TABLE 6—PROPERTIES OF FRESH CONCRETE FOR BEAM SHEAR TESTS

Mixture	No. of Batches	No. of Specimens	Slump in. (mm)	Unit Weight lbs/cu ft (kgs/cu m)	Air Content %
LWC1	3	27	5.6 (142)	116.6 (1868)	4.8
LWC2	3	27	5.1 (130)	112.4 (1801)	5.8
HSLWC	3	27	5.1 (130)	128.4 (2057)	4.4

Note: Nine 6 by 12 in. (150 by 300 mm) cylinders were made from each batch. One batch was used to cast each shear beam test specimen.

TABLE 8—PROPERTIES OF FRESH CONCRETE FOR SHEAR FRICTION TEST SPECIMENS

Mixture	Batch No.	Slump in.	Slump (mm)	Air Content %	Unit Weight lbs/cu ft	Unit Weight (kgs/cu m)
LWC1	1	5.9	(150)	4.6	115.2	(1846)
	2	5.3	(135)	5.4	115.6	(1852)
	3	5.9	(150)	5.0	115.6	(1852)
	Avg.	5.7	(145)	5.0	115.5	(1850)
LWC2	1	5.6	(142)	5.6	113.8	(1823)
	2	6.5	(165)	6.4	111.4	(1785)
	3	5.7	(145)	6.0	112.3	(1799)
	Avg.	5.9	(150)	5.0	112.5	(1802)
HSLWC	1	8.1	(206)	4.5	127.5	(2043)
	2	5.0	(127)	4.5	128.7	(2062)
	3	8.3	(211)	4.2	127.7	(2046)
	Avg.	7.1	(180)	4.3	128.0	(2051)

TABLE 7—SUMMARY OF BEAM SHEAR TEST RESULTS

Mixture	Spec. No.	28-day Moist Cured Compressive Strength, f'c psi	(MPa)	Compressive Strength at Test, fc, psi	(MPa)	Splitting Tensile Strength, fct, psi	(MPa)	Vcr* psi	(MPa)	Vcr / √f'c	Vu** psi	(MPa)	Vu / √fc
LWC1	1	8300	(57.2)	8750	(60.3)	480	(3.3)	230	(1.6)	2.5	520	(3.6)	5.6
	2	8240	(56.8)	8700	(60.0)	420	(2.9)	240	(1.7)	2.6	530	(3.7)	5.7
	3	8160	(56.3)	8290	(57.2)	420	(2.9)	210	(1.4)	2.3	280	(1.9)	3.1
LWC2	1	8340	(57.5)	8800	(60.7)	440	(3.0)	230	(1.6)	2.5	530	(3.7)	5.6
	2	8730	(60.2)	8720	(60.1)	410	(2.8)	230	(1.6)	2.5	520	(3.6)	5.6
	3	9280	(64.0)	9440	(65.1)	420	(2.9)	210	(1.4)	2.2	430	(3.0)	4.4
HSLWC	1	10910	(75.2)	10980	(75.7)	540	(3.7)	240	(1.7)	2.2	520	(3.6)	5.0
	2	11110	(76.6)	10360	(71.4)	550	(3.8)	250	(1.7)	2.5	400	(2.8)	3.9
	3	10740	(74.1)	11120	(76.7)	440	(3.0)	280	(1.9)	2.6	700	(4.8)	6.6

* Vcr = nominal average shear stress at inclined cracking at each end of beam.
= Pcr/2bd, where Pcr = total load on beam at occurrence inclined cracking; b = 6 in. (152 mm); d = 10 in. (254 mm).

** Vu = nominal shear stress at maximum load.
= Pu/2bd, where Pu = total maximum load on beam; b = 6 in. (152 mm); d = 10 in. (254 mm).

TABLE 9—PROPERTIES OF HARDENED CONCRETE FOR SHEAR FRICTION TEST SPECIMENS

Mixture	Batch No.	Shear Friction Specimen No.	Compressive Strength 28-days Age* psi (MPa)	Compressive Strength At Test** psi (MPa)	Splitting Tensile Strength At Test** psi (MPa)
LWC1	1	1 and 4	8120 (56.0)	8490 (58.5)	--- (----)
	2	2 and 5	8410 (58.0)	8510 (58.7)	--- (----)
	3	3 and 6	8300 (57.2)	8290 (57.2)	--- (----)
	Avg.		8270 (57.0)	8430 (58.1)	--- (----)
LWC2	1	1 and 4	9110 (62.8)	9270 (63.9)	420 (2.90)
	2	2 and 5	8610 (59.4)	8760 (60.4)	400 (2.76)
	3	3 and 6	8530 (58.8)	8730 (60.2)	370 (2.55)
	Avg.		8750 (60.3)	8920 (61.5)	400 (2.76)
HSLWC	1	1 and 4	10750 (74.1)	10310 (71.1)	490 (3.38)
	2	2 and 5	10940 (75.4)	10910 (75.2)	530 (3.65)
	3	3 and 6	10620 (73.2)	11020 (76.0)	500 (3.45)
	Avg.		10770 (74.3)	10750 (74.1)	510 (3.52)

* Moist cured.

** Moist cured for 14-days, then cured in air until tested. Shear Friction tests of Specimens 3 and 6 of both LWC1 and LWC2 were tested at 28-days age. All other specimens were tested at 29-days age.

TABLE 10—SUMMARY OF SHEAR FRICTION TEST RESULTS

Mixture	Specimen Number	A_{vf} sq in.	A_{vf} (sq mm)	f_y* ksi	f_y* (MPa)	ρf_y psi	ρf_y (MPa)	Average Initial Crack Width in.	Average Initial Crack Width (mm)	Maximum Stress Vu** psi	Maximum Stress Vu** (MPa)	$Vu/\rho fy$	μ***
LWC1	1	0.44	(284)	53.6	(370)	281	(1.94)	0.010	(0.25)	287	(1.98)	1.02	1.19
	2	0.44	(284)	53.6	(370)	281	(1.94)	0.013	(0.33)	365	(2.52)	1.30	1.19
	3	0.44	(284)	53.6	(370)	281	(1.94)	0.011	(0.28)	413	(2.85)	1.47	1.19
	4	0.80	(516)	68.0	(469)	648	(4.47)	0.010	(0.25)	761	(5.25)	1.17	1.19
	5	0.80	(516)	69.0	(476)	657	(4.53)	0.012	(0.30)	680	(4.69)	1.04	1.19
	6	0.80	(516)	68.0	(469)	648	(4.47)	0.012	(0.30)	727	(5.01)	1.12	1.19
LWC2	1	0.44	(284)	53.6	(370)	280	(1.93)	0.008	(0.20)	489	(3.37)	1.75	1.19
	2	0.44	(284)	53.6	(370)	280	(1.93)	0.011	(0.28)	335	(2.31)	1.20	1.19
	3	0.44	(284)	53.6	(370)	280	(1.93)	0.010	(0.25)	299	(2.06)	1.07	1.19
	4	0.80	(516)	68.0	(469)	648	(4.47)	0.010	(0.25)	739	(5.10)	1.14	1.19
	5	0.80	(516)	68.5	(472)	652	(4.50)	0.010	(0.25)	692	(4.77)	1.06	1.19
	6	0.80	(516)	68.5	(472)	652	(4.50)	0.011	(0.28)	680	(4.69)	1.14	1.19
HSLWC	1	0.44	(284)	72.1	(497)	378	(2.61)	0.009	(0.23)	668	(4.61)	1.77	1.19
	2	0.44	(284)	72.1	(497)	378	(2.61)	0.008	(0.20)	548	(3.78)	1.45	1.19
	3	0.44	(284)	72.1	(497)	378	(2.61)	0.010	(0.25)	585	(4.03)	1.55	1.19
	4	0.80	(516)	66.8	(461)	636	(4.39)	0.010	(0.25)	870	(6.00)	1.37	1.19
	5	0.80	(516)	66.8	(461)	636	(4.39)	0.011	(0.28)	870	(6.00)	1.37	1.19
	6	0.80	(516)	66.8	(461)	636	(4.39)	0.009	(0.23)	894	(6.16)	1.41	1.19

* Yield stress of transverse reinforcement as determined by test.
** Based on maximum measured load prior to rapid increases in slip.
*** ACI 318-89 for sanded lightweight concrete where $\mu = 1.4\lambda$ and $\lambda = 0.85$.

TABLE 11—PROPERTIES OF FRESH CONCRETE FOR BEARING TEST SPECIMENS

Mixture	Batch No.	Slump in.	Slump (mm)	Air Content %	Unit Weight lbs/cu ft	Unit Weight (kgs/cu m)
LWC1	1	5.8	(147)	6.0	114.6	(1838)
	2	5.0	(127)	5.3	116.7	(1870)
	3	5.4	(137)	5.6	115.6	(1852)
	4	5.5	(140)	5.7	115.5	(1850)
	Avg.	5.4	(137)	5.6	115.6	(1852)
LWC2	1	5.8	(147)	5.4	115.5	(1850)
	2	5.9	(150)	5.1	116.0	(1858)
	3	5.9	(150)	5.6	116.5	(1866)
	4	5.3	(135)	5.7	115.6	(1852)
	Avg.	5.7	(145)	5.4	115.9	(1857)

TABLE 13—PROPERTIES OF CONCRETE FOR REINFORCING BAR DEVELOPMENT LENGTH TESTS

	Unhardened Concrete			Compressive Strength	
Mixture	Slump in. (mm)	Air Content %	Unit Weight lbs/cu ft (kgs/cu m)	28 Days psi* (MPa)	At Test psi** (MPa)
LWC1	5.4 (137)	5.2	117.3 (1879)	8970 (61.8)	8900 (61.4)
LWC2	5.8 (147)	5.1	114.8 (1839)	9020 (62.2)	9320 (64.3)

* 28 days moist cured.
** 14 days moist cured followed by curing in air until tested.

TABLE 12—SUMMARY OF BEARING TEST RESULTS

Mixture	Batch No.	Bearing Test Specimen No.	28-Day Moist Cured Compressive Strength* psi (MPa)	At Test** Age at Test days	At Test** Compressive Strength* psi (MPa)	At Test** Splitting Tensile Strength* psi (MPa)	Bearing Test Observations Load at First Cracking*** (kips) (kN)	Bearing Test Observations Maximum Load**** (kips) (kN)
LWC1	1	1	8720 (60.1)	7	8030 (55.4)	410 (2.83)	600 (2667)	774 (3443)
	2	2		7			600 (2667)	810 (3603)
	3	3	8950 (61.7)	28	8800 (60.7)	480 (3.31)	650 (2891)	852 (3790)
	4	4		28			650 (2891)	889 (3954)
LWC2	1	1	8630 (59.5)	7	7800 (53.8)	400 (2.76)	600 (2667)	780 (3469)
	2	2		7			550 (2446)	748 (3327)
	3	3	8790 (60.6)	28	8810 (60.7)	430 (2.96)	600 (2667)	828 (3683)
	4	4		28			650 (2891)	804 (3576)

* Average of three 6 by 12 in. (150 by 300 mm) cylinders.

** Specimens tested 7 days after fabrication were moist cured for the entire period. Specimens tested 28-days after fabrication were moist cured for 7-days and then cured in air for an additional 21-days.

*** First visually observed cracking.

**** Maximum measured load.

TABLE 14—FLEXURAL CONSTANTS FROM STRESS VERSUS STRAIN TESTS

Mixture	Spec. No.	Cylinder Strength* psi (MPa)	k_1k_3	k_3	$\frac{k_2}{k_1k_3}$	ε_u	k_1	k_2	Modulus of Elasticity: By Compressometer Test ksi (MPa)	Modulus of Elasticity: By Stress-Strain Curve ksi (MPa)
LWC1	1	8540 (58.9)	0.52	0.98	0.67	0.0028	0.53	0.35	3050 (21030)	3440 (23719)
	2	9300 (64.1)	0.54	0.94	0.63	0.0031	0.57	0.34	3310 (22823)	3420 (23581)
	3	9040 (62.3)	0.55	1.00	0.60	0.0030	0.55	0.33	3380 (23306)	3400 (23443)
LWC2	1	9080 (62.6)	0.55	0.97	0.60	0.0033	0.56	0.33	3360 (23168)	3100 (21375)
	2**	9150 (63.1)	--	--	--	--	--	--	3230 (22271)	-- ---
	3	9320 (64.3)	0.52	0.96	0.65	0.0033	0.54	0.34	3290 (22685)	3170 (21858)
HSLWC	1	10390 (71.6)	0.57	1.02	0.65	0.0035	0.56	0.37	3990 (27512)	3850 (26546)
	2	10700 (73.8)	0.54	0.96	0.67	0.0035	0.56	0.36	4020 (27718)	3700 (25512)
	3	10620 (73.2)	0.57	1.06	0.60	0.0026	0.54	0.34	4170 (28753)	4670 (32200)

* Average of compressive strengths measured on three 6 by 12 in. (150 by 300 mm) cylinders cured with the C-shaped test specimen.

** Specimen cracked in the test zone due to malfunctioning of the loading equipment. The results were disregarded.

TABLE 15—CALCULATION OF BOND DEVELOPMENT LENGTH

1. Basic Development Length (ACI 318-89, Section 12.2.2)

$\ell_{db} = 0.04\ A_b\ f_y / \sqrt{f'_c}$

but not less than $0.03\ d_b\ f_y / \sqrt{f'_c}$

for f_y = 60,000 psi (414 MPa)

A_b = 0.44 sq in. (284 sq mm)

d_b = 0.75 in. (19 mm)

f'_c = 7,000 psi (48 MPa)

ℓ_{db} = 12.6 in. (320 mm)

2. Modification Factor for Sanded Lightweight Concrete (ACI 318-89, Section 12.2.4.2)

ℓ_d = 1.3 x 12.6 in. (320 mm) = 16.4 in. (417 mm)

Use 16 in. (406 mm)

3. Modification for Bar Spacing (ACI 318-89, Section 12.2.3.4)

ℓ_d = 0.8 x 1.3 x 12.6 in. (320 mm) = 13.1 in. (333 mm)

Use 13 in. (330 mm) -- Meets minimum length requirement for design.

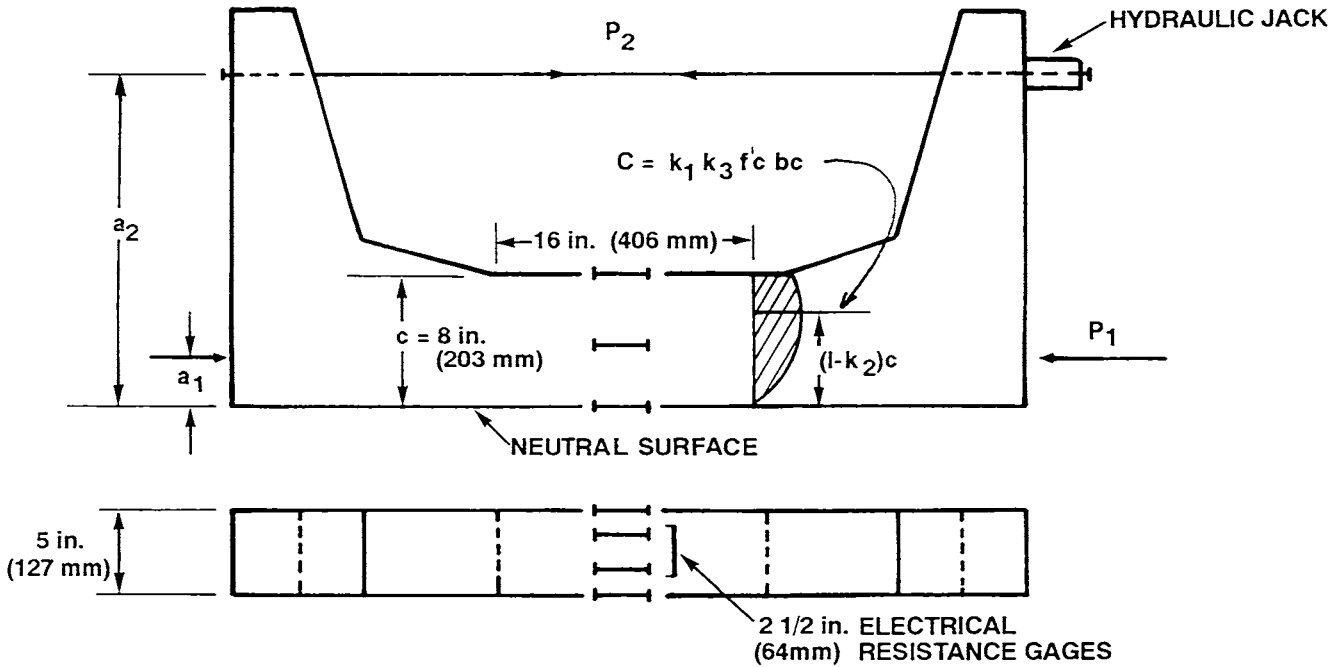

Fig. 1—C-shaped specimen for stress versus strain tests

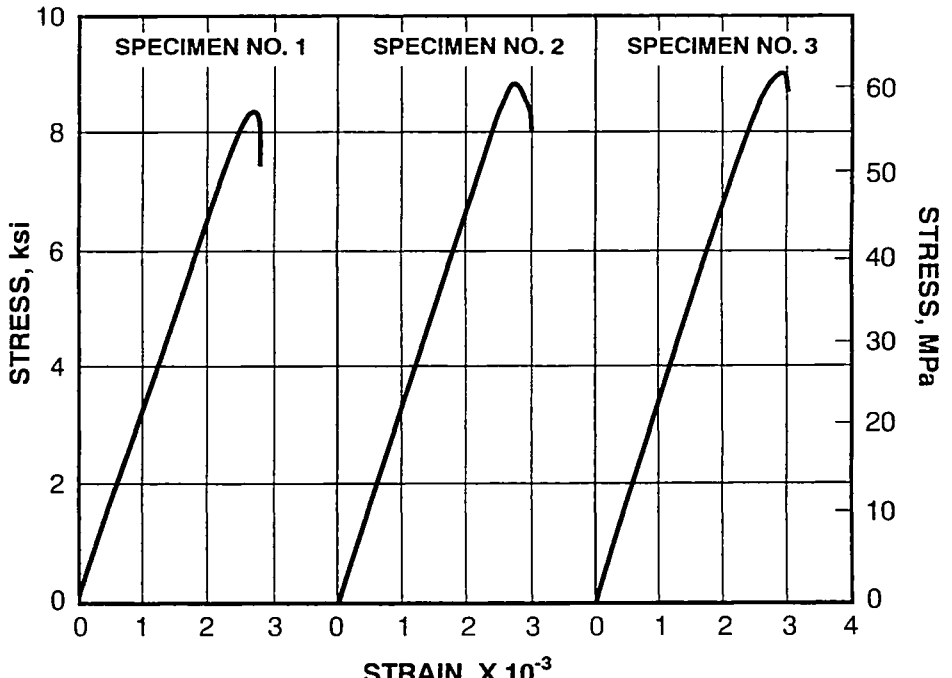

Fig. 2—Stress versus strain curves for LWC1