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Study of Reverse Torque Ratio in the Helical Probe Test

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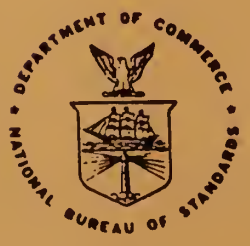

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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

A helical test probe, developed by the National Bureau of Standards for shallow soil exploration does not extract soil samples from the ground. A study was therefore conducted to determine whether the ratio of the torque required to extract the Helical Test Probe to the torque required to advance the probe (the reverse torque ratio) can be used to determine the average grain size (D_{50}) of the soil. On the basis of 274 test points in sandy, silty, and clayey soils, it was concluded that the reverse torque ratio decreases with increasing average grain size. The relation between grain size and reverse torque ratio is apparently not sensitive to the magnitude of the torque required to advance the probe.

Key Words:Construction supervision; field test equipment; helical augers; in situ measurements; penetration tests; soil investigation; test procedures.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The National Bureau of Standards developed a helical test probe for shallow soil exploration. In a previous study [1] the results of helical probe tests (HPT) were correlated with other commonly used in-situ tests, including the Standard Penetration test (SPT), the Cone Penetration test (CPT), and the flat plate dilatometer test (DMT), and it was shown that the results obtained in these latter tests can be predicted on the basis of the HPT torque. It was also shown that the HPT test can be used to predict the dry density of compacted soils.

For shallow soil exploration, the HPT test is much more practical and economical than other in-situ tests. However, when compared with the SPT test, it has the disadvantage of not retrieving a soil sample. Thus, if it is important to determine the soil type, soil samples have to be retrieved separately. The CPT test also does not retrieve samples, but the soil type can be infered from the correlation between the tip resistance and the side friction. A similar parameter could probably also be derived from the HPT test. When the helix is advanced, the torque needed is a measure of the force required to penetrate the soil, expand a cavity for the helix within the soil, and overcome the frictional resistance of the sides of the helix. When the helix is retracted, the torque required to retract the helix is solely a measure of the frictional resistance of the side of the helix.

The ratio between the torque required to retract the helix and the torque required to advance the helix is herein defined as the "Reverse Torque Ratio" (R). This report is part of a study which has the objective of determining whether the reverse torque ratio can be correlated with the soil type and used to characterize the soil without retrieving soil samples.

2. TEST RESULTS

A total of 274 reverse torque measurements were performed in 32 separate test holes. Of these, 179 measurements in 20 borings were in residual silts, 53 measurements in 6 borings were in sands, and 42 measurements in 6 borings were in clays.

Average values for the test results are summarized in Table 1. In the table, the soil type in Column 2 is defined in accordance with ASTM D2487 [2]; "n" in column 3 is the number of tests; t_{12} in column 4 is the downward torque measured with the Y12 (3/4 inch diameter) test probe (refer to [1]); TR_{12} in column 5 is the reverse torque taken in the same location as the torque in column 4 (the probe was turned 180^{o} in the counterclockwise direction); column 6 shows the reverse torque ratio , R, in percent [(TR/t) x 100]; column 7 shows data on SPT blowcount, N, (if available); column 8 shows CPT tip resistance, q_c, (if available); column 9 shows relative compaction data, RC, (ASTM D 1556 [3]),(if available); column 10 shows dry density, γ_d; and column 11 shows grain size D_{50}, below which 50% of the sample by dry weight is smaller.

Tables 2 to 9 present the detailed test results. Tables 2 and 3 are for the Groveton, VA site (CH), tables 4 and 5 are for the McLean, VA site (ML), tables 6 and 7 are for the NBS site (ML), and tables 8 and 9 are for the Kingstowne VA site (SP).

For each site the test results are given in two tables. The first table shows the test results for each boring. The downward arrows signify downward torque, the upward arrows upward torque, and R is the reverse torque ratio. The average reverse torque ratio, R, and sample standard deviation, sR, for each depth range for all the borings are listed in the last column to the right. The average of the torques, reverse torques, and reverse torque ratios for each boring , as well as the sample standard deviation

Table 1. Average Values of Reverse Torque Test Results

Location	Soil Type	n	T_p in-lb	TR_{12} in-lb	R %	SPT N blow/ft	CPT q_c kg/cm	RC %	Γ_d lb/ft	D_{50} mm
Groveton, VA	CH	42	30.6	17.5	57.2	6.7				0.008
McLean, VA	ML	126	51.6	23.9	46.3	8.6	14.9			0.030
NBS, MD	ML	53	66.0	25.4	38.5					0.046
Kingstowne, VA	SP	53	97.2	37.9	39.0			95 -100	113	0.600

CH - High Plasticity Clay
ML - Low Plasticity Silt
SP - Poorly Graded Sand

Table 2. Reverse Torque Ratios for the Groveton, VA Site

Depth (ft)	1			2			3			4			5			6			Average			
	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	$\bar{R}$	sR
1.5/2.0	25	13	52.0	15	14	93.3	12	6	50.0	16	7	43.8	18	7	38.9	16	8	50.0	17.0	9.2	54.7	19.5
2.0/2.5	30	14	46.7	19	12	63.2	27	10	37.0	24	15	62.5	19	11	57.9	27	11	40.7	24.3	12.2	51.3	11.4
2.5/3.0	28	18	64.3	25	12	48.0	33	15	45.5	28	17	60.7	22	12	54.5	30	14	46.7	27.7	14.7	53.3	7.9
3.0/3.5	31	23	74.2	36	16	44.4	29	19	65.5	28	18	64.3	30	14	46.7	35	15	42.9	31.5	17.5	56.3	13.3
3.5/4.0	42	25	59.5	36	18	50.0	31	18	58.1	27	18	66.7	35	16	45.7	37	23	62.2	34.7	19.7	57.0	7.8
4.0/4.5	44	30	68.2	35	21	60.0	41	24	58.5	32	20	62.5	38	24	63.2	36	26	72.2	37.7	24.2	64.1	5.2
4.5/5.0	53	29	54.7	36	22	61.1	41	24	58.5	38	24	63.2	43	26	60.5	38	26	68.4	41.5	25.2	61.1	4.6
Average	36.1	21.7	59.9	28.9	16.4	60.0	30.6	16.6	53.3	27.6	17.0	60.5	29.3	15.7	52.5	31.3	17.6	54.7	30.6	17.5	56.8	****
SR			(9.6)			(16.4)			(9.7)			(7.6)			(8.9)			(12.7)			(4.5)	

↙ = Downward Torque
↗ = Upward Torque

Table 3. Reverse Torque Ratios for 20 in-lb Torque Increments at the Groveton, VA Site

Torque (lb-in)	1 - 20			21 -40			41 - 60		
No.	↓	↑	R	↓	↑	R	↓	↑	R
1	15	14	93.3	25	13	52.0	42	25	59.5
2	19	12	63.2	30	14	46.7	44	30	68.2
3	12	6	50.0	28	18	64.3	53	29	54.7
4	16	7	43.8	31	23	74.2	41	24	58.5
5	18	7	38.9	25	12	48.0	41	24	58.5
6	19	11	57.9	36	16	44.4	43	26	60.5
7	16	8	50.0	36	18	50.0			
8				35	21	60.0			
9				36	22	61.1			
10				27	10	37.0			
11				33	15	45.5			
12				29	19	65.5			
13				31	18	58.1			
14				24	15	62.5			
15				28	17	60.7			
16				28	18	64.3			
17				27	18	66.7			
18				32	20	62.5			
19				38	24	63.2			
20				22	12	54.5			
21				30	14	46.7			
22				35	16	45.7			
23				38	24	63.2			
24				27	11	40.7			
25				30	14	46.7			
26				35	15	42.9			
27				37	23	62.2			
28				36	26	72.2			
29				38	26	68.4			
Average	16.4	9.3	56.7	31.3	17.7	56.2	44.0	26.3	60.0
SR			(18.1)			(10.1)			(4.5)

Table 4. Reverse Torque Ratios for the McLean, Va Site

Depth(ft)	S - 2			S - 3			S - 4			S - 5			S - 6			S - 7			S - 8		
	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R
0.5 - 1.0	19	7	36.8	24	8	33.3	23	10	43.5	29	5	17.2	25	6	24.0	21	9	41.9	22	10	45.5
1.0 - 1.5	33	13	39.3	41	19	46.3	52	19	36.5	53	22	41.5	50	12	24.0	38	14	36.8	41	19	46.3
1.5 - 2.0	89	25	28.1	45	27	60.0	65	28	43.1	56	32	57.1	69	29	42.0	48	25	52.1	48	25	52.1
2.0 - 2.5	84	42	50.0	72	26	36.1	60	24	40.0	37	22	59.5	42	30	71.4	43	22	51.2	39	20	51.3
2.5 - 3.0	71	35	49.3	89	39	43.8	45	21	46.7	43	20	46.5	65	23	35.4	32	23	71.9	32	19	59.4
3.0 - 3.5	81	33	40.7	53	29	54.7	38	20	52.6	60	32	53.3	92	44	47.8	33	18	54.6	45	19	42.2
3.5 - 4.0	74	37	50.0	58	30	51.7	33	16	48.5	66	31	47.0	62	42	63.6	37	18	48.7	42	20	47.6
4.0 - 4.5	83	28	33.7	71	33	46.5	31	17	54.8	50	28	56.0	55	28	50.9	36	21	58.3	41	20	48.8
4.5 - 5.0	98	46	46.9	68	38	55.9	42	22	52.4	59	27	45.8	51	25	49.0	39	23	59.0	40	23	57.5
Average	70.2	29.6	41.7	57.9	27.7	47.6	43.2	19.7	46.5	50.3	24.3	47.1	56.8	26.6	45.4	36.3	19.2	52.7	38.9	19.4	50.1
SR			(7.9)			(9.0)			(6.2)			(12.7)			(16.2)			(10.2)			(5.6)

S - 9			S - 10			S - 13			S -14			S - 15			S - 16			S - 16			Average			
↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	$\bar{R}$	sR
30	8	26.7	23	8	34.8	21	9	42.9	32	7	21.9	21	11	52.4	29	6	20.7	22	6	27.3	24.4	7.9	33.5	10.8
42	15	35.7	31	14	45.2	35	22	62.9	53	20	33.7	43	17	39.5	42	16	38.1	65	25	38.5	44.2	17.6	40.3	8.7
61	31	50.8	36	16	44.4	40	22	55.0	68	23	33.8	40	21	52.5	47	21	44.7	61	34	55.7	55.2	25.6	48.0	9.1
55	27	49.1	38	20	42.6	43	23	53.5	82	27	32.9	33	16	48.5	48	22	45.8	40	23	57.5	51.1	24.6	49.2	9.9
46	21	45.7	31	18	58.1	37	23	62.2	80	35	38.8	35	26	45.7	65	26	40.0	86	32	37.2	54.1	24.8	48.6	10.6
44	19	43.2	34	16	47.1	40	19	47.5	81	36	44.4	37	18	48.7	86	29	33.7	130	56	43.1	61.0	27.7	46.7	6.0
40	18	45.0	32	16	50.0	42	22	52.4	77	35	45.5	42	20	47.6	96	40	41.7	119	56	47.1	58.9	28.6	49.0	5.0
40	19	47.5	29	22	75.9	42	25	59.5	81	37	45.7	44	27	61.4	100	40	40.0	86	48	55.8	56.4	28.1	52.5	10.3
40	21	52.5	38	22	57.2	46	26	56.5	82	38	46.3	41	24	58.5	103	46	39.3	80	38	47.5	59.1	29.9	51.8	6.1
44.2	19.9	44.0	32.4	16.9	50.7	38.4	21.2	54.7	70.7	28.2	38.1	37.3	18.9	50.5	68.4	27.3	38.2	76.6	5.3	45.5	51.6	23.9	46.6	****
		(8.1)			(11.9)			(6.6)			(8.3)			(6.6)			(7.5)			(10.1)			(6.0)	

Table 5. Reverse Torque Ratios for 20 in-lb Torque Increment at the McLean, VA Site

Torque (lb-in)	1 - 20			21 - 40			41 - 60			61 - 80			81 - 100			more than 100		
No.	↓	↑	R	↓	↑	R	↓	↑	R	↓	↑	R	↓	↑	R	↓	↑	R
1	19	7	36.8	33	13	39.3	41	19	46.3	71	35	49.3	89	25	28.1	103	46	39.3
2				24	8	33.3	45	27	60.0	74	37	50.0	84	42	50.0	119	56	47.1
3				23	10	43.5	53	29	54.7	72	26	36.1	81	33	40.7	130	56	43.1
4				38	20	52.6	58	30	51.7	71	33	46.5	83	28	33.7			
5				33	16	48.5	52	19	36.5	68	38	55.9	98	46	46.9			
6				31	17	54.8	45	21	46.7	65	28	43.1	89	39	43.8			
7				29	5	17.2	42	22	52.4	66	31	47.0	92	44	47.8			
8				37	22	59.5	53	22	41.5	69	29	42.0	82	27	33.9			
9				25	6	24.0	56	32	57.1	65	23	35.4	81	36	44.4			
10				21	9	41.9	43	20	46.5	62	42	63.6	81	37	45.7			
11				38	14	36.8	60	24	40.0	61	31	50.8	82	38	46.3			
12				32	23	71.9	60	32	53.3	68	23	33.8	86	29	33.7			
13				33	18	54.6	50	28	56.0	80	31	38.8	96	40	41.7			
14				37	18	48.7	59	27	45.8	77	35	45.5	100	40	40.0			
15				36	21	58.3	50	12	24.0	65	26	40.0	86	32	37.2			
16				39	23	59.0	42	30	71.4	65	25	38.5	86	48	55.8			
17				22	10	45.5	55	28	50.9	61	34	55.7						
18				39	20	51.3	51	25	49.0	80	38	47.5						
19				32	19	59.4	48	25	52.1									
20				30	8	26.7	43	22	51.2									
21				40	18	45.0	41	19	46.3									
22				40	19	47.5	48	25	52.1									
23				40	21	52.5	45	19	42.2									
24				23	8	34.8	42	20	47.6									
25				31	14	45.2	41	20	48.9									
26				36	16	14.4	40	23	57.5									
27				38	20	42.6	42	15	35.7									
28				31	18	58.1	55	27	49.1									
29				34	16	47.1	46	21	45.7									
30				32	16	50.0	44	19	43.2									
31				29	22	75.9	43	23	53.5									
32				38	22	57.9	42	22	52.4									
33				21	9	42.9	42	25	59.5									
34				35	22	62.9	46	26	56.5									
35				40	22	55.0	53	20	33.7									
36				37	23	62.2	43	17	39.5									
37				40	19	47.5	42	20	47.6									
38				32	7	21.9	44	27	61.4									
39				21	11	52.4	41	24	58.5									
40				40	21	52.5	42	16	38.1									
41				33	16	48.5	47	21	44.7									
42				35	16	45.7	48	22	45.8									
43				37	18	48.7												
44				29	6	20.7												
45				22	6	27.3												
46				40	23	57.5												
Average	19.0	7.0	36.8	32.7	15.8	47.3	47.2	23.0	48.7	68.9	31.4	45.5	87.3	36.5	41.9	117.3	52.7	43.2
SR						(12.8)			(8.6)			(8.0)			(7.2)			(3.9)

Table 6. Reverse Torque Ratios for the NBS site

Depth (ft)	1			2			3			4			5			6			Average			
	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	$\bar{R}$	sR
0.5/1.0	38	11	29.0	25	8	32.0	22	6	27.3	33	8	24.2	26	6	28.1	28	11	39.3	28.7	8.3	30.0	5.2
1.0/1.5	49	22	44.9	50	13	26.0	39	9	23.1	66	12	18.2	43	9	20.9	48	14	29.2	49.2	13.2	27.0	9.6
1.5/2.0	47	25	53.2	47	17	36.2	48	15	31.3	66	10	15.2	49	15	30.6	56	18	32.1	52.2	16.7	33.1	12.2
2.0/2.5	55	25	45.5	93	20	21.5	56	24	42.9	54	17	31.5	62	19	30.7	49	20	40.8	61.5	20.8	35.5	9.1
2.5/3.0	61	49	80.3	85	32	37.7	64	25	39.1	75	20	26.7	75	28	37.3	61	25	41.0	70.2	29.8	43.7	18.6
3.0/3.5	91	33	36.3	98	37	37.8	85	36	42.4	78	31	39.7	88	25	28.4	93	28	30.1	88.8	31.7	35.8	5.5
3.5/4.0	83	38	45.8	108	43	39.8	97	42	44.0	82	30	36.6	88	35	39.8	84	42	50.0	90.3	38.3	42.7	4.9
4.0/4.5	73	37	50.7	77	38	49.4				68	36	59.4	77	32	41.6	78	37	47.4	74.6	36.0	48.4	4.3
4.5/5.0	78	28	35.9	66	38	42.4	132	38	28.8	67	30	44.8	69	34	49.3	58	36	62.1	78.3	34.0	43.9	11.4
Average	63.9	29.8	46.8	72.1	27.3	35.9	67.9	24.4	34.8	65.4	21.6	32.2	64.1	22.6	34.1	61.7	25.7	41.3	66.0	25.4	37.8	***
SR			(14.7)			(8.4)			(8.2)			(12.5)			(8.6)			(10.6)			(7.2)	

Table 7. Reverse Torque Ratios for 20 in-lb Torque Increments at the NBS Site

Torque (lb-in)	21 - 40			41 - 60			61 -80			81 - 100			more than 100		
NO.	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R
1	38	11	29.0	49	22	44.9	61	49	80.3	91	33	36.6	108	43	39.8
2	25	8	32.0	47	25	53.2	73	37	50.7	83	8	45.8	132	38	28.8
3	22	6	27.3	55	25	45.6	78	28	35.9	93	20	21.5			
4	39	9	23.1	50	13	26.0	77	38	49.4	85	32	37.7			
5	33	8	24.2	47	17	36.2	66	38	44.4	98	37	37.8			
6	26	6	28.1	48	15	31.3	64	25	39.1	85	36	42.4			
7	28	11	39.3	56	24	42.9	66	12	18.2	97	42	44.0			
8				54	17	31.5	66	10	15.2	82	30	36.6			
9				43	9	20.9	75	20	26.7	88	25	28.4			
10				49	15	30.6	78	31	39.7	88	35	39.8			
11				48	14	29.2	68	36	52.9	93	28	30.1			
12				56	18	32.1	67	30	44.8	84	42	50.0			
13				49	20	40.8	62	19	30.7						
14				58	36	62.1	75	28	37.3						
15							77	32	41.6						
16							69	34	49.3						
17							61	25	41.0						
18							78	37	47.4						
Average	30.1	8.4	29.0	50.6	19.3	37.6	70.1	27.7	41.4	88.9	33.2	37.5	120	40.5	34.3
SR			(5.4)			(11.2)			(14.4)			(7.9)			(7.8)

Table 8. Reverse Torque Ratios for the Kingstowne, VA Site

Depth (ft)	1			2			3			4			5			6			Average			
	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	R	↙	↗	$\bar{R}$	sR
0.5/1.0	94	37	41.1	116	28	24.1	115	35	30.4	107	27	25.2	144	61	42.4	93	37	39.8	111.5	37.5	33.8	8.3
1.0/1.5	357	141	39.5	184	44	23.9	112	44	39.3	133	45	33.8	162	75	46.3	82	55	67.1	171.7	67.3	41.7	14.5
1.5/2.0	100	36	36.0	139	68	48.9	99	26	26.3	105	56	53.3	136	58	42.6	200	53	26.5	129.8	49.5	38.9	11.3
2.0/2.5	78	30	46.5	159	54	34.0	88	32	36.4	69	36	52.2	77	30	39.0	102	49	48.0	95.5	38.5	42.7	7.2
2.5/3.0	58	40	69.0	158	90	57.0	74	30	40.5	62	28	45.2	122	28	23.0	83	32	38.6	92.8	41.3	45.6	15.9
3.0/3.5	68	33	48.5	116	43	37.1	73	26	35.6	54	24	44.4	120	42	35.0	111	42	37.8	90.3	35.0	39.7	5.5
3.5/4.0	68	26	38.2				66	21	31.8	32	13	40.6	62	29	46.8	60	38	65.0	57.6	25.4	44.5	12.7
4.0/4.5	86	26	30.2	68	24	35.3	49	13	26.5	60	18	30.0	60	31	51.7	82	30	36.6	67.5	23.7	35.1	9.0
4.5/5.0	94	32	34.0	45	21	46.7	44	12	27.3	48	18	37.5	48	21	43.8	70	31	44.3	58.2	22.5	38.9	7.4
Average	111.4	44.6	42.6	123.1	46.5	38.4	80.0	26.6	32.7	74.4	29.4	40.2	103.4	41.7	41.2	98.1	40.9	44.9	97.2	37.9	40.1	****
SR			(11.5)			(11.8)			(5.5)			(9.6)			(8.3)			(13.4)			(4.0)	

Table 9. Reverse Torque Ratios for 20 in-lb Torque Increments at the Kingstowne, VA Site

Torque (lb-in)	21 - 40			41 - 60			61 - 80			81 - 100			more than 100		
NO.	↓	↑	R	↓	↑	R	↓	↑	R	↓	↑	R	↓	↑	R
1	32	13	40.6	58	40	69.0	78	30	46.5	94	37	41.1	357	141	39.5
2				45	21	46.7	68	33	48.5	100	36	36.0	116	28	24.1
3				49	13	26.5	68	26	38.2	86	26	30.2	184	44	23.9
4				44	12	27.3	68	24	25.3	94	32	34.0	139	68	48.9
5				54	24	44.4	74	30	40.5	99	26	26.3	159	54	34.0
6				60	18	30.0	73	26	35.6	88	32	36.4	158	90	57.0
7				48	18	37.5	66	21	31.8	93	37	39.8	116	43	37.1
8				60	31	51.7	69	36	52.2	82	55	67.1	115	35	30.4
9				48	21	43.8	62	28	45.2	83	32	38.6	112	44	39.3
10				60	38	65.0	77	30	39.0	82	30	36.6	107	27	25.2
11							62	29	46.8				133	45	33.8
12							70	31	44.3				105	56	53.3
13													144	61	42.4
14													162	75	46.3
15													136	58	42.6
16													122	28	23.0
17													120	42	35.0
18													200	53	26.5
19													102	49	48.0
20													111	42	37.8
Average	32.0	13.0	40.6	52.6	23.6	44.2	69.6	28.7	41.2	90.1	34.3	38.6	144.9	54.2	37.4
SR						(14.7)			(7.7)			(10.9)			(10.1)

for the reverse torque ratios (in parentheses) are shown in the last two rows of each table. In the second table for each site, the data for the site are arranged by ranges of torque magnitudes and averaged, in order to determine whether the reverse torque ratio is sensitive to the magnitude of the torque (in the CPT the friction ratio is sensitive to the magnitude of the tip resistance).

Figures 1, 2, and 3 show grain size distributions for the Groveton, VA, NBS, and Kingstowne, VA sites, respectively. No grain size distribution was determined for the McLean, VA site, but avalable data [1] indicate that D_{50} for the McLean site is 0.03mm and the material is silt (ML).

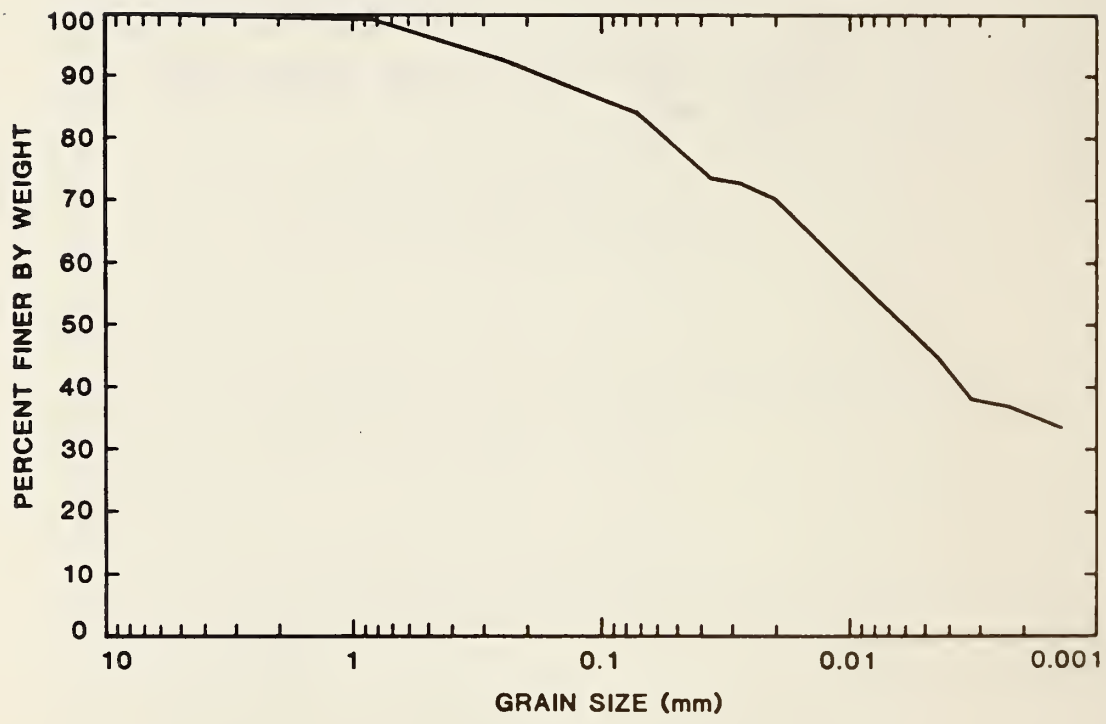

Figure 1. Grain Size Distribution for the Groveton, VA Site

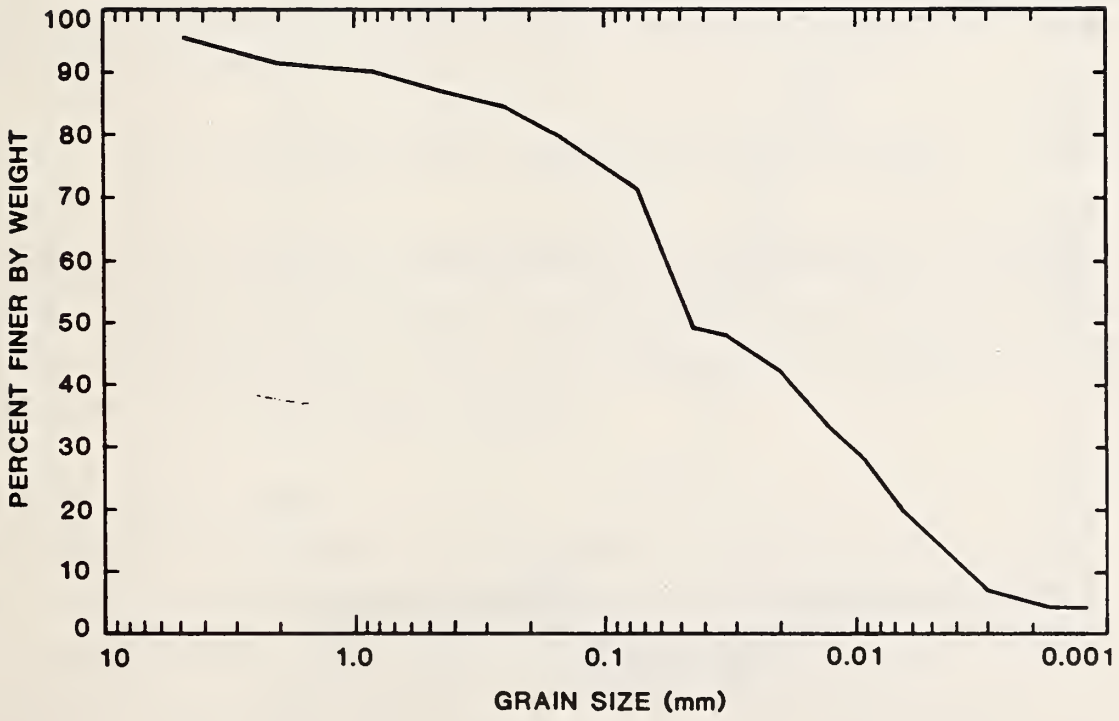

Figure 2. Grain Size Distribution for the NBS Site.

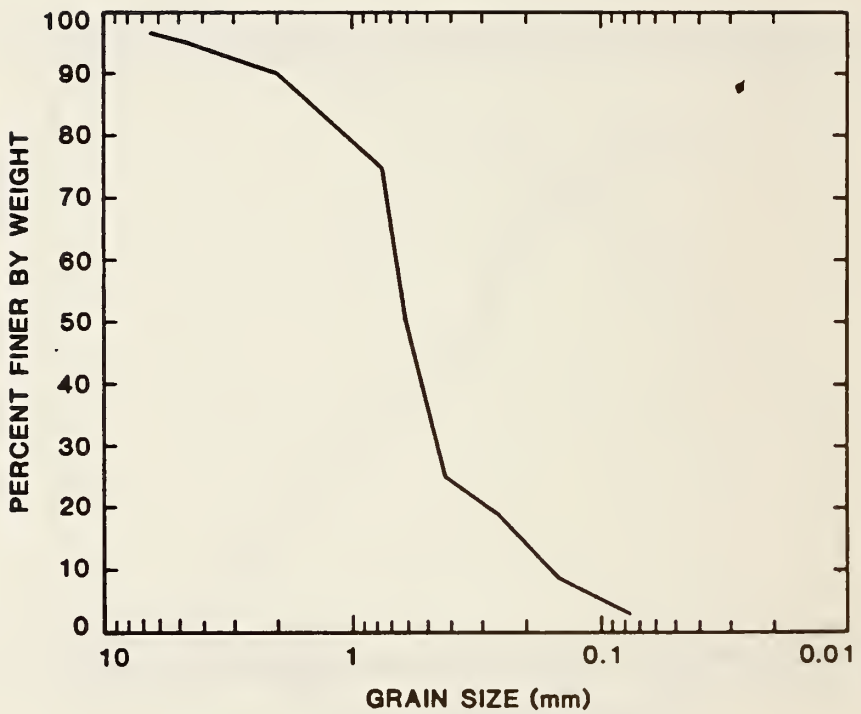

Figure 3. Grain Size Distribution for the Kingstowne, VA Site.

3. ANALYSIS OF TEST RESULTS

Relation Between Reverse Torque Ratio and Particle Size:
Figure 4 shows a plot of average values of the reverse torque ratio against D_{50}. The figure clearly illustrates that R decreases with increasing grain size. There are not enough data points to suggest an equation for the relation between R and D_{50}, but the figure shows that it will be possible to infer grain size characteristics from reverse torque ratio after sufficient data become available. A tentative correlation derived from the small data sample available is:

$$R \simeq 35 \times D_{50}^{-0.08} \text{ , where R is in percent.}$$

Sensitivity of Reverse Torque Ratio to Magnitude of Torque:
Figure 5 shows variation of R with t_{12} for the various sites. The figure indicates that R does not appear to be sensitive to the magnitude of the downward torque.

Variability of Data:
The average coefficient of variation of the reverse torque ratios was 0.18 for the Groveton, site, 0.19 for the McLean site, 0.24 for the NBS site, and 0.25 for the Kingstowne site. While this variability is considerable, it is in part caused by the variability of the soils within the site, and it is within the range of variabilities that would be anticipated for soil exploration data.

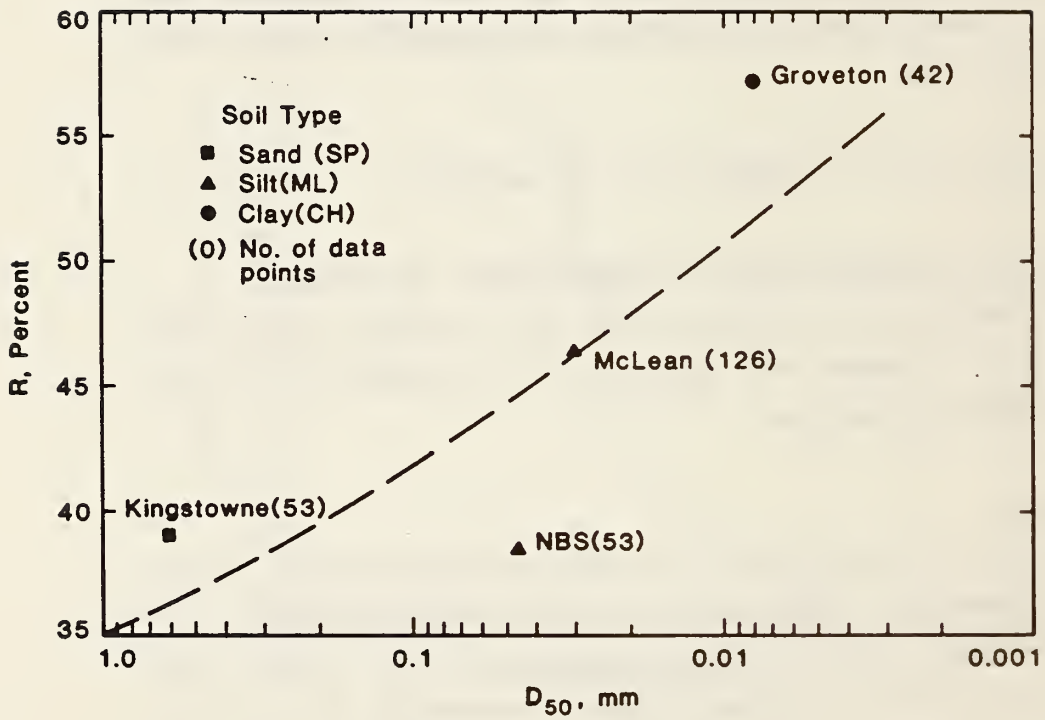

Figure 4. Relation between D_{50} and Reverse Torque Ratio

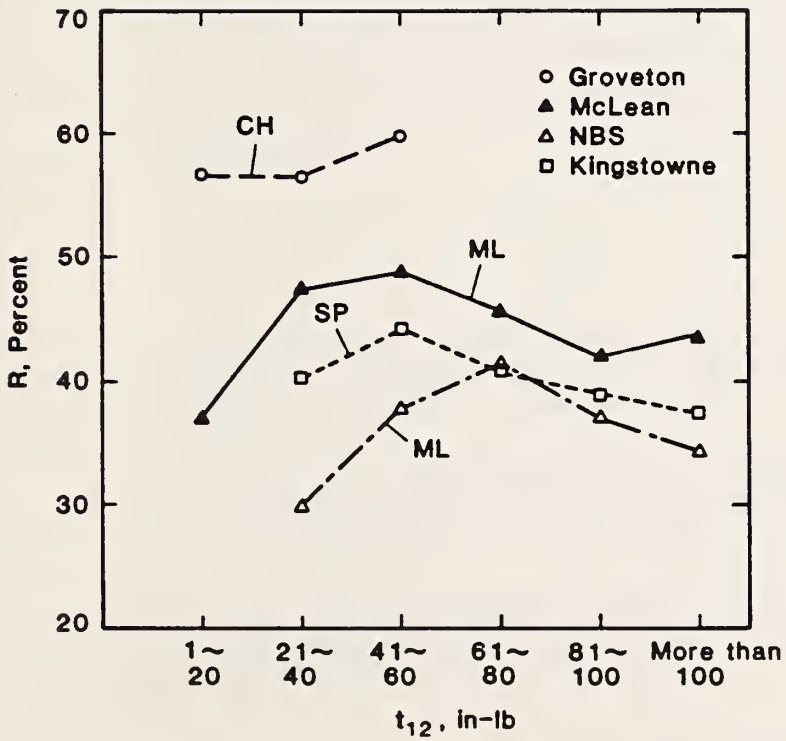

Figure 5. Variation of R with t_{12}.

4. CONCLUSIONS

The helical probe test data presented in this report indicate that there is a definite trend for the reverse torque ratio to increase with decreasing average particle size. The variability of the data is within the range that would be expected for soil exploration data. The data sample in this study was not large enough to allow recommending a relation between the reverse torque ratio and the particle size characteristics that can be used in the field, however the tentative relation suggested could be used in pilot explorations.

5. REFERENCES

[1] Yokel, F.Y., and Mayne, P.W., Helical Probe Tests for Shallow Soil Exploration, NBSIR 86-3351, National Bureau of Standards, Washington, D.C. January, 1986.

[2] ASTM Designation D2487-83, Standard Test Method for Classification of Soils for Engineering Purposes, American Society for Testing and Materials, Vol. 4.08, 1985.

[3] ASTM Designation D1556-82, Standard Test Method for Density of Soils In Place by the Sand Cone Method, American Society for Testing and Materials, Vol.4.08, 1985.

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

A helical test probe, developed by the National Bureau of Standards for shallow soil exploration does not extract soil samples from the ground. A study was therefore conducted to determine whether the ratio of the torque required to extract the Helical Test Probe to the torque required to advance the probe (the reverse torque ratio) can be used to determine the average grain size (D_{50}) of the soil. On the basis of 274 test points in sandy, silty, and clayey soils, it was concluded that the reverse torque ratio decreases with increasing average grain size. The relation between grain size and reverse torque ratio is apparently not sensitive to the magnitude of the torque required to advance the probe.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Construction supervision; field test equipment; helical augers; in situ measurements; penetration tests; soil investigation; test procedures.

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