

Appendix I

Mechanical comfort Analysis

Matrix M with fabric mechanical properties:

J	E2 ₁ N/mm ²	E2 ₂ N/mm ²	G gm-cm	q kg/cm ²	Eb %	H mgm/cm ³ X 10 ⁴	h gm/cm ²	p mgm/cm ³	Faf gf	Fab gf
I	1	2	3	4	5	6	7	8	9	10
A1	195	42	0.162	11.30	2.95	1429	794	491	4.04	4.04
A2	182	74	0.200	19.39	3.98	2000	996	532	4.16	4.20
A3	248	53	0.150	15.78	4.53	1600	776	522	5.01	4.78
A4	229	59	0.094	13.34	2.9	1818	798	533	4.76	4.68
A5	235	55	0.054	11.62	3.1	1143	438	507	4.68	6.56
A6	226	423	0.107	13.97	3.83	1333	603	520	3.54	3.72
A7	277	64	0.096	19.28	2.7	1081	423	537	3.94	4.40
A8	230	83	0.068	24.11	3.13	1481	480	556	6.04	6.08
A9	702	84	0.038	13.37	5.63	1176	382	468	3.13	3.48
A10	255	231	0.083	21.65	1.38	1667	597	609	6.18	5.09
A11	571	61	0.036	19.47	4.18	1176	331	498	5.11	4.14
B1	234	45	0.117	12.19	4	1481	721	499	4.87	4.78
B2	295	40	0.104	11.44	5.05	1333	636	501	4.09	4.13
B3	376	45	0.105	12.99	2.8	1379	633	508	4.19	4.45
B4	255	31	0.101	14.97	3.63	1290	557	528	2.84	2.84
B5	1041	52	0.115	18.16	4.25	1143	485	517	3.14	3.22
C1	371	39	0.088	16.97	4.3	1111	441	534	4.78	6.73
C2	147	162	0.142	20.45	1.13	1212	530	568	5.41	5.49
C3	152	75	0.109	13.88	12.35	1212	552	574	3.81	3.74
C4	190	55	0.100	12.35	5.05	1081	497	585	8.51	7.59
D1	220	44	0.124	17.76	3.03	1481	649	610	5.40	5.82
D2	158	91	0.117	16.01	2.55	1333	592	586	5.73	5.36
D3	181	52	0.080	12.81	4.58	1379	582	552	5.65	6.35
D4	230	99	0.109	14.05	2.9	1481	671	565	3.59	3.16
Mean	300	86	0.104	15.72	3.91	1368	590	537	4.69	4.78
Var	41489	7061	0.001	12.84	4.42	54964	23384	1424	1.54	1.56

Standard matrix M_s of original matrix M

-0.0025	-0.0062	57.882	-0.3441	-0.2172	0.0011	0.0087	-0.0323	-0.4228	-0.4766
-0.0028	-0.0017	95.533	0.2856	0.0158	0.0115	0.0174	-0.0034	-0.3415	-0.3727
-0.0013	-0.0047	46.022	0.0047	0.1403	0.0042	0.0080	-0.0108	0.2085	-0.0030
-0.0017	-0.0038	-9.940	-0.1853	-0.2285	0.0082	0.0089	-0.0028	0.0468	-0.0666
-0.0016	-0.0044	-49.618	-0.3197	-0.1833	-0.0041	-0.0065	-0.0214	-0.0074	1.1427
-0.0018	0.0477	3.496	-0.1364	-0.0181	-0.0006	0.0005	-0.0120	-0.7492	-0.6795
-0.0006	-0.0031	-7.940	0.2776	-0.2738	-0.0052	-0.0072	0.0001	-0.4845	-0.2451
-0.0017	-0.0004	-35.665	0.6534	-0.1765	0.0021	-0.0047	0.0130	0.8741	0.8364
0.0097	-0.0003	-65.765	-0.1834	0.3891	-0.0035	-0.0089	-0.0487	-1.0145	-0.8333
-0.0011	0.0205	-21.238	0.4615	-0.5724	0.0054	0.0003	0.0505	0.9666	0.2019
0.0065	-0.0035	-68.001	0.2920	0.0611	-0.0035	-0.0111	-0.0272	0.2721	-0.4113
-0.0016	-0.0058	13.291	-0.2752	0.0204	0.0021	0.0056	-0.0267	0.1200	0.0022
-0.0001	-0.0065	-0.495	-0.3330	0.2579	-0.0006	0.0020	-0.0252	-0.3928	-0.4168
0.0018	-0.0058	0.667	-0.2128	-0.2511	0.0002	0.0018	-0.0206	-0.3265	-0.2123
-0.0011	-0.0078	-3.430	-0.0585	-0.0633	-0.0014	-0.0014	-0.0065	-1.1989	-1.2466
0.0179	-0.0048	11.370	0.1902	0.0769	-0.0041	-0.0045	-0.0144	-1.0046	-1.0002
0.0017	-0.0067	-15.526	0.0972	0.0882	-0.0047	-0.0064	-0.0021	0.0608	1.2499
-0.0037	0.0108	38.236	0.3686	-0.6290	-0.0028	-0.0026	0.0214	0.4673	0.4574
-0.0036	-0.0016	4.923	-0.1436	1.9095	-0.0028	-0.0016	0.0257	-0.5697	-0.6677
-0.0027	-0.0044	-3.828	-0.2625	0.2579	-0.0052	-0.0040	0.0336	2.4787	1.8022
-0.0019	-0.0059	20.354	0.1588	-0.1991	0.0021	0.0025	0.0510	0.4581	0.6670
-0.0034	0.0007	12.795	0.0228	-0.3077	-0.0006	0.0001	0.0341	0.6786	0.3725
-0.0029	-0.0048	-23.779	-0.2267	0.1516	0.0002	-0.0003	0.0106	0.6226	1.0033
-0.0017	0.0018	4.839	-0.1301	-0.2285	0.0021	0.0035	0.0197	-0.7126	-1.0416
-0.0025	-0.0062	57.882	-0.3441	-0.2172	0.0011	0.0087	-0.0323	-0.4228	-0.4766

covariance matrix V_M of M_s

2.31E-05	-7.64E-06	-5.80E-02	1.47E-04	1.48E-04	-6.84E-06	-1.31E-05	-5.61E-05	-1.44E-03	-1.37E-03
-7.64E-06	1.36E-04	-9.41E-04	5.73E-04	-8.97E-04	3.77E-06	-1.03E-06	5.22E-05	-3.06E-04	-1.23E-03
-5.80E-02	-9.41E-04	1.30E+03	6.65E-02	-1.29E+00	7.46E-02	1.85E-01	1.47E-01	-2.13E+00	-4.20E+00
1.47E-04	5.73E-04	6.65E-02	7.46E-02	-3.97E-02	1.67E-04	-3.26E-04	2.87E-03	4.12E-02	1.68E-02
1.48E-04	-8.97E-04	-1.29E+00	-3.97E-02	2.17E-01	-4.43E-04	-3.10E-04	-9.84E-04	-6.80E-02	-6.36E-02
-6.84E-06	3.77E-06	7.46E-02	1.67E-04	-4.43E-04	1.74E-05	2.28E-05	1.54E-05	8.45E-05	-4.40E-04
-1.31E-05	-1.03E-06	1.85E-01	-3.26E-04	-3.10E-04	2.28E-05	4.10E-05	7.61E-06	-3.64E-04	-9.00E-04
-5.61E-05	5.22E-05	1.47E-01	2.87E-03	-9.84E-04	1.54E-05	7.61E-06	6.73E-04	1.15E-02	8.25E-03
-1.44E-03	-3.06E-04	-2.13E+00	4.12E-02	-6.80E-02	8.45E-05	-3.64E-04	1.15E-02	6.22E-01	5.17E-01
-1.37E-03	-1.23E-03	-4.20E+00	1.68E-02	-6.36E-02	-4.40E-04	-9.00E-04	8.25E-03	5.17E-01	6.13E-01

Eigen vector analysis:

Approximate error bound - 0.001, Maximum no. of iterations - 600,

I	10	9	8	7	1	6	2	3	5	4
C _i	3.20E-08	2.33E-05	9.99E-05	3.53E-05	1300.018405	3.65E-04	1.131714	0.214179	0.104971	5.77E-02
W _i *	4.96E-06	1.34E-04	2.77E-04	1.65E-04	9.99E-01	5.29E-04	2.95E-02	1.28E-02	8.98E-03	6.66E-03
R _i	-6.30E-02	2.40E-02	6.93E-02	-7.16E-02	-4.46E-05	-8.46E-02	1.92E-03	9.44E-04	-9.58E-04	3.03E-03
	-9.37E-03	-2.78E-03	9.93E-03	-1.01E-02	-7.20E-07	0.1779	8.42E-04	5.40E-03	-6.71E-03	1.73E-03
	5.72E-05	5.84E-05	-5.97E-05	5.96E-05	1.0000	-1.43E-04	-3.30E-03	-1.41E-03	9.77E-04	5.37E-04
	-4.30E-03	-4.76E-03	4.34E-03	-4.32E-03	5.11E-05	-3.24E-02	-0.042977	0.244146	-0.345781	0.904353
	-5.77E-05	-4.12E-05	1.06E-04	-1.05E-04	-9.92E-04	-6.90E-03	0.107599	-0.961993	-0.128395	0.215462
	0.707581	0.7224	-0.6921	0.6923	5.74E-05	1.87E-03	-4.89E-05	1.89E-03	-2.63E-03	-6.41E-04
	-0.703716	-0.6910	0.7183	-0.7180	1.42E-04	-1.30E-03	2.24E-04	3.56E-04	-2.75E-04	-6.77E-03
	-6.08E-03	1.87E-04	6.53E-03	-6.69E-03	1.13E-04	0.9796	-1.29E-02	-3.50E-04	-0.025952	2.53E-02
	3.68E-05	-1.40E-05	-9.15E-05	9.06E-05	-1.64E-03	-0.0195	0.709378	-5.27E-02	-0.649277	-0.26844
	-1.30E-04	8.75E-05	2.05E-04	-2.08E-04	-3.23E-03	2.65E-03	0.695108	-0.110232	0.664577	0.250921

* W_i = sqrt(C_i / tr V_m) where tr V_m = ∑ C_i, is the weight of ith component of Y_M

Feature Matrix M_F of the original matrix M

	10	9	8	7	1	6	2	3	5	4
A1	436.67	488.21	-401.52	401.44	0.38	473.17	-11.66	2.49	-21.41	17.58
A2	698.78	760.68	-651.90	651.99	0.48	520.66	-12.60	4.74	-27.14	24.44
A3	566.68	625.41	-528.80	528.61	0.37	501.18	-13.19	2.34	-24.68	22.87
A4	706.54	767.23	-665.07	664.96	0.34	515.10	-13.19	3.77	-24.41	20.30
A5	482.08	528.55	-456.28	455.95	0.20	487.68	-14.05	1.54	-19.97	21.50
A6	497.44	550.53	-466.14	465.85	0.30	566.71	-11.13	4.18	-25.37	23.08
A7	445.82	495.08	-420.92	420.47	0.24	514.78	-12.69	4.03	-24.24	29.04
A8	691.39	743.44	-659.75	659.47	0.24	541.23	-15.84	5.33	-27.85	33.09
A9	515.38	602.19	-486.95	485.53	0.16	415.21	-9.20	0.61	-21.64	24.11
A10	737.39	797.17	-700.90	700.60	0.29	617.65	-15.82	7.71	-30.44	30.96
A11	559.53	634.33	-532.67	531.53	0.16	451.43	-12.15	3.04	-24.90	29.62
B1	522.30	577.15	-487.16	486.97	0.32	478.38	-12.73	1.69	-22.28	19.36
B2	473.59	530.46	-441.59	441.22	0.29	474.15	-11.51	0.33	-21.75	19.85
B3	503.05	567.68	-469.87	469.31	0.29	475.10	-12.04	3.02	-22.26	21.24
B4	501.18	553.04	-471.25	470.93	0.29	502.33	-10.48	2.56	-23.30	23.86
B5	398.17	515.39	-366.60	364.43	0.24	428.50	-9.36	3.24	-24.63	29.61
C1	448.72	506.64	-422.52	421.87	0.23	499.53	-14.43	1.64	-22.57	27.68
C2	470.30	512.38	-442.55	442.44	0.32	573.64	-15.26	6.31	-26.38	29.39
C3	455.31	497.57	-427.26	427.15	0.29	563.75	-11.56	-6.27	-25.26	25.73
C4	399.05	441.92	-373.60	373.37	0.25	567.60	-18.38	-0.64	-24.11	23.29
D1	573.16	626.57	-539.11	538.91	0.33	588.04	-15.65	3.76	-26.58	27.56
D2	512.17	557.43	-481.61	481.52	0.31	577.98	-15.32	3.73	-25.66	25.43
D3	550.89	598.24	-519.66	519.53	0.26	535.98	-15.15	0.80	-23.10	22.43
D4	556.82	611.46	-522.37	522.16	0.32	553.01	-11.72	3.69	-25.09	22.83

Correlation analysis:

	10	9	8	7	1	6	2	3	5	4
E2, N/mm ²	-0.246	-0.082	0.245	-0.250	-0.492	-0.688	0.549	0.00046	0.169	0.263
E2 ₂ N/mm ²	0.159	0.141	-0.164	0.164	0.049	0.454	0.006	0.361	-0.433	0.174
G gm-cm	0.004	-0.024	0.031	-0.028	0.919	0.223	-0.004	0.142	-0.203	-0.245
q kg/cm ²	0.447	0.467	-0.461	0.460	-0.014	0.301	-0.270	0.608	-0.785	0.914
Eb%	-0.287	-0.284	0.287	-0.287	-0.142	-0.128	0.284	-0.902	0.181	-0.116
H X 10 ⁴ mgm/cm ³	0.824	0.808	-0.800	0.802	0.771	0.239	-0.070	0.395	-0.433	-0.191
h gm/cm ²	0.413	0.382	-0.377	0.379	0.952	0.172	0.026	0.156	-0.149	-0.509
p mg/cm ³	0.252	0.177	-0.261	0.263	0.204	0.907	-0.700	0.175	-0.713	0.455
Fa gf	0.177	0.105	-0.189	0.191	-0.044	0.515	-0.933	0.101	-0.328	0.205
Fa gf	0.018	-0.057	-0.034	0.035	-0.163	0.369	-0.891	0.009	-0.024	0.138

Regression summery:

Factor 1 - Hardness:

Dependent variable - Component 1 of the Feature matrix.

Independent variable – G gm-cm, H X 10⁴ mgm/cm³, h gm/cm²

Regression Statistics					
Multiple R	0.992015944				
R Square	0.984095633				
Adjusted R Square	0.981709978				
Standard Error	0.009650413				
Observations	24				
ANOVA					
	Df	SS	MS	F	Significance F
Regression	3	0.115250482	0.038417	412.5054	3.8E-18
Residual	20	0.00186261	9.31E-05		
Total	23	0.117113092			
	Coefficients	Standard Error	t Stat		
Intercept	-0.007289388	0.01409587	-0.517129		
X Variable 1	1.091479993	0.114338301	9.546057		
X Variable 2	7.24941E-05	2.04922E-05	3.537645		
X Variable 3	0.000138825	4.56539E-05	3.040813		

Factor 2 - Extensibility:

Dependent variable - Component 6 of the Feature matrix.

Independent variable – $E2_1$ N/mm², $E2_2$ N/mm², ρ mg/cm³

Regression Statistics	
Multiple R	0.871926142
R Square	0.760255197
Adjusted R Square	0.724293476
Standard Error	27.41679301
Observations	24

ANOVA					
	Df	SS	MS	F	Significance F
Regression	3	47673.11147	15891.04	21.14068	2.05E-06
Residual	20	15033.61078	751.6805		
Total	23	62706.72225			

	Coefficients	Standard Error	t Stat
Intercept	207.8582582	95.33778872	2.180229
X Variable 1	-0.165639227	0.028336784	-5.845378
X Variable 2	0.353867121	0.077111013	4.589061
X Variable 3	0.612450456	0.170653112	3.588862

Factor 3 - Smoothness :

Dependent variable - Component 2 of the Feature matrix.

Independent variable – ρ mg/cm³, Faf gf, Fab gf

Regression Statistics					
Multiple R	0.984632841				
R Square	0.969501831				
Adjusted R Square	0.964927105				
Standard Error	0.422601556				
Observations	24				
ANOVA					
	df	SS	MS	F	Significance F
Regression	3	113.5447455	37.84825	211.9257	2.54E-15
Residual	20	3.571841503	0.178592		
Total	23	117.116587			
	Coefficients	Standard Error	t Stat		
Intercept	3.591165097	1.369918105	2.621445		
X Variable 1	-0.017741319	0.002858327	-6.206888		
X Variable 2	-0.735511887	0.145204467	-5.065353		
X Variable 3	-0.780983959	0.130411456	-5.988615		

Factor 4 - Fullness :

Dependent variable - Component 4 of the Feature matrix.

Independent variable – $q \text{ kg/cm}^2$, $\rho \text{ mg/cm}^3$, $h \text{ gm/cm}^2$

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.986970165
R Square	0.974110107
Adjusted R Square	0.970226623
Standard Error	0.700781293
Observations	24

ANOVA					
	df	SS	MS	F	Significance F
Regression	3	369.5496429	123.1832	250.8341	4.95E-16
Residual	20	9.821888422	0.491094		
Total	23	379.3715313			

	Coefficients	Standard Error	T Stat
Intercept	7.66946708	2.140761077	3.582589
X Variable 1	0.886333716	0.045751132	19.37294
X Variable 2	0.016732538	0.004272461	3.91637
X Variable 3	-0.009841659	0.000981594	-10.0262

Factor 5 – Shear Stiffness :

Dependent variable - Component 3 of the Feature matrix.

Independent variable – $q \text{ kg/cm}^2$, Eb %

Regression Statistics	
Multiple R	0.964747785
R Square	0.930738288
Adjusted R Square	0.924141935
Standard Error	0.741702343
Observations	24

ANOVA					
	df	SS	MS	F	Significance F
Regression	2	155.2433324	77.62167	141.0989	6.69E-13
Residual	21	11.55256967	0.550122		
Total	23	166.795902			

	Coefficients	Standard Error	T Stat
Intercept	2.336436327	0.871760544	2.680135
X Variable 1	0.27149303	0.045432637	5.975727
X Variable 2	-1.010024863	0.077405263	-13.04853

Mechanical comfort Value:

Dependent variable -- WD_{OM} value from table 21.

Independent variable – Predicted values of comfort factors Hardness,
extensibility, smoothness, fullness and shear stiffness.

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.964499
R Square	0.930258
Adjusted R Square	0.910885
Standard Error	0.367925
Observations	24

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	5	32.50136	6.500273	48.01896	8.74E-10
Residual	18	2.43664	0.135369		
Total	23	34.938			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>
Intercept	-3.485656	1.136228	-3.067743
X Variable 1	3.063714	1.302232	2.352664
X Variable 2	0.019434	0.002098	9.26334
X Variable 3	-0.122525	0.04353	-2.814728
X Variable 4	0.137331	0.026609	5.161141
X Variable 5	-0.059995	0.03729	-1.60887

Percentage rank of the mechanical comfort factors:

Fabric code	Softness factor		Extensibility factor		smoothness factor		Fullness factor		shear stiffness factor		Mechanical comfort Factor	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
A1	0.383	0.956	491	0.217	-11.24	0.826	18.09	0	2.43	0.391	10.95	0.086
A2	0.494	1	530	0.608	-12.19	0.652	23.95	0.521	3.58	0.739	12.89	0.652
A3	0.380	0.913	512	0.478	-13.08	0.391	22.75	0.304	2.05	0.26	12.23	0.521
A4	0.338	0.869	501	0.304	-13.02	0.434	20.56	0.13	3.03	0.565	11.52	0.26
A5	0.196	0.086	529	0.565	-13.96	0.347	22.13	0.217	2.36	0.347	12.00	0.391
A6	0.290	0.521	607	1	-11.14	0.869	22.82	0.347	2.26	0.304	13.55	0.782
A7	0.235	0.173	490	0.173	-12.27	0.565	29.59	0.826	4.84	0.869	12.03	0.478
A8	0.241	0.217	505	0.391	-15.46	0.13	33.61	1	5.72	0.913	13.23	0.739
A9	0.173	0.043	428	0.043	-9.72	1	23.58	0.478	0.28	0.043	9.78	0
A10	0.287	0.478	558	0.782	-15.74	0.086	31.17	0.956	6.82	1	14.04	1
A11	0.163	0	458	0.086	-12.24	0.608	30.01	0.869	3.40	0.695	11.33	0.173
B1	0.328	0.826	501	0.347	-12.58	0.478	19.72	0.043	1.60	0.217	11.42	0.217
B2	0.291	0.565	500	0.26	-11.53	0.782	19.94	0.086	0.34	0.086	11.26	0.13
B3	0.295	0.608	509	0.434	-11.97	0.695	21.44	0.173	3.03	0.608	11.54	0.304
B4	0.273	0.391	528	0.521	-10.08	0.956	24.28	0.608	2.73	0.478	12.02	0.434
B5	0.269	0.347	412	0	-10.40	0.913	27.64	0.782	2.97	0.521	10.24	0.043
C1	0.231	0.13	480	0.13	-14.66	0.304	27.30	0.739	2.60	0.434	11.93	0.347
C2	0.309	0.695	559	0.826	-14.75	0.26	30.08	0.913	6.75	0.956	13.86	0.956
C3	0.276	0.434	538	0.695	-12.31	0.521	24.14	0.565	-6.37	0	13.02	0.695
C4	0.249	0.26	569	0.913	-18.97	0	23.51	0.434	0.59	0.13	13.85	0.913
D1	0.326	0.782	560	0.869	-15.74	0.043	27.22	0.695	4.10	0.782	13.82	0.869
D2	0.299	0.652	573	0.956	-15.20	0.217	25.83	0.652	4.11	0.826	13.72	0.826
D3	0.261	0.304	534	0.652	-15.31	0.173	22.53	0.26	1.19	0.173	12.60	0.608
D4	0.312	0.739	551	0.739	-11.54	0.739	22.97	0.391	3.22	0.652	12.55	0.565