

### Table A.3.3

**Comparison of key published data in which cement 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	Poon C.S.	2000	Natural	
2	Naik T.R.	1991	Natural	
3	Naik T.R.	1991	Natural	
4	Naik T.R.	1994	Natural	
5	Neville A.	2003	Natural	
6	Neville A.	2003	Natural	
7	Shafiq N.	2006	Natural	
8	Abukersh S.A.	This study-2009	Natural and recycled	

  

<b>Legened:</b> C = Cement <span style="float: right;">kg/m<sup>3</sup></span> CA = coarse aggregate <span style="float: right;">kg/m<sup>3</sup></span> FA = Fine aggregate <span style="float: right;">kg/m<sup>3</sup></span> PFA= Percentage ratio of PFA to FA <span style="float: right;">(%)</span> PFA= Fly ash <span style="float: right;">kg/m<sup>3</sup></span> w = Water <span style="float: right;">kg/m<sup>3</sup></span> b = Total binder = C+PFA <span style="float: right;">kg/m<sup>3</sup></span>	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 Fcu = Cube compressive strength <span style="float: right;">N/mm<sup>2</sup></span>
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Note: Figures in red colour are Control mixes

  

(Poon C.S. 2000) Natural aggregate													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP l/m <sup>3</sup>	Fcu (28 days)	Fcu (90 days)
	637	936	711	0	0	150	637	0	0.24	0.24	18.4	97.4	110.2
	475	924	681	25	158	150	633	0.25	0.32	0.24	18.3	105.9	124.5
1	347	920	639	45	283	148	630	0.45	0.43	0.23	23.7	89.4	107.2
	702	949	641	0	0	135	702	0.00	0.19	0.19	35.1	96.8	114.5
	512	932	620	25	173	133	685	0.25	0.26	0.19	34.7	102.3	123.6
	372	927	608	45	305	130	677	0.45	0.35	0.19	33.8	88.5	109.2

  

(Naik T.R. 1991) Natural aggregate design strength = 41 N/mm <sup>2</sup> (at 28 days)													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP l/m <sup>3</sup>	Fcy (28 days)	Fcu (28 days)
	362	1120	915	0	0	116	362	0	0.32	0.32	6.4	47.0	43.0*
	210	1085	890	40	145	116	355	0.41	0.55	0.33	6.2	43.8	40.3
2	180	1078	880	50	180	116	360	0.50	0.64	0.32	6.0	35.5	32.6
	145	1070	875	60	217	116	362	0.60	0.80	0.32	5.9	34.6	31.8

\*Cube strength is about 92% of the cylinder strength

  

(Naik T.R. 1991) Natural aggregate design strength = 41 N/mm <sup>2</sup> (at 28 days)													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP l/m <sup>3</sup>	Fcy (28 days)	Fcu (28 days)
	362	1120	915	0	0	116	362	0	0.32	0.32	6.4	47.0	43.0*
	180	1088	890	50	180	116	360	0.50	0.64	0.32	5.90	40.8	37.5
3	145	1109	882	60	218	158	363	0.60	1.09	0.44	6.70	31.5	29.0

  

(Naik T.R. 1994) Natural aggregate design strength = 41 N/mm <sup>2</sup> (at 28 days)													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP l/m <sup>3</sup>	Fcy (28 days)	Fcu (28 days)
	375	1182	687	0	0	135	375	0	0.36	0.36	2.9 (270)*	43.0	40.0
	180	1139	655	50	226	136	406	0.56	0.76	0.33	2.7 (886)	31.0	28.5
4	110	1145	606	70	316	155	426	0.74	1.41	0.36	2.6 (380)	17.0	15.6

\*Values in bracket is air entraining admixture in ml/m<sup>3</sup>

  

(Neville A. 2003) Natural aggregate design strength = 46 N/mm <sup>2</sup> (at 28 days)													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	kg/m <sup>3</sup>	Fcu (28 days)	Fcu (90 days)
	450	1100	815	0	0	127	450	0	0.28	0.28	15.3*	99	109
	365	1115	810	21	95	129	460	0.21	0.35	0.28	13*	90	111
5	505	1030	630	11	60	195	565	0.11	0.39	0.35	975**	65	79

\* Sodium salt of naphthalene sulfonate  
 \*\* SP in ml/m<sup>3</sup>

  

(Shafiq N. 2006) Natural aggregate													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	kg/m <sup>3</sup>	Fcu (28 days)	Fcu (90 days)
	325	1137	757	0	0	179	325	0	0.55	0.55	-	55	57
	227.5	1137	757	30	97.5	112	325	0.30	0.49	0.34	-	32	48
	195	1137	757	40	130	94	325	0.40	0.48	0.29	-	32	45
7*	325	1137	757	0	0	179	325	0	0.55	0.55	-	40	40
	227.5	1137	757	30	97.5	112	325	0.30	0.49	0.34	-	23	37
	195	1137	757	40	130	94	325	0.40	0.48	0.29	-	23	37
7**													

\*Concrete components from UK  
 \*\* Concrete components from Malaysia

  

(Abukersh S. 2009) Natural and recycled aggregate aggregate Design strength = 50 N/mm <sup>2</sup> (at 28 days)													
Study no	C	CA	FA	% PFA	PFA	w	b= C+PFA	PFA/(C+PFA)	w/c	w/b	SP (%)	Fcu (28 days)	Fcu (90 days)
	425	1280	545	0	0	170	425	0	0.40	0.40	0.00	69.0	76.0
	425	1280	545	0	0	143	425	0	0.34	0.34	0.80	74.0	91.7
8a	345	1265	540	30	145	155	490	0.30	0.45	0.32	0.00	65.0	75.6
	345	1265	540	30	145	130	490	0.30	0.38	0.27	0.80	75.4	90.0
	425	1235	530	0	0	170	425	0	0.40	0.40	0.00	52.0	58.3

	425	1235	530	0	0	143	425	0	0.34	0.34	0.80	64.0	73.0
8b	345	1210	515	30	145	155	490	0.30	0.45	0.32	0.00	50.8	59.5
	345	1210	515	30	145	143	490	0.30	0.41	0.29	0.80	61.6	69.0
a Natural aggregate concrete with PFA replacing cement													
b Recycled aggregate concrete with PFA replacing cement													
	<b>C</b>	<b>CA</b>	<b>FA</b>	<b>% RGD</b>	<b>RGD</b>	<b>w</b>	<b>b= C+RGD</b>	<b>RGD/(C+RGD)</b>	<b>w/c</b>	<b>w/b</b>	<b>SP (%)</b>	<b>Fcu (28 days)</b>	<b>Fcu (90 days)</b>
	425	1280	545	0	0	170	425	0	0.40	0.40	0.00	69.0	76.0
8c	425	1280	545	0	0	143	425	0	0.34	0.34	0.80	74.0	91.7
	345	1265	540	30	145	155	490	0.30	0.45	0.32	0.00	64.1	72.6
	345	1265	540	30	145	130	490	0.30	0.38	0.27	0.80	72.0	73.8
	425	1235	530	0	0	170	425	0	0.40	0.40	0.00	52.0	58.3
8d	425	1235	530	0	0	143	425	0	0.34	0.34	0.80	64.0	73.0
	345	1210	515	30	145	155	490	0.30	0.45	0.32	0.00	50.8	59.5
	345	1210	515	30	145	130	490	0.30	0.38	0.27	0.80	61.6	69.0
c Natural aggregate concrete with RGD replacing cement													
d Recycled aggregate concrete with RGD replacing cement													