Standard Method of Test for

Determining Riprap Gradation by Wolman Count

FLH Designation: T 521-13

1. SCOPE

1.1. This method describes the procedure that will be used to determine riprap gradation by Woman count. The method is designed to determine a size distribution of riprap rock based on a random sampling of individual particles within a matrix.

1.2. After individual particles have been measured, a gradation curve can be developed based on the frequency of the various sizes.

2. REFERENCED DOCUMENTS

2.1 *National Cooperative Highway Research Program:*

- Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control.

3. TERMINOLOGY

3.1. *Intermediate dimension* – The longest, straight-line distance across the rock that is perpendicular to the longest axis on the face of the rock with the largest projection plane. This dimension can be visualized as the smallest sieve opening that will pass a given rock particle. For the idealized rock particle shown in Figure 1, this would be dimension 'B'.

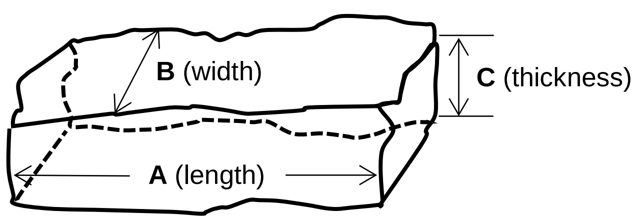

Figure 1 – Rock particle dimensions (dimensions exaggerated for illustrative purposes)

3.2. *transect* – A single transverse crossing of a riprap pile or installation for the purpose of measuring individual rock particles.

Note 1– In order to obtain the minimum number of particles to be measured as stated in the method, multiple transects may need to be performed depending on size and shape of the riprap mass.

4. PROCEDURE

4.1. Stretch a suitable flexible tape measure across the top and completely over riprap mass. Index the 'zero' value on the tape as the count starting point.

4.2. At intervals equal to the maximum particle size specified for the riprap class or one foot, whichever is greater, select the rock particle directly below the interval mark on the tape measure. Measure and record the intermediate dimension of the particle. (The dimension should be estimated as accurately as possible if direct access is obstructed by large rock or other heavy debris.) If the size of the selected rock is larger than the selection interval, record the measured intermediate dimension of the rock twice as if two rock particles are present.

4.3. Continue across the riprap mass measuring the rock particles at the specified interval until the traverse is completed. This constitutes one transect of the riprap mass.

4.4. Repeat the procedures in 4.1 to 4.3 for additional transects if necessary until a minimum of 100 particles have been measured. Multiple transects must be evenly spaced over the rock mass.

4.5. Once a minimum of 100 particles have been measured, record the particle count for the various size ranges listed in Table 1. The particle count is the number of individual rocks that meet the particle size range listed in the table.

4.6. Determine the cumulative percent smaller by dividing the cumulative particle count by the total number of particles measured.

Table 1— Particle Count and Cumulative Percent Smaller Determination

Particle Size (inches)	Particle Size Range	Particle Count	Cumulative Particle Count	Cumulative Percent Smaller (Cum. Particle count / total particles)
3.00	≤ 3.00			
4.25	3.00 < x ≤ 4.25			
6.00	4.25 < x ≤ 6.00			
8.50	6.00 < x ≤ 8.50			
12.00	8.50 < x ≤ 12.00			
17.00	12.00 < x ≤ 17.00			
24.00	17.00 < x ≤ 24.00			
34.00	24.00 < x ≤ 34.00			
48.00	34.00 < x ≤ 48.00			
68.00	48.00 < x ≤ 68.00			
96.00	68.00 < x ≤ 96.00			

5. REPORT

5.1. The report shall include the following:

5.1.1. Report the intermediate dimension for all rock particles measured.

5.1.2. Plot the cumulative percent smaller versus the particle size on a semi-log graph to produce the representative Wolman count gradation curve as shown in Figure 2.

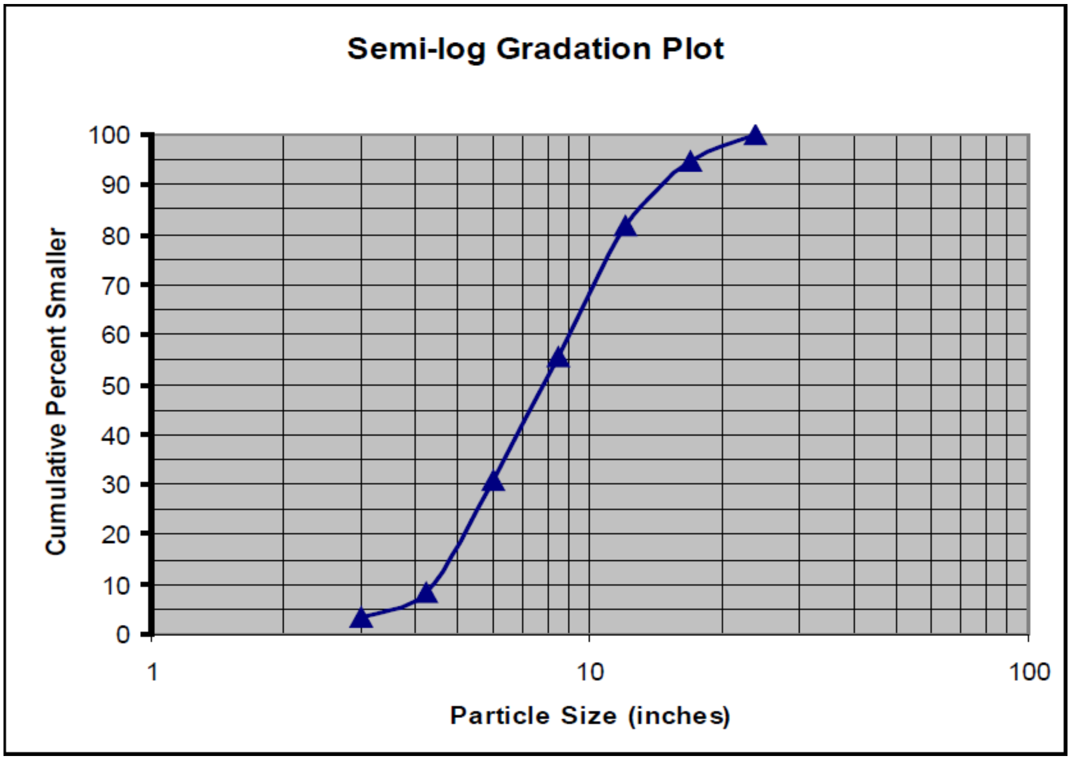

Figure 2 – Example Gradation Plot

5.1.3. Report the particle sizes that are cumulatively 15, 50, 85 and 100 percent smaller by size (i.e. D_{15}, D_{50}, D_{85}, and D_{100}).

APPENDIX

(Example)

X. WOLMAN COUNT AND ANALYSIS

X1.1. Conduct a Wolman count and analysis on the rock produced and stockpiled for use on the project.

X1.2. Given the configuration of this particular pile, three transects of the pile will be needed in order to obtain a minimum of 100 particle measurements. The three transects were taken at equal intervals along the pile. The data collected is shown in Table 2, Table 3, and Table 4.

Table 2— Particle Count Transect No. 1

Rock Count	Intermediate Dimension (inches)	Rock Count	Intermediate Dimension (inches)	Rock Count	Intermediate Dimension (inches)
1	0.6	36		71	
2	4.8	37		72	
3	12	38		73	
4	7.2	39		74	
5	3.6	40		75	
6	9.6	41		76	
7	9.6	42		77	
8	4.8	43		78	
9	6	44		79	
10	8.4	45		80	
11	4.8	46		81	
12	10.8	47		82	
13	8.4	48		83	
14	7.2	49		84	
15	6	50		85	
16	4.8	51		86	
17	15.6	52		87	
18	6	53		88	
19	4.8	54		89	
20	10.8	55		90	
21	8.4	56		91	
22	10.8	57		92	
23	8.4	58		93	
24	18	59		94	
25	12	60		95	
26	9.6	61		96	
27	7.2	62		97	
28	7.2	63		98	
29	6	64		99	
30	8.4	65		100	
31	18	66		101	
32	12	67		102	
33	10.8	68		103	
34	4.8	69		104	
35	15.6	70		105	

Table 3— Particle Count Transect No. 2

Rock Count	Intermediate Dimension (inches)	Rock Count	Intermediate Dimension (inches)	Rock Count	Intermediate Dimension (inches)
1	12	36	8.4	71	
2	13.2	37	12	72	
3	7.2	38	12	73	
4	9.6	39	13.2	74	
5	3.6	40	8.4	75	
6	7.2	41		76	
7	8.4	42		77	
8	7.2	43		78	
9	2.4	44		79	
10	4.8	45		80	
11	6	46		81	
12	7.2	47		82	
13	4.8	48		83	
14	6	49		84	
15	8.4	50		85	
16	12	51		86	
17	13.2	52		87	
18	8.4	53		88	
19	16.8	54		89	
20	6	55		90	
21	10.8	56		91	
22	18	57		92	
23	7.2	58		93	
24	7.2	59		94	
25	7.2	60		95	
26	14.4	61		96	
27	16.8	62		97	
28	6	63		98	
29	18	64		99	
30	15.6	65		100	
31	10.8	66		101	
32	6	67		102	
33	15.6	68		103	
34	12	69		104	
35	18	70		105	

Table 4— Particle Count Transect No. 3

Rock Count	Intermediate Dimension (inches)	Rock Count	Intermediate Dimension (inches)	Rock Count	Intermediate Dimension (inches)
1	18	36		71	
2	12	37		72	
3	10.8	38		73	
4	4.8	39		74	
5	15.6	40		75	
6	6	41		76	
7	8.4	42		77	
8	6	43		78	
9	13.2	44		79	
10	4.8	45		80	
11	6	46		81	
12	7.2	47		82	
13	10.8	48		83	
14	4.8	49		84	
15	8.4	50		85	
16	7.2	51		86	
17	6	52		87	
18	15.6	53		88	
19	12	54		89	
20	6	55		90	
21	10.8	56		91	
22	10.8	57		92	
23	3.6	58		93	
24	12	59		94	
25	2.4	60		95	
26	9.6	61		96	
27	2.4	62		97	
28	8.4	63		98	
29	10.8	64		99	
30	3.6	65		100	
31	12	66		101	
32	13.2	67		102	
33	7.2	68		103	
34	9.6	69		104	
35	3.6	70		105	

X1.3. From the 110 particles measured, determine the number of particles that fit in the appropriate established particle size ranges. From the particle count, the "Cumulative Particle Count" and the "Cumulative Percent Smaller" can be computed (Table 5).

Table 5— Particle Count and Cumulative Percent Smaller Determination

Particle Size (inches)	Particle Size Range	Particle Count	Cumulative Particle Count	Cumulative Percent Smaller (cum. Particle count / total particles)
3.00	≤ 3.00	4	4	3.6
4.25	$3.00 < x \leq 4.25$	5	9	8.2
6.00	$4.25 < x \leq 6.00$	25	34	30.9
8.50	$6.00 < x \leq 8.50$	27	61	55.5
12.00	$8.50 < x \leq 12.00$	29	90	81.8
17.00	$12.00 < x \leq 17.00$	14	104	94.5
24.00	$17.00 < x \leq 24.00$	6	110	100.0
34.00	$24.00 < x \leq 34.00$	0		
48.00	$34.00 < x \leq 48.00$	0		
68.00	$48.00 < x \leq 68.00$	0		
96.00	$68.00 < x \leq 96.00$	0		

X1.4. To complete the report, plot the cumulative percent smaller versus the particle size on a semi-log graph, as shown in Figure 3, and report D_{15} = 4.8", D_{50} = 7.8", D_{85} = 13.0", and D_{100} = 24".

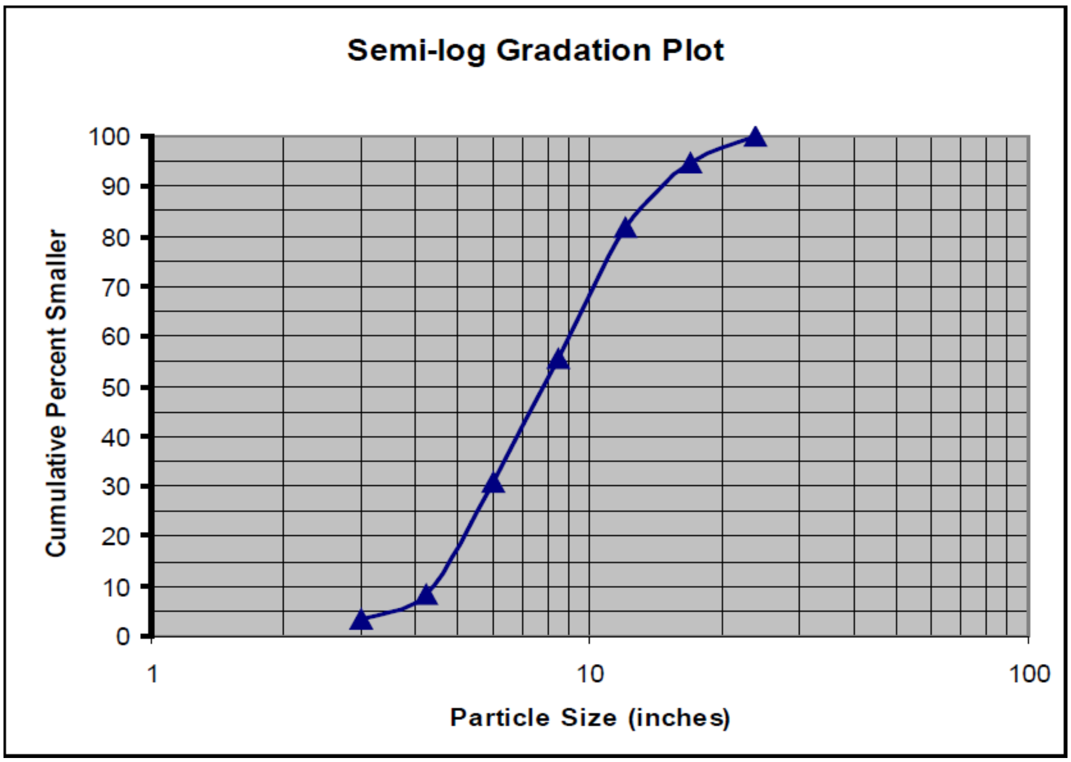

Figure 3 – Example Gradation Plot