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APPENDIX A
EVAPORATION RATE

Table A.1: Evaporation Rate for 30-C
Preparation Time = 45 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2405						
10	2390	15		35.5	35	0.97	
20	2370	20		36.0	34	1.29	
30	2355	15	50	36.5	31	0.97	1.08
40	2345	10		36.5	30	0.65	
50	2325	20		36.5	30	1.29	
60	2310	15	45	37.0	30	0.97	0.97
70	2295	15		35.5	32	0.97	
80	2275	20		36.5	31	1.29	
90	2265	10	45	35.0	30	0.65	0.97
100	2245	20		35.0	31	1.29	
110	2230	15		35.5	30	0.97	
120	2215	15	50	35.0	30	0.97	1.08
130	2200	15	15	35.5	30	0.97	0.97
Average				36.0	31.0	-	1.01

Table A.2: Evaporation Rate for 30-10FA

Preparation Time = 39 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2490						
10	2475	15		37.0	40	0.97	
20	2460	15		38.0	34	0.97	
30	2445	15	45	39.0	32	0.97	0.97
40	2425	20		38.5	31	1.29	
50	2410	15		39.0	31	0.97	
60	2390	20	55	39.5	31	1.29	1.18
70	2375	15		38.0	32	0.97	
80	2360	15		35.5	38	0.97	
90	2340	20	50	37.0	32	1.29	1.08
100	2325	15		35.5	36	0.97	
110	2305	20		36.0	39	1.29	
120	2290	15	50	39.0	31	0.97	1.08
130	2275	15		35.5	34	0.97	
140	2255	20		38.5	31	1.29	
150	2240	15	50	37.0	32	0.97	1.08
160	2225	15		34.0	40	0.97	
170	2205	20		34.5	42	1.29	
180	2190	15	50	36.0	36	0.97	1.08
190	2175	15		34.5	41	0.97	
200	2160	15		37.0	35	0.97	
210	2140	20	50	38.0	35	1.29	1.08
220	2125	15		38.0	35	0.97	
230	2110	15		37.0	37	0.97	
240	2090	20	50	38.0	35	1.29	1.08
250	2075	15		37.5	36	0.97	
256	2065	10	25	37.0	36	1.08	1.02
Average				37.0	35.0	-	1.07

Table A.3: Evaporation Rate for 30-30FA

Preparation Time = 34 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2325						
10	2310	15		35.0	53	0.97	
20	2295	15		36.0	46	0.97	
30	2280	15	45	36.0	43	0.97	0.97
40	2275	5		35.5	42	0.32	
50	2260	15		35.0	41	0.97	
60	2240	20	40	36.0	42	1.29	0.86
70	2225	15		37.0	38	0.97	
80	2210	15		37.0	37	0.97	
90	2190	20	50	37.5	38	1.29	1.08
100	2175	15		37.0	38	0.97	
110	2160	15		37.5	36	0.97	
120	2140	20	50	38.0	35	1.29	1.08
130	2125	15		37.0	37	0.97	
140	2110	15		37.5	37	0.97	
150	2090	20	50	38.0	35	1.29	1.08
160	2075	15		37.5	36	0.97	
170	2060	15		38.0	34	0.97	
180	2040	20	50	37.5	35	1.29	1.08
190	2025	15		38.0	34	0.97	
200	2010	15		38.0	34	0.97	
210	1990	20	50	37.5	34	1.29	1.08
220	1975	15		37.0	35	0.97	
230	1955	20		37.5	35	1.29	
240	1940	15	50	37.0	36	0.97	1.08
250	1925	15		36.5	35	0.97	
260	1910	15		37.0	37	0.97	
266	1895	15	45	37.0	37	1.61	1.18
Average				37.0	38.0	-	1.05

Table A.4: Evaporation Rate for 30-50FA
Preparation Time = 31 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2400						
10	2380	20		36.0	40	1.29	
20	2365	15		36.0	41	0.97	
30	2350	15	50	36.5	39	0.97	1.08
40	2335	15		37.0	36	0.97	
50	2320	15		38.0	35	0.97	
60	2300	20	50	38.5	34	1.29	1.08
70	2285	15		38.0	33	0.97	
80	2270	15		38.0	33	0.97	
90	2250	20	50	36.5	35	1.29	1.08
100	2235	15		36.0	38	0.97	
110	2220	15		37.0	35	0.97	
120	2200	20	50	38.0	37	1.29	1.08
130	2185	15		38.0	32	0.97	
140	2170	15		38.0	31	0.97	
150	2150	20	50	36.0	35	1.29	1.08
160	2135	15		37.0	33	0.97	
170	2115	20		35.0	39	1.29	
180	2095	20	55	34.5	42	1.29	1.18
190	2080	15		35.0	42	0.97	
200	2065	15		35.0	42	0.97	
210	2040	25	55	35.5	42	1.61	1.18
220	2025	15		36.0	40	0.97	
230	2010	15		37.0	38	0.97	
240	1990	20	50	37.0	38	1.29	1.08
250	1975	15		37.0	38	0.97	
260	1960	15		37.0	38	0.97	
270	1940	20	50	37.5	39	1.29	1.08
280	1925	15		37.0	39	0.97	
290	1910	15		37.0	38	0.97	
300	1890	20	50	38.0	38	1.29	1.08
310	1875	15		37.0	38	0.97	
314	1870	5	20	37.5	38	0.81	0.89
Average				37.0	37.0	-	1.08

Table A.5: Evaporation Rate for 40-C

Preparation Time = 39 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	1510						
10	1490	20		32.0	36	1.29	
20	1470	20		34.0	28	1.29	
30	1455	15	55	33.0	29	0.97	1.18
40	1440	15		33.0	29	0.97	
50	1420	20		33.0	29	1.29	
60	1400	20	55	33.0	28	1.29	1.18
70	1385	15		32.5	29	0.97	
80	1365	20		33.0	28	1.29	
90	1350	15	50	33.0	28	0.97	1.08
100	1335	15		32.5	28	0.97	
110	1315	20		34.0	27	1.29	
120	1300	15	50	33.5	28	0.97	1.08
130	1285	15		34.0	28	0.97	
140	1270	15		34.5	26	0.97	
150	1250	20	50	33.5	27	1.29	1.08
160	1230	20		33.5	27	1.29	
170	1210	20		34.5	30	1.29	
180	1200	10	50	35.0	28	0.65	1.08
190	1185	15		35.0	29	0.97	
200	1170	15		35.0	29	0.97	
210	1150	20	50	35.0	28	1.29	1.08
220	1130	20		35.0	28	1.29	
226	1120	5	25	34.0	28	0.54	0.91
Average				33.5	29.0	-	1.08

Table A.6: Evaporation Rate for 40-10FA
Preparation Time = 34 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2275						
10	2260	15		35.0	46	0.97	
20	2245	15		36.0	44	0.97	
30	2225	20	50	36.0	42	1.29	1.08
40	2210	15		36.5	42	0.97	
50	2195	15		37.0	39	0.97	
60	2175	20	50	38.0	40	1.29	1.08
70	2160	15		37.5	39	0.97	
80	2145	15		37.0	39	0.97	
90	2125	20	50	37.5	38	1.29	1.08
100	2110	15		38.0	37	0.97	
110	2095	15		38.0	38	0.97	
120	2075	20	50	37.0	38	1.29	1.08
130	2060	15		37.5	38	0.97	
140	2045	15		38.0	40	0.97	
150	2025	20	50	37.0	39	1.29	1.08
160	2010	15		36.5	42	0.97	
170	1995	15		37.0	41	0.97	
180	1975	20	50	36.5	39	1.29	1.08
190	1960	15		35.5	40	0.97	
200	1945	15		37.0	40	0.97	
210	1925	20	50	38.0	40	1.29	1.08
220	1905	20		38.0	41	1.29	
230	1890	15		37.0	39	0.97	
240	1875	15	50	37.0	38	0.97	1.08
250	1860	15		37.0	38	0.97	
256	1850	10	25	37.0	38	1.08	1.02
Average				37.0	40.0	-	1.07

Table A.7: Evaporation Rate for 40-20FA

Preparation Time = 34 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	1605						
10	1585	20		33.0	36	1.29	
20	1570	15		33.5	34	0.97	
30	1550	20	55	34.0	33	1.29	1.18
40	1535	15		34.0	32	0.97	
50	1520	15		35.5	29	0.97	
60	1500	20	50	34.5	30	1.29	1.08
70	1480	20		34.5	30	1.29	
80	1465	15		35.5	29	0.97	
90	1450	15	50	35.5	29	0.97	1.08
100	1435	15		34.5	30	0.97	
110	1415	20		34.0	31	1.29	
120	1400	15	50	35.5	29	0.97	1.08
130	1380	20		34.0	31	1.29	
140	1365	15		35.5	29	0.97	
150	1350	15	50	35.5	29	0.97	1.08
160	1330	20		34.0	30	1.29	
170	1315	15		35.5	29	0.97	
180	1300	15	50	35.5	28	0.97	1.08
190	1280	20		34.5	30	1.29	
200	1265	15		35.0	29	0.97	
210	1250	15	50	35.0	29	0.97	1.08
220	1230	20		32.0	29	1.29	
230	1215	15		35.0	30	0.97	
240	1195	20	55	34.5	30	1.29	1.18
250	1180	15		33.5	31	0.97	
260	1165	15		35.5	29	0.97	
270	1145	20	50	34.0	30	1.29	1.08
280	1125	20		34.0	30	1.29	
290	1110	15		33.5	29	0.97	
291	1110	0	35	33.5	29	0.00	0.75
Average				34.5	30.0	-	1.07

Table A.8: Evaporation Rate for 40-30FA

Preparation Time = 35 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2450						
10	2425	25		38.5	38	1.61	
20	2410	15		39.0	33	0.97	
30	2395	15	55	39.0	33	0.97	1.18
40	2380	15		39.0	33	0.97	
50	2365	15		39.0	34	0.97	
60	2345	20	50	39.0	33	1.29	1.08
70	2330	15		39.5	33	0.97	
80	2315	15		40.0	32	0.97	
90	2295	20	50	39.5	35	1.29	1.08
100	2280	15		39.0	33	0.97	
110	2265	15		39.5	33	0.97	
120	2245	20	50	40.0	35	1.29	1.08
130	2230	15		40.0	36	0.97	
140	2215	15		40.0	33	0.97	
150	2195	20	50	39.0	34	1.29	1.08
160	2180	15		39.0	33	0.97	
170	2165	15		39.0	34	0.97	
180	2145	20	50	39.5	32	1.29	1.08
190	2130	15		40.0	32	0.97	
200	2115	15		35.0	40	0.97	
210	2095	20	50	39.0	39	1.29	1.08
220	2180	-85		39.0	37	-5.49	
230	2165	15		38.5	40	0.97	
240	2045	120	50	39.0	35	7.75	1.08
250	2030	15		39.0	34	0.97	
260	2015	15		39.0	37	0.97	
270	1995	20	50	38.0	36	1.29	1.08
280	1980	15		38.5	36	0.97	
289	1965	15	30	38.0	36	1.08	1.02
Average				39.0	35.0	-	1.08

Table A.9: Evaporation Rate for 40-40FA
Preparation Time = 35 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2485						
10	2465	20		35.5	35	1.29	
20	2450	15		36.0	34	0.97	
30	2430	20	55	36.5	31	1.29	1.18
40	2415	15		36.6	30	0.97	
50	2395	20		36.3	30	1.29	
60	2380	15	50	36.9	30	0.97	1.08
70	2365	15		35.4	32	0.97	
80	2345	20		36.5	31	1.29	
90	2330	15	50	35.0	30	0.97	1.08
100	2315	15		35.0	31	0.97	
110	2295	20		35.5	30	1.29	
120	2280	15	50	35.0	30	0.97	1.08
130	2265	15		35.5	30	0.97	
140	2245	20		34.5	31	1.29	
150	2230	15	50	35.0	30	0.97	1.08
160	2215	15		33.5	32	0.97	
170	2200	15		33.5	32	0.97	
180	2180	20	50	35.0	30	1.29	1.08
190	2160	20		35.5	30	1.29	
200	2145	15		33.0	32	0.97	
210	2125	20	55	33.5	34	1.29	1.18
220	2110	15		33.5	35	0.97	
230	2095	15		33.0	35	0.97	
240	2075	20	50	33.0	35	1.29	1.08
250	2060	15		33.0	35	0.97	
260	2045	15		33.0	36	0.97	
270	2025	20	50	33.0	36	1.29	1.08
280	2010	15		33.0	38	0.97	
290	1995	15		33.0	38	0.97	
300	1975	20	50	33.0	37	1.29	1.08
310	1955	20		33.5	36	1.29	
320	1940	15		33.0	36	0.97	
330	1925	15	50	33.0	36	0.97	1.08
335	1915	5		33.0	36	0.65	0.65
Average				34.5	33.0	-	1.06

Table A.10: Evaporation Rate for 40-50FA
Preparation Time = 33 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2350						
10	2330	20		35.5	35	1.29	
20	2315	15		36.0	34	0.97	
30	2295	20	55	36.5	31	1.29	1.18
40	2280	15		36.6	30	0.97	
50	2260	20		36.3	30	1.29	
60	2245	15	50	36.9	30	0.97	1.08
70	2230	15		35.4	32	0.97	
80	2215	15		36.5	31	0.97	
90	2195	20	50	35.0	30	1.29	1.08
100	2175	20		35.0	31	1.29	
110	2155	20		35.5	30	1.29	
120	2140	15	55	35.1	30	0.97	1.18
130	2125	15		35.5	30	0.97	
140	2105	20		34.5	31	1.29	
150	2090	15	50	35.0	30	0.97	1.08
160	2070	20		33.5	32	1.29	
170	2055	15		33.5	32	0.97	
180	2040	15	50	35.0	30	0.97	1.08
190	2025	15		35.5	30	0.97	
200	2010	15		33.0	32	0.97	
210	1990	20	50	33.5	34	1.29	1.08
220	1975	15		33.5	35	0.97	
230	1955	20		33.0	35	1.29	
240	1940	15	50	33.0	35	0.97	1.08
250	1925	15		33.0	35	0.97	
260	1905	20		33.0	36	1.29	
270	1890	15	50	33.0	36	0.97	1.08
280	1870	20		33.0	38	1.29	
290	1855	15		33.0	38	0.97	
300	1840	15	50	33.0	37	0.97	1.08
310	1825	15		33.5	36	0.97	
320	1805	20		33.0	36	1.29	
327	1795	10	45	33.0	36	0.92	1.06
Average				34.5	33.0	-	1.09

Table A.11: Evaporation Rate for 50-C
Preparation Time = 33 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	1410						
10	1395	15		36.5	44	0.97	
20	1380	15		36.0	43	0.97	
30	1360	20	50	35.0	45	1.29	1.08
40	1345	15		36.0	47	0.97	
50	1330	15		35.5	47	0.97	
60	1310	20	50	37.5	42	1.29	1.08
70	1295	15		35.5	47	0.97	
80	1280	15		35.5	47	0.97	
90	1260	20	50	36.0	45	1.29	1.08
100	1240	20		35.5	47	1.29	
110	1225	15		35.0	47	0.97	
120	1210	15	50	35.5	49	0.97	1.08
130	1190	20		36.0	49	1.29	
140	1175	15		35.0	49	0.97	
150	1160	15	50	34.5	49	0.97	1.08
160	1145	15		35.5	49	0.97	
170	1130	15		35.5	49	0.97	
180	1110	20	50	37.0	49	1.29	1.08
190	1095	15		38.0	43	0.97	
200	1080	15		39.0	43	0.97	
210	1060	20	50	38.5	44	1.29	1.08
220	1045	15		38.0	45	0.97	
230	1025	20		38.5	41	1.29	
240	1010	15	50	38.0	40	0.97	1.08
247	1000	10	10	38.0	40	0.92	0.92
Average				36.5	46.0	-	1.06

Table A.12: Evaporation Rate for 50-10FA
Preparation Time = 32 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	1410						
10	1390	20		37.0	33	1.29	
20	1375	15		37.0	31	0.97	
30	1355	20	55	38.0	29	1.29	1.18
40	1335	20		38.0	29	1.29	
50	1320	15		38.0	30	0.97	
60	1300	20	55	37.0	29	1.29	1.18
70	1280	20		38.0	29	1.29	
80	1265	15		37.0	28	0.97	
90	1250	15	50	38.0	29	0.97	1.08
100	1235	15		37.0	30	0.97	
110	1215	20		37.0	30	1.29	
120	1200	15	50	36.5	30	0.97	1.08
130	1180	20		36.0	31	1.29	
140	1165	15		36.0	30	0.97	
150	1150	15	50	36.5	30	0.97	1.08
160	1130	20		36.0	31	1.29	
170	1115	15		36.5	31	0.97	
180	1100	15	50	36.0	31	0.97	1.08
190	1090	10		36.0	32	0.65	
200	1070	20		38.0	29	1.29	
210	1050	20	50	38.0	28	1.29	1.08
220	1035	15		38.0	28	0.97	
230	1015	20		38.0	28	1.29	
240	1000	15	50	37.0	30	0.97	1.08
250	985	15		35.5	32	0.97	
260	970	15		35.5	33	0.97	
270	950	20	50	35.5	34	1.29	1.08
280	935	15		35.5	35	0.97	
290	920	15		36.5	34	0.97	
293	915	5	35	35.6	34	1.08	1.00
Average				37.0	31.0	-	1.09

Table A.13: Evaporation Rate for 50-30FA

Preparation Time = 32 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2410						
10	2390	20		33.5	34	1.29	
20	2375	15		34.0	33	0.97	
30	2360	15	50	34.0	31	0.97	1.08
40	2345	15		33.5	31	0.97	
50	2330	15		34.5	30	0.97	
60	2310	20	-50	34.0	31	1.29	1.08
70	2295	15		35.0	30	0.97	
80	2280	15		35.0	29	0.97	
90	2260	20	50	34.0	30	1.29	1.08
100	2245	15		34.0	30	0.97	
110	2225	20		34.5	29	1.29	
120	2210	15	50	34.0	29	0.97	1.08
130	2195	15		34.0	30	0.97	
140	2175	20		35.0	29	1.29	
150	2155	20	55	35.0	29	1.29	1.18
160	2140	15		34.5	29	0.97	
170	2125	15		35.0	28	0.97	
180	2105	20	50	35.0	28	1.29	1.08
190	2090	15		34.5	28	0.97	
200	2075	15		35.0	28	0.97	
210	2060	15	45	34.5	28	0.97	0.97
220	2045	15		34.5	28	0.97	
230	2025	20		34.5	28	1.29	
240	2010	15	50	34.5	28	0.97	1.08
250	1995	15		34.5	28	0.97	
260	1975	20		35.0	27	1.29	
270	1960	15	50	35.0	27	0.97	1.08
280	1945	15		35.0	27	0.97	
290	1925	20		35.5	27	1.29	
300	1910	15	50	35.5	27	0.97	1.08
310	1895	15		35.5	27	0.97	
313	1890	5	20	35.5	27	1.08	1.02
Average				34.5	29.0	-	1.07

Table A.14: Evaporation Rate for 50-50FA
Preparation Time = 33 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2525						
10	2510	15		33.0	35	0.97	
20	2495	15		33.5	32	0.97	
30	2475	20	50	34.0	31	1.29	1.08
40	2460	15		34.5	30	0.97	
50	2445	15		35.0	30	0.97	
60	2425	20	50	34.5	29	1.29	1.08
70	2410	15		35.0	28	0.97	
80	2390	20		34.5	29	1.29	
90	2375	15	50	34.5	29	0.97	1.08
100	2360	15		35.5	28	0.97	
110	2345	15		35.5	28	0.97	
120	2325	20	50	35.5	27	1.29	1.08
130	2310	15		35.5	27	0.97	
140	2290	20		36.0	29	1.29	
150	2275	15	50	36.0	27	0.97	1.08
160	2260	15		35.5	27	0.97	
170	2245	15		36.0	25	0.97	
180	2225	20	50	35.5	26	1.29	1.08
190	2210	15		36.0	26	0.97	
200	2190	20		36.0	25	1.29	
210	2170	20	55	36.5	25	1.29	1.18
220	2155	15		36.5	24	0.97	
230	2135	20		36.5	25	1.29	
240	2120	15	50	37.0	26	0.97	1.08
250	2105	15		36.0	26	0.97	
260	2085	20		37.0	25	1.29	
270	2070	15	50	36.0	26	0.97	1.08
280	2050	20		36.5	25	1.29	
290	2035	15		37.0	25	0.97	
300	2020	15	50	36.5	25	0.97	1.08
310	2005	15		35.0	27	0.97	
320	1990	15		36.0	26	0.97	
330	1970	20	50	36.0	26	1.29	1.08
340	1950	20		36.0	26	1.29	
350	1935	15		35.5	27	0.97	
357	1925	10	45	36.0	26	0.92	1.06
Average				35.5	27.0	-	1.08

Table A.15: Evaporation Rate for 50-3SF
Preparation Time = 37 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2510						
10	2490	20	55	34.5	34	1.29	1.18
20	2475	15		35.5	31	0.97	
30	2455	20		35.5	30	1.29	
40	2440	15	50	36.0	30	0.97	1.08
50	2420	20		35.5	30	1.29	
60	2405	15		36.0	30	0.97	
70	2385	20	55	36.0	29	1.29	1.18
80	2370	15		36.5	29	0.97	
90	2350	20		36.0	29	1.29	
100	2330	20	55	35.5	29	1.29	1.18
110	2315	15		36.0	27	0.97	
120	2295	20		34.5	28	1.29	
130	2275	20	40	36.0	27	1.29	0.86
140	2265	10		36.0	27	0.65	
150	2255	10		36.5	27	0.65	
160	2235	20	50	36.0	27	1.29	1.08
170	2220	15		35.5	29	0.97	
180	2205	15		34.5	31	0.97	
190	2190	15	50	34.5	34	0.97	1.08
200	2170	20		34.0	33	1.29	
210	2155	15		34.0	34	0.97	
220	2140	15	45	33.5	34	0.97	1.11
230	2125	15		33.5	34	0.97	
237	2110	15		33.5	34	1.38	
Average				35.0	30.0	-	1.09

Table A.16: Evaporation Rate for 50-5SF
Preparation Time = 43 min

Time	Weight	Δ_{10}	Δ_{30}	Temp	RH	Evap. Rate ₁₀	Evap. Rate ₃₀
(min)	(g)	(g)	(g)	(C°)	(%)	(kg/m ² h)	(kg/m ² h)
0	2490						
10	2470	20		35.5	35	1.29	
20	2450	20		36.0	34	1.29	
30	2435	15	55	36.5	31	0.97	1.18
40	2415	20		36.6	30	1.29	
50	2400	15		36.3	30	0.97	
60	2385	15	50	36.9	30	0.97	1.08
70	2370	15		35.4	32	0.97	
80	2350	20		36.5	31	1.29	
90	2335	15	50	35.1	30	0.97	1.08
100	2315	20		35.1	31	1.29	
110	2300	15		35.5	30	0.97	
120	2285	15	50	35.1	30	0.97	1.08
130	2270	15		35.5	30	0.97	
140	2250	20		34.5	31	1.29	
150	2235	15	50	35.0	30	0.97	1.08
160	2215	20		33.5	32	1.29	
170	2200	15		33.5	32	0.97	
180	2185	15	50	35.0	30	0.97	1.08
190	2170	15		35.5	30	0.97	
200	2150	20		33.0	32	1.29	
210	2135	15	50	33.5	34	0.97	1.08
220	2120	15		33.5	35	0.97	
223	2115	5	20	33.0	35	1.08	1.02
Average				35.0	31.0	-	1.08

APPENDIX B

BLEEDING RATE

Table B.1: Bleeding Rate for 50-C

Time until towelling = 14 min

Time min	Time Interval		Water Collected		Bleed Rate	
	min	hr	ml	kg	kg/m ²	kg/m ² ·h
0	-	-	-	-	-	-
10	10	0.17	10	0.01	0.20	1.17
20	10	0.17	11	0.01	0.22	1.29
30	10	0.17	13	0.01	0.25	1.53
40	10	0.17	12	0.01	0.23	1.41
70	30	0.50	31	0.03	0.61	1.21
100	30	0.50	29	0.03	0.57	1.14
130	30	0.50	5	0.01	0.10	0.20
160	30	0.50	0	0.00	0.00	0.00

Table B.2: Bleeding Rate for 50-10FA

Time until towelling = 14 min

Time min	Time Interval		Water Collected		Bleed Rate	
	min	hr	ml	kg	kg/m ²	kg/m ² ·h
0	-	-	-	-	-	-
10	10	0.17	86	0.09	1.68	10.10
20	10	0.17	114	0.11	2.23	13.39
30	10	0.17	65	0.07	1.27	7.64
40	10	0.17	65	0.07	1.27	7.64
70	30	0.50	52	0.05	1.02	2.04
100	30	0.50	16	0.02	0.31	0.63
130	30	0.50	7	0.01	0.14	0.27
160	30	0.50	0	0.00	0.00	0.00

Table B.3: Bleeding Rate for 50-30FA

Time until towelling = 16 min

Time min	Time Interval		Water Collected		Bleed Rate	
	min	hr	ml	kg	kg/m ²	kg/m ² ·h
0	-	-	-	-	-	-
10	10	0.17	227	0.23	4.44	26.67
20	10	0.17	114	0.11	2.23	13.39
30	10	0.17	50	0.05	0.98	5.87
40	10	0.17	30	0.03	0.59	3.52
70	30	0.50	43	0.04	0.84	1.68
100	30	0.50	19	0.02	0.37	0.74
130	30	0.50	8	0.01	0.16	0.31
160	30	0.50	0	0.00	0.00	0.00

Table B. 4: Bleeding Rate for 50-50FA

Time until towelling = 13 min

Time min	Time Interval		Water Collected		Bleed Rate	
	min	hr	ml	kg	kg/m ²	kg/m ² ·h
0	-	-	-	-	-	-
10	10	0.17	268	0.27	5.25	31.49
20	10	0.17	135	0.14	2.64	15.86
30	10	0.17	48	0.05	0.94	5.64
40	10	0.17	46	0.05	0.90	5.40
70	30	0.50	63	0.06	1.23	2.47
100	30	0.50	38	0.04	0.74	1.49
130	30	0.50	11	0.01	0.22	0.43
160	30	0.50	18	0.02	0.35	0.70
190	30	0.50	5	0.01	0.10	0.20
220	30	0.50	0	0.00	0.00	0.00

APPENDIX C

CRACK WIDTH MEASUREMENTS

Table C.1: Crack Widths of Fly Ash Concrete Specimens with w/b = 0.30

Control	10 % FA	30 % FA	50 % FA
0.70	0.86	1.07	0.65
0.54	0.80	0.97	0.76
0.54	0.77	0.66	0.76
0.62	0.66	0.46	0.70
0.52	0.65	0.56	0.50
0.56	0.41	0.51	0.65
0.82	0.72	0.66	0.56
0.92	0.86	0.71	0.58
1.08	0.72	0.66	1.09
0.92	0.72	0.63	0.65
1.02	1.12	0.71	0.80
0.72	0.82	0.66	0.70
0.82	0.92	0.33	0.80
0.92	0.72	0.66	1.10
1.08	1.08	0.82	0.76
0.82	0.77	1.02	0.95
0.56	0.66	1.05	0.80
0.77	0.92	0.86	0.80
0.92	0.46	0.76	0.52
0.86	0.77	0.86	0.76
1.02	0.82	0.76	0.76
1.08	1.08	0.54	0.46
0.92	1.12	0.83	0.85
0.86	0.86	1.16	0.76
0.92	1.12	0.98	1.21
0.33	0.98	0.86	0.65
1.08	0.97	0.97	0.65
0.97	0.86	0.71	0.80
0.49	1.08	0.91	1.08
0.97	0.82	1.08	0.97
0.82	0.92	0.91	0.40
0.86	1.21	0.71	1.11
1.03	0.86	0.82	0.77
0.76	1.08	0.79	0.65
0.86	0.97	0.97	1.03
1.02	0.86	0.82	0.76
0.86	0.92	0.63	1.11
0.82	1.08	0.66	0.80
0.77	0.86	0.85	1.08
0.72	1.11	0.66	0.95
0.49	0.57	0.86	1.19
0.82	0.92	0.76	0.90
0.66	0.92	0.71	1.30
0.51	1.08	1.02	1.21
0.33	0.91	0.97	0.86



Control	10 % FA	30 % FA	50 % FA
0.59	0.86	0.92	0.56
0.92	0.97	0.62	1.15
0.65	0.97	0.38	1.21
0.65	0.61	0.76	1.00
0.59	0.91	0.80	1.00
0.65	0.41	0.85	1.21
0.59	0.38	1.25	0.80
0.65	0.41	0.85	0.50
0.59	0.38	1.21	0.76
0.77	0.50	0.85	0.90
0.36	0.58	0.95	1.09
0.86	0.46	0.70	0.95
0.82	0.51	1.01	0.95
0.86	0.66	0.56	0.56
0.65	0.30	0.76	0.90
0.77	0.50	0.70	0.76
0.72	0.38	0.82	0.70
0.51	0.46	0.59	0.60
0.62	0.38	0.54	0.60
0.66	1.10	0.65	0.80
0.71	1.05	0.65	0.76
0.56	0.90	0.49	0.76
0.36	0.74	0.65	0.56
0.56	0.65	0.38	0.65
0.40	0.55	0.70	0.34
0.39	1.00	0.50	0.28
0.45	0.50	0.65	0.60
0.50	0.74	0.65	0.52
0.36	0.70	0.65	0.46
0.50	0.94	0.70	0.28
0.53	0.74	0.41	0.43
0.58	0.50	0.70	0.30
0.18	0.70	0.65	0.33
0.58	0.43	0.65	0.65
0.58	0.74	0.17	0.33
1.14	0.64	0.69	0.33
0.66	0.76	0.53	0.50
0.70	0.71	0.85	0.46
0.53	0.79	0.70	0.58
0.18	1.10	1.05	0.58
0.23	0.65	0.56	0.65
0.49	0.76	0.35	0.70
0.76	0.40	0.46	0.89
0.76	0.58	0.46	0.35
0.82	0.46	0.69	0.58
0.63	0.59	0.63	0.41
0.53	0.54	0.40	0.70
0.70	0.51	0.63	0.58
0.91	0.61	0.74	0.43
0.95	0.77	0.70	1.00
1.21	0.65	0.74	0.74
0.90	0.71	1.08	0.56

Control	10 % FA	30 % FA	50 % FA
1.10	0.52	0.64	0.80
0.75	0.55	0.40	0.85
1.10	0.66	0.67	0.90
0.90	0.47	0.71	0.80
0.68	0.43	0.67	0.65
0.65	0.77	0.90	0.85
0.25	0.66	0.74	0.95
0.81	0.50	0.65	0.85
0.83	0.76	0.67	0.70
0.70	0.33	0.60	1.39
0.38	0.61	0.67	1.35
0.78	0.33	0.45	1.05
0.84	0.52	0.70	0.80
0.84	0.60	0.57	0.65
0.44	0.43	0.50	0.70
0.38	0.57	0.85	1.17
0.59	0.55	0.60	0.91
0.39	0.52	0.95	0.72
0.57	0.65	0.74	0.85
0.27	0.55	0.40	1.00
0.59	0.65	0.70	0.85
0.62	0.65	0.74	0.98
0.45	1.20	0.74	0.78
0.56	0.85	0.95	0.91
0.51	0.52	0.85	0.78
0.65	0.60	0.90	1.04
0.39	0.55	1.28	0.78
0.50	0.44	0.74	0.56
0.70	0.53	0.83	0.74
0.60	0.83	0.80	0.86
0.60	0.65	0.95	0.95
0.85	0.85	0.67	0.28
0.21	0.74	0.80	0.90
0.31	0.37	0.60	0.66
0.44	0.37	0.56	0.43
0.66	0.37	0.67	0.48
0.50	0.44	0.60	0.60
0.60	0.44	0.95	0.26
0.44	0.50	0.47	0.28
0.95	0.31	0.60	0.22
0.90	0.61	0.54	0.26
0.60	0.25	0.60	0.35
0.65	0.31	0.45	0.30
0.29	0.71	0.60	0.30
0.29	0.50	0.40	0.30
0.25	0.62	0.29	0.43
0.41	0.44	0.19	0.30
0.32	0.50	0.40	0.35
0.66	0.44	0.50	0.48
0.69	0.50	0.50	0.30
0.41	0.39	0.29	0.43
0.53	0.33	0.40	0.56

Control	10 % FA	30 % FA	50 % FA
0.25	0.36	0.40	0.35
0.41	0.36	0.50	0.48
0.61	0.34	0.45	0.35
0.32	0.42	0.60	0.38
0.32	0.45	0.45	0.61
0.49	0.40	0.40	0.30
0.49	0.50	0.50	0.38
0.61	0.50	0.40	0.48
0.41	0.68	0.64	0.43
0.49	0.36	0.24	0.56
0.49	0.62	0.45	0.30
0.49	0.39	0.55	0.30
0.57	0.39	0.60	0.22
0.49	0.29	0.34	0.52
0.45	0.29	0.69	0.38
0.49	0.29	0.24	0.52
0.49	0.33	0.50	0.52
0.45	0.39	0.40	0.35
0.20	0.33	0.50	0.80
0.49	0.39	0.45	0.48
0.53	0.29	0.45	0.48
0.53	-	0.50	0.35
0.57	-	0.40	0.22
0.53	-	0.29	0.35
0.45	-	0.45	0.22
0.37	-	0.34	0.35
0.41	-	0.40	0.30
0.41	-	0.29	0.26
0.32	-	0.24	0.56
0.41	-	0.34	0.22
0.17	-	0.15	0.48
0.32	-	0.40	0.26
0.32	-	0.24	0.43
0.61	-	0.34	0.43
0.29	-	0.45	0.48
0.41	-	0.34	0.56
0.41	-	0.40	0.56
0.37	-	0.34	0.43
0.32	-	0.55	0.56
0.37	-	0.40	0.52
0.24	-	0.50	0.38
0.37	-	0.40	0.30
0.41	-	0.40	0.22
0.49	-	0.29	0.48
0.57	-	0.50	0.56
0.32	-	0.29	0.48
0.29	-	0.40	0.48
0.37	-	0.40	0.43
0.32	-	0.45	0.60
0.41	-	0.50	0.30
0.49	-	0.55	0.43
0.41	-	0.50	0.22

Control	10 % FA	30 % FA	50 % FA
0.37	-	0.29	0.30
0.32	-	0.19	0.52
0.32	-	0.34	-
0.29	-	0.40	-
0.20	-	0.29	-
0.49	-	0.45	-
-	-	0.50	-
-	-	0.50	-
-	-	0.24	-
-	-	0.34	-
-	-	0.40	-
-	-	0.34	-
-	-	0.40	-
-	-	0.45	-
-	-	0.55	-
-	-	0.29	-

Table C.2: Crack Widths of Fly Ash Concrete Specimens with w/b = 0.40

Control	10 % FA	20 % FA	30 % FA	40 % FA	50 % FA
0.50	0.67	0.29	0.51	0.99	1.09
0.43	0.56	1.00	0.67	0.67	0.67
0.93	0.67	0.72	0.61	0.61	0.73
0.50	1.08	0.76	0.57	0.99	0.93
0.83	0.55	0.68	0.78	0.99	0.73
0.64	0.33	0.81	0.52	0.89	0.79
0.78	0.82	0.87	0.89	0.84	0.73
0.99	0.52	0.36	0.73	0.73	0.92
0.57	0.67	0.61	0.78	0.89	0.67
0.78	0.62	1.06	0.83	0.87	0.63
0.85	0.51	0.92	0.73	1.25	0.73
0.85	0.73	0.84	0.78	1.15	0.33
0.71	0.73	0.97	0.78	0.83	0.78
0.83	0.93	0.76	0.78	1.09	0.61
0.85	0.95	0.79	0.67	0.83	0.89
0.44	0.78	0.92	0.57	1.04	0.73
0.78	0.62	0.92	0.73	0.96	0.89
0.55	0.73	0.81	0.78	0.99	0.73
0.61	0.82	0.84	0.41	0.57	0.67
0.45	0.99	0.94	0.67	0.89	0.73
0.60	0.88	1.19	0.93	1.04	0.83
0.73	0.93	0.94	0.94	0.73	0.55
0.67	0.67	0.94	0.99	0.63	0.45
0.93	0.65	0.74	0.67	1.04	0.63
0.94	0.52	0.84	0.78	0.67	0.90
0.78	0.78	0.90	0.61	0.78	1.31
0.73	0.84	0.90	0.84	0.93	1.04
0.83	0.61	0.90	0.96	1.30	0.78
0.93	0.93	1.01	0.73	0.78	0.73
0.73	1.04	0.81	1.09	0.78	0.90
0.61	1.00	0.79	1.04	0.67	0.90
0.94	0.73	0.87	1.04	0.78	0.78
0.67	0.99	0.57	0.39	0.73	1.12
0.39	0.55	0.87	0.39	0.41	1.02
0.51	0.45	1.13	0.78	0.73	1.02
0.55	0.55	0.87	0.67	0.78	0.90
0.84	1.13	0.94	0.93	0.63	1.15
0.74	0.56	0.79	0.89	1.04	1.06
0.94	0.56	0.79	1.06	0.93	0.67
0.51	0.78	0.79	0.99	1.09	0.67
0.67	0.78	0.45	0.55	0.35	0.51
0.61	0.89	0.45	0.89	0.89	0.90
0.90	0.78	0.41	0.84	0.72	0.96
0.84	0.78	0.41	0.78	0.63	0.94
0.51	0.78	0.56	0.63	0.99	0.52
0.28	0.73	0.67	0.67	0.83	0.67
0.73	0.55	0.61	1.09	1.09	0.73
0.22	1.00	0.76	0.78	0.67	0.90
0.94	0.73	0.51	1.09	0.47	0.78
0.78	0.73	0.36	0.73	0.83	0.73
0.94	0.88	0.31	0.78	0.73	0.99

Control	10 % FA	20 % FA	30 % FA	40 % FA	50 % FA
0.90	0.67	0.45	0.63	0.39	0.89
0.33	0.88	0.45	0.67	0.30	1.04
0.61	0.45	0.38	0.67	0.45	0.55
0.78	0.45	0.45	0.28	0.39	0.61
0.51	0.45	0.39	1.04	0.26	0.78
0.39	0.28	0.29	0.78	0.27	0.63
0.51	0.78	0.61	0.73	0.27	0.63
0.84	0.61	0.29	0.83	0.34	0.73
0.78	0.84	0.52	0.73	0.54	0.73
0.67	0.51	0.61	1.04	0.37	0.51
0.78	0.51	0.57	1.09	0.59	0.78
0.55	0.45	0.46	1.15	0.50	0.73
0.61	0.45	0.63	0.78	0.59	0.51
0.67	0.67	0.65	0.78	0.59	0.67
0.78	0.55	0.56	1.25	0.83	0.73
0.61	0.55	0.52	0.73	0.59	0.93
0.78	0.51	0.52	0.83	0.73	0.74
0.45	0.51	0.61	0.67	0.78	0.50
0.28	0.45	0.52	0.63	0.79	0.30
0.45	0.39	0.65	0.83	0.59	0.50
0.51	0.47	0.37	0.67	0.54	0.39
0.30	0.51	0.56	0.67	0.65	0.37
0.39	0.66	0.51	0.55	0.59	0.68
0.54	0.59	0.39	0.48	0.70	0.74
0.80	0.67	0.52	0.48	0.79	0.59
0.64	0.59	0.69	0.50	0.68	0.45
0.60	0.35	0.43	0.39	0.84	0.59
0.58	0.32	0.64	0.39	0.79	0.74
0.65	0.47	0.34	0.39	0.37	0.83
0.51	0.71	0.39	0.50	0.27	0.78
0.29	0.60	0.69	0.33	0.46	0.65
0.45	0.32	0.43	0.31	1.06	0.50
0.29	0.63	0.52	0.48	0.73	1.06
0.62	0.39	0.39	0.51	0.54	0.54
0.57	0.57	0.39	0.34	0.59	0.44
0.82	0.51	0.30	0.45	0.84	0.74
0.68	0.32	0.43	0.39	0.79	0.96
0.57	0.51	0.74	0.51	0.74	0.45
0.68	0.35	0.30	0.41	0.32	0.84
0.57	0.67	0.86	0.38	0.76	0.34
0.80	0.44	0.30	0.97	0.77	0.30
0.45	0.71	0.48	0.39	0.54	0.34
0.63	0.39	0.43	0.57	0.64	0.30
0.65	0.35	0.50	0.84	0.59	0.53
0.63	0.39	0.77	0.78	0.37	0.84
0.80	0.32	0.48	0.39	0.65	0.58
0.68	0.67	0.53	0.72	0.54	0.63
0.62	0.51	0.75	0.67	0.27	0.63
0.75	0.63	1.00	1.00	0.59	0.58
0.55	0.56	0.34	0.76	0.83	0.67
0.40	0.32	0.59	0.45	0.46	0.39
0.49	0.35	0.50	0.79	0.65	0.63

Control	10 % FA	20 % FA	30 % FA	40 % FA	50 % FA
0.63	0.45	0.34	0.55	0.59	0.53
0.35	0.48	0.48	0.27	0.50	0.67
0.37	0.53	0.61	0.51	0.46	0.63
0.73	0.22	0.18	0.48	0.54	0.48
0.50	0.40	0.34	0.34	0.70	0.48
0.50	0.53	0.77	0.79	0.61	0.63
0.57	0.40	0.52	0.34	0.70	0.53
0.89	0.40	0.77	0.45	0.46	0.92
0.74	0.58	0.77	0.34	0.32	0.97
0.57	0.53	0.57	0.48	0.37	0.87
0.23	0.53	0.62	0.39	0.18	0.89
0.37	0.40	0.43	0.39	0.22	0.67
0.39	0.45	0.43	0.39	0.32	0.53
0.63	0.40	0.48	0.50	0.37	0.58
0.57	0.40	0.63	0.55	0.54	0.67
0.50	0.53	0.33	0.55	0.50	0.63
0.40	0.31	0.55	0.24	0.37	0.58
0.40	0.91	0.44	0.83	0.47	0.67
0.74	0.42	0.53	0.68	0.59	0.58
0.68	0.39	0.42	0.41	0.35	0.53
0.64	0.49	0.38	0.38	0.29	0.63
0.55	0.44	0.46	0.55	0.41	0.63
0.87	0.69	0.29	0.45	0.29	0.39
0.68	0.49	0.54	0.52	0.35	0.34
0.23	0.44	0.58	0.48	0.53	0.30
0.40	0.65	0.48	0.60	0.41	0.48
0.50	0.35	0.32	0.60	0.41	0.58
0.45	0.35	0.21	0.66	0.25	0.48
0.45	0.39	0.43	0.50	0.49	0.49
0.68	0.39	0.24	0.66	0.49	0.29
0.44	0.54	0.43	0.44	0.32	0.36
0.50	0.35	0.29	0.72	0.25	0.35
0.45	0.25	0.33	0.77	0.41	-
0.50	0.35	0.42	0.55	0.54	-
0.50	0.39	0.65	0.55	0.61	-
0.55	0.30	0.46	0.27	0.58	-
0.70	0.49	0.29	0.44	0.29	-
0.35	0.35	0.29	0.55	0.37	-
0.34	0.39	0.37	0.35	0.46	-
0.40	0.65	0.46	0.42	0.49	-
0.42	0.44	0.65	0.35	0.49	-
0.40	0.39	0.37	0.28	0.61	-
0.34	0.35	0.37	0.62	0.66	-
0.38	0.44	0.42	0.56	0.46	-
0.46	0.59	0.33	0.42	0.66	-
0.40	0.44	0.33	0.49	0.29	-
0.32	0.35	0.33	0.28	0.46	-
0.40	0.44	0.46	0.35	0.29	-
0.32	0.59	0.33	0.35	0.49	-
0.47	0.44	0.42	0.42	0.41	-
0.47	0.30	0.46	0.56	0.25	-
0.47	0.30	0.36	0.49	0.29	-

Control	10 % FA	20 % FA	30 % FA	40 % FA	50 % FA
0.56	0.44	0.36	0.56	0.29	-
0.31	0.25	0.36	0.56	0.46	-
0.31	0.35	0.30	0.56	0.46	-
0.38	0.30	0.42	0.49	0.32	-
0.56	-	0.42	0.42	0.66	-
-	-	0.48	0.35	0.41	-
-	-	0.63	0.56	0.25	-
-	-	0.42	0.49	0.29	-
-	-	0.42	0.35	0.41	-
-	-	0.37	0.49	0.37	-
-	-	0.37	0.56	0.29	-
-	-	-	0.56	0.32	-
-	-	-	0.49	0.41	-
-	-	-	0.56	0.32	-
-	-	-	0.62	0.41	-
-	-	-	0.42	0.37	-
-	-	-	0.49	0.19	-
-	-	-	0.56	-	-
-	-	-	0.44	-	-
-	-	-	0.49	-	-
-	-	-	0.54	-	-
-	-	-	0.44	-	-
-	-	-	0.54	-	-
-	-	-	0.44	-	-
-	-	-	0.40	-	-
-	-	-	0.40	-	-
-	-	-	0.35	-	-
-	-	-	0.49	-	-
-	-	-	0.38	-	-
-	-	-	0.44	-	-
-	-	-	0.38	-	-
-	-	-	0.38	-	-
-	-	-	0.66	-	-
-	-	-	0.28	-	-
-	-	-	0.28	-	-
-	-	-	0.28	-	-
-	-	-	0.34	-	-
-	-	-	0.38	-	-
-	-	-	0.34	-	-
-	-	-	0.28	-	-
-	-	-	0.49	-	-
-	-	-	0.28	-	-
-	-	-	0.34	-	-

Table C.3: Crack Widths of Fly Ash
Concrete Specimens with w/b = 0.50

Control	10 % FA	30 % FA
1.07	0.54	0.54
0.54	0.82	0.54
0.47	0.47	0.47
0.95	0.74	0.67
0.67	0.74	0.54
0.67	0.74	0.88
0.82	0.40	0.54
0.62	0.67	0.62
0.54	0.61	0.47
0.75	0.67	0.40
0.54	0.74	0.40
0.95	0.82	0.54
0.47	1.15	0.54
0.88	0.87	0.67
1.02	0.95	0.67
0.62	1.49	0.62
0.47	1.02	0.82
0.82	0.74	0.88
0.95	0.61	0.88
0.88	0.61	0.67
0.88	0.95	0.62
0.40	0.82	0.75
0.67	0.82	0.47
1.09	1.15	0.62
0.95	0.87	0.40
1.56	1.02	0.62
0.75	0.67	0.47
0.82	0.54	0.47
0.62	0.87	0.62
0.82	0.67	0.67
0.62	0.95	0.62
1.22	0.82	0.62
1.62	0.95	0.62
0.88	0.61	0.47
1.15	0.74	0.67
1.83	0.74	0.67
1.36	0.61	0.62
0.47	1.09	0.47
0.95	0.34	0.54
1.22	0.95	0.38
0.95	1.09	0.38
0.40	1.02	0.60
1.49	1.15	0.38
1.15	0.40	0.55
1.09	0.54	0.63
1.02	0.47	0.70
1.02	0.40	0.94
0.88	0.40	0.60
1.42	0.82	0.70
1.42	0.82	0.60

Control	10 % FA	30 % FA
1.09	0.54	0.74
1.29	1.15	0.54
0.47	0.82	0.78
0.54	0.74	0.70
1.02	1.08	0.65
1.02	0.61	0.70
0.95	0.54	0.50
0.88	0.87	0.85
0.75	0.54	0.70
0.62	0.40	0.80
0.88	0.67	0.85
0.88	0.67	0.74
1.09	0.34	0.50
1.29	0.40	0.99
1.09	0.61	0.74
0.82	0.87	0.99
0.67	0.67	0.80
0.62	0.67	0.47
0.62	0.54	0.54
0.75	0.54	0.45
0.95	0.61	-
0.64	0.82	-
0.51	0.40	-
0.83	0.34	-
0.70	0.61	-
0.77	0.64	-
0.58	0.51	-
0.77	0.45	-
0.64	0.51	-
0.51	0.70	-
0.83	0.96	-
0.64	0.83	-
0.45	0.72	-
0.51	0.72	-
0.51	0.90	-
0.83	0.80	-
0.70	0.72	-
0.96	0.72	-
0.58	0.80	-
0.77	0.80	-
1.11	0.63	-
0.77	0.91	-
0.77	0.90	-
0.83	0.99	-
0.70	0.45	-
0.64	0.54	-
0.64	0.72	-
0.58	0.72	-
0.83	0.90	-
0.90	0.99	-
0.77	0.72	-
0.81	0.96	-

Control	10 % FA	30 % FA
0.56	0.80	-
0.77	0.44	-
0.58	0.97	-
0.81	0.61	-
0.64	0.79	-
0.77	0.88	-
0.70	0.61	-
0.70	0.79	-
0.90	0.91	-
1.09	0.71	-
0.96	1.06	-
1.09	0.79	-
1.02	1.05	-
1.09	0.88	-
0.77	0.85	-
0.90	0.55	-
0.83	0.53	-
0.83	0.88	-
0.38	0.61	-
0.45	0.88	-
0.58	0.61	-
0.77	0.53	-
0.83	0.53	-
0.83	0.61	-
0.90	1.06	-
0.58	0.79	-
0.77	0.61	-
0.90	0.61	-
0.83	0.53	-
0.45	0.61	-
0.96	0.71	-
0.64	0.71	-
0.64	0.53	-
0.48	0.61	-
0.35	0.44	-
0.43	0.46	-
0.52	0.46	-
0.52	0.33	-
0.57	0.24	-
0.43	0.39	-
0.52	0.46	-
0.48	0.33	-
0.40	0.29	-
0.43	0.52	-
0.40	0.38	-
0.35	0.48	-
0.39	0.52	-
0.57	0.48	-
0.17	0.57	-
0.52	0.62	-
0.35	0.43	-
0.34	0.60	-

Control	10 % FA	30 % FA
0.50	0.52	-
0.39	0.32	-
0.29	0.43	-
0.45	0.43	-
0.34	0.38	-
0.59	0.48	-
0.64	0.48	-
0.34	0.48	-
0.34	0.32	-
0.59	0.49	-
0.39	0.54	-
0.34	0.43	-
0.43	0.43	-
0.29	0.32	-
0.43	0.32	-
0.39	0.49	-
0.43	0.49	-
0.39	0.43	-
0.54	0.54	-
0.54	0.38	-
0.50	0.43	-
0.50	0.27	-
0.69	0.43	-
0.43	0.38	-
0.39	-	-
0.59	-	-
0.39	-	-
0.34	-	-
0.34	-	-
0.45	-	-
0.43	-	-
0.39	-	-
0.39	-	-
0.39	-	-
0.43	-	-
0.43	-	-
0.29	-	-
0.45	-	-

Table C.4: Crack Widths of Silica
Fume Concrete Specimens

Control	3 % SF	5 % SF
1.07	0.49	0.54
0.54	0.58	0.54
0.47	0.54	0.45
0.95	0.49	0.54
0.67	0.54	0.54
0.67	0.39	0.59
0.82	0.54	0.59
0.62	0.77	0.50
0.54	0.97	0.46
0.75	0.54	0.40
0.54	0.87	0.45
0.95	0.82	0.50
0.47	0.68	0.64
0.88	0.63	0.64
1.02	0.77	0.54
0.62	0.87	0.50
0.47	0.92	0.45
0.82	0.73	0.69
0.95	0.58	0.40
0.88	0.35	0.69
0.88	0.39	0.59
0.40	0.87	0.22
0.67	0.49	0.40
1.09	0.87	1.05
0.95	0.97	0.50
1.56	0.92	0.33
0.75	0.97	0.45
0.82	0.68	0.76
0.62	0.54	0.30
0.82	0.82	0.27
0.62	1.03	0.35
1.22	0.73	0.52
1.62	0.77	0.44
0.88	0.97	0.79
1.15	0.92	0.48
1.83	0.73	0.57
1.36	0.58	0.30
0.47	0.68	0.52
0.95	0.92	0.76
1.22	0.63	0.27
0.95	0.82	0.48
0.40	0.77	0.39
1.49	0.63	0.35
1.15	0.73	0.39
1.09	0.58	0.82
1.02	0.58	0.73
1.02	0.68	0.52
0.88	0.63	0.52
1.42	0.63	0.79
1.42	0.77	0.57

Control	3 % SF	5 % SF
1.09	1.31	0.39
1.29	0.77	0.57
0.47	0.82	0.39
0.54	0.73	0.39
1.02	1.07	0.82
1.02	0.77	0.39
0.95	0.68	0.65
0.88	0.87	0.48
0.75	0.44	0.57
0.62	0.77	0.65
0.88	0.58	0.61
0.88	0.49	0.79
1.09	0.49	0.70
1.29	0.97	0.39
1.09	0.63	0.44
0.82	0.51	0.79
0.67	0.56	0.57
0.62	0.30	0.57
0.62	0.53	0.52
0.75	0.61	0.86
0.95	0.67	0.57
0.64	0.63	0.70
0.51	0.73	0.39
0.83	0.73	0.61
0.70	0.54	0.29
0.77	0.77	0.65
0.58	0.60	0.29
0.77	0.54	0.60
0.64	0.66	0.49
0.51	0.81	0.24
0.83	0.73	0.71
0.64	0.28	0.49
0.45	0.53	0.49
0.51	0.54	0.49
0.51	0.45	0.38
0.83	0.80	0.64
0.70	0.63	0.56
0.96	0.60	0.41
0.58	0.92	0.34
0.77	0.65	0.38
1.11	0.29	0.47
0.77	0.32	0.52
0.77	0.32	0.34
0.83	0.32	0.29
0.70	0.57	0.52
0.64	0.63	0.58
0.64	0.51	0.37
0.58	0.57	0.49
0.83	0.69	0.59
0.90	0.32	0.44
0.77	0.49	0.72
0.81	0.32	0.29

Control	3 % SF	5 % SF
0.56	0.53	0.36
0.77	0.37	0.86
0.58	0.38	0.43
0.81	0.60	0.56
0.64	0.38	0.43
0.77	0.38	0.48
0.70	0.38	0.53
0.70	0.49	0.43
0.90	0.54	0.62
1.09	0.32	0.48
0.96	0.38	0.53
1.09	0.32	0.38
1.02	0.22	0.48
1.09	0.32	0.53
0.77	0.66	0.58
0.90	0.38	0.67
0.83	0.71	0.67
0.83	0.54	0.58
0.38	0.60	0.34
0.45	0.54	0.38
0.58	0.43	0.58
0.77	0.43	0.67
0.83	0.43	0.68
0.83	0.60	0.67
0.90	0.66	0.43
0.58	0.38	0.58
0.77	0.54	0.48
0.90	0.43	0.43
0.83	0.49	0.53
0.45	0.51	0.62
0.96	0.35	0.48
0.64	0.25	0.38
0.64	0.35	0.53
0.48	0.39	0.43
0.35	0.54	0.37
0.43	0.35	0.31
0.52	0.50	0.49
0.52	0.54	0.43
0.57	0.50	0.49
0.43	0.50	0.31
0.52	0.30	0.43
0.48	0.44	0.43
0.40	0.25	0.55
0.43	0.50	0.55
0.40	0.52	0.49
0.35	0.59	0.68
0.39	0.52	0.37
0.57	0.47	0.43
0.17	0.35	0.55
0.52	0.64	0.61
0.35	0.59	0.68
0.34	0.52	0.55

Control	3 % SF	5 % SF
0.50	0.54	0.49
0.39	0.39	0.68
0.29	0.29	0.74
0.45	0.35	0.43
0.34	0.45	0.49
0.59	0.65	0.43
0.64	0.39	0.55
0.34	0.29	0.43
0.34	0.74	0.55
0.59	0.44	0.49
0.39	0.54	0.61
0.34	0.40	0.55
0.43	0.47	0.37
0.29	0.62	0.43
0.43	0.44	0.49
0.39	0.30	0.55
0.43	0.69	0.49
0.39	0.69	0.49
0.54	0.60	0.43
0.54	0.60	0.55
0.50	0.52	0.18
0.50	0.62	0.49
0.69	0.57	0.49
0.43	0.60	0.37
0.39	0.44	0.43
0.59	0.52	0.37
0.39	0.57	0.74
0.34	0.77	0.68
0.34	0.69	0.55
0.45	0.50	0.37
0.43	0.62	0.61
0.39	0.60	0.37
0.39	0.57	0.43
0.39	0.57	0.25
0.43	0.60	0.37
0.43	0.57	0.43
0.29	0.25	0.43
0.45	0.44	0.31
-	0.44	0.61
-	0.56	0.49
-	0.77	0.55
-	0.82	0.37
-	0.69	-
-	0.44	-
-	0.50	-
-	0.50	-
-	0.25	-
-	0.60	-
-	0.30	-
-	0.62	-
-	0.50	-

APPENDIX D

DATA SUMMARY

Table D.1: Ave Crack Width for Fly Ash Specimens

Designation	Average Crack Width		
	mm		
w/b-%FA			
30-C	0.61	0.75	0.41
30-10FA	0.66	0.78	0.43
30-30FA	0.68	0.78	0.41
30-50FA	0.69	0.79	0.41
40-C	0.55	0.68	0.42
40-10FA	0.48	0.70	0.42
40-20FA	0.52	0.73	0.40
40-30FA	0.52	0.78	0.44
40-40FA	0.57	0.78	0.41
40-50FA	0.59	0.78	0.37
50-C	0.74	0.89	0.43
50-10FA	0.73	0.73	0.43
50-30FA	0.70	0.58	0.00
50-50FA	0.00	0.00	0.00

Table D.2: Ave Crack Width for Silica Fume Specimens

Designation	Average Crack Width		
	mm		
w/b-%SF			
50-C	0.74	0.89	0.43
50-3SF	0.51	0.72	0.51
50-5SF	0.50	0.54	0.48

Table D.3: Max Crack Widths of Fly Ash Specimens

Designation	Maximum Crack Width		
	mm		
w/b-%FA			
30-C	1.21	1.08	0.69
30-10FA	1.20	1.21	0.71
30-30FA	1.28	1.25	0.69
30-50FA	1.39	1.30	0.80
40-C	0.89	0.99	0.70
40-10FA	0.91	1.13	0.69
40-20FA	1.00	1.19	0.65
40-30FA	1.00	1.25	0.66
40-40FA	1.06	1.30	0.66
40-50FA	1.06	1.31	0.49
50-C	1.11	1.83	0.69
50-10FA	1.06	1.49	0.62
50-30FA	0.99	0.88	0.00
50-50FA	0.00	0.00	0.00

Table D.4: Max Crack Widths of Silica Fume Specimens

Designation	Maximum Crack Width		
	mm		
w/b-%SF			
50-C	1.11	1.83	0.69
50-3SF	0.92	1.31	0.82
50-5SF	0.86	1.05	0.74

Table D.5: Crack Area for Fly Ash Specimens

Designation	Crack Area		
	mm ²		
w/b-%FA			
30-C	189.00	231.15	120.20
30-10FA	187.10	221.66	62.91
30-30FA	187.05	219.26	114.73
30-50FA	184.72	218.32	98.11
40-C	143.16	203.55	28.60
40-10FA	85.77	188.01	68.78
40-20FA	166.14	186.06	66.85
40-30FA	159.94	186.66	94.21
40-40FA	146.33	184.36	75.63
40-50FA	148.84	181.11	6.20
50-C	184.83	257.31	90.60
50-10FA	181.25	228.99	68.33
50-30FA	80.98	99.90	0.00
50-50FA	0.00	0.00	0.00

Table D.6: Crack Area for Silica Fume Specimens

Designation	Crack Area		
	mm ²		
w/b-%SF			
50-C	184.83	257.31	90.60
50-3SF	148.83	204.30	131.30
50-5SF	109.78	174.14	105.77

Table D.7: Change in Ave Crack Width Due to Curing (Fly Ash)

Designation	Ave Width at Day 1		Ave Width at Day 28		Percent Change	
	air curing	moist curing	air curing	moist curing	air curing	moist curing
w/b-%FA	mm		mm		%	
30-C	0.61	0.75	0.57	0.60	7.37	20.73
30-10FA	0.66	0.78	0.61	0.61	6.21	22.60
30-30FA	0.68	0.78	0.61	0.62	9.37	20.30
30-50FA	0.69	0.79	0.69	0.62	0.33	22.09
40-C	0.55	0.68	0.50	0.58	9.08	14.07
40-10FA	0.48	0.70	0.47	0.59	2.16	14.94
40-20FA	0.52	0.73	0.52	0.59	0.00	19.07
40-30FA	0.52	0.78	0.52	0.60	0.00	22.63
40-40FA	0.57	0.78	0.52	0.61	8.29	21.60
40-50FA	0.59	0.78	0.54	0.62	9.30	21.04
50-C	0.74	0.89	0.60	0.67	19.98	25.42
50-10FA	0.73	0.73	0.54	0.54	25.74	26.43
50-30FA	0.70	0.58	0.44	0.50	36.99	14.14
50-50FA	-	-	-	-	-	-

Table D.8: Change in Ave Crack Width Due to Curing (Silica Fume)

Designation	Ave Width at Day 1		Ave Width at Day 28		Percent Change	
	air curing	moist curing	air curing	moist curing	air curing	moist curing
w/b-%SF	mm		mm		%	
50-C	0.74	0.89	0.60	0.67	19.98	25.42
50-3SF	0.51	0.72	0.42	0.54	16.64	24.95
50-5SF	0.50	0.54	0.41	0.44	18.15	18.41

Table D.9: Change in Max Crack Width Due to Curing (Fly Ash)

Designation	Max Width at Day 1		Max Width at Day 28		Percent Change	
	air curing	moist curing	air curing	moist curing	air curing	moist curing
w/b-%FA	mm		mm		%	
30-C	1.21	1.08	1.01	0.95	16.18	11.36
30-10FA	1.20	1.21	1.04	1.02	13.29	15.36
30-30FA	1.28	1.25	1.06	1.07	16.72	15.04
30-50FA	1.39	1.30	1.20	1.09	14.00	15.87
40-C	0.89	0.99	0.82	0.89	7.78	10.48
40-10FA	0.91	1.13	0.77	0.96	14.89	15.29
40-20FA	1.00	1.19	0.89	1.00	11.28	16.31
40-30FA	1.00	1.25	0.95	1.04	4.88	16.86
40-40FA	1.06	1.30	0.98	1.08	7.92	17.12
40-50FA	1.06	1.31	1.01	1.11	4.55	15.13
50-C	1.11	1.83	0.96	1.11	13.68	39.22
50-10FA	1.06	1.49	0.95	0.86	10.77	42.25
50-30FA	0.99	0.88	0.74	0.68	25.82	22.06
50-50FA	-	-	-	-	-	-

Table D.10: Change in Max Crack Width Due to Curing (Silica Fume)

Designation	Max Width at Day 1		Max Width at Day 28		Percent Change	
	air curing	moist curing	air curing	moist curing	air curing	moist curing
w/b-%SF	mm		mm		%	
50-C	1.11	1.83	0.96	1.11	13.68	39.22
50-3SF	0.92	1.31	0.83	0.79	10.07	39.57
50-5SF	0.86	1.05	0.66	0.62	23.70	41.59

Table D.11: Change in Crack Area Due to Curing (Fly Ash)

Designation	Crack Area at Day 1		Crack Area at Day 28		Percent Change	
	air curing	moist curing	air curing	moist curing	air curing	moist curing
w/b-%FA	mm ²		mm ²		%	
30-C	189.00	231.15	157.81	169.71	16.50	26.58
30-10FA	187.10	221.66	157.23	160.99	15.97	27.37
30-30FA	187.05	219.26	156.51	159.67	16.33	27.18
30-50FA	184.72	218.32	149.09	156.20	19.29	28.46
40-C	143.16	203.55	114.74	158.91	19.85	21.93
40-10FA	85.77	188.01	72.17	154.13	15.85	18.02
40-20FA	166.14	186.06	144.58	154.02	12.98	17.22
40-30FA	159.94	186.66	130.26	153.38	18.56	17.83
40-40FA	146.33	184.36	129.03	133.49	11.82	27.59
40-50FA	148.84	181.11	128.14	127.51	13.91	29.59
50-C	184.83	257.31	161.89	187.03	12.41	27.31
50-10FA	181.25	228.99	146.66	125.54	19.09	45.18
50-30FA	80.98	99.90	49.85	61.35	38.43	38.59
50-50FA	-	-	-	-	-	-

Table D.12: Change in Crack Area Due to Curing (Silica Fume)

Designation	Crack Area at Day 1		Crack Area at Day 28		Percent Change	
	air curing	moist curing	air curing	moist curing	air curing	moist curing
w/b-%SF	mm ²		mm ²		%	
50-C	184.83	257.31	161.89	187.03	12.41	27.31
50-3SF	148.83	204.30	114.73	142.85	22.91	30.08
50-5SF	109.78	174.14	84.98	113.59	22.59	34.77

Table D.13: Weekly Data of Fly Ash Specimens under Air Curing

Designation	After Testing			Week 1			Week 2			Week 3			Week 4		
	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width
w/b-%FA	mm ²	mm	mm	mm ²	mm	mm	mm ²	mm	mm	mm ²	mm	mm	mm ²	mm	mm
30-C	189.00	1.21	0.61	176.93	1.10	0.57	174.63	1.05	0.57	-	-	-	157.81	1.01	0.57
30-10FA	188.22	1.22	0.61	173.53	1.13	0.61	172.71	1.11	0.61	165.84	1.06	0.60	157.23	1.04	0.61
30-30FA	187.50	1.27	0.61	172.07	1.19	0.60	165.43	1.17	0.61	163.67	1.07	0.61	156.10	1.06	0.61
30-50FA	184.60	1.38	0.69	170.57	1.27	0.67	160.50	1.24	0.67	155.26	1.21	0.68	149.09	1.20	0.69
40-C	143.16	0.89	0.55	130.18	0.88	0.54	128.82	0.85	0.51	121.51	0.82	0.55	114.74	0.82	0.50
40-10FA	85.77	0.91	0.48	81.81	0.86	0.47	81.04	0.81	0.47	78.74	0.79	0.46	72.17	0.77	0.47
40-20FA	166.14	1.00	0.52	-	-	-	-	-	-	145.55	0.90	0.52	144.58	0.89	0.52
40-30FA	159.94	1.00	0.52	150.29	0.97	0.51	139.46	0.96	0.51	135.93	0.98	0.51	130.26	0.95	0.52
40-40FA	146.33	1.06	0.57	140.37	1.02	0.56	-	-	-	133.93	0.98	0.52	129.03	0.98	0.52
40-50FA	148.84	1.06	0.59	142.53	1.03	0.52	140.04	1.02	0.52	138.36	1.02	0.54	128.14	1.01	0.51
50-C	184.83	1.11	0.74	176.55	1.04	0.63	165.19	0.98	0.61	163.24	0.96	0.61	161.89	0.96	0.60
50-10FA	181.25	1.06	0.73	164.63	1.00	0.60	161.72	0.98	0.59	159.58	0.98	0.58	155.96	0.95	0.59
50-30FA	80.98	0.99	0.70	61.50	0.84	0.55	56.83	0.80	0.46	55.04	0.75	0.44	49.85	0.74	0.44

Table D.14: Weekly Data of Fly Ash Specimens under Moist Curing

Designation	After Testing			Week 1			Week 2			Week 3			Week 4		
	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width	Crack Area	Max Crack	Ave Crack Width
w/b-%FA	mm ²	mm	mm	mm ²	mm	mm	mm ²	mm	mm	mm ²	mm	mm	mm ²	mm	mm
30-C	231.15	1.08	0.75	184.81	0.98	0.59	182.50	0.97	0.59	-	-	-	169.71	0.95	0.60
30-10FA	221.66	1.21	0.78	182.27	1.03	0.60	177.03	1.02	0.58	169.26	1.02	0.57	160.99	1.02	0.61
30-30FA	219.26	1.25	0.78	181.71	1.09	0.59	174.40	1.08	0.58	166.85	1.07	0.58	159.67	1.07	0.62
30-50FA	218.32	1.30	0.79	171.70	1.11	0.68	164.60	1.10	0.59	159.77	1.09	0.58	156.20	1.09	0.62
40-C	203.55	0.99	0.68	181.11	0.97	0.63	171.70	0.91	0.59	161.72	0.91	0.59	158.91	0.89	0.58
40-10FA	188.01	1.13	0.70	177.86	1.02	0.64	168.81	0.96	0.61	160.53	0.96	0.61	154.13	0.96	0.59
40-20FA	186.06	1.19	0.73	-	-	-	-	-	-	158.08	1.00	0.61	154.02	1.00	0.59
40-30FA	186.66	1.25	0.78	171.68	1.12	0.63	164.71	1.06	0.60	157.56	1.06	0.60	153.38	1.04	0.60
40-40FA	184.36	1.30	0.78	165.29	1.14	0.64	145.00	1.08	0.39	140.60	1.08	0.61	133.49	1.08	0.61
40-50FA	181.11	1.31	0.78	150.13	1.20	0.63	149.20	1.13	0.63	142.35	1.12	0.63	127.51	1.11	0.62
50-C	257.31	1.81	0.89	218.31	1.23	0.69	215.96	1.16	0.69	204.20	1.09	0.66	187.03	1.11	0.67
50-10FA	228.99	1.49	0.73	147.40	0.97	0.55	142.97	0.94	0.54	135.83	0.90	0.53	125.54	0.86	0.51
50-30FA	99.90	0.88	0.58	74.81	0.68	0.50	68.85	0.68	0.51	66.35	0.68	0.50	61.35	0.68	0.50

Table D.15: Cracking Reduction Ratio for Fly Ash Specimens

Designation	Average Width			Cracking Reduction Ratio		
	w/b-%FA	mm		%		
30-C	0.61	0.75	0.41	-	-	-
30-10FA	0.66	0.78	0.43	-7.29	-3.85	-5.19
30-30FA	0.68	0.78	0.41	-10.70	-3.03	0.00
30-50FA	0.69	0.79	0.41	-13.42	-5.14	0.00
40-C	0.55	0.68	0.42	-	-	-
40-10FA	0.48	0.70	0.42	12.70	-3.20	0.00
40-20FA	0.52	0.73	0.40	6.99	-7.29	4.49
40-30FA	0.52	0.78	0.44	6.43	-14.64	-4.16
40-40FA	0.57	0.78	0.41	-3.00	-14.84	3.60
40-50FA	0.59	0.78	0.37	-7.01	-15.80	12.10
50-C	0.74	0.89	0.43	-	-	-
50-10FA	0.73	0.73	0.43	1.76	17.90	0.00
50-30FA	0.70	0.58	0.00	5.82	34.59	100.00
50-50FA	0.00	0.00	0.00	100.00	100.00	100.00

Table D.16: Cracking Reduction Ratio for Silica Fume Specimens

Designation	Average Width			Cracking Reduction Ratio		
	w/b-%SF	mm		%		
50-C	0.74	0.89	0.43	-	-	-
50-3SF	0.51	0.72	0.51	31.63	19.09	-18.46
50-5SF	0.50	0.54	0.48	32.84	40.10	-11.59

APPENDIX E

IMAGE PROCESSING EXAMPLE

It should be noted that the following procedure was done with the use of the imaging software HyperCube for rectification of the images taken during testing. Depending on the user's needs, such program could be replaced.

Before any images of the specimen would be taken, the coordinates of the points along the inner edges of the guide frame must be noted. These coordinates, in mm, would be known as the control points. These points would essentially facilitate in the conversion of image units from pixels to millimeters (for convenience in the quantification of cracks soon after). The coordinates of the guide frame used, which has the same dimensions as the specimen studied, are as follows:

(x, y)	(x, y)	(x, y)	(x, y)
0, 0	475, 0	0, 202	125, 357
25, 0	500, 0	574, 202	150, 357
50, 0	525, 0	0, 225	175, 357
75, 0	550, 0	574, 225	200, 357
100, 0	574, 0	0, 252	225, 357
125, 0	0, 25	574, 252	250, 357
150, 0	574, 25	0, 275	275, 357
175, 0	0, 51	574, 275	300, 357
200, 0	574, 51	0, 302	325, 357
225, 0	0, 75	574, 302	350, 357
250, 0	574, 75	0, 325	375, 357
275, 0	0, 101	574, 325	400, 357
300, 0	574, 101	0, 352	425, 357
325, 0	0, 125	574, 352	450, 357
350, 0	574, 125	0, 357	475, 357
375, 0	0, 152	25, 357	500, 357
400, 0	574, 152	50, 357	525, 357
425, 0	0, 175	75, 357	550, 357
450, 0	574, 175	100, 357	574, 357

The metal guide frame would be used in all of the digital pictures taken during testing. When a picture of the specimen would be taken, the guide frame would be positioned on top of the said specimen. The chosen image for rectification would be loaded into HyperCube. For this example, a chosen picture of a 40-10FA specimen

was used. In HyperCube, select *File*→*Open...* then browse for the image file to be loaded. Then select *JPEG(*.*)* from the drop down selection in *Files of Type* and click *Open*. The image would comprise of the specimen with the guide frame. The said image would be magnified in order to clearly distinguish where the exact position of the control points were. To magnify, select *Image*→*Magnify Image*→*2x*.

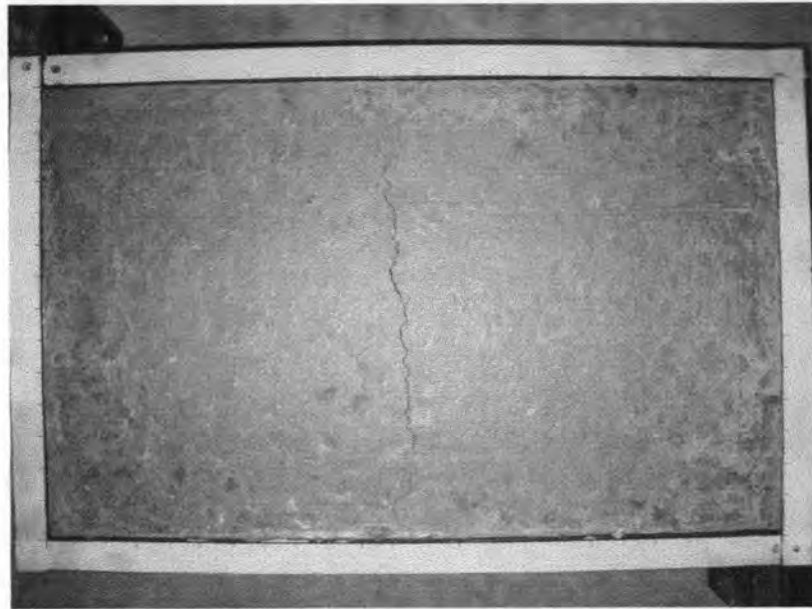


Figure E.1: Image of 40-10FA specimen

After magnifying the image, select *Functions*→*Warp...* Follow the instructions written in the warp menu to be able to determine the pixel coordinates of the control points. Select the file name of the magnified 40-10FA image (40-10FA.JPG 2xr) from the *Image 1* and *Image 2* drop-down menu. Hold the *Shift* button while clicking on the position of the control point of the image to automatically determine its pixel coordinates in the same order as how the millimeter coordinates of the control points were determined. Once the selection was correctly done, a colored cross-hair icon would be seen as marking of the control points in the image. An alternate in cross-hair colors, red and green, would be seen with a number connoting the order of selection. When the entire pixel coordinates of the 76 control points have been determined, click *Save Pts...* to save the points in *.pts format (40-10FA points.pts). The new set of coordinates in pixels is as follows:

(x', y')	(x', y')	(x', y')	(x', y')
206, 2391	2965, 2389	167, 1231	878, 304
342, 2398	3100, 2386	3509, 1217	1027, 300
487, 2401	3245, 2380	167, 1084	1169, 297
626, 2405	3379, 2375	3507, 1070	1321, 295
773, 2402	3503, 2371	166, 939	1463, 292
913, 2404	197, 2245	3504, 927	1617, 291
1061, 2407	3506, 2222	166, 796	1760, 290
1206, 2408	191, 2101	3502, 780	1914, 289
1355, 2409	3510, 2081	167, 650	2057, 290
1503, 2410	186, 1958	3498, 636	2210, 289
1651, 2411	3512, 1937	167, 507	2352, 290
1799, 2411	180, 1813	3495, 492	2504, 292
1946, 2410	3512, 1796	167, 364	2643, 294
2092, 2408	177, 1670	3489, 348	2793, 295
2241, 2405	3513, 1648	170, 324	2930, 298
2387, 2404	172, 1523	310, 320	3079, 301
2561, 2399	3513, 1504	453, 313	3218, 306
2678, 2397	170, 1377	590, 311	3360, 305
2818, 2393	3511, 1360	738, 307	3489, 311

Open the 40-10FA.pts file using NotePad or WordPad. Edit the points to incorporate the previously measured control points in millimeters (x, y) using the following format:

n			
x'_1	y'_1	x_1	y_1
x'_2	y'_2	x_2	y_2
\vdots	\vdots	\vdots	\vdots
x'_n	y'_n	x_n	y_n

Based on this format, the incorporated coordinates are as follows:

76			
206	2391	0	0
342	2398	25	0
487	2401	50	0
626	2405	75	0
773	2402	100	0
913	2404	125	0
1061	2407	150	0
1206	2408	175	0
1355	2409	200	0
1503	2410	225	0
1651	2411	250	0
1799	2411	275	0
1946	2410	300	0
2092	2408	325	0
2241	2405	350	0
2387	2404	375	0
2561	2399	400	0

2678	2397	425	0
2818	2393	450	0
2965	2389	475	0
3100	2386	500	0
3245	2380	525	0
3379	2375	550	0
3503	2371	574	0
197	2245	0	25
3506	2222	574	25
191	2101	0	51
3510	2081	574	51
186	1958	0	75
3512	1937	574	75
180	1813	0	101
3512	1796	574	101
177	1670	0	125
3513	1648	574	125
172	1523	0	152
3513	1504	574	152
170	1377	0	175
3511	1360	574	175
167	1231	0	202
3509	1217	574	202
167	1084	0	225
3507	1070	574	225
166	939	0	252
3504	927	574	252
166	796	0	275
3502	780	574	275
167	650	0	302
3498	636	574	302
167	507	0	325
3495	492	574	325
167	364	0	352
3489	348	574	352
170	324	0	357
310	320	25	357
453	313	50	357
590	311	75	357
738	307	100	357
878	304	125	357
1027	300	150	357
1169	297	175	357
1321	295	200	357
1463	292	225	357
1617	291	250	357
1760	290	275	357
1914	289	300	357
2057	290	325	357
2210	289	350	357
2352	290	375	357
2504	292	400	357
2643	294	425	357
2793	295	450	357
2930	298	475	357
3079	301	500	357
3218	306	525	357
3360	305	550	357
3489	311	574	357

Once edited, save the points using the same 40-10FA.pts filename. In HyperCube, open the 40-10FA.JPG image file and select *Functions*→*Warp...* Select 40-10FA.JPG for both *Image 1* and *Image 2*. Click on *Load Pts...* and browse for 40-10FA.pts to open it. Once opened, the coordinates in pixels would be marked as red cross-hair marks while the millimeter coordinates are marked as green cross-hair marks as seen in Figure E.2. Select *Cubic(10 terms)* from the *Transform* drop-down menu and click *Warp*. After a few seconds, HyperCube would generate the rectified image.

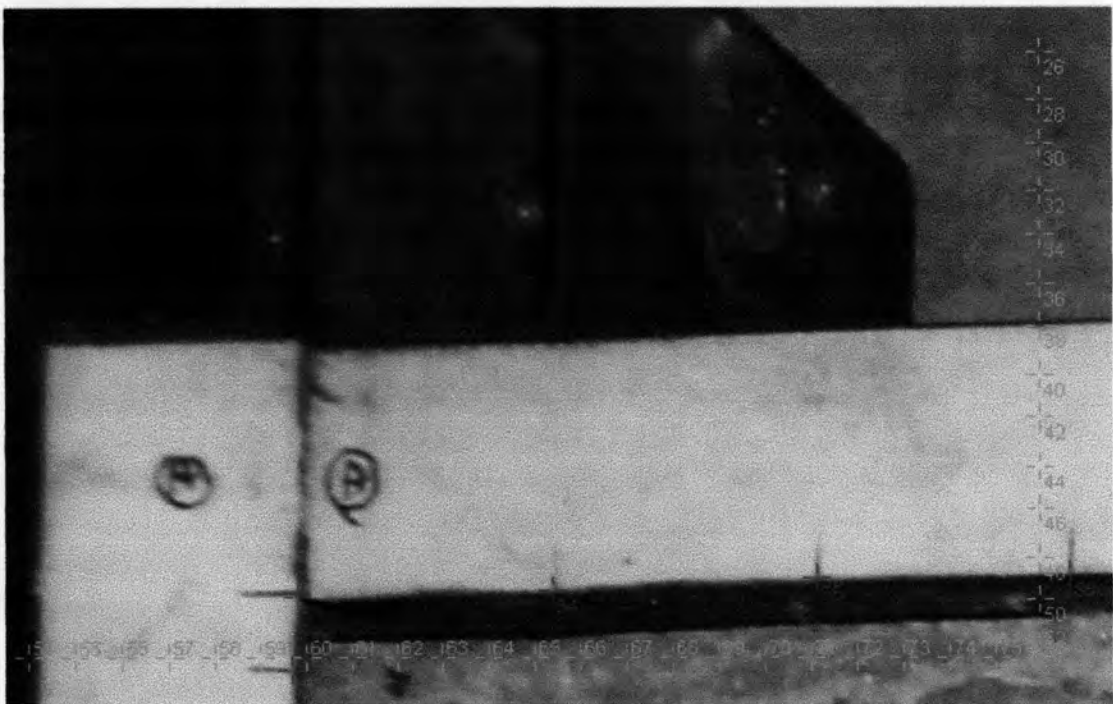


Figure E.2: Control points (red in pixels, green in millimeters) as shown HyperCube

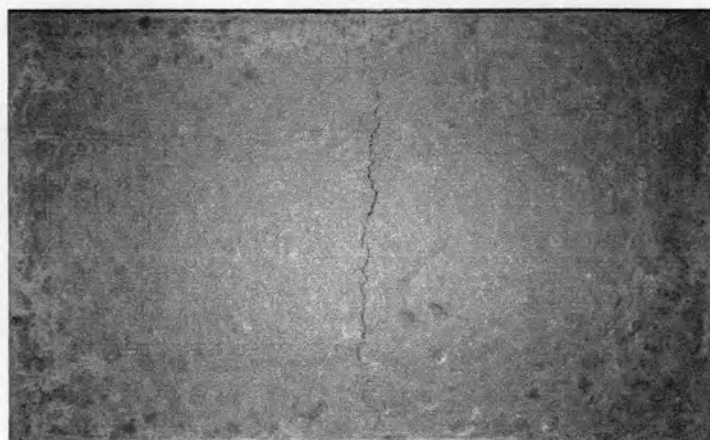


Figure E.3: Rectified image of 40-10FA specimen

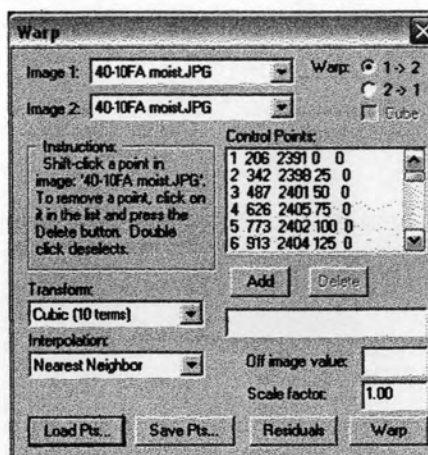


Figure E.4: Warp function in HyperCube

The residual error could be determined in the warp function (Figure E.4) by clicking on *Residual* in the warp function menu. From the 40-10FA specimen, it has a residual error of 5.06.

Save the corrected image in *.tiff format by selecting *File*→*Save* and type 40-10FA warped.tiff in *File name*. Select *TIFF(*.*)* in the drop down selection of *Save as type* and click save.

APPENDIX F
SAMPLE CALCULATION FOR
40-10FA

40-10FA

condition: moist

initial crack length: 5 mm

Mark	Crack Width	Ave Crack Width	Crack Area
mm	mm	mm	mm ²
0			
5			
10			
15			
20			
25	0.67		
30	0.56	0.62	3.09
35	0.67		
40	1.08	0.88	4.38
45	0.55	0.82	4.09
50	0.33		
55	0.82	0.58	2.88
60	0.52	0.67	3.35
	0.67		
65	0.62	0.65	3.24
	0.51		
70	0.73	0.62	3.09
	0.73		
75	0.93	0.83	4.15
80	0.95	0.94	4.71
85	0.78	0.86	4.32
90	0.62		
95	0.73	0.68	3.38
100	0.82	0.78	3.88
105	0.99	0.91	4.53
110	0.88	0.94	4.68
115	0.93		
120	0.67	0.80	4.00
	0.65	0.66	3.29
125	0.52		
130	0.78	0.65	3.24
135	0.84	0.81	4.03
140	0.61		
145	0.93	0.77	3.85
150	1.04	0.98	4.91
155	1.00	1.02	5.09
160	0.73	0.86	4.32
165	0.99	0.86	4.29
170	0.55	0.77	3.85
175	0.45		
180	0.55	0.50	2.50
185	1.13	0.84	4.21
190	0.56	0.85	4.24
	0.56		

Mark	Crack Width	Ave Crack Width	Crack Area
mm	mm	mm	mm ²
195	0.78	0.67	3.35
200	0.78	0.78	3.88
205	0.89	0.84	4.18
210	0.78	0.84	4.18
215	0.78	0.78	3.88
220	0.78	0.78	3.88
225	0.73		
230	0.55	0.64	3.21
235	1.00	0.78	3.88
240	0.73	0.86	4.32
245	0.73	0.73	3.65
250	0.88	0.81	4.03
255	0.67	0.78	3.88
260	0.88	0.78	3.88
265	0.45	0.66	3.32
	0.45		
270	0.45	0.45	2.24
	0.28		
275	0.78	0.53	2.65
280	0.61	0.69	3.47
285	0.84	0.72	3.62
290	0.51	0.67	3.35
295	0.51		
300	0.45	0.48	2.38
305	0.45		
310	0.67	0.56	2.79
315	0.55	0.61	3.06
320	0.55	0.55	2.77
325	0.51		
330	0.51	0.51	2.53
335			
340			
345			
350			
355			
357			

Total Crack Area 188.01 mm²
Max Crack Width 1.13 mm
Average Crack Width 0.70 mm

40-C Data:

Average Crack Width 0.68 mm

∴

Cracking Reduction -3.20 %
Ratio



BIOGRAPHY

Irene Olivia Ubay was born in Manila, Philippines in 1980. She received her Bachelor's Degree in Civil Engineering with Specialization in Structural Engineering from De La Salle University, Manila, Philippines in 2002. Soon after, she passed the Professional Board Exam for Licensed Civil Engineers in 2003 and worked as a junior structural designer for a private company. In 2005, she continued to pursue her Master's Degree in Civil Engineering in Chulalongkorn University, Bangkok, Thailand under the AUN/SEED-Net – JICA scholarship. Her research is on concrete technology under the Structural Engineering Division.