alpha) = {} & 0.615 - 0.00123Y_1 - 0.000502Y_2 - 0.000368Y_3 + 0.01616Y_4 \\ & - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 \\ & + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 \\ & - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \end{aligned} \tag{6.26}$$

Frequency 6300 Hz

$$\begin{aligned} NAC(\alpha) = {} & 0.690 - 0.00052\ Y_1 - 0.000622Y_2 - 0.000243Y_3 + 0.01666Y_4 \\ & - 0.000047Y_1 * Y_1 + 0.000000Y_2 * Y_2 - 0.000000Y_3 * Y_3 - 0.000280Y_4 * Y_4 \\ & + 0.000013Y_1 * Y_2 + 0.000009Y_1 * Y_3 + 0.000125Y_1 * Y_4 + 0.000001Y_2 * Y_3 \\ & - 0.000015Y_2 * Y_4 - 0.000025Y_3 * Y_4 \end{aligned} \tag{6.27}$$

Table:4 Estimated regression coefficient and corresponding p-value for physical properties of milkweed fibre nonwoven fabric

Term	**Coef**	**SE Coef**	**T-Value**	**P-Value**
Constant	0.571	0.0224	25.54	<0.001
A	-0.3333	0.0998	-3.34	0.001

Term	Coef	SE Coef	T-Value	P-Value
B	0.621	0.119	5.2	<0.001
C	0.2731	0.0565	4.84	<0.001
D	-0.2435	0.0328	-7.42	<0.001
E				
250	-0.3546	0.0109	-32.66	<0.001
500	-0.3187	0.0109	-29.36	<0.001
1000	-0.2615	0.0109	-24.09	<0.001
2000	-0.1612	0.0109	-14.85	<0.001
2500	0.0325	0.0109	2.99	0.003
3150	0.1389	0.0109	12.8	<0.001
4000	0.202	0.0109	18.61	<0.001
5000	0.3056	0.0109	28.15	<0.001
A*A	-0.356	0.139	-2.56	0.011
B*B	0.069	0.145	0.48	0.635
C*C	0.1144	0.0359	3.19	0.002
D*D	0.0667	0.0208	3.21	0.002
A*B	0.347	0.276	1.26	0.209
A*C	-0.415	0.12	-3.46	0.001
A*D	0.2009	0.0973	2.06	0.04
A*E				
250	0.0871	0.038	2.29	0.023
500	0.0511	0.038	1.34	0.18
1000	0.0669	0.038	1.76	0.08
2000	0.011	0.038	0.29	0.772
2500	-0.0494	0.038	-1.3	0.195
3150	-0.1195	0.038	-3.14	0.002
4000	-0.0126	0.038	-0.33	0.74
5000	0.0186	0.038	0.49	0.626
B*C	0.607	0.155	3.92	<0.001
B*D	-0.344	0.101	-3.39	0.001
B*E				

Term	Coef	SE Coef	T-Value	P-Value
250	-0.1193	0.0387	-3.08	0.002
500	-0.0677	0.0387	-1.75	0.082
1000	-0.0848	0.0387	-2.19	0.03
2000	-0.0133	0.0387	-0.34	0.732
2500	0.0803	0.0387	2.07	0.039
3150	0.11	0.0387	2.84	0.005
4000	0.032	0.0387	0.83	0.409
5000	0.0065	0.0387	0.17	0.867
C*D	-0.1638	0.0395	-4.14	<0.001
C*E				
250	-0.0097	0.0149	-0.65	0.518
500	-0.006	0.0149	-0.4	0.69
1000	-0.0097	0.0149	-0.65	0.516
2000	-0.0083	0.0149	-0.56	0.577
2500	0.0225	0.0149	1.51	0.132
3150	0.0041	0.0149	0.27	0.785
4000	0.0009	0.0149	0.06	0.954
5000	-0.0011	0.0149	-0.07	0.944
D*E				
250	0.0366	0.0122	3	0.003
500	0.0292	0.0122	2.4	0.017
1000	0.0276	0.0122	2.27	0.024
2000	-0.001	0.0122	-0.08	0.936
2500	-0.0183	0.0122	-1.5	0.136
3150	-0.0672	0.0122	-5.51	<0.001
4000	-0.016	0.0122	-1.31	0.19
5000	0.0168	0.0122	1.38	0.17

Following equation indicate the regression equation of NAC (α) versus milkweed fabric GSM, thickness, air permeability, porosity and its interactive effect at different frequency level.

Regression equation of sound absorption coefficient at different frequency level

Frequency 250 Hz

$$\begin{aligned} NAC(\alpha) = {} & 185.3 - 0.0646A + 13.16B + 0.03258C - 4.39D - 0.000014A * A \\ & + 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B \\ & - 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D \\ & - 0.000394C * D \end{aligned} \tag{6.28}$$

Frequency 500 Hz

$$\begin{aligned} NAC(\alpha) = {} & 185.7 - 0.0648A + 13.20B + 0.03260C - 4.40D - 0.000014A * A \\ & + 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B \\ & - 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D \\ & - 0.000394C * D \end{aligned} \tag{6.29}$$

Frequency 1000 Hz

$$\begin{aligned} NAC(\alpha) = {} & 185.9 - 0.0647A + 13.19B + 0.03258C - 4.40D - 0.000014A * A \\ & + 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B \\ & - 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D \\ & - 0.000394C * D \end{aligned} \tag{6.30}$$

Frequency 2000 Hz

$$\begin{aligned} NAC(\alpha) = {} & 187.5 - 0.0650A + 13.24B + 0.03259C - 4.42D - 0.000014A * A \\ & + 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B \\ & - 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D \\ & - 0.000394C * D \end{aligned} \tag{6.31}$$

Frequency 2500 Hz

$$\begin{aligned} NAC(\alpha) = {} & 188.5 - 0.0654A + 13.31B + 0.03271C - 4.43D - 0.000014A * A \\ & + 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B \end{aligned}$$

$$- 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D$$
$$- 0.000394C * D \tag{6.32}$$

Frequency 3150 Hz

$$NAC(\alpha) = 191.5 - 0.0659A + 13.33B + 0.03264C - 4.46D - 0.000014A * A$$
$$+ 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B$$
$$- 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D$$
$$- 0.000394C * D \tag{6.33}$$

Frequency 4000 Hz

$$NAC(\alpha) = 188.7 - 0.0652A + 13.28B + 0.03262C - 4.43D - 0.000014A * A$$
$$+ 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B$$
$$- 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D$$
$$- 0.000394C * D \tag{6.34}$$

Frequency 5000 Hz

$$NAC(\alpha) = 186.9 - 0.0650A + 13.26B + 0.03262C - 4.40D - 0.000014A * A$$
$$+ 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B$$
$$- 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D$$
$$- 0.000394C * D \tag{6.35}$$

Frequency 6300 Hz

$$NAC(\alpha) = 188.4 - 0.0654A + 13.29B + 0.03265C - 4.42D - 0.000014A * A$$
$$+ 0.0382B * B + 0.000002C * C + 0.02606D * D + 0.00164A * B$$
$$- 0.000010A * C + 0.000797A * D + 0.001735B * C - 0.1596B * D$$
$$- 0.000394C * D \tag{6.36}$$