APPENDIX D
PHYSICAL CHARACTERISTICS OF SANDED GROUTS

The physical data noted in Tables D-1 through D-4 and Figures D-1 and D-2 covering the investigation of sanded grout mixtures are provided from WES Technical Memorandum 6-419 to show the sand-carrying capacity of various pumpable mixtures as well as to furnish information regarding setting times and strength development with age for such mixtures. The addition to these mixtures of such additives as retarders, accelerators, water reducers, expansive agents, and air-entraining agents will modify the fluid properties as well as the hardened physical properties to meet various project requirements for new construction, remedial work, and grouting associated with research and development experiments.

Table D-1

Grout Pumpability Test Data

Parts by Weight of	Proportion by Weight: Sand	Water	Cement	Age Grout min Before*	Consistency Torque Degree: Before*	After*	Line Pressure psi: Before*	After*	Pump Speed Strokes per min: Before*	After*	Discharge cu ft per hr: Before*	After*	Grout Temp F	Time of Set hr: Initial	Final	Compressive Strength psi†: 7 days	28 days
Cement																	
	2	0.65	1	26	129	181	168	183	65	65	57	63	66	7	24	1570	3535
Intrusion Aid																	
0.005	2.25	0.71	1	30	134	182	141	200	63	62	59	63	70‡	7§	24	1400	2810
0.020	2.5	0.74	1	29	133	194	155	170	68	68	58	63	70‡	7§	23	1130	2190
Methocel																	
0.002	2.25	0.72	1	43	130	157	165	170	69	70	62	57	70‡	7§	23	1270	2625
Diatomite																	
0.015	2.5	0.79	1	29	130	164	147	152	68	63	66	66	70‡	3§	18	1240	2650
0.03	3	0.95	1	29	136	148	153	168	65	60	71	65	70‡	4§	21	860	1840
0.06	3.25	1.01	1	31	134	176	147	148	67	67	68	69	70‡	3§	19	745	1900
Bentonite																	
0.025	4	1.35	1	23	136	191	152	172	71	70	74	82	77	8§	22‖	375**	670**
0.05	6	2.03	1	26	136	210	148	163	71	71	78	77	78	7§	27‖	175††	308††
0.10	11	3.55	1	24	133	212	190	215	71	75	79	77	72	3§	89‖	43**	63**
0.20	14	5.88	1	24	141	204	140	155	71	63	79	77	70‡	72§	---	15	25
0.30	24	9.76	1	29	138	206	145	163	77	64	88	83	70‡	122§	---	10	10
0.40	32	12.17	1	40	131	178	140	140	74	70	84	81	70‡	70‡	500§	---	---

* Before or after 15-min interruption in pumping.
† All compressive strength cube tests are the average of three specimens unless indicated.
‡ Estimated.
§ Set after hour shown.
‖ Set prior to hour shown.
** Average of six specimens.
†† Average of nine specimens.

Table D-2

Grout Pumpability Test Data

Sand, % Passing 100	Proportion by Weight			Consistency				Line Pressure psi		Pump Speed Strokes per min		Discharge cu ft per hr		Grout Temp F	Time of Set hr		Per Cent Bleeding	Compressive Strength psi	
				Torque Degree		Flow Cone sec													
	Sand	Water	Cement	Before*	After*	Before*	After*	Before*	After*	Before*	After*	Before*	After*		Initial	Final		7 days	28 days
0	2.00	0.63	1.0	131	154	12	12	173	193	67	60	64	60	75	4	7	1.2	1730	3505
5	2.50	0.72	1.0	137	171	12	12.5	200	200	57	61	63	62	72	4	8	1.6	1345	2805
10	2.50	0.76	1.0	138	170	12	13	150	150	57	57	63	58	71	5	8	1.7	1540	3030
15	2.75	0.82	1.0	129	168	12	12.5	160	165	65	53	68	60	73	4	8	1.7	1420	2700
20	2.75	0.82	1.0	129	171	12	12.5	160	165	61	53	64	59	75	4	18‡	2.7	1285	2485
25	3.00	0.87	1.0	133	150	12.5	13	160	160	47	42	53	50	74	4	7	3.5	1055	2120
Parts by Wt Diatomite§																			
0.11	3.90	1.19	1.0	135	187	12	12.5	140	140	63	57	73	69	73	6	20‡	1.2	585	1035
0.25	5.00	1.54	1.0	141	161	11	12	133	135	73	69	81	77	74	3†	21	1.1	235	495
0.43	5.70	1.87	1.0	134	175	11	12	140	145	72	69	86	81	74	5†	24	0.7	150	485
0.67	7.10	2.37	1.0	134	203	11	12.5	135	150	75	71	87	78	75	3†	24	0.4	120	410
1.00	9.00	3.18	1.0	125	170	11	12	120	140	72	72	77	84	72	6†	19‡	0.4	55	235
Parts by Wt Fly Ash§																			
0.11	3.10	0.88	1.0	134	174	12	12.5	150	160	60	53	67	60	73	6	21‡	1.5	1195	2210
0.25	3.80	1.07	1.0	131	180	12	13	160	165	55	57	65	61	74	2†	17‡	1.7	960	1720
0.43	4.30	1.16	1.0	131	172	12	12.5	165	170	55	59	68	63	72	6†	20‡	1.6	800	1270
0.67	5.40	1.35	1.0	131	179	12	12.5	155	160	60	55	67	62	74	3†	17‡	1.4	570	855
1.00	6.50	1.62	1.0	131	176	12	13	160	165	59	54	63	61	73	7†	26	1.3	435	715
Parts by Wt Pumicite§																			
0.11	3.10	0.94	1.0	136	176	12	12	142	146	61	53	64	61	75	3†	17‡	1.8	1095	1965
0.25	3.80	1.11	1.0	136	171	12	13	142	140	64	55	62	61	71	6	22‡	2.3	715	1260
0.43	4.30	1.27	1.0	145	173	12.5	13	152	148	56	52	61	57	73	3†	65‡	2.3	600	1080
0.67	5.40	1.67	1.0	125	159	12	13	138	133	60	58	64	66	72	6	18	1.5	275	575
1.00	6.50	2.04	1.0	132	177	12	13	135	115	56	53	60	57	71	3†	26	1.9	170	380
Parts by Wt Loess§																			
0.11	2.80	0.88	1.0	129	172	11	12	135	145	72	68	75	75	76	5†	18‡	1.3	1300	2355
0.25	3.40	1.04	1.0	140	203	12	13	155	155	69	59	74	64	72	5	20‡	1.4	845	1610
0.43	4.30	1.34	1.0	128	167	11.5	12	137	150	65	69	68	78	74	3†	17‡	1.7	400	765
0.67	5.00	1.52	1.0	135	180	11.5	12	147	152	75	66	73	74	75	3†	18‡	1.6	385	665
1.00	6.00	1.88	1.0	133	203	12	12.5	148	147	72	69	83	71	75	2†	50‡	1.2	255	410

* Before or after 15-min interruption in pumping.
† Set after hour shown.
‡ Set prior to hour shown.
§ Using a sand with a nominal 0 per cent passing the No. 100 sieve.

Table D-3

Pumping and Laboratory Test Data for All Grout Mixtures

Sand	Sand, % Passing No. 100 Sieve	Proportion by Weight: Sand	Proportion by Weight: Water	Proportion by Weight: Cement	Consistency: Torque, deg: Before*	Consistency: Torque, deg: After*	Consistency: Flow Cone, sec: Before*	Consistency: Flow Cone, sec: After*	Line Pressure psi: Before*	Line Pressure psi: After*	Pump Speed Strokes per min: Before*	Pump Speed Strokes per min: After*	Discharge cu ft per hr: Before*	Discharge cu ft per hr: After*	Grout Temp F	Time of Set hr: Initial	Time of Set hr: Final	Bleeding %	Compressive Strength, psi: 7-day	Compressive Strength, psi: 28-day
										Limestone										
A	0	1.75	0.66	1.0	125	159	12.1	12.3	137	148	60	44	59	51	70	6**	17†	0.9	1795	3780
B	10	3.25	1.08	1.0	133	159	12.2	12.7	137	143	55	51	51	56	73	7**	18	1.3	660	1405
C	25	7.00	1.95	1.0	132	155	12.3	12.3	153	155	56	54	66	66	71	7**	70†	1.7	160	340
	Parts by Wt Fly Ash††																			
A	0.11	1.90	0.73	1.0	126	150	12.0	12.4	133	135	56	50	64	59	73	6**	18†	0.9	1650	3370
A	0.25	2.50	0.80	1.0	126	155	12.0	12.2	137	142	54	55	62	59	76	5**	18†	0.8	1200	2590
A	0.43	3.20	1.08	1.0	130	157	11.8	12.3	140	142	53	51	64	59	75	5**	17	0.8	880	2095
A	0.67	3.80	1.21	1.0	129	156	12.1	12.3	140	142	54	51	62	69	78	6**	18	0.7	795	1990
A	1.00	5.00	1.58	1.0	126	145	12.0	12.3	140	143	61	56	68	65	78	7**	24	0.9	595	1385
	Parts by Wt Loess††																			
A	0.11	1.90	0.74	1.0	131	161	11.8	12.2	140	140	59	52	64	56	77	5	19	0.8	1595	3000
A	0.25	2.50	0.92	1.0	131	162	12.1	12.7	140	143	51	45	61	56	70	7**	18†	1.0	985	1545
A	0.43	2.90	1.05	1.0	141	177	12.2	13.0	140	145	53	47	63	57	71	6-1/2	17†	0.9	735	1350
A	0.67	3.80	1.35	1.0	131	174	11.9	12.7	138	143	51	45	61	55	72	7**	23	1.1	445	845
A	1.00	4.50	1.62	1.0	129	178	11.6	12.4	140	147	55	50	65	60	77	6**	21	1.0	265	535
										Traprock										
	Sand, % Passing No. 100 Sieve																			
A	0	1.75	0.68	1.0	129	146	12.0	12.3	143	143	52	49	64	62	72	5	16†	1.8	2020	4565
B	10	2.00	0.72	1.0	133	158	12.4	12.9	150	157	55	49	60	58	73	6	21†	1.6	1315	3180
C	25	2.25	0.83	1.0	130	168	12.3	12.9	155	157	53	45	64	56	75	6	17†	2.1	1265	2830
	Parts by Wt Fly Ash††																			
A	0.11	1.94	0.73	1.0	128	150	12.2	12.7	152	152	57	53	62	58	73	4**	16†	1.5	1435	3420
A	0.25	2.50	0.90	1.0	130	149	12.3	12.7	158	157	59	54	70	67	75	7**	21†	2.2	1230	2405
A	0.43	2.90	1.03	1.0	136	151	12.3	12.6	152	153	56	54	66	65	74	6**	17†	1.6	1065	2190
A	0.67	3.80	1.24	1.0	142	163	12.3	12.9	155	158	54	52	67	64	73	7**	19	2.2	795	1770
A	1.00	4.50	1.49	1.0	132	157	12.5	12.9	153	153	56	51	69	61	74	7**	22†	1.4	710	1450

* Before or after 15-min interruption in pumping.
** Set after hour shown.
† Set prior to hour shown.
†† Using a sand with a nominal 0 per cent finer than the No. 100 sieve.

Table D-4

Pumping and Laboratory Test Data for All Grout Mixtures

Sand		Maximum Proportions by wt of Pumpable Mixtures			Consistency				Line Pressure psi		Pump Speed Strokes per min		Discharge cu ft per hr		Grout Temp F	Time of Set hr		Bleeding %	Compressive Strength, psi	
					Torque, deg		Flow Cone, sec													
		Sand	Water	Cement	Before*	After*	Before*	After*	Before*	After*	Before*	After*	Before*	After*		Initial†	Final		7-day	28-day
									Limestone Sand, Paddle Mixer											
	Parts by wt Fly Ash**																			
B	0.11	3.00	1.03	1.0	133	144	12.4	12.6	135	140	54	50	65	63	74	5	21††	1.5	1025	1775
B	0.25	3.75	1.18	1.0	124	149	12.4	12.5	135	140	59	53	66	64	75	4	20††	1.1	800	1515
B	0.43	5.00	1.51	1.0	129	158	14.1	14.5	135	140	59	47	68	64	77	4	20††	1.7	435	925
B	0.67	6.25	1.83	1.0	124	155	14.2	14.5	135	140	57	55	72	70	78	4	20††	1.4	360	840
B	1.00	7.00	2.02	1.0	138	156	14.6	15.5	140	140	57	57	70	71	78	4	23	1.6	345	820
B	1.50	7.50	2.10	1.0	132	149	13.7	14.3	140	140	55	55	66	66	79	3	23	0.8	440	1025
	Parts by wt Diatomite**																			
B	0.11	4.50	1.54	1.0	136	149	12.3	12.4	135	140	63	62	72	74	73	4	19††	1.7	355	805
B	0.25	5.00	1.93	1.0	140	158	12.5	13.0	135	140	63	60	77	76	70	4	32††	1.1	200	625
B	0.43	7.25	2.44	1.0	140	172	12.8	12.5	135	140	65	65	70	70	70	4	37††	0.9	120	395
B	0.67	9.25	3.18	1.0	135	180	12.0	12.4	140	140	66	63	78	78	71	3	32††	0.7	80	330
B	1.00	12.00	4.17	1.0	135	180	11.9	12.7	138	138	66	64	80	78	74	3	82††	0.6	75	255
									Natural Sand, Colcrete Mixer											
	Sand, % Passing No. 100 Sieve																			
A	0	2.00	0.68	1.0	132	161	12.2	13.0	150	163	64	55	74	65	88	3	9††	1.4	2095	4115
B	10	3.00	0.90	1.0	133	168	12.5	13.8	160	160	59	50	72	66	90	2	17††	1.9	1310	2625
C	25	3.50	1.00	1.0	132	165	12.5	14.0	160	160	49	45	67	62	86	2	18††	4.1	890	1910
									Limestone Sand, Colcrete Mixer											
B	10	3.25	1.10	1.0	133	172	12.9	13.3	160	160	61	55	71	68	86	1	17††	2.0	985	1650
									Traprock Sand, Colcrete Mixer											
B	10	2.00	0.82	1.0	125	168	12.0	12.7	160	160	64	61	71	71	89	4	9††	1.3	1460	2765

* Before or after 15-min interruption in pumping.
** Using a sand with a nominal 10 per cent passing the No. 100 sieve.
† Set after hour shown.
†† Set prior to hour shown.

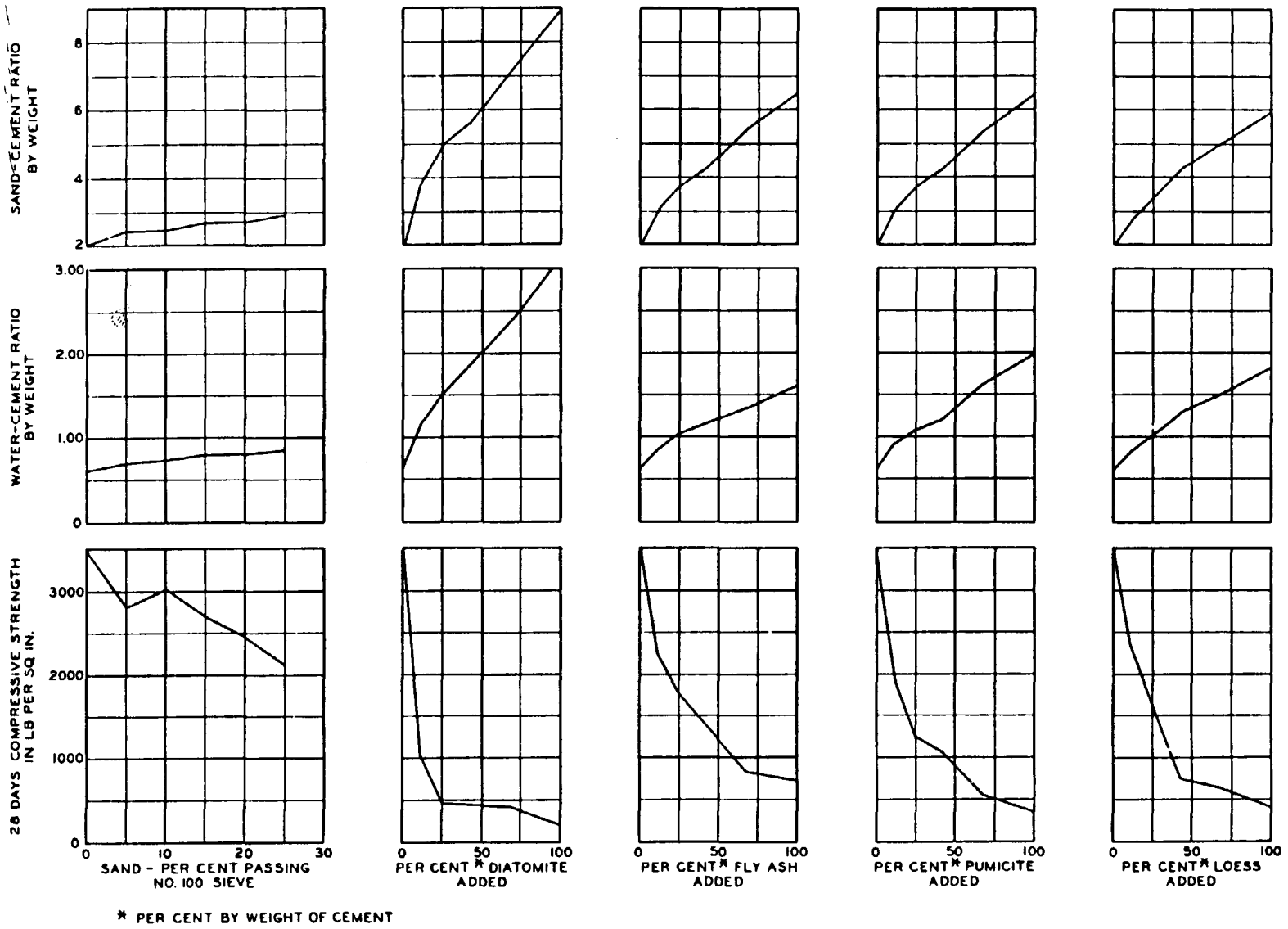

Figure D-1. Characteristics of grout mixtures

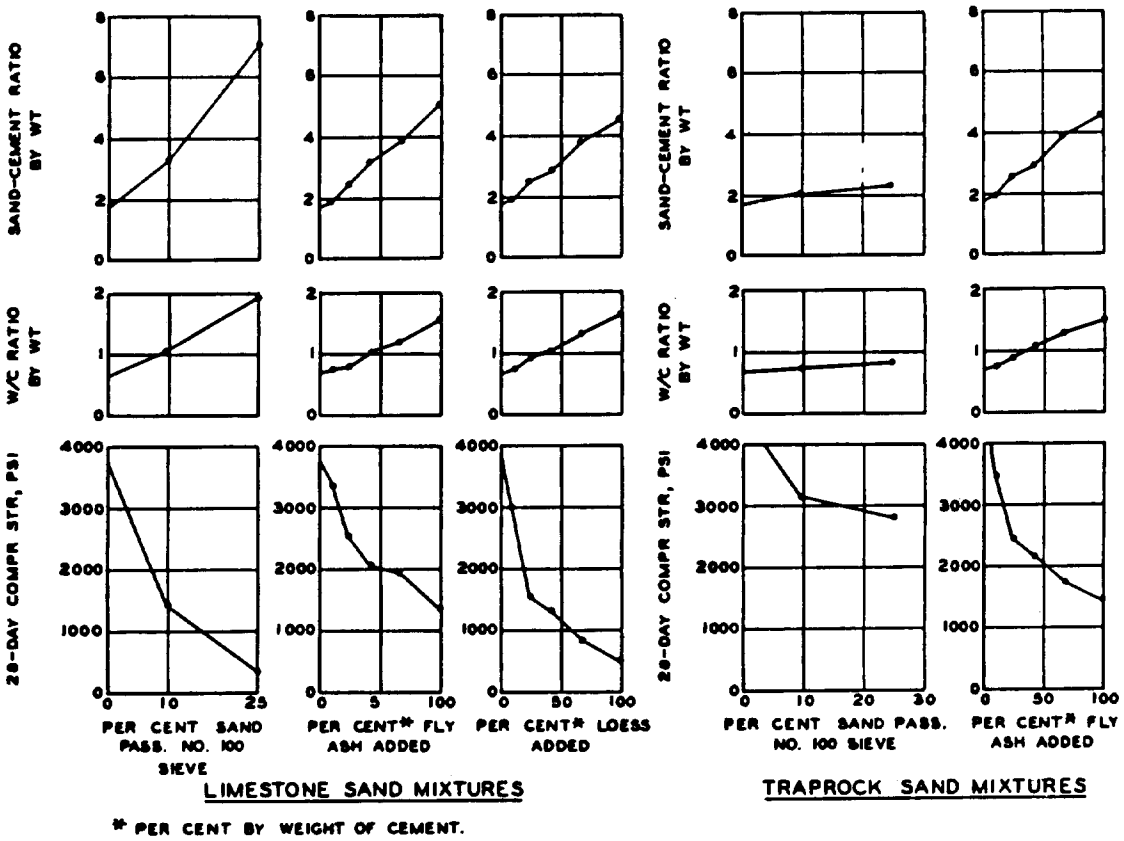

Figure D-2. Compressive strength, water-cement, and sand-cement ratios of the grout mixtures