

## Attachment F - Material Properties Test Results

The results presented in this appendix are given in the units in which the particular tests were originally conducted. In all data tables, the mixture description code shall be taken as:

Aggregate Type – Binder – Sequential Mixture Number

Six evaluated aggregate types are defined by:

CL#	Expanded Clay from source #1 & 2
SH#	Expanded Shale from source #1, 2, & 3
SL#	Expanded Slate from source #1

Four different binder descriptions have been abbreviated to describe the cementitious material content, by weight, and are defined as:

<i>OPC</i>	= 100% ordinary portland cement, ASTM Type I/II
<i>FA</i>	= 20% fly ash + 80% ordinary portland cement, ASTM Type I/II
<i>SF</i>	= 7% silica fume + 93% ordinary portland cement, ASTM Type I/II
<i>SLAG</i>	= 40% slag cement + 60% ordinary portland cement, ASTM Type I/II

The following sections present the specific test results from laboratory screening mixtures used to evaluate combinations of aggregate type, binder type or combination and water-to-cementitious material ratio by weight (w/cm), and total cementitious material (TCM) content expressed as lb total cementitious material per cubic yard of concrete.

### Fresh Concrete Tests

#### Air Content, Unit Weight, and Slump

Properties of the freshly mixed concrete were tested prior to placement in specimen molds in accordance with AASHTO T 121. Air contents of the lightweight concrete mixtures were measured using the volumetric method (roll-a-meter). Originally, plastic unit weight,  $w_c$ , was only determined by using the known volume of the measuring bowl used in the volumetric test for air content. After approximately half of the mixtures had been completed, it was

determined that the relatively small volume of the measuring bowl (0.075 ft<sup>3</sup>) could contribute to inadequate precision in measured unit weight. For this reason, a second unit weight was tested in a container having a known volume of 0.25 ft<sup>3</sup>. Slump of concretes was also determined in accordance with AASHTO T 119.

**Table F-1 Concrete Properties; air (%),  $w_c$  (lb/ft<sup>3</sup>), and slump (in.)**

Mixture Description	w/cm	TCM	Air Content	Plastic Unit Wt, $w_c$ 0.25 cu.ft. (lb/ft <sup>3</sup> )	Plastic Unit Wt, $w_c$ 0.075 cu.ft. (lb/ft <sup>3</sup> )	Slump (in.)
SL1-OPC-1	0.40	752 lb.	4.50%	-	121.9	2.50
SL1-FA-2	0.40	752 lb.	5.00%	-	123.2	2.75
SL1-SLAG-3	0.40	752 lb.	7.00%	-	117.9	3.50
SH1-OPC-4	0.40	752 lb.	4.25%	-	124.6	4.25
SH1-FA-5	0.40	752 lb.	4.50%	-	120.6	3.75
SH1-SLAG-6	0.40	752 lb.	4.25%	-	117.9	5.00
SH2-OPC-7	0.40	752 lb.	6.50%	-	121.9	3.00
SH2-FA-8	0.40	752 lb.	6.75%	-	121.9	3.00
SH2-SLAG-9	0.40	752 lb.	8.00%	-	119.3	3.00
SL1-OPC-10	0.30	800 lb.	3.25%	-	121.9	3.75
SL1-SF-11	0.30	800 lb.	3.50%	-	121.9	2.75
SL1-SLAG-12	0.30	800 lb.	4.00%	-	120.6	9.25
SL1-OPC-13	0.30	850 lb.	3.25%	-	124.6	3.75
SL1-SF-14	0.30	850 lb.	2.50%	-	123.2	8.50
SL1-SLAG-15	0.30	850 lb.	3.00%	-	119.3	-
SL1-OPC-16	0.30	850 lb.	3.25%	-	124.6	2.50
SL1-SF-17	0.30	850 lb.	2.75%	-	123.2	3.25
SL1-SLAG-18	0.30	850 lb.	5.00%	-	121.9	5.50
CL1-OPC-19	0.40	752 lb.	5.75%	-	121.9	0.50
CL1-FA-20	0.40	752 lb.	5.00%	-	119.3	5.25
CL1-SLAG-21	0.40	752 lb.	8.00%	-	116.6	4.25
SH3-OPC-22	0.40	752 lb.	5.50%	-	123.2	2.25
SH3-FA-23	0.40	752 lb.	5.00%	-	123.3	2.75
SH3-SLAG-24	0.40	752 lb.	8.00%	-	119.3	3.75
SH3-OPC-25	0.30	800 lb.	3.25%	-	127.2	1.50
SH3-SF-26	0.30	800 lb.	2.75%	-	128.5	2.75
SH3-SLAG-27	0.30	800 lb.	4.00%	-	127.2	2.00
CL2-OPC-28	0.40	752 lb.	5.50%	-	116.6	2.25
CL2-FA-29	0.40	752 lb.	6.00%	-	116.6	2.00
CL2-SLAG-30	0.40	752 lb.	7.25%	-	116.6	2.00
CL2-OPC-31	0.30	800 lb.	4.25%	-	120.6	2.25
CL2-SF-32	0.30	800 lb.	4.50%	-	121.9	2.25

CL2-SLAG-33	0.30	800 lb.	5.00%	-	121.9	8.75
SH3-OPC-34	0.40	752 lb.	6.25%	-	123.2	2.25
SH3-FA-35	0.40	752 lb.	5.50%	-	123.2	2.50
SH3-SLAG-36	0.40	752 lb.	7.00%	-	121.9	3.00
SH3-OPC-37	0.30	800 lb.	6.00%	-	125.9	7.50
SH3-FA-38	0.30	800 lb.	3.50%	-	127.2	9.50
SH3-SLAG-39	0.30	800 lb.	4.00%	-	127.2	4.00
SH3-SF-40	0.30	800 lb.	3.50%	-	128.5	2.50
CL2-FA-41	0.30	800 lb.	4.50%	-	120.6	1.75
CL2-OPC-42	0.30	800 lb.	4.00%	-	124.6	1.50
CL2-SF-43	0.30	800 lb.	4.25%	-	123.2	3.50
CL2-SLAG-44	0.30	800 lb.	4.00%	-	120.6	3.75
SH3-OPC-45	0.30	800 lb.	6.50%	123.6	124.5	2.50
SH3-FA-46	0.30	800 lb.	5.00%	125.2	125.8	10.25
SH3-SLAG-47	0.30	800 lb.	7.25%	122.8	121.9	3.50
SH3-SF-48	0.30	800 lb.	6.50%	124.0	124.6	6.75
SH3-FA-49	0.30	800 lb.	7.00%	122.4	120.6	4.50
CL2-FA-50	0.30	800 lb.	6.00%	124.8	124.6	8.25
CL2-OPC-51	0.40	752 lb.	6.25%	122.4	121.9	4.75
CL2-FA-52	0.40	752 lb.	6.00%	122.4	120.6	2.50
CL2-SLAG-53	0.40	752 lb.	6.75%	118.4	-	-
SH1-OPC-54	0.40	752 lb.	5.00%	120.8	119.3	5.50
SH1-FA-55	0.40	752 lb.	3.75%	122.8	121.9	2.75
SH1-SLAG-56	0.40	752 lb.	4.00%	122.4	121.9	4.50
SH2-OPC-57	0.40	752 lb.	5.25%	123.2	121.9	2.50
SH2-FA-58	0.40	752 lb.	5.50%	122.0	120.5	2.75
SH2-SLAG-59	0.40	752 lb.	4.75%	122.0	121.9	2.50
SL1-OPC-60	0.40	752 lb.	4.00%	122.0	120.6	2.50
SL1-FA-61	0.40	752 lb.	5.50%	120.4	120.6	4.25
SL1-SLAG-62	0.40	752 lb.	5.25%	118.8	117.9	4.25
CL1-OPC-63	0.40	752 lb.	6.00%	119.2	119.3	3.50
CL1-FA-64	0.40	752 lb.	5.00%	120.8	119.3	3.00
CL1-SLAG-65	0.40	752 lb.	2.75%	122.4	121.9	2.75
SL1-OPC-66	0.30	800 lb.	3.25%	123.2	122.2	5.25
SL1-FA-67	0.30	800 lb.	4.00%	122.8	-	3.00
CL1-OPC-68	0.30	800 lb.	3.25%	123.6	124.6	2.00
CL1-FA-69	0.30	800 lb.	2.75%	124.8	125.9	10.00
CL1-SF-70	0.30	800 lb.	3.50%	122.0	121.9	2.50
SL1-SLAG-71	0.25	900 lb.	-	123.2	123.2	8.00
CL1-OPC-72	0.30	800 lb.	2.75%	124.4	124.6	2.75
CL1-FA-73	0.30	800 lb.	4.50%	122.8	123.2	4.25
SL1-FA-74	0.30	800 lb.	3.75%	123.6	124.6	7.50

CL1-SLAG-75	0.30	800 lb.	3.50%	122.8	123.2	2.00
CL1-SLAG-76	0.30	800 lb.	3.50%	124.0	124.6	4.00
CL1-SF-77	0.30	800 lb.	3.50%	124.0	123.2	-
SH1-OPC-78	0.30	800 lb.	2.75%	125.2	125.9	8.25
SH1-FA-79	0.30	800 lb.	2.75%	124.8	124.6	7.00
SH1-SLAG-80	0.30	800 lb.	3.75%	122.8	121.9	8.25
SL1-FA-81	0.30	900 lb.	3.50%	122.8	123.2	6.00
SL1-SLAG-82	0.30	900 lb.	3.50%	122.8	123.2	10.75
SH2-OPC-83	0.30	800 lb.	6.50%	124.4	124.6	5.25
SH2-FA-84	0.30	800 lb.	4.75%	124.8	124.6	8.25
SH2-SLAG-85	0.30	800 lb.	6.00%	123.6	124.6	4.00
SH2-SF-86	0.30	800 lb.	5.50%	124.4	125.9	5.50
SH2-FA-87	0.30	800 lb.	6.00%	122.8	123.2	6.50
SH1-OPC-88	0.30	800 lb.	3.50%	124.0	123.2	4.00
SH1-FA-89	0.30	800 lb.	3.00%	124.8	124.6	9.25
SH1-SLAG-90	0.30	800 lb.	3.75%	123.6	123.2	6.00
SH1-SF-91	0.30	800 lb.	2.75%	124.8	123.2	4.25
SH1-SF-92	0.30	800 lb.	3.50%	123.6	121.9	2.75
SH2-OPC-93	0.30	800 lb.	5.50%	123.6	124.6	8.00
SH2-SF-94	0.30	800 lb.	5.00%	124.4	124.6	4.25
SH2-SLAG-95	0.30	800 lb.	5.50%	123.6	124.6	9.25

## Hardened Concrete Tests

### Compressive Strength

Compressive strength of 4"×8" concrete cylinders was tested in accordance with AASHTO T 22. Generally, the values reported for compressive strength,  $f_c$ , represent an average of two specimens tested at 7 and 90 days of age and an average of three specimens tested at 28 and 56 days of age. A few rare instances occurred in which only two cylinders (or even a single cylinder in one case) constituted the reported average for that test date.

**Table F-2 Average Compressive Strength,  $f_c$  (psi)**

Mixture Description	w/cm	TCM	$f_c$ at 7 Days	$f_c$ at 28 Days	$f_c$ at 56 Days	$f_c$ at 90 Days
SL1-OPC-1	0.40	752 lb.	6,260	7,473	7,820	7,680
SL1-FA-2	0.40	752 lb.	5,120	6,650	7,387	7,230
SL1-SLAG-3	0.40	752 lb.	4,450	7,027	7,493	7,490
SH1-OPC-4	0.40	752 lb.	5,490	6,587	6,877	7,040
SH1-FA-5	0.40	752 lb.	4,220	5,310	6,283	6,720
SH1-SLAG-6	0.40	752 lb.	3,890	6,030	6,447	6,583
SH2-OPC-7	0.40	752 lb.	5,320	5,910	6,097	6,308
SH2-FA-8	0.40	752 lb.	4,260	5,263	5,770	5,890
SH2-SLAG-9	0.40	752 lb.	4,190	6,077	6,328	6,150
SL1-OPC-10	0.30	800 lb.	8,240	9,037	9,650	9,250
SL1-SF-11	0.30	800 lb.	8,060	9,347	9,730	9,180
SL1-SLAG-12	0.30	800 lb.	7,570	9,770	9,840	9,270
SL1-OPC-13	0.30	850 lb.	7,990	8,645	9,050	9,310
SL1-SF-14	0.30	850 lb.	8,230	9,537	10,188	9,430
SL1-SLAG-15	0.30	850 lb.	8,540	9,583	10,305	9,800
SL1-OPC-16	0.30	850 lb.	7,700	8,843	9,057	9,210
SL1-SF-17	0.30	850 lb.	7,870	9,330	7,927	9,730
SL1-SLAG-18	0.30	850 lb.	7,400	9,080	7,873	9,310
CL1-OPC-19	0.40	752 lb.	5,250	6,237	6,170	6,378
CL1-FA-20	0.40	752 lb.	3,333	4,492	4,870	5,300
CL1-SLAG-21	0.40	752 lb.	2,440	3,880	4,340	4,518
SH3-OPC-22	0.40	752 lb.	5,080	5,990	6,207	6,900
SH3-FA-23	0.40	752 lb.	4,460	6,030	6,840	7,400
SH3-SLAG-24	0.40	752 lb.	3,790	5,877	6,615	6,970
SH3-OPC-25	0.30	800 lb.	8,170	9,012	9,157	9,380
SH3-SF-26	0.30	800 lb.	7,760	9,090	9,183	9,100
SH3-SLAG-27	0.30	800 lb.	7,970	8,970	9,150	8,820
CL2-OPC-28	0.40	752 lb.	5,340	5,957	6,190	6,150
CL2-FA-29	0.40	752 lb.	4,410	5,423	5,990	6,320
CL2-SLAG-30	0.40	752 lb.	4,420	6,217	6,530	6,290
CL2-OPC-31	0.30	800 lb.	6,583	7,447	7,633	7,970
CL2-SF-32	0.30	800 lb.	6,350	7,680	7,420	8,038
CL2-SLAG-33	0.30	800 lb.	6,418	7,787	7,293	7,895
SH3-OPC-34	0.40	752 lb.	5,270	5,663	6,780	7,450
SH3-FA-35	0.40	752 lb.	4,160	5,603	6,262	7,150
SH3-SLAG-36	0.40	752 lb.	3,660	5,977	6,840	7,200
SH3-OPC-37	0.30	800 lb.	8,040	8,310	8,843	9,230

SH3-FA-38	0.30	800 lb.	7,110	8,343	8,963	9,250
SH3-SLAG-39	0.30	800 lb.	7,550	8,568	8,950	9,180
SH3-SF-40	0.30	800 lb.	7,890	8,740	9,057	9,265
CL2-FA-41	0.30	800 lb.	5,960	6,628	7,200	7,460
CL2-OPC-42	0.30	800 lb.	6,240	7,293	7,853	8,170
CL2-SF-43	0.30	800 lb.	6,098	7,173	7,693	7,520
CL2-SLAG-44	0.30	800 lb.	6,150	7,367	7,560	7,670
SH3-OPC-45	0.30	800 lb.	7,340	8,013	8,703	7,920
SH3-FA-46	0.30	800 lb.	6,663	7,827	8,840	8,090
SH3-SLAG-47	0.30	800 lb.	6,428	8,112	8,250	8,100
SH3-SF-48	0.30	800 lb.	7,360	8,870	9,097	9,080
SH3-FA-49	0.30	800 lb.	6,448	7,533	7,853	8,010
CL2-FA-50	0.30	800 lb.	6,180	7,207	7,913	7,970
CL2-OPC-51	0.40	752 lb.	5,610	6,382	6,628	6,673
CL2-FA-52	0.40	752 lb.	4,280	5,503	6,150	6,425
CL2-SLAG-53	0.40	752 lb.	3,950	5,777	6,270	6,505
SH1-OPC-54	0.40	752 lb.	4,920	5,937	6,393	6,650
SH1-FA-55	0.40	752 lb.	4,360	5,650	6,352	6,693
SH1-SLAG-56	0.40	752 lb.	4,210	6,327	7,030	6,860
SH2-OPC-57	0.40	752 lb.	4,940	6,290	6,090	6,200
SH2-FA-58	0.40	752 lb.	4,280	5,377	5,903	6,305
SH2-SLAG-59	0.40	752 lb.	4,410	6,282	6,747	6,653
SL1-OPC-60	0.40	752 lb.	5,570	6,880	7,223	7,590
SL1-FA-61	0.40	752 lb.	4,655	5,823	6,707	7,240
SL1-SLAG-62	0.40	752 lb.	4,615	7,033	7,610	7,960
CL1-OPC-63	0.40	752 lb.	4,390	4,843	5,240	4,855
CL1-FA-64	0.40	752 lb.	3,910	4,720	5,290	5,160
CL1-SLAG-65	0.40	752 lb.	4,260	5,277	5,910	5,850
SL1-OPC-66	0.30	800 lb.	8,030	8,970	9,137	9,485
SL1-FA-67	0.30	800 lb.	6,990	8,460	8,863	9,370
CL1-OPC-68	0.30	800 lb.	5,790	6,195	6,535	6,538
CL1-FA-69	0.30	800 lb.	5,265	6,375	6,887	6,663
CL1-SF-70	0.30	800 lb.	4,980	5,730	6,037	5,810
SL1-SLAG-71	0.25	900 lb.	8,610	9,865	9,417	10,113
CL1-OPC-72	0.30	800 lb.	5,940	6,228	6,568	7,250
CL1-FA-73	0.30	800 lb.	4,820	5,943	5,897	6,010
SL1-FA-74	0.30	800 lb.	6,755	8,545	8,703	9,820
CL1-SLAG-75	0.30	800 lb.	5,150	6,113	6,203	6,655
CL1-SLAG-76	0.30	800 lb.	5,660	7,153	6,523	6,720
CL1-SF-77	0.30	800 lb.	5,460	6,817	6,348	6,240

SH1-OPC-78	0.30	800 lb.	6,688	7,767	7,853	8,158
SH1-FA-79	0.30	800 lb.	6,070	7,107	7,597	7,840
SH1-SLAG-80	0.30	800 lb.	6,348	7,417	7,343	7,650
SL1-FA-81	0.30	900 lb.	7,420	8,610	9,137	9,590
SL1-SLAG-82	0.30	900 lb.	8,730	9,830	9,693	10,270
SH2-OPC-83	0.30	800 lb.	6,593	7,253	7,380	7,710
SH2-FA-84	0.30	800 lb.	5,970	6,877	7,643	7,690
SH2-SLAG-85	0.30	800 lb.	6,960	7,287	7,627	8,333
SH2-SF-86	0.30	800 lb.	6,360	7,300	7,713	8,168
SH2-FA-87	0.30	800 lb.	5,850	6,300	6,833	7,285
SH1-OPC-88	0.30	800 lb.	6,680	7,230	7,460	7,760
SH1-FA-89	0.30	800 lb.	6,100	7,363	7,587	7,690
SH1-SLAG-90	0.30	800 lb.	6,268	7,533	7,567	7,960
SH1-SF-91	0.30	800 lb.	6,358	7,243	7,720	7,680
SH1-SF-92	0.30	800 lb.	6,515	7,373	7,810	7,560
SH2-OPC-93	0.30	800 lb.	6,000	6,755	7,280	7,535
SH2-SF-94	0.30	800 lb.	5,970	6,940	7,390	7,940
SH2-SLAG-95	0.30	800 lb.	6,435	7,370	7,497	7,550

The following figures show the distribution of compressive strengths measured for each combination of aggregate type, binder composition,  $w/cm$ , and total cementitious material content (TCM).

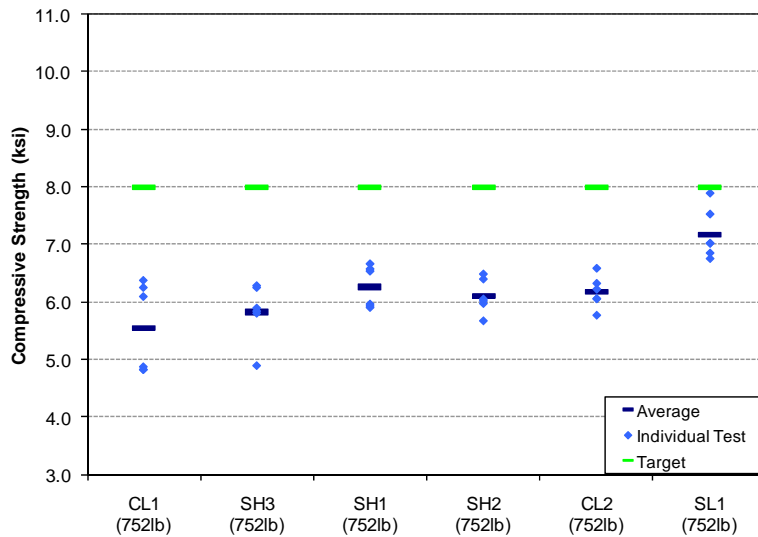


Figure F-1 28-Day Compressive Strength, 100% OPC at 0.40  $w/cm$

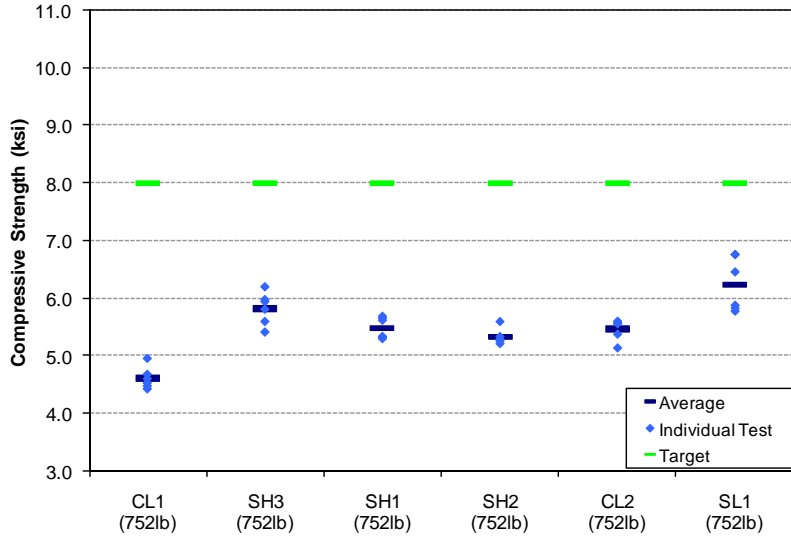


Figure F-2 28-Day Compressive Strength, 20% FA + 80% OPC at 0.40 w/cm

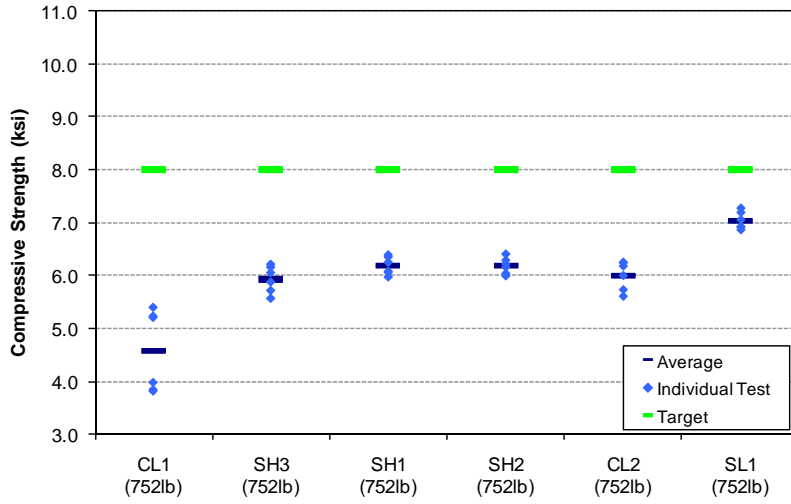
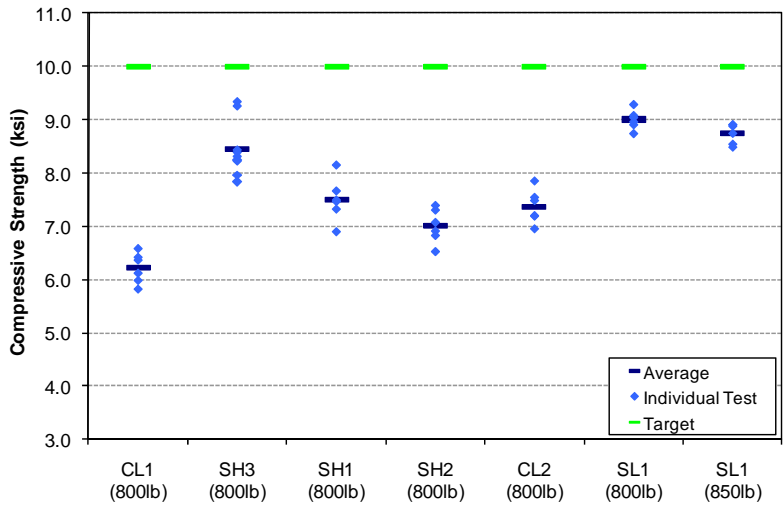
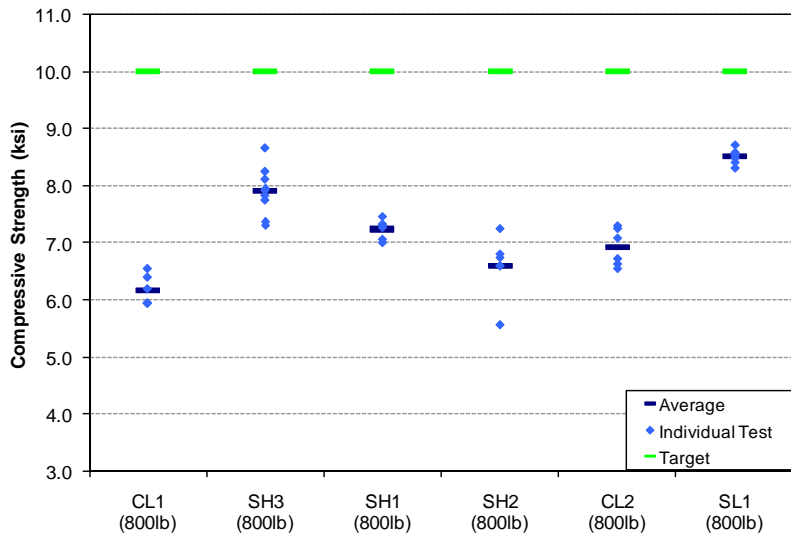


Figure F-3 28-Day Compressive Strength, 40% SLAG + 60% OPC at 0.40 w/cm





**Figure F-4 28-Day Compressive Strength, 100% OPC at 0.30 w/cm**



**Figure F-5 28-Day Compressive Strength, 20% FA + 80% OPC at 0.30 w/cm**

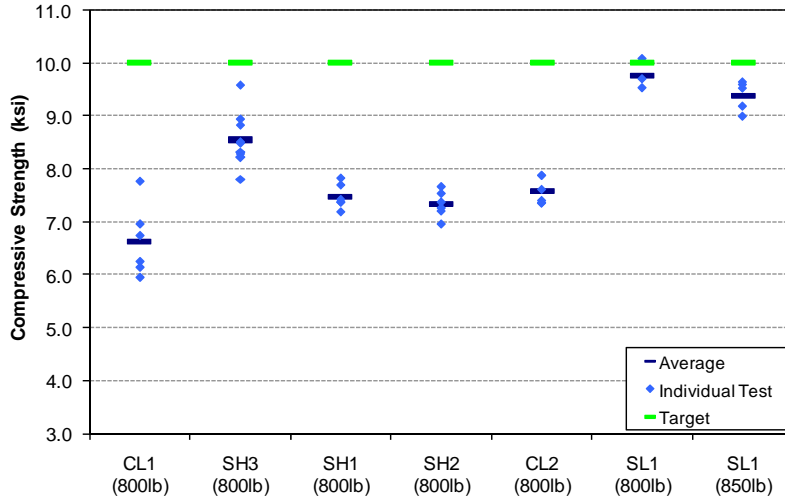


Figure F-6 28-Day Compressive Strength, 40% SLAG + 60% OPC at 0.30 w/cm

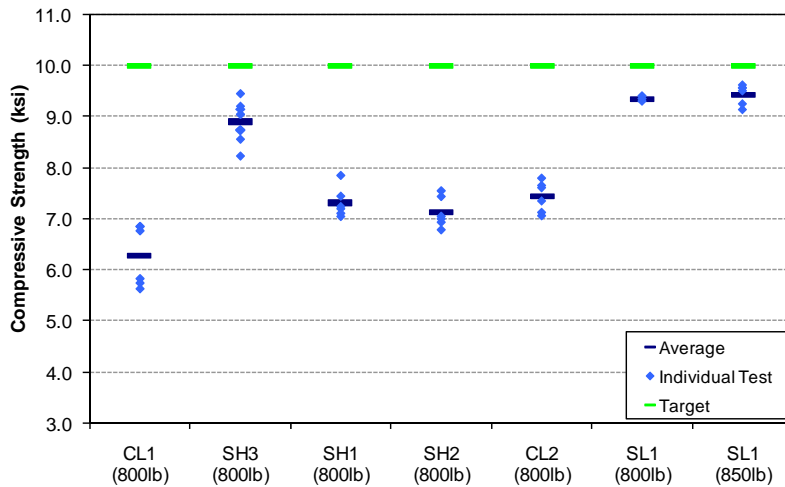


Figure F-7 28-Day Compressive Strength, 7% SF + 93% OPC at 0.30 w/cm

### Splitting Tensile Strength

Splitting tensile strength of 4"×8" concrete specimens was tested in accordance with AASHTO T 198. As stated in the previous section, the test results for splitting tensile strength,  $f_{ct}$ , were averaged from 2 specimens tested at 7 and 90 days of age and 3 specimens tested at 28 and 56 days of age. Fewer cylinders comprised a test on a few occasions, depending upon available specimens. Splitting tensile tests were typically omitted in favor of other tests when insufficient samples were available.

**Table F-3 Average Splitting Tensile Strength,  $f_{ct}$  (psi)**

Mixture Description	w/cm	TCM	$f_{ct}$ at 7 Days	$f_{ct}$ at 28 Days	$f_{ct}$ at 56 Days	$f_{ct}$ at 90 Days
SL1-OPC-1	0.40	752 lb.	603	712	667	705
SL1-FA-2	0.40	752 lb.	545	637	660	718
SL1-SLAG-3	0.40	752 lb.	503	643	658	678
SH1-OPC-4	0.40	752 lb.	615	665	625	605
SH1-FA-5	0.40	752 lb.	493	540	560	598
SH1-SLAG-6	0.40	752 lb.	450	570	577	593
SH2-OPC-7	0.40	752 lb.	553	555	560	650
SH2-FA-8	0.40	752 lb.	498	527	578	620
SH2-SLAG-9	0.40	752 lb.	468	612	613	593
SL1-OPC-10	0.30	800 lb.	730	757	760	710
SL1-SF-11	0.30	800 lb.	600	740	700	820
SL1-SLAG-12	0.30	800 lb.	685	778	760	830
SL1-OPC-13	0.30	850 lb.	633	795	820	840
SL1-SF-14	0.30	850 lb.	615	768	780	775
SL1-SLAG-15	0.30	850 lb.	685	750	810	735
SL1-OPC-16	0.30	850 lb.	675	720	728	788
SL1-SF-17	0.30	850 lb.	630	687	810	790
SL1-SLAG-18	0.30	850 lb.	660	722	700	778
CL1-OPC-19	0.40	752 lb.	545	653	625	630
CL1-FA-20	0.40	752 lb.	468	487	493	525
CL1-SLAG-21	0.40	752 lb.	298	418	457	508
SH3-OPC-22	0.40	752 lb.	500	612	678	703
SH3-FA-23	0.40	752 lb.	485	603	628	720
SH3-SLAG-24	0.40	752 lb.	478	543	583	623
SH3-OPC-25	0.30	800 lb.	670	730	770	873
SH3-SF-26	0.30	800 lb.	615	682	683	758
SH3-SLAG-27	0.30	800 lb.	635	825	885	833
CL2-OPC-28	0.40	752 lb.	518	585	615	625
CL2-FA-29	0.40	752 lb.	463	547	568	620
CL2-SLAG-30	0.40	752 lb.	498	578	598	593
CL2-OPC-31	0.30	800 lb.	693	670	710	788
CL2-SF-32	0.30	800 lb.	583	712	665	735
CL2-SLAG-33	0.30	800 lb.	553	717	700	718
SH3-OPC-34	0.40	752 lb.	545	587	620	725
SH3-FA-35	0.40	752 lb.	498	558	620	705
SH3-SLAG-36	0.40	752 lb.	485	598	583	668
SH3-OPC-37	0.30	800 lb.	693	775	768	735

SH3-FA-38	0.30	800 lb.	618	718	758	900
SH3-SLAG-39	0.30	800 lb.	703	730	720	845
SH3-SF-40	0.30	800 lb.	648	777	808	810
CL2-FA-41	0.30	800 lb.	585	640	672	703
CL2-OPC-42	0.30	800 lb.	640	685	735	748
CL2-SF-43	0.30	800 lb.	598	672	768	750
CL2-SLAG-44	0.30	800 lb.	625	705	712	808
SH3-OPC-45	0.30	800 lb.	645	735	743	730
SH3-FA-46	0.30	800 lb.	620	733	745	748
SH3-SLAG-47	0.30	800 lb.	588	732	730	723
SH3-SF-48	0.30	800 lb.	640	765	815	830
SH3-FA-49	0.30	800 lb.	583	632	735	720
CL2-FA-50	0.30	800 lb.	615	647	673	735
CL2-OPC-51	0.40	752 lb.	565	607	597	640
CL2-FA-52	0.40	752 lb.	515	555	615	593
CL2-SLAG-53	0.40	752 lb.	470	580	635	593
SH1-OPC-54	0.40	752 lb.	528	583	655	583
SH1-FA-55	0.40	752 lb.	528	570	578	618
SH1-SLAG-56	0.40	752 lb.	455	593	610	640
SH2-OPC-57	0.40	752 lb.	573	615	668	570
SH2-FA-58	0.40	752 lb.	510	583	585	603
SH2-SLAG-59	0.40	752 lb.	580	663	665	608
SL1-OPC-60	0.40	752 lb.	595	663	660	670
SL1-FA-61	0.40	752 lb.	503	600	640	668
SL1-SLAG-62	0.40	752 lb.	498	607	667	735
CL1-OPC-63	0.40	752 lb.	463	527	517	533
CL1-FA-64	0.40	752 lb.	453	522	567	598
CL1-SLAG-65	0.40	752 lb.	498	547	608	663
SL1-OPC-66	0.30	800 lb.	725	752	802	783
SL1-FA-67	0.30	800 lb.	615	757	805	768
CL1-OPC-68	0.30	800 lb.	665	657	615	653
CL1-FA-69	0.30	800 lb.	588	707	670	690
CL1-SF-70	0.30	800 lb.	565	615	617	650
SL1-SLAG-71	0.25	900 lb.	723	770	897	865
CL1-OPC-72	0.30	800 lb.	645	678	717	713
CL1-FA-73	0.30	800 lb.	585	642	638	640
SL1-FA-74	0.30	800 lb.	698	680	782	798
CL1-SLAG-75	0.30	800 lb.	635	682	703	605
CL1-SLAG-76	0.30	800 lb.	635	675	662	685
CL1-SF-77	0.30	800 lb.	645	707	702	675

SH1-OPC-78	0.30	800 lb.	705	705	705	745
SH1-FA-79	0.30	800 lb.	573	697	670	745
SH1-SLAG-80	0.30	800 lb.	610	665	665	705
SL1-FA-81	0.30	900 lb.	628	762	723	655
SL1-SLAG-82	0.30	900 lb.	770	743	830	835
SH2-OPC-83	0.30	800 lb.	653	683	738	728
SH2-FA-84	0.30	800 lb.	593	652	673	720
SH2-SLAG-85	0.30	800 lb.	643	770	717	690
SH2-SF-86	0.30	800 lb.	623	698	698	735
SH2-FA-87	0.30	800 lb.	563	663	653	675
SH1-OPC-88	0.30	800 lb.	650	730	683	760
SH1-FA-89	0.30	800 lb.	575	602	697	750
SH1-SLAG-90	0.30	800 lb.	613	622	672	655
SH1-SF-91	0.30	800 lb.	633	632	713	670
SH1-SF-92	0.30	800 lb.	545	670	665	658
SH2-OPC-93	0.30	800 lb.	590	672	693	685
SH2-SF-94	0.30	800 lb.	580	687	685	695
SH2-SLAG-95	0.30	800 lb.	685	707	708	698

The distribution of splitting tensile strengths versus predicted values are shown in the following figures as a function of aggregate and binder composition.

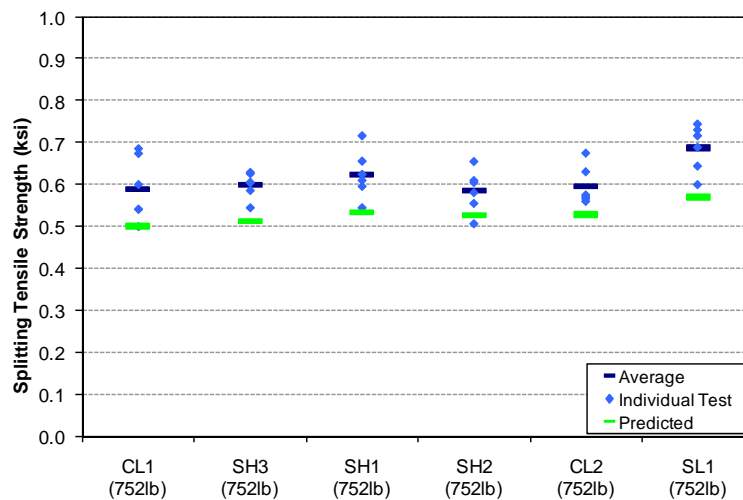


Figure F-8 28-Day Splitting Tensile Strength, 100% OPC at 0.40 w/cm

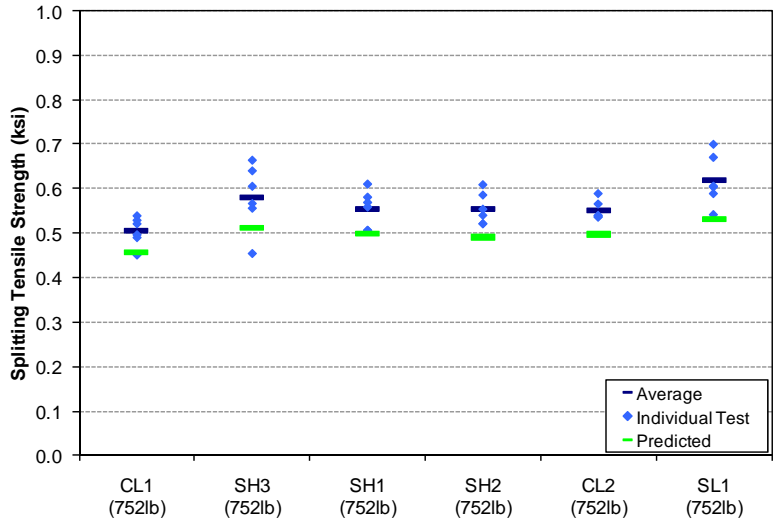


Figure F-9 28-Day Splitting Tensile Strength, 20% FA + 80% OPC at 0.40 w/cm

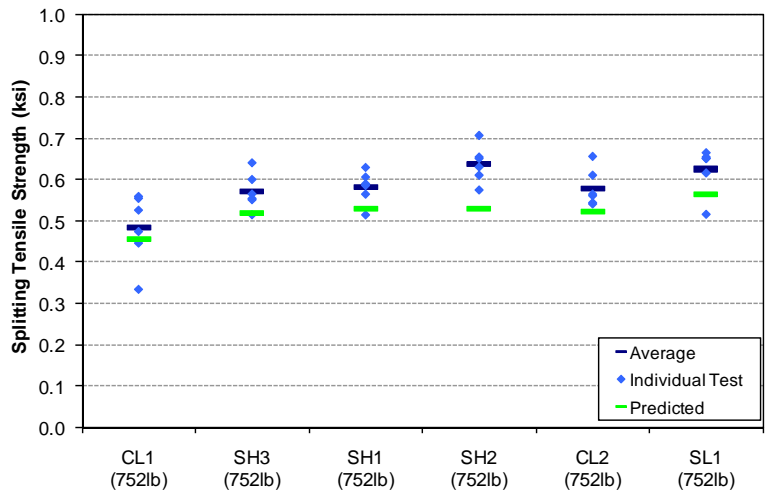


Figure F-10 28-Day Splitting Tensile Strength, 40% SLAG + 60% OPC at 0.40 w/cm

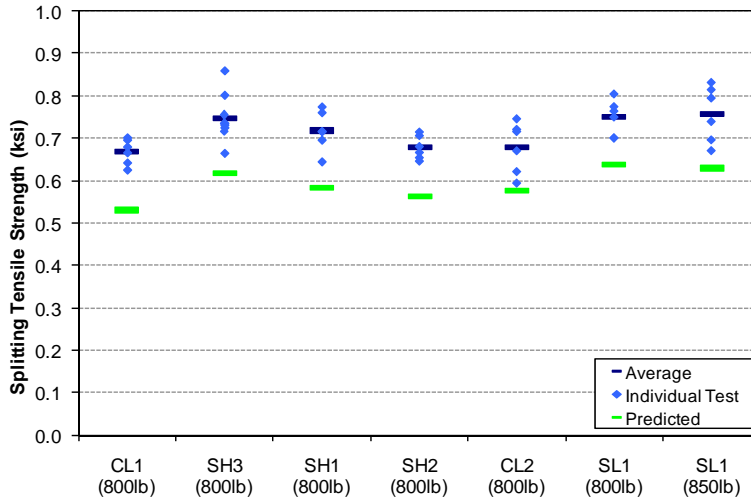


Figure F-11 28-Day Splitting Tensile Strength, 100% OPC at 0.30 w/cm

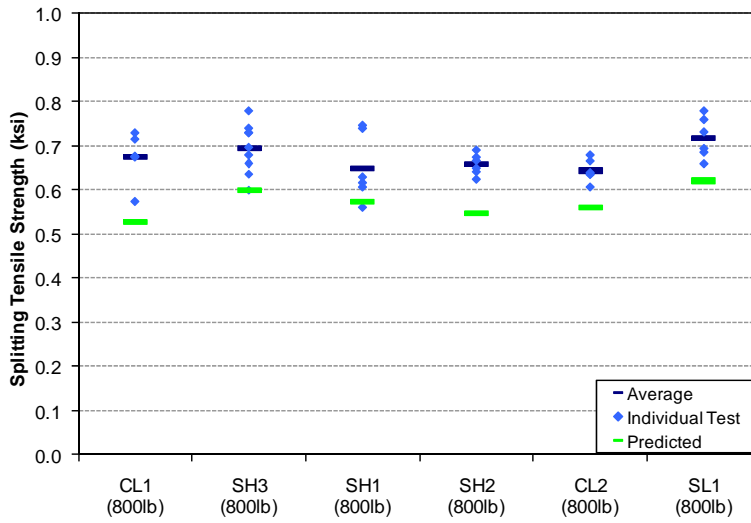


Figure F-12 28-Day Splitting Tensile Strength, 20% FA + 80% OPC at 0.30 w/cm

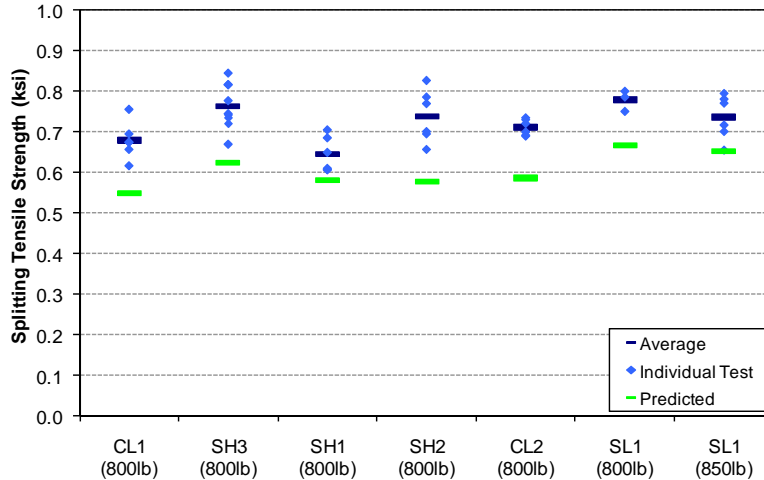


Figure F-13 28-Day Splitting Tensile Strength, 40% SLAG + 60% OPC at 0.30 w/cm

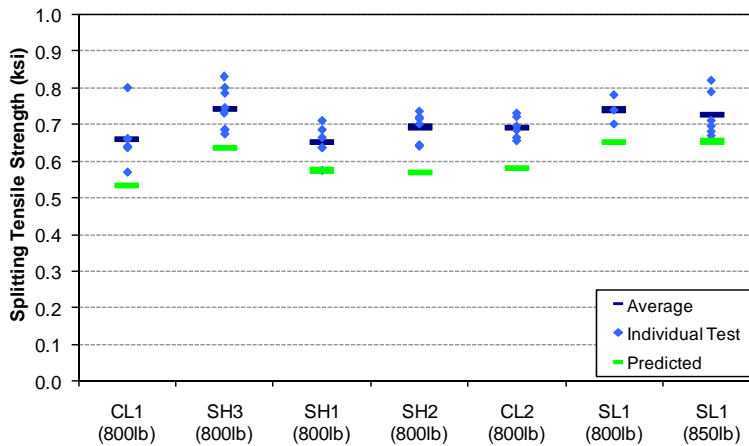


Figure F-14 28-Day Splitting Tensile Strength, 7% SF + 93% OPC at 0.30 w/cm

### Modulus of Elasticity

Modulus of elasticity of 4 in.×8 in. concrete cylinders was determined in accordance with AASHTO T 22 and ASTM C 469-02. Unlike compressive strength and splitting tensile strength, the reported average values for modulus of elasticity,  $E_c$ , were computed from tests of between three (minimum) and six (maximum) specimens per sample. In the initial stages of the study, modulus of elasticity testing was conducted on all cylinders to be tested for compressive or splitting tensile tests. However, as the study progressed, modulus of elasticity testing was reduced due to time constraints, such that researchers typically tested two compressive strength



cylinders, which were capped with a sulfur mortar compound, and one splitting tensile strength cylinder, which employed unbonded neoprene caps, to determine elastic modulus.

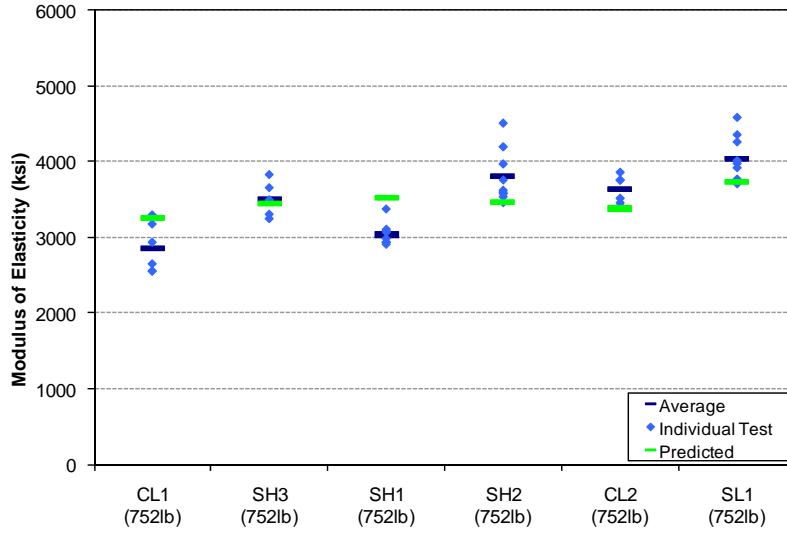
**Table F-4 Average Modulus of Elasticity,  $E_c$  ( $\times 10^6$  psi)**

Mixture Description	w/cm	TCM	$E_c$ at 7 Days	$E_c$ at 28 Days	$E_c$ at 56 Days	$E_c$ at 90 Days
SL1-OPC-1	0.40	752 lb.	3.90	4.04	4.27	4.51
SL1-FA-2	0.40	752 lb.	3.27	3.68	3.93	4.27
SL1-SLAG-3	0.40	752 lb.	2.91	3.55	3.94	3.98
SH1-OPC-4	0.40	752 lb.	2.80	3.09	3.34	3.38
SH1-FA-5	0.40	752 lb.	2.36	2.76	3.23	3.09
SH1-SLAG-6	0.40	752 lb.	2.05	2.72	2.92	3.03
SH2-OPC-7	0.40	752 lb.	3.51	3.65	3.81	3.78
SH2-FA-8	0.40	752 lb.	3.02	3.40	3.75	3.89
SH2-SLAG-9	0.40	752 lb.	2.82	3.36	3.89	3.77
SL1-OPC-10	0.30	800 lb.	4.29	4.52	4.51	4.73
SL1-SF-11	0.30	800 lb.	4.21	4.41	4.46	4.44
SL1-SLAG-12	0.30	800 lb.	4.35	4.63	4.77	4.56
SL1-OPC-13	0.30	850 lb.	4.40	4.60	4.46	4.65
SL1-SF-14	0.30	850 lb.	4.01	4.72	4.47	4.54
SL1-SLAG-15	0.30	850 lb.	4.17	5.14	4.52	4.89
SL1-OPC-16	0.30	850 lb.	4.32	4.60	4.73	4.60
SL1-SF-17	0.30	850 lb.	4.26	4.44	4.82	4.52
SL1-SLAG-18	0.30	850 lb.	3.77	4.30	4.41	4.31
CL1-OPC-19	0.40	752 lb.	2.86	3.14	3.35	3.21
CL1-FA-20	0.40	752 lb.	2.07	2.32	2.85	2.72
CL1-SLAG-21	0.40	752 lb.	1.38	1.74	2.34	2.24
SH3-OPC-22	0.40	752 lb.	2.92	3.54	3.29	3.79
SH3-FA-23	0.40	752 lb.	3.22	3.14	3.49	3.81
SH3-SLAG-24	0.40	752 lb.	2.60	3.27	3.15	3.49
SH3-OPC-25	0.30	800 lb.	4.04	4.81	4.34	4.49
SH3-SF-26	0.30	800 lb.	3.97	4.86	4.46	4.56
SH3-SLAG-27	0.30	800 lb.	4.06	4.82	4.53	4.64
CL2-OPC-28	0.40	752 lb.	3.37	3.61	3.58	3.62
CL2-FA-29	0.40	752 lb.	2.80	3.24	3.45	3.48
CL2-SLAG-30	0.40	752 lb.	2.60	3.35	3.50	3.39
CL2-OPC-31	0.30	800 lb.	3.80	4.07	4.60	4.36
CL2-SF-32	0.30	800 lb.	4.27	4.20	4.43	4.54
CL2-SLAG-33	0.30	800 lb.	3.69	4.20	4.43	4.20
SH3-OPC-34	0.40	752 lb.	3.22	3.47	3.58	3.67

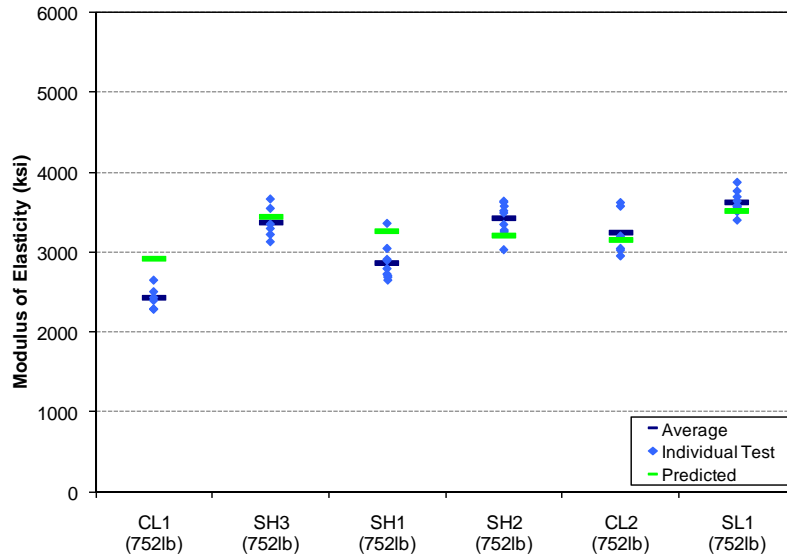
SH3-FA-35	0.40	752 lb.	3.29	3.32	3.66	3.65
SH3-SLAG-36	0.40	752 lb.	2.44	3.50	3.36	3.45
SH3-OPC-37	0.30	800 lb.	3.91	4.27	4.29	4.49
SH3-FA-38	0.30	800 lb.	3.82	4.57	4.40	4.63
SH3-SLAG-39	0.30	800 lb.	4.00	4.26	4.40	4.34
SH3-SF-40	0.30	800 lb.	4.08	4.29	4.93	4.34
CL2-FA-41	0.30	800 lb.	3.84	4.07	3.99	4.25
CL2-OPC-42	0.30	800 lb.	3.64	4.20	4.13	4.52
CL2-SF-43	0.30	800 lb.	3.81	4.24	4.04	4.17
CL2-SLAG-44	0.30	800 lb.	3.78	4.18	4.27	4.02
SH3-OPC-45	0.30	800 lb.	3.76	4.00	4.04	4.35
SH3-FA-46	0.30	800 lb.	3.97	3.94	4.22	4.52
SH3-SLAG-47	0.30	800 lb.	3.45	4.00	3.86	3.92
SH3-SF-48	0.30	800 lb.	3.87	4.01	4.19	4.37
SH3-FA-49	0.30	800 lb.	3.48	3.68	3.81	4.02
CL2-FA-50	0.30	800 lb.	3.95	3.85	4.10	4.53
CL2-OPC-51	0.40	752 lb.	3.46	3.64	3.73	3.70
CL2-FA-52	0.40	752 lb.	3.04	3.23	3.46	3.46
CL2-SLAG-53	0.40	752 lb.	2.60	3.08	3.37	3.36
SH1-OPC-54	0.40	752 lb.	2.71	2.94	2.98	3.10
SH1-FA-55	0.40	752 lb.	2.73	3.07	3.25	3.17
SH1-SLAG-56	0.40	752 lb.	2.30	2.97	3.25	3.12
SH2-OPC-57	0.40	752 lb.	3.29	4.10	3.78	3.90
SH2-FA-58	0.40	752 lb.	3.36	3.45	3.91	3.81
SH2-SLAG-59	0.40	752 lb.	2.93	3.70	3.97	3.97
SL1-OPC-60	0.40	752 lb.	3.97	4.05	4.08	4.06
SL1-FA-61	0.40	752 lb.	3.07	3.51	3.93	3.95
SL1-SLAG-62	0.40	752 lb.	2.88	3.69	3.92	3.84
CL1-OPC-63	0.40	752 lb.	2.40	2.59	2.84	2.68
CL1-FA-64	0.40	752 lb.	2.21	2.53	2.76	2.77
CL1-SLAG-65	0.40	752 lb.	2.31	2.72	2.98	2.98
SL1-OPC-66	0.30	800 lb.	4.22	4.70	4.74	4.59
SL1-FA-67	0.30	800 lb.	4.06	4.14	4.22	4.38
CL1-OPC-68	0.30	800 lb.	2.98	3.08	3.27	3.26
CL1-FA-69	0.30	800 lb.	2.87	3.43	3.48	3.50
CL1-SF-70	0.30	800 lb.	2.62	2.94	3.14	3.25
SL1-SLAG-71	0.25	900 lb.	4.09	4.63	4.85	4.96
CL1-OPC-72	0.30	800 lb.	3.00	3.19	3.24	3.67
CL1-FA-73	0.30	800 lb.	2.72	2.96	3.25	3.18
SL1-FA-74	0.30	800 lb.	3.84	4.35	4.64	4.72

CL1-SLAG-75	0.30	800 lb.	2.61	3.14	3.31	3.40
CL1-SLAG-76	0.30	800 lb.	2.83	3.46	3.43	3.54
CL1-SF-77	0.30	800 lb.	2.81	3.41	3.32	3.19
SH1-OPC-78	0.30	800 lb.	3.11	3.50	3.49	3.67
SH1-FA-79	0.30	800 lb.	2.90	3.36	3.32	3.60
SH1-SLAG-80	0.30	800 lb.	2.75	3.38	3.47	3.64
SL1-FA-81	0.30	900 lb.	4.32	4.15	4.40	4.54
SL1-SLAG-82	0.30	900 lb.	4.42	4.41	4.20	4.64
SH2-OPC-83	0.30	800 lb.	4.02	4.38	4.50	4.93
SH2-FA-84	0.30	800 lb.	3.68	4.27	4.42	4.55
SH2-SLAG-85	0.30	800 lb.	3.91	4.21	4.51	4.84
SH2-SF-86	0.30	800 lb.	4.12	4.09	4.60	4.65
SH2-FA-87	0.30	800 lb.	3.90	3.78	4.11	4.46
SH1-OPC-88	0.30	800 lb.	3.02	3.30	4.43	3.67
SH1-FA-89	0.30	800 lb.	2.98	3.27	4.63	3.67
SH1-SLAG-90	0.30	800 lb.	2.99	3.58	4.53	3.58
SH1-SF-91	0.30	800 lb.	3.42	3.34	3.45	3.41
SH1-SF-92	0.30	800 lb.	3.06	3.49	3.57	3.79
SH2-OPC-93	0.30	800 lb.	4.00	3.98	4.30	4.50
SH2-SF-94	0.30	800 lb.	4.05	4.40	4.59	4.72
SH2-SLAG-95	0.30	800 lb.	4.22	4.29	4.48	4.75

The following figures illustrate distributions of modulus of elasticity and comparison to values predicted using the AASHTO equation based on compressive strength for the various aggregates and binder compositions studied.



**Figure F-15 28-Day Modulus of Elasticity, 100% OPC and 0.40 w/cm**



**Figure F-16 28-Day Modulus of Elasticity, 20% FA + 80% OPC at 0.40 w/cm**

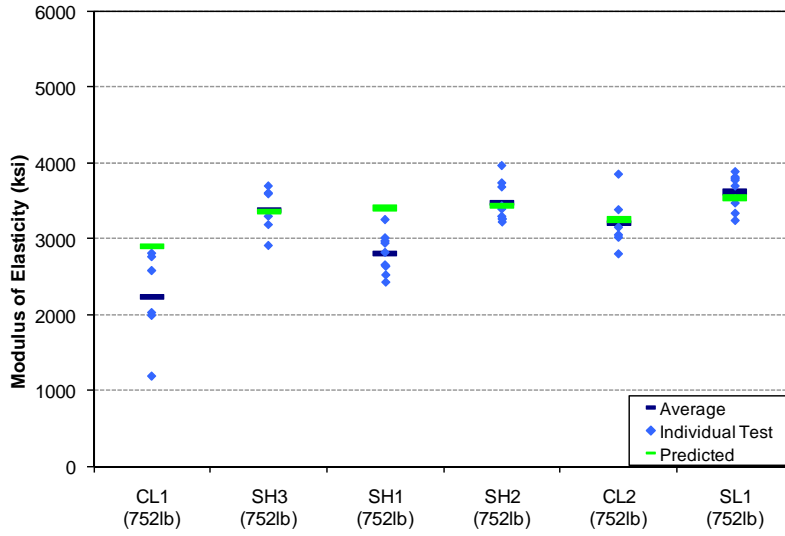


Figure F-17 28-Day Modulus of Elasticity, 40% SLAG + 60% OPC at 0.40 w/cm

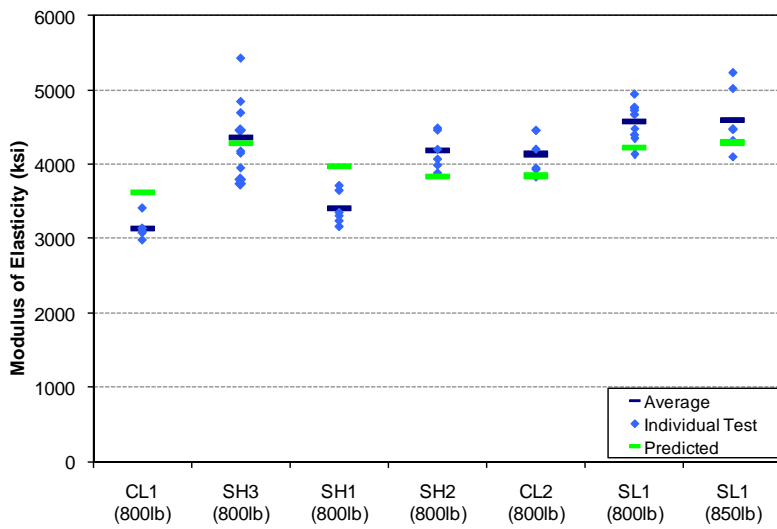


Figure F-18 28-Day Modulus of Elasticity, 100% OPC and 0.30 w/cm

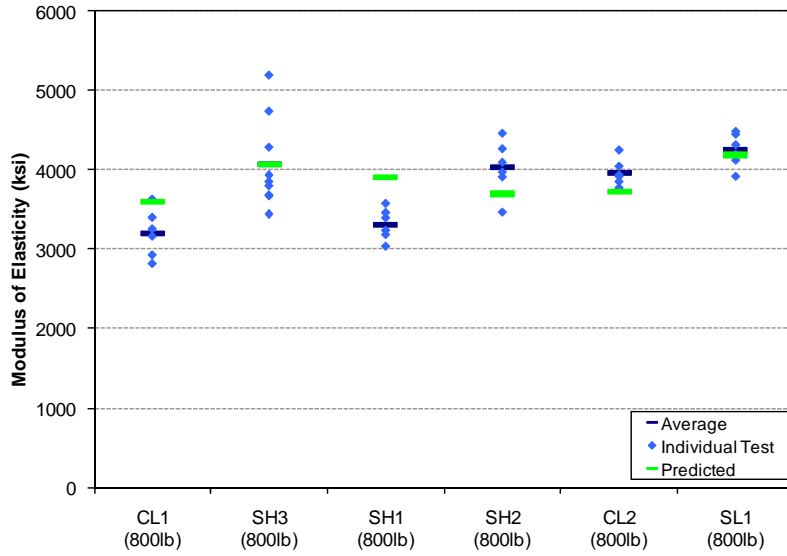


Figure F-19 28-Day Modulus of Elasticity, 20% FA + 80% OPC at 0.30 w/cm

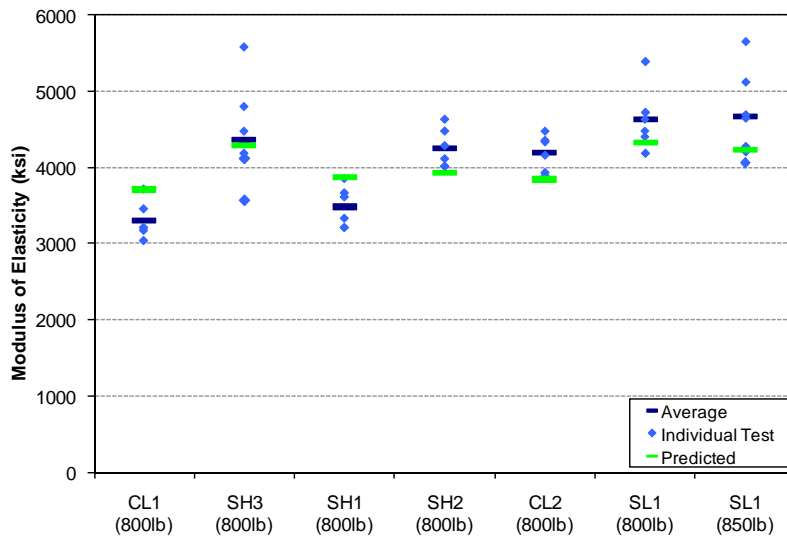


Figure F-20 28-Day Modulus of Elasticity, 40% SLAG + 60% OPC at 0.30 w/cm

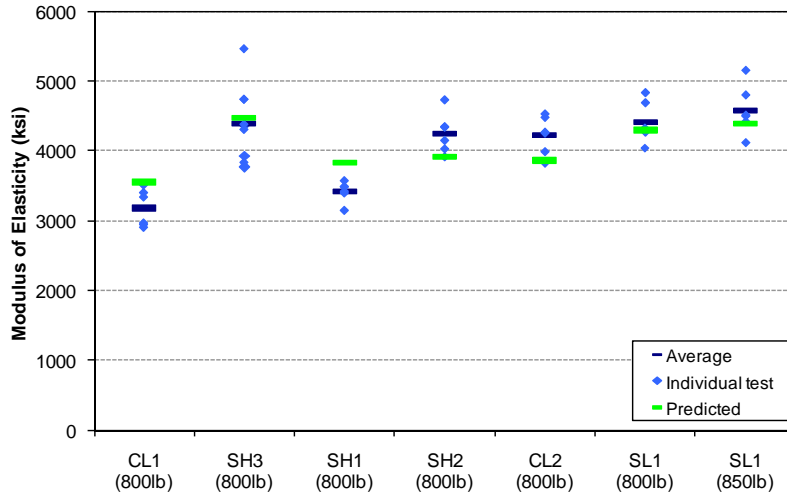


Figure F-21 28-Day Modulus of Elasticity, 7% SF + 93% OPC at 0.30 w/cm

### Modulus of Rupture

Characterization tests for modulus of rupture (flexural strength),  $f_r$ , were tested on 3"×3"×11" beams at 28 days of age in accordance with AASHTO T 97 (ASTM C 78-02) and reported values represent an average of two flexural beams.

Table F-5 Average Flexural Strength,  $f_r$  (psi)

Mixture Description	w/cm	TCM	$f_r$ @28-Day
SL1-OPC-1	0.40	752 lb.	765
SL1-FA-2	0.40	752 lb.	758
SL1-SLAG-3	0.40	752 lb.	685
SH1-OPC-4	0.40	752 lb.	775
SH1-FA-5	0.40	752 lb.	643
SH1-SLAG-6	0.40	752 lb.	680
SH2-OPC-7	0.40	752 lb.	820
SH2-FA-8	0.40	752 lb.	680
SH2-SLAG-9	0.40	752 lb.	715
SL1-OPC-10	0.30	800 lb.	925
SL1-SF-11	0.30	800 lb.	900
SL1-SLAG-12	0.30	800 lb.	978
SL1-OPC-13	0.30	850 lb.	928
SL1-SF-14	0.30	850 lb.	898
SL1-SLAG-15	0.30	850 lb.	900
SL1-OPC-16	0.30	850 lb.	940

SL1-SF-17	0.30	850 lb.	840
SL1-SLAG-18	0.30	850 lb.	840
CL1-OPC-19	0.40	752 lb.	790
CL1-FA-20	0.40	752 lb.	608
CL1-SLAG-21	0.40	752 lb.	550
SH3-OPC-22	0.40	752 lb.	770
SH3-FA-23	0.40	752 lb.	665
SH3-SLAG-24	0.40	752 lb.	650
SH3-OPC-25	0.30	800 lb.	993
SH3-SF-26	0.30	800 lb.	938
SH3-SLAG-27	0.30	800 lb.	928
CL2-OPC-28	0.40	752 lb.	763
CL2-FA-29	0.40	752 lb.	698
CL2-SLAG-30	0.40	752 lb.	705
CL2-OPC-31	0.30	800 lb.	815
CL2-SF-32	0.30	800 lb.	860
CL2-SLAG-33	0.30	800 lb.	913
SH3-OPC-34	0.40	752 lb.	750
SH3-FA-35	0.40	752 lb.	718
SH3-SLAG-36	0.40	752 lb.	705
SH3-OPC-37	0.30	800 lb.	885
SH3-FA-38	0.30	800 lb.	863
SH3-SLAG-39	0.30	800 lb.	955
SH3-SF-40	0.30	800 lb.	888
CL2-FA-41	0.30	800 lb.	795
CL2-OPC-42	0.30	800 lb.	905
CL2-SF-43	0.30	800 lb.	855
CL2-SLAG-44	0.30	800 lb.	905
SH3-OPC-45	0.30	800 lb.	870
SH3-FA-46	0.30	800 lb.	910
SH3-SLAG-47	0.30	800 lb.	825
SH3-SF-48	0.30	800 lb.	853
SH3-FA-49	0.30	800 lb.	770
CL2-FA-50	0.30	800 lb.	835
CL2-OPC-51	0.40	752 lb.	715
CL2-FA-52	0.40	752 lb.	695
CL2-SLAG-53	0.40	752 lb.	675
SH1-OPC-54	0.40	752 lb.	775
SH1-FA-55	0.40	752 lb.	663
SH1-SLAG-56	0.40	752 lb.	638



SH2-OPC-57	0.40	752 lb.	773
SH2-FA-58	0.40	752 lb.	698
SH2-SLAG-59	0.40	752 lb.	725
SL1-OPC-60	0.40	752 lb.	820
SL1-FA-61	0.40	752 lb.	713
SL1-SLAG-62	0.40	752 lb.	755
CL1-OPC-63	0.40	752 lb.	743
CL1-FA-64	0.40	752 lb.	N/A
CL1-SLAG-65	0.40	752 lb.	738
SL1-OPC-66	0.30	800 lb.	955
SL1-FA-67	0.30	800 lb.	848
CL1-OPC-68	0.30	800 lb.	853
CL1-FA-69	0.30	800 lb.	845
CL1-SF-70	0.30	800 lb.	710
SL1-SLAG-71	0.25	900 lb.	1,023
CL1-OPC-72	0.30	800 lb.	880
CL1-FA-73	0.30	800 lb.	845
SL1-FA-74	0.30	800 lb.	843
CL1-SLAG-75	0.30	800 lb.	735
CL1-SLAG-76	0.30	800 lb.	888
CL1-SF-77	0.30	800 lb.	865
SH1-OPC-78	0.30	800 lb.	910
SH1-FA-79	0.30	800 lb.	790
SH1-SLAG-80	0.30	800 lb.	813
SL1-FA-81	0.30	900 lb.	845
SL1-SLAG-82	0.30	900 lb.	1,023
SH2-OPC-83	0.30	800 lb.	908
SH2-FA-84	0.30	800 lb.	840
SH2-SLAG-85	0.30	800 lb.	905
SH2-SF-86	0.30	800 lb.	878
SH2-FA-87	0.30	800 lb.	808
SH1-OPC-88	0.30	800 lb.	868
SH1-FA-89	0.30	800 lb.	798
SH1-SLAG-90	0.30	800 lb.	728
SH1-SF-91	0.30	800 lb.	720
SH1-SF-92	0.30	800 lb.	813
SH2-OPC-93	0.30	800 lb.	905
SH2-SF-94	0.30	800 lb.	868
SH2-SLAG-95	0.30	800 lb.	948

The following figures illustrate the distribution of modulus of rupture,  $f_r$ , as they compare to the value predicted using the AASHTO relation to compressive strength, for the range of binder compositions and  $w/cm$  studied.

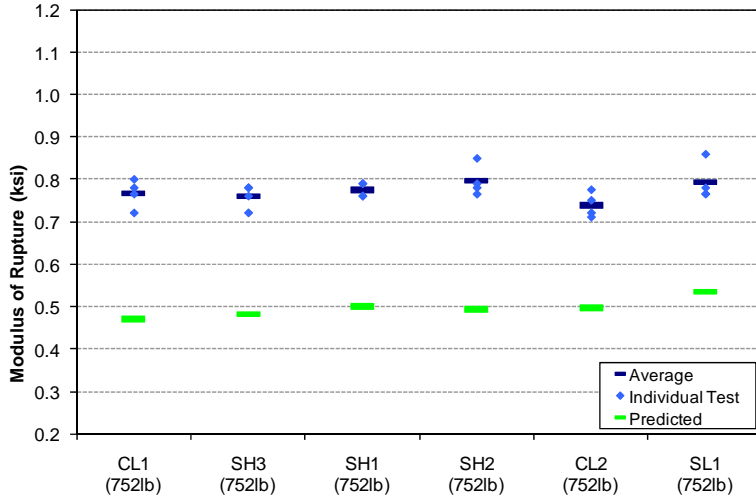


Figure F-22 28-Day Modulus of Rupture, 100% OPC at 0.40  $w/cm$

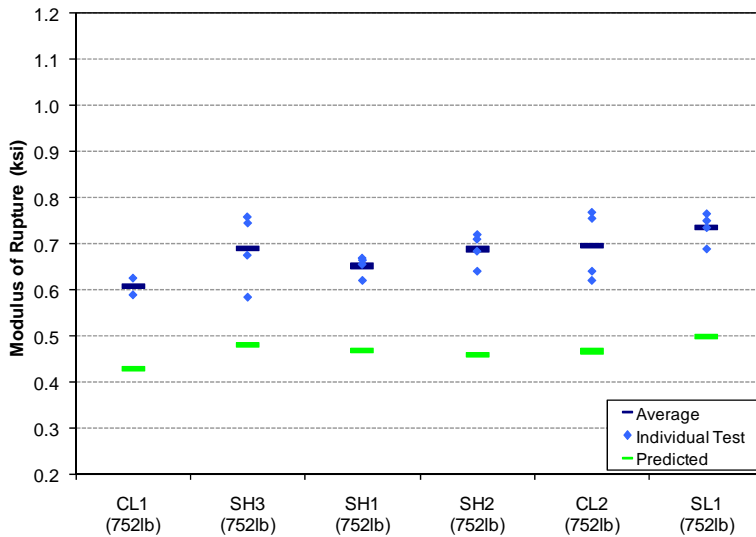


Figure F-23 28-Day Flexural Strength, 20% FA + 80% OPC at 0.40  $w/cm$

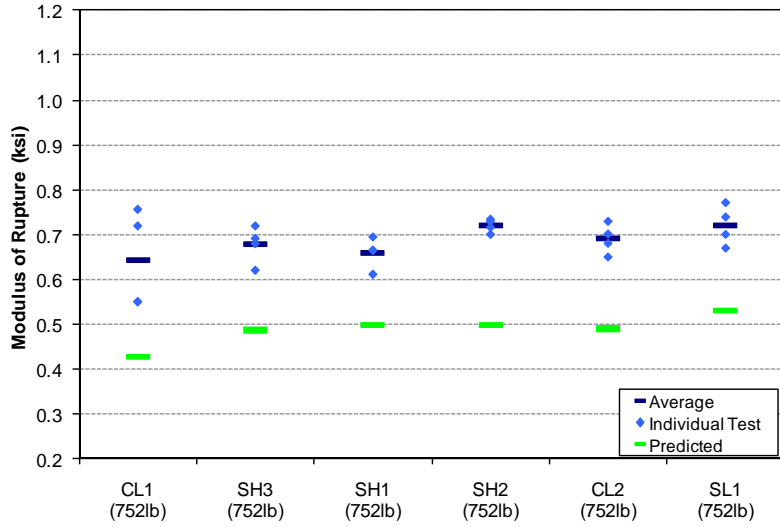


Figure F-24 28-Day Flexural Strength, 40% SLAG + 60% OPC at 0.40 w/cm

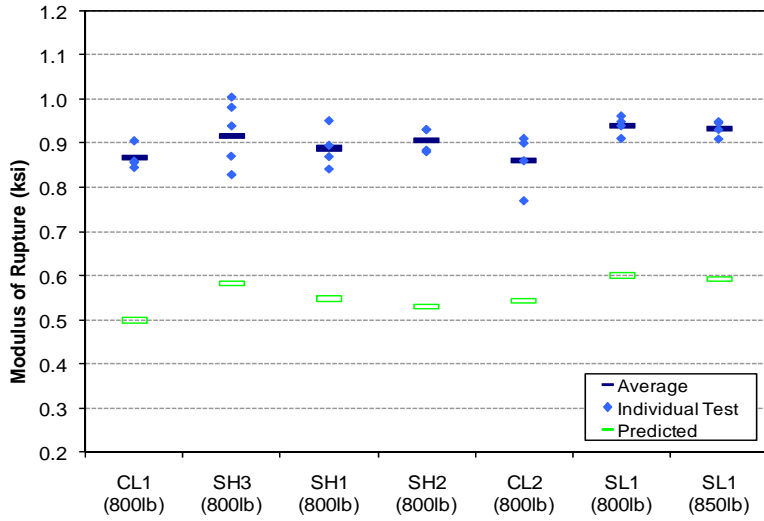


Figure F-25 28-Day Modulus of Rupture, 100% OPC at 0.30 w/cm

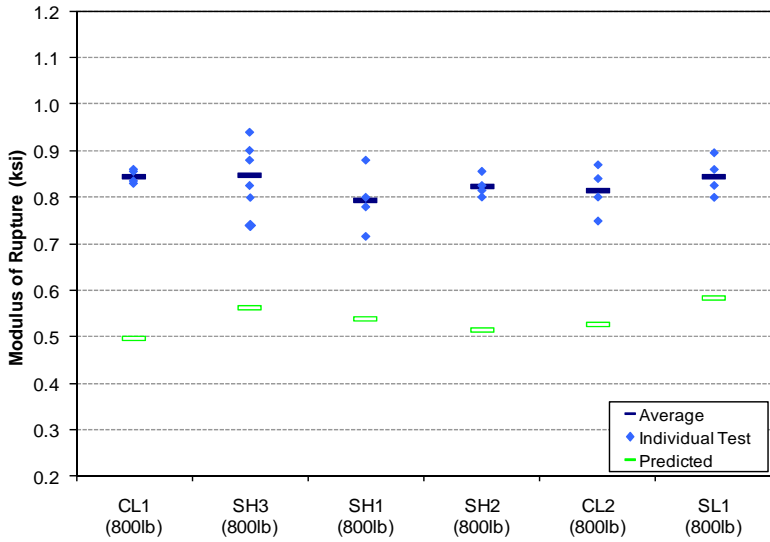


Figure F-26 28-Day Flexural Strength, 20% FA + 80% OPC at 0.30 w/cm

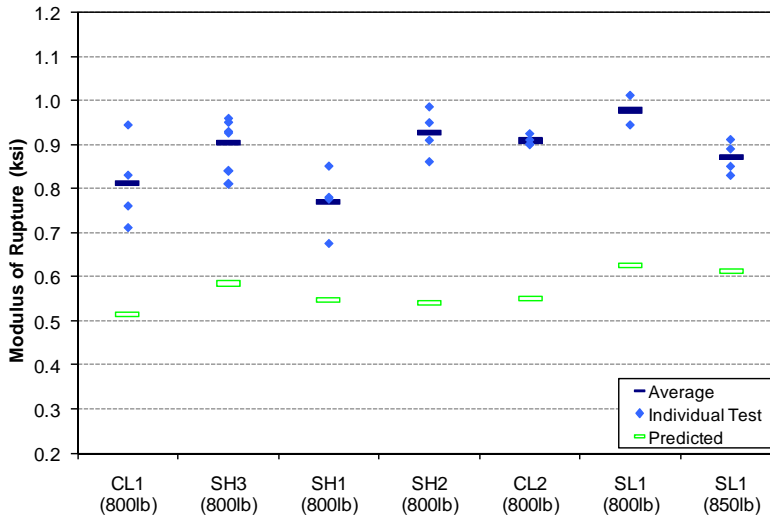


Figure F-27 28-Day Flexural Strength, 40% SLAG + 60% OPC at 0.30 w/cm

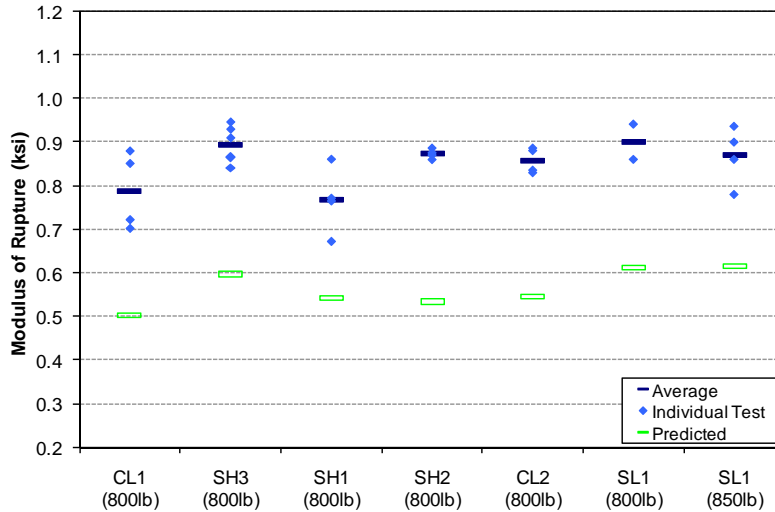


Figure F-28 28-Day Flexural Strength, 7% SF + 93% OPC at 0.30 w/cm

### Length Change

Length change values were averaged from the results of two 3"×3"×11" prisms cast with studs for determining shrinkage effects over time in accordance with AASHTO T 160 (ASTM C 157-06). Each entry in the table refers to the change in length, expressed as a percentage, compared with the initial length recorded on the day after casting. The 28-day moist cure value was recorded after continuous exposure in a controlled moisture room for 28 days. The second value reported was obtained after the specimens were allowed to dry in a temperature and humidity-controlled environment (~73°F and ~50% RH) for a period of 28 days immediately following the 28-day moist cure period.

Table F-6 Average Length Change (% of 24-hr Value)

Mixture Description	w/cm	TCM	28-Day Moist Cure (%)	28-Day Air Dried (%), After 28-Day Moist Cure
SL1-OPC-1	0.40	752 lb.	0.0045	-0.0080
SL1-FA-2	0.40	752 lb.	0.0020	-0.0210
SL1-SLAG-3	0.40	752 lb.	0.0055	-0.0090
SH1-OPC-4	0.40	752 lb.	-0.0005	-0.0065
SH1-FA-5	0.40	752 lb.	0.0015	-0.0185
SH1-SLAG-6	0.40	752 lb.	0.0105	-0.0010
SH2-OPC-7	0.40	752 lb.	0.0010	-0.0205

SH2-FA-8	0.40	752 lb.	-0.0005	-0.0350
SH2-SLAG-9	0.40	752 lb.	0.0060	-0.0065
SL1-OPC-10	0.30	800 lb.	0.0130	-0.0075
SL1-SF-11	0.30	800 lb.	0.0060	-0.0065
SL1-SLAG-12	0.30	800 lb.	0.0080	-0.0040
SL1-OPC-13	0.30	850 lb.	0.0060	-0.0090
SL1-SF-14	0.30	850 lb.	0.0030	-0.0065
SL1-SLAG-15	0.30	850 lb.	0.0050	-0.0075
SL1-OPC-16	0.30	850 lb.	0.0100	-0.0085
SL1-SF-17	0.30	850 lb.	0.0055	-0.0090
SL1-SLAG-18	0.30	850 lb.	0.0120	-0.0015
CL1-OPC-19	0.40	752 lb.	0.0060	-0.0095
CL1-FA-20	0.40	752 lb.	0.0070	-0.0275
CL1-SLAG-21	0.40	752 lb.	0.0110	-0.0100
SH3-OPC-22	0.40	752 lb.	0.0070	-0.0105
SH3-FA-23	0.40	752 lb.	0.0060	-0.0220
SH3-SLAG-24	0.40	752 lb.	0.0185	0.0020
SH3-OPC-25	0.30	800 lb.	0.0105	0.0015
SH3-SF-26	0.30	800 lb.	0.0075	0.0015
SH3-SLAG-27	0.30	800 lb.	0.0120	0.0055
CL2-OPC-28	0.40	752 lb.	0.0040	-0.0165
CL2-FA-29	0.40	752 lb.	0.0030	-0.0370
CL2-SLAG-30	0.40	752 lb.	0.0105	-0.0075
CL2-OPC-31	0.30	800 lb.	0.0085	0.0000
CL2-SF-32	0.30	800 lb.	0.0080	0.0000
CL2-SLAG-33	0.30	800 lb.	0.0125	0.0050
SH3-OPC-34	0.40	752 lb.	0.0035	-0.0100
SH3-FA-35	0.40	752 lb.	0.0015	-0.0240
SH3-SLAG-36	0.40	752 lb.	0.0035	-0.0085
SH3-OPC-37	0.30	800 lb.	0.0065	0.0000
SH3-FA-38	0.30	800 lb.	0.0035	-0.0055
SH3-SLAG-39	0.30	800 lb.	0.0090	0.0050
SH3-SF-40	0.30	800 lb.	0.0005	0.0000
CL2-FA-41	0.30	800 lb.	-0.0005	-0.0095
CL2-OPC-42	0.30	800 lb.	0.0130	0.0035
CL2-SF-43	0.30	800 lb.	0.0050	-0.0005
CL2-SLAG-44	0.30	800 lb.	0.0150	0.0025
SH3-OPC-45	0.30	800 lb.	0.0115	0.0000
SH3-FA-46	0.30	800 lb.	0.0065	-0.0090
SH3-SLAG-47	0.30	800 lb.	0.0120	0.0020

SH3-SF-48	0.30	800 lb.	0.0085	0.0015
SH3-FA-49	0.30	800 lb.	0.0065	-0.0090
CL2-FA-50	0.30	800 lb.	0.0055	-0.0120
CL2-OPC-51	0.40	752 lb.	0.0050	-0.0145
CL2-FA-52	0.40	752 lb.	0.0035	-0.0265
CL2-SLAG-53	0.40	752 lb.	0.0080	-0.0040
SH1-OPC-54	0.40	752 lb.	0.0045	-0.0060
SH1-FA-55	0.40	752 lb.	0.0015	-0.0160
SH1-SLAG-56	0.40	752 lb.	0.0135	0.0035
SH2-OPC-57	0.40	752 lb.	0.0045	-0.0130
SH2-FA-58	0.40	752 lb.	0.0020	-0.0235
SH2-SLAG-59	0.40	752 lb.	0.0070	-0.0035
SL1-OPC-60	0.40	752 lb.	0.0030	-0.0190
SL1-FA-61	0.40	752 lb.	-0.0035	-0.0360
SL1-SLAG-62	0.40	752 lb.	0.0030	-0.0110
CL1-OPC-63	0.40	752 lb.	-0.0030	-0.0165
CL1-FA-64	0.40	752 lb.	-0.0030	-0.0250
CL1-SLAG-65	0.40	752 lb.	0.0090	0.0030
SL1-OPC-66	0.30	800 lb.	0.0045	-0.0090
SL1-FA-67	0.30	800 lb.	0.0000	-0.0205
CL1-OPC-68	0.30	800 lb.	0.0030	-0.0025
CL1-FA-69	0.30	800 lb.	0.0005	-0.0110
CL1-SF-70	0.30	800 lb.	0.0005	-0.0055
SL1-SLAG-71	0.25	900 lb.	0.0040	-0.0005
CL1-OPC-72	0.30	800 lb.	0.0025	-0.0095
CL1-FA-73	0.30	800 lb.	-0.0010	-0.0175
SL1-FA-74	0.30	800 lb.	0.0015	-0.0175
CL1-SLAG-75	0.30	800 lb.	0.0130	0.0005
CL1-SLAG-76	0.30	800 lb.	0.0095	0.0040
CL1-SF-77	0.30	800 lb.	-0.0030	-0.0055
SH1-OPC-78	0.30	800 lb.	0.0030	-0.0040
SH1-FA-79	0.30	800 lb.	0.0000	-0.0080
SH1-SLAG-80	0.30	800 lb.	0.0080	0.0035
SL1-FA-81	0.30	900 lb.	0.0025	-0.0170
SL1-SLAG-82	0.30	900 lb.	0.0055	-0.0075
SH2-OPC-83	0.30	800 lb.	0.0090	-0.0030
SH2-FA-84	0.30	800 lb.	0.0025	-0.0105
SH2-SLAG-85	0.30	800 lb.	0.0040	0.0000
SH2-SF-86	0.30	800 lb.	0.0025	-0.0015
SH2-FA-87	0.30	800 lb.	0.0030	-0.0120

SH1-OPC-88	0.30	800 lb.	0.0010	-0.0025
SH1-FA-89	0.30	800 lb.	-0.0020	-0.0090
SH1-SLAG-90	0.30	800 lb.	0.0035	0.0015
SH1-SF-91	0.30	800 lb.	0.0020	-0.0040
SH1-SF-92	0.30	800 lb.	0.0060	0.0020
SH2-OPC-93	0.30	800 lb.	0.0065	0.0025
SH2-SF-94	0.30	800 lb.	0.0040	0.0000
SH2-SLAG-95	0.30	800 lb.	0.0040	-0.0015

The following figures summarize the length change observed after 28 days air drying, following removal from 28-day moist cure, as a function of binder composition and total cementitious materials (TCM) content.

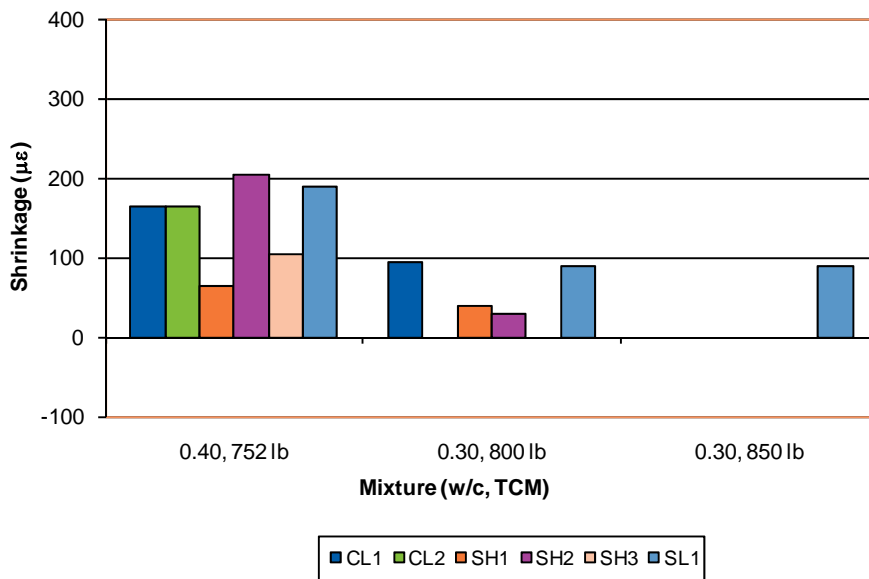


Figure F-28 28-Day Max Shrinkage, 100% OPC



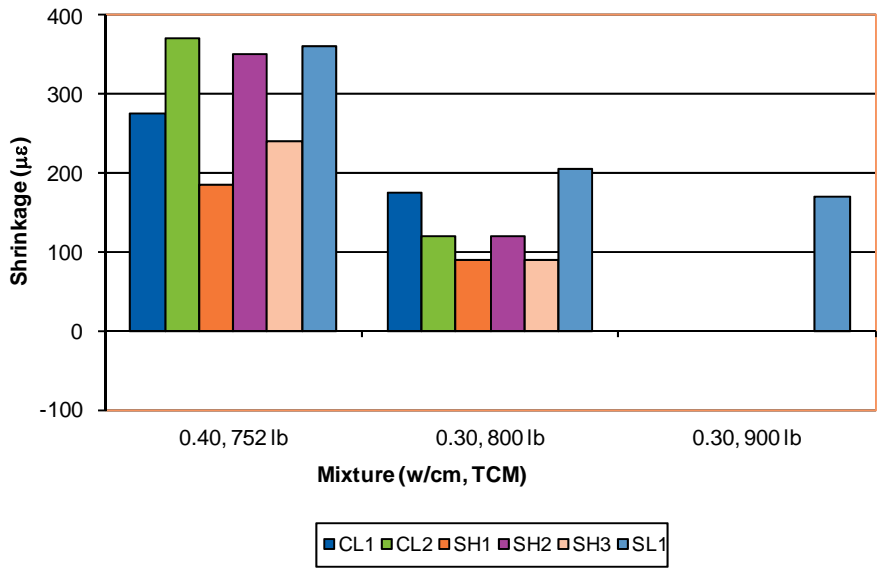


Figure F-29 28-Day Max Shrinkage, 20% FA + 80% OPC

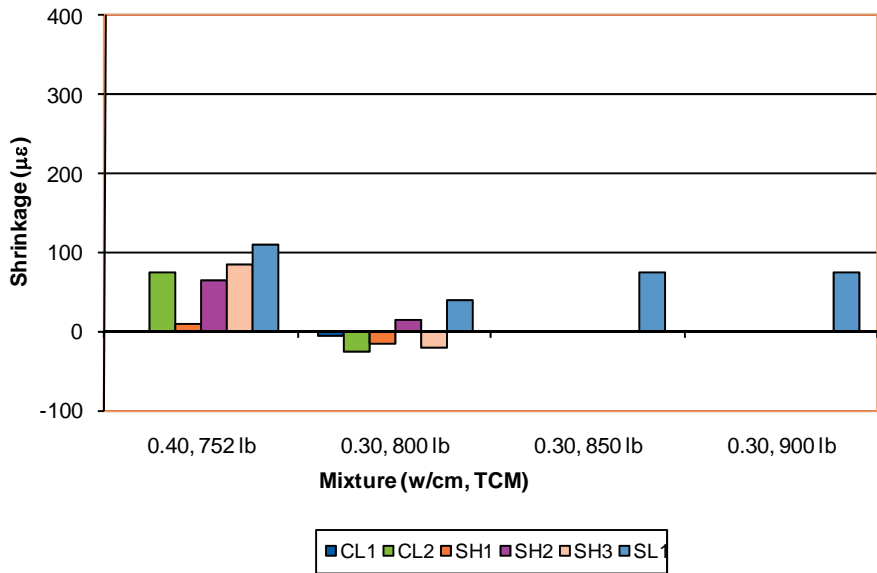
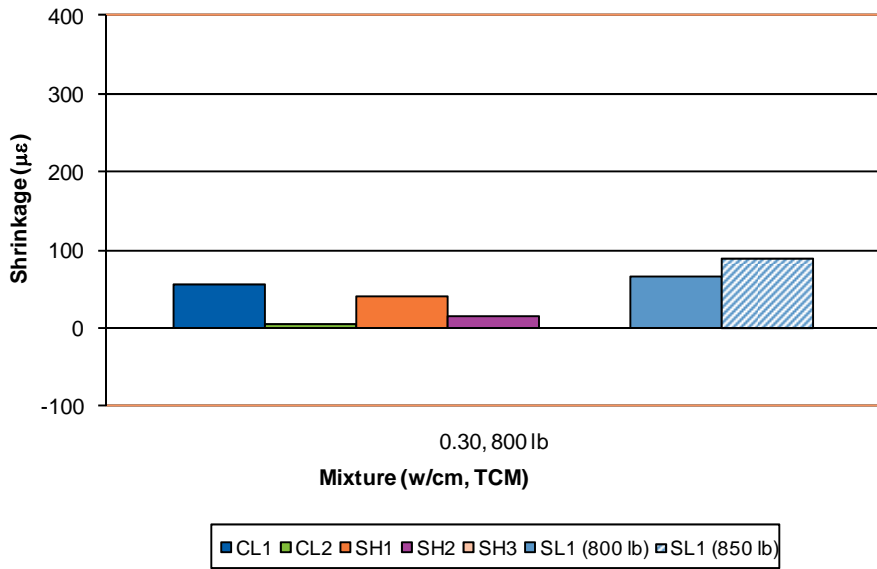
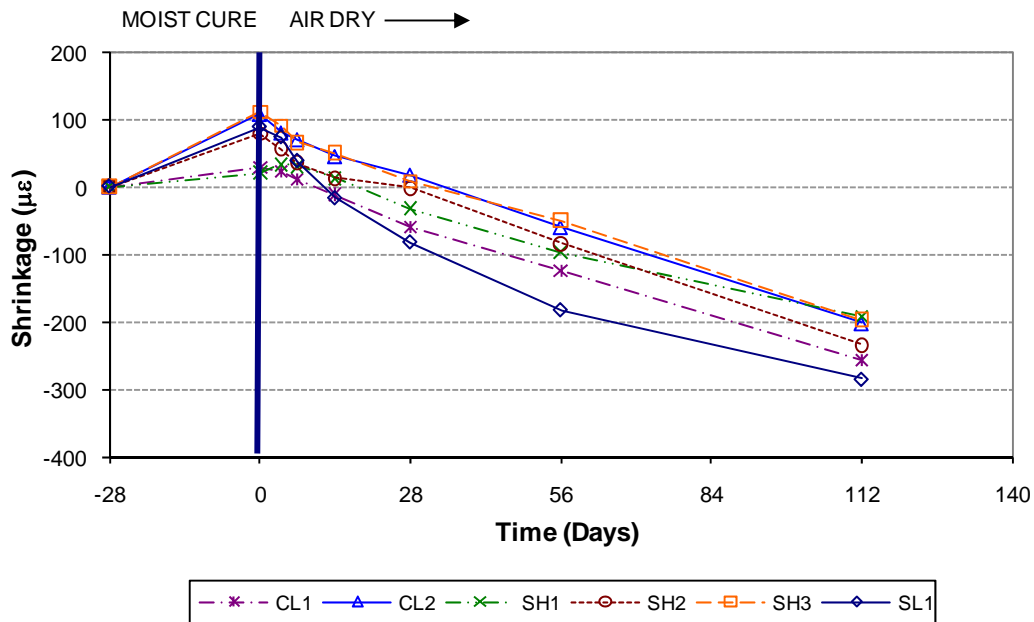


Figure F-30 28-Day Max Shrinkage, 40% SLAG + 60% OPC



**Figure F-31 28-Day Max Shrinkage, 7% SF + 93% OPC**

Length change was measured over a period of 16 weeks after removal from moist curing. The following figures demonstrate the development of length change as a function of aggregate type and binder composition.



**Figure F-32 Effect of Lightweight Aggregate Type on Length Change in 100% OPC Mixtures**

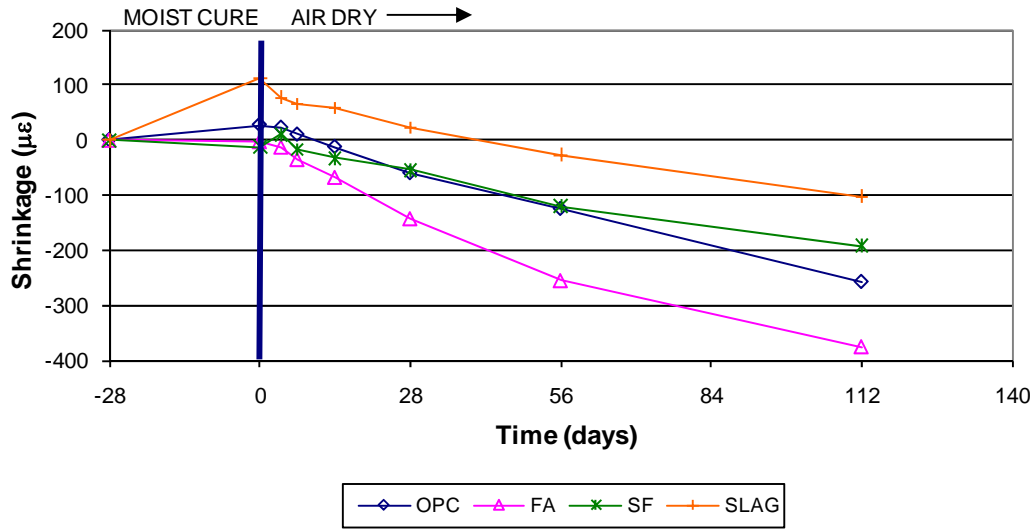


Figure F-33 Effect of Binder on shrinkage using CL1 Aggregate (28 Days)

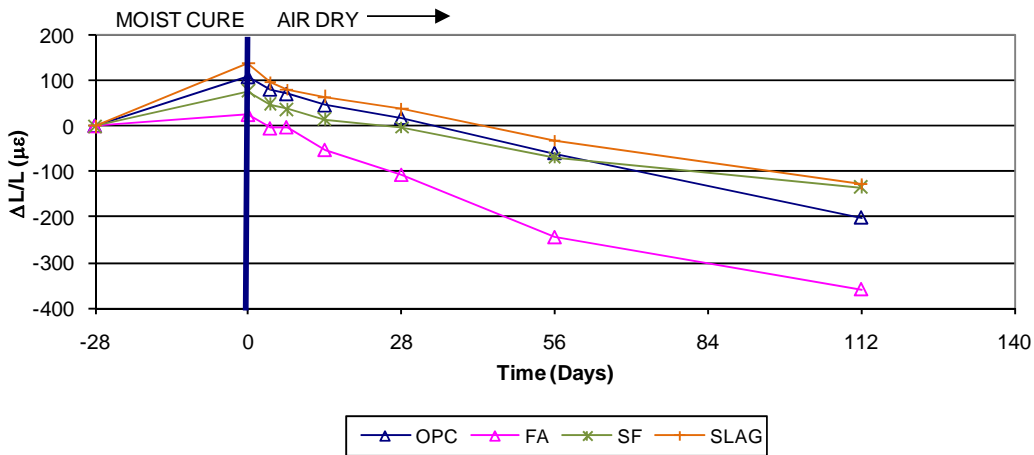


Figure F-34 Effect of Binder on shrinkage using CL2 Aggregate (28 Days)

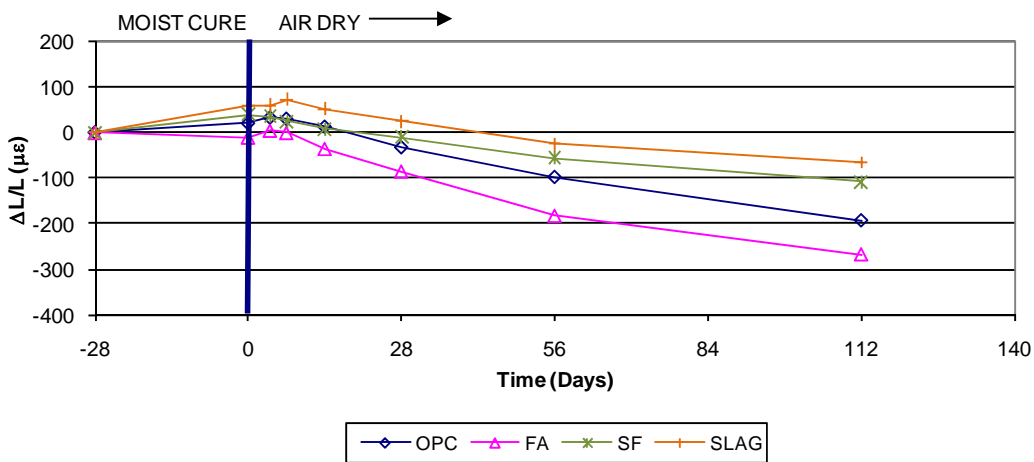


Figure F-35 Effect of Binder on shrinkage using SH1 Aggregate (28 Days)

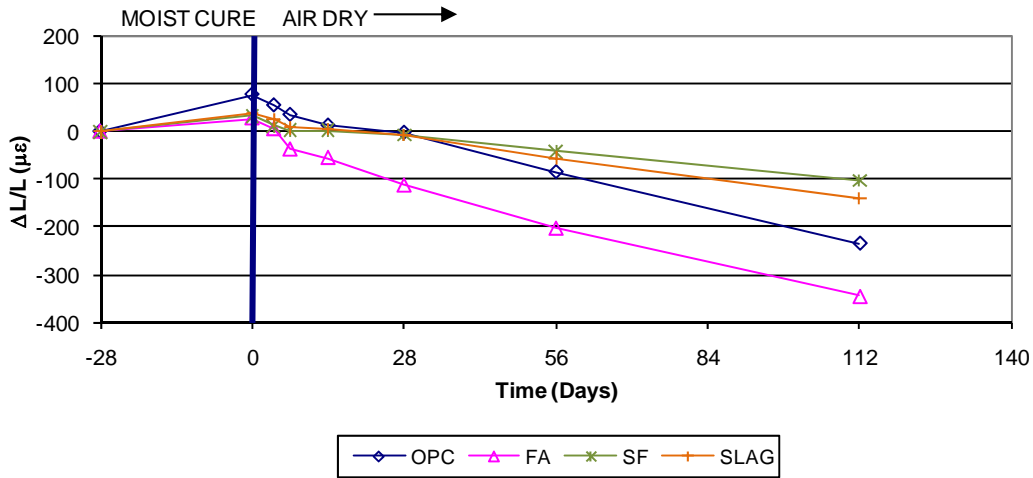


Figure F-36 Effect of Binder on shrinkage using SH2 Aggregate (28 Days)

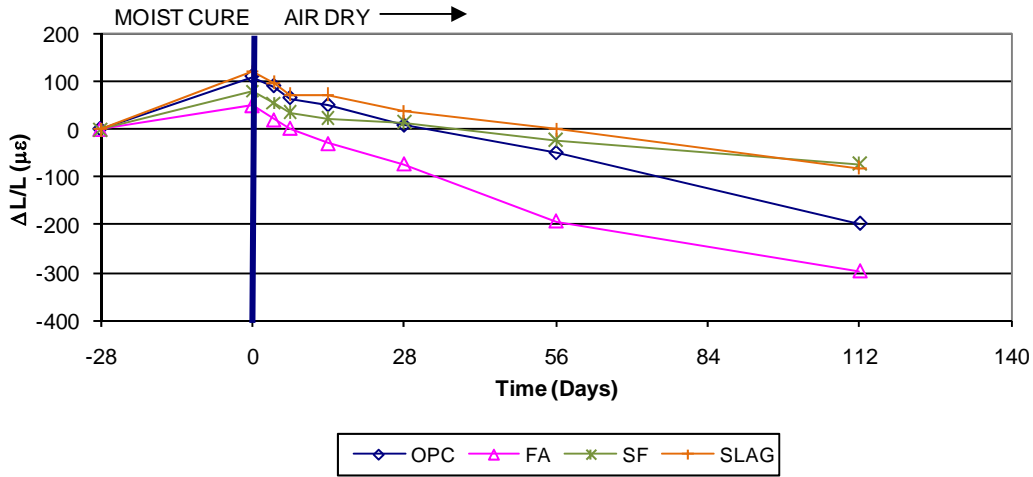


Figure F-37 Effect of Binder on shrinkage using SH3 Aggregate (28 Days)

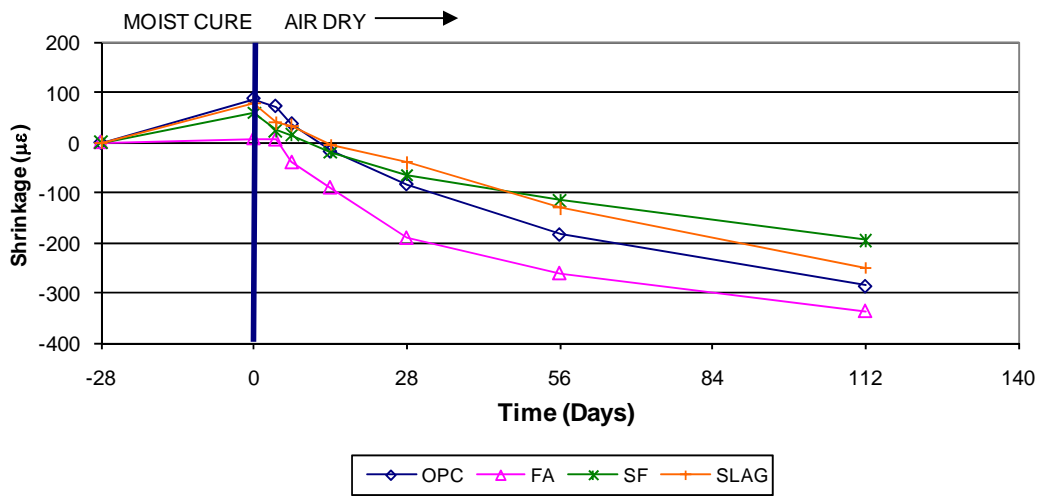


Figure F-38 Effect of Binder on shrinkage using SL1 Aggregate (28 Days)

## Permeability

Testing for electrical indication of chloride ion permeability by the rapid chloride ion test method, AASHTO T 277 (ASTM C 1202-05), was conducted on 4"×4" concrete cylinders at both 28 and 56 days.

**Table F-7 Average Charge Passed (Coulombs) and Corresponding Rating from Rapid Chloride Ion Permeability Test**

Mixture Description	w/cm	TCM	28-Day Avg.	Rating	56-Day Avg.	Rating
SL1-OPC-1	0.40	752 lb.	3,235	Moderate	3,318	Moderate
SL1-FA-2	0.40	752 lb.	647	Very Low	697	Very Low
SL1-SLAG-3	0.40	752 lb.	1,102	Low	1,264	Low
SH1-OPC-4	0.40	752 lb.	4,941	High	4,310	High
SH1-FA-5	0.40	752 lb.	1,459	Low	1,346	Low
SH1-SLAG-6	0.40	752 lb.	1,487	Low	1,504	Low
SH2-OPC-7	0.40	752 lb.	3,773	Moderate	3,520	Moderate
SH2-FA-8	0.40	752 lb.	1,005	Low	948	Very Low
SH2-SLAG-9	0.40	752 lb.	1,192	Low	1,144	Low
SL1-OPC-10	0.30	800 lb.	2,205	Moderate	1,876	Low
SL1-SF-11	0.30	800 lb.	369	Very Low	272	Very Low
SL1-SLAG-12	0.30	800 lb.	977	Very Low	647	Very Low
SL1-OPC-13	0.30	850 lb.	2,436	Moderate	2,032	Moderate
SL1-SF-14	0.30	850 lb.	374	Very Low	292	Very Low
SL1-SLAG-15	0.30	850 lb.	850	Very Low	638	Very Low
SL1-OPC-16	0.30	850 lb.	2,795	Moderate	2,084	Moderate
SL1-SF-17	0.30	850 lb.	319	Very Low	201	Very Low
SL1-SLAG-18	0.30	850 lb.	1,015	Low	753	Very Low
CL1-OPC-19	0.40	752 lb.	3,795	Moderate	2,670	Moderate
CL1-FA-20	0.40	752 lb.	1,549	Low	1,025	Low
CL1-SLAG-21	0.40	752 lb.	1,480	Low	1,056	Low
SH3-OPC-22	0.40	752 lb.	4,782	High	3,412	Moderate
SH3-FA-23	0.40	752 lb.	1,068	Low	804	Very Low
SH3-SLAG-24	0.40	752 lb.	1,222	Low	1,068	Low
SH3-OPC-25	0.30	800 lb.	2,856	Moderate	2,225	Moderate
SH3-SF-26	0.30	800 lb.	353	Very Low	337	Very Low
SH3-SLAG-27	0.30	800 lb.	762	Very Low	700	Very Low
CL2-OPC-28	0.40	752 lb.	3,590	Moderate	2,594	Moderate
CL2-FA-29	0.40	752 lb.	725	Very Low	647	Very Low
CL2-SLAG-30	0.40	752 lb.	892	Very Low	934	Very Low

CL2-OPC-31	0.30	800 lb.	2,311	Moderate	1,796	Low
CL2-SF-32	0.30	800 lb.	295	Very Low	305	Very Low
CL2-SLAG-33	0.30	800 lb.	861	Very Low	707	Very Low
SH3-OPC-34	0.40	752 lb.	2,829	Moderate	2,566	Moderate
SH3-FA-35	0.40	752 lb.	944	Very Low	733	Very Low
SH3-SLAG-36	0.40	752 lb.	1,392	Low	1,110	Low
SH3-OPC-37	0.30	800 lb.	2,756	Moderate	2,369	Moderate
SH3-FA-38	0.30	800 lb.	602	Very Low	520	Very Low
SH3-SLAG-39	0.30	800 lb.	952	Very Low	899	Very Low
SH3-SF-40	0.30	800 lb.	344	Very Low	316	Very Low
CL2-FA-41	0.30	800 lb.	578	Very Low	471	Very Low
CL2-OPC-42	0.30	800 lb.	3,004	Moderate	2,547	Moderate
CL2-SF-43	0.30	800 lb.	265	Very Low	285	Very Low
CL2-SLAG-44	0.30	800 lb.	840	Very Low	796	Very Low
SH3-OPC-45	0.30	800 lb.	3,002	Moderate	2,607	Moderate
SH3-FA-46	0.30	800 lb.	597	Very Low	591	Very Low
SH3-SLAG-47	0.30	800 lb.	805	Very Low	869	Very Low
SH3-SF-48	0.30	800 lb.	304	Very Low	365	Very Low
SH3-FA-49	0.30	800 lb.	605	Very Low	545	Very Low
CL2-FA-50	0.30	800 lb.	704	Very Low	710	Very Low
CL2-OPC-51	0.40	752 lb.	5,272	High	4,184	High
CL2-FA-52	0.40	752 lb.	1,014	Low	882	Very Low
CL2-SLAG-53	0.40	752 lb.	1,452	Low	1,283	Low
SH1-OPC-54	0.40	752 lb.	5,437	High	4,360	High
SH1-FA-55	0.40	752 lb.	1,296	Low	1,185	Low
SH1-SLAG-56	0.40	752 lb.	1,622	Low	1,560	Low
SH2-OPC-57	0.40	752 lb.	3,780	Moderate	3,614	Moderate
SH2-FA-58	0.40	752 lb.	787	Very Low	718	Very Low
SH2-SLAG-59	0.40	752 lb.	1,185	Low	1,181	Low
SL1-OPC-60	0.40	752 lb.	3,691	Moderate	3,342	Moderate
SL1-FA-61	0.40	752 lb.	707	Very Low	615	Very Low
SL1-SLAG-62	0.40	752 lb.	929	Very Low	937	Very Low
CL1-OPC-63	0.40	752 lb.	4,262	High	3,537	Moderate
CL1-FA-64	0.40	752 lb.	990	Very Low	999	Very Low
CL1-SLAG-65	0.40	752 lb.	1,091	Low	1,026	Low
SL1-OPC-66	0.30	800 lb.	2,850	Moderate	2,568	Moderate
SL1-FA-67	0.30	800 lb.	416	Very Low	373	Very Low
CL1-OPC-68	0.30	800 lb.	2,828	Moderate	2,231	Moderate
CL1-FA-69	0.30	800 lb.	742	Very Low	722	Very Low
CL1-SF-70	0.30	800 lb.	574	Very Low	620	Very Low

SL1-SLAG-71	0.25	900 lb.	548	Very Low	584	Very Low
CL1-OPC-72	0.30	800 lb.	3,100	Moderate	3,142	Moderate
CL1-FA-73	0.30	800 lb.	788	Very Low	752	Very Low
SL1-FA-74	0.30	800 lb.	413	Very Low	446	Very Low
CL1-SLAG-75	0.30	800 lb.	685	Very Low	738	Very Low
CL1-SLAG-76	0.30	800 lb.	613	Very Low	679	Very Low
CL1-SF-77	0.30	800 lb.	387	Very Low	327	Very Low
SH1-OPC-78	0.30	800 lb.	3,809	Moderate	3,745	Moderate
SH1-FA-79	0.30	800 lb.	913	Very Low	801	Very Low
SH1-SLAG-80	0.30	800 lb.	1,035	Low	1,011	Low
SL1-FA-81	0.30	900 lb.	443	Very Low	603	Very Low
SL1-SLAG-82	0.30	900 lb.	914	Very Low	979	Very Low
SH2-OPC-83	0.30	800 lb.	2,519	Moderate	2,488	Moderate
SH2-FA-84	0.30	800 lb.	472	Very Low	386	Very Low
SH2-SLAG-85	0.30	800 lb.	836	Very Low	904	Very Low
SH2-SF-86	0.30	800 lb.	294	Very Low	351	Very Low
SH2-FA-87	0.30	800 lb.	545	Very Low	624	Very Low
SH1-OPC-88	0.30	800 lb.	3,980	Moderate	3,202	Moderate
SH1-FA-89	0.30	800 lb.	825	Very Low	711	Very Low
SH1-SLAG-90	0.30	800 lb.	1,174	Low	1,161	Low
SH1-SF-91	0.30	800 lb.	778	Very Low	762	Very Low
SH1-SF-92	0.30	800 lb.	767	Very Low	601	Very Low
SH2-OPC-93	0.30	800 lb.	3,539	Moderate	2,701	Moderate
SH2-SF-94	0.30	800 lb.	421	Very Low	307	Very Low
SH2-SLAG-95	0.30	800 lb.	1,157	Low	891	Very Low

The following figures summarize the permeability values observed as a function of aggregate type, binder composition, and also relation to compressive strength.

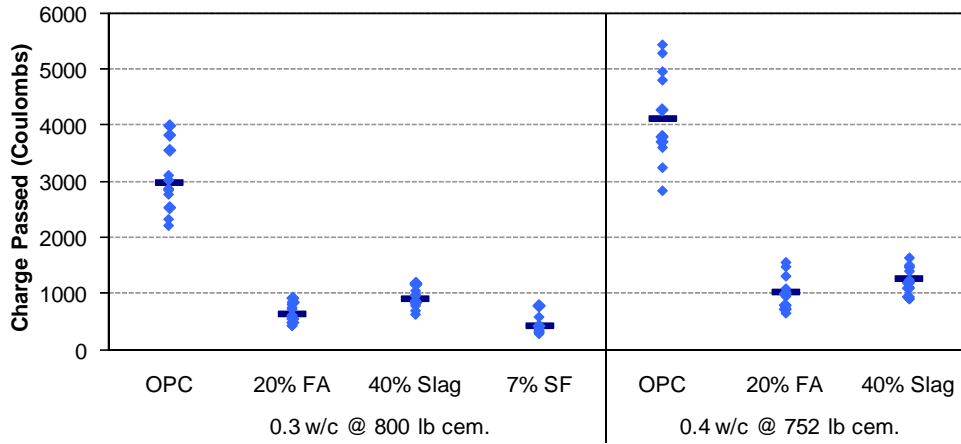


Figure F-39 Average permeability (charge-passed) values as a function of binder composition

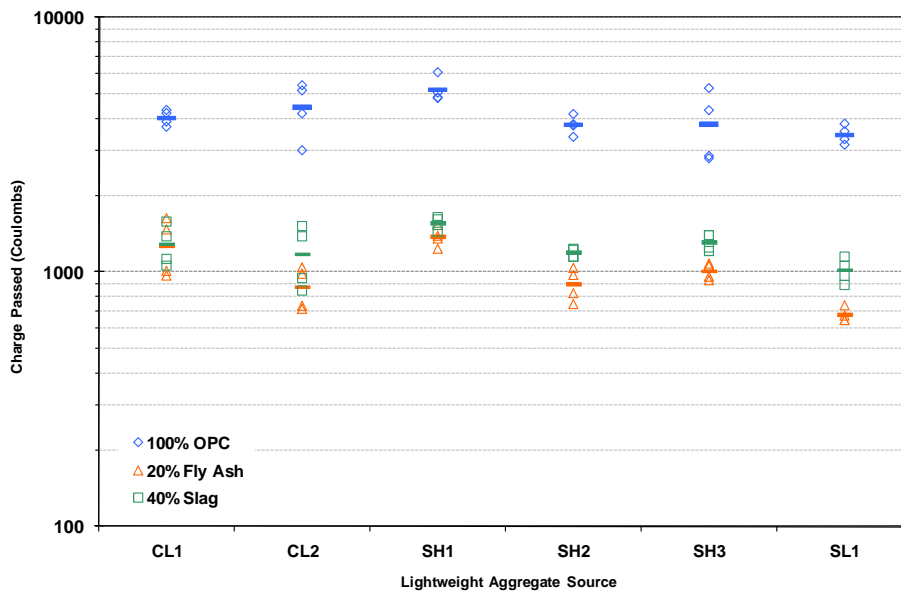


Figure F-40 Permeability by aggregate for select binder compositions at 0.40 w/cm and 752lb TCM



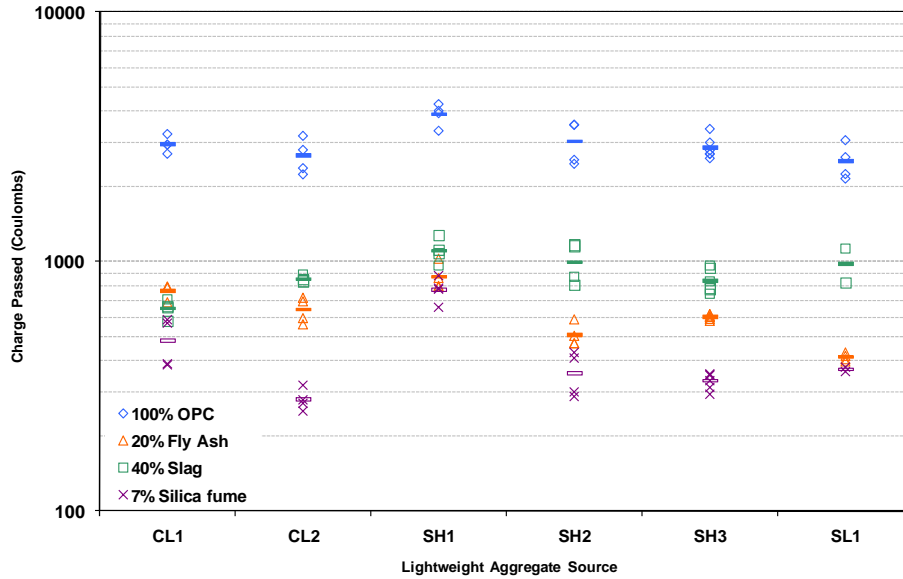


Figure F-41 Permeability by aggregate for select binder compositions at 0.30 w/cm and 800lb TCM

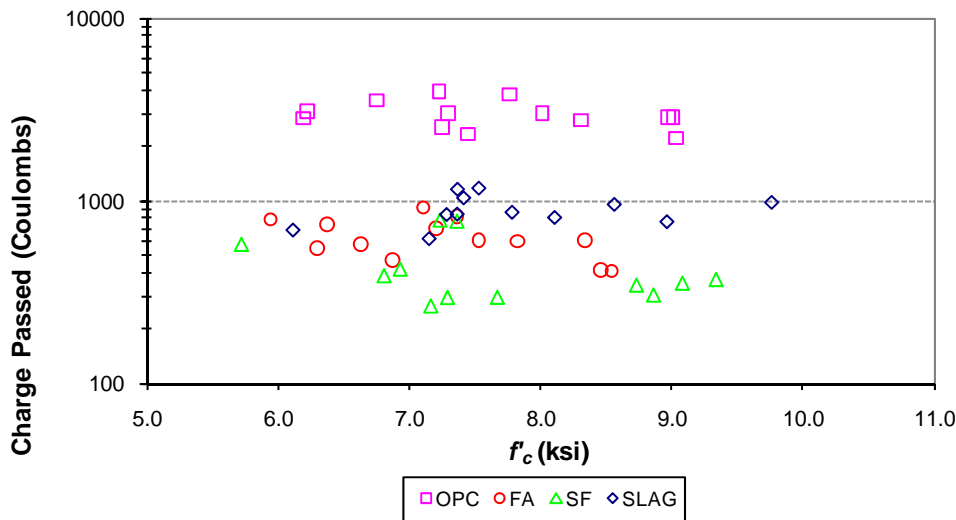


Figure F-42 Relationship between compressive strength and permeability for various binder compositions.

### Equilibrium Unit Weight

Testing for equilibrium unit weight was conducted according to a modified version of ASTM C 567, *Standard Test Method for Determining Density of Structural Lightweight Concrete*. Tests deviated slightly from the ASTM standard, as only one cylinder was cast and tested for both the SSD/air-dry and oven-dry tests for every batch of concrete due to limited capacity of the concrete mixer.

**Table F-8 Equilibrium Unit Weight (Density),  $w_c$  (lb/ft<sup>3</sup>)**

Mixture Description	w/cm	TCM	Fresh $w_c$ (lb/ft <sup>3</sup> )	Equilib. $w_c$ (lb/ft <sup>3</sup> )	Oven-Dry $w_c$ (lb/ft <sup>3</sup> )	E-O Diff. (lb/ft <sup>3</sup> )
SL1-OPC-1	0.40	752 lb.	121.9	124.3	118.9	5.4
SL1-FA-2	0.40	752 lb.	123.2	121.7	116.7	5.0
SL1-SLAG-3	0.40	752 lb.	117.9	118.5	113.1	5.3
SH1-OPC-4	0.40	752 lb.	124.6	0.0	0.0	0.0
SH1-FA-5	0.40	752 lb.	120.6	117.0	108.3	8.6
SH1-SLAG-6	0.40	752 lb.	117.9	115.0	106.2	8.8
SH2-OPC-7	0.40	752 lb.	121.9	120.7	114.9	5.7
SH2-FA-8	0.40	752 lb.	121.9	120.1	114.2	5.9
SH2-SLAG-9	0.40	752 lb.	119.3	118.3	112.5	5.7
SL1-OPC-10	0.30	800 lb.	121.9	124.2	119.7	4.5
SL1-SF-11	0.30	800 lb.	121.9	122.9	118.6	4.3
SL1-SLAG-12	0.30	800 lb.	120.6	126.7	122.6	4.1
SL1-OPC-13	0.30	850 lb.	124.6	126.0	121.3	4.7
SL1-SF-14	0.30	850 lb.	123.2	124.6	120.1	4.5
SL1-SLAG-15	0.30	850 lb.	119.3	124.0	120.0	4.0
SL1-OPC-16	0.30	850 lb.	124.6	124.1	119.8	4.3
SL1-SF-17	0.30	850 lb.	123.2	124.3	119.9	4.4
SL1-SLAG-18	0.30	850 lb.	121.9	122.5	118.3	4.2
CL1-OPC-19	0.40	752 lb.	121.9	120.7	113.5	7.2
CL1-FA-20	0.40	752 lb.	119.3	117.5	108.6	8.9
CL1-SLAG-21	0.40	752 lb.	116.6	110.2	101.9	8.3
SH3-OPC-22	0.40	752 lb.	123.2	120.5	113.8	6.7
SH3-FA-23	0.40	752 lb.	123.3	123.0	116.5	6.4
SH3-SLAG-24	0.40	752 lb.	119.3	118.1	111.6	6.5
SH3-OPC-25	0.30	800 lb.	127.2	127.6	122.2	5.4
SH3-SF-26	0.30	800 lb.	128.5	126.7	121.3	5.4
SH3-SLAG-27	0.30	800 lb.	127.2	127.5	122.7	4.8
CL2-OPC-28	0.40	752 lb.	116.6	117.4	111.4	6.0
CL2-FA-29	0.40	752 lb.	116.6	117.9	112.1	5.8
CL2-SLAG-30	0.40	752 lb.	116.6	115.5	110.1	5.5
CL2-OPC-31	0.30	800 lb.	120.6	123.4	118.6	4.8
CL2-SF-32	0.30	800 lb.	121.9	123.2	117.8	5.4
CL2-SLAG-33	0.30	800 lb.	121.9	121.3	116.5	4.8
SH3-OPC-34	0.40	752 lb.	123.2	121.3	114.4	6.8
SH3-FA-35	0.40	752 lb.	123.2	121.9	115.2	6.7
SH3-SLAG-36	0.40	752 lb.	121.9	119.4	112.6	6.8
SH3-OPC-37	0.30	800 lb.	125.9	126.2	120.6	5.6

SH3-FA-38	0.30	800 lb.	127.2	130.0	124.9	5.1
SH3-SLAG-39	0.30	800 lb.	127.2	126.7	121.7	5.0
SH3-SF-40	0.30	800 lb.	128.5	127.6	122.1	5.5
CL2-FA-41	0.30	800 lb.	120.6	122.6	117.8	4.8
CL2-OPC-42	0.30	800 lb.	124.6	122.2	116.7	5.5
CL2-SF-43	0.30	800 lb.	123.2	122.1	116.5	5.6
CL2-SLAG-44	0.30	800 lb.	120.6	121.6	116.4	5.1
SH3-OPC-45	0.30	800 lb.	124.5	123.4	117.0	6.4
SH3-FA-46	0.30	800 lb.	125.8	125.3	119.5	5.8
SH3-SLAG-47	0.30	800 lb.	121.9	121.1	115.3	5.8
SH3-SF-48	0.30	800 lb.	124.6	122.7	116.7	6.0
SH3-FA-49	0.30	800 lb.	120.6	121.9	116.4	5.5
CL2-FA-50	0.30	800 lb.	124.6	124.9	119.6	5.3
CL2-OPC-51	0.40	752 lb.	121.9	120.8	113.6	7.2
CL2-FA-52	0.40	752 lb.	120.6	120.2	113.3	7.0
CL2-SLAG-53	0.40	752 lb.	-	120.9	113.8	7.1
SH1-OPC-54	0.40	752 lb.	119.3	0.0	107.5	-107.5
SH1-FA-55	0.40	752 lb.	121.9	0.0	109.9	-109.9
SH1-SLAG-56	0.40	752 lb.	121.9	119.8	110.8	9.0
SH2-OPC-57	0.40	752 lb.	121.9	118.7	112.8	5.9
SH2-FA-58	0.40	752 lb.	120.5	121.8	116.1	5.6
SH2-SLAG-59	0.40	752 lb.	121.9	123.7	118.3	5.4
SL1-OPC-60	0.40	752 lb.	120.6	120.5	114.9	5.6
SL1-FA-61	0.40	752 lb.	120.6	119.0	113.9	5.1
SL1-SLAG-62	0.40	752 lb.	117.9	120.3	115.2	5.1
CL1-OPC-63	0.40	752 lb.	119.3	0.0	109.7	-109.7
CL1-FA-64	0.40	752 lb.	119.3	0.0	109.4	-109.4
CL1-SLAG-65	0.40	752 lb.	121.9	120.9	113.0	7.9
SL1-OPC-66	0.30	800 lb.	122.2	124.4	120.0	4.4
SL1-FA-67	0.30	800 lb.	-	122.5	118.9	3.6
CL1-OPC-68	0.30	800 lb.	124.6	122.6	116.0	6.6
CL1-FA-69	0.30	800 lb.	125.9	123.8	117.4	6.3
CL1-SF-70	0.30	800 lb.	121.9	119.0	111.3	7.6
SL1-SLAG-71	0.25	900 lb.	123.2	125.1	121.9	3.1
CL1-OPC-72	0.30	800 lb.	124.6	122.2	115.3	6.9
CL1-FA-73	0.30	800 lb.	123.2	119.6	113.2	6.4
SL1-FA-74	0.30	800 lb.	124.6	123.4	119.6	3.9
CL1-SLAG-75	0.30	800 lb.	123.2	121.2	114.5	6.8
CL1-SLAG-76	0.30	800 lb.	124.6	122.1	115.5	6.6
CL1-SF-77	0.30	800 lb.	123.2	121.7	114.6	7.1

SH1-OPC-78	0.30	800 lb.	125.9	0.0	113.9	-113.9
SH1-FA-79	0.30	800 lb.	124.6	0.0	112.5	-112.5
SH1-SLAG-80	0.30	800 lb.	121.9	119.7	112.0	7.8
SL1-FA-81	0.30	900 lb.	123.2	122.6	118.8	3.8
SL1-SLAG-82	0.30	900 lb.	123.2	121.4	117.9	3.5
SH2-OPC-83	0.30	800 lb.	124.6	122.1	117.7	4.4
SH2-FA-84	0.30	800 lb.	124.6	125.6	121.7	3.9
SH2-SLAG-85	0.30	800 lb.	124.6	123.7	120.2	3.5
SH2-SF-86	0.30	800 lb.	125.9	126.5	122.2	4.3
SH2-FA-87	0.30	800 lb.	123.2	123.2	119.3	3.9
SH1-OPC-88	0.30	800 lb.	123.2	119.4	111.8	7.7
SH1-FA-89	0.30	800 lb.	124.6	119.6	112.7	6.9
SH1-SLAG-90	0.30	800 lb.	123.2	120.0	112.5	7.5
SH1-SF-91	0.30	800 lb.	123.2	119.7	111.5	8.2
SH1-SF-92	0.30	800 lb.	121.9	118.1	110.9	7.2
SH2-OPC-93	0.30	800 lb.	124.6	122.3	117.5	4.8
SH2-SF-94	0.30	800 lb.	124.6	124.0	119.3	4.7
SH2-SLAG-95	0.30	800 lb.	124.6	123.0	119.0	4.1

## Relationships among Fresh and Hardened Properties

The following figures investigate potential relationships between series of measured properties.

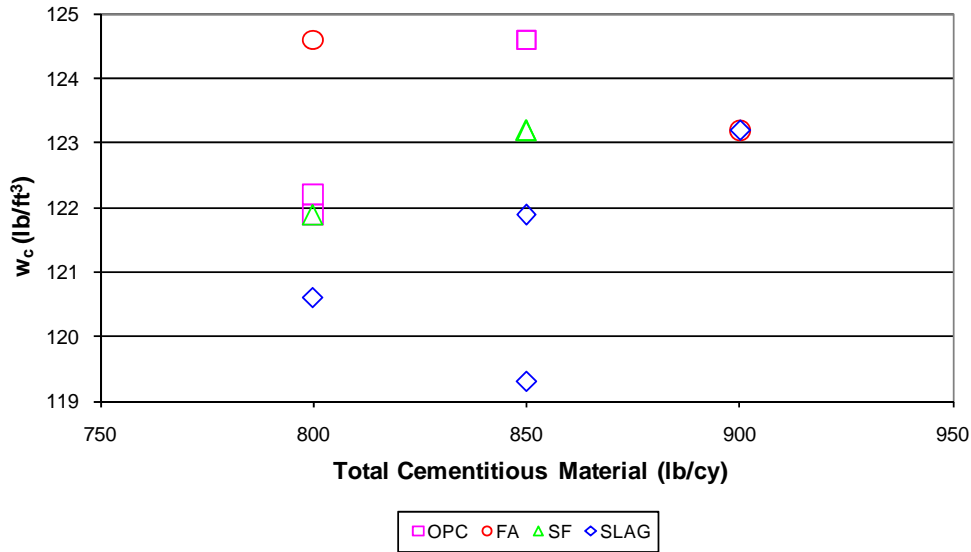


Figure F-43 TCM Effect on Fresh Unit Weight

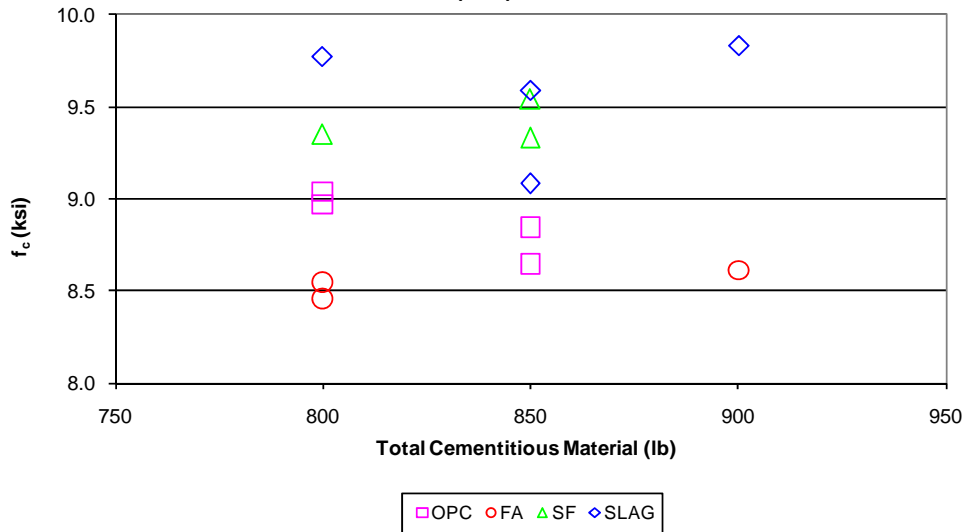


Figure F-44 TCM Effect on Compressive Strength at 28 days

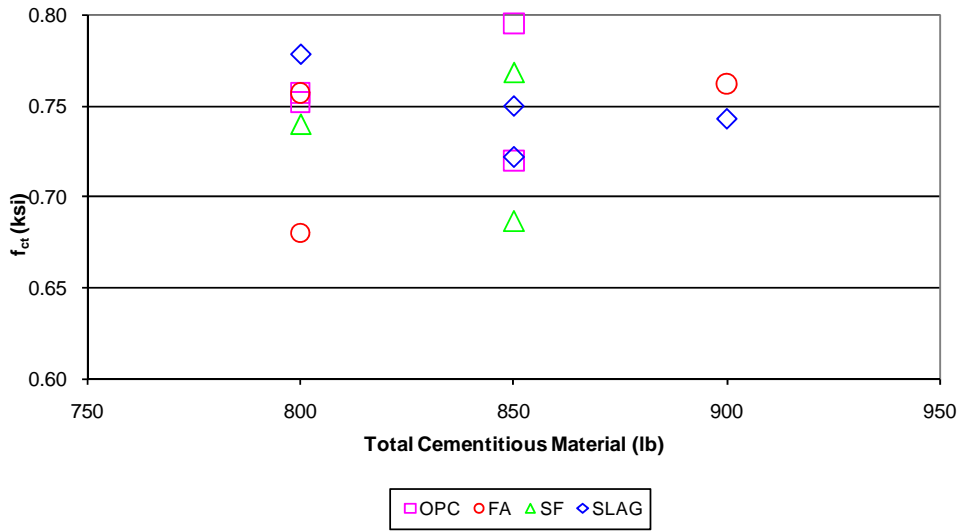


Figure F-45 TCM Effect on Splitting Tensile Strength at 28 days

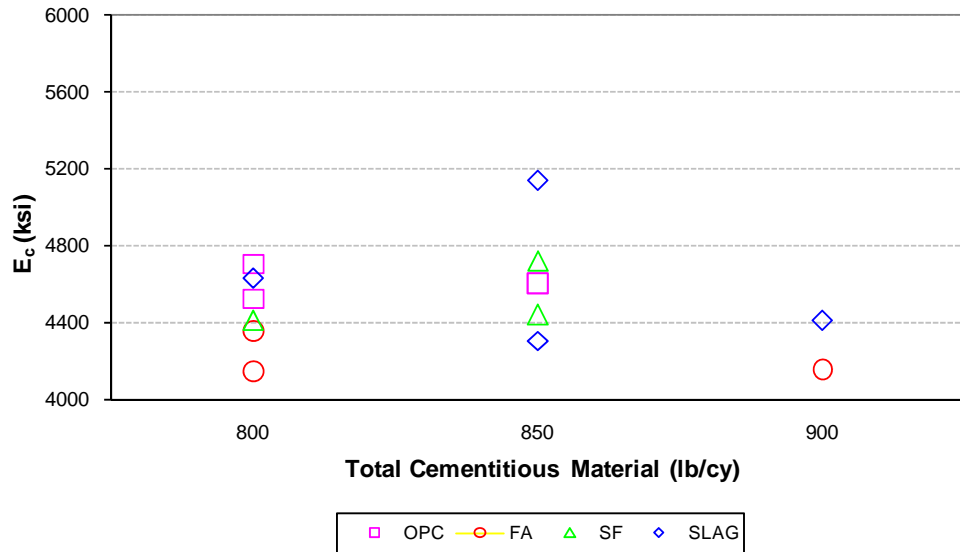


Figure F-46 TCM Effect on Modulus of Elasticity at 28 days

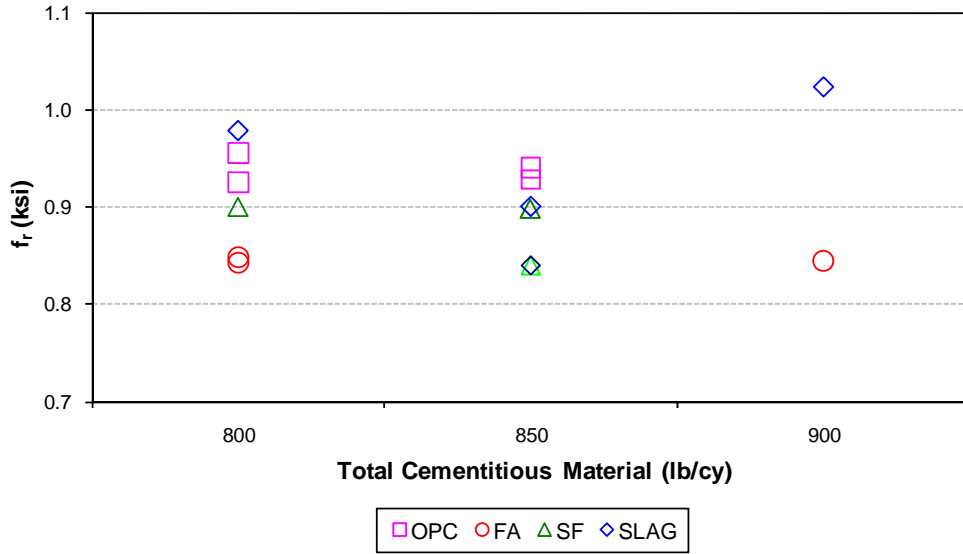


Figure F-47 TCM Effect on Modulus of Rupture at 28 days

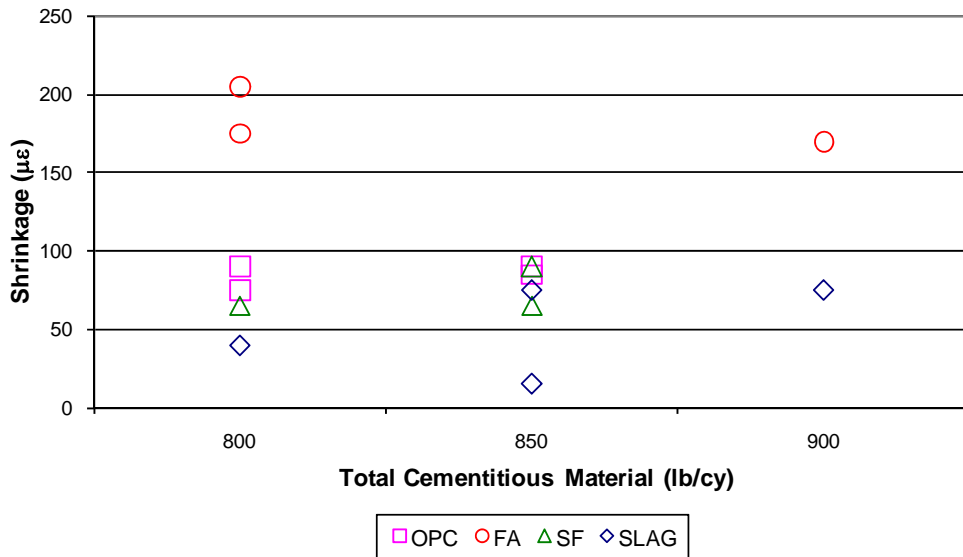


Figure F-48 TCM Effect on Shrinkage after 28 days wet cure and 28 days air-drying

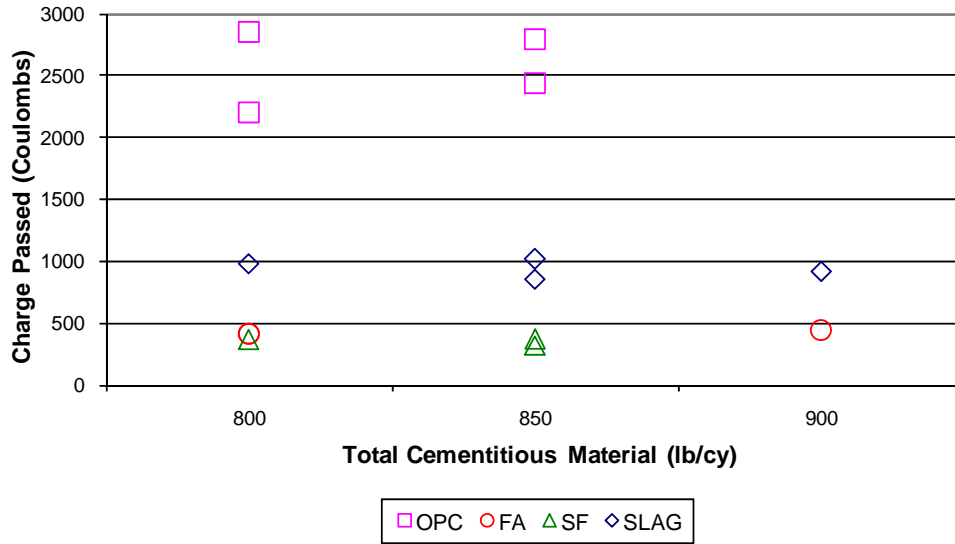


Figure F-49 TCM Effect on Permeability at 28 days

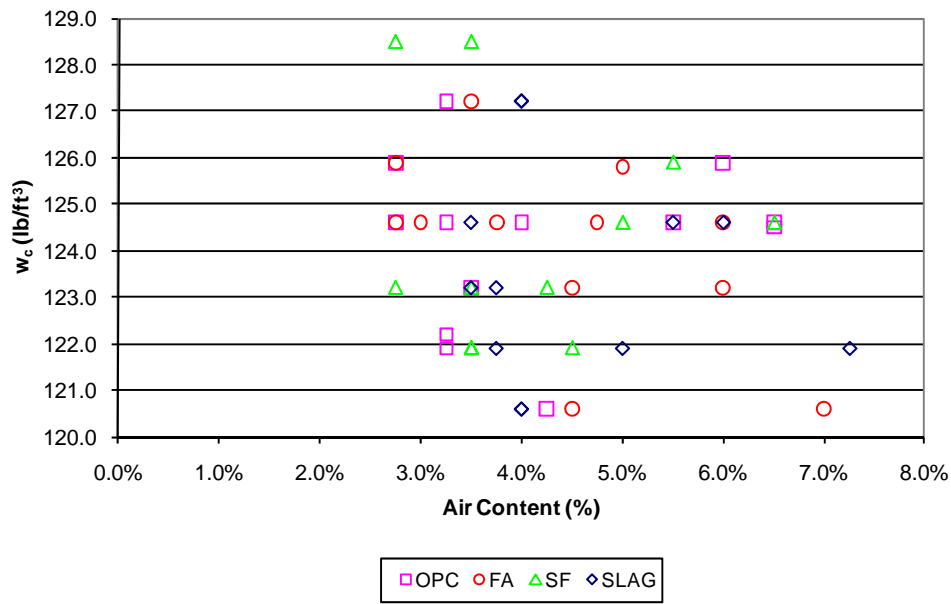


Figure F-50 Relationship of Fresh Unit Weight to Air Content



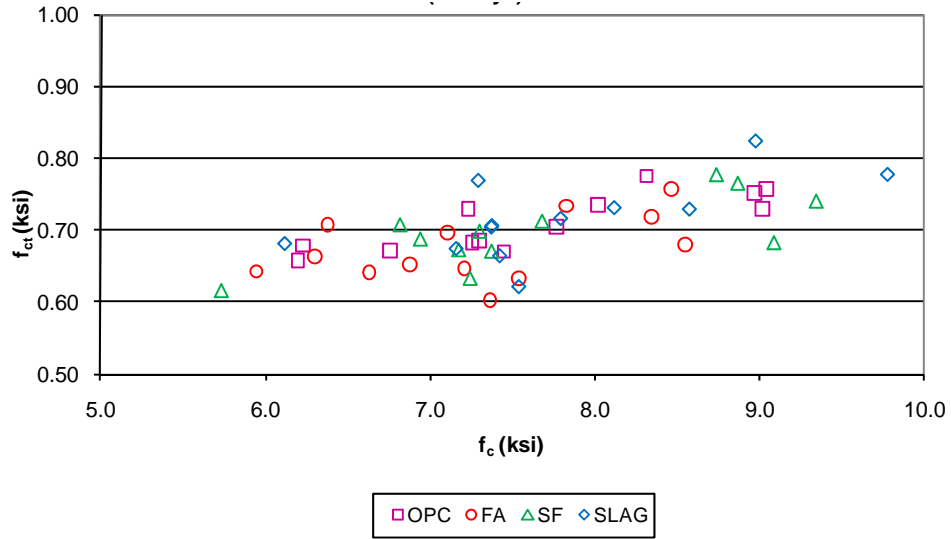


Figure F-51 Relationship of Splitting Tensile Strength to Compressive Strength

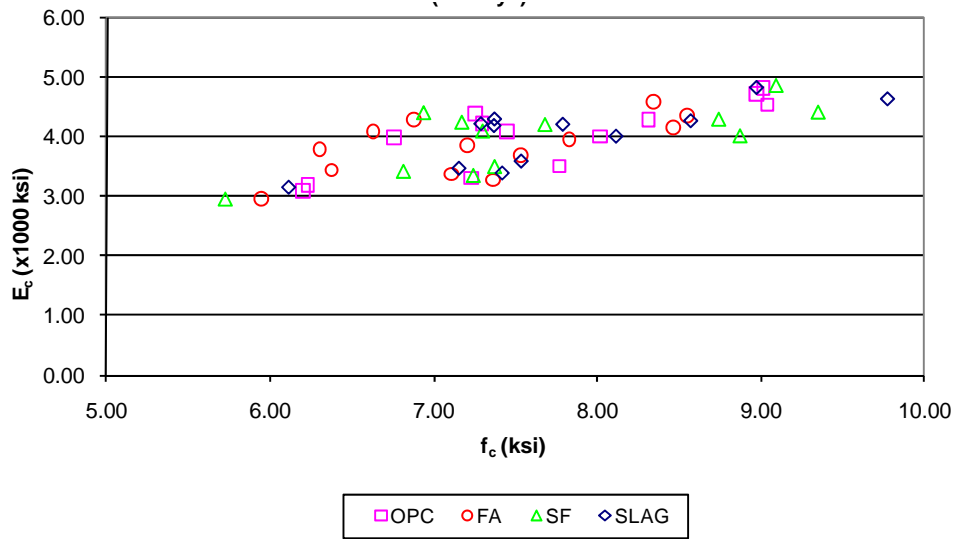
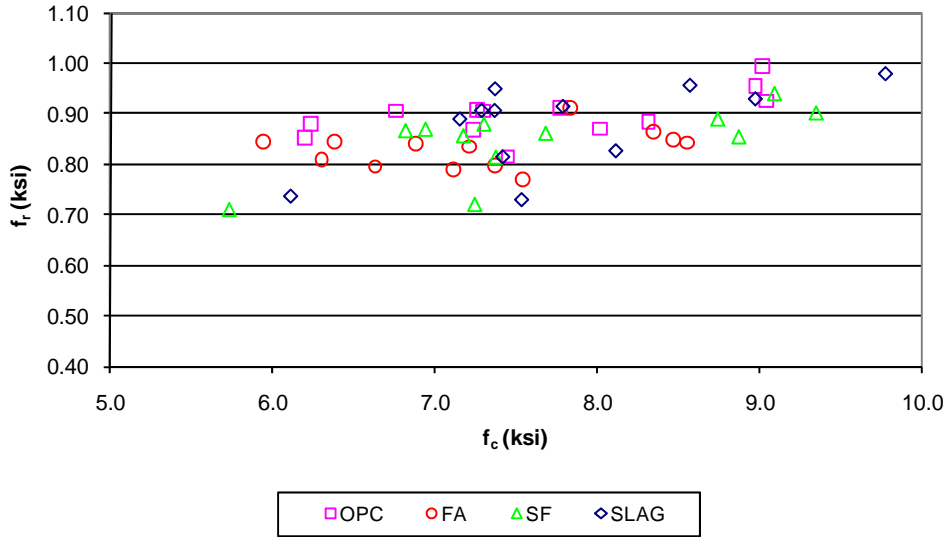
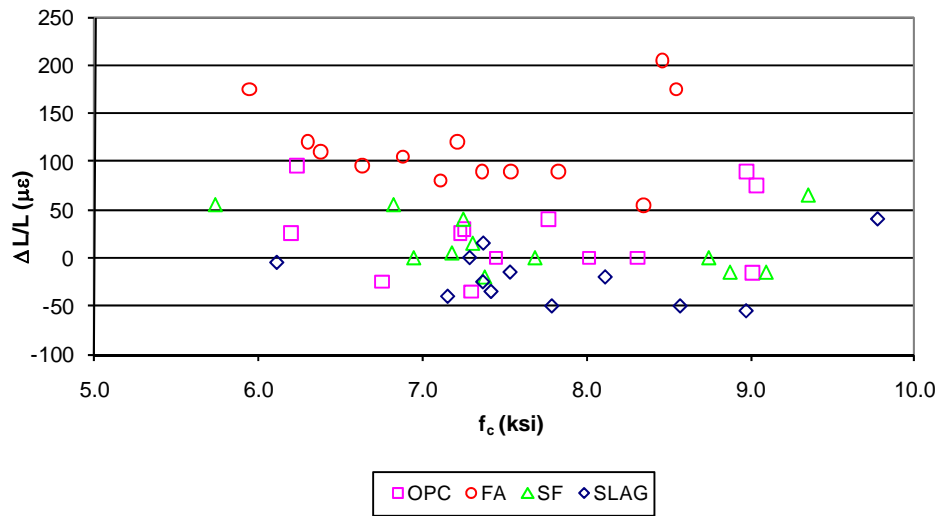


Figure F-52 Relationship of Modulus of Elasticity to Compressive Strength



**Figure F-53 Relationship of 28-day Modulus of Rupture to Compressive Strength**



**Figure F-54 Relationship of Length Change to Compressive Strength**

### Time-Dependent properties of Full-Scale Testing Mixtures

The following plots present shrinkage and creep deformations of the production mixtures used in large and full-scale structural tests over time.

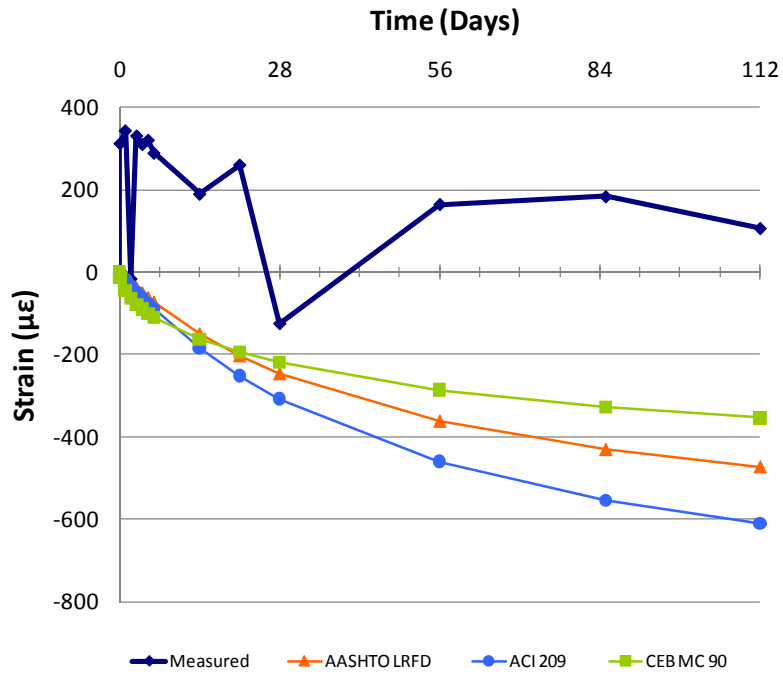


Figure F-55 Shrinkage strain versus models for NWHPC1 (PCBT-45)

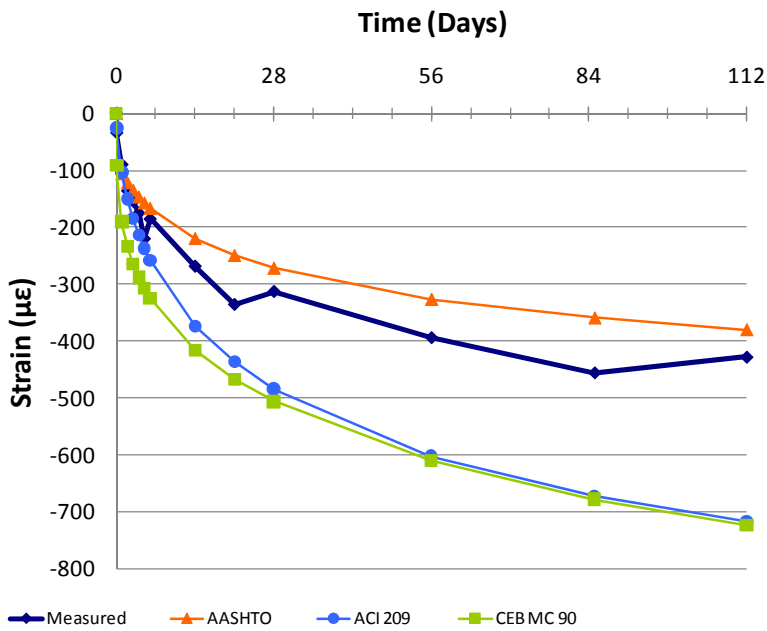


Figure F-56 Creep strain versus models for NWHPC1 (PCBT-45)

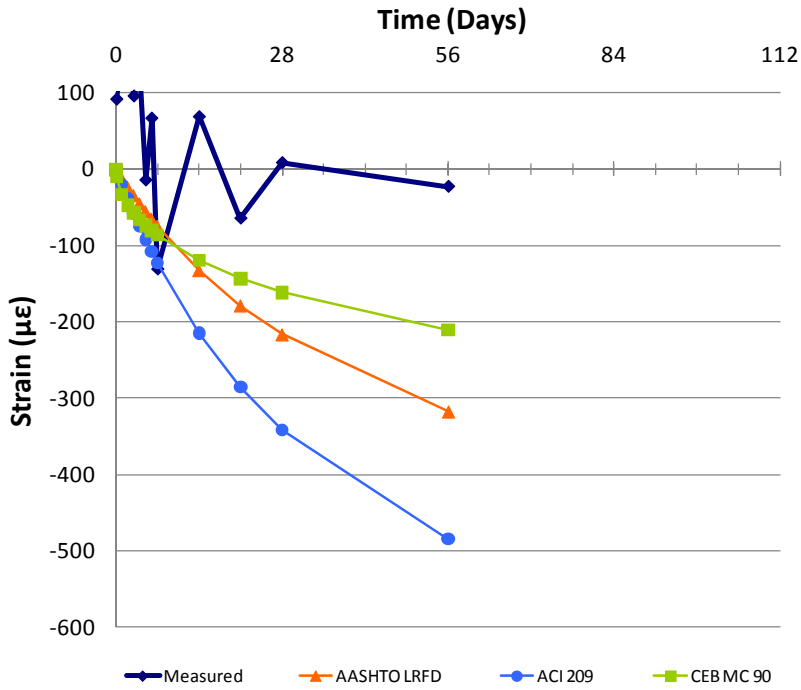


Figure F-57 Shrinkage strain versus models for NWHPC1 (Lab-cast beams)

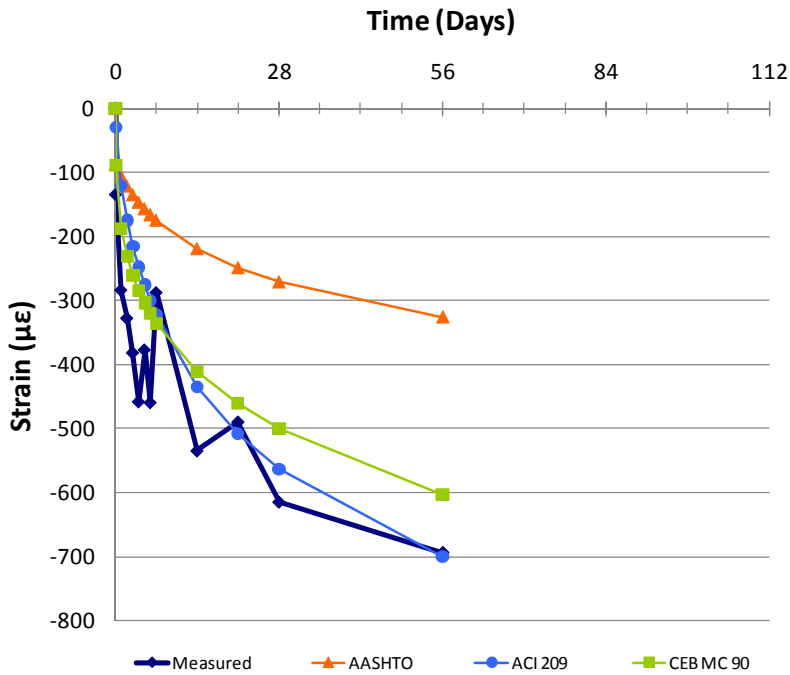


Figure F-58 Creep strain versus models for NWHPC1 (Lab-cast beams)

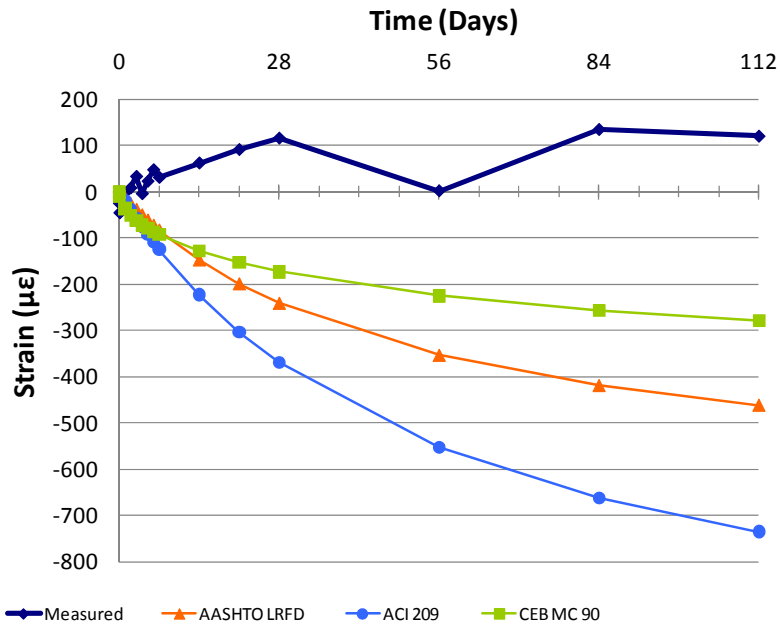


Figure F-59 Shrinkage strain versus models for LWHPC1 (AASHTO-II)

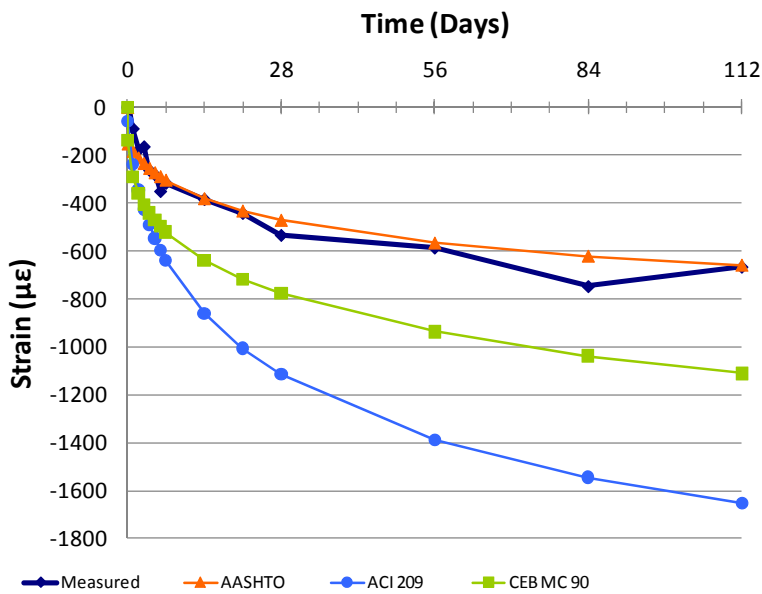


Figure F-60 Creep strain versus models for LWHPC1 (AASHTO-II)

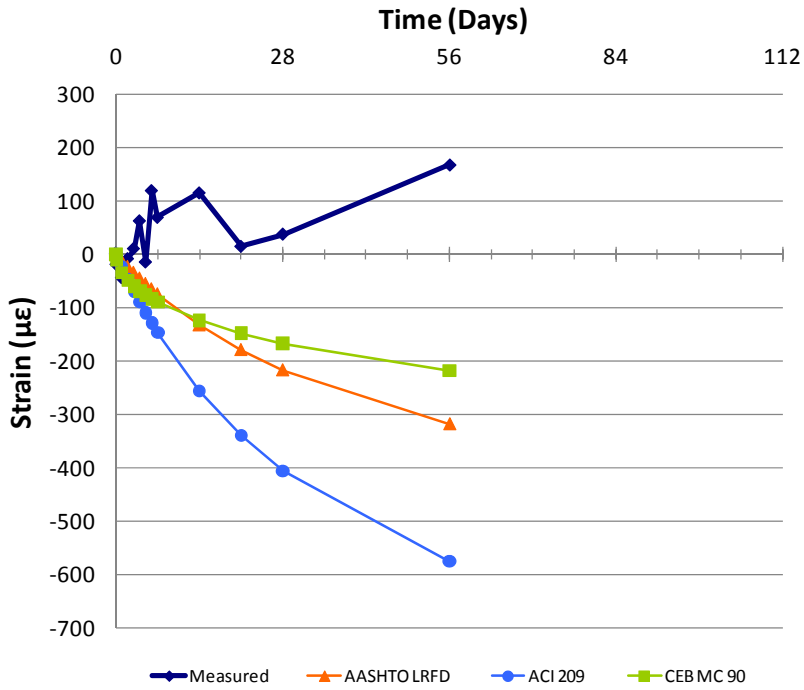


Figure F-61 Shrinkage strain versus models for LWHPC2 (Lab-cast beams)

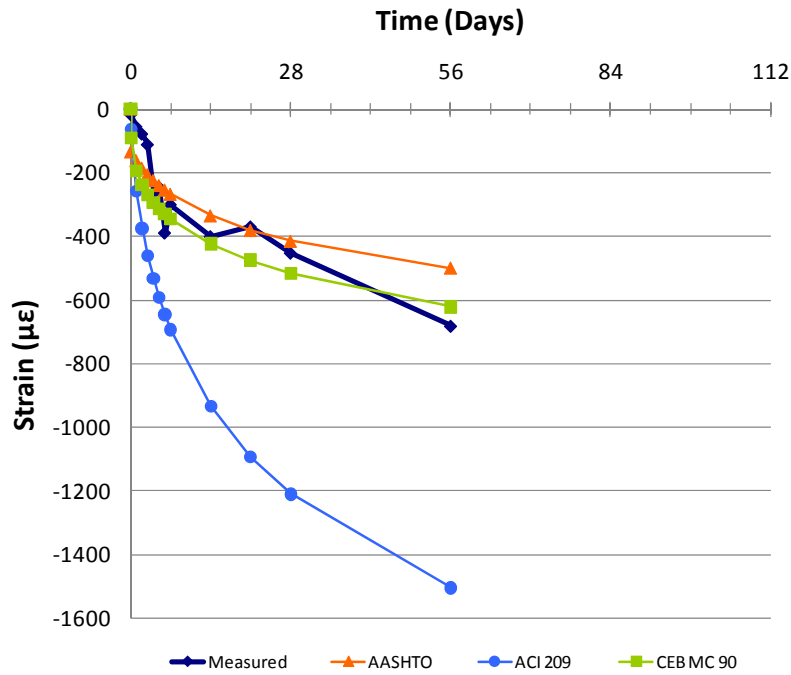


Figure F-62 Creep strain versus models for LWHPC2 (Lab-cast beams)

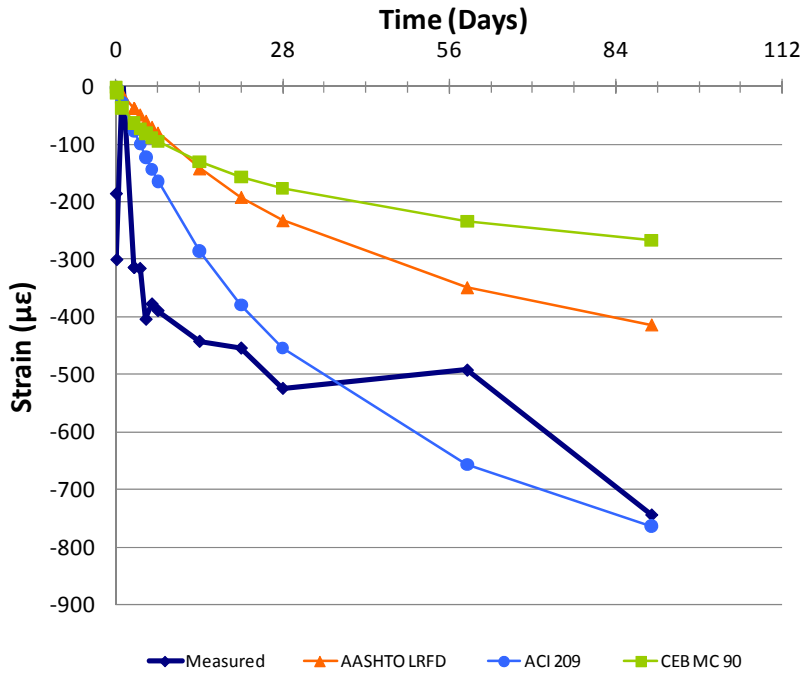


Figure F-63 Shrinkage strain versus models for LWHPC3 (Lab-cast beams)

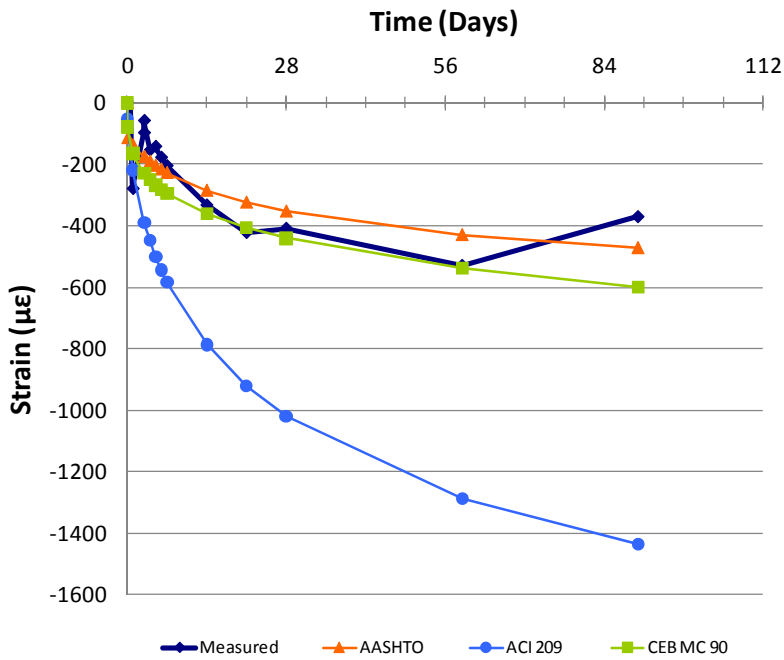


Figure F-64 Creep strain versus models for LWHPC3 (Lab-cast beams)

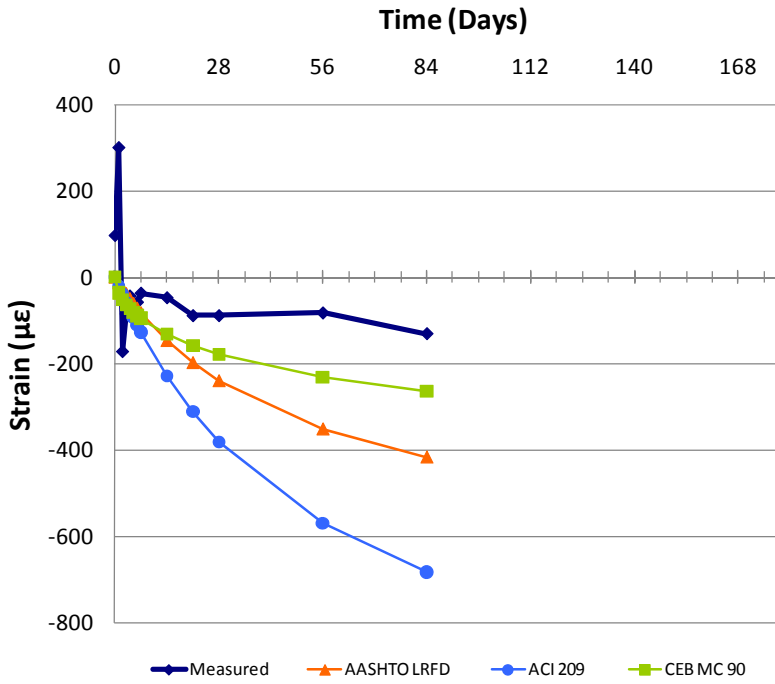


Figure F-65 Shrinkage strain versus models for LWHPC3 (PCBT-45)

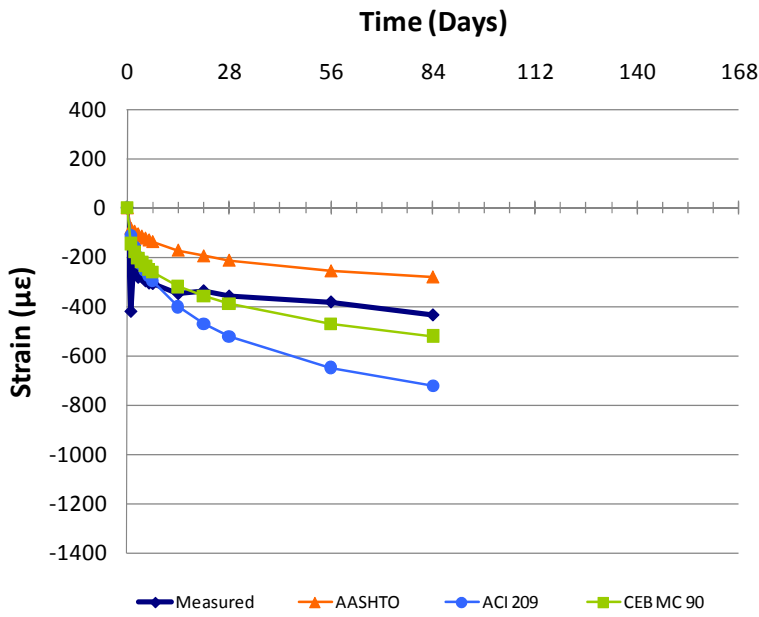


Figure F-66 Creep strain versus models for LWHPC3 (PCBT-45)



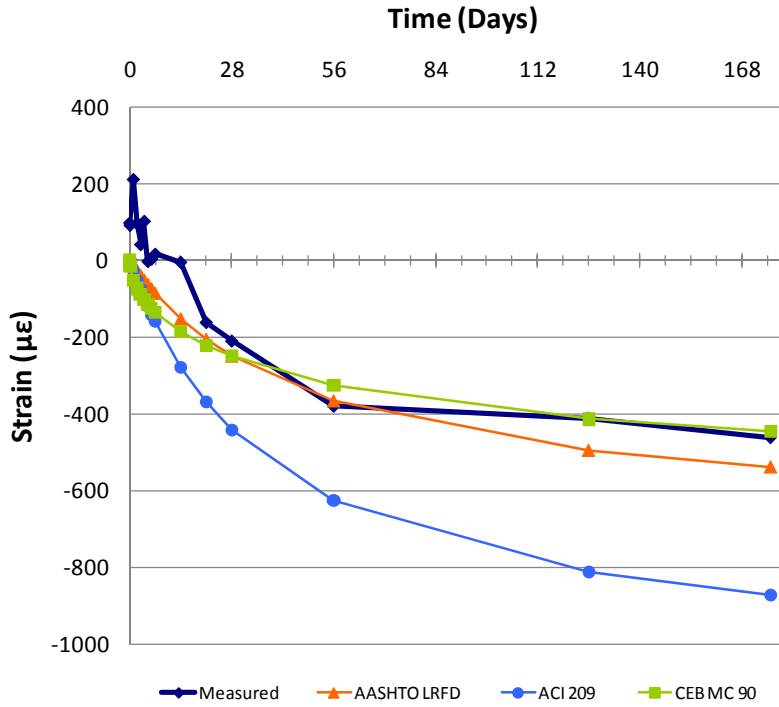


Figure F-67 Shrinkage strain versus models for LWHPC4 (Deck 10/1/09)

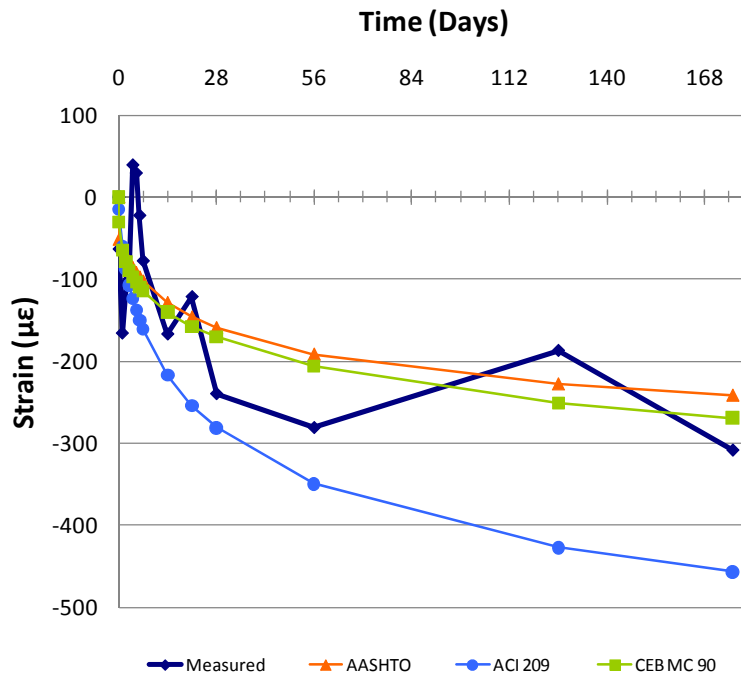


Figure F-68 Creep strain versus models for LWHPC4 (Deck 10/1/09)

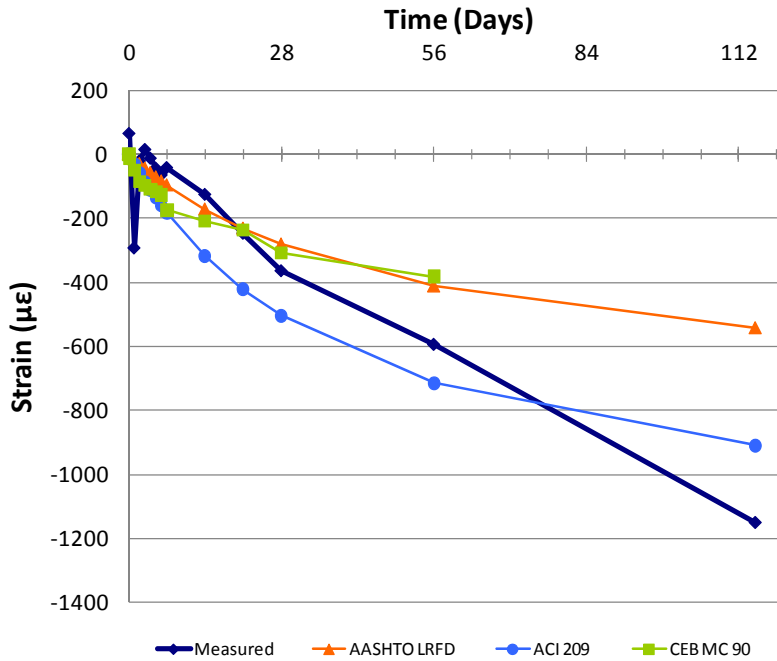


Figure F-67 Shrinkage strain versus models for LWHPC4 (Deck 1/15/10)

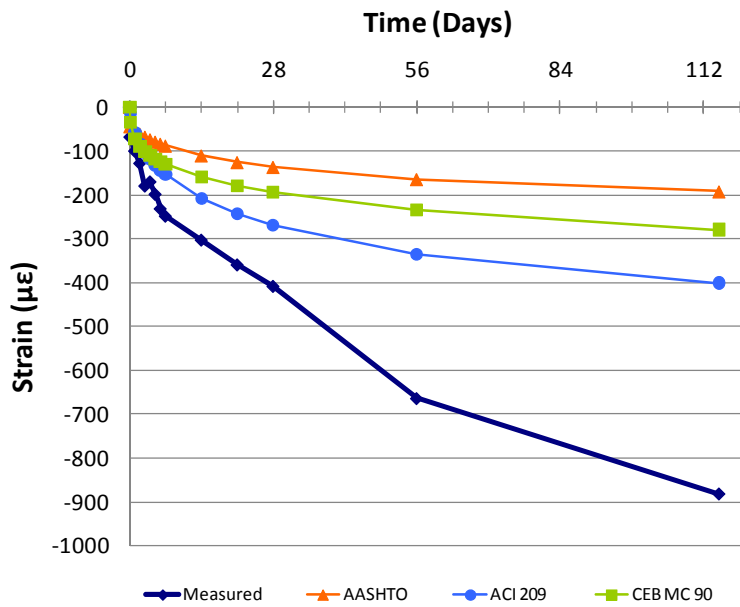


Figure F-68 Creep strain versus models for LWHPC4 (Deck 1/15/10)

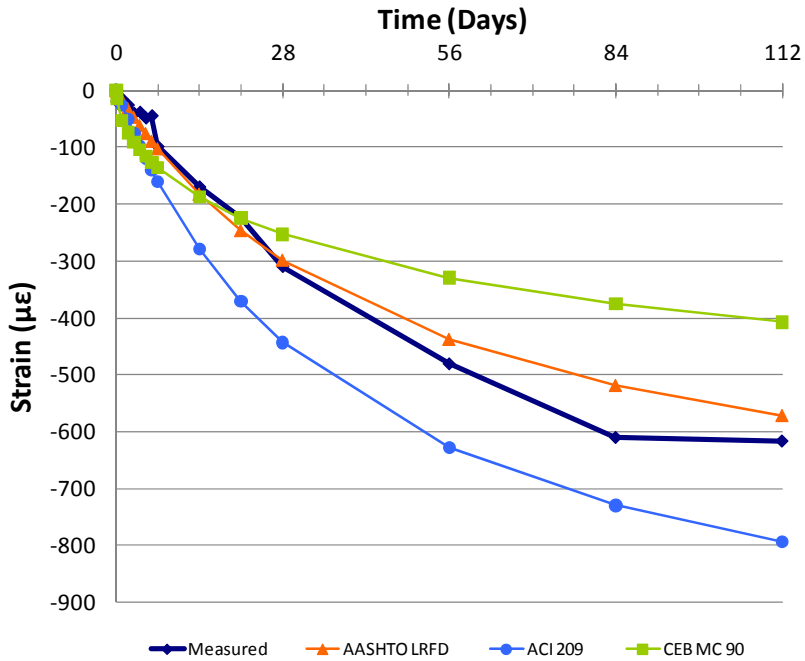


Figure F-67 Shrinkage strain versus models for LWHPC4 (Deck 1/28/10)

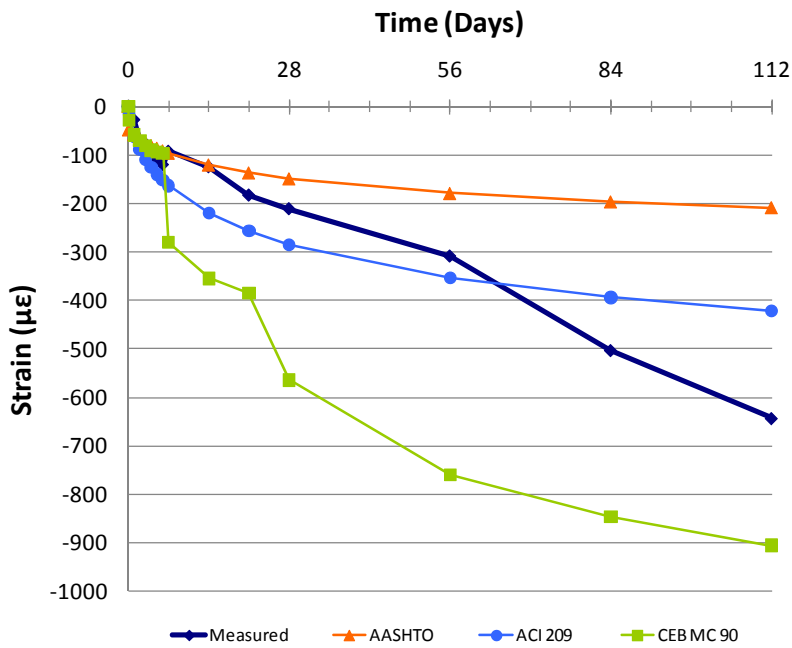


Figure F-68 Creep strain versus models for LWHPC4 (Deck 1/28/10)

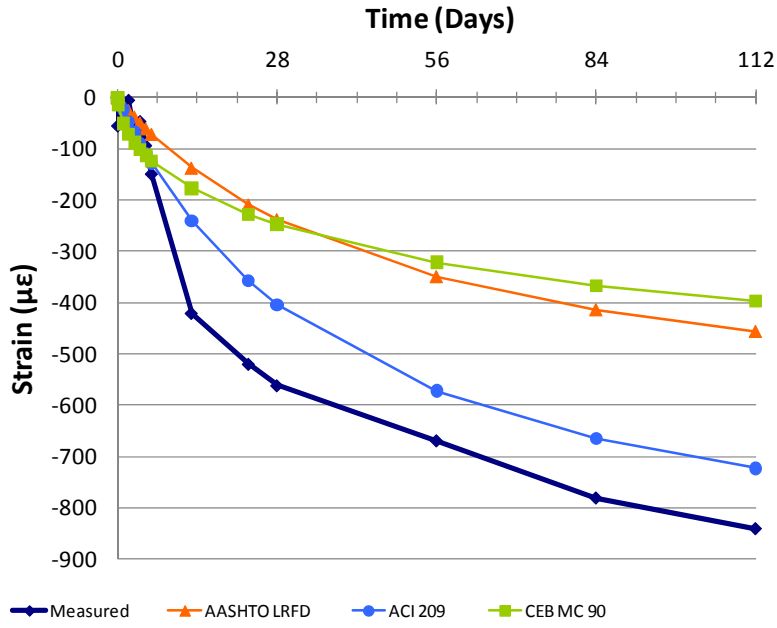


Figure F-67 Shrinkage strain versus models for LWHPC4 (Deck 5/11/10)

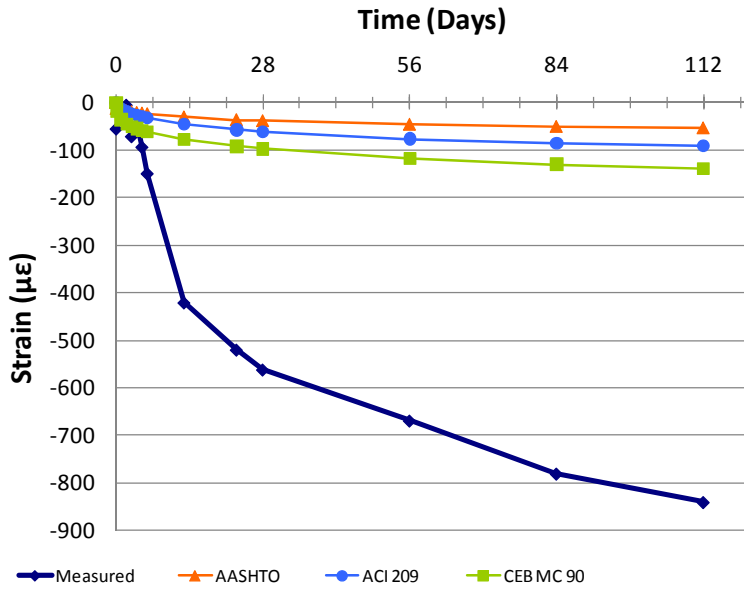


Figure F-68 Creep strain versus models for LWHPC4 (Deck 5/11/10)

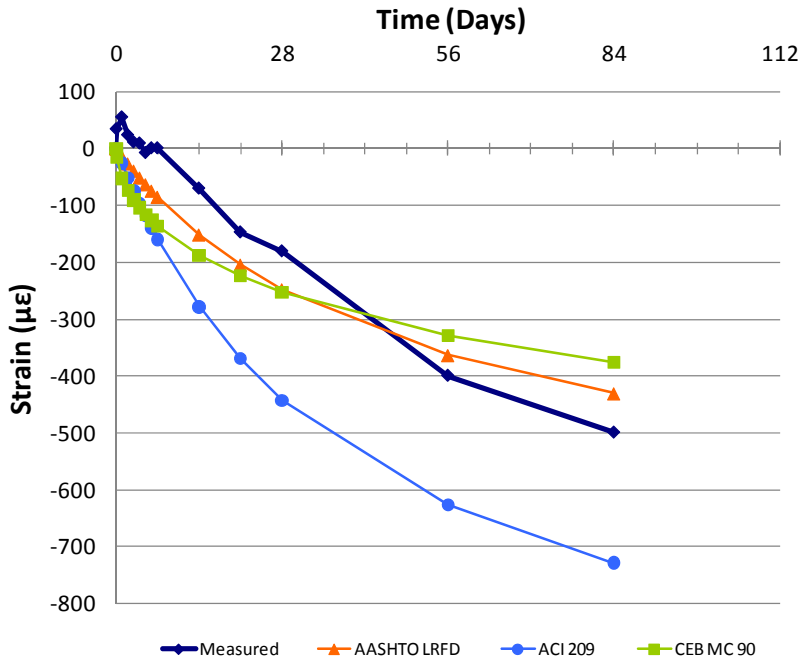


Figure F-67 Shrinkage strain versus models for LWHPC4 (Deck 7/15/10)

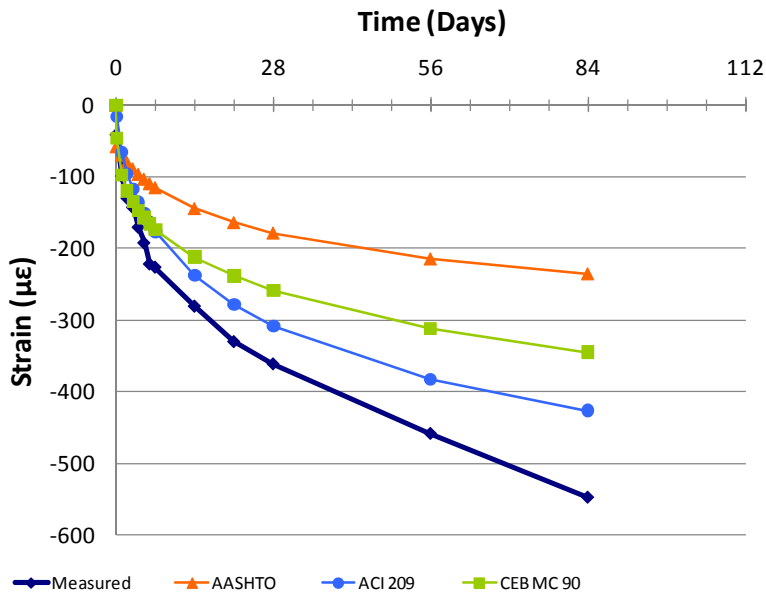


Figure F-68 Creep strain versus models for LWHPC4 (Deck 7/15/10)