# Riprap Gradation Test Method

Updated September 2016

## DATA COLLECTION

The riprap gradation shall be tested using the equal interval variation of the Wolman pebble count described in NCHRP 568, Section 5.2.5. The engineer further defines this method according to the following steps:

1. Spread a trailer load of riprap onto a rectangular area of ground. The layer height should be uniform, and should be approximately the maximum height of the bigger rocks.
2. Starting at one end of the rectangle, create a transect by laying a tape measure lengthwise across the pile.
3. With spray paint, mark the rock that falls under the tape measure at every three-foot interval. If the interval falls on a void space, mark the next rock to the right. Do not mark any rock more than once. If the rock is too large for three-foot intervals (i.e. $D_{50}$=24"), use intervals of four or more feet.
4. Pick up the tape and lay another transect parallel to the first transect. The distance between transects should equal the interval from step three, and should be large enough such that no rocks fall under more than one transect.
5. Repeat steps three and four until a total of at least 40 rocks are marked. If the full trailer load is less than 40 rocks, just measure all of the rocks in the load.
6. Measure the length of the intermediate axis (B axis) of each marked rock. The intermediate axis is the middle dimension, not the longest or shortest dimension.
7. Record the measured lengths.

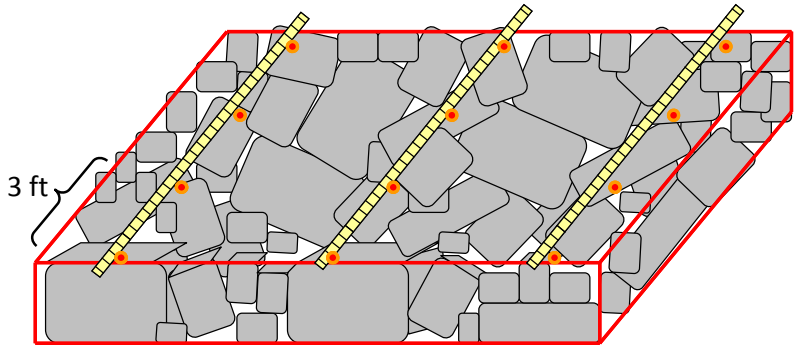


**Figure 1:** Equal interval method example layout. Not to scale.

**References:**

National Cooperative Highway Research Program. *NCHRP Report 568: Riprap Design Criteria, Recommended Specifications, and Design Criteria.* 2006.

**ANALYSIS**

1. Enter the measured data into a spreadsheet, and sort the rock sizes from smallest to largest.
2. Create size bins (categories) that span at least the range of measured rock sizes. Count the number of rocks that are in each size bin. Then, calculate the cumulative number and percent of rocks that are equal to or smaller than the size bin. See example spreadsheet.
3. Calculate the D100, D85, D50, and D15 rock sizes. Interpolation may be necessary. See example spreadsheet.
4. Enter into the spreadsheet the specified minimum and maximum limits for D100, D85, D50, and D15 for the particular rock size class.
5. Plot the four points calculated in step 3, and connect them with a line. This is the gradation of the measured rock. Also plot the specified minimum and maximum gradations. The plot should show:
   X-axis: Rock diameter
   Y-axis: Cumulative percent smaller or equal by number
   If the measured line lies between the specified minimum and maximum lines, then the rock gradation fits the specification.
6. Provide to the engineer at minimum the raw data, the plot, and a table showing the calculated D100, D85, D50, and D15. See attached example.

**EXAMPLE**

Based on the plots of the measured data, the rock sample does not quite comply with the required gradation.

| RAW DATA | | WORKED DATA | | | | |
|---|---|---|---|---|---|---|
| Measured B-axis, Rounded, inches | | SAMPLE SIZE | BIN SIZE (INCHES) | BIN COUNT | COUNT EQUAL OR SMALLER | PERCENT EQUAL OR SMALLER |
| 23 | | 43 | 0 | 0 | 0 | 0.0% |
| 32 | | | 1 | 0 | 0 | 0.0% |
| 31 | | | 2 | 0 | 0 | 0.0% |
| 38 | | | 3 | 0 | 0 | 0.0% |
| 35 | | | 4 | 0 | 0 | 0.0% |
| 22 | | | 5 | 0 | 0 | 0.0% |
| 18 | | | 6 | 0 | 0 | 0.0% |
| 20 | | | 7 | 0 | 0 | 0.0% |
| 34 | | | 8 | 0 | 0 | 0.0% |
| 11 | | | 9 | 0 | 0 | 0.0% |
| 31 | | | 10 | 0 | 0 | 0.0% |
| 14 | | | 11 | 2 | 2 | 4.7% |
| 11 | | | 12 | 3 | 5 | 11.6% |
| 20 | | | 13 | 1 | 6 | 14.0% |
| 18 | | | 14 | 1 | 7 | 16.3% |
| 20 | | | 15 | 0 | 7 | 16.3% |
| 37 | | | 16 | 0 | 7 | 16.3% |
| 12 | | | 17 | 2 | 9 | 20.9% |
| 19 | | | 18 | 3 | 12 | 27.9% |
| 13 | | | 19 | 1 | 13 | 30.2% |
| 34 | | | 20 | 5 | 18 | 41.9% |
| 12 | | | 21 | 0 | 18 | 41.9% |
| 43 | | | 22 | 2 | 20 | 46.5% |
| 34 | | | 23 | 2 | 22 | 51.2% |
| 31 | | | 24 | 2 | 24 | 55.8% |
| 26 | | | 25 | 0 | 24 | 55.8% |
| 22 | | | 26 | 1 | 25 | 58.1% |
| 24 | | | 27 | 0 | 25 | 58.1% |
| 35 | | | 28 | 1 | 26 | 60.5% |
| 20 | | | 29 | 0 | 26 | 60.5% |
| 17 | | | 30 | 0 | 26 | 60.5% |
| 34 | | | 31 | 3 | 29 | 67.4% |
| 12 | | | 32 | 2 | 31 | 72.1% |
| 18 | | | 33 | 0 | 31 | 72.1% |
| 28 | | | 34 | 5 | 36 | 83.7% |
| 38 | | | 35 | 2 | 38 | 88.4% |
| 24 | | | 36 | 1 | 39 | 90.7% |
| 23 | | | 37 | 1 | 40 | 93.0% |
| 34 | | | 38 | 2 | 42 | 97.7% |
| 32 | | | 39 | 0 | 42 | 97.7% |
| 36 | | | 40 | 0 | 42 | 97.7% |
| 17 | | | 41 | 0 | 42 | 97.7% |
| 20 | | | 42 | 0 | 42 | 97.7% |
| | | | 43 | 1 | 43 | 100.0% |
| | | | 44 | 0 | 43 | 100.0% |

| REQUIRED GRADATION | | | MEASURED SAMPLE | |
|---|---|---|---|---|
| PERCENT EQUAL OR SMALLER | SIZE, MIN (in) | SIZE, MAX (in) | SIZE (in) | WITHIN RANGE? |
| 100% | 36 | 41 | 43.0 | NO |
| 85% | 29 | 34 | 34.3 | NO |
| 50% | 24 | 28 | 22.8 | NO |
| 15% | 10 | 14 | 13.5 | YES |

Plot This