APPENDIX A.3.2

Comparison of key published data in which fine aggregate was replaced by fly ash at different content with the author's results.

Study No	Author	Year of publication	Type of coarse aggregate used
1	Rafat S.	2003a	Natural
2	Rafat S.	2003b	Natural
3	Dhir R.K. & McCarthy M.J.	2000	Natural
4	Mangaraj B.K & Krishnamoorthy S.	1994	Natural
5	Rajamane N.P.	2007	Natural
6	Abukersh S.A.	This study-2009	Natural and recycled

Legened:

C = Cement (Kg/m^3)
CA = coarse aggregate (Kg/m^3)
FA = Fine aggregate (Kg/m^3)
% PFA = Percentage ratio of PFA to FA (%)
PFA = Fly ash (Kg/m^3)
w = Water (Kg/m^3)
b = Total binder = C+PFA (Kg/m^3)

PFA/(C+PFA) = Ratio of fly ash to the total binder (%)
w/c = Water to cement ratio
w/b = Water to binder ratio
SP = Superplasticizer
F_{cu} = Cube compressive strength (N/mm^2)

Note: Figures in red colour are Control mixes

(Rafat S. 2003a) Natural aggregate

Study	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP (%)	F_{cu} (28 days)	F_{cu} (90 days)
	390	1170	560	0	0	185	390	0	0.47	0.47	2.6	26.4	31
	390	1170	510	10	50	187	440	0.11	0.48	0.43	3.5	28.2	34.2
1	390	1170	450	20	110	190	500	0.22	0.49	0.38	3.6	30.8	38.0
	390	1170	390	30	170	190	560	0.30	0.49	0.34	3.7	34.9	44.0
	390	1170	340	40	220	192	610	0.36	0.49	0.31	3.7	38.9	49.8
	390	1170	280	50	280	195	670	0.42	0.50	0.29	3.9	40.0	51.4

(Rafat S. 2003b) Natural aggregate

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP (%)	F_{cu} (28 days)	F_{cu} (90 days)
	370	1180	580	0	0	175	370	0	0.47	0.47	2.6	25.2*	30.2*
	370	1180	520	10	60	178	430	0.14	0.48	0.41	3.4	27	33.5
2	370	1180	460	20	120	179	490	0.24	0.48	0.37	3.5	29.7	38.3
	370	1180	400	30	180	182	550	0.33	0.49	0.33	3.6	33.2	46.2
	370	1180	340	40	240	185	610	0.39	0.50	0.30	3.7	37.5	47.1

* Results obtained from compressive strength graph

(Dhir R.K. & McCarthy M.J. 2000) Natural aggregate

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP	F_{cu} (28 days)	F_{cu} (90 days)
	350	1170	700	0	0	185	350	0	0.53	0.53	0	45	47
3	350	1170	665	5	35	185	385	0.09	0.53	0.48	0	47	53
	350	1170	630	10	70	185	420	0.17	0.53	0.44	0	49	55
	350	1170	595	15	105	185	455	0.23	0.53	0.41	0	52	60

(Mangaraj B.K. & Krishnamoorthy S. 1994) Natural aggregate

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP	F_{cu} (28 days)	F_{cu} (90 days)
	1	3.3	1.86	0	0	0.6	1	0	0.60	0.60	0	20	-
	1	3.3	1.77	5	0.09	0.6	1.09	0.08	0.60	0.55	0	22	-
4	1	3.3	1.67	10	0.19	0.6	1.19	0.16	0.60	0.50	0	23	-
	1	3.3	1.58	15	0.28	0.6	1.28	0.22	0.60	0.47	0	23.5	-
	1	3.3	1.49	20	0.37	0.6	1.37	0.27	0.60	0.44	0	23	-
	1	3.3	1.40	25	0.47	0.6	1.47	0.32	0.60	0.41	0	29	-

(Rajamane N.P. 2007) Design strength = 46 N/mm^2 (at 28 days)

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP (%)	F_{cu} (28 days)	F_{cu} (90 days)
	561	1121	561	0	0	196	561	0	0.35	0.35	0.85	46.1	-
5	561	1121	448.8	20	112.2	171	673.2	0.17	0.30	0.25	0.85	65.2	-
	561	1121	448.8	20	112.2	280.5	673.2	0.17	0.50	0.42	0.85	35.9	-
	561	1121	448.8	20	112.2	252.5	673.2	0.17	0.45	0.38	0.85	41.5	-
	561	1121	336.6	40	224.4	168.3	785.4	0.29	0.30	0.21	0.85	70.2	-
5	561	1121	438.8	40	224.4	336.6	785.4	0.29	0.60	0.43	0.85	30.2	-
	561	1121	438.8	40	224.4	252.45	785.4	0.29	0.45	0.32	0.85	46.2	-
	561	1121	438.8	60	336.6	224.4	897.6	0.38	0.40	0.25	0.85	59.1	-
5	561	1121	438.8	60	336.6	336.6	897.6	0.38	0.60	0.38	0.85	34.9	-
	561	1121	438.8	60	336.6	308.5	897.6	0.38	0.55	0.34	0.85	42.2	-
	561	1121	110.0	120	131.6	168.3	692.6	0.19	0.30	0.24	0.85	69.4	-
5	561	1121	110.0	120	131.6	280.5	692.6	0.19	0.50	0.40	0.85	36.4	-
	561	1121	110.0	120	131.6	252.5	692.6	0.19	0.45	0.36	0.85	43.1	-
	561	1121	220.0	120	264	168.3	825	0.32	0.30	0.20	0.85	71	-
5	561	1121	220.0	120	264	336.6	825	0.32	0.60	0.41	0.85	35.1	-
	561	1121	220.0	120	264	252.5	825	0.32	0.45	0.31	0.85	45.6	-
	561	1121	338	120	406	224.4	967	0.42	0.40	0.23	0.85	59.1	-
5	561	1121	338	120	406	336.6	967	0.42	0.60	0.35	0.85	39.5	-
	561	1121	338	120	406	308.5	967	0.42	0.55	0.32	0.85	44.6	-
	561	1121	110.8	160	177.2	168.3	738.2	0.24	0.30	0.23	0.85	62.9	-
5	561	1121	110.8	160	177.2	280.5	738.2	0.24	0.50	0.38	0.85	36.2	-
	561	1121	110.8	160	177.2	252.5	738.2	0.24	0.45	0.34	0.85	45.9	-
	561	1121	224.4	160	359	224.4	920	0.39	0.40	0.24	0.85	62.7	-
5	561	1121	224.4	160	359	336.6	920	0.39	0.60	0.37	0.85	37.5	-
	561	1121	224.4	160	359	308.5	920	0.39	0.55	0.34	0.85	42.1	-
	561	1121	336.9	160	539	224.4	1100	0.49	0.40	0.20	0.85	65.9	-
5	561	1121	336.9	160	539	392.7	1100	0.49	0.70	0.36	0.85	34.1	-
	561	1121	336.9	160	539	308.5	1100	0.49	0.55	0.28	0.85	49.2	-

Results of this study (Author's study) Natural & Recycled aggregates Design strength = 40 N/mm^2 (at 28 days)

a- Natural granite was used as coarse aggregates (SP A)

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP (%)	F_{cu} (28 days)	F_{cu} (90 days)
	475	1125	610	0	0	200	475	0	0.42	0.42	0	68.5	75.3
	355	1125	457.5	25	132	112	487	0.27	0.32	0.23	3.89 (A)	72.1	85.8
6	355	1125	305	50	264	112	620	0.43	0.32	0.18	4.96 (A)	62.5	78.2
	355	1125	152.5	75	396	112	750	0.53	0.32	0.15	6.00 (A)	50.75	64.5

b-Recycled aggregate was used as coarse aggregates (SP A)

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP(%)	F_{cu} (28 days)	F_{cu} (90 days)
	475	1080	580	0	0	200	475	0	0.42	0.42	0	54.5	60.89
	355	1080	435	25	125.5	112	480	0.26	0.32	0.23	3.84 (A)	56.1	65.72
6	355	1080	290	50	251	112	606	0.41	0.32	0.18	4.85 (A)	43.98	55.2
	355	1080	145	75	376.5	112	730	0.52	0.32	0.15	5.84 (A)	35.8	46.8

c- Natural granite was used as coarse aggregates (SP A B and C) and 50% fine aggregate was replaced by PFA

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP (%)	F_{cu} (28 days)	F_{cu} (90 days)
	355	1125	305	50	264	112	620	0.43	0.32	0.18	4.96 (A)*	62.5	78.2
6	355	1125	305	50	264	112	620	0.43	0.32	0.18	3.72 (B)	60.3	76.9
	355	1125	305	50	264	112	620	0.43	0.32	0.18	15.5 (C)	54.84	73.9

d- Recycled aggregate was used as coarse aggregates and 50% fine aggregate was replaced by PFA

	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP	F_{cu} (28 days)	F_{cu} (90 days)
	355	1080	290	50	251	112	606	0.41	0.32	0.18	4.85 (A)	43.98	55.2
6	355	1080	290	50	251	112	606	0.41	0.32	0.18	3.64 (B)	46.3	53.1
	355	1080	290	50	251	112	606	0.41	0.32	0.18	15.2 (C)	40.35	55

*(SP A B and C) are three different types of superplasticizer