APPENDIX A

SUMMARY OF RESULTS OF FREEZING TESTS ON NATURAL SOILS

A-1. Introduction. The U.S. Army Cold Regions Research and Engineering Laboratory (USACRREL) has conducted frost-susceptibility tests on scores of soils. Generally, these were base course materials proposed for use in roads or airfield pavements. Most soils came from construction projects within the United States, but some came from Canada, Greenland, Antarctica, Africa, and Asia. In addition, many fine-grained soils were obtained for special studies at USACRREL and have been tested. They are included in the tables of this appendix. These data are presented for general guidance for estimation of the relative frost-susceptibility of similar soils. It should be noted, however, that a freezing test on a sample of a specific soil will give a more accurate evaluation.

A-2. Presentation of test data and results. Table A-1 contains the test data of soil specimens grouped according to the Unified Soil Classification System. The soils are positioned within each group according to the increasing percentage of grains finer than the 0.02-millimeter size by weight present in the soil. Other data include the physical properties of the material, the results of freezing tests, and the relative frost-susceptibility classification as shown in figure 2-2. Table A-1 contains the test results on 1) soils that met the test specification of having a dry unit weight of 95 percent or greater than that obtained by the appropriate compactive procedure used or specified, and 2) soils that had an initial moisture content before freezing equal to or greater than 85 percent of full saturation. The test results listed in table A-1 (average rate of heave versus percentage by weight of grains finer than the 0.02-millimeter size) are plotted in figure 2-2, in envelopes according to soil type. Table A-2 contains data grouped similarly in every respect to those in table A-1, except that they do not meet the compaction criterion of 95 percent or greater and the initial degree of saturation. Table A-3 contains heave rate data on specimens tested under a lower load pressure than specimens in tables A-1 and A-2. Data from tables A-2 and A-3 have not been plotted in figure 2-2.

A-3. Discussion.

a. Two heave rates have been computed for each specimen presented in the tables: an average heave rate and a maximum heave rate, in millimeters per day. This is done to measure the maximum degree of variability, if any, occurring during each test. The degree of variability is expressed as a heave rate variability index. The reason for high variability is not known. It may be reflective of several variables either in some portion of the specimen or in the test controls, such as specimen inhomogeneity (density, layer discontinuities or other internal influencing factors), friction

between the soil and container, rate of heat extraction, and interruption of water supply (internal and external). A large variability index could be indicative of dominance of several counter forces during tests. Such a test result might be assigned a smaller degree of confidence than one whose test variability index is low.

b. Recent experimentation at USACRREL indicates that some variable degree of friction may exist between the specimen and its container during freezing and heaving. Freezing tests of specimens performed in horizontally segmented (multi-ring) cells usually showed higher heave rate than those of counterpart specimens in inside-tapered, solid-walled cells. The inside-tapered cells were a great improvement over straight-walled soil cells.

c. More recent investigations at USACRREL to simplify and shorten the time interval for the frost-susceptibility test revealed that soil specimens in cylinders made of segmented rings 1 inch high usually gave considerably higher heave rates than their counterparts in inside-tapered solid-walled cylinders, especially at the highest rates of frost penetration. Studies to simplify and reduce time for frost-susceptibility testing are still in the development and evaluation stage. When sufficient data are available from segmented ring cylinders, it may be possible to correlate these data with the maximum heave rate.

d. For each specimen listed in tables A-1 through A-3, a detailed temperature and heave versus time plot for the complete period of freezing is available in the USACRREL data files. A plot of moisture content distribution with depth after freezing for each inch of specimen height is also available. The tabular data presented in this appendix give only the overall initial and final average water content, the percentage of heave, and the rates of heave computed in the manner detailed in the notes within the tables.

e. Figure 2-3 presents a summary grouping of the individual envelopes shown in figures 2-2a-c. There are no distinct, neat groupings, nor is there a unique heave rate for any given percentage of 0.02-millimeter grains in the gradation. The groupings overlap considerably, and it should be noted that the Unified Soil Classification System was not developed for frost classification but is used here because of its wide acceptance in soils engineering.

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils-Open System Nominal Load Pressure 0.5 psi

The following table contains tests results on soils having dry weights equal to or greater than 95 percent of compactive density and initial moisture content of 85 percent or greater of saturation. Heave rate data from table A-1 is presented in figure 2-2.

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils -Open System Nominal Load Pressure 0.5 psi[1]

Material Source	Unified Soil Classification Symbol (2)	Maximum Size	SOIL GRADATION DATA (AS FROZEN) Percent Finer, mm						Coefficients (3)		PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4)		Specific Gravity
		in.	4.76	0.42	0.074	0.02	0.01	0.005	C_u	C_c	LL	PI	
CLAYEY SANDY GRAVELS													
Washington, D.C.	GW-GC	1-1/4	37	16.0	6.4	4.2	-	-	57.0	2.5	26.0	9.0	2.65
Washington, D.C.		1-1/4	37	16.0	6.4	4.2	-	-	57.0	2.5	26.0	9.0	2.65
Present Isle	GP-GC	3/4	37	14.0	11.0	6.6	5.0	3.2	145.0	16.0	24.9	8.7	2.72
Present Isle		3/4	33	15.0	12.0	8.7	6.9	-	315.0	32.0	22.3	8.1	2.75
CLAYEY SILTY GRAVELS													
Clinton County	GM-GC	1-1/2	54	30.0	20.0	15.0	9.0	5.0	485.0	1.9	24.88	6.8	2.74
CLAYEY GRAVELS													
Great Falls	GC	1-1/2	48	36.0	22.0	17.0	15.0	12.0	4000.0	1.2	42.6	24.6	2.66
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
SANDS AND GRAVELLY SANDS													
Stewart	SW	2	58	15.0	4.9	2.3	1.5	1.1	23.0	1.3			2.72
Stewart		2	58	15.0	4.9	2.3	1.5	1.1	23.0	1.3			2.72
Plattsburg	SP	1-1/2	59	20.0	2.1	1.0	0.8	0.5	24.0	0.3			2.67
Plattsburg		1-1/2	59	20.0	2.1	1.0	0.8	0.5	24.0	0.3			2.67
Plattsburg		1	72	7.0	3.0	1.3	0.9	0.5	5.3	2.0			3.20
Fairchild		2	85	8.6	3.6	1.3	1.2	-	3.4	0.2			2.74
Fairchild		2	70	6.9	3.4	1.4	1.3	-	4.7	1.3			2.74
Plattsburg		1-1/2	72	36.0	4.5	1.8	1.4	1.0	5.1	0.7			2.67
Plattsburg		1-1/2	72	36.0	4.5	1.8	1.4	1.0	5.1	0.7			2.67
GRAVELS AND SANDY GRAVELS													
Alaska Highway	GW	1	41	11.0	2.0	1.0	0.6	0.4	24.0	1.1			2.75
Loring		3/4	45	9.0	3.9	1.8	1.5	1.2	16.0	1.3			2.71
Loring		3/4	46	10.0	4.4	3.4	2.9	2.1	18.0	1.4			2.71
Koflavik	GP	2	37	9.0	3.0	1.0	-	-	38.0	0.8			2.81
Alaska Highway		1	44	11.0	2.6	1.2	0.7	0.5	26.0	0.9			2.73
Koflavik		3	38	12.0	4.1	1.6	0.9	0.5	91.0	0.5			2.64
SILTY SANDY GRAVELS													
Koflavik	GW-GM	3	32	14.0	6.0	2.1	1.1	0.1	159.0	2.7			2.65
Loring		3/4	53	10.0	6.2	4.9	4.4	3.4	15.0	1.0			2.71
Loring		3/4	53	10.0	6.2	4.9	4.4	3.4	15.0	1.0			2.71
Loring		3/4	53	10.0	6.2	4.9	4.4	3.4	15.0	1.0			2.71
Loring		3/4	53	10.0	6.2	4.9	4.4	3.4	15.0	1.0			2.71
Loring		2	41	9.0	6.4	5.3	4.4	3.4	22.0	1.3	24.0	5.5	2.71
Marble Point	GP-GM	2	56	32.0	11.0	3.7	3.0	2.0	101.0	0.3			2.74
Marble Point		2	38	21.0	10.0	3.9	-	-	185.0	5.7			2.75
Marble Point		2	38	21.0	10.0	3.9	-	-	185.0	5.7			2.75
Project Blue Jay		3/4	54	32.0	10.0	4.0	2.2	1.5	139.0	0.2			2.73
CLAYEY GRAVELS													
Loring	GC	3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
Loring		3/4	68	52.0	41.0	30.0	25.0	18.0	945.0	0.1	22.1	7.8	2.73
SANDS AND GRAVELLY SANDS													
Plattsburg	SP	3/8	60	1.0	0.1	<0.1	<0.1	<0.1	3.8	0.9			2.96
SILTY GRAVELLY SANDS													
Hutchinson's Pit	SW-SM	2	57	20.0	8.7	5.0	3.5	2.0	43.0	1.3			2.75
Hutchinson's Pit		2	57	20.0	8.7	5.0	3.5	2.0	43.0	1.1			2.75
Thule	SP-SM	3/4	65	41.0	8.6	2.8	2.0	1.4	35.0	0.3			2.75
Tobyhanna		1-1/2	59	39.0	8.5	4.5	2.5	1.6	6.0	0.2			2.72
SILTY SANDS													
Alaska Highway	SM	-	100	100.0	33.0	2.5	-	-	1.6	1.0			2.79
Tobyhanna		1-1/2	79	45.0	14.0	5.5	4.0	3.1	24.0	0.7			2.72
Dow		3/4	61	27.0	14.0	7.8	5.5	3.8	160.0	2.7	17.6	3.1	2.72
Fairchild		3/4	71	34.0	23.0	11.0	6.3	4.0	95.0	2.2	21.6	2.9	2.79
Ball Mountain		3/4	88	58.0	28.0	12.0	7.5	3.6	36.0	1.2			2.77
Ball Mountain		3/4	88	58.0	28.0	12.0	7.5	3.6	36.0	1.2			2.77
Hill Field		-	100	95.0	28.0	13.0	10.0	7.5	17.0	4.3			2.64
Project Blue Jay		3/4	70	54.0	31.0	19.0	12.0	8.5	147.0	0.4	16.0	3.7	2.70
Project Blue Jay		3/4	70	54.0	31.0	19.0	12.0	8.5	147.0	0.4	16.0	3.7	2.70

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8) Avg.	Rate of Heave mm/day (8) Mos.	Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%	%				
133.9(d)	4.7	135	101	0.220	97	8.0	12.7	15.6	2.1	3.0	1.42	M
133.9(d)	4.7	136	101	0.218	96	7.7	12.0	15.5	2.6	3.3	1.26	M
136.8(b)	-	134	98	0.265	97	9.7	22.3	42.5	2.9	3.7	1.28	M
-	-	131	96	0.250	98	8.8	16.2	19.9	1.5	2.0	1.33	L
130.2(a)	9.0	129	99	0.320	100	11.7	30.3	65.6	4.6	5.7	1.24	M
140.0(d)	5.6	133	95	0.252	100	9.5	21.0	28.0	2.4	5.0	2.08	M-H
135.8(d)	7.5	129	95	0.320	100	11.6	34.8	84.4	4.0	6.8	1.70	H
135.8(d)	7.5	132	97	0.290	100	10.3	19.0	30.2	2.3	3.7	1.60	M
135.8(d)	7.5	136	100	0.250	100	9.0	17.6	28.5	1.5	2.7	1.80	L-M
135.8(d)	7.5	134	99	0.270	100	9.7	24.3	42.5	2.6	4.0	1.54	M
135.8(d)	7.5	132	97	0.290	95	10.0	32.0	81.9	4.9	13.2	2.69	H-VH
139.9(b)	-	136	97	0.254	100	9.7	18.1	20.6	2.9	4.0	1.38	M
139.9(b)	-	136	97	0.250	100	9.3	21.4	32.3	2.4	3.8	1.58	M
132.8(b)	-	130	98	0.281	100	10.5	11.2	6.0	0.6	0.7	1.16	VL
132.8(b)	-	130	98	0.283	100	10.6	12.8	9.6	0.3	0.4	1.33	M
139.1(b)	-	139	100	0.440	86	11.7	11.7	7.5	0.3	0.4	1.33	M
119.2(b)	-	116	98	0.469	100	17.0	19.0	10.4	0.8	1.6	2.00	VL-L
132.1(b)	-	125	95	0.368	100	13.4	15.4	10.8	0.7	1.1	1.57	VL-L
125.2(b)	-	124	99	0.338	95	12.0	12.0	5.3	0.6	0.8	1.33	VL
125.2(b)	-	125	100	0.329	90	12.3	13.9	9.8	0.7	0.9	1.28	VL
143.9(b)	-	136	95	0.261	80	7.6	11.6	11.3	0.7	1.0	1.42	VL
143.8(d)	6.1	123	86	0.374	91	12.5	14.4	13.8	1.3	1.8	1.38	L
143.8(d)	6.1	130	90	0.300	98	10.8	11.1	8.3	1.1	1.8	1.64	L
112.0(b)	-	112	100	0.562	82	16.6	16.6	9.3	0.1	0.1	1.00	M
143.3(b)	-	127	95	0.341	83	10.4	13.9	9.6	0.7	1.3	1.86	VL-L
145.5	-	137	94	0.390	81	11.4	11.4	7.8	0.5	1.4	2.80	VL-L
138.6(b)	-	137	98	0.380	70	8.7	8.7	2.7	0.3	0.7	2.33	M-VL
139.1(b)	-	139	100	0.210	74	6.0	11.1	24.6	1.5	3.0	2.00	L-M
139.1(b)	-	133	96	0.273	72	7.4	14.9	23.9	1.8	3.5	1.94	L-M
139.1(b)	-	126	91	0.342	75	9.5	13.1	20.0	1.5	2.8	1.86	L-M
139.1(b)	-	120	86	0.409	73	11.0	13.3	11.4	1.1	1.7	1.54	L
139.1(b)	-	135	94	0.256	100	9.5	17.7	33.1	2.9	3.8	1.31	H
150.8(b)	-	141	93	0.213	100	7.8	12.8	17.0	1.4	2.2	1.57	L-M
145.6(b)	-	137	94	0.252	100	9.2	9.6	3.5	0.3	0.8	2.66	VL
145.6(b)	-	137	94	0.252	100	8.6	11.0	7.7	0.6	1.0	1.66	VL
143.4(b)	-	138	96	0.238	79	6.9	24.6	47.4	3.3	5.2	1.58	L-H
135.8(d)	-	120	88	0.420	97	15.1	69.7	134.3	8.0	13.8	1.72	VH
135.8(d)	-	122	90	0.394	94	13.5	58.5	106.5	8.5	10.3	1.58	H-VH
135.8(d)	-	127	93	0.290	98	12.3	56.8	111.3	6.6	10.8	1.64	H-VH
126.7(b)	-	127	100	0.455	80	12.3	12.3	1.4	0.1	0.1	1.00	M
143.3(c)	5.3	141	98	0.220	71	5.7	29.5	61.7	4.3	5.3	1.23	H
143.3(c)	5.3	140	98	0.231	78	6.5	34.1	73.8	4.8	5.8	1.20	H
143.7(b)	-	135	94	0.271	100	9.8	12.9	10.6	0.8	1.0	1.25	VL
140.6(b)	-	132	94	0.280	100	10.0	20.5	24.6	1.4	2.8	2.00	M
105.7(b)	-	104	98	0.672	78	18.9	24.0	7.0	0.3	0.5	1.66	H
140.6(b)	-	130	92	0.300	100	11.1	27.2	38.0	2.6	5.5	2.12	H-H
136.7(b)	-	135	99	0.254	60	5.5	35.7	70.5	4.0	5.8	1.45	H
144.4(b)	-	134	93	0.287	100	10.3	30.3	56.0	3.0	5.2	1.73	H-H
141.8(d)	5.6	133	94	0.300	100	10.8	38.5	77.3	6.1	7.2	1.18	H
141.8(d)	5.6	132	94	0.307	100	11.1	30.4	45.6	5.3	7.2	1.36	H
120.4(d)	-	113	94	0.460	95	15.6	26.2	16.8	1.9	2.7	1.42	L-H
137.3(d)	7.5	136	99	0.238	73	6.4	14.8	16.7	1.6	2.7	1.68	L-H
137.3(d)	7.5	132	96	0.275	68	6.9	26.9	37.4	3.0	5.8	1.93	L-H

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

Material Source	Unified Soil Classification Symbol (2)	Maximum Size in.	SOIL GRADATION DATA (AS FROZEN) Percent finer, mm 4.76	0.42	0.074	0.02	0.01	0.005	Coefficients (3) C_u	C_c	PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4) LL	PI	Specific Gravity
SILTY SANDS (CONT.)													
Truax		3/4	92	79.0	35.0	22.0	15.0	1.9	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	1.9	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	1.9	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	1.9	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	1.9	55.0	1.9	14.4	1.6	2.72
Plattsburg	SM	-	100	95.0	28.0	1.5	1.2	0.9	2.5	0.9			2.68
Plattsburg		-	100	95.0	28.0	1.5	1.2	0.9	2.5	0.9			2.68
Alaska		-	100	100.0	33.0	2.5	-	-	1.6	1.0			2.79
Westover		-	100	86.0	20.0	2.5	-	-	4.1	1.2			2.69
Minnesota		-	100	95.0	20.0	3.8	2.2	-	3.7	1.3			2.68
Bradley		3/4	79	27.0	14.0	4.2	2.6	-	47.0	1.9			2.76
Bradley		3/4	67	31.0	14.0	4.4	2.6	-	62.0	0.9			2.76
Bethel		-	100	100.0	21.0	4.5	2.5	1.0	3.0	1.1			2.68
Bethel		-	100	100.0	21.0	4.5	2.5	1.0	3.0	1.1			2.68
Westover		-	100	86.0	26.0	5.1	-	-	27.0	1.3			2.69
Greenland		3/4	66	45.0	17.0	5.2	3.7	2.4	47.0	0.4			2.73
Greenland		3/4	66	45.0	17.0	5.2	3.7	2.4	47.0	0.4			2.73
Greenland		3/4	66	45.0	17.0	5.2	3.7	2.4	47.0	0.4			2.73
Project Blue Jay		3/4	82	53.0	21.0	6.0	5.2	2.8	25.0	0.6			2.71
Afghanistan		1	57	23.0	12.0	6.2	3.9	2.7	111.0	3.1			2.69
Korea		2	88	43.0	18.0	6.5	4.0	2.5	28.6	1.3			2.58
Westover		-	100	85.0	27.0	7.0	-	-	6.9	1.2			2.71
Westover		-	100	85.0	27.0	7.0	-	-	6.9	1.2			2.71
M.I.T.		2	84	47.0	13.0	7.5	5.3	3.6	17.0	1.9			2.70
M.I.T.		2	76	49.0	17.0	7.8	4.5	3.0	28.0	1.4			2.70
Portsmouth		3/4	98	94.0	29.0	8.2	5.4	3.7	4.0	1.8			2.73
Minnesota		-	100	97.0	48.0	8.8	4.5	-	4.4	0.8			2.72
Westover		2	58	27.0	14.0	8.9	7.5	6.0	250.0	2.2	21.9	3.0	2.70
Volk Field		-	100	88.0	13.0	11.0	9.5	7.7	20.0	7.5			2.72
Mansfield Hollow		3/4	78	53.0	23.0	11.0	7.5	4.5	38.0	1.3			2.70
Mansfield Hollow	SM	3/4	78	53.0	23.0	11.0	7.5	4.5	38.0	1.3			2.70
Fairchild		3/4	71	34.0	23.0	11.0	6.3	4.0	95.0	2.2	21.6	2.0	2.79
Thule		3/4	73	47.0	20.0	12.0	9.0	6.9	71.0	1.8	14.1	2.2	2.88
Thule		3/4	73	47.0	20.0	12.0	9.0	6.9	71.0	1.8	14.1	2.2	2.88
Portsmouth		3/4	68	45.0	23.0	14.0	9.1	1.2	14.0	1.2			2.71
Westover		3/4	97	75.0	38.0	14.0	7.0	-	17.0	0.8			2.65
Truax		3/4	90	79.0	28.0	15.0	12.0	9.0	36.0	4.2			2.70
Minnesota		3/4	97	73.0	31.0	17.0	14.0	13.0	280.0	18.0	18.3	2.8	2.73
Truax		1/2	82	71.0	32.0	19.0	13.0	9.4	50.0	4.6	14.0	2.0	2.72
M.I.T.		1-1/2	81	58.0	38.0	19.0	12.0	6.5	56.0	0.9	20.7	0.9	2.70
Truax		3/4	82	71.0	32.0	19.0	13.0	9.5	50.0	4.6	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	12.0	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	12.0	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	12.0	55.0	1.9	14.4	1.6	2.72
Truax		3/4	92	79.0	35.0	22.0	15.0	12.0	55.0	1.9	14.4	1.6	2.72
CLAYEY SILTY SANDS													
Sioux Falls	SM-SC	1	71	28.0	16.0	9.0	6.0	4.3	108.0	3.7	24.1	5.9	2.72
Loring		1/2	87	22.0	15.0	13.0	11.0	8.0	260.0	34.0	24.0	6.0	2.72
Thule		3/4	65	39.0	22.0	14.0	10.0	7.0	310.0	0.9	16.1	4.3	2.87
Thule		3/4	65	39.0	22.0	14.0	10.0	7.0	310.0	0.9	16.1	4.3	2.87
Casper		1-1/2	91	48.0	23.0	15.0	13.0	11.0	225.0	13.0	22.0	4.6	2.64
Patterson		1-1/2	62	33.0	22.0	15.0	10.0	5.5	400.0	2.7	22.0	6.1	2.74
Casper		1-1/2	98	62.0	21.0	16.0	14.0	12.0	137.0	14.0	21.8	6.0	2.65
Casper		3/4	98	68.0	29.0	18.0	16.0	14.0	195.0	11.0	22.0	4.6	2.66
Bong	SM-SC	1-1/2	94	75.0	44.0	21.0	15.0	10.0	33.0	1.3	16.8	5.1	2.76
Bong		1-1/2	94	75.0	44.0	21.0	15.0	10.0	33.0	1.3	16.8	5.1	2.76
Bong		1-1/2	94	75.0	44.0	21.0	15.0	10.0	33.0	1.3	16.8	5.1	2.76
Loring		1-1/2	83	63.0	46.0	30.0	25.0	18.0	188.0	0.8	21.1	6.0	2.71
Loring		1-1/2	87	62.0	48.0	32.0	24.0	15.0	100.0	0.2	21.1	6.0	2.71
Fairchild		3/4	76	29.0	17.0	9.5	7.0	4.5	55.0	7.2	24.6	6.3	2.77
Loring		1-1/2	83	60.0	47.0	34.0	27.0	20.0	320.0	0.3	21.1	6.0	2.71
CLAYEY SANDS													
Pierre	SC	1-1/2	67	31.0	17.0	8.7	7.0	4.3	100.0	3.0	25.3	7.3	2.77
Fargo		3/4	98	33.0	17.0	9.5	7.5	5.5	50.0	5.2	30.7	10.5	2.70
Fargo		3/4	98	33.0	17.0	9.5	7.5	5.5	50.0	5.2	30.7	10.5	2.70
Fargo		3/4	98	33.0	17.0	9.5	7.5	5.5	50.0	5.2	30.7	10.5	2.70
Fargo		3/4	98	33.0	17.0	9.5	7.5	5.5	50.0	5.2	30.7	10.5	2.70

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8)		Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%	%	Avg.	Mos.		
137.3(d)	5.6	129	94	0.315	94	10.9	23.2	28.2	3.3	4.2	1.27	H-H
137.3(d)	5.6	119	87	0.423	91	14.3	16.5	7.4	1.1	1.7	1.54	L
137.3(d)	5.6	126	91	0.350	90	11.7	17.0	13.0	2.0	3.0	1.50	M
137.3(d)	5.6	126	91	0.348	100	12.8	27.0	41.2	2.8	3.5	1.25	H
137.3(d)	5.6	118	86	0.431	100	15.9	24.0	20.2	1.4	2.0	1.42	L
110.3(b)	-	107	97	0.567	85	18.6	18.7	4.4	0.2	0.5	2.50	M
110.3(b)	-	109	99	0.540	96	19.2	19.2	4.4	0.1	0.2	2.00	M
106.4(b)	-	108	101	0.605	100	21.7	24.6	9.4	0.7	1.5	2.14	VL-L
119.9(b)	-	115	96	0.458	99	18.5	17.6	4.3	0.2	0.3	1.50	M
114.2(d)	-	114	100	0.434	99	16.0	42.8	49.8	2.3	9.3	4.04	M-VH
133.6(b)	-	133	100	0.300	100	10.9	20.6	20.0	1.2	1.6	1.33	L
143.1(b)	-	143	100	0.202	100	7.3	21.9	21.9	2.4	3.3	1.38	M
106.4(d)	-	106	100	0.578	96	20.7	21.6	21.6	0.5	1.0	2.00	VL
106.4(d)	-	105	99	0.593	88	19.4	21.6	21.6	0.6	1.0	1.66	VL
114.3(b)	-	114	100	0.467	100	17.7	23.9	14.2	0.7	1.0	1.42	VL
137.9(b)	-	135	98	0.258	100	9.5	22.6	35.3	2.2	2.7	1.22	M
137.9(b)	-	137	99	0.244	97	8.6	31.6	60.2	3.8	5.5	1.44	M-H
137.9(b)	-	136	99	0.252	100	9.2	22.9	38.4	2.0	2.9	1.45	M
136.0(c)	7.0	129	95	0.312	88	10.1	28.5	36.9	2.9	3.8	1.31	M
144.6(b)	-	144	99	0.155	98	6.0	13.9	24.7	2.2	3.7	1.68	M
120.0(b)	-	120	99	0.398	96	12.5	27.2	39.5	5.5	8.0	1.45	H
116.4(b)	-	117	100	0.450	100	16.5	26.5	19.6	1.2	1.8	1.50	L
116.4(b)	-	111	95	0.521	100	19.2	22.4	10.8	0.6	1.3	2.16	VL-L
123.0(d)	13.2	123	100	0.374	96	13.2	21.9	22.4	2.3	3.2	1.39	M
122.1(d)	14.2	122	100	0.384	100	14.2	25.3	28.3	1.9	2.7	1.42	L-M
111.2(d)	-	109	98	0.560	96	19.8	26.2	13.5	0.8	1.5	1.86	VL-M
126.0(b)	-	120	95	0.419	99	15.3	22.0	18.3	1.4	3.3	2.35	L-M
129.4(b)	-	128	> 99	0.312	100	11.5	12.4	8.5	0.9	1.2	1.33	VL-L
119.5(b)	-	114	95	0.375	100	16.7	33.5	37.2	2.2	3.0	1.36	M
136.0(d)	-	131	96	0.290	98	10.5	30.1	45.0	3.3	4.0	1.21	M
136.0(d)	-	131	96	0.291	88	9.5	24.2	35.3	4.6	6.5	1.41	M-H
142.9(b)	-	136	95	0.280	100	10.0	22.2	27.1	2.8	4.8	1.71	M-H
150.9(b)	-	145	96	0.243	100	8.4	30.2	58.0	2.6	5.3	2.04	M-H
150.9(b)	-	144	95	0.248	98	8.4	34.1	66.4	3.0	6.5	2.16	M-H
128.6(b)	-	127	99	0.333	100	12.3	46.1	81.8	5.6	8.8	1.57	H-VH
-	-	112	> 95	0.483	97	17.6	73.1	116.9	4.9	7.4	1.51	H
137.3(d)	5.6	130	95	0.300	93	10.2	19.5	23.2	1.5	2.7	1.80	L-M
130.2(b)	-	124	95	0.374	100	13.7	63.3	118.0	6.3	10.2	1.62	H-VH
-	-	129	> 95	0.311	95	10.8	14.8	10.8	2.2	3.0	1.36	M
119.0(d)	15.0	119	100	0.404	100	15.0	30.2	35.4	2.1	2.8	1.33	M
139.0(c)	5.3	136	98	0.246	100	9.1	17.2	21.0	1.8	3.5	1.94	L-M
137.3(d)	5.6	130	95	0.303	100	11.1	18.2	22.0	2.5	2.8	1.12	M
137.3(d)	5.6	134	98	0.265	98	9.6	14.9	14.7	2.5	2.8	1.12	M
137.3(d)	5.6	139	102	0.216	100	8.0	16.3	15.5	1.3	1.7	1.30	L
137.3(d)	5.6	132	96	0.280	100	10.3	23.3	37.1	2.9	3.3	1.34	M
137.0(d)	7.2	131	96	0.292	100	10.6	15.7	16.6	1.7	2.7	1.58	L-M
139.1(b)	-	134	96	0.265	99	9.7	29.1	56.7	5.5	7.5	1.36	H
152.5(b)	-	148	97	0.215	100	7.5	31.0	61.4	2.6	4.7	1.80	M-H
152.5(b)	-	146	96	0.223	100	7.8	35.9	68.8	3.3	6.5	1.96	M-H
120.8(d)	7.2	120	99	0.378	100	14.2	19.6	17.1	1.5	2.7	1.80	L-M
-	-	135	95	0.267	100	9.7	26.0	44.4	3.3	4.2	1.27	M-H
120.8(d)	7.2	118	98	0.403	100	15.2	21.7	17.7	1.6	2.3	1.44	L-M
120.8(d)	7.2	119	99	0.393	95	14.0	22.0	20.0	2.2	3.2	1.45	M
139.5(c)	-	135	97	0.290	100	10.8	13.1	13.1	1.3	2.0	1.54	L
139.5(c)	-	136	97	0.267	100	9.7	12.8	12.8	1.3	1.7	1.30	L
139.5(c)	-	134	96	0.282	100	10.2	16.2	21.8	1.7	3.7	2.18	L-M
-	-	127	> 95	0.334	100	12.3	44.0	77.6	6.7	8.7	1.30	H-VH
-	-	127	> 95	0.334	100	12.3	50.1	56.9	2.8	3.3	1.18	H
142.1(b)	-	131	92	0.314	94	10.7	22.7	29.0	3.2	5.7	1.78	H-H
135.8(d)	-	123	91	0.369	100	13.5	78.8	159.4	15.4	21.3	1.38	H
134.5(d)	6.9	123	91	0.381	100	14.0	16.5	9.7	0.6	0.7	1.16	VL
127.2(d)	9.0	113	89	0.494	87	15.9	40.5	52.6	5.0	7.8	1.56	H
127.2(d)	9.0	117	92	0.438	89	14.4	37.6	40.8	3.5	5.5	1.57	H-W
127.2(d)	9.0	103	81	0.641	99	25.1	74.9	80.0	2.9	5.0	1.72	M-H
127.2(d)	9.0	107	84	0.581	100	23.1	33.8	28.8	1.9	2.8	1.47	L-M

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

Material Source	Unified Soil Classification Symbol (2)	Maximum Size	SOIL GRADATION DATA (AS FROZEN) Percent finer, mm						Coefficients (3)		PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4)		Specific Gravity
		in.	4.76	0.42	0.074	0.02	0.01	0.005	C_u	C_c	LL	PI	
CLAYEY SANDS (CONT.)													
Fargo		3/4	98	33	17	9.5	7.5	5.5	50	5.2	30.7	10.5	2.70
Fargo		3/4	98	33	17	9.5	7.5	5.5	50	5.2	30.7	10.5	2.70
Project Blue Jay		3/4	73	55	35	23.0	20.0	15.0	500	1.7	24.7	3.1	2.73
Lowry		-	100	86	39	25.0	21.0	17.0	150	6.9	24.5	7.3	2.64
Lowry		-	100	86	39	25.0	21.0	17.0	150	6.9	24.5	7.8	2.64
Lowry		-	100	86	39	25.0	21.0	17.0	150	6.9	24.5	7.3	2.64
Lowry		-	100	90	44	32.0	28.0	22.0	150	1.5	24.5	7.3	2.64
SILTS AND SANDY SILTS													
New Hampshire	ML	-	100	99	97	60.0	22.0	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22.0	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22.0	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22.0	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22.0	10.0	-	-	26.6	0.1	2.70
CLAYEY SILTS													
Dow Field	ML-CL	3/4	88	76	66	40.0	30.0	20.0	-	-	22.0	0.9	2.71
Loring		3/4	84	70	59	44.0	35.0	27.0	-	-	21.1	6.0	2.70
Loring		1	90	73	61	48.0	40.0	30.0	-	-	21.1	6.0	2.70
New Hampshire		-	100	96	90	67.0	36.0	16.0	-	-	24.8	5.1	2.70
New Hampshire		-	100	96	90	67.0	36.0	16.0	-	-	24.8	5.1	2.70
New Hampshire		-	100	96	90	67.0	36.0	16.0	-	-	24.8	5.1	2.70
New Hampshire		-	100	97	93	67.0	39.0	26.0	-	-	26.5	6.0	2.71
New Hampshire		-	100	97	93	67.0	39.0	26.0	-	-	26.5	6.0	2.71
New Hampshire		-	100	97	93	67.0	39.0	26.0	-	-	26.5	6.0	2.71
New Hampshire		-	100	97	93	67.0	39.0	26.0	-	-	26.5	6.0	2.71
SILTS WITH ORGANICS													
Fairbanks	ML-OL	-	100	100	95	32.0	16.0	10.0	-	-	28.4	4.4	2.72
Fairbanks		-	100	100	95	32.0	16.0	10.0	-	-	28.4	4.4	2.72
Fairbanks		-	100	100	95	32.0	16.0	10.0	-	-	28.4	4.4	2.72
Ladd Field		-	100	100	91	38.0	13.0	6.0	-	-	31.6	0.0	2.75
Ladd Field		-	100	100	91	38.0	13.0	6.0	-	-	31.6	0.0	2.75
Ladd Field		-	100	100	91	38.0	13.0	6.0	-	-	31.6	0.0	2.75
Fairbanks		-	100	100	94	40.0	23.0	13.0	-	-	25.3	3.3	2.67
Fairbanks		-	100	100	94	40.0	23.0	13.0	-	-	25.3	3.3	2.67
Fairbanks		-	100	100	94	40.0	23.0	13.0	-	-	25.3	3.3	2.67
Fairbanks		-	100	100	97	42.0	22.0	12.0	-	-	25.3	3.3	2.68
LEAN CLAYS													
Portsmouth	CL	-	100	98	91	33.0	24.0	19.0	-	-	28.0	12.0	2.71
Crosby		-	100	98	91	58.0	41.0	31.0	-	-	36.5	16.8	2.78
Greenland		-	100	100	97	60.0	43.0	34.0	-	-	31.3	15.2	2.79
Yukon		-	100	100	100	67.0	37.0	29.0	-	-	28.0	3.6	2.74
Yukon		-	100	100	100	67.0	37.0	29.0	-	-	28.0	3.6	2.74
Yukon		-	100	100	100	67.0	37.0	29.0	-	-	28.0	3.6	2.74
Yukon		-	100	100	100	67.0	37.0	29.0	-	-	28.0	3.6	2.74
Yukon		-	100	100	100	67.0	37.0	29.0	-	-	28.0	3.6	2.74
LEAN CLAYS WITH ORGANICS													
Malad, Idaho	CL-OL	-	100	99	96	65.0	48.0	35.0	-	-	37.0	13.0	2.58
Malad, Idaho		-	100	99	96	65.0	48.0	35.0	-	-	37.0	13.0	2.58
Malad, Idaho		-	100	99	96	65.0	48.0	35.0	-	-	37.0	13.0	2.58
Malad, Idaho		-	100	99	96	65.0	48.0	35.0	-	-	37.0	13.0	2.58
FAT CLAYS													
Frederick	CH	-	100	99	74	61.0	52.0	43.0	-	-	55.0	37.0	2.38

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8) Avg.	Rate of Heave mm/day (8) Mos.	Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%	%				
127.2(d)	9.0	108	85	0.560	100	20.8	60.2	65.0	3.9	6.2	1.58	M-H
127.2(d)	9.0	112	88	0.507	100	18.8	41.9	49.0	3.0	4.3	1.43	M-H
133.1(d)	9.4	128	96	0.334	83	10.0	44.4	77.1	5.1	9.2	1.80	H-VL
121.0(d)	-	112	92	0.468	100	17.7	34.3	37.8	2.7	4.3	1.59	M-H
121.0(d)	-	111	91	0.491	100	18.6	38.1	42.8	3.2	4.0	1.25	H-M
121.0(d)	-	112	92	0.467	98	17.4	27.4	32.1	2.9	3.8	1.31	M
121.0(d)	-	112	92	0.472	100	17.8	57.1	103.3	5.8	8.0	1.38	H
106.7(c)	16.5	90	85	0.872	100	32.3	72.0	60.4	8.3	12.8	1.54	VH
106.7(c)	16.5	95	89	0.773	100	28.5	63.7	68.8	9.3	11.7	1.26	VH
106.7(c)	16.5	98	92	0.712	100	26.0	123.2	72.7	6.2	12.7	2.04	H-VH
106.7(c)	16.5	95	89	0.781	100	26.8	166.6	105.6	11.4	15.7	1.38	VH
106.7(c)	16.5	97	91	0.742	100	27.4	185.4	144.4	15.9	19.0	1.19	VH
127.6(d)	-	119	93	0.418	100	15.4	87.1	155.4	11.4	16.3	1.42	VH
133.8(d)	8.3	112	84	0.506	99	18.5	78.0	164.4	13.1	19.6	1.47	VH
133.8(d)	8.3	113	85	0.502	81	15.0	47.1	82.1	7.4	15.0	2.82	H-VH
106.7(c)	16.5	100	94	0.685	100	25.4	166.3	262.2	12.3	16.5	1.34	VH
106.7(c)	16.5	99	93	0.702	100	26.0	103.3	139.3	13.3	20.5	1.54	VH
106.7(c)	16.5	100	94	0.685	100	25.3	95.8	119.1	11.5	17.0	1.48	VH
109.9(d)	15.6	105	96	0.605	70	15.7	164.6	275.5	27.6	36.0	1.30	VH
109.9(d)	15.6	105	96	0.605	82	18.2	138.9	221.7	22.7	21.8	1.26	VH
109.9(d)	15.6	106	96	0.600	61	13.4	161.3	275.8	26.2	33.7	1.28	VH
109.9(d)	15.6	104	94	0.631	100	23.3	142.1	226.4	24.7	31.3	1.26	VH
112.5(d)	15.7	85	75	1.000	100	36.6	34.4	2.9	0.5	1.0	2.00	VL
112.5(d)	15.7	90	80	0.890	100	32.6	34.6	7.9	0.7	1.5	2.14	VL-L
112.5(d)	15.7	98	87	0.740	100	26.9	29.2	12.4	0.5	1.7	3.40	VL-L
101.6(d)	18.1	84	83	1.040	98	37.1	38.4	7.8	0.6	1.5	2.50	VL-L
101.6(d)	18.1	90	89	0.899	97	31.6	35.8	11.2	0.6	1.0	1.66	VL
101.6(d)	18.1	94	93	0.811	99	29.4	39.8	25.5	1.8	2.0	1.11	L
107.4(d)	17.1	94	88	0.702	96	25.0	65.5	124.0	4.5	8.7	1.93	H-VH
107.4(d)	17.1	98	91	0.703	100	26.2	65.8	81.8	7.4	8.7	1.76	H-VH
108.4(d)	17.1	97	91	0.717	100	26.8	82.1	102.1	8.0	9.7	1.21	VH
108.5(d)	14.8	99	91	0.695	86	22.4	30.1	10.4	0.7	1.2	1.71	VL-L
113.4(d)	-	113	100	0.474	92	16.3	38.0	47.1	4.0	4.8	1.20	H
119.3(a)	13.5	117	98	0.485	100	17.5	24.6	17.7	1.4	2.3	1.64	L-M
119.4(d)	15.0	116	97	0.518	100	18.3	30.1	26.8	2.2	5.3	2.40	M-M
121.4(d)	12.8	117	96	0.460	89	15.0	22.0	24.0	1.1	2.5	2.27	L-M
121.4(d)	12.8	118	97	0.448	94	15.4	33.0	45.7	3.8	5.3	1.39	M-M
121.4(d)	12.8	123	101	0.385	100	14.1	29.5	38.5	2.1	4.0	1.90	M
121.4(d)	12.8	120	98	0.424	100	15.5	29.1	34.3	1.8	3.7	2.06	L-M
121.4(d)	12.8	115	95	0.476	94	16.5	36.6	46.2	2.5	4.2	1.68	M-M
99.6	21.0(a)	99	99	0.630	100	24.4	31.4	20.9	3.4	4.0	1.18	M
99.6	21.0(a)	96	96	0.676	100	26.3	60.8	61.0	4.6	7.3	1.58	M
99.6	21.0(a)	98	98	0.644	100	25.0	42.5	42.3	4.1	5.2	1.26	M
99.6	21.0(a)	99	99	0.627	100	24.3	45.0	45.0	4.2	5.0	1.19	M
106.7	19.5(a)	105	98	0.715	86	21.2	38.4	39.0	0.8	1.7	2.12	VL-L

Table A-1. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

NOTES:

1. Data based on 6-inch molded specimens frozen under laboratory conditions of 85 percent or greater saturation before freezing, molded dry wt. - 95 percent or greater of applicable standard, penetration rate of 1/4 or 1/2 inch/day at 32 degrees, and free water at specimen base (38 degrees).

2. Soil classifications according to MIL-STD-619 (CE).

3. Gradation coefficients (MIL-STD-619 (CE)): $C_u = \frac{D_{60}}{D_{10}}$ and $C_c = \frac{(D_{30})^2}{(D_{60})\ (D_{10})}$

4. Atterberg limits on plastic materials only. Test on material passing No. 40 sieve only.

5. Natural soil maximum dry weight and optimum moisture for compaction test type: a) AASHTO T99 Method A, b) Providence vibrated density test, c) AASHTO T180 Method D, d) AASHTO T180 Method A, e) Harvard minature compaction.

6. Saturation percent at start of freezing test (drained for 24 hours).

7. Based on original frozen height.

8. Average rate of heave determined from maximum representative portion of heave versus time plot (minimum 5 consecutive days).

9. Maximum heave rate (average of 3 highest daily heave rates)/average heave rate (see Note 7).

10. Definition of classes by rate of heave (mm/day): N (negligible) 0-0.5, VL (very low) 0.5-1.0, L (low) 1.0-2.0, M (medium) 2.0-4.0, H (high) 4.0-8.0, VH (very high) above 8.0.

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Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi

The following table contains tests results on soil samples that did not meet the criteria of 95 percent dry weight or 85 percent moisture content.

Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1]

Material Source	Unified Soil Classification Symbol (2)	Maximum Size	SOIL GRADATION DATA (AS FROZEN) Percent Finer, mm						Coefficients (3)		PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4)		Specific Gravity
			4.76	0.42	0.074	0.02	0.01	0.005	C_u	C_c	LL	PI	
		in.											
SILTY GRAVELLY SANDS													
Koflavik	SW-SM	3/4	57	16	5.0	1.4	-	-	27.0	1.1			2.81
B.P.R. Alaska		1	68	12	5.6	2.9	2.3	1.8	10.0	1.0			2.75
Spokane		1-1/2	68	11	7.0	3.5	2.3	1.2	6.7	1.4			2.80
Minnesota		2	69	20	9.6	3.8	-	-	28.0	1.8			2.73
Stewart		2	68	26	9.1	4.0	2.9	1.8	31.0	1.1	19.3	4.3	2.70
Stewart	SW-SM	2	68	26	9.1	4.0	2.9	1.8	31.0	1.1	19.3	4.3	2.70
M.I.T.		1-1/2	70	29	9.7	4.4	3.2	2.5	24.0	1.2			2.70
Hutchinson's Pit		1	57	20	8.7	5.0	3.5	2.0	43.0	1.1			2.75
Hutchinson's Pit		1	57	20	8.7	5.0	3.5	2.0	43.0	1.1			2.75
Hutchinson's Pit		1	57	20	8.7	5.0	3.5	2.0	43.0	1.1			2.75
Loring		1/2	62	13	7.2	5.7	5.0	4.0	15.0	1.3			2.71
Rapid City		1-1/2	57	30	12.0	8.7	7.1	5.8	183.0	1.1	19.0	2.0	2.75
Afghanistan		2	58	23	8.2	3.7	2.3	1.8	48.0	1.2			2.71
Greenland	SP-SM	3/4	60	39	9.7	1.8	0.8	-	62.0	0.2			2.73
Fairchild		2	84	11	5.3	1.9	1.7	-	4.0	1.6			2.75
Minnesota		-	100	71	8.8	2.2	1.3	-	4.3	1.5			2.70
Volk Field		-	100	86	5.0	2.6	2.4	1.8	2.0	0.9			2.66
Indiana		-	100	100	6.3	2.6	2.2	1.7	1.9	1.0			2.65
Indiana		-	100	100	6.3	2.6	2.2	1.7	1.9	1.0			2.65
Indiana		-	100	100	6.3	2.6	2.2	1.7	1.9	1.0			2.65
Minot		1-1/2	73	11	5.2	2.7	2.2	1.6	8.1	0.9			2.73
Dow Field		3/4	66	18	6.0	2.8	1.7	1.0	15.0	0.9			2.72
Selfridge		1-1/2	74	25	6.9	3.2	2.7	1.8	15.0	0.6			2.70
Selfridge		1-1/2	77	27	7.1	3.3	3.0	2.6	13.0	0.7			2.70
Schenectady		3/4	99	84	10.0	3.3	3.0	2.0	3.4	1.8			2.68
Schenectady	SP-SM	3/4	99	84	10.0	3.3	3.0	2.0	3.4	1.8			2.68
Kinross		1-1/2	98	80	8.8	3.3	2.0	0.9	2.8	1.4			2.62
Kinross		-	100	82	9.0	3.4	2.0	0.9	2.8	1.4			2.62
Kinross		-	100	82	9.0	3.4	2.0	0.9	2.8	1.4			2.63
Hutchinson's Pit		2	56	17	6.0	3.5	2.4	-	28.0	0.7			2.74
Korea		2-1/2	58	28	9.4	3.5	2.1	1.4	111.0	0.3			2.61
Korea		2-1/2	56	28	9.4	3.5	2.1	1.4	111.0	0.3			2.61
Lincoln		1	66	22	6.5	3.9	2.7	2.0	17.0	0.9			2.65
Spokane		3/4	79	13	8.1	4.1	2.7	1.5	6.4	3.2			2.80
Spokane		3/4	79	13	8.1	4.1	2.7	1.5	6.4	3.2			2.30
Kinross		3/4	92	67	9.0	4.5	2.9	1.8	4.2	1.2			2.65
Kinross		3/4	92	67	9.0	4.5	2.9	1.8	4.2	1.2			2.65
Kinross		1-1/2	92	67	9.0	4.5	2.9	1.8	4.2	1.2			2.65
Project Blue Jay		3/4	71	46	10.0	4.5	4.0	1.8	20.0	0.3			2.70
Project Blue Jay		3/4	71	46	10.0	4.5	4.0	1.8	20.0	0.3			2.70
Tobyhanna		1-1/2	59	39	8.5	4.5	2.5	1.6	6.0	0.2			2.72
Lincoln		1	80	24	6.5	4.9	3.8	3.0	15.0	0.8			2.65
Lincoln		1	63	30	7.0	5.0	3.0	2.0	28.0	0.4			2.65
Lincoln		1	72	27	7.8	5.0	4.0	3.2	16.0	0.6			2.65
Cape Dyer		2	61	29	9.7	5.1	4.2	3.1	52.0	0.7			2.68
Afghanistan	SP-SM	1	71	32	11.9	5.5	3.9	2.8	-	-			2.73
West Virginia		1-1/2	57	33	10.0	5.6	4.5	-	81.0	0.3			2.70
Volk Field		2	94	83	10.0	5.6	5.0	3.6	3.0	1.5			2.62
Loring		1	65	14	8.0	7.1	6.2	4.6	260.0	34.0	24.0	6.0	2.71
Loring		1	88	17	10.0	8.2	7.2	5.8	20.0	4.9			2.72
CLAYEY SANDS													
Fargo	SC	3/4	98	33	17.0	9.5	7.5	5.5	50.0	5.2	30.7	10.5	2.70
Fargo		3/4	98	33	17.0	9.5	7.5	5.5	50.0	5.2	30.7	10.5	2.70
Project Blue Jay		3/4	73	55	35.0	23.0	20.0	15.5	500.0	1.7	24.7	8.1	2.70
Breed's Hill (EDT)		3/4	76	60	41.0	24.0	-	-	191.0	1.1	24.0	11.0	2.75
Westover		3	82	66	48.0	30.0	23.0	17.0	115.0	0.9	20.7	7.2	2.71
Minnesota		3/4	97	78	48.0	31.0	-	-	-	-	28.7	10.7	2.70
Project Blue Jay		3/4	80	58	44.0	35.0	31.0	22.0	310.0	0.1	18.6	9.2	2.75
Project Blue Jay		3/4	80	58	44.0	35.0	31.0	22.0	310.0	0.1	18.6	9.2	2.75

Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8) Avg.	Rate of Heave mm/day (8) Mos.	Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%					
112.0(b)	-	111	99	0.532	100	19.5	19.3	2.0	0.3	0.5	1.66	L
123.1(b)	-	117	95	0.467	93	15.8	21.6	15.7	1.2	1.8	1.50	L
-	-	128	> 95	0.365	100	13.0	15.8	13.6	1.1	2.0	1.82	L
135.6(d)	6.5	135	100	0.268	97	9.4	22.0	37.0	2.8	4.3	1.54	M-M
141.7(b)	-	139	98	0.214	100	8.6	18.2	27.9	4.4	6.0	1.35	H
141.7(b)	-	138	98	0.224	100	8.5	20.4	32.2	2.7	4.3	1.39	M-M
137.9(b)	-	131	95	0.285	97	10.2	20.7	21.9	1.2	2.0	1.66	L
143.3(c)	5.3	144	101	0.179	99	6.7	24.7	49.7	6.1	7.7	1.26	M
143.3(c)	5.3	141	98	0.221	87	7.0	37.0	81.3	4.8	5.8	1.20	M
143.3(c)	5.3	138	96	0.242	99	8.7	23.3	43.8	3.5	4.8	1.37	M-M
139.1(b)	-	135	97	0.256	98	9.2	24.7	37.4	3.3	4.7	1.42	M-M
-	-	137	> 95	0.253	98	8.9	13.9	16.4	1.7	2.5	1.47	L-M
146.7(b)	-	147	>100	0.150	100	5.4	16.4	31.3	3.7	5.3	1.43	M-M
138.0(d)	5.3	137	99	0.246	100	9.0	16.9	20.4	1.3	1.8	1.38	L
123.5(b)	-	121	98	0.421	100	15.3	17.9	10.8	0.9	1.5	1.66	VL-L
114.4(b)	-	114	100	0.473	100	16.8	16.0	2.4	0.2	0.5	2.50	L
115.6(b)	-	115	100	0.450	100	15.3	16.3	2.8	0.1	0.5	5.00	M
107.1(b)	-	109	102	0.516	100	19.3	16.7	0.7	0.1	0.5	5.00	M
107.1(b)	-	109	98	0.576	100	21.8	19.8	1.3	0.1	0.5	5.00	M
107.1(b)	-	109	102	0.514	100	19.4	20.5	2.3	0.4	0.5	1.25	M
130.5(b)	-	129	99	0.316	100	11.5	14.3	8.8	0.5-	1.0	2.00	VL
137.6(b)	-	133	97	0.278	100	10.7	21.8	27.6	1.8	3.3	1.83	L-M
126.8(b)	-	127	100	0.329	100	12.2	19.9	18.3	1.0	1.7	1.70	L
126.8(b)	-	127	100	0.329	100	12.2	20.7	18.0	1.2	2.2	1.83	L-M
113.0(b)	-	113	100	0.484	98	17.7	25.5	16.5	1.1	2.2	2.00	L-M
113.0(b)	-	112	99	0.487	100	18.2	26.2	17.5	1.0	2.0	2.00	L
109.0(b)	-	108	99	0.518	100	19.8	21.5	6.2	0.7	1.2	1.71	VL-L
109.0(b)	-	106	98	0.542	100	20.6	20.9	3.3	0.4	0.7	1.75	M-VL
109.0(b)	-	105	97	0.552	100	20.4	21.1	4.0	0.4	0.8	2.00	M-VL
141.0(b)	-	140	99	0.222	100	8.1	18.2	28.1	3.7	5.5	1.48	M
127.0(b)	-	126	100	0.268	96	9.6	13.0	46.2	2.2	3.5	1.59	M
127.0(b)	-	124	98	0.310	99	11.9	17.3	20.8	3.8	5.0	1.32	M-M
134.0(d)	-	134	100	0.238	100	9.0	13.7	14.0	0.8	1.4	1.75	VL-L
-	-	128	< 95	0.361	100	12.6	17.7	13.5	1.1	1.4	1.27	L
-	-	128	< 95	0.351	90	11.3	18.5	16.3	1.4	2.3	1.64	L-M
120.4(b)	-	115	95	0.438	100	16.5	19.3	8.2	0.8	1.7	2.12	VL-L
120.4(b)	-	119	98	0.396	100	14.9	31.1	36.5	2.7	3.7	1.37	M
120.4(b)	-	120	100	0.367	99	13.9	32.9	44.4	5.4	7.8	1.44	M
142.6(b)	-	138	97	0.215	100	8.0	25.8	29.0	3.1	4.5	1.45	MH
142.6(b)	-	137	96	0.230	100	8.5	37.8	69.4	3.2	5.8	1.81	MH
140.4(b)	-	134	96	0.280	100	9.9	20.2	21.8	1.5	2.3	1.53	L-M
133.1(b)	-	135	101	0.228	98	8.6	13.5	14.9	1.0	1.4	1.40	L
133.1(b)	-	137	103	0.212	100	8.0	12.7	15.8	1.0	1.4	1.40	L
133.1(b)	-	132	99	0.250	98	9.3	15.6	19.6	1.2	1.7	1.42	L
134.8(h)	-	130	97	0.289	94	10.1	24.1	37.3	2.1	3.3	1.57	M
143.2(b)	-	141	-	0.205	96	7.2	19.8	35.5	3.9	7.1	1.82	MH
129.1(b)	-	125	97	0.349	87	11.3	23.4	27.6	1.8	3.3	1.83	L-M
121.6(b)	-	120	97	0.364	100	13.9	31.2	39.2	2.3	3.2	1.39	M
139.1(b)	-	135	97	0.254	93	8.6	14.6	17.4	2.0	3.8	1.90	M
139.1(b)	-	135	97	0.259	99	8.5	31.6	59.8	2.0	4.2	2.10	MH
127.2(d)	9.0	123	97	0.374	100	13.9	21.5	18.7	1.5	2.7	1.80	L-M
127.2(d)	9.0	118	93	0.424	100	15.7	32.8	42.4	3.3	4.5	1.36	M-H
133.1(c)	9.8	134	101	0.272	100	8.0	17.9	25.3	2.2	2.8	1.27	M
138.7(c)	7.2	139	100	0.237	94	8.0	10.5	7.3	0.6	1.0	1.66	VL
-	-	130	> 95	0.297	100	10.9	22.3	31.5	3.1	4.6	1.48	M-M
-	-	114	> 95	0.478	91	16.2	32.0	38.6	1.8	2.5	1.38	L-M
139.6(c)	7.0	139	100	0.234	100	8.5	17.3	26.3	2.2	3.8	1.72	M
139.6(c)	7.0	132	95	0.301	100	10.9	34.7	83.0	4.6	8.3	1.80	H-VM

Table A-2. Summary of Supplementary Frost-Susceptibility tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

Material Source	Unified Soil Classification Symbol (2)	Maximum Size	SOIL GRADATION DATA (AS FROZEN) Percent Finer, mm						Coefficients (3)		PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4)		Specific Gravity
		in.	4.76	0.42	0.074	0.02	0.01	0.005	C_u	C_c	LL	PI	
SILTS AND SANDY SILTS													
Goose Bay	ML	-	100	99	54	6.0	-	-	-	-			2.74
Westover		-	100	91	53	13.0	-	-	-	-			2.69
Labrador		-	100	100	95	27.0	10	-	-	-	26.0	3.0	2.77
Labrador		-	100	100	95	27.0	10	-	-	-	26.0	3.0	2.77
Valparaiso		-	100	100	99	54.0	25	15.0	-	-	23.7	4.0	2.72
Valparaiso		-	100	100	99	54.0	25	15.0	-	-	23.7	4.0	2.72
Hanover		-	100	100	98	35.0	18	8.0	-	-	29.5	12.7	2.75
Dow Field		3/4	95	91	87	54.0	40	28.0	-	-	32.8	8.1	2.66
Minnesota	ML	3/4	97	92	83	63.0	44	28.0	-	-	36.0	5.1	2.6
New Hampshire		-	100	99	97	60.0	22	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22	10.0	-	-	26.6	0.1	2.70
New Hampshire		-	100	99	97	60.0	22	10.0	-	-	26.6	0.1	2.70
CLAYEY SILTS													
Yukon	ML-CL	-	100	100	98	60.0	37	22.0	-	-	25.3	5.8	2.73
New Hampshire		-	100	100	86	61.0	34	14.0	-	-	24.1	5.9	2.76
New Hampshire		-	100	96	90	67.0	36	16.0	-	-	25.0	6.0	2.70
New Hampshire		-	100	93	85	73.0	47	23.0	-	-	26.0	5.0	2.70
New Hampshire		-	100	100	99	73.0	37	13.0	-	-	23.7	6.0	2.70
New Hampshire		-	100	100	99	73.0	37	13.0	-	-	23.7	6.0	2.70
SILTS AND ORGANICS													
Ladd Field	ML-OL	-	100	100	91	38.0	13	6.0	-	-	31.6	0.0	2.75
Fairbanks		-	100	100	97	42.0	22	12.0	-	-	32.6	6.2	2.67
Fairbanks		-	100	100	97	42.0	22	12.0	-	-	32.6	6.2	2.67
GRAVELLY AND SANDY CLAYS													
Dow Field	CL	3/4	82	70	62	40.0	31	23.0	-	-	25.6	7.9	2.73
Fort Belvoir		3/4	95	87	64	43.0	36	30.0	-	-	41.0	18.0	2.70
East Boston		3/4	84	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	84	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	84	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston	CL	3/4	84	72	56	43.0	35	25.0	-	-	23.0	7.0	2.75
Fort Belvoir		1/4	98	90	61	49.0	41	34.0	-	-	43.8	20.3	2.73
Fort Belvoir		1/4	98	90	61	49.0	41	34.0	-	-	43.8	20.3	2.73
Fort Belvoir		1/4	98	90	61	49.0	41	34.0	-	-	43.8	20.3	2.73
Fort Belvoir		1/4	98	98	61	49.0	41	34.0	-	-	43.8	20.3	2.73
Portsmouth		-	100	100	96	49.0	38	30.0	-	-	30.0	11.7	2.73
East Boston		3/4	86	73	57	49.0	42	30.0	-	-	21.0	7.0	2.76
East Boston		3/4	86	73	57	49.0	42	30.0	-	-	21.0	7.0	2.76
East Boston		3/4	86	73	57	49.0	42	30.0	-	-	21.0	7.0	2.76
East Boston		3/4	86	73	57	49.0	42	30.0	-	-	21.0	7.0	2.76
Dow Field		3/4	96	93	86	51.0	38	27.0	-	-	26.4	8.4	2.69
Dow Field		3/4	85	82	78	53.0	40	30.0	-	-	27.6	9.5	2.73
AASHTO		1-1/4	95	87	74	58.0	48	38.0	-	-	27.6	11.9	2.74
AASHTO		1-1/4	95	87	74	58.0	48	38.0	-	-	27.3	11.9	2.74
AASHTO		1-1/4	95	87	74	58.0	48	38.0	-	-	27.3	11.9	2.74
AASHTO		1-1/4	95	87	74	58.0	48	38.0	-	-	27.3	11.0	2.74
AASHTO		1-1/4	95	87	74	58.0	48	38.0	-	-	27.3	11.0	2.74
Bong		3/4	97	90	80	60.0	48	36.0	-	-	28.6	12.6	2.80
Bong		3/4	97	90	80	60.0	48	36.0	-	-	28.6	12.6	2.80
Bong		3/4	97	91	81	61.0	50	35.0	-	-	29.6	13.6	2.80
Dow Field		1-1/2	94	88	80	64.0	52	37.0	-	-	30.0	12.0	2.71
Dow Field		1-1/2	94	88	80	64.0	52	37.0	-	-	30.0	12.0	2.71
East Boston	CL	3/4	86	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	86	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	86	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	86	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	86	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
East Boston		3/4	86	72	56	43.0	35	25.0	-	-	23.0	7.0	2.76
Portsmouth		-	100	100	92	46.0	36	30.0	-	-	30.0	11.7	2.73
Portsmouth		-	100	100	92	46.0	36	30.0	-	-	30.0	11.7	2.73
East Boston		3/4	86	72	56	49.0	42	30.0	-	-	21.0	7.0	2.76
East Boston		3/4	86	72	56	49.0	42	30.0	-	-	21.0	7.0	2.76
AASHO		1-1/2	95	88	75	58.0	49	37.0	-	-	27.3	11.9	2.74

Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight*	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8)		Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%	%	Avg.	Mos.		
102.0(c)	7.9	102	100	0.688	100	24.4	25.6	7.0	0.3	1.0	3.33	M-VL
113.6(d)	11.0	112	99	0.484	100	18.0	26.0	17.3	1.0	1.0	1.60	L
102.0(d)	18.1	106	104	0.626	100	22.7	27.3	11.4	1.2	1.5	1.25	L
102.0(d)	18.1	103	102	0.668	94	22.4	30.0	16.3	1.5	2.3	1.53	L-M
115.8(d)	13.5	113	98	0.601	98	18.4	62.1	95.3	9.8	11.5	1.17	VH
115.8(d)	13.5	113	98	0.601	100	18.0	65.5	100.0	10.0	11.9	1.33	VH
103.6(d)	16.9	101	96	0.695	100	24.8	19.0	105.6	14.1	16.8	1.19	VH
107.1(c)	-	104	98	0.500	100	22.2	136.8	104.0	13.0	23.3	1.68	VH
-	-	101	95	0.611	99	23.0	50.6	84.6	3.5	5.8	1.66	M-H
106.7(c)	16.5	106	90	0.580	100	21.7	79.6	126.2	15.9	20.7	1.30	VH
106.7(c)	16.5	104	98	0.618	100	22.8	120.7	130.1	15.9	18.0	1.13	VH
106.7(c)	16.5	108	101	0.567	100	20.9	99.9	190.6	26.0	28.3	1.08	VH
106.7(c)	16.5	105	98	0.611	100	22.6	116.7	239.2	12.8	19.7	1.54	VH
124.5(d)	11.5	123	99	0.389	100	14.2	28.9	37.0	2.2	3.5	1.51	M
106.7(c)	16.5	105	98	0.643	88	20.5	78.1	150.2	7.9	15.8	2.00	M-VH
106.7(c)	16.5	101	95	0.662	100	24.5	84.6	117.6	14.0	18.3	1.30	VH
106.7(c)	16.5	101	95	0.674	100	25.0	86.8	235.3	14.0	15.5	1.10	VH
110.1(c)	14.7	107	97	0.577	99	21.2	42.4	50.8	3.7	4.5	1.22	M-H
110.1(c)	14.7	106	96	0.596	100	22.0	36.4	29.8	4.0	5.3	1.32	H
101.6(d)	18.1	98	97	0.737	100	26.8	45.7	36.5	3.1	4.0	1.20	M
107.4(c)	17.1	101	95	0.646	100	24.2	112.6	223.6	11.3	14.0	1.24	VH
107.4(c)	17.1	111	103	0.505	100	18.9	105.7	281.2	11.5	13.7	1.19	VH
-	-	133	95	0.352	100	12.8	42.7	73.0	4.8	10.3	2.14	M-VH
114.9(a)	15.6	115	100	0.468	94	16.3	25.1	25.0	1.3	2.0	1.54	L
130.8(d)	-	126	96	0.371	100	13.4	46.5	95.3	6.5	10.5	1.62	H-VH
130.8(d)	-	130	99	0.324	100	11.7	30.2	47.7	4.0	5.5	1.38	H
130.8(d)	-	125	96	0.374	100	13.6	22.9	122.9	7.0	11.1	1.58	H-VH
130.8(d)	-	130	99	0.328	100	11.0	34.0	81.1	6.5	7.5	1.15	H
114.9(a)	15.6	110	96	0.536	100	19.8	81.6	188.4	7.7	12.0	1.56	VH
114.9(a)	15.6	117	102	0.456	90	15.0	22.3	18.2	1.6	3.7	2.46	L-M
114.9(a)	15.6	113	98	0.504	100	18.5	27.4	22.1	1.3	3.0	2.30	L-M
114.9(a)	15.6	118	103	0.441	100	16.2	27.0	27.6	2.2	3.2	1.45	M
110.3(a)	17.7	109	99	0.569	95	10.8	60.7	112.7	4.5	12.8	2.84	H-VH
130.8(d)	-	129	98	0.336	100	12.2	37.4	72.5	7.8	12.7	1.62	H-VH
130.8(d)	-	130	99	0.328	100	11.9	29.9	48.3	7.3	37.2	1.2	H-VH
130.8(d)	-	129	98	0.336	100	12.2	32.0	61.2	8.0	10.6	1.31	VH
130.8(d)	-	131	100	0.317	100	11.5	18.3	22.8	4.6	5.7	1.24	M
119.8(d)	14.0	118	98	0.424	100	15.7	49.1	67.0	6.2	10.7	1.72	H-VH
119.8(d)	14.0	119	99	0.429	100	15.8	66.0	125.0	6.6	11.0	1.66	M-VH
121.0(a)	13.5	117	97	0.467	100	17.2	26.4	28.4	2.3	4.3	1.86	V-M
121.0(a)	13.5	120	99	0.420	100	15.5	20.2	17.1	1.3	2.0	1.54	L
121.0(a)	13.5	125	103	0.367	100	13.5	18.6	13.9	1.1	2.3	2.03	L-M
121.0(a)	13.5	119	98	0.442	100	16.3	26.2	27.0	2.8	3.8	1.36	M
121.0(a)	13.5	126	104	0.360	100	13.3	18.0	10.1	1.2	1.3	1.08	L
128.8(c)	-	125	98	0.395	96	13.5	16.1	16.1	1.5	1.7	1.13	L
128.8(c)	-	125	98	0.403	100	14.5	17.7	17.4	1.2	1.7	1.42	L
126.8(c)	-	126	98	0.389	97	13.6	16.7	16.7	1.4	1.5	1.07	L
119.8(d)	14.0	117	98	0.448	100	16.4	69.7	124.3	10.1	12.0	1.20	VH
119.8(d)	14.0	118	98	0.431	100	16.1	42.4	70.7	3.3	3.8	1.15	M
130.8(d)	-	110	84	0.565	100	20.5	76.9	109.1	7.7	10.7	1.38	H-VH
130.8(d)	-	120	91	0.435	100	15.8	122.2	145.0	9.8	12.7	1.30	VH
130.8(d)	-	110	84	0.565	100	20.5	65.8	42.2	6.8	10.2	1.50	H-VH
130.8(d)	-	120	91	0.435	100	15.8	84.1	101.8	8.2	12.2	1.48	VH
130.8(d)	-	120	91	0.430	87	13.6	49.5	45.7	2.4	3.2	1.33	M
130.8(d)	-	110	84	0.561	88	17.8	47.4	27.4	1.9	2.8	1.47	L-M
110.3(c)	17.3	96	-	0.772	98	27.7	62.2	95.3	4.2	7.0	1.66	H
110.3(c)	17.3	95	-	0.798	95	27.7	73.3	114.9	4.1	8.0	1.95	H
130.8(d)	-	120	91	0.433	100	15.7	60.4	96.2	4.1	9.8	2.39	H-VH
130.8(d)	-	110	84	0.561	100	20.3	56.0	70.0	2.6	7.3	2.80	M-H
121.0(a)	13.5	110	91	0.553	100	20.3	90.2	156.8	7.2	11.3	1.56	M-VH

Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

Material Source	Unified Soil Classification Symbol (2)	Maximum Size	SOIL GRADATION DATA (AS FROZEN) Percent Finer, mm						Coefficients (3)		PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4)		Specific Gravity
		in.	4.76	0.42	0.074	0.02	0.01	0.005	C_u	C_c	LL	PI	
LEAN CLAYS													
Greenland	CL	-	100	100	97	60	43	34	-	-	36.5	16.3	2.78
Volk Field		-	100	100	93	77	70	58	-	-	45.0	24.4	2.75
Searsport		-	100	100	100	80	69	49	-	-	36.5	17.9	2.77
Searsport		-	100	100	100	80	69	49	-	-	36.5	17.9	2.77
Searsport		-	100	100	100	80	69	49	-	-	36.5	17.9	2.77
Searsport		-	100	100	100	80	69	49	-	-	36.5	17.9	2.77
Searsport		-	100	100	100	80	69	49	-	-	36.5	17.9	2.77
Searsport		-	100	100	100	80	69	49	-	-	36.5	17.9	2.77
Boston Blue C		-	100	100	100	84	74	63	-	-	43.3	21.6	2.72
Boston Blue C		-	100	100	100	84	74	63	-	-	43.3	21.6	2.72
Dow		-	100	100	100	89	75	57	-	-	33.8	16.4	2.79
Dow		-	100	100	100	89	75	57	-	-	33.8	16.4	2.79
Dow		-	100	100	100	89	75	57	-	-	33.8	16.4	2.79
Dow		-	100	100	100	89	75	57	-	-	33.8	16.4	2.79
Boston Blue C		-	100	100	99	90	81	72	-	-	47.3	27.4	2.72
Boston Blue C		-	100	100	99	90	81	72	-	-	47.3	27.4	2.72
Boston Blue C		-	100	100	99	90	81	72	-	-	47.3	27.4	2.72
Boston Blue C		-	100	100	99	90	81	72	-	-	47.3	27.4	2.72
LEAN CLAYS WITH ORGANICS													
Malad, Idaho	CL-OL	-	100	99	96	65	48	35	-	-	36.9	13.3	2.58
Malad, Idaho		-	100	99	96	65	48	35	-	-	36.9	13.3	2.58
Malad, Idaho		-	100	99	96	65	48	35	-	-	36.9	13.3	2.58
Malad, Idaho		-	100	99	96	65	48	35	-	-	36.9	13.3	2.58
Malad, Idaho		-	100	99	96	65	48	35	-	-	36.9	13.3	2.58
Malad, Idaho		-	100	99	96	65	48	35	-	-	36.9	13.3	2.58
FAT CLAYS													
Volk Field	CH	-	100	98	78	68	65	59	-	-	55.5	38.0	2.76
Boston Blue C		-	100	100	100	94	88	81	-	-	52.7	26.1	2.78
Boston Blue C		-	100	100	100	94	88	81	-	-	52.7	26.1	2.78
Niagara		-	100	100	100	94	92	86	-	-	59.3	37.0	2.79
Niagara		-	100	100	100	96	95	91	-	-	60.0	37.4	2.79
Niagara		-	100	100	100	96	95	91	-	-	60.0	37.4	2.79
FAT CLAYS WITH ORGANICS													
Fargo	CH-OH	-	100	100	98	86	76	64	-	-	67.8	45.8	2.76
Fargo		-	100	100	98	86	76	64	-	-	67.3	45.3	2.76

Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8) Avg.	Rate of Heave mm/day (8) Mos.	Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%	%				
119.4(c)	15.0	92	77	0.930	99	31.3	52.8	41.3	2.9	5.3	1.82	M-H
-	-	101	-	0.683	100	24.8	28.5	19.3	1.0	1.5	1.50	L
-	-	99	-	0.742	96	25.6	214.1	182.2	8.6	12.8	1.48	VH
-	-	99	-	0.753	100	27.2	69.0	131.3	4.7	6.7	1.43	H
-	-	96	-	0.804	93	27.0	46.7	47.2	2.1	3.8	1.80	M
-	-	96	-	0.806	94	27.3	127.3	240.3	8.4	14.0	1.66	VH
-	-	98	-	0.755	98	27.3	88.5	155.2	6.2	7.7	1.24	H
-	-	98	-	0.755	98	26.8	47.5	38.6	2.5	3.7	1.48	H
106.2(c)	20.2	82	-	1.083	94	37.3	60.4	38.4	4.6	5.3	1.15	H
106.2(c)	20.2	79	-	1.162	100	42.5	107.6	141.8	12.6	17.8	1.41	VH
117.0(d)	-	100	85	0.739	87	23.0	115.4	173.4	15.4	21.2	1.38	VH
117.0(d)	-	103	88	0.684	94	23.0	109.2	188.8	19.8	22.8	1.15	VH
117.0(d)	-	105	90	0.660	92	21.8	54.3	67.7	8.6	11.0	1.28	VH
117.0(d)	-	102	87	0.706	93	23.4	87.3	127.8	13.3	17.8	1.54	VH
106.2(c)	20.2	80	-	1.197	97	41.3	124.7	83.3	8.1	11.2	1.38	VH
106.2(c)	20.2	80	-	1.186	98	41.2	124.2	130.8	9.5	15.7	1.65	VH
106.2(c)	20.2	78	-	1.245	98	43.2	96.5	78.1	8.9	12.0	1.34	VH
106.2(c)	20.2	80	-	1.200	100	42.7	93.1	84.7	7.9	11.7	1.48	H-VH
99.6(a)	21.0	92	92	0.745	100	28.9	53.2	63.3	5.4	6.8	1.26	H
99.6(a)	21.0	90	90	0.790	100	30.6	56.0	58.6	5.1	6.3	1.24	H
99.6(a)	21.0	80	80	1.012	100	39.7	94.4	110.7	6.0	9.5	1.58	H-VH
99.6(a)	21.0	84	84	0.913	99	35.7	78.6	90.5	5.2	8.7	1.67	H-VH
99.6(a)	21.0	88	88	0.828	100	32.4	99.1	116.1	5.8	9.2	1.58	H-VH
99.6(a)	21.0	90	90	0.788	100	30.3	101.6	129.9	6.5	9.7	1.49	H-VH
-	-	108	-	0.592	100	21.3	21.3	5.8	0.4	0.5	1.25	H
106.2(c)	20.2	85	<95	1.031	97	36.1	101.8	111.8	4.1	8.3	2.02	H-VH
106.2(c)	20.2	87	<95	0.989	100	35.3	61.2	58.9	2.4	4.8	2.00	M-H
-	-	95	88	0.835	95	29.8	43.7	43.9	2.4	3.0	1.25	M
-	-	93	86	0.874	100	31.4	41.6	35.7	1.5	2.3	1.53	L-M
-	-	94	87	0.845	100	30.4	-	36.8	1.5	2.8	1.86	L-M
-	-	89	<95	0.988	100	35.7	44.5	18.4	1.0	2.0	2.00	L
-	-	89	<95	0.988	100	35.7	48.0	24.0	1.5	2.0	1.33	L

Table A-2. Summary of Supplementary Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.5 psi[1] (Cont.)

NOTES:

1. Data based on 6-inch molded specimens frozen under laboratory conditions of penetration rate of 1/4 to 1/2 inch/day at 32 degrees and free water at specimen base (38 degrees).

2. Soil classifications according to MIL-STD-619 (CE).

3. Gradation coefficients (MIL-STD-619 (CE)):

$$C_u = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_c = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$$

4. Atterberg limits on plastic materials only. Tests on material passing No. 40 sieve only.

5. Natural soil maximum dry weight and optimum moisture for compaction test type a) AASHTO T99 Method A; b) Providence vibrated density test; c) AASHTO T180 Method D; d) AASHTO T180 Method A; e) Harvard minature compaction.

6. Saturation percent at start of freezing test (drained for 24 hours).

7. Based on original frozen height.

8. Average rate of heave determined from maximum representative portion of heave versus time plot (minimum 5 consecutive days).

9. Maximum heave rate (average of 3 highest daily heave rates)/ average heave rate (see Note 7).

10. Definition of classes by rate of heave (mm/day): N (negligible) 0-0.5; VL (very low) 0.5-1.0; L (low) 1.0-2.0; M (medium) 2.0-4.0; H (high) 4.0-8.0; VH (very high) above 8.0.

U.S. Army Corps of Engineers

Table A-3. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.073 psi

The following table contains data on soil samples tested at lower load pressures.

Table A-3. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.073 psi[1]

Material Source	Unified Soil Classification Symbol (2)	Maximum Size	SOIL GRADATION DATA (AS FROZEN) Percent Finer, mm						Coefficients (3)		PHYSICAL PROPERTIES OF BASIC SOIL Atterberg Limits (4)		Specific Gravity
		in.	4.76	0.42	0.074	0.02	0.01	0.005	C_u	C_c	LL	PI	
SANDY GRAVELS													
Alaska Highway	GW	2	40	10	3.7	1.9	1.5	0.9	22.0	1.6	-	-	2.64
SILTY SANDY GRAVELS													
Alaska Highway	GP-GM	2	27	10	5.2	3.1	2.0	1.2	40.0	4.7	38.6	2.7	2.73
Alaska Highway	GW-GM	2	44	16	7.2	5.4	3.8	2.4	67.0	2.2	38.6	2.7	2.73
Alaska Highway	GP-GM	2	34	18	11.0	6.2	4.2	2.7	440.0	3.6	25.7	3.6	2.72
Alaska Highway	GP-GM	2	37	20	12.0	8.5	6.5	5.1	310.0	3.1	25.7	3.6	2.70
SILTY GRAVELS													
Ball Mountain Till	GM	2	91	35	18.0	7.0	-	-	250.0	0.3	-	-	2.81
GRAVELLY SANDS													
Alaska Highway	SW	2	53	13	3.8	1.8	1.4	0.9	20.0	1.0	-	-	2.65
Alaska Highway	SC	-	100	100	33.0	2.5	-	-	1.6	1.0	-	-	2.79
Alaska Highway		-	100	100	33.0	2.5	-	-	1.6	1.0	-	-	2.79
CLAYEY SANDS													
Till	SM-SC	3/4	84	65	49.7	36.0	30.0	21.0	225.0	1.0	21.1	6.0	2.72
CLAYEY SILTS													
Valparaiso, Indiana	ML	-	100	100	99.0	54.0	25.0	15.0	-	-	23.7	4.0	2.72
Silt		-	100	100	99.0	54.0	25.0	15.0	-	-	23.7	4.0	2.72
New Hampshire Silt		-	100	99	97.0	60.0	22.0	10.0	-	-	26.6	0.1	2.70
SILTS													
Ladd Field Silt	ML-CL	-	100	100	91.0	38.0	13.0	6.0	-	-	31.6	0.2	2.75
Fairbanks Silt		-	100	100	97.0	42.0	22.0	12.0	-	-	32.6	6.2	2.67
SANDY CLAYS													
East Boston Till	CL	3/4	84	72	56.0	43.0	35.0	25.0	-	-	23.0	7.0	2.76
AASHTO Road Test		1-1/2	95	87	74.0	58.0	48.0	38.0	-	-	27.3	11.9	2.74
AASHTO Road Test		1-1/2	95	87	74.0	58.0	48.0	38.0	-	-	27.3	11.9	2.74
AASHTO Road Test		1-1/2	95	87	74.0	58.0	48.0	38.0	-	-	27.3	11.9	2.74
Yukon Silt		-	100	100	100.0	67.0	37.0	29.0	-	-	28.0	8.6	2.74
Yukon Silt		-	100	100	100.0	67.0	37.0	29.0	-	-	28.0	8.6	2.74

NOTES:

1. Data based on 6-inch molded specimens frozen under laboratory conditions of penetration rate of 1/4 to 1/2 inch/day at 32 degrees and free water at specimen base (38 degrees).

2. Soil classifications according to MIL-STD-619 (CE).

3. Gradation coefficients (MIL-STD-619 (CE)):

$$C_u = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_c = \frac{(D_{30})^2}{(D_{60}) \times (D_{10})}$$

4. Atterberg limits on plastic materials only. Tests on material passing No. 40 sieve only.

5. Natural soil maximum dry weight and optimum moisture for compaction test type a) AASHTO T99 Method A, b) Providence vibrated density test, c) AASHTO T180 Method D, d) AASHTO T180 Method A, e) Harvard miniature compaction.

6. Saturation percent at start of freezing test (drained for 24 hours).

Table A.3. Summary of Frost-Susceptibility Tests on Natural Soils - Open System Nominal Load Pressure 0.073 psi[1] (Cont.)

PHYSICAL PROPERTIES OF BASIC SOIL		SPECIMEN DATA (AS MOLDED)				FREEZING TEST DATA						
Compaction Data (5)						Avg. Water Content						
Maximum Dry Unit Weight	Optimum Moisture Content	Dry Unit Weight	Degree of Compaction	Void Ratio	G. at Start of Test (6)	Before Test	After Test	Total Heave (7)	Rate of Heave mm/day (8)		Heave Rate Var. Index (9)	Frost Susc. Class (10)
pcf	%	pcf	%	%	%	%	%	%	Avg.	Mos.		
133.4(b)	-	132	99	0.249	100	9.4	11.6	1.9	0.9	1.3	1.45	VL-L
123.6(b)	-	121	98	0.401	100	14.7	18.3	17.6	1.1	2.5	2.27	L-M
118.5(b)	-	121	102	0.401	100	10.6	20.8	17.6	2.4	3.8	1.65	M
127.0(b)	-	126	99	0.336	77	9.5	20.8	30.5	1.9	3.7	1.95	L-M
126.7(b)	-	128	101	0.315	94	11.0	19.6	29.7	1.9	3.3	1.74	L-M
-	-	147	-	0.195	100	5.6	11.7	17.4	1.4	3.8	2.71	L-M
132.9(b)	-	129	97	0.277	100	10.5	12.2	10.2	1.0	1.7	1.70	L
106.4(b)	-	112	105	0.551	92	18.2	32.8	20.0	2.0	3.0	1.50	M
106.4(b)	-	111	105	0.565	100	20.3	29.3	11.1	1.1	1.7	1.54	L
133.8(d)	8.3	133	99	0.279	100	10.2	17.1	24.7	1.4	2.7	1.93	L-M
115.8(d)	13.5	112	96	-	72	13.5	53.1	81.4	6.8	11.0	1.62	H-VH
115.8(d)	13.5	112	96	-	94	17.7	45.2	142.3	5.6	11.5	1.98	H-VH
106.7(c)	16.5	105	99	0.609	100	22.5	105.8	155.1	11.7	17.8	1.52	VH
101.6(d)	16.1	99	92	0.724	100	26.4	66.1	93.2	7.1	9.5	1.34	H-VH
107.4(c)	17.1	102	95	0.602	100	24.8	61.0	55.7	5.5	11.3	2.05	H-VH
130.8(d)	-	125	96	0.380	100	13.8	63.9	130.1	11.5	14.0	1.28	VH
121.0(a)	13.5	116	96	0.481	100	17.6	31.2	34.9	3.1	3.3	1.06	M
121.0(a)	13.5	114	94	0.497	100	11.2	29.0	31.4	3.5	4.3	1.03	M-H
121.0(a)	13.5	122	105	0.414	100	15.3	43.8	72.7	2.5	3.7	1.48	M
121.4(d)	12.8	120	99	0.443	91	15.3	26.2	33.1	1.6	2.8	1.75	L-H
121.4(d)	12.8	118	97	0.775	99	15.1	27.2	24.3	4.2	4.5	1.07	H

7. Based on original frozen height.

8. Average rate of heave determined from maximum representative portion of heave versus time plot (minimum 5 Consecutive days).

9. Maximum heave rate (average of 3 highest daily heave rates)/average heave rate (see Note 7).

10. Definition of classes by rate of heave (mm/day): N (negligible) 0-0.5, VL (very low) 0.5-1.0, L (low) 1.0-2.0, M (medium) 2.0-4.0, H (high) 4.0-8.0, VH (very high) above 8.0.

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