

Appendix B

Design Matrix and ANOVA results

TABLE B.1: Design matrix of input and response of FCC and BB design methods for model type B

Face Central composite (FCC) design					Box-Behnken (BBD) design				
Run No.	Input parameters			Response	Run No.	Input parameters			Response
	w/L	γ_d	t (days)	UCS (kPa)		w/L	γ_d	t (days)	UCS (kPa)
1	1	0	0	1080.304	1	0	0	0	1457.52
2	-1	-1	1	1808.843	2	1	1	0	1645.5
3	1	-1	1	865.846	3	0	0	0	1387.05
4	-1	0	0	2179.087	4	1	-1	0	564.263
5	0	0	0	1507.844	5	0	-1	1	1267.73
6	0	1	0	946.333	6	0	-1	-1	442.736
7	0	0	0	1477.844	7	1	0	1	1406.56
8	0	0	-1	962.191	8	0	0	0	1435.46
9	1	1	-1	1013.603	9	-1	-1	0	1410.21
10	-1	1	1	3969.629	10	0	1	-1	1438.87
11	1	1	1	2033.959	11	0	0	0	1395.83
12	0	1	0	2163.398	12	1	0	-1	584.909
13	0	0	0	1507.844	13	0	1	1	2598.57
14	1	-1	-1	401.068	14	-1	1	0	3002.84
15	-1	-1	-1	897.354	15	-1	0	1	2635.75
16	0	0	1	1827.142	16	-1	0	-1	1412.82
17	0	0	0	1507.844	17	0	0	0	1407.18
18	-1	1	-1	2124.651					
19	0	0	0	1473.844					
20	0	0	0	1507.380					

TABLE B.2: Summary of various predictive model based on FCC and BB design for model type B

Face centered composite (FCC)						
Source	Std. Dev.	p-value	R^2	Adj R^2	Pre R^2	Remarks
Linear	247.18	< 0.0001	0.90930	0.89230	0.79590	Significant
2FI	116.15	< 0.0001	0.98370	0.97620	0.90320	Opted
Quadratic	81.84	0.00120	0.99650	0.99330	0.91790	significant
Cubic	21.02	0.00130	0.99980	0.99920	0.85300	Aliased
Box Behnken (BB)						
Source	Std. Dev.	p-value	R^2	Adj R^2	Pre R^2	Remarks
Linear	247.18	< 0.0001	0.90930	0.89230	0.79590	Significant
2FI	116.15	< 0.0001	0.98370	0.97620	0.90320	Insignificant
Quadratic	61.84	0.00120	0.99650	0.99330	0.94790	Opted
Cubic	21.02	0.00130	0.99980	0.99920	0.85300	Aliased

TABLE B.3: ANOVA results for FCC design for model B

Source	Sum of Squares (SS)	Degree of Freedom (df)	Mean Square (MS)	F Value	p-value	Prob > F	Remarks
Model	11050000.00	9.00	1227000.00	389.26	< 0.0001		significant
$\frac{w}{L}$	3200000.00	1.00	3200000.00	1014.97	< 0.0001		insignificant
γ_a	4152000.00	1.00	4152000.00	1316.79	< 0.0001		significant
t	2856000.00	1.00	2856000.00	905.69	< 0.0001		significant
$\frac{w}{L} \times \gamma_a$	346600.00	1.00	346600.00	109.92	< 0.0001		insignificant
$\frac{w}{L} \times t$	179700.00	1.00	179700.00	57.00	< 0.0001		insignificant
$\gamma_a \times t$	256100.00	1.00	256100.00	81.22	< 0.0001		significant
$(\frac{w}{L})^2$	22177.97	1.00	22177.97	7.03	0.02		insignificant
γ_a^2	616.62	1.00	616.62	0.20	0.67		insignificant
t^2	251.01	1.00	251.01	0.08	0.78		insignificant
Residual	31530.33	10.00	3153.03				
Lack of Fit	23876.31	5.00	4775.26	3.12	0.1187		significant
Pure Error	7654.02	5.00	1530.80				
Cor Total	11080000.00	19.00					

TABLE B.4: ANOVA results for BB design for model B

Source	Sum of Squares (<i>SS</i>)	Degree of Freedom (<i>df</i>)	Mean Square (<i>MS</i>)	F Value	p-value Prob > F	Remarks
Model	10740000.00	9.00	1194000.00	312.11	< 0.0001	significant
$\frac{w}{L}$	3119000.00	1.00	3119000.00	815.47	< 0.0001	significant
γ_d	4078000.00	1.00	4078000.00	1066.16	< 0.0001	significant
t	2608000.00	1.00	2608000.00	681.79	< 0.0001	significant
$\frac{w}{L} \times \gamma_d$	323000.00	1.00	323000.00	84.44	< 0.0001	significant
$\frac{w}{L} \times t$	202000.00	1.00	202000.00	52.82	< 0.0001	significant
$\gamma_d \times t$	277200.00	1.00	277200.00	72.47	< 0.0001	significant
$(\frac{w}{L})^2$	63833.94	1.00	63833.94	16.69	0.00	significant
γ_d^2	16528.41	1.00	16528.41	4.32	0.06	insignificant
t^2	18795.69	1.00	18795.69	4.91	0.05	insignificant
Residual	38247.79	10.00	3824.78			
Lack of Fit	36884.18	5.00	7376.84	27.05	0.00	significant
Pure Error	1363.62	5.00	272.72			
Cor Total	10800000	19				

TABLE B.5: Design matrix of input and response of FCC and BB design methods for model type C

Face central composite(FCC)design					Box-Behnken(BB) design				
Run No.	w (%)	t (days)	(η/Lv')	Response <i>UCS</i> (kPa)	Run No.	w (%)	t (days)	(η/Lv')	Response <i>UCS</i> (kPa)
1	0	0	0	1380.51	1	0	1	1	1159.95
2	0	0	0	1349.15	2	-1	0	1	803.31
3	0	0	1	750.153	3	1	-1	0	853.785
4	0	-1	0	951.25	4	-1	0	-1	3096.31
5	0	0	0	1324.39	5	-1	1	0	1871.27
6	0	1	0	1886.44	6	0	-1	-1	1785.51
7	-1	-1	-1	2123.27	7	0	0	0	1380.51
8	0	0	-1	3308.91	8	0	0	0	1349.15
9	-1	1	-1	3744.34	9	0	0	0	1392.28
10	-1	0	0	1348.64	10	1	0	1	735.93
11	1	-1	1	500.04	11	1	1	0	1901.375
12	-1	1	1	1136.84	12	0	0	0	1392.28
13	1	1	-1	4692.97	13	1	0	-1	3408.09
14	0	0	0	1392.28	14	0	-1	1	437.88
15	0	0	0	1405.26	15	0	1	-1	4461.02
16	1	0	0	1480.57	16	0	0	0	1337.06
17	0	0	0	1337.06	17	-1	-1	0	942.71
18	-1	-1	1	430.71					
19	1	1	1	847.896					
20	1	-1	-1	2407.332					

TABLE B.6: Summary of various predictive model based on FCC and BB design for model type C

Face centered composite (FCC)				
Source	p-value	R^2	Adj R^2	Remarks
Linear	0.00000	0.82667	0.71404	Significant
2FI	0.08569	0.86936	0.44963	Insignificant
Quadratic	0.00002	0.98424	0.94921	Opted
Cubic	0.00181	0.99794	0.48560	Aliased
Box Behnken (BB)				
Source	p-value	R^2	Adj R^2	Remarks
Linear	< 0.0001	0.842575	0.8062461	Significant
2FI	0.2108446	0.8977643	0.8364229	Insignificant
Quadratic	0.0029732	0.9844902	0.9645491	Opted
Cubic	0.0001649	0.9998543	0.9994172	Aliased

TABLE B.7: ANOVA results for FCC design for model C

Source	Sum of Squares (SS)	Degree of Freedom (df)	Mean Square (MS)	F Value	p-value Prob > F	Remarks
Model	22660000.00	9.00	2517000.00	132.81	< 0.0001	significant
w	131100.00	1.00	131100.00	6.92	0.03	significant
t	3476000.00	1.00	3476000.00	183.39	< 0.0001	significant
$\eta/Lv^{0.11}$	15900000.00	1.00	15900000.00	839.05	< 0.0001	significant
$w \times t$	11727.00	1.00	11727.00	0.62	0.45	insignificant
$w \times \eta/Lv^{0.11}$	263600.00	1.00	263600.00	13.91	0.00	significant
$t \times \eta/Lv^{0.11}$	1017000.00	1.00	1017000.00	53.67	< 0.0001	significant
w^2	43.79	1.00	43.79	0.00	0.96	insignificant
t^2	0.17	1.00	0.17	0.00	1.00	insignificant
$(\eta/Lv^{0.11})^2$	1026000.00	1.00	1026000.00	54.15	< 0.0001	significant
Residual	189500.00	10.00	18954.99			
Lack of Fit	184300.00	5.00	36852.71	34.86	0.0007	significant
Pure Error	5286.36	5.00	1057.27			
Cor Total	22850000.00	19.00				

TABLE B.8: ANOVA results for BB design for model C

Source	Sum of Squares (<i>SS</i>)	Degree of Freedom (<i>df</i>)	Mean Square (<i>MS</i>)	F Value	p-value Prob > F	Remarks
Model	17720000.00	9.00	1969000.00	49.37	< 0.0001	significant
<i>w</i>	4304.99	1.00	4304.99	0.11	0.75	insignificant
<i>t</i>	3610000.00	1.00	3610000.00	90.50	< 0.0001	significant
$\eta/Lv^{0.11}$	11550000.00	1.00	11550000.00	289.67	< 0.0001	significant
<i>w</i> × <i>t</i>	3542.04	1.00	3542.04	0.09	0.77	insignificant
<i>w</i> × $\eta/Lv^{0.11}$	35940.58	1.00	35940.58	0.90	0.37	insignificant
<i>t</i> × $\eta/Lv^{0.11}$	954000.00	1.00	954000.00	23.92	0.00	significant
<i>w</i> ²	5433.98	1.00	5433.98	0.14	0.72	insignificant
<i>t</i> ²	812.99	1.00	812.99	0.02	0.89	insignificant
$(\eta/Lv^{0.11})^2$	1540000.00	1.00	1540000.00	38.61	0.00	significant
Residual	279200.00	7.00	39884.54			
Lack of Fit	276600.00	3.00	92189.69	140.60	0.0002	significant
Pure Error	2622.70	4.00	655.67			
Cor Total	18000000.00	16.00				

TABLE B.9: Design matrix of input and response for split tensile strength based on *FCCDB* and *FCCDC*

Face Central composite (FCC) design for model <i>FCCDB</i>					Face Central composite (FCC) design for model <i>FCCDC</i>				
Run No.	Input parameters			Response	Run No.	Input parameters			Response
	<i>w/L</i>	γ_d (kN/m ³)	<i>t</i> (days)	<i>UCS</i> (kPa)		<i>w</i> (%)	<i>t</i> (days)	$\eta/Lv^{0.11}$	<i>UCS</i> (kPa)
1	0	0	0	196.127409	1	1	0	0	155.6153
2	0	0	0	173.87812	2	-1	-1	1	287.6826
3	0	0	1	118.6362756	3	1	-1	1	109.3745
4	0	-1	0	109.05125	4	-1	0	0	319.116
5	0	0	0	181.342892	5	0	0	0	210.1209
6	0	1	0	310.462428	6	0	-1	0	115.3075
7	-1	-1	-1	353.600554	7	0	0	0	204.5038
8	0	0	-1	588.485582	8	0	0	-1	128.8756
9	-1	1	-1	575.588172	9	1	1	-1	132.2973
10	-1	0	0	226.33768	10	-1	1	1	715.4073
11	1	-1	1	67.2561	11	1	1	1	348.7234
12	-1	1	1	175.7365	12	0	1	0	315.027
13	1	1	-1	780.590366	13	0	0	0	230.5464
14	0	0	0	201.673544	14	1	-1	-1	49.34557
15	0	0	0	216.405814	15	-1	-1	-1	148.5391
16	1	0	0	195.6998	16	0	0	1	297.4143
17	0	0	0	150.070554	17	0	0	0	263.9915
18	-1	-1	1	48.633258	18	-1	1	-1	334.0657
19	1	1	1	113.908608	19	0	0	0	209.5918
20	1	-1	-1	346.8717348	20	0	0	0	248.6823

TABLE B.10: ANOVA results for split tensile strength based model *FCCDB*

Source	Sum of Squares (<i>SS</i>)	Degree of Freedom (<i>df</i>)	Mean Square (<i>MS</i>)	F Value	p-value Prob > F	Remarks
Model	369338.01	9.00	41037.56	58.75	< 0.0001	significant
$\frac{w}{L}$	101899.87	1.00	101899.87	145.89	< 0.0001	significant
γ_d	128884.15	1.00	128884.15	184.52	< 0.0001	significant
t	93214.94	1.00	93214.94	133.45	< 0.0001	significant
$\frac{w}{L} \times \gamma_d$	10581.54	1.00	10581.54	15.15	0.003	not significant
$\frac{w}{L} \times t$	7443.84	1.00	7443.84	10.66	0.009	not significant
$\gamma_d \times t$	19859.75	1.00	19859.75	28.43	0.0003	significant
$(\frac{w}{L})^2$	2434.81	1.00	2434.81	3.49	0.091	not significant
γ_d^2	157.05	1.00	157.05	0.22	0.646	not significant
t^2	84.24	1.00	84.24	0.12	0.736	not significant
Residual	6984.78	10.00	698.48			
Lack of Fit	4044.61	5.00	808.92	1.38	0.367	not significant
Pure Error	2940.17	5.00	588.03			
Cor Total	376322.79	19.00				

TABLE B.11: ANOVA results for BB design for model *FCCDC*

Source	Sum of Squares (<i>SS</i>)	Degree of Freedom (<i>df</i>)	Mean Square (<i>MS</i>)	F Value	p-value Prob > F	Remarks
Model	670000	9	74449.95	36.4	< 0.0001	significant
w	1548.29	1	1548.29	0.757	0.4047	not significant
t	106300	1	106300.00	51.96	< 0.0001	significant
$\eta/Lv^{0.11}$	449800	1	449800.00	219.96	< 0.0001	significant
$w \times t$	2154.31	1	2154.31	1.05	0.3289	not significant
$w \times \eta/Lv^{0.11}$	7288.98	1	7288.98	3.56	0.0884	not significant
$t \times \eta/Lv^{0.11}$	29034.54	1	29034.54	14.2	0.0037	significant
w^2	249.6	1	249.60	0.122	0.7341	not significant
t^2	320.1	1	320.10	0.1565	0.7007	not significant
$(\eta/Lv^{0.11})^2$	48655.9	1	48655.90	23.79	0.0006	significant
Residual	20451.75	10	2045.17			
Lack of Fit	17721.5	5	3544.30	6.49	0.0304	not significant
Pure Error	2730.25	5	546.05			
Cor Total	690500	19				

